Notice of Requirement
Resource Consent Applications
Assessment of Effects on the Environment

Masterton Wastewater Treatment Plant and Disposal System Long-Term Upgrade

Masterton District Council

14 May 2007

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1 Introduction

1.1 Purpose and Structure of Report

Since 1994, the Masterton District Council (MDC) has been investigating a comprehensive range of options to upgrade the Masterton Wastewater Treatment Plant (MWTP), at Homebush, south of the Masterton urban area. In 2003, the Council received interim resource consents from the Greater Wellington Regional Council (GW) to undertake initial upgrading of its wastewater treatment system. Under regional resource consent WAR 020074, MDC is required to obtain resource consents and implement the long-term upgrade of its wastewater treatment plant by 2010.

Since that date, a number of detailed environmental, economic and technical investigations have been undertaken to identify the most effective upgrading option to satisfy a number of environmental, economic and social objectives. In June 2005, the Council selected its preferred scheme, and is now seeking the appropriate Resource Management Act (RMA) authorisations to proceed with its long-term upgrade of the Plant and to carry out various ancillary works including flood and erosion protection works.

The Notice of Requirement (NOR) and the resource consent applications contained herein seek to establish an appropriate environmental management regime for the construction, operation and maintenance of the MWTP. The Notice and applications are supported by an Assessment of Effects on the Environment (AEE), prepared in accordance with the Fourth Schedule of the Resource Management Act 1991, and incorporating those considerations set out in section 168A(3) of the RMA. The document is supported by the various additional reports as listed in Section 13.

This report is structured as follows:

Section 2 comprises the ***Notice of Requirement and the resource consent applications*** lodged in accordance with sections 88 and 168A of the RMA

Section 3 provides the ***background to the proposed upgrade***, identifying the site and its location, outlining the upgrade design process, the water quality targets used in its design, and a summary of the key elements of the upgrade

Section 4 describes the ***existing sewage treatment system***, including the history of its development, the inflow and infiltration issue, the improvements made in 2003 and the current performance of the wastewater system

Section 5 describes the ***existing environment***, focusing on physical and climatic conditions, the current water quality characteristics (both groundwater and river water), community characteristics and values, and the effects of the existing discharge on the environment

Section 6 sets out ***details of the proposed upgrade*** to the sewerage system and, in particular, the improvements to the treatment system, the proposed land disposal and river discharge regimes, the intended flood and erosion protection works, and the anticipated monitoring regime

Section 7 provides a review of the relevant **receiving water standards and guidelines**, including a review of section 107 thresholds, the proposed receiving water quality targets and the contribution of DRP.

Section 8 provides the ***Assessment of Effects on the Environment***, drawing on the technical investigations undertaken to date, including potential effects on surface and ground water, nutrient and bacterial removal, community health, soil sustainability, and natural hazards, as well as the key mitigation measures proposed to address any potential adverse effects

Section 9 sets out an assessment of the proposed upgrade against ***statutory requirements***, including regional and district plan policies

Section 10 provides a ***summary of the alternatives*** that were considered for the upgrade, including the reasons for choosing the preferred method

Section 11 summarises the ***consultation*** undertaken during the options assessment and design process

Section 12 recommends a range of ***conditions of consent*** on the resource consents

Section 13 sets out a list of ***reference documents***, including the technical reports that provide the basis of this AEE and other background reports and studies.

The Appendices contain supporting information.

1.2 Glossary

BOD (Biochemical Oxygen Demand) Measure of the amount of oxygen needed to convert the unstable constituents of sewage into stable ones. It is normally measured over 5 days at 20ºC and hence designated as BOD_5

BPO (Best Pracitable Option), as defined in the RMA 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

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

Diffuse discharges (or non-point sources) refer to a general discharge or seepage, either over or underground, of water borne material, which is not from any readily identifiable point. Also known as non-point source discharges.

DRP refers to “dissolved reactive phosphorus”, the most common form of phosphorus found in wastewater, and the type of phosphorus that is most easily taken up by plants.

E.coli (Escherichia coli) is one of the main species of bacteria living in the lower intestines of mammals, known as gut flora. *E.coli* can generally cause several intestinal and extra-intestinal infections such as urinary tract infections, meningitis, peritonitis, mastitis, septicaemia and gram-negative pneumonia. While the presence of coliform bacteria in surface water is a common indicator of faecal contamination, *E.coli* is also commonly used as a model organism for bacteria in general. "Presence" of E. coli numbers beyond a certain cut-off indicates faecal contamination of water and indicates the potential presence of other faecal derived pathogens.

Effluent refers to the wastewater after it has been treated and is then discharged into the ground or to water.

Evapotranspiration refers to the loss of water by evaporation and plant usage.

Groundwater refers to water located beneath the ground surface in soil pore spaces and in the fractures of geologic formations (such as aquifers). The depth at which soil pore spaces become fully saturated with water is called the water table. Groundwater is recharged from, and eventually flows to, the surface naturally; natural discharge often occurs at springs or seeps to form wetlands. Groundwater is also often withdrawn for agricultural, municipal and industrial use by extraction wells. Typically, groundwater is thought of as liquid water flowing through shallow aquifers, but technically it can also include soil moisture, permafrost (frozen soil), and immobile water in very low permeability bedrock.

Guidelines are numeric or narrative indications of a desired state of water quality that do not have the force of standards.

Infiltration refers to groundwater that seeps into pipes, channels or chambers through cracks, joints or breaks

Influent refers to the raw untreated wastewater that enters the treatment plant.

Median refers to the middle value of an ordered set of values (as compared to *average* or *arithmetic mean*, which refers to the value obtained by dividing the sum of a set of quantities by the number of quantities in that set).

Near-field mixing zone refers to an area close to the outfall where the effluent mixes rapidly with the receiving water because of the momentum and/or buoyancy of the effluent and turbulence in the receiving water.

Nutrients Biostimulants essential to the growth of plants, bacteria algae and protozoa. Macro nutrients include nitrogen and phosphorus

Pathogens refer to disease-causing organisms, such as bacteria and viruses.

Peak Dry Weather Flow Rate refers to the peak rate of flow on a dry day. It should be measured on the third of three consecutive dry days. The preferred unit is l/s.

Peak Wet Weather Flow Rate refers to the peak rate of flow on a wet day. The preferred unit is l/s.

Periphyton refers to the community of tiny organisms, such as algae, small crustaceans, insect larvae, and snails, which live attached to plants and surfaces projecting from the bottom of a freshwater aquatic environment.

Point source discharges refers to a discharge from a readily identifiable source, such as from the end of a pipe.

Reasonable mixing refers to the zone where the discharge is reasonably but not fully mixed with the receiving water and underlying standards need not be met.

Standards are statutory or plan requirements which must be met unless a consent provides an exemption.

Summer period for aesthetics and recreational effects is period 1 November - 30 April (MfE 2000)

Suspended Solids Insoluble matter in sewage which could be removed by a standard filtration process to leave a clear liquid.

Threshold flow range refers to a defined band of flows just after the discharge is initiated and before the river becomes markedly affected by upstream contaminants at higher flows (e.g., median flow for summer discharge, threshold flow range of 12.3 – 14.0 m^3/s).

Toxics Poisonous substances

Tradewaste Wastewater from industry, generally excluding human waste

1.3 Acknowledgements

This Assessment of Effects on the Environment was drafted by Beca Carter Hollings and Ferner Ltd, with significant input from the following:

4 Chris Hickey of NIWA – water quality analysis

4 Graeme Proffitt of Pattle Delamore Partners Ltd – groundwater analysis

4 Brent Clothier and Steve Green of HortResearch Ltd – analysis of soil sustainability, soil treatment of the wastewater and the soil water balance

4 Andrew Ball of ESR – Health Impact Assessment

4 Gary Williams – analysis of river flood and erosion control

4 Philip Milne of Simpson Grierson – legal review

4 John Harding – independent peer reviewer and contributor to discussion of health risk

4 Kevin Montgomerie – input from Masterton District Council

4 Hugh Wilde of Landcare Research – soil mapping on the irrigation site

4 Neal Borrie of Aqualinc Research Ltd – development of the irrigation scheme

Working with the above, the draft AEE was reviewed and finalised by Robert Schofield, Senior Environmental Planner of Boffa Miskell Limited.

2 Notice of Requirement and Applications for Resource Consent

2.1 Notice of Requirement for Alteration and Extension of Operative Designation

To: Masterton District Council

Pursuant to Sections 168, 168A and section 181 of the Resource Management Act 1991, the **Masterton District Council** gives notice of a requirement to extend the existing designation for *Masterton District Council Sewage Treatment Plant* purposes to include land for the proposed land disposal scheme and flood protection works and to alter the purpose of the existing designation to be as described below:

The amended and extended designation is proposed to be as follows:

- Modify the existing designation (42 ha) for the Masterton Wastewater Treatment Plant so that it covers all land use activities associated with the operation of the upgraded Plant; and
- Designates an additional 89 ha adjacent to the existing Masterton Wastewater Treatment Plant (to the northeast, adjacent to the Ruamahanga River) for the irrigation of treated wastewater to land and a further 107ha of land bounded by Martinborough Masterton Road and the Makoura Stream for the irrigation of treated wastewater to land.

The amended and extended designation is for

"Sewage treatment and disposal and ancillary works and activities including:

- *The upgrade of, and ongoing use, operation and management of the site as a sewage treatment plant and for land disposal of effluent*
- *Flood and erosion protection works to reduce the risk of damage to the infrastructure and land*
- *and all ancillary activities."*

The land is located off the Martinborough-Masterton Road adjacent to the Ruamahanga River, approximately 5 kilometres southeast of Masterton urban area, and approximately 1 kilometre upstream of Wardells Bridge. The existing (to be altered) designation and intended new designation are shown on the attached Plan in Appendix D.

Legal Description:

The new designation relates to approx 91 ha of land purchased by the Council in 2004 as follows:

Lot 1 DP 4333 and Pt Lot 1 Application Plan 2698; Pt Lots 1 & 2 DP 9928; Lots 1, 4 & 5 DP 351720; comprised in CT's WN11B/301; WN48B/596; 212321, 212324 & 212325.

The new designation also extends to an area of approx 107 ha of land which will transfer to the Council in 2007 as follows:

Pt Lot 3 DP 5669; Lots 2 & 3 DP 351720; Lots 1 & 3 DP 358970 comprised in CT's WN291/82; 212322; 212323; 240139; 240141.

The existing designation which is to be altered, extends to an area of approximately 42 ha as follows:

Pt Lots 4 & 5 DP 2412 comprised in CT's WN300/245; Pt Lots 4 & 5 DP 2412; Pt's Taumatakaihuka B3 & B4 Blocks; Pt Old River Bed SO 27745. These are all taken by Gazette 1972 P371, Pt Ruamahanga River.

The nature of the proposed public work (or project or work) is:

The Masterton wastewater irrigation scheme is part of the proposed upgrade to the Masterton Wastewater Treatment Plant. The treated wastewater from the existing Masterton Treatment Plant will be irrigated on the site largely using border strip irrigation. The treated wastewater will be irrigated mainly during the drier and summer periods when the land can accept it.

Some upgrading of the erosion control and the flood protection works alongside the river will be required. In addition, the existing Wastewater Treatment Plant will be upgraded, although little visible change to the treatment ponds would occur.

This Notice of Requirement incorporate the following activities associated with the upgrade works:

- The construction and operation of the upgraded Wastewater Treatment Plant
- The construction and operation of a land irrigation scheme to dispose of treated wastewater (effluent)
- Pump stations for the irrigation scheme
- The construction of the rock embankment outfall
- Pond de-sludging
- Sludge storage and dewatering lagoons
- Erosion protection measures, comprising in-river works;
- Raising the existing stop bank immediately upstream of the oxidation ponds;
- General ongoing operation, management and maintenance of the MWTP and
- Any other activities ancillary to the operation and maintenance of the MWTP.

The nature of the proposed work is described in more detail in the Assessment of Effects on the Environment (AEE).

The nature of the proposed restrictions that would apply is:

No other restrictions shall apply other than any conditions that may be imposed under section 171(2) of the Resource Management Act 1991.

In addition, there will be restrictions imposed through conditions of consent on the discharge permits sought from the Greater Wellington Regional Council. Note that applications for discharge permits in relation to the 107 ha site which the council is purchasing, will not be made until a later date. Those consents will address the effects of the proposed discharge to land on that part of the designated site. The effects of those subsequent discharge permits are not assessed in this document.

The effects that the public work (or project or work) would have on the environment, and the ways any adverse effects on the environment will be mitigated, are:

The effects on the Environment are described in more detail in the Assessment of Environmental Effects ("AEE").

Any effects on the environment from any discharges to air and land from the irrigation are to be considered as part of the resource consent applications required by Greater Wellington Regional Council.

In terms of the visual and amenity impacts of the irrigation scheme, it is expected that they will be no greater than those effects associated with primary production activity permitted under the Masterton District Plan.

The effects of the proposed flood and erosion protection works including construction impacts are described in the AEE. These works should not be visible beyond the immediate reach of the river, and will be comparable with standard flood protection and erosion control works along many New Zealand rivers.

Alternative site, routes or methods have been considered to the following extent:

A number of alternative options for treatment and disposal have been considered. These are outlined in the attached AEE and in further detail in the *Masterton Wastewater Upgrade Project: Technical Report on Recommended Scheme* (Beca 2005).

The public work and alteration of designation are reasonably necessary for achieving the objectives of the requiring authority:

- To allow for the long term treatment and disposal of wastewater from Masterton at the site.
- To provide authority under the Resource Management Act 1991 and the District Plan and Proposed Combined District Plan, for the works and activities described in the Notice of Requirement.
- To signal the use of the land in the District Plan and Proposed Combined District Plan.

The following resource consents from the Regional Council are needed for the proposed activity:

Regional Council consents as follows:

- Land use consent (erosion protection works and rock embankment)
- Discharge permit (discharge of wastewater and stormwater runoff to water)
- Discharge to air (odour and aerosols)
- Discharge to land (irrigation scheme, sludge disposal and leakage from base of the ponds)
- Water Permit (divert flood waters and authorize inflows to the ponds)
- Discharge permits for discharge to air and discharge to land on the future extended land disposal area (to be applied for later)

The following consultation has been undertaken with parties that are likely to be affected

Consultation has been undertaken with respect to the proposed upgrade to the wastewater treatment plant and options for disposal of wastewater, as outlined in the *Wastewater Upgrade Project. Recommended Scheme Summary Report* (Beca 2005). A summary of that consultation and subsequent consultation is summarised in section 11 and Appendix C of this report.

The District Council has also released several newsletters to residents to describe the proposed upgrading scheme.

The Masterton District Council, attaches the following information required to be included in this notice by the district plan or any regulations made under the Resource Management Act 1991.

4 Plan of the proposed designation, including treatment ponds and effluent irrigation scheme is shown in Appendix D

4 An assessment of Environmental effects of the proposed works.

Signature of person giving notice (*or* person authorised to sign on behalf of person giving notice)

14 May 2007

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Kevin Montgomerie, Assets Manager
Telephone: 06-3789666

2.2 Application for Resource Consent: Water Permit

To: Greater Wellington Regional Council

Masterton District Council applies for the following type of resource consent:

Water Permit to divert water pursuant to s 14 Resource Management Act 1991.

The proposed activity is:

- To upgrade and maintain the stopbanks, adjacent to the Ruamahanga River, to the north of the wastewater treatment plant oxidation ponds; and
- To authorise inflow of groundwater into the oxidation ponds through the base of the ponds.

The duration sought for the consent is 35 years.

A more detailed description of the proposed activity is outlined in the attached Assessment of Effects on the Environment. The activity is shown on the plans in Appendix D.

The names and addresses of the owner and occupier (other than the applicant) of any land to which the application relates are as follows:

Stuart Forbes, a lessee and occupier of the land

The location of the proposed activity is as follows:

Parts of the Masterton Wastewater Treatment Plant at Homebush described below and the Ruamahanga River adjoining that land.

Legal description

Lot 1 DP 4333; Lots 1, 4 & 5 DP 351720; comprised in CT's WN11B/301; 212321, 212324 & 212325.

Pt Lots 4 & 5 DP 2412 comprised in CT's WN300/245; Pt Lot 5 DP 2412; Pt's Taumatakaihuka B3 & B4 Blocks; Pt Old River Bed SO 27745. These are all taken by Gazette 1972 P371.

The following resource consents are needed for the proposed activity and have been applied for:

- Land use consent to place and use and maintain structures in the river bed and associated disturbance, pursuant to s 13 of the Resource Management Act 1991;
- Discharge permit to discharge to water, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit to discharge to land, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit to discharge to air, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permits for discharge to air and discharge to land on the future extended land disposal area (to be applied for later)

In accordance with the Fourth Schedule of the Resource Management Act 1991, an assessment of the effects which the proposed activity may have on the environment is attached.

Any information required to be included in this application by the district plan, the regional plan, the Resource Management Act 1991, or any regulation made under that Act.

No additional information (not encompassed in the assessment of environmental effects) is required to be included in this application).

Signature of applicant (or person authorised to sign on behalf of applicant)

14 May 2007

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Kevin Montgomerie, Assets Manager
Telephone: 06-3789666

2.3 Application for Resource Consent: Land Use (Ruamahanga Riverbed)

To Greater Wellington Regional Council

Masterton District Council applies for the following type of resource consent:

Land Use Consent to place use and maintain a structure in the river bed, and associated disturbance of the bed, pursuant to s 13 of the Resource Management Act 1991;

The proposed activity is:

- The construction, placement, use and maintenance of a rock embankment diffuser outfall, for the discharge of treated wastewater,to be located within the proposed erosion protection works that will line the main river channel of the Ruamahanga River; and
- The construction, placement, use and maintenance of riverbank erosion protection works on the bed of the Ruamahanga River.

The duration sought for the consent is 35 years.

A more detailed description of the proposed activity is outlined in the attached Assessment of Effects on the Environment.

The names and addresses of the owner and occupier (other than the applicant) of any land to which the application relates are as follows:

The Crown

D Holmes and J Wardell occupier of the land for the true left bank erosion protection works (with joint owners J Griffith, J Sadler and N Beetham).

The location of the proposed activity is as follows:

The Ruamahanga River adjoining the Masterton Wastewater Treatment Plant at Homebush

The location of the diffuser is proposed to be on the true right bank of the river at a location approximately mid length of the secondary oxidation pond. Drawing C104 (refer Appendix D) shows the location of the discharge. The location of the erosion protection works are shown on Drawing C104.

Legal description:

The diffuser is in the Ruamahanga River adjoining Pt Lot 5 DP 2412; Pt's Taumatakaihuka B3 & B4 Blocks; Pt Old River Bed SO 27745. These are all taken by Gazette 1972 P371.

The erosion protection works are in the Ruamahanga river bed adjoining Pt Lot 2 DP1499 & Lot 1 DP 34654

The following resource consents are needed for the proposed activity and have been applied for:

4 Discharge permit to discharge to water, pursuant to s 15 of the Resource Management Act 1991;

4 Discharge permit to discharge to land, pursuant to s 15 of the Resource Management Act 1991;

4 Discharge permit to discharge to air, pursuant to s 15 of the Resource Management Act 1991;

4 Water permit to divert water pursuant to s 14 Resource Management Act 1991.

4 Discharge permits for discharge to air and discharge to land on the future extended land disposal area (to be applied for later)

In accordance with the Fourth Schedule of the Resource Management Act 1991, an assessment of the effects which the proposed activity may have on the environment is attached.

Any information required to be included in this application by the district plan, the regional plan, the Resource Management Act 1991, or any regulation made under that Act.

No additional information (not encompassed in the assessment of environmental effects) is required to be included in this application).

Signature of applicant (or person authorised to sign on behalf of applicant)

14 May 2007

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Kevin Montgomerie, Assets Manager
Telephone: 06-3789666

2.4 Application for Resource Consent: Discharge to Water

To Greater Wellington Regional Council

Masterton District Council applies for the following type of resource consent:

Discharge to water, pursuant to s 15 of the Resource Management Act 1991.

The proposed activity is:

- The discharge of treated wastewater (effluent) to the Ruamahanga River; and
- The discharge of runoff from the wastewater irrigation land to the Ruamahanga River and Makoura Stream.

The duration sought for the consent is 35 years.

A more detailed description of the proposed activity is outlined in the attached Assessment of Effects on the Environment.

The names and addresses of the owner and occupier (other than the applicant) of any land to which the application relates are as follows:

The riverbed is owned by the Crown.

The stream is owned by Masterton District Council on either side.

The location of the proposed activity is as follows:

Masterton Wastewater Treatment Plant at Homebush

The location of the diffuser discharge is proposed to be on the true right bank of the river at a location approximately mid length of the secondary oxidation pond. Drawing C104 (refer Appendix D) shows the location of the discharge.

The potential discharge of surface run off from the land disposal area to the Ruamahanga river and the Makoura stream will normally be point source discharges at the downstream ends of wipe-off drains, the exception being high rainfall events where the capacity of the wipeoff drainage system may be exceeded and non point discharges at various locations may occur. Refer to Drawing C110 in Appendix D.

Legal description:

The Ruamahanga river adjoining Part Lot 5 DP 2412

The Makoura stream adjoining Lot 1 DP 4333; Pt Lots 1 & 2 DP 9928; Lots 1, 4 & 5 DP 351720; comprised in CT's WN11B/301; WN48B/596; 212321, 212324 & 212325.

The following resource consents are needed for the proposed activity and have been applied for:

4 Land use consent to place and use and maintain structures in the river bed and associated disturbance, pursuant to s 13 of the Resource Management Act 1991;

4 Discharge permit to discharge to land, pursuant to s 15 of the Resource Management Act 1991;

4 Discharge permit to discharge to air, pursuant to s 15 of the Resource Management Act 1991;

4 Water permit to divert water pursuant to s 14 Resource Management Act 1991.

4 Discharge permits for discharge to air and discharge to land on the future extended land disposal area (to be applied for later)

In accordance with the Fourth Schedule of the Resource Management Act 1991, an assessment of the effects which the proposed activity may have on the environment is attached.

Any information required to be included in this application by the district plan, the regional plan, the Resource Management Act 1991, or any regulation made under that Act.

No additional information (not encompassed in the assessment of environmental effects) is required to be included in this application).

Signature of applicant (or person authorised to sign on behalf of applicant)

14 May 2007

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Kevin Montgomerie, Assets Manager
Telephone: 06-3789666

2.5 Application for Resource Consent: Discharge to Land

To Greater Wellington Regional Council

Masterton District Council applies for the following type of resource consent:

Discharge to land, pursuant to s 15 of the Resource Management Act 1991. The proposed activity is the discharge to land of:

- Treated wastewater (effluent) through an irrigation system;
- Partially treated wastewater by leakage through the base of the oxidation ponds; and
- Wastewater sludge and residual liquid from the sludge dewatering process.

The duration sought for the consent is 35 years.

A more detailed description of the proposed activity is outlined in the attached Assessment of Effects on the Environment.

The names and addresses of the owner and occupier (other than the applicant) of any land to which the application relates are as follows:

Stuart Forbes, a lessee and occupier of the land

The location of the proposed activity is as follows:

Masterton Wastewater Treatment Plant at Homebush

Legal description:

Lot 1 DP 4333 and Pt Lot 1 Application Plan 2698; Pt Lots 1 & 2 DP 9928; Lots 1, 4 & 5 DP 351720; comprised in CT's WN11B/301; WN48B/596; 212321, 212324 & 212325.

Pt Lot 3 DP 5669; Lots 2 & 3 DP 351720; Lots 1 & 3 DP 358970 comprised in CT's WN291/82; 212322; 212323; 240139; 240141.

Pt Lots 4 & 5 DP 2412 comprised in CT's WN300/245; Pt Lot 5 DP 2412; Pt's Taumatakaihuka B3 & B4 Blocks; Pt Old River Bed SO 27745. These are all taken by Gazette 1972 P371, Pt Ruamahanga River.

The following resource consents are needed for the proposed activity and have been applied for:

- Land use consent to place, use and maintain structures in the river bed and associated disturbance, pursuant to s 13 of the Resource Management Act 1991;
- Discharge permit to discharge to water, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit to discharge to air, pursuant to s 15 of the Resource Management Act 1991; and
- Water permit to divert water pursuant to s 14 Resource Management Act 1991.
- Discharge permits for discharge to air and discharge to land on the future extended land disposal area (to be applied for later)

In accordance with the Fourth Schedule of the Resource Management Act 1991, an assessment of the effects which the proposed activity may have on the environment is attached.

Any information required to be included in this application by the district plan, the regional plan, the Resource Management Act 1991, or any regulation made under that Act.

No additional information (not encompassed in the assessment of environmental effects) is required to be included in this application).

Signature of applicant (or person authorised to sign on behalf of applicant)

14 May 2007

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Kevin Montgomerie, Assets Manager
Telephone: 06-3789666

2.6 Application for Resource Consent: Discharge to Air

To Greater Wellington Regional Council

Masterton District Council applies for the following type of resource consent:

Discharge to air, pursuant to s 15 of the Resource Management Act 1991;

The proposed activity is the discharge of odours and aerosols to air from:

- The oxidation ponds; and
- Land irrigation systems; and
- Sludge dewatering activities.

The duration sought for the consent is 35 years.

A more detailed description of the proposed activity is outlined in the attached Assessment of Effects on the Environment.

The names and addresses of the owner and occupier (other than the applicant) of any land to which the application relates are as follows:

Stuart Forbes, a lessee and occupier of the land

The location of the proposed activity is as follows:

Masterton Wastewater Treatment Plant at Homebush

Lot 1 DP 4333 and Pt Lot 1 Application Plan 2698; Pt Lots 1 & 2 DP 9928; Lots 1, 4 & 5 DP 351720; comprised in CT'sWN11B/301; WN48B/596; 212321, 212324 & 212325.

Pt Lot 3 DP 5669; Lots 2 & 3 DP 351720; Lots 1 & 3 DP 358970 comprised in CT's WN291/82; 212322; 212323; 240139; 240141.

Pt Lots 4 & 5 DP 2412 comprised in CT's WN300/245; Pt Lot 5 DP 2412; Pt's Taumatakaihuka B3 & B4 Blocks; Pt Old River Bed SO 27745. These are all taken by Gazette 1972 P371, Pt Ruamahanga River.

The following resource consents are needed for the proposed activity and have been applied for:

- Land use consent to place, use and maintain structures in the river bed and associated disturbance, pursuant to s 13 of the Resource Management Act 1991;
- Discharge permit to discharge to water, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit to discharge to land, pursuant to s 15 of the Resource Management Act 1991; and
- Water permit to divert water pursuant to s 14 Resource Management Act 1991.
- Discharge permits for discharge to air and discharge to land on the future extended land disposal area (to be applied for later)

In accordance with the Fourth Schedule of the Resource Management Act 1991, an assessment of the effects which the proposed activity may have on the environment is attached.

Any information required to be included in this application by the district plan, the regional plan, the Resource Management Act 1991, or any regulation made under that Act.

No additional information (not encompassed in the assessment of environmental effects) is required to be included in this application).

Signature of applicant (or person authorised to sign on behalf of applicant)

14 May 2007

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Kevin Montgomerie, Assets Manager
Telephone: 06-3789666

3 Background

3.1 Site and Location

The existing MWTP at Homebush is situated on approximately 42 ha of flat land located in the rural area 5 km southeast of Masterton urban area, as shown in Figure 1.

The total area of the site for the proposed upgraded treatment plant and irrigation scheme is 240 ha (including recently acquired land intended for future land disposal). The land is owned (or in the case of the future disposal area, soon will be owned by the Masterton District Council), and is located off the Martinborough-Masterton Road adjacent to the Ruamahanga River, approximately 1 km upstream of Wardells Bridge. The map reference for the wastewater treatment plant is NZMS 260 Map T26 355202.

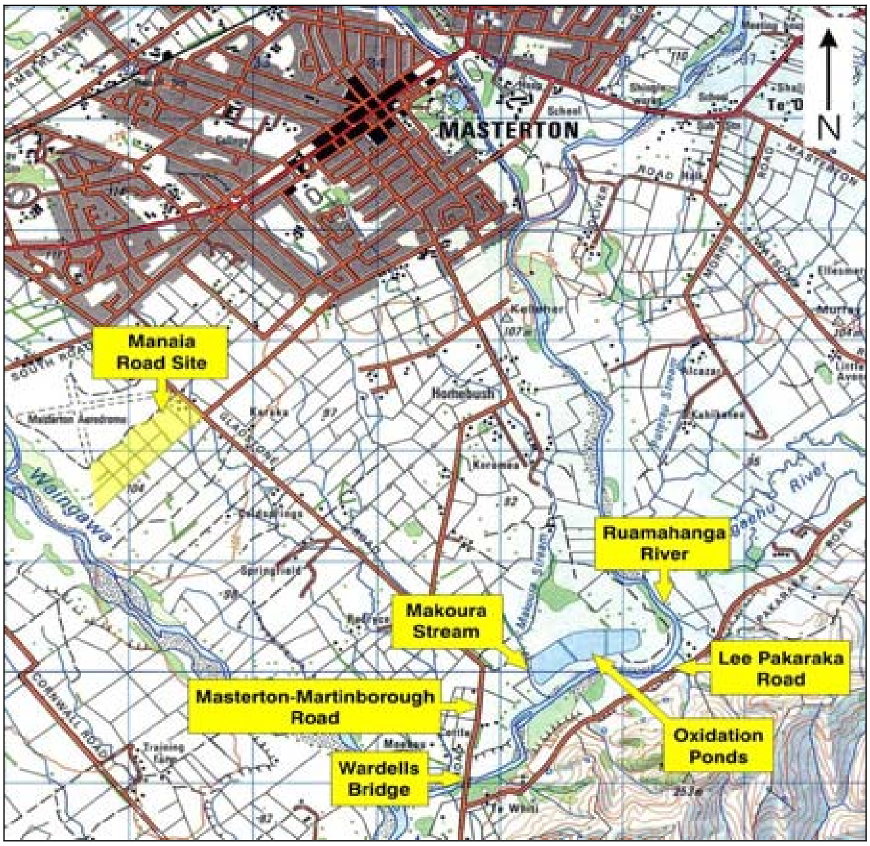

Figure 1 Location of Masterton Wastewater Treatment Plant

3.2 The Upgrade Design Process

3.2.1 History

Investigations commenced in 1994 into a long-term strategy for the treatment and disposal of Masterton's wastewater. In 1996, a range of potential treatment and disposal sites were investigated, focusing on a 6 km radius around the Homebush site to maximise existing gravity-fed infrastructure. This study identified two locations, the existing Homebush site and land adjacent to the Hood Aerodrome (Manaia Road), as potentially the most suitable sites for land disposal either by rapid infiltration or slow rate irrigation. The suitability of these sites was subsequently confirmed when further testing of other potential sites was undertaken in 1997-98.

The next stage of the project entailed an investigation into alternative treatment and disposal systems. In 1999, the Masterton District Council set up a Working Party with representation from key stakeholders in the community, which considered the options and shortlisted a number of these for further investigation.

Investigations of various aspects of these options continued between 1999 and 2003, although a delay in obtaining access to land for testing in the Homebush area delayed some specific investigations. One of the key results of these investigations was that neither the Homebush nor Manaia Road site was suitable for using the Rapid Infiltration (RI)[1] option.

In early February 2004, Council negotiated an agreement for the purchase of approximately 91 ha of land at Homebush adjoining the existing Masterton Wastewater Treatment Plant site, with the view to using it for land treatment of the effluent. The additional land acquired at Homebush enabled the RI and slow rate irrigation investigations at Homebush to be completed.

In April 2004, the Consultation Task Group was formed to facilitate the consultation as part of Council's decision-making process to select a preferred option to upgrade the wastewater system.

During 2004 work continued with investigations into:

- Matters raised during the hearing for the 'Interim Consent' applications, in connection with the existing ponds (Beca 2004a); and
- Ongoing investigations into the viability of a range of treatment and disposal schemes (Issues and Options Report, Beca 2004d).

The investigations identified that slow rate irrigation land treatment system, using "cut-and-carry" and tree cropping, as a method of disposing and providing further treatment of the effluent, will be feasible at Homebush during certain times of the year, particularly the dry summer periods. This disposal method could be combined with a part-time discharge to the Ruamahanga River, so as to maximise the quantities of effluent disposed to land, and minimise discharges to the river.

A range of other wastewater treatment options was also investigated, including a spectrum of technology, with options from upgrading the existing ponds, new oxidation ponds, dual power aerated ponds, mechanical treatment plants, phosphorus removal plants, and UV disinfection.

A key issue associated with the existing oxidation ponds has been the leakage through their bases. Detailed investigations were undertaken on the leakage from the ponds, including an assessment of the leakage rate and effects of pond leakage on the water quality in the Ruamahanga River and the surrounding groundwater. Although an increase in algal growth was recorded immediately downstream of the ponds, the extent of algal cover on the river bed and other water quality parameters were found to be within the relevant guidelines[2] for water quality in the river (the leakage rates and pathways are discussed in section 4.5.4, while the effects of pond leakage are discussed in sections 8.2.2 and 8.2.3).

Other investigations carried out as part of the preliminary design process focused on:

- Developing more detail on soil types and characteristics
- Further assessment on the rate of leakage
- Detailed water balance modelling
- Detailed groundwater modelling.

A list of the key reports produced in relation to the treatment and disposal investigations, and the design of the long-term upgrade is included in the Reference section of this AEE.

1 A form of high rate land disposal.
2 The relevant guidelines are shown in Table 2 in Section 1.9.

The results of the investigations undertaken following the completion of the Issues and Options Report, which were used by Council to make a decision regarding the preferred scheme, were reported in the Technical and Summary Reports on Recommended Scheme (Beca 2005a and 2005b). In June 2005, MDC selected its preferred option for the upgrade as:

- The expansion and upgrading of the existing oxidation ponds to produce higher quality effluent; and
- The development of an irrigation scheme as the primary disposal method of effluent, combined with part-time discharge of effluent to the Ruamahanga River through a new outfall.

MDC also resolved to continue to seek, over the long-term, to acquire more land for irrigation of the effluent. In March 2007–, the Council entered into a contract to purchase an additional 107 ha land which it proposes to use for additional land disposal of effluent. Separate applications for discharge permits will be made for this land at a later date once technical investigations are complete.

3.2.2 Existing Consents

The existing consents for the MWTP were granted on 20 January 2003 for discharges to water, land and air (see Table 1 below).

These "interim" resource consents provided for a number of upgrades to be made to the existing Plant, including improvements to pond mixing, the installation of new brush aerators and an outlet screen, and the construction of a bund and rock filter to create a new maturation cell within the secondary oxidation pond. These upgrades were completed in June 2003.

Also as part of the upgrade, riprap was added to selected areas of the inner pond embankments to enhance existing wave protection. The outlet channel and weir were also modified in 2003 to improve the accuracy of discharge flow measurements. The influent flowmeter (inlet flume and level sensor) has also been upgraded with the installation of a new electromagnetic flowmeter.

The existing consents expire in 2010, with condition 6 of the consent to discharge into water requiring a long-term upgrade of the treatment plant to be operating by the expiry of the consent. The current discharge permit was granted on an interim, short-term basis because it was considered that the plant required upgrading beyond that provided by the consents. As discussed later, the current discharge generally meets the existing guidelines in the Wellington Fresh Water Plan. However, at times of the year and at lower flows (in summer low flows when the river is most desirable for contact recreation) there are clearly effects of the existing discharge that MDC wishes to address. The primary reason for the proposed upgrade is the Council's desire to move to a longer-term and more sustainable form of treatment and disposal to reflect community expectations.

Table 1 Existing RMA Consents and Authorities Held for Wastewater Treatment Plant

Relevant Regional/District Plan	Consents Held	Consent Effective From	Date Expires
Freshwater Plan	Discharge permit to discharge treated wastewater to surface water l (Makoura Stream)	2003	2010
Plan for Discharges to Land	Discharge permit to discharge contaminants (treated wastewater) to land (where it may enter water)	2003	2010
Air Quality Management Plan	Discharge Permit to discharge contaminants to air	2003	2010
Masterton District Plan	Designation D88 (refer to Appendix 9 and Planning Map 10)	1997 (plan operative)	Not applicable

3.2.3 Principal Environmental Issues

Following consultation and investigations, the following environmental issues were identified as the key matters to address in the upgrade of the MWTP:

- ***Colour and clarity of the river***

  The Ruamahanga River, immediately below the confluence with the Makoura Stream[3] exhibits poor colour and clarity for significant periods. This discoloration is particularly evident in summer, when river flows are low and the river is most used for contact recreation. The poor colour and clarity is largely due to the presence of pond algae from the discharge, giving the appearance of a green plume from the discharge. While algae are an important part of the treatment process in oxidation ponds and the green colour in the ponds indicates a healthy system, they can increase suspended solids in the discharge and reduce water clarity, particularly in summer. Discoloration and reduced clarity of the water during low flows affect visual and recreation amenity values.

- ***Build-up of undesirable biological growths (periphyton) in waterways***

  Attached algae (periphyton) can have an undesirable effect on recreation, in that it can make the riverbed slippery and aesthetically unattractive. During prolonged periods of low flow in the Ruamahanga River, the concentration of dissolved reactive phosphorus (DRP) in the effluent discharge increases the degree of attached algal growth on the bed of the River for a distance downstream of the discharge. Periphyton build-up also occurs upstream of the treatment plant. Periphyton downstream does not reach nuisance levels and is readily removed by even minor floods or freshes, nevertheless there is some localised increase in build up as a result of the discharge, which it should ideally be avoided.

- ***Effects on aquatic ecosystems***

  Investigations have determined that the existing discharge is not having a significant adverse effect on aquatic ecosystems. Nevertheless, there is a local and minor impact in terms of an increase in the relative abundance of pollution-tolerant macro-invertebrates immediately downstream of the discharge.

- ***Contribution to health risks***

  Although contact recreation guidelines are generally met, the discharge to the river increases the levels of pathogens downstream and contributes to an increased health risk, particularly at times of low flow when the river is used for primary contact recreation and when the upstream concentrations of pathogens are at their lowest. This risk is exacerbated by the lack of full mixing of the discharge at Wardells Bridge, but is minimal by the Cliffs site where more primary contact recreation occurs.

- ***Effects on recreational value***

  The community places a high value on the Ruamahanga River, which provides for a variety of recreational activities including swimming, fishing and jet boating. Concern has been expressed about health risks associated with recreation activities in or on the river and, while investigations suggest a low level of risk at present, such perception diminishes the recreational value of the River.

- ***Tangata Whenua values***

  The Ruamahanga River also has traditional significance to Ngati Kahungunu and Rangitaane for food gathering and many of their ancestral sites of special value are located alongside the river. The discharge of effluent into the river adversely affects the mauri of the waters. Tangata whenua have expressed a desire to minimise the direct discharge of human effluent to water with a preference for discharge to land where practicable. This is also reflected in policies of the Wellington Fresh Water Plan.

[3] The point where the existing effluent discharge mixes with the Ruamahanga River.

3.2.4 Design Principles and Project Objectives

Design Principles

The 1999 Working Party developed the following project principles for the wastewater treatment plant upgrade:

- Wastewater treatment is essential to protect public health
- Cultural and social issues, and water quality are seen as having high importance
- Surface water quality is seen to have equal priority with cultural and social issues
- Groundwater is a resource that is valuable to some sections of the community
- The solution that is finally adopted must be affordable for the community
- The Ruamahanga River has a high recreational usage, particularly in the summer
- The existing oxidation ponds are not considered to cause significant odour or other air impacts
- The existing oxidation ponds are considered acceptable in terms of visual effects
- High inflows to the plant may impact on the scheme selection.

In 2004, the Masterton District Council and the Consultation Task Group (CTG)[4] developed project objectives from the project's principles. The objectives are outlined below.

3.2.5 Project Objectives

Overall Objective

- To provide a sustainable long-term solution to the treatment and disposal of Masterton's wastewater.

Social and Cultural Objectives

- To construct and operate a wastewater treatment plant that is robust and reliable.
- To recognise Maori cultural values associated with the Ruamahanga River and other water bodies
- To recognise the use and amenity value of the Ruamahanga River for recreation.
- That the treated wastewater, after mixing, meets nationally recognised standards for bacteria to minimise the risk to public health in relation to recreation in and food gathering from, the Ruamahanga River
- To have input and support from the Masterton and affected communities (including tangata whenua) for the selected upgrade option.

Environmental Objectives

- That the wastewater is treated to a standard, particularly in terms of suspended solids, colour, clarity and nutrients that protects surface water for current and future users and recognises the objectives of the Regional Freshwater Plan for the Wellington Region.
- That the wastewater is treated to a standard, particularly in terms of suspended solids, colour, clarity and nutrients that protect groundwater for current and future users.
- That the wastewater upgrade project promotes sustainability, particularly in resource consumption (for example non-renewable chemical use, energy use and gas emission).

[4] The CTG was formed to provide for some community/stakeholder-based input into the consultation and the project development.

- That the wastewater treatment plant upgrade does not result in any significant odour beyond the site boundary.
- To reduce over time the inflow and infiltration of stormwater and groundwater into the reticulation system and/or manage the peak flow in the treatment process.

Economic Objectives

- That the proposed upgrade is cost effective and affordable for the Masterton Community.

3.3 Summary of Proposed Upgrade

3.3.1 Key Elements of Proposed Upgrade

A summary description of the upgrade, including a summary of the restrictions on the discharge of effluent to the river, is detailed in this section: a fuller description is provided in section 6, which includes a schematic diagram of the upgraded treatment and disposal scheme (refer to Figure 21).

The upgrade comprises the following key elements:

- The construction and operation of three additional maturation cells-in-series (total of four cells) in the secondary oxidation pond which will significantly improve microbiological quality of the effluent;
- A pump station to deliver effluent to the irrigation area
- Construction of a land disposal/irrigation scheme north of the ponds to irrigate effluent to land whenever soil conditions allow
- No discharge of effluent to the river at flows below median flow in the Ruamahanga River (from 1 November to 30 April), and below half median flow in the Ruamahanga River in winter (from 1 May to 31 October)
- Whenever there is a discharge to the Ruamahanga River, the ratio of river flow to effluent discharge will be a minimum of 30:1
- New effluent discharge point in the Ruamahanga River with an outfall diffuser
- Extended rip rap lining to internal pond embankments to cater for storage in the ponds when irrigation and river discharge are not permitted
- Desludging of Pond 1 (Pond 2 to be desludged within ten years as part of the Council's Asset Management programme)
- Establishment of a sludge dewatering area (sludge to be used as landfill cover)
- Raising the level of the Pond 1 and upstream stopbank to provide protection for a 100-year return period flood
- Further erosion protection works on the right bank adjacent to Ponds 2 and 3 and on the left bank at the bend opposite the upstream end of Pond 1and extending downstream on the left bank.

3.3.2 Key Improvements Resulting from Proposed Upgrade

The key improvements that will result from the proposed long-term upgrade of the existing wastewater treatment and disposal system are as follows:

- Improved effluent quality with regard to bacteria and pathogens as a result of the installation of maturation cells in the secondary pond
- Maximisation of land based disposal and minimisation of direct discharge to the river

4 No discharge of treated wastewater to the Ruamahanga River when river flow is below median flow (≤12.3 m3/s) in summer (1 November-30 April) or below ½ median flow (≤6.2 m3/s) in winter (1 May-31 October)

4 The new discharge location will result in improved faster mixing which, combined with the intermittent nature of the discharge, will result in full mixing well upstream of Wardells Bridge and a significant improvement in aesthetic impacts and reduction in health risk.

4 Raising an area of stop bank to the north of the ponds will improve flood protection to the ponds and irrigation area

4 There will be no discharge of effluent directly to the Makoura Stream, with a subsequently significant improvement of water quality in the lower reaches of that stream

In addition to these improvements to the treatment and disposal system, the Council has committed funding of an ongoing asset management programme to repair/replace the worst sections of the reticulation network (in terms of inflow and infiltration), which would further improve the operation of the MWTP.

4 **The key improvements during low flows when there is no direct discharge to the river will be:**

- No green colouring in the water from pond algae
- No change to river water clarity
- No nutrients directly discharged to the river that would encourage undesirable biological growths (periphyton/slime) on bed of river
- No discharge of effluent directly to the river (i.e., reduced bacterial and pathogen loads in the river) when the river is more attractive for swimming and other forms of contact recreation
- No metals or chemicals discharged directly to the river
- Residual discharge via pond leagage will have negligible effects on the water quality in the river

4 **The key improvements at higher flows, when there is a direct discharge to the river will be:**

- Improved water quality in the Ruamahanga River and in particular at Wardells Bridge
- Reduced mixing zone due to improved mixing;
- Moving of the mixing zone upstream as a result of the diffuser and new upstream the discharge point, so that full mixing will occur upstream of Wardells Bridge (currently full mixing occurs downstream of Wardells Bridge)
- The discharges into the Ruamahanga River will generally occur when the river water quality is already of a lower quality due to diffuse upstream sources
- Discharge will occur at times when little if any primary contact recreation occurs

Overall, the treatment, and disposal regime and associated upgrades:

4 Will result in significant environmental improvements over the existing discharge

4 Removes the direct discharge from the river at the times and flows when the river is most sensitive, most valued and most used.

4 Will allow the Masterton community to ensure that its wastewater can continue to be safely disposed of into the long term.

4 Will ensure that the discharges will have no more than minor adverse effects on the environment and will not compromise public health or aquatic ecosystems

4 Will improve the quality of the water in the Ruamahanga River during the most sensitive periods in terms of ecological, social and cultural values and use;

4 Will not adversely effect the long term sustainability of the soils;

4 Will not adversely affect the quality of groundwater;

4 Addresses the issues raised in consultation with the community; and

4 Is consistent with the objectives and policies of the relevant regional and district plans.

4 Is a sound and affordable long term solution for Masterton,

4 Involves known technology and best utilises the existing infrastructure

4 Will achieve the Council's objectives as specified earlier.

4 Is consistent with Part II of the RMA with respect to:

- The purpose of the RMA (section 5 - sustainable management of resources); and
- The principles of the RMA (sections 6, 7 and 8).

3.3.3 Consents and Designations Sought

Consents Sought from the Greater Wellington Regional Council

The resource consents being sought are as follows:

4 To place and use erosion and protection works in the river bed, and any associated disturbance

4 To raise the existing stopbank immediately upstream of the oxidation ponds

4 To construct the outfall diffuser

4 To dam or divert water (Ruamahanga River during floods) by upgrading a stopbank

4 To discharge contaminants to water as follows:

- To discharge effluent to the Ruamahanga River; and
- Stormwater runoff from the irrigation area to the Makoura Stream and Ruamahanga River;
- Leakage from the base of the oxidation ponds

4 To discharge contaminants to land through irrigation of effluent and leakage from the base of the oxidation ponds

4 To discharge contaminants to air from oxidation ponds and irrigation area (excluding for present purposes the future irrigation area recently purchased by the Council which will be the subject of a later application)

4 Maintenance of the erosion protection measures, diffusers and stopbank

Proposed Designation in the District Plan

The Masterton District Council has lodged a Notice of Requirement (NoR) to:

4 Modify the existing designation (42 ha) for the MWTP so that it covers all land use activities associated with the operation of the upgraded Masterton Wastewater Treatment Plant; and

4 Extend the designation to cover the 198ha adjacent to the existing MWTP designation for the irrigation of treated wastewater to land (including the 107 ha of additional land that has recently been purchased by Council).

The Notice of Requirement incorporates the following activities associated with the upgrade works:

4 The construction and operation of the upgraded Wastewater Treatment Plant

4 The construction and operation of a land irrigation scheme to dispose of effluent

4 Pump stations for the irrigation scheme

4 The construction of the rock embankment outfall

4 Pond de-sludging

4 Sludge storage and dewatering lagoons

4 Erosion protection measures, comprising in-river works

4 Raising the existing stop bank immediately upstream of the oxidation ponds;

4 General ongoing operation, management and maintenance of the MWTP and

4 Any other activities ancillary to the operation and maintenance of the MWTP.

The extended designation will be limited to land owned by MDC, with the exception of that part of the outfall diffuser that is within the erosion protection works and any erosion protection works within the bed of the Ruamahanga River.

4 Existing Wastewater Treatment Plant

4.1 Introduction

This section provides a description of the existing Masterton Wastewater Treatment Plant, commencing with a brief overview of the oxidation pond treatment process – the process currently used at the Plant –and the advantages of such systems. The history, functioning and characteristics of the existing Masterton Wastewater Treatment Plant are then outlined, addressing:

- Influent flows and characteristics, including the relative high inflow/infiltration of stormwater and groundwater into the wastewater reticulation system;
- The operation and effectiveness of the existing oxidation ponds, including the characteristics of the treated wastewater, managing pond sludge, and pond leakage; and
- The existing discharge regime, including monitoring and compliance reporting.

The effects of the existing Masterton Wastewater Treatment Plant on the environment are examined in the next section, as part of the description of the existing environment, concluding with a summary of those environmental issues which the proposed upgrade is intended to address.

4.2 Oxidation Pond Treatment Systems

Incoming wastewater is treated in the oxidation ponds by aerobic processes that depend on bacteria, algae, and minute animal life. Pond aerobic processes rely mainly on algal photosynthesis for supply of oxygen. Bacteria break down the organic matter in the wastewater and convert it into living cells. The living cells are eaten by other animal life, which controls their numbers.

Part of the treatment process includes the formation, at the bottom of the ponds, of a layer of sludge in which anaerobic processes take place, breaking down the settled solids. Anaerobic processes occur without oxygen. Biogas is produced and belching occurs, lifting small amounts of the sludge up to the surface. Wind and wave action break up the sludge and it returns to the bottom of the pond again.

The following processes take place in the oxidation ponds (refer to Figure 2):

- Wind and wave action, together with oxygen generated by algae, combine to keep the processes aerobic - mechanical aerators can be used to add extra oxygen and more importantly mixing in calm conditions.
- Bacteria feed on the organic matter and use oxygen to produce carbon dioxide.
- Algae use dissolved nutrients and carbon dioxide (during daylight hours) for growth and to produce oxygen by photosynthesis - the bacteria produce carbon dioxide for the algae to use and the algae produce oxygen for the bacteria to use.
- Natural die-off of bacteria and algae occurs and some settle to the floor of the pond where anaerobic decomposition takes place - the recycled products of the anaerobic decomposition are used by the algae and biomass in the aerobic zone.
- Minute animal life feed on the bacteria and algae - this food chain, as well as natural die-off, helps control algae levels in the pond.
- Waterborne pathogenic (disease-causing) bacteria are significantly reduced by:
  - Having no natural host and competition for suitable nutrients
  - Photo-oxidative damage from the combination of sunlight and oxygen
  - Hostile environment with higher pH at times

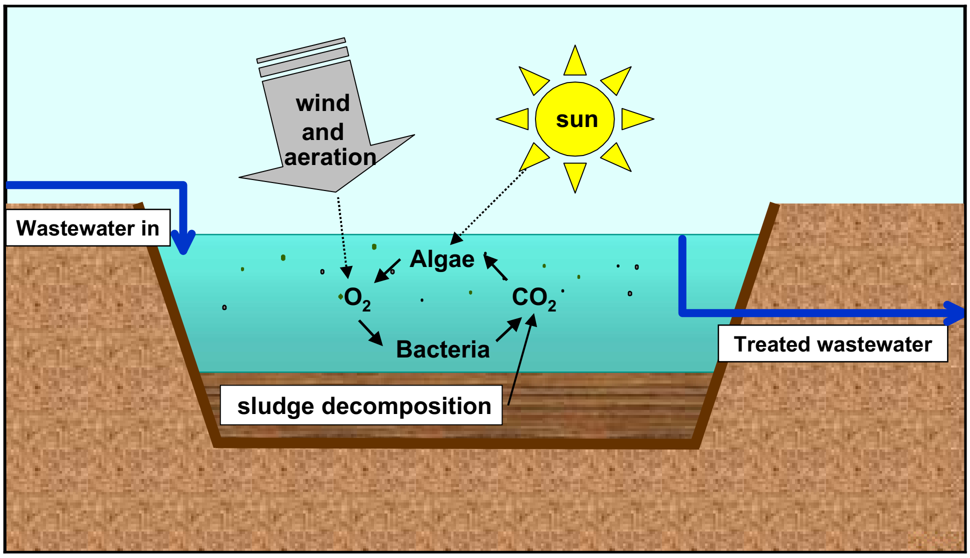

Figure 2 Schematic of Processes Within An Oxidation Pond

Oxidation ponds are a well-proven method for the treatment of domestic wastewater and are used extensively around the world. Most of the approximately 200 oxidation pond systems in New Zealand are single or two ponds-in-series systems designed to the Ministry of Works and Development's guidelines published in 1974. Over the past ten years, approximately 15 of these pond systems have been upgraded, typically with the subdivision of a secondary pond or construction of new ponds to form four to six ponds-in-series for improved treatment and efficiency. Reductions in microbiological indicators of more than two orders of magnitude have been achieved using 'ponds-in-series'.

Oxidation ponds are robust, natural wastewater treatment process unit with large volumes that can buffer peak flows and loads and provide storage for higher inflows during wet weather. Oxidation ponds require low energy input as the decomposition of organic matter is provided by oxygen supplied by naturally occurring algae. Wind and wave action also provide oxygen to maintain aerobic conditions. Low powered aerators are often installed to provide mixing and prevent stratification. Oxidation ponds have the ability to treat a dilute influent and buffer peak flows.

Oxidation ponds provide excellent method for reducing waterborne pathogenic (disease-causing) bacteria due to the long retention time and natural disinfection provided by sunlight. Oxidation ponds achieve good reductions of organic matter and solids. However, in common with mechanical treatment plants they provide only a moderate reduction of nutrients (nitrogen and phosphorus). The concentration of suspended solids and colour of oxidation pond effluent can be elevated in the summer months as a result of increased algae numbers.

Oxidation ponds produce lower *E.coli* concentrations in summer than in winter. This is because, as noted above, the extended periods of higher air temperatures and longer sunlight hours in summer, compared with winter conditions, cause more photo-oxidative damage to disease carrying organisms.

Oxidation ponds are an appropriate treatment technology for Masterton because:

- They already exist and are a considerable investment in land and capital facilities, and can be readily upgraded to target a higher standard of effluent
- They require a low level of operator supervision, with relatively low operating costs and energy requirements
- The ponds have the ability to effectively treat Masterton's highly diluted wastewater influent
- The treatment processes in oxidation ponds are not adversely affected by peak flows and oxidation ponds also provide good buffering to stormwater inflows
- A pond system can also be upgraded, or added to, for improved performance if required in the future (i.e., after the proposed upgrade).

4.3 Existing Wastewater Treatment System

4.3.1 History

The first sewerage scheme for Masterton was constructed circa 1900 and involved a septic tank sited adjacent to the present landfill site on Nursery Road. In 1914, the sewer was extended to the Homebush area where new septic tanks were constructed close to where the present oxidation pond system is sited. The Lansdowne area, which had previously had its own system, was connected to the Borough sewerage system in 1963 via a siphon over the Waipoua River.

Small stabilisation ponds, designed to reduce the level of solids in the wastewater, were constructed between the septic tanks and open channel discharge to the Ruamahanga River in the mid to late 1960s.

Due to problems with overloading of the septic tank system, the three [existing] oxidation ponds (primary and secondary) at Homebush were built in 1970-71, and commissioned in 1971, with the plant discharging into the Makoura Stream, just above its confluence with the Ruamahanga River.

In 1991, the MWTP was upgraded to include an inlet step screen (6mm aperture) and hydraulic press, two aerators in each of the primary ponds and an operations building.

4.3.2 Existing Facility and Operation

The Masterton urban sewerage system comprises approximately 127 kilometres of piped reticulation of varying size and material types, two small pumping stations, a sewer siphon, trunk mains and the MWTP at Homebush. The treatment plant building contains a garage/workshop, laboratory, office, lunchroom, and ablution facilities.

Power to the MWTP is provided via overhead power lines along the Manaia Road corridor. Access to the existing treatment site is via a formed, metalled right-of-way from the Masterton-Martinborough Road.

Figure 3 below identifies the location of key components of the existing MWTP.

The MWTP receives an average daily flow of approximately 15,500 m^3/d and services an urban population of approximately 17,793 (2001 census).

The flow rate delivered to the MWTP through the trunk mains is measured with an electromagnetic flowmeter (installed in 2004). This instrument has a stated accuracy of 1% at full pipe flow and 3 to 5% at partially full flow. The wastewater is then piped approximately 350 m into another open channel in which a grit collection sump is located prior to a step screen. If required[5], the incoming flow can be diverted through a manually cleaned screen. The screenings are collected in a sealed trailer and regularly disposed at the landfill. Following screening, the flow is evenly split by two weirs within a manhole into each of the two primary oxidation ponds (Ponds Nº 1 and Nº 2). The two primary ponds feed into the secondary oxidation pond (Pond Nº 3). Located within the secondary pond are the recently constructed bund and a rock filter. The wastewater passes through the rock filter into a maturation cell.

There are two brush aerators in each of the primary ponds and one aerator in the secondary pond to enhance the circular flow within the ponds. Wastewater from the maturation cell is discharged to the Makoura Stream over a rectangular weir, which enables measurement of the discharge flow. This weir controls the discharge volume, up to a maximum of 35,000 m^3/day.

Ponds Nº 1, Nº 2 and Nº 3 are approximately 8.0ha, 9.0ha and 8.5ha in area respectively.

[5] For example, if the inflows are excessive as occurred during the heavy rainfall event of July 2006.

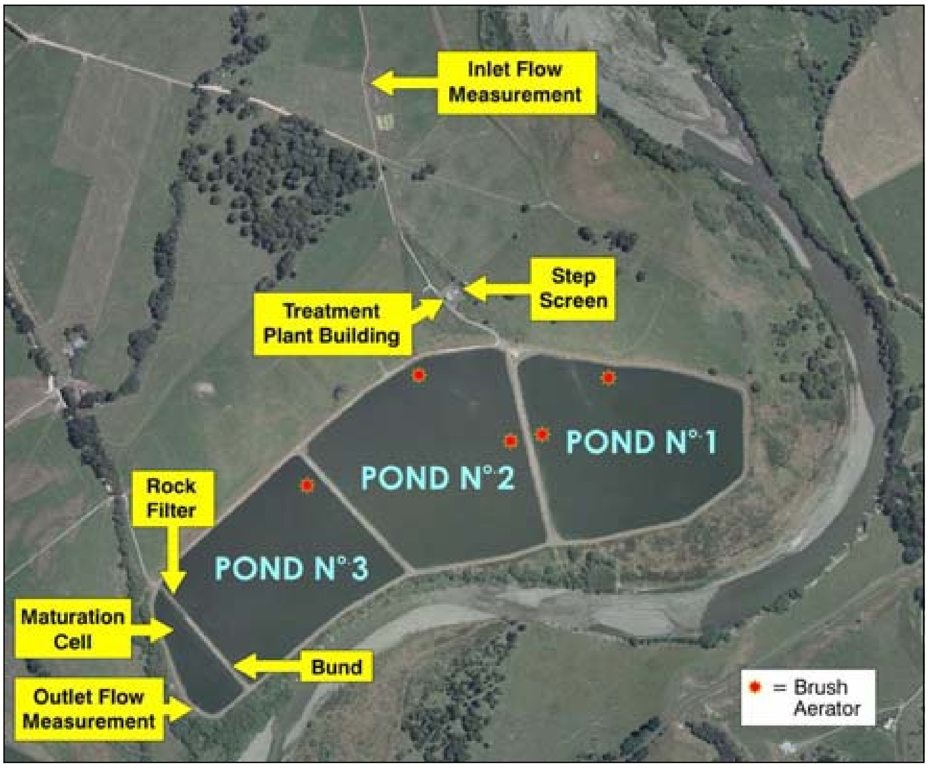

Figure 3 Key Components of the Treatment Plant

The ponds were constructed over a filled alluvial meander of the Ruamahanga River. The pond embankments were constructed in 1970 from fill obtained from the excavation of the ponds. The specification required that no turf, stumps, roots, peat or other perishable material be placed in the embankments, and that the more "impervious" material be located in the central part of the embankment and the more pervious material placed on the sides. The fill was to be place in horizontal layers, not more than 150mm thick.

