Waipa District Council

Cambridge WWTP - Option 3

Offsetting Options for Managing Wastewater Discharge from Cambridge WWTP

May 2019

Table of contents

Table index

Figure index

Appendices

Abbreviations

AAF	Annual Average (Daily) Flow
ADWF	Average Dry Weather Flow
AEE	Assessment of Environmental Effects
CBOD5	Carbonaceous 5-day Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DIN	Dissolved Inorganic Nitrogen
DRP	Dissolved Reactive Phosphorus
EP	Equivalent Persons
EPA	Environment Protection Authority
FMU	Freshwater Management Unit
HCC	Hamilton City Council
NH_4-N	Ammoniacal Nitrogen
NO_3-N	Nitrate Nitrogen
NPS	National Policy Statement
PC1	Plan Change 1
PFD	Process Flow Diagram
PIF	Peak Instantaneous Flow
PWWF	Peak Wet Weather Flow
RMA	Resource Management Act
TN	Total Nitrogen
TP	Total Phosphorus
TSS	Total Suspended Solids
UV	Ultraviolet (Disinfection)
WDC	Waipa District Council
WRA	Waikato River Authority
WRC	Waikato Regional Council
WWTP	Wastewater Treatment Plant

Executive Summary

The consents that Waipa District Council (WDC) holds to discharge contaminants from Cambridge Wastewater Treatment Plant (Cambridge WWTP) expired on 1 December 2016 and a consent application was lodged by WDC in December 2011 which was put on hold immediately. Apart from minor improvement to current plant operation, WDC has put continuous effort into finding alternative, more cost effective ways to meet expected final effluent quality. This included a significant trial at Cambridge WWTP to test the effectiveness of high rate algae ponds, which proved to be unsuccessful. The introduction of the Waikato Regional Plan - Waikato and Waipa River Catchments (Plan Change 1) (notified October 2016), with its policy provisions for offset mitigation for point source discharges, has led to the development of a new alternative contaminant offsetting option (Option 3), not previously considered by Council in detail.

The Cambridge WWTP effluent discharges are likely to have a low contribution to the Waikato River nutrient and pathogen loads. An upgrade to the Cambridge WWTP to achieve nutrient removal will require significant capital investment which is unlikely to result in a commensurate decrease in nitrogen loads. Nutrient offset mitigation measures in the wider catchment alongside some level of WWTP upgrade may therefore support an overall betterment of the wider catchment environment, at a lower all of life cost to the Waipa community and thus warrants further consideration.

On behalf of WDC, GHD Limited (GHD) has investigated the feasibility of implementing a nutrient offset scheme for Cambridge WWTP. The key objective of this investigation is to identify a list of plausible offset mitigation options in conjunction with necessary WWTP upgrades to meet environmental and community needs. As the proposed Plan Change 1 is still at submission stage and its offset mitigation framework is undeveloped, GHD have adopted general principles of offsetting options based on international practice, specifically:

1. Deliver net environmental benefit compared to actions that would otherwise be required.
2. Be cost-effective in addressing the potential adverse environmental impact.
3. Not facilitate or reward poor environmental management practices.

In light of the principles above, the objective of this investigation is not intended to be a substitute for good environmental practices (e.g. significant upgrade of treatment works to achieve high levels of nutrient removal etc.). Rather, the environmental offset options explored in this study will be one component of an overall strategy to ensure the best economic, social, and environmental outcome at the site.

GHD carried out a high level assessment of the potential for WDC to apply a nutrient offset approach as an alternative to upgrades to the Cambridge WWTP. The assessment findings have shown that this is potentially a viable and affordable option.

Of the offsets considered a combination of fencing and riparian planting is considered to be the most practicable to apply within the Waikato River catchment. It shall be noted that the implementation of an offsetting approach does not over-ride the need to also undertake some upgrades to the plant. The combination of both approaches offers a robust and flexible solution that meet the vision and strategy for the Waikato River.

Catchment-level offset location options were identified by GHD and a multi-criteria analysis (MCA) framework was used to compare identified options. Based on the preliminary MCA findings, option 3B – involving Fencing and Riparian Planting within the Karapiro catchment hill country sub-catchment and a suite of optimisation/upgrade works at the plant, has been shown to provide adequate nutrient removal capacity that meets the required nutrient offset target for the Cambridge WWTP. It is noted that other areas may be suitable for offset as part of a staged solution.

Refinement and confirmation of the option assessment framework and methodology; and subsequently refinement of the offset option development is necessary to confirm that net environmental benefit can be achieved by Option 3 and recommendations are included in section 4 to progress this. A Detailed Business Case is also proposed to be advanced in combination with these further works.

In addition a consultation process is underway with key stakeholders including iwi and WRC which will further inform the option viability.

1. Introduction

1.1 Background

Waipa District Council (WDC) holds resource consents (No. 960697, 960698 and 960699) to discharge treated wastewater to the Waikato River (either via rapid infiltration beds or directly into the Waikato River as a contingency discharge only) and discharge contaminants into the air (odour) from Cambridge Wastewater Treatment Plant (Cambridge WWTP). The consents expired on 1 December 2016 and a consent application was lodged by WDC in December 2011 which specified a set of future discharge parameters. This consent application, supported by the 2018/28 Long Term Plan funding, proposed a staged WWTP upgrade with a total cost estimated at $27M to meet the future proposed discharge limits (referred to herein as Option 1).

Discussions have also been underway with Hamilton City Council (Hamilton CC) regarding long term solutions for providing an effective wastewater solution for servicing growth in the southern area of Hamilton and how this may support Councils treatment needs for Cambridge. This discussion is a continuation of previous work undertaken between Hamilton CC and W DC, and is focused on whether there could be a long-term joint solution(s) to Southern Wastewater servicing (referred to as Option 2). Option 2 is still in its infancy and requires further discussions between Hamilton CC and WDC. Option 2 is therefore unlikely to be considered as a short term solution for the Cambridge Plant, but may become a medium to longer term solution for the district, particularly with growth discussions underway between the Future Proof family and Central Government agencies.

The Cambridge WWTP has a history of consent compliance challenges in terms of discharge quality, particularly due to the lack of nitrification and poor removal of dissolved inorganic nitrogen (DIN). Apart from minor improvement to current plant operation, WDC has put continuous effort into finding alternative, more cost effective ways to meet expected final effluent quality. This included a significant trial at Cambridge WWTP to test the effectiveness of high rate algae ponds, which proved to be unsuccessful.

The introduction of the Waikato Regional Plan - Waikato and Waipa River Catchments (Plan Change 1) (notified October 2016), with its policy provisions for offset mitigation for point source discharges, has led to the development of a new alternative contaminant offsetting option (Option 3), not previously considered by Councilin detail

The Cambridge WWTP typically contributes approximately 0.03% to the total flow of the Waikato River[1]. In addition, approximately 55% of land cover within the catchment of the Cambridge WWTP has been categorised as nutrient contributing land. This suggests that the Cambridge WWTP outputs are likely to have a low contribution to the Waikato River nutrient and pathogen loads. An upgrade to the Cambridge WWTP to achieve nutrient removal will require significant capital investment which is unlikely to result in a commensurate decrease in nitrogen loads. Nutrient offset mitigation measures in the wider catchment alongside some level of WWTP upgrade may therefore support an overall betterment of the wider catchment environment, at a lower all of life cost to the Waipa community and thus warrants further consideration.

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[1] GHD 2018 Three Waters Review: Cost Estimates for Upgrading Wastewater Treatment Plants to Meet Objectives of the NPS Freshwater, Report prepared for Department of Internal Affairs.

1.2 Objectives

The purpose of this work is to investigate the feasibility of implementing a nutrient offset scheme for Cambridge WWTP and to identify a list of plausible offset mitigation options in conjunction with necessary WWTP upgrades to meet environmental and community needs. As the proposed Plan Change 1 is still at submission stage and its offset mitigation framework is undeveloped, GHD have adopted general principles of offsetting options based on international practice[2], specifically:

4. Deliver net environmental benefit compared to actions that would otherwise be required.
5. Be cost-effective in addressing the potential adverse environmental impact.
6. Not facilitate or reward poor environmental management practices.

In light of the principles above, the objective of this investigation is not intended to be a substitute for good environmental practices (e.g. significant upgrade of treatment works to achieve high levels of nutrient removal etc.). Rather, the environmental offset options explored in this study will be one component of an overall strategy to ensure the best economic, social, and environmental outcome at the site.

1.3 Purpose of this report

This report outlines the statutory framework for nutrient offset mitigation option development and implementation, describes the methodology adopted, and summarises the identified high-level offset options for Cambridge WWTP. After screening of potential options, the short-listed options were assessed using a multi-criteria assessment framework.

To build on this high level option development, recommendations for further work have been proposed. These include in-depth investigation of the recommended option(s), consultation with all stakeholders, and establishment of a monitoring and reporting programme to ensure that the identified offset mitigation option can be implemented successfully. This is all proposed to be carried out through a Better Business Case framework.

1.4 Scope and limitations

This report: has been prepared by GHD for Waipa District Council and may only be used and relied on by WDC for the purpose agreed between GHD and the WDC as set out in section 1.0 of this report.

GHD otherwise disclaims responsibility to any person other than WDC arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

[2] Alluvium 2015, Water Quality Offsets Framework, Report prepared for adoption by Victorian Water Industry.

GHD has prepared this report on the basis of information provided by WDC and others who provided information to GHD (including Government authorities)], which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

GHD has prepared the preliminary cost estimate set out in section 3.5.4 of this report ("Cost Estimate") using information reasonably available to the GHD employee(s) who prepared this report; and based on assumptions and judgments made by GHD.

The Cost Estimate has been prepared for the purpose of high level comparison only and must not be used for any other purpose.

The Cost Estimate is a preliminary estimate only. Actual prices, costs and other variables may be different to those used to prepare the Cost Estimate and may change. Unless as otherwise specified in this report, no detailed quotation has been obtained for actions identified in this report. GHD does not represent, warrant or guarantee that the [works/project] can or will be undertaken at a cost which is the same or less than the Cost Estimate.

Where estimates of potential costs are provided with an indicated level of confidence, notwithstanding the conservatism of the level of confidence selected as the planning level, there remains a chance that the cost will be greater than the planning estimate, and any funding would not be adequate. The confidence level considered to be most appropriate for planning purposes will vary depending on the conservatism of the user and the nature of the project. The user should therefore select appropriate confidence levels to suit their particular risk profile.

1.5 Assumptions

A range of assumptions were made throughout the offsets option development and assessment process of the project. These include, in particular, nutrient generation rates, and the nutrient removal performance of offset options, etc. most of which were derived from literature review. Where technical uncertainties exist, GHD have endeavoured to apply conservative measures to ensure that the potential uncertainties are accounted for. All the assumptions and references are recorded in this report.

2. Nutrient Offsetting Opportunities and Requirements

2.1 Statutory Framework

A detailed statutory assessment for each offset option is not considered necessary at this stage, but will be undertaken if a particular option is determined to be carried forward by WDC.

This section summarises the statutory framework that regulates the offset option development and assessment. The likely planning risks associated with offset proposals are also highlighted in this section and incorporated in the option assessment process as detailed in section 3.5.

The key relevant planning instruments include the Resource Management Act 1991 (RMA), the Waikato Regional Policy Statement, the Waikato Regional Plan, and particularly the Proposed Plan Change 1 of the Waikato Regional Plan.

2.2 Current Cambridge WWTP

The current Cambridge WWTP comprises of a screen, a grit removal channel, an anaerobic lagoon, an aerated lagoon, and a sedimentation lagoon. Two parallel wetland systems are used for effluent polishing, followed by a series of eight (8) rapid infiltration beds (RIBs) for final effluent disposal. The treated effluent percolates through the porous soils into the Waikato River.

The sludge produced from the treatment processes is intermittently pumped to one of the two sludge storage lagoons. The sludge is periodically removed and dewatered on site using geobags.

Historically, there have been non-compliance issues at Cambridge WWTP. Key issues have included elevation of BOD concentrations in the effluent, solids carry-over leading to breaches in TSS consent limit, and the on-going challenge of meeting the consent dissolved inorganic nitrogen (DIN) limit of 10 mg/L. WDC is continuously making effort to improve the effluent quality. Recent operational improvements have included increased aeration capacity to remove BOD and improved sedimentation to minimise solids carry-over. Short term Chlorine dosing was recently implemented to reduce the pathogen level within the treated effluent, however this is understood to be approved by WRC as a short term measure only. Further operational improvements are being investigated and will be implemented independently from the current consenting work these include the following:

- A screen replacement.
- Anaerobic pond bypass.
- Improved trade waste management.
- Aeration basin liner repair.
- Sludge lagoon desludge.
- Anaerobic pond desludge.
- New aerators in aerated pond.

2.3 Previously Identified Options

Two Cambridge WWTP upgrade options have previously been explored by WDC. These included Option 1, comprising a significant upgrade to the current WWTP as proposed within the previous consent application (lodged in Dec 2011); and Option 2, comprising a long term joint solution to Southern Wastewater servicing with Hamilton CC.

Option 1 is currently being further investigated by others as a separate work stream, with the aim of developing a fully automated WWTP with improved nutrient removal capacity on site. The findings of this work stream have not been made available to GHD. Option 1 proposed a staged approach to treatment upgrades, including the following stages:

- Stage 1: Retain existing WWTP, with limited physical works between 2011 and 2019.
- Stage 2: Upgrade the plant to achieve treatment scenario 1 between 2019 and 2022[3].
- Stage 3: Further upgrades between 2022 and 2046 to achieve treatment scenario 3[3].

The proposed effluent quality and associated upgrade work proposed in the previous AEE (WDC 2011[4]) are summarised in Table 1 and provided for benchmark comparison purposes only (referred as Option 1 in this report).

