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

15 August 2008

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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 (GWRC) to undertake initial upgrading of its wastewater treatment system. The interim consents expire in 2010, however the Council can continue to discharge pursuant to that consent until these replacement consents are determined.

Since 2003, a number of environmental, economic and technical investigations have been undertaken to identify the most effective upgrading option to satisfy the Council's environmental, economic and social objectives.

In June 2005, the Council selected its preferred scheme, which involved upgrading the existing oxidation ponds and developing 91 hectares of land adjacent to the plant for border-strip land disposal of treated effluent. Further work was then undertaken to prepare applications for the appropriate Resource Management Act, 1991 (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. In May 2007, Council lodged the necessary resource consent applications, as well as a Notice of Requirement to amend and extend the existing designation for the Plant. The Notice and resource consent applications were notified and a range of submissions was received.

In December 2007, following a review of options that became available after the purchase of an additional 107 hectares adjoining the Plant site, Council unanimously selected the option of constructing new clay lined ponds on part of the 91 hectare site, and using part of the 107 hectare site for border-strip land disposal in conjunction with the remainder of the original 91 hectare site. It also decided that if necessary, the remainder of the 107 hectare site could be developed for irrigation at some time in the future.

The Notice of Requirement (NoR) and the resource consent applications seek to establish an appropriate environmental management regime for the construction, operation and maintenance of the MWTP. The NoR and applications are supported by an Assessment of Effects on the Environment (AEE), prepared in accordance with the Fourth Schedule of the RMA, and incorporating those considerations set out in section 168A(3) of the RMA. This 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 wastewater 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 treatment 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 of the RMA thresholds, the proposed receiving water quality targets and the contribution of Dissolved Reactive Phosphorus.
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 the AEE and other background reports and studies.

The Appendices contain supporting information.

1.2 Glossary

BOD (Biochemical Oxygen Demand) a 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 Practicable 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.
CTG Consultation Task Group
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 (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) 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 the potential presence of other faecal derived pathogens.
Effluent wastewater after it has been treated and then discharged into the ground or to water.

Evapotranspiration the loss of water by evaporation and plant usage.
Groundwater 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 numeric or narrative indications of a desired state of water quality that do not have the force of standards.
GWRC Greater Wellington Regional Council
Infiltration groundwater that seeps into pipes, channels or chambers through cracks, joints or breaks.
Inflow rainwater runoff from roofs and roads that enters the sewerage systems via illegal connections, or surface ponding and entry through vents or access chamber covers.
Influent raw untreated wastewater that enters the treatment plant.
Median 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 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 disease-causing organisms, such as bacteria and viruses.
Peak Dry Weather Flow Rate 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 litres/sec (L/s).
Peak Wet Weather Flow Rate refers to the peak rate of flow on a wet day. The preferred unit is litres/sec (L/s).
Periphyton a 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 discharge a discharge from a readily identifiable source, such as from the end of a pipe.
Reasonable mixing zone (RMZ) the zone where the discharge is reasonably but not fully mixed with the receiving water, and underlying standards need not be met.
RFI (Request for Further Information) made by GWRC in respect to the 2007 AEE and Consent Applications.
Sewage the waste liquid from toilets, showers and washing machines, normally from domestic sources.
Sewerage the pipework and pumping station system in a community, which collects wastewater from houses and commercial/industrial premises
Standards statutory or plan requirements that must be met unless a consent provides an exemption.
Summer period for aesthetic and recreational effects, 1 November - 30 April (MfE 2000)
Suspended solids insoluble matter in sewage that could be removed by a standard filtration process to leave a clear liquid.

Threshold flow range 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.
Wastewater general term for the discharge (containing contaminants) from domestic and commercial/industrial premises.
Winter [1 May – 31 October]
WRFP Wellington Regional Freshwater Plan

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:

- Chris Hickey of NIWA – water quality analysis
- Graeme Proffitt of Pattle Delamore Partners Ltd – groundwater analysis
- Brent Clothier and Steve Green of HortResearch Ltd – analysis of soil sustainability, soil treatment of the wastewater and the soil water balance
- Andrew Ball of ESR – Health Impact Assessment
- Gary Williams – analysis of river flood and erosion control
- Philip Milne of Simpson Grierson – legal review
- John Harding – independent peer reviewer and contributor to discussion of health risk
- Kevin Montgomerie – providing input from Masterton District Council
- Hugh Wilde of Landcare Research – soil mapping on the irrigation site
- Trevor Webb of Landcare Research – advice on irrigation rates for various soil types and methods of application to land
- Neal Borrie of Aqualinc 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 (NoR) 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 continue and 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:

- Continue and modify the existing designation (42 ha) for the Masterton Wastewater Treatment Plant so that it covers all land use activities associated with the modified Plant; and
- Designate an additional 91 ha adjacent to the existing Masterton Wastewater Treatment Plant (to the northeast, adjacent to the Ruamahanga River) for the construction of new ponds and discharge of treated wastewater to land, as well as a further 107 ha of land (to the north-northwest of the proposed new ponds between the Masterton-Martinborough Road and the Makoura Stream) for the treatment and disposal of wastewater to land and all associated land use activities.

The amended and extended designation is for

> *"Wastewater treatment and disposal and ancillary works and activities including:*
>
> - *The upgrade of, and ongoing use, operation and management of the whole site as a wastewater treatment plant and for land disposal of effluent*
> - *Flood and erosion protection works to reduce the risk of damage to the infrastructure and land*
> - *A sludge storage area*
> - *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 existing designation that is to be continued and 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 new designation relates in part 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 relates to an area of approx 107 ha of land acquired by 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 nature of the proposed public work (or project or work) is:

The upgrade of the Masterton Wastewater Treatment Plant will comprise the construction of new silt-clay lined oxidation ponds and a land treatment system for a portion of the wastewater. The treated wastewater from the new ponds will be applied on the site largely using the border strip irrigation method. The treated wastewater will be applied 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.

This NoR includes but is not limited to, the following activities:

- The construction and operation of a new Wastewater Treatment Plant
- The construction of new clay/silt lined oxidation ponds
- The construction and operation of a land treatment scheme to dispose of treated wastewater (effluent)
- Pump stations and pipelines for the land treatment scheme
- The construction of a new outfall in the Ruamahanga River
- Pond de-sludging, drying and storage in an on-site landfill
- River erosion protection measures, being a planted buffer and minor modifications to existing rock protection
- Raising the existing stop bank immediately upstream of the oxidation ponds for a length of 630 m
- All earthmoving activities associated with the construction of the new ponds, land treatment scheme, and restoration of the existing ponds area, including, but not limited to; haul roads, excavation from borrow areas, trommel screening, rock crushing, stockpiling, spreading, vibratory compaction and site restoration
- General ongoing operation, management and maintenance of the MWTP (ponds and land treatment area)
- Any other land use activities ancillary to the construction, 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 included 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 Potential Future Irrigation Area on the 107 ha site as shown on Drawing C601 will not be made until a later date.

The effects that the public work (or project or work) would have on the environment, and the ways any adverse effects on the environment would 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 of effluent are to be considered as part of the resource consent applications required by Greater Wellington Regional Council.

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).

[A further consideration of alternative options incorporating the 107 ha site purchased by the Council is recorded in *Masterton Wastewater Upgrade Project: Review of Pond and Irrigation Area Options Incorporating Additional Land* (Beca January 2008).]

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, 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:

- Land use consent (erosion protection works and river diffuser)
- Discharge permit (discharge of wastewater and stormwater runoff to water, including stormwater runoff from earthworks during construction)
- Discharge to air (dust and vehicle exhaust emissions during construction, and odour and aerosols during operation)
- Discharge to land (irrigation scheme, sludge storage 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 potential future land disposal area (to be applied for later if required).

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.

The District Council has also met with various stakeholder groups and released several newsletters to residents in the Masterton District to describe the proposed upgrade of the 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.

- A plan of the proposed designation, including treatment ponds and effluent disposal to land scheme, is shown in Appendix D
- 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)

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Wes ten Hove, Chief Executive
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 existing stopbank, adjacent to the Ruamahanga River, directly to the north of the wastewater treatment plant oxidation ponds to provide 100 year flood protection; and
- To permanently divert the Makoura Stream around the new maturation 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 name of the owner and occupier (other than the applicant) of any land to which the application relates is 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, as generally shown on Drawing C601 and C602.

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, use and maintain structures in the river bed, and associated disturbance, pursuant to s 13 of the Resource Management Act 1991;
- Discharge permit for discharge to water, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit for discharge to land, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit for discharge to air, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permits for discharge to air and discharge to land in the potential future 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 that 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 person giving notice (*or* person authorised to sign on behalf of person giving notice)

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Wes Ten Hove, Chief Executive
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 riverbed, 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 diffuser outfall for the discharge of treated wastewater to be located within the bed of the Ruamahanga River; and
- Flattening of the slope of the river bank adjacent to adjacent to Ponds 2 and 3 and repositioning of the existing rock groynes at the upper sections of the batter.

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

The Crown

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 C602 (refer Appendix D) shows the location of the discharge. The location of the rock groynes to be repositioned are shown on Drawing C602.

Legal description:

The diffuser is in the Ruamahanga River adjoining Pt Lot 5 DP 2412; taken by Gazette 1972 P371.

The erosion protection works are adjacent to the Ruamahanga riverbed adjoining Pt Lot 5 DP2412, 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:

- Discharge permit for discharge to water, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit for discharge to land, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit for discharge to air, pursuant to s 15 of the Resource Management Act 1991;
- Water permit for divert water pursuant to s 14 Resource Management Act 1991;
- Discharge permits for discharge to air and discharge to land in the potential future 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 that 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 person giving notice (*or* person authorised to sign on behalf of person giving notice)

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Wes ten Hove, Chief Executive
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 discharge of sediment-laden stormwater to the Ruamahanga River and Makoura Stream from construction 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 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 as shown on Drawing C 601 in Appendix D.

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 existing secondary oxidation pond. Drawing C602 (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 C603 & 604 in Appendix D.

The dewatering groundwater will be discharged at various locations including (but not limited to) from a cut off trench to the north of Pond 1A and from drainage trenches constructed in the existing ponds when they are drained for sludge removal.

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, 2, 3, 4 & 5 DP 351720; comprised in CT's WN11B/301; WN48B/596; 212321, 212322, 212323, 212324 & 212325.

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 for discharge to land, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit for discharge to air, pursuant to s 15 of the Resource Management Act 1991;
- Water permit to divert water pursuant to s 14 Resource Management Act 1991;
- Discharge permits for discharge to air and discharge to land in the potential future 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 that 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 person giving notice (*or* person authorised to sign on behalf of person giving notice)

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Wes ten Hove, Chief Executive
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) by way of irrigation to land;
- Partially treated wastewater by leakage through the base of the current and new oxidation ponds;
- Wastewater sludge and residual liquid from the sludge dewatering process and sludge landfill.

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 name 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. The location of the activities are shown on Figure 1.

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 for discharge to water, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit for discharge to air, pursuant to s 15 of the Resource Management Act 1991;
- Water permit to divert water pursuant to s 14 Resource Management Act 1991;
- Discharge permits for discharge to air and discharge to land in the potential future 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 that 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 person giving notice (*or* person authorised to sign on behalf of person giving notice)

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Wes ten Hove, Chief Executive
Telephone: 06-3789666

2.6 Application for Resource Consent: Extraction of Groundwater During Construction

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 of the Resource Management Act 1991

The proposed activity is:

The extraction of groundwater during construction activities to reduce groundwater levels which would otherwise impede construction, particularly during times of flood events:

- From a cut-off trench located to the north of Pond 1A
- From drainage trenches to be formed in the existing ponds when they are drained for sludge removal and restoration to pasture.

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 including the drawings in Appendix D.

The name of the owner and occupier (other than the applicant) of any land to which the application relates is 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 for discharge to water, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit for discharge to land, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit for discharge to air, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permits for discharge to air and discharge to land in the potential future 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 that 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 person giving notice (*or* person authorised to sign on behalf of person giving notice)

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Wes ten Hove, Chief Executive
Telephone: 06-3789666

2.7 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 and sludge landfilling; and
- All other activities on site

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 land treatment scheme, oxidation ponds and sludge landfill area are shown on Drawings C601 and C602 in Appendix D.

The name of the owner and occupier (other than the applicant) of any land to which the application relates is 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 for discharge to water, pursuant to s 15 of the Resource Management Act 1991;
- Discharge permit for discharge to land, pursuant to s 15 of the Resource Management Act 1991;
- Water permit to divert water pursuant to s 14 Resource Management Act 1991;
- Discharge permits for discharge to air and discharge to land in the potential future 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 that 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 person giving notice (*or* person authorised to sign on behalf of person giving notice)

Date

Address for Service:

Masterton District Council
PO Box 444
63 Chapel Street
Masterton
Attention: Wes ten Hove, Chief Executive
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. The land is 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.

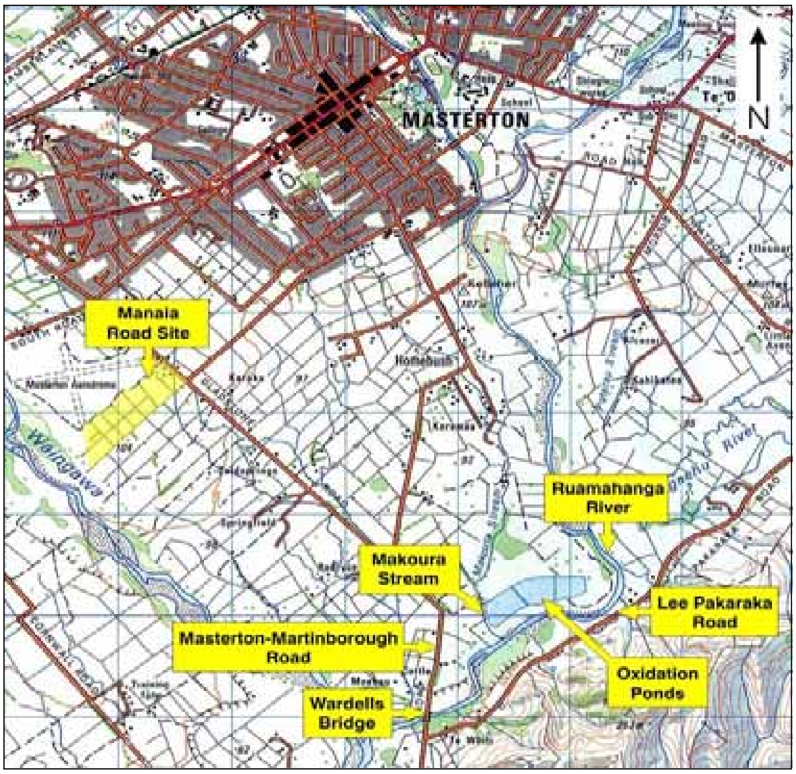

Figure 1 **Location of Masterton Wastewater Treatment Plant**

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 the Manaia Road sites were 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 a 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, to maximise the quantities of effluent disposed to land, and minimise discharges to the river.

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

In November 2004, Council resolved to consider ongoing work associated with the siting and operation of the existing and new ponds including detailed consideration of erosion protection works, further detailed assessment of leakage and detailed on-site geotechnical investigations.

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 the 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 as to soil types and characteristics
- Further assessment on the rate of leakage from the existing ponds
- Detailed water balance modelling
- Detailed groundwater modelling.

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[1] A form of high rate land disposal.

[2] The relevant guidelines are shown in Table 2 in Section 1.9.

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 (section 13).

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 then preferred option for the upgrade and lodged consents for the scheme in May 2007. The original scheme selected was as follows:

- 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.

The Council also resolved in June 2005 to continue to seek to acquire more land for the disposal of effluent. In March 2007 it purchased the 107 hectare site to the west of the 91 ha block. This created additional options that were not viable with only the 91 hectare site.

Construction of new ponds had been carefully considered in the past, but this was not feasible at the time because new ponds on the 91 hectare site would have reduced the irrigation area from 75 to 42 hectares. With the purchase of the additional 107 ha site, Council decided to re-evaluate the options for new ponds and the extent of the land disposal area.

The availability of gravelly fill material in the terraces to the west of the 107 hectare site, allows the construction of new ponds at a significantly lower cost compared to hauling fill material from further away. In addition, construction of new ponds avoids expenditure on substantial erosion protection works required for the banks of existing Ponds 2 and 3 facing the Ruamahanga River.

Seven options were considered for the construction of new oxidation ponds, on either the 91 hectare or the 107 hectare site, with various irrigation permutations developed on the sites. The options are reported in detail in *Masterton Wastewater Upgrade Project: Review of Pond Irrigation Area Options Incorporating Additional Land* (Beca 2008).

In December 2007, following the review of options, the Council unanimously selected the option of constructing new clay lined ponds on part of the 91 hectare site, and using part of the 107 hectare site for border-strip land disposal in conjunction with the remainder of the original 91 hectare site. It has reserved the option of developing the remainder of the 107 hectare site for further land disposal at some time in the future.

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).

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.

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. Condition 6 of the consent to discharge into water purports to require a long-term upgrade of the treatment plant to be operating by the expiry of the consent. In practice the existing consent will continue until the current applications are determined and then, if granted, the new consents will authorise the existing discharge until such time as the upgrade is completed. The Council aims to have the works completed as quickly as practicable following the commencement of the necessary consents.

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 Regional Fresh Water Plan (WRFP). However, at times of the year and at lower flows (in summer 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 (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)	No expiry date

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 because of the discharge, which should ideally be avoided.

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

- ***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 due to full mixing, is minimal at 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.

- ***Effects of land treatment of effluent on soils and groundwater***

  So that effects on the Ruamahanga River are minimised, treated effluent will be irrigated to land when soil conditions allow. Concern has been expressed that the extra water (as pond effluent) will saturate the soils and nutrients will be leached to groundwater, most of which enters Ruamahanga 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 WRFP.

3.2.4 Design Principles

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

- 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.

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

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) in 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 Wellington Regional Freshwater Plan.
- That the wastewater is treated to a standard, particularly in terms of suspended solids, colour, clarity and nutrients, that protects 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).
- 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 the Proposed Upgrade

3.3.1 Key Elements of the Proposed Upgrade

This section provides a summary of the proposed upgrade, including a summary of the restrictions on the discharge of effluent to the river. A more detailed description of the scheme is provided in section 6, which includes a schematic diagram of the upgraded treatment and disposal scheme (refer Figure 21). The upgrade comprises the following key elements:

- The construction of a new oxidation pond system comprising two primary ponds operating in parallel and five maturation ponds-in-series; with provision for live storage of up to 275,000 m3 in the ponds to provide storage when irrigation or discharge to the Ruamahanga River is not possible or is limited.
- New inlet works comprising coarse grit removal, a new step screen, and emergency/high flow channel with manually raked bar screen.
- Installation of a new influent pumping station and rising main with flow monitoring and distribution system to the primary oxidation ponds.
- Decommissioning the existing ponds with pond sludge air dried and stored in a fill area at the existing pond site.
- A pump station to deliver effluent to the land treatment area.
- Construction of a land treatment scheme on the 91 ha site, the decommissioned pond area, and the eastern part of the 107 ha site adjacent to the Makoura Stream, to apply pond 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, maintain a minimum ratio of 30:1 of river flow to effluent discharge.
- New effluent discharge point in the Ruamahanga River adjacent to existing Pond 3, with an outfall diffuser.
- Raising the level of the stopbank upstream of existing Pond 1 to provide protection for a 100-year return period flood.
- A 60 m wide planted buffer area for erosion control, adjacent to the existing ponds with minor bank protection works (the original proposal to provide major rock protection for erosion control is no longer required due to the existing ponds being decommissioned).

3.3.2 Key Improvements Resulting from the 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 because of new oxidation ponds with five maturation ponds-in-series
- Significant reduction in pond leakage with the construction of new silty clay lined oxidation ponds and the decommissioning of the existing ponds
- Maximisation of discharge to land and minimisation of direct discharge to the river
- No discharge of treated wastewater to the Ruamahanga River when river flow is below median flow ($\leq$12.3 m^3/s) in summer (1 November-30 April) or below half median flow ($\leq$6.2 m^3/s) in winter (1 May-31 October)
- The new discharge location will result in improved 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 a reduction in health risk

- Raising an area of stop bank to the north of the existing ponds will improve flood protection to the ponds and irrigation area
- There will be no discharge of effluent directly to the Makoura Stream, with a subsequently significant improvement in 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 will further improve the operation of the MWTP.

- **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 reduction in river water clarity as a result of the discharge
    - No nutrients directly discharged to the river that will encourage undesirable biological growths (periphyton/slime) on the 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
    - Significantly reduced discharge via pond leakage, will have negligible effects on the water quality in the river.
- **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 because of the diffuser and new upstream 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 regimes, and associated upgrades will:

- Result in significant environmental improvements over the existing discharge
- Remove the direct discharge from the river at the times and flows when the river is most sensitive, most valued and most used
- Allow the Masterton community to safely dispose of treated wastewater over the long term
- Ensure that the discharges have no more than minor adverse effects on the environment and do not compromise public health or aquatic ecosystems
- 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
- Not adversely effect the long term sustainability of the soils
- Not adversely affect the quality of groundwater
- Address the issues raised in consultation with the community
- Be consistent with the objectives and policies of the relevant regional and district plans
- Be sound and affordable long term solutions for Masterton
- Involve known technology
- Achieve the Council's objectives for the upgrade as specified earlier, and
- Be consistent with Part II of the RMA with respect to its purpose (section 5 - sustainable management of resources) and principles (sections 6, 7 and 8).

3.3.3 Consents and Designations Sought

Consents Sought from Greater Wellington Regional Council

The resource consents sought are for the following purposes:

- To construct new oxidation ponds
- To place and use buffer planting for erosion control on the river embankment, and any associated disturbance
- To raise the existing stopbank immediately upstream of the existing oxidation ponds
- To air-dry pond sludge and store in an on-site landfill in the area of the existing ponds
- To extract groundwater to allow for the air-drying of sludge in the base of the existing oxidation ponds, and also to avoid groundwater effects on the construction of the liner in the base of new ponds
- To construct the outfall diffuser in the Ruamahanga River
- To dam or divert water (Ruamahanga River during floods) by upgrading a stopbank
- To relocate a portion of the Makoura Stream to allow construction of new ponds
- To discharge contaminants to water as follows:
    - Pond effluent to the Ruamahanga River
    - Stormwater runoff from the irrigation area to groundwater via infiltration beds, to Makoura Stream and to Ruamahanga River
    - Extracted groundwater from the area of the existing oxidation ponds, to the Makoura Stream and Ruamahanga River, during sludge drying and removal
    - Minor leakage from the base of the new oxidation ponds to groundwater
- To discharge contaminants to land through irrigation of treated effluent, infiltration of pasture runoff and leakage from the base of the oxidation ponds
- To discharge odorous and aerosol contaminants to air from oxidation ponds, irrigation area, sludge drying area and sludge landfill
- To discharge dust and vehicle exhaust emission contaminants to air from earthmoving operations during construction of the new ponds and land treatment area, and during drying and removal of sludge from the existing ponds
- Maintenance of the erosion protection measures, outfall diffuser and stopbank.

Proposed Designation in the District Plan

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

- Continue with modifications to the existing designation (42 ha) for the MWTP so that it covers all land use activities associated with the upgrade of the MWTP; and
- Extend the designation to cover the 198 ha of land adjoining the existing MWTP designation for the construction of new ponds and associated works, and for the application of treated wastewater to land (including the 107 ha of additional land purchased by Council in 2007).

The NoR incorporates the following activities associated with the upgrade works:

- The construction and operation of the new Wastewater Treatment Plant
- The construction of new silt-clay lined oxidation ponds
- The construction and operation of a land treatment scheme to dispose of effluent
- All earthmoving activities associated with the construction of the new ponds, land treatment scheme, and restoration of the existing ponds area, including, but not limited to; haul roads, excavation from borrow areas, trommel screening, rock crushing, stockpiling, spreading, vibratory compaction and site restoration
- Relocation of a portion of the Makoura Stream
- Pump stations and pipelines for the land treatment scheme
- Construction of the outfall diffuser in the river
- Existing pond decommissioning, desludging and on-site landfilling of the sludge
- Erosion protection measures, comprising river embankment works
- Raising the existing stopbank immediately upstream of the oxidation ponds
- General ongoing operation, management and maintenance of the MWTP, and
- Any other activities ancillary to the construction operation and maintenance of the MWTP.

The extended designation will be limited to land owned by the Masterton District Council, with the exception of the outfall diffuser and a section of riverbed directly to the east of the existing Pond 1 (Refer Designation Plan in Appendix D).

Timing of works

Detailed design, contract documentation and letting tenders for the upgrading works will follow granting of the resource consents for the project, expected to be in 2009. Preparation of the site, diversion of Makoura Stream and construction of the new inlet works will start in mid 2010. The earthworks for the new ponds will be carried out over the 2010/11 summer period. The irrigation scheme will be constructed in parallel with the new pond construction. The new ponds will be commissioned in mid 2011 with the irrigation scheme commissioning during Spring of 2011. The above timing is based on average summer conditions. If there is high rainfall, a second summer period might be required to complete the earthworks.

Assuming that the new ponds are completed in mid 2011, the existing ponds will be decommissioned and the sludge air dried over the 2011/2012 summer and then moved to the sludge landfill. A second summer period might be required to complete the sludge drying operation, if there is high rainfall or high river flows. The existing pond area will be restored to pasture in 2012/13, and irrigation will commence in this area when the pasture has developed sufficiently.

If both contingency summer construction periods are required, the scheme would be completed by mid 2015. The consent conditions need to be based on the above timing.

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 MWTP 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 MWTP on the environment are examined in section 5, as part of the description of the existing environment, concluding with a summary of those environmental issues that 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 the 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 then 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

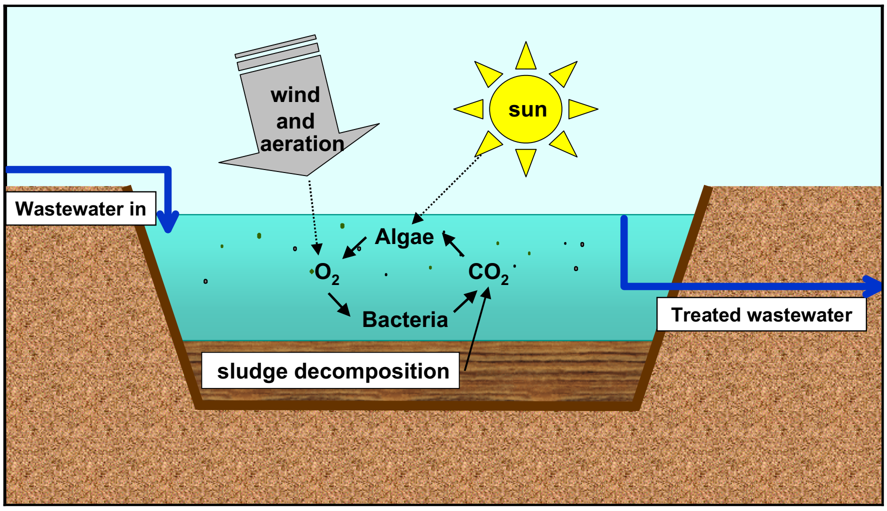

Figure 2 Schematic of Processes Within An Oxidation Pond

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 20 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 a robust and natural wastewater treatment process, with large volumes that can buffer peak flows and loads, and provide storage for higher inflows during wet weather. Oxidation ponds have the ability to efficiently treat dilute wastewater, which is the case for Masterton.

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. Wind or mechanical mixing brings algae to the surface where algae are exposed to sunlight and produce oxygen. Algae trapped at depths greater than 300mm do not receive sunlight.

Oxidation ponds provide an 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 because 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 provide an appropriate standard of effluent quality for discharge to land and direct discharge to the river during higher river flows
- They require a low level of operator supervision, with relatively low operating costs and very low energy requirements – effectively a solar and wind energy system
- Ponds have the ability to effectively treat Masterton's highly dilute wastewater

- The treatment processes in oxidation ponds are not adversely affected by peak flows and oxidation ponds also provide good buffering to stormwater inflows
- Sludge is stabilised on the base of the ponds by anaerobic digestion and the volume of sludge is reduced. Sludge removal is required at about 20 to 30 year intervals, which avoids ongoing sludge handling costs experienced at "in-tank" type treatment plants
- A pond system can also be upgraded, or added to, for improved performance if required in the future.

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 identifies the location of key components of the existing MWTP.

The MWTP receives an average daily flow of approximately 15,750 m^3/d and services an urban population of approximately 17,673 (2006 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 of 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.

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

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 8.0 ha, 9.0 ha and 8.5 ha respectively.

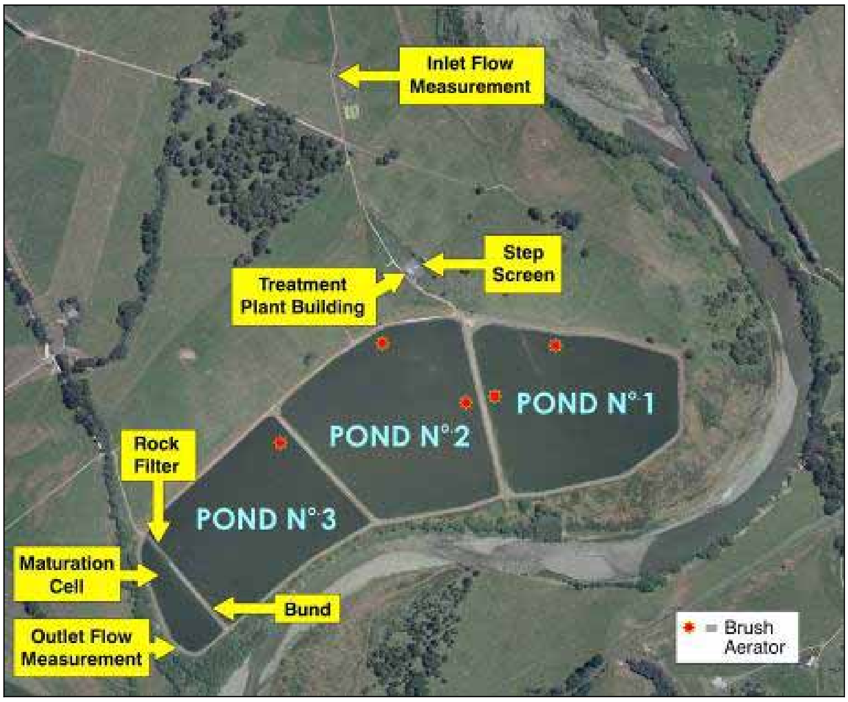

Figure 3 Key Components of the Existing Treatment Plant

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 placed in horizontal layers, not more than 150 mm 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*."

This specification for sealing of the ponds base is minimal in terms of current engineering standards. The existing ponds do leak and the nature and effects of the leakage are described in sections 4.5.4, 5.5.3, 8.2.2, and 8.3.5.

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. On average, the MWTP receives 15,750 m^3/day.