The specification for sealing of the pond bed required that "*a nominal two inch (50 mm) thick layer of soil or silt is to be spread around the inner toe of embankments below the concrete wave band, and this layer shall extend for half a chain from the toe of the embankment on the pond bed*."

Concrete wave bands were constructed around the inside of the pond embankments to prevent erosion of the embankments by wave action.

4.4 Existing Influent Characteristics

4.4.1 Existing Rates of Flow – The Inflow/Infiltration Issue

Typical influent flows into the MWTP are set out in Table 2 below. On average, the MWTP receives 15,500m^3/day.

Table 2 Existing Influent Flow to the Ponds

Flows	m3/day
Dry weather (summer time minimums)	8,200
Peak wet weather	60,480 (during a July 2006 storm event)
Average	15,500

The average flow is significantly higher than will be expected from a town with a population of almost 18,000 people, due to the relatively high amount of groundwater that inflows or infiltrates (I/I) into the reticulation system. This results in a greater volume of wastewater arriving at the Masterton Wastewater Treatment Plant than otherwise will be anticipated. During wet weather, the influent flows can be very high as indicated in Table 3 above.

While groundwater inflow/infiltration is a common characteristic of wastewater reticulation systems; the rate of I/I in Masterton is relatively large. Based on the typical flow rate that might be expected (250 litres/person/day), plus 670 m^3/day trade waste, the flow with a normal design amount of I/I could be approximately 5,170 m^3/day – this compares with the average of 15,500 m^3/day that the Masterton Wastewater Treatment Plant actually receives.

However the existing oxidation ponds have sufficient capacity to cope with the additional flow, and the high flows that are received periodically do not appear to have had a detrimental effect on the treatment plant performance.

A study of the reticulation system (Beca 2004c) concluded that groundwater infiltration appears to be the dominant issue in Masterton for the reticulation system. This infiltration is persistent when the groundwater levels are high. However, high direct inflows due to direct connections of stormwater pipes to the sewerage system reticulation also occur for shorter periods during and immediately following periods of heavy rainfall.

The effect of high flows due to rainfall was investigated and reported in *Sampling After Rainfall Events* (Beca 2004e). This report concluded that while there was a small increase in the *E.coli* levels in the MWTP effluent, the rainfall events did not affect the overall performance of the ponds. It is also important to recognise that the additional flow from infiltration does not contribute significantly to the mass of contaminants discharged: i.e., the inflow is well-diluted wastewater.

The relatively high rate of influent does have some implications for the proposed upgrade in that the additional flows results in –

- A higher volume of effluent being applied in a land treatment scheme, with a corresponding greater land area required, and with excess being discharged into the river
- New treatment options requiring to be sized for a greater hydraulic capacity
- A higher volume of effluent needing to be discharged to the river, or be stored at times when river discharges are not possible and when land-based disposal is limited by higher soil moisture conditions.

In conclusion, therefore, reducing the level of I/I into the wastewater reticulation system is a key imperative to improving the functioning of the Masterton Wastewater Treatment Plant, in conjunction with the upgrading of the Masterton Wastewater Treatment Plant itself.

4.4.2 Proposed Upgrade of Reticulation System

MDC has a commitment as part of its ongoing asset management strategy to progressively upgrade areas of the reticulation system that are significantly under performing in terms of the inflow/infiltration of stormwater and groundwater.

MDC's Long Term Council Community Plan has allocated approximately $3.7 million over the next ten years to fund a programme of annual investigations and capital works improvements targeting the known areas of highest inflow/infiltration (I/I). Investigations would include, for example, an extension of the recent targeted programme of smoke testing on private properties aimed at identifying direct connections of stormwater drainage to the sewerage network. Private property-owners with direct connections would then be required to undertaken repairs to eliminate these links.

With regard to capital works, these would generally comprise replacement or remediation of sewers in order to provide improved hydraulic capacity, which will be achieved in part by a reduction in infiltration.

The expenditure of $3.7 million over the next ten years represents a base allocation of funding, which will be adjusted for specific projects arising from the ongoing programme of investigations. Targeting the worst affected areas provides the greatest reduction in flows for expenditure, and hence provides the greatest immediate benefit.

Extensive work has already been undertaken by MDC (Beca 2004c) to identify those areas that are significantly underperforming and that should be subject to I/I improvements. The areas identified have been categorised in terms of severity and will be scheduled into the ongoing programme of works.

4.4.3 Existing Influent Characteristics

The raw influent concentrations are significantly lower than typical domestic wastewater, due to the dilution effects caused by groundwater infiltration into the reticulation system (discussed in subsection 4.4.1). The concentrations of metals and volatile organic compounds measured in the raw wastewater were also at the lower end of the range for typical domestic wastewater, which reflects the limited amount of industrial trade waste entering the sewerage system.

The characteristics of the influent are shown in Table 3, while the existing concentrations of metals in the Masterton influent wastewater are shown in Table 4. This data shows that the existing influent is either comparable to or is of a better quality than that entering many other urban wastewater systems.

Table 3 Comparative Existing Raw Wastewater Concentrations

Parameter	Masterton Average	NZ Average (Range in brackets)*
BOD (g/m3)	158	244 (154-456)
Suspended Solids (g/m3)	133	239 (140-439)
Total Nitrogen (g/m3)	19.1	39 (23-51)
Ammonia (g/m3)	11.5	N/A
Total Phosphorus (g/m3)	3.7	10.8 (6-18)
Faecal Coliforms (x106 cfu/100 mL)	1.6	23.32 (4.1-74)
E.coli (x106 cfu/100 mL)	1.44	N/A
pH	7.1	N/A

** Data from Hauber, 1995*

Table 4 Existing Metals Concentrations in Influent

Metal	Level (g/m3)
Arsenic (As)	< 0.002
Cadmium (Cd)	< 0.006
Copper (Cu)	0.04
Lead (Pb)	< 0.06
Mercury (Hg)	< 0.001
Nickel (Ni)	< 0.06
Zinc (Zn)	0.032

Table 5 details the existing concentrations of effluent discharged by the ponds, while Table 6 provides the results of the metal concentrations in the effluent, which is sampled annually as required by the interim consent. The sampling date was 5 December 2005.

Table 5 Existing Oxidation Pond Effluent Concentrations

Parameter		Masterton Effluent [1]	Typical NZ Ponds[2]
BOD (g/m^3)	Median Range	18 3-102	27 7-70
Suspended Solids (g/m^3)	Median Range	22 2-98	56 6-171
Total Nitrogen (g/m^3)	Median Range	11 0.7-50.6	No data
Ammonia-Nitrogen (g/m^3)	Median Range	5.6 0.001–35.6	7.0 0.001-29
Total Phosphorus (g/m^3)	Median Range	3.12 1.4-7.9	8.2 1.3-11.3
Dissolved Reactive Phosphorus (g/m^3)	Median Range	2.5 0.29-4.1	5.0 0.8-9.5
Faecal Coliforms (cfu/100 mL)	Median Range	1,420 20-150,000	4,300 90-230,000
E.coli (cfu/100 mL)	Median Range	625 10-35,000	No data

Notes:

1 Based on wastewater data collected during the period July 1994 to January 2006.

2. Data from Hickey et al., 1989: 1 & 2 cell pond systems; 5 percentile and 95 percentile given for the range.

Table 6 Existing Metal Concentrations in Effluent

Parameter	Result	Result with 26x Dilution Factor Applied[6]	ANZECC (2000)	ANZECC (2000) Stockwater Guidelines
Total Silver (g/m^3)	0.0038	0.00015	0.05	-
Total Arsenic (g/m^3)	<0.001	<0.00004	0.013	0.5
Total Cadmium (g/m^3)	<0.00005	<0.000002	0.0002	0.01
Total Chromium (g/m^3)	<0.0005	<0.000019	0.001	1
Total Copper (g/m^3)	0.0104	0.00040	0.0014	0.4-5 depending on type of stock
Total Mercury (g/m^3)	<0.00008	<0.000003	0.0006	0.002
Total Nickel (g/m^3)	0.0009	0.000035	0.011	1
Total Lead (g/m^3)	0.0011	0.000042	0.0034	0.1
Total Zinc (g/m^3)	0.009	0.00034	0.008	20
Total Alkalinity (g/m^3 as CaCO3)	106	-	-	-
Total Hardness (g/m3 as $CaCO_3$)	50	-	-	-

6 This dilution factor is based on the effluent flows for 5 December 2005 and the 95%tile low river flow.

4.5 Existing Oxidation Pond System

4.5.1 Upgrades to Ponds in 2003

The interim upgrade in 2003 included improvements to pond mixing, installation of new brush aerators and an outlet screen, plus construction of a bund and rock filter to create a new maturation cell within the secondary oxidation pond. During the interim upgrade, riprap was added to selected areas of the inner pond embankments to enhance existing protection against wave action that could cause erosion. The outlet channel and weir and influent flow meter have also been upgraded to improve accuracy.

The purpose of the maturation cell was to enhance the removal of bacteria and pathogens. This upgrade has performed well and, following the upgrade, the median *E.coli* reduced from 1,130cfu/100 mL to 540cfu/100 mL.

4.5.2 Effectiveness of Existing Pond Treatment

Table 7 below compares the existing raw wastewater (influent) quality with the existing treated wastewater (effluent) quality. This shows that the oxidation ponds are effective in removing BOD, suspended solids and pathogens. However, oxidation ponds are only moderately effective at removing nutrients (nitrogen and phosphorus).

Conventional secondary treatment plants without enhanced nutrient removal provide a comparable wastewater quality to the Masterton oxidation ponds in terms of BOD and nutrients. However, pond wastewater is typically higher in suspended solids and colour, than other treatment methods, as a result of the algae in the wastewater.

Table 7 Comparison of Existing Masterton Raw Wastewater and Effluent Qualities

Parameter	Raw Wastewater[1]	Pond Effluent[2]	Percentage Removal
BOD (g/m^3)	158	22 [3]	86%
Suspended Solids (g/m^3)	133	32	76%
Total Nitrogen (g/m^3)	19.1	12	40%
Ammonia-Nitrogen (g/m^3)	11.5	4.7	59%
Total Phosphorus (g/m^3)	3.7	3.2	14%
Faecal Coliforms (cfu/100mL)	1.6 x 106	1,820	99.9%
E.coli (cfu/100mL)	1.4 x 106	825	99.9%
Alkalinity (g/m^3)	97.9	41.3	58%

Notes:

1 *Average of influent data collected during November 2005.*

2 *Average of pond effluent data collected during the period July 1994 to August 2004 (Medians for bacterial data).*

3 *Note, in ponds "sewage BOD" is converted into "algal BOD". Therefore a large proportion of the BOD in the pond effluent is due to the algae it contains.*

At the average winter influent flow, the total retention time in the Masterton pond system is approximately 21 days. This is less than some other oxidation pond systems due to the high inflows experienced at Masterton. However, the quality of effluent from the Masterton oxidation ponds remains good despite the shorter retention times. The retention time in the ponds increases to around 28 days during summer weather as the influent flows reduce and evaporation increases.

In summary, the quality of the existing effluent that is being discharged is relatively good. The oxidation ponds are effective in removing BOD, suspended solids and some pathogens, but only moderately effective at removing nutrients (nitrogen and phosphorus). Pathogen removal will be improved with the additional maturation cells.

4.5.3 Sludge Accumulations

Pond Nº 1 is approaching the point where desludging will be required. The remaining ponds are not yet at the stage of requiring desludging. However, Pond Nº 2 will need routine monitoring and possibly desludging within the next decade. The pond sludge depths and volumes and depth of wastewater over the sludge are shown in Table 8 below. The sludge volumes are derived from a site survey of sludge depth undertaken in June 2004.

Table 8 Estimated Depths and Volumes of Existing Sludge

	Pond Mean Depth (m)	Mean Sludge Depth (m)	Depth of wastewater over sludge (m)	Sludge Volume (m^3)
Pond Nº 1	1.52	0.48	1.04	34,494
Pond Nº 2	2.18	0.39	1.79	32,345
Pond Nº 3a	2.57	0.18	2.57	11,677
Pond Nº 3b	2.86	0.24	2.60	1,277

Sludge Constituents

The constituents of the sludge in the oxidation ponds are outlined in Table 9 below. The sludge complies with the NZ Biosolids guidelines for grade 'B' (for chemical contaminants), and also meets Grade B requirements (stabilisation grade). Accordingly, the sludge from the oxidation ponds is classified as a biosolid and can be applied to land (for example, pastoral or horticultural use) with site-specific controls in accordance with any conditions of resource consent.

Table 9 Existing Sludge Constituents

Contaminant Name	NZ Biosolids Guideline value (Grade b)	Average Sludge Composition (2005) (mg/kg)
Arsenic	30	5.8
Cadmium	10	1.3
Chromium	1,500	15.9
Copper	1,250	519
Lead	300	88.1
Mercury	7.5	0.3
Molybdenum	No guideline	-
Nickel	135	7.3
Selenium	No guideline	1.5
Zinc	1,500	601

4.5.4 Pond Leakage

As outlined in section 4.3.2, the existing ponds do not have an “engineered” lining and hence wastewater seeps through the base and sides to the groundwater, which then discharges to the river under normal circumstances. As discussed later in this section, in some conditions, this flow is temporarily reversed, with river and groundwater infiltrating into the ponds.

There is limited knowledge about the alluvial deposits underneath the existing ponds. However, the geology of the pond area is likely to be similar to that observed to the north of the ponds (overbank silt deposits overlying gravel and sand deposits). Aerial photographs show that, in geologically recent times, much of the pond area was occupied by a meander in the main river channel (see Figure 4). This meander would have cut through the silt into the underlying sand and gravel, reworking the gravel, sand and silt deposits in the process. The river was then artificially straightened by a diversion cut across the base of the meander in the 1960s as part of erosion control works. The construction of the ponds hid any evidence of the meander and probably modified the near surface geology.

The base of the ponds probably consists of a combination of the original silt where this has not been removed during pond construction or by river erosion, and gravel. Within the meander, the gravel may be as the river originally deposited it, or a combination of gravel and silt deposited by the river after the meander was closed. The gravel and silt may have been reworked during construction but the distribution and thickness of any gravel and overbank and channel infill silt over the bases of the ponds, and particularly within the meander channel, is not known. It is probable, that the gravel now within the [old] meander channel is generally more permeable than the original gravel deposits, and certainly more permeable than any silt that remains. Therefore, it is probable that there are preferential flow paths for groundwater below the ponds.

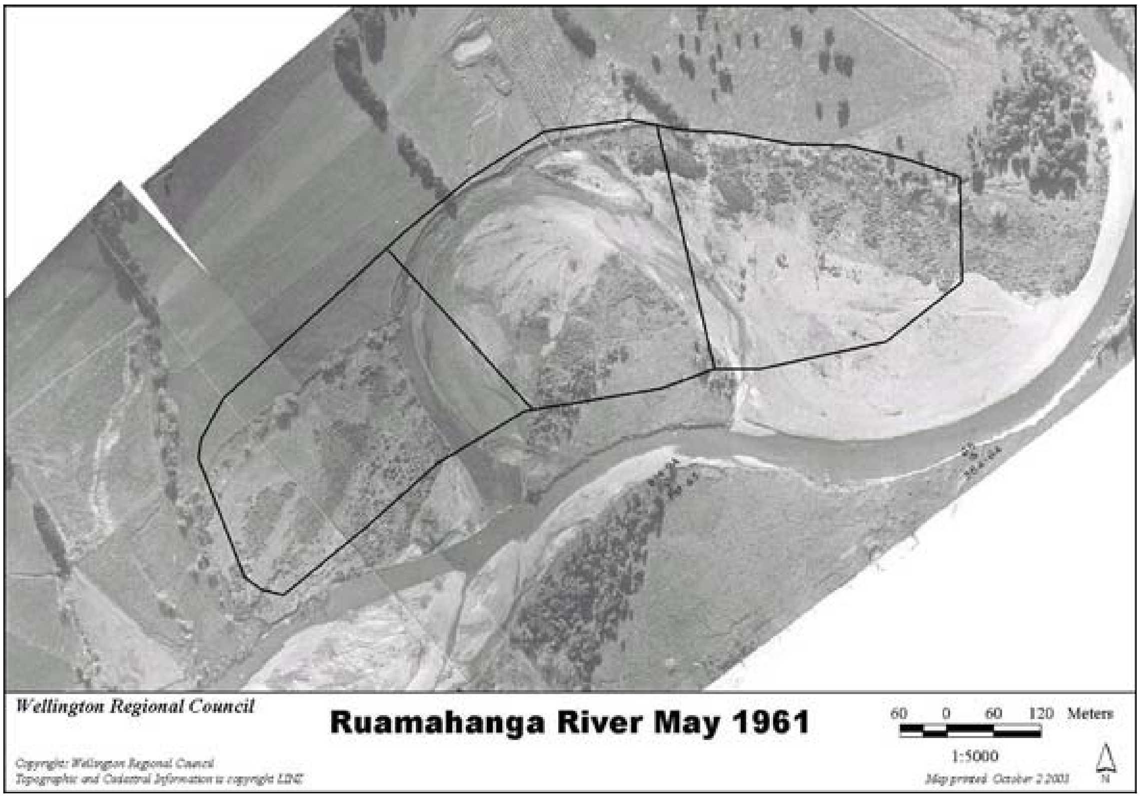

Figure 4 Aerial Photo of Former River Meanders Relative to Existing Oxidation Ponds

When the ponds were first constructed there was likely to have been a relatively permeable leakage path, particularly in the region of the old meanders[7]. Since then the permeability of the base of the ponds has been substantially decreased by a build-up of 30 or more years of sludge. This appears to be quite effective, as the measured leakage rate of about 800 m^3/day is quite small when the area of the ponds is considered, compared with what might be expected if the ponds were in direct contact with the underlying sandy gravel found at Homebush (which is similar in permeability to some gravel aquifers used for water supply).

The leakage is driven by the difference between pond level and groundwater level (which in turn is controlled by the river level. However, during very high floods the level in the river can be higher than the water level in the ponds, creating the potential for inflow to the ponds from groundwater. Such inflow has been observed as localised "boils" on the surfaces of ponds 2 and 3 during both the 1998 and 2000 flood events. The presence of the boils suggests that the inflow is occurring at discrete points/preferred flow paths at relatively high velocities, rather than diffusely across the entire base of the ponds, presumably locally disrupting the sludge blanket.

Following such events, the extent to which the settling of sludge reseals the rest of the ponds is not known. However, the sludge probably remains thinner than average at these points, if not totally absent, immediately following a high flood level in the river. Following the flood event there will be a period where a localised boil area would re-establish the infilling of sludge as a sealing mechanism. This suggests that under normal river conditions leakage is more likely to occur through the base of the ponds over the meander channel deposits than elsewhere under the ponds.

The presence of higher permeability channels under the ponds has some significance for the amount of leakage (or inflow) that occurs, and some influence on the groundwater regime in the immediate vicinity of the ponds. However, they are likely to have little or no influence on the groundwater regime over the wider site. This limited influence could potentially include:

- A more rapid response to river level fluctuations than might otherwise occur, which may have a slight influence on groundwater fluctuations under the irrigated area close to the ponds. The limited extent of this influence is not considered to be particularly significant. Groundwater mounding at the irrigation site is discussed in section 8.3.2.
- A more direct path to the river for pond leakage and therefore the potential for less attenuation of contaminants contained in the treated wastewater. The potential for adverse impact on the groundwater from contaminants has been assessed with the conclusion being that the impacts are no more than minor. This is detailed in section 8.3.5.

Investigations have concluded that the effects of pond leakage on surface and groundwater quality are minor and do not warrant any attempt to seal the ponds or the construction of new ponds – the effects of pond leakage on the existing environment are discussed in section 5.4.

4.6 Monitoring and Compliance Reporting

4.6.1 Annual Monitoring

In accordance with the requirements of the interim consent (WAR 020074), MDC has been monitoring the effects of the existing discharge on the receiving waters since 2003. The 'Interim Consent' required the compiling and supply of an annual monitoring report to GW. These reports have demonstrated that the wastewater discharge complies with the requirements of the relevant consents.

The effects of the existing discharge on the water quality of the Makoura Stream and the Ruamahanga River are reported in the annual monitoring reports to the Regional Council (refer Beca, 2003b, 2004b and 2005).

Key conclusions from the 2005/2006 Annual Monitoring Report about the environmental effects of the effluent discharge on the Makoura Stream and Ruamahanga River are summarised in section 5.3 (Figure A1.1 in Appendix A1 shows the location of the surface water monitoring sites)

[7] There is anecdotal evidence of the ponds having been difficult to first fill.

4.6.2 Compliance Performance

Annual Compliance Monitoring

The Greater Wellington Regional Council undertakes an annual compliance assessment of consents in the Wellington Region, which has consistently shown that MDC has complied with its consent requirements. The GW Compliance Inspection Reports note the following compliance ratings:

- *Report June 2003*
    - All three consents – Fully complying
- *Report June 2004*
    - Discharge to Water – Mainly complying (reasons – volume exceeded daily limit during high rainfall event for the periods of 4 to 7 October 2003 and 14 to 16 October 2003 and 16 to 22 February 2004.) Following these events, a control gate was installed on the outlet so that the flow would remain within the resource consent conditions
    - Discharges to Land and Air – Fully complying
- *Report June 2005*
    - All three consents – Fully complying
- *Report June 2006*
    - Discharge to Water – Mainly complying (reasons – the periphyton taxonomic assessment in the Ruamahanga River was not carried out and GWRC requested that this be done retrospectively)
    - Discharge to Land and Air – Fully complying

State of the Environment Report

The *State of the [Regional] Environment Report* (SER) for 2005 prepared by the Greater Wellington Regional Council identified some key factors of relevance to the Masterton Wastewater Treatment Plant discharge, namely:

- Pathogen levels at the Ruamahanga River swimming holes (including ‘The Cliffs’, the closest “official” public swimming spot downstream of the existing discharge) were below the “surveillance” threshold for bacterial contamination, about 80% of the time in summer (i.e., the river had a low level of health risk). The report also notes that “…rivers flowing through agricultural catchments were in a poorer state…..” and also that “Compliance was best during the dry summer 2002 – 2003 and lowest over the much wetter 2003-2004 summer”
- Phosphorus and DRP concentrations in the river increase at consecutive monitoring sites further downstream, and downstream from Te Ore Ore, these concentrations were consecutively above the ANZECC 2000 trigger value for total phosphorus for aquatic ecosystem health. In other words, the background level of these concentrations is already at relatively elevated levels from a range of likely sources.

In summary, the Ruamahanga River in general is in good health but some aspects of water quality could be improved.

5 Existing Environment

5.1 Introduction

This section of the AEE outlines the nature and sensitivity of the existing environment.

The assessed effects of the upgrade can be compared with the effects of the existing discharge, to gauge the likely level of improvements. In assessing the potential future effects of the proposed upgrade, one must also assess the effects of the various existing discharges against background environmental characteristics. For example, background water quality conditions in the Ruamahanga River are already highly modified by other, and usually diffuse, sources of contamination.

This section is in two parts. The first part describes the overall state of the existing environment, focusing on the Homebush site, including:

- Land and climate, such as land uses, landscape values, geology and soils
- The Ruamahanga River, including its catchment characteristics, water flows and quality, biological condition, and flooding and erosion patterns
- Groundwater flows and qualities
- Community characteristics and values, including its recreational use and values, tikanga Maori, and community health

The second part of this section examines the effects of the existing MWTP on the environment, particularly the effects of discharges (including pond leakage) on groundwater and river quality.

5.2 Land and Climate

5.2.1 Land Use

The oxidation ponds are located adjacent to the Ruamahanga River, in part of an "elbow" of the river that was part of the old riverbed. The land is generally flat and is surrounded by farmland, primarily intensive farming and horticulture, with associated residential uses. The Masterton landfill is located approximately 1.6 km to the north of the site, while Masterton Aerodrome is approximately 4 km to the northwest.

Approximately half of the land occupied by the ponds situated closest to the Ruamahanga River has a Land Use Capability assessment classified as Class VIs4 on the NZ Land Resource Inventory Worksheets (RIW), which is not of high productive value due to the limitations caused by the predominance of gravel in the soils. The vegetation consists of a range of pasture, broom and gorse (scrubs) and a small copse of native trees. The other half of the ponds and the remainder of the proposed treatment site have a Land Use Capability Assessment of Class Iw1, which is classified as largely flat river plains and terraces, with deep fertile soils and a very slight wetness (drainage) limitation. The rock type is generally undifferentiated flood plain alluvium.

The existing wastewater treatment plant is located in relatively close proximity (5 km southeast) to the Masterton urban area, with the closest residential areas approximately 1 km to the north of the MWTP.

5.2.2 Landscape

The oxidation ponds sit on the southeastern edge of the valley floor. The river systems (in particular the Ruamahanga River), the river plains and the rolling hills dominate the immediate landscape. The rolling hills to the southeast of the ponds contrast with the flat plains to the north. Land holdings to the east and north of the ponds are large, while to the west, towards the Waingawa River, a number of smaller holdings adjoin the Masterton-Martinborough Road.

Pastoral farmland is the predominant land use character, with groupings of trees, particularly shelterbelts, breaking up the landscape. Native species make up a large group to the north of the ponds, while exotic species such as eucalypts, conifers and deciduous varieties are more common to the west. The land immediately around the existing MWTP is currently in dry-land pasture except for a small area (~2 ha) of native trees on the southwest corner.

The groupings of trees break the scale of the landscape by limiting views across the extensive plains and form several character zones within the locality (refer Figure 5). Two of these zones, located on either side of the MWTP, are small-scale relatively intimate landscapes, dominated by smaller landholdings and relatively denser groupings of trees. Zone 1 occurs to the southwest of the ponds in the vicinity of Wardells Bridge, while Zone 3 is to the east of the ponds, in the vicinity of several houses along Lee-Pakaraka Road.

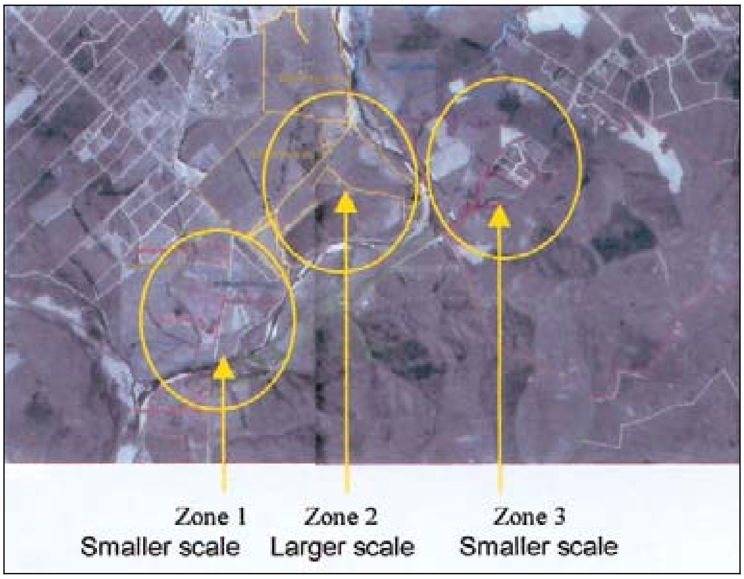

Figure 5 Different Landscape Scale Zones around the Oxidation Ponds

The landscape in which the existing ponds are located (described as Zone 2) is of a larger scale than the smaller scale settings to the west and east. Existing exotic riparian vegetation separates the ponds from the river to the south, while open farmland extends northward from the ponds, with groups of trees several hundred metres to the north. It is this openness to the north that contributes to the larger scale of this setting. Considering the size of the ponds, such a scale is quite appropriate in terms of integrating the existing ponds with the local landscape.

5.2.3 Geology

The MWTP is located on the floodplain of the Ruamahanga River (see Figure 1 and Figure 4). The Ruamahanga River is largely responsible for the near-surface geology in the vicinity of the site, as the River has, over time, deposited unconsolidated sediments ranging from very coarse-grained gravel strata to very fine-grained silt and clay strata.

In this area, gravel deposits are overlain by silt-dominated strata, which represent overbank flood plain deposits associated with high water levels occupying large sections of the flood plain. As the gravel-dominated channel has meandered across the flood plain, overbank deposits have been stripped off and replaced by new deposits of gravel. The Ruamahanga River is a major source of recharge to the aquifers formed in these gravel deposits. Figure 6 shows the near surface geology of the area.

Geological investigations[8] at the Homebush site have revealed silty sediments consisting of silts, clay, and fine sand deposits of an average thickness of approximately 2 m, which are extensive across the site. These silty deposits, formed by over-bank deposition from the Ruamahanga River, cap more permeable gravel dominated deposits, with lenses of interstitial clay, silt and sand strata. This layering is illustrated in Figure 7.

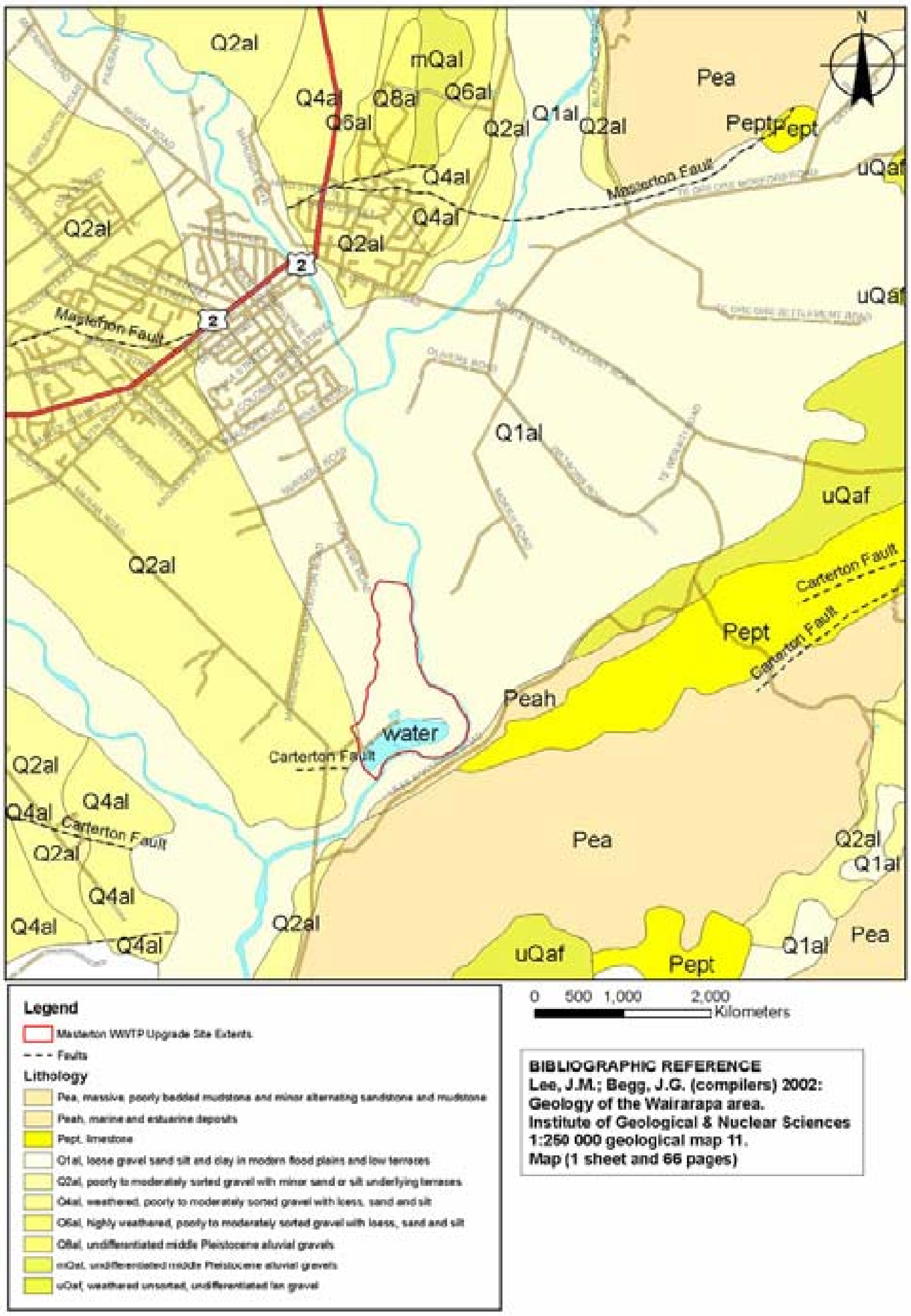

Figure 6 Map Showing Surface Geology Across the Wider Homebush Area

8 Numerous test pits, excavations and hand-augured bores (PDP, 2006)

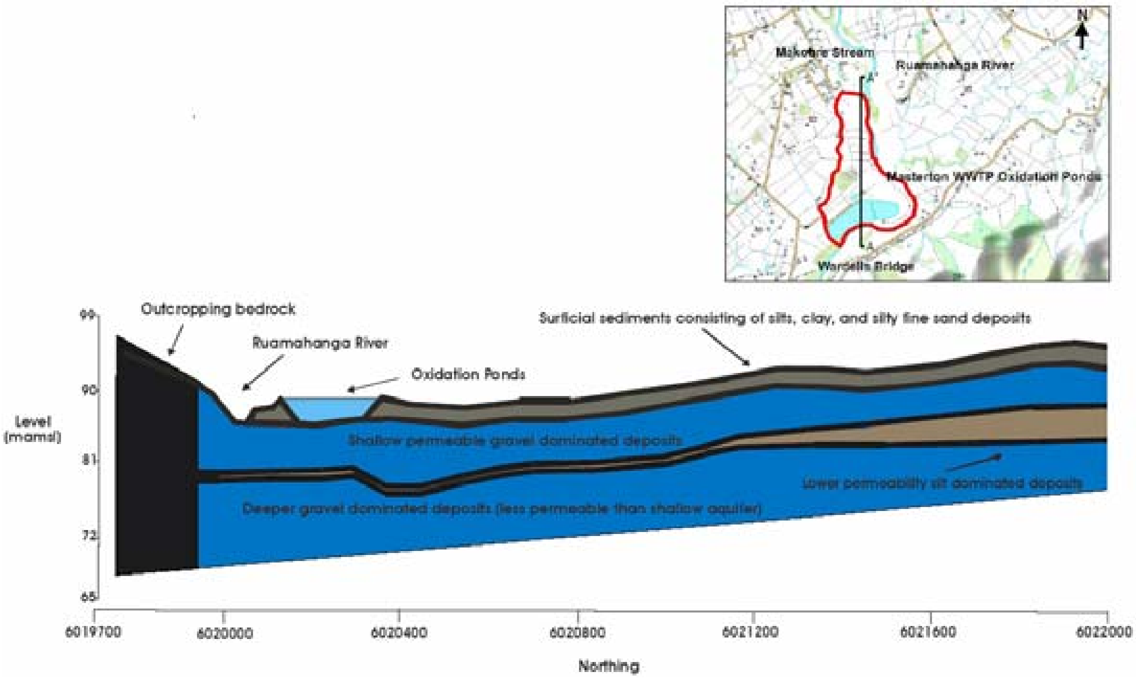

Figure 7 Geological Cross-section Through the Homebush Site (A-A')

5.2.4 Faulting and Seismicity

The Masterton Basin is the northern end of the wider central Wairarapa valley that extends to the southwest and is bounded on the western side by the West Wairarapa fault, at the foot of the Tararua Ranges.

The Ruamahanga River is one of a series of rivers that transport gravel from the Tararua Ranges. The basin is crossed by a series of northeast to east-northeast striking active faults, including the Carterton and Masterton Faults, which are splays of the Wairarapa Fault.

A possible splay of the Carterton Fault has been mapped a short distance to the southwest of the ponds (shown in Figure 6)[9]. However, the precise position of the Carterton Fault in the vicinity of the Ruamahanga River is unknown.

The Carterton Fault is in two sectors on the geological map, the first trending NE-SW through hill country from Otahoua to Te Kopuanui, and the second from about 1 km west of the confluence of the Waingawa and Ruamahanga Rivers to Carterton town. The surface trace is lost over some 7.5 km between these two sectors in the area in which the oxidation ponds are sited, although a short length of fault is marked on the terrace a few hundred metres southwest of the ponds. There is a possible scarp on land to the west of the ponds, which it is considered could represent a splay of the Carterton Fault and might extend through the southern corner of Pond 3 (Wairarapa Geological Services Ltd, 2005).

Trenching undertaken as part of the project investigations (Beca 2005a) indicated that this was possibly a sedimentary feature or an inactive fault. If it is a fault then the depth of clays deposited over the gravel indicated that it would not been active for at least 2,700 years and therefore does not present a hazard to the ponds.

The most active fault in proximity to the ponds is considered to be the Masterton Fault at 6 to 7 km distance, which is expected to generate a Richter magnitude M 8.1 earthquake at a recurrence interval of 1,500 years.

9 Lee and Begg cited in Beca 2005a

5.2.5 Soils

The 91 ha of the MWTP irrigation site are located on a former floodplain of the Ruamahanga River, immediately west of the river. The soils have been formed from the river alluvium, comprising gravely sediments overlain by predominantly sandy and silty alluvial sediments.

Nearer the river, the alluvium is coarser, with a tendency to have sandy textures sometimes interspersed with gravels plus fine sandy loams, sandy loams and gravely sand textures as well as some loamy silts. These soils are named Greytown sandy loam and gravely sandy loam in the Soil Survey of the Wairarapa Valley (HortResearch, 2007). Westward of these coarser soils, a finer-textured sediment overlies the gravels, and the soils are silty-textured (silt loam and silty clay loam textures) with intermittent clay-rich layers at depth. These soils are named Greytown silt loam.

The northern land area is generally free draining, while the southwest area is generally poorly draining. The soils for the proposed irrigation site were extensively investigated as part of the upgrade work (Figure A3.1 in Appendix A3 shows extent of on-site investigations for the soil's physical and transport properties) (HortResearch, 2007). These investigations analysed soil texture, the soils' capacities to store and transport nutrients, as well as the soils' hydraulic qualities (i.e., how fast the water moves though the soil, and how much water the soil holds).

In terms of the hydraulic properties of the site's soils, the analysis indicates that, where clay-rich soil materials occur at shallow depth, interpedal cracks and macropores, most of which are invisible to the naked eye, conduct water at significant rates (>77 mm/hr). However, the deeper clay-rich layers tend to conduct water at much slower rates of between 0.5-4 mm/hr, mainly because there are fewer macropores. Locations having silty clays at depth are classified as poorly drained, and they would transport less water and nutrients at much slower rates.

In terms of the soils' nutrient characteristics, soil pH ranges from moderately acid on the wetter soils in the south of the property to near neutral in the north. Mineralisable nitrogen, which results from activities of the soil's microbial biomass, varies quite markedly across the property, but is generally quite low. Total organic carbon is also very low on all soils, although the carbon to nitrogen ratio is typical of soils under pasture. Soil phosphate values[10] in the top 100 mm of soil also varies across the site, being generally adequate to low. Crop growth is expected to be nitrogen limited on the Homebush soils.

5.2.6 Climate

Climate data for Masterton obtained by NIWA (2004) is summarised as follows:

- Mean annual rainfall is 916 mm, with mean winter rainfall of 511 mm and mean summer rainfall of 405 mm
- Mean annual sunshine is 1915 hours for Masterton
- Mean annual air temperature is 12.7°C (compared with a winter mean of 11.4°C and a summer mean of 15.4°C)
- Mean annual relative humidity is 73.9% for Masterton
- Evaporation is 949 mm/year (compared with 261 mm over winter and 701 mm over summer)
- Mean annual number of days of ground frost is 60 days for Masterton

The average number of wet days in summer is significantly less than average number of wet winter days. The average summer rainfall is also significantly lower than winter, with autumn and spring rainfall being very similar (NIWA 2004).

The results from the East Taratahi wind rose show that the prevailing wind direction is from the northeast direction and typically in the range of 5.0 to 9.9 km/hr (22% of the time). Northwest and southwest wind directions are the next most predominant.

10 Referred to as Olsen P values.

5.3 Ruamahanga River

5.3.1 Catchment Characteristics

The Ruamahanga River flows from its headwaters in the northern part of the Tararua Ranges down to Lake Onoke, which flows into Palliser Bay. Many tributaries join the Ruamahanga River before it enters Lake Onoke, including the Kopuaranga, Waipoua, Whangaehu Waingawa, Taueru, Waiohine and Huangarua Rivers.

The Ruamahanga River at Makoura Stream drains a catchment of approximately 63,346 ha. Although the headwaters of the Ruamahanga River pass through bush and scrub, most of the River above Homebush meanders through pastureland as shown in Figure 8 and Figure 9 below[11], with a noticeable increase in high production pasture as the river flows closer to Homebush. In the area around Double Bridges high production pasture comprises 25.5% of land use, while in the vicinity of Te Ore Ore, just upstream of the Masterton MWTP discharge, high production pasture comprises 67.1% of land use[12].

The water level recorder at Wardells Bridge just above the confluence with the Waingawa River has recorded Ruamahanga River water levels since 1954: Figure 10 shows the recorded data for the period January 1997 to October 2005.

Figure 11 and Figure 12 present the river flow data for the summer (November to April) and winter (May to October) for the same overall period (January 1997 to October 2005). These figures illustrate the variability of the river flow during both summer and winter. In particular, for the summer river flow record, the record shows that there are frequent minor floods ("freshes') where river flow rises rapidly to a peak flow well above the median river flow of 12.3 m^3/s. Similarly in winter, the flow record displays a far greater trend of frequent short, sharp 'freshes' in the river. This characteristic of frequent freshes is particularly relevant to proposed discharge regime, as discussed later in this AEE.

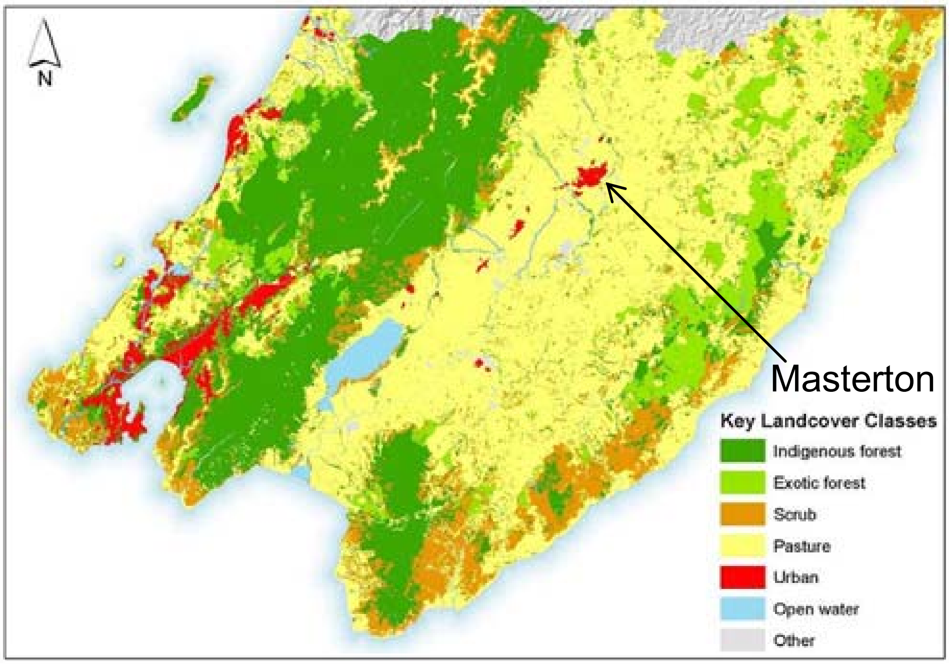

Figure 8 Regional Land Cover (Simplified) in the Wellington Region

11 Refer Figure A1.2 in Appendix A1 for river management classes
12 Refer to Figure A1.1 in Appendix A1 for location of all water quality monitoring sites

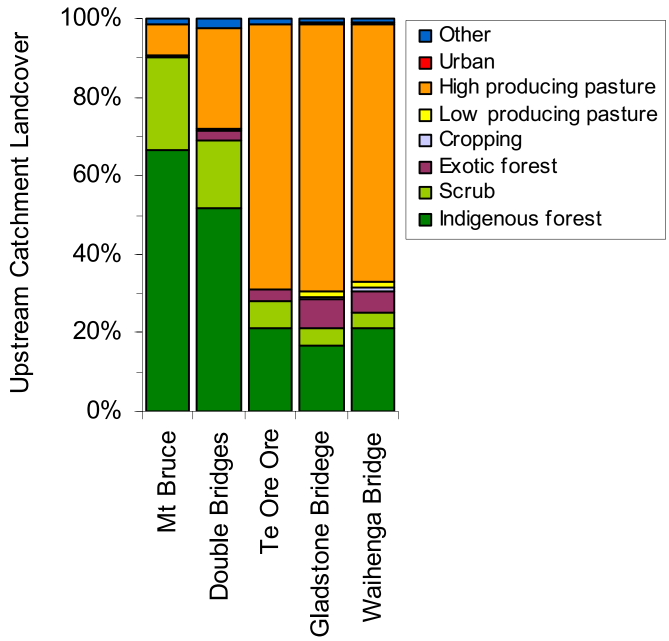

Figure 9 Major Landcover Types in the Catchment Area[13]

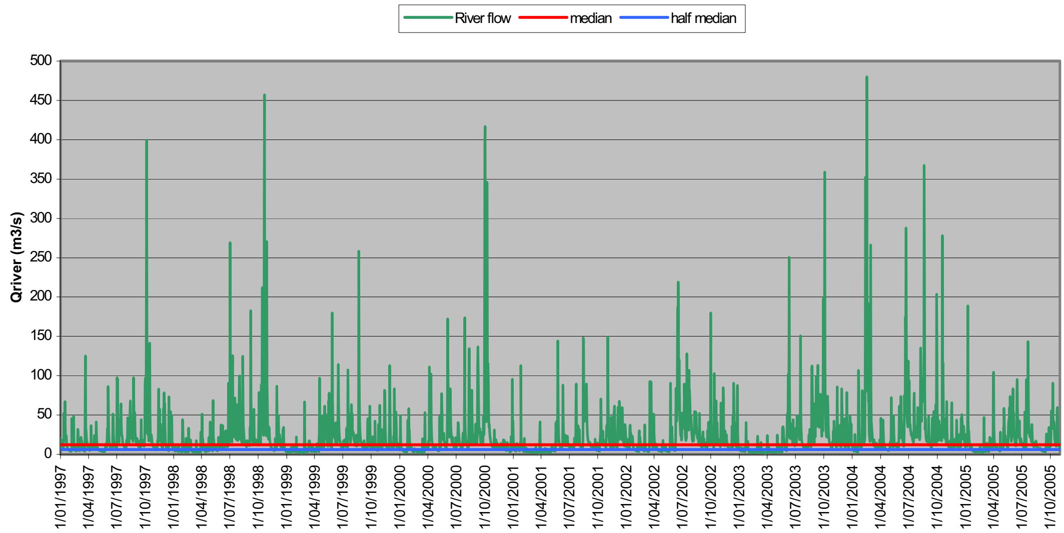

Figure 10 Ruamahanga River Flow (1997-2005)

13 Upstream of each of the five Regional State of the Environment monitoring sites on the Ruamahanga River (from Milne & Perrie 2005). See Figure A1.1 in Appendix A1 for site locations.

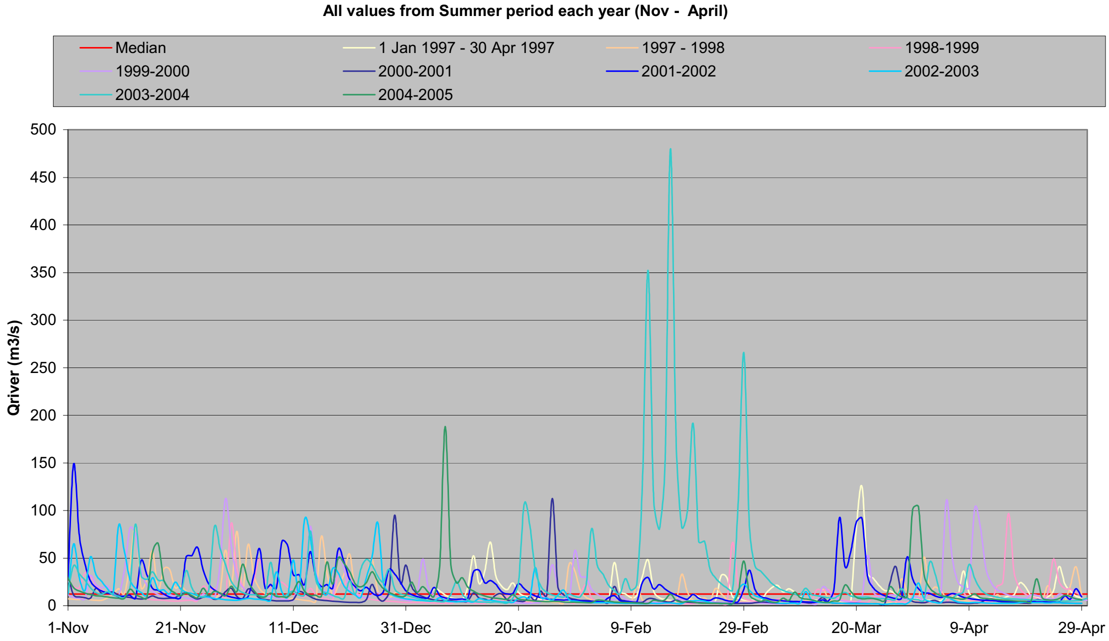

Figure 11 Ruamahanga Summer Flows

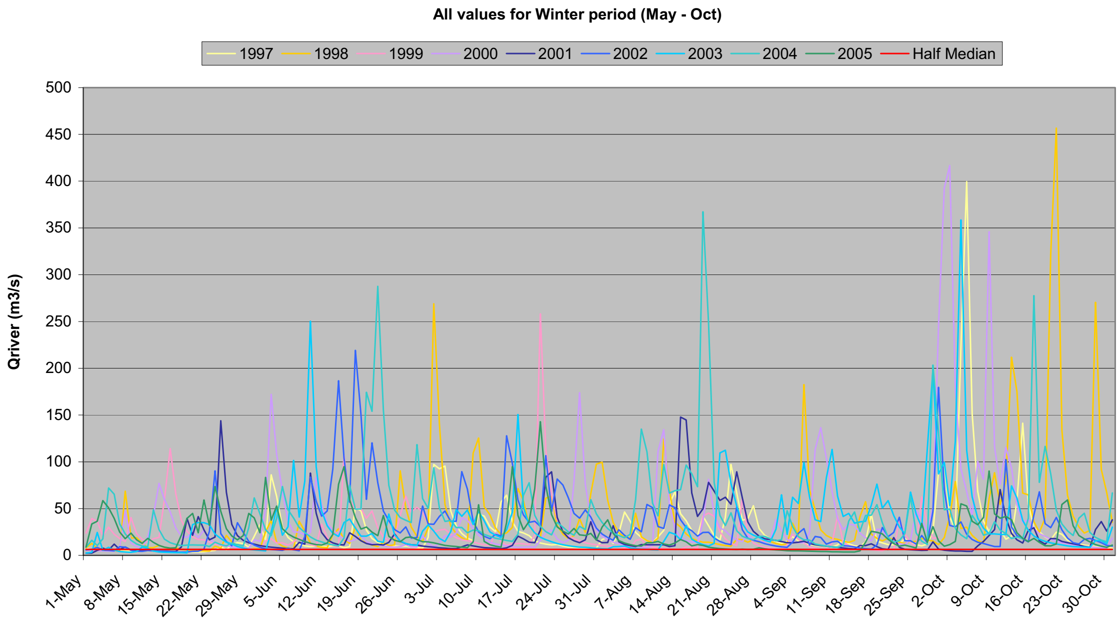

Figure 12 Ruamahanga Winter Flows

The upper catchment of the Ruamahanga River (and its tributary the Waipoua River) is in the Tararua Ranges, where intense short-term rainfalls in this very steep land generate the sharp flood hydrographs. The eastern tributaries of the Ruamahanga, the Kopuaranga and Whangaehu Rivers, drain steep pastureland, but channel storage and local ponding reduces their relative flood flows into the Ruamahanga River.

The Ruamahanga River in the vicinity of Masterton has a rocky (largely cobble) channel, with a common pool-run-riffle structure associated with such riverbeds. Cross section data at Wardells Bridge for a range of flows from 5 to 15 m^3/s shows the average depth and velocity increasing from 0.36 m to 0.53 m and 0.41 m/s to 0.73 m/s respectively[14]. Analysis of the complete flow record gives an annual median flow of 12.3 m^3/s and summer median of 6.6 m^3/s, with a high flood frequency of 23.6 floods/yr[15].

A draft water allocation plan for the Ruamahanga River (WRC 1999) provides details of flow abstractions and initiates a process to establish the minimum acceptable flow. It proposes that when the flow falls below 2.7 m^3/s (based on the Wardells Bridge gauging site), abstractions should be restricted by 50%; and that abstractions will be banned if the flow falls below 2.4 m^3/s. These values equate approximately to the 5%ile and 2%ile respectively of the summer flow percentiles.

5.3.2 Water Quality

The intensification of land use as the Ruamahanga River flows south from its headwaters in the Tararua Ranges (shown in Figure 7 and Figure 8 above) results in increasing inputs of pollutants from diffuse sources (particularly nutrients and faecal material) into the Ruamahanga River[16], thereby affecting the water quality before the River reaches the Homebush vicinity.

The relative importance of diffuse sources in the Ruamahanga River catchment can be illustrated by the cumulative nutrient (nitrogen and phosphorus) load data obtained in a recent analysis (Sevicke-Jones, WRC 2003). This information (presented in Figure 13 and Figure 14) shows that diffuse sources of pollution (in this case defined as all those sources other than the consented municipal wastewater discharges) amounts to ~95 % of the total Nitrogen and 85% of the total Phosphorus load measured at Waihenga, respectively.

Hydrology is another significant influence on river water quality. This is particularly the case for parameters responsive to runoff such as *E.coli* clarity and nutrients. The influence of flow on *E coli* levels at sites upstream (Te Ore Ore) and downstream (at The Cliffs where the existing discharge is fully mixed) during the 2003-2004 bathing season is shown in Figure 15. This figure clearly shows that, at high flows, existing *E.coli* levels both upstream of the MWTP (at Te Ore Ore) and downstream of the MWTP are elevated and, at times exceed the recommended bathing water guidelines for the Ruamahanga River, whereas at lower flows *E.coli* levels at each location are correspondingly lower. Figure 15 is indicative of a typical *E.coli* pattern in the Ruamahanga River.

Periods of low flow in the Ruamahanga River will also typically be periods of low rainfall, which means there will be less diffuse source runoff (from agricultural land in particular) and, as a consequence, the levels of *E.coli* in the river from these non-point sources will be at low levels. At low river flows, therefore, the impact of point source discharges has a much more significant impact. Periods of low river flow, combined with low rainfall and (typically) warm weather are also when the river is most attractive for contact recreation (for example, swimming).

Following periods of rainfall, flow in the Ruamahanga River increases and with it, runoff from agricultural land and other non-point sources. This runoff transports material such as faecal matter and nutrients into the river, and, combined with a re-suspension of sediments that has settled on the riverbed during low flows, leads to elevated levels of *E.coli* and reduced clarity in the river system.

14 NIWA 2004a, Table Appendix 3

15 FRE3 is the flood exceeding 3X the median flow. This data is for a 1 day period between floods (NIWA 2004a, Table A2.2)

16 Diffuse source pollution is that arising form land use activities that is dispersed across a catchment. In rural catchments it is usually a much greater source of contaminants to waterways than point source discharges of wastewater.

Firgure 16 is typical of the impact on clarity of increasing river flow. At higher river flows, the clarity reduces and at lower river flows there is correspondingly higher (better clarity). As described in section 3.2.3, the Ruamahanga River immediately below the confluence with the Makoura Stream exhibits poor colour and clarity for significant periods at lower flows. This is an impact that is attributable to the existing effluent discharge, and is specifically addressed by the proposed upgrade. No similar relationships to flow were apparent with DRP or NH_4-N, which is not surprising since both are in solution and will be modified by passage through the soil profile. On the other hand it is likely that particulate phosphorus and nitrogen will show a similar relationship with flow, as they will be entrained in surface runoff during storm events and/or mobilised in river sediment.

There is a marked increase in nitrogen and phosphorus immediately downstream of the Makoura Stream confluence with the Ruamahanga River as measured at Rua 2 (which is within the mixing zone). However, further downstream, and once the flow is fully mixed the in-river concentration decreases to levels more compatable with those upstream of the MWTP (Table 19). The regional State of the Envirronment monitoring has shown increased dissolved nutrient concentrations from upstream (Te Ore Ore) to the downstream site (Gladstone Bridge) below the MWTP, with the greatest increase for dissolved phosphorus (see Figure A1.4). As noted above, much of the nutrient increase, particularly at low flows, is attributable to the MWTP discharge.