Table 1 Discharge Limits Proposed for Option 1 (2011), Along with Current Effluent Quality

Parameters	Unit	Current Effluent [1]	Current Consent	Stage 1 (Between 2011 and 2019)	Stage 2 (Between 2019 and 2022)	Stage 3 (Between 2022 and 2046)
Flow	m^3/day	3,950 (median) 6,600 (90%ile) 7,930 (max)	7,200(AAF)[2]	7,200(AAF)[2]	35,200 (PWWF)[2]	35,200 (PWWF)[2]
cBOD	mg/L	11 (median) 18 (90%ile) 39 (max)	20 (90%ile) 50 (max)	15 (median) 25 (90%ile)	10 (median) 20 (90%ile)	10 (median) 20 (90%ile)
TSS	mg/L	14 (median) 35 (90%ile) 110 (max)	20 (90%ile) 50 (max)	18 (median) 40 (90%ile)	10 (median) 20 (90%ile)	10 (median) 20 (90%ile)
Total N	mg/L	37 (median) 45 (90%ile)	-	40 (median) 48 (90%ile)	<130 kg/day Equivalent to 12.7 mg/L[3]	<52 kg/day Equivalent to 5.1 mg/L[3]
DIN	mg/L	35 (median) 40 (90%ile) 45 (max)	10 (90%ile) 20 (max)	-	-	-
Total P	mg/L	-	-	6 (median) 7 (90%ile)	25 kg/day (Dec-May) Equivalent to 2.5 mg/L[3]	13 kg/day (Dec-May) Equivalent to 1.3 mg/L[3]
DRP	mg/L	5.4 (median) 7.6 (90%ile) 9.2 (max)	10 (90%ile) 20 (max)	-	-	-
E. Coli	Cfu/100 mL	-	-	-	126 (median)	126 (median)

[3] Refer WDC 2011 for definition of Scenario 1 and Scenario 3 treated effluent quality.

[4] WDC 2011 Cambridge Wastewater Scheme Resource Consent Applications, December 2011.

Parameters	Unit	Current Effluent [1]	Current Consent	Stage 1 (Between 2011 and 2019)	Stage 2 (Between 2019 and 2022)	Stage 3 (Between 2022 and 2046)
F. Coli	Cfu/100 mL	-	10,000 (median)	3,000 (median) 37,000 (90%ile)	-	-

Note:
1: Data from previous AEE document (Dec 2011) and is considered reflective of the current 2018 effluent characteristics.
2: Peak Wet Weather Flow (PWWF) is estimated to be approximately 35,200 m^3/day for 2045. The Average Annual Flow (AAF) however is estimated to be approximately 10,200 m^3/day. Current AAF (2018) is approximately 6,100 m^3/day, with PWWF estimated to be approximately 23,000 m^3/day.
3: TP and TN concentrations calculated based on average flow of 10,200 m^3/day.

The proposed Stage 3 total nitrogen concentration target of 5.1 mg/L (Table 1 above) for the Cambridge WWTP effluent is considered by GHD to be very ambitious. It is expected this level of Nitrogen removal would be challenging to meet on a regular basis for any modern wastewater treatment plant with biological nutrient removal capabilities.

The previous AEE (WDC 2011) reported the Cambridge WWTP was having a low environmental impact on the receiving environment. In the absence of any regular monitoring data to quantify the current effects of the WWTP it is assumed the Cambridge WWTP is continuing to have low environmental impacts on the receiving waters. As such, GHD has tentatively adopted the Stage 2 effluent quality above as the proposed effluent quality target for the treatment plant throughout the development of Option 3. Pending a detailed environmental impact assessment and discussion with WRC, this set of effluent quality limits may be modified or refined at the consent application stage.

Option 2, the connection of Cambridge wastewater to Hamilton, or some other larger sub regional “boundary less” solution is still in its infant stage, and pending further strategic discussions with various territorial authorities and central government, Option 2 may involve a joint solution incorporating staged upgrade works for various southern-Waikato WWTPs. Option 2 is therefore unlikely to be a short-term solution (i.e. next 10 years) for the Cambridge WWTP and for this reason is not considered a viable solution at this stage but may form a medium to long-term solution in future (i.e. 15 – 25 year solution).

2.4 Water Quality Impact of Cambridge WWTP Discharge

A detailed assessment of the existing and future impact of the Cambridge WWTP discharge on the Waikato River water quality is not within the scope of this study. This section summarises briefly the current water quality of the Waikato River at Cambridge and summarises previous findings carried out as part of the 2011 AEE regarding the WWTP’s contaminant load contribution to the Waikato River water quality.

2.4.1 Water Quality within Waikato River at Cambridge

Plan Change 1 sets out an 80 year timeframe for achieving water quality that is swimmable and safe for food collection along the entire length of both the Waikato and Waipa rivers and their tributaries . In achieving this, WRC has set a higher standard than the requirements stipulated within the National Policy Statement for Freshwater Management 2014 (NPS Freshwater amended 2017).

The Cambridge WWTP currently discharges treated wastewater into the Waikato River near Pukerimu Lane, Cambridge. A WRC State of Environment (SoE) water quality monitoring site is located approximately 12 km downstream of the discharge point at Narrows boat ramp (immediately downstream of Airport Road bridge). The current and targeted water quality at Narrows boat Ramp as stipulated within Plan Change 1 is summarised in Table 2.

Table 2 Current and Target Water Quality at Narrows Boad Ramp

Parameter		Unit	Current	Short Term (10 year)	Long Term (80 year)	NPS Target Attribute A	NPS Target Attribute B
Chlorophyll a	Annual Median	mg/m^3	5.5	5.5	5	2	2-5
	Annual Maximum	mg/m^3	23	23	23	10	10-25
Nitrate-N	Annual Median	mg/L	0.235	0.235	0.235	1	1-2.4
	Annual 95%ile	mg/L	0.5	0.5	0.5	1.5	1.5-3.5
Ammonia	Annual Median	mg/L	0.009	0.009	0.009	0.03	0.03-0.24
Total Phosphorus	Annual Median	mg/L	28	28	20	10	10-20
E. Coli	Annual 95%ile	cfu/100mL	340	340	260	540	1000
Clarity	Annual Median	m	1.68	1.7	1.7	Not specified	

Current monitoring records show that the Waikato River water quality at this location (downstream of the Cambridge WWTP discharge) is mostly within the NPS Freshwater Attribute A or Attribute B values. Overall the water quality within Waikato River at this location (12 km downstream of Cambridge WWTP discharge point) can be considered relatively high.

2.4.2 Contribution of Cambridge WWTP to Catchment Water Quality

Receiving environment monitoring data availability in the immediate vicinity of the Cambridge WWTP discharge point is scarce. The water quality monitoring results of springs located along the Waikato river bank downslope of the RIBs show significant improvements in BOD_5, TSS, DIN, ammonia, and faecal coliforms concentrations, when compared to the treated effluent quality. This is considered to be a result of dilution by groundwater[4].

The WWTP typically contributes approximately 0.03% to the total flow of the Waikato River[5]. This is a small contributing volume to the River. In addition, approximately 55% of land cover within the Cambridge WWTP catchment has been categorised as nutrient contributing land. This indicates that there is a moderate proportion of land within the catchment that could be contributing towards the existing nutrient concentrations being monitored in the Waikato River and the WWTP is likely to be a very small contributor of nutrient and pathogen loads to the river.

In terms of near-field effects of the discharge, the previous AEE (WDC 2011) stated that the potential impact of wastewater discharge on water quality, instream ecology, and recreational contact within Waikato River was negligible at the edge of the 100 m mixing zone. The low significance of potential environmental impact from the Cambridge WWTP discharge provides opportunities of exploring nutrient offset options within the proposed Plan Change 1, as summarised in Section 2.1.

[5] GHD 2018 Three Waters Review: Cost Estimates for Upgrading Wastewater Treatment Plants to Meet Objectives of the NPS Freshwater, Report prepared for Department of Internal Affairs.

2.5 Offsetting Opportunity and Requirements

2.5.1 Offset Mitigation Opportunity

As mentioned above, an upgrade of the existing Cambridge WWTP to produce improved nutrient discharge into Waikato River would likely provide “low” environmental benefit to the Waikato River water quality when compared against overall costs. This is because the Cambridge WWTP sits in a catchment with a moderate proportion of nutrient contributing land cover, and the contributing discharge volume is very small (i.e. less than 0.1% of the Waikato River flow rate).

The delineation of Freshwater Management Units (FMUs, as defined in PC1), River Sub-catchments, the jurisdiction of WDC, and the location of the Cambridge WWTP, are shown in Figure 1. A land use map of the Waikato and Waipa FMUs are presented in Figure 2.

The Cambridge WWTP is located in the Central Waikato FMU, surrounded by areas largely dominated by dairy or other farming land use. Sub-catchments identified within Plan Change 1 as high-priority sub-catchments due to their sediment loss or nutrient leaching status immediately next to the Cambridge WWTP (35) or upstream (44,45) are also shown in Figure 1.

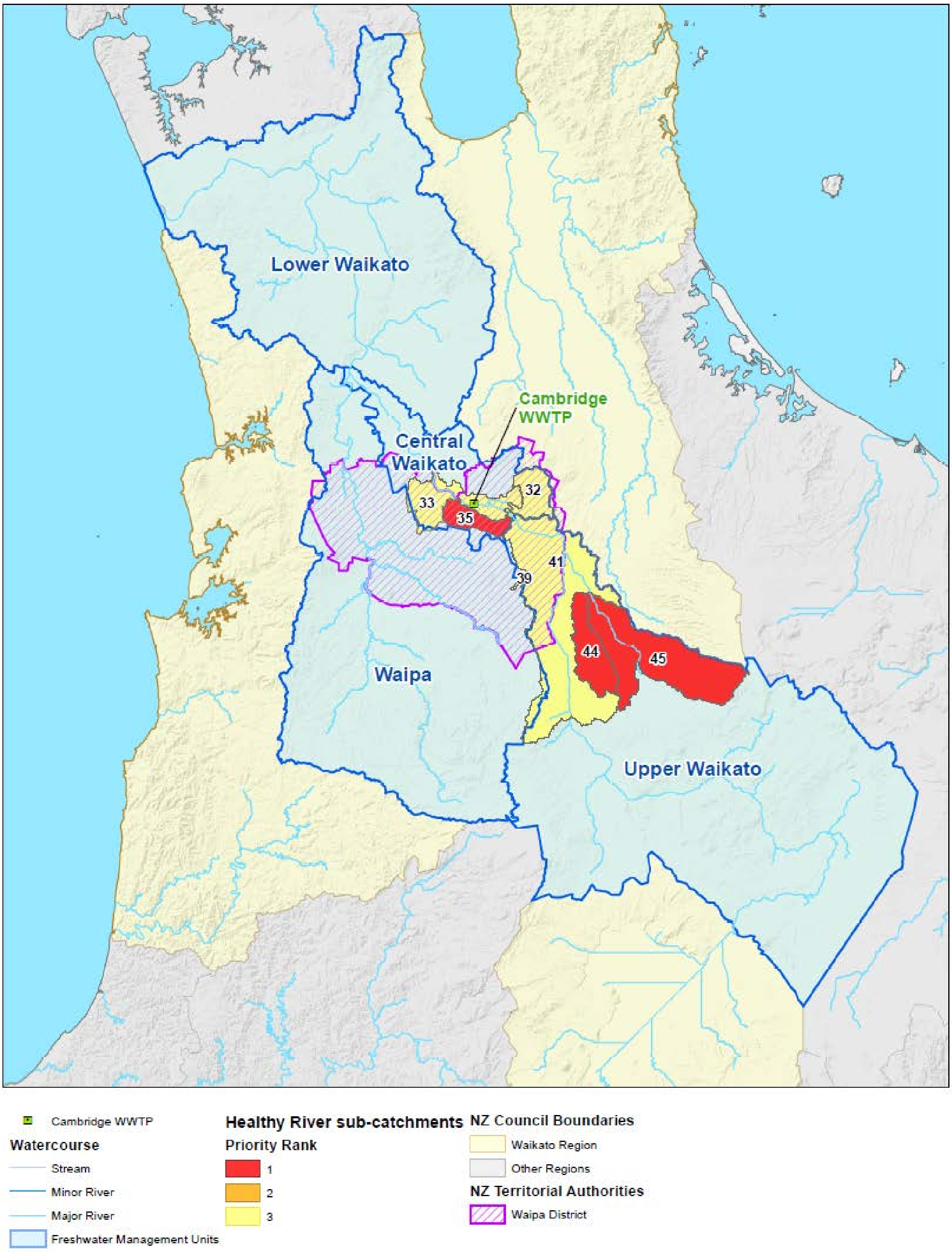

Figure 1 Location of Cambridge WWTP

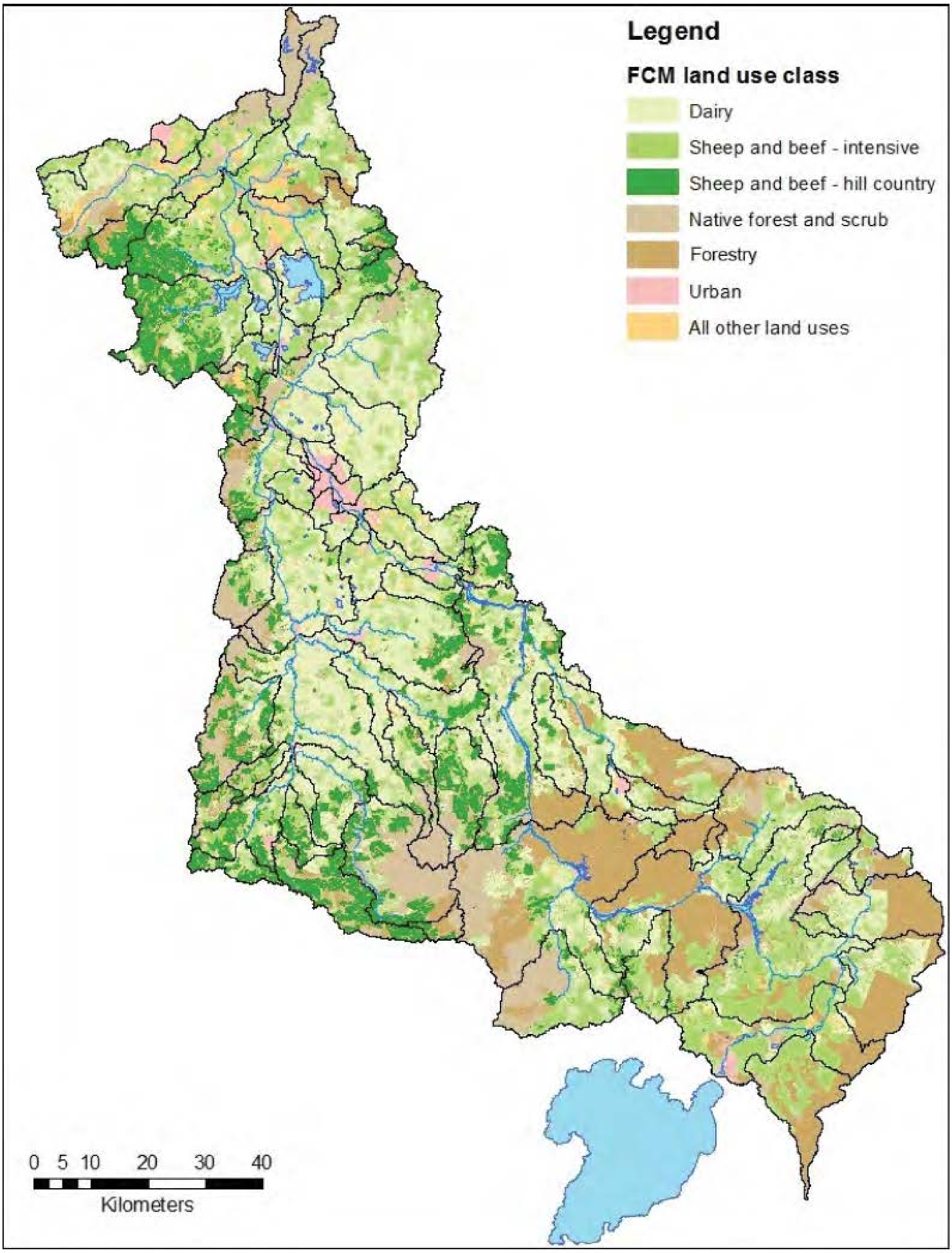

Figure 2 Land Use For the Waikato and Waipa Freshwater Management Units (from NIWA 2015)

2.5.2 Waikato River Authority Projects

The Waikato River Authority (WRA) was established as an independent entity, aiming to restore and protect the health and wellbeing of the Waikato River for future generations. The key functions of WRA include the following two aspects[6]:

[6] WRA, DairyNZ and WRC 2018 Waikato and Waipa River Restoration Strategy.