Table 2 Existing Influent Flow to the Ponds

Flows	**m^3/day**
Dry weather (summer time minimums)	7,980
Peak wet weather	60,480 (during a July 2006 storm event)
Average	15,750

The average flow is significantly higher than would 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 would be anticipated. During wet weather, the influent flows can be very high as indicated in Table 2.

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 5,100 m^3/day – this compares with the average of 15,750 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 flow 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, 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 will 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 will then be required to undertake repairs to eliminate these links.

With regard to capital works, these will 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 (2)	NZ Average (Range in brackets)(1)
BOD (g/m^3)	158	244 (154-456)
Suspended Solids (g/m^3)	133	239 (140-439)
Total Nitrogen (g/m^3)	19.1	39 (23-51)
Ammonia (g/m^3)	11.5	N/A
Total Phosphorus (g/m^3)	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

1 Data from Hauber, 1995

2. Data for the raw wastewater is from the November 2005 characterisation and are the average results made up of 24-hour composite samples on 7 days.

Table 4 Existing Metals Concentrations in Influent

Metal	**Level (g/m^3)**
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

Data for raw wastewater metal concentrations is for one 24 hour composite sample taken on the 19 July 2000

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 for Table 6 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/m^3 as $CaCO_3$)	50	-	-	-

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, and construction of a bund and rock filter to create a new maturation cell within the secondary oxidation pond. During the interim upgrade, rock 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 were 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 1,130 cfu/100 mL to 540 cfu/100 mL.

4.5.2 Effectiveness of Existing Pond Treatment

Table 7 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, because of the algae in the wastewater. It should be noted that the solids in a pond effluent are not raw wastewater solids, but naturally occurring algae and higher forms of life.

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

Table 7 Comparison of Existing Masterton Raw Wastewater and Effluent Qualities

Parameter	Raw Wastewater[1]	Pond Effluent[2]	Percentage Removal
Total BOD (g/m^3)	158	22	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(4)	99.9%
Alkalinity (g/m^3)	97.9	41.3	58%

Notes:

1 *Average of influent data collected during November 2005. Wastewater influent characterisations were 24-hour composites carried out over one week periods in July 2000, February/March 2005 and November 2005: i.e, one prior to the interim upgrade and two following the upgrade.*

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

At the average winter influent flow, the total retention time in the existing 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 existing ponds increases to around 28 days during summer weather as the influent flows reduce and evaporation increases.

In summary, the quality of the existing pond effluent 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 further improved with the construction of new oxidation ponds that will have six ponds-in-series.

4.5.3 Sludge Accumulations

The depths and volumes of pond sludge and the depth of wastewater over the sludge are shown in Table 8. The sludge volumes are derived from a site survey of sludge depth undertaken in June 2004. The ponds will be decommissioned following the construction of new ponds and the sludge will be air dried and stored in an on-site landfill.

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. 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 could 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 Leakage from the Existing Ponds

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 river flood conditions, this flow is temporarily reversed, with 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 will 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 be 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, 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.

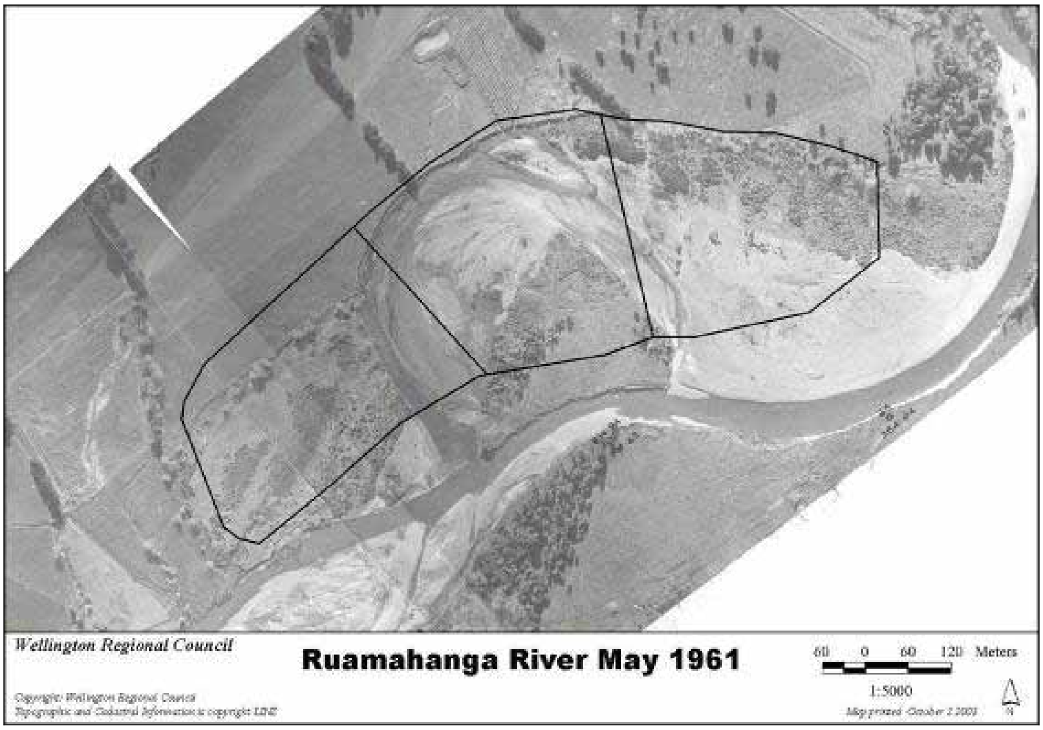

Figure 4 Aerial Photo of Former River Meanders Relative to Existing Oxidation Ponds

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 along preferred flow paths at relatively high velocities, rather than diffusely across the entire base of the ponds. The boils will presumably locally disrupt the sludge layer.

Following such events, the extent to which the settling of sludge reseals the “boil areas” 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 before the localised boil areas will be re-sealed by sludge. This suggests that under normal river conditions, leakage is more likely to occur through the base of the ponds over the meander channels, 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:

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

- 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 current relatively high rate of pond leakage on surface and groundwater quality are minor. The leakage from the proposed new ponds will be largely avoided with the construction of a low permeability silty clay liner. There will still be some minor leakage, however experience with silty clay lined ponds elsewhere indicates that this will be minimal.

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 GWRC. 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 GWRC (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 5.7 (Figure B1.1 in Appendix B1 shows the location of the surface water monitoring sites).

4.6.2 Compliance Performance

Annual Compliance Monitoring

The GWRC undertakes an annual compliance assessment of consents in the Wellington Region, which has consistently shown that MDC has complied with its consent requirements. The GWRC 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 will 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
- *Report June 2007*
  - Discharge to Water – Mainly complying (reasons – discharge exceeded the maximum permitted instantaneous rate during the July 2006 storm event. This high discharge was notified to GWRC at the time)
  - Discharge to Land and Air – Fully complying.

State of the Environment Report

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

- Microbiological indicator concentrations 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 "…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 increased at consecutive monitoring sites further downstream, and these concentrations were consecutively above the ANZECC 2000 trigger value for total phosphorus for aquatic ecosystem health downstream from Te Ore Ore. In other words, the background concentrations are elevated from a range of diffuse sources.

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, soils, and climate
- 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 the rivers 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. A 3-4 ha stand of grazed remnant kahikatea are located immediately to the north of the ponds, while exotic species such as eucalypts, conifers and deciduous varieties are more common to the west and along a narrow riparian strip on both sides of the Makoura Stream. There are also a number of isolated trees scattered across the site, most of which are to the north and north-west of the oxidation ponds. Of these, totara (*Podocarpus totara*) are the most predominant followed by occasional titoki trees (*Alectryon excelsus*).

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.

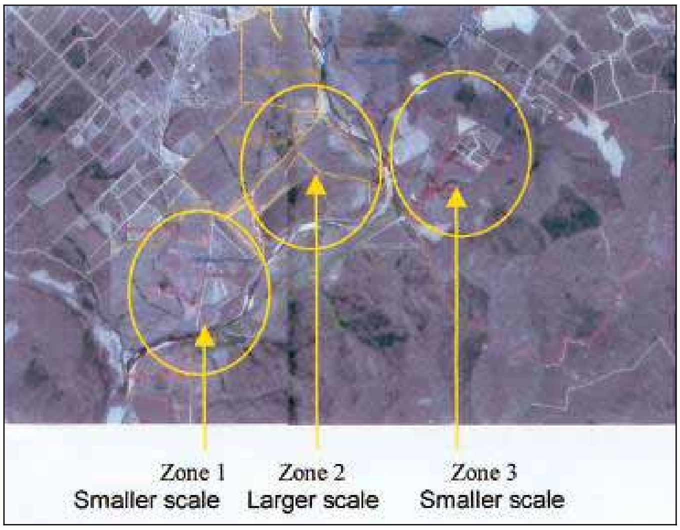

Figure 5 Different Landscape Scale Zones around the Oxidation Ponds

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.

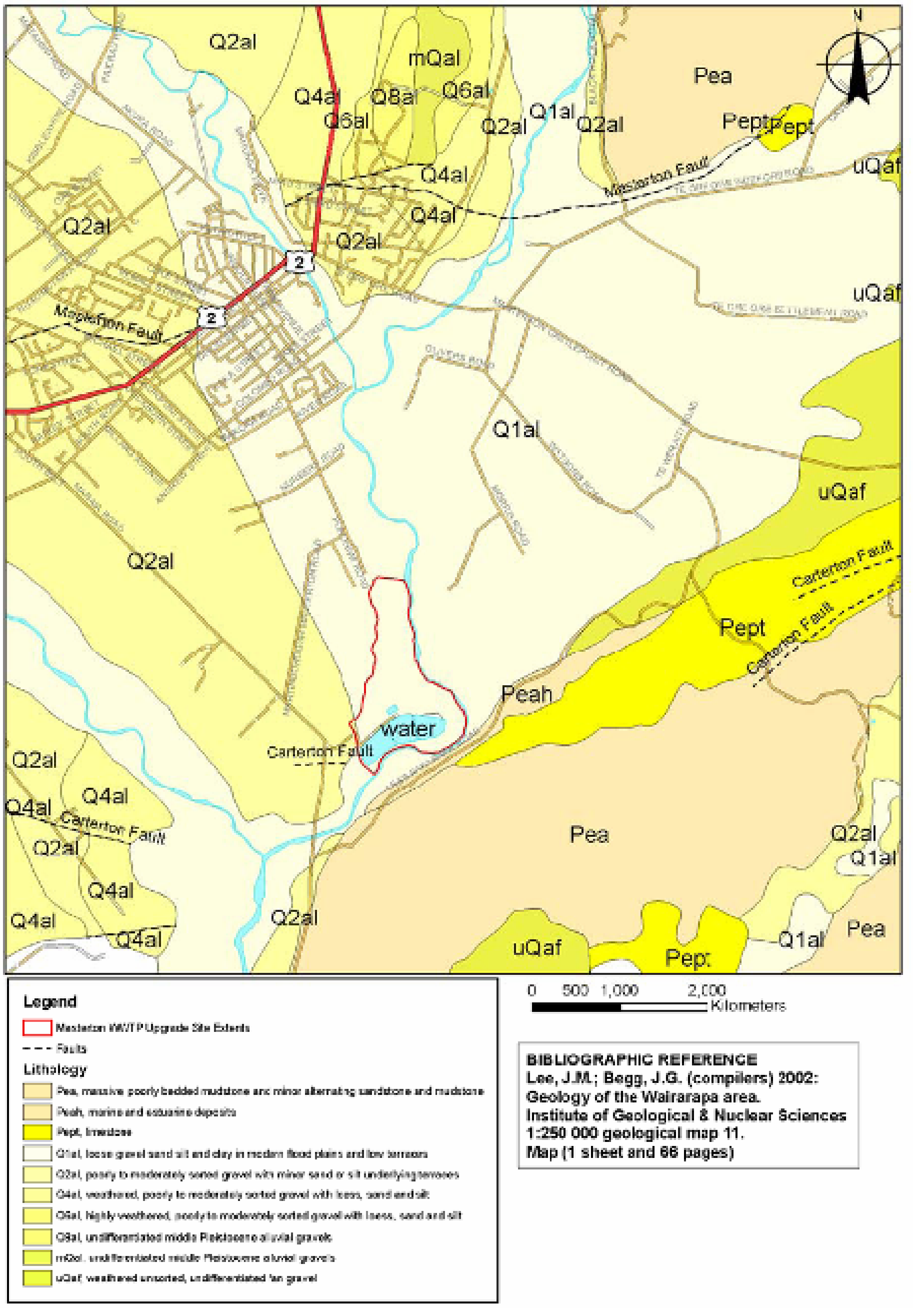

Figure 6 Map Showing Surface Geology Across the Wider Homebush Area

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

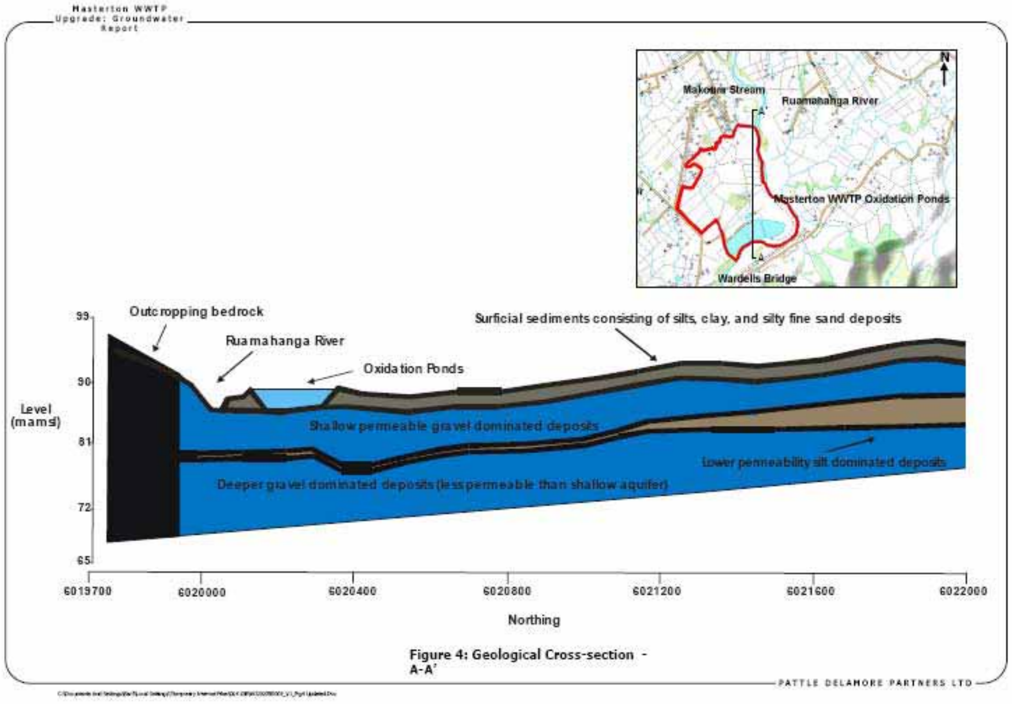

Figure 7 **Geological Cross-section Through the Homebush Site (A-A')**

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. This could represent a splay of the Carterton Fault and might extend through the southern corner of Pond 3 (Wairarapa Geological Services Ltd, 2005).

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[9] Lee and Begg cited in Beca 2005a

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 has 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.

5.2.5 Soils

The 91 ha site

The 91 ha of the proposed border-strip land disposal site is located on a former floodplain of the Ruamahanga River, immediately west of the river. The soils have been formed from the river alluvium, comprising gravelly 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 gravelly sand textures as well as some loamy silts. These soils are named Greytown sandy loam and gravelly 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 B2.1 in Appendix B2 shows the extent of on-site investigations for the soil's physical and transport properties) (HortResearch, 2007). These investigations analysed soil texture, the soils' capacity 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 0.5-4 mm/hr, mainly because there are fewer macropores. Locations having silty clays at depth are classified as poorly drained, and they will 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 theactivities 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 vary across the site, being generally adequate to low. Crop growth is expected to be nitrogen limited on the Homebush soils.

The 107 ha site

Soil mapping of the 107 ha site shows the overall distribution of drainage classes, particle-size classes, depths to gravels and depths to underlying clay-rich layers, on all of which the identification and naming of the soils is based (Figure B2.2 in Appendix B2 shows the extent of the soil investigations).

On the 107 ha site, the soils are generally finer textured than those on the 91 ha site adjacent to the river, where the coarser-textured alluvium was deposited. There is also a slight trend of the soils on the 107 ha site becoming finer textured from the margin towards the centre.

Similarly, the clay-enriched layers tend to be at shallower depth nearer the centre of the property, occurring in a strip running north–south, although their distribution is sporadic. There are "gaps" in these clayey layers, similar to that on the 91 ha site that may provide improved soil drainage.

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[10] Referred to as Olsen P values.

Depths to the underlying gravels are variable, with greater depths occurring along the eastern parts of the property, nearer the river. The assessment of internal soil drainage shows that much of the western part of the 107 ha site is poorly drained, with the area of poor drainage (Ahikouka soils) commonly occurring where the underlying clay-rich materials occur at shallow depth (less than 50 cm depth). The generally poorer soil drainage of part of the 107ha block probably relates to a greater distance from the Ruamahanga River where finer-textured alluvium was deposited, possibly in a former back swamp abutting the older and higher terrace (Tauherenikau soils).

Whereas the 91 ha Homebush site, contained predominantly well drained and moderately well drained Greytown soils (Wilde 2006), much of the 107 ha property contains poorly and imperfectly drained soils. Permeability measurements made on the adjacent 91 ha block (Wilde & Dando 2004b) showed that Ahikouka soils had the slowest permeability of all the soil on that property.

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 1,915 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, 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 the average number of wet winter days. The average summer rainfall is also significantly lower than winter. Rainfall is very similar between autumn and spring (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.

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[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 flow 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. 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 the proposed discharge regime, as discussed later in this AEE.

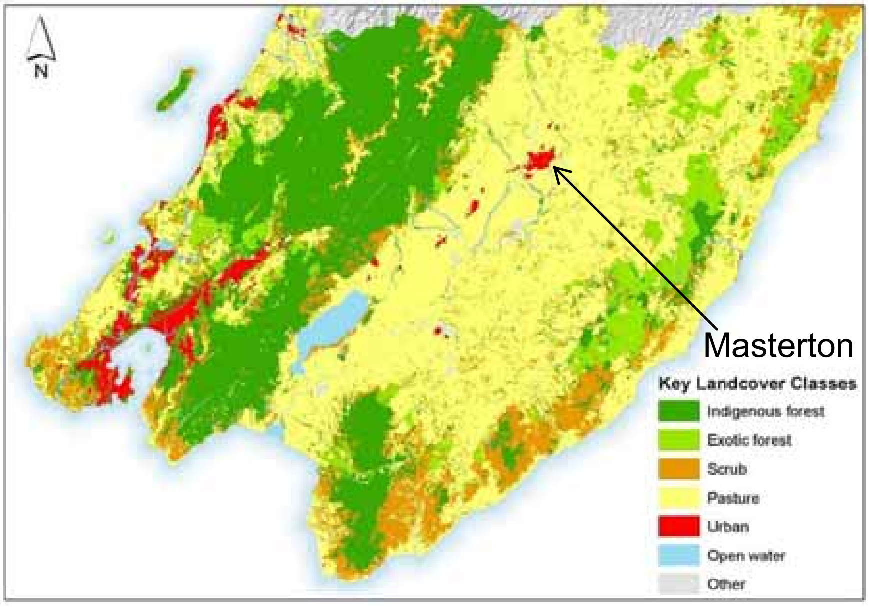

Figure 8 **Regional Land Cover (Simplified) in the Wellington Region**

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[11] Refer Figure B1.2 in Appendix B1 for river management classes

[12] Refer to Figure B1.1 in Appendix B1 for location of all water quality monitoring sites

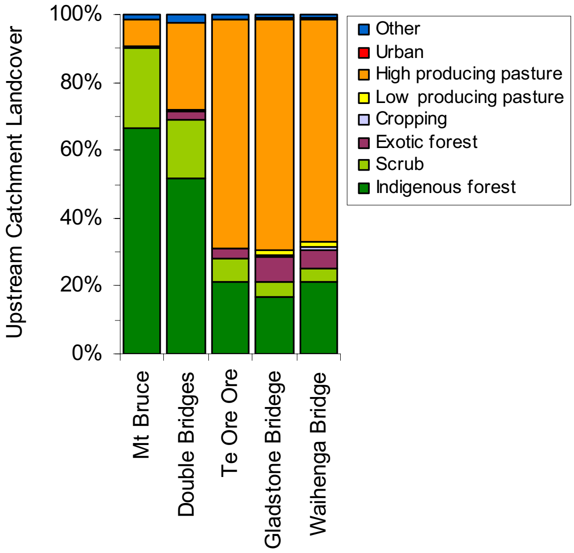

Figure 9 **Major Landcover Types in the Catchment Area**[13]

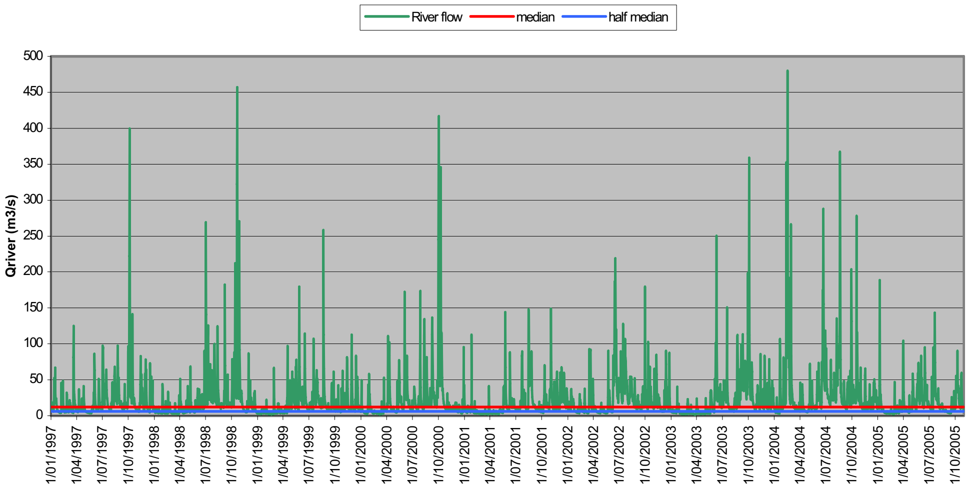

Figure 10 **Ruamahanga River Flow (1997-2005)**

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.

Near Masterton, the Ruamahanga River 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].

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[13] Upstream of each of the five Regional State of the Environment monitoring sites on the Ruamahanga River (from Milne & Perrie 2005). See Figure B1.1 in Appendix B1 for site locations.

[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)

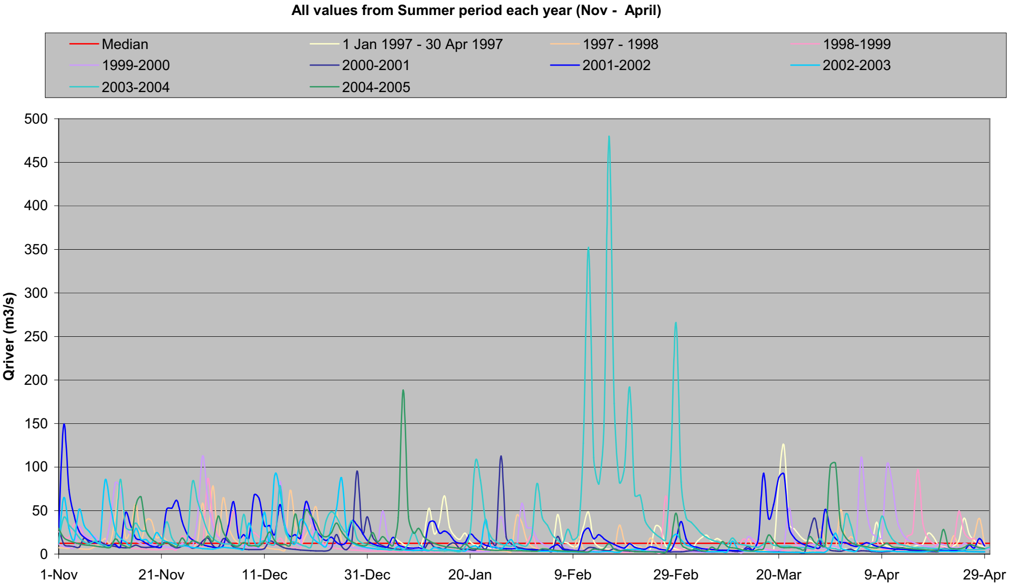

Figure 11 Ruamahanga Summer Flows

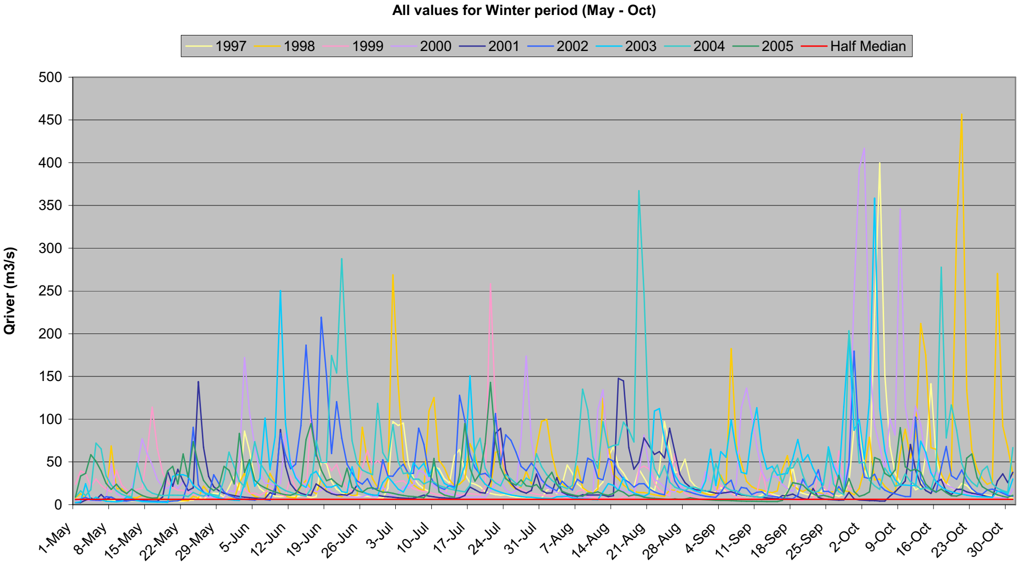

Figure 12 Ruamahanga Winter Flows

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 8 and Figure 9 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.

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.

Figure 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 are marked increases in nitrogen and phosphorus concentrations 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 comparable with those upstream of the MWTP (Table 19). The regional State of the Environment monitoring has shown increased dissolved nutrient concentrations from the upstream site (Te Ore Ore) to the downstream site (Gladstone Bridge) below the MWTP, with the greatest increase for dissolved phosphorus (see Figure 14). As noted above, much of the nutrient increase, particularly at low flows, is attributable to the MWTP discharge.

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[16] Diffuse source pollution is that arising from 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.