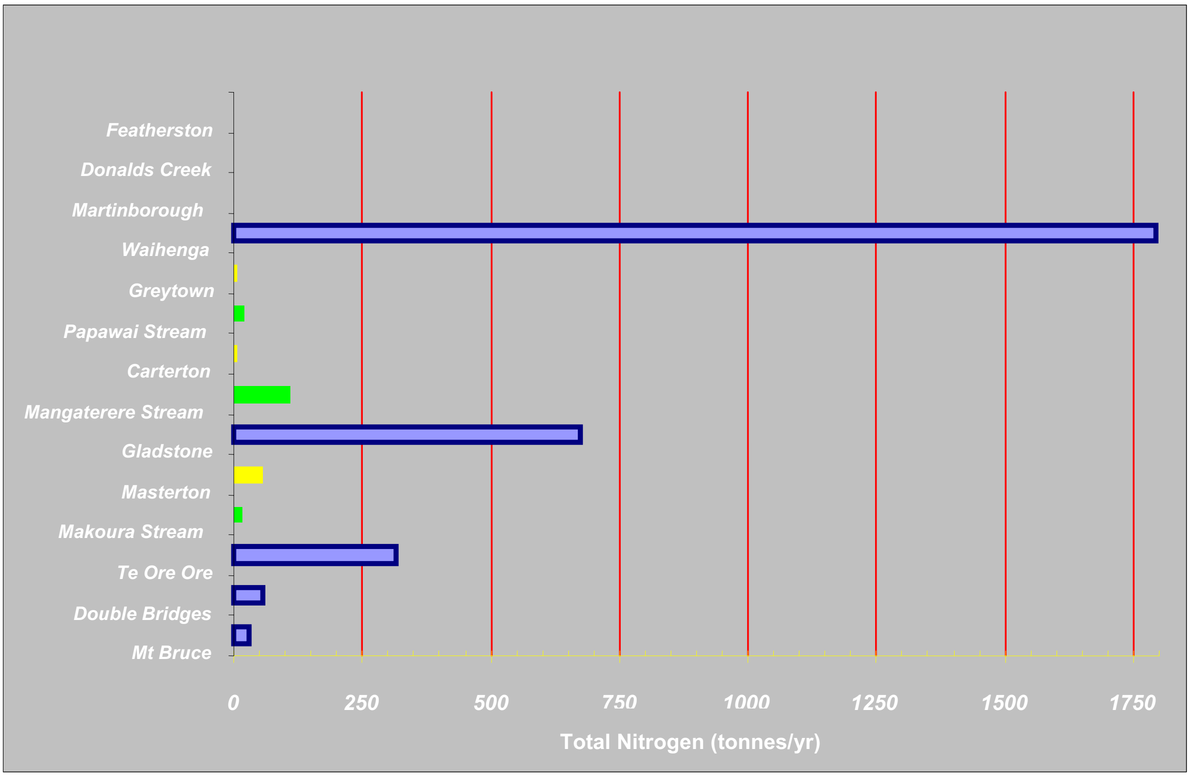

Figure 13 Total Nitrogen Load to the Ruamahanga River

Blue bars represent the cumulative load on the Ruamahanga River at the designated point. i.e. for the Ruamahanga River at Te Ore Ore the total Nitrogen load is 314 tonnes N/y, while at Waihenga it is 1792 tonnes N/y. The yellow bars represent the Nitrogen load from municipal wastewater treatment plants and the green bars the load from tributary streams

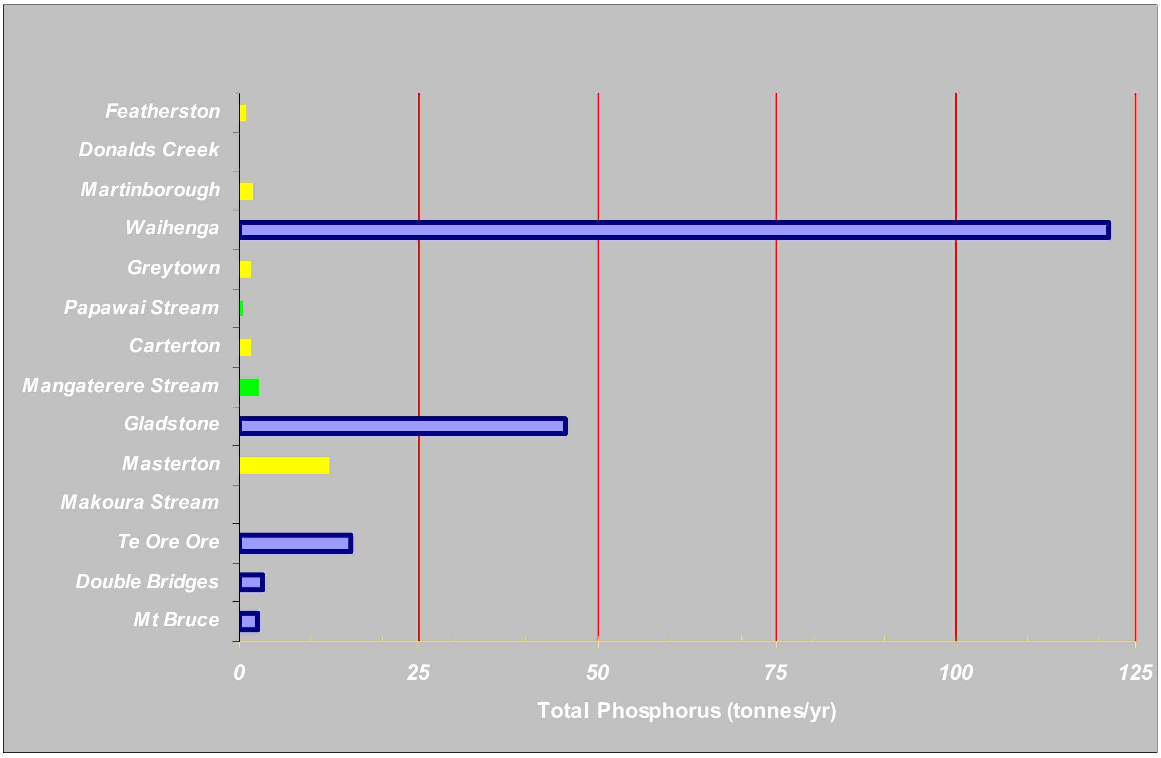

Figure 14 Total Phosphorus Load to the Ruamahanga River, Mountains to Sea

(Legend as in Fig 13)

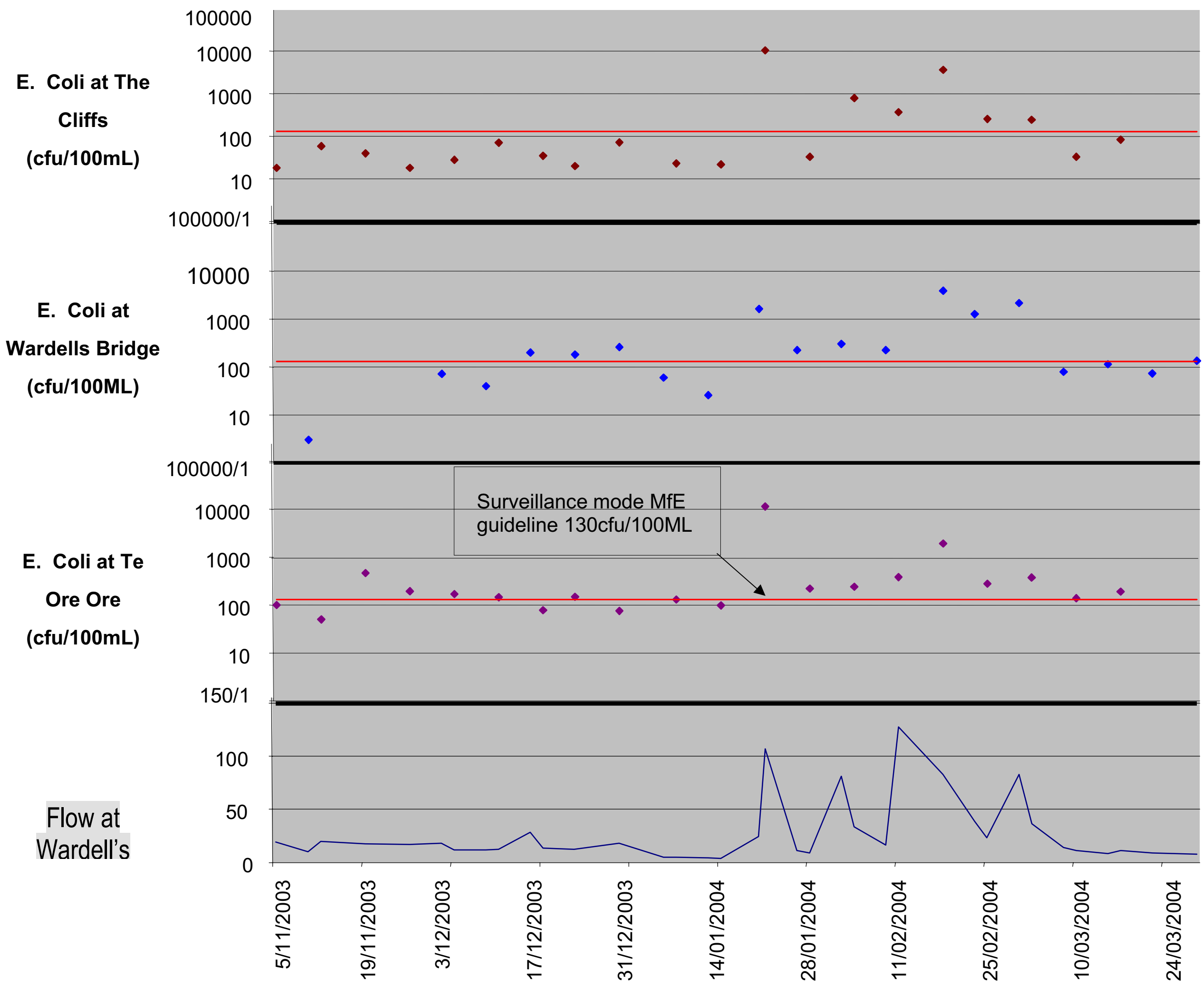

Figure 15 E.coli and Flow in Ruamahanga River (Bathing Season 2003-2004)

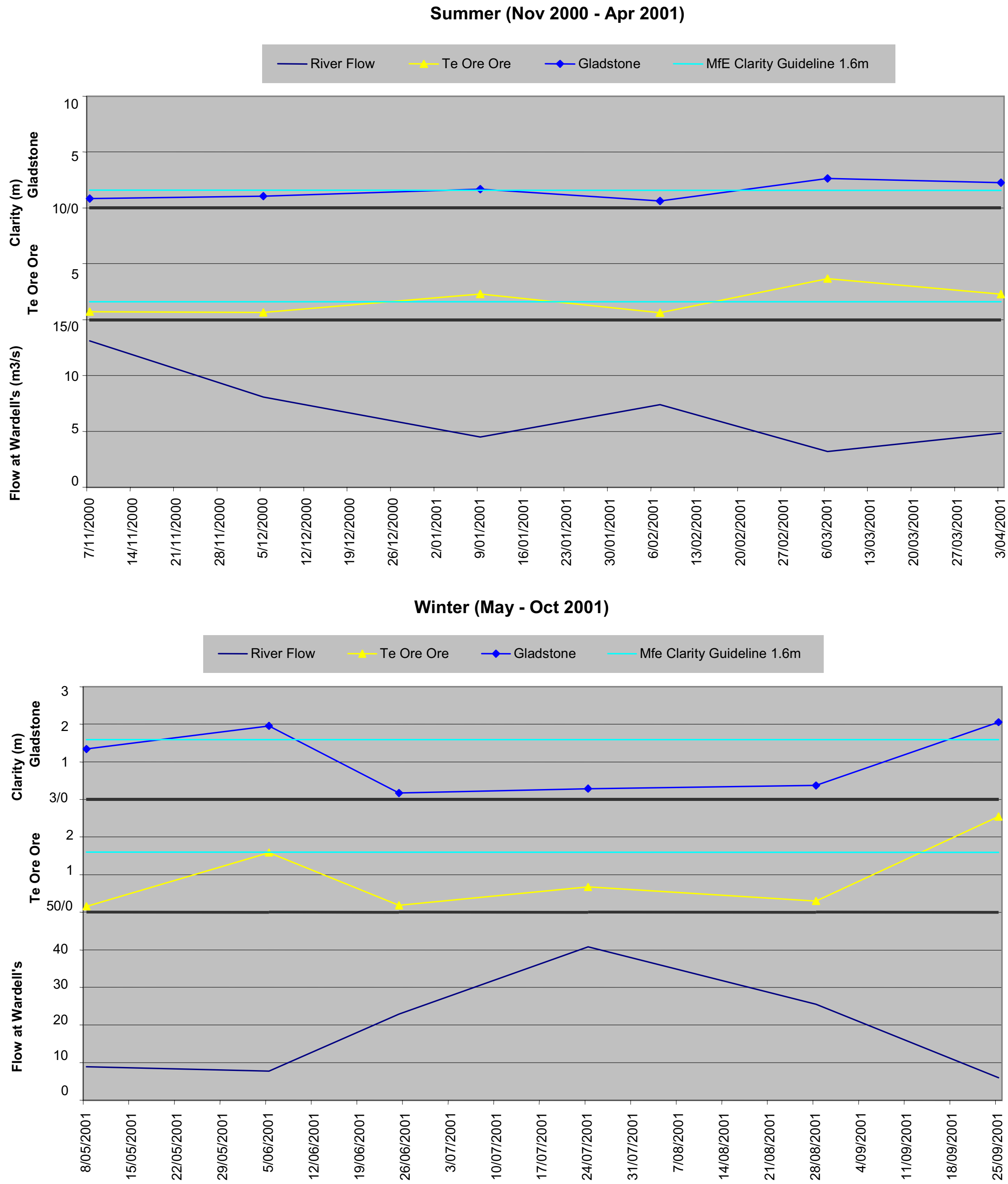

Figure 16 Clarity and Flow of the Ruamahanga River

(Taken from measurements at Rua 1 site)

The variability of E.coli concentrations and clarity is further illustrated in Figure 17 and Figure 18 below which present data for the Rua 1 site (upstream of the MWTP) for longer term periods. This data illustrates the variability of these two important parameters at a location where they are not influenced by the MWTP.

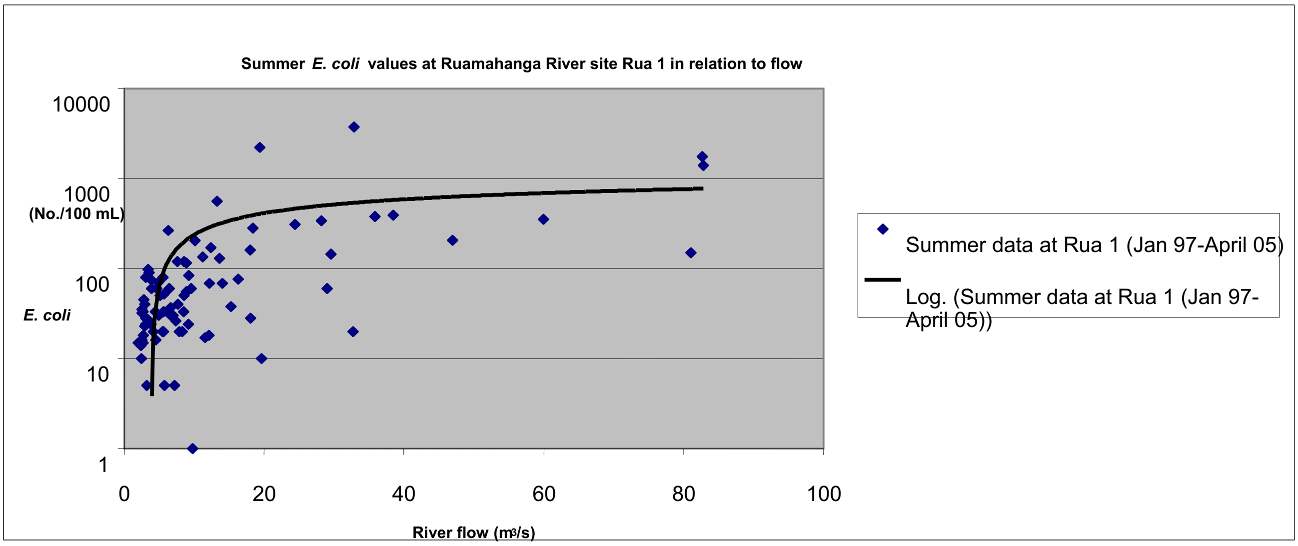

Figure 17 E.coli and Flow in Ruamahanga River (Bathing Season 2003-2004)

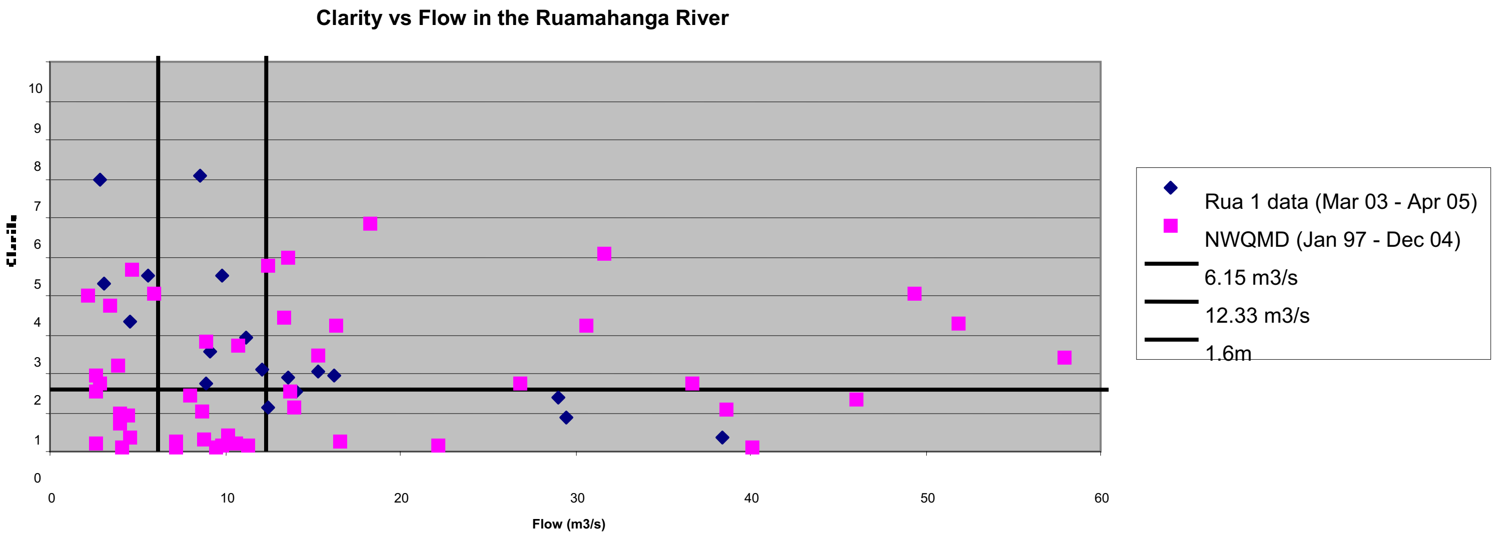

Figure 18 Clarity and Flow of the Ruamahanga River

5.3.3 Biological Qualities

The presence/absence and relative abundance of biological communities (invertebrate, fish, algae and macrophytes) in a river system is a good indicator of habitat condition and suitability. The suitability of a particular river reach to support a particular species, community or ecosystem is dependent on a number of factors including substrate, hydrology and water quality. The resident sessile (non-mobile) communities (macro-invertebrates and periphyton, and macrophytes) are 'integrators' of all these factors, responding directly according to their environmental conditions. In comparison, fish, being mobile, can 'avoid' reaches that do not provide the optimum habitat; nevertheless fish are also impacted by the same environmental factors.

The Ruamahanga River has a generally rocky bed (largely cobble), with a range of hydraulic habitats (i.e., pool, run, riffles). Thus, within the main stem of the river at least, there are no major differences in substrate that would result in differences in biological communities. Rainfall runoff in the headwaters (Tararua Ranges) is the dominant hydrological driver and therefore broadly similar hydrological responses will be expected along the main stem of the Ruamahanga (although the headwater channel gradients and tributary inflows would also have an effect). Therefore, it is reasonable to conclude that, if there are significant differences in biological communities along the length of the Ruamahanga, these differences are due to differences in water quality.

Invertebrates

The macro-invertebrate community associated with the riverbed are integrators of both the physical (for example, temperature, pH, sediment particle size, flood flows) and chemical habitat (for example, water chemistry), together with factors that affect survival and growth (for example, food supply). Thus, measurements of community parameters, together with the presence or absence of 'sensitive' species, can provide robust measures of biological impairment associated with environmental modifications.

The base dataset on invertebrates allows the average Ruamahanga River community characteristics to be benchmarked against other New Zealand rivers[17]. The results of the general compliance monitoring have shown that the Wardells Bridge site has a high invertebrate density relative to the 88 rivers in the national water quality monitoring dataset (Quinn & Hickey, 1990). The results have been reported in annual monitoring reports (Beca 2003b, 2004b and 2005). The effect of the current effluent discharge on invertebrate communities is discussed in Appendix A.

The abundance of Ephemeroptera, Plecoptera, and Trichoptera (EPT) community groups, is a good index of the degree of organic enrichment in a river system (Quinn and Hickey, 1993) with a high proportion of EPT (relative to total taxa), indicating a healthy ecosystem. The abundance of EPT species, including the predominant mayfly (Deleatidium sp.) shows a progressive downstream increase[18]. The proportion of EPT and Deleatidium is high in the Ruamahanga River, with median values of 41% and 25% respectively at Wardells Bridge. The proportion of EPT and Delatidium declines at Wardells Bridge compared with upstream at SH2; however, this apparent response is caused by an increase in other opportunistic species relative to the upstream site (Figure A1.4). Elmid beetle larvae are a major component of the macro-invertebrate community at most sites and the free-living caddis, Aoteapsyche sp., is a major component of the community at the upstream (SH2) site. Chironomid (midge) larvae that are tolerant of organic enrichment are a highly variable component at all sites, but the median values tend to increase downstream.

The mayfly Deleatium is at times a particularly dominant species at each of these sites, with 95%ile values of 77% at SH2, 71% at Wardells and 67% at Waihenga. This finding is particularly relevant as low numbers of Deleatium is an indicator of potential adverse effects of contaminants such as ammonia. Deleatium has been found to be amongst the most sensitive of invertebrate and fish species to ammonia, being only slightly less sensitive to rainbow trout and more sensitive than all native fish species tested (Hickey 2000). Thus a high abundance of Deleatidium is indicative of the absence of toxic conditions occurring in the river.

17 NRWQN
18 Refer Table A1.1, Figure A1.4 in Appendix A.1

While not definitive, the overall weight of evidence from the invertebrate data is that the river is of generally good quality (compared with most NZ rivers) but that there is increasing organic enrichment with distance downstream.

Algae

Microscopic algae are always present in aquatic ecosystems. As with terrestrial plants, the factors that govern their growth are light, temperature and nutrients. In shallow river ecosystems, free-floating algae rarely reach levels where they are noticeable. However, some species of algae (termed 'periphyton'[19]) can attach to the riverbed, submerged debris, or rooted plants. Given suitable habitat conditions (suitable attachment substrate, hydraulic and light conditions) they respond to increased nutrient inputs and elevated temperature by rapidly increasingly their growth rates. In turn, a high abundance of periphyton may result in adverse ecological effects and aesthetic concerns. Major controllers of algal abundance are grazing by benthic invertebrates, scouring by floods and reduced light (for example, through turbidity and shading).

Ministry for the Environment guidelines state that any river with greater than 30% of its bed covered by filamentous periphyton is recommended as a guideline for the protection of aesthetic and contact recreation values in streams during periods when recreational use is likely.[20]. Intermittent algal proliferation events have been recorded at sites along the Ruamahanga River, particularly during sustained warm periods with low flow conditions. There has been a low incidence of exceedance of the MfE guideline at Mt Bruce and Double Bridges (2.4% and 2.8% of monitoring occasions respectively), increasing to 7.1% at Te Ore Ore, but progressively decreasing downstream (Gladstone 5.7%; Waihenga 2.9%)[21].

The National Rivers Water Quality Network (NRWQN) periphyton monitoring data from Wardells Bridge, downstream of the discharge, indicate that the mean maximum filamentous algal cover is 21%, with mat 17% and total 35% cover (NIWA 2003). These values are less than the guideline values of 30% (filamentous) and 60% (mats). Examination of this data for the period March 1989 until June 1999, shows that the algal proliferations only occur in summer months and that exceedance of the nuisance guideline for filamentous growths occurred on only 1 occasion (February 1994) and for 2 occasions for mat growths (March '98, April '99). Commonly the cross-section measurements showed greater proliferations on the right-bank of the river (downstream of the Makoura Stream= and MWWTP discharge) rather than uniform growths downstream of the discharge. These data indicate that the existing effluent discharge at Homebush does not have a significant effect immediately downstream, and does not cause nuisance algae proliferation at distant downstream sites (Refer Appendix A for site locations). Investigations suggest that this is in large part due to the "flashy" nature of the hydrology of the river. Frequent floods or freshes cause attached algae to slough off (NIWA 2003 and NIWA 2004a).

Fish

The range of fish species present in the Ruamahanga River system includes native and exotic species, as well as some exotic pests such as perch and tench[22].

The upper Ruamahanga River appears to support a diverse range of fish species, including native and exotics. Summer low flows and associated elevated temperatures are a major factor restricting distribution of fish species largely in the headwaters and tributaries of the Ruamahanga River.

Diadromous Torrent fish and Common bully are present in the Ruamahanga main stem immediately upstream of the existing MWTP discharge, while the Koaro migrates only to the headwater areas[23]. The distribution of brown trout is largely restricted to river areas above the Waingawa River confluence[24]. Greater Wellington has reported that this pattern is likely to be attributable to high summer river temperatures (WRC 1999).

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19 Periphyton is a generic term and may include bacteria and fungi living in association with the benthic algae
20 MFE, (2000), p91
21 Table 4.7; Milne & Perrie (2005)
22 Refer Table A1.4, Figures A1.5 – A1.8 in Appendix A.1
23 Figures A1.5 and A1.7 in Appendix A1, and Figure A1.6 in Appendix A.1 respectively
24 Figure A1.8 in Appendix A.1

Bacteria and Pathogen Levels

Pathogenic organisms in the Ruamahanga River from human and animal waste pose a health hazard for people using the river for recreational activities. Primary contact activities, such as swimming and kayaking, involve a reasonable risk that water will be swallowed, inhaled, or come into contact with ears, nasal passages, mucous membranes or cuts in the skin, which allows pathogens to enter the body.

The main indicator of pathogen levels is the presence and abundance of *E.coli*. Table 10 below summarises the *E.coli* levels from monitoring of key sites along the Ruamahanga River[25]. The Ministry for the Environment and Ministry of Health guidelines on *E.coli* have set three different levels for monitoring the presence of *E.coli* in freshwater used for recreational contact. These guidelines apply to the receiving water at the swimming hole, or "beach" as referred to in the guidelines.

- Surveillance Level – Acceptable or green mode — no single sample > 130cfu/100 mL
- Alert Level – or Amber mode — single sample > 260cfu/100 mL
- Action Level – or Red mode — single sample > 550cfu/100 mL

The amount of monitoring recommended in the guidelines depends on the amount of recreational (contact) use. The guidelines state that: "*Samples should be collected during the bathing season, or when the water body is used for contact recreation. For rivers, this may exclude periods of high flow, during which hazardous river conditions would prohibit bathing".*

The results confirm the 'picture' that is illustrated in Figures 15 and 17. The summer monitoring undertaken by GWRC for the period 2001 – 2005 shows that *E.coli* results display a wide variability. Water quality deteriorates during freshes, but conversely at low flows the microbiological water quality upstream of the MWTP becomes very good (see Tables 34 and 39). Accordingly, it is during low flow conditions that the current discharge has the most effect on downstream microbiological water quality, this also coincides with the flows when most primary contact recreation occurs.

Table 10 GWRC E.coli Monitoring – Summary Statistics (2001-2005)[26]

Site	Min	Max	Median	95% Value
Recreation Sites (Summer Monitoring)				
Ruamahanga @ Double Bridges	9	6,200	124	647
Ruamahanga @ Te Ore Ore	24	11,400	140	1,364
Ruamahanga @ The Cliffs	<1	10,400	45	909
Ruamahanga @ Kokotau	<1	16,000	55	1,852
Ruamahanga @ Morrisons Bush	1	7,455	46	1,476
Ruamahanga @ Waihenga	<3	20,000	53	1,833
Waingawa @ Kaituna	<1	760	9	348
Waingawa @ South Road	2	3,400	22	356
Waiohine @ SH2	<1	2,700	4	104
Other Sites (All Year Monitoring)				
Ruamahanga @ McLays	<1	220	4	164
Ruamahanga @ Te Ore Ore	2.5	4,500	60	1,969
Ruamahanga @ Gladstone Bridge	<1	3,600	20	555
Ruamahanga @ Pukio	16	3,800	130	2,400
Ruamahanga @ SH2 Mt Bruce	<1	80	5	63

[25] Refer to Appendix A for location plan of sites
[26] Source: GW State of the Environment Report 2005.

Site	Min	Max	Median	95% Value
Ruamahanga @ Double Bridges	<1	390	20	166
Ruamahanga @ Waihenga Bridge	<1	11,000	30	591
Waingawa @ South Rd	<1	260	12	106
Waiohine @ Gorge	<1	320	1	10
Waiohine @ Bicknells	1	820	33	450
Site	**Min**	**Max**	**Median**	**95% Value**
Recreation Sites (Summer Monitoring)				
Ruamahanga @ Double Bridges	9	6,200	124	647
Ruamahanga @ Te Ore Ore	24	11,400	140	1,364
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Waingawa @ South Road	2	3,400	22	356
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Other Sites (All Year Monitoring)				
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Ruamahanga @ Gladstone Bridge	<1	3,600	20	555
Ruamahanga @ Pukio	16	3,800	130	2,400
Ruamahanga @ SH2 Mt Bruce	<1	80	5	63
Ruamahanga @ Double Bridges	<1	390	20	166
Ruamahanga @ Waihenga Bridge	<1	11,000	30	591
Waingawa @ South Rd	<1	260	12	106
Waiohine @ Gorge	<1	320	1	10
Waiohine @ Bicknells	1	820	33	450

Notes: The summer period used by Greater Wellington Regional Council for the monitoring of recreational sites is 1 November to 31 March. The data for "other Sites" is for data gathered over the full year

5.3.4 Flooding and Erosion

Flooding

As outlined above, prior to 1960, the Ruamahanga River looped across the area where the existing oxidation ponds are located (refer Figure 4 in section 4.5.4). In 1960, and separate from the construction of the oxidation ponds, the then Wairarapa Catchment Board constructed a diversion to cut off the loop and straighten the river. This diversion was constructed for a JC Milligan who owned land on the right bank of the river, because the looped river alignment was causing severe erosion of his land during floods. This work required land to be purchased from the Wardell Estate and a considerable length of the diversion was made through farmland on the left bank.

There has been a period of relatively intense flooding events since about 1990, with the records for Wardells Bridge showing especially high flood intensities in the years 1991, 1994, 1998 and 2000 and 2004. The greater the flood intensity, the more active the river processes, and hence the greater the amount of erosion and deposition along the river.

Greater Wellington Regional Council carried out investigations of the upper Ruamahanga River in 1995, covering catchment and channel characteristics, flood and erosion hazards, and environmental, recreational and cultural values. Subsequently, the Council examined river and floodplain management options and then drew up a programme of erosion and flood protection works as part of its updated River Management Scheme.

The River Management Scheme protects a number of assets of MDC, apart from the MWTP, and the Council is directly involved in scheme funding and liaison with GW. The Scheme aim is to minimise land loss and reduce flooding along the river through the management of the river as a whole, in accordance with a design river channel. Where a higher standard of protection is required for major assets, then the asset owner has to fund the protection works directly. MDC, therefore, directly funds river works to protect its major assets, as well as contributing to the GW scheme.

Along the reach between Wardells Bridge and the Te Ore Ore Bridge, the Ruamahanga River has a well-defined channel within an alluvial plain. It has a single thread meandering channel, with alternating gravel beaches from bend to bend, which slowly migrates within the alluvial floodplain (unlike upstream and downstream, where the channel is more mobile and has a braided form). Within this reach, there is progressive erosion along the outer bank at the bends, with deposition on the inner side beaches.

An existing stopbank provides flood protection to land along the right side of the river, from Masterton down to the MWTP. This stopbank was re-located further back from the river channel from its original position, because bank retreat from river erosion removed or threatened lengths of the stopbank. The height of the stopbank was also increased in 1999.

There is no stopbank on the left side of the river, and low lying land around the Whangaehu confluence and elsewhere on the Te Ore Ore plains is prone to flooding.

In 2004, GW reviewed and updated the rating curve for the Ruamahanga River at Wardells Bridge. The rating curve is the relationship between water level and river flow for a particular site that is used to convert water level measurements into river flows. In particular, river gauging during the floods in October 2000 and February 2004 indicated that the rating curve could be over-estimating the high-end flows. Accordingly, GW revised the rating curve, which was verified by NIWA as part of the studies for the MWTP upgrade. One of the key consequences of the revision is that flood flows with return periods of 10 to 100 years have been reduced by 9% to 11%, meaning that the level of protection from high intensity flood events is less than previously estimated.

As part of the investigations for the MWTP Upgrade, a hydraulic model was prepared for the Ruamahanga River from Henley Lake to Wardells Bridge, using the revised flows and river cross section data from the most recent 2002 survey[27]. Table 11 below provides the latest estimates of return period for different levels of floods, based on the revised rating curve. The revised estimates confirm that the stopbank protection for the MWTP is not adequate, with the stopbank crest height below the design 100-year return period levels. This was demonstrated in the floods of October 2000 and February 2004 when floodwaters overflowed the stopbank in this area. There is therefore currently a flood risk to the MWTP in medium to large flood event.

Table 11 Estimated Return Periods for Flood Events in the Ruamahanga River

Return Period (years)	Flows (m3/s)
2	460
10	674
20	760
50	871
100	955

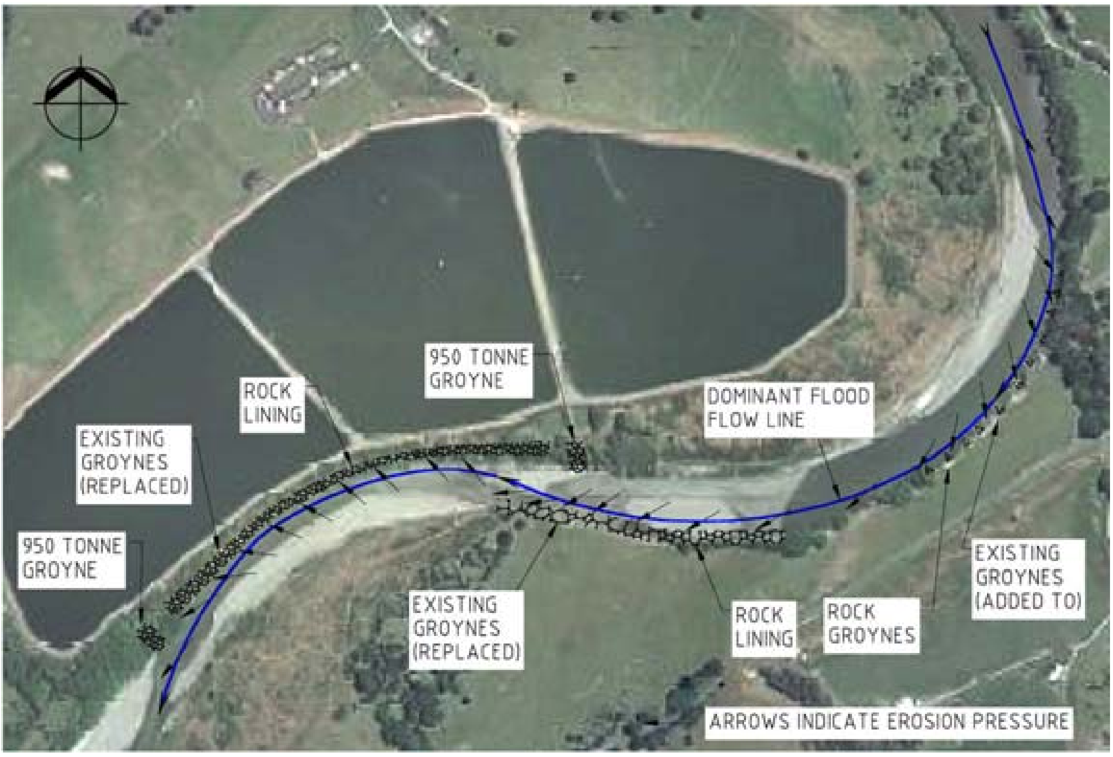
27 The long-section of the river flood levels adjacent to the oxidation ponds was provided in the Pond Location Report (Beca 2004a).

Erosion

Since the straightening of the River loop in 1960, the Ruamahanga River above Wardells Bridge has settled into a relatively well-defined channel with a natural meander curvature. There are a number of sections of this reach that are prone to river erosion, and several erosion protection works have been constructed since 1960 at the most susceptible points.

In particular, substantial rock protection works have been placed beside the oxidation ponds and along the bottom of the cliff at the tight bend opposite Pond 1. The figure below shows the river channel and the line of the dominant flood, which would if not restrained, migrate the channel in a downstream direction and towards the oxidation ponds. The right bank of the river, adjacent to Ponds 1 and 2, has been protected with rock groynes and this is likely to place greater erosion pressure on the left bank opposite the ponds. The current erosion protection on the left bank opposite the upstream end of the oxidation ponds consists of nine groynes along a 250 m length at the cliffs, with a gap of approximately 200 m to the short stub groynes downstream of the cliffs.

The figure below also shows the existing and proposed erosion protection works. The proposed erosion protection works are discussed in more detail in Section 6.8.2.



Gravel Build-up

There has been a particularly high degree of river flooding recently (late 2005 – early 2006), which will have increased both gravel deposition and scouring. There is channel widening and distortion just upstream of the Whangaehu confluence with a particularly serious embayment on the right bank. GW is aware of this and is currently taking steps to address the problem. It is understood that GW intends to have remedial work undertaken, comprising bed re-working and gravel extraction.

5.4 Groundwater Flow and Quality

5.4.1 General Groundwater Characteristics

The Homebush site on which the MWTP is located is within the Te Ore Ore groundwater zone (refer Figure 19[28]). This groundwater zone extends as far west as the Masterton-Martinborough Road, which marks the approximate western boundary with the Masterton groundwater zone. Four aquifers are located within the alluvial deposits of the Te Ore Ore basin. The uppermost aquifer is unconfined or semi-confined and is typically 5 to 15 m thick. This aquifer comprises compact brown gravels with a variable sand, silt and clay content. A number of shallow bores penetrating into this aquifer are used for domestic and stock water purposes. The depth of the water table in this aquifer varies seasonally between 1 to 4 m.

A deeper confined or semi-confined aquifer extends to over 50 m in the centre of the Te Ore Ore plains. Deeper bores from this aquifer are principally used for irrigation purposes.

Two other deeper aquifers have been identified to the west of the Ruamahanga River. These deeper aquifers have moderate to poor groundwater yields.

GW surveyed regional groundwater flow in the shallow aquifers over a number of sites between April 1977 and October 1993[29]. Based on these plots, it appears that the rivers exert a major control on head distribution across the wider plains area. The groundwater flow direction varies from a southeasterly direction near the Waingawa River in the west, to a southerly direction at the Ruamahanga River in the east.

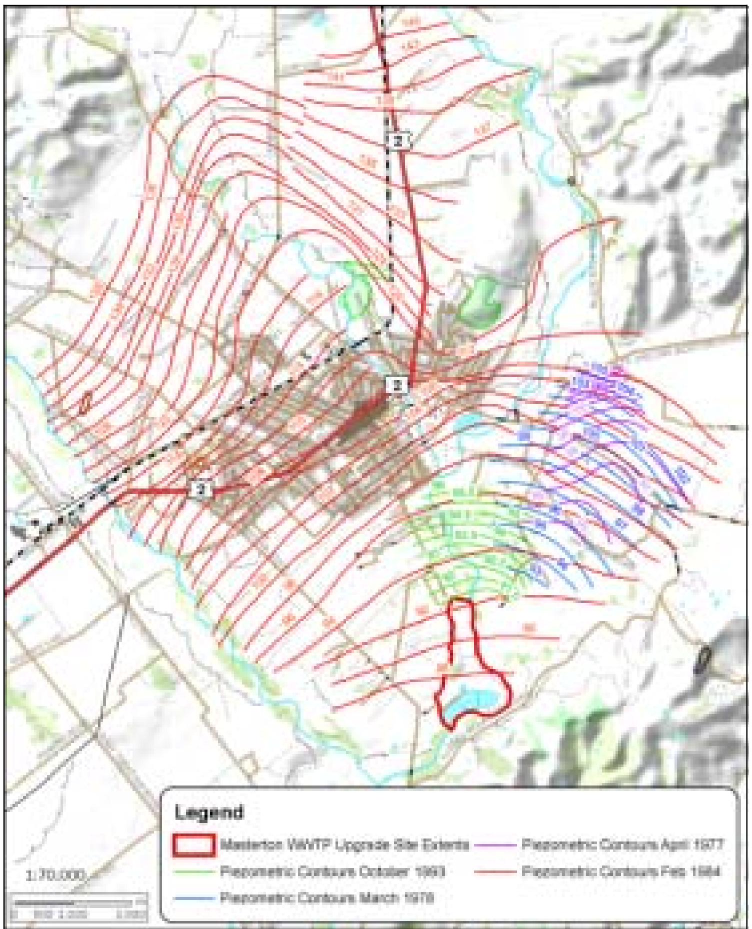


Figure 19 Groundwater Contours[30]

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28 Source: PDP, 2006.

29 *Pers.com* Lindsay Annear, November 2005.

30 Groundwater flow direction is perpendicular to the contours (surveyed by Wellington Regional Council).

5.4.2 Existing Groundwater Flows at Homebush

Extensive analysis of the Homebush site was undertaken to assess its groundwater characteristics (PDP, 2006)[31]. The results of this analysis are outlined below.

The gravel deposits, which form the shallow semi-confined aquifer at the Homebush site, are generally in the order of less than 10 m thick.

Groundwater on the eastern side of the site flows towards the Ruamahanga River, while groundwater in the centre and to the west of the site runs due south, with some variation to the southwest where groundwater seepage enters the Makoura Stream. The groundwater at the southern end of this site flows directly south, towards the Ruamahanga River.

The shallow aquifer in the area has a significant hydraulic connection to the Ruamahanga River and the Makoura Stream. The Ruamahanga River gains from groundwater along the majority of its length adjacent to the Homebush site during average river flows. At other times, groundwater may either discharge to the river or receive recharge through riverbed losses. For example, the rapid increase in groundwater levels that has been observed during floods in the river suggests that the hydraulic gradient is reversed during flood conditions and that the river contributes significant flow to local groundwater.

The Makoura Stream gains water from the groundwater system. These gains are generally from groundwater in the stream's path across the Homebush site.

The ground water level is shallow across the Homebush site and lies within the silt deposits, typically less than 2 m from the ground surface. The surface sediments act as a confining (or semi-confining) layer to the aquifer in the underlying gravels, when groundwater levels are sufficiently high.

The groundwater response to flood events in the Ruamahanga River is rapid. The rise in groundwater closely follows river flow increases, with the subsequent fall being somewhat slower (the river typically falls over a one to three day period whereas the groundwater takes several days to return to the pre-flood level).

The key feature is that seasonal changes in average river flow are a major factor in controlling the average groundwater level. However, the short nature of floods means they have little influence on the average groundwater levels and thus flow direction. This is discussed further below in the context of effects on private bores to the southwest.

5.4.3 Existing Pond Leakage

The level of existing pond leakage was assessed using a water balance approach involving inputs, outputs and change in pond storage. "Leakage" is defined as the inputs – outputs – change in storage, as follows:

- ***Inputs*** include influent flow and rainfall
- ***Outputs*** include wastewater flows, evaporation and leakage
- ***Change in storage*** refers to the changing pond water levels.

Pond leakage has been assessed on a number of occasions as outlined below:

- The average pond leakage was calculated as 890 m^3/day for an assessment undertaken in June 2003, during normal pond levels, prior to the upgrade of the inlet flowmeter (Beca 2004a).
- For the period from April to May 2005, the average pond leakage was assessed as 490 m^3/day, during which time, the pond levels had been raised and were being drained down and were on average 0.4 to 0.5 m higher than normal operating levels.[32]

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31 Figure A2.1 in Appendix A2 shows the extent of boreholes and test pits on the site

32 Monitoring was carried out over a period following the outlet flowmeter being calibrated on 1 April 2005 and the new inlet flowmeter being successfully commissioned on 8 April 2005.

- Leakage was calculated for the period from February to May 2006 with pond levels at normal operating levels, indicating that the average pond leakage 800 m^3/day, with an upper bound estimate of 1,700 m^3/day (PDP, 2007).
- Pond leakage was assessed again in June 2006 in an exercise aimed at determining the impact on the leakage rate with high pond water levels (to simulate a high level of storage). Pond water levels were raised by 0.5 m-0.7 m to a top level of approximately RL88, and the calculated leakage rate was 1,200m^3/day, with an upper bound of 2,400m^3/day.

The 2006 assessment used the same methodology as the previous estimates, but included the use of on-site rainfall and evaporation measurements (whereas previous assessments used data from the Te Ore Ore climate station).

A separate check was undertaken in 2005, in parallel with other investigations, as a means of providing an alternative assessment of the leakage rate. In this assessment, NIWA determined the leakage based on the mass of DRP leaking from the ponds. The calculation (NIWA 2005a) used measured concentrations of DRP in the ponds and in the receiving water as the basis of quantifying the leakage rate. The conclusion of this assessment was that leakage is in the range of 5 L/s to 10 L/s, which equates to 430-860 m^3/day.

In conclusion, the following leakage rates have been adopted as the basis for the assessment of effects of the pond leakage. These are based on the trial undertaken in June 2006 which involved raising pond water levels (as discussed above).

Pond Operating Level	Rate of Leakage (m^3/day)	Upper Bound (m^3/day)
Normal	800	1,700
Elevated (high storage scenario)	1,200	2,400

Under the scenario of elevated pond water levels and the adopted leakage rate of 2400m^3/day, the dilutions become 443 fold at median flow and 221 fold at half median flow. This conservative leakage rate has been used in the prediction of effects of leakage for the proposed upgrade (refer section 8.2.3)

The effects of pond leakage on surface water quality are discussed in sections 8.2.2 and 8.2.3.

5.4.4 Existing Groundwater Quality at Homebush

Groundwater quality has been measured in a number of monitoring wells around the MWTP since 2003 for a range of general groundwater quality parameters. In addition, one-off samples for a wider range of parameters, particularly heavy metals and PAHs have also been taken for comparison with Pond 3 wastewater samples (PDP, 2006).

The consent monitoring shows groundwater quality up-gradient of the ponds is generally good, with all but *E.coli* complying with the New Zealand Drinking-water Standards 2005 (MoH, 2005). The on-off testing[33] for a suite of metals listed in the drinking-water standards showed a general absence of metals (at the laboratory detection limits) and in all cases compliance with the standards. There was also an absence of PAHs[34], which is expected for groundwater in a rural area.

Groundwater to the west of the ponds appears to have water of slightly different origin to that of the wells north of the ponds, being distinctly harder, and having higher iron, manganese, bicarbonate, sodium and chloride concentrations than the wells to the north of the ponds (PDP, 2006). This indicates that groundwater to the west of the ponds is likely to be from a different aquifer than the groundwater to the north of the ponds.

33 In borehole 6 located centrally in the proposed irrigation site
34 Poly Aromatic Hydrocarbons

In conclusion, the groundwater quality can be considered to be reasonably typical of a rural environment in that quality is good, without any contaminents of concern. Although the E.coli results show non compliance with NZ drinking water standards, this is not unusual for a rural catchment where farming is the dominant land use.

5.5 Community Characteristics and Values

5.5.1 Profile and Population Demographics

Recent New Zealand Census population figures for Masterton are shown in Table 12 below, with the population projected out to 2026. Masterton's District population grew slightly between 1991 and 1996, but slightly decreased (0.63%) between 1996 and 2001. Based on medium growth predictions the growth rate in Masterton would rise slightly in 2006 before declining. Masterton's predicted population over the 20-year period between 2006 and 2026 is expected to decline from 23,300 people in 2006 people to 22,100 people respectively.

Initial information from the 2006 census is that the district population that was 'usually resident' on census night (7 March 2006) was 22,623. However, further more detailed information from the 2006 census is not yet available.

Table 12 Masterton District Population 1991 to 2026[35]

Year	District Population	Urban Population*
1991	22,600	18,407
1996	22,800	18,069
2001	23,200	17,793
2006	23,300	17,793
2011	23,100	17,793
2016	22,800	17,793
2021	22,500	17,793
2026	22,100	17,793

** Based on static urban growth from 2001*

The population of the Masterton Urban Area decreased slightly between 1991 and 2001. As there are no projections available for the urban area, a static population growth rate has been assumed.

Age and Ethnic Distribution

The majority of Masterton residents (61.1%) are between the ages of 15-64. The age groups for 0-14 (23.4) and 65+ (15.5%) are a greater proportion in comparison to New Zealand as a whole (22.7 and 12.1 respectively). This is a common feature of New Zealand provincial centres.

The majority of Masterton residents are of European ethnicity (88.4%), followed by smaller proportion, of Maori (16.3%), Pacific people (2.6%) and Asian (1.5%). Masterton has a greater proportion of Europeans and Maori and a lesser proportion of other ethic groups compared with the national average.

Deprivation Index

The socio-economic wellbeing of the Masterton community was investigated as part of the project, using the Ministry of Health's measure of socioeconomic deprivation, the *NZDep2001 Index of Deprivation* (contained in BERL 2005). The extent of variability of a region's index from the national base of 1000 indicates the region's

[35] Source: GHD (2006) & Statistics New Zealand, Projected Population of Territorial Authorities 2001(base) – 2026. Medium projections used for 2006-2026. Census usually resident population used for 1991- 2001 figures.

relative deprivation. A rate above 1000 indicates a higher level of deprivation, while a rate below 1000 indicates an above average wellbeing, according to the attributes included in the NZDep2001 measure, which are income, employment, (access to) communication, (access to) transport, support (from family members), qualifications, home ownership status, and living space.

The Index allows the comparison of relative socioeconomic position of Masterton with other districts. Table 13 below shows that Masterton has a slightly higher deprivation rate relative to the national scale, with an NZDep2001 index of 1,004.8. This rate is important factor in considering the community's ability to pay for significant infrastructure projects, compared with the principal alterative schemes[36].

Table 13 Comparative Deprivation Rates

District	Deprivation index NZDep 2001
Upper Hutt	965.9
Carterton	975.9
South Wairarapa	980.5
Palmerston North	991.6
Tararua	995.1
South Taranaki	1,004.1
Masterton	1,004.8
Taupo	1,023.5
Waikato	1,024.4
Rotorua	1,029.1

Source: Index NZDep2001

5.5.2 Recreational Use of Ruamahanga River

The Ruamahanga River is a popular recreational destination, being used for jet boating, canoeing, kayaking, angling, swimming and food gathering. Its recreational use is particularly high during summer when it is frequently used for activities such as swimming, kayaking and fishing.

A survey by Abernathy revealed that, during the summer of 2001-2002, anglers spent approximately 6,900 days fishing, while in the six months from November-April other visitors took approximately 2,000 jet boat rides and 3,200 kayaking trips with local tour operators. These usage rates equate to a total of approximately 12,000 visits to the river in one summer, not including people who visit the swimming spots between Masterton and Martinborough (Abernathy, 2005).

Mills (2002) reported various recreational activities in the Ruamahanga River, observing that, in the 1994-95 season, approximately 7,300 people used the river for angling, with the most intensive period of use being from December to May.

Another survey collected data on the use of two sites on the Ruamahanga River ("The Cliffs" and Morrisons Bush) on five days between 14 January and 11 February 1996, the results of which are shown in Table 14 below[37].

36 The economic effects of the proposed upgrade on the community is discussed in section **Error! Reference source not found.**, while the relative costs of the alternative systems is outlined in section 10

37 Part of a study to determine these sites' suitability for inclusion in a national assessment of water quality at freshwater recreation sites (McBride et al, 1996)

Table 14 Surveyed Occurrence of Swimming in Ruamahanga River

		Number of swimmers	
Ruamahanga site	**Days surveyed**	**Range**	**Mean**
The Cliffs	5	40 - 250	133
Morrisons Bush	5	15 - 250	110

The nearest officially recognised public swimming spots on the River are at "The Cliffs", some 5 km downstream, and at Te Ore Ore bridge, some 5 km upstream from the ponds[38]. These spots are popular summer swimming holes. Consultation identified that the closest point on the River to the MWTP which is used for primary contact recreational activity (i.e., swimming) is at Wardells Bridge, although there is no gazetted or designated public reserve at this locality, and access requires approval of the landowner. In addition, there is a privately accessed swimming hole on the opposite side of the river to the oxidation ponds.

Wardells Bridge is also the closest recognised angling location to the MWTP, although the Fish and Game pamphlet *Ruamahanga River Fishery* notes that the site is on private property and that anglers should stay on the track. Otherwise, there are no other known specific recreation sites in close proximity to the ponds other than 'passing' activities like rafting or kayaking or jet boating.

Wardells Bridge is about 200 metres downstream of Makoura Stream confluence, the tributary into which the oxidation pond wastewater presently discharges. The treated wastewater from the existing discharge is not fully mixed within the Ruamahanga River by the time it reaches Wardells Bridge, and there is therefore a higher recreational exposure risk at that point, than downstream at the Cliffs where it is fully mixed (refer to section 5.7.2 for more detail)

In order to obtain more information on recreational use of the River over summer, an informal observation survey was carried out by MDC over the summer of 2005/06. The survey targeted particular river flows and at four locations: Te Ore Ore Bridge, the swimming hole adjacent to the oxidation ponds, Wardells Bridge and 'The Cliffs'.

A key aim was to observe recreation at about half median (6.15 m^3/s) and median (12.3 m^3/s) flows in the river and immediately following "freshes" (elevated river flows after rain).

The survey information confirmed expectations that contact recreation generally occurred in hotter conditions (air temperatures above 20 degrees Celsius), with swimming observed to occur only when temperatures were greater than 25°. The most popular swimming locations were Te Ore Ore and 'The Cliffs', with 70 people observed swimming at 'The Cliffs' on one occasion. During the times people were observed swimming, the river flow was generally below median flow. However, there was one occasion when people were observed swimming at 'The Cliffs' and Te Ore Ore when the river flow was 19.2 m^3/s.

It was also noted that for all occasions when the river flow was greater than median the water was murky and slightly turbid. When the river flow was less than median, the river was generally clear.

Rafters and kayakers were observed on two occasions using the river when flows were greater than 8.5 m^3/s. Boys were observed fishing at "The Cliffs" when river flow was about 10 m^3/s. Swimmers were observed on one occasion using the private swimming hole opposite the ponds but no one was observed using Wardells Bridge area.

While the representativeness of the survey is limited due to the restricted number of observations (ten), because of the targeting of specific flow regimes, the information supports anecdotal information about the value of the river for contact recreation upstream and downstream of the existing discharge.

Given its recreational value, the quality of the river in terms of public health risk and aesthetics are both important considerations in managing river quality. These recreational values are recognised in the Wellington Regional

[38] As listed in the Greater Wellington's pamphlet, "*Wairarapa Rivers Popular swimming sites*" (2005)

Freshwater Plan (Wellington Regional Freshwater Plan), which, under Appendix 5, identifies the following key management goals for the Ruamahanga River near Masterton:

- "Water Bodies with Regionally Important Amenity and Recreational Values – Water Quality to be Managed for Contact Recreation Purposes": For angling, the Ruamahanga River from State Highway 2 at T25 301 461 to the confluence with the Waingawa River at T26 342 187
- *'Water bodies with water quality identified as needing enhancement"*: For contact recreation purposes (for example, kayaking, canoeing and angling), the mid and lower Ruamahanga River from T26 355 334 to R28 890 796

5.5.3 Tikanga Maori

Rangitaane O Wairarapa and Ngati Kahungunu Ki Wairarapa are tangata whenua and have kaitiaki of the Wairarapa rohe.

In order to explore the values, beliefs, issues and concerns held by tangata whenua in relation to the proposed wastewater upgrade, two initial reports were commissioned by MDC in 1997: *Masterton District Sewerage Upgrade: Maori Consultation Discussion Document* (Burge 1997a) and *Papatuanuku Te Matua O Te Tangata: Consultation Document for Masterton District Council's Sewage Upgrade* (Burge, 1997b). Following these report, Masterton District Council engaged tangata whenua in consultation involving technical workshops, ongoing discussions/correspondence and meetings (tangata whenua were members of the Consultation Task Group) to confirm their views and to ensure ongoing input into the project.

The cultural interests of tangata whenua in the MWTP upgrade may be summarised as follows:

- Maintaining tikanga (traditional values, customs, rules, principles and obligations) for tangata whenua when making decisions on aspects that affect their cultural wellbeing
- Protecting the water quality of the Makoura Stream, one of the "blood veins of Papatuanuku"
- Reinstatement of and having safe kai (food resources) gathering areas
- The protection of ancestral sites and other sites of special value to Tangata Whenua.

The main concern of tangata whenua has consistently been that any discharge of human effluent to water is offensive to their cultural values. Accordingly, they have expressed a strong preference for all effluent to be irrigated to land.

5.5.4 Community Health and Recreation

The health of the community in terms of potentially water borne diseases is discussed in this section. More detailed information is available in the Health Impact Assessment prepared in relation to the proposed upgrade (ESR, 2006).

Waterborne Health Risks

The average annual numbers of notified cases of diseases that are potentially waterborne are given in 16 below[39].

The data reveals that only salmonellosis has a higher annual incidence rate in the Wairarapa than the national average. However, further scrutiny of the national notified diseases database revealed that only 9/100 salmonellosis cases that were investigated by the DHB included recreational water as a possible risk factor; the Ruamahanga River was not implicated in any of these cases.

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39 Information is available through the EpiSurv notifiable diseases database.

Table 15 Notified Potentially Waterborne Diseases Cases (1997-2004)

	Wairarapa		New Zealand	
Notifiable diseases	**Notified cases**	**Ave annual cases/100,000**	**Notified cases**	**Ave annual cases/100,000**
Campylobacteriosis	657	214.7	86,719	292.3
Cryptosporidiosis	72	23.5	6,587	22.2
Gastroenteritis	59	19.3	6,544	22.0
Giardiasis	69	22.5	14,025	47.4
Hepatitis A	3	1.0	1,004	3.4
Leptospirosis	7	2.3	741	2.5
Salmonellosis	221	72.2	13,895	46.8
Shigellosis	8	2.6	997	3.4
VTEC/STEC disease	1	0.3	534	1.8
Yersiniosis	22	7.2	3,697	12.5

For most of the notified diseases, the trend in annual incidence rates for the Wairarapa cases generally follows that of the nationally reported cases (see ESR, 2006 for further detail). It is not possible to determine whether any of the notified cases were linked to contact with the Ruamahanga River, or whether they were from other exposures (i.e., contaminated food, animal contact, person-to-person contact etc). While these pathogens may be transmitted to people via water, they can also be transmitted via contaminated food, person-to-person contact with another case and, with the exception of Hepatitis A and Shigella, which are human pathogens, contact with infected animals/faeces. Of these exposure routes, it is generally accepted that contaminated food and animal contact are the two most common vehicles of infection for most of these pathogens.

The microbiological quality of water in the Ruamahanga River may potentially impact on human health in three ways.

- It may cause additional risk of waterborne disease through recreational contact in the river
- It may cause additional risk of waterborne disease through contaminated drinking-water within the Ruamahanga catchment
- It may lead to additional risk of disease through consumption of mahinga kai collected from the river.

Each of these exposure routes is discussed below.