1. Coordinate and influence relevant policies for protection of the Waikato River
2. Crown-allocated funding of $220M over 30 years is managed by the Waikato River Clean-up Trust (WRCuT), under the auspices of the WRA.

WRA currently have a suite of projects in the Waikato River FMUs, and specific river stretches or sub-catchments have been identified where waterway fencing and riparian planting will prevent and remediate erosion and nutrient leaching into waterway. Figure 3 and Figure 4 show identified sediment and erosion priority waterways and nutrient priority sub-catchments within Waikato River FMUs, identified by WRA.

Relevant to the interested area of this study, some identified key WRA projects include:

- Riparian management along selected tributaries flowing from Maungatautari into Lake Karapiro (WRA Project UW1).
- Karapiro catchment hill country and streambank erosion protection and remediation (WRA Project CLW30).
- Waione Stream erosion protection and riparian enhancement (WRA Project UW3).

Further discussions of the applicability of riparian planting or streambank fencing for nutrient release mitigation and assessment methodology are provided in Section 3. Riparian land management and restoration to filter agricultural runoff is currently the most widely practised nutrient offset mitigation measure.

For instance, available information shows that a narrow 5 m riparian margin can reduce N and P loss by 50% and a 10 m strip may achieve approximately 73% reduction in both N and P loss[7]. In addition, a recent cost-benefit investigation of riparian restoration programmes on a New Zealand national basis revealed that the benefits on climate and freshwater are significantly greater than the implementation costs of riparian restoration[7].

WRA's Restoration Strategy (2018) recognise the important role that PC1 may potentially have over the long term for catchment management and acknowledge that the implementation of PC1 will be complementary to WRA's projects.

[7] Daigneault et al. 2017 A National Riparian Restoration Programme in New Zealand : Is It Value For Money, Journal of Environmental Management 187: 166-177.

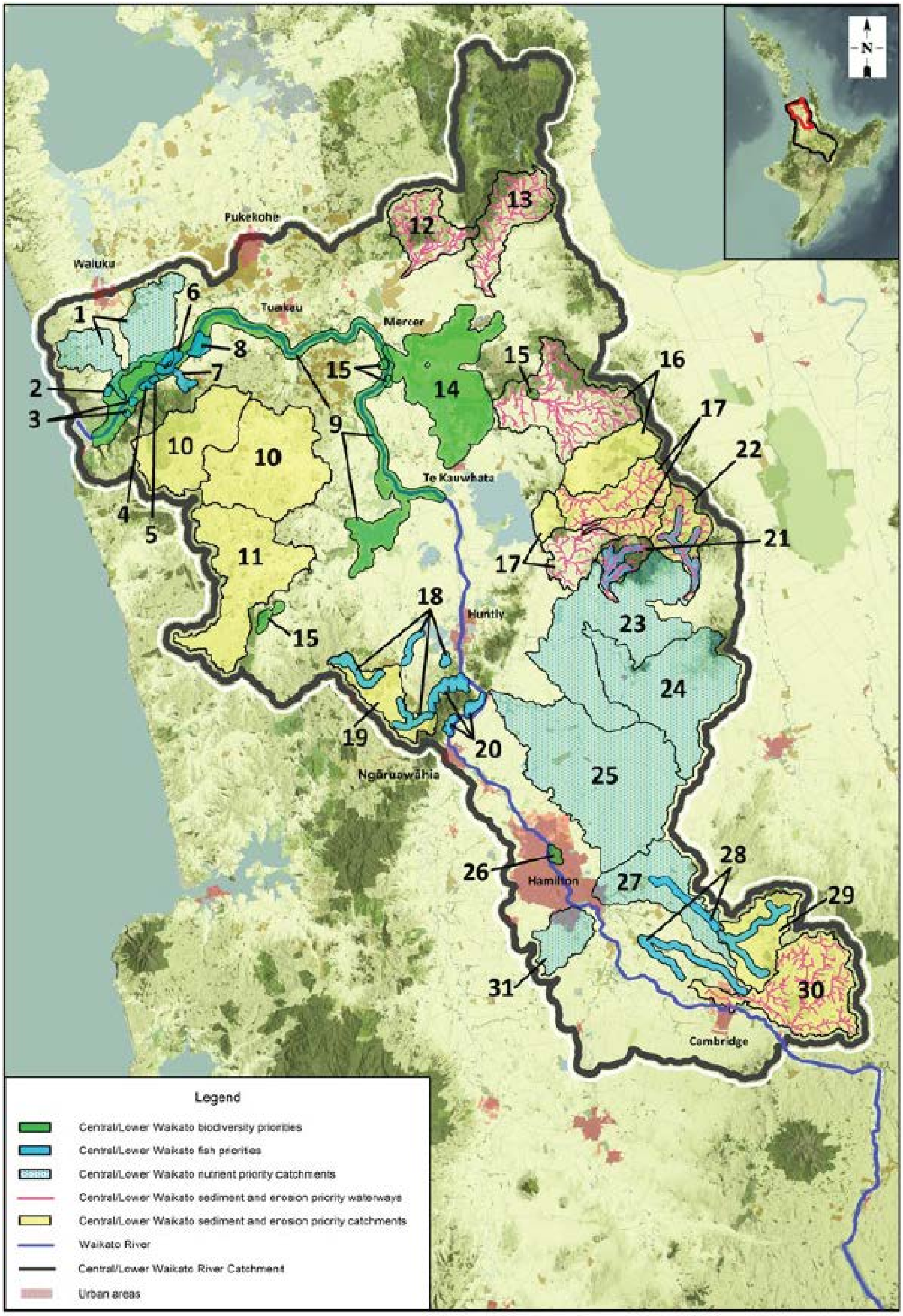

Figure 3 Location of priority projects by WRA in the central/lower Waikato (CLW) FMUs (from WRA 2018)

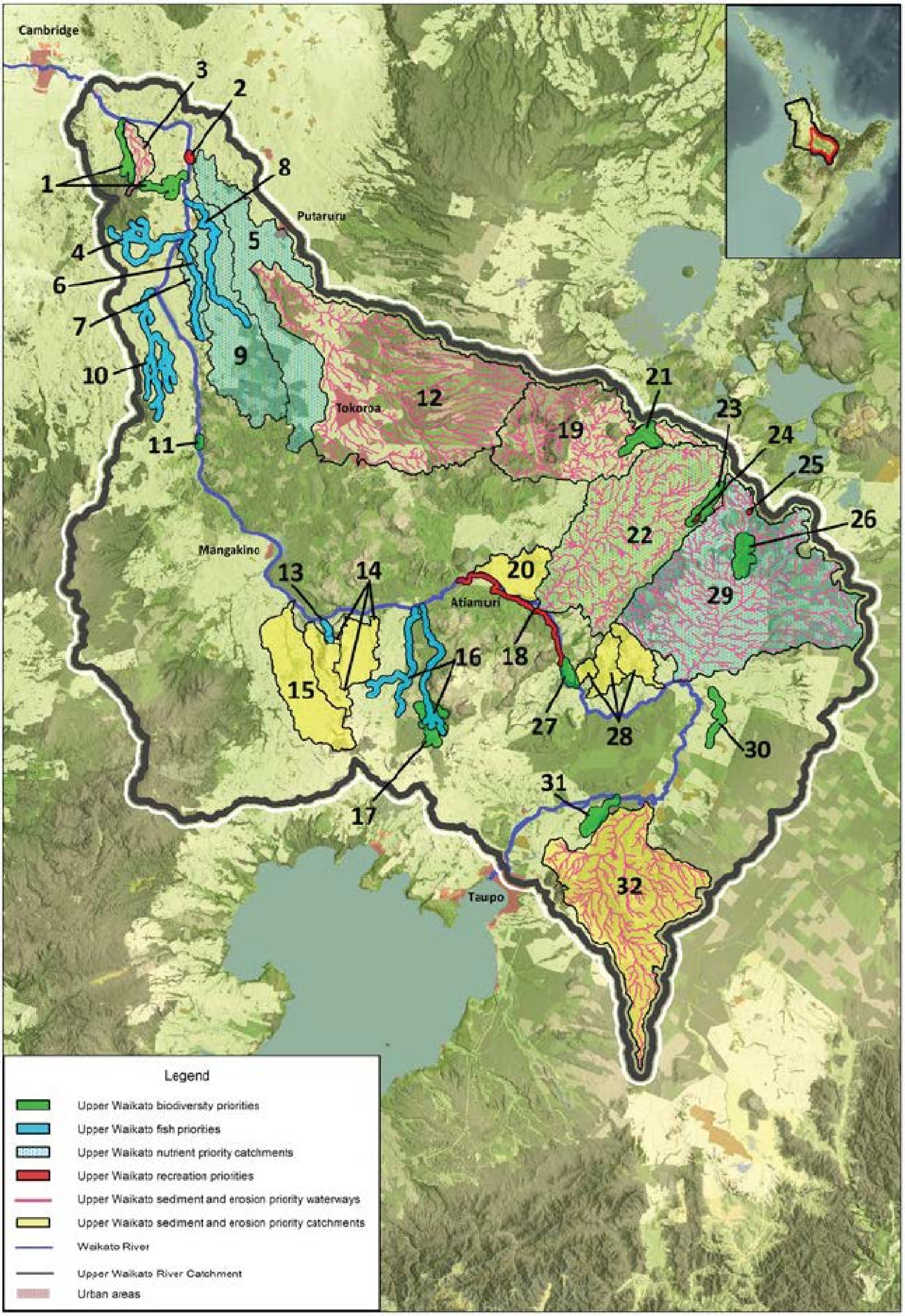

Figure 4 Location of priority projects by WRA in the Upper Waikato (UW) FMU (from WRA 2018)

2.5.3 Key Principles for Nutrient Offset Option Development

Overall, the development of offset mitigation options for the Cambridge WWTP is aimed to be consistent with the vision of the previous Project Control Group (PCG): "to ensure any future wastewater solution for Cambridge is undertaken in such a manner as to protect and restore the health and wellbeing of the receiving environment"[8]. The ultimate objective of any offset proposal is to deliver a net environmental benefit at a lower community cost.

A formal, widely accepted approach for managing water quality offsets in the Waikato Region does not exist at this stage. However, the land management options to offset impacts of nutrient loads from the Cambridge WWTP to the Waikato River can be investigated based on the current provision of Policy 11 of proposed Plan Change 1.

Policy 11 provides a mechanism for applying the Best Practicable Option to avoid or mitigate adverse effects and where all adverse effects cannot be avoided or mitigated enable the offset of effects to point source discharges. Specifically, the policy requires:

> *… any person undertaking a point source discharge of nitrogen, phosphorus, sediment or microbial pathogens to water or onto or into land in the Waikato and Waipa River catchments to adopt the Best Practicable Option to avoid or mitigate the adverse effects of the discharge, at the time a resource consent application is decided. Where it is not practicable to avoid or mitigate all adverse effects, an offset measure may be proposed in an alternative location or locations to the point source discharge, for the purpose of ensuring positive effects on the environment to lessen any residual adverse effects of the discharge(s) that will or may result from allowing the activity provided that the:*

a. *Primary discharge does not result in any significant toxic adverse effect at the point source discharge location; and*

b. *Offset measure is for the same contaminant; and*

c. *Offset measure occurs preferably within the same sub-catchment in which the primary discharge occurs and if this is not practicable, then within the same Freshwater Management Unit or a Freshwater Management Unit located upstream, and*

d. *Offset measure remains in place for the duration of the consent and is secured by consent condition.*

A detailed set of offset option development criteria is presented in Section 2.5.4. Based on the provisions of Plan Change 1 and international practices (Alluvium 2015[2]), we adopted the key offsetting principles as following:

1. Net environmental improvement

   Any offset option proposed is to deliver net environmental benefit compared to actions that would otherwise be required.

2. Cost effective

   Any offset option proposed must be cost-effective and in proportion to the significance of the adverse environmental impact being addressed.

3. Best practicable option for the WWTP upgrade.

   It is important to note that any offset option proposal should not intend to be a substitute for good environmental practice. As outlined in Policy 11 of Proposed Plan Change 1, the

[8] WDC 2011 Cambridge Wastewater Scheme Resource Consent Application.

Best Practicable Option shall be adopted at the WWTP site. And the offset option shall be only one component of an overall strategy to ensure best economic, social and environmental outcome.