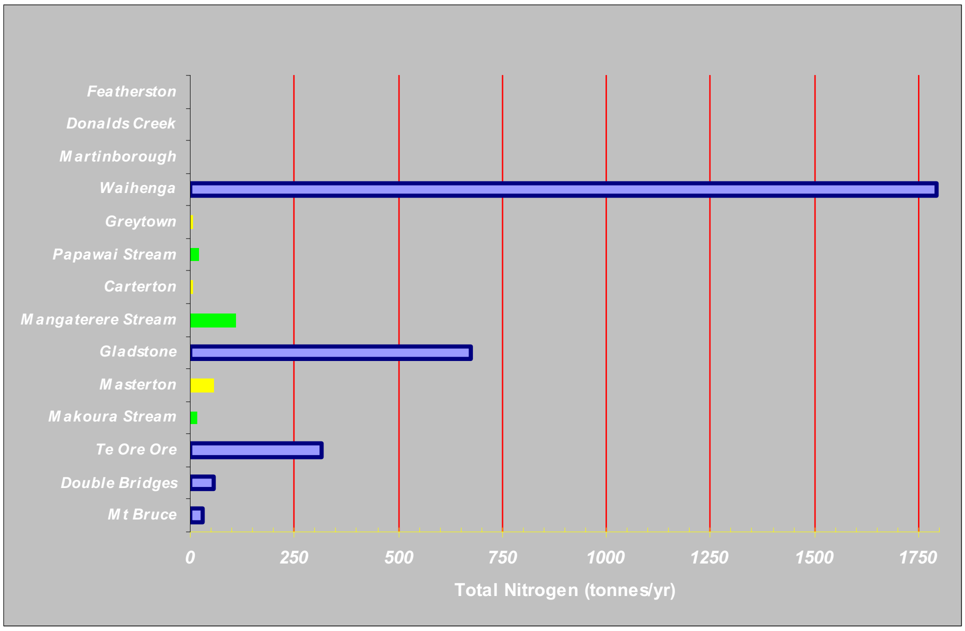


Figure 13 Total Nitrogen Load to the Ruamahanga River

Note: 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

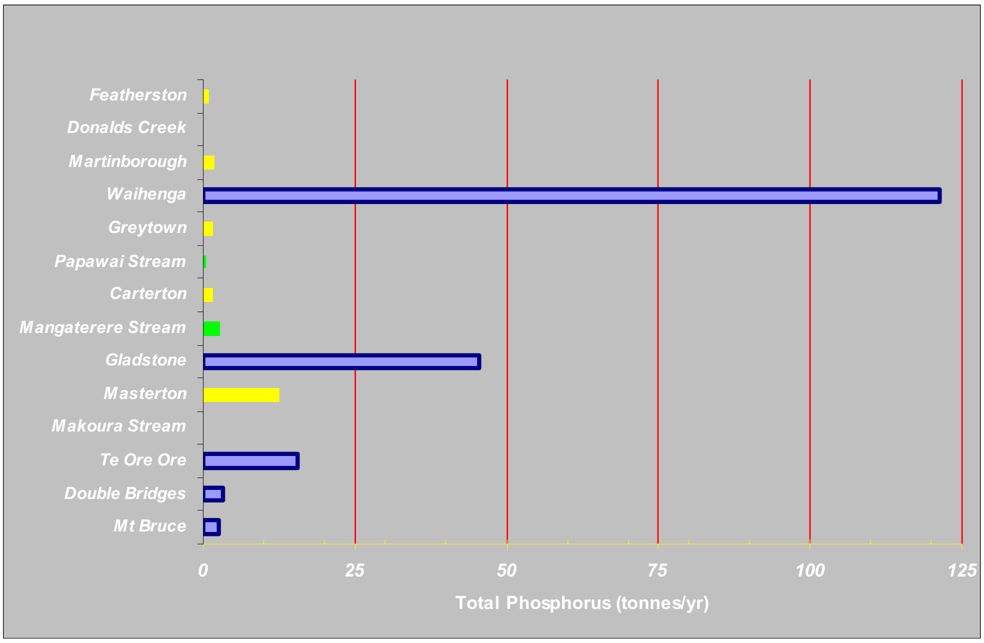


Figure 14 Total Phosphorus Load to the Ruamahanga River, Mountains to Sea

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 Phosphorus Load is 15.6 tonnes P/y, while at Waihenga it is 121 tonnes P/y. The yellow bars represent the Phosphorus Load from municipal wastewater treatment plants and the green bars the load from tributary streams

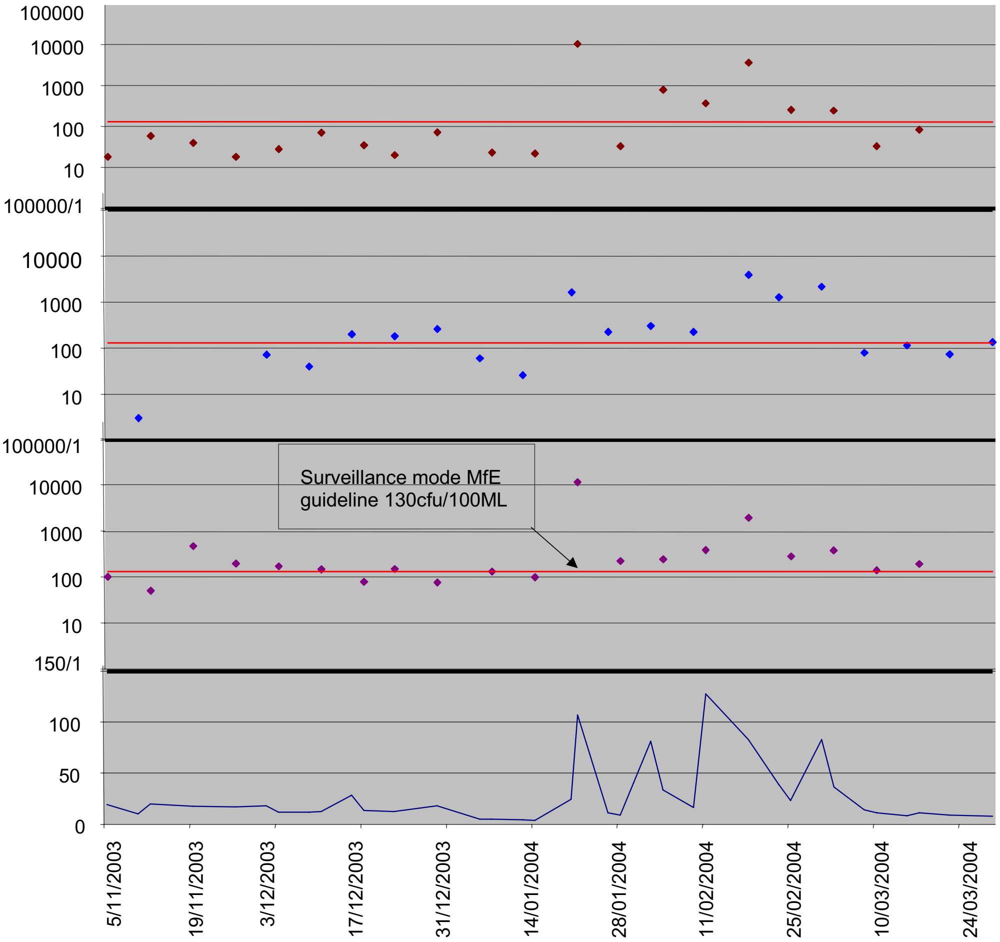
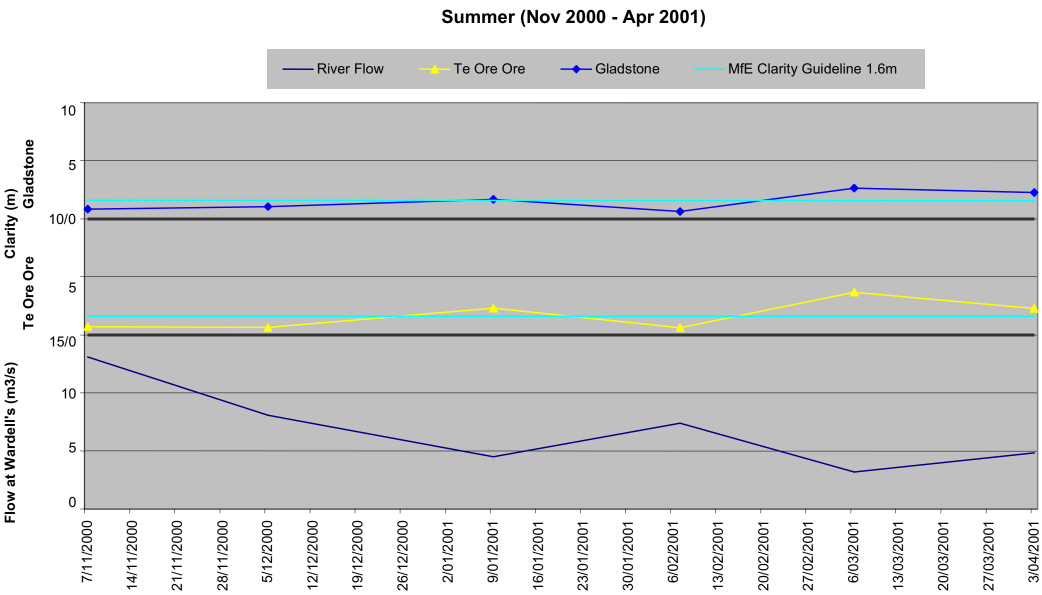


Figure 15 E.coli and Flow in Ruamahanga River (Bathing Season 2003-2004)



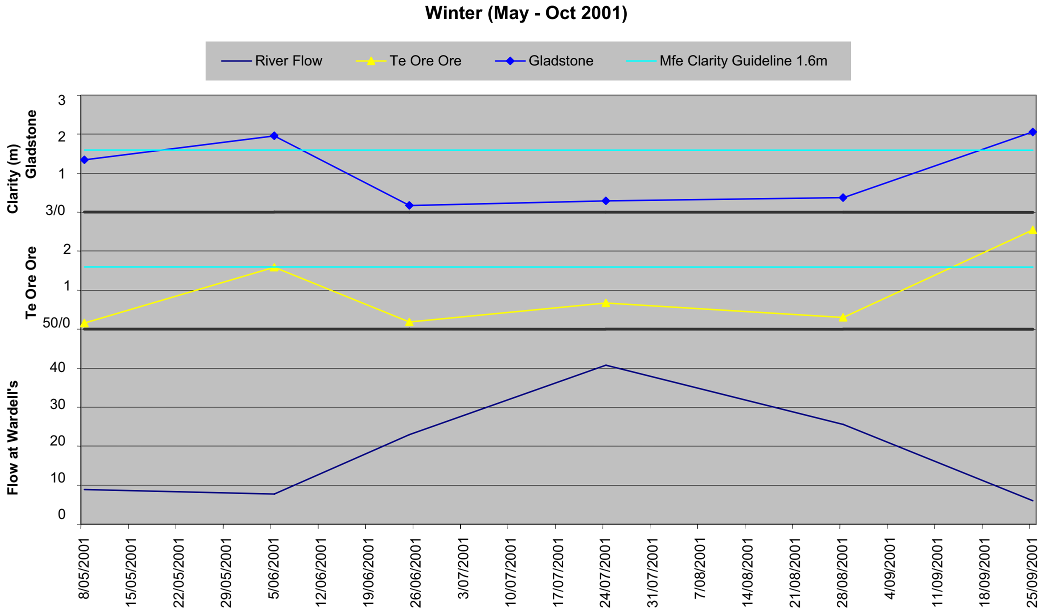


Figure 16 **Clarity and Flow of the Ruamahanga River**

(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.

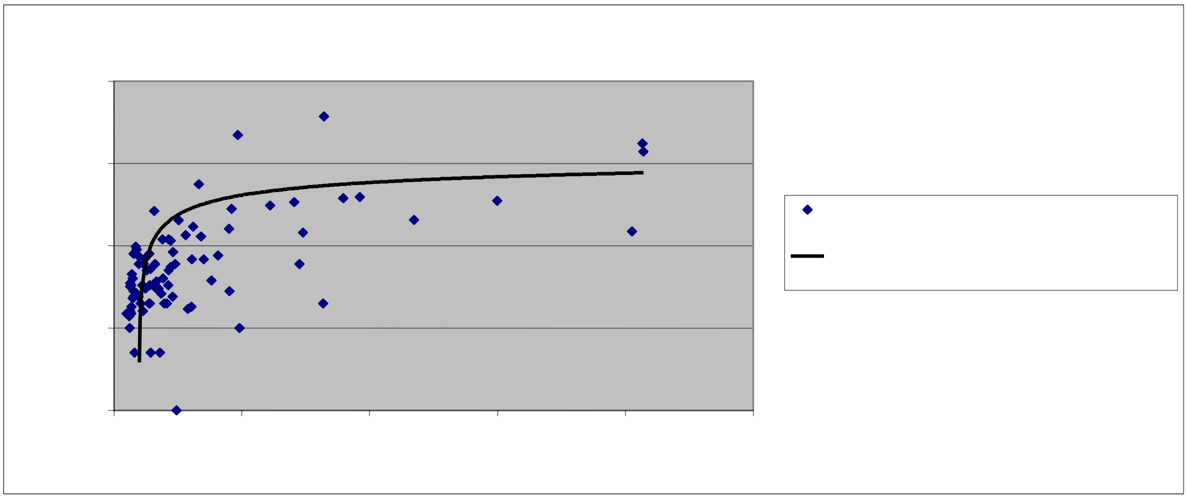


Figure 17 E.coli and Flow in the Ruamahanga River

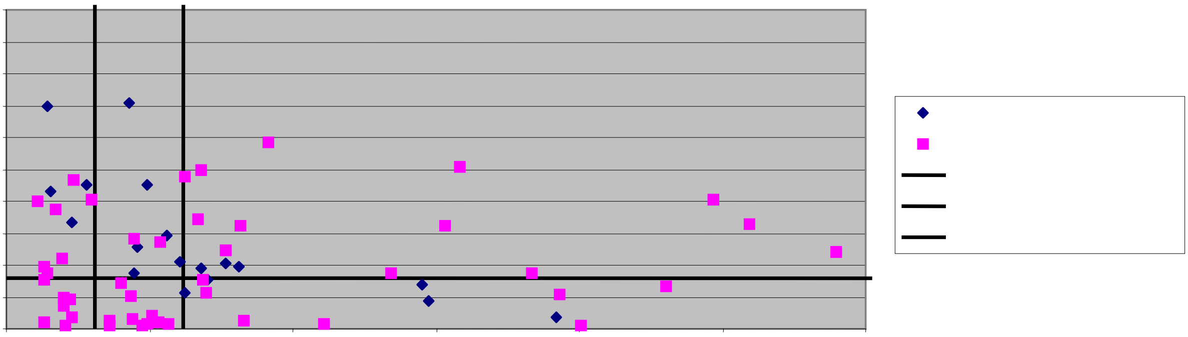


Figure 18 Clarity and Flow in Ruamahanga River

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 will 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 will 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 habitat (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 B.

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 increase downstream[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 B1.5 in Appendix B). 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 Deleatidium 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 a low number of Deleatidium is an indicator of potential adverse effects of contaminants such as ammonia. Deleatidium has been found to be amongst the most sensitive of invertebrate and fish species to ammonia, being only slightly less sensitive than 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.

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.

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[17] National Rivers Water Quality Network

[18] Refer Table B1.1, Figure B1.4 in Appendix B.1

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 increasing 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 recommend a maximum of 30% cover of the river bed by filamentous periphyton 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 cover of 35% (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 one occasion (February 1994) and on two occasions for mat growths (March 1998, April 1999). Commonly the cross-section measurements showed greater proliferations on the right-bank of the river (downstream of the Makoura Stream and MWTP 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 B1 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 native and exotic fish species. Summer low flows and associated elevated temperatures are a major factor restricting distribution of fish species largely to 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]. GWRC has reported that this pattern is likely to be attributable to high summer river temperatures (WRC 1999).

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 allow pathogens to enter the body.

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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 B1.4, Figures B1.5 – B1.8 in Appendix B.1

[23] Figures B1.5 and B1.7 in Appendix B1, and Figure B1.6 in Appendix B.1 respectively

[24] Figure B1.8 in Appendix B.1

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 Figure 13 and Figure 15. 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 Table 34 and Table 39). Accordingly, it is during low flow conditions that the current discharge has the most effect on downstream microbiological water quality and this also coincides with the flows when most primary contact recreation occurs.

Table 10 GWRC E.coli Monitoring (cfu/100mL) – 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
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

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[25] Refer to Appendix B for location plan of sites

[26] Source: GWRC State of the Environment Report 2005.

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, separately 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.

GWRC 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 GWRC. The aim of the scheme 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, 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 GWRC 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, GWRC 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, GWRC 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 for existing stopbanks from high intensity flood events is greater 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

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

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 events.

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

Return Period (years)	Flows (m^3/s)
2	460
10	674
20	760
50	871
100	955

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 aerial photos in Appendix E show the design river channel, which will 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 current erosion protection will remain in place for the new wastewater scheme.

Gravel Build-up

There has been a particularly high degree of river flooding during 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. GWRC is aware of this and is currently taking steps to address the problem. It is understood that GWRC intends to have remedial work undertaken, comprising bed re-working and gravel extraction.

5.4 Makoura Stream

The Makoura Stream environment is highly modified by historic vegetation removal and ongoing stock access, similar to many small streams of this nature within the Wairarapa Plains. The stream edges are dominated by introduced plants, predominantly willow and *Robinia* with some poplar, macrocarpa and pine. There are some small areas that have retained indigenous values with areas of flax, ferns, grasses, sedges and the occasional cabbage tree and kowhai. Despite the riparian fencing being in poor condition and stock being obsevered in the stream itself, the trees that are present are well established and provide shade and good conditions and habitat for freshwater species. Pasture surrounds the immediate stream vegetation.

This lower portion of the Makoura Stream is relatively slow and consists of gently meandering channels of approximately 3-4 metres width. The stream channels are deep, well defined and are relatively stable. There are pools in the portion of the stream that is proposed to be diverted. Water quality has been observed to be good and there are no odours or water colouration issues.

A number of macroinvertebrates were present in the stream. Sewage from the existing treatment plant is already discharged to the Makoura Stream and this has resulted in a macroinvertebrate population that is representative of modified farm stream habitats with high sediment loadings.

According to the New Zealand Freshwater Fisheries database, two sites within the Makoura Stream were surveyed in 2005 using an electric fishing machine. The following table lists the freshwater species that were identified, and their relevant threat classification:

Table 12 Freshwater species in the Makoura Stream

Common Name	National Threat Status (Hitchmough et al 2007)
Long-fin eel (Anguilla dieffenbachia)	5. Gradual decline
Short-fin eel (Anguilla australis)	Not threatened
Freshwater crayfish / koura (Paranephrops)	Not threatened
Brown trout (Salmo trutta)	Introduced

5.5 Groundwater Flow and Quality

5.5.1 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 and 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.

GWRC 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.

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[28] Source: PDP, 2006.

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

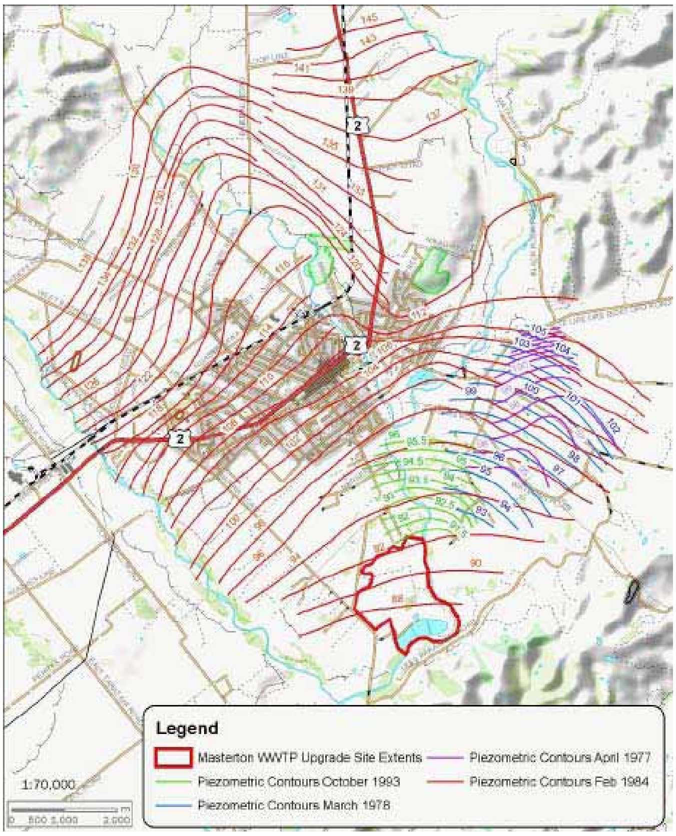

Figure 19 Groundwater Contours[30]

5.5.2 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.

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

[31] Figure B2.1 in Appendix B2 shows the extent of boreholes and test pits on the 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.

5.5.3 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]
- 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 1,700m^3/day (PDP, 2007).
- Pond leakage was assessed again in June 2006 in an exercise aimed at determining the impact on the leakage rate of 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 for 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 from the existing ponds. These are based on the trial undertaken in June 2006 that involved raising pond water levels (as discussed above).

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[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.

Table 13 Leakage Rates

Pond Operating Level	Rate of Leakage (m³/day)	Upper Bound (m³/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 2,400 m³/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 estimated leakage from the new clay / silt lined oxidation ponds is expected to be within the range of 150 to 750 m³/day, trending to the lower end of the range as algae seals the silt/clay liner over the first year of operation.

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

5.5.4 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 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.

In conclusion, the groundwater quality can be considered to be reasonably typical of a rural environment in that quality is good, without any contaminants 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.

5.6 Community Characteristics and Values

5.6.1 Profile and Population Demographics

Recent New Zealand Census population figures for Masterton District are shown in Table 14, with the population projected out to 2026. Masterton's District population grew slightly between 1991 and 1996, but slightly decreased (2.5%) between 1996 and 2006. Based on medium growth predictions, the growth rate in Masterton District will rise slightly in 2006 before declining. Masterton District predicted population over the 20-year period between 2011 and 2031 is expected to decline from 23,300 people in 2011 people to 22,400 people.

Information from the 2006 census is that the district population that was 'usually resident' on census night (7 March 2006) was 22,623.

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[33] In borehole 6 located centrally in the proposed irrigation site

[34] Poly Aromatic Hydrocarbons

Table 14 Masterton District Population 1991 to 2031[35]

Year	District Population	Urban Population*
1991	22,600	18,407
1996	22,800	18,069
2001	23,200	17,793
2006	23,200	17,673
2011	23,300	17,673
2016	23,300	17,673
2021	23,200	17,673
2026	22,900	17,673
2031	22,400	17,673

** Based on static urban growth from 2006*

The population of the Masterton Urban Area decreased slightly between 1991 and 2006. 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 aged 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 ethnic 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 relative deprivation. A rate above 1000 indicates a higher level of deprivation, while a rate below 1000 indicates an above average wellbeing. The attributes included in the NZDep2001 measure, 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 the relative socioeconomic position of Masterton with other districts. 0 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 an important factor in considering the community's ability to pay for significant infrastructure projects, compared with the principal altenative schemes[36].

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[35] Source: Statistics New Zealand, Projected Population of Territorial Authorities 2006 (base) – 2031. Medium projections used for 2011-2031. Census usually resident population used for 1991- 2006 figures.

[36] The economic effects of the proposed upgrade on the community are discussed in section 8.8.4, while the relative costs of the alternative systems is outlined in section 10

Table 15 Comparative Deprivation Rates

District	Deprivation index NZDep 2006
Carterton	970.0
South Wairarapa	974.5
Upper Hutt	976.6
Palmerston North	997.2
Taupo	1004.6
Tararua	1008.0
Waikato	1010.9
Masterton	1013.0
South Taranaki	1017.4
Rotorua	1036.7

Source: Index NZDep2001

5.6.2 Recreational Use of Ruamahanga River

The Ruamahanga River is a popular recreational destination, 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 River ("The Cliffs" and Morrisons Bush) on five days between 14 January and 11 February 1996, the results of which are shown in Table 16[37].

Table 16 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 8.5 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 that 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.

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[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)

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

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 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, kayaking, or jet boating.

Wardells Bridge is about 200m downstream of the 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 8.2.6 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 the 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. People were observed fishing at "The Cliffs" when the 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 the 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 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

5.6.3 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 reports, 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.

5.6.4 Community Health and Recreation

The health of the community in terms of potential 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 Table 17[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 District Health Board (DHB) included recreational water as a possible risk factor; the Ruamahanga River was not implicated in any of these cases.

Table 17 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

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[39] Information is available through the EpiSurv notifiable diseases database.

any of the notified cases were linked to contact with the Ruamahanga River, or whether they were from other exposures. 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 affect 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 Ministry for the Environment/ Ministry of Health guidelines state that when discharging from oxidation ponds or after UV disinfection, the relationship between indicators and pathogens is altered, and a site-specific risk assessment is recommended. 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 18 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 18 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 risk 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 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. 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 per 1,000). 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. Overall, taking into account the relatively low exposure rates (low primary recreational usage) the current risk of infection swimming in the Ruamahanga River from the existing (continuous) effluent discharge, is assessed to be minor.

Table 18 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 for 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 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 appears to be little health risk via consumption of contaminated mahinga kai, as all of the chemicals tested were below the limit of detection.

5.7 Effects of Existing Discharge on the Environment

5.7.1 Effects on the Makoura Stream

The lower Makoura Stream is regarded as significantly 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 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 discharge on 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, with the ANZECC (2000) toxicity guideline for aquatic ecosystems 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

5.7.2 Effects on the Ruamahanga River

The impact of the existing discharge is discussed in section 5.3.2. Additional information is provided in Table 19 that 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 (refer section 5.3.2).
- There is an increase in ammonia-nitrogen, nitrite-nitrogen and nitrate-nitrogen downstream of the MWTP 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 165 occasions since December 1999. The MfE/MoH (2003) microbiological bathing water quality guidelines 'alert' level (260 cfu/100 mL) was exceeded upstream (Rua 1) on 25 occasions and downstream of the MWTP (Rua 2) on 37 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 was greater than 2.9 times median flow.
- The downstream periphyton levels were below nuisance levels in the 2005 and 2006 annual samples.
- 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 5.5.3).

Under the WRFP, 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 WRFP. 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.

Table 19 shows the effects of the existing discharge on the water quality of the Ruamahanga River downstream of the discharge. The Rua 4 monitoring point downstream of the mixing zone shows improved water quality.

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

[41] Refer Figure B1.1 in Appendix B1

Table 19 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 (μS/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 upstream (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 MWTP discharge).

Table 20 addresses the degree of compliance with the actual alert and action guidelines (260 and 550 cfu/100 mL respectively) both upstream and downstream of the discharge:

Table 20 (RFI Table Q23.1): Exceedance of MfE/MoH guidelines above and below the existing discharge (December 1999-June 2007)

Guideline	***RUA1 Upstream no. of exceedances n=165 (% exceedance)***	***RUA2 Downstream no. of exceedances n=148 (% exceedance)***
>130 cfu/100 mL	*41 (25%)*	*78 (53%)*
>260 cfu/100mL	*25 (15%)*	*37 (22%)*
>550 cfu/100mL	*14 (8.5%)*	*22 (15%)*

5.7.3 Other Effects

Historically, there have been no complaints associated with odour from the ponds, with one exception in August 2005, that was caused in part by increasing volumes of sludge in Pond 1. 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 in terms of increasing the overall risks from flooding and river erosion. The proposal to construct new oxidation ponds set back 270 m from the river mitigates these risks.

5.8 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, a number of adverse effects that the proposed long-term upgrade will address.

5.8.1 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. In particular, the effluent appears 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.

5.8.2 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.

5.8.3 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 buildup is not at a nuisance level, it does have some minor impacts on the recreational and aesthetic values of this section of the river.

5.8.4 Aquatic Ecosystems

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

  While the river ecosystem is generally in a healthy condition, in 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.

5.8.5 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 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).

5.8.6 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, prefer that there be no discharge to water except via land.

5.8.7 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, particularly 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 existing ponds could 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 by border-strip irrigation as a secondary treatment process. 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.

As described in section 3.2.1, in March 2007, the Council purchased an adjoining 107 ha block of land for the future disposal of treated wastewater to land. In late 2007, the Council decided to review the original scheme to take advantage of the new opportunities provided by the additional 107 ha. In December 2007, following a review of several options incorporating the additional land, Council unanimously selected the option of constructing new clay lined ponds on part of the 91 hectare site, and developing a border-strip land disposal scheme on the remaining area in conjunction with part of the additional 107 hectares. The remainder of the 107 ha site could be developed for irrigation at some time in the future.

6.1.2 Summary of the Proposed Upgrade

The new scheme includes the following:

- Construction of new oxidation ponds, comprising two primary ponds operating in parallel and five maturation ponds operating in series, to the southwest of the area of remnant native bush, requiring a 500 m diversion of the Makoura Stream
- Provision of new inlet works comprising coarse grit removal, a new step screen, and an emergency or high-storm flow channel with manually raked bar screen
- Installation of a new influent pumping station and pressure main with flow monitoring and a distribution system to the primary oxidation ponds

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[42] Pond Location Report (Beca 2004a)

- Provision of live storage of up to 275,000 m^3 in the ponds for the effluent when irrigation or discharge to the Ruamahanga River is not possible, with pond storage to be controlled by automated valves
- Discharge of effluent to the Ruamahanga River through a diffused outfall below the riverbed, with the discharge point to the river located upstream from the confluence with the Makoura Stream.
- No discharge of effluent to the Ruamahanga River will occur during river flows less than median in the summer and less than half-median in winter. The automatic control of the discharge will be based on telemetered river flow readings at Wardells Bridge and Mt Bruce.
- Decommissioning the existing ponds with the pond sludge air dried and stored in a fill area at the existing pond site
- River erosion protection works proposed for the previous scheme will no longer be required, providing a significant cost saving; however, a 60-metre wide willow planted buffer area will be developed adjacent to the decommissioned ponds.
- The proposed treated effluent land disposal system consists of the following:
    - An effluent pumping station and distribution system
    - A border-strip land disposal scheme covering a net area of 75 hectares of existing pasture on parts of the 91 ha and 107 ha sites. On the western side of the 107 ha site, a net irrigation area of approximately 52 hectares could be developed in the future, but will remain in normal farming use in the interim.
    - Development of an additional area of approximately 22 hectares for border-strip land disposal in the area that currently contains the existing treatment ponds. This area will be developed one to three years after sludge removal to allow time for topsoil and pasture establishment.
    - A wipeoff drain system to collect excess irrigation runoff and stormwater runoff. Flow in the drains will be preferentially discharged to constructed infiltration beds, with “first flush” flows that reach the downstream ends of the drain systems, being recycled to the treatment plant, and during extremely heavy rainfall, discharged directly to the Makoura Stream, which will be in flood at that time.
    - Runoff collection pumping stations, returning runoff to the maturation ponds
    - Drip irrigation over the buffer planting along Makoura Stream and the west boundary of the proposed irrigation area, when the soil moisture is low; the buffer areas will be planted in native trees and shrubs.

New discharge regime

A key component of the proposed upgrade is the new discharge regime, which is the same as that proposed under the 2007 resource consent applications. It involves a balance between the influent (incoming volume of raw wastewater), storage in the ponds (calculated required maximum of 200,100 m^3), volumes of effluent discharged 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)
- The discharge to the river will be suspended at river flows of greater than 300 m^3/s. This is in order to address iwi concerns about the floodwaters containing the discharge of wastewater flowing onto private properties
- If irrigation and disposal to the river are prevented, or are limited to less than the inflows, then the 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:

- Flow and load forecast
- How the scheme will be upgraded, including the proposed construction of new oxidation ponds
- The proposed land treatment system
- The new location and method of discharge into the river
- Expected quality of effluent discharge
- 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 New Oxidation Ponds (Beca, 2008).