Risk to Recreational Users

The MfE/MoH guidelines state that when discharging from oxidation ponds or after UV disinfection the relationship between indicators and pathogens is altered, and recommend a site specific risk assessment. The Health Impact Assessment (HIA) undertaken for the proposed upgrade (ESR, 2007) includes an assessment of the current infection risk from swimming at Wardells Bridge at flows below median, as summarised in Table 17 below. The analysis used *E.coli* / pathogen relationships derived from the Bromley (Christchurch) oxidation ponds, taking a precautionary (i.e., conservative) approach, and accordingly the results are likely to overstate the actual risks. The most significant risk (7.3 infectious disease cases per 1,000 swimmers at median flow) is caused by adenovirus and this risk increases somewhat as the river flow falls below median (less dilution).

The infection risk reported in Table 16 below reflects the risk from the existing MWTP discharge alone, and not pathogens contributed from upstream sources. This is a reasonable assumption because upstream water quality improves markedly at low flows and the highest risk pathogen is adenovirus, which is not likely to be present upstream of the MWTP (ESR 2007). At flows above median, the risk from upstream non-point sources does increase, but this is offset by greater dilution of the effluent and a significant reduction in recreational use at higher flows as the river becomes swifter, cooler and more turbid.

The figure of 7.3 per 1,000 at Wardells Bridge assumes full mixing, which is not the case at present because the effluent plume discharged to the river via the Makoura Stream hugs the right bank downstream of the confluence. The actual risk is likely to be lower than 7.3 per 1,000 towards the left bank, and higher towards the right bank. It should be noted that these risk figures are based on 1000 people engaging in primary contact recreation at Wardells Bridge. However, there is minimal recreational use at Wardells Bridge at the present time, partly due to the presence of signs warning of the proximity of the effluent discharge. These warning signs actively discourage recreational use of the river at Wardells Bridge for swimming and food gathering. Access to the site is across private property, and although it is publicised as an access point for fishing, there is no formed public access to the site. Further downstream, there is a popular swimming location, called the 'Cliffs', which is located approximately 7.5 km downstream of Wardells Bridge.

To provide perspective for the 7.3 figure, the HIA (ESR 2006) reports that the Ministry for the Environment/Ministry of Health guidelines measure health risk from recreational exposure to freshwater in terms of the risk of *Campylobacter* infection, with the alert mode being triggered at an infection rate of 1% (*i.e.* 10/10,000). The current risk for adenovirus/*Gastroenteritis* at median flow for recreational users (7.3 per 1,000) reduces due to the effect of die-off (sunlight and time) and dilution (Waingawa confluence) as the river continues to the Cliffs. Accordingly, overall, taking into account the relatively low exposure rates (low primary recreational useage) the current risk of infection as a result of swimming in the Ruamahanga River from the existing (continuous) effluent discharge is assessed to beminor.

Table 16 Assessment of Potential Risk of Infection from Various Pathogens

Pathogen/*Notifiable Disease*	Infection Risk from Swimming at Wardells Bridge (Risk/1,000 swimmers at median flow)	Wairarapa Annual Cases for Notified Disease (Cases/1,000 of Population)
Adenovirus/*Gastroenteritis*	7.3	Unknown – not notified
Enterovirus/*Gastroenteritis*	1.9	Unknown – not notified
Giardia/*Giardiasis*	0.072	22.5
Cryptosporidium/*Cryptosporidiosis*	0.020	23.5
Salmonella/*Salmonellosis*	0.012	72.2
C.jejuni/*Campylobacteriosis*	1.8	214.7

Risks as a Source of Drinking-water

The Ruamahanga River is not listed in the WRFP as a water body in which water quality needs to be managed for water supply purposes, which is not surprising given the amount of runoff from farming and urban sources. There are no registered community drinking-water supplies that are sourced directly from the Ruamahanga River, and no groundwater bores (that use groundwater as a drinking water source) close enough to the MWTP effluent discharge to be a concern.

Hence, the risk of illness arising from using the Ruamahanga River as a drinking water source is considered to be negligible.

Risks as a Source of Mahinga Kai

Section 4.2 of the WRFP includes a policy to manage sites of special value to the tangata whenua, which includes mahinga kai sites.

With wastewater discharges to water bodies, there is a risk that chemical contaminants and waterborne pathogens may adversely affect human health via consumption of mahinga kai (aquatic food) collected from the affected part of the river. Accordingly, the mahinga kai for Ruamahanga River has been assessed, and is reported in more detail in the Health Impact Assessment (ref Ball, 2007). Based on the limited chemical monitoring data to date, there would appear to be little health risk via consumption of contaminated mahinga kai, as all of the chemicals tested were below the limit of detection.

5.6 Effects of Existing Discharge on the Environment

5.6.1 Effects on the Makoura Stream

The lower Makoura Stream is regarded as significant degraded. However, while the treated wastewater from the MWTP is currently discharged to the Makoura Stream, and therefore contributes to this degraded state, the poor environmental quality of the Stream is due to a range of sources, particularly agricultural and urban runoff. The Wellington Regional Freshwater Plan (WRFP) identifies the Makoura Stream, both upstream and downstream of the discharge, as requiring enhancement for ecosystem purposes.

The wastewater contributes approximately 50% of the Makoura Stream flow at the point below the current discharge. Investigations have drawn the following findings about the effects of the existing environmental quality of the Makoura Stream:

- The discharge causes a conspicuous change in water clarity at the downstream monitoring point
- The effluent discharge appears to cause significant increases in the concentrations of ammonia-nitrogen and the ANZECC (2000) toxicity guideline for aquatic ecosystems is often exceeded downstream of the discharge
- Water quality both upstream and downstream of the discharge meets the ANZECC (2000) guideline for nutrients in livestock drinking water
- The stream complies with the ANZECC (2000) nitrate-nitrogen guideline for the aquatic ecosystems both upstream and downstream of the discharge
- The discharge has a negligible effect on pH, *E.coli* , nitrate-nitrogen and temperature
- Dissolved oxygen was typically lower than 80% saturation downstream approximately half of the time

5.6.2 Effects on the Ruamahanga River

The impact of the existing discharge is discussed in sections 5.3 and 5.4. Additional information is provided in Table 17 which shows the effect of the existing discharge on the Ruamahanga River in terms of median values of various parameters upstream and downstream of the discharge point. Effects of the proposed upgraded effluent discharge are addressed in Section 8.2. The following overall conclusions can be drawn about the existing environmental quality of the Ruamahanga River (Beca 2004b, 2005; and references noted below):

- The discharge causes a conspicuous change in water clarity in the mixing zone (as measured at 'Rua2'[40] just downstream of Wardells Bridge). However, at 'Rua4' further downstream (measured just upstream of the Waingawa confluence) the water clarity is similar to that upstream of the discharge. [a] (refer section 5.3.2)

[40] Rua1, Rua2, Rua3 and Rua4 are the river monitoring sites.

- There is an increase in ammonia-nitrogen, nitrite-nitrogen and nitrate-nitrogen downstream of the WWTP discharge (refer section 5.3.2). However the river complies with the ANZECC (2000) aquatic ecosystem toxicity guidelines for all the parameters on all monitoring occasions.
- The discharge has a negligible effect on temperature, pH and dissolved oxygen.
- The Ruamahanga River has been sampled upstream and downstream of the discharge for *E.coli* concentrations on more than 130 occasions since December 1999. The MfE/MoH (2003) microbiological bathing water quality guidelines 'alert' level (130 cfu/100 mL) was exceeded upstream (Rua 1) on 20 occasions and downstream of the MWTP (Rua 2) on 34 occasions. The median downstream increase in *E.coli* concentration was 2-fold for these occasions. The upstream contamination is attributable to rainfall runoff with 95% of the 'alert' samples occurring when the average river flow is greater than 2.9 times median flow
- The downstream periphyton levels were below nuisance levels in the 2005 and 2006 annual samplings.
- Pond Leakage does not appear to have a significant effect on groundwater quality, although it may be making a minor contribution to *E.coli* levels in the Ruamahanga River (refer section 5.4.3).

Under the Wellington Regional Freshwater Plan, the reach of the Ruamahanga River where the MWTP is located is managed for contact recreation purposes[41]. The discharge from the MWTP has a long plume, which, at low flows, hugs the right bank of the Ruamahanga River until downstream of Wardells Bridge. The receiving water quality is tested at Wardells Bridge (Rua2 site), which is located in the mixing zone for the Makoura Stream (includes the MWTP discharge).

In summary, the existing discharge, after reasonable mixing, does not have significant adverse effects on the receiving water quality in the Ruamahanga River and on the whole complies with the relevant guidelines in the Wellington Regional Freshwater Plan. Nevertheless, it is apparent that at lower flows, the direct discharge does have somewhat greater adverse effects on water quality, particularly in terms of colour, clarity, nutrients and pathogens.

[41] Refer Figure A1.1 in Appendix A1

Table 17 Water Quality of Ruamahanga River Upstream and Downstream of Makoura Stream Confluence (1)

Parameter	Rua 1 (Upstream of Makoura Stream) Median	Rua 2 (Downstream from Makoura Stream) Median	Rua 4 (upstream from Waingawa River) Median	Rua 1 to Rua 2 Increase
PH	7.31	7.14	7.26	-2%
Conductivity (›S/cm)	124	113	110	-9%
Dissolved Oxygen (g/m^3)	9.5	10.3	11.1	9%
Dissolved Oxygen % saturation (%)	96	92	98	-4%
Black Disc (m)	1.4	1.17	1.15	-16%
Colour - Hue (Munsell points)	37.5	35	37.5	2.5 points change
E.coli (cfu/100mL)	56	130	50	2.5 fold
Ammonia-N (g/m^3)	0.02	0.17	0.02	9 fold
Nitrate-N (g/m^3)	0.549	0.95	0.693	73%
Nitrite-N (g/m^3)	0.003	0.019	0.004	6 fold
Total Kjeldahl Nitrogen (g/m^3)	0.2	0.45	0.15	2 fold
Total Nitrogen (g/m^3)	0.7	1.45	0.9	2 fold
Total Phosphorus (g/m^3)	0.012	0.121	0.025	10 fold
Dissolved Reactive Phosphorus (g/m^3)	0.010	0.099	0.012	10 fold
Turbidity (NTU)	0.72	5.19	3.56	7 fold
Total Organic Carbon (g/m^3)	2.65	3.8	3.65	38%

(1) Data from Beca (2005) for period 4 May 2004–16 May 2005. Sites ustream (Rua 1), downstream of Makoura Stream Confluence at Wardells Bridge (Rua 2), and above Waingawa River Confluence (Rua 4) approximately 0.5 km downstream and fully mixed. Rua2 is within the mixing area of the Makoura Stream (includes the WWTP discharge).

5.6.3 Other Effects

Historically, there has been no ongoing history of odour problems from the ponds resulting in complaints, with one brief recent exception in August 2005, which highlighted the need to desludge Pond 1 (part of the proposed upgrade – refer to section 8.5). Pond odour is monitored weekly in accordance with the MDC's Odour, Air & Noise Management Plan, measuring the odour intensity downwind of each pond. The odour at the Masterton oxidation ponds is typically described as 'weak' to 'very weak' and, only occasionally, 'distinct'.

As described in section 5.2.2, the existing plant is well located and screened to minimise its visual impact and any adverse effect on the landscape.

The proximity of the MWTP to the Ruamahanga River does have an effect of terms of increasing the overall risks from flooding and river erosion, through its location immediately next to the river, but these effects can be satisfactorily mitigated, and the costs of relocation would outweigh such risks.

5.7 Summary of Principal Effects of Existing Discharge

In overall terms, the existing MWTP treatment and disposal system, since it was upgraded in 2003, does not have significant adverse effects on the environment. There are, nevertheless are a number of adverse effects that the proposed further upgrade will address.

5.7.1 Significant Contribution to Degraded Water Quality of the Makoura Stream

Although already in a degraded state before reaching the discharge point, the MWTP makes a significant contribution to the poor condition of the Makoura Stream, with the effluent appearing to cause significant increases in the concentrations of ammonia-nitrogen, with the ANZECC (2000) toxicity guideline for aquatic ecosystems often being exceeded downstream of the discharge

5.7.2 Health Risk

- **Minor contribution to health risk**

The discharge to the river increases the levels of pathogens downstream and contributes, albeit at a minor level, to an increased health risk, particularly at times of low flow when the river is used for primary contact recreation and when the upstream concentrations of pathogens are at their lowest. This increase in health risk is highest at Wardells bridge where the discharge is not fully mixed and decreases downstream to become very low at "The Cliffs". At higher flows, upstream non-point source contamination poses the greatest risk to health.

5.7.3 Nutrients and Algal Growth

- **Build-up of undesirable biological growths in waterways**

The level of nutrients in the discharge in combination with nutrient inputs from upstream can contribute to a build-up of algal growth (periphyton) on the bed of the Ruamahanga River during periods of sustained low flow in the summer. Although this build up is not at nuisance levels, it does have some minor impacts on the recreational and aesthetic values of this section of the River.

5.7.4 Aquatic Ecosystems

- **Effect of organic enrichment on some biological communities**

While the River ecosystem is generally in a healthy condition in of terms of the presence and abundance of aquatic biological species, the abundance of some community groups indicates the organic enrichment of the River downstream of the MWTP.

5.7.5 Recreational and Aesthetic Amenity

- **Reduction of the River's recreational values**

The existing discharge does have some adverse impacts on the recreational values of the river, especially for that section of the Ruamahanga River downstream of the discharge until full mixing is achieved, particularly during periods of low flows (usually in summer). The impacts derive from the slightly elevated health risk, and the aesthetic considerations discussed below.

- **Reduction of the River's aesthetic values**

During summer low river flows in summer, the algae in the treatment process result in a discernible bright green plume from the discharge while mixing with the river water. There is also a reduction in clarity for some distance downstream of the discharge. The visual effect of the discharge plume before it becomes fully mixed has a negative impact on the aesthetic and amenity values of the Ruamahanga. The effect of the added nutrients on the creation of periphyton (algae) on the river bed also has a minor effect on the aesthetic value of the river, particularly at times the river is most valued for recreational use. (at times of lower flows in warm summer periods).

5.7.6 Tangata Whenua Values

- **Effects of the discharge on the mauri of the River**

The Ruamahanga River has traditional significance to Ngati Kahungunu and Rangitaane and is regarded as a taonga (treasure). While the existing discharge does not appear to be degrading the state of mahinga kai, the discharge of effluent directly into the river affects the mauri of the river. The tangata whenua, as the kaitiaki of the Ruamahanga, would prefer that there be no discharge to water except via land.

5.7.7 Conclusion

It is clear that the existing discharge is a major contributor to the degraded water quality in the Makoura Stream into which it discharges. However the effects of the discharge on the Ruamahanga River are generally minor and are principally the result of incomplete mixing in the reach between the confluence with the Makoura Stream and RUA2 (the point for compliance monitoring). The effects of concern are primarily with respect to water clarity and E coli levels, particulalrly at summer low flows when the river is used for contact recreation. Minor effects on periphyton growths (though not reaching nuisance levels) have also been recorded.

6 Description of Proposed Upgrade

6.1 Overview

6.1.1 Key Components of the Upgrade

The value of oxidation ponds as the principal treatment process is discussed in section 4.5.2. The suitability of the existing oxidation ponds to be used as the basis for the long-term upgrade of the MWTP was extensively investigated as part of the upgrade design process, in terms of:

- Risk of natural hazards (earthquakes, flooding and erosion)
- Leakage
- Operations and treatment processes
- Land use and landscape issues
- Affordability
- Alternative treatment processes.

The investigations concluded that the ponds should be retained and enhanced as a key part of the MWTP upgrade, as they are an effective and affordable means of meeting Masterton's needs in achieving good quality effluent, meeting receiving water quality targets, and enhancing the river's amenity, recreational and cultural values[42].

Other associated investigations concluded that the effectiveness of upgraded pond treatment could be further enhanced through land disposal through border irrigation as a secondary treatment process. Land irrigation could also be used as the primary disposal method, considerably reducing the need to dispose treated wastewater into the river[43]. A change to the location and form of the discharge into the river was also identified as an additional means of improving the effectiveness of the MWTP.

6.1.2 Summary of Proposed Upgrade

In summary, the proposed upgrade involves making the following improvements to the existing MWTP:

- The construction and operation of two additional maturation cells in series in the secondary oxidation pond (currently there are two)
- A pump station to deliver effluent to the irrigation area
- Construction of a land disposal/irrigation scheme at Homebush to irrigate effluent to land whenever soil conditions allow (the majority of effluent will be irrigated in summer)
- Desludging of Pond 1 (Pond 2 to be desludged within ten years as part of the Council's Asset Management programme)
- New outfall diffuser located within the Ruamahanga River erosion protection wall
- Establishment of a sludge dewatering area (dewatered sludge to be used as landfill cover)
- Raising the level of the Pond 1 and upstream stopbank to provide protection for a 100-year return period flood

42 Pond Location Report (Beca 2004a)
43 Issues and Options Report (Beca 2004d)

- Erosion protection works on the right bank adjacent to Ponds 2 and 3 and on the left bank at the bend upstream of the ponds and immediately downstream
- Change in discharge regime, from a continuous effluent discharge to the river, to a regime that has land disposal as the first preference.

A key component of the proposed upgrade is the new discharge regime. It involves a balance between the influent (incoming volume of raw wastewater), storage in the ponds (calculated maximum of 275,000 m^3), volumes of effluent irrigated to land and the volumes that have to be discharged to the river. To identify the most effective discharge regime, a water balance model was constructed to determine the volumes irrigated to land, stored in the ponds and discharged to the river. From this model, the operating philosophy for the proposed disposal of treated wastewater was established, based on the following criteria:

- Irrigation of treated wastewater will occur whenever soil conditions allow (summer and winter)
- In summer (1 November to 30 April) there will be no discharge to the river when the flow in the river is less than 12.3 m^3/s (median river flow)
- In winter (1 May to 31 October) there will be no discharge to the river when the flow in the river is less than 6.1 m^3/s (half median river flow)
- Whenever there is a discharge to the river, the river flow will be at least 30 times greater than the discharge rate of effluent (i.e., a minimum dilution of 30X)
- If irrigation and disposal to the river are prevented, or are limited to less than the inflows, then the expanded pond system will be used for storage.

6.1.3 Structure of this Section

This section provides a description of the proposed upgrade, as follows:

- A summary of the projected wastewater loads that the upgraded MWTP will treat and dispose
- How the ponds will be upgraded, including improvements to the existing ponds and the construction of new ponds
- The expected quality and characteristics of effluent to be discharged
- The proposed method of land irrigation of treated wastewater
- The new location and method of discharge into the river
- The proposed discharge regime
- Flood and erosion protection works
- Ongoing asset management works
- How the upgraded plant is to be "future proofed" for further improvements
- The proposed monitoring regime.

Figure 20 shows the layout of the proposed upgraded MWTP, while a schematic diagram of the proposed treatment process is shown in Figure 21. Detailed design plans are provided in Appendix D, while the design of the upgrade is set out in more detail in the Preliminary Design Report (Beca, 2007).

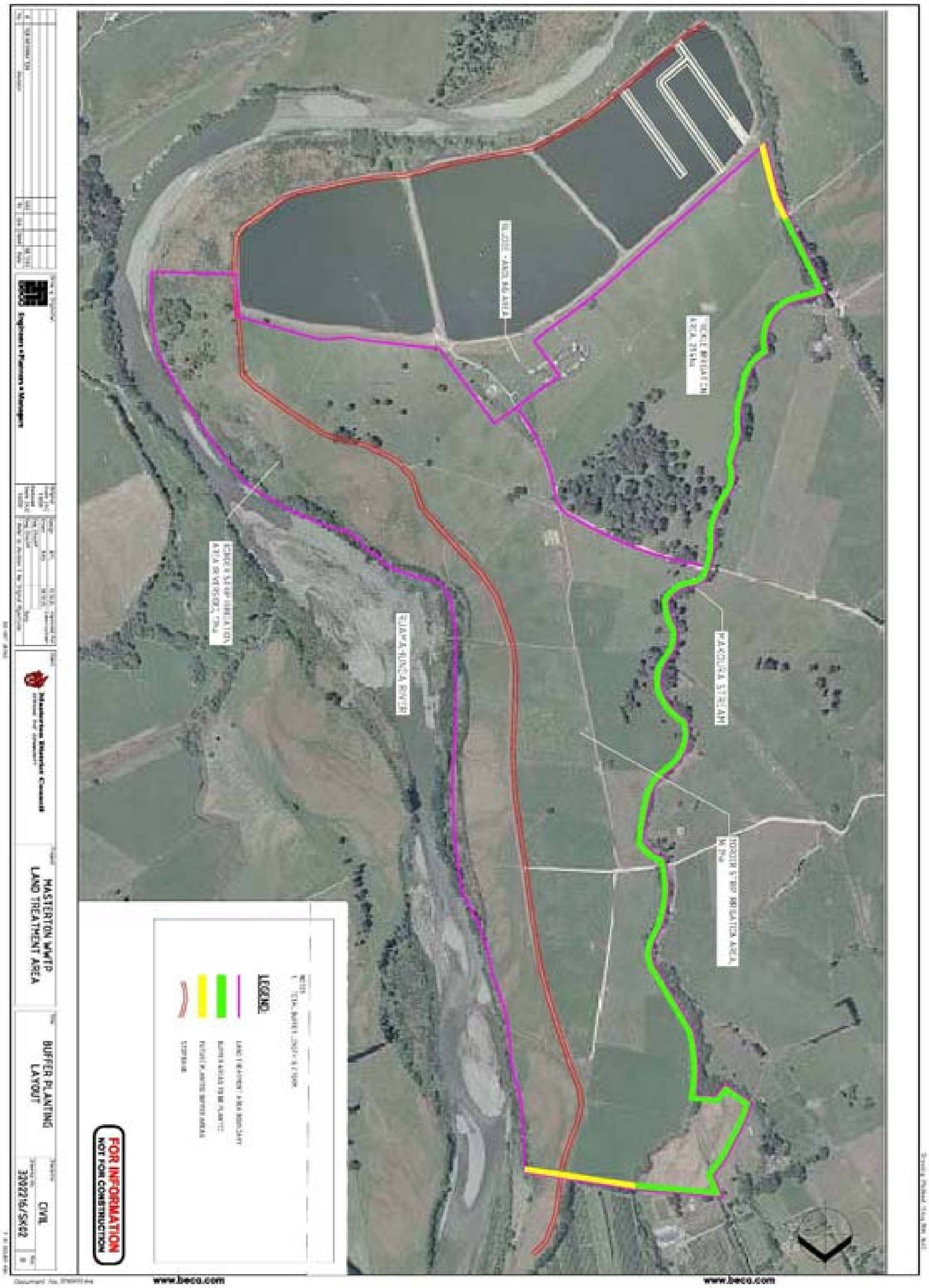

Figure 20 Layout of the Proposed Upgrade

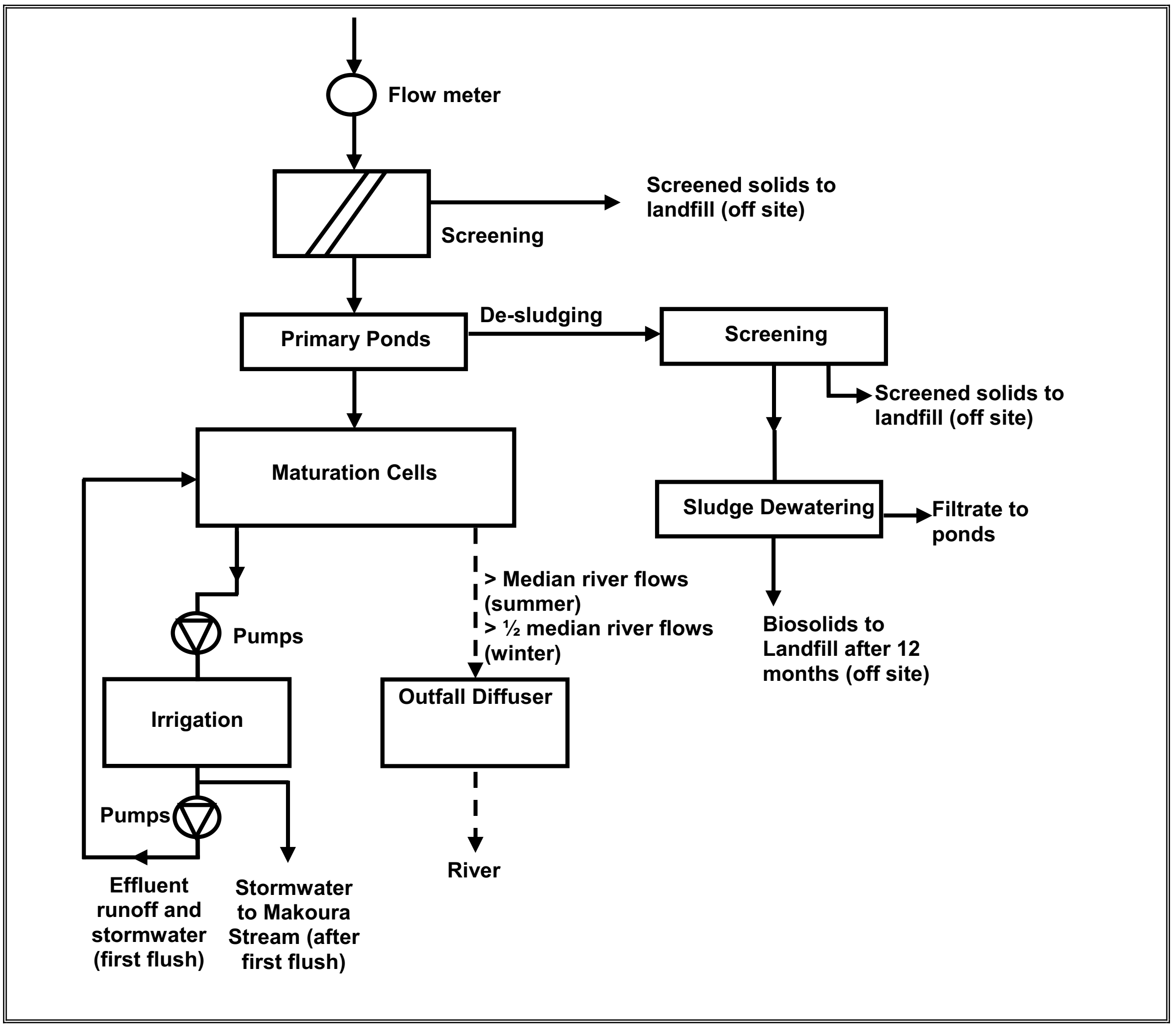

Figure 21 Schematic Drawing of Proposed Masterton Wastewater Treatment Plant Upgrade

6.2 Flow and Load Forecasts

The inflow wastewater to the MWTP was forecast for a 20-year period (i.e., through to 2026), based on Statistics NZ's projections using 2001 census data[44]. This forecast period is considered appropriate as a longer period would mean that less certainty or reliability can be placed on the forecast. However, trade waste projections were only forecast over a ten-year period, as commercial activity carries the highest level of uncertainty: it is assumed that trade waste flow would remain static for the subsequent ten years.

6.2.1 Population

In its population projections, Statistics NZ used three alternative projection scenarios incorporating different fertility, mortality and migration assumptions, which are summarised in Table 18. These projections indicate a reducing district population under either a low or medium growth scenario, and a moderate population increase under the high growth scenario.

[44] GHD, 2006 (preliminary results of the 2006 census indicated that these projections are still valid)

Table 18 Population Projections for Masterton District

Scenario	Projected 2026 Population	2001-2026 Change
High	24,500	1.3%
Medium	22,100	-5%
Low	19,700	-15%

In terms of the urban area that the MWTP services, MDC expects there to be an ongoing moderate rate of greenfields residential subdivision and infill in the urban area into the foreseeable future, based on recent trends, indicating that the town will have a differing rate to the district as a whole. As is occurring elsewhere in New Zealand, much of this urban development is due to a decreasing average household size rather than an actual increase in population: Census results show a trend of decreasing occupancy rate both nationally and within Masterton District (Statistics, 2004d).

Therefore, notwithstanding the projected decrease in population for the District as a whole (except under a high growth scenario), a static domestic urban population was assumed for forecasting wastewater flows to the MWTP over the next 20 years to determine the design flows and loads to the MWTP. A static rate was considered appropriate as this balances an anticipated further reduction in average household size with the continued development of the town (compared with the rural area). The population of the urban area in the 2001 Census was 17,793 which has been adopted as the population that is projected to contribute wastewater to the MWTP over the forecast period.

Accordingly, domestic wastewater flows and loads to the MWTP are expected to remain largely unchanged over the next 20 years, although there may be some reduction in wastewater flows from improvements in water conservation such as the increasing use of appliances with water-saving systems (e.g. dishwashers and washing machines) and half-flush toilet cisterns.

6.2.2 Trade Waste

The growth in GDP for the Wairarapa is projected at 2.9% per annum for the period to 2016 (BERL 2005). This growth rate has been applied to the existing trade waste component of the Masterton wastewater influent to determine the flow and load in ten years time.

For wood and paper product manufacturing, the growth in GDP is expected to be 3.4% per annum (BERL 2005). As it is possible that existing and new wood processing facilities in the district may discharge pre-treated wastewater to the Masterton sewerage system in the future, an allowance was therefore made for the two main wood processing facilities in the Waingawa area to discharge to the treatment plant with the load based on the characteristics of typical pre-treated wood processing wastewater.

6.2.3 Influent Flows and Loads

The current and projected total influent loads (comprising domestic and trade waste loads) are shown in Table 19 below:

Table 19 Current and Projected MWTP Flows and Loads, 2005 to 2015

	Current (2005)				Future (2015)			
	Av. flow (m^3/d)	Peak Flow (litres/sec)	BOD (kg/d)	SS (kg/d)	Av. flow (m^3/d)	Peak Flow (litres/sec)	BOD (kg/d)	SS (kg/d)
Domestic	14,830	692	1,316	1,530	14,830	692	1,316	1,530
Trade	670	8	516	292	1,220	14	710	429
TOTAL	15,500	700[1]	1,832	1,822	16,050	706	2,026	1,959

Note: Peak flow recorded during 5-7 July 2006 storm event.

6.3 Proposed Upgrade of Oxidation Ponds

6.3.1 Maturation Cells and Configuration

The proposed MWTP upgrade involves retaining the existing ponds and enhancing them with extra maturation ponds-in-series. The existing secondary pond will be divided into four maturation cells in series (the number of maturation ponds is generally governed by the required bacteriological quality of the wastewater).

Maturation ponds or "polishing ponds" are a type of waste stabilisation pond that provides further treatment to wastewater following the primary oxidation ponds. The main function of maturation ponds is to enhance the removal of pathogens from the wastewater. Pathogen removal mechanisms in maturation ponds are mainly dependent on sunlight, together with high dissolved oxygen concentrations and retention time.

The maturation cell configuration is shown on Drawing C104 in Appendix D. The use of multiple cells-in-series reduces the potential for hydraulic 'short-circuiting' to occur, thereby increasing the overall treatment efficiency of the pond system.

It is estimated that approximately 20,000 m^3 of gravel will be required to construct the bunds.

6.3.2 Storage in Ponds

The storage capacity of the upgraded pond system is an important aspect of the operation of the treatment and discharge regime, as –

- The land cannot take all of the daily volume of summer influent (see section 6.4) and the excess wastewater must be stored in the ponds until it can be irrigated to land or, when in-river conditions are met, discharged to the river; and
- Land irrigation can be interrupted by wet weather, and therefore the wastewater would need to be stored in the ponds until it can be irrigated to land or discharged to the river (again, only when in-river conditions are met).

Due to these factors, as well as variable influent rates, the discharge regime would therefore result in variable water levels within the ponds.

The proposed discharge regime requires a maximum storage volume of 275,000 m^3 until irrigation and/or discharge to the river is possible, compared with the storage capacity of approximately 363,000 m^3 that the existing ponds can provide, based on a top water level of RL 88m (MSL datum). The relatively large storage capacity will also assist in buffering for peak flows during wet weather.

Accordingly, there is sufficient storage within the oxidation ponds, with some excess capacity, to adequately cater for weather fluctuations, with contingency for conditions beyond the eight years of weather data used in the modelling.

In order to cater for the greater fluctuation in water levels that will occur in the ponds (compared with the existing situation) the internal face of the pond embankments will have enhanced wave protection incorporated. This will involve removing the existing concrete wavebands and placing rock rip rap lining around the full internal perimeter of the pond embankments, and extending it to the level of the maximum storage capacity of the ponds. The net volume of rip rap involved in this construction is estimated to be 11,000 m^3 which requires a gross volume of 20,000 m^3 to be screened to produce the graded rip rap.

Given that the modelling is based on historic statistical data, there is a small risk of an unusual event whereby land irrigation and discharge to the river are both prevented and there is insufficient storage in the ponds. However, given all the constraints and factors that have been designed into the modelling and design of the proposed upgrade, this occurrence will be such an unusual event that it would represent an emergency in terms of the Resource Management Act. Consequently, it is not proposed to seek to have such an eventuality covered by the consents being sought. If, in future, there was an indication that such an occurrence should be accommodated, it could be addressed by way of a future variation to the consent.

6.3.3 Aerators

Brush aerators will be installed in each maturation cell. The purpose of these aerators is to promote mixing and circulation within the ponds, thereby maximising retention time for the wastewater.

In addition, the aerators will be used to minimise the growth of blue-green algae that tend to form in oxidation ponds under hot and still weather conditions. These are undesirable because they form floating mats that decay, emit odour and they fix nitrogen from the atmosphere. They can also release toxins, which could be released into receiving water and land through the outfall to the river or the irrigation scheme.

6.3.4 Pond Lining

As outlined in section 4.5, the existing ponds do not have an “engineered” lining, although the perimeter of the ponds was provided with a nominal silt layer. Investigations into the rate of pond leakage and its effects, particularly on groundwater, were carried out as part of the design process, the findings of which are summarised in section 5.4.

The effects of leakage are summarised in section 8.2.10.

6.3.5 Pond Desludging

Pond desludging, while an infrequent event (every 20 to 30 years, depending on the loading), is a normal part of pond maintenance requirements.

The proposed upgrade includes desludging Pond 1 prior to the operation of the upgraded scheme. The sludge from the pond will be dredged while the ponds are full, as they cannot practically be drained down due to the high groundwater level at the site. Dredging of Pond 1 is expected to take in the order of three months. A small layer of sludge (approximately 100mm) will remain at the bottom to limit leakage.

While the pond is being dredged, it can be taken out of service without detrimentally affecting the treatment processes in the ponds. During this operation, the full wastewater flow will be diverted to the Pond 2. In addition, the clear liquid obtained from the dewatered sludge will be returned to the operating pond and result in an increase in organic loading. This process will be carried out during the summer months when the warmer temperatures would allow a higher loading rate in the one pond. The pond in service would use the brush aerators and the ‘AquaJet’ aerators to provide additional aeration

Dewatering of the sludge is required to remove excess water to reduce volume of sludge and to thicken it to a consistency where it can be easily handled for transportation and reuse. The dredged sludge will be screened prior to dewatering to remove rags and other debris that has accumulated in the sludge (for approximately the first 20 years the ponds were operated without an inlet screen). Dewatering will be carried out on-site using geotubes or other appropriate dewatering technology.

Geotubes (an example of generic geotextile bags) consist of a bag made from a geotextile that allows the sludge filtrate to pass through but prevent rainwater from entering. The dredged sludge is pumped into the Geotube and allowed to stand for a period of time depending on the dryness of the sludge required. The sludge entering the Geotube would at first comprise approximately 1–2% solids, increasing up to approximately 40% after one year. A polymer is added to the sludge to assist in the dewatering. Typical polymer dosing rates are 2 to 4 kg/tonne of dry solids.

The Geotubes will be placed in a dedicated sludge dewatering area, which will be lined to contain the filtrate, and the area is graded to allow the filtrate to be collected and pumped back to the ponds. The liner will be either polyethylene or a liner constructed from selected on-site soils with a low permeability. The preferred option will be confirmed at the time of detailed design. Geotubes are rested on a drainage blanket to collect the filtrate. Each bag has a capacity of 2,000m^3 of sludge. Thirteen bags will be needed for the 26,000m^3-27,000m^3 of sludge in Pond Nº 1, assumes a depth of approximately 100mm of sludge remains in Pond 1. Each bag has a footprint of approximately 13.5m x 60m and when full the height varies between 2–2.5m. The Geotubes will require a land area of approximately 1ha.

It is proposed that the dewatered sludge (biosolids) be blended with cleanfill and used at Masterton's Nursery Road cleanfill as final cover material (this proposal will be subject to a separate land use consenting process as part of the landfill consent). The dewatered sludge will remain at the treatment plant site for a minimum 12-month precautionary stabilising period and then be used until it is required at the cleanfill. Stages 1 and 2 of the cleanfill are expected to be ready for cover in mid 2007 and the final stage 9 will be filled in 2021. When Pond 2 is desludged in approximately 2016, this material will be used for the final stages of the landfill cover programme.

6.4 Proposed Land Irrigation

6.4.1 Irrigation Area Overview

The initial MWTP irrigation area occupies approximately 91 ha of land and is bounded to the south by the existing ponds, on the eastern side by the Ruamahanga River, on the western side by the Makoura Stream and on the northern boundary partly by an apple and pear orchard and partly by farmland. (Note that the additional 107 ha of land recently acquired for future irrigation has not yet been investigated and accordingly, is not included in this discussion.)

Border strip irrigation is proposed for the disposal of wastewater to the site. The irrigation layout is depicted on Drawing 110 in Appendix D, an aerial photo of the site.

Generally, there are two different soil types at the site (as described in Section 5 of this report), namely sandy and silty loam soils that are free draining, and silty clay soils that are less free draining. Therefore, two different irrigation rates are proposed in accordance with the different hydraulic capacities of these soils. The adopted irrigation rates are summarised in section 6.4.3.

The original water balance model used a net area available for irrigation of approximately 75ha, comprising 54ha of free-draining soils being irrigated by border strip irrigation and 17ha of clay-rich less free draining soils being irrigated by surface drip irrigation. However, since the initial modelling was carried out, soil hydraulic testing on the site (as detailed in section 6.4.2) determined that the whole area can be irrigated using border strip irrigation at higher application rates than initially allowed for.

The following outputs relate to the proposed scheme that comprises border strip irrigation only:

- Maximum storage volume in the ponds
- Tabulated summaries of volumes disposed to land and river (as detailed in section 6.7.4)

It is important to recognise that the predicted effects of nutrients applied to soils and the groundwater effects at the perimeter of the site are estimates only and are based on specific application rates. It is a fundamental concept of the scheme that the applicant seeks to have the flexibility to vary application rates as site conditions allow, consistent with maintaining 'good practice' with respect to irrigation. In addition, it is intended, during the detailed design stages of the project, to maximise the amount of land used for irrigation. Hence the irrigation areas may increase slightly as a result of the refinement of the design, thereby improving the capacity of the scheme to use land irrigation as the primary disposal method. The potential to vary from the modelled scenario is an important feature of the scheme and is consistent with the modelling of the effects being treated as an estimate. The fact that the original modelling of effects, as described above, is on a different basis from the finally adopted scheme configuration (border strip irrigation over the whole site) is not seen as a significant matter as the change in effects will be minor and are not expected to change the overall conclusions.

The further 107 ha of land which has been purchased by the Council, will potentially allow irrigated volumes to be more than doubled in the near future, however this will be the subject of a specific assessment of environmental effects and separate discharge permit applications.

6.4.2 Use of Poorer Draining Soils

During the early development of the irrigation scheme, an assessment was undertaken of the appropriate liquid application rates (effluent plus rainfall) that will be used as the basis for proceeding with the preliminary design.

At the time of the assessment, it was considered that the heavier soils of the site might require the construction/installation of artificial drainage in order to achieve the design application rates. In order to test this, it was decided to undertake a field trial to determine the type and extent of drainage improvements. The drainage trial was undertaken over two periods, a summer trial in February 2006, and a winter trial in June 2006 (PDP, 2006a).

Key outcomes from the summer trial were:

- An irrigation rate of approximately 15 mm/d was appropriate
- Drainage was adequate at all times except during rainfall events
- Periods of heavy rain caused groundwater levels to rise rapidly, but then fell rapidly following the cessation of rainfall.

With regard to the winter trial, the key outcomes were:

- An irrigation application of 5 mm/d was found to be appropriate
- Rainfall caused groundwater levels to rise rapidly, but then fell rapidly on the day following the rainfall, followed by a slower fall on the following days.

Overall conclusions from the field trial are as follows:

- The widespread use of artificial drainage over the heavier soils is not necessary
- The current average design application depths for the heavier soils could potentially be increased from 5 mm/d in summer to 10 mm/d, and from 0mm/d in winter to 5 mm/d, although winter application could not continue during prolonged rainfall or high groundwater levels, but could resume after several days of no irrigation
- Operational experience may demonstrate that some localised areas may benefit from artificial drainage – this change could be determined and implemented based on operating experience
- The positive results from the trial provide an indication that application depths (effluent plus rainfall) for the free draining soils could be increased above those currently used for the design of the irrigation system.

MDC will need to vary irrigation depths, based on sound operating principles and experience so as to maximise land disposal whilst ensuring that there are no adverse effects in terms of soil structure or run off. This variation is standard practice in the operation of wastewater irrigation systems. Accordingly, it will not be appropriate for the conditions of consent to specify irrigation rates, these can however be detailed in a subsequent management plan which would be adapted from time to time as required.

6.4.3 Adopted Application Rates

The adopted application rates are summarized in Table 20 below.

Table 20 Proposed Average Application Rates

Soil type	Area (ha)	Summer (mm/day)	Winter (mm/day)
Free draining	58	10	5
Clay rich	17	10	0
Total	75		

Note: The application rate is the total liquid applied i.e. effluent plus rainfall

It is noted that although the drainage trial (as discussed in section 6.4.2) indicated a winter application rate of 5 mm/day on the clay rich soils may be possible, there are periods when irrigation could not be undertaken due to potential rapid increases in groundwater during winter. For this reason, and to retain an appropriate degree of conservatism, the updated model has been based on no irrigation to the clay rich soils during winter.

6.4.4 Border Strip Irrigation Method

Border strip irrigation is well suited to free draining soils and pastoral land use systems where there is good ground level control to operate efficiently. It is proposed to irrigate pasture rather than tree plantation because pasture is effective in taking up the nutrients from the soil if a cut-and-carry system is used[45] (see subsection 6.4.8 below). In addition, it is noted that trees are not suitable for use with a border strip system due to the fact that an uninterrupted flow path down the borders is required, and trees would prevent this.

Border strip irrigation is a traditional irrigation method used on farms, using a series of graded strips of land (borders) with levees to contain the water. The effluent is applied to the top end of the strip by a headrace or pipeline and flows by gravity to the bottom end of the strip, gradually soaking into the ground it flows over.

The irrigated area will be formed into a series of graded strips (borders) separated by formed levees approximately 300mm high. Generally, the strips will be approximately 150 to 200m long, with a minimum width of approximately 12m, but may vary depending on site-specific topography.

Effluent will be supplied to each strip by a system of pipelines and bubble-up valves that can be operated independently. Any excess effluent at the bottom end of the border strips will be collected by a wipe-off drain and pumped back to the oxidation ponds. The relatively high infiltration rates of these well drained and moderately well drained soils mean that, under border strip irrigation, average applications depths per irrigation strip are likely to be in the order of 70-100 mm. The irrigation return intervals will be approximately seven to ten days during the summer months, with increased return intervals used during the winter months.

To irrigate the land adjacent to the Ruamahanga River, rider mains must cross the stopbank. The locations for these crossings are indicated on Drawing C110 in Appendix D.

6.4.5 Excess Runoff Recycling System

Excess runoff from the border strips will be collected in a network of drains, called a ‘wipe-off drain’. The wipe-off drain will be a flat swale, large enough to convey the runoff from the border strips. The wipe-off drain along the Makoura Stream will run back to a recycle pump station in the southwest corner of the site (as indicated on Drawing C110 in Appendix D). A similar system will be installed along the Ruamahanga River boundary.

There is a small area at the northwest corner of the site, from which runoff from the border strips will drain back into the gravity sewer via a manhole. The recycle pump station will operate when irrigation is taking place and for a two-hour period after irrigation has ceased (called the first flush). This two-hour period will allow for surface runoff of effluent to be pumped back into the oxidation ponds.

[45] The pasture is regularly cut and carried offsite for feeding to stock (i.e., no stock shall directly graze the irrigation site)

Flows reaching the recycle pump station two hours after irrigation has ceased will be stormwater, and hence will be suitable for direct discharge to a waterbody.

6.4.6 Discharge of Stormwater Run-off

The 'wipe-off' drain network would also collect stormwater at times when effluent irrigation is not being applied – i.e., during rainfall. As outlined above, therefore, stormwater from the irrigation area would be collected by these drains and either channelled to the Makoura Stream or to the Ruamahanga River. The level of contamination in this stormwater will be negligible as it will essentially be stormwater with minimal contribution from effluent.

6.4.7 Buffer Strip and Screen Planting

A ten-metre buffer area along the boundaries of the irrigation area will be established as part of the upgrade. The buffer bounding the Makoura Stream and the northern boundary will be planted in a range of evergreen tree species (for example, Leyland Cypress).

This buffer strip will provide an appropriate setback distance from waterways and adjacent properties that is free of irrigation and other MWTP operations. The planted boundary will also screen the site from properties to the west and north of the site. The planted buffer areas will be watered by a drip irrigation scheme, at least until the trees are established.

6.4.8 Proposed Cut-and-Carry Pasture Management

A cut-and-carry pasture system is proposed for the area that will be irrigated by border strip irrigation. A cut-and-carry system involves periodically harvesting the pasture (and hence the assimilated nutrients) in silage or balage (wrapped bales) to remove it from the growing area.

Fonterra's May 2005 revised policy on human sewage application to dairy farms only permits very high quality treated wastewater (i.e., treated with UV disinfection) being spread onto pasture fed to dairy cows. The proposed quality of the effluent from the upgraded oxidation ponds therefore would exclude the silage or balage being fed to dairy cows. However, it has been confirmed that there will be a demand in the area locally by dry stock farmers for the harvested silage or balage (David Baker, Baker & Associates Ltd, *pers comm.*).

Cut-and-carry pasture provides the ability to assimilate large quantities of nitrogen and phosphorus from the applied effluent. The nutrient uptake in pasture varies, depending on the quantities of nitrogen and phosphorus that are applied to the land and the rate that the pasture can assimilate them. With the proposed quality and quantity of the effluent, it is likely that pasture growth will become limited due to a deficiency of nitrogen. This deficiency will be addressed by including some nitrogen fixing species within the pasture mix. It is noted that pasture has a proven good growth record at this site, which can have relatively high groundwater table conditions at certain times, even during summer.

It is proposed that a perennial ryegrass pasture mix be used, together with white and/or red clover due to the nitrogen deficiency that is likely to occur at the site.

Inherent in a cut-and-carry wastewater irrigation operation is the need to exclude grazing animals, although limited use of grazing animals (for example, sheep) will be beneficial at certain times of the year to 'tidy up' those areas unable to be harvested.

The pasture dry matter yield is likely to be in the range of 12,000-16,000 kg/ha/yr.

Good management of the crop/water/soil system is very important to the successful operation of a cut-and-carry pastureland treatment system. The following important management issues for a cut-and-carry pasture system have been based on experience from Taupo District Council's land treatment cut-and-carry system (Mike O'Connor, AgResearch and Colin Light, Taupo District Council, *pers comm.*) and local knowledge (David Baker & Associates, *pers comm.*):

- Prior to harvesting the pasture should be spelled for a period of at least ten days with no treated wastewater irrigation being applied
- Harvesting of the pasture should occur whenever there is a yield of approximately 3,000 kg dry matter per ha, with harvesting generally confined to the months of September to May
- It will be important to avoid having heavy harvesting equipment on the land at times of wet soil conditions, with balloon tyres used on harvesting equipment to reduce damage to soil structure
- Weeds will need to be controlled to maintain good pasture quality
- With a cut-and-carry system it is likely that potassium will become deficient and hence would need to be applied regularly to the land
- It is expected that pastures would need to be regrassed every four to six years, using direct drilling to avoid cultivation
- Regular monitoring of the soil/plant system is important so that potential problems can be identified and addressed before they become significant issues; such monitoring should also include the preparation of a regular nutrient budget.

6.4.9 Treatment Capacity of Soils

The soil acts as a reservoir to filter, retain or remove particular constituents from the effluent. The degree of effluent renovation will depend on the interaction between soil processes and water movement. To be effective, the effluent needs both a sufficient residence time and adequate travel distance in the soil to adsorb and attenuate. The main potential for adverse outcomes to occur relate to pathogens (bacteria) and nutrients (phosphorus and nitrogen) leaching from the base of the root-zone into the receiving waters. The water balance model used to calculate the pond storage volumes was also used to determine the filtering ability of the soil (HortResearch, 2007). The results are summarised below.

Nitrogen

Total nitrogen content of the effluent proposed for land application is about 12 mg/L, on average. The applied nitrogen is in the form of ammonium and nitrate. Ammonium adsorbs to the soil's mineral and organic matter and is also rapidly oxidised to nitrate by microbial processes. Nitrate is highly mobile and would travel freely though the soil, being transported downwards along with the percolating effluent.

For the proposed scheme, nitrate leaching will be of little concern with regard to potential contamination of the groundwater as a result of effluent application. Figure 22 below shows the profile of nitrate-nitrogen in the soil water for sites 3 and 7. The solution concentration in the effluent at 1 m depth will remain well below the NZ Drinking Water Standard of 11.3 mg/L of nitrogen, even after a period of 28 years of irrigation to the soil (as shown in Figure 22). There is unlikely to be any significant accumulation of nitrate in the soil profile over time, because nitrogen uptake by the pasture can easily account for all of the applied nitrogen. Furthermore, the cut-and-carry process for pasture would remove a large fraction of the pasture nitrogen from the site leaving little excess nitrogen to leach.

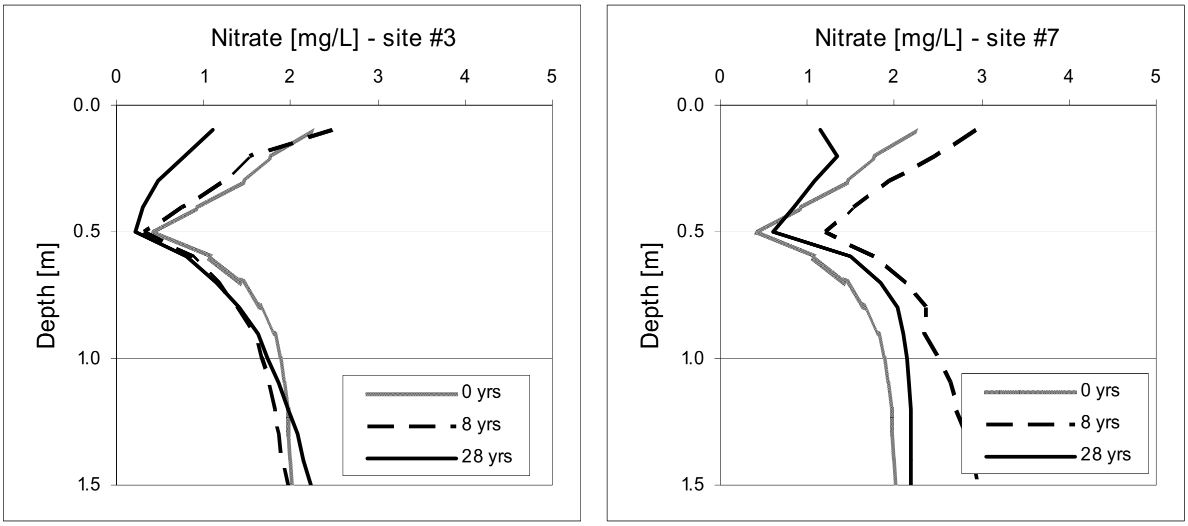

Figure 22 Profile of Nitrate-Nitrogen[46]

Note: Site 3 is a clay rich soil, and site 7 is a free draining soil.

Phosphorus

Phosphorus (P) is a relatively immobile element in most New Zealand soils. When applied to land, it would normally be bound to the soil and accumulate within the top 10-20 cm of the root-zone where it can be taken up by plants. The total phosphorus content of the wastewater will be on average 3.2 mg/L. Most of this phosphorus is in the form of dissolved reactive phosphorus (DRP) which is readily taken up by plants, yet strongly adsorbed to the soil's mineral and organic surfaces. Because the ability of soils to adsorb DRP varies greatly, equilibrium sorption isotherms were constructed for the range of soils at the site (HortResearch, 2007).

The results of investigations at the site show that the P retention capacity on all soils is very low: 8-19% (HortResearch, 2007: Table 3). This retention capacity means the surface soil could become "saturated" with phosphorus, under a heavy load, thereby possibly enabling some leaching of P to occur.

Figures 21 and 22 below illustrate the situation for two areas within the site that would receive different amounts of effluent. Site 3 (the clay rich heavier soil type) receives the lowest effluent input equivalent to about 28kg P/ha each year (see Table 21). Over 28 years of effluent application, 61% of the applied phosphorus would remain in the top 1m of soil and the concentration of P entering the ground water would remain below 0.02mg/L.

In contrast, site 7 would receive the highest wastewater input, with some 63kg/ha of phosphorus being added each year (see Table 21). The topsoil here has a lower P retention capacity because of lower clay content, which would result in a greater amount of the surface-applied P moving downward through the soil profile. Over a 28-year period, 66% of the applied phosphorus would remain in the top 1m of soil and the concentration of P entering the groundwater would remain below 0.2 mg/L.

46 In-soil water solution draining through soil, site 3 with an annual loading of 130 kg N/ha at site 3, and 290 kg N/ha at site 7 – the NZ Drinking Water Standard for nitrate nitrogen is 11.3 mg/L.

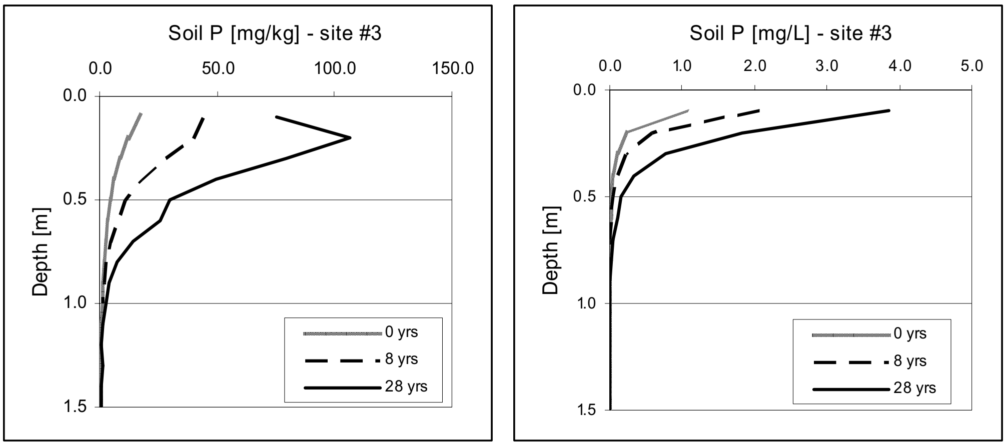

Figure 23 Predicted Concentration of Soil Phosphorus and Soil Solution Concentration at Site 3

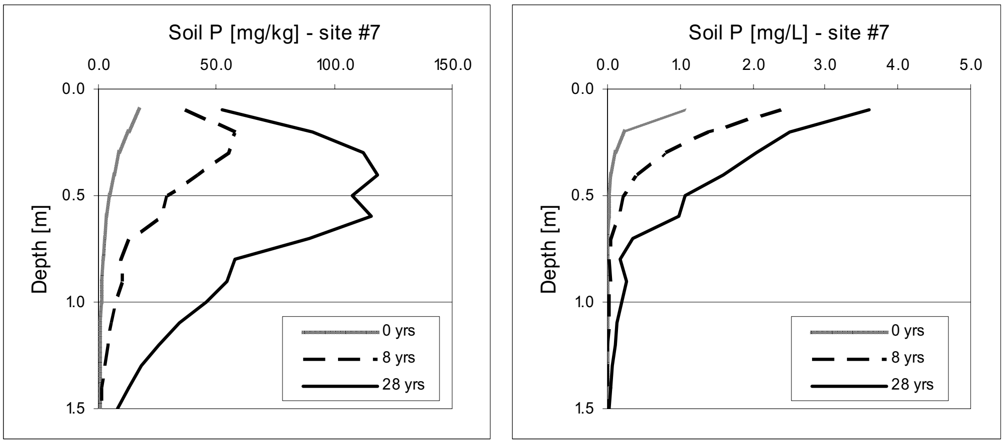

Figure 24 Predicted Concentration of Soil Phosphorus and Soil Solution Concentration at Site 7

Bacteria

The effluent contains a variety of pathogens, including bacteria and viruses. Land application of effluent may increase the risk of groundwater contamination by these pathogenic micro-organisms, which can cause disease in humans and livestock.

The NZ Drinking Water Standard for bacteria is currently set at <1 cfu/100 mL. Groundwater concentrations that exceed this guideline value are indicative that faecal matter and possibly other disease-causing organisms (pathogens) may be present. For the purposes of analysis, the average *E.coli* concentration of the wastewater was set at 1000 cfu/100 mL[47].

Two main processes remove bacteria from the soil. Colloidal filtration is the process by which bacteria are intercepted by and 'stick' to soil particles. Inactivation represents the rate of bacteria 'die off' under natural conditions. These processes were modelled to assess the environmental risks of bacteria reaching the groundwater. The results of the analysis are plotted in Figure 25.

47 Winter effluent quality (refer section 4).

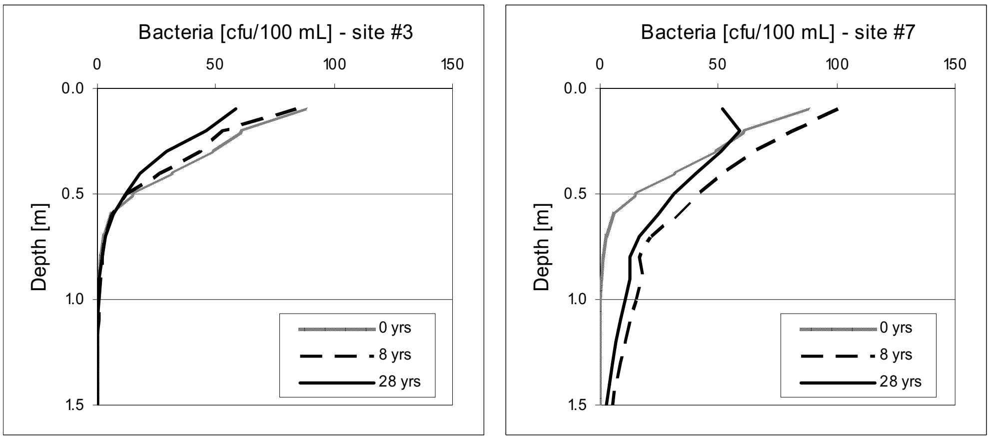

Figure 25 Soil Bacteria[48]

Figure 25 above shows the expected bacteria removal rates in the drainage water at Sites 3 and 7. Between 95 and 99% of surface-applied bacteria will be removed during transport through the top 1 m of soil. Leaching to groundwater accounts for the remainder. There would not be any accumulation of bacteria numbers over time. Drainage water concentrations at 1 m exceed NZ Drinking Water Standards by a significant margin as shown in Figure 25 for site 7. However, additional die-off and dilution in the groundwater will act to reduce these concentrations further (the impact on groundwater is discussed in section 8.2.10).