2.5.4 Key Assessment Criteria for Offset Options

In line with the key offsetting principles above, GHD has adopted a suite of criteria for general considerations of any offsetting options. The criteria considered includes the following:

- Equivalence: Demonstrated by modelling or measurement to predict the equivalent amount of the parameter (may include ratios for timeliness, uncertainty of offset action and/or location). Refer to Section 3.2.4 for further discussion.
- Alignment with management priorities: Offset action needs to be in alignment with management priorities where applicable.
- Additional: The offsetting option needs to be additional to any existing works. Does not preclude offsets from piggybacking on other planned works. Consideration needs to be given if the offset action is a regulated activity or responsibility for another party.
- Measurable: Will be situation dependant (i.e. a diffuse source of nutrients such as stormwater would be modelled, point source discharge could be measured). Offset proposals should include either adequate demonstration of relevant scientific literature to give confirmation of the outcome (for approval by the Regional Council) or details of a monitoring program to confirm results.
- Timely: The offset should be operating prior or at the same time as the impact. Envisaged delay shall be incorporated as certain factors to the predicted output. All offsets will be time bound (usually over the same period as the duration of a resource consent). Refer to Section 3.2.4 for further discussion.
- Located appropriately: As offset is dealing with the specific impact the location will already be determined. A specific location factor may be applicable to predict output. Refer to Section 3.2.4 for further discussion. Note that Plan Change 1 requires offset preferably occurs within the same FMU or further upstream where necessary.
- Enforceable: Offset requirements will be stipulated as conditions of consent.
- Verifiable: Should be verifiable to the satisfaction of both the WRC and WDC. Will be dependent on the actions taken but if possible should be undertaken based on accepted standard. Offset evaluation should be undertaken at the end of the offset period.
- Socially acceptable: Consultation with landholder, iwi, Waikato River Authority, and all other relevant stakeholders will be required. It may also be possible to align the offset option with priority planning work done by WRA.
- Life cycle cost analysis: Costing of offset options will largely dictate result - offset should be the least cost for the community that achieves the same result.

Pending the selection of potential offset options, safety factors that account for potential uncertainty may be derived and applied in the relevant option assessment. Further details of such safety factors are provided in 3.2.4.

2.5.5 Location Requirements

Based on Map 3.11-1 of Plan Change 1 and Figure 1 of this report, the Cambridge WWTP is located within the Middle Waikato River FMU, sub-catchment 33. The upstream sub-catchments within the same FMU include sub-catchments 32 and 35. Sub-catchment 35 has been identified as Priority 1 sub-catchment (i.e. there is a greater gap between the proposed water quality targets and current water quality in priority catchments). According to the provision of current Plan Change 1, the potential offset options should be located preferably within the same FMU (i.e. Middle Waikato River FMU) or the immediate upstream FMU (i.e. Upper Waikato River FMU). The location of the Cambridge WWTP is considered to be perfect in relation to the catchment location and quality of the non-point discharges.

2.5.6 Nutrient Equivalency Requirements

Plan Change 1 requires offset measures for point source discharge to target the contaminant of concern.

Current and future projected contaminant loads for the Cambridge WWTP are summarised in Table 3. The annual average flow was applied in this study to generate the average nutrient load received at the plant and subsequently the nutrient load within the treated effluent on an annual average basis.

Comparing the targeted average effluent nutrient load (where less than minor environmental impact is envisaged) and best practicably achievable effluent nutrient load, the equivalent nutrient offset capacity can be calculated. This is tabulated in Table 4.

Table 3 Current and Projected Flow and Contaminant Load at Cambridge WWTP

Contaminant	Unit	Current Influent (2010)[1]	2050 Influent Projection [2]	Current Effluent	Future Feasible Effluent [3]	Future Effluent with Minimum Adverse Effects [4]
AAF	m^3/day	6,100	17,285	-	-	-
PWWF	m^3/day	23,000	67,392	-	-	-
TN	g/m^3	49	49	45	20	12.7
TP	g/m^3	10	10	6	6	2.5

Note:
1: Based on wastewater flow and strength estimated in the previous AEE (WDC 2011).
2: Based on wastewater flow projection for Cambridge area to approximately 2050 and assumes no change will occur to wastewater strength[9].
3: Best practicably achievable effluent at Cambridge WWTP. This is the level of effluent quality that is considered not to have significant toxic adverse effects as stipulated by the proposed Plan Change 1.
4: Based on previous AEE (WDC 2011). Pending further assessment of potential environmental effects, this is the level of effluent quality that is considered to have no more than minor adverse effects on the receiving environment.

Table 4 Proposed Average Daily Nutrient Offset Target for Cambridge WWTP

Contaminant	Unit	2050 Influent Projection [1]	Envisaged 2050 WWTP Effluent [2]	With Minimum Adverse Effects	
				Future Effluent [3]	To Be Offset [4]
TN	Kg/day	850	346	220	126
TP	Kg/day	170	104	43	60

Note:
1: Based on wastewater flow and load estimates outlined in Table 3.
2: Based on TN 20 mg/L and TP 6 mg/L.
3: Equivalent to TN 12.7 mg/L and TP 2.5 mg/L.

[9] Direct communication with WDC.

4: This is the offset capacity for the projected flow and loading at 2050. Offset actions may be implemented by stages throughout the consent validity period.

2.5.7 Timing and Duration Requirements

In accordance with Plan Change 1, any offset measure should remain in place for the duration of the consent and is required to be secured by conditions of consent. This ensures that the offset measure and performance target is enforceable.

Due to the application of offsets being a new approach, it is envisaged that the offset measure is to be undertaken on a staged-basis. Pending further development of the offset option and discussion with WRC, flow or nutrient load trigger levels may be agreed and stipulated in the resource consent to allow staged implementation of offset actions.

3. Offsetting Options Development and Assessment

3.1 Point Source Control

In light of the offsetting requirements set out by Plan Change 1, GHD has undertaken a resource consent search within the relevant area and identified a number of discharge points (3, TBC) that may potentially contribute to an elevation of river nutrients in the same Freshwater Management Unit (FMU) as the Cambridge WWTP. These are summarised in Table 5 and their location are shown in Figure 5.

A review of these three discharge consents revealed the Fonterra discharge as the only viable offset option due to its steady operation and consistent nutrient load into the Waikato River. Based on current consent conditions, the nutrient load into the Waikato River from this site is likely to be approximately 125 kg/day (Total Nitrogen) and 5 kg/day (Total Phosphorus), with a maximum flow of 2,500 m^3/day. Further investigation is required to gain a clearer understanding of the Fonterra current and future (proposed) wastewater discharge characteristics. This is particularly relevant as the current discharge consent is soon to expire.

The Fonterra site is located approximately 1 km upstream of Cambridge WWTP and currently discharges its wastewater directly into the Waikato River. The proximity of the two sites makes it feasible to consider diverting the wastewater from Fonterra to the Cambridge WWTP, as long as the upgraded Cambridge WWTP has adequate hydraulic and treatment capacity.

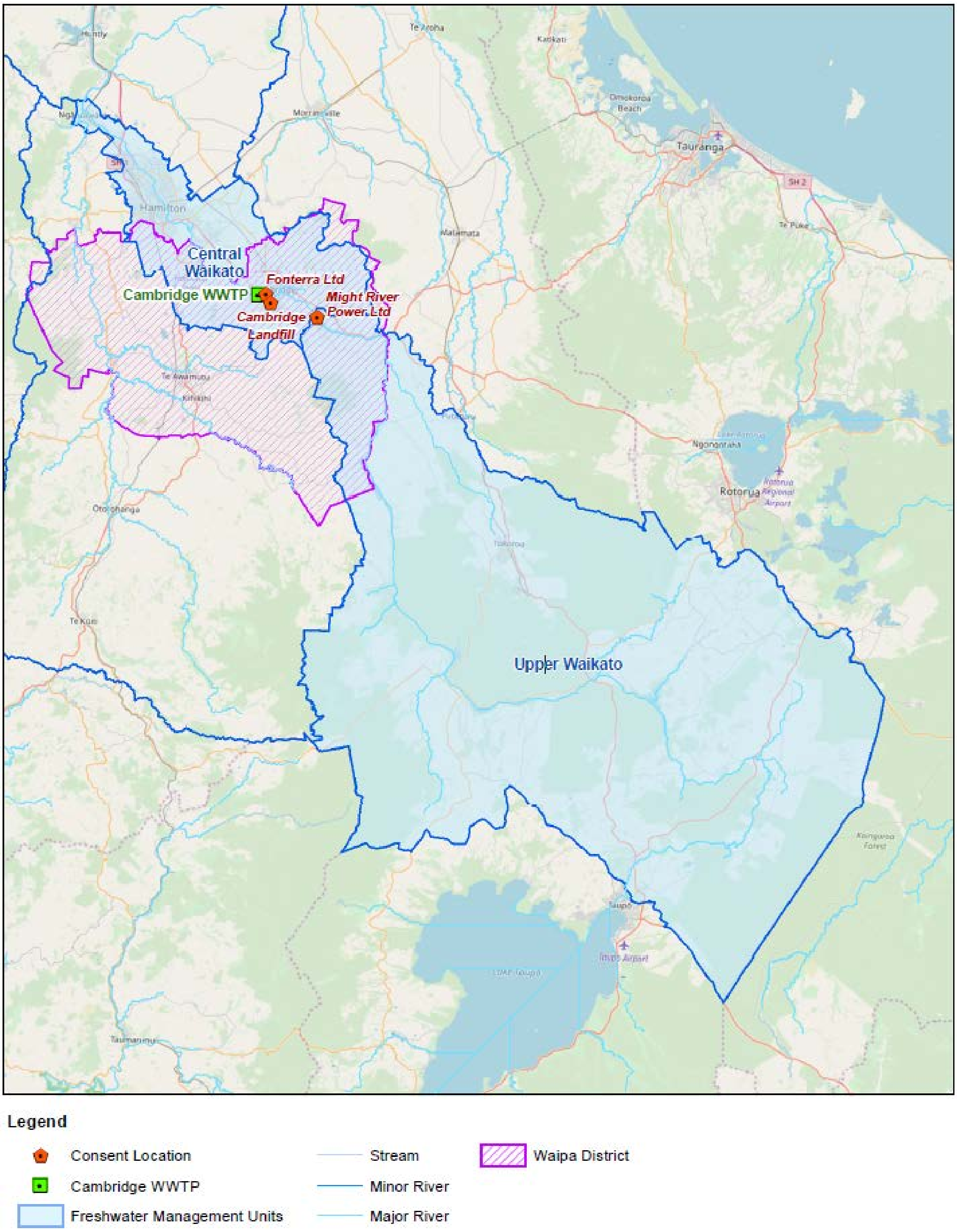

Figure 5 Location of Alternative Point Source Control Options

Table 5 Point Source Wastewater Discharge Consents within the same FMU

Consent No.	Consent Holder	Description	Expiration date	Flow Limit	Nitrogen Limit	Phosphorus Limit	Comments
961133.01.05	Fonterra Ltd.	Discharge dairy factory processing water to Waikato River	Jan 2019	2500 m^3/d	TN: 125 kg/d NH_4-N: 110 kg/d	5 kg/d	Considerable nitrogen loading, hence may be considered as a potential offset option, albeit the current consent is soon to expire and Fonterra is likely to be in the process of renewing its consent.
118073.01.01	Mighty River Power Ltd	Discharge of shredded aquatic weed matter into the Waikato River from Lake Aratiatia to the Karapiro Dam, in association with operation and maintenance of the Waikato hydro system	Aug 2028	Unspecified	Unspecified	Unspecified	Release of nutrients trapped within the aquatic weed into the Waikato River. Due to the unsteady nature of the operation. It's not considered as a viable offset option.
940170.01.02	WDC	Discharge 330 cubic metres of stormwater and treated leachate per day to stream from the Cambridge Landfill site, Leamington	Dec 2027	330 m^3/d	Unknown	Unknown	Likely to contain inadequate nitrogen and phosphorus loading for consideration as offset option
Note: As per direct discussion with WDC, point sources located outside of WDC area (e.g. upstream FMU) is not considered at this stage. Furthermore, we have limited our assessment to point source discharges within the middle FMU in line with the requirements of Plan Change 1 however wish to note there could be opportunity to consider point source discharges downstream of the Cambridge WWTP.							

3.2 Diffuse Source Control

It is also possible to consider corresponding diffuse source nutrient reduction actions from rural, urban or other diffuse sources as off-set mitigation options, as long as the diffuse sources are located within the same or the immediately upstream FMU. These are often referred to as land management off-set mitigation options. A significant amount of sediment entering the Waikato River comes from non-urban diffuse sources. Therefore a reduction in sediment runoff from private agricultural land will result in a reduction of sediment loads and associated nutrient loads.

Potential land management options have been assessed at a high desktop level only. The nutrient mitigation or offset capacity calculation and assessment methodology applied is provided in the following sections. As the project progresses, further research will be required to quantify sediment and nutrient inputs at various identified sites and confirm areas for nutrient offset within the catchment.

3.2.1 Potential Land Management Options

There has been limited research done on the effectiveness of land management options overseas and little has been carried out or published within New Zealand. GHD has carried out an extensive literature review and the key identified potential land management options that may achieve the nutrient reduction objectives are summarised in Table 6 below.

Table 6 Potential nutrient offsetting options for Cambridge WWTP

Offsetting options	Descriptions	Nutrient Offset Performance	Comments
Livestock exclusion	Restricting stock access around waterways such as fencing off waterway and riparian access points. This is often the first step to riparian re-vegetation.	Significant removal of nutrient input from livestock excretion. Refer Section 3.2.3.	Can significantly reduce sediment input from bank erosion and reduce nutrient/pathogen contamination from dung.
Riparian area restoration[10, 11, 12]	Riparian rehabilitation work that will improve the following: • Streambank stabilisation • Shading • Sediment and nutrient buffering Typical riparian buffer may include[12]: • Wooded riparian buffer (planting of native trees and shrubs) (demonstrated to be effective in nitrogen removal) • Grassed riparian buffer (demonstrated	50-98% sediment removal. 10-90% phosphorus removal. 55-90% nitrogen removal. 0.1-2 log removal of protozoa. 0.2-0.3 log removal of virus. 0.2-2 log removal of faecal coliform.[12]	The performance of the riparian buffer is often directly related to riparian width. For instance: • 3m: 40% sediment reduction. • 6m: 70% sediment reduction. • 12m: 85% sediment reduction. • 20m: 98% sediment reduction. Maximum benefits are achieved by revegetating a 20-30 m streambank perimeter

[10] State of Queensland 2010 Development of a Water Quality Metric for South-east Queensland.

[11] Zhang, X. et al. 2010 A Review of Vegetated Buffers and a Meta-analysis of Their Mitigation Efficacy in Reducing Nonpoint Source Pollution. J. Environ. Qual. 39: 76-84.

[12] GHD 2013 Best Management Practices in ACTEW Water Catchments.