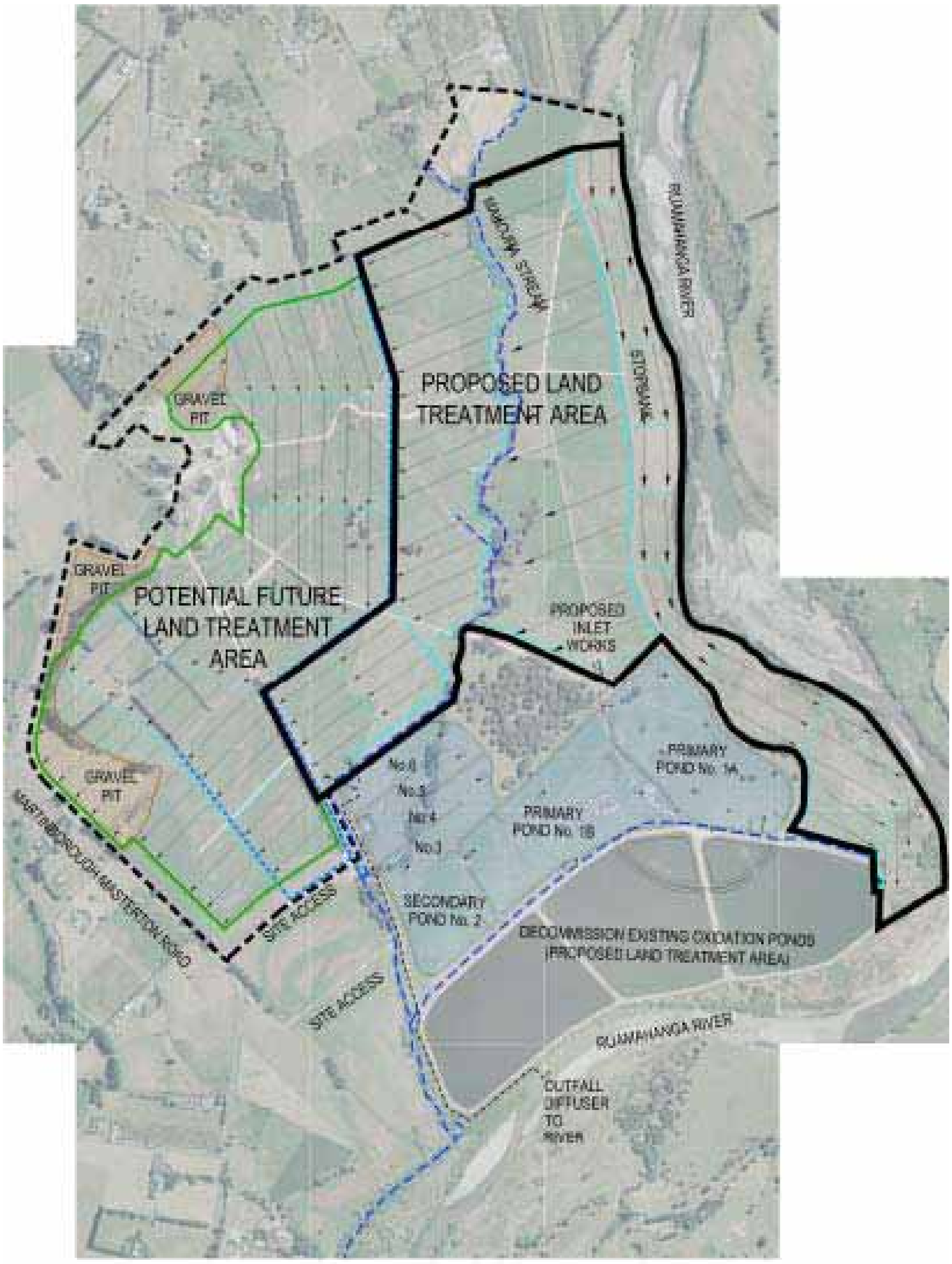

Figure 20 **Layout of the Proposed Upgrade**

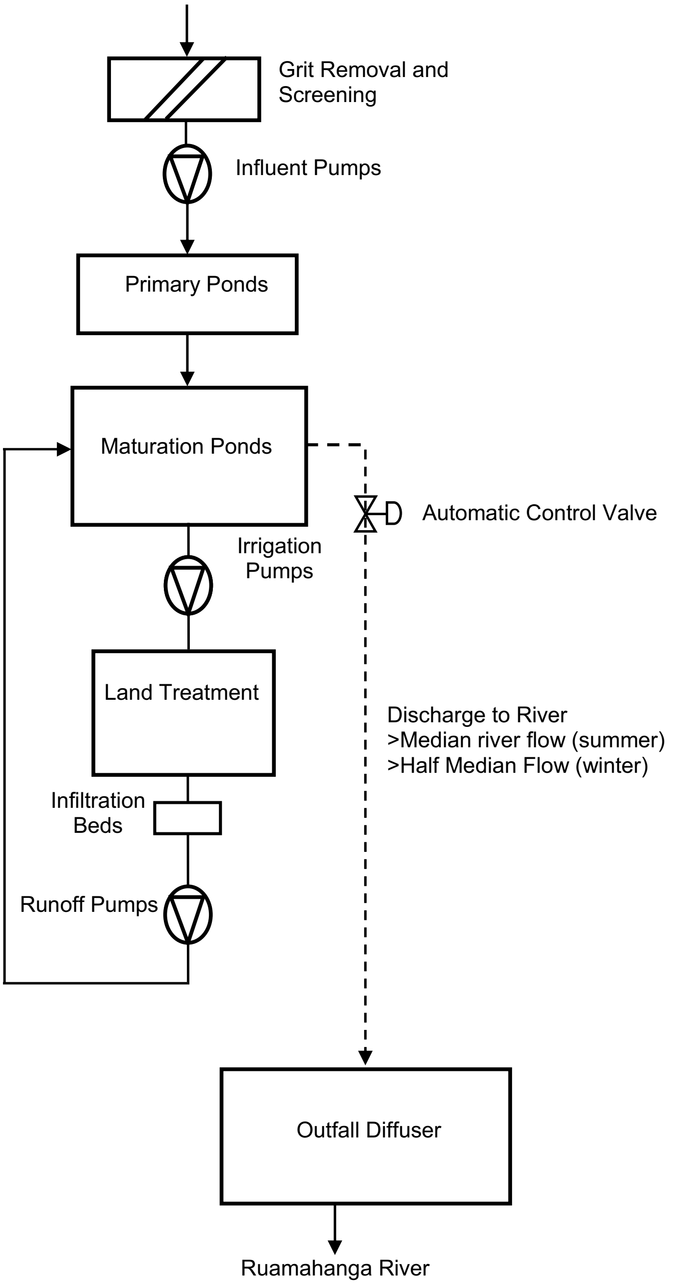

Figure 21 Schematic Drawing of Proposed Masterton Wastewater Treatment Plant Upgrade

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 2006 census data[43]. This forecast period is considered appropriate as a longer period will 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 will 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 21. 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.

Table 21 Population Projections for Masterton District

Scenario	Projected 2031 Population	2006-2031 Change
High	24,500	5.6%
Medium	22,400	-3.5%
Low	20,400	-12%

In terms of the urban area that the MWTP services, MDC expects there to be an ongoing moderate rate of greenfield 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 2006 Census was 17,673, 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 has therefore been 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.

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

6.2.3 Influent Flows and Loads

The current and projected total influent loads (comprising domestic and trade waste loads) are shown in Table 22.

Table 22 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	15,080	692	1,316	1,530	15,080	692	1,316	1,530
Trade	670	8	516	292	1,220	14	710	429
TOTAL	15,750	700[1]	1,832	1,822	16,300	706	2,026	1,959

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

6.3 Proposed New Oxidation Ponds

NOTE: Changes in this section from the 2007 AEE, describe the new oxidation pond and revised land treatment scheme as well as the diversion of Makoura Stream.

6.3.1 Inlet Works

The existing inlet works are located beneath the proposed location of the new primary ponds. Therefore, construction of new inlet works is required. The new inlet works will comprise:

- A coarse grit removal chamber to protect the screens and influent pumping station from damage
- A new 3 mm aperture step screen and screenings press is recommended for the new inlet works rather than the existing 6mm aperture screen
- A bypass weir to a manually raked bar screen to provide screenings removal during failure of the step screen, and to provide temporary screenings removal during maintenance of the step screen.

Screened effluent will discharge by gravity to a new influent pumping station, which will pump the wastewater to a flow splitter box. The 500 mm diameter Parti-Mag flowmeter from the existing inlet works will be relocated to the discharge side of the influent pumping station.

The flow splitter box will consist of weirs that divide flow to the two primary oxidation ponds. The weirs will be fitted with stop logs or gates to adjust flow between the two ponds if required. Discharge from the splitter box will be through a submerged pipeline into each pond.

6.3.2 Primary Oxidation Ponds

Two primary oxidation ponds are proposed to allow for the isolation of one pond for future de-sludging purposes while the other pond remains in operation.

Aeration of the primary ponds will be through transfer of the existing brush and AquaJet aerators currently located in the existing oxidation ponds to the new primary oxidation ponds. Preliminary locations of the aerators are shown on Drawing C602.

Each primary oxidation pond will be provided with a discharge structure for transfer of effluent to the maturation cells. The discharge structures also provide for dewatering of the ponds for maintenance purposes. Discharge from the primary ponds to the maturation cells will be through a transfer pipeline located directly beneath the primary pond embankments. Refer to Drawing C602 for a preliminary alignment of the transfer pipelines.

The ponds will be constructed of earthen banks with internal and external slopes of 3:1. Dividing banks between the ponds will have slopes of 2:1 because of the reduced differential head. The top of the bunds will consist of a 3.5 metre wide platform around their entire periphery to allow for vehicle access and maintenance. The southeastern bank of the ponds will be built adjacent to the banks of the existing oxidation ponds with the drain around the ponds remaining (refer Drawings C602 & C608).

The bottom of the ponds will follow the general grade of the site. Therefore, the ponds will slope in a southwesterly direction towards the secondary oxidation pond. Wave protection, consisting of a 0.325m deep layer of rock riprap with a 0.75 m toe, will be provided around the entire internal periphery of the pond banks.

6.3.3 Maturation Ponds and Configuration

The proposed MWTP upgrade involves constructing new oxidation ponds, including five maturation ponds-in-series (the number of maturation ponds is generally governed by the required bacteriological quality of the wastewater after treatment).

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 use of multiple ponds-in-series reduces hydraulic ‘short-circuiting’, thereby increasing the overall treatment efficiency of the pond system.

Flow from the primary ponds will discharge to five maturation ponds that will operate in series to enhance the removal of bacteria and pathogens. The serpentine layout with many changes of direction will minimise wind-driven short-circuiting and increase the actual hydraulic residence time.

Four additional 4 kW aerators are required, one aerator in each maturation pond. The main function of the aerators is to provide mixing which helps to minimise the formation of blue green algae. Preliminary locations of the aerators are shown on Drawing C602.

To reduce the required earth fill volumes, the top of the maturation cell bunds are designed to be above normal pond operating level, but submerged during infrequent maximum storage events. Additional retention time coincident with high storage volume will offset the potential shortcircuit paths.

Maturation Pond 6 will be provided with a structure to discharge effluent to the outfall into the Ruamahanga River. The discharge structure also provides for dewatering the maturation ponds for maintenance purposes. An emergency spillway to Makoura Stream will also be provided in Pond 6 for use in the event of excessive effluent storage.

Construction of the maturation ponds will be similar to that described for the primary oxidation ponds. The external earthen banks will have slopes of 3:1. The top of the bunds will consist of a 3.5 m wide platform around their entire periphery to allow for vehicle access and maintenance of the ponds. The internal bunds will be constructed from granular material with a bank slope of 2:1.

The ponds will slope in a northwesterly direction towards the outlet in Pond 6. Wave protection consisting of 0.325 m rock riprap layer with a 0.75 m toe, will be provided around the entire internal periphery of the pond banks.

Refer to the Drawings in Appendix D for additional details.

The new ponds will have a total retention time (primary plus maturation cells) of 32 days at the minimum storage level and at average influent flows. This compares to 31 days for the existing ponds. Because of the proposed maturation ponds-in-series, improved disinfection is expected to reduce *E.coli* from a summer geometric mean of 485/100 mL currently to a target of 200/100mL. Although there is likely to be some improvement in winter concentrations, they are not expected to be reduced significantly (refer Table 25).

6.3.4 Diversion of Makoura Stream

So that the ponds can be constructed in one location and during one construction season it is proposed that the Makoura Stream will be diverted around the western edge of the new maturation ponds.

The new primary ponds need to have sufficient area so that the inlet BOD loads can be handled safely and the maturation ponds needs to have sufficient volume to retain the effluent long enough for sunlight disinfection to achieve the desired reduction of disease causing organisims. In addition, a working storage volume above normal pond level is needed so that discharages to the river below the trigger flow value do not occur.

The site for new ponds is constrained at the north by an area of highly permeable soils, the native tree area and the Makoura Stream. A separate portion of the new ponds could have been located on the west side of the Makoura Stream, but this would have increased costs significantly because of extra bank length and pipe connections.

The new stream alignment will be constructed in a manner that continues the current natural meandering flow of the stream (i.e. not as a straight channel). As part of the stream diversion, stream edges will be planted with appropriate native species to provide habitat and maintain stream water quality. The realignment will be designed with ecological input to ensure the channel can provide appropriate habitat, whilst ensuring the Stream has sufficient capacity to contain 50-year flood flow events. Rock armouring will be installed alongside the maturation pond embankments to provide erosion and embankment failure protection during a 100-year flood flow event.

Iwi have expressed concerns at the Stream diversion and the alternatives are discussed in Section 10.2.5.

6.3.5 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 will need to be stored in the ponds until it can be applied 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 will result in variable water levels within the ponds.

The 2007 AEE was based on a nominal 75 ha of irrigable pasture within the 91 ha site that that was to be used for discharge of pond effluent. Because the 107 ha site contains soils with a higher clay content and the groundwater level is closer to the surface, particularly in the western part of the 107 ha site, the proposed effluent irrigation area has been confined to the portion of the 107 ha site closest to the Makoura Stream. A total area of 75 ha of existing pasture (consistent with the 2007 AEE) is proposed for border strip irrigation of pond effluent, as shown in Figure 20. When new ponds are constructed, with much reduced leakage from the base of the ponds compared to the existing ponds, there will be extra flow to discharge to land or directly to the river. To accommodate this extra flow, an additional 22 ha of border strip irrigation is proposed in the area of the existing ponds, which is expected to have relatively high infiltration rates. Thus, the total border strip land disposal area will be 97 ha.

Figure 22 illustrates the predicted pond storage over the period of the modelling from 1996 to March 2008. The peak storage volume required is 200,100 m^3. A storage volume of 275,000 m^3 is proposed, which can be constructed within the new ponds cost efficiently, thus providing a spare margin of 75,000 m^3 storage to cater for abnormal climate events and operational inefficiencies. Figure 23 illustrates the period of maximum storage required from 2004 to 2006, together with river flows during that period. It is of interest that the peak storage events occurred in spring and early summer, most likely due to wastewater flows being high due to groundwater infiltration. In late summer, the rates of groundwater infiltration into sewers reduce as groundwater levels are lowered over summer.

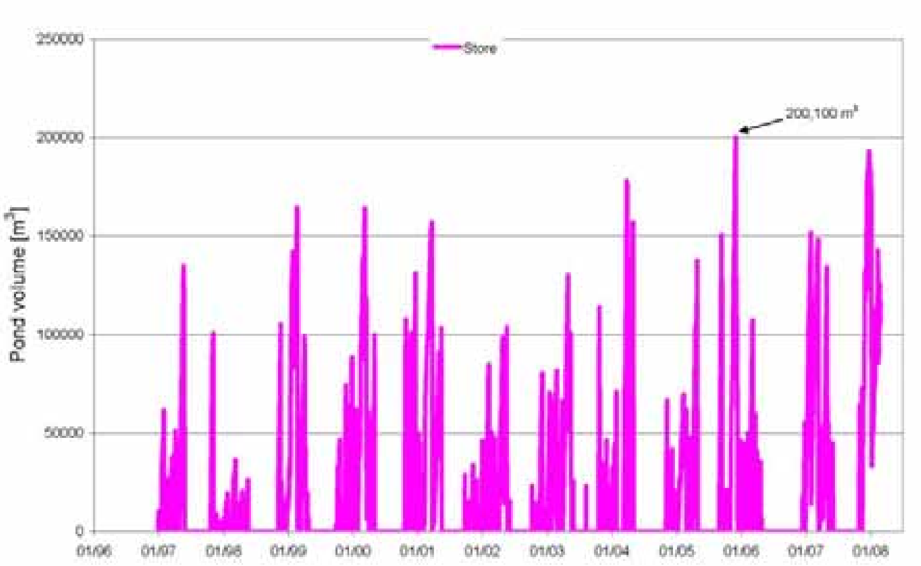

Figure 22 Storage Volume Required with Land Disposal Area of 97 ha and Summer Median River Flow Trigger (1996 to March 2008)

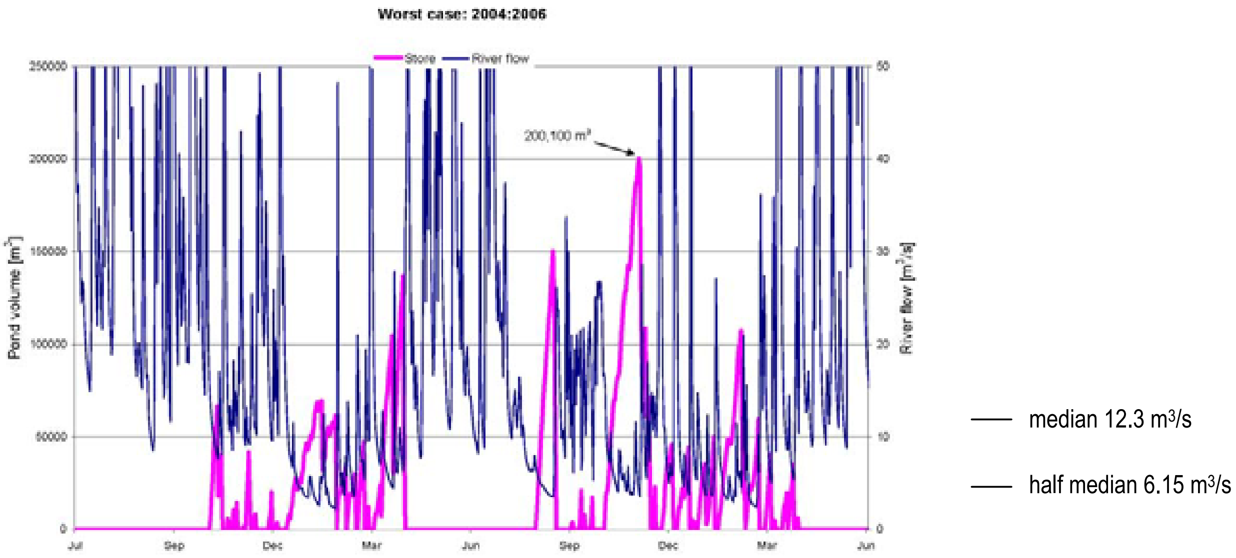

Figure 23 Model Prediction of Storage Volume vs River Flows for Maximum Storage Period 2004 to 2006

Given that the modelling is based on a good basis of historic statistical data, and that there is 275,000 m^3 of storage proposed compared to the 200,100 m^3 indicated as required by the modelling, it is considered that there is only a very small risk of an unusual event whereby land irrigation cannot occur, and there is insufficient storage in the ponds to avoid the necessity for a discharge of treated effluent into the river, outside the terms sought by this resource consent application. Given all the constraints and factors that have been designed into the modelling and design of the proposed upgrade, any discharge into the river that will occur under such circumstances will be such an unusual event that it will represent an emergency discharge in terms of the Resource Management Act. Consequently, it is probably unnecessary to seek to have such an eventuality covered by the consents being sought. In this context it is noted that any such discharge would be of better quality than the current discharge to the river.

6.3.6 Pond Lining

The effects of leakage from the existing ponds on river water quality are considered to be minor and are summarised in section 8.3.5. The new ponds will be lined with approximately 400 mm of silty clay to minimise leakage. It is considered that a 400 mm thick liner (2x 200 mm compacted layers) is the minimum liner thickness that can be reliably compacted. Refer to the Drawings in Appendix D for additional details.

Soil investigations were carried out to determine whether the on-site soils at the proposed pond site will make a suitable liner for new oxidation ponds (Beca 2005a). Laboratory testing showed that the lower permeability natural soils (clayey silts) have in situ permeabilities in the order of 1×10^{-8} m/s to 5×10^{-8} m/s. Testing on re-compacted silt samples shows that for these samples, the permeability is reduced by two orders of magnitude to around 2×10^{-10} m/s. This is less (better than) than the permeability typically used in the design of liners. Testing of re-compacted samples indicates that if the material was excavated, allowed to dry, mixed and re-compacted, it would be suitable to construct a liner with a low permeability in the range of 1 to 5×10^{-9} m/s.

6.3.7 Pond Desludging and Decommissioning

Pond Draining – Air Drying

The existing oxidation ponds are proposed to remain in operation during construction of the new ponds. Once construction of the new ponds is complete, the existing ponds will be de-sludged and decommissioned.

During construction, up to approximately 40% of the effluent from the existing ponds will be transferred to the new ponds to prevent shrinkage and cracking of the clay/silt liner. This effluent will also seed the new ponds with algae which will provide oxygen and prevent nuisance odours when raw wastewater is fed to the new ponds. The balance of the effluent in the existing ponds, up to approximately 90%, will be discharged to Makoura Stream with the quality and discharge rate complying with the Interim Consent conditions. Leakage from the existing ponds will continue until the ponds are emptied and the leakage rate will decrease as the pond level is reduced.

The sludge in the existing ponds will be air-dried in-situ following decommissioning and draining. Based on experience at Blenheim, Waimate and Pleasant Point, the sludge can be dried to a moisture content of about 50% solids (the consistency of dry soil) when it can be relocated to a storage landfill within the decommissioned ponds. Approximately 3 to 4 months in summer will be required to give sufficient drying and the time taken will be dependent on weather conditions.

Dewatering

The issues associated with dewatering the ponds include:

- Inflow to the ponds, from groundwater flowing from north of the site towards the river, as the water table intersects low-lying areas in existing Ponds 2 and 3 under certain conditions.
- Inflow to the ponds from the riverside of the ponds during a significant flood event.

Wide bladed bulldozers or long-reach excavators will be used to move sludge from low-lying areas affected by groundwater to dry areas. Sandy gravel bunds will be constructed in the base of the ponds to retain the sludge and prevent it flowing into the low areas. Residual liquid sludge in hollows will be pumped into the new oxidation ponds.

Groundwater will be directed to sumps in low-lying areas of the existing ponds and pumped into Makoura Stream. Discharge rates of up to 500 litres/sec may be required. Groundwater quality discharged will be of similar or better quality than the existing pond effluent. During sludge drying, there is a risk of a flood level in the Ruamahanga River that is above the base of the ponds and that results in an inflow of river water through the base of the pond. This will result in some wetting of the sludge and the need to re-start the drying process. However, once sludge has been windrowed, any re-wetting will not cause the sludge to reach the starting moisture content. Hence, second phase drying could be achieved in less time than first phase drying. To allow for flood events, or a high rainfall summer, the consents should allow two summer seasons for sludge drying and landfilling.

Sludge Storage Landfill

Dried sludge will be stored in a landfill constructed within the existing pond area. An area of approximately 0.7 ha is required to store dewatered sludge. The northwest corner of Pond 1 allows two existing pond embankments to be used thereby minimising construction works. A 400mm thick silty clay liner will be placed on the landfill base and embankments to minimise leaching of sludge liquids to groundwater. The landfill will be capped with a 300 mm thick silty clay liner to seal the fill and prevent water ingress.

A second landfill in the northeast corner of Pond 2 beside the initial landfill is intended for future sludge storage when the new oxidation ponds are desludged, at a future date of about 30 years.

The sludge landfill is outlined on Drawing C602 in Appendix D.

6.4 Proposed Land Treatment System

6.4.1 Overview

The preliminary site layout is outlined in Figure 20 and Drawing 601.

The land treatment areas have been delineated into three major areas for border strip irrigation of pond effluent, as follows:

- Either side of the stopbank on the 91 ha site plus the paddocks adjacent to the Makoura Stream on the 107 ha site with an irrigation area of 75 ha – this is included in the 'Proposed Land Treatment Scheme'
- Decommissioned oxidation ponds, with the existing ponds desludged and converted to 22 ha of border-strip irrigation – this area is included in the 'Proposed Land Treatment Scheme'
- The western side of the 107 ha site is the future area (52 ha) which could be developed at a later date – this area is the 'Potential Future Land Treatment Area'. Until developed for effluent disposal, this area will be irrigated using the existing fresh water supply system.

For clarification, references to the 91 ha and 107 ha sites are the gross areas of those sites, while the land disposal areas are net irrigated areas that make allowances for buffer areas, operations building, inlet works area, access roads, stop banks and the 5 ha of native bush not irrigated.

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 used for modelling purposes. It is a fundamental concept of the scheme that the applicant has the flexibility to vary application rates as site conditions allow, consistent with maintaining 'good practice' with respect to treatment of effluent by application to land, and avoiding effects on groundwater and nearby surface waters. The potential to vary from the modelled scenario is an important feature of the scheme, that ensures that effluent application to land is maximised.

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 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 they 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 they 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 0 mm/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 treatment, 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 the management plan which will be adapted from time to time as required.

6.4.3 Adopted Application Rates

The adopted application rates are summarised in Table 23.

Table 23 Proposed Application Rates

Soil type	Area (ha)	Summer Average/Max (mm/d)	Winter Average/Max (mm/d)
Free draining	71	10/15	5/5
Clay rich	26	10/10	0/5
Total	97		

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 the AEE section 6.4.2) indicated a winter application rate of 5 mm/d on the clay rich soils may be possible, there will be 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 storage model was based on no irrigation to the clay rich soils occurring during winter (Note, the groundwater modelling conservatively uses the maximum irrigation rates to determine the worst-case effects on groundwater).

It is important to note that the results of the drainage trial on the southwestern area of heavier soils (on the 91 ha site) suggest that summer irrigation of 10 mm/d and up to 15 mm/d is possible. The winter trial period of the drainage trial suggests that these soils could, with care, be used for winter irrigation at low rates. The system therefore should be designed with the ability to vary the average application depth to suit conditions.

With regard to the area of effluent irrigation, some border strips may accept greater hydraulic loading than 10 mm/d and, where possible, this should be an operational aim of the scheme in order to reduce the volume that is discharged directly to the Ruamahanga River. Identification of the capacity of the border strips will be ongoing and will vary with season, river levels, and pasture cover.

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 more effective in taking up the nutrients from the soil if a cut-and-carry system is used[44] (see subsection 6.4.8). 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 will 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 re-grading of the land to consistent slopes (and elimination of hollows) is essential when applying treated effluent to land, because if the land is not re-graded, algae in the effluent will accumulate in hollows, clog the soil and exacerbate ponding in the hollows.

The irrigated area will be formed into a series of graded strips (borders) separated by formed levees approximately 300 mm high. Generally, the strips will be approximately 150 to 200 m long, with a minimum width of approximately 12 m, 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 infiltrated to groundwater or 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

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

depths per irrigation strip are likely to be in the order of 70-150mm. Applications of up to 150mm may be possible during drought conditions when there is a soil moisture deficit. 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, sub-mains must cross the stopbank. The locations for these crossings are indicated on Drawing C601 in Appendix D. Concrete water stops, and bentonite mixed into the well compacted backfill, will be installed with the pipes through the stopbank to prevent water travelling along the pipe route[45].

A detailed evaluation of the use of the border strip method, in relation to centre-pivot irrigation for crop growing purposes, is contained in Masterton Land Treatment of Wastewater (Beca, May 2008b). Refer also to Section 10.4 of this AEE, for a discussion of alternative methods of irrigating pond effluent to pasture – in particular, spray and dripline irrigation methods.

Typically, the earthworks for the formation of border strips involve grading the near-surface soils to provide a shallow fall of between 1 in 300 and 1 in 500 gradient. Border strips will be a minimum width of 12 m and up to 50 m in width, separated with a low (300 mm) bund (or levee). Some modification of the land surface is therefore necessary.

To achieve effective treatment of the effluent by filtration through the topsoil and subsoils, the re-contouring will be more intensive than is the case for typical on-farm situations, so that local areas with extremes in permeability will be modified to be close to the average values for the site. This will be achieved by the following measures:

a) Topsoil will be stripped and temporarily stored in longitudinal piles to allow the sub-base to be graded to the required fall. Uniform depths of topsoil will be placed on the re-graded sub-base, the local depth being dependent on the available topsoil in the locality. Since the topsoil provides a significant portion of the water holding capacity, border strips will have a more uniform water absorption rate compared to a spray system on "natural" alluvial ground that would have variable topsoil depths.

b) Where gravels protrude to the surface, these will be removed and reused for the construction of pond banks. This source of gravel will be lower cost than alternative sources and the extracted gravel volume from the irrigated area will be maximised. The gravel areas will be backfilled with silty sand as a sub-base and compacted to match the density of the surrounding soils, so as not to provide a preferential flow path, and the topsoil will be reinstated.

c) Localised areas of known existing ponding will be investigated during construction and the drainage improved with sand-filled slit drains if needed (most likely to be required where there are soils with significant depths of underlying silty clay).

d) The earthworks will be carried out in the summer season to avoid excessive compaction of the soils. Full-time construction monitoring of the earthworks will be implemented for good quality control.

e) Construction equipment will be fitted with laser- levelling and GPS - guided features for precise control of the re-grading work.

f) By handling the topsoil separately, there will be minimal changes to the near surface soil characteristics, thus allowing pasture to be re-established quickly. The proposed changes to subsoils will be to improve the filtration characteristics.

It is acknowledged that the riverside area is subject to relatively infrequent flood events of a five-year return period. During flood events there will be some deposition of silt on the berm area, the effect of which will depend on the severity of the event. Where significant silt deposits have occurred, these may need rotary hoeing and re-sowing of the grass. As stated in section 6.4.8, pastures will be re-sown every four to six years. Re-sowing of the riverside area will not be more frequent than the land to west of the stopbank. Flood events are not expected to cause damage to the border strip earthworks due to inundation.

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[45] Bentonite is a clay which swells when in contact with water.

Flood flows over the berm area border strips will have no discernable effects on water quality. Irrigation to these areas will be stopped well before the flood flows cover the berm, providing the effluent with time to percolate through the soil and thus not be removed during floods.

This reach of Ruamahanga River is managed by GWRC as part of the river management scheme. The stopbank protects the Homebush area. The objective of the scheme is to mitigate erosion of farm land, and manage bank erosion to reduce land loss. Because of the substantial existing assets of the MDC alongside this reach, stronger bank protection works have been placed, including willows adjacent to the berm area and rock groynes in other areas.

This reach is relatively well-defined, with an entrenched single channel form, and channel migration is relatively slow. However, the outer banks at bends are continually under attack during flood events, and there is a relatively distorted split channel just upstream of the Whangaehu River confluence. River works by GWRC have improved the alignment and substantially increased the buffer vegetation at this location in recent years.

A design channel and vegetation buffer zones have been drawn up for the Ruamahanga River, to guide scheme management, and the proposed effluent irrigation area is set back outside the defined buffer zones. These design channels and buffer zones are shown in the *Upper Ruamahanga 'Te Ore Ore' River Management Scheme* Aerial Photos in Appendix E (*note the additional line outside the design channel indicates the buffer zones).* The riverside land, between the stopbank and the river channel, is classified as erosion prone under the scheme classification, and there is an on-going risk to the land. However, the intention of the scheme is to provide sufficient protection to allow farming activity.

Provided the irrigation infrastructure is kept to a minimum on the riverside land, the overall damage potential is little different to the present farming use. Each irrigation area will be self contained with its own wipe off drain and can be operated independently in the event of erosion to another irrigation area. The trunk main will be on the west side of the stopbank and therefore will be protected, and each irrigation area will be fed by a sub-main. Therefore if an area is eroded, it will not result in a significant loss of capital, nor impede the operation of the land treatment scheme.

Planting along the river bank will be enhanced to reduce erosion by the river. This planted buffer will typically be 30 m wide. If erosion occurs, it is likely to be localised and some irrigated pasture may be lost. Sub-mains delivering treated effluent to each set of border-strips in the riverside zone will terminate about 40 m from the existing river edge. If erosion does occur, this setback will provide time for a decision to be made as to whether further rock groynes or other erosion control measures are economically justified, in comparision with the value of lost pasture or sub-mains.

Drainage System

A new drainage system will be constructed along the west boundary of the Proposed Land Treatment Area as shown on Drawing C601. The new drain will flow from north to south and will discharge to the Makoura Stream diversion at the south-west corner of Pond No. 6. The drain will penetrate the gravels below the surface silts and will provide drainage of the groundwater. Without the drain, groundwater mounding would be excessive (refer Section 8.3.2).

Irrigation Pump Station

A new irrigation pump station is proposed to be constructed adjacent to the final Pond 6 and will be fed by a transfer pipe from the pond. Ultimately, three pumps are proposed for the border strip irrigation system and will be sized to supply the different irrigation areas. The border strips on the decommissioned pond area will be fed by gravity with a 500 mm diameter main directly from the transfer pipe from Pond 6.

The irrigation pump station will include the pumps, screens, filters, controls and telemetry associated with the border strip irrigation and buffer zone drip systems. Preliminary sizing indicates a 60m^2 building will provide sufficient room for the irrigation pumps.

Also within the pump station will be:

- Variable speed drives for pump motors
- Isolation and check valves installed with each pump
- A flow meter for each irrigation system
- Drip irrigation filtration equipment
- Control room
- Workshop area
- Operator toilet, including associated plumbing.

The pumps will feed two irrigation distribution mains (capacity 300 litres/sec each), one on each side of Makoura Stream. This will allow a high instantaneous overall flow rate of 600 litres/sec so that irrigation scheduling can “catch-up” when conditions are favourable. The twin main system will also allow each main to operate at different static heads and deliver the target flow rate accurately to individual strips, despite elevation differences from north to south over the whole site.