6.4.10 Nutrient Uptake by Crops

The irrigation site soils will be planted in a perennial ryegrass and clover sward. Such pastures are normally high yielding on fertile sites, and they have the potential to remove large amounts of nutrient annually (500–600 kg/ha of N, 130–160 kg/ha of P, 140–160 kg/ha of K) under a cut-and-carry operation (HortResearch, 2007).

Table 21 below summarises the average values of the nutrient budget of crops on the irrigated pasture.

Table 21 Estimated Nutrient Budget[49]

Component		site 3 (kg/ha)	site 7 (kg/ha)
Inputs	Hydraulic load [mm/year]	1,140	2,500
	N effluent	130	290
	N fixed by clover	160	180
	P (effluent)	28	63
Outputs	DM harvest	9,300	12,100
	N harvest	300	420
	P harvest	20	35

Note: Refer to Figure A3.1 in Appendix A3 for location of sites 3 and 7.

48 Soil bacteria (solution concentration) at site 3 (low hydraulic load) and site 7 (a high hydraulic load)
49 An estimated nutrient budget for 'cut and carry' pasture (sites 3 and 7); unless otherwise stated, all units are kg/ha/year. (Source: HortResearch, 2006. Table 4)

The pasture would take up some 300-420 kg/ha of nitrogen per year, including an annual nitrogen fixation of between 160-180 kg/ha based on 15% clover content. The cut-and-carry operation would remove most of the pasture dry-matter (between 75-85%) and nutrients from the site (HortResearch, 2007).

The irrigation adds between 28-63 kg/ha each year to the soil. Some 20-35 kg/ha of phosphorus will be taken up each year by the pasture. This will be subsequently harvested and removed from the site under the cut-and-carry operation.

6.5 New Discharge Location and Method

The proposed upgrade involves moving the discharge point for the effluent from the Makoura Stream to the Ruamahanga River, using an outfall diffuser to the river. Drawing C109 in Appendix D shows the location of the proposed outfall, a plan of the diffuser, and a cross section of the rock embankment in which the outfall will be sited.

The discharge pipes will be below the half median flow levels of the river and, as a result, even in winter the discharge would rarely be visible after reasonable mixing.

The diffuser allows the distribution over a wider area to assist in the mixing within the river. The diffuser comprises a concrete chamber receiving the piped discharge that diverts the flow into a number of pipes (four based on the preliminary design). The concrete chamber will be accessible from ground level for monitoring and maintenance purposes. The outfall pipes will extend to the river-side face of the rock erosion protection and distribute the flow over a wider area than would a single pipe protruding from the erosion protection.

The proposed discharge point and method will offer a number of advantages compared with the existing site:

- It will eliminate any discharge into Makoura Stream, which has a limited assimilation capacity
- It will provide improved mixing and a smaller zone of impact as compared to a discharge into the Ruamahanga River via Makoura Stream
- It will ensure full mixing of a better quality effluent within a much shorter distance, thereby avoiding the adverse aesthetic effects (discoloration and increased turbidity) associated with the currently only partially mixed discharge at Wardells Bridge
- It will facilitate the installation of an outfall structure capable of discharge during high flow events in the Ruamahanga River.

The only potential disadvantage in moving the discharge into the river upstream of the Makoura Stream is that it will put it upstream of an existing irrigation water take and a family swimming hole. However, the water quality will be suitable for irrigation, and the discharge will not be occurring when the hole is likely to be use d(i.e., inbelow median flows during summer periods).

6.6 Expected Quality of Effluent Discharge

The receiving water quality targets for the upgrade are outlined in Section 7.1.1. In conjunction with mixing and dilution calculations, these targets were used to benchmark appropriate effluent standards for the upgrade, and the proposed flow based restrictions on discharges into the Ruamahanga River. The influent and effluent water quality data are outlined below in Table 22, which indicate the expected effluent quality improvement following the upgrade. The proposed treatment upgrades are primarily targeted at achieving significant reductions in faecal bacteria levels, as well as reduced ammonia-nitrogen concentrations in summer.

It is proposed that the existing standards be included in the conditions of consent, with lower *E. coli* compliance standards to reflect the improved treatment system. The percentile standards have been calculated for all monitoring parameters (NIWA 2006b) and are presented and discussed in Section 12.1.1.

Table 22 Comparison of Raw Wastewater and Effluent Quality (Pre and Post upgrade)

Parameter	Raw Wastewater Quality	Existing Effluent Quality (geometric mean)	Proposed Target Effluent Quality
BOD_5 (g/m^3)	158	17.7	No change from existing quality
Filtered BOD (g/m^3)		5.2	No change from existing quality
Suspended solids (g/m^3)	133	22.5	No change from existing quality
Total Nitrogen (g/m^3)	19.1	10.1	No change from existing quality
Ammonia-Nitrogen (g/m^3)	11.5	0.7 3.0	No change from existing quality
E.coli (cfu/100 mL)	1,440,000	485 651	200 (summer) No change from existing quality (winter)
Dissolved reactive phosphorus (g/m^3)	2.4	2.4	No change from existing quality

Notes:

1. *Raw wastewater quality data as detailed in Table 8*
2. *Existing effluent quality data is based on results of testing since July 1994 (n = 180), and following the interim upgrade of the oxidation ponds in 2003 for* E. coli *(n = 65 summer, 43 winter), to April 2006 (NIWA 2006b).*

It is important to note that the upgrade to the oxidation ponds is focussed on reducing the *E.coli*level in the effluent. Improvements in terms of impacts of other parameters in the effluent are being addressed by the proposed discharge regime. (maximising discharge to land and ensuring no direct discharge to the river at times when it it is most sensitive to such discharge)

6.7 Proposed Discharge Regime

6.7.1 Operating Philosophy

The proposed discharge regime for disposal to land, river, or a combination of both has been developed following numerous iterations of a water and nutrient balance model for the site (HortResearch, 2007). The model, based on historical records for influent flows and river flows, yields practical volumes for irrigation, storage and discharge to the river for a given discharge regime.

The operating philosophy of the proposed upgrade seeks to maximise application of effluent to land when the soil conditions allow for irrigation and to minimise the volume of effluent discharged to the river, particularly in the summer when the river is the most attractive for swimming and other contact recreation activities. To achieve this goal, the proposed upgrade regime will prevent the discharge of wastewater into the Ruamahanga River whenever river flows are below median flow (12.33 m^3) during ‘summer’ (November to April) and at flows below half median (6.15 m^3/s) during ‘ winter’.

In terms of the proposed effluent discharge to land, the eventual maximum operational irrigation rates for the land will be confirmed after an appropriate period of monitoring soil conditions. In the long-term, different rates will need to be applied to different sites within the irrigation area, depending upon the nature of the soils. The irrigation regime is discussed in more detail in section 6.4.

6.7.2 Proposed Dilution Factor

A dilution factor of 30 is considered to be an appropriate value for oxidation pond wastewater discharges to freshwater. This means that the flow in the River will always be at least 30 times greater than the rate of effluent discharge.

Previous work of relevance to the proposed scheme for Masterton indicates that a dilution factor of 30 to 50 should usually prevent any stress on benthic invertebrate communities from occurring (Quinn & Hickey 1993). Other work reports that a dilution factor of 30 or more will also reduce the degradation of clarity in a clear stream from an oxidation pond effluent of average clarity[50]. The effects of the discharge on the river clarity are discussed later in section 8.2.

6.7.3 Trigger Conditions for Discharge to River

As discussed in section 7.1.4, a site-specific study was undertaken by NIWA with regard to developing a site specific receiving water target for DRP, which concluded that the DRP target should apply at below half median river flow (NIWA, 2003 and 2004a). In other words, it was recommended that the half median river flow be the "trigger flow" to initiate a discharge to the river. Although this regime was considered appropriate in terms of nutrients, it was decided to adopt a more conservative "trigger flow" of median river flow during the summer to further reduce any impact on health risk during periods when recreational use may still occur albeit at a lower intensity (i.e., during flows between half median and median). Thus, it is proposed that a discharge into the river over summer will only occur at times when the river is at higher flows, which is during and immediately after times of rainfall when river conditions are not conducive to contact recreation (i.e., colder water temperatures, more turbidity and discolouration). At flows above median the upstream water quality is poorer in terms of pathogens and clarity and accordingly at flows above median the discharge will have relatively less impact.

The proposed discharge regime also includes a requirement for discharges to be proportional to river flow to maintain a minimum dilution factor of 30, as discussed in sections 6.7.5 and 6.7.6 below.

The major advantages of the proposed discharge regime are:

- Summer discharge to the river will only occur at times of higher river flows when such additions are unlikely to stimulate algal growths due to unsuitable conditions (i.e., greater dilution, lower temperatures, higher turbidity, higher velocities and greater scouring of attached algae)
- The prevention of discharge at less than median flows during summer will considerably reducing nutrient contribution at the time when it matters the most – that is, when the discharge from non-point sources is low, and the river is most vulnerable to the proliferation of undesirable biological growths because it is warm and clear and there is insufficient flow for scouring
- This regime will also reduce visual effects and health risk by ensuring the discharge is at times when little if any primary contact recreation will occur and where upstream microbiological quality and clarity is poorer
- The elimination of winter discharge to the river at low flow conditions (i.e., below half median) is eliminated, also leading to a reduction in the aesthetic impact of discharge
- The minimum dilution requirement and the proposed discharge location and method will ensure that receiving water quality guidelines (particularly in terms of colour and clarity) will be fully met well upstream of Wardells Bridge. Full mixing will occur at 800m which is well upstream of Wardells Bridge.

50 Assuming a clear stream from a pond at median level of clarity (Hickey, Quinn, Davies-Colley 1989).

6.7.4 Determination of Discharge, Irrigation and Storage Volumes

A water and nutrient balance model (HortResearch, 2007) was used to forecast river discharge volumes, wastewater irrigation volumes and pond storage requirements. Key factors used in the modelling are outlined below:

- The model calculations were based on weather data and records of influent and wastewater flows between 1997 and 2005. Although, suitable weather data is available for a longer period, modelling is limited to the period where wastewater flow data is available. However, the model does take into account past variations of weather patterns.
- The volume of pond leakage initially used for the model was a single value of 490 m^3/d, based on the best available data at the time. Subsequent investigations have lead to the adoption of higher leakage rates, as described in section 5.4.3. The effect of using higher leakage rates in the water balance model is to reduce the volume of storage required, and this outcome is detailed in the results presented in this report (refer also section 6.4.1).
- The model used average daily values of river flow to calculate the volume of wastewater to be discharged to the river. In reality, river flows can vary considerably throughout the day. Since the actual discharge to the river can only occur when the instantaneous discharge is above median river flows in summer and half median river flows in winter, there will be a minor variance with the average flows used in the model.
- In summer, a minimum discharge volume of 35,000 m^3 was set as a means of avoiding frequent short duration discharges to the river. In winter, a minimum discharge was not applied
- For the average summer irrigation application, a cut-off rate of total liquid of 10mm/d[51] was used for the water and nutrient balance modelling.

The model contains a number of simplifying assumptions and approximations regarding the many complex and inter-related processes that occur when wastewater is applied to land, such as soil water and nutrient flows, pond leakage rates, weather conditions and soil variability. As such, the model cannot predict exactly how the system will perform as some of these factors may change in an unpredictable way over the lifetime of the MWTP. Nevertheless, modelling is an appropriate tool to enable a prediction of the performance of the system, in advance, under a defined set of disposal rules.

In regard to land irrigation rates, the proposed rates may prove to be overly conservative once the scheme becomes operational. MDC seeks that conditions of consent provide flexibility and do not specify irrigation rates. Instead, conditions should be directed at ensuring that irrigation rates are optimised to maximise irrigation whilst avoiding surface runoff and/or water logging the soils.

Table 23 below provides a summary of the average seasonal volumes and occurrences of discharges to land and the river based on average values for the year's climate, influent wastewater volumes and river flow data. Table 24 provides a monthly summary of the average daily volume and occurrences of discharges to land and the river based on an average year's weather, influent wastewater and river flow data (noting that there could be a simultaneous discharge to the river and to land).

It should be emphasised that the relative proportion of discharge volumes to influent volumes do not necessarily equal 100% for each period, as the modelling takes into pond leakage and the occasional need to store wastewater in the ponds before it is able to be discharged. It should also be noted that the average daily application volumes are expected to vary in terms of maximums and minimums applied on any given day or period depending upon soil and weather conditions.

[51] The estimated annual average soil moisture capacity (HortResearch 2006)

Table 23 Summary of Average Seasonal Discharges

Season	Daily Average Influent Flow (m3/d)	Daily Average Discharge to River (m3/d) (% of inflow)	Daily Average Discharge to Land (m3/d) (% of inflow)	Average Nº of days/month of no river discharge	Average Nº of days/month to land	Average Nº of days/month to river	Average Daily River Flow (m3/s)
Summer	13,330	6680 (45)	4,945 (41)	26	27	4	15.39
Winter	17,380	15,120 (85)	2,305 (15)	2	26	28	31.29

Note: Data from 1 January 1997 – 30 September 2005

Table 24 Summary of Average Daily Discharge

Month	Daily Average Influent Flow (m^3/d)	Discharge to River (m^3/d)	% of inflow to river	Discharge to Land (m^3/d)	% of inflow to land	% of days/month of no river discharge	% of days/month to land	% of days/month to river	Average Daily River Flow (m^3/s)
January	12,865	4,841	32	5,481	46	92	90	8	12.1
February	12,877	5,681	35	5,068	45	90	89	10	16.5
March	12,534	6,737	52	4,887	43	87	90	13	12.0
April	11,974	6,123	48	4,356	38	88	91	12	11.5
May	12,796	13,226	101	2,320	20	31	87	69	18.0
June	15,777	13,472	84	2,164	15	3	86	97	33.0
July	19,330	16,976	86	2,093	12	-	83	100	33.4
August	19,441	16,779	84	2,278	13	1	86	99	32.5
September	17,272	14,053	78	2,447	16	7	83	93	24.8
October	19,856	16,264	78	2,552	15	7	83	93	47.7
November	15,232	8,207	48	4,950	35	84	86	16	20.5
December	14,823	8,809	54	4,925	37	82	85	18	21.0

Note: Using data from 1 January 1997 – 30 September 2005

Finally, it should be noted that these volumes relate to the initial land disposal area. Once the additional 107ha of land becomes available the total volumes of discharge to land are likely to more than double with a corresponding decrease in the volume discharged to the river. It is not at this stage proposed to change the discharge triggers (median and half median flow). In practice, however, the additional irrigation area will allow less frequent and/or shorter duration discharge and/or a lesser volume of discharge in the future. This in turn will in the future lead to greater dilution than the 1:30 minimum proposed.

In brief, the key points to note from these tables are:

- In summer the effluent is applied as irrigation for the significant majority (approximately 90%)of time with only 4 days per month on average where there is a discharge directly to the river. It is important to recognise that this outcome is based on modelling that includes as one of its rules a minimum summer discharge of 35,000m^3 (as referred to above). This particular rule is influential in reducing the average number of days of discharge in summer to 4, which represents a desirable outcome. However, whether this outcome will be fully implemented is dependant to some extent on experience that will be gained by the operator of the scheme in terms of accounting for daily inflow, rainfall, state of the irrigation site and the general weather pattern at the time. The other end of the spectrum in terms of this aspect of the scheme is to adopt a zero minimum discharge. Under this scenario there would be a discharge to river whenever the river flow reaches median, which in turn would mean that the number of days of discharge to the river (in summer) would increase to approximately 10 based on the river flow record showing that in summer the river flow is above the median flow for approximately 33% of time in summer (refer section 8. 2.1)
- In winter, there is still a high proportion of days (approximately 85% of time) when irrigation of effluent occurs, although a smaller volume is irrigated compared to summer. Also during the winter period there is a high proportion of time (approximately 92%) when ther will be a discharge of effluent to the river

Again, it is noted that these figures do not allow for the additional discharge area recently purchased. Once this is in use there will be a significant reduction in the volume and/or frequency and/or duration of discharge to the river.

6.7.5 Summer Discharge Regime

Frequency and Volume of Discharge to Land vs. River

As an indication of the output from the model for a dry summer, Table 25 and Table 26 below tabulate results for the summer of the year in which the maximum storage volume occurred. The results show very little difference from 'average' situation as presented in Tables 23 and 24 above. In practice it is considered very likely that, in a dry year, the most permeable of the free draining soils could accept irrigation of up to 50% more than the irrigation rate used in the model, with a corresponding proportionate increase in the volume of effluent discharged to land.

Table 25 Summary of Summer (1 Nov '98 – 30 Apr '99) Average Discharge (for Maximum Storage Year 1999)

Season	Daily Average Influent Flow (m3/d)	Daily Average Discharge to River (m3/d) (% of inflow)	Daily Average Discharge to Land (m3/d) (% of inflow)	Average Nº of days/month of no river discharge	Average Nº of days/month to land	Average Nº of days/month to river	Average Daily River Flow (m3/s)
Summer	13,075	6,667 (48)	5,121 (41)	27	26	4	12.8

Note: Summary of data from summer of 1 Nov 1998 to 30 Apr 1999), with average discharge for Maximum Storage Year 1999

Table 26 Summary of Summer (1 Nov '98 – 30 Apr '99) Average Discharge (for Maximum Storage Year 1999)

Month	Daily Average Influent Flow (m^3/d)	Discharge to River (m^3/d)	% inflow to river	Discharge to Land (m^3/d)	% inflow to land	% of days/month of no river discharge	% of days/month to land	% of days/month to river	Average Daily River Flow (m^3/s)
November	16,737	8,078	46	5,260	32	84	90	16	13.5
December	13,503	7,476	48	5,332	41	87	90	13	19.0
January	12,474	0	0	5,220	43	100	84	0	4.9
February	11,711	5,834	50	5,718	50	93	86	7	6.2
March	12,125	6,674	51	4,941	41	87	90	13	7.1
April	11,899	11,938	95	4,255	37	77	83	23	15.5

Note: Summary of monthly data from summer of 1 Nov 1998 to 30 Apr 1999), with average discharge for Maximum Storage Year 1999

Summer Irrigation Rates to Land

During summer, effluent plus rainfall will be applied by the border strip irrigation at an average rate of 10 mm/d for the purposes of effluent disposal. This amount is a total water balance budget that includes both rain and effluent applied to the land. However, as noted in section 6.7.5, the land may well be able to take up to an average of 15 mm/d (Beca 2007).

The summer average rate at which the effluent alone will be applied is approximately 7-8 mm/d. The effluent will be applied on one day to a series of border strips, which will then be followed by a number of days of rest, before effluent is applied again. For example, a typical application could be 100mm on one day with those borders then being rested for 9 days before receiving another application of effluent.

It is expected that the heavy soils in the south western corner of the site will also be irrigated at an average of 10 mm/day; however, conservatively, for the purposes of the water balance it has been assumed that water will be applied at an average of 5 mm/d (effluent and rainfall) for the purposes of effluent disposal. This approach provides some buffer in the modelling for soil variability and other factors.

Summer Discharge Rates to the River

During summer, river discharges will only be allowed to occur when river flows exceed the median river flow of 12.3 m^3/s[52]. The discharge rate will be increased proportionally with the river flow up to a maximum of 1,200 L/s, and will always be maintained to achieve a minimum dilution factor of 30 times (i.e., the river flow will always be at least 30 times greater than the discharge flow). This ratio is illustrated in below in Figure 26.

As discussed earlier, as the additional irrigation land becomes available average dilution rates will increase.

[52] As measured at Wardells Bridge gauge

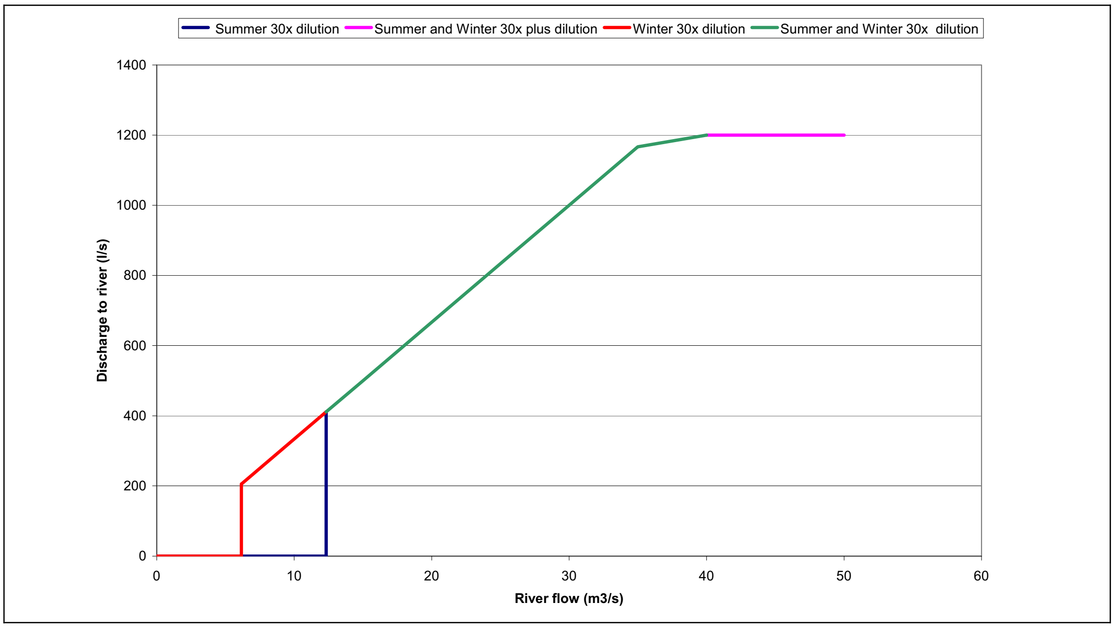

Figure 26 Dilution Relationship as a Function of River Flow and Discharge Volume

6.7.6 Winter Discharge Regime

Winter Irrigation Rates to Land

As detailed in section 6.4.3, the adopted winter application rates are 10mm/day on the free draining soils, and no application on the heavier clay rich soils. It is expected that in practice, there will be periods during winter when the heavier clay soils will be able to have effluent applied, although this will be intermittent. Hence the water balance model has taken a conservative approach.

The application of effluent to the border strips will use the same approach as in summer, that is, application of effluent to the border strips on a particular day will be followed by a rest period before further effluent is applied.

Winter Discharge Rates to the River

During winter the discharge to the river will only occur when the river flow is above half median flow (6.15 m^3/s)[53]. At all times, the discharge to the river will be maintained at a minimum dilution factor of 30, with a maximum discharge rate 1,200 L/s (Figure 26 above).

6.7.7 Likely Impact of Additional Irrigation Area

As discussed earlier in this report, Council has recently purchase an additional 107 ha of land to the west of the Makoura Stream. This land is intended to be used for effluent irrigation, and has considerable benefits for the Upgrade. The additional 107 ha of land has not yet been the subject of specific site investigations and other detailed assessments. These will be undertaken as part of the work to support separate resource consent applications that will be lodged in 2008.

In broad terms, the intended use of the land is for effluent disposal by border strip irrigation, and possibly also drip irrigation if heavier soils are present. The irrigation area will be surrounded by an appropriate buffer zone to provide separation from neighbours. The benefits from the additional area of land are:

4 A greater volume of effluent can be disposed of to land. This could potentially double the volume of effluent disposed of to land compared to the scheme that is currently proposed.

[53] As measured at Wardells Bridge gauge.

4 There will be a corresponding decrease in the volume of effluent disposed to the river. This could be implemented in a number of ways including a reduced frequency and duration of discharge, or a changed rate of discharge (increased dilution) or higher trigger flows.

6.8 Flood and Erosion Protection Works

6.8.1 Flood Protection

As outlined in section 5.3.4, stopbank protection works are needed to address current the flood hazard risks to the existing ponds. The works required include raising the section of the existing stopbank immediately upstream of Pond 1 and raising the pond embankment adjacent to the Ruamahanga River to the same standard (Beca 2007 and 2004d).

This improvement will result in a stopbank top level that has 500 mm of freeboard above the level of the 100-year flood. This level of enhanced standard of flood protection also provides some security in terms of potential adverse impacts from climate change.

A general location plan of the propoded erosion and flod protection works, including a cross-section of the proposed upgraded stopbank, is shown in Drawing C104 in Appendix D.

6.8.2 Erosion Protection

Erosion at the Ponds

The right bank of the Ruamahanga River adjacent to Ponds 2 and 3 is subject to erosion pressure due to the natural meander of the river towards the ponds. Erosion issues have been discussed in detail in the *Issues and Options Report and Technical Report on Recommended Scheme* (Beca 2007).

The rock protection provided by the existing groynes consists of about 150 tonnes of rock. As a standard erosion protection measure, these groynes are an effective river management and protection measure, at least for the immediate future. Over the longer-term, however, the river channel at the site is relatively narrow, and the well-defined single channel form means that the groynes will be subject to strong erosion pressure. Bank erosion during a flood event has the potential to generate an instability collapse of the river and pond embankment.

Therefore it is desirable to upgrade the existing level of erosion protection. It is proposed to remove the existing erosion protection groynes, re-using the rock contained therein, establishing rock lining to the riverbank adjacent to the Ponds 2 and 3 where the river cuts in close to the ponds. Rock lining is proposed as it provides a continuous buttress along the bank to support the pond embankment under seismic loadings, as well as protecting the bank from river erosion.

The steep sections of the existing riverbank, which have a low factor of safety, will be trimmed back to a stable batter of 1.5H:1V. A 1.6 m thick layer of rock will be placed from below the riverbed to the top of the riverbank. In addition, a 4.5 m wide, 1.4 m thick rock toe is to be installed below the riverbed to provide additional support while being at general scour depths estimated to be up to 1.4m. The quantity of rock required is 39-tonnes/lineal metre. Erosion protection on the right bank in the vicinity of Ponds 2 and 3 is proposed to comprise a continuous rock lining over an approximate length of 400m.

In addition, a 950 tonne groyne is proposed at each end of the rock lining to provide protection beyond the ends of the lining, as a transition measure to the vegetated bank. The total quantity of rock required for the right bank is approximately 17,500 tonnes. Approximately 70% of the rock from the existing right bank groynes can be recovered, equating to 1,750 tonnes of rock that can be recovered and re-used for the new rock lining.

Erosion at the Left Bank Bend opposite Pond 1

The existing nine groynes at the bend opposite Pond 1 are 150 tonnes each and require substantial topping up to provide more robust protection. An additional 200 tonnes/groyne is proposed, with two additional groynes of 400 tonnes and constructed to the 2-year flood height. This requires a total of 2,600 tonnes of rock. The proposed concept is shown on Drawing C107 in Appendix D.

6.8.3 Embankment Stability

The discharge regime requires storage in the pond system to cater for those periods when it is not possible to dispose of all effluent outflows to land or to the river. As described in section 6.3.2 above, the potential storage volume that can be provided by the ponds is 363,000$m^{3,}$ while the pond discharge regime requires a maximum storage volume of 275,000 m^3

In order to provide the necessary storage volume, pond embankments need to be high enough to cater for maximum water levels in the ponds (refer section 6.3.2). Pond embankments have been assessed in terms of their stability under operating conditions (minimum and maximum water levels), as well as under flooding and seismic events.

A rip-rap facing placed over the existing river channel side-slope in a toe that extends into the river bed has been designed to maintain pond embankment stability with a Factor of Safety (FOS)[54] of 1.5 for the pond embankments under static conditions, and a FOS of about 1.0 under a 100-year seismic event. A FOS greater than unity (FOS>1.0) is used in engineering design to cover variation and uncertainty in soil profile geometry, soil/rock strength and other physical and chemical properties, groundwater levels and inaccuracies in construction and methods of calculation. In doing so, it provides a margin of safety and limits the risk of failure. A FOS of 1.5 equates to a risk of about 1 in 200 (0.5%) that failure will occur in any single year. The use of a FOS of 1.5 is the normally accepted level of risk for this type of structure in New Zealand engineering practice. The proposed FOS in the embankment design also will provide enhanced protection against erosion.

6.8.4 In-River Construction Methodology

The construction of the rock protection works along the banks of the Ruamahanga River has been discussed with Operations staff of GW. In general, the construction methodology will follow GW practices. The works are similar to what has been constructed along the river in the vicinity of the oxidation ponds by GW, and in fact some of the works involve additions to or enlargements of existing GW works.

General Construction Practices

The rock works will, generally, be constructed from the riverbank, with the bank prepared first to the design batter slope down to the required depth, and then rock placed progressively up and along the bank. The rock will be brought to the riverbank by trucks and temporarily stored in small stockpiles of graded rock on the berm land beside the river channel, before being placed by hydraulic excavators on the riverbank.

This work will be done in flowing water, as diversions and bunding off of the banks to allow construction in still water is considered to be more disruptive. The river has a well-defined single channel form, which is relatively narrow and entrenched. Temporary diversions across the beaches will then be difficult to construct and maintain, and involve considerable disruption of the channel bed and disturbance of river flows. Only very small percentages of dirt or soil will be allowed in any truckload of rock, and the careful placement of the rock that is required minimises contamination on site. The main disturbance will be during the preparation of the bank.

Construction will not take place within the trout-spawning period as defined by 1 June to 30 August. There will be no disruption to fish passage. The river disturbance will have a visual and turbidity effect on recreational use of

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54 FOS is a measure of the stability of the structure and is the ratio of resisting forces (shear strength of the soils) to destabilising forces (gravity).

the river during summer months. Mostly, though, the work will disturb coarse gravel materials and involve the placement of large rock units, which will have a relatively low impact on the river water.

Proposed Right Bank Lining By Ponds

The proposed right bank lining will be the largest rockwork required, with the deepest rock foundation level being 1.5metre into the gravel bed of the river. The rock in the existing groynes will be recovered, as far as practical, and re-used in the lining.

The preparation of the bank and the placement of the rock lining is a straightforward operation by hydraulic excavators from the riverbank. The length of the lining does mean though that the operation will last for some weeks (depending on weather conditions and especially flood events). To facilitate the placement of the toe, it may be necessary to form a gravel beach (from the left side) to the edge of the pond embankment. The rock will be brought to the riverbank through MDC property.

The construction of these rock works will require working in the river, but this in-channel work will be minimised as much as practical by the proposed construction methodology. The rock will have to be transported to the site, and temporarily stored on-site as graded loads of rock, before being placed on the riverbank.

The main items of work for the right bank lining will be as follows:

- Establish on-site clearing areas for the storage of rock loads and for access to the work sites along the riverbank
- Transport rock from the quarry to the site, with the rock being supplied continually on a load-by-load basis, with temporary stockpiling at the site away from the active river channel
- Prepare the bank by removing existing edge vegetation, and shaping the bank to the required batter
- Form access and working platforms out from the beaches, using river bed gravels where necessary
- Place rock, on a load-by-load basis, to form a tight well-placed and appropriately graded rock mass throughout any lining or groyne, with each groyne to be completed one at a time, and the linings to be placed from the upstream end, as a continuous lining
- Finish the beaches to a natural channel shape after completion of the work associated with any platform or working access
- Form a uniform, smooth and well-finished berm behind the linings and groynes (except at the cliff), with planting of suitable vegetation along the bank margin and between groynes
- Tidy up of temporary stockpile and accessways, and disestablishment.

The construction will be best undertaken when the land is dry and river flows are at a low level. The work could, if sufficient resources are applied, be completed over two to three months.

Proposed Left Bank Lining

This lining will be much shorter than that proposed to be used for the right bank lining, as well as being of less depth into the riverbed and of less thickness. The rock should be easily placed within the bed, with the rock being brought to the riverbank from Lee-Pakaraka Road across the farm flats beside the river. Again, existing groyne rock will be incorporated into the proposed lining.

Proposed Works on Left Bank Bend Opposite Pond 1

It is proposed to enlarge the rock groynes at the cliffs, with an additional two groynes to be constructed. In this site, the rock will have to be transported across the river because of the access difficulties on the cliff side. One crossing will be developed at each groyne, and off-road trucks will be used to cart the rock from one side of the river to the other. Rock will be transported to the site in graded loads (on a truck and trailer) of about 25 tonnes, and a large 6-wheeler truck could cart about the same amount across the river (at 14 m^3 capacity). Thus, there will be about 100 crossings of the river to deliver the rock.

To facilitate the delivery and placement of material, the gravel beach on the left side will be pushed out by up to 20 metres to place the rock on the groyne. Because of the depth of water beside the cliffs and the tight construction space, it will also be necessary to create a small platform at the groyne on which to site the hydraulic excavator. These platforms will be formed from the gravel bed material of the river, and after use will be re-formed generally to the natural shape of the channel.

Construction time will depend on the sequencing of all the rock works and the plant capacity of the Contractor, but should require between one to two weeks.

6.9 Ongoing Asset Management Works

6.9.1 General Maintenance and Renewals

The MWTP, as with any infrastructure facility, will require ongoing maintenance works. The expected maintenance activities are summarised below.

Oxidation Ponds

Maintenance activities for the oxidation ponds will include, but not be limited to:

- Checking flow meters for calibration and possibly removing flow meters from service for a short time during maintenance
- Maintenance and removal of aerators for cleaning and service as required
- Maintenance on flow control penstock on outfall
- Step screen and screenings press may be taken out of service for a short time for servicing (manual bypass screen will be operated at these times)
- Removal of scum from the surface of the oxidation ponds (this will be disposed of to the screenings trailer for disposal at the landfill)
- Dissolved oxygen probes in the ponds may need to be removed and serviced
- Maintenance of the pond embankments, which also act as a flood protection stopbank along that part of the ponds closest to the river, involving an inspection for localised depressions and topping up as necessary to maintain the required height.

Irrigation System

The two key situations when maintenance requirements could alter the normal operational regime of the irrigation scheme are:

- Maintenance on zone valves or pipelines; and
- The need to stop irrigation prior to harvesting pasture.

Routine maintenance on zone valves, pipelines or other irrigation equipment is not expected to greatly impact on the operating regime. The border strip irrigation system will have duty and standby pumps, enabling servicing of a pump whilst maintaining the normal operating regime. Maintenance periods on zone valves or pipelines are expected to be short, and during these periods irrigation can be diverted to other zones.

Harvesting times and extent will vary depending on crop rotation and weather, but will generally occur during summer. As described in section 6.4, irrigation will need to be stopped prior to harvesting.

6.9.2 Plant Wear and Tear and Failures

The proposed upgrade is relatively "low tech", with no complex chemical or mechanical treatment processes, thereby minimising the risk of failures due to breakdown. Nevertheless, as with all mechanical and electrical equipment, there is a risk of failure. For example, if a power failure were to occur at the site due to an interruption in the supply or an electrical equipment failure, it would render the land treatment scheme inoperable and incoming sewage flows would need to be stored in the oxidation ponds providing there was sufficient storage volume available. If the maximum storage limit were reached then treated wastewater would need to be discharged to the river, even if river flows were low – This would only occur as an emergency and is very unlikely because there will be around 2 days' reserve storage capacity available. .

Failures in the border irrigation system could potentially result in wastewater discharging in zones not scheduled for irrigation. The proposed layout of the border strips will mean that discharges to land (be they leaks, ruptures or irrigation discharges) are contained within the irrigation area, and excess flows that do not infiltrate through the soils will run off to the wipe-off drains and return to the ponds.

It is expected that the duration of any such unscheduled discharges will be short, as the plant operator will detect anomalies in the irrigation scheme as part of the monitoring and maintenance schedule or as a result of an alarm being tripped. The schedule will include daily monitoring of flow volumes and a monthly inspection (minimum) of pipelines and valves.

6.9.3 Erosion Protection Works

The rock lining and groynes will need routine inspection to monitor for signs of slumping or dislodgement of rock, particularly following flood events. Reinstatement will be required if rock has been dislodged, with this work generally being planned to be undertaken as part of an annual maintenance regime.

In addition to any work arising from routine or flood related inspections, the rock groynes will require maintenance, and a quantity of 10% of the rock mass (260 tonnes) should be allowed for topping up after the first few significant flood events (above a 2-year return period).

6.10 "Future Proofing" Upgrade

A key benefit of using oxidation ponds as the primary treatment process is that additional treatment units can be added relatively easily – although at a significant cost – to the plant in the future if standards become more stringent: for example, an Ultraviolet Disinfection Unit (UV) for bacteria and virus reduction, or a Dissolved Air Flotation Plant (DAF) for phosphorus and suspended solids reduction. It should be emphasised, however, that neither of these upgrades are considered necessary to mitigate adverse effects. Indeed, it is unlikely that either of these "add-ons" would achieve any real environmental benefit.

When it selected its preferred upgrade, Masterton District Council resolved to endeavour to acquire more irrigation land over time to further reduce the volume of wastewater discharged to the Ruamahanga River. The irrigation area will be enlarged as a result of the additional land that has been purchased in 2007.

Accordingly, the "future proofing" of the proposed upgrade is four-fold:

- *Treatment processes* – additional treatment units (such as UV or DAF systems) could be investigated and if appropriate readily implemented.
- *Influent to ponds* – MDC has resolved to improve influent management in terms of both volume and composition, through a programme to reduce the volume of infiltration into the sewerage system, and through the enhancement of its trade waste database and bylaws by which the nature and composition of trade waste inputs can be monitored and managed by on-site treatment prior to discharge to the sewerage system.

- *Disposal processes* – MDC has acquired more land in the general proximity of the MWTP to extend the irrigation area, thereby increasing the capacity to discharge to land (rather than to the river) and providing additional flexibility and contingency in the operation of the plant.
- *Flooding and erosion* – The existing stopbanks and erosion protection can be upgraded further if river floodflows increase in size.

6.11 Proposed Monitoring

The following monitoring is proposed as part of the scheme:

- *Influent flow and load* (as currently undertaken).
- *Discharge flow* – including the current parameters and frequency as defined in the existing consent, except where modified by the New Zealand Municipal Wastewater Monitoring Guidelines.
- *Surface water* – including the current parameters, frequency and locations defined in the existing consent.
- *Groundwater* – including the current parameters, frequency and locations defined in the existing consent.
- *Irrigation land* – including soil pH, N, P, K, and S, cation exchange capacity, exchangeable bases (Ca, Na, K, Mg), base saturation, organic carbon, soluble salts and bulk density, moisture, salt nutrient and bacterial concentrations at various depths and groups of soil types above.

A schematic diagram of the proposed monitoring sites is presented in Figure 27 below.

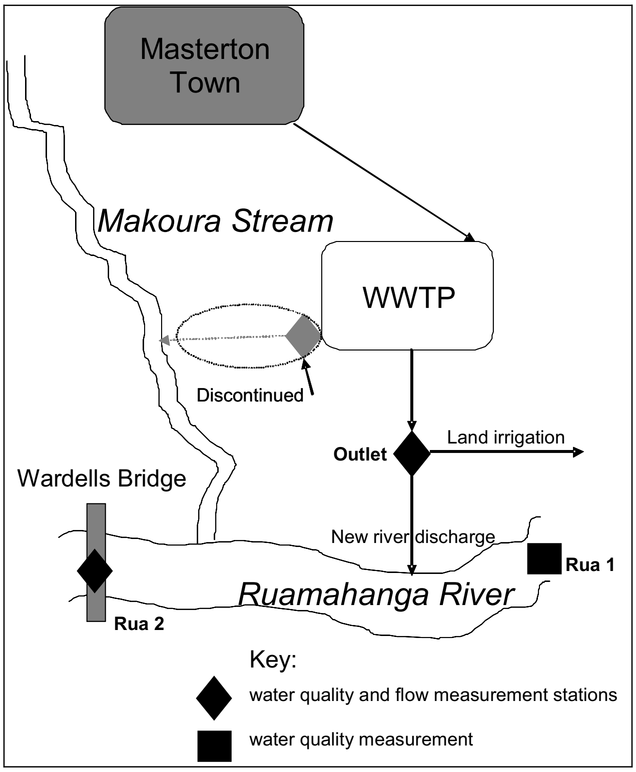

Figure 27 Schematic Diagram of Proposed Monitoring Sites

Note: Water quality will be monitored at indicated sites with continuous flow monitoring at Wardells Bridge (existing gauging station) used to regulate discharge

7 Receiving Water Standards and Guidelines

7.1.1 Relevant Guidelines, Standards and Targets

This section discusses the guideline and standards used in order to derive the water quality targets.

Wellington Regional Freshwater Plan (WRFP) 1999

This plan sets out the policies and rules relating to the sustainable management of freshwater in the Wellington Region. The WRFP identifies the need to enhance water quality mid and lower Ruamahanga River, specifically for the purpose of contact recreation, and requires applicants for a resource consent for an activity that might compromise recreational water quality, to have regard to (amongst other things): (i) the nature of the discharge, (ii) the dispersal characteristics of the water body including dilution, and (iii) consideration of alternative methods of discharge, including discharge into any other receiving environment, and the reasons for choosing the particular method of discharge. These provisions have guided the Council's choice of treatment and discharge location and methods

Some guidance is provided in respect of potential nutrient thresholds needed to prevent nuisance growths of algae that may compromise contact recreation; however, these are of limited value in devising a target for discharge from the MWTP.

ANZECC Water Quality Guidelines

The Australian and New Zealand Environment and Conservation Council (ANZECC) promulgated the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (2000). The primary objective of these guidelines is: "*To provide an authoritative guide for setting water quality objectives required to sustain current, or likely future, environmental values for natural and semi-natural water resources in Australia and New Zealand.*" These guidelines are comprehensive and provide guidance for the protection of a range of uses for example, stock watering, as well as in-stream "protection of aquatic ecosystems".

Aquatic ecosystems are classified by type and geographical region (for example, they vary between Australia and New Zealand, high country and lowland streams etc). The ANZECC (2000) guidelines also set out procedures whereby risk-based guidelines can be developed for a particular use or site. NIWA used this approach, in conjunction with the New Zealand Periphyton Guidelines (MFE 2000) to develop site-specific DRP guidelines downstream of the discharge. The ANZECC (2000) guidelines are freely available to download from the MfE website at:

http://www.mfe.govt.nz/publications/water/anzecc-water-quality-guide-02/

Ministry for the Environment (2003) Microbiological Water Quality Guidelines for Marine and Freshwater Recreation Areas

These guidelines published jointly by MfE and Ministry of Health incorporate a risk-based approach to monitoring water quality promoted by the World Health Organization. The guidelines presented here move away from the sole use of guideline values of faecal indicator bacteria, and instead use a combination of a qualitative risk grading of the catchment, supported by the direct measurement of appropriate faecal indicators to assess the suitability of a site for recreation. In addition, alert and action guideline levels are used for surveillance throughout the bathing season.

The two components used to provide a grading for an individual beach[55] are, first, the Sanitary Inspection Category (SIC), which generates a measure of the susceptibility of a water body to faecal contamination, and second historical microbiological results, which generate a Microbiological Assessment Category (MAC) and

55 Beach refers to both marine and freshwater bathing zones

provides a measurement of the actual water quality over time. The MAC for A-grade recreational receiving water has as the standard: "sample 95%ile ≤ 130 Escherichia coli per 100 mL." While the attainment of an A grade MAC in the Ruamahanga is unlikely (because of pollution from upstream diffuse sources – see Section 3), this category was selected as the target concentration upon which to assess the MWTP discharge.

The Guidelines for Recreational Water Quality are available from the MfE website at:

http://www.mfe.govt.nz/publications/water/microbiological-quality-jun03/

Other Standards and Guidelines

The third schedule of the Act contains some quantitative and narrative standards applicable to different water quality classes. For example, for waters being managed for aquatic ecosystem purposes, it states, "the concentration of dissolved oxygen shall exceed 80% of saturation concentration", and, there shall be no undesirable biological growths as a result of any discharge of a contaminant into the water". The Ministry for the Environment has subsequently developed guideline documents to provide some quantitative guidance to the narrative standards. Water Quality guidelines (no 1) Biological Growths (1992) and Water Quality Guideline (Nº 2) Colour and Clarity (1994) are particularly relevant to this application. These guidelines are not available on the MfE website but may be interloaned from the MfE library (information@mfe.govt.nz).

7.1.2 Section 107

Section 107 of the RMA provides a "bottom line" narrative relating to discharge of contaminants to waters.. Subject to some exceptions a consent authority is not able to grant a discharge permit that will allow, after reasonable mixing, the production of any conspicuous oil or grease films, scum or foams or floatable or suspended materials; any conspicuous change in the colour or visual clarity; any emission of objectionable odour; the rendering of fresh water unsuitable for consumption by farm animals, or any significant adverse effects on aquatic life. The exceptions relate to temporary breaches of the standards.

7.1.3 Proposed Receiving Water Quality Targets

To assist with the determination of an acceptable effluent quality and discharge regime a number of receiving water quality targets for the Ruamahanga River at Wardells Bridge were developed. The proposed receiving water quality targets are set out below in Table 27. All targets apply after reasonable mixing has occurred, which will be well upstream of Wardells Bridge[56].

A starting point for these targets was WRFP guidelines, which largely rely on ANZECC, MfE and RMA guidelines/standards for assessing the quality of the receiving water (the relevant guidelines are set out in Appendix B). All guidelines have been applied after reasonable mixing (refer to section 8.2.1 for a discussion of mixing).

The WRFP contains no specific guidelines on allowable nutrient loadings to the Ruamahanga River – the only reference is to a discharge not causing undesirable biological growths in the river, which is of little assistance as undesirable or nuisance levels of attached algae seldom occur with the existing discharge. The site-specific guideline suggested for DRP is based on the site-specific study carried out by NIWA57.

It should be noted that the targets have been developed to confirm that the proposed discharge regime and effluent quality are appropriate. They are not intended as conditions of consent, but can be used as a basis for monitoring future performance of the scheme.

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56 Analysis has determined that reasonable mixing would actually occur upstream from Wardells Bridge (approximately 800m downstream from the proposed discharge outlet), but for the purposes of maintaining ongoing monitoring, Wardells Bridge is a more convenient point to use.
57 NIWA 2004a

Table 27 Suggested Receiving Water Quality Targets after Reasonable Mixing

Parameter	Receiving Water Target	Source Document	Water Management Purpose
Filtered BOD (g/m3)	2.0	MfE Water Quality Guidelines Nº 1 (1992), Biological growths.	To assess compliance with Minimum RMA Standard - s107(1)(c) and 3rd Schedule guideline
Visual Clarity - Black disc (m)	1.6	MfE Water Quality Guidelines Nº 2 (1994), Guideline 4: For water managed for contact recreation the horizontal sighting of a 200 mm black disc should exceed 1.6 m.	Contact Recreation & to assess compliance with RMA 3rd Schedule Guideline
Visual Clarity change (%)	33% - 50% change for contact recreation	MfE Water Quality Guidelines Nº 2 (1994), Guidelines for the Management of Waste Colour and Clarity; For water managed for contact recreation purposes the visual clarity should not change by more than 33% - 50% depending on site conditions	Aesthetic & to assess compliance with Minimum RMA Standard - s107(1)(d)
Colour –Hue (Munsell points)	10 points change	MfE Water Quality Guidelines Nº 2 (1994), Guideline 2: The hue of the water body should not be changed by more than 10 points on the Munsell scale.	To assess compliance with Minimum RMA Standard - s107(1)(d)
Ammonia-Nitrogen (g/m3)	1.61[1]	ANZECC Guidelines (2000), Table 8.3.7: Effects on aquatic life for "slightly-moderately disturbed" ecosystems, for a 95% level of protection.	Aquatic Ecosystems & to assess compliance with Minimum RMA Standard - s107(1)(g)
Nitrate–Nitrogen (g/m3)	7.2	ANZECC Guidelines (2000) recalculated value from Table 3.4.12: Effects on aquatic life for "slightly-moderately disturbed" ecosystems.	Aquatic Ecosystems & to asses compliance with Minimum RMA Standard - s107(1)(g)
Nitrite–Nitrogen (g/m3)	9	ANZECC Guidelines (2000), Section 4.3.3.3 for livestock drinking water quality.	To assess compliance with Minimum RMA Standard - s107(1)(f)
E.coli (cfu/100mL) (95%ile value)	130	MfE Microbiological Water Quality Guidelines (2003): Guideline value for <0.1% risk of Campylobacter infection (from Table H2).	Contact Recreation & to assess compliance with RMA 3rd Schedule
E.coli (cfu/100mL) (median value)	100	ANZECC Guidelines (2000), Section 9.3.3.2 for livestock drinking water quality.	To assess compliance with Minimum RMA Standard - s107(1)(f)
Dissolved Reactive Phosphorus (g/m3)4	Not specified in WRFP Shall not cause undesirable biological growths	NZ Periphyton Guideline (MfE, 2000) (13-day accrual time)3. ANZECC (2000) for derivation of site-specific guidelines. NIWA (2003, 2004a) derive these site-specific guidelines.	Contact Recreation & to assess compliance with RMA 3rd Schedule

1 At pH of 7.5 (Receiving water monitoring 1994 – 2004 shows that the mean pH upstream of the ponds is 7.5).

2 Refer http://www.mfe.govt.nz/publications/water/anzecc-water-quality-guide-02/anzecc-nitrate-correction-sep02.html

3 A site-specific DRP guideline has been developed as part of the investigations undertaken for the project. This guideline is not relevant to the intermittent discharge of effluent, however it is relevant to the leakage through the base of the ponds. Refer to sections 7.1.4 and 8.2.3 for more detail, and also NIWA, 2004a

4 These guidelines/standards are used for assessing compliance in terms of the Water Management Purpose. The sources of these guidelines/standards are set out in Appendix B.

7.1.4 Contribution of Dissolved Reactive Phosphorus (DRP)

As part of the investigations undertaken for the MWWTP upgrade, NIWA (2003, 2004) derived a site-specific DRP target for the Ruamahanga River downstream of the proposed MWTP discharge point. The DRP target has been developed in response to the WRFP, which has an objective to control undesirable filamentous algal growths.

NIWA studies showed that phosphorus was the nutrient limiting algal growth upstream of the discharge but that it was the frequency of river 'freshes' that limited the accumulation of algae that attach to the bed of the river. NIWA developed a site-specific target by developing a model that linked nutrient concentrations and flood frequency to determine a phosphorus concentration that limited filamentous algal growths so that they remained below a nuisance threshold of 30% cover (MFE, 2000).

NIWA's analysis of flood frequency indicated that, on average, a 'fresh' flow in the river sufficient to displace algal growths occurred every 13 days during the summer recreation period. In other words, algal growths could 'accrue' for an average of 13 days before being dislodged. Using this accrual period, the NIWA model conservatively predicted that an in-river DRP concentration downstream of the discharge (after reasonable mixing) of less than 0.03 g/m3 would be appropriate.

The site-specific DRP target was developed at an early stage of the project when consideration was being given to a having a continuous effluent discharge. However, the subsequent adoption of an intermittent effluent discharge regime will result in an absence of effluent in the river during the summer optimal growth times for algae (apart from the pond leakage). Discharge during high summer flows, with associated bed scouring, are times when the application of this site-specific guideline is not relevant to protection from nuisance growths. Accordingly, the guideline is only applicable to the period in summer when there is an indirect discharge of leakage through the base of the ponds. Similarly, the guideline is not relevant to managing winter DRP, since nuisance growths are not present in the river during this period.

The effects of the discharge in terms of periphyton growth are addressed via the proposed discharge regime, rather than by reference to any particular effluent quality. The proposed regime is such that no purpose would be achieved by chemically reducing DRP in the effluent.

8 Assessment of Effects on the Environment

8.1 Introduction

The section provides a summary of the assessment of effects on the environment, based on the various technical reports (listed in References, section **13**). The assessment examines the likely effects of the proposal on the "*existing environment*" as it would be without the existing discharges. In particular it will compare water quality and amenity values upstream and predicted quality and amenity values downstream of the discharge, to assess the impacts of the discharge.

A range of sources (usually diffuse non-point sources) significantly affect the existing water quality of the Ruamahanga River upstream of the MWTP and therefore also impact on the downstream water quality. It is essential to take the contribution of these upstream sources into account when assessing the effects of the discharges from the treatment plant.

The assessment will also consider the improvements in downstream water quality and amenity that will result from the upgrade, by comparing existing water quality downstream of the existing discharge with predicted future water quality following the proposed upgrade.

Both assessments are related to flows in the river because both existing water quality and recreational amenity are related to flow. The discharge has the most potential for adverse effects at lower river flows when upstream water quality is reasonably good and when the river is at its most used and most valued for recreation and general amenity.

8.2 Effects on Ruamahanga River Water Quality and Amenity Values

This section is prefaced with a short discussion on full and reasonable mixing and dilution.

8.2.1 Mixing and Dilution

The Concepts of Full and Reasonable Mixing

In a situation such as this, where effluent is discharged to a shallow river, a distinct set of physical mixing processes define the characteristics of the effluent plume as it enters and then mixes into the receiving water. These include jet momentum of the effluent as it leaves the diffuser, river flow depth and riverbed characteristics.

The effluent plume initially makes contact with the receiving water, with rapid mixing occurring as the jet effect dominates. The area of the river closest to the effluent discharge point is called the “near-field mixing zone”, where the effluent mixes rapidly with the receiving water because of the momentum and/or buoyancy of the effluent and the natural turbulence of the receiving water.

Once the jet effect dissipates, the rate of mixing slows down, and further mixing depends on the natural currents and turbulence of the river. Gradually, the width of the effluent plume increases across the river until the effluent is fully mixed over the full width of the river flow. ‘Full mixing’ therefore occurs once the effluent is completely dispersed through the receiving water, and all parts of the river flow are mixed with the same proportion of effluent.

As full mixing does not occur instantaneously, contaminant concentrations close to the point of discharge may exceed the various water quality targets (or standards) for the receiving water. It is only after a period of mixing occurs, as the effluent flows downstream, that the effluent becomes diluted with the receiving water to a point at where compliance with the relevant water quality target is appropriate.

The RMA recognises that discharges into water cannot be instantaneously fully mixed, and refers to the concept of "reasonable mixing". The reasonable mixing zone is, in effect a zone where the discharge is not required to meet the relevant guidelines or standards. The reasonable mixing zone for a particular contaminant, is where that contaminant is reasonably well mixed with the receiving water, and which reflects what will be reasonable in terms of the effects in issue. The point of reasonable mixing zone will accordingly be at some point between the point at which the plume is reasonably well mixed and the point of full mixing. This may vary for different contaminants. Determining the point of reasonable mixing is based on assessing, on a case-by-case basis, the point at which the adverse effects of the contaminants on the river do not frustrate the overall purpose for which the river is being managed. In some cases reasonably well mixed and reasonable mixing will coincide. In other circumstances the RMZ may be closer to the point of full mixing. While a RMZ for a particular contaminant may be larger than what is required for that parameter to be *reasonably well mixed*, the RMZ will usually be no smaller than what is required for a reasonable degree of mixing.

The different mixing concepts are shown schematically in Figure 28 below.

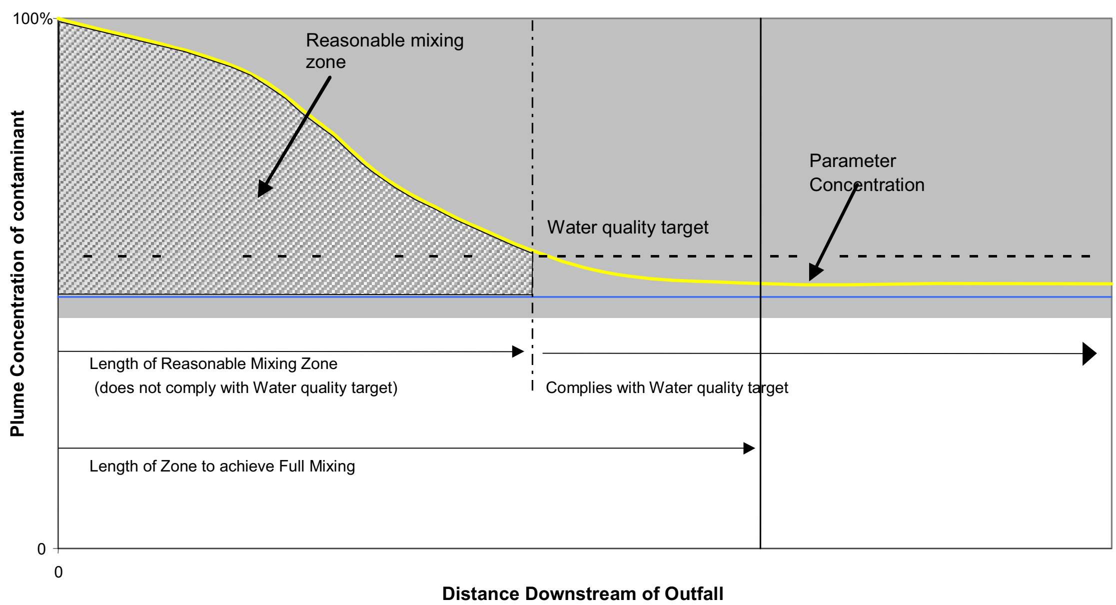

Figure 28 Conceptual River Mixing of Plume Downstream of Outfall

Under the Wellington Regional Freshwater Plan, the extent of a particular RMZ depends on the effects that non-compliance within the zone will have on the management purpose for the receiving water (which for the Ruamahanga River is for contact recreation). What is a "reasonable degree of mixing" in a specific case is a matter of judgement. It will vary according to the parameter concerned and the sensitivity of the receiving environment. Consideration of the potential for and the nature of possible effects in this zone can also be a key factor in establishing the extent of a RMZ.

In defining the RMZ, Policy 5.2.11 of the Wellington Regional Freshwater Plan (WRFP) sets out as follows:

Mixing Zones

5.2.11 To ensure that any zones allowed on a discharge permit for reasonable mixing of contaminants or water with the receiving water are determined by having regard to:

- *the purpose for which the receiving water is being managed, and any effects of the discharge on that management purpose; and*

- *any tangata whenua values that may be affected; and*
- *the volume of water or concentration of contaminants being discharged, and the area of receiving water that could potentially be affected; and*
- *the physical, hydraulic and hydrological characteristics of the receiving water.*

> ***Explanation**. Both s107 and the Third Schedule of the Act direct that the effects of discharges are to be considered after reasonable mixing of the contaminants with the receiving water. The size of the zone allowed for reasonable mixing depends on the effects that non-compliance within the zone will have on the management of the receiving water as directed by Policies 5.2.1 to 5.2.6 of the Plan and by s 107 of the Act. For example, the size of a zone allowed for reasonable mixing of ammonia may depend on whether the zone impedes fish passage (because of its toxicity). The size of the zone allowed for reasonable mixing of nutrients may depend on whether excessive algal growths will attach to stones on the bed downstream of the discharge (undesirable biological growths are not allowed in waters managed for contact recreation, fish spawning, water supply, or aquatic ecosystems).*

The applicant is not proposing receiving water quality standards that apply after reasonable mixing, but rather effluent (or "end-of-pipe") standards. The proposed effluent standards, in conjunction with the proposed discharge regime, are intended to ensure achievement of the proposed receiving water quality targets after reasonable mixing. The primary relevance of reasonable mixing, is in terms of the applicant satisfying the Regional Council that the section 107 standards will be met after reasonable mixing and that relevant guidelines will be achieved after reasonable mixing.