Offsetting options	Descriptions	Nutrient Offset Performance	Comments
	to be effective in phosphorus and pathogen removal)		
Ground cover (grazing) [10]	This generally involves establishing a vegetation cover (e.g. a dense cover of tussock-shaped grasses) across the runoff area and throughout the grazing zone. Groundcover level of 60-70% is recommended by Commonwealth Scientific and Industrial Research Organisation (CSIRO). The performance of ground cover for nutrient offset is largely unknown and only very limited studies have been completed. Hence this option has not been considered further.		
Conservation tillage [10]	A typical method of soil cultivation that leaves the previous year's crop residue on fields before and after planting the next crop to reduce soil erosion and runoff. Limited studies showed a 70-95% sediment removal. This is not expected to be feasible for WDC to implement within the catchment and has therefore not been presented in any detail.		
Contour, swales, and barriers	Level spreader contour swales are constructed to laterally disperse runoff uniformly across a slope. They consist of a minimum of one long, narrow trench with an outlet lip of uniform elevation constructed in stable soil. Small berms or raised contours are frequently used to break up concentrated flow downslopes and to redirect it as sheet flow. Contour swales appear to perform less effective in nutrient removal when compared to riparian revegetation. It is also difficult for WDC to implement on a large catchment scale, hence this option has not been presented in any further detail.		
Constructed wetlands and wet ponds	This generally requires large area and involves greater land disturbance leading to high construction and maintenance costs. Their performance on nutrient reduction in a large catchment scale is not adequately reported in literature. Therefore it is not expected to be a feasible option for WDC to implement within the catchment and have therefore not been considered in any further detail.		
Fertiliser application management	Not expected to be feasible for WDC to implement on a broad scale within the catchment due to the reliance generally on third parties to implement such management practices and has therefore not been considered in any further detail.		
Alternate water and shade	This option involves setting up the grazing land with alternate water and shaded area to maximise production, control water contamination, and reduce surface runoff. Limited success in many countries and ranked poorly when compared to other options. Not recommended for effective contaminant removal, hence this option have not been considered in any further detail.		
Land use conversion	This option involves large scale geographic change where catchment areas that have high surface runoff potential are modified to reduce the nutrient loss into the surface water. This option entails extensive planning, consultation, and if deemed feasible, high construction costs and long construction period. It is not considered a viable option hence not discussed further as part of this investigation.		

Based on the findings of the literature review with consideration of each option and its applicability to the Cambridge situation, the proposed offset options for the Cambridge WWTP discharge include:

1. Riparian revegetation, which would reduce nutrients and sediment being transported from grazing land into the Waikato River; and
2. Fencing along waterways to eliminate direct cattle access from the watercourse (therefore avoiding direct excretion into the waterway by cattle).

In this high level study, GHD have combined these two options as one single land management option, as it is preferable to fence the re-vegetated riparian area to prevent potential livestock damage.

In addition to nutrient removal, good riparian vegetation will provide additional benefits such as shading, improved habitat and stream health.

3.2.2 Potential Land Management Areas

In conjunction with current Waikato River Authority's priority projects and aerial review of the relevant FMUs (to align with proposed Plan Change 1 Policy 11), GHD have identified a number of areas where waterway protection and better management of nutrient leaching are considered important. These areas are shown in

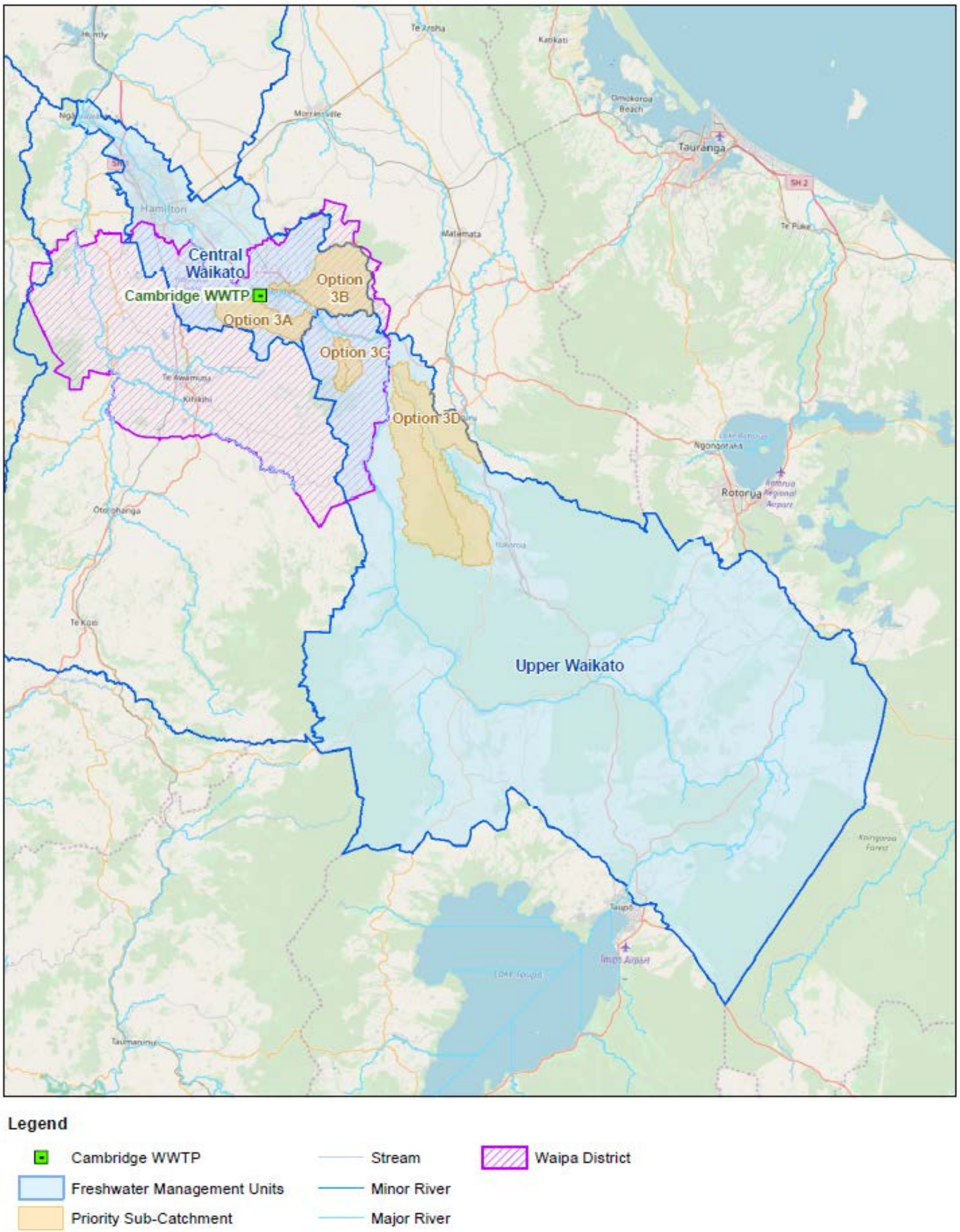

Figure 6, and outlined in Table 7.

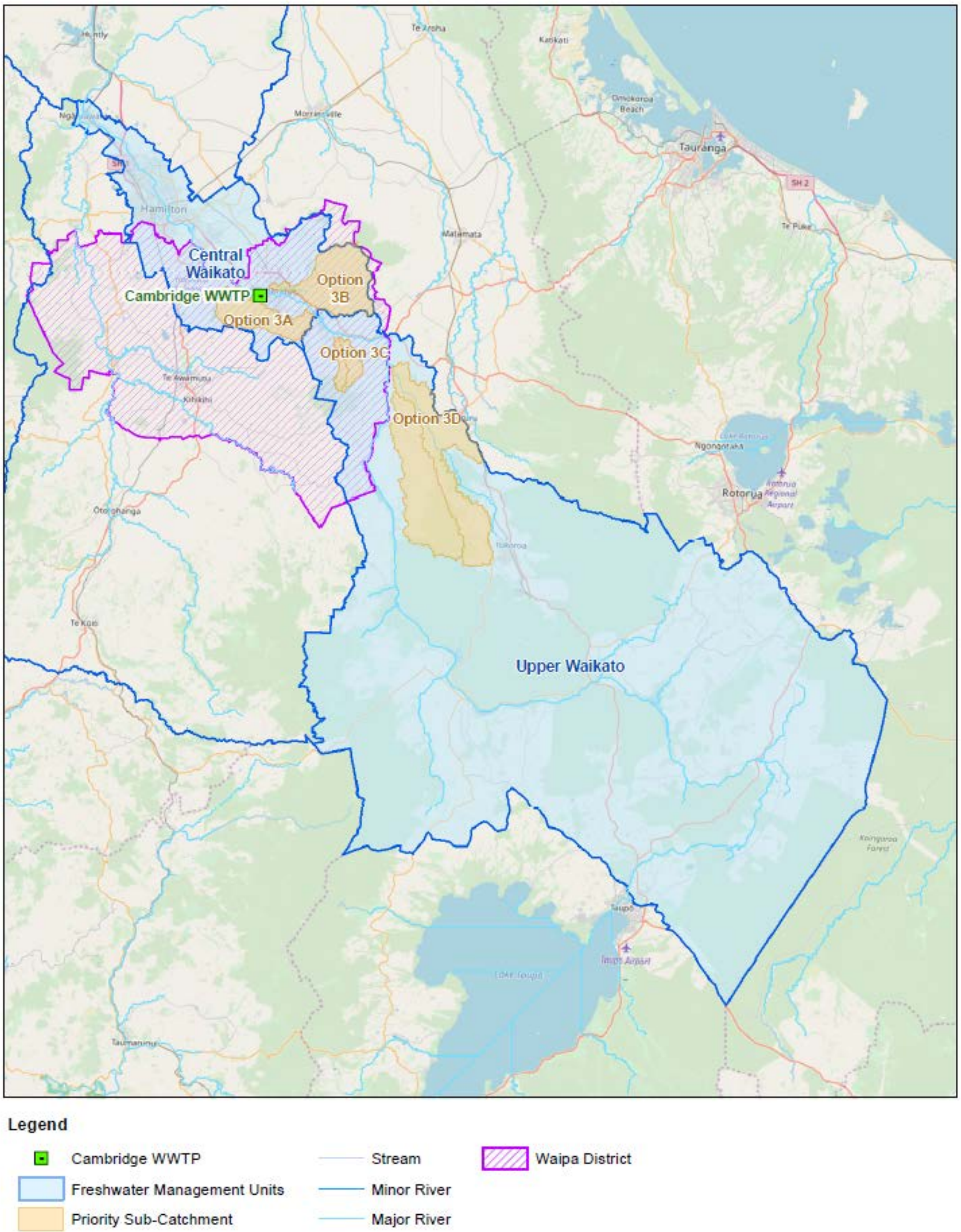

Figure 6 Location of Land Management Offset Options Considered For Cambridge WWTP

Table 7 Potential Land Management Areas

Site/Area No	Unit	A	B	C	D
Area description	-	Mangawhero sub-catchment	Karapiro catchment hill country	Maungataurari to Lake Karapiro and along Waione stream	Lower Pokaiwhenua and Little Waipa catchment
Within WDC		Yes	Yes	Yes	No

FMU	-	Middle Waikato	Middle Waikato	Upper Waikato	Upper Waikato
PC1 sub-catchment number	-	35 (Priority 1)	32 (Priority 3)	41 (Priority 3)	41 (Priority 3), 44 (Priority 1)
WRA project Reference number	-	-	30 (CLW) Medium priority	1,3 (UW) Medium-high priority	5,9 (UW) High Priority
Total area [1]	Ha	5,347	8,558	2,188	24,484
Total agricultural area available [1]	Ha	5,047	7,413	1,784	23,540
Total grassland [1]	Ha	4,770	7,083	1,781	23,209
Total Stream length [1]	km	77	145	41	399
Stream length applicable for riparian planting and waterway fencing [2]	km	19	45	7	118
Note: 1: High level estimates only based on shape files sourced from Waikato Regional Council. 2: Assuming that only major and minor rivers are applicable at this desktop investigation stage.					

It is noted that other Land Management Areas outside of the Middle and Upper Waikato River FMUs may also be appropriate for offset mitigation, however our assessment as aligned with the requirements of proposed Plan Change 1. The nutrient release estimates from each of the option areas above are presented in the following section.

3.2.3 Nutrient Release Estimate Methodology

Nutrient Release from Agricultural Land Use

The annual load of nutrients, sediments and other pollutants sourced from agricultural land can vary depending on a wide range of factors. The factors which influence pollutant generation rates include:

- Land management practices;
- Timing of fertiliser application;
- Crop type;
- Stocking rates;
- Soils and geology;
- Slope;
- Groundwater interaction;
- Rainfall; and
- Presence of land instability and erosion.

Examples of nutrient generation rates from the Waikato Region and various other references are presented in Table 8 with relatively conservative potential estimates.

Comparing local reference (i.e. NIWA 2015) and international practice, it appears that the local rural areas within Waikato River FMUs have relatively high nutrient generation capacity and confirms nutrient loss is indeed an issue. Tackling nutrient loss in the wider catchment is likely to have a significant improvement on receiving stream water quality.

For the purpose of this study, GHD have adopted a conservative nutrient generation rate. Specifically total nitrogen and total phosphorus generation rates are assumed to be 2.8 kg/ha/yr and 0.28 kg/ha/yr, respectively. The adopted generation rates are on the lower end of their respective potential range. As mentioned above, future site-specific investigation will be required to confirm the actual nutrient generation capacity at identified sites. For the purpose of this high level assessment, we have endeavoured to apply conservative rates to account for any uncertainties and thus may be under-estimating the potential nutrient removal achievable through the offset mitigation measures proposed.

Table 8 Nutrient generation rate from various references

Reference	Land Use	Total N (kg/ha/year)	Total P (kg/ha/year)
Atech Group 2000 [13]	Pasture	2.2-3.3	0.1-0.3
Average in Waikato Region [14]	Dairy	36	0.5
	Sheep & Beef	13	0.3
Little Waipa Sub-catchment [15]	Mixed pasture	14.51	1.43
Waikato at Karapiro Sub-catchment [15]		5.18	0.47
Karapiro Subcatchment [15]		2.82	0.81
Waikato at Narrows Sub-catchment [15]		5.42	0.49
Mangawhero Sub-catchment [15]		6.44	0.77
Estimate applied for this study:		**2.8**	**0.28**

Nutrient Generation from Direct Excretion into Waterway by Livestock

Livestock which have direct access to a waterway have an opportunity to directly excrete into the water and this is a direct pathway for nutrients (and other contaminants) into waterways. An estimation of the nutrient load into the Waikato River from direct livestock access requires a number of assumptions to be made about the livestock and their behaviour, these include:

- Livestock type;
- Time spent in or near to water (may be influenced by alternative water and shade);
- Stocking rate (depends on land type / soil type / climate);
- Likelihood of excretion when near water (known to increase);
- Excretion rate; and
- Life stage (e.g. calf, weaner, pregnant cow etc.).

At this high level investigation stage, an estimation for each of the variables for excretion of livestock into waterways is presented in Table 9.