6.4.5 Excess Runoff Recycling System

Excess runoff from the border strips, will be collected in a network of drains, called ‘wipe-off drains’. 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 and from the 107 ha site will run back to a recycle pump station adjacent to Pond 6 (as indicated on Drawing C602 in Appendix D). Wipe-off drains on the river berm area (east of the stopbank) will extend into the sandy gravel subsoils (at shallow depth) which are very permeable, and will therefore not need to be linked to a recycle pump station.

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. 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.

The two-hour period is the “time of concentration” when the flow from the extremities of the catchment reaches the pump station. At this time, the peak flow that occurs will be predominantly rainfall runoff, and contain only a very dilute concentration of treated effluent. On most occasions, treated effluent will not have been applied to land when heavy rainfall is predicted. Therefore, it is expected that runoff after two hours will have low concentration of contaminants.

Generally, the irrigation depths will be controlled to provide an average application of effluent plus rainfall of 10 mm/d in the summer and 5 mm/d in the winter for the free draining soils. Rainfall and soil moisture will be monitored daily and the operator will make a decision on the actual depth of effluent to be applied. An automatic rain gauge will be used to stop the irrigation pumps in the event of significant rainfall that will result in an effluent/rainfall depth greater than an average application of 10 mm/d. It should be noted that only some areas will be irrigated on any particular day. Thus, any runoff from recently irrigated areas due to unexpected heavy rainfall will be diluted by runoff from areas that have not received effluent for about one week.

Some experience will be needed to determine the depth of application required to allow the effluent to just reach the end of the border, and no further. In the event that effluent or rainfall runoff reaches the end of the border strip, it will be discharged to the wipe-off drain for collection. The proposal is to discharge effluent collected in the wipe-off drain back to the ponds, with excess rainfall discharged to the Makoura Stream. The drains will be enhanced by removing areas of silty clay and replacing them with sandy gravels to increase infiltration of the effluent/stormwater. This will reduce runoff pumped back to the ponds or stormwater discharges to the Makoura Stream.

6.4.6 Discharge of Stormwater Run-off

The 'wipe-off' drain network will also collect stormwater at times when effluent irrigation is not being applied – i.e., during rainfall. As outlined above stormwater from the irrigation area will 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

Buffer areas along the west boundary of the proposed irrigation area and bounding the east side of Makoura Stream, will be established as part of the upgrade. The buffers will be 10 m wide and will be planted in a range of tree species, compatible with proposals for enhancing the ecological and recreational potential of the stream.

A 10 m buffer planting will also be provided around the boundary of the 107 ha site and at the north of the 91 ha site, where this is agreed with neighbours (some neighbours have expressed a preference for views of open space). In addition to the 10 m planted buffer, there will be a 40 m zone that will not have border strip irrigation. The planted buffer areas are shown on Drawing C600.

This buffer strip will provide an appropriate setback distance from waterways and adjacent properties, that is free of border strip irrigation and other MWTP operations. The planted boundary will also screen the site, where agreed, from properties to the south, west and north of the site. The planted buffer areas will be irrigated by buried driplines using pond effluent, 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 2007 revised policy on human sewage application to dairy farms only permits very high quality treated wastewater (i.e., treated with filtration and UV disinfection) being spread onto pasture fed to dairy cows (refer to Beca, May 2008). The proposed quality of the effluent from the upgraded oxidation ponds will exclude the silage or baleage 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 baleage (David Baker, Baker & Associates Ltd, *pers comm.*).

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

Inherent in a cut-and-carry wastewater irrigation operation is the need to exclude grazing animals, although limited use of small grazing animals (for example, sheep) will be beneficial at certain times of the year to 'tidy up' those areas unable to be harvested. Cattle will be excluded from the wastewater irrigated areas, because of the pugging they will cause which would reduce infiltration rates.

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 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 will need to be applied regularly to the land
- It is expected that pastures will need to be re-grassed 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 will 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 because of effluent application. Figure 24 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 24). 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 will remove a large fraction of the pasture nitrogen from the site, leaving little excess nitrogen to leach.

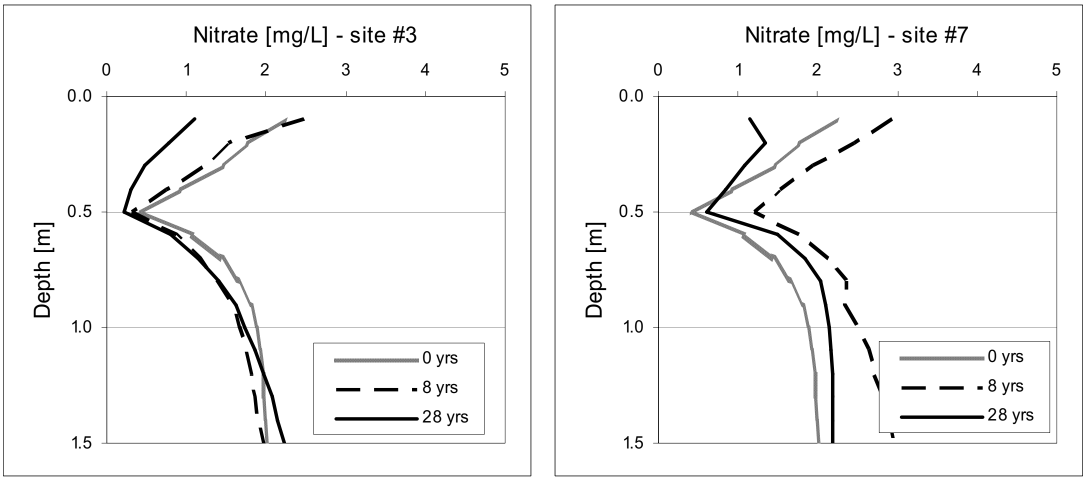

Figure 24 Profile of Nitrate-Nitrogen[46]

Note: Site 3 is a clay rich soil, while 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 will 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.

Table 24 illustrates the situation for two areas within the site that will 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. Over 28 years of effluent application, 61% of the applied phosphorus will remain in the top 1m of soil and the concentration of P entering the ground water will remain below 0.02mg/L.

In contrast, site 7 will receive the highest wastewater input, with some 63kg/ha of phosphorus being added each year. The topsoil here has a lower P retention capacity because of lower clay content, which will 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 will remain in the top 1m of soil and the concentration of P entering the groundwater will remain below 0.2 mg/L.

Modelling was carried out to assess the environmental fate of the surface-applied phosphorus. The results were reported in the HortResearch (2007) report that forms part of the AEE. The total phosphorus content of treated effluent from the oxidation ponds is expected to be, on average, 3.2 mgL^{-1}. Most of this content will be in the form of dissolved reactive phosphorus (DRP) which adsorbs partially to the soil's clay and mineral particles, and is also easily taken up by plants.

The proposed irrigation scheme will add between 28 and 63 kg P/ha each year to the pasture sites. Some 20-35 kg/ha of this will be assimilated by pasture that is subsequently harvested and removed from the site under the

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[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.

cut-and-carry operation. Irrigation of treated effluent adds more phosphorus to the soil than can be utilized by the pasture, so there is opportunity for leaching to occur. However, the remaining DRP is largely retained, or filtered, by the soil profile. The degree of renovation will depend on the interaction between soil processes and water movement.

For the purpose of modelling, P partitioning in the soil was described using a Langmuir adsorption-isotherm that relates the equilibrium solution concentration [C, mg/L] to the amount of P adsorbed onto the soil matrix [q, mg/kg]. Figure 25 presents isotherm data from the Bw horizon (clay loam at 50 cm) where the P retention is 19%. The maximum sorption capacity of these clay rich layers is typically between 410-615 mg/kg.

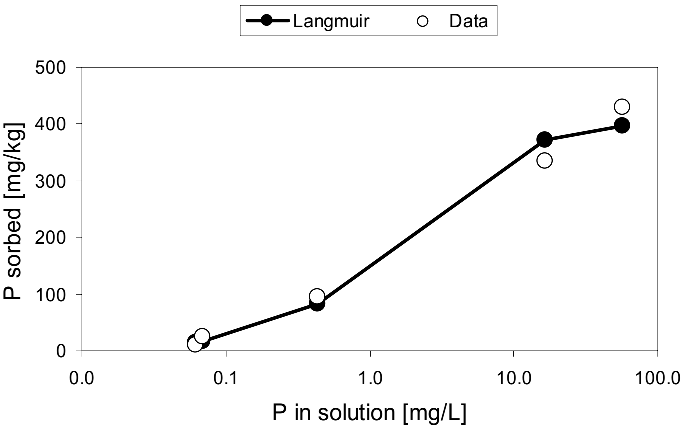

Figure 25 (RFI Figure Q9.1): Langmuir isotherm for P retention in soil from the Bw horizon (50-53 cm deep) at the Homebush site (source: HortResearch, 2007; Figure B2)

Following 28 years of application of phosphorus to the pasture, a large fraction (~60-80%) of the applied phosphorus still resides in the top 1.0 m of the soil profile (Figure 24 and Figure 25). While the soil concentration slowly increases over time, it is still a factor of 2-6 times lower than the maximum concentration at saturation. On site 3, the solution concentration in the drainage water at 1.0 m depth is < 0.01 mg/L^{-1}, representing a 99.7% reduction in the concentration of DRP. The corresponding concentration could slowly rise to 0.2 mg/L^{-1} on the most free-draining soils receiving the highest nutrient loadings (for example, site 7). On those sites, there will be a 94% reduction in the concentration of DRP. It should be noted that additional dilution in the groundwater, combined with strong adsorption by the deeper clay-rich layers, means that the off-site impacts on surrounding ground water are likely to be negligible.

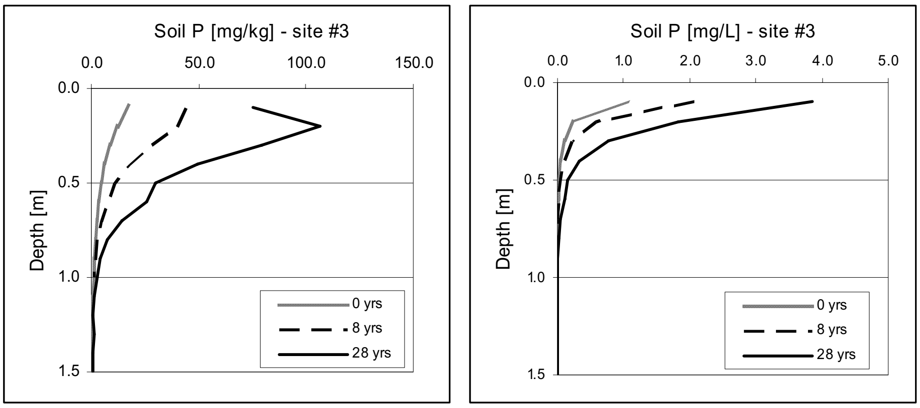

Figure 26 Predicted Concentration of Soil Phosphorus and Soil Solution Concentration at Site 3

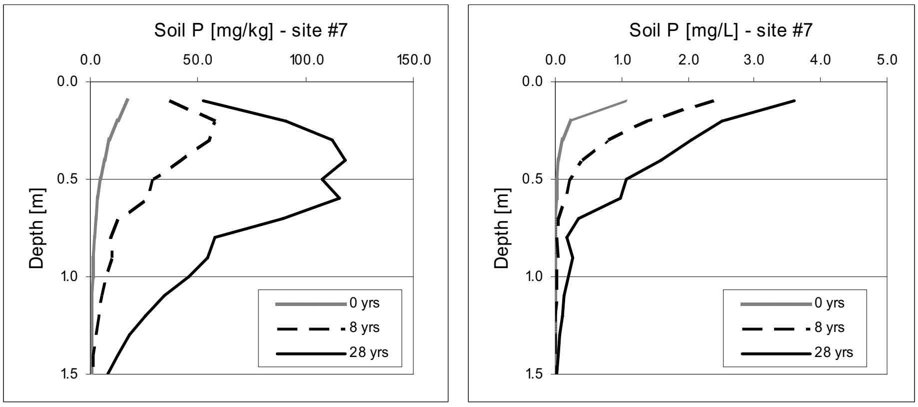

Figure 27 Predicted Concentration of Soil Phosphorus and Soil Solution Concentration at Site 7

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 28.

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[47] Winter effluent quality (refer section 4).

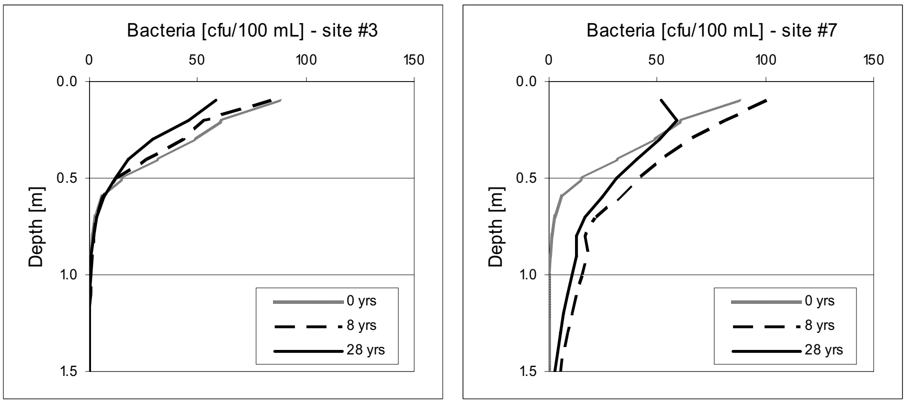

Figure 28 Soil Bacteria[48]

Figure 28 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 will 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 28 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 8.3).

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 24 summarises the average values of the nutrient budget of crops on the irrigated pasture.

Table 24 Estimated Annual Nutrient Budget[49]

Component		site 3 (kg/ha/year)	site 7 (kg/ha/year)
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

The pasture will 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 will 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 of phosphorus 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.

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[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)

6.5 New Location and Method of Discharge to River

NOTE: Changes in this section from the 2007 AEE are the modification of the outlet diffuser from discharging behind a rock embankment, to a diffuser set below the riverbed. These changes were necessary due to the erosion rock protection originally proposed for the embankment being deleted and replaced with a planted buffer. The use of hard structures like a rock embankment for the discharge as proposed in the previous scheme will not be compatible with the planted buffer proposed at the edge of the river.

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 C602 in Appendix D shows the location of the proposed outfall. Drawing C607 in Appendix D shows a plan of the diffuser, and a cross section of the embankment and riverbed in which the outfall will be sited.

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

The diffuser allows the distribution over a wider area to assist in the mixing within the river. The flow will be split between four 500 mm diameter pipes branching off from a common 1050 mm diameter pipe located below the river bed scour depth. The outlets will be surrounded by medium sized rock to prevent the pipe outlets from being blocked with finer gravels. Large rock placed on the riverbed near the discharge structure will be used to reduce scour of the riverbed.

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 current 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 of moving the discharge into the river upstream of the Makoura Stream is that it will put it upstream of an existing irrigation water intake 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 used (i.e., below median flows during summer periods).

6.6 Expected Quality of Effluent Discharge

The receiving water quality targets for the upgrade are outlined in section 7.1.3. 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 in Table 25, and 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, in general, the existing standards be included in the conditions of consent, with revised *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 25 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 (summer) 3.0 (winter)	No change from existing quality
E.coli (cfu/100 mL)	1,440,000	485 (summer) 651 (winter)	200 (summer) 1,000 (winter)
Dissolved reactive phosphorus (g/m^3)	2.4	2.4	No change from existing quality

Note 1. Raw wastewater quality data as detailed in Table 3.

Note 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 addition of extra maturation ponds to the new pond system is focussed on reducing the *E.coli* concentration in the effluent. Improvements in terms of the impacts of other parameters in the effluent are being addressed by the proposed discharge regime (i.e., maximising discharge to land and ensuring no direct discharge to the river at times when 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 (12.3 m^3/s) during summer 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 of 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.

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

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 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.

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 when upstream microbiological quality and clarity is poorer
- The elimination of winter discharge to the river at low flow conditions (i.e., below half median), 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 800 m from the diffuser, which is well upstream of Wardells Bridge.

Operationally, a mean daily flow trigger will not work in this river because of the very peaky nature of the hydrograph (see Figure 10 AEE) and the inherent delay before a daily flow value can be obtained. It will be necessary to start to discharge to the river, on most occasions, when the hourly flow exceeds the trigger value and there is a reasonable likelihood of the river flow being sustained above the trigger value for more than six to twelve hours, which is the case for about 90 % of "freshes" during summer.

A predictive model will be used "to overview" the discharge operation, to give more certainty that the exceedance of median flow will be sustained for a sufficient duration. This will avoid discharging when the river flow exceeds the trigger value for durations of less than about six hours. The flow recordings from the Mt Bruce gauging station have been analysed and compared to Wardell's Bridge readings. The Mt Bruce flow recorder will provide six to nine hours advance warning of the magnitude of a fresh. This flow data will be used by the automatic control system to initiate a discharge when the trigger at Wardell's Bridge is exceeded and there is a strong likelihood that the fresh will be sustained for more than six hours (the minimum 35,000 m^3/day discharge rule referred to in the 2007 AEE is no longer proposed as the means to achieve this).

The key proposed operating constraints are the minimum 30:1 dilution rule for all discharges and discharge only above median river flows (12.3 m^3/s) in the summer period. The hourly flow measurements at Wardell's Bridge will be telemetered to the MWTP for discharge control based on the proposed discharge rules for summer of (i) no discharge below median river flow, and (ii) a minimum dilution of 30:1 to be maintained at all times, (ii), and (iii) no discharge in river flows greater than 300 m^3/s. The MWTP contribution to the river flow will be automatically taken into consideration. On all occasions when the river flow drops below the trigger value, the discharge will stop automatically.

The hourly flow data for river flow has been analysed and for virtually all freshes, the river flow rate increases very rapidly. A "start to discharge" delay of 15 to 30 minutes will ensure that the river flow has comfortably exceeded the trigger value, thus overcoming any minor errors in the flow measurement data.

6.7.4 Determination of Discharge, Irrigation and Storage Volumes

A water and nutrient balance model (HortResearch, 2008) was used to forecast river discharge volumes, wastewater irrigation volumes and pond storage requirements. Key factors used in the modelling are:

- The model calculations were based on weather data and records of influent and wastewater flows between 1997 and 2007. 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 in weather patterns.
- The volume of leakage from the proposed new ponds used for the model, was a single value of 150 m^3/d, based on an estimate of leakage from a 400 mm thick low permeability clay liner and a pond depth of 2.5 m. The effect of using a lower leakage rate in the water balance model is to increase the volume of storage required, and this outcome is described in section 6.3.5.
- The model used hourly daily values of river flow to calculate the volume of wastewater to be discharged to the river. This provides greater accuracy than the previous modelling that used average daily river flows.
- No minimum discharge volume was set. The model was set up to discharge to the river when the river flow exceeded the trigger value for a duration of more than six hours. In winter, a minimum discharge was not applied.
- For irrigation application on well-drained soils over the average summer, a cut-off rate of total liquid of 10 mm/d[51] was used for the water and 15 mm/d for nutrient balance modelling. This is a conservative approach for both the outputs of the water balance and the nutrient balance models.

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, and 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 land treatment whilst avoiding surface runoff and/or water logging of the soils.

Table 26 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 27 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).

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

Table 26 Summary of Average Seasonal Discharges

Season	Daily average influent flow (m^3/d)	Daily average discharge to river (m^3/d) (% of inflow)	Daily average discharge to land (m^3/d) (%of inflow)	Average Number days/month of no river discharge	Average Number days/month to land	Average Number days/month to river	Average daily river flow [m^3/s]
Summer	13,714	5,818 (42)	7,243 (53)	21	28	9	14.7
Winter	17,799	14,892 (84)	3,543 (20)	3	25	27	31.8

Notes: Data from 1 January 1997 – 3 March 2008. Refer to Glossary, section 1.2 for defnitions of summer and winter periods.

Table 27 Summary of Average Daily Discharge

Month	Daily average influent flow [m^3/d]	Discharge to river	% of inflow to river	Discharge to Land	% of inflow to land	% of days with no river discharge	% days to land	% days to river	Average daily river flow [m3/d]
January	13,228	4,333	33	7,747	59	80	93	20	11.1
February	13,104	4,860	37	7,596	58	81	93	19	14.7
March	13,050	5,828	45	7,228	55	77	95	23	11.3
April	12,397	5,041	41	6,635	54	77	98	23	12.1
May	13,131	12,259	93	2,990	23	28	84	72	18.3
June	16,106	14,006	87	2,868	18	2	83	98	32.9
July	20,707	18,741	91	2,698	13	0	79	100	38.0
August	19,964	17,401	87	2,950	15	1	83	99	32.3
September	17,159	14,164	83	3,,056	18	6	81	94	26.9
October	19,652	12,730	65	6,607	34	21	85	79	42.0
November	15,626	7,413	47	7,153	46	51	88	49	21.9
December	14,939	7,593	51	7,035	47	51	88	49	17.9

Note: Using data from 1 January 1997 – 3 March 2008

It is emphasised that the relative proportion of discharge volumes to influent volumes do not necessarily equal 100% for each period, as the modelling takes into account 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.

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

- In summer, the effluent is applied as irrigation for the significant majority (88 to 98%) of time with only 9 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 discharge whenever the river is above median flow for more than approximately six hours. However, whether this outcome will be fully implemented is dependent 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.
- In winter, there is still a high proportion of time when irrigation of effluent occurs, although a smaller volume is irrigated compared to summer. (approximately 90% of the time, or 83% of days during winter).

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 28 and Table 29 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 Table 26 and Table 27. 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 28 Summary of Summer (1 Nov 2004 – 30 April 2005) Average Discharge (for Maximum Storage Year 2005)

Season	Daily average influent flow [m^3/d]	Daily average discharge to river (m^3/d) (% of inflow)	Daily average discharge to land (m^3/d) (% of inflow)	Average Number of days/month of no river discharge	Average Number of days/month to land	Average Number of days/month to river	Average daily river flow (m^3/s)
Summer	13,888	6,292 (45)	7,275 (52)	22	28	8	13.6

Note: Summary of data from summer of 1 Nov 2004 to 30 Apr 2005, with average discharge for Maximum Storage Year 2005

Table 29 Summer (1 Nov 2004 – 30 April 2005) Average Discharge (for Maximum Storage Year 2005)

Month	Daily average influent flow (m^3/d)	Discharge to river (m3/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
November	14,648	0	0	7,731	53	100	90	0	6.19
December	13,570	10,479	77	7,237	53	61	90	39	14.3
January	13,118	4,530	35	8,231	63	74	90	26	15.4
February	13,617	4,610	34	7,401	54	86	93	14	6.46
March	14,241	9,150	64	6,698	47	71	94	29	9.83
April	14,140	8,700	62	6,353	45	47	93	53	29.1

Note: Summary of monthly data from summer of 1 Nov 2004 to 30 Apr 2005), with average discharge for Maximum Storage Year 2005

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. However, as noted in section 6.4, 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 100 mm on one day with those borders then rested for 9 days before receiving another application of effluent.

It is expected that the heavy soils on the 107 ha site will also be irrigated at an average of 10 mm/d in summer and 5 mm/d in winter. However, conservatively, for the purposes of the water balance it has been assumed that no irrigation will occur in winter. This approach provides some buffer in the modelling for soil variability and other factors.

Summer Discharge Rates to the River

In the interim period, when only the 75 ha of land is irrigated and prior to the irrigation scheme in the area of the decommissioned ponds being established (a period of approximately 2 to 3 years), it has been determined that with the proposed discharge triggers of median river flow in summer and half median in winter, 350,000 m^3 of storage will be required. This is neither practical nor cost effective when this storage volume will only be required prior to the irrigation of the decommissioned ponds and only for extended low river flow conditions.

The half-median trigger river flow in the summer was also modelled. The storage model showed that under this discharge regime, 214,000 m^3 of storage will be required. While this required storage volume is within the proposed 275,000 m^3, it is not proposed to change the trigger river flow values, but instead request that a transition period is included in the conditions such that compliance with the summer median river discharge regime is only required once the 22 ha of effluent irrigation is established in the area of the existing ponds. During the transitional period a half-medium trigger flow is proposed.

After a 2-3 year transitional period, river discharges during summer 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 Figure 29.

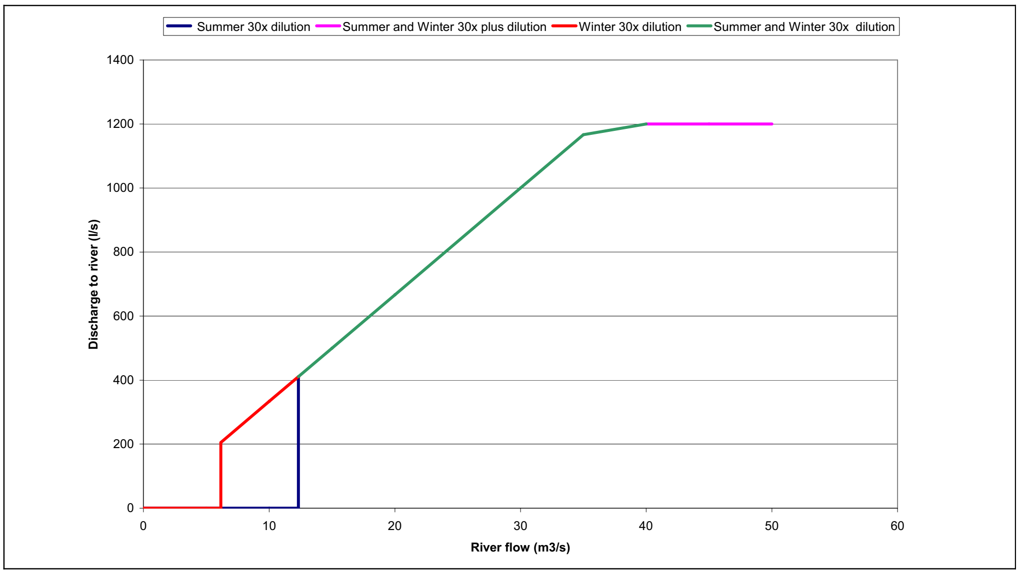

Figure 29 Dilution Relationship as a Function of River Flow and Discharge Volume

6.7.6 Winter Discharge Regime

Winter Irrigation Rates to Land

As detailed in section 6.4.3, the adopted winter application rates are 10 mm/d 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/storage model has taken a conservative approach.

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[52] As measured at Wardells Bridge gauge

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 (6.15m^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 29).

6.7.7 Likely Impact of Additional Future Land Treatment Area

An additional irrigation area on the west side of the 107 ha site could be added to the scheme in the future. As this area has generally poorly drained soils, the irrigation rates would need to be conservative, as outlined in section 6.4.3 for the 'clay rich' soils. Operating experience on the eastern side of the 107 ha site, parts of which have similar soils to the west side, will allow a better assessment of the potential irrigation rates, if this area was to be considered for additional irrigation. The benefits from the additional area of land would be:

- A greater volume of effluent could be disposed of to land (mainly during summer)
- There would be a corresponding decrease in the volume of effluent disposed to the river (mainly during summer).

At present, the extra cost of developing this additional area is not justified by the potential benefits, which would be restricted by the high groundwater level and lower infiltration rates through clay rich soils.

6.7.8 Increased Infiltration Rates in the Future (Note that this proposal is not part of the current application)

This consent application is based on full-scale border strip irrigation occurring in the decommissioned pond area, at rates proposed for existing pasture elsewhere on the 91 ha site (as shown in Table 23), which equate to approximately 1.8m depth of effluent applied per year.

There is potential for increased irrigation rates in the future, particularly in the area of the existing ponds, because of the topography and groundwater flow direction (see section 6.7.9).

The increased application rates would need to be proven by full-scale trials which would require separate consent applications at a later date. The trials would determine:

- feasible maximum infiltration rates
- extent of groundwater mounding
- sustainability of pasture growth, under increased effluent application
- degree of breakthrough of nutrients or microbiological indicators and effects on river water quality at various flows (expected to be negligible)

The increased irrigation rates would only be applied during higher river flow periods to avoid nutrient enrichment effects – i.e., when above the median river flow value. As in section 6.7.7, the benefit of this proposal is that it would allow a greater portion of pond effluent to have land treatment, rather than be directly discharged to the Ruamahanga River.

It is emphasised that the increased infiltration rates will remain within the range defined for "Slow Rate Irrigation" of 0.5 m to 6 m/year (refe Table 13.7 *WEF Manual of Practice No 8, Design of Municipal Wastewater Treatment Plants,* 1998). "Rapid Infiltration" involves much greater volumes of effluent and has application depths in the range between 6 m to 100 m/year.

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[53] As measured at Wardells Bridge gauge.

6.7.9 Potential for Groundwater Abstraction from MDC Land for Supply to Private Farms[54]

The potential for groundwater abstraction near the riverbank adjoining existing Ponds 2 and 3, for supply to private farms in the vicinity will also be assessed at the time of the increased infiltration trials described in section 6.7.8, because abstraction of groundwater would reduce seepage from the irrigation area entering the river. The proposal to extract groundwater from this location is based on the groundwater contours shown in Figure 19 and the geological cross-section in Figure 7. Groundwater moves at right angles to the contours and the bend in the river acts as a natural collection area for groundwater.

Assuming that there is a demand for irrigation water, supplying private farms in the vicinity with "groundwater of wastewater origin," would be a more sustainable approach than supplying pond effluent directly to private farms, for these reasons;

- Groundwater would have low health risk due to infiltration through topsoil and sandy gravels which would remove bacteria
- Existing spray irrigation equipment on private farms could be used with negligible risk of odour or infection from aerosols
- There would be no algae in the groundwater, which could cause clogging of soils in hollows
- Soluble nutrients would be beneficial for enhanced crop growth and would not enter the river

The area of private farmland which could be irrigated with extracted groundwater sourced from MDC-owned land, could be in the order of 300 ha – this will be confirmed during future investigations. Up to five of the border strips in the 22 ha area of decommissioned ponds could be trialled at the increased infiltration rates, so that representative sub-soil conditions are included.

It is emphasised that consents for the abstraction of groundwater for supplying private farms, are not being applied for at this time. The concept is "flagged" in this AEE as a potentially sustainable method of further development of the land treatment scheme.

6.8 Flood and Erosion Protection Works

NOTE: Changes in this section from the 2007 AEE include the removal of the existing oxidation pond embankment and stopbank adjacent to the Ruamahanga River, deletion of the major erosion rock protection, its replacement this with a planted buffer adjacent to the existing ponds, and minor bank protection work. Embankment stability has been reassessed for the new oxidation pond embankments.

6.8.1 Flood Protection

Stopbank protection works are needed to address the current flood hazard risks to the new ponds. The works required include raising the section of stopbank immediately upstream of the existing Pond 1, which currently has protection for only a 20-year flood. The upgraded stopbank will keep flood flows away from the new Pond 1A embankment. This improvement will result in a stopbank top level that has 300 mm of freeboard above the level of the 100-year flood.