In this case MDC suggests that reasonable mixing can be regarded as being somewhere between 300m to 500m downstream of the proposed new discharge point for all parameters. Full mixing occurs by about 800m downstream of the discharge point, which is 450 m upstream of the first sensitive site in the river; Wardells bridge. (Currently the reasonable mixing zone extends to at least Wardells bridge and full mixing is well downstream of Wardells Bridge). 300 m has been used as the basis of tabulated water quality predictions for the proposed new outfall location because by that point the discharge is reasonably well mixed, however in practice what is reasonable in terms of effects may be somewhat further downstream.

It should be noted that it is not proposed that the monitoring location be shifted from Wardells Bridge. That is still the most appropriate location to monitor the effects of the discharge on receiving water quality since that is the first point at which any significant degree of contact recreation occurs and allows ready access for monitoring. Continuing with monitoring at that point, will also allow comparison of the upgraded water quality with pre upgrade quality.

Statutory Requirements

In terms of the proposed discharges being sought, section 107 of the Act requires that a consent authority shall not grant a discharge of contaminant or water into water, or a contaminant onto or into land in circumstances that may result in that contaminant (or any other contaminant emanating as a result of natural processes from that contaminant) entering water [emphasis added] –

> *If, **after reasonable mixing**, the contaminant or water discharged (either by itself or in combination with the same, similar, or other contaminants or water), is likely to give rise to all or any of the following effects in the receiving waters:*
>
> - *The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials*
> - *Any conspicuous change in the colour or visual clarity*
> - *Any emission of objectionable odour*
> - *The rendering of fresh water unsuitable for consumption by farm animals*
> - *Any significant adverse effects on aquatic life.*

The Wellington Regional Freshwater Plan (WRFP) has a policy, which provides for the river to be managed for the purposes of contact recreation and aquatic ecosystem functioning, but does not provide rules (standards) for water quality[58].

Appendix 5 of the Wellington Regional Freshwater Plan (WRFP) lists the Ruamahanga River within waterbodies with Regionally Important Amenity and Recreation values, whilst Appendix 7 lists it as a waterbody with water quality needing enhancement in order to meet those values. The Ruamahanga River is therefore subject to Policy 5.2.9 of the WRFP which requires that any management of the river enhances water quality for the purposes of contact recreation.(Note –the Ruamahanga River is NOT listed as being managed for aquatic ecosystems –only the Ruamahanga floodway wetland)

Appendix A8.3 of the WRFP is a guideline to assist with resource consents which reflects the water quality standards in the third schedule of the RMA. The guidelines state that consent shall not be granted if the discharge *either by itself or in combination with other contaminants* is likely to cause any of the following effects after reasonable mixing:

- *All those effects in A8.1* [minimum water quality standards in sections 70 and 107 of the Act]
- *All those effects in A8.2* [the water quality standards in the Third Schedule of the Act regarding water managed for aquatic ecosystem purposes]
- *The visual clarity of the water to be so low as to be unsuitable for bathing*
- *The water to be rendered unsuitable for bathing by the presence of contaminants*
- *The presence of undesirable biological growths as a result of any discharge of a contaminant into the water*

The focus of Appendix 8.3 is on ensuring that the discharge does not ***cause*** the effects in question after reasonable mixing, when such effects are not occurring upstream. Thus for example if visual clarity upstream is suitable for bathing at a particular flow and the discharge would cause it to become unsuitable for bathing at that flow, after reasonable mixing, the guideline would not be met. Conversely, the guideline will not be breached if the river is unsuitable for bathing because of upstream contamination rather than as a result of the discharge.

Methodology for Determining Dilution and Mixing Effects

An assessment was undertaken to determine the distance downstream from the new outfall at which full mixing will occur. This was based on a combination of fieldwork, involving dye testing in the river, and calculations to determine the dilutions, and hence concentrations, of various effluent parameters at distances downstream from the new outfall.

Dye release studies were conducted to characterise the transverse mixing characteristics in the Ruamahanga River at potential discharge sites (NIWA 2005b). Subsequent simulations were undertaken using the CORMIX model (Jirka et al 1996) to combine the dye study dispersion results with the initial diffuser mixing performance (NIWA 2007). The CORMIX modelling was used to evaluate options for the configuration of the outfall for an effluent discharge at half-median and median river flows.

Once the preferred outfall configuration had been confirmed, this enabled the extent of mixing and dilution at various downstream distances to be determined.

Analysis was then carried out to determine the concentrations of various parameters at distances downstream of the outfall until the point of full mixing was reached;, and also at Wardells Bridge. These analyses have been carried out for the summer discharge regime at just above and just below median river flow, and also for the winter discharge regime at just above and just below half median river flow.

The parameters modelled were:

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[58] Except in regard to the discharge of free or combined residual chlorine, acid soluble aluminium, suspended solids, and fluoride.

- Filtered BOD
- Ammonia
- Nitrate
- Nitrite
- DRP
- *E.coli*
- Clarity

The outcome of these analyses are reported in the remainder of Section 8.

Dilution and Mixing Assessment

Based on the outcome of the CORMIX modelling, the most effective effluent diffuser was a four-port diffuser (minimally recessed), with a pipe diameter of 0.5 m. For this outfall configuration, the effluent dilutions and corresponding mixing percentage are detailed in Table 30.

Table 28 Effluent Dilutions Downstream for Half-Median and Median River Flows

Distance Downstream from Discharge Point (m)	Half Median River Flow (%mixed)	Median River Flow (%mixed)	Nominal Dilution
200	16.4 (55%)	17.6 (59%)	17
300	19.8 (66%)	21.1 (70%)	20
400	22.5 (75%)	25.0 (83%)	24
600	27.3 (91%)	29.1 (97%)	28
800	30.0 (100%)	30.0 (100%)	30

(Source, NIWA 2007)

As an example, Table 28 shows that at 300m downstream from the point of discharge, and at median river flow, the concentration **of each** parameter in the effluent is 21.1 times less than at the outfall when the effluent first mixed with the river flow. This means, for example, that if a particular parameter has a concentration of 500 units at the outfall, then the concentration at 300 m downstream of the outfall will be 24 units as a result of mixing and dilution. This corresponds to the effluent being 70% mixed. Another point to note in terms of Table 28 is that there is little difference between the dilution at half median and median river flows, and accordingly a single 'nominal' dilution is tabulated for each of the downstream distances.

Full mixing occurs at a distance of approximately 800m downstream from the point of discharge of effluent. This distance is approximately 450 m upstream of Wardells Bridge. Accordingly, the concentrations of parameters in the effluent can be taken as being the same at 800m downstream of the outfall and at Wardells Bridge (this ignores the effect of the minor flow and concentration addition from the Makoura Stream).

Currently, full mixing occurs downstream of Wardells Bridge and for monitoring purposes Wardells Bridge has, in effect, become the end of the reasonable mixing zone. The shifting of the discharge upstream and the addition of a diffuser will ensure that full mixing is upstream of Wardells Bridge and reasonable mixing will be well upstream. It is suggested that the most appropriate approach is to take reasonable mixing as being between 300m-400m downstream. At 300m the plume will be about 66% mixed at just above the winter trigger flow and in summer it will be about 70% mixed. Subsequent predictions of water quality have used 300m (i.e., 20-fold dilution) to show the effects of the discharge before it is fully mixed.

Reasonable mixing is generally assessed on a continuous discharge at low flow conditions, when flow conditions are relatively stable. However, the proposed discharge for the MWTP upgrade will only be initiated at median flows in summer, which will generally occur when the river is at the onset of fresh/flood conditions – i.e., river flow rising from low to high flow due to a significant rainfall event. Characteristically, very rapid increases in flow occur in this part of the Ruamahanga River, with low to flood-flow conditions transitioning over only a few hours, as is shown in the hydrograph of a typical summer flood event at Wardells Bridge in Figure 29.

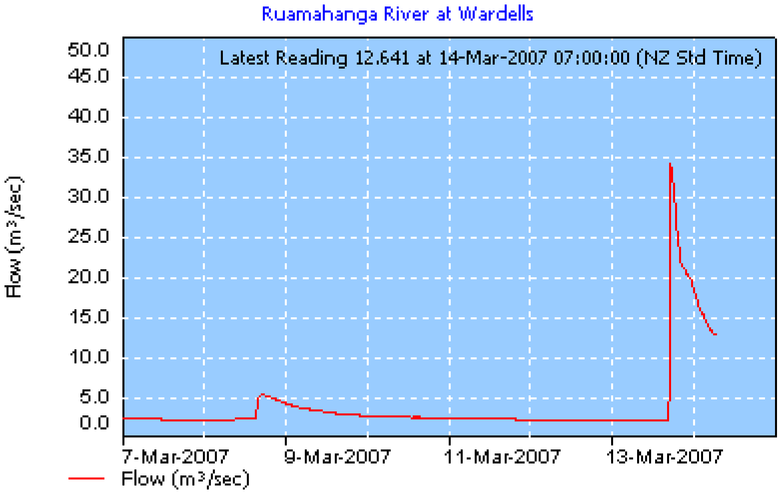

Figure 29 Example of a Typical Summer Flood Event at Wardells Bridge

The Ruamahanga River flow characteristics are summarised in Figure 28 for summer and Figure 29 for winter data from the Wardells Bridge gauging site. The cumulative frequency presentation indicates the percentage of the time the river will exceed a given value in an average year, and summarises the high flow variability data which occurs for both summer and winter in the Ruamahanga River (see Figs. 11 & 12). Thus, for example, the river is expected to be below 10 m^3/s flow for 60% of the time in summer. Figure 28 indicates that flows above median flow (12.3 m^3/s), when the effluent can be discharged, can potentially occur for 33% of the summer period (i.e., 66% of the time the effluent will not be discharging). The winter data (Figure 29) shows that the river is expected to be below 10 m^3/s flow for only 22% of the time and above half-median (6.15 m^3/s), when the effluent can be discharged, can potentially occur for 92% of the winter period.

Threshold flow range

For the purposes of assessing effects and predictive modelling, the analysis has focussed in particular on a 'threshold flow range' appropriate to summer and winter flows. This is a band of flows just above half-median (for winter discharge) or median (for summer discharge) after the discharge is initiated and before the river becomes markedly affected by upstream contaminants at higher flows. This approach was used for the following reasons: (i) in order to provide suitable basis for characterising the receiving water quality data relevant to the discharge initiation; (ii) to facilitate modelling of predicted upgraded effluent contaminant concentrations to the upstream background contaminants; and (iii) to provide a quantitative basis for assessing effects of the flow-triggered intermittent effluent discharge to the river. The particular contaminants warranting this analysis were faecal micro-organisms and clarity, each of which showed strong trends in relation to river flow (see Figs. 15 & 16). The significance of the effects predicted for the threshold flow range are then assessed in relation to the duration of time during which the river flows occur in this flow range for the particular season.

A threshold flow range of 30% above the half-median flow (i.e., 6.15 – 8.0 m^3/s) was used for the winter period effects assessment, while a range 15% above the median flow (i.e., 12.3 – 14.0 m^3/s) was used for the summer period. The summer threshold flow range is shown on Fig 28 with the results of the analysis discussed in Section 8.2.2. It is important to appreciate that this threshold range only occurs for about 4% of the summer time and 13% of the time that the effluent will be discharging during summer. The winter threshold flow range occurs for 5.5% of the time and 6% of the time the effluent will be discharging (Fig. 29).

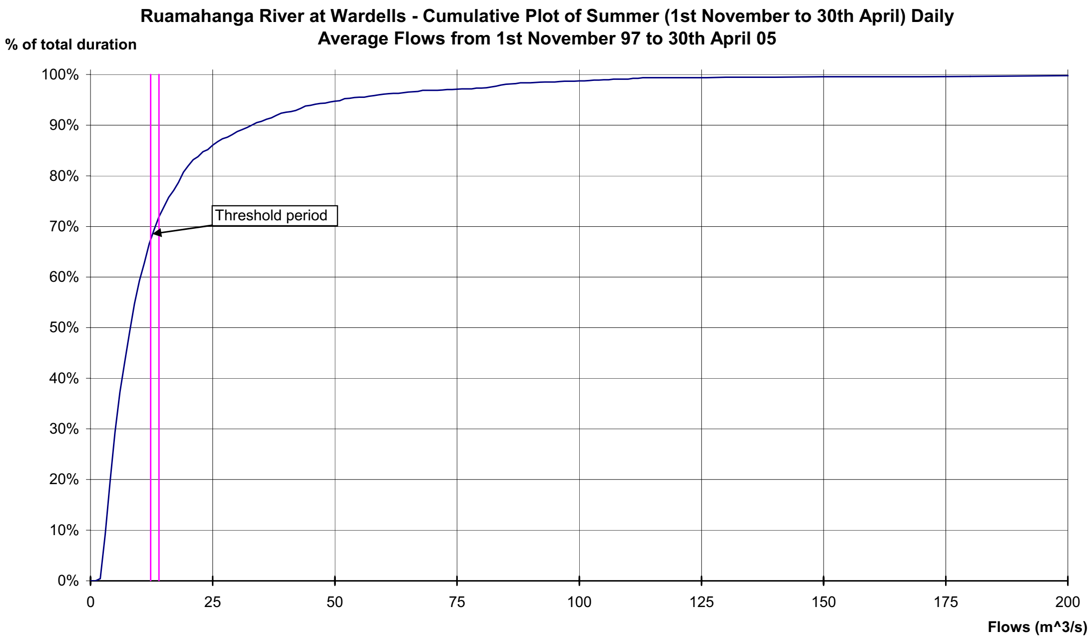

Figure 30 Cumulative plot of Ruamahanga River (@Wardells) summer flows

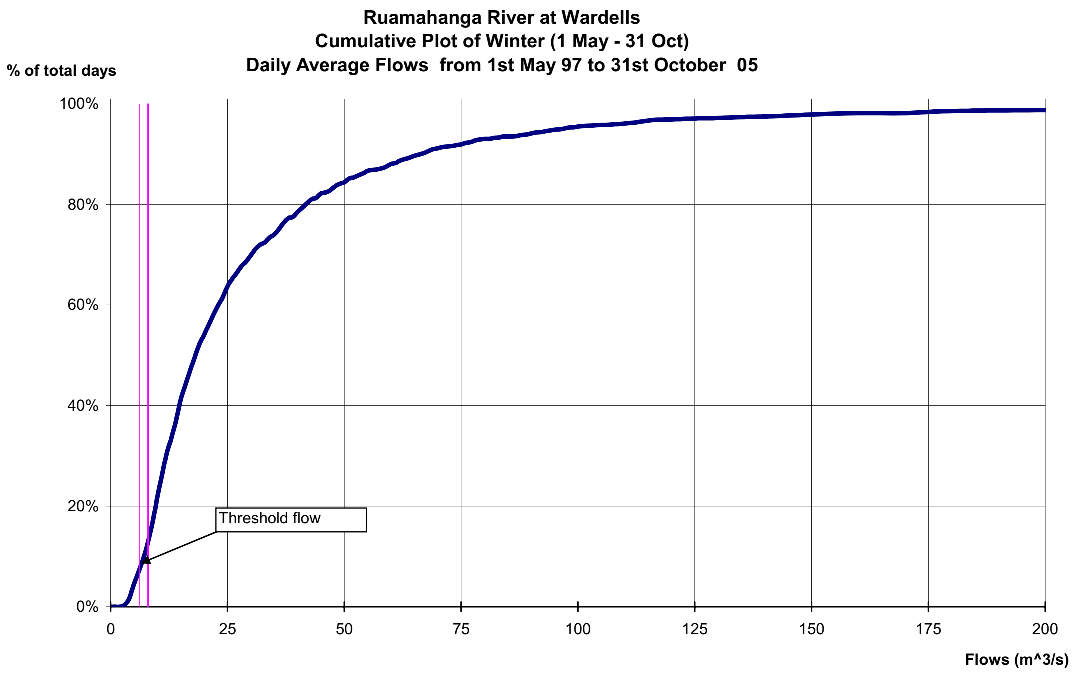

Figure 31 Cumulative plot of Ruamahanga River (@Wardells) winter flows

8.2.2 Effects of Pond Leakage on Surface Water Quality

The effects of leakage from the oxidation ponds have been assessed on the basis that the existing ponds remain unlined.

As discussed in section 4.5.4, the quantity of leakage has been investigated on separate occasions. In addition, in order to quantify the significance of leakage, NIWA assessed its effects on the Ruamahanga River at summer low flows (NIWA 2005). The objective of this study was to:

4 Assess whether there is a measurable increase in concentration of various parameters in the receiving water due to pond leakage, adjacent to and downstream of the oxidation ponds, and if so to assess the significance of an increase; and

4 Investigate the effects of any pond leakage on periphyton growths in the Ruamahanga River downstream of the oxidation ponds.

All studies were undertaken during summer low flow conditions, once algal proliferation had been established. In summary the main findings of these studies were:

4 The hydraulic leakage volume was estimated at 490-1,300m^3/d at the time of these trials. Subsequent measurements have resulted in revised values being adopted for normal and elevated pond levels. (PDP, 2007) These are discussed in Section 5.4.3.

4 Under the scenario of elevated pond water levels and the adopted leakage rate of 2400 m^3/day (the upper bound value), the dilutions become 443 fold at median flow and 221 fold at half median flow. This conservative leakage and dilution rate has been used in the prediction of effects of leakage for the proposed upgrade. In practice, actual leakage will normally be less and accordingly there will normally be greater dilution

4 Ammonia data showed no increase and were markedly lower than the guideline value

4 The *E.coli* data were highly variable and provide no indication of a general increase along the reach

4 Faecal coliforms indicated a slight increase (upstream to downstream) although the result is not statistically significant

4 There was a slight increase in dissolved reactive phosphorus (DRP) from 0.006g/m^3 to a mean of 0.009g/m^3.,

4 A downstream response of algal biomass and cover was identified when compared with the upstream site, but there was no change in the abundance of filamentous algae[59]. In addition,, the presence of a distinct gradient of algal response across the river reinforced the possibility that these algal growths were associated with existing pond leakage. However, the overall conclusion from this aspect of the site study was that the increase in matt cover to 47% coverage remained below the nuisance threshold of 60%.

Sampling undertaken adjacent to the ponds showed there to be no more than a minor impact as a result of pond leakage and as noted above, there is very significant dilution of the pond leakage in the river.

The predicted impacts of pond leakage on the River are discussed in the next section.

8.2.3 Effects of Discharges on Water Quality in the River

Introduction

This section provides a comparison of upstream water quality (i.e. upstream of the MWTP) with predicted water quality downstream following the proposed upgrade.

The comparison is presented for summer and winter periods, in order to account for the proposed discharge regimes for these periods, and provides monitoring results for concentrations of key parameters upstream of the MWTP and predictions for locations downstream of the effluent discharge point allowing for mixing and dilution.

[59] An increase in algal mat cover is less of a concern for reducing aesthetic and recreational amenity value than proliferation of more conspicuous filamentous algae.

Summer Discharge Regime

Key Parameter Concentrations

In this section, the results of analysis to assess the concentrations of various parameters at just above and just below the summer trigger flow are detailed. The approach was to take the median upstream water quality for a parameter and appropriately diluted effluent from both the primary discharge and pond leakage. This has generally used a highly conservative seasonal effluent 95%ile parameter value and a median effluent value for the pond leachate, with the leakage expected to be of average composition, because of the time taken for transport through the gravels. The fully mixed summer effluent is diluted 30x and the leachate contribution is based on the upper bound value of 2400 m^3/d which gives a dilution of 443x at median flow (12.3 m^3/s). The winter effluent concentrations are included for key parameters. The leakage only assessment is based on a conservative dilution for half-median flow (6.15 m^3/s; 221x) for comparison with trigger values. The predicted receiving water concentrations are compared with guideline targets (Table 29) for a range of dilutions, which have been predicted for the river downstream of the discharge. Further details of the mixing and contaminant predictions are provided in NIWA (2007).

A specific modeling approach was used for the assessment of *E.coli* and clarity effects with results presented later in this section. The Monte-Carlo modeling approach was used to statistically combine the upstream river and pond effluent distributions for these parameters and then to predict a downstream concentration after mixing. This statistical approach was required to provide a predictive model appropriate for existing and upgraded pond contaminant concentrations. This model was calibrated on summer river data for a data range around median flow, in order to provide predictions relevant to the threshold flow range where the discharge is initiated (Section 8.2.1).

The predicted values for key parameters for effluent and leakage are summarised in Table 29 for the 95%ile effluent concentrations and leachate to median flow based on mixing dilutions given in Table 28. These predicted values are based on the highest anticipated leaching rate (2400 m^3/d, dilution 443x; as discussed in Section 5.4.3) for conditions of maximum pond retention. At this flow upstream water quality is reasonably good and accordingly the discharge has the most potential to affect downstream water quality. All downstream values are well within guidelines for both partially mixed sites from 200 m to the fully mixed site at 800 m downstream. The ammoniacal-N concentrations maximally reach about 35% of the toxicity guideline value. The values for DRP have not been included in this summary table as the intermittent nature of the discharge, together with the discharge at high flows to turbid waters, will not result in significant stimulation to result in nuisance algal periphyton growths in the downstream Ruamahanga River. The effects of *E. coli* and clarity are addressed in the following section.

Table 29 Predicted Concentrations of Key Parameters for Effluent Discharge at Just Above Median River Flow

	Concentrations (g/m^3)					Distance downstream of outfall (m)					
Parameter	Median Upstream	95%ile Effluent	Median Leakage	Receiving Water Target		200	300	300 %RWT	400	800 & Wardells Bridge	800 %RWT
fBOD	0.3	6.1	3.7	2.00		0.66	0.60	30%	0.56	0.51	26%
NH4-N(S)	0.01	11.3	1.1	1.61		0.65	0.55	34%	0.47	0.39	24%
NH4-N(W)	0.01	11.1	6.7	1.61		0.66	0.56	35%	0.47	0.40	25%
NO2-N	0.002	2.01	0.14	9.00		0.12	0.10	1%	0.08	0.07	1%
NO3-N	0.5	4.29	0.84	7.20		0.75	0.71	10%	0.67	0.64	9%

Notes: Table from NIWA (2007). Uses upstream background concentrations with leakage (2400 m^3/d; 443x dilution). Receiving water targets provided in Table 27.
RWT = receiving water target

Ammoniacal-nitrogen is the major potential toxicant of concern in the oxidation pond treated discharge. The predictions for the potential pond discharge effects are conservatively based on the measured summer and winter 95%ile values, which are maximally 41% of the guideline value at 200 m downstream (55% mixed), declining to 24% of the guideline at 800 m (fully mixed) (Table 31). The risk to receiving water organisms is further reduced by:

(i) The intermittent nature of the discharge;

(ii) Use of the 95%ile effluent ammoniacal-nitrogen concentration (note the summer median value is 10x lower as used for leakage inputs, Table 31); and

(iii) Application of the chronic ANZECC (2000) guideline value to this assessment. Studies with New Zealand native fish and macroinvertebrate species have indicated that compliance with the chronic ANZECC guideline would provide good protection for most species (Hickey et al 1999, Hickey 2000).

Table 30 below presents the results for the scenario for just below median flow in summer when there is no effluent discharge, but there is leakage from the base of the ponds. The values were conservatively calculated based on the dilution available at half-median flow in the river and the maximum anticipated leakage rate. These predicted values are based on the highest anticipated leakage rate (2400 m^3/d, 221x dilution; as discussed in Section 5.4.3) for conditions of maximum pond retention. This indicates that only the DRP value at 200 m downstream may approach the site-specific guideline, and that all other parameters are markedly below guideline values both within and downstream or the reasonable mixing zone. By 300m downstream the predicted DRP value is below the target value. The DRP increase within the RMZ may slightly increase periphyton growth, but nuisance growth will not occur as a result of the discharge (see the discussion at section 7.1.4).

Table 30 Predicted Concentrations of Key Parameters for River Flow at Just Below Median Flow (no direct discharge in summer)

	Concentrations (g/m^3)					Distance downstream of outfall (m)					
Parameter	Median Upstream	95%ile Effluent	Median Leakage	Receiving Water Target		200	300	300 %RWT	400	800 & Wardells Bridge	800 %RWT
FBOD	0.30	0	3.7	2.00		0.33	0.32	16%	0.32	0.32	16%
NH4-N(S)	0.01	0	1.1	1.61		0.02	0.02	1%	0.02	0.01	1%
NH4-N(W)	0.01	0	6.7	1.61		0.061	0.053	3%	0.047	0.040	3%
NO2-N	0.002	0	0.14	9.00		0.003	0.003	<0.1%	0.003	0.003	<0.1%
NO3-N	0.5	0	0.84	7.20		0.51	0.51	7%	0.50	0.50	7%
E.coli (S)	103	0	200	130		105	104	80%	104	104	80%
E.coli (W)	49	0	260	130		51	51	39%	50	50	38%
DRP	0.010	0	2.7	0.030		0.031	0.027	92%	0.025	0.022	74%

Notes: Table from NIWA (2007); Upstream Background with Leakage (2400 m^3/d; 221x dilution) to Half- Median River Flow, with (s) = summer; (w) = winter. Receiving water targets provided in Table 27.

Comparison of Upstream and Downstream E.coli and Clarity Concentrations

As discussed in Section 5.3.2, upstream *E.coli* and clarity values vary significantly with flow. In addition, the concentrations of *E.coli* and clarity in the effluent will typically be variable.

In view of this inherent variability, the approach used to determine *E.coli* and clarity impacts of the discharge, was to undertake a Monte-Carlo simulation. This is a recognised statistical technique that is used to combine variable distributions, and produce an output for the mixed product. Taking *E.coli* as the example, the approach used was to select a threshold flow range of 12.3 m^3/s to 14 m^3/s (just after discharge commences in summer) and combine the upstream *E.coli* concentrations (based on monitored data) with the predicted distribution of *E.coli* in the effluent from the upgraded oxidation ponds. The output is a distribution of *E.coli* in the receiving water (Ruamahanga River) downstream of the treatment plant. The same approach was taken with clarity.

Table 31 Summer E.coli and Clarity in Ruamahanga River upstream of discharge, in relation to River Flow

	E.coli (cfu/100 mL)	**Clarity (visibility of Black Disc in metres)**
Flow category [1]	**Median (5 – 95%ile)**	**Median (5 – 95%ile)**
< Half-median	29 (7 – 87)	3.4 (1.1 – 5.8)
Half-median to Median	40 (4 – 219)	2.0 (0.22 – 4.3)
Threshold flow range [2]	83 (13 – 1058)	1.0 (0.17 – 4.6)
High flow	207 (16 – 2909)	0.34 (0.09 – 1.92)

Notes: [1] Flow ranges are: <Half-median = < 6.15 m3/s; Half-median to Median = 6.15 – 12.3 m3/s; Threshold flow range = 12.3 – 14.0 m3/s; High flow = >14 m3/s.

[2] The analysis uses actual data (between 21 and 36 data points) for each flow range except for the threshold flow range, which is based on modelled values derived from the Monte-Carlo simulation (this is discussed below).

[3] "Threshold flow range" is the flow region where the discharge is initiated and prior to higher flows where upstream quality is poorer. This range occurs approximately 4% of the time and 13% of the time when discharging (see Figure 28)

As can be seen from Table 31, there is a general tendency to higher *E. coli* values as flow increases and a marked reduction in river clarity. At flows below median, the river upstream of the discharge is relatively clear and has low *E. coli* levels. In these situations the existing discharge causes a reasonably significant deterioration in water quality, particularly in the partially mixed region between Makoura Stream and Wardells Bridge. At higher flows, the discharge does not have a significant effect on water quality, which is already relatively poor. Accordingly, the removal of the direct discharge from the river at flows below median will have a considerable benefit in terms of water quality. Discharge above median flow has considerably less impact than discharge at lower flows. Furthermore, at flows below median there is considerably more use made of the river for contact recreation.

The downstream concentrations were predicted at 300 m (20x dilution - Table 32) and for full mixing at 600 – 800 m (30x dilution, Table 33). The predictions showed slight increases at threshold flows for *E.coli* (average <6.5% for 300m, Table 32; & <4.3% for 800m, Table 33). The “No change” indicated for these predictions refers to flow periods where the discharge is not occurring, with “Negligible change” indicating that the magnitude of change would be very small at higher flows. The upper 95%ile values are markedly elevated in the threshold flow region as a result of the high natural variability (refer Figure Figure 15), with the predicted increase indicating a negligible change as a result of effluent addition (Table Table 32 and Table 33).

Compliance with the proposed target guideline value of 130 /100 mL (Figure 31 is based on the 95%ile concentration for conditions existing during recreational use (MFE 2003). The existing upstream 95%ile concentration for *E.coli* for below median flow is 127/100 mL indicating compliance with the proposed target for this flow range. Elimination of the discharge for below median flow will mean that river water quality downstream of the effluent discharge location is virtually the same as the upstream water quality (given the minimal impact of leakage on receiving water quality).

The clarity reduction at threshold flows averaged a reduction of 17% at 300m and a reduction of 13% at 800m (the range was 0-50% reduction and 0-42% reduction respectively). The upper 95%ile of clarity reduction for the partially mixed effluent in the threshold range is at the target range guideline value (Table 29). Flows in this threshold range only occur for 4% of the time in summer (Figure 30) and thus any aesthetic impacts will be minimal. It is considered that a clarity change of at least 50% would be required to result in a conspicuous change in this shallow river, where the bed generally dominates the received clarity and colour. Clarity impacts will decline at higher river flows as a result of higher background levels and greater available receiving water dilution.

In conclusion, this analysis of summer data has shown that the predicted impact after reasonable mixing (at 300 m) and at Wardells Bridge for *E.coli* and clarity will be no change or negligible change as a result of discharges from the proposed upgraded ponds. The elimination of discharge at below median flows removes all effects at these flows where there is high recreational use.

The quantitative analysis has concentrated on the threshold flow region where effects would be most apparent after the initiation of the discharge. The analysis has shown that the *E.coli* increase is negligible in this region and that the slight clarity reduction is within guideline targets. The plume will generally be inconspicuous (i.e., <50% change in clarity) once reasonable mixing has occurred. The overall impact of the effluent on summer water quality will be a marked improvement in key recreational periods of below median flows and negligible change during discharge at high flows.

Table 32 Predicted Summer E.coli and Clarity at 300m Downstream of Discharge in relation to River Flow

Flow category [1]	*E.coli* (cfu/100 mL) Median (5 – 95%ile)	Clarity (visibility of Black Disc in metres) Median (5 – 95%ile)
< Half-median	No change	No change
Half-median to Median	No change	No change
Threshold flow range [2]	89 (15 – 1012)	0.85 (0.17 – 2.3)
High flow	Negligible change	Negligible change

Notes: 'No change' refers to distribution values given in Table 33.

[1] See Table 33 footnotes;

[2] Model predicted values for E.coli is based on a median effluent concentration of 330 /100mL added to upstream distribution.

Table 33 Predicted Summer E.coli and Clarity at Wardells Bridge in relation to River Flow

Flow category [1]	*E.coli* (cfu/100 mL) Median (5 – 95%ile)	Clarity (visibility of Black Disc in metres) Median (5 – 95%ile)
< Half-median	No change	No change
Half-median to Median	No change	No change
Threshold flow range [2]	87 (14 – 1014)	0.89 (0.17 – 2.67)
High flow	Negligible change	Negligible change

Notes: 'No change' refers to distribution values upstream as given in Table 32. 'Negligible change' indicating that the magnitude of change would be very small.

[1] See Table 32 footnotes;

[2] Model predicted values for E.coli is based on a median effluent concentration of 330 /100mL added to upstream distribution.

Taken together, Tables 31, 32 and 33 show that the predicted impact at Wardells Bridge for E.coli and clarity is that there will be negligible change as a result of the proposed upgrade.

Winter Discharge Regime

With regard to the winter discharge regime (1 May to 31 October) there are a number of significant differences (compared to a summer discharge of effluent) that apply to the assessment of impacts of a discharge of effluent just above and just below the half median river flow (the winter trigger flow). These are:

- Much less contact recreation in the river due to unfavourable river and climatic conditions
- River and climatic conditions that do not promote rapid growth of algae
- Insufficient river water quality data on which to base a robust numerical analysis (the main focus of monitoring of river water quality had been during the summer season when recreational use of the river is greatest)

The approach taken to analyse the impacts of the winter discharge of effluent has been to prepare a comparative assessment as set out in Tables 34, 35 and 36 below.

Table 34 Winter E.coli and Clarity in Upstream Ruamahanga River in relation to River Flow

Flow category [1]	*E.coli* (cfu/100 mL) Median (5 – 95%ile)	Clarity (visibility of Black Disc in metres) Median (5 – 95%ile)
< Half-median	6 (2 – 10)	3.6 (0.3 – 7.1)
Threshold flow range [2]	ND	3.0 (0.7 – 5.2)
High flow [3]	50 (5 – 291)	0.6 (0.084 – 3.6)

Notes: ND = No Data available.

[1] Clarity data for <Half-median flows comprises 8 data points;E coli data for <Half-median flows comprises 2 data points

[2] A 'threshold flow range' of 5 to 8 m3/s was used to summarise data in the range where the effluent discharge commences; 9 data points available for clarity;

[3] Clarity data for high flows (>6.15 m3/s) comprises 16 data points; 32 data points for E. coli (range 3 – 493 cfu/100 mL).

Table 35 Winter E.coli and Clarity at 300m Downstream of Discharge in relation to River Flow

Flow category [1]	*E.coli* (cfu/100 mL) Median (5 – 95%ile)	Clarity (visibility of Black Disc in metres) Median
< Half-median	No change	No change
Threshold flow range	Negligible change	2.5 [a]
High flow	Negligible change	Negligible change

[a] Estimated value based on a 17% reduction predicted for Monte-Carlo modelling of summer discharge.

Because of the lack of data, winter 'predicitons' are not based on modelling, but rather providing an expert view based on the summer data and winter conditions (e.g. ponds generally clearer, high variabilibity in E coli and clarity upstream).

Table 36 Predicted Winter *E.coli* and Clarity at Wardells Bridge in relation to River Flows

Flow category [1]	*E.coli* (cfu/100 mL) Median (5 – 95%ile)	Clarity (visibility of Black Disc in metres) Median
< Half-median	No change	No change
Threshold flow range	Negligible change	2.6 [a]
High flow	Negligible change	Negligible change

Notes; [a] Estimated value based on a 13% reduction predicted for Monte-Carlo modelling of summer discharge.

Notes: 'No change' refers to distribution values upstream as given in Table 32. 'Negligible change' indicating that the magnitude of change would be very small.

[1] See Table 32 footnotes;

Tables 34, 35 and 36 summarise the available *E. coli* concentrations in relation to river flow, though only the >half-median flow category provides a reasonable number of data points (n = 58). The predicted change for flows above half-median is either no change or negligible change as a result of the discharge during the winter period.

With regard to winter clarity conditions, the upstream value for the low flow and threshold flow scenarios indicates a good clarity (median of 3.6 m and 3.0 m respectively) which does not change significantly following the onset of a discharge. It is predicted that the plume will be inconspicuous (i.e., <50% change in clarity) once reasonable mixing has occurred

8.2.4 Comparison with Existing Water Quality

A comparison of Ruamahanga River summer water quality is summarised for flows below and above median for before and after the proposed upgrade for the downstream site at Wardells Bridge (Table 37. The highlighted values indicate marked (>50%) improvements from the existing conditions that will occur for water quality at Wardells Bridge under low flow (< Median) conditions, particularly for increased clarity and reduced *E. coli* and nutrients. Marked improvements will also occur above median flow for ammoniacal-nitrogen and nitrite-nitrogen.

The predicted changes in downstream water quality at low flows are a result of elimination of the discharge during this period. At high flows (>median) the improvements are the result of the combination of 3 major factors: (i) pond treatment upgrade to reduce *E.coli* concentrations; (ii) full mixing occurring upstream of Wardells as a result of a change in discharge location and installation of diffusers; and (iii) use of a flow-proportional (i.e. constant 30x dilution) relationship.

The elimination of the discharge from the river at low flows will result in greatly improved water quality, especially clarity and faecal contaminants, and improve the receiving environment for the higher recreational use occurring during this period. The nutrient parameters (nitrogen & phosphorus) which increase at high flows are intermittent in nature and occur at times when the river conditions prevent the stimulation of attached growths (i.e., scour and turbidity).

Table 37 Comparison of Water Quality at Wardells Bridge in Summer

	< Median flow			> Median flow		
Parameter	**Before**	**After**	**Change (%)**	**Before**	**After**	**Change (%)**
	Median	**Median**		**Median**	**Median**	
Flow (m^3/s)	5.6			19.4		
PH	7.4	7.5	1%	7.3	7.2	-1%
Conductivity (›S/cm)	152	134	-12%	112	106	-5%
Dissolved Oxygen (g/m^3)	9.4	9.6	2%	9.8	9.9	1%
Dissolved Oxygen % saturation (%)	97.3	98.3	NC	95.9	95.4	NC
Black Disc (m)	1.34	3.6	**170%**	1.21	1.3	7%
Colour - Hue (Munsell points)	32.5	35	8%	33.8	37.5	11%
E.coli (cfu/100mL)	93.5	34	**-63%**	300	198	-34%
Ammonia-N (g/m^3)	0.11	0.016	**-86%**	0.12	0.054	**-55%**
Nitrate-N (g/m^3)	0.81	0.52	-35%	0.54	0.41	-24%
Nitrite-N (g/m^3)	0.029	0.003	**-91%**	0.023	0.0077	**-67%**
Total Kjeldahl Nitrogen (g/m^3)	0.57	0.18	**-68%**	0.41	0.55	33%
Total Nitrogen (g/m^3)	1.48	0.70	**-53%**	1	0.93	-7%
Total Phosphorus (g/m^3)	0.24	0.028	**-88%**	0.12	0.15	24%
Dissolved Reactive Phosphorus (g/m^3)	0.19	0.020	**-89%**	0.071	0.11	**52%**
Turbidity (NTU)	2.55	0.85	**-67%**	6.42	5.15	-20%
Total Suspended Solids (g/m^3)	3	0.94	**-69%**	17.5	12.0	-31%
Total Organic Carbon (g/m^3)	4.2	ND	NC	3.8	ND	NC

Notes: **1)** NC = No Change; ND = No Data. **2**) Monitoring data from March 1994 to October 2005 for <Median flow (12.3 m^3/s; n = 57) and > Median flow (n = 31). **3**) Rua 2 concentrations are measured values before upgrade and calculated after using: <Median - using Rua 1 values with addition of summer median effluent data to estimate leachate (diluted 443x); and (ii) >Median flow have effluent (diluted 30x) + leachate (dilute 443x). **4**) E.coli concentrations use the predicted upgrade median of 330 /100mL.

8.2.5 Effects of the Discharge on Health Risk

The potential risks resulting from any chemical and microbial hazards emanating from the upgraded MWTP were investigated for the three potential exposure routes: accidental ingestion/inhalation during aquatic recreational activities, consumption of drinking-water, and mahinga kai harvested from the Ruamahanga River (ESR 2007). As discussed in section 5.5.4, the highest risk relates to primary contact recreation in the river. The Health Impact Assessment (ESR 2007) conservatively determined that the current risk at median flow for swimmers at Wardells Bridge is 7.3 infectious disease cases per thousand persons engaging in primary contact recreation.

In practice, Wardells Bridge is not heavily use for primary contact recreation and accordingly the actual risk of someone contracting disease as a result of even the existing discharge is quite low. The risk of disease also reduces considerably as one moves downstream out of the mixing zone. The risk will be considerably lower as a result of dilution and die-off, by the time the much more popular recreation site at the Cliffs is reached.

The proposed upgrade of the MWTP and associated changes to the effluent discharge regime will reduce the risk of infectious disease to recreational users of the river downstream of the ponds. The estimated degree of this improvement, at below-median flows in summer (no direct discharge) is a reduction in risk from 7.3 cases per thousand at present to 1.0 case per thousand contacts at Wardells Bridge after the upgrade (the actual reduction is likely to be higher given the conservative assumptions involved). This is the risk from the pond leakage since at these flows there is no direct discharge. This risk is well within the acceptable limit of 8 per thousand stated in the Recreational Water Guidelines, and the 10 per thousand limit inferred from the current *Microbiological Water Quality Guidelines for Marine and Freshwater Recreational Areas* (MfE/MoH, 2003).

Again it should be noted that the minimal risks at the Wardells Bridge site will be further reduced by the Cliffs site, as a result of dilution and die-off.

The MfE/MoH 2003 Guidelines have moved away from the sole use of guideline values of faecal indicator bacteria, and instead use a combination of a qualitative *risk grading* of the catchment, supported by the *direct measurement of appropriate faecal indicators* to assess the suitability of a site for recreation. In addition alert and action guideline levels are used for surveillance throughout the bathing season.

The two components used to provide a grading for a freshwater recreational site are:

- The *Sanitary Inspection Category* (SIC), which generates a measure of the susceptibility of a water body to faecal contamination
- Historical microbiological results, which generate a *Microbiological Assessment Category* (MAC), which provides a measurement of the actual water quality over time.

The removal of effluent from the river during low river flow in summer will benefit both the SIC (no direct discharge of treated effluent close to a swimming location) and MAC (the 95%ile upstream *E.coli* concentration at < median flow is < 130 per 100ml). With reference to Table E2 of the Guidelines, the Suitability for Recreation Grade for the Wardells Bridge and Cliffs sites at less than median flow will be “Very Good”.

When freshes occur, discharge with a 30:1 minimum dilution will commence at median flow. The health risk attributed to the effluent for river flows > median have been assessed as 4.2 per 1000 at Wardells Bridge (ESR 2007), which is below the acceptable limit of 8 per 1000 referred to above. It should also be noted that during freshes upstream water quality deteriorates as flow increases (turbidity and microbiological), the water temperature drops and the current becomes swifter. These factors all discourage swimming, which markedly reduces numbers of swimmers and consequent exposure to health risk. As discussed in Section 8.2.3, the water quality upstream of the MWTP deteriorates to such an extent that the addition of treated effluent has only a marginal negative effect on health risk (Tables 31 and 33). Furtheremore, as outlined earlier, the threshold flow range between discharge occurring and when the river becomes more polluted upstream only occurs for a very short duration.

Based on the limited chemical monitoring data to date, there would appear to be little health risk via consumption of contaminated mahinga kai, as all of the chemicals tested were below the limit of detection in the samples of pond effluent tested. The investigation of the existing state of mahinga kai found no significant effects from 35 years of the existing discharge (see section 5.5.3), and the upgraded plant, with its more limited discharge into the river taking place at higher flows, together with higher standards of treatment, would, if there were any effect, improve the quality of the aquatic environment.

In summary, effects on health risk will primarily be mitigated by eliminating the direct discharge of effluent to the river during low flow periods. At these times the river is often clear and warm, attracting peak numbers of swimmers and upstream microbiological quality is high. At times when there is a direct discharge, effects on health risk will be less than minor for the reasons outlined above. Neither the pond leakage nor the direct discharge will cause contact recreation standards to be breached after reasonable mixing.

8.2.6 Summary of predicted effects of the discharge.

Effects of the Discharge on Health Risk

Recreational health risk will be mitigated by eliminating the discharge of treated effluent to the river during low flow periods. At these times the river is often clear and warm, attracting peak numbers of swimmers. In the future, treated effluent will only be discharged to the river during the summer when freshes occur and the flow exceeds the median value of 12.3 m3/s.

During freshes, water quality deteriorates (colour, turbidity and microbiological), the water temperature drops and the current becomes swifter. These factors all discourage swimming, which markedly reduces numbers of swimmers and consequent exposure to health risk. In addition, as discussed in Section 8.2.3, the water quality upstream of the MWTP deteriorates to such an extent that the addition of treated effluent has a negligible negative effect on health risk. The threshold flow range where the river is most sensitive to the discharge (just above median flow) only occurs for a short duration.

Effects of the Direct Discharge on Periphyton Growth

The potential for undesirable biological growths is relevant to both the intermittent effluent discharge and the leakage from the ponds. The Ruamahanga River was found to be phosphorus limited and the peak periphyton growths limited by frequent flood flows (NIWA 2003). Presently, although there is currently a detectable impact in terms of increased biological growth downstream of the existing discharge, the extent of the biological growth does not reach nuisance (*undesirable*) levels.

In the future, four factors will together further reduce periphyton growths: (i) the cessation of direct discharge during summer at flows below median flow; (ii) the intermittent nature of the discharge; (iii) improved mixing of the effluent discharge; and (iv) the discharge at high flows with turbid waters and high scour conditions. Together, these factors will continue to avoid nuisance growths occurring and will reduce algal growth as compared to present. The leakage from the ponds is upstream of Wardells Bridge and presently causes some slight stimulation of periphyton growths, but not to nuisance levels. Predicted nutrient increases from the maximum leakage rate to half-median flows will be below the site-specific DRP concentration guideline of 0.030 g/m^3 (NIWA 2004a) after reasonable mixing (refer Section 8.2.2). Though some algal growth stimulation will occur from the leakage, the periphyton will continue to be below the nuisance guideline and the peak growths will be controlled by the high river flood frequency.

In summary, in the future following the upgrade, there will be a marked improvement in nutrient status, with there being no direct effluent discharge at less than median river flow in summer (the time when biological growth is most prolific). At flows above median, the additional nutrients from the plant will not cause any undesirable growths because the frequency of high flow periods (river freshes) is predicted to be sufficient to scour the river bed and in doing so will limit the undesireable growths.

Effects of the direct discharge on aquatic life

The existing discharge does not cause significant adverse effects on macroinvertebrate communities at Wardells Bridge, nor fish populations in the Ruamahanga River or catchment (Sections 5.3.3).

The proposed upgrade to an intermittent discharge, with improved downstream mixing of effluent and limitation of discharge to flows greater than median in summer (>half-median in winter) will not result in exceedance of ammonia toxicity guidelines and will improve water quality both immediately downstream of the discharge (as a result of improved mixing) and at the Wardells Bridge site. An increase in sensitive invertebrate species, such as mayflies, will be expected in the previously poorly mixed region at Wardells Bridge which is downstream of the Makoura Stream inflow. Additionally, the removal of the discharge from the Makoura Stream will result in a significant improvement in water quality which will have beneficial effects on resident macroinvertebrate and fish communities.

Effects of direct discharge on colour and clarity

The Ruamahanga River at Wardells Bridge will show a marked improvement in clarity as a result of the elimination of the summer discharge for flows below median (Table 37). Initiation of the discharge at median flow will not result in a conspicuous reduction in clarity, either during the threshold flow period when the discharge is initiated, or at higher flows when the river clarity naturally declines (see Section 8.2.3). The shifting of the discharge point upstream and the use of a mixing diffuser will eliminate the highly visual partial mixing zone which currently exists below the Makoura Stream inflow. The combined result will be a significant improvement in river clarity during high use recreational periods.

The ponds have a lower algal production in winter with a consequent reduction in suspended solids and increased clarity compared to summer (median suspended solids 38% lower and black disk clarity >2-fold higher than summer). Flows in the Ruamahanga River are higher in winter (Fig. 29) and clarity shows a marked reduction with increasing flow, with generally good, though highly variable, clarity at below half-median flow (Table 37). The predicted improvements in clarity will be high for below half-median flow when the discharge does not occur (this is 7.5% of the time) and a predicted 'no significant change' for higher flows. It is predicted that the plume will be inconspicuous (i.e., <50% change in clarity) once reasonable mixing has occurred.

With regard to colour, oxidation ponds have a characteristic yellow green colour as a result of the algae in the wastewater. During lower river flows the pond algae can settle on the riverbed, and this gives the appearance of a green plume. This is currently the situation in the Ruamahanga River primarily because at the confluence with the Makoura Stream the river flow is frequently low enough to allow algae to settle. The settled pond algae are a negative impact for recreational users of the river, and on its aesthetic appearance.

The measure of colour is the Munsell Scale. The actual colour of the river upstream of the confluence is yellow-green (upstream Rua 1 typically Munsell hue 10GY(40)8/2 in summer) and has a colour similar to the wastewater (Beca 2006). Therefore, even in the summer when there is more green colour from the algae, the discharge typically changes the river colour by only 2.5 Munsell points (downstream Rua 2 typically 7.5 GY(37.5)7/6). This is lower than the 10-point guideline in MfE Water Quality Guidelines Nº 2 (1994), Guideline 2. (Appendix B).

The impact of the discharge on perceived colour will be markedly reduced following the proposed upgrade. This will occur for three main reasons:

- There will be no algae settling on the bed below median flows (summer) because there will be no discharge;
- There will be markedly reduced settling of pond algae on the bed when the flows are median and above because higher river velocities will keep algae entrained in the water column;
- Moving the discharge point from the Makoura Stream to the main stem of the Ruamahanga River and discharging via a diffuser will result in better mixing and less visual impact; and
- The discharge occurs only during flows above median, when the river is naturally discoloured, this will result in a lesser ability to perceive any colour changes.

The future colour-related effects on the receiving water will therefore be minor and significantly less than the existing situation.

8.2.7 Compliance with Section 107 Standards

The following discussion addresses compliance with section 107 minimum standards following the proposed upgrade. These standards all apply after reasonable mixing.

- **The production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials**

  There will be no conspicuous oil or grease films, scums or foams, or floatable or larger particulate material after the treatment process. It is predicted that the effluent will continue to achieve a suspended solids content of typically less than the 20 g/m^3 that has been achieved following the interim upgrade, , which is a very good performance (the incoming raw wastewater typically has a concentration of around 130 g/m^3 (refer Table 22 for tabulation of the existing effluent quality following the interim upgrade in 2003) (suspended algae is discussed below in relation to colour)

- **Any conspicuous change in the colour or visual clarity**

  MFE (1994) defines a conspicuous change in visual clarity to be 33% - 50% reduction and that the hue of a water body should not be changed by more than 10 points on the Munsell scale for contact recreation purposes (Table 29). The analysis detailed above with respect to clarity, predicts that compliance with section 107 (no conspicuous change to colour or clarity) can be achieved by 300 m downstream both in summer and winter**.**

  In summer when flows are > median, the average summer clarity reduction will be 17% after 300m with a maximum (upper 95%ile) change in clarity of 50% reduction 300m occurring during the threshold flow period (flows 12.3 – 14.0 m^3/s) just after the initiation of the discharge. This threshold flow range occurs only 4% of the time on average. The effects of the discharge on clarity will rapidly diminish with increasing flows (as flow increases upstream turbidity will begin to dominate).

  The above discussion relates to anaysis and modelling undertaken to predict effects, and is not intended to propose a RMZ, which is subject to consideration of a range of factors.

  Both colour and clarity effects will be eliminated at flows less than median in summer (<half-median in winter). The existing adverse effect of suspended algae in the effluent contributing to poor colour and clarity will be eliminated at these times.

  At times when discharge does occur, colour change is expected to be less at high flows than the existing measured change of 2.5 Munsell points occurring at Wardells Bridge. (A conspicuous change would be 10 Munsell points (Table 29)

- **Any emission of objectionable odour from the discharge to water**

  The existing discharge to the river does not result in any objectionable odour in the Ruamahanga River. On this basis, plus the fact that there are specific measures to prevent the generation of odours incorporated in the design and operation of the ponds, means that there will be no objectionable odour as a result of the discharge to water.

4 **Rendering of freshwater unsuitable for consumption by farm animals**

Freshwater (in this case the Ruamahanga River) will not be rendered unsuitable for consumption by farm animals. Assessment of chemical contaminants in the pond discharge water is based on an annual sampling for heavy metals and organic contaminants and has shown these to be below ANZECC (2000) water quality guidelines after mixing. The consumption of downstream river water for livestock is not currently an issue and will continue to not be an issue. The intermittent nature of the proposed discharge will further reduce exposure of river organisms to contaminants.

The animal health protection guideline for drinking water protection is 100 /100mL as a median value (ANZECC 2000, section 9.3-5; Table 29). The elimination of the discharge at less than median flow and the minimal increase in concentrations at higher flows will result in no additional risk for livestock as a result of the discharge.

Any significant adverse effects on aquatic life, including undesirable biological growths

Factors that could have an adverse impact on aquatic life include pH, dissolved oxygen, deposition of matter on the bed of the river and ammonia toxicity. The predicted changes downstream after reasonable and full mixing are summarised below in Table 38 and the guideline targets are provided in Table 29. Each of these factors is discussed below.

The pH of Masterton's incoming raw wastewater is an average of 7.1 (refer Table 4). The treatment process in the oxidation ponds is expected to result in negligible change to this pH level, and on this basis there will not be any adverse effect due to the pH of the effluent.

In order for oxidation ponds to function efficiently, it is necessary for a minimum dissolved oxygen concentration to be maintained. Natural processes in the ponds will usually ensure this happens, although there may be times (these are infrequent) when the addition of additional oxygen is necessary. This is provided for by permanently installed surface aerators which can be operated as necessary to provide additional aeration, thereby boosting the concentration of dissolved oxygen in the ponds. The existing changes in dissolved oxygen concentration at Wardells Bridge are negligible and will remain negligible with the upgrade.

The biochemical oxygen demand guideline is based on minimizing potential bacterial growths on dissolved organic components (MFE 1992). The guideline value will be met after reasonable mixing (Table 38).

The deposition of matter on the bed is a site-specific issue relating to the nature of both the discharge and the receiving water. There are inlet and outlet screens on the plant to prevent discharge and potential deposition of large material. The change to an intermittent discharge with initiation at median flow and the use of discharge diffusers to improve mixing will result in negligible deposition of organic material onto the river bed after reasonable mixing.

Ammoniacal-nitrogen, nitrate-nitrogen and nitrite-nitrogen each have the potential to cause toxic effects to aquatic organisms. Estimates of the downstream concentrations of these parameters have been made after reasonable mixing and based on the 95%ile effluent values. All these parameters are markedly less than the guidelines values (Table 38), which combined with the intermittent discharge, indicates a negligible potential for toxic effects on aquatic biota.

Nuisance growths of attached algae, or periphyton, are stimulated by river nutrients (nitrogen & phosphorus) and are controlled by a range of factors (e.g. light, floods, grazing). The potential for nuisance growth stimulation is greatly reduced by the intermittent discharge with the median flow threshold, since periphyton growths at high river flows will be limited by scour and low light conditions.

The leachate from the ponds provides some limited potential for stimulation of periphyton, however, calculations indicate that this will be below (66%) of the site-specific guideline developed for the Rumahanga River (Table 38). There will be no significant nuisance growths as a result of the pond discharge.

In conclusion, the discharge will readily meet the minimum standards set out in section 107 of the Act.

8.2.8 Consistency with Relevant Water Quality Guidelines and Targets

Compliance with section 107 is discussed above. This section addresses whether the discharge will meet other relevant guidelines.

The majority of relevant guidelines have been considered in terms of the section 107 requirements and are summarised in Table 38. Because of the nature of the proposed upgrade, with discharge triggered by elevated river flows, the analysis and future compliance monitoring of effectsrequires a different approach from what would be used for a full time discharge. Predominantly this relates to assessing effects against the natural decline in river water quality which occurs during flood events. We have addressed these by considering the 'threshold flow region', which examines data in the flow region where the discharge will be initiated, and the downstream mixing behaviour of the contaminants. We have used a nominal benchmark of 300 m (20-fold dilution) for 'reasonable mixing' and have shown that full mixing occurs at approximately 800 m downstream of the new outfall location. (the applicant suggests 400m as the actual length of the RMZ) The proposed compliance regime is addressed in detail in Section 12.1, with the majority of contaminants to be assessed relative to percentile standards derived from upgraded pond performance values, which can be compared with guideline targets after allowing for reasonable mixing. Receiving water validation requires upstream and downstream comparisons of contaminants, recognising that some parameters will already exceed guideline triggers when the river is in flood.

River clarity may be assessed against guidelines in terms of both "conspicuous change" and a bathing water guideline benchmark value of 1.6 m (Table 29). The analysis used for this assessment has concentrated on the change attributable to the discharge rather than the benchmark value (section 8.2.3). The reason for this approach is that the river is naturally below the benchmark value around median flow (median 1.0 m), and it is thus more appropriate to consider the additional change. The elimination of the summer discharge below median flow would remove any additional recreational impairment of use during this maximum use time.

The health risk from micro-organisms also warrants additional consideration. The proposed guideline targets are based on *E. coli* for both human and animal health protection (Table 29). The human health guideline is 130 /100 mL and based on a 95%ile compliance measured "in relation to recreational use" (MFE 2003). This assessment assumes that the primary recreational use will be in summer during periods when the flow is less than median, at which time the discharge will not be occurring. (which is a reasonable assumption confirmed by the survey of recreation use)Thus there will be no increased health risk from the discharge during times of high recreational use. The animal health protection guideline for drinking water protection is 100 /100mL and is based on a median value (Table 29). The elimination of the discharge at less than median flow and the minimal increase in concentrations at higher flows will result in no additional risk for livestock as a result of the discharge.

A suite of chemical contaminants is currently monitored annually in the pond water and compared with ANZECC (2000) water quality guidelines. It is proposed that this monitoring would continue and that the compliance would be assessed after allowing for reasonable mixing (i.e., 20-fold dilution).

Macroinvertebrate community composition is currently monitored upstream and downstream of the discharge. Ongoing compliance monitoring of macroinvertebrate communities is proposed for both upstream and downstream (downstream at Wardells Bridge & above Waingawa River confluence) in order to measure trends in the biological response to the improved water quality conditions. The compliance with the narrative guideline would be measured for total number of taxa and abundance of key species and groups (e.g., mayflies).

Details of the proposed compliance monitoring are presented in Section 12.1.

Table 38 Predicted Values of Water Quality Parameters after reasonable mixing (i.e. 20x dilution at 300 m downstream) and at Wardells Bridge in Summer for the Threshold Flow Region [a]

Parameter	Receiving Water Target	Measured values (just below median flow) [b]	Predicted value: after reasonable mixing	Predicted value: Wardells Bridge
Filtered BOD (g/m3)	2.0	0.31	0.60	0.51
Visual Clarity - Black disc (m)	1.6	1.0	0.85	0.89
Visual Clarity change (%)	33-<50% change	Nil	17%	13%
Colour –Hue (Munsell points)	10 points change	10GY(40)8/2	c. 7.5 GY(37.5) (2.5 points change)	7.5 GY(37.5)7/6 (2.5 points change)
Ammonia-Nitrogen (g/m3)	1.61	0.01	0.55	0.39
Nitrate–Nitrogen (g/m3)	7.25	0.50	0.71	0.64
Nitrite–Nitrogen (g/m3)	9	0.001	0.10	0.07
E.coli (cfu/100 mL) – human [livestock]	130 [100]	83	89	87
E.coli change (%)			6.5%	4.3%
Dissolved Reactive Phosphorus (g/m3)	0.03	0.015	NR	0.020 [c]

[a] Threshold flow range = 12.3 – 14.0 m3/s. "Threshold flow range" is the flow region where the discharge is initiated. This occurs approximate 4% of the time and 13% of the time when potentially discharging (see Figure 28).