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[13] Atech Group 2000. Aggregated Nutrient Emissions to the Murray-Darling Basin. Prepared for the National Pollutant Inventory, Environment Australia.

[14] Ledgard S. and Power I. 2006. Nitrogen and Phosphorus Losses from “Average” Waikato Farms to Waterways as Affected by Best or Potential Management Practices. Environment Waikato Technical Report 2006/37. Waikato Regional Council, Hamilton.

[15] NIWA 2015. Modelling Nutrient Loads in the Waikato and Waipa River Catchments: Development of Catchment-Scale Models. Report prepared for the Technical Leaders Group for the Healthy Rivers Wai Ora Project.

Table 9 Parameters used for estimating livestock excretion into waterways

Parameters	Value
Livestock type/life stage	Cattle, adult 500 kg cow
Time spent in or near water	2 hours/day (8.3%)
Stocking rate	0.5 head/ha
Regular Excretion rate	Total N: 100 kg/head/year
	Total P: 15 kg/head/year
Likelihood of excretion when near water	50% increase
Note: Methodology adopted from Senn et al. 2012[16]	

The nutrient load from livestock direct excretion is calculated to be approximately 6.225 kg TN/year/ha and 0.934 kg TP/year/ha. These figures will be further updated or confirmed as further information about the grazing practices of identified sites becomes available in future. Applying the assumptions listed above, the estimates of direct excretion load within the Waikato River catchment and the potential of nutrient reduction capacity by riparian revegetation can be calculated and are summarised in Section 3.3.

3.2.4 Allowances for Uncertainty

The removal of nutrients or other contaminants via land management options is highly variable over the limited literature sites investigated and is subject to a suite of site-specific conditions such as catchment geomorphology, climate conditions, vegetation species, etc.

Following other international common practice (Alluvium 2015 [2]), GHD adopted factors of safety for the assessment of offsets options to manage issues of scientific uncertainty. In summary, factors of safety address three key categories of uncertainty:

- The uncertainty and reliability of the offset action proposed (i.e. an equivalence factor).
- The time to implement the offset option (i.e. a time factor).
- The location of the offset action relative to the impact location (i.e. a location factor).

To use the 'factors of safety', the identified potential land management options (i.e. waterway fencing and riparian planting) are assessed against the key criteria below and an appropriate safety factor is determined for each of the categories (equivalence, time, location) using the Victoria Water Quality Offset Framework [2] and these numbers are multiplied together. The resulting value is a factor that increases the amount of the offset required in order to take into account the uncertainty and risk associated with the proposed activity. This is summarised in Table 10. Based on the assessment in Table 10, the uncertainty factors applicable for the two offset options are:

- Riparian revegetation: 3.0
- Waterway fencing: 1.0

They are applied in the offset potential calculations presented in section 3.3.

[16] Senn A, O'Connor J, Dougherty W, Machar S (2012) Assessing on-ground works that reduce farm nutrient exports. Extension and Farming Systems Journal. 7, 67-71. Australian Farm Business Management (AFBM) Network - Charles Sturt University Horticulture

Table 10 Safety factor determination for nutrient removal applicable to nutrient offsetting (based on Alluvium 2015 [2])

Offset Criteria	Comments	Riparian Revegetation	Waterway Fencing
Equivalence	High reliability (high level of control, small variance in performance, established technology) (1:1) Medium reliability (control intermittent such as a constructed wetland, medium but well understood variance in performance, established technology) – (use a ratio of 1.5:1) Low reliability (minimum control such as works requiring private landholder to maintain, high variance, novel technology) (use a ratio of 2:1)	Low reliability, use a ratio of 2:1	High reliability use a ratio of 1:1
Alignment with management priorities	Offset action has been assessed to be in alignment with management priorities where applicable.	Would meet management priorities through equivalence	Would meet management priorities through equivalence
Additional	Needs to be additional to any existing works. Does not preclude offsets from piggybacking on other planned works. Consideration needs to be given if the offset action is a regulated activity or responsibility of another party.	The proposed riparian works would be additional.	Removal of cattle from waterway would be additional.
Measurable	Will be situation dependant (i.e. a diffuse source of nutrients such as stormwater would be modelled, point source discharge could be measured). Offset proposals should include either: • Adequate demonstration of relevant scientific literature to give confirmation of the outcome (for approval by the offsets technical panel) • Details of a monitoring program to confirm results	Scientific literature available with regards to riparian zone removal of pollutants. Can estimate nutrient generation from agricultural land using models or other methods.	Literature available as a first estimate. Onsite measurement would be able to provide more confidence.
Timely	Ratios for timing multiply the predicted output by the following factors: • Before or at time of impact (1:1) • 0-3 years post impact (1.5:1) • 3+ years (2:1) All offsets will be time bound (usually over the same period as the duration of consent)	Assuming that the timing of the installation and establishment of the riparian zone would be 0-3 years. This would use a ratio of 1:1.5. i.e. the time factor = 1.5	Timing would be instantaneous – time factor 1:1
Located appropriately	Ratios for location multiply the predicted output by the following factors: • Immediately downstream (within 2 km downstream) or upstream location (1:1) • Greater than 2 km downstream from site (1.5:1)	The proposed riparian revegetation projects (3B, 3C, and 3D) are located upstream of the Cambridge WWTP discharge point – use a ratio of 1:1.	Upstream of impact so location factor is 1:1

Offset Criteria	Comments	Riparian Revegetation	Waterway Fencing
	• >5 km downstream of impact site (2:1)	i.e. the location factor = 1 The proposed riparian project 3A is located downstream (approx. 3.5 km) of the Cambridge WWTP discharge point – use a location factor = 1.5	
Enforceable	Offset requirements will be stipulated as consent conditions.	Project targets, scope and performance will be part of consent conditions. The physical project will require a contract or memorandum (or similar) of understanding between WDC/WRC/WRA/private landholder.	
Verifiable	Should be verifiable to the satisfaction of both the WRC and WDC. Will be dependent on the actions taken but if possible should be undertaken based on accepted standard. Offset evaluation should be undertaken at the end of the offset period.	Implement a water quality monitoring program to verify the effectiveness of the riparian zone and cattle exclusion activities.	
Socially acceptable	Consultation with landholder, iwi, Waikato River Authority, and other key stakeholders will be required. If there are several feasible offset options and there are multiple benefits of each, the community preferences may provide extra weight in determining the preferred action. It may also be possible to align the offset option with the priority planning work done by WRA.	Landholder, iwi, and WRA consultation will be undertaken.	
Life cycle cost analysis	Costing of offset options will largely dictate result - offset should be the least cost for the community that achieves the same nutrient removal result. More complex if there are several offset options with multiple benefits where higher costs may be accepted for other benefits.	Life cycle costs for riparian zones revegetation can be defined.	Life cycle costs for livestock exclusion can be verified.

3.3 Estimate of Nutrient Removal and Offsetting Requirements

Using the method and assumptions specified in the previous sections, the nutrient offset capacities of land management options can be calculated and compared against the required equivalent offset targets as shown in Table 4 above. The considered options are as follows:

- Option 3A: Riparian revegetation and waterway fencing within the Mangawhero sub-catchment.
- Option 3B: Riparian revegetation and waterway fencing within the Karapiro sub-catchment hill country.
- Option 3C: Riparian revegetation and waterway fencing from Maungataurari to Lake Karapiro.
- Option 3D: Riparian revegetation and waterway fencing within the lower Pokaiwhenua and little Waipa sub-catchments.
- Option 3E: Diverting wastewater from the Fonterra Cambridge Plant to the Cambridge WWTP.

Note the above options are considered as sub-options of Option 3.

The locations of these options are depicted in Figure 7. Option 3A, 3B and 3E are in immediate vicinity of the Cambridge WWTP and located in the same FMU as the Cambridge WWTP. Furthermore they are within the jurisdiction boundary of Waipa District Council and are therefore likely to be highly prioritised as part of the option selection process if deemed to be viable options moving forward.

Option 3C encompasses a smaller agricultural area when compared to Options 3A and 3B, and is located in the upstream FMU. Option 3D is also located in the upstream FMU and covers a large grazed area. In addition, Option 3D is located outside WDC’s boundary, and is likely to be of a lower preference to Council even though it is acceptable under the provisions of proposed Plan Change 1.

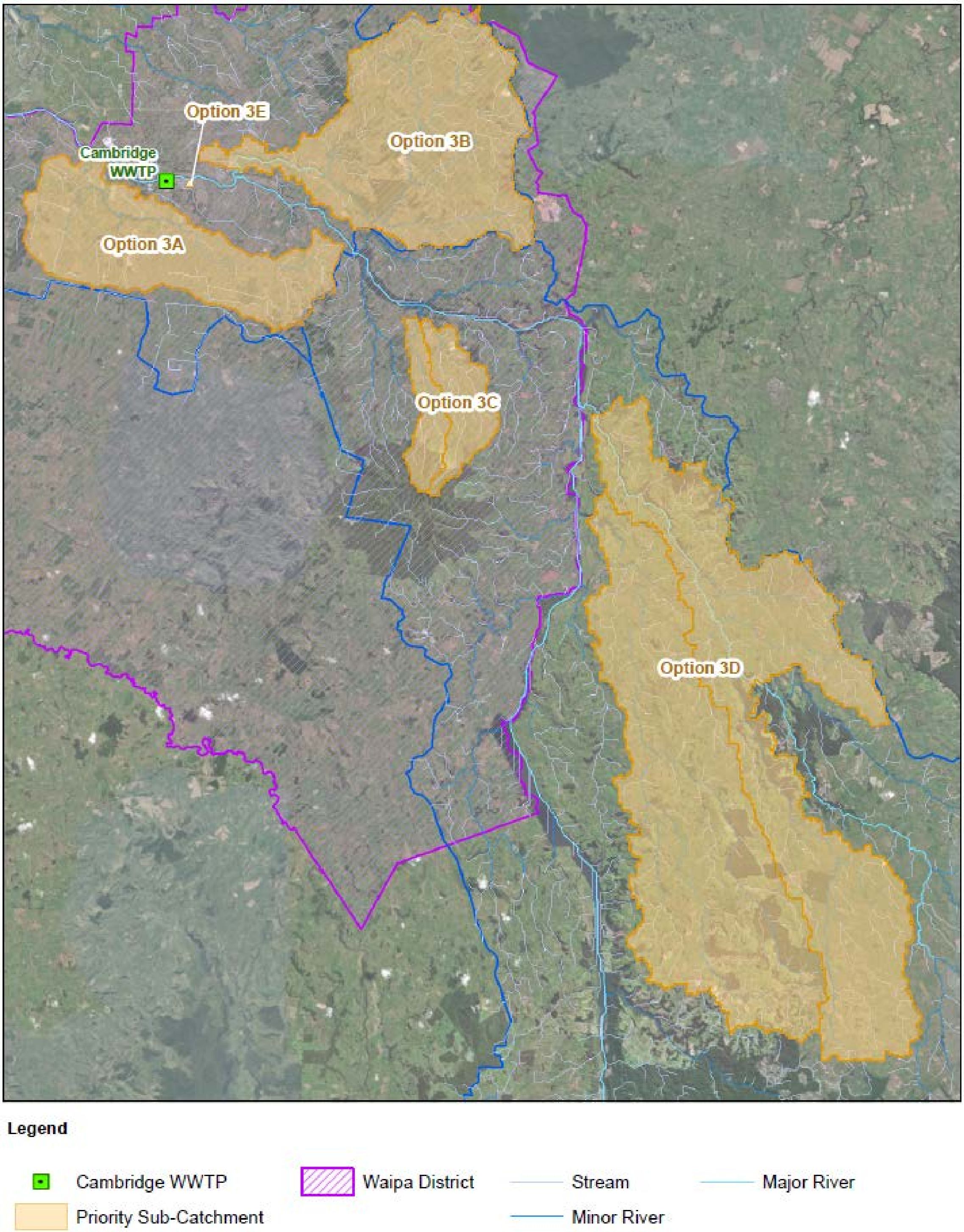

Figure 7 Location of Offset Options Considered For Cambridge WWTP

Using the calculation methods presented above, high level estimates of nutrient offset potentials of Options 3A – 3E can be calculated and are presented in Table 11. The calculation has adopted a low level of nutrient removal capabilities by riparian strips (i.e. 50% TN and TP reduction by 20 m of riparian strip) and incorporated all the relevant safety factors to account for potential technical uncertainty and therefore are considered to be conservative estimates.

Table 11 Nutrient loads and offset capacities compared against offset targets

Items	Unit	Option 3A	Option 3B	Option 3C	Option 3D	Option 3E
TN target to be offset	kg/d	126				
TP target to be offset	kg/d	60				
TN generation rate [1]	kg/ha/yr	2.8				
TP generation rate [1]	kg/ha/yr	0.28				
Total grassland for stock grazing [2]	Ha	4,770	7,083	1,781	23,209	
Stream length (Major and minor river only) [3]	km	19	45	7	118	
TN generation from agricultural land	kg/ha/yr	14,132	20,756	4,995	65,912	
TN generation from livestock direct excretion	kg/ha/yr	29,693	44,092	11,087	144,476	
TP generation from agricultural land	kg/ha/yr	1,413	2,076	500	6,591	
TP generation from livestock direct excretion	kg/ha/yr	4,454	6,614	1,663	21,671	
Riparian area (20 m width) [4]	ha	38	90	14	236	
TN offset potential [5]	kg/d	86	130	33	426	75
TP offset potential [5]	kg/d	13	19	5	62	-70
TN balance to be removed [6]	kg/d	41	-4	94	-300	51
TP balance to be removed [7]	kg/d	48	41	56	-2	130
TN balance to be removed	kg/yr	14,792	-1,495	34,137	-109,405	18,681
TP balance to be removed	kg/yr	17,471	15,122	20,335	-688	47,632

Note:
1: From assumptions specified in Section 3.2.3.
2: High level estimates only based on land use map layers.
3: High level estimates only, excluding small streams pending further confirmation.
4: Assuming planting up to 20 m riparian width to achieve highest nutrient removal performance.
5: Including nutrient offset potential from both riparian revegetation and waterway fencing, and incorporating all relevant safety factors as summarised in Table 10. Only conservative nutrient removal potential applied for riparian zone (i.e. 50% of TN and TP removal by 20 m width riparian strip).
6: Negative balance signifies over-offset, which is in line with adopted principle of “net environmental benefit”. Positive balance signifies inadequate offset.
7: TP offset appears to be inadequate for most options, indicating that TP removal requirement needs to be accommodated at the WWTP site.