The existing pond embankments adjacent to the river and Makoura Stream will be initially cut down to the height of the 2-year flood level to allow major flood flows to go over the area of the decommissioned oxidation ponds. This could be cut down to a lower level at a later date to encourage siltation of this area. The northern embankment of the existing ponds will be removed and the material used to fill the decommissioned ponds area.

To provide protection for the stopbank, a planted zone of poplars, alders and willows will be required in front of the new pond embankment/stopbank, with shrub willows or tall grasses on the stopbank face to retain a good cover.

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[54] Note that this proposal is not part of the current application

The long-section of the river flood levels adjacent to the oxidation ponds is shown in Drawing C621 in Appendix D. This drawing shows the section of the existing stopbank to be raised and the existing stopbank/bund which will be cut down to the 2-year flood level. River levels are based on the most recent flood modelling which determined flood levels following the upgrade to the stopbanks and with no gravel extraction (Wallace 2007). The flood model was not updated for the decommissioned oxidation ponds scenario, but this will reduce flood levels in the vicinity of the ponds.

6.8.2 Erosion Protection

Erosion at the Ponds

The new ponds will be constructed about 270 m from the river, which will allow channel meander movements to be accommodated within a 60 m buffer area adjacent to the Ruamahanga River. The buffer will be planted in willows and other vegetation. Drawing C602 shows the location of the buffer. Some permeable structures such as fences and groynes of piles and cabling could be added to provide some initial strength to the buffer area and act as on-going strengthening. The steep sections of the river bank adjacent to Ponds 2 and 3 will be re-graded to flatter slopes and the existing rock groynes will be repositioned at the upper sections of the slope.

The riverside of the existing northern embankment will also be a planted zone of poplars, alders and willows in front of the stopbank, with shrub willows or tall grasses on the stopbank face to retain a good cover.

Allowing river channel movements in this location, as opposed to fixing the channel with the major rock protection as proposed for retention of the existing ponds, lessens the erosion pressures on the opposite bank. Erosion protection works on the opposite bank, and at the right hand bend adjacent to the existing Pond 1, are not proposed as part of the wastewater scheme upgrade. While there will be a requirement for ongoing erosion protection works in the section of the river adjacent to the ponds, this work should be considered as part of the whole river scheme in conjunction with the GWRC.

Embankment Stability

The effect of ground shaking on the stability of the new pond embankments was assessed as part of the preliminary design process. 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.

The analysis was carried out for the highest (worst case) embankment having slopes of 3H:1V and with water storage levels at the maximum level, equivalent to 275,000m^3. A static stability analysis was carried out to assess the likely margins of stability for the proposed embankment design under static loads. The calculated FOS of the pond embankment section was greater than 2.0 for both the internal and external cases.

Two scenarios were considered in assessing the seismic stability of the pond embankments: when liquefaction does not occur and when liquefaction occurs.

Seismic accelerations for stability analyses have been assessed using NZS1170.50:2004 inclusive of Amendment 2. Peak ground accelerations (PGAs) were determined using this standard with importance level criteria for wastewater treatment facilities. Using this approach resulted in a very high PGA of 0.61g and it is not feasible to design the embankments to withstand such high accelerations. In an earthquake with high PGAs, it is possible that the wastewater conveyance system fails but having the ponds remain operational would not be the highest priority.

In the previous geotechnical analysis of pond options at the site, PGAs modelled were 0.18g for a 50-year return period and 0.25g for a 100-year return period. These return periods have been considered for the current analyses also. The results of the analysis are presented in Section 8.6.

6.8.3 In-River Construction Methodology

This section referred to the construction of erosion protection for the original scheme. With the major rock protection being deleted, the only in-river construction work proposed is the outfall diffuser.

General Construction Practices

The construction of the outfall diffuser will require work within the Ruamahanga River channel. This work will be done in flowing water, as diversions and bunding-off the banks to allow construction in still water is considered to be more disruptive. The careful placement of the rock that is required minimises disruption of the river bed and increasing turbidity of the water. Construction will not take place within the trout-spawning period (1 June to 30 August). There will be no disruption to fish passage. The river disturbance will have some visual and turbidity effects on recreational use of the river during summer months. Mostly the work will disturb coarse gravel materials and involve the placement of rock units, which will have a relatively low impact on the river water quality. It should be possible to regrade steep sections of the riverbank adjacent to Ponds 2 and 3 without working in the river bed and therefore there should be minimal disturbance due to this activity.

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 of flow control penstock at 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 grit from the grit trap at the inlet works
- Maintenance of the inlet pump station
- 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 old pond embankments, which also act as a flood protection stopbank along that part of the ponds closest to the river. This may involve 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 of 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 will render the land treatment scheme inoperable and incoming sewage flows will 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. However, this will only occur in an emergency and is very unlikely because there will be around two 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) will be 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 because 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 planted buffer on the right bank of the Ruamahanga River will require on-going maintenance, including re-establishment and willow layering etc, as required to maintain the buffer over time.

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 could be added. 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 the MDC selected its preferred upgrade, it 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 can be enlarged because 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 adjoining the MWTP to potentially 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. There is potential for increased application rates to pasture in the area of the existing oxidation ponds, which will reduce the volume discharged to the river – refer to section 6.7.8. In addition, there is potential to extract groundwater from MDC owned land and to supply private farms in the vicinity with irrigation water – refer to section 6.7.9.
- *Flooding and erosion* – The existing stopbanks and planted buffer 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.

A schematic diagram of the proposed monitoring sites is presented in Figure 30.

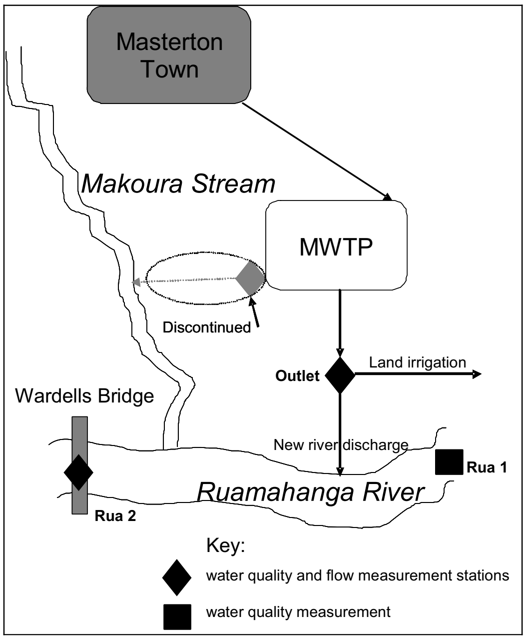

Figure 30 Schematic Diagram of Proposed Monitoring Sites

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 in the 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 Ministry for the Environment 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 the Ministry for the Environment and Ministry of Health incorporate a risk-based approach to monitoring water quality promoted by the World Health Organization. The guidelines 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

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[55] Beach refers to both marine and freshwater bathing zones

second, historical microbiological results, which generate a Microbiological Assessment Category (MAC) and 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* is available from the Ministry for the Environment website at http://www.mfe.govt.nz/publications/water/microbiological-quality-jun03/.

Other Standards and Guidelines

The third schedule of the RMA 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 because 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 30. All targets apply after reasonable mixing has occurred, which (in contrast to the current situation) 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 NIWA[57].

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 30 Suggested Receiving Water Quality Targets after Reasonable Mixing

Parameter	Receiving Water Target	Source Document	Water Management Purpose
Filtered BOD (g/m^3)	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/m^3)	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/m^3)	7.2	ANZECC Guidelines (2000) recalculated value from Table 3.4.1[2]: Effects on aquatic life for "slightly-moderately disturbed" ecosystems.	Aquatic Ecosystems & to asses compliance with Minimum RMA Standard - s107(1)(g)
Nitrite–Nitrogen (g/m^3)	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/m^3)	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

Notes: 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.

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 leakage through the base of the ponds and flow of groundwater from the land treatment area. Refer to sections 7.1.4 and 8.2.4 for more detail, andalso NIWA, 2004a.

7.1.4 Contribution of Dissolved Reactive Phosphorus (DRP)

As part of the investigations undertaken for the MWTP upgrade, NIWA(NIWA 2003, 2004a) derived a site-specific DRP target for the Ruamahanga River downstream of the proposed MWTP discharge point. The DRP target was 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 recommended in the New Zealand Periphyton Guideline (MFE, 2000).

In order to determine a DRP guideline for a specific river, the periphyton guidelines use 'mean days of accrual' with an average accrual period over the whole study period (summer and winter seasons) and a river flow threshold of 3x median flow to displace algal growths from the river bed (NIWA 2003). The NIWA model, however, conservatively used the average accrual period during summer when the MFE periphyton guidelines apply. 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 (NIWA 2004a). In other words, algal growths could 'accrue' for an average of 13 days before being dislodged. Using this accrual period, the guidelines (MFE 2000, p43) predicted that an in-river DRP concentration downstream of the discharge (after reasonable mixing) of less than 0.03 g/m^3 would be appropriate. However, it should be noted that there is uncertainty in the data used to derive the biomass/accrual period relationship as used and acknowledged in the MfE (2000) guidelines. A mathematical model was applied to predict benthic algal growths in relation to river flood events, and to predict algal biomass in reaches upstream and downstream of the Masterton wastewater discharge for the summer periods for 1988 to 2002.

The scientific analysis has shown that nutrients are naturally present upstream and that the Ruamahanga River is generally dominated by a high frequency of significant flood events during summer periods. The conservative modelling predictions have indicated that nuisance growths may occur, but would generally be of short duration; occurring in 6 of the 15 years, with durations from 3.5 days to 35 days, with most being of around 5 days (NIWA 2004a). The frequency and duration of predicted nuisance growths would be considered low, generally occurring for only a small fraction of the summer season. Thus, while nutrient targets may be established for the Ruamahanga River and subsequently calculated for the wastewater discharge, the improvements in river condition in terms of reduction in average nuisance algal biofilm growths will be slight – since flood frequency and upstream phosphorus concentrations are controlling growths for the majority of the time. A small increase in accrual periods will result in slightly higher attached algal biomass, both upstream and downstream of the discharge. It should also be noted that during extended periods of low flow, DRP concentrations reduce below the detection limit of 0.004g/m^3.

Other factors can be important to the growth of periphyton such as invertebrate grazers and shading from sunlight. The effects of invertebrate grazing in the Ruamahanga River were assessed by installing tiles in the river bed over the summer period in 2003. The experiment indicated that invertebrate grazing was very significant at times during the summer season, particularly at the upstream site. Grazing levels were lower at the site downstream of the pond discharge (NIWA 2003).

The site-specific DRP target was developed at an early stage of the project, when consideration was being given to having a continuous effluent discharge in summer. 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). The site-specific guideline is not relevant to discharges of pond effluent during summer river freshes, with associated bed scouring and higher turbidity. 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 pond discharge (direct to river) in terms of periphyton growth are addressed via the proposed discharge regime, rather than by effluent or receiving water standards. The proposed regime is such that no purpose would be achieved by chemically reducing DRP in the pond effluent. The effects of continuous inputs to the river during summer, via groundwater movement from the area of proposed new ponds and land treatment areas, are described in section 8.2.4. Table 39 in particular, demonstrates that future contributions from the MDC site will be well below guideline values for in-river DRP concentrations.

8 Assessment of Effects on the Environment

8.1 Introduction

This 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 affect 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”, and is 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 at a point 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 (RMZ) is, in effect, a zone where the discharge is not required to meet the relevant guidelines or standards. The downstream end of a reasonable mixing zone for a particular contaminant, is where that contaminant is reasonably well mixed with the receiving water, and matches a water quality target concentration which reflects what will be reasonable in terms of the effects in issue. 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 circumstances the RMZ may be closer to the point of full mixing.

The different mixing concepts are shown schematically in Figure 31.

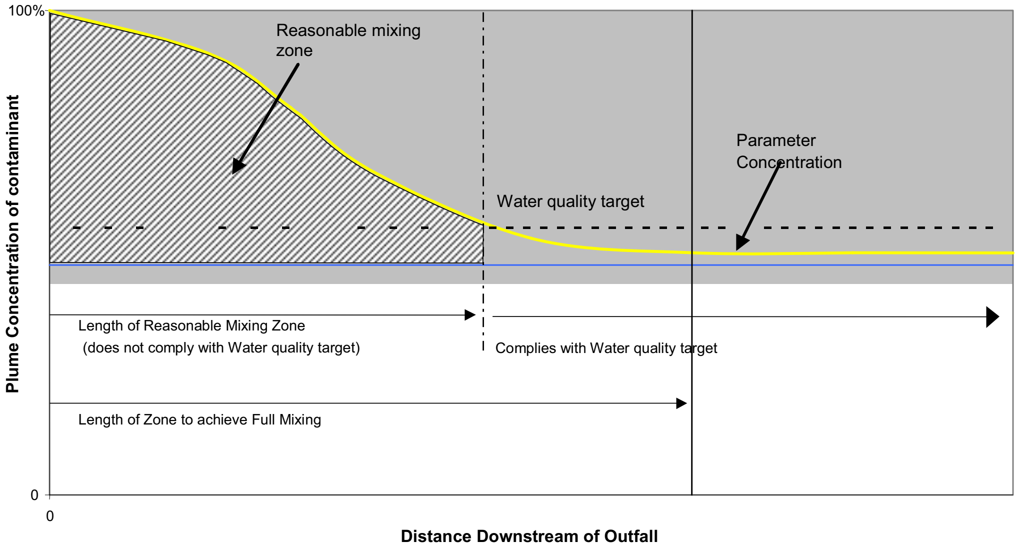

Figure 31 Conceptual River Mixing of Plume Downstream of Outfall

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. Under the WFWP, 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). Policy 5.2.11 of the Wellington Regional Freshwater Plan (WRFP) is 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 [Resource Management] 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 achieve the proposed receiving water quality targets after reasonable mixing. The primary relevance of reasonable mixing, is in terms of the applicant satisfying the GWRC 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 300 m to 500 m 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). A plume travel distance of 300 m downstream of the proposed new discharge point has been used as the basis of tabulated water quality predictions 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 it allows ready access for monitoring. Continuing with monitoring at that point will also allow comparison of the upgraded water quality with pre-upgrade quality.

The upstream monitoring point is proposed to be shifted to the northern boundary of the land treatment area to avoid effects of groundwater recharge on the river. (GWRC request for information question 25).

Statutory Requirements

In terms of the proposed discharges being sought, section 107 of the RMA 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 because 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 WRFP has a policy that 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 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 that – the Ruamahanga River is NOT listed as being managed for aquatic ecosystems – only the Ruamahanga floodway wetland.)

Appendix B8.3 of the WRFP is a guideline to assist with resource consents that 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 RMA 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 is to be rendered unsuitable for bathing by the presence of contaminants*
- *The presence of undesirable biological growths because 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 will cause it to become unsuitable for bathing at that flow (after reasonable mixing) the guideline will not be met. Conversely, the guideline will not be breached if the river is unsuitable for bathing because of upstream contamination rather than because 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.

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[58] Except in regard to the discharge of free or combined residual chlorine, acid soluble aluminium, suspended solids, and fluoride.

The parameters modelled were:

- 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 31.

Table 31 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 31 shows that at 300 m 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 because of mixing and dilution. This corresponds to the effluent being 70% mixed. Another point to note in terms of Table 31 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 800 m 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 800 m 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 300 m and 400 m downstream. At 300 m 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 300 m (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 typical fresh events at Wardells Bridge in Figure 32.

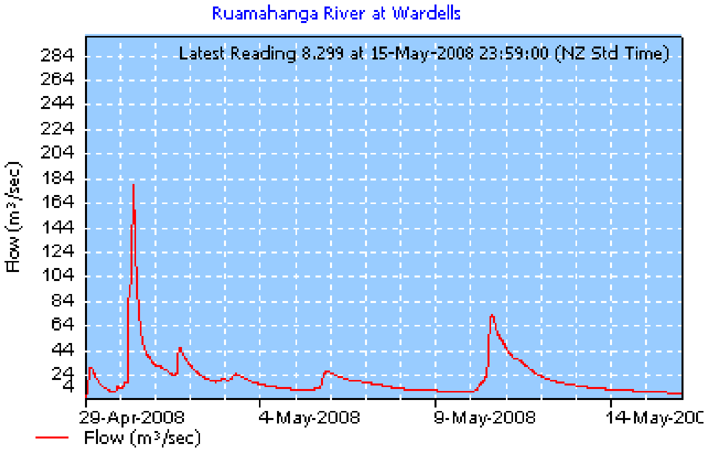

Figure 32 **Example of Typical Fresh Events at Wardells Bridge**

The Ruamahanga River flow characteristics are summarised in Figure 33 for summer and Figure 34 for winter data from the Wardells Bridge gauging site. The cumulative frequency presentation indicates the percentage of the time that the river will exceed a given value in an average year, and summarises the high flow variability data from both summer and winter in the Ruamahanga River (see Figure 11 and Figure 12). Thus, for example, the river is expected to be below 10 m^3/s flow for 60% of the time in summer. Figure 33 indicates that flows above median flow (12.3m^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 34) show 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, for 92% of the time.

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 a suitable basis for characterising the receiving water quality data relevant to the discharge initiation;

(ii) To facilitate modelling of predicted upgraded effluent contaminant concentrations compared to the upstream background contaminants; and

(iii) To provide a quantitative basis for assessing the 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 Figure 17 and Figure 18). 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.

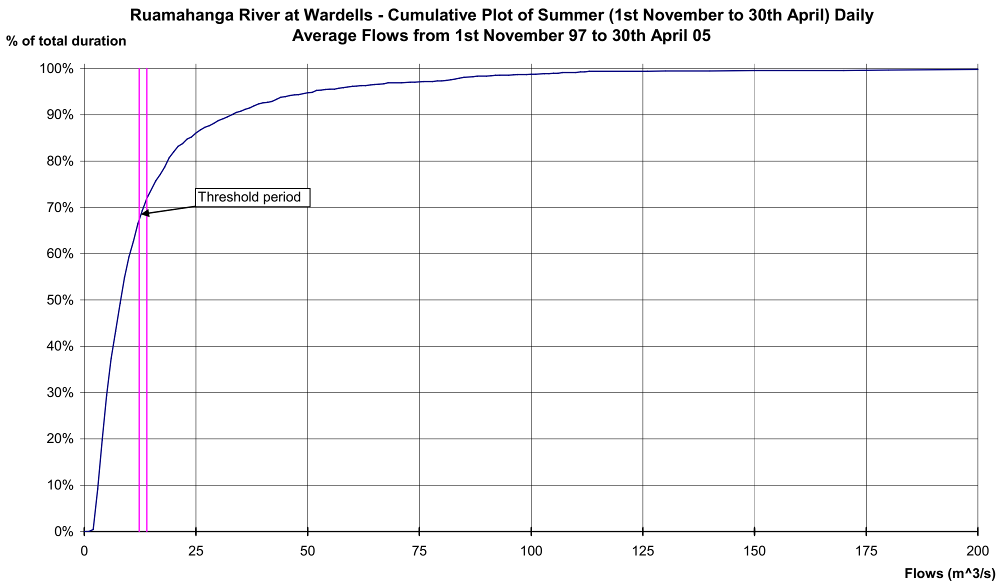

Figure 33 Cumulative plot of Ruamahanga River (@Wardells) summer flows

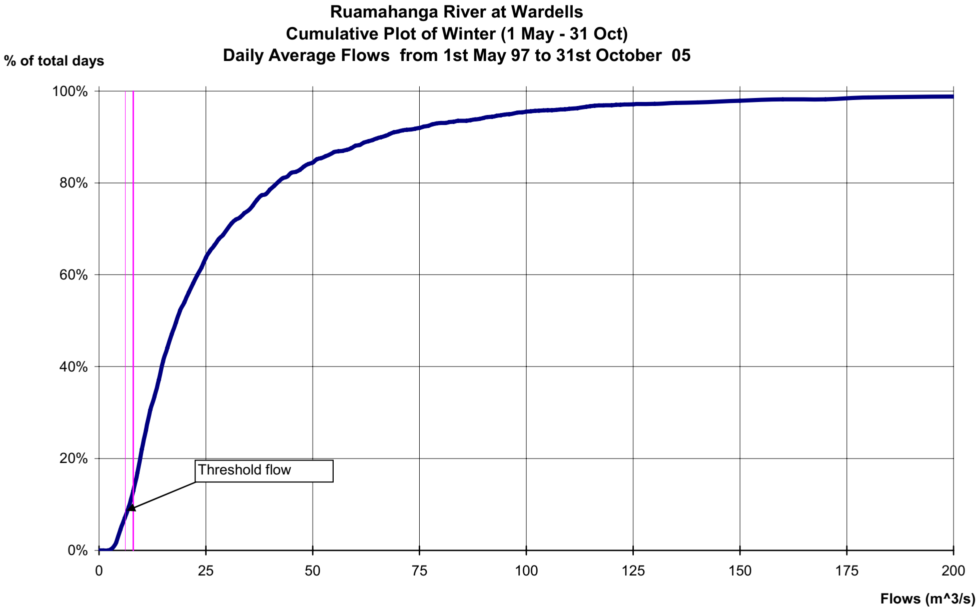

Figure 34 Cumulative plot of Ruamahanga River (@Wardells) winter flows

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 Figure 33 with the results of the analysis discussed in Section 8.2.3. 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 (Figure 34).

8.2.2 Effects of Existing Pond Leakage on Surface Water Quality

It is noted that the key change in this section from the 2007 AEE, is the construction of new oxidation ponds that will be clay/silt lined to significantly reduce leakage. While the leakage from the existing ponds only has a minor affect on the river water quality, this section outlines the improvement in water quality as a result of the new lined oxidation ponds. The estimated leakage for new ponds with a 400 mm thick clay liner is in the range of 150 to 750 m^3/day. For a very conservative assessment, the figure of 750 m^3/day has been used.

The assessment of effects of the existing pond leakage has been retained for convenience in this section.

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:

- 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
- 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:

- The hydraulic leakage volume was estimated at 490-1,300m^3/day at the time of these trials. Subsequent measurements have resulted in revised values being adopted for normal and elevated pond levels. (PDP, 2007).
- 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. These conservative leakage and dilution rates were used in the prediction of effects of leakage.
- Ammonia data showed no increase and were markedly lower than the guideline value
- The *E.coli* data were highly variable and provide no indication of a general increase along the reach
- Faecal coliforms indicated a slight increase (upstream to downstream) although the result is not statistically significant
- There was a slight increase in dissolved reactive phosphorus (DRP) from 0.006g/m^3 to a mean of 0.009g/m$^{3.}$
- 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 existing ponds showed there to be no more than a minor impact because of pond leakage because, as noted above, there is very significant dilution of the pond leakage in the river.

The predicted impacts on the river of leakage from the new ponds and direct discharges from the new ponds are discussed in the next section.

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[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.

8.2.3 Effects of Proposed 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.

Summer Discharge Regime

Key Parameter Concentrations

This section presents the results of river parameters at just above and just below the summer trigger flow. The effluent discharge (conservative 95%ile) and new pond leakage (median effluent value) have been used to determine the river concentrations downstream of the discharge. The pond leakage is expected to be of average composition given the time taken for transport through the clays and gravels. The approach is conservative as it ignores the effect of adsorption of contaminants to clay particles within the pond liner. The fully mixed summer effluent is diluted 30x and the leachate contribution is based on the upper bound value of 750m^3/d which gives a dilution of 1414x at median flow (12.3m^3/s). It should be noted that leakage from the new ponds will be much less than the assumed rate of 750m^3/d once algae sludge has sealed the silty clay liner. The winter effluent concentrations are included for key parameters which is a further conservative assumption. The leakage only assessment is based on a conservative dilution for half-median flow (6.15m^3/s; 707x) for comparison with trigger values. The predicted receiving water concentrations are compared with guideline targets (Table 30) 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 modelling approach was used for the assessment of *E.coli* and clarity effects with results presented later in this section. The Monte-Carlo modelling 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 are summarised in Table 32 for the 95%ile effluent and median leachate concentrations based on mixing dilutions given in Table 31. These predicted values are based on the highest anticipated leaching rate (750m^3/d, dilution 1414x; as discussed in Section 5.5.3) 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 reach about 35% of the toxicity guideline value. While DRP concentrations are significantly greater than the Receiving Water Target (RWT), the intermittent nature of the discharge, together with the discharge at high flows to turbid waters, will not 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 32 Predicted Concentrations of Key Parameters for Effluent Discharges 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 (g/m^3)**	**300 (g/m^3)**	**300 %RWT**	**400 (g/m^3)**	**800 and Wardell's Bridge(g/m^3)**	**800 %RWT**
fBOD	0.3	28	5	2.00	1.89	1.64	82%	1.43	1.24	62%
NH4-N(S)	0.01	11.3	1.1	1.61	0.65	0.55	34%	0.46	0.39	24%
NH4-N(W)	0.01	11.1	6.7	1.61	0.65	0.55	34%	0.46	0.38	24%
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	0.74	0.71	10%	0.67	0.64	9%
DRP	0.01	3.3	2.7	0.030	0.20	0.17	566%	0.14	0.12	406%

Notes:

Table updated from NIWA (2007). Uses upstream background concentrations with conservative new pond leakage (750 m^3/d; 1414x dilution).

Receiving water targets provided in Table 30.

RWT = receiving water target.

S= Summer.

W= Winter.

The results in Table 32, show that concentrations are the same or slightly less than concentrations for the existing pond situation which has greater leakage. The river concentrations are all within the receiving water targets, except as noted above for DRP.

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 41% of the guideline value at 200 m downstream (55% mixed), declining to 24% of the guideline at 800 m (fully mixed) (Table 32). The risk to receiving water organisms will be 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 32); 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 will provide good protection for most species (Hickey et al 1999, Hickey 2000)).

Table 33 presents the results for the scenario for just below median flow in summer when there is no direct effluent discharge, but there is leakage from the base of the new 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 from new ponds (750m^3/d, 1414x dilution; as discussed in section 5.5.3) for conditions of maximum pond retention. This indicates that all parameters are markedly below guideline values both within and downstream of the reasonable mixing zone.

Table 33 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 and Wardell's Bridge**	**800 %RWT**
FBOD	0.30	0	5	2.00	0.31	0.31	16%	0.31	0.31	15%
NH4-N(S)	0.01	0	1.1	1.61	0.013	0.012	1%	0.012	0.012	1%
NH4-N(W)	0.01	0	6.7	1.61	0.026	0.024	1%	0.021	0.019	1%
NO2-N	0.002	0	0.14	9.00	0.002	0.002	0%	0.002	0.002	0%
NO3-N	0.5	0	0.84	7.20	0.50	0.50	7%	0.50	0.50	7%
E.coli (S)	103	0	200	130	103	103	80%	103	103	79%
E.coli (W)	49	0	260	130	50	50	38%	49	49	38%
DRP	0.010	0	2.7	0.030	0.016	0.015	52%	0.015	0.014	46%

Notes: Modified Table from NIWA (2008); Upstream Background with Leakage (750 m^3/d; 707x dilution) to Half- Median River Flow, with (s) = summer; (w) = winter. RWT= Receving Water Target. Receiving water targets provided in Table 30.

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 34 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	83 (13 – 1058)	1.0 (0.17 – 4.6)
High flow	207 (16 – 2909)	0.34 (0.09 – 1.92)

Notes:

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).

[1] Flow ranges are: <Half-median = < 6.15 m^3/s; Half-median to Median = 6.15 – 12.3 m^3/s; Threshold flow range = 12.3 – 14.0 m^3/s; High flow = >14 m^3/s.

[2] "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 33)

As can be seen from Table 34, 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 35) and for full mixing at 600-800m (30x dilution, Table 36). The predictions showed slight increases at threshold flows for *E.coli* (average <6.5% for 300 m, Table 35; & <4.3% for 800 m, Table 36). 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 will be very small at higher flows. The upper 95%ile values are markedly elevated in the threshold flow region because of the high natural variability, with the predicted increase indicating a negligible change because of effluent addition (Table 35 and Table 36).

Compliance with the proposed target guideline value of 130/100 mL (Table 30 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 300 m and a reduction of 13% at 800 m (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 30). Flows in this threshold range only occur for 4% of the time in summer (Figure 33) and thus any aesthetic impacts will be minimal. It is considered that a clarity change of at least 50% will 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 because 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 resulting from discharges from the proposed upgraded ponds. The elimination of direct discharge at below median flows, removes all effects at these flows at times when there may be high recreational use.

The quantitative analysis has concentrated on the threshold flow region where effects will be most apparent after the initiation of the discharge. The analysis has shown that the *E.coli* increase is negligible at these flows 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 at below median flows (when most recreational use occurs), and negligible change during discharge at higher flows.

Table 35 Predicted Summer E.coli and Clarity at 300m Downstream of Discharge in relation to River Flow

Flow category [1]	*E.coli* (cfu/100 mL)	Clarity (visibility of Black Disc in metres)
	Median (5 – 95%ile)	Median (5 – 95%ile)
< Half-median	No change	No change
Half-median to Median	No change	No change
Threshold flow range	89 [2] (15 – 1012) [3]	0.85 [2] (0.17 – 2.3) [3]
High flow	Negligible change	Negligible change

Notes: 'No change' refers to distribution values given in Table 34.

[1] See footnotes for Table 34;

[2] Model predicted values for E.coli are based on a median effluent concentration of 330 /100mL added to upstream distribution.

[3] Model predicted values for E.coli are based on the 5 to 95%ile effluent concentrations added to upstream distribution.

Table 36 Predicted Summer E.coli and Clarity at Wardells Bridge in relation to River Flow

Flow category [1]	*E.coli* (cfu/100 mL)	Clarity (visibility of Black Disc in metres)
	Median (5 – 95%ile)	Median (5 – 95%ile)
< Half-median	No change	No change
Half-median to Median	No change	No change
Threshold flow range [2]	87 [2] (14 – 1014) [3]	0.89 [2] (0.17 – 2.67) [3]
High flow	Negligible change	Negligible change

Notes: 'No change' refers to distribution values upstream as given in Table 34. 'Negligible change' indicating that the magnitude of change will be very small.

[1] See Table 34 footnotes;

[2] Model predicted values for E.coli is based on a median effluent concentration of 330 /100mL added to upstream distribution.

[3] Model predicted values for E.coli is based on the 5 to 95%ile effluent concentrations added to upstream distribution.

Taken together, Tables 33, 34 and 35 show that the predicted effects at Wardells Bridge for E.coli and clarity is that there will be negligible change from upstream values as a result of the proposed upgrade.

8.2.4 Cumulative Effects of the Discharges on DRP Concentrations in the River

The cumulative effect of pond leakage, groundwater from the land treatment area, and the direct river discharge, on concentrations of DRP and resultant potential effects has been assessed. The principal potential environmental effects relate to periphyton growth. Periphyton is mainly an issue in the Ruamahanga during summer months, so the analysis can be focussed on the period 1 November-30 April.