[b]. Measured upstream medians except model predicted median values for E. coli and clarity (from Tables 34 & 35).

[c] leachate contribution at less than median flow (Table 41)

NR = Not relevant to target guideline.

8.2.9 Summary of Expected Improvement in Receiving Water Quality

Details of the proposed discharge regime and the point of discharge are given in sections 4.4 and 4.7, respectively. In summary, the above tables show that the predicted concentrations for all parameters are less than the receiving water targets at 300m downstream of the point of discharge and that there is negligible impact at Wardells Bridge as a result of the effluent discharge either in summer or winter.

In summary, the main changes are:

- There will be no discharge of effluent to the Makoura Stream;
- There will be no direct discharge of effluent to the Ruamahanga River when the river is below median flow in the summer and ½ median flow in winter;
- There is a minimum dilution requirement (30x) for direct discharge of effluent to the Ruamahanga River when the river is above median flow in summer, and half median flow in winter;
- There will be an improved microbiological quality as a result of; improved pond performance; elimination of discharge below median flow in summer (half-median flow in winter); and relocation and enhanced mixing from the discharge diffuser;
- The discharge point will be moved upstream away from Wardells Bridge;
- The inclusion of a diffuser will result in better mixing of the discharge and full mixing well upstream of Wardells Bridge.

The predicted environmental improvements as a result of these changes are:

- A significant improvement in water quality
- No coloured plume in the Ruamahanga River downstream from the Makoura Stream to Wardells Bridge, along with enhanced clarity.
- No conspicuous change to colour and clarity after reasonable mixing
- Elimination of the presence of settled algae from the pond in the partially mixed region downstream of the Makoura confluence and upstream of Wardells Bridge.
- An improvement in the water quality of the Ruamahanga River during summer low flows downstream of the MWTP because there will be no effluent discharged directly to the river at low river flows (below median river flow), when the river is most attractive for contact recreation (especially swimming).
- An improvement in microbiological water quality of the Ruamahanga River downstream of the MWTP when effluent is discharged above median flow (summer) and compliance with water quality targets after reasonable mixing and at Wardells Bridge.
- Zone to achieve full mixing reduces from well below Wardells Bridge to approximately **450 m** upstream of Wardells Bridge.

8.2.10 Effects of Riverbed Works

The construction of the erosion protection works will require work in the riverbed, as well as land-based construction activities. The nature of these works is described in section 6.8. The construction methodology will generally follow GWRC practices developed from similar works at other sites.

The work will be carried out in flowing water, as this will have less effect than river diversions or bunding off the relevant section of riverbank. Careful placement of the rock will minimise the disturbance on site. The main disturbance will be during the excavation of the riverbanks as they are shaped in preparation for placement of rock.

Construction will take place outside the trout-spawning season from 1 June to 30 August and accordingly there will be no disruption to fish passage. The river disturbance will have some visual impact from the increase in turbidity of the water. While this work will be carried out during the summer months the effects will be minor and temporary. Mostly the work will disturb coarse gravel material and involve the placement of large rocks and therefore will have a relatively low impact on water quality. There will be construction noise with trucks delivering rock to the site and excavators placing the rock on the riverbank. However, the construction contractor will be required to comply with the relevant standards for construction noise and work within the nominated working hours specified in the construction contract. The nearest house is approximately 100 m from the erosion protection works on the left bank at the river bend opposite Pond 1.

In conclusion, while there will be effects during construction of the in-river works, these will be temporary and minor in nature, and will not result in any long term adverse effect.

8.3 Effects on Groundwater

8.3.1 Introduction

There are two potential sources of effects on the groundwater from the proposed scheme, namely from the irrigation of effluent onto the soil, and from leakage from the oxidation ponds. These sources may have potential effects on groundwater mounding (potential to raise the water table), and on groundwater quality. The discharge of contaminants also has the potential to affect soil characteristics. Each of these potential impacts has been investigated.

To assess impacts, a model (PDP, 2006) of the groundwater flow pattern at the site has been developed. This model enabled the groundwater flow direction, groundwater mounding (the impact on the water table), impact on groundwater quality, and groundwater-surface water interaction to be quantified spatially across the site. The site was subdivided into eleven 'plots' of like soil type so that an appropriate representation of the variable permeability across the site could be factored into the development of the groundwater model.

8.3.2 Effects on the Water Table (Groundwater Mounding Impact)

In term of the proposed irrigation process, when the effluent is applied to the soil surface it infiltrates vertically down through the soil profile. Some of the applied effluent is used by the pasture for growth, and some of the nutrients and contaminants are adsorbed by the soil. The net effect is that a reduced volume of effluent leaches through the soil profile to the groundwater. When this effluent reaches the groundwater (the underlying aquifer), a small additional 'head' will be created (referred to as mounding).

The groundwater model was developed for three scenarios:

- A dry-land scenario representing the site prior to irrigation with effluent, with recharge only from rainfall and surface water under specific circumstances
- Two scenarios with effluent irrigation:
    - High Rate – to assess short term impacts when high application rates are implemented
    - Average Rate. – to assess longer term impacts

High Rate (HRI) and Average Rate (ARI) represent average increases in drainage to the aquifer of 6.4 mm/day and 4.4 mm/day on average, respectively.

Pond leakage will make a separate contribution to the quantity of groundwater in the immediate vicinity of the oxidation ponds.

Groundwater Mounding

The modelling indicates that the maximum simulated change to the groundwater level in the aquifer to be less than 0.2 m on average, and commonly in the order of 0.1 m. The mounding expected from irrigation is small compared with the natural seasonal fluctuations, and is of a similar order of magnitude to the groundwater fluctuations caused by passing floods in the Ruamahanga River. Such small changes are not expected to significantly change groundwater flow directions, with the predominant direction continuing towards the south (i.e. towards the Ruamahanga River). In other words, the groundwater flow direction under irrigated conditions does not deviate from its pre-irrigation state.

In summary, the groundwater analysis shows that the proposed effluent irrigation scheme should not cause excessive mounding in the underlying aquifer.

Effects on Flows in Ruamahanga River and Makoura Stream

The direction of groundwater flow from the irrigation area is towards the Makoura Stream and Ruamahanga River. Excess drainage from the irrigation area therefore has the potential to change the flow regime in these systems, particularly during summer low flow, and particularly for the Makoura Stream, which has a small catchment area.

A summary of the assessed flow increases is presented in Table 39. The results show that, in the Makoura Stream, the maximum increase in flow at the higher irrigation rate is 6%, whilst for the Ruamahanga it is only 1.3%. Such changes in the levels of stream/river flows will have minimal effect on the flow regime of the Ruamahanga River and Makoura Stream.

Table 39 Estimated Flow Increases - Makoura Stream and Ruamahanga River

	Increase in flow upstream to downstream past site (m3/s)		
Scenario	Natural	High Rate	Av Rate
Makoura Stream	0.1	0.11	0.11
Ruamahanga River	0.25	0.29	0.28

8.3.3 Effects of Irrigation on Groundwater (Aquifer) Quality

Contaminants from the irrigated effluent have the potential to pollute groundwater and therefore affect the quality of abstractions from the aquifer, or the quality of surface waters once it enters the river/stream systems.

The predominant transport pathways are considered to be down through the soil and then through the aquifer. This may be slightly affected by the presence of disused tile drains[60] in the southwest of the site (part of the paddock immediately to the north of Pond 3). However, it is expected that they are probably now ineffective and, since the area involved is small relative to the total irrigated area, they will not have any significant impact.

As noted in the previous section, the direction of groundwater flow beneath the irrigation area and ponds is towards the Makoura Stream and Ruamahanga River, away from the nearest aquifer wells, therefore, any effect on abstraction bores is very unlikely. However, to address the potential for aquifer contamination, Landcare and HortResearch undertook extensive field and modelling studies through the unsaturated soils of the irrigation area (HortResearch, 2007) to provide input to a groundwater model (PDP, 2006).

In general, it is expected that the proposed irrigation scheme will result in the downstream aquifer having higher levels of some contaminants than those found in natural rainfall derived recharge. However, the infiltration process through the surficial soil column will treat and substantially reduce the contaminant concentrations reaching the aquifer (see section 6.4.9). The residual concentrations will then be further reduced through dilution with groundwater, advection, dispersion, and, in the case of microbiological contaminants, die-off and filtration in the aquifer.

The parameters modelled were *E.coli*, adenovirus, nitrate (as nitrogen nitrate-N) and phosphorus. *E.coli* and Adenovirus were used as indicators to assess the potential transport of micro-organisms of concern for human health. Nitrate and phosphorus were modelled to assess the potential effects on human health (nitrate) and on the receiving waters of the Ruamahanga River and the Makoura Stream (nitrate and phosphorus). Virus attenuation through the unsaturated zone was not modelled to obtain a worst-case input concentration in the water reaching the aquifer. However, in practice, considerable attenuation through the soil is likely and accordingly the modelled scenario is very conservative.

The results of modelling through the unsaturated zone (in Table 40 below) show that significant reduction in *E.coli* can be expected after passage through the soil, but that removal rates are highly variable. Similarly, the reduction in nitrate-N and phosphorus is predicted to be at least 73% and 97%, respectively. The reference to numbered plots is based on the results of fieldwork that has subdivided the irrigation area into eleven 'plots' with similar soil characteristics.

[60] The locations, number of tile drains and discharge point(s) are unknown, although an earthenware pipe was found protruding from the bank of the Makoura Stream near the ponds. If the drains exist they potentially provide a preferential drainage path for the irrigated wastewater.

Table 40 Comparison of Contaminant Concentrations at Surface and at 1 m Depth*

Parameters	Concentration when applied to soil surface	Input to Aquifer – High Rate Irrigation (drainage from surface soil)		Input to Aquifer - Av Rate Irrigation (drainage from surface soil)	
		Min	*Max*	*Min*	*Max*
E.coli (cfu/100mL)	1000 (winter av) 200 (summer av)	0.07 (at Plot 11)	35.34 (at Plot 9)	0.07 (at Plot 11)	19.98 (at Plot 8)
Nitrate (mg/L)	11.5 Total N (annual av)	0.05 (at Plot 11)	3.10 (at Plot 8)	0.05 (at Plot 11)	3.02 (at Plot 8)
Phosphorus (mg/L)	2.5 (annual av)	0.003 (at Plot 11)	0.066 (at Plot 9)	0.003 (at Plot 11)	0.038 (at Plots 9 and 10)
Virus1 (virus/L)	10	No attenuation of viruses through the unsaturated zone was allowed for, so the input concentration was set to the expected pond wastewater concentration			

**After passing through the unsaturated zone[61]*

Further reductions in concentration can be expected in groundwater due to advection and dispersion, adsorption (phosphorus) and die-off (micro-organisms). The predicted summer average concentrations at the site boundaries are shown in Table 41 below[62]. The values for viruses and bacteria in this table will in practice be lower as the modelling did not account for filtration or adsorption given the uncertainty of appropriate factors for the Homebush aquifer.

Table 41 Expected Groundwater Contaminant Concentrations Along River Boundaries63

		Simulated Concentration at boundary							
Waterway	**Adjacent Irrigated Plot No**	**E.coli (CFU/100 mL)**		**Adenovirus (virus/L)**		**Nitrate (mg/L)**		**Phosphorus (mg/L)**	
		HRI	**ARI**	**HRI**	**ARI**	**HRI**	**ARI**	**HRI**	**ARI**
Drinking water Guidelines (DWSNZ, 2005)		**1.0**		**No limit set**		**11.3**		**n/a**	
Makoura Stream	1	1	1	2	2	0.5	0.5	0.001	0.001
	2	1	1	0.8	0.8	0.5	0.5	0.005	0.005
	3	0.5	0.5	0.8	0.8	0.5	0.5	0.0025	0.001
	4	3	1	2	1.5	1	0.8	0.0075	0.005
	5	2	0.5	1	0.5	0.5	0.3	0.0025	0.001
	11	0.05	0.01	0.5	0.5	0.01	0.01	0.001	0.001
Ruamahanga River	8	10	5	2.5	0.5	2	1	0.01	0.005
	9 and 10	10	5	0.8	0.3	0.5	0.3	0.01	0.005
	Ponds	0.0001	0.0001	0.2	0.1	1	1	0.02	0.01

HRI – High Rate Irrigation
ARI – Average Rate Irrigation

61 Refer to Appendix A3 for a plan showing location of plots referred to in this Table\
62 Taken from PDP, 2006, Table 8
63 Refer to Appendix A3 for a plan showing location of plots referred to in this Table 30).

The estimated concentrations of nitrate and phosphorus will be low compared with background concentrations in groundwater at the site. The average background nitrate level up-gradient of the ponds is 1.3 mg/L, which is nearly ten times lower than the drinking water standard for nitrate, probably due to agricultural runoff. The average background DRP concentrations are 0.02 mg/L. It can be seen from Table 41 that predicted nitrate and DRP concentrations at the irrigation area boundary are, at most, approaching the background concentration for the average rate application, and are generally less than half the background concentrations.

The *E.coli* concentrations will be slightly higher than the background levels. The average *E.coli* level up-gradient of the ponds is 1.2 cfu/100 mL. The most significant change is expected to occur under High Rate irrigation along the Ruamahanga River, where it forms the eastern site boundary. High Rate Irrigation of these plots will result in the highest predicted *E.coli* levels at the boundary of the site. However, even these highest *E.coli* concentrations are such as to have a minimal impact.

There have been no adenovirus measurements at the site, and therefore, no direct comparisons can be made. There is also no guideline value set in the Drinking Water Standards for viruses due to a lack of reliable evidence for these concentrations to be compared to. The analysis and results are considered to be conservative, as no filtration effects or attenuation in the unsaturated zone have been incorporated in the model.

8.3.4 Effects of Irrigation on Surface Water Quality

The predicted concentrations of *E.coli*, nitrate-N and phosphorus in groundwater at the boundary of the irrigation site are also small compared with concentrations within the Makoura Stream and Ruamahanga River (see Chapter 3). In all cases, the modelled concentrations in the groundwater are small compared with receiving water concentrations before dilution is considered.

In summary, analysis has shown that the concentrations of bacteria, viruses, nitrates and phosphorus will be largely contained within the site boundaries. There should be no effects from the irrigation on any groundwater abstractions beyond the site boundaries (for example, the private bores to the southwest) and only minimal effects on receiving waters.

8.3.5 Effects of Pond Leakage on Groundwater (Aquifer) Quality

The issue of the effects of existing pond leakage on river water quality was addressed in Sections 8.2.2 and 8.2.3.

To identify the potential effects of leakage from the existing and proposed ponds on drinking water bores, an investigation into groundwater quality in the area surrounding the ponds was undertaken (PDP 2006). The investigation revealed that the general groundwater flow is towards the river and away from the nearest wells. Consequently, it is expected that groundwater quality will deteriorate downstream from the Plant. Table 42 below summarises the results of these investigations.

Table 42 Existing Groundwater Quality Up-gradient and Down-gradient of Ponds

	E.coli (/100mL)	Nitrate-N (mg/l)	Ammoniacal-N (mg/l)	Total Nitrogen (mg/l)	DRP (mg/l)
Up-gradient	1.2	1.34	0.014	1.4	0.02
Median Wastewater (2004/05)	607	0.086	4.87	11.7	2.27
Down-gradient	1.2	0.30	2.4	2.9	0.18

For many parameters, the effects of pond leakage on groundwater quality are insignificant, with the results indicating little effect on the groundwater downstream from the pond leakage. Of particular note is the absence of any apparent effect on *E.coli* numbers. This is likely to be due to a combination of dilution, natural bacterial die-off and a filtering effect in the gravel aquifer. It should also be noted that the because the Ruamahanga River and

Makoura Stream act as physical boundaries to groundwater flow, the area potentially affected is very small (i.e., between the ponds and the river/stream).

It is of note that nitrate concentrations in upstream wells are higher than those downstream. This result could be due to the dilution effect of the leakage entering the groundwater system, as the effluent has considerably lower levels of nitrate.

A one-off monitoring for a suite of heavy metals and PAHs was carried out in bores between the ponds and the river (PDP, 2006). In all cases, this investigation revealed that there was an absence of heavy metals and PAHs in the down-gradient monitoring wells (at the various laboratory detection limits), and a general compliance with the New Zealand Drinking-water Standards 2005 (MoH, 2005).

There are a number of shallow bores on farms and smallholdings close to the Masterton-Martinborough Road, to the southwest of the ponds. The closest of these bores is approximately 540m from Pond 3. As the direction of groundwater flow in the vicinity of the ponds is generally towards the south – i.e., directly towards the Ruamahanga River – there will be no effects on the private bores under normal groundwater conditions.

As discussed in section 5.4.2, monitoring shows that groundwater levels respond rapidly to river level changes, although the response is relatively small (in the order of a few hundreds of millimetres at most). Given that the river and groundwater respond rapidly to rainfall events, any change in flow direction induced by high river levels will also be of short duration. The effect is that any change in flow direction towards the private bores will not be of long enough duration for contaminants to reach the bores before the flow direction is back to flowing towards the river. Averaged over time, the mean flow direction will still be very much towards the river.

At least one bore exists on the true left bank of the Ruamahanga River, opposite and downstream of the ponds. It is unlikely that there will be any adverse effects from contaminated groundwater travelling under the river to the far bank due to the geology of locality (PDP, 2006). The groundwater will be in hydraulic contact with the river and thus any pond leakage will discharge to the river.

In conclusion, the environmental effects of leakage from the upgraded and new ponds leakage will only be only minimal, and will be largely confined to some minor effects on the quality of the river.

8.4 Effects on Soils

The potential risk to the long-term sustainability of the soils from effluent disposal by irrigation is from excessive irrigation, which in turn could lead to –

- Excessive leaching of nutrients to groundwater
- Excessive salt build-up and the degradation of soil structure, by blocking pores, limiting aeration and reducing soil permeability to water
- Excessive build up of phosphorus (so it could potentially become "ecotoxic").

Such effects have the potential to eventually reduce crop growth, or lead to a failure of the land-based disposal system. The scale and significance of these potential effects are discussed below.

8.4.1 Water Balance and Nutrient Leaching

A number of scenarios were analysed to examine the effect that different rates and return periods for irrigation have on the water balance and potential nutrient leaching (HortResearch, 2007). The results of these studies indicate that, on average, irrigation will lead to a reduction in the nitrate concentration of the drainage water because of greater nitrogen uptake by the pasture and increased dilution due to larger drainage volumes. Under irrigation the nitrate concentration of the drainage water will be 2.6mg/L, compared with 6.0mg/L under a no irrigation scenario. The apparently high nitrate values under the no irrigation scenario are a consequence of low pasture uptake and very low leaching losses.

8.4.2 Effects on Soil Structure

One issue that can be of concern when land is irrigated by effluent is the impact of salts. These concerns relate to the effects of total soluble salts on plant health, and the effects of sodium on soil structure. Excessive salt accumulation in soil can reduce crop production and sodium accumulation can degrade soil structure, thereby reducing the permeability for water.

Generally, the risk of salt or sodium problems for New Zealand soils irrigated with sewage effluent is low as the chemistry lies within acceptable limits and winter rainfall and flushing of salts generally limits any effects (HortResearch, 2007). Nevertheless, HortResearch recommend periodic monitoring of the soil exchange, given the potential effects on crop nutrient balance.

8.4.3 Potential for Phosphorus Build-up

Phosphorus is an essential nutrient important for plant growth. However, if it accumulates in the soil at a greater rate than it can be utilised by pasture, then there is potential for phosphorus loss to groundwater. Soils vary in their ability to adsorb phosphorus; the maximum amount a soil can adsorb before additional phosphorus is lost to drainage waters is known as the phosphorus sorption capacity (PSS). A PSS of 25% has been established in the Netherlands as the critical value above which potential for P movement into groundwater becomes unacceptable, while in Belgium a limit of 30% has been used (HortResearch, 2007).

Irrigation of effluent will add more phosphorus to the soil than can be taken up by the pasture and, as a result, soil P will slowly accumulate in the top 1.0m of the soil shown in Figures 21 and 22. The analysis by HortResearch (2007) predicts that, after 28 years of application, the maximum soil P concentration (inorganic form) will reach about 100-125mg/kg, compared with a PSS of 410-615mg/kg. After 28 years of wastewater application, the maximum soil P concentration is expected to remain at less than the critical value cited above. Accordingly, the accumulation of P in the topsoil is unlikely to cause any long term problems with pasture production or soil function at Homebush (HortResearch, 2007).

8.4.4 Conclusion

In summary, the irrigation will not compromise the long-term sustainability of the soils. Analysis, indicates that there is at least 28 years life (and likely longer) in the soils capacity to accept the effluent under the operation proposed.

8.5 Effects on Air Quality

8.5.1 Air Discharges from Ponds

Odour

The treatment of wastewater is always potentially odorous because of the inherent nature of wastewater. Oxidation ponds can become a source of odour where they turn anaerobic (low levels of dissolved oxygen). This can result from either shock loads or upsets to the biological processes in the ponds. When ponds become anaerobic, reduced sulphur compounds like hydrogen sulphide (the “rotten egg” smell) are produced. These odours can be offensive. In ponds that are correctly operating, the gases are treated in the aerobic layer and converted to odourless sulphur compounds.

Under normal operating conditions in a well-run plant, odour is not considered to be a problem. However, the inherently variable nature of wastewater means that there is the potential for an odour nuisance during treatment.

The Masterton oxidation ponds have historically not generated odours resulting in complaints. However, an exception occurred in August 2005 when odours varied in intensity over a period of a week. The odour was related to a drop in dissolved oxygen (less than 2 g/m3) and was addressed at the time by remedial measures including the introduction of additional aeration and over-pumping from one pond to another. This incident highlighted the need to de-sludge pond 1; consequently, Pond 1 will be desludged as part of the upgrade.

Currently, pond odour is monitored weekly in accordance with the MDC's *Odour, Air & Noise Management Plan*. The process for odour inspections, which has been agreed with Greater Wellington, is that there is a routine odour inspection undertaken at the downwind side of all three oxidation ponds, to determine the odour intensity downwind of each pond and an overall determination of the odour impact rating. This method of recording odour is in accordance with the German Standard VDI 3882 (I) (1992): *Olfactometry Determination of Odour Intensity*. As described earlier, there has been no ongoing history of odour problems from the ponds. Given this history, it is unlikely that odour will be a problem.

Following the proposed upgrade, the oxidation ponds will be used to provide storage, and hence will be operated in a different manner from the existing situation. This change in operation is not expected to change the situation with respect to the potential for odour generation due to the fact that a key requirement in the operation of the ponds is to maintain a satisfactory level of dissolved oxygen. Hence the overall conclusion is that following the upgrade the ponds are not expected to be a source of objectionable odour.

Aerosols

There is the potential for sewage aerosols (wind blown droplets) to contain viable bacteria and viruses. Aerosol transport is reliant on wind picking up small droplets of moisture from a surface and carrying the droplets downwind. Windy conditions increase the generation and dispersal of aerosols.

However, aerosols are not generally of concern from oxidation ponds. The Masterton ponds use brush aerators to promote circulation in the ponds, and these brush aerators create only a minor amount of splashing. In some specific circumstances, to improve treatment efficiency, additional aeration may be used in the primary ponds under certain atmospheric and pond loading conditions. Such additional aeration will be used in the summer time in the maturation cells to control blue green algae. This additional aeration could potentially create aerosols from an increased splash effect, but this will be a relatively localised effect and should not create excessive spray drift and transmission of aerosols. In addition, the distance to the nearest dwelling is approximately 350m, and aerosols are unlikely to travel this far.

In addition to the anticipated low odour and aerosol emissions from the ponds, there is a suitable separation distance between the ponds and any habitable dwelling to act as a buffer for further mitigation of any potential odour and aerosol effects. The proposed screen planting along the length of the Makoura Stream will also assist in reducing any minor potential for adverse effects from aerosols or odour.

Conclusion

It is concluded that the potential effects from odour and aerosols from the ponds will be no more than minor, and will be readily mitigated through an ongoing odour monitoring and management process.

8.5.2 Air Discharges from Irrigation

Odour

A well-operated system and maintaining the soil in an aerobic condition will not result in the creation of odours.

For odours to be released during application to land, anaerobic conditions would need to exist in the wastewater, either during the treatment process or within the conveyance pipelines. The risks of odour emissions and the proposed processes to manage them relate to the design and operation of the irrigation scheme. These aspects are outlined in sections 6.4 and 6.9.

Nearby properties that could potentially be affected by odour transmission include a dairy farm (with a residential house) adjacent to the western boundary of the irrigation area, and an orchard and several residential properties adjacent to the northern boundary of the irrigation area. The nearest residences to the west of the irrigation area are a dwelling at approximately 550 m (on the west side of Manaia Rd) from the edge of the irrigation area, and to the north of the site a dwelling at approximately 100m from the irrigation area. In the proposed border strip system, the effluent will be piped to each border strip rather than being conveyed in an open channel, as is the case with traditional border strip systems. The piped system will prevent any potential for odour generation from effluent ponding in headraces.

The ponding of effluent for extended periods on the ground surface has the potential to generate odours. Border strips will be constructed with a shallow grade, falling towards wipe-off drains, thus encouraging wastewater to flow off the strip. The management regime proposed for the irrigation scheme will also require that risk of ponding be minimised.

Odours can also be released from saturated soils when anaerobic conditions prevail. Border strips will be operated on a cyclic schedule, maximising the return period and re-aeration time for the soils, thus restoring aerobic conditions to the soil and avoiding odours.

The automated control system will monitor the performance of the irrigation scheme, including a warning system to alert the operator of problems with irrigation cycles, and durations, pump pressures, valve malfunctions and excess wastewater in the wipe-off drain. This system will provide a rapid response to ineffective operation of the irrigation scheme, thus mitigating the potential for odour generation.

In addition, any potential odours that might be generated by problems in the operation of the irrigation scheme will be mitigated by the presence of trees, as a buffer, around the irrigation area.

Thus while there is potential for an effect for odour generation from the irrigation area, the engineering design of the scheme, operational and mitigation measures are aimed at minimising odour from the irrigation area. Existing border strip applications in New Zealand have shown that even when standing next to an operating border irrigation system (in a properly functioning plant) that odour transmission is practically negligible.

In summary, therefore, the proposed upgrade is unlikely to create objectionable odour beyond the boundary of the site, with the risks effectively mitigated through the automated warning system and ongoing monitoring and management through an odour management plan.

Spray Drift and Aerosols

The proposed land application of treated wastewater through border irrigation will have no potential to create spray drift and negligible potential to create aerosols.

Conclusion

It is concluded that the potential effects from odour and aerosols from the proposed border irrigation application of treated wastewater will be no more than minor, and will be mitigated through planted buffer areas, an automated warning system, and an ongoing odour monitoring and management process.

8.6 Effects on Natural Hazards Risks

8.6.1 Earthquake Risks

The key risks from earthquakes are in relation to the stability of the pond embankments from ground shaking and fault rupture (Beca 2004d and Beca 2007)

Ground Shaking

The effect of ground shaking on the stability of the pond embankments was assessed as part of the initial design process. As discussed in section 6.7.7, general engineering practice in New Zealand normally uses a Factor of Safety (FOS) of 1.5 for civil engineering works (including embankments). A lesser FOS of 1.3 is sometimes used for temporary conditions (a few weeks to months), while a FOS of 1.1 is used for earthquake and flood loading.

Two scenarios were considered in assessing the seismic stability of the pond embankments: when –

- Liquefaction does not occur
- Liquefaction occurs.

Liquefaction is a relevant consideration at the site as the soils have been identified as being potentially prone to liquefaction. Liquefaction is the process where, during an earthquake, the soils lose all their strength and in effect behave like quicksand. Liquefaction occurs when the excess pore water pressures generated during an earthquake approach or exceed the effective confining stress of a soil. This results in a significant reduction in available shear strength and causes the soil to behave like a fluid.

The looser layers of recently deposited sandy alluvial soils at this site are considered potentially liquefiable. A 100-year return earthquake could cause bund failure under liquefaction that will result in displacements, in the order of 200mm to 500mm, which could potentially result in breach of the embankment.

A return period of 1 in 100 years is an appropriate assessment criteria for the stability of the embankment given that a breach of the embankment is unlikely and will not result in a severe risk to human life or the environment.

Ponds 2 and 3 will be the critical 'at risk' sections for embankment failure as it is along this section that the maximum slope heights (embankment plus river bank) and greatest water depth contrast (pond level down to low river flow) occur. Pond 1 is less critical because the distance between the pond embankment and the riverbank is greater than for Ponds 2 and 3.

A 100-year return period earthquake could cause some bund movement with small lateral displacements (expected to be in the order of 50 mm) and settlement of up to 50 mm. These displacements could occur differentially along the embankments, and if abrupt and not "self-healing", may result in a breach. However, the risks of such rupture are considered acceptable, given the low level of risks concerned.

The rip rap facing over the existing embankments and the rock toe to be constructed in the river adjacent to Ponds 2 and 3 has been designed to maintain a FOS of 1.0 under a 100 year seismic event. While a FOS of 1.0 indicates that the embankment is on the point of moving, the damage occurring is likely to be such that the structure is still serviceable or at least is repairable. Large displacements occurring during liquefaction may result in a breach of the embankment.

An ecological risk assessment was undertaken to investigate the potential level of risk to the Ruamahanga River associated with a breach of the pond embankment (NIWA 2004b). The assessment concluded that a breach of the embankment will result in a significant effect on river communities, primarily due to the substantial amount of sediment that could be deposited on the bed. However, this effect will be short-lived and recovery will be expected to be relatively rapid.

Fault Rupture and the Potential Ecological Impact

The available data suggests that the ponds are located away from active fault traces and are therefore most unlikely to be directly affected by fault displacement. Failure of the embankments will be expected at higher earthquake accelerations associated with activity on the Masterton or Carterton Faults, which have very much longer return periods (estimated to be 1500 years and 3000 years respectively).However, should abrupt ground displacement occur beneath an embankment, then breach will be likely to result.

8.6.2 Flooding and Erosion Risks

The Ruamahanga River channel in the area of the MWTP is well defined and readily contains the flows of small flood events. When floodflows increase above the defined channel, floodwaters will spill onto the adjacent floodplain land. There is no artificial containment of floodwaters, by stopbanks or other such measures, along the left side of the river and therefore larger flood flows spill onto the immediately adjoining flood plain. On the right side, however, overflow flood waters are confined by a stopbank down to the pond embankments, and then by the pond embankments themselves. These banks protect a considerable amount of low-lying land in the Homebush area.

The effect of the right side stopbanks on preventing the spread of overflow floodwaters onto land is relatively small. Most of the floodwaters flow within the main channel of the river and small rises in flood levels are sufficiently accommodated within the normal channel of the River. The width of the channel and remaining berm areas is large, while the fast flowing waters with high forward velocities are in the main channel. The narrowest section of river is around the tight bend by Pond 1, where the embankment around the pond restricts flows across the outer side of the bend. The upgrading of the stopbanks will not exacerbate the effects of the existing stopbanks on the river's capacity to contain floodwaters.

Upgrading the stopbank on the true right side of the river by the treatment ponds is to provide protection against the 1 in 100 year return event, which is considered to be an appropriate level of protection for the amount and value of asset being protected. Otherwise, the management of flooding risks in the wider area is unaffected by the upgrade proposal.

8.6.3 Effects of Flood and Erosion Protection Construction Works

The effects of the erosion protection works are primarily short-term effects that relate to those in-river construction activities that were outlined in section 6.8.4.

Any in-river works will be planned to avoid fish spawning periods and when the river is in its most sensitive state. There will be no disruption to fish passage. Fish are generally able to avoid turbid zones of water with little effects.

A number of bird species (for example, banded dotterel, black-fronted dotterel and pied stilt) breed locally on the large rivers of the Wairarapa Plains (including the Ruamahanga River). However, based on an assessment of effects on the environment for routine river engineering works and maintenance activities for the Upper Ruamahanga River Control Scheme (MWH, 2000), the area immediately around the ponds has not been identified as a nesting site.

The construction of the erosion protection work will be carried out in flowing water, as diversions and bunding off of the banks to allow construction in still water is considered to be more disruptive. Only very small percentages of dirt or soil will be allowed in any truckload of rock, and the careful placement of the rock that is required minimises contamination on site. There will be some disturbance during the preparation of the bank. The river disturbance will have a visual and turbidity effect on recreational use of the river during summer months. Any movement of the bed materials will disturb fine materials that will increase the suspended solids in the water, increase the tubidity and reduce the water clarity. Water quality monitoring during the placement of rock groynes in the Waikanae River showed a temporary increase in the suspended solids from a baseline of 2 g/m^3 to 98 g/m^3.

The work could, with sufficient resources applied, be completed over two to three months and hence the effects are of short duration.

With respect to the long-term impacts, these are no more than minor once the construction works are complete.

Accordingly, the effects of the flood and erosion protection construction works will be no more than minor.

In overall terms, the effects of the proposed flood and erosion protection works will be less than minor, given the existing level of flood/erosion protection in the area, the nature and temporary duration of in-river construction works. Any effects will be minimal, particularly in relation to the benefits that will be obtained in protecting a key community infrastructural asset.

8.7 Effects on Ecological Systems

The proposed upgrade of the MWTP, in terms of the proposed quality, quantity and frequency of discharge into the river, could have potential effects on the ecology of the river, in terms of:

- Macro-invertebrate community
- Fish
- Insects
- Waterfowl
- Farming practices

8.7.1 Macro-invertebrate Community

Studies on the macro-invertebrate population in relation to the existing discharge indicated ‘possible mild pollution’ downstream of the discharge (Bioresearches, 2002). However, the effects were determined to be minor compared with the deterioration in invertebrate quality caused by diffuse source pollution upstream of the MWTP.

Overall, there are no marked changes or ecologically significant degradation in macro-invertebrate community structure between sites upstream and downstream of the existing MWTP discharge. Some downstream changes were apparent, which are consistent with the enhancement of communities associated with increased algal growths (snails, midge larvae). More distant downstream sites show changes that are consistent with the combined effects of non-point agriculture and point source discharges (i.e., nutrient enrichment, sediment loads) and higher summer river temperatures.

The proposed changes to the discharge regime will eliminate direct summer low flow discharges, which will reduce the stimulatory effects on attached periphyton growths that currently contribute to the presently observed macro-invertebrate community effects. In conclusion, the proposed upgrade will assist in decreasing the proportion of species associated with algal growths (snails, midge larvae) and will therefore result in an improvement to macro-invertebrate indices reflecting low pollution species.

8.7.2 Fish

The existing discharge does not show any noticeable adverse effect on the fish life[64]. Accordingly, the proposed upgrade is not expected to have an adverse effect on fish life. To the extent that there are any potential effects those will be mitigated by the removal of direct discharge at low flows.

8.7.3 Insects

It is quite common for insects to live and breed at wastewater treatment plants. This is generally due to the presence of free water surfaces that attract insects, which lay their eggs in aquatic environments. The organic matter in the wastewater can be a source of food for the insects. Insects at wastewater treatment plants become a problem if they form large populations and create a nuisance for neighbouring residents. The most common nuisance insects associated with wastewater treatment plants in New Zealand are midges, mosquitoes and occasionally other species of fly (Browne, 2003; cited in Beca 2004).

The nuisance factors associated with midges and mosquitoes are:

- Biting behaviour (mosquitoes)
- Tendency to form large swarms, particularly in the warmer months when there is rapid breeding

[64] However it does appear to attract eels (an abundance of eels have been observed around outfall and in the ponds).

4 Attraction to lights, flying indoors and leaving remains on windowsills (Browne, 2003).

Many nuisance insects are small and have poor flying abilities, but they may be carried on strong winds and reach neighbouring properties. Therefore, the prevailing wind direction and the proximity of residential properties affect the potential for insect nuisance to occur (Browne, 2003; cited in Beca 2004).

No large populations of insects have been observed at the Homebush oxidation ponds in recent years and there have been no complaints about insect nuisance associated with the oxidation ponds. Midge larvae have not been seen in the oxidation ponds. It is possible that with the improvement in effluent quality, the pond wave band protection may be a more attractive habitat for midges than in the past, although the varying water level in the ponds will reduce this attractiveness. There is no reason to believe that insects will cause an adverse environmental effect following the upgrade.

8.7.4 Water Fowl

This section is based on an assessment of waterfowl at the oxidation ponds undertaken by ornithologist, TA Caithness, and reported in the *Pond Location Report* (Beca 2004a).

Species Attracted

Oxidation ponds worldwide attract water birds. The species and numbers of birds using the ponds will vary through the birds' breeding cycles. Waterfowl use both the primary and secondary ponds.

The oxidation ponds make a dynamic contribution to the sustainability and avian biodiversity of the immediate area. Frequently wetlands, which are important for the well being of water birds, are drained or destroyed in urban precincts to suit alternative land uses. In the greater Masterton area the oxidation ponds are an important buffer to those losses and are a valuable habitat for protected species of birds. The oxidation ponds, particularly in winter, are an important refuge for dabchick, scaup and shoveler. The ponds are also an invaluable holding area for a variety of waterfowl during the hunting season, with local hunters enjoying the early morning and evening flights to and from the ponds throughout the duck-shooting season.

Bird noise (i.e., ducks quacking) will, at worst, only be a complementary background to general rural stock noises.

Disease and Contaminants

There is no empirical evidence worldwide that birds using wastewater oxidation ponds transfer contaminants. The birds feed on the invertebrates and micro faunas produced by the oxidation pond treatment process, and suspended solids from the influent (including faecal material) in the primary ponds. It is expected that if there were diseases in the oxidation ponds it would affect the morbidity rate in the birds. There is no evidence of that occurring.

Further, there is no documented evidence that duck hunters near the Homebush oxidation ponds, or any other oxidation ponds, have experienced any related illnesses.

Farming Practices

Birds, along with insects, fungi and diseases, can interfere with cash cropping. Farming practices have been modified to ameliorate many of these problems. Waterfowl abound in the Wairarapa and are common on the myriad of drains, streams, rivers, ponds and lakes in the area. The Masterton oxidation ponds along with the nearby Henley Lake and Queen Elizabeth Park Lake are valuable local amenities that support large numbers of waterfowl throughout the year. Most species of waterfowl are strong fliers and can cover significant distances to a suitable food source within a short space of time. Therefore, the birds will feed wherever they locate good food, despite where they roost (i.e., the birds will be attracted to the neighbouring crops even without the presence of the oxidation ponds). Further, while mallards and paradise shelduck are the principal cause of agricultural damage, many of the species using the Masterton oxidation ponds are not interested in the crops.

In the Wairarapa, improved pasture management systems adopted progressively over the past thirty years have seen a significant increase in two species of waterfowl particularly adapted to grazing, namely Canada geese and paradise shelduck.

All species of waterfowl undergo an annual moult to replace their flight feathers. Most species undergo their moult through January. The birds are flightless for about three weeks during this moult and they commonly gather together in “safe” places that offer some feeding and grazing for sustenance and protection from interference and predators. Moulting areas, once established, are used annually and generally become ancestral.

A segment of the Wairarapa paradise shelduck population uses the Masterton oxidation ponds as their moulting site. In addition, members of the local farming community report that the shelduck population regularly causes damage to pea crops in particular and also pasture damage.

In conclusion, the upgraded oxidation ponds will be beneficial in terms of providing a refuge for bird species, particularly in winter. There is no evidence that the birds cause a significant environmental effect except for shelduck, which causes crop and pasture damage. However, if the ponds were not present, there is no shortage of suitable aquatic habitat for the paradise shelduck. Therefore adverse environmental effects caused by the ponds with respect to waterfowl will be negligible.

8.7.5 Conclusion

In conclusion, the quality of the river’s ecological systems will improve through the proposed upgrade, both in terms of the improved quality of effluent and the reduced discharge into the river, particularly over summer period of low flows. The expanded oxidation ponds are unlikely to create adverse effects through bird and insect nuisances.

8.8 Effects on the Community

8.8.1 Recreation and Amenity Values

The effects of the proposal in terms of water quality and community health are discussed earlier. These improvements will in summary result in the following improvements in terms of recreational aesthetic amenity:

- Health risk to recreational users will be reduced (from already low levels) by removal of the direct discharge at times of low to median flow, in summer, when most recreational use occurs and when upstream microbiological quality is relatively high.
- There will be a reduced health risk at Wardells Bridge from the discharge at threshold flows (just above median). This will occur at times when there is little recreational use and furthermore, this flow band occurs for a very limited time.
- This discharge regime will also minimise the potential for contribution to periphyton growth downstream of the discharge. This growth is, in any event, not currently a nuisance.)
- There will be no adverse effects on colour and clarity at less than median flow in "summer", which is when the current discharge has the most impact on recreational and aesthetic values.
- At above median flows little recreational use occurs and at these flows the upgrade will be fully mixed well upstream of Wardells Bridge (cf present).
- Effects on colour and clarity at these flows will be minimal.

Overall, the proposed upgrade will result in significant improvements to the recreational and amenity values of the river and any residual effects will be minor.

8.8.2 Tangata Whenua Values

Ways in which MDC has sought to address issues raised by tangata whenua in relation to the wastewater upgrade are summarised in Tables 7.7 and 7.8.

Table 43 Action in Response to Tangata Whenua Concerns

Nº	Recommendation1	MDC Action
1	That the recommendations are adopted	MDC is addressing the recommendations as outlined in this table.
2	MDC continue a close and active partnership with Tangata Whenua throughout the planning, operation and monitoring of the system.	Tangata whenua were represented on the CTG to assist consultation. MDC also met directly with tangata whenua representatives to discuss the project. After discussions with tangata whenua representatives it was agreed that hui were not required.
3	MDC take a precautionary approach in all aspects of planning and operation of application to land, including the analysis of long-term consequences and mitigation options.	MDC has thoroughly and comprehensively investigated feasible land application options including fulltime and part time land disposal. It has also identified water quality and wastewater standards to apply if there is any ongoing discharge to water.
4	MDC address the Maori communities' outstanding issues regarding the Rapid Infiltration option for sewage disposal, and past problems of the current system.	Rapid infiltration was investigated for the Manaia Road and Homebush sites and ruled out from further consideration.
5	MDC pass a Trade Waste Bylaw. This will include a requirement of industries and organisations that use the sewer for disposal of oils, grease, detergents, toxic chemicals and heavy metals to install a pre-treatment system to remove these "harmful elements" from the system.	MDC has introduced a Trade Waste bylaw to control and manage discharges of trade waste to the sewer. It is based on the New Zealand Standard 9201.
6	MDC in partnership with the Maori community approach Hospital Authorities, Ministry of Health and Funeral Directors Association to investigate alternative methods of disposal for wastes that are culturally offensive.	Council and tangata whenua representatives met with funeral directors. Discussion indicated that waste from embalming process was very small. No human body parts go down the sewer from hospitals and funeral homes. At this stage MDC have been unable to bring parties together for further consultation.
7	MDC adopt New Zealand specific standards for wastewater where possible and follow current research programmes centred on this issue.	MDC developed guidelines for wastewater quality based on national guidelines for water quality and specific a phosphorus target was developed for the length of the Ruamahanga River affected by the discharge. These guidelines have also received specialist input from NIWA.

Modified from Papatuanuku Te Matua O Te Tangata: Consultation Document for Masterton District Council's Sewage Upgrade (Burge, 1997b)

Table 44 Response to Maori Issues with Wastewater Treatment Plant Upgrade

Nº	*Maori Community Issue*	MDC Response
A	*The proposed site needs to be decided upon with tangata whenua*	Refer to MDC Action to Recommendation 2 in Table 7.7
B	*When the site is identified it will be researched by specialist people (kaitiaki) with traditional knowledge of waahi tapu or waahi taonga areas*	Ongoing consultation did not produce a strong drive to pursue this issue
C	*The make-up of sewage (e.g., body parts, fluids, blood from hospitals, morgues, funeral parlours and other medical and dental) is offensive to the Maori community*	MDC has been made aware of tangata whenua concerns regarding sewage content. The issues were discussed during the preparation of the Trade Waste Bylaw
D	*Concern over materials' (e.g., toxic chemicals, fats, oils, grease, etc) effects on land-based systems and groundwater. Assimilative and accumulative capacities should be addressed. Seek assurance that resources will not be contaminated*	MDC's trade waste bylaw limits the concentrations of toxic chemicals and oil and grease that can be discharged to the sewer. Application rates to land have been based on the soil and crops assimilative capacity and also consider the effects on groundwater (Refer to section 4)
E	*Concern over saturation of soils from high rainfall, storm water and groundwater infiltration*	Land saturation from rainfall is considered as part of the detailed investigation of land-based disposal options. Land treatment will be designed and operated to account for periods of high rainfall (Refer to section 4)
F	*Concern that a land-based disposal system may create offensive odours*	Prevention of odours is considered essential and is addressed in section 4
G	*Concern that a land-based disposal system may result in airborne disease and viruses.*	Transmission of aerosols has been considered and is a low risk (Refer to section 4)
H	*Concern over suitability of land on the other side of the Waingawa or Ruamahanga rivers for this proposed Wastewater Upgrade project. Particularly in relation to piping sewage under or over the river.*	The land on the "other side" of the Ruamahanga or Waingawa Rivers did not form part of the options selected. There will be no piping of sewage under or over the river.
I	*Concerns over existing ponds, located in a flood zone on the river edge*	MDC examined the flood risks and proposes to increase the height of the stopbanks and continuing with erosion protection works
J	*Concerns that the quality of the wastewater at its current outfall will not be of a better quality than it is currently*	Wastewater quality standards based on national water quality guidelines have been developed. The proposed project includes improved wastewater quality (refer section 4) and the restrictions on discharge to greater than median flow (summer) and half median flow (winter) mean that river water quality will be greatly improved, especially during summer.

There are several requirement of the Resource Management Act in respect to addressing and taking into account Maori culture, traditions and values, namely:

6(e) to recognise and provide for the relationship of Maori and their culture and traditions with their ancestral lands, water waahi tapu and other taonga

7(a) to have particular regard to Kaitiakitanga

8 …to take into account the principles of the Treaty of Waitangi…

Consultation with tangata whenua o Wairarapa as kaitiaki of the Ruamahanga River was an important requirement of the upgrade design process

As discussed earlier in this report (section 5.5.3), tangata whenua participated in the decision-making process through their involvement with the Working Party and Consultation Task Group, as well as through general consultation. Through this process, the views of tangata whenua have been recognised and considered both in the assessment of alternatives and, consequently, in the design of the selected upgrade option in terms of its impact on cultural or spiritual values.

Tangata whenua have consistently advised that they would prefer to see all the wastewater discharged to land. This option was carefully assessed but it was not considered practical or cost effective in this case (the assessment of this option is outlined in more detail in section 10.4.1)

Whilst it is acknowledged that the upgrade does not fully achieve the desire of the kaitiaki to remove the discharge entirely from the river, the relationship of tangata whenua with the river has been recognised and will be provided for, as far as practical, by the following:

- There will be no direct discharge to the river during low flows
- As much of the treated wastewater, as is practical, will be discharged to land
- There will be an improvement in the quality of the wastewater discharged (to both land and water)
- There will be a significant improvement in the water quality in the river, particular at low flows, when the upstream quality of the river is at its best
- There will no degradation of mahinga kai.

8.8.3 Visual and Landscape Values

By their very nature, oxidation ponds are extensive flat elements, with a strong horizontal line. While being a human-made feature, the existing and proposed oxidation ponds are constructed made from natural materials (i.e., grassed earth embankments) and have a lake-like appearance, sitting comfortably into the primarily intensive agricultural landscape beside the curve of the river against the base of the rolling hills.

While the linear edge of the ponds is the main feature that indicates their constructed origin, their appearance could equally be water storage lakes as wastewater ponds. The visual effect is one of a large water body that integrates well into the local setting, which itself combines natural and human made elements and shapes. The landscape effect is of a constructed feature that retains water, but fits in well at the edge of the plains with its flat terrain, horizontal elements (for example, shelterbelts, fences and roads) and diverse vegetated surrounds.

The groups of trees growing on the flat land limits views into the site, with distance and vegetation virtually preventing any visibility of the ponds themselves, either from dwellings on the surrounding plains or from the Masterton-Martinborough Road.

There are minimal views, if any, of the pond area from dwellings to the north, with the enclosing earth bunds being the only visible part of the facility. The bunds will have a grassed outer batter that integrates well with the adjacent farmland, and their long horizontal line is in keeping with the flat terrain of the river plain. The few buildings at the MWTP are small utilitarian structures, at some distance from the nearest dwellings or public road, and not dissimilar from farm sheds and the like.

Riparian planting exists along the southern side of the ponds, with large deciduous trees providing some screening of the near edge of the ponds when viewed from the hills to the south. Additional planting has recently taken place between the ponds and the river. The existing planting, combined with the new planting when it matures, will serve to screen most of the linear edge of the ponds from the hillside view, thereby reducing their artificial appearance, and contributing positively to their visual integration. This planting also will assist in screening the ponds from views along Lee Pakaraka Road, although from here the low angle of view causes the ponds to appear as natural lakes as their linear bunding is difficult to discern.

One house has been built on a small land holding directly south of the ponds, looking across them and over the plains to the north. This property has the most exposed views of the ponds of any house in the area. From this property, the ponds appear as lakes lying parallel to the river. Their human-made origin is apparent through their straight edges and dividing bunds, but their appearance is similar to that of water storage lakes (for example, farm dams).

In summary, the proposed ponds, in addition to the existing ponds, will integrate well into the modified agricultural landscape and cause no significant adverse visual effect.

8.8.4 Affordability

One of the issues MDC considered in selecting a preferred upgrade was affordability[65], which was a principle established at the start of the project by the Working Party. MDC commissioned a study on this issue, which identified and analysed the cost and benefits of four main considerations (*Chandler, Nana & Sanderson 2005*).

The study found that the residents of Masterton have relatively low incomes compared to similar districts and have a relatively high index of deprivation. Rates in Masterton are currently relatively low compared to the other regions represented, and sewerage rates are also very low by these standards. While it was accepted that the MWTP upgrade would require some increase in rates, it was important that such rates were comparative with rates in similar districts. The only shortlisted scheme that would increase rates to within the range of other similar districts (but at the high end) while achieving a high quality of treatment was the current upgrade proposal. The other schemes that were considered were significantly more costly, and were far less affordable in terms of the District's rating base, and the consequent effects on the community (refer to section 10).

The affordability analysis concluded that the other schemes could not provide considerably greater benefits to justify the extra costs involved, and accordingly it was the lowest cost scheme that was considered most affordable, the proposed scheme, based on utilising, improving and expanding an existing capital investment (*Chandler, Nana & Sanderson 2005*).

8.9 Conclusions

Referring to the environmental issues that the proposed upgrade is seeking to address (outlined in section 5.7), the main conclusions are as follows:

8.9.1 Water Quality

- **Significant reduction in the MWTP's impact on the water quality of the Ruamahanga River**

  The proposed upgrade will eliminate the discharge of effluent at low flows, when upstream water quality is typically very good recreation use is highest and the impact of the existing discharge is most significant.

  The upgrade will also improve water quality at Wardells Bridge at times when there is a discharge.

- **Elimination of the contribution of contaminants from the MWTP to the degraded water quality of the Makoura Stream**

  The significant contribution of the existing discharge to the poor condition of the Makoura Stream will be eliminated, thereby improving the environmental quality of the stream and its aquatic ecosystems.

[65] Questions of cost and affordability are relevant to the whether an option is the Best Practicable Option.

8.9.2 Pathogens and Microbiology

- **Contribution of E-coli to already high levels in the Ruamahanga River**

The upgraded microbiological quality of the discharge quality and the removal of discharge at low-median summer flows will significantly reduce the MWTP's contribution to the levels of *E.coli* and pathogens in the river.

8.9.3 Health Risk

- **Minor contribution to health risk**

The existing discharge of effluent to the river increases the levels of pathogens downstream and thereby contributes, albeit at a minor level, to an increased health risk, particularly at times of low flow when the river is used for primary contact recreation and when the upstream concentrations of pathogens are at their lowest. The proposed upgrade will ensure that health risks are negligible at times when the river is most used for contact recreation. Whilst residual risks will still be elevated thus at other times, (particularly at threshold flows just above the trigger flows) these risks are also considered to be minor and acceptable (ESR 2007). Little contact recreation occurs at these flows and this flow range occurs for a very limited time, at higher flow upstream water quality becomes the dominant risk factor. The risk will still be lower than the 8 per 1000 stated in the Recreational Water Guidelines).

8.9.4 Colour and Clarity

- **Discoloration and reduced clarity in the river**

The proposed quality of effluent and the intermittent effluent discharge as a result of the proposed effluent discharge regime during summer low flows will eliminate the discernible bright green plume from the discharge mixing with the river water and will significantly improve the clarity of the river downstream of the discharge.

There will be no conspicuous change to colour and clarity at below median flow in summer and half median flow in winter (no direct discharge) and no conspicuous change to colour and clarity after reasonable mixing (300m) when discharge does occur. The reasonable mixing and full mixing zones will be moved upstream of Wardells Bridge.

8.9.5 Nutrients and Algal Growth

- **Build-up of undesirable biological growths in waterways**

The proposed upgrade will result in a significant reduction in the contribution of nutrients into the river during periods of low flows, reducing the occurrence and extent of algal growth (periphyton) on the bed of the Ruamahanga River during periods of sustained low to median flow in the summer.

8.9.6 Aquatic Ecosystems

- **Effect of organic enrichment on some biological communities**

While the river ecosystem is generally in a healthy condition in of terms of the presence and abundance of aquatic biological species, the improved quality of discharge, combined with the more limited discharge into the river, will reduce the organic enrichment of the river downstream of the MWTP.

8.9.7 Recreational and Aesthetic Amenity Values

- **Diminishment of the river's recreational values**

The proposed quality and effluent discharge regime will contribute to the improved quality of the river, and the ability of the community to use and enjoy it for recreational activities, especially at Wardells Bridge and the Cliffs.

- **Degradation of the River's aesthetic values**

The proposed upgrade and discharge regime will remove the present adverse visual impact of the discharge plume before it becomes fully mixed, thereby having a positive impact on the aesthetic and amenity values of the Ruamahanga River at Wardells Bridge and further downstream. Furthermore, the elimination of the plant's contribution of nutrients to the river, and the subsequent build-up of periphyton (algae) on the river bed, will enhance the aesthetic values of the river, particularly at times the river is most valued for visiting, in warm summer periods.

8.9.8 Tangata Whenua Values

- **Discharge of effluent on the mauri of the River**

The discharge of effluent directly into the Ruamahanga River affects its mauri, and accordingly tangata whenua, as the kaitiaki of the Ruamahanga, would prefer that there be no discharge to water except via land. This scenario has been considered, and as discussed, the costs of those options that would provide this result are significant, and would impose a significant economic burden on the community. The proposed upgrade will yield an improved quality of effluent and minimise the amount of direct discharge into the river, thereby recognising and providing for tangata whenua's concerns insofar as it is practicable (discharge to land to the greatest extent practicable and affordable).

8.10 Proposed Mitigation Measures

Overall, as summarised above, the proposed upgrade and discharge regime will improve water quality and will mitigate a number of the existing effects as follows:

- Improved aquatic health (as a result of reduced growth of attached algae and improved MIV values)
- Improved aesthetic quality (colour, clarity and algal growth)
- Improved recreational amenity (colour, clarity, reduced algal growth, reduced health risk)
- Recognising and providing for Tangata Whenua values by discharging to land so far as is practicable
- Reduced health risk
- Reduction in the risk of pond failure as a result of flooding and erosion
- Improved operational flexibility and contingency management.

The measures to achieve these improvements have been described earlier. In summary:

- Improved microbiological treatment
- Land disposal maximised and river discharge minimised
- No summer direct discharge to the river at below median flows
- No winter direct discharge at flows below half median
- Maintaining adequate dilution when discharge does occur
- Shifting the discharge point and improving the discharge mechanism to increase mixing and to shift the mixing zone upstream

In addition to these measures, it is proposed to undertake a number of additional mitigation measures to ensure that the potential for adverse environmental effects to occur during the operation of the upgraded MWTP continues to be less than minor

8.10.1 Management Plans

A management plan for the operation and maintenance of the oxidation ponds and irrigation area will be developed to address ongoing environmental and health risks. This Plan will address the irrigation rates, storage and the discharge regime and routine operational, maintenance and monitoring activities. It will include measures to minimise risks associated with:

- Odour
- Noise
- Health risk
- Discharge quality (for ecosystem effects)
- Avoiding discharge to river outside of proposed discharge rules.

MDC already have a number of management plans in place for managing the natural processes in the oxidation ponds, such as:

- *Contingency Mitigation Plan* (responding to plant failures or deterioration in effluent quality for example) as required by Condition 19 of the existing consent
- *Noise and Odour Management Plan* required by Condition 40 of the existing consent
- *Risk Communication Strategy* to notify potentially affected persons with respect to health effects as required by Condition 20 of the existing consent.
- *Operational records log* as required by Condition 25 of the existing consent
- *General monitoring* of the influent and wastewater quality.

These plans and processes will be reviewed and updated to reflect the new operational requirements for the upgraded ponds.

In addition, an *Irrigation Management Plan* will be developed to monitor and guide the operator in irrigation rates and scheduling, crop planting and harvesting and other management issues associated with the proposed irrigation scheme.

8.10.2 Landscape and Visual Effects

The irrigation area contains a buffer zone and will be planted with trees to act as a buffer (with the exception of the boundary with the Ruamahanga River). This is shown on Drawing C110 in Appendix D.

8.10.3 Insect and Waterfowl Nuisance

At present, insects are not considered to be a problem at the MWTP, and it unlikely that they will become a problem after the proposed upgrade. If insects become a problem, there are a variety of methods that may be used to control nuisance insects, including the following:

- Natural predators (e.g. fish or birds)
- Habitat reduction
- Insecticides.

There has been research undertaken recently in New Zealand into the effectiveness of insecticides that are more environmentally friendly than traditional insecticides (NIWA, 2003 and Browne, 2003 cited in Beca 2004). These findings will be taken into account if the application of insecticides were deemed necessary in future.

In terms of waterfowl, the Wellington Fish and Game Council (F&G) is responsible for managing the game bird resource in the area, with the following approaches being possible management measures.

- Special seasons are regularly arranged so that "licensed" game bird hunters have the opportunity to hunt/control the local Canadian goose population.
- F&G issue limited permits to the affected landowners to enable them to carry out their own crop protection[66].

If waterfowl were to become a nuisance, then Masterton District Council will work with F&G and affected landowners to address the problem. On the basis of experience with the existing Plant, it is unlikely, however, that such measures will be required.

66 Neighbouring landowners have advised that the current permit system is too restrictive and does not allow them to adequately contain the problem. Special seasons timed for cash crop protection could be workable and would also give the licensed hunters further hunting opportunities. This idea has the support of some neighbouring landowners, although there have been concerns expressed about the noise from shooting.

9 Assessment Against Statutory Requirements

9.1 Introduction

This section summarises the assessment of the proposed upgrade against the key statutory requirements, including:

- The purpose and principles of the Act
- Consistency with Policy and Plan provisions
- Designation considerations.

9.2 Purpose and Principles of the Act

The Resource Management Act 1991 (RMA) is the governing legislation with respect to the use of land, air and water. It establishes the regulatory framework for discharges to land, air and water.