Comparing the required offset targets against the calculated offset potentials of identified options, it appears that only Option 3B and Option 3D can achieve negative TN balance. This means that TN offset capacities of these two options exceed the required TN offset target. The negative TN balance is in line with the adopted principle of “net environmental benefit” for this offset option investigation study. Both Option 3A and 3C offer inadequate TN offset potential, possibly due to the short stream length and overall small size of the area.

As stated in Section 2.5.6, the required offset target is estimated based on the recently updated wastewater flow projections for the Cambridge area with a time horizon up to 2050.

GHD understand that the flow projections may be highly conservative and that there is a high likelihood of projected population connection and subsequent wastewater flow not materialising as forecasted. If the offset actions are staged– increased wastewater flow triggers offset requirement accordingly, then the implementation of Option 3A and 3C may be potential options for early stages of a future consent.

For the purpose of this high level assessment, however, only Option 3B and 3D have been considered to provide adequate TN offset potential long-term and therefore are considered as part of the next option assessment phase (Section 3.5).

The proposed TP offset target cannot be met by most of the identified options. This is because phosphorus species are less mobile when compared to nitrogen species (phosphorus has higher potential to be absorbed onto the soil particles and hence less leaching into the waterway), so the overall phosphorus release into the receiving water bodies is much smaller when compared to nitrogen. The lack of TP offset capacity via the land management options confirms that the total phosphorus offset target will need to be accommodated within the WWTP. This is achievable via improved chemical dosing and clarification/solid removal. This should be incorporated with any WWTP upgrade works as part of the consent application, which is briefly summarised in the next Section (3.4).

3.4 WWTP Upgrade Requirements Along with Offset Options

We understand that the Cambridge WWTP does not achieve consistent resource consent compliance. Operational review work was undertaken in early 2018[17]. More operational improvement workshops were held recently (i.e. October and November 2018). Key improvement or optimisation works have been identified and are required to ensure that current plant is operating efficiently and as effectively as possible while the consenting process progresses. Detailed communication records and recent operational improvement workshops' outcome have been summarised separately and submitted to Waikato Regional Council.

The optimisation works identified will only improve the plant operation within the plants current capacity. There are aged infrastructure on site that needs renewing and upgrade works that need to be planned to meet future capacity demand. Detailed Cambridge WWTP upgrade requirements will be determined and confirmed as part of the next phase option assessment and revised AEE preparation.

Based on our current knowledge of the treatment plant, GHD have identified, at a high level, a list of upgrade requirements that need to be addressed at the WWTP site. These would be implemented alongside the offsetting options discussed in Section 3.4 to ensure the overall scheme meets the definition of Best Practicable Option (BPO) one of the founding principles of this study for Nutrient Offset Option Development.

As set out in the RMA, the definition of BPO is:

> *in relation to a discharge of a contaminant or an emission of noise, means the best method for preventing or minimising the adverse effects on the environment having regard, among other things, to-*
>
> *a. The nature of the discharge or emission and the sensitivity of the receiving environment to adverse effects; and*
>
> *b. The financial implications, and the effects on the environment, of that option when compared with other options; and*

[17] CH2M Beca and The Wastewater Specialists 2018 Cambridge WWTP Capacity Assessment – Technical Letter Report 2. April 2018.

c. *The current state of technical knowledge and the likelihood that the option can be successfully applied*

Giving regard to the current constraints of technology, environmental impacts and financial limitations the proposed optimisation works for Cambridge WWTP include the following:

- Screen upgrade.

  The current screen is undersized and cannot cope with the wastewater load, particularly the loading from the septage receiver. A screen upgrade project is underway, which is to be commissioned by February 2019. Nevertheless, the new screen does not take into consideration of future capacity demand.

- Grit removal upgrade.

  Current grit channel is not fit for purpose and should be upgraded to prevent grit from entering the secondary reactor/pond.

- Modify/upgrade the existing aerated lagoon.

  A detailed hydraulic and capacity assessment of the Cambridge WWTP is beyond the scope of this project, and is required before the plant upgrade works can be confirmed. At a high level, GHD consider the hydraulic capacity of the existing aeration basin being adequate for the envisaged flow demand in 2050.

  Pending further understanding of the geotechnical stability of the land and the current liner damage issues of the aerated lagoon, the required aeration basin upgrade works may involve installing baffle walls and additional mechanical plant to facilitate biological nitrogen removal. Aeration system upgrade is also needed to suit the new configuration and aeration demand.

- Install a new clarifier.

  Current sedimentation basin is not fit for purpose and may need to be decommissioned and replaced by standalone clarifier to meet future capacity demand.

- Upgrade the Waste Activated Sludge (WAS) handling system.

  Current sludge retention time is not adequate to facilitate ammonia removal. This may be improved by incorporating a Returned Activated Sludge (RAS) return line from the new clarifier or the existing WAS wasting line. The existing WAS wasting line also needs to be upgraded once the existing hydraulic condition and future demand are determined.

  The current sludge storage lagoons are full and need to be desludged accordingly. Desludging of the sludge lagoons is considered a regular maintenance task, hence not part of this optimisation works list.

  Once the current storage lagoons are desludged, the WAS may continue to be stored in the lagoons, allowed to be thickened/aged slowly before being dewatered onsite (e.g. via geobags). This is envisaged to occur periodically as part of the plant operation and maintenance routine. Hence mechanical thickening and dewatering plant upgrade on site has not been considered as part of the required optimisation works.

- Install chemical phosphorus removal facility.

  As discussed in Section 3.3, most of the identified offset options cannot adequately achieve the proposed total phosphorus offset target. It is therefore necessary to incorporate a chemical dosing facility as part of the optimisation and upgrade requirements to facilitate TP removal at the WWTP site.

- Install a UV disinfection system, including a separate UV building.

The historical pathogen removal non-compliance issue has been temporarily resolved by introducing a chlorine dosing system on site. Chlorine dosing of treated wastewater has some inherent issues, including existing NOM posing high chlorine demand, formation of chlorination by-products, residual chlorine toxicity to aquatic life etc. GHD consider constructing a properly designed UV system is a preferred low risk long-term solution for Cambridge WWTP.

- Install a new outfall to allow direct discharge into Waikato River

  The existing Rapid Infiltration Beds (RIBs) are deemed not suitable to handle future increased wastewater flows due to increased river bank instability issues. It is therefore necessary to design and construct a new outfall for discharge directly into Waikato River.

- Upgrade of the current MCC building and amenity facilities.

The above proposed optimisation and upgrade works at the Cambridge WWTP site are considered necessary while the nutrient offset target is being achieved elsewhere. High level cost estimates of these upgrade works are provided in the next section and incorporated in the life cycle cost estimates of the options as part of the overall option assessment framework. The detailed work components associated with each optimisation/upgrade item listed above would be further developed and confirmed as the consenting process progresses.

3.5 Option Assessment

3.5.1 Options Considered

In summary, GHD have investigated a suite of potential land management options and point source control options for Cambridge WWTP, as part of this Option 3 feasibility investigation. Of these considered options, two offsetting options have been identified (i.e. Option 3B and Option 3D) as being capable of providing adequate nutrient offset capacity and have been selected for the next stage option assessment.

The previous AEE (WDC 2011) proposed a staged plant upgrade option (Option 1), to meet a suite of future proposed discharge limits. The cost estimate of this option was approximately $27M, and was supported by the 2018/28 Long Term Plan funding. Although out of date, this Option 1, along with its cost estimate, is retained in this study for the purpose of a benchmark comparison.

3.5.2 Multi-Criteria Assessment

In order to undertake a balanced comparison of the options, a multi-criteria framework of ranking and comparison was adopted so that a range of criteria, as well as their relative importance, could be considered. The Multi-Criteria Assessment (MCA) is concerned with structuring and solving decision and planning problems involving multiple criteria. The purpose is to support decision-making when, typically, there does not exist a unique optimal solution and it is necessary to use criteria to differentiate between solutions.

Multi-criteria analysis provides the opportunity to compare not only the relative benefits of each option versus potential capital and operating costs, but also qualitative impacts such as the environment and the community, operations and safety.

The framework and methodology applied to the MCA for Option 3 is summarised in this section.

3.5.3 Non-Cost Criteria

The criteria proposed for the options assessment provides a framework of non-cost criteria by which options have been be qualitatively ranked. A ranking system from 1 (worst) to 5 (best) has then be applied to each option.

The adopted assessment criteria and definitions proposed to be applied to the options assessment are presented in Table 12**Error! Reference source not found.**.

Table 12 Selected Criteria and Ranking Examples

Criteria	Ranking – examples
	5 = Best to 1 = Worst
Flexibility Ease of design modifications for: • Flow increases. • Water quality changes. • Changes to regulatory targets.	5 – Easily modify the design to deal with changes in flow increases, or water quality changes or changes to regulatory targets. High level of performance 1 – Hard to modify the design to deal with changes in flow increases, or water quality changes or changes to regulatory targets. Low level performance
Constructability & commissioning Site suitability, availability & access. Feasible to design & build. Ease of construction and commissioning the system with minimal plant interruptions.	5 – Easily constructed, with minimal disruption to existing infrastructure, and safe access to construct. Easily feasible to maintain operation of current pump station 1 – Very difficult to construct, with major disruption to existing infrastructure, and difficult/unsafe to access areas. Difficult/complex to maintain operation of during construction
Operations & Maintenance Level of servicing required. Availability of parts and technical help. Reliability of system.	5 – Automated with minimal upgrades required over life of treatment 1 – High labour input with increased frequency of upgrades required
Cultural Local iwi cultural values.	5 – High alignment with iwi cultural values 1 – Low alignment with iwi cultural values
Industry experience of technology selected Expert input required on regular basis or operate on standard staff training.	5 – Low level of expert input and training required 1 – High level of expert input and training required
Environmental impact Energy use, heritage, biodiversity, resource use, waste generation, community engagement, traffic, visual, noise, air quality, etc.	5 – Low level of impact. 1 – High Level of impact.
Regulatory Risks Complexity of approvals for the additional treatment processes. Ease of demonstration of meeting requirements.	5 – Straightforward approvals required, or high likelihood of being granted approval once studies have been completed. Easy to demonstrate it meets regulatory requirements. 1 – Complicated approval requirement, multiple time-consuming studies required to satisfy approvals. Hard to demonstrate it meets regulatory requirements.
Safety Construction phase. Operations. Maintenance. Personnel or public safety.	5 – Low level of risk to safety, or safety risk can be eliminated through design phase 1 – Unacceptable potential safety concerns / risks that cannot easily be eliminated or mitigated through the design phase and normal safety controls.
Alignment with management priority or regional strategy Freshwater management target and priority.	5 – High alignment with catchment management objectives and visions. 1 – Low alignment with catchment management objectives and visions.

Criteria	Ranking – examples
Alignment with local catchment restoration strategy and vision.	

Consultation is critical to understand the social acceptability and impact of cultural values of the offset options. This is currently not part of this investigation and is being carried out as a separate work package, therefore the results of engagement have been excluded from this study.

3.5.4 Cost Criterion

The cost assessment should include the life cycle cost estimates of the identified options incorporating all elements of capital and operational costs. At this stage all capital and operating cost estimates are based on GHD's in-house expertise and experience, and should be further refined as the project progresses.

The cost criteria definition proposed to be applied to the options assessment are shown in Table 13**Error! Reference source not found.**.

Table 13 Cost Criteria and Ranking Examples

Criteria	Ranking – examples
Cost NPV cost incorporating all elements of capital and operational costs. 25 years at a rate of 5%.	5 – Lowest cost option 4-2 – Middle score options directly proportional to where they lie between the highest and lowest cost option. 1 – Highest cost option

Cost Basis of Land Management Options

The cost basis of land management options including capital costs of waterway fencing and riparian revegetation are shown in Table 14 and are incorporated in the NPV estimates.

Table 14 Estimated costs of various land management options

Options	Average Cost	Comment
Fences	$8,000 /km	There are a range of fence styles that can be installed on the border of a revegetated riparian zone or around another best management practice. These include: single or multiple strand post and wire, single or multiple strand electrical fences, barbed wire, prefabricated mesh, fence with mesh at the bottom, or a combination of these options. Average at approximately $8,000/km, with a range of over $2,000-16,000/km[18]
Riparian Revegetation	Typically $30,000/ha	The riparian planting costs may vary significantly, pending the species planted and level of effort required. The cost estimate needs to consider the key components such as project planning/management, site preparation, cost of seedlings, cost of planting, cost of tree guards, and other costs such as fertiliser, thinning, watering, infill planting, weeding, etc.
Note: Costs based on personal communication with various local Councils, subject to confirmation from suitable contractors.		

[18] Daigneault et al. 2017 A National Riparian Restoration Programme in New Zealand: Is It Value For Money, Journal of Environmental Management 187: 166-177.

The costs of stream fencing and riparian planting have been combined for the purpose of this study as GHD believes that the riparian margin and vegetation need protection from livestock.

Cost Basis of WWTP Upgrade

GHD have estimated the WWTP upgrade costs based on our in-house cost estimate database. This high level estimate is presented in Table 15.

Table 15 WWTP Upgrade Requirements and Cost Estimates

Components	Cost	Descriptions
Inlet Works	$250,000	Bypass pump station
	$160,000	New grit removal facility
	$100,000	Biofilter
	$160,000	New screen
Pond Upgrades (Carrousel or other similar)	$1,320,000	Civil/structural/mechanical/electrical works associated with pond upgrade.
Clarifier (if current sedimentation tank not suitable)	$2,000,000	Include Civil, mechanical, and electrical works.
UV Disinfection system	$300,000	Open channel UV system.
UV Building	$250,000	
Discharge pump station	$300,000	
Alum dosing system	$130,000	Based on 50 kd/d dosing rate
New outfall	$2,800,000	Include civil/mechanical/electrical works. Enabling works to account for any site geotechnical issues have not been considered at this stage.
WAS System	$160,000	Civil/mechanical/electrical works associated with Waste Activated Sludge system.
Aeration System upgrade	$420,000	Blowers, aeration pipework, and all associated electrical/instrumentation work.
Building and Site Amenities	$650,000	MCC room, Site amenity building and potable water system upgrade
Subtotal	**$9,000,000**	
Contingency (20%)	$1,800,000	Unforeseen works required to complete project.
Subtotal	**$10,800,000**	
Design	$1,080,000	10% for contractor design fees.
P&G	$1,944,000	18% for Preliminary & General costs.
Commissioning	$756,000	7% for contractor commissioning & testing.
Standby Generator	$500,000	Provisional
Total Cost	**$15,080,000**	
Note: These are high-level capital cost estimates based on the assumed inflow volumes and desired discharge quality levels. The considered costs include total estimated construction costs. The costs		

Components	Cost	Descriptions
exclude any consenting or administration costs and cost risk allocation but allow for 18% P&G (preliminary and general component) for construction. Note that all cost estimates are at a very high level, based on GHD's local and international experience, so may have an error margin of ±50% for this stage of the investigation.		