Under 'fresh' or 'flood' conditions, the discharge of DRP from the scheme will have little or no environmental effect, because catchment-induced turbidity will prevent DRP uptake from periphyton, which will be scoured by flood flows in any case. The relatively short travel time to the sea will ensure that DRP is flushed from the river, thus there will be little if any residual effect once the river returns to baseflow (<median flow). The only period of possible concern is the threshold period when direct discharge may occur (just above median flow). The actual total duration of discharge under these conditions will be very short in the summer. Using the HortResearch model, it is calculated that, in January for example, discharge under these threshold conditions is likely to occur for ~8 hours per month. At this threshold flow, the NIWA developed guideline will be exceeded but because this period is so transitory and is usually followed by higher flows during which scouring will occur, the actual environmental effects will be less than minor.

Below median flows, cumulative effects will be reduced to pond leakage and groundwater return flows from the land treatment area, since there will be no direct discharge.

It is noted that in the current situation, under summer conditions (< median flow) with direct discharge to the river (plus pond leakage), the effects on periphyton growth is considered to be only minor. Therefore, taking out direct discharge (by far the major source of DRP) to the river during this period will further reduce this minor effect. The significant reduction in pond leakage will also have a beneficial effect.

Groundwater concentrations from the modelling of the irrigation scheme have been used to determine the combined effects on the Ruamahanga River and Makoura Stream. Table 37 provides the river DRP concentrations based on the cumulative effects of the following worst case discharges;

- effiuent discharge direct to the river (95 percentile discharge)
- maximum expected leakage for the new ponds (750 m^3/d)
- long term (after 28 years) groundwater return to the river from the proposed and potential future irrigation areas (at maximum irrigation rates).

It is noted that these assumptions, in combination, represent a very conservative analysis. Also, the contribution of DRP from Makoura Stream enters the river further downstream from the direct discharge and the irrigation scheme groundwater recharge, and is not cumulative in the Ruamahanga River adjoining the Homebush site.

Table 37 Predicted worst case DRP discharge to river from direct discharge, pond leakage and groundwater (irrigation return flow) at just above median flow in the river

Component	DRP mass (kg/day)	Change in fully mixed river DRP concentration (g/m^3)
Direct discharge	117	0.11
New Pond leakage	2.0	0.002
Groundwater (from irrigation)	0.82	0.001
TOTAL	120	0.113

Table 38 provides the DRP masses and concentrations for the original scheme (existing ponds and irrigation on the 91 ha site) by way of comparison.

Table 38 Original Scheme; Predicted worst case DRP discharge to river from direct discharge, pond leakage and groundwater (irrigation return flow) at just above median flow in the river

Component	DRP mass (kg/day)	Change in fully mixed river DRP concentration (g/m^3)
Direct discharge	117	0.11
Existing Pond leakage	6.5	0.0065
Groundwater (from irrigation)	0.5	0.00048
TOTAL	124	0.117

This confirms that at just above median flow, direct discharge is by far the major contributor (95%) of DRP, and that by removing the discharge (as will be the case below median flow in summer) there will a large reduction in river DRP concentration. This will further reduce the “minor” effects of DRP on periphyton growths noted with the current discharge regime.

From Table 37 and Table 38, the conservative assessments of the increase in DRP as a result of pond leakage and long term irrigation groundwater are to increase DRP concentrations in the river by 0.003 g/m^3 which is less than the scheme with the existing oxidation ponds at 0.0065 g/m^3. With background DRP concentrations of 0.01 g/m^3, total DRP is predicted to increase to 0.013 g/m^3 downstream of the ponds as a result of pond leakage and irrigation groundwater. This is significantly lower than the guideline value of 0.030 g/m^3 (refer Section 7.1.4).

The analysis was also carried out for the situation during low river flow. Table 39 provides the DRP mass loads and concentrations for the potential irrigation scheme on all of the MDC land at the maximum irrigation rates, and at a 5 percentile low river flow of 2.7 m^3/s. While MDC is not applying for discharge consents to apply effluent to the western portion of the 107 ha site at this stage, the modelling has been carried out on a very conservative basis to identify the potential future effects. This approach also supports the designation of the full area for land treatment of pond effluent in the future.

Table 39 Predicted worst case DRP discharge to River from pond leakage and groundwater (irrigation return flow) at 2.7 m^3/s low flow

Component	DRP mass (kg/day)	Change in fully mixed River DRP concentration (g/m^3)
Direct discharge	0	0
Pond leakage (new ponds)	2.0	0.009
Groundwater (from irrigation)	0.82	0.003
TOTAL	2.82	0.012

Table 39 shows that at low river flows, the in-river DRP concentration increases by 0.012 g/m^3. At sustained low river flows, upstream DRP concentrations also become very low. This is consistent with the findings in other rivers, that as flow decreases, DRP concentration decreases e.g. Manawatu River catchments (McBride & Quinn, 1993). During the low river flows from December 2007 to April 2008, DRP in the Ruamahanga River upstream of the oxidation ponds dropped to below the detection limit of 0.004 g/m^3. Therefore DRP concentrations downstream of the ponds, will be less than 0.016 g/m^3 during low flow conditions, which is significantly less than the DRP guideline value of 0.030g/m^3.

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 has been during the summer season, when recreational use of the river is greatest)

The approach taken to analyse the effects of the winter discharge of effluent has been to prepare a comparative assessment as set out in Table 40, Table 41, and Table 42 below.

Table 40 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 m^3/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 m^3/s) comprises 16 data points; 32 data points for E. coli (range 3 – 493 cfu/100 mL).

Table 41 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 [2]
High flow	Negligible change	Negligible change

Notes:

[1] See Table 34 footnotes

[2] Estimated value based on a 17% reduction predicted for Monte-Carlo modelling of summer discharge.

Because of the lack of data, winter ‘predictions’ are not based on modelling, but rather are based upon an expert assessment based on the summer data applied to winter conditions (e.g. ponds generally clearer, high variability in E coli and clarity upstream).

Table 42 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 [2]
High flow	Negligible change	Negligible change

Notes: ‘No change’ refers to distribution values upstream as given in Table 34. ‘Negligible change’ indicating that the magnitude of change will be very small.

[1] See Table 34 footnotes;

[2] Estimated value based on a 13% reduction predicted for Monte-Carlo modelling of summer discharge.

Table 40, Table 41, and Table 42 summarise the available *E. coli* concentrations in relation to river flow, though only the greater than 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.

8.2.5 Comparison with Existing Water Quality

NOTE: The main change in this section from the 2007 AEE is the construction of new oxidation ponds that will be clay/silt lined to significantly reduce leakage.

A comparison of Ruamahanga River summer water quality is summarised for flows below and above median (before and after the proposed upgrade) at the downstream site at Wardells Bridge (Table 43). 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. Note that the 2% change in dissolved oxygen represents, a betterment in that parameter, and likewise, the significant increase in black disc of 170% is an improvement in the water clarity.

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 three major factors: (i) oxidation pond including maturation cells to reduce *E.coli* concentrations; (ii) full mixing occurring upstream of Wardells because 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 and phosphorus) which increase at high flows are intermittent in nature and occur at times when the river conditions (i.e. scour and turbidity) prevent the stimulation of attached growths.

Table 43 Comparison of Water Quality at Wardells Bridge in Summer Before & After Upgrade

	< 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 (µS/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	0.012	**-89%**	0.12	0.053	**-56%**
Nitrate-N (g/m^3)	0.81	0.50	-38%	0.54	0.41	-24%
Nitrite-N (g/m^3)	0.029	0.002	**-93%**	0.023	0.0077	**-67%**
Total Kjeldahl Nitrogen (g/m^3)	0.57	0.18	**-68%**	0.41	0.53	29%
Total Nitrogen (g/m^3)	1.48	0.70	**-53%**	1	0.91	-9%
Total Phosphorus (g/m^3)	0.24	0.028	**-88%**	0.12	0.14	17%
Dissolved Reactive Phosphorus (g/m^3)	0.19	0.014	**-93%**	0.071	0.100	41%
Turbidity (NTU)	2.55	0.85	**-67%**	6.42	5.11	-20%
Total Suspended Solids (g/m^3)	3	0.94	**-69%**	17.5	11.9	-32%
Total Organic Carbon (g/m^3)	4.2	ND	NC	3.8	ND	NC

Notes: NC = No Change; ND = No Data. Shading indicates >50% change in parameter. Monitoring data from March 1994 to October 2005 for <Median flow (12.3 m^3/s; n = 57) and > Median flow (n = 31). Rua 2 concentrations are measured values before upgrade and calculated after using: (i) <Median - using Rua 1 values with addition of summer median effluent data to estimate leachate (diluted 707x); and (ii) >Median flow have effluent (diluted 30x) + leachate (dilute 1414x). E.coli concentrations use the predicted upgrade median of 330 /100mL.

8.2.6 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 currently not heavily used 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, and is further reduced 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 would reduce the risk of infectious disease to recreational users of the river downstream of the ponds. A risk of one case per thousand persons bathing at Wardells Bridge was determined in the Health Impact Assessment (ESR 2007) for the option involving retention of the existing ponds when the river flow is < median and there is no discharge. This risk is attributed to the current pond leakage and assumes no attenuation of viruses, which is a conservative assumption.

With the new pond option, the estimated leakage would be much reduced (less than one third of the current leakage and likely to reduce further as the liner blinds with algae sludge) and the quality of any seepage through the fine grained silty clay liner would benefit from significant attenuation of bacteria and viruses. At river flows of < median in summer there would be no direct discharge of treated effluent and the current 7.3 cases per thousand risk at Wardells Bridge would drop to less than 0.3 cases per thousand swimmers. This situation should be compared to 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 would be further reduced by the Cliffs site, as a result of subsequent 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 95th percentile 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 would be “Very Good”.

When freshes occur, discharge with a 30:1 minimum dilution would 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 (Table 35 and Table 36). Furthermore, 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 would 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 would be less than minor for the reasons outlined above. In addition, neither the pond leakage nor the direct discharge would cause contact recreation standards to be breached after reasonable mixing.

8.2.7 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 and by reducing the residual pond leakage to the point where there should be no detectable impact on river water quality. At these times, the river is often clear and warm, attracting peak numbers of swimmers. Within three years of the initial upgrade, treated effluent will only be discharged to the river during the summer when freshes occur and the river flow exceeds the median value of 12.3 m^3/s. Once the new silty clay lined ponds are in place and algae sludge has sealed the silty clay liner, leakage from the new ponds into the river will have no effect on the health risk due to capture of disease causing organisms by the fine grained liner and sludge seal.

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 and the discharge is diluted to a minimum of 1 in 30. In summary, the effects on health risk of the direct discharge are assessed as less than minor.

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). Currently, although there is 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, five 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;
(iv) The discharge at high flows with turbid waters and high scour conditions and
(v) Significant reduction in leakage from the new ponds.

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 cumulative effects of a conservatively high pond leakage rate, and the irrigation groundwater recharge to the river at 5 percentile low river flows, will be well below the site-specific DRP concentration guideline of 0.030 g/m^3 (NIWA 2004a) after reasonable mixing. The site-specific guideline developed by NIWA was modelled based on nutrient concentrations predicted from measured flood frequency and the MFE guideline relationship, so that filamentous algal growths remained below a nuisance threshold of 30% cover (NIWA 2004, MFE, 2000) (refer to Section 7.1.4). Table 37, Table 38, and Table 39 in Section 8.2.4 show the predicted in-river DRP concentrations from the cumulative discharges at median and low river flows.

With the construction of clay-lined ponds, the effects of leakage will be negligible and the periphyton will continue to be below the nuisance guideline and the peak growths will be controlled by the high river flood frequency.

The very conservative assumptions used for the predictions of in-river DRP concentrations in Tables 37, 38 and 39, show a “safety margin” to the site-specific guidelines value of 0.030 g/m^3. A slight increase in accrual periods will result in slightly higher attached algal biomass upstream and downstream of the discharge.

In summary, 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) as well as much reduced pond leakage. At flows above median, the additional nutrients from the discharge will not cause any undesirable growths, because the frequency of high flow periods (river freshes) will be sufficient to scour the riverbed and in doing so will limit undesirable 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 (because of improved mixing) and at the Wardells Bridge site. An increase in sensitive invertebrate species, such as mayflies, is 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 that 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 because of the elimination of the summer discharge for flows below median (Table 43 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 8.2.1). The shifting of the discharge point upstream and the use of a mixing diffuser will eliminate the highly visible partial mixing zone that 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 an 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 (Figure 12) and clarity shows a marked reduction with increasing flow, with generally good, though highly variable, clarity at below half-median flow (Table 43). 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 there is 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 because 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
- As 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.

8.2.8 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 expected that the effluent suspended solids content will be 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 25 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 30). 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 300 m with a maximum (upper 95%ile) change in clarity of a 50% reduction after 300 m, 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 analysis 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 – refer to Table 30).

- **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, there will be no objectionable odour from the discharge to water.

  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 by livestock is not currently an issue and will be not an issue in the future. 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 30). 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 from 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 in Table 44 and the guideline targets are provided in Table 30. Each of these factors is discussed below.

  The pH of Masterton's incoming raw wastewater is an average of 7.1 (refer Table 3). The treatment processes in the oxidation ponds may increase pH slightly but due to dilution there will not be an 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 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 44).

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 riverbed 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 44), which combined with the intermittent discharge, indicate a negligible potential for toxic effects on aquatic biota.

Nuisance growths of attached algae, or periphyton, are stimulated by river nutrients (nitrogen and phosphorus) and are controlled by a range of factors (for example, 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 leakage from the existing ponds provides some limited potential for stimulation of periphyton, however, this will be significantly reduced with the construction of new clay lined ponds. In-river DRP concentrations are conservatively predicted to be less than 0.016 g/m^3 at 5 percentile low river flows downstream of the site (refer Section 8.2.4).

In conclusion, the discharge will readily meet the minimum standards set out in section 107 of the RMA.

8.2.9 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 44. Because of the nature of the proposed upgrade, with discharge triggered by elevated river flows, the analysis and future compliance monitoring of effects requires a different approach from that used for a full time discharge. Predominantly this relates to assessing effects against the natural decline in river water quality that 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 (we suggest 400 m 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 1.6m (Table 30). 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 will 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 30). 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 30). 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 in the pond water is currently monitored annually and compared with ANZECC (2000) water quality guidelines. It is proposed that this monitoring will continue and that the compliance will 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 and above the Waingawa River confluence) in order to measure trends in the biological response to the improved water quality conditions. The compliance with the narrative guideline will be measured for total number of taxa and abundance of key species and groups (for example, mayflies).

Details of the proposed compliance monitoring are presented in Section 12.1.

Table 44 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 [b]	Measured values (just below median flow) [c]	Predicted value: after reasonable mixing	Predicted value: Wardells Bridge
Filtered BOD (g/m^3)	2.0	0.31	1.64	1.24
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	7.5 GY(37.5) (2.5 points change)	7.5 GY(37.5)7/6 (2.5 points change)
Ammonia-Nitrogen (g/m^3)	1.61	0.010	0.55	0.39
Nitrate–Nitrogen (g/m^3)	7.25	0.50	0.71	0.64
Nitrite–Nitrogen (g/m^3)	9	0.002	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/m^3) [pond leakage and groundwater from irrigation area]	0.030 [d]	0.010	0.17 [0.016] [d]	0.12 [0.015] [d]

Notes: [a] Threshold flow range = 12.3 – 14.0 m^3/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 33).

[b] See Table 30.

[c] Measured upstream medians except model predicted median values for E. coli and clarity (from Tables 32 & 33).

[d] A site-specific DRP guideline (0.030 g/m^3) 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 and groundwater from irrigated area [bracketed values]. Refer to sections 7.1.4 and 8.2.4 for more detail, and also NIWA, 2004a. Pond leakage contribution at less than median flow (Table 33).

8.2.10 Summary of Expected Improvement in Receiving Water Quality

Details of the proposed discharge regime and the point of discharge are given in sections 6.5 and 6.7, respectively. In summary, the above tables show that the predicted concentrations for all parameters are less than the receiving water targets at 300 m downstream of the point of discharge, and that there is negligible impact at Wardells Bridge as a result of the effluent discharge, in either summer or winter.

In summary, the main changes are:

- There will be no discharge of effluent to the Makoura Stream;
- Pond leakage will be significantly reduced with the construction of lined ponds
- There will be no direct discharge of effluent to the Ruamahanga River when the river is below median flow in the summer, and half 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 because 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 because 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 algae from the ponds settling 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) and because pond leakage will be greatly reduced.
- 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.

8.2.11 Effects of Riverbed Works

NOTE: Changes to this section from the 2007 AEE, include the deletion of the major erosion protection rock and replacing this with a planted buffer adjacent to the existing ponds. The buffer will not involve construction in the riverbed. However, the construction of the outfall diffuser will involve works in the river that iscovered in this section.

The construction of the outfall diffuser will require work within the Ruamahanga River channel. The effects of this will be primarily short-term and relate to construction activities. The work will be carried out in flowing water, as bunded diversions to allow construction in still water, are considered to be more disruptive. 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. The river disturbance will have some 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 turbidity 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.

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 work could, with sufficient resources applied, be completed over a period of one month 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.

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 minor leakage from the new 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 from the irrigation, a model of the groundwater flow pattern at the site was developed for the originally proposed scheme (PDP, 2006). This model has been modified to cover the enlarged site, incorporating new hydrogeological information gained from installing an additional nine monitoring wells to the west of the Makoura Stream and additional soil investigation information. This model has 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 29 ‘plots’, including the old ponds as irrigated plots, of like soil type, so that an appropriate representation of the variable soil permeability across the site could be factored into the development of the model.

8.3.2 Effects on the Water Table (Groundwater Mounding Impact)

In terms 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 absorbed 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 two scenarios:

- A dry-land scenario, representing the site prior to irrigation with effluent, with recharge only from rainfall and surface water under specific circumstances. This scenario includes the effect of a drain running down the centre of the area to the west of the Makoura Stream, and the realigned and deepened Makoura Stream in the vicinity of the new ponds. The effect of these changes is to lower the groundwater level below the unmodified un-irrigated scenario.
- A high-rate irrigation scenario over the complete area available to be irrigated. The high rate represents average drainage to the aquifer of 5.4 mm/d.

Pond leakage will make a separate contribution to the quantity of groundwater in the immediate vicinity of the oxidation ponds. This has not been specifically modelled as the small leakage which will occur is insignificant relative to the effects of irrigation.

Groundwater Mounding

The modelling indicates that the maximum simulated change to the groundwater level in the aquifer will be less than 0.25 m on average, and commonly in the order of 0.15 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 freshes 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).

A greater effect on groundwater levels is induced by the drainage system in the area west of the Makoura Stream. The drains penetrate to the gravels below the surficial silts, and are intended to lower the groundwater level where otherwise the groundwater level would be too close to the surface. This results in additional flow in the drains, and in the Makoura Stream below the point where the drains discharge to the stream, and will also locally modify the groundwater flow direction on either side of the drain.

In summary, the groundwater analysis shows that the proposed effluent irrigation scheme will not cause excessive mounding in the underlying aquifer, and the overall groundwater flow direction remains essentially unchanged.

Effects on Flows in Ruamahanga River and Makoura Stream

The direction of groundwater flow from the irrigation area is locally towards the drain system and the Makoura Stream but generally towards the 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. The proposed drain system will discharge to the Makoura Stream immediately west of the new ponds, and because it intercepts new groundwater (because of its depth) as well as seepage from irrigated effluent, it will add to the original flow in the Makoura Stream.

A road-side drain beside the Martinborough – Masterton Road will have a reduced flow as some of the water it currently receives will be diverted back into the site by a new drain discharging to the Makoura Stream. The road-side drain currently discharges to the Makoura Stream within farmland to the west of the current ponds.

A summary of the assessed flow increases is presented in Table 45. The results show that, in the Makoura Stream, the increased flow from the central drain alone (without irrigation) is 0.094 m^3/s, in the Makoura Stream, including the central drain, the increase is 0.19 m^3/s (an 87% increase), whilst for the Ruamahanga the increase is only 0.036 m^3/s or 1.4% at the summer low flow. Such changes in the levels of stream/river flows will have minimal effect on the flow regime of the Ruamahanga River, but because of the increase from the proposed central drain, there is a significant increase for the Makoura Stream.

Table 45 Estimated Flow Increases - Makoura Stream, Ruamahanga River and Drain

	Increase in flow (m^3/s) upstream to downstream past site	
Scenario	Natural*	High Rate
Drain System	0.094	0.14
Makoura Stream (incl. new drain)	0.19	0.25
Ruamahanga River (upstream of Makoura)	0.25	0.29

**The drain does not currently exist but this is the predicted flow into the drain with no irrigation*

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.

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 groundwater abstraction wells immediately north of the site and not towards wells adjacent to the Martinborough-Masterton Road. 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 and subsequent modelling updates) to provide input to the groundwater and contaminant transport models (PDP, 2006, 2007, 2008).

In general, it is expected that the proposed irrigation scheme will result in the gravel aquifer beneath the site having higher levels of some contaminants than those found currently from the natural rainfall derived recharge and the effects of farming. 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 within the groundwater, by advection and 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 and therefore starting concentrations were not available for PDP's groundwater modelling. Instead, PDP used a nominal virus concentration, ignoring attenuation effects within the unsaturated zone. This is a worst-case scenario. In practice, considerable attenuation through the soil is likely and accordingly the modelled scenario is very conservative (Gilbert et al 1976).

The results of modelling through the unsaturated zone (in Table 46) 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 in the table to numbered plots is based on the results of fieldwork that has subdivided the irrigation area into 29 'plots' with similar soil characteristics.

Table 46 Comparison of Contaminant Concentrations at Surface and at 1 m Depth (1)

Parameters	**Concentration when applied to soil surface**	**Input to Aquifer – High Rate Irrigation (drainage from surface soil)**	
		Min	***Max***
E.coli (cfu/100mL)	1000 (winter av) 200 (summer av)	0 (at Plot 2)	139 (at Plot 13)
Nitrate (mg/L)	11.5 Total N (annual av)	0.7 (at Plot 22)	6.4 (at Plot 12)
Phosphorus (mg/L)	2.5 (annual av)	0.0026 (at Plot 18)	0.142 (at Plot 8)
Virus[1] (virus/L)	10	*No attenuation of viruses through the unsaturated zone was allowed for (refer Note 2)*	

Notes (1) After passing through the unsaturated zone[60] (2) Conservatively assumed that there is no attenuation of viruses through the unsaturated zone. The input concentration was set to an assumed pond wastewater concentration (based on Christchurch data). Gilbert et al (1976) determined that a highly loaded rapid infiltration system achieved an absence of any detectable viuses in the well water with passage through a sandy loam soil. Slow rate irrigation will achieve better virus removal than rapid infiltration systems due to the lower application rates.

The predicted summer average concentrations at the site boundaries are shown in Table 47. 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 47 Expected Groundwater Contaminant Concentrations Along River Boundaries[61]

		Simulated Concentration at boundary/adjacent to waterway			
Waterway	**Adjacent Irrigated Plot No**	**E.coli (CFU/100 mL)**	**Adenovirus (virus/L)**	**Nitrate (mg/L)**	**Phosphorus (mg/L)**
		HRI	**HRI**	**HRI**	**HRI**
Drinking water Guidelines (DWSNZ, 2005)		**1.0**	**No limit set**	**11.3**	**n/a**
Drain	9, 10 & 15	0.037	0.74	1.2	0.01
	11, 12, 17 & 18	0.239	1.4	1.8	0.04
	13, 14, 23, & 19	0.017	0.84	1.0	0.02
	23 - 26	0.105	1.1	1.0	0.03
Road-side Drain	25, 26	3.9×10^{-10}	0.0014	0.5	0.02
Makoura Stream	24	2.3×10^{-9}	9.9	1.4	0.1
	13 & 14	0.9	2.0	2.8	0.4
	4, 5 & 12	0.7	2.6	3.0	0.1
	1, 2, 3, 9, 10 & 11	0.1	1.4	1.8	0.04
Ruamahanga River	6	0.0001	0.013	0.2	0.01
	7	0.01	0.11	0.1	0.06
	8	0.0001	0.012	0.2	0.05
	29	2.1×10^{-4}	0.13	1.8	0.5
	28	1.1×10^{-1}	0.74	1.6	0.5
	27	2.4×10^{-1}	1.3	2.3	0.4

HRI – High Rate Irrigation

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[60] Refer to Appendix B3 for a plan showing location of plots referred to in this Table

[61] Refer to Appendix B3 for a plan showing location of plots referred to in this Table.

The estimated concentration increases of nitrate are similar to, or slightly higher than, the background concentrations in groundwater at the site. The average background nitrate level up-gradient of the ponds is 1.3 mg/L, possibly due to agricultural runoff. This is nearly ten times lower than the drinking water standard for nitrate. Phosphorus concentration increases are also similar to the average background DRP concentration, but an order of magnitude higher for some locations adjacent to the Makoura Stream and Ruamahanaga River. The average DRP concentration is 0.02 mg/L. It can be seen from Table 47 that predicted additional nitrate and DRP concentrations at the irrigation area boundary are, at most, approaching the background concentration, and are generally less than half the background concentrations.

The *E.coli* concentrations are generally much lower than the background levels. The average *E.coli* level up-gradient of the ponds is 1.2 cfu/100 mL. The exception is adjoining the middle reaches of the Makoura Stream. At these locations the increase is predicted to be about 60 – 75% of the background concentration. However, even the highest *E.coli* concentrations are likely 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 viruse, due to a lack of reliable evidence for the predicted 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 into 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. This section presents the effects of the leakage from the existing ponds. With the construction of new lined ponds the effects of leakage on groundwater quality will be significantly reduced from the levels in the data presented in this section. This section has been retained to show what the effects would be if the proposed new ponds were not consented. The maximum expected leakage from the new ponds will be significantly reduced from 2400 m^3/day to 750 m^3/day, and therefore the environmental effects of leakage from the new lined ponds will only be minimal, and will be largely confined to some minor effects on the quality of the river

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 ponds, while they continue to exist. Table 48 summarises the results of these investigations.

Table 48 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 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 in wells downstream. This could be due to the dilution effect of the leakage entering the groundwater system, as the effluent has considerably lower levels of nitrate than the up-gradient groundwater.

A one-off sampling of 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 540 m from Pond 3 (refer Distance To Immediate Neighbours Plan in Appendix C). As the direction of groundwater flow near the ponds is generally to the south – i.e., directly towards the Ruamahanga River – there will be no effects on the private bores under normal groundwater conditions.

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 changes to flowing back 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 the locality (PDP, 2006). The groundwater will be in hydraulic contact with the river and thus any pond leakage will discharge to the river.

Following decommissioning and desludging of the existing ponds, the effects on groundwater from these ponds will cease. However, when the area is restored and used for irrigation purposes, there will be minor effects as noted for the whole effluent irrigation system, but considerably less than the current effect. The new, lined ponds will have considerably less leakage than the existing ponds and a longer travel path to the river.

In conclusion, the leakage from the existing ponds has minimal adverse effects on the environment. The maximum expected leakage from the new ponds will be significantly reduced from 2400 m^3/day to 750 m^3/day (initially) and therefore the environmental effects of leakage from the new lined ponds will be less than minor. In practice, pond leakage will reduce to approximately 150m^3/day, due to blinding of the silty clay liner by the build up of sludge on the pond base.

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 nitrogen 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
- Saturation of the soils resulting in anoxic conditions and emission of odour.

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 wastewater 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 recommends 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, 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 phosphorus 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 Saturation of the Soils

The proposed treated effluent application rates are stated in Table 23 (section 6.4.3) and these rates are in excess of typical freshwater irrigation rates, which are intended to satisfy soil moisture deficits.

Spray irrigation systems (such as centre pivots) have been developed to apply water to satisfy soil moisture deficits, and for the area proposed for effluent irrigation would have a hydraulic capacity of 60L/s. This delivery rate would result in an application every 1 to 2 days, which would result in almost daily application of effluent and would not allow the soils to drain and re-aerate. Consequently, the border-strip method is proposed, which will deliver effluent at 300L/s. This delivery rate will allow a 7 to 10 day application cycle. This extended application cycle will allow the soils to drain and aerate. In addition, the land will be re-graded to avoid localised hollows where ponding would occur, particularly in the case of pond effluent containing algae, which would seal the soil and exacerbate the ponding. When there is significant rainfall, effluent will not be applied to land, which will reduce the potential for saturation of the soils.

8.4.5 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. Border-strip irrigation has been selected as the irrigation method because the 7 to 10 day application cycle will allow soils to drain and to re-aerate, thus avoiding anoxic conditions and soil damage.

8.5 Effects on Air Quality

8.5.1 Air Discharges from Ponds

Odour

The treatment of wastewater is potentially odorous because of the inherent nature of wastewater. Oxidation ponds can become a source of odour when 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 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 historically have not generated odours resulting in complaints. However, an exception occurred in August 2005 when odours (mainly from Pond 1) varied in intensity over a period of a week. The odour was related to a drop in dissolved oxygen (less than 2 g/m^3) and was addressed at the time by remedial measures, including the introduction of additional aeration and the pumping of algae rich liquid from other ponds to Pond 1. Pond 1 is at the point where desludging is required. High volumes of sludge can also exert a greater oxygen demand and reduce the depth of wastewater over the sludge – an aerobic liquid layer is needed to reduce odours. The depth of wastewater over the sludge should be greater than 1 m to provide sufficient treatment of the gases. Greater sludge digestion activity will occur during periods of warmer weather, which causes the production of volatile acids and exerts a greater demand on the pond oxygen. The new ponds will eliminate the problem of odours caused by excess sludge accumulation for about 20 years, after which sludge accumulations should be monitored annually.

Buffer areas are often provided around odour sources such as wastewater treatment plants. These are intended to prevent sensitive activities locating close to an odour source in the area where odours are most likely to cause a problem. People located beyond the buffer zone may still experience odours from time to time, but the frequency and duration of the episodes should be less and the intensity of the odours reduced. This reduces the risk of the odours causing adverse effects. The *Guideline for Design, Construction and Operation of Oxidation*

Ponds (MWD, 1974) recommends a 300 m separation distance between oxidation ponds and urban areas, and a 150 m separation distance to isolated dwellings. The nearest dwelling is about 540 m from the ponds (refer Distance To Immediate Neighbours Plan in Appendix C), which is greater than the guideline separation distances. Therefore, noticeable odours from oxidation ponds functioning normally are not expected to occur other than rarely.

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 GWRC, 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. Therefore it is unlikely that odour will be a problem when the new ponds are constructed. .

The new 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 potential for odour generation, because a key requirement in the operation of the ponds is to maintain a satisfactory level of dissolved oxygen. Hence, the overall conclusion is that the new ponds are not expected to be a source of objectionable odour.

Aerosols

There is the potential for 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 (due to wave action on ponds) and dispersion of aerosols.

However, the dispersion of aerosols from oxidation ponds is generally not an area of concern. The new ponds will also use brush and other types of aerators to promote circulation in the ponds and to supply oxygen. These aerators create a minor amount of splashing, which will have a localised effect and will not create excessive spray drift and transmission of aerosols. In addition, the distance from the new ponds to the nearest dwelling is approximately 500 m, and aerosols will not travel beyond the MDC boundary.