The purpose and principles of the RMA under Part II have guided the investigations and has fed into the Council's decision-making, along with the Council's wider Local Government Act responsibilities.

Under Part II, section 5 of the Act states that the purpose of the Act is "to promote the sustainable management of natural and physical resources", with 'sustainable management' defined as:

> *… managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic, and cultural wellbeing and for their health and safety while—*
>
> *(a) Sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
>
> *(b) Safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
>
> *(c) Avoiding, remedying, or mitigating any adverse effects of activities on the environment.*

The proposed upgrade will enable the community of Masterton to provide for its wellbeing in a way that will –

- Sustain the potential of natural and physical resources for future generations, particularly in terms of enhancing the quality of the river, its ecology and associated values and attributes;
- The life-supporting capacity of the air, water, soil and ecosystems will be maintained if not enhanced by the proposed upgrade; and
- The proposed upgrade will remedy or mitigate of the existing adverse effects from the MTWP on the environment, while the precautionary design parameters in conjunction with the proposed management and monitoring systems will minimise risks of future adverse effects to the environment.

Section 6 of the Act outlines matters of national importance that need to be recognised and provided for by the consent authority in terms of the wastewater treatment plant upgrade. The proposed upgrade recognises and provides for the two key matters of national importance, namely:

- The preservation of the natural character of rivers and their margins (i.e., the Ruamahanga River); and
- The relationship that tangata whenua have with the River (and Makoura Stream).

Section 7 outlines other matters to which, particular regard should be had. The concept of Kaitiakitanga has been addressed through the significant opportunities created for tangata whenua consultation in this project. The proposal is considered to be an efficient use and development of natural and physical resources. The amenity values of the River and Makoura Stream and the intrinsic values of ecosystems within these waterways are maintained and enhanced by this proposal.

Section 8 requires the principles of the Treaty of Waitangi (Te Tiriti o Waitangi) to be taken into account when considering an application for resource consent. These principles have been incorporated into the consultation and decision making process.

As set out in the AEE, MDC has fully considered the application against the relevant matters referred to above. In particular, the project has endeavoured to recognise and provide for the relationship of Maori to water and the maintenance and enhancement of the quality of the environment by maximising the application of wastewater to land and limiting the discharge to the river to times when the river is above median flow.

Overall, it is considered that the recommended scheme is consistent with Part II of the RMA referred to above.

9.2.1 Consent Requirements

Section 104 of the RMA

This section applies when considering a resource consent application. In addition to Part II, the consent authority must have regard to matters including:

- The actual and potential effects on the environment of allowing the activity
- The provisions (in this case) of the regional policy statement and regional and district plans
- Other matters the consent authority considers relevant and reasonable necessary to determine the application.

In addition, the consent authority must not grant resource consent contrary (in this case) to sections 107 and 107A (referred to below).

Section of this report addresses the first matter, while the following section addresses the consistency of the proposal with the relevant provisions of the planning instruments.

Section 105(1) of the RMA

Section 105(1) sets out matters a consent authority must have regard to when considering a resource consent application for a discharge permit. Consideration should be given to the nature of the discharge and the sensitivity of the receiving environment to adverse effects, the applicant's reasons for the proposed choice as well as any possible alternative methods of discharge, including discharge into any other receiving environment.

These matters have been addressed in detail throughout the upgrade design process, and are summarised in this report.

Section 107 of the RMA

Section 107 sets out particular restrictions on the granting of discharge permits. This section is discussed in section 8.2 above.

The upgrade will ensure that none of the effects set out in section 107 will occur after reasonable mixing (refer to section 8.2). Furthermore the reasonable mixing zone will be much reduced in size from present and will no longer extend to Wardells Bridge (full mixing upstream of Wardells cf present).

9.3 Policy and Plan Provisions

The District and Regional plans set out the requirements with respect to taking of and discharging to, freshwater and identify whether consent is required and what matters should be considered.

9.3.1 Operative and Proposed District Plans

Designation

The existing MWTP site is designated for the purpose of "Sewage Treatment" (D88 shown on Planning Map Nº 10) in the operative Masterton District Plan (MDP). The Requiring Authority responsible for the Designation is the Masterton District Council. The designation applies to all the land described as "Lot 14 DP 24225, Pt 3, 4, & 5 DP 2412, Pt of DP 1384, Part of Old River Bed, all of assessment 17980/37".

The wastewater treatment site is recorded in NZ Gazette 1972 page 371 and shown on SO Plan 27745.

The MDP outlines the purpose of Designations for public works as "providing special powers relating to the use and development of the affected land." The rules in the District Plan for Designations relate to the procedures for Notices of Requirement, information to be supplied, conditions which may be recommended by the Council to avoid, remedy or mitigate the adverse effects of the designation and outline plans prior to construction of the work.

Issues, Objectives and Policies

The MDP outlines a number of significant resource management issues affecting the District. The Plan recognises that land use activities have both direct and indirect adverse effects on the natural and physical resources of the District. The most relevant objective and policies in the Plan relate to Infrastructure and Water Resources.

4 **Importance of Physical Resources**

The Plan recognises that infrastructure is an essential part of the district's physical resources and its maintenance is essential to the social, economic, and cultural wellbeing of the people and their health and safety. The main objective for managing the district's infrastructure is to achieve "An efficient sustainable infrastructure that can meet the needs of today's community and the reasonably foreseeable needs of the district's future generations" (Objective 6).

The relevant policies that seek to achieve this objective are Policy 6.1, 6.2 and 6.3. These policies reflect the District's dependency on the provision of public services and facilities, and that these should be able to be developed so long as they meet environmental standards. The policies seek to manage the potential adverse effects of such developments by encouraging consideration of alternative options. In particular, Policy 6.3 seeks to maximize the capacity of existing infrastructure before new infrastructure is established and is related to the considerable investments in infrastructure and the need to ensure efficiency for the sake of that investment.

The proposed upgrade is considered to be consistent with these objectives and policies, as a detailed consideration of alternative options has been undertaken, and the proposed scheme will result in a major upgrading of existing infrastructure and the discharge regime, maximising the existing investment in public infrastructure, with consequential improvements in the receiving water quality and flow-on benefits for the community.

4 **Protection of Water Resources**

Another significant district wide issue is the protection of the quality and quantity of the district's water resources (Objective 2). The Plan seeks to achieve this objective by enhancing those aspects of the environment that are not at an acceptable level and by managing those characteristics that contribute to people's health and wellbeing. These policies also seek to manage activities (such as the MWTP) where there is the potential to affect the quality of water resources, including those of importance to tangata whenua for mahinga kai and for their cultural values.

These policies will be met by the proposed upgrade, through which the quality of the receiving waters will be improved as a consequence of the improved wastewater quality and proposed new discharge regime.

4 **Protection of the Land Resource**

Objective 1 (and associated policies) seeks to maintain the productive potential of districts soils. The proposal to discharge treated wastewater to land will add nutrients to the soil and will not affect the long-term sustainability of the soil for future productive use.

The District Plan also seeks some outcomes with respect to rural amenity, including (1) '…maintenance and enhancement of the natural character… (predominance of rural activities)…" (4) "The protection of highly visible parts of the rural area from obtrusive or excessive landscape modification." and (9) "A pattern and diversity of development that is consistent with rural landscape." This proposal is in effect an irrigation scheme, which is consistent with rural activities and is not considered to contrary to the outcomes sought for the rural area.

4 **Kaitiakitanga**

Objective 3 of the Plan and Policy 3.1 seek to provide for Kaitiakitanga in the management of the District's natural and physical resources. This policy has been implemented throughout the consultation process that has occurred since 1996. Removing the discharge from the Ruamahanga River when the river is in low to average flow and maximising the discharge to land at all times, recognises, insofar as practicable and affordable, the concerns of tangata whenua as kaitiaki in regard to the disposal of wastewater to freshwater.

4 **Minimising Risks of Natural Hazards**

Another issue for the District is the minimisation of risks from natural hazards to the community and the environment. In particular, the District Plan contains details of flood hazard areas, including the flood potential for the Ruamahanga River.

The district plan aims to manage effects from natural hazards by controlling activities in high-risk areas. The relevant map identifies the existing treatment site showing the boundary of the "100 year probable flood extent" along the southern edge of the ponds. It shows the "100 year possible flood extent" including the entire site and considerable land to the north between the site and the Masterton landfill. The flood and erosion risks have been fully addressed in the proposed upgrade, with the protection works to be part of the proposed upgrade adequately seeking to minimise the risks to the community in the event of flooding. The project is therefore consistent with this objective.

9.3.2 Proposed Combined Wairarapa Combined District Plan

The Proposed Wairarapa Combined District Plan (WCDP) was notified on 25 August 2006, with the period for further submissions closing on 19 February 2007. The WCDP provides for generally consistent policies and methods between the South Wairarapa, Carterton and Masterton District Councils.

The WCDP addresses many of the same issues as that contained within the Masterton District Plan, including issues relating to the maintenance and enhancement of amenity values and the quality of the environment. Section 12 addresses the issues facing the Wairarapa in regard to its freshwater environments. It seeks to provide for sustainable land use activities that are compatible with the natural character and risk of natural hazards in the freshwater environment.

9.3.3 Wellington Regional Policy Statement

The Wellington Regional Policy Statement, operative on 15 May 1995 contains objectives, policies and methods regarding the management, protection and enhancement of freshwater appropriate to a range of values and uses. Closely linked to the overall management approach is recognition of tangata whenua values regarding water, and particular concerns regarding disposal of human waste. The values are reflected in the relevant regional plans, which are outlined below.

9.3.4 Wellington Regional Freshwater Plan

The Regional Freshwater Plan (WRFP) is relevant where the discharge of contaminants is to water. The RFP sets out a regime for the management for receiving waters based on maintaining surface water quality for specific purposes.

Objectives and Policies

Several objectives in the WRFP (Objectives 4.4.1, 4.1.2, 4.1.3) seek to recognise and provide for the relationship that tangata whenua have with freshwater, and the need to protect the mauri of water bodies and rivers. The operating philosophy for the proposed upgrade is to maximise the application of wastewater to land. This approach is intended to address so far as is practicable and affordable the concerns raised by the tangata whenua. While tangata whenua have consistently sought the wastewater to be disposed of totally to land, this option cannot be able to be practically achieved in a cost effective manner.

The lower and mid Ruamahanga River is identified in the WRFP (Policy 5.2.4) to be managed for contact recreation purposes and it is regionally important for its amenity and recreational values (Policy 4.2.15 – particularly angling – refer Appendix 7 of WRFP). The upgrade will not cause the receiving water to not achieve contact recreation guidelines (at times that would not occur as a result of upstream water quality) and is therefore consistent with the objectives and policy requirements of the WRFP (i.e. Appendix 8 reasonable mixing guidelines). The proposed upgrade will enhance the value of the river for contact recreation.

Under Policy 5.2.6, the Makoura Stream is identified as needing enhancement for aquatic ecosystems purposes and should be managed for aquatic ecosystems purposes. The removal of the discharge will provide significant improvements to the quality of this stream, and will assist in this policy being met.

Policy 5.2.13 seeks to encourage discharges to land, where possible, rather than to water. The proposed upgrade is consistent with this policy as it involves discharges to land at all times when the land is able to take the wastewater. As discussed, fulltime disposal to land is not currently feasible, however the purchase of additional land for irrigation of effluent will further meet this policy..

Policy 5.2.11 relating to mixing requires the consideration of a number of factors such as the purpose of the receiving waters, tangata whenua values, volume or concentrations of contaminants and characteristics of the receiving water. The proposed discharge is consistent with this policy as there will be no discharge to water during key contact recreation periods and, when there is a discharge, it is small in relation to the river flow (minimum 30x dilution), and the proposed new discharge point is the most efficient in terms of mixing (i.e., it takes into account hydrological and other river characteristics, including the nearest main sites for public recreation). The proposed reasonable mixing zone of 300-500m (400m is suggested) is considerably smaller than present and is consistent with the policy.

Policy 5.2.12 (Discharges Containing Sewage) is particularly relevant to the project. It provides for a policy guideline that discharges of sewage should pass through land or artificial wetland, unless the discharge direct to water better meets the purpose of the Act than disposal to land, and there has been consultation with the tangata whenua and generally with the community.

These matters have been specifically considered throughout the development of the options since 1996. There has been significant consultation with tangata whenua and the community. The practical difficulty in obtaining a fulltime discharge to land has already been discussed. In terms of disposal via wetlands, one of the conclusions from the process was that a small wetland would not satisfy Maori cultural values, while a full treatment wetland would not be appropriate in relation to the upgrade proposed. When all social, cultural, environmental and economic factors are taken into consideration, it is considered that the proposed upgrade better meets the purpose of the RMA than full time land disposal.

Policy 5.2.4 refers to the receiving water quality guidelines in Appendix 8; these guidelines have been used to assist with the development of water quality targets and wastewater standards for the project. The guidelines/targets apply after reasonable mixing of the discharge with the receiving waters.

The WRFP does not provide any numerical standards for a river discharge. It sets out qualitative policies and narrative guidelines for assessing whether the policies can be met. MDC has used national guidelines and site-specific studies as appropriate in order to establish appropriate quantitative receiving water targets, as discussed in detail in section 8.2.

The proposed upgrade is consistent with the receiving water quality guidelines in the RMA and the WRFP and is consistent with the overall objectives and policies of the WRFP.

9.3.5 Regional Air Quality Management Plan

The Regional Air Quality Management Plan (RAQMP) became operative on 8 May 2000. Change 1 to the RAQMP was made operative on 1 September 2003.

The Plan applies to discharges to air in the whole of the Wellington region, except for the coastal marine area.

Objectives

Objective 4.1.1 and 4.1.2 seek to maintain high quality air and to enhance areas of degraded air quality, while allowing discharges at a rate that enables the community to provide for their social, economic, and cultural well being as well as their health and safety. The proposal will have little impact on the air quality and is consistent with these two objectives.

Policies

The key relevant policies are Policy 4.2.4, 4.2.5, 4.2.6, 4.2.7 and 4.2.14. These policies relate to the duty under both sections 5 and 17 of the Act to avoid, remedy or mitigate any adverse effect of any discharge of contaminants to air that is noxious, dangerous, offensive or objectionable as well as any discharge that has adverse effects on amenity values.

Good management practices will be employed to ensure that odour from the sewage treatment is controlled. Accordingly, any discharge to air from the upgraded MWTP will be consistent with the relevant objectives and policies of the plan.

9.3.6 Regional Plan for Discharges to Land

The Regional Discharges to Land Plan (RDLP) is relevant when considering disposal or discharge of contaminants to land (for example, leakage from ponds and land disposal). The Plan identifies that the area around Masterton and the Ruamahanga River as one of the most vulnerable areas to groundwater pollution in the

Wellington Region. Section 8.1 of this report provides an assessment of effects of discharges into land on groundwater quality.

Objective and Policies

Objective 4.1.4 seeks to achieve a significant reduction in contamination of surface water, groundwater and coastal water from discharges of human wastewater to land. Policies 4.2.12 to 4.2.18 are designed to achieve the above objective and relate specifically to discharges of human wastewater, the most relevant being Policies 4.2.12 and 4.2.13.

Policy 4.2.12 requires that particular consideration be given to any relevant iwi management plans or statements of tangata whenua views when considering applications for the discharge of human wastewater (treated or untreated) to land. Full consideration has been given to the values and beliefs of the tangata whenua in the selection of this proposal as the preferred upgrade option for the sewage treatment plant.

Policy 4.2.13 sets out those matters to which particular regard should be given when assessing applications to discharge contaminants to land from reticulated sewerage systems. The matters include the nature of the contaminants, monitoring of trade wastes entering the system, potential for overload by stormwater, hydro geological conditions, effects of odour, effects on human health or amenity, plants, animals or ecosystems, other uses of the discharge site and surrounding are, tangata whenua values, and Public Health Guidelines. These matters are addressed in this report. However, it should be noted that the proposed discharges to land from the proposed upgrade will be managed in accordance with a site-specific discharge management plan. As such it is considered that the proposed upgrade is consistent with this policy.

9.3.7 Regional Soil Plan

The provisions of the Regional Soil Plan are not considered to be relevant to this proposed upgrade.

9.4 Designation Considerations

A Notice of Requirement for a designation in respect of the proposed sewage treatment plant upgrade is given under Section 168A of the Act, which provides specifically for those instances where the requiring authority is also the territorial authority responsible. The alteration of the existing designation is authorised by section 181 of the Act.

In considering the requirement and any submissions received, the consent authority must consider the effects on the environment of allowing the requirement (addressed in section 7), having particular regard to the relevant provisions of any relevant plans and policy statements (section 9.3) and to any alternative sites, routes, or methods of undertaking the work (section 10).

9.4.1 Necessity for Achieving Project Objectives

As discussed in section 8.9, the proposed upgrade was selected because it achieves the Council's objectives (set out in section 3.2.5). In brief, the project is reasonably necessary to achieve Council's objectives because it:

- Upgrades the existing MWTP to produce a higher quality wastewater
- Enhances the receiving water quality (Ruamahanga River) in comparison to the existing discharge
- Removes the direct discharge of wastewater from the River during the period when the river is the most attractive for swimming
- Removes the discharge from the river during winter low flows (below half median flow)
- Removes the direct discharge of wastewater from the Makoura Stream
- Involves discharge to land to the greatest extent practicable

The designation method is reasonably necessary to achieve Council's objectives because it is considered to be the most efficient and effective method, in that it:

- Provides for its ongoing management and maintenance
- Is an appropriate method of managing the effects from this form of land use over time
- The Outline Plan process can if necessary, be used to address detailed matters of design such as landscape treatment
- The new site to be designated adjoins the existing MWTP designation
- It provides clear notice on the Planning Maps as to the type of land use and what controls are in place to manage the effects.

9.4.2 Consideration of Alternatives to the Designation

A number of alternatives to a designation have been considered:

- Resource consents
- Plan Change.

Resource Consents

Resource consent could be sought from Masterton District Council. However, the resource consent process is not as flexible as the designation and Outline Plan process for later modifications with respect to ongoing management, maintenance and upgrading, of the MWTP. Furthermore, resource consent will not be able to clearly identify the location and purpose of the MWTP within the District Plan, and provide the plant with the level of regulatory priority afforded by a designation. This process would also be inconsistent with the current designation. It is more appropriate to extend the designation to cover all relevant land use activities on the MDC land.

Plan Change

A plan change could also authorise the project or work. Plan changes can be drafted to provide the necessary flexibility in the wording to provide for the ongoing requirements of the MWTP. However, given that the proposed upgrade is intended to be long-term in nature, there appears to be little necessity to develop discrete and separate district plan provisions for the MWTP to manage all activities associated with the MWTP. This is better achieved by way of a comprehensive designation.

Designation

The advantages to a designation process are described below. A designation:

- Provides certainty and continuity for large capital works projects
- Gives the public notice of the proposed public work
- Is usually more flexible than a resource consent
- Is not subject to the rules in the District Plan
- The site to be designated adjoins the existing MWTP designation
- Is shown in the district plan
- Replaces multiple rules in the district plan that may affect a project.
- Allows all relevant land use effects to be considered together.

9.5 Consent Duration

The existing plant is a significant investment in its own right. The upgrade will significantly add to the value of that investment. In that context a 35 year term of consent for all regional consents is considered appropriate.

9.6 Conclusion

Overall, it is considered that the proposed upgrade is in accordance with the purpose and principles of the RMA and is well aligned with the objectives and policies of the relevant planning documents.

The adverse effects of the proposed activities will be minor. The upgrade will result in significant improvements to the quality of the existing environment and the key values the river and its immediate environs and provides for the needs of the community, particularly in terms of safe affordable treatment and disposal of sewage, public health, recreation and visual effects.

10 Consideration of Alternatives

10.1 Overview

This section summarises the various alternative treatment and disposal processes that were considered as part of the investigations into options for developing a scheme that will best meet the upgrade objectives (section 3.2.4).

At the commencement of the investigations into the long term upgrading options in 1994, 15 general treatment and disposal technologies were evaluated. Through this process a shortlist of options appropriate for achieving the objectives of the MWTP Upgrade was developed and presented to the Wastewater Working Party (WWP) in May 2000, which considered a 'mix-and-match' range of treatment and disposal technologies, with treatment options ranging from upgrading the existing oxidation ponds to a new high-tech mechanical plant, while disposal options included a number of land and river discharge scenarios.

Under the direction of the WWP, investigations then continued into the best practicable options for the upgrade of the MWTP and, consequently, the many various combinations of treatment and disposal methods were distilled into 14 alternative schemes (Issues & Options Report, Beca 2004). These schemes were grouped into four categories (labelled Scheme 1 to 4), with different scheme variants labelled Scheme 1a, 1b and so forth. The four schemes were as follows:

- **Retention of existing oxidation ponds –** four options that included some of the following components: upgrade of maturation cells, land treatment/disposal, wetland discharge, DAF (Dissolved Air Flotation) for DRP removal, microfiltration with chemical dosing.
- **New oxidation ponds –** three options that included some of the following components: new maturation cells, land treatment/disposal, wetland discharge, DAF (DRP removal).
- **Dual power lagoons –** three options that included some of the following components: land treatment/disposal, UV disinfection, and clarifier with chemical dosing (DRP removal) and wetland discharge.
- **Mechanical treatment plants –** four options that included parts of the following components: land treatment/disposal, mechanical aeration, UV disinfection, chemical dosing (DRP removal), wetland discharge, and membrane bioreactor as a 'high rate' treatment process.

All of the schemes assumed that effluent disposal would be either fulltime to the river, or would be to the land at times when river flows are below half median.

The following options were short listed and carried forward into further consideration and investigations:

- Scheme 1a (Existing oxidation ponds, maturation cells and part time land treatment)
- Scheme 1b (Existing oxidation ponds, maturation cells, wetland, part time land treatment
- Scheme 2a (New oxidation ponds, part time land treatment)
- Scheme 2b (New oxidation ponds, part time land treatment, wetland).

Following the completion of the investigations and analysis, in June 2005, MDC selected Scheme 1a, which is the combination of treatment and disposal systems outlined in section 6. A key part of that decision was a commitment by Masterton District Council to continue to seek more land to increase the amount of effluent irrigated and to further reduce the amount discharged to the river. In the period from July 2005 to June 2006, further investigations were undertaken to refine scheme detail.

The principal reasons for choosing the preferred option (Scheme 1a) were that:

4 It meets Council's objectives (set out in section 3.2.5 of this report) for the upgrade project

4 It is considered to be consistent with the Regional Policy Statement and the Freshwater Plan

4 It will meet national receiving water quality guidelines

4 It is consistent with Part 2 of the RMA, and in particular:

- It will adequately avoid remedy and mitigate adverse effects
- Will provide for the well being and health and safety of the community
- Is an efficient use of natural and physical resources (including the physical resource in the existing infrastructure).

4 There are a number of distinct advantages relating to the existing treatment plant and its location including:

- Oxidation ponds are low energy users, have low complexity, are robust, low operator input, and can handle peak flows from inflow and infiltration (I/I)
- It will build upon the existing communities invested capital
- The relatively short distance from the Masterton urban area
- Gravity flow from the urban area to the site is possible
- The rural location of the site and sufficiently large distances to the town and to nearby dwellings
- Suitable topography
- The current site is designated for "Sewage Treatment Purposes".

The remainder of this section summarises the principal reasons for not adopting the use of the principal alternative methods for:

4 Wastewater treatment

4 Sludge Disposal

4 Effluent disposal

The section also includes a review of the reasons why it is not considered necessary or appropriate to line the existing oxidation ponds.

10.2 Alternative/Additional Methods of Treatment

A number of alternative additional methods of treatment were considered. These options were included as components in the 14 various scheme options considered (outlined above) – refer to the Issues and Options Report (Beca, 2004d) for further detail on the treatment options considered.

10.2.1 Dissolved Air Floatation (DAF) to Achieve Fulltime Nutrient Stripping

The DAF process can be used to remove algae (responsible for the distinctive green colour) and nutrients (primary focus in this case was DRP) from oxidation pond effluent, which will be necessary if there was a discharge to the river at low flows.

The DAF process is a compact mechanical tertiary treatment plant in which wastewater flows through a flotation tank where compressed air is introduced at the base. The air comes out of the solution as minute bubbles, which then attach to particulate matter (algae) and rise to the surface of the tank. The particles that are carried to the surface by the air are skimmed off and collected for further processing.

The DAF process can also be used to reduce phosphorus by dosing the wastewater prior to the DAF process with a coagulant such as alum or ferric chloride. The metal salt forms a precipitate with the phosphorus ion and is removed with the DAF sludge.

Investigations were carried out to assess the viability of the process for use at the MWTP, with the conclusion being that a DAF unit will be effective at removing DRP and colour.

It is noted that one consequence of the inclusion of a DRP process would be the production of sludge. The sludge volumes produced by the DAF process are estimated to be approximately 50 m^3/day, which would need to be disposed of daily.

At present, there are no DAF plants used for tertiary treatment of domestic wastewater in New Zealand, although it is an option being considered for the Waihi wastewater treatment plant upgrade. DAF is used at some wastewater treatment plants for sludge thickening (for example, Hutt Valley and Manukau), and is a common clarification process at water treatment plants (for example, Wainuiomata and Mount Grand in Dunedin).

When considered in conjunction with the analysis of nutrient issues for the Ruamahanga River, a DAF process would not provide any further benefits in conjunction with the land treatment scheme proposed for the following reasons:

- Nutrient removal is only required during low flows in the river (when the proposed scheme is disposing treated wastewater through irrigation)
- Land treatment removes a very high proportion of contaminants, including bacteria, solids, nitrogen and phosphorus, and is considered to be more efficient in contaminant removal than a DAF process.

In addition, a DAF process has a continuous sludge side stream from the solids removed and the chemical precipitation of phosphorus. It would also have an additional capital of cost in the order of $2.7 million along with higher operational costs.

For these reasons, the use of the DAF process would not be the Best Practicable Option (BPO) for Masterton.

10.2.2 Chemical dosing to strip DRP

For the reasons outlined above, chemical stripping of DRP would achieve no environmental benefit. A clarifier could be used to reduce phosphorus by dosing the wastewater with a coagulant such as alum or ferric chloride. The metal salt forms a precipitate with the phosphorus ion and is removed by settlement in the clarifier. The disadvantage of this process is that a continuous sludge sidestream is produced. Dissolved reactive phosphorus (DRP) can be reduced to very low levels of less than 0.5 g/m^3 by chemical stripping. The clarification process is suited to providing tertiary treatment of effluents that do not contain algae, as algae have a tendency to float and the clarifier relies on settlement of solids. This process is neither necessary nor appropriate for the MWTP.

10.2.3 Ultraviolet (UV) Disinfection

UV disinfection is an established method to reduce pathogens such as viruses, bacteria and protozoa in wastewater. It is used at a number of wastewater treatment plants in New Zealand, including Whangarei, Tauranga, Paraparaumu, Hutt Valley, Wellington, Porirua and Manukau.

UV disinfection is a process where electromagnetic energy is applied to micro-organisms in wastewater, in the form of light radiation emitted from banks of UV lamps. The radiation penetrates the cell wall of the micro-organism and alters the genetic material within the cell, preventing replication and causing the death of the cell (Metcalf & Eddy, 1991). The most common method of UV application is in an open channel where treated wastewater flows around UV lamps as the final part of the treatment process. The UV lamps are in modular units, so extra capacity can be easily achieved by adding more modules. Operating costs (electricity and replacement bulbs) are relatively high.

As there are no chemicals used in the UV disinfection process, there is no residual toxicity in the wastewater leaving the disinfection unit that could affect the receiving water. The lack of chemicals also means that there is minimal risk to plant operators, and no special storage facilities are required to handle hazardous chemicals. UV disinfection is also a single-step process, with no need for correction steps (for example, pH correction and residual removal).

The main requirement for UV disinfection is a low suspended solids concentration in the inflow to the UV unit, to avoid shading of micro-organisms from the UV light. If shading occurs, it gives protection to micro-organisms, resulting in a lower kill rate. Similarly, fouling of the UV lamps results in poor disinfection performance. As wastewater still contains a moderate amount of suspended solids after treatment, fouling can occur rapidly, requiring the lamp surfaces to be cleaned regularly. Consequently, to get the best results from UV, the suspended solid content in the treated wastewater would need to be at relatively low levels, and this would require further treatment at the MWTP in order to achieve a quality of effluent that would make UV disinfection fully effective.

UV is typically used for a mechanical treatment plant where the land area is constrained and does not provide sufficient area to construct maturation ponds. UV treatment is not routinely used with oxidation ponds because ponds themselves provide excellent bacterial and pathogen reduction, and therefore UV disinfection will provide little further benefit in addition to the use of maturation cells. Furthermore, the proposed discharge of effluent to land is an effective means of removing any remaining bacteria, with land disposal typically removing 95-99% of bacteria during transport through the top 1m of soil.

UV disinfection at times of direct discharge to the river would provide very little benefit. This is because:

- The maturation cells will provide good microbiological quality.
- There will be a minimum of 30 times dilution when discharge occurs.
- At flows above median little primary contact recreational occurs.
- As flows increase above median the upstream microbiological quality declines and the effect of the effluent will be minor.

For these reasons, given the additional costs involved, the addition of UV disinfection is unnecessary, would be inefficient and would achieve little environmental benefit. (minimal further reduction in health risk as compared to the current proposal)

10.2.4 Wetlands

Constructed wetlands can be used either for secondary wastewater treatment after primary treatment processes, or for wastewater 'polishing' (i.e., improvement in effluent quality) after secondary treatment. Constructed surface flow wetlands typically consist of shallow ponds that are planted with aquatic plants and flooded with wastewater. The wastewater receives treatment by natural processes as the wastewater flows between the plants from one end of the wetland to the other. Constructed wetlands also provide wildlife habitat and landscape enhancement.

Two types of wetland were considered for Masterton: a large-scale treatment wetland, and a small intermediate passage wetland (for example, as used in Palmerston North).

The main disadvantage of a treatment wetland is the large land area required to achieve a satisfactory level of treatment – a large-scale treatment wetland for Masterton's wastewater would require at least 15 ha of land area. In addition, the planting costs for wetlands can be substantial as the plants are grown in a nursery and then planted out. Natural propagation from seeds and roots can result in effective plant coverage if features are incorporated into the wetland's design so that water levels can be controlled to avoid excessive flooding.

A small (1 hectare) wetland system was considered in the *Issues and Options Report* to provide additional land passage for discharges to the river. A wetland of this size would provide minimal treatment benefit, but was considered that the land passage, wildlife habitat, and landscape enhancement may provide some wider environmental benefits. However, there would be some significant difficulties with addressing flood and erosion protection risks for the scenario where the existing ponds are retained.

To date, tangata whenua have not openly supported a wetland of the nature proposed (described above) as it did not provide any real treatment benefit, although verbal comments received during consultation was that there could be some advantages for growing flax.

In conclusion, it has been decided that there is no compelling case for inclusion of a wetland in the scheme, given the additional costs and practical difficulties relative to the limited benefits.

10.3 Alternative Methods of Sludge Disposal

The ponds and maturation cells will typically require desludging once every 20 to 40 years. As part of the MWTP upgrade, Pond 1 will be desludged by dredging, while Pond 2 will be desludged at a later date. The sludge from the ponds needs to be dredged while the ponds are in service, as they cannot practically be drained down due to the high groundwater level at the site.

The only alternative option considered worthy of evaluation was to screen the dredged sludge to remove debris and then directly discharged to the border strip areas prior to the land treatment scheme being put into operation for wastewater treatment.

The *NZ Biosolids Guidelines* contain maximum contaminant levels for the sludge to be applied to land under controlled conditions. The contaminant concentrations of the sludge have been analysed and the sludge is classified as Grade B in terms of the Guidelines. However, because of the risk of 'blinding' the soils (i.e., filling all the pores in the soils and reducing the effectiveness of its percolation and drainage properties) and thereby negating the effectiveness of irrigation disposal, this method was not considered a feasible option.

In terms of wider land application options, MDC has evaluated a range of options for disposal and beneficial reuse of sludge (Montgomerie, 1994).

The method of disposal is for the sludge to be used as landfill cover at the Nursery Road landfill when it is closed[67].

10.4 Alternative Methods of Wastewater Disposal

A number of alternative methods of effluent disposal were considered, including:

- Fulltime land disposal
- Fulltime river discharge
- Reducing the discharge to the river:
  - By reducing I/I
  - Buying more land
  - Higher trigger flow for discharge.

10.4.1 Fulltime Land Discharge

Fulltime discharge to land is an alternative method of discharge, as this process is used by a number of land treatment schemes around New Zealand on a year-round basis. This was an option preferred by tangata whenua

67 MDC is preparing the necessary RCA's independently to the RCA's and NoR for the MWTP upgrade

as well as others in the community, and MDC carefully considered this option. However, these fulltime schemes elsewhere in New Zealand are established on permeable soils, which are ideal for high irrigation rates. For example:

- Levin – dune sands irrigated at 90 mm/week
- Rotorua – free draining pumice soils irrigated at 80 mm/week
- Taupo – Taupo silty sand (free draining pumice soil) irrigated at 31 mm/week.

Generally, there are two different soil types at the MWTP site; silty clay soils that are poorly drained and are not suitable for year round irrigation, and sandy and silty loam soils, which are relatively free draining and therefore have some potential for fulltime irrigation. However, for an average winter influent flow of approximately 17,000 m^3/day, a fulltime irrigation system would require at least 340 hectares of free draining land to dispose all the effluent. The acquisition of such an area of land would represent a significant cost and discharge to the river would still be necessary during major wet weather events.

The possibility of off-site disposal was also considered at the Masterton District Council's property on Manaia Road or a new site to be purchased or leased by MDC. The Manaia Road site has approximately 30 hectares of land potentially available for irrigation, and, assuming an application rate of 2 mm/day, an effluent volume of 600 m^3/day could be irrigated on the site. In combination with the current area at Homebush proposed for irrigation, the Manaia Block would still not provide adequate area for a fulltime land disposal system. In addition, a significant disadvantage of using another site like the Manaia Road block for effluent disposal is the infrastructure required and associated operating costs to pump treated wastewater 4.5 km from the existing MWTP at Homebush. Due to the proximity of the Manaia Road site to the Masterton Aerodrome and neighbouring houses, a surface application irrigation system would be preferable. Spray application is less desirable because of the potential for spray drift and the generation of aerosols.

Other site options would require the Council to buy or lease additional land elsewhere. As outlined above, this would require a total of 340 ha, including the current site. The purchase or lease of this amount of land area in the vicinity of the treatment plant is not considered to be feasible, as it is valuable intensive farming land, subdivided into numerous smaller farm holdings. It would therefore be an expensive option for the Council to purchase or lease such a large block of land. . Even with Council's recent puchase of 107 ha of land on the west side of the Makoura Stream, the total area available for irrigation would be in the order of 165 ha (assuming that 90 ha of the new land is available for irrigation), and therefore an additional land area in the order of 210 ha would still be required to provide a total irrigation area of 340 ha. At an assumed cost of $30,000/ha the cost would be in the vicinity of $6.3 million. There would then be further substantial costs associated with site infrastructure and ongoing operational costs.

In addition, piping and pumping the wastewater to another irrigation site will present a significant infrastructural and ongoing operating cost. These costs would increase the cost of developing an irrigation scheme on other land (in addition to acquisition costs) to about $15 million, plus the ongoing cost to pump treated wastewater to the disposal area. These factors make the cost of fulltime land disposal unaffordable for the community, and therefore not a BPO for Masterton.

As outlined in section 7, a fulltime land treatment scheme is also not necessary as the effluent can be discharged to the river at times of higher flows within minimal effects on the environment. However, the MDC has resolved (Council decision, June 2005) to purchase more land where practical, on a willing seller/willing buyer basis. This approach is considered a BPO for reducing the discharge to the river over time as MDC can acquire land when it comes up for sale at market rates and is affordable to the community.

10.4.2 Fulltime River Discharge

A fulltime discharge to water was an alternative method of disposal that was considered by Masterton District Council, as discharging wastewater to a river offers a simple and cost effective alternative to a land disposal scheme.

Under the current standards, the Makoura Stream is not an appropriate receiving environment for the MWTP discharge as it provides minimal dilution and the discharge has a significant impact on the water quality of that stream. A discharge directly to the Ruamahanga River will remove the impact of the discharge on the Makoura Stream, and will allow the discharge location to be shifted further upstream allowing the discharge to be fully mixed across the width of the river upstream of Wardells Bridge.

For a fulltime discharge to the Ruamahanga River, however, the effluent would need to be further treated to a higher quality than that proposed because of the potential effects during periods of low river flow, particularly in summer. This treatment would be required to meet the receiving water guidelines, for health risks from swimming downstream of the discharge (bacteria, viruses and pathogens), colour/clarity and nutrients (DRP for undesirable biological growths). The reduction in these parameters would require additional tertiary treatment, such as disinfection and nutrient stripping, which introduces additional complexity and cost. A mechanical treatment plant configured for nutrient removal and suitable for a fulltime discharge to the river would cost in the order of $25 million and have an annual operating cost of $1.7 million.

These costs, relative to the benefits of a primary discharge to land, mean that fulltime discharge to the river is not considered to be the BPO for Masterton. Furthermore, a fulltime discharge to the river is unacceptable to many in the community, irrespective of the quality of wastewater.

10.4.3 Reduced Discharge to River

Reduce Infiltration/Inflows (I/I)

As discussed earlier (refer to section 4.4.1), groundwater infiltration and high inflows of stormwater are a significant problem in Masterton (as it is in other communities) as the additional water significantly increases the amount of influent entering the MWTP for treatment.

The main benefits from reducing the amount of I/I would be to decrease the total volume and the number of occasions on which effluent has to be discharged into the river. It would also reduce storage pressure on the ponds. Unfortunately, while there are significant benefits to be gained from a reduction in I/I, information from successful I/I reduction programmes around New Zealand indicates that the cost of achieving even a moderate reduction is relatively high.

There are many factors that influence the effectiveness of an I/I reduction programme – for example:

- The potential for groundwater infiltration to migrate to pipes that have not been repaired,
- The condition of sewage pipes throughout the system, particularly the water tightness of joints, and,
- The ability to have faults in private property remedied in conjunction with repairs on public faults (the private section of the lateral sewerage reticulation system significantly contributes to I/I).

As outlined in section 4.4.2, MDC investigated the sewerage reticulation system to identify areas that are significantly underforming as a result of having high infiltration (Beca, 2004c) Further work on the reticulation system included an assessment of the cost effectiveness of a reduced inflow to the MWTP as a result of I/I reduction in the reticulation system. That analysis looked at the following scenarios:

- Varying levels of annual expenditure on I/I ($0.32 million, $1 million and $2 million) and the impact on MWTP inflows which may result in reduced discharges to the river depending on the level of expenditure, the rate of deterioration of the sewer network and the degree of success of the repairs
- Expenditure on I/I of $3 million over 2 years and the impact of this on MWTP construction costs, assuming construction in year 3 and the impact on MWTP inflows.

The findings of the analysis showed that, under any of the expenditure scenarios, the inflow to the MWTP could not be reduced significantly by year 3 when construction of the upgrade needs to start. The reduction that is achieved will only result in a minor reduction in construction costs of $150,000. Also, sustained levels of high expenditure on I/I, which could reduce inflow to the MWTP, will not provide significant "value" to Masterton over the longer term in regard to relative benefits for the costs.

The approach MDC has taken with respect to inflow into the MWTP for the long-term upgrade is to 'hold the line' on inflow volumes through an asset management programme and to allow for sufficient storage capacity in the ponds for the current inflow volumes. In addition, investigations and remedial works will continue with a view to implementing cost effective upgrades to those parts of the sewerage network that exhibit high inflow and infiltration.

The analysis on the reduction of I/I showed that even with an expenditure of $2 million per annum over the next 20 years is unlikely to reduce I/I so that the summer influent volumes can be fully disposed of without the need to discharge to the river (excluding wet weather discharges). Therefore reduction of I/I as a means of reducing discharges to the river is not considered to be the BPO.

Trigger above Median flow

Another option could be to increase the summertime 'trigger flow' to some point above the median river flow, thereby possibly reducing the effects further.

However, raising the trigger flow, given the amount of land available for irrigation, will not reduce the volume of discharge to the river. It will only serve to postpone the period when it will need to be discharged. This will require a greater amount of storage to hold wastewater until it could be discharged and noticeably increase the cost of the project. The increased storage requirements could increase the cost of the project in the order of $1 million-$2 million. It is not considered that this increase is justified by the very limited potential benefits it offers. A summer trigger of median flow is considered to be conservative since little primary contact recreation occurs at higher flows.

Purchase of additional land for irrigation Format at for previous sub heading above

Additional land for effluent irrigation is an option providing it can be aquired cost effectively. In the June 2005 Council resolution to adopt the preferred scheme, Council also resolved to seek to aquire additional land for effluent disposal, and hence the recent purchase is the first implementation of that resolution. As discussed previously, Council has recently purchased an additional 107 ha of land on the west side of the Makoura Stream

A summary of the likely impact of the recently aquired additional land is detailed in section 6.7.7.

10.5 Pond Lining

A liner is not considered necessary for either the existing oxidation ponds or as part of an upgrade. The reasons for this are essentially two-fold:

- Even at a time when there is no discharge to the river, the effects from pond leakage will be negligible (refer to sections 8.2.2 and 8.2.3 for the assessment of effects of the leakage); and
- In 2000, an attempt was made to draw down the level of the ponds, which was not fully successful due to water flowing up through the base of the ponds (refer to section 5.4.3 for a discussion on the leakage pathways), and accordingly, it was determined that it would be impractical to try to line the ponds, or if possible it would be prohibitively expensive (Beca 2004a).

11 Consultation

11.1 Consultation Process

Masterton District Council has undertaken an extensive public and stakeholder consultation programme on the issues and options for upgrading the wastewater system since 2003. The consultation process is outlined in the *Technical Report on the Recommended Scheme* (Beca 2005). The consultation has been undertaken in two phases.

Phase 1	On the issues and options leading to Council's December 2004 decision to shortlist the options and to request some further investigations
Phase 2	On the further investigations and Council's December 2004 decision.

Both Phases involved stakeholder meetings/workshops, public meetings and open days with site visits and a free telephone enquiry line.

A Consultation Task Group was established with the function of facilitating an effective consultation process. The CTG included specific industry and sector group representatives, including:

4 Rangitaane O Wairarapa

4 Ngati Kahungunu Ki Wairarapa

4 Dairy Farmers of New Zealand (Wairarapa)

4 Industry

4 Recreational Users – Wellington Fish and Game Council

4 Masterton District Council

There was also consultation outside the Consultation Task Group, with other interested parties and the community in general.

Formal feedback from key stakeholder groups is included in the Appendices to the Technical Report. Feedback has been received from Rangitaane O Wairarapa, Ngati Kahungunu Ki Wairarapa, Department of Conservation, Fish and Game New Zealand and the DHB.

One outcome of the consultation was that there was still opposition from some quarters to aspects of the schemes short-listed in December 2004 and to the recommended scheme.

In particular, the two iwi expressed residual concerns regarding any ongoing discharge to the river. These concerns have also been echoed to a degree by other submitters.

11.2 Issues Raised

The consultation process identified a number of issues. In summary, the main issues identified were:

4 Cultural concerns including whether there should be fulltime land based disposal

4 Nature of treatment – pond technology and nutrient removal

4 Pond leakage volume and effects

4 Erosion risks to ponds

4 Discharge regime (median or half median)

4 River water quality – standards/targets, including metals, attached algae

- 4 Health impacts/risk
- 4 Fonterra's requirements (in relation to wastewater discharges)
- 4 Sludge volume in ponds
- 4 Blue green algae impacts from Oxidation Ponds
- 4 Land treatment/disposal
- 4 Aerosols
- 4 Application method
- 4 High irrigation rates
- 4 Effect on soils
- 4 Nutrient removal
- 4 Ground water effects
- 4 Discharge to the Ruamahanga River vs. Makoura Stream
- 4 Reticulation – addressing high inflows.

The CTG considered these issues and, in December 2004, confirmed what it considered to be the "Top 5" issues:

- 4 Wastewater and river water quality
- 4 Risks to the existing treatment plant from natural hazards
- 4 Leakage from the existing treatment plant
- 4 Inflow and Infiltration to the reticulation network
- 4 Future proofing of the treatment process.

A summary of how these and other relevant issues have been addressed is contained in Table 45 below, with further detail to be found in section **6** of this report.

Table 45 Consultation Issues and Measures to Address them

Issue	How the issue has been addressed
Concern over wastewater and river water quality	• The preferred option provides the best environmental outcome in the most cost-effective manner • Receiving water targets (e.g. phosphorus and bacteria) have been developed from national and international guidelines, and the upgrade will meet these targets • The direct discharge of effluent will be eliminated from the river during low river flows, particularly in summer, thereby providing significant improvements to the river water quality
Risks to the treatment plant from natural hazards	• The potential risks have been investigated in depth in the Masterton and are considered to be acceptable and manageable as part of the proposed upgrade
Leakage from the existing treatment plant – some groups and individuals considered that the ponds should be lined	• As a result of further investigations, it is considered impractical to put an engineered liner in the existing ponds (Beca 2004) • Even if the ponds could be provided with an engineered liner there would still be a certain amount of leakage • There is minimal impact from pond leakage based on he outcome of site sampling undertaken at low river flows

Issue	How the issue has been addressed
	• The settled sludge provides a significant degree of natural sealing of the ponds bases • Given the impracticalities of putting an engineered liner into the existing ponds or any new ponds and that the amount and effects of the leakage is not significant, the degree of leakage is considered acceptable • The predicted impact of leakage on receiving water quality has been assessed and found to be negligible
Inflow and infiltration (I/I) to the reticulation system	• The existing ponds have sufficient capacity for coping with large peak flows. However, an ongoing asset management program is in place to address potential excessive inflow and infiltration during wet periods.
Future proofing of the treatment process	• With respect to the proposed option, future proofing is an issue of flexibility to address future changes in environmental standards (e.g. higher receiving water quality). The proposed system can be readily upgraded to produce higher quality effluent. The Council has also resolved to pursue further irrigation land. • In addition the Council can develop a strategy to review its standard of treatment with changes in receiving water quality and standards and upgrade its plant as necessary.
Desire to see wastewater discharged/ irrigated to land rather than into the Ruamahanga River	• The recommended scheme option includes part time land irrigation to eliminate the discharge from the river during critical low river flows and significantly improve the river water quality • The costs of ensuring a fulltime land irrigation disposal system are significant, and, when compared to the limited additional benefits in environmental outcomes, would not represent the BPO
Discharge to Ruamahanga River vs. Makoura Stream	• The recommended scheme option is to discharge directly to the River as it is considered this will improve the overall receiving water quality, and remedy the adverse effects of the existing effluent discharge into the Makoura Stream
Discharge of treated wastewater to water bodies – i.e., wetland	• Investigations into the costs and benefits of a wetland disposal system (Issues and Options Report, Beca 2004) found that there would be little benefit in terms of treatment efficacy, compared with the costs of such a component
Sludge Disposal –concerns expressed about heavy metals in sludge and implications for disposal	• There is not a high heavy metal presence in the sludge as there are very few industries in Masterton producing heavy metals and discharging them to the sewer • There are a number of standard methods for disposing of sludge, with the most effective involving dewatering the sludge and disposing of it as landfill cover
Concern over outbreaks of Blue Green Algal Blooms as a result of discharge	• This issue can be prevented through strategy to identify times of risk during certain weather conditions, and to respond by increasing aeration to the relevant ponds at the appropriate times to prevent the conditions occurring within the ponds that could cause an outbreak of Blue algae • In addition, the fact that there will not be any direct discharges in summer low flows (the time of greatest risk of Blue Green algal blooms) provides a significant reduction in the risk to community health

11.3 Responses

The consultation process has been thorough and extensively undertaken to determine a preferred wastewater upgrade option, including system and design changes, as well as possible mitigation measures that may be further required.

The consultation forums have provided a number of opportunities for key stakeholders and the public to comment on the findings and recommendations through the process, including the shortlisting of options and the final selection of the proposed scheme.

Through the consultation process, the main areas of concern and the issues of particular importance to key stakeholders and the wider community have been clearly articulated and investigated, with a number of additional studies and assessment being undertaken in response to some concerns and suggestions. In consequence, the proposed upgrade option takes into account a number of key issues raised by the general public and stakeholders through

- Improving effluent quality;
- Meeting or exceeding receiving water quality targets;
- Land disposal of effluent as the primary discharge method;
- Avoiding discharge into the river during periods of contact recreation; and
- Minimising the financial effect on rates.

The proposed upgrade scheme selected addresses and provides for these matters as described earlier in the AEE. Therefore, the final upgrade scheme for which consent is sought is consistent with the direction sought by those parties involved in the consultation process and delivers the Best Practicable Option for the long-term improvement of the treatment and disposal of Masterton's wastewater.

12 Proposed Conditions/Restrictions

The following key restrictions are proposed in relation to the operational parameters of the proposed scheme (note: these may be amended during the consent process).

12.1 Resource Consent Conditions

12.1.1 Discharge to Water

Discharge Rate

- During the period November to April (inclusive), there shall be no discharge to the Ruamahanga River when the river flow is less than 12.33 m^3/s as recorded at the Wardells Bridge gauge station.
- During the period May to October (inclusive), there shall be no discharge to the Ruamahanga River when the river flow is less than 6.15 m^3/s as recorded at the Wardells Bridge gauge station.
- The instantaneous discharge rate shall be at least 30x less than the instantaneous flow in the river as recorded at the Wardells Bridge gauge station, up to a maximum of 1200 litres/second.
- Frequency and compliance calculation shall be in accordance from New Zealand Municipal Wastewater Monitoring Guidelines (NZWWA 2002 –see below) as indicated in Table 52 and based on the monitoring frequency given in Table 53. Compliance with the ANZECC guideline values for chemical contaminants shall be assessed after a 20-fold dilution factor to allow for reasonable mixing.
- The consent holder to adopt the best practicable option to avoid direct discharge to the river other than in accordance with the above.

Discharge Quality

The proposed percentile discharge compliance standards are based on the risk of a 10% exceedance of target values (90 percentile limit) over a 1 year compliance period (Bell et al 2002; NIWA 2006b).The exception is ammoniacal-nitrogen and E.coli , which have different targets for summer and winter and non-compliance is accordingly based on exceedances over a 6 month period. Higher (95% percentile) compliance is proposed for E.coli.

Table 46 Proposed Effluent Quality Compliance

Parameter	Geometric Mean	Percentile compliance standard	Compliance (Exceedances over period)
BOD5 (g/m3)	21	42 90%ile	No more than 4 over 1 year
Filtered BOD	10	28 90%ile	No more than 4 over 1 year
Suspended solids (g/m3)	32	91 90%ile	No more than 4 over 1 year
Dissolved reactive phosphorus (g/m3)	3.0	4.0 90%ile	No more than 3 over 1 year
Total Nitrogen (g/m3)	13	20 90%ile	No more than 3 over 1 year
Nitrate Nitrogen (g/m3)	1.0	7.5 90%ile	No more than 3 over 1 year
Nitrite Nitrogen (g/m3)	0.5	2.0 90%ile	No more than 3 over 1 year
Ammonia-Nitrogen (g/m3)	2.0 (summer) 6.0 (winter)	11 90%ile 11 90%ile	No more than 4 over 6 months No more than 4 over 6 months
E.coli (cfu/100 mL)	300 (summer)	330 median 1800 95%ile	No more than 15 above 330 over 6 months No more than 3 above1800 over 6 months

Parameter	Geometric Mean	Percentile compliance standard	Compliance (Exceedances over period)
E.coli (cfu/100 mL)	1,000 (winter)	1,000 median	No more than 8 above1000 over 6 months
Metals		ANZECC (2000)	95%ile trigger values
TPH, PAHs, SVOCs, VOCs		ANZECC (2000)	95%ile trigger values

Note: Geometric means are provided to enable consistency with historical monitoring and trend reporting

Effluent Monitoring

It is proposed that the wastewater monitoring requirements shall be as set out in Table 47 below:

Table 47 Proposed Effluent Monitoring Requirements

Constituent	Monitoring Frequency	Detection Limit
Flow (influent and effluent)	Continuously	10%
PH	As per *E.coli*	0.1 pH
Temperature	Weekly	0.1 Degrees Celsius
Colour and Clarity:		
Suspended Solid	Fortnightly	0.1 g/m3
Total Solids	Monthly	0.1 g/m3
Colour	As per *E.coli*	
Foam and Scum	As per *E.coli*	
Oxygen Demand:		
Dissolved Oxygen	Weekly	0.2 g/m3
BOD5	Fortnightly	0.1 g/m3
Nutrients:		
Total Nitrogen	Monthly	0.1 g/m3
Nitrite-N	Monthly	0.1 g/m3
Nitrate-N	Monthly	0.1 g/m3
Total Kjeldahl Nitrogen	Monthly	0.1 g/m3
Ammonia-N	Fortnightly	0.1 g/m3
Dissolved Reactive Phosphorus	Monthly	0.1 g/m3
Total Phosphorus	Monthly	0.1 g/m3
Metals and Metalloids:		
Cd, Cu, Ni, Pb, Zn, Hg, As, Ag, Cr	Annually	0.001 g/m3
Alkalinity and hardness	Annually	0.1 g/m3
Organics:		
TPH (Total Petroleum Hydrocarbons) PAH (Poly Aromatic Hydrocarbons) SVOC (Semi volatile Organic Hydrocarbons) VOC (Volatile Organic Hydrocarbons)	Annual	0.001 g/m3
Pathogens and Indicators		
E.coli	Weekly (1 Dec-31 Mar) Fortnightly (1 Apr-30 Nov)	10 Cfu/100mL

Receiving Surface Water Monitoring

It is proposed that the surface water monitoring requirements shall be as set out in Table 48 below:

Table 48 Proposed Surface Water Monitoring Requirements

Constituent	Unit	Detection Unit	Frequency
Field Measurements:			
PH	pH	0.1	Monthly
Conductivity	μS/cm	0.1	Monthly
Dissolved Oxygen	g/m3	0.01	Monthly
Dissolved Oxygen % saturation (by calculation)		5%	Monthly
Black Disc	Metres	.1	Monthly
Colour	Munsell	-	Monthly
Bacteriological:			
E.coli	Cfu/100mL	10	Weekly, Summer Fortnightly winter -
Nutrients:			
Ammonia-N	g/m3	0.01	Monthly
Nitrite-N	g/m3	0.002	Monthly
Nitrate-N	g/m3	0.002	Monthly
Total Kjeldahl Nitrogen	g/m3	0.1	Monthly
Total Nitrogen (by calculation)	g/m3	0.1	Monthly
Total Phosphorus	g/m3	0.004	Monthly
Dissolved Reactive Phosphorus	g/m3	0.004	Monthly
Biological Analysis:			
Macro-invertebrate analysis (species composition and abundance – to SQMCI level of identification)			Annually
Periphyton taxonomic and biomass assessment (qualitative and quantitative)			Annually
Miscellaneous:			
Turbidity	NTU	0.05	Monthly
Total Organic Carbon	g/m3	0.5	Monthly

The sites sampled shall be Ruamahanga River sites Rua1 (upstream) and Rua2 (downstream).

12.1.2 Discharge to Land

Discharge Quality

The same discharge quality as for water is proposed for the discharge to land.

Receiving Environment Monitoring

It is proposed that the groundwater monitoring requirements shall be as set out in Table 49 below.

The samples for analysis are to be taken using standard groundwater sampling methodology as detailed in the New Zealand guidelines for the collection of groundwater sampler for chemical and isotopic analysis (Rosen et al., 1999: Geological & Nuclear Sciences Publication 99/9).

The frequency of the monitoring shall be at three monthly intervals. Following the first year of monitoring and after satisfactory review, the monitoring frequency should be decreased to 6 monthly. The first six months should include data collection for January or February and June or July.

Table 49 Proposed Groundwater Monitoring Requirements

Constituent	Unit	Detection Limit	Frequency
Field Measurements:			
PH	pH	0.1	3 monthly (inc from Jan)
Conductivity	µS/cm	0.1	3 monthly (inc from Jan)
Dissolved Oxygen	g/m3	0.01	3 monthly (inc from Jan)
Bacteriological:			3 monthly (inc from Jan)
E.coli	Cfu/100mL	10	3 monthly (inc from Jan)
Nutrients:			
Ammonia-N	g/m3	0.01	3 monthly (inc from Jan)
Nitrite-N	g/m3	0.002	3 monthly (inc from Jan)
Nitrate-N	g/m3	0.002	3 monthly (inc from Jan)
Total Kjeldahl Nitrogen	g/m3	0.1	3 monthly (inc from Jan)
Total Nitrogen (by calculation)	g/m3	0.1	3 monthly (inc from Jan)
Dissolved Reactive Phosphorus	g/m3	0.004	3 monthly (inc from Jan)
Total Phosphorus	g/m3	0.004	3 monthly (inc from Jan)
Miscellaneous:			
Total Organic Carbon	g/m3	0.5	3 monthly (inc from Jan)

The sites proposed to be monitored are HB1-4HB6, HB10, HB11, HB13, HB17, HB18 and HB20. Refer to Appendix A.2 for location of sites.

Soil Analysis

Analyses to be carried out after land preparation before application of effluent, and at the following time intervals:

1 Every two years measure:

- A standard soil test for pH, N, P, K, and S
- Samples should be taken at 15 locations within the following three groups of soil types with a small-diameter core-sampler to a depth of 7.5 cm: Greytown mottled soils, Greytown unmottled soils and Ahikouka soils. Samples from each group of soils can be bulked together into one bag for analysis.

2 Every six years measure:

- Total phosphorus, cation exchange capacity, exchangeable bases (Ca, Na, K, Mg), base saturation, and pH in the 0–20, 20–40 and 40–80 cm layers for each of the three groups of soil types above.
- Organic carbon, soluble salts and bulk density at 0–10 cm and 10–20 cm depth.

Samples can be taken from four locations within each group of soils, and samples from each depth can be bulked together into one bag for analysis.

In regard to the physical assessment and analysis methodology, it is proposed that visual soil assessments of soil structure, porosity and colour using Shepherd method should be made on topsoil after land preparation and before application of wastewater (Shepherd 2000). These assessments will provide baseline estimates of these properties for the three groups of soils listed above.

Bulk density at 0–10 cm depth should also be measured at the same time for each of the three soil groupings. At least three bulk density analyses should be done for each of the three soil groupings. The assessments and measurements then need to be repeated after two years and if no change in physical properties is detected, the tests should be repeated at intervals of no more than six years. If changes are detected then remedial work needs to take place and further change closely monitored.

12.1.3 Discharges to Air

The treatment, storage and disposal activities shall not cause any noxious, offensive or objectionable odour at any dwelling or at any place more than 50m from the boundary of the designated site.

12.2 Designation Conditions

No specific conditions for the proposed designation are proposed for the following reasons:

- The principal environmental issues and the measures to avoid, remedy or mitigate any potential adverse effects on the environment are primarily addressed through the resource consents sought and through any conditions imposed thereon;
- The existing plant and its proposed extension is sited at some distance from any significant area of habitation, and is well screened and buffered by farmland, the Ruamahanga River, trees and topography.

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