Net Present Value (NPV) Estimates of Options

NPVs for the selected options have been estimated using a common interest rate of 5% over a total period of 25 years. NPVs are presented in Table 16 and depicted in Figure 8.

Table 16 NPV Estimates for The Considered Options

Items	Unit	Option 3B	Option 3D	Option 1
Fencing Cost	$/km	$8,000		
Riparian planting cost	$/ha	$30,000		
Capital Cost (low) [1]	$	$3,060,000	$8,024,000	
Capital Cost (high) [2]	$	$5,440,000	$9,928,000	
Offset Average Capital Cost	$	$4,250,000	$8,976,000	$0
WWTP Upgrade Cost	$	$15,080,000	$15,080,000	$26,600,000[3]
Total Capital Cost	$	$19,330,000	$24,056,000	$26,600,000
Operational Cost [4]	$/yr	$1,480,600	$1,953,200	$1,862,000
NPV Operational Cost	$	$20,867,494	$27,528,293	$26,242,925
Interest Rate	%	5%		
Total Cost over 25 years [5]	$	$40,197,000	$51,584,000	$52,843,000
Note: 1: Lower end cost estimate is based on lower estimate of stream length. 2: Higher end cost estimate is based on higher estimate of stream length. 3: From previous AEE (WDC 2011) without inflation consideration. 4: Operation cost of land management options was assumed to be 10% of the total capital cost; while the operation cost of WWTP was assumed to be 7% of the plant upgrade capital cost. 5: NPV estimates based on a common inflation rate of 5% over a period of 25 years, assuming all capital cost is spent on the first year.				

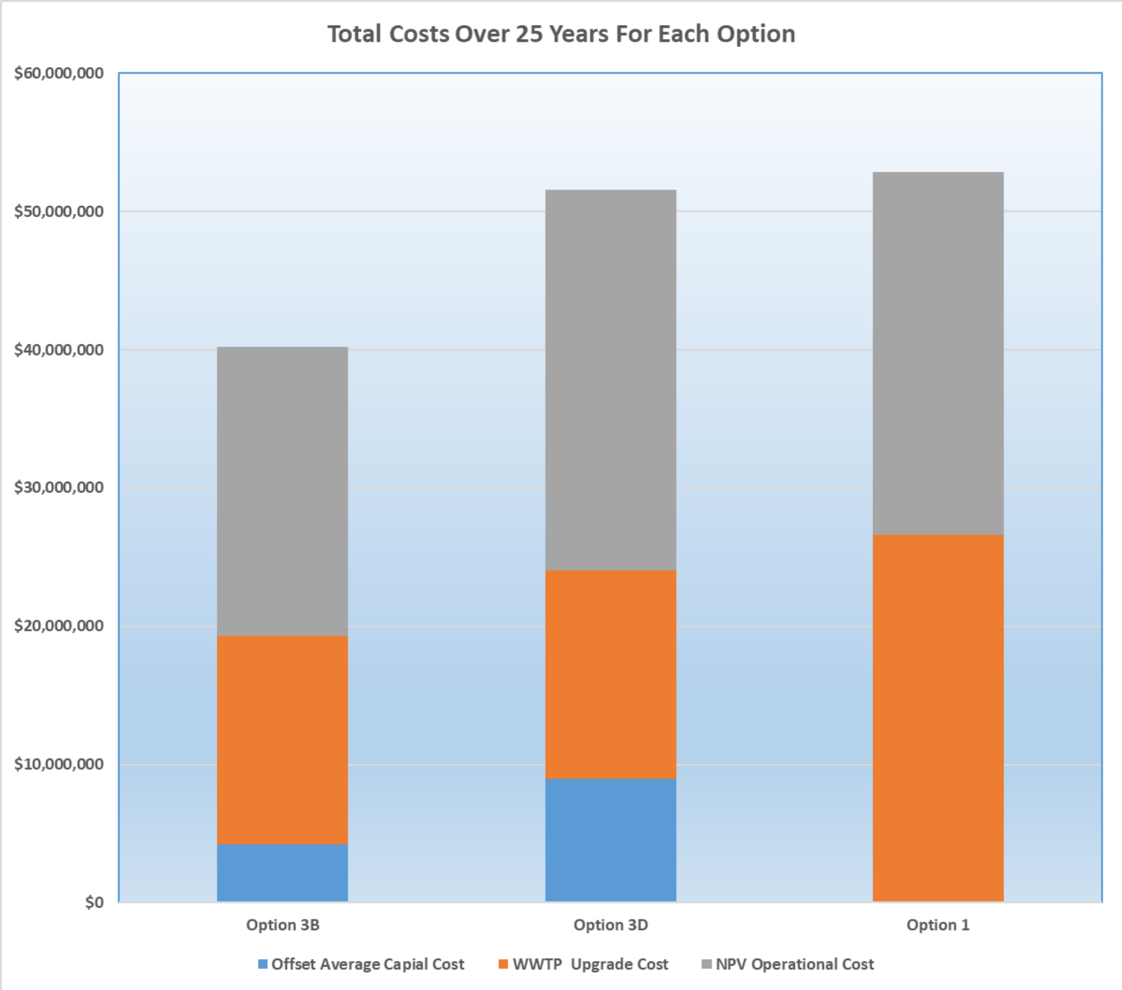

Figure 8 Total Cost Comparison For Proposed Options

3.5.5 Weighting of assessment criteria

The criteria identified in the assessment are acknowledged to be of varying degrees of relative importance to WDC. To determine the relative importance, a process of forced rankings is applied to each paired combination. The question applied is "Is Criteria 1 more important than Criteria 2?" If the answer is yes, then a score of 1 is applied, otherwise a score of 0 is given. In considering the 10 criteria identified for this assessment, there is a matrix of 10 x 10 paired ratings.

The weighting of each criteria was determined during a workshop with participants from both WDC and GHD. A table summarising the outcome of the assessment of relative weightings is presented in Table 17. The assessed criteria can be grouped into the three key components as stipulated by the BPO definition (i.e. technical, financial and environmental) and which have been color-coded accordingly in Table 17. Overall at this stage, the agreed weighting split among the three components are 18%, 39%, and 43% for financial, technical, and environmental, respectively. Note that all social and cultural criteria have been grouped into the environmental category.

The weightings are likely to be further modified as the project moves forward and engagement with iwi and other key stakeholders is progressed.

Table 17 Development of Criteria Weighting

Criteria/Risk	Flexibility	Constructability & Commissioning	Operation & Maintenance	Cultural	Industry experience of technology selected	Environmental Impact	Regulatory Risks	Safety	Alignment with management priority or regional strategy	Cost	Relative Importance
Flexibility		1	0	0	1	0	0	0	0	0	4.55%
Constructability & Commissioning	0		0	0	0	0	0	0	0	0	0.00%
Operation & Maintenance	1	1		1	1	0	0	0	1	0	11.36%
Cultural	1	1	0		1	1	1	0	1	0	13.64%
Industry experience of technology selected	0	1	0	0		0	0	0	0	0	2.27%
Environmental Impact	0	1	1	0	1		1	0	0	0	9.09%
Regulatory Risks	1	1	1	0	1	0		0	0	0	9.09%
Safety	1	1	1	1	1	1	1		1	1	20.45%
Alignment with management priority or regional strategy	1	1	0	0	1	1	1	0		0	11.36%
Cost	1	1	1	1	1	1	1	0	1		18.18%

BPO Assessment	
Financial (F)	18%
Technical (T)	39%
Environmental (E)	43%
Total	100%

3.5.6 Assessment Results

Applying the agreed weightings for all criteria as presented above, GHD undertook an initial ranking of the considered options as shown in Table 18. In this study, Option 1 represents the WWTP upgrade works proposed in 2011, which is used as a reference benchmark for comparison purposes. The WWTP upgrade options are considered to provide slightly more flexibility for future growth, and pose less regulatory risks in obtaining consent. In comparison, the land management offset options are thought to be easier to operate/maintain with less safety issues, likely to be more likely to be acceptable by local iwi and lower cost. They are also more in line with current management priority and regional strategy. Both Option 3B and Option 3D are scored similarly higher than Option 1. Option 3D is located in the upper Waikato FMU and outside of the WDC boundary. The MCA therefore indicates that Option 3B is likely to be the preferred option moving forward although further work is required to confirm this.

Table 18 Multi-Criteria Assessment Results

Criteria	Weight	Option 1	Option 3B	Option 3D
Flexibility	4.55%	4	2	3
Constructability & Commissioning	0.00%	3	5	4
Operation & Maintenance	11.36%	2	5	4
Cultural	13.64%	4	3	3
Industry experience of technology selected	2.27%	3	5	5
Environmental Impact	9.09%	3	4	5
Regulatory Risks	9.09%	5	3	3
Safety	20.45%	2	4	4
Alignment with management priority or regional strategy	11.36%	3	5	5
Cost	18.18%	2	4	3
Total Score		**2.9**	**3.9**	**3.8**

3.6 Recommendations

As noted in Section 1 of this report, the key purpose of this high level assessment has been to investigate the feasibility of nutrient offset for Cambridge WWTP and identify high-level options in this regard.

Based on the assessment undertaken, Option 3B – involving Fencing and Riparian Planting within the Karapiro catchment hill country sub-catchment and a suite of optimisation/upgrade works at the plant, has been shown to provide adequate nutrient removal capacity that meets the required nutrient offset target for the Cambridge WWTP. However, this is not to say that Option 3B is the only area that could be applicable. For instance, even though Option 3A is found not to have adequate nutrient removal capacity, it is located within the same FMU and may still be considered as part of the overall staged solution. Therefore pending the confirmation of the suitability of the sites identified in this report, the final solution may consist of a combination of sites within Option 3A and Option 3B areas. This is particularly relevant as the nutrient offset actions are likely to be staged with wastewater flow and loading trigger levels.

Option 3C and 3D are located outside of the Cambridge WWTP FMU, and are therefore not preferred according to the provision of the current proposed Plan Change 1. They may be considered, only if Option 3A and 3B areas are found not to provide adequate offset capacity as part of the next stage of detailed investigations.

4. Future Work

Based on the current provisions of the proposed Plan Change 1, GHD has adopted a nutrient offset assessment framework with key principles commonly applied internationally. This framework and calculation methodology may be further refined and agreed with Waikato Regional Council and other relevant stakeholders.

Furthermore, it is recognised that more detailed investigations are required to support Option 3. Recommendations for the further work required through Stage 2 of the process and the Detailed Business Case is outlined in this section.

4.1 Establishment of Environmental Baseline Condition

Further desktop review of relevant existing data and previous investigations is necessary to identify information gaps, particularly those relevant to the identified areas (e.g. Option 3B and 3A). This review would include previous water quality sampling, investigations and reports, waterway strategies, community survey results and risk assessment. This would assist in developing a conceptual understanding of the system, highlighting the key stressors to the stream health at a more refined scale.

A gap analysis would identify any additional data or information required and support development of a water quality monitoring and reporting programme, in consultation with WRC. The programme would need to meet WRC's requirements for water quality monitoring and reporting. This programme must establish monitoring activities and procedures capable of predicting potential and detecting actual impacts from the project. Prior to the implementation of the offset project, the monitoring programme should be capable of providing sufficient information for the establishment of pre-action baseline.

4.2 Option Confirmation and Implementation

Refinement and confirmation of the option assessment framework and methodology; and subsequently refinement of the offset option development is necessary to ensure that net environmental benefit can be achieved by Option 3. This may involve:

- Solidifying collaborations (e.g. Waikato River Authority, etc.);
- Detailed site selection, in collaboration with relevant parties (e.g. land owners);
- Potential small-scale site assessment including site set up, installation, and field challenge experiments for nutrients and sediment. Given that the offset effectiveness is topography, vegetation and farming practice specific, it is anticipated that a great deal of benefit will be derived from the outcomes of the field assessments.
- Update of the option assessment and Refinement of the implementation plan with updated cost benefit analysis.

When actions are approved as part of the consenting process, the approved actions need to be implemented in such a manner that the “verifiable” principle requirement of the offsetting option can be met.

Following approval from WRC, a land management code of practice or similar document should be developed to ensure that the water quality objectives are achieved, accounting for seasonal variability and the type of agricultural land use. Pending the requirements by the Regional Council, an Offset Management Plan may be required to be prepared. This Management Plan may include:

- Details of management measures, such as timing, frequency and duration, for each offset area;
- Performance and completion assessment criteria;
- The detailed monitoring and reporting programme;
- Potential risks to the successful implementation of the offset project, and associated mitigation measures.

4.3 Monitoring and Reporting

Ongoing evaluation and monitoring of the offset actions will be needed. A long-term monitoring programme, which may form part of the suggested Offset Management Plan, should specify all necessary details (e.g. sampling parameters, locations, events, frequencies, methodology, etc.) so that the monitoring results provide sufficient information to enable the determination of the water quality offset performance.

The monitoring results will be used for review of offset performance and to inform the offsetting assessment framework and any future offset options and/or consenting processes. Should the monitoring indicates that the offset project does not achieve the desired outcomes, alternative options and/or additional offset mitigation measures may be required as a result of the review.

5. Conclusions

An assessment of the potential for WDC to apply a nutrient offset approach as an alternative to upgrades to the Cambridge WWTP has shown this to be a viable and affordable option. Of the offsets considered a combination of fencing and riparian planting is considered to be the most practicable to apply within the Waikato River catchment. The implementation of an offsetting approach does not over-ride the need to also undertake some upgrades to the plant.

Catchment-level offset location options were identified by GHD and a multi-criteria analysis (MCA) framework was used to compare identified options. Based on the preliminary MCA findings, Option 3B – **involving Fencing and Riparian Planting** within the Karapiro catchment hill country sub-catchment **and a suite of optimisation/upgrade works at the plant**, has been shown to provide adequate nutrient removal capacity that meets the required nutrient offset target for the Cambridge WWTP. It is noted that other areas may be suitable for offset as part of a staged solution. Therefore pending the confirmation of the suitability of the sites identified in this report, the final solution may consist of a combination of sites within Option 3A and Option 3B areas.

Refinement and confirmation of the option assessment framework and methodology; and subsequently refinement of the offset option development is necessary to confirm that net environmental benefit can be achieved by Option 3 and recommendations are included in section 4 to progress this. A Detailed Business Case is also proposed to be advanced in combination with these further works.

In addition a consultation process is underway with key stakeholders including iwi and WRC which will further inform the option viability.

Appendices Maps

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Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
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