The proposed screen planting along the length of the Makoura Stream will also assist in reducing any potential for minor 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

Properties that could potentially be affected by odour emissions include an orchard and several residential properties adjacent to the northern boundary of the irrigation area, and residences to the west and southwest (on the west side of Manaia Rd and on Martinborough Masterton Road adjacent to the 107 ha site). The closest dwelling is located approximately 150 m from the proposed border strip area. In addition, the decommissioned ponds will be converted to irrigation of pasture, with the nearest property to this area being some 400 m to the east, across the Ruamahanga River (Refer Distance To Immediate Neighbours Plan in Appendix C).

For odours to be released during application to land, anaerobic conditions will 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 section 6.4.

In the proposed border strip irrigation system, the effluent will be piped to each border strip rather than being conveyed in an open channel type headrace, 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 treated wastewater to flow down the strip and, if there is excess, into wipe off drains. The management regime proposed for the irrigation scheme will also require that ponding be avoided.

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 (7-10 days) for re-aeration of 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 to 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.

In summary, while there is potential for odour generation from the land treatment area, the engineering design of the scheme, and operational and mitigation measures, are aimed at minimising odour. Existing border strip applications in New Zealand have shown that even when standing next to an operating border strip irrigation system (in a properly functioning plant), odour emission is negligible.

Provided that it is well operated, the proposed upgrade will not create objectionable odour beyond the boundary of the site. The risks can be effectively mitigated through the automated warning system, and ongoing monitoring and management through an odour management plan. This will be backed up with a condition requiring that the plant must not cause any objectionable odour beyond the boundary of the designated site.

Spray Drift and Aerosols

The proposed land application of treated wastewater through border strip irrigation will not create spray drift and it has negligible potential to create aerosols. The avoidance of spray drift and aerosols was one of the factors in selecting the border strip irrigation method.

Conclusion

The potential effects from odour and aerosols from the proposed border strip irrigation application of treated wastewater will be minor, and will be mitigated through planted buffer areas, an automated warning system, and an ongoing odour management and monitoring process.

8.5.3 Odour from sludge drying and sludge landfill

Sludge from the decommissioned oxidation ponds will be air dried prior to storing in the sludge landfill within the existing pond area. Air-drying should be achieved over one summer period. However depending on weather conditions, a further summer period should be allowed as a contingency.

While odour from the drying sludge is potentially an issue, experience has shown that if sludge is allowed to stabilise for two months in early summer after raw wastewater inflow is stopped, the sludge drying operation does not create odour problems. Warmer conditions in summer allow anaerobic digestion to proceed more rapidly which stabilises the sludge to a residual which has no more than an earthy, musty odour. This odour should not be noticeable beyond 50 m from a pond.

For example, at the Christchurch oxidation ponds, de-sludging of stabilised sludge has been carried out in close proximity to houses (< 200 m) without odour being a problem. Other successful examples of sludge drying on the base of ponds without odour release include ponds at Blenheim, Picton, Waimate and Pleasant Point.

Given the rural locality of the Masterton oxidation pond site, and the distance to the nearest dwelling (approximately 500 m), odour from sludge drying is unlikely to be a concern. The contract for sludge drying will have contingency provisions for the spreading of lime, if an odour release did occur.

8.6 Effects on Natural Hazards Risks

NOTE: Changes in this section from the 2007 AEE, include the construction of new oxidation pond embankments which will be engineered to higher standards than the existing embankments.

8.6.1 Earthquake Risks

The effect of ground shaking on the stability of the new pond embankments was assessed as part of the preliminary design process. 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 and when liquefaction occurs.

Seismic accelerations for stability analyses have been assessed using NZS1170.50:2004 inclusive of Amendment 2. Peak ground accelerations (PGAs) were determined using this standard with importance level criteria for wastewater treatment facilities. Using this approach resulted in a very high PGA of 0.61g and it is not feasible to design the embankments to withstand such high accelerations. Other aspects of the wastewater conveyance system are likely to be damaged to the point of failure in an earthquake generating these higher PGAs and therefore having the ponds remaining operational is unlikely to be the highest priority. Damage to main sewers will not allow wastewater to reach the MWTP and there will be overflows to local streams of raw wastewater in such an event.

In this regard, an assessment of the potential effects of existing pond embankment failure on the ecology of the Ruamahanga River was carried out in 2004 by NIWA. The study concluded that recovery of river ecological communities was likely to be relatively rapid. While stability of the ponds under more frequent, lesser earthquake magnitude events is desirable, designing the embankments to withstand large events is not likely to be necessary, nor viable. Furthermore, repairs to damaged pond banks can be actioned relatively quickly using standard earthmoving equipment.

In the previous geotechnical analysis of pond options at the site, PGAs modelled were 0.18g for a 50-year return period and 0.25g for a 100-year return period. These return periods were also applied to the current proposal.

a) Liquefaction does not occur

The stability analysis results are summarised in Table 49. Analyses indicate that the bund equals or exceeds the accepted FOS of 1.1 for the seismic case at PGAs of 0.18g and 0.25g. These FOS indicate that the proposed design will be adequate, assuming liquefaction does not occur. The FOS could be further improved by lowering the embankment slope angle, or adding an external toe load to the embankment.

Table 49 Seismic Stability – Without Liquefaction

PGA	Location	Description	FoS
0.18g	Internal	Bund crest into pond	1.6
0.18g	External	Embankment face (< 0.5 m)	1.2
0.25g	Internal	Side of bund, far into pond	1.2
0.25g	External	Embankment face (<0.5 m)	1.1
0.25g	External	Bund crest, into stream	1.1

b) Liquefaction occurs

For this site, it is anticipated that the granular materials (the channel deposits – sands and sandy gravels) are potentially liquefiable. The results of stability analyses are summarized in Table 50. The results indicate that if liquefaction of the sandy gravels occurs beneath the embankment, the embankment could fail at some location along its length. In order to predict likely displacements following liquefaction, a post-liquefaction analysis was run.

Table 50 Seismic Stability – With Liquefaction

PGA	Location	Description	FoS
0.18g	Internal	Failure under bund into pond	0.4
0.18g	External	Toe of bund (pond side) through to Makoura Stream	0.3
0.25g	Internal	Failure under bund into pond	0.3
0.25g	External	Toe of bund (pond side) through to Makoura Stream	0.2

Predicted liquefaction induced lateral spread displacements (DLL) were calculated for the embankment. The DLL was predicted for an earthquake of Richter magnitude 8.1, at a distance of 5.2 km, and a smaller event from another source, of magnitude 7.5 at a distance of 10 km. The assumptions of earthquake magnitude and distance made here should be refined by a site specific seismic hazard study as part of detailed design.

For a magnitude 8.1 earthquake the DLL ranges from 4 to 10 m, and for a magnitude 7.5 event, from 0.5 to 7 m displacement. These deformations risk breaching the pond embankment, by either a drop in the embankment crest allowing overtopping, or by the lining system being ruptured and allowing the pond wastewater to flow out through the embankment.

While the potential effects of pond embankment failure on the ecology of the Ruamahanga River are not catastrophic, options to reduce the susceptibility to failure by liquefaction will be explored in detailed design. Such options would include excavation of localised areas of liquefiable sub soils or compaction of underlying strata.

Fault Rupture

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 a breach will be likely to result. Such damage can be repaired relatively quickly using standard earthmoving equipment and local materials.

8.6.2 Flooding and Erosion Risks

NOTE: Changes to this section from the 2007 AEE, include the removal of part of the existing oxidation pond embankment and stopbank adjacent to the Ruamahanga River, and deletion of the major erosion protection rock and replacing this with a planted buffer adjacent to the existing ponds, and minor bank protection work.

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 floodwaters are confined by a stopbank north of the pond embankments, and then by the pond embankments themselves. These banks protect a considerable amount of low-lying land in the Homebush area.

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 Ruamahanga. 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 existing Pond 1, where the embankment around the pond restricts flows across the outer side of the bend. With the construction of the new ponds, most of the existing pond embankments will be cut down to the 2-year flood level to allow floodwater to spread over the area of the decommissioned ponds. This significantly widens the width of the flood plain, which will result in lower flood levels. The existing northern stopbank will be retained to provide flood protection to the new ponds that will be located behind the existing stopbank. Floodwaters will be quite strong on the berm land and concentrated at the northern stopbank. To provide protection to the stopbank a planted zone of poplars, alders and willows at the river's edge will be required, with shrub willows or tall grasses on the stopbank face to retain a good cover.

It is proposed to upgrade the stopbank on the true right side of the river upstream of the existing ponds and adjacent to the ponds, to provide protection against the 1 in 100 year return event, which is considered an appropriate level of protection for the amount and value of the asset being protected. Otherwise, the management of flooding risks in the wider area is unaffected by the upgrade proposal.

Further modelling of the Ruamahanga River, comparing the pre and post upgrade of the stopbank upstream of the existing ponds, shows that the estimated increases in river levels for a 100-year flood are 60 mm near the oxidation ponds, and increase to 80 90 mm downstream of the oxidation ponds to Wardells Bridge. Given the small increase in river levels because of the stopbank upgrade, there will be a negligible increase in flood risk at properties on the left bank opposite and downstream of the oxidation ponds. Floodable land is on the lower terraces and flood flows should be contained within the stop banks.

The modelling incorporated a peak flow in the Ruamahanga River with a 100-year return period, combined with flood flows in the Whangaehu River with a 2-year return period, and in the Waipoua River with a 10 year return period, all occurring at the same time. This is the same approach used in the Wellington Regional Council report "The Upper Ruamahanga River & Floodplain Investigation; Phase 1 - Issues" (1995). For the Whangaehu, Waipoua, Kopuaranga and Ruamahanga Rivers to have coinciding 100 year floods would give a total flow of 1319 cumecs and would be a 0.02% or 1 in 5000 year flood event at Wardells Bridge.

To summarise, the upgrade to the existing stopbank will provide protection to the MWTP site against a 100-year flood. Decomissioning the existing ponds will create a wider floodway and avoid the erosion issues associated with the existing pond banks.

8.6.3 Effects of Flood and Erosion Protection Construction Works

The erosion protection works include the establishment of a planted buffer zone on the embankment adjacent to the Ruamahanga River. The effects of these works are primarily short-term and relate to construction activities. Generally, the planting will be restricted to the embankments, and will not encroach into the river channel. As such, the construction effects will be minor, with the possibility of some effects of disturbance of the river channel during the preparation of the bank, with minor effects on water turbidity.

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 agricultural and point source discharges (i.e., nutrient enrichment, sediment loads) and higher summer river temperatures.

The proposed changes to the discharge regime, including eliminating the direct summer low flow discharges and a significant reduction in pond leakage, 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 in macro-invertebrate indices reflecting low pollution species.

8.7.2 Fish (effects from discharges)

As highlighted in section 5.3.3 above, there is a diverse range of fish species present in the Ruamahanga River, including native and exotic species (brown trout), as well as some exotic pest species such as perch and tench. Diversity is greatest in the Upper Ruamahanga, but GWRC’s own studies have shown that low flows and associated elevated water temperatures are the main factor restricting the distribution of fish species in the middle to lower Ruamahanga River. Fish species known to be present in the Ruamahanga River catchment are presented in Table B1.4, in Appendix B, sorted by the maximum distance each species has been found from the mouth of the River. Distribution maps in Appendix B (Figures B1.5 – B1.7)[62] show that the diadromous torrent fish, koaro, and common bully are found in the upper Ruamahanga (and tributaries such as the Waingawa) and close to the river mouth, but not in the middle to lower-middle reaches that are known to be affected by low summer flows and high water temperatures. This shows that these species are able to pass through the main stem of Ruamahanga (including those sections most impacted by the existing discharge) for both upstream and downstream migrations. A similar distribution pattern was presented for brown trout (Figure B1.8 in Appendix B) again suggesting that they avoid the lower-middle reaches in preference to areas above the Waingawa confluence, which have better habitat (through riverbank vegetation cover and cooler water temperatures).

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[62] Note these distribution maps constructed from records retrieved from the NZFFD December 2005, superseded similar maps prepared by Cawthron Institute for Greater Wellington in 2001.

It could be argued that the dearth of fish species present in the lower-middle Ruamahanga main stem is indicative of the presence of a pollutant or pollutants. However, the data presented on invertebrate populations and densities do not support this argument. High populations (and proportion of total invertebrate populations) of EPT[63] species (indicative of good water quality) are present at Wardell's Bridge, within the mixing zone of the current discharge. In particular, the presence of high numbers of Deleatidium is significant because this species is very sensitive to toxic contaminants such as ammonia[64]. Thus, the high populations of Deleatidium is good evidence that water quality immediately downstream of the existing discharge will not have a significant effect on either native or exotic fish populations. This supports the hypothesis that habitat conditions, low flows and high water temperatures, are the most likely cause of restricted fish distribution in the middle-lower Ruamahanga main stem.

Bowie and Henderson (2002) studied the distribution of Short-Jawed kokopu (Galaxias postvectis) at 50 sites in the Mangatainoka, Makakahi, and Ruamahanga catchments of the northern Tararua Ranges. Short-jawed kokopu were not recorded in any of the Ruamahanga sites, despite there being comparable habitat to the other two catchments surveyed. Bowie and Henderson commented that a barrier to migration in the lower catchment was the most likely reason for the apparent lack of short-jawed kokopu in the headwaters. While they suggested that "some pollutant" in the lower reaches may be responsible, this diadromous species is the only category A fish in the Department of Conservation's threatened species list[65], and it is noted that sightings have usually been made in smallish streams surrounded by unmodified broadleaf/podocarp forest, and in pools with very thick vegetation cover. High summer water temperatures and lack of cover in the lower-middle Ruamahanga are not likely to be conducive to their survival.

Watts and Perrie (2007) recently reported on instream flow issues as the first stage of the Lower Ruamahanga instream flow assessment. They proposed two (relevant to the MWTP Upgrade) instream flow objectives for the Lower Ruamahanga, being:

- to ensure adequate water depth for migratory fish passage and recreational boating; and
- to ensure sufficient habitat is maintained for fish, in particular brown trout.

Watts and Perrie document the ecological values of the Lower Ruamahanga with respect to fish and note that low flows can have an indirect effect on these values, due to further impairment of water quality during times of low flow. They also noted that habitat quality decreases with distance downstream in the Ruamahanga mainstem, and that there are a number of reasons for this, including a large number of point source discharges, as well as non-point source (diffuse) discharges from the high degree of agricultural land use. The fish experts present on a field trip organised by GWRC as part of the instream flow studies, considered that low dissolved oxygen, high water temperatures, and nutrient enrichment were their key concerns.

As Watts and Perrie note, there is no continuous dissolved oxygen or water temperature data. However, it should be emphasised that there is no evidence that the current MDC discharge is linked with either low DO or high temperatures, and the effect of the existing discharge on nutrient loads is minor compared with other sources (though major at low flows). The proposed upgrade will remove Masterton effluent-derived nutrients from the river at the time when river flows (as a source of dilution) will be at their lowest.

The information presented in section 5.3.3 indicates that low flows and high summer water temperature in the mid-lower main stem of the river are the main factors influencing fish distribution and habitat in the Ruamahanga, and that the existing MWTP discharge has minimal effect.

Overall, the existing discharge appears to attract eels[66] and does not have any noticeable adverse effects on fish in the river. While it is proposed to remove the direct discharge to the Ruamahanga when fish could be expected to be most affected (during low flow periods, particularly in summer), it is considered that any potential adverse effects on fish species and their habitats will be less than minor.

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[63] EPT = Ephemeroptera (mayflies), Plecoptera (Stoneflies), Trichoptera (Caddisflies).

[64] More so than the native fish species mentioned above - see Table 13.6 in Hickey 2000.

[65] Refer to http://www.mfe.govt.nz/publications/ser/ser1997/html/chapter9.7.3.html

[66] An abundance of eels have been observed around outfall and in the ponds.

8.7.3 Effects on the ecology of diverting Makoura Stream

The effects of the proposed diversion of the Makoura Stream on its water flow and natural ecology will be limited to the temporary effects associated with the construction activity, and the short period within which habitat becomes established in the new stream channel. These temporary effects are considered to be minor and can be managed through conditions of resource consent.

The WRFP identifies the Makoura Stream, both upstream and downstream of the discharge, as requiring enhancement for habitat purposes.

This proposal will result in some short-term and minor effects associated with loss of the current streambed. This section of the stream should provide good macroinvertebrate habitat, and habitat for a number of freshwater fish species. Earlier research (Bioresearches, 2002) indicates that the existing discharge does not show any noticeable adverse effect on the fish life and there is anecdotal evidence that the discharge appears to attract eels (which have been observed around the outfall and in the oxidation ponds). One of the recommendations proposed is that an ecologist be on site at the time of the stream diversion to assist with hand-removing and relocating freshwater fish species into the newly formed channel. It is also recommended that the stream diversion be undertaken in a manner that temporarily retains a small residual flow of water to allow freshwater fish species to move out of the old stream channel. It is recommended that the filling of the old stream bed be undertaken from the north end moving south, to allow any freshwater fish the opportunity to seek new habitat downstream.

To mitigate for the short-term adverse effects associated with the stream diversion, the new section of the stream will be created in a manner that is consistent with the natural meander and flow environment of the existing channel. Large rocks will be placed in suitable sections of the new stream channel to replicate natural stream channel and habitat, and the riparian margins on both sides (unless constrained by embankment and flood protection works) of the newly reinstated stream will be planted and permanently retired from grazing. An environmental management plan for the new stream channel will be prepared consistent with GWRC's '*Restoration Planting: A Guide to Planning Restoration Projects in the Wellington Region*'.

Revegetation will have long-term positive effects on the local ecology of this degraded stream through providing better long-term habitat and water quality improvements. The revegetation will also assist in the ongoing management of nutrients entering the Ruamahanga River. Consistent with Policy 4.2.33 of the WRFP, this proposal will ensure that any adverse effects on plants, animals or their habitats are confined to a small area, and are temporary, and the area will naturally re-establish habitat values comparable with those prevailing before commencement of the activity. Best practice techniques will be used as part of the stream diversion. The new diversion will be formed prior to the actual diversion, and will be planted prior to actual stream flow diversion.

The effects of diverting the lower section of this permanent stream will be no more than minor, and the proposal to retire and revegetate the riparian margin of the newly reinstated stream will lead to long-term enhancements in water quality and habitat values. This situation, combined with the proposal to move the outlet pipe from the Makoura Stream, will have beneficial effects on habitat and water quality effects.

8.7.4 Effects on Indigenous Vegetation (Remnant Bush)

The vegetation that would be removed as part of the Makoura Stream diversion is largely exotic, the habitat is of low value and suitable mitigation has been proposed. The proposed diversion would result in the loss of a small number of cabbage trees, some smaller kowhai trees, and some smaller areas of riparian vegetation dominated by flax, rushes and native ferns.

There is a stand (approximately 3 ha) of remnant alluvial plain kahikatea (*Dacrycarpus dacrydioides*) to the north of the proposed maturation ponds. This Makoura Stream Bush has been identified in a number of biological inventories of the region, including Fuller & Wassilieff (Biosites WERI) and the Wairarapa Plains Survey Report for the PNAP (DOC 2000) which identifies this remnant as Site No. WP0712. The PNAP report includes the site as an area having 'moderate' biological importance. Inclusion in the PNAP means that the remnant is considered as being significant and worthy of protection, although not a Recommended Area for Protection. The Makoura

Stream Bush is regularly grazed by stock and there is no regeneration of the kahikatea forest occurring. Although heavily grazed and with no regeneration, the remnant is in good condition and was observed to be undergoing regular possum control. Matai, tawa, pukatea and titoki trees also occurred within the remnant. There is also a 3.5 ha kahikatea marginal strip protected by the Department of Conservation along the upper section of the Makoura Stream, north of the existing ponds.

The revised proposal for Secondary Pond No.2 has been designed to avoid the other small stand of these kahikatea trees close to the main forest remnant. Accordingly, the proposal would not require the loss of any remnant kahikatea trees. The stream diversion is downstream of the kahikatea stand which will ensure any potential hydrological changes associated with the stream diversion would not affect the remnant trees. Although the remnant kahikatea stand is located within the proposed border-dyke land disposal area, this system has been designed to ensure that volumes of irrigation are spread over a wide area (75 ha with the possibility of an additional 52 ha on the balance of the 107 ha site) and would not cause any permanent adverse effects on soil quality (refer section 8.4 above). Although kahikatea are sensitive to hydrological changes, this species can respond well to increases in nitrogen and phosphorus. Accordingly, no adverse effects are anticipated to the health of this remnant stand of trees.

The proposed formation of Primary Pond 1A will require the removal of approximately 10 older isolated totara and titoki trees and one matai. With the exception of 3-4 trees suffering from die-back associated with stock and possum browsing, the majority of these trees are in relatively good condition. These isolated trees are not considered to be significant indigenous vegetation on their own, nor do they provide significant habitats for indigenous fauna, and their removal will have no more than minor effects on the site's ecology. Two smaller stands of older totara and titoki trees in the vicinity of Primary Pond No.1A have been retained through a redesign of this pond.

A small area of scattered treeland adjacent to the Ruamahanga River is proposed to be removed as part of this proposal for riverside borderstrip irrigation in this zone. This remnant is dominated by titoki, with tawa, totara, mahoe and occasional kahikatea. Similar to other remnants in the area, this vegetation is heavily grazed and a number of the trees are suffering die-back as a result of possum browsing, ongoing cattle trampling and associated edge effects. It is proposed that the southern portion of this remnant, which is in better condition, be excluded from the borderstrip irrigation and retained as both habitat and to assist with visual screening of the site from the river.

8.7.5 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
- 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 construction of new ponds, even with the slightly reduced buffer distances to nearby dwellings.

Mosquitoes and midge nuisance are often perceived to be a consequence of constructing open water ponds near to residential development. In fact, properly loaded ponds do not have insect problems.

MDC will adopt a mix of appropriate pond design and other insect management techniques, including:

- Low organic loading in the maturation ponds which will help maintain aerobic conditions (mosquitoes breed in anaerobic conditions),
- Maintenance of DO levels >2 g/m^3 in the primary ponds (by mechanical aeration and natural wind mixing) which will help maintain surface aerobic conditions,
- Gently sloping embankments and shallow areas will be minimised in pond design (shallow areas enhance midge habitat),
- Artificial insect control agents (for example, Malathion) will be used if required.

8.7.6 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 will 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 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 and to pasture. Refer to section 8.11.4 for waterfowl management.

In conclusion, the new 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.

8.7.7 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 the summer period of low flows. Makoura Stream habitats will also be improved. The new 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. The proposal 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.
- Discharges will only occur at times when there is little recreational use and furthermore, discharges at threshold flows (just above median) will only occur for a very limited time.
- The health risk from leakage from the current ponds is very low. Nevertheless, the decommissioning of these ponds and their replacement with silty clay lined ponds will further reduce health risk at lower flows.
- A significant reduction in pond leakage will further reduce the potential for periphyton growth downstream of the ponds.
- 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.
- Effects on colour and clarity at above median 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

There are several requirement of the RMA 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 part of the upgrade design process.

As discussed earlier in this report (section 5.6.3), 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
- Leakage from the new ponds will be minimal compared to the current ponds. This discharge is in any event via 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
- There is a potential to further increase discharges to land in the future if necessary.

Ways in which MDC has sought to address issues raised by tangata whenua in relation to the wastewater upgrade are summarised in Table 51 and Table 52.

Table 51 Action in Response to Tangata Whenua Concerns

Nº	Concern/Recommendation	MDC Action
1	MDC continues 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.
2	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 full time and part time land disposal. It has also identified water quality and wastewater standards to apply if there is any ongoing discharge to water.
3	MDC addresses 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.
4	MDC to pass a Trade Waste Bylaw. This will include a requirement for 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.
5	MDC in partnership with the Maori community approaches 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.
6	MDC adopts 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 a specific phosphorus target was developed for the length of the Ruamahanga River affected by the discharge. These guidelines have also received specialist input from NIWA.
7	MDC addresses the Maori communities' concerns in relation to the diversion of the Makoura Stream.	MDC has proposed riparian planting along both sides of the realigned Makoura Stream. The new stream will be designed and formed to ensure habitat conditions are maintained through natural contours, stream planting and riparian protection. An ecologist will be on-site to ensure freshwater species are transferred to the newly formed channel and that other freshwater species have an opportunity to move downstream prior to filling of the old stream channel.
8	MDC addresses the Maori communities' concerns in relation to the kahikatea stand and smaller remnant trees across the site.	Secondary Pond No.2 has been redesigned to avoid an additional small remnant of kahikatea trees to the south of the large kahikatea remnant. Primary Pond No.1A has also been redesigned to retain a small stand of totara and titoki trees to the north. In addition, the proposed land treatment area has also been revised to retain two other stands of remnant trees, including kahikatea, totara and tiotoki adjacent to both the Makoura Stream and the Ruamahanga River.

Modified from Papatuanuku Te Matua O Te Tangata: Consultation Document for Masterton District Council's Sewage Upgrade (Burge, 1997b)

Table 52 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 1 and 2 in Table 51
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 was 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 and section 8.4).
F	*Concern that a land-based disposal system may create offensive odours.*	Prevention of odours is considered essential and is addressed in section 4 and section 8.5)
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 and section 8.5)
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.*	Existing ponds will be decommissioned. Also, MDC has examined the flood risks and proposes additional erosion and flood 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 8.2) 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.
K	*Diversion of the Makoura Stream*	Iwi were invited to inspect the affected parts of the Stream with representatives of MDC to gain a better understanding of the affected area and actual works proposed. As described in section 8.7 and 8.10.7 it is considered that diverting the Makoura Stream will have less than minor adverse effects on natural ecosystems and existing habitats and water quality will be maintained in the long term. The design of the stream diversion (including construction) ensures additional indigenous vegetation will be retained and fish habitats will be suitably provided for. In addition, the proposed remedial treatment is anticipated to enhance existing amenity values associated with the stream and overall, the proposed stream diversion is considered to maintain the quality of the Makoura stream environment.

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 new oxidation ponds will be constructed from natural materials (i.e., grassed earth embankments) and have a lake-like appearance, sitting comfortably into the primarily intensive agricultural landscape, set back from the curve of the river against the base of the rolling hills.

While the linear edge of the proposed 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 will be 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 are similar to farm sheds and the like.

The relocation of the treatment ponds further north, and away from the edge of the river, will have the benefit of reducing their visibility from elevated areas to the east (although such views are presently limited by topography and vegetation).

Riparian planting will be provided along the riverside of the old pond embankment, 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, and with the proposed upgrade a 60 m wide planted buffer will also be established. 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 will also 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 existing 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 existing 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). The new ponds will be constructed some 300 m to the north, which will reduce their visual impact.

In summary, the new 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[67], 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. The study was updated with the selection of the option of new oxidation pond and land treatment scheme (BERL 2008).

The study found that the residents of Masterton have relatively low incomes compared to similar districts and are marginally more deprived (relative to New Zealand averages) according to the Ministry of Health's Index of Deprivation. Sewerage rates in Masterton are currently relatively low, while rates overall are comfortably within the range of comparator regions.

While it was accepted that upgrading the MWTP will require some increase in rates, it was important that such rates were comparative with rates in similar districts. BERL's analysis supports the MDC's preferred scheme of constructing new ponds and land treatment, with the potential for additional land treatment to be added in the future. The scheme would take Masterton's total rates to the lower middle of the comparator range in dollar terms. The sewerage component, in dollar terms, would remain within the range for that component as compared to other regions but would be above the average. The cheaper schemes of upgrading the existing ponds leave both the total rates and the sewerage component at the lower end of the range of the comparator regions.

These options do not suggest an affordability problem relative to other districts in dollar or percentage of income terms. In addition, as incomes in the region are expected to be flat over the forecast period, or grow just below the national trend, affordability is not expected to improve.

The affordability analysis concludes that MDC's proposed option, being the more expensive of the four options reviewed, does not raise serious affordability issues for the Masterton community. Compared to the existing ponds options, the new pond scheme would:

- deliver substantial performance benefits
- leave the District's total and sewerage component of rates comparable with other districts (including some with similar levels of relative deprivation) in dollar terms
- put the proportion of income spent on total rates at the middle of the comparator range and the proportion due to sewerage rates towards the upper end of the range.

8.8.5 Noise

MDC carried out a noise level survey on 20 July 2004 to assess the noise effects of the brush aerators. Noise measurements were taken and assessed in accordance with the relevant New Zealand Standards at eight sites with the aerators operating and with the aerators turned off.

Noise measurements at the boundaries of the treatment plant site while the aerators were operating indicate that the sound produced by the aerators meets the noise limits specified in the Masterton District Plan (MDP).

The MDP (operative June 1997) states:

B.7.5.2 The following noise limits shall apply to all activities in the district:

> *(a) All activities, except within an industrial area and audible bird scaring devices:*
> *No activity may generate noise which exceeds the following limits measured at or outside the boundary of the site upon which the activity is being conducted:*
> *55 dBA L10 7am-7pm daily*
> *45 dBA L10 7pm-7am daily*

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[67] Questions of cost and affordability are relevant to the whether an option is the Best Practicable Option.

These standards have been carried over into the proposed Wairarapa Combined District Plan.

The noise measurements at the boundaries of the treatment plant site while the aerators were operating (42 dBA, 41 dBA and 37 dBA) were all below both the nighttime and daytime noise limits of the operative and Proposed District Plans.

8.8.6 Traffic and Parking

Currently, a part-time operator who attends on two or three occasions per week operates the treatment plant. The MWTP upgrading will result in the requirement for a full time operator. There will be little change in everyday traffic movements because of the treatment plant upgrade.

Parking will be provided at the new operation building. There may be a greater demand from visitors wanting to view the operation from time to time, but sufficient parking will be provided on site, and in the vicinity, to accommodate these intermittent visits without creating any adverse effect.

8.9 Effects of Construction

8.9.1 Introduction

The construction of the new oxidation ponds and land treatment scheme using border strip irrigation, involves the excavation of significant quantities of soil and has the potential to cause nuisance to surrounding landowners unless properly managed.

The mitigation of the effects of projects that involve significant quantities of earthworks is well understood by MDC, Beca and the civil contractors who are likely to be selected. Experience with other similar projects at Oamaru and Blenheim shows that these construction works can be carried out with minimal temporary effects on neighbours and the environment. The contractor selected for this project will be required to have the experience and resources to undertake the work in an environmentally sustainable manner.

Prior to construction, the contractor will be required to complete a Construction Management Plan (CMP) that identifies procedures for minimising potential construction effects on the environment. The CMP approach is standard industry practice. The main issues associated with large earthworks usually include the generation of dust, noise and vibration, increased traffic movements, and sediment runoff, and the handling and storage of hazardous materials such as diesel. The contractor will be required to prepare a draft CMP containing a description of the works, the construction programme, a Consents/Permits Register, a list of key personnel and communications protocols, measures to mitigate potential adverse effects, proposed staff induction and training, a Complaints Register, and an appropriate monitoring and audit programme. Subordinate plans addressing specific issues (e.g. erosion and sediment control) will also be prepared. The CMP draft will be submitted to MDC and the Engineer for approval, at least one month prior to construction commencing. This draft will be reviewed and comments given to the contractor for inclusion in the final CMP. The final document will be signed off by MDC and the Engineer before construction commences.

In conclusion, the temporary effects caused by the earthworks can be mitigated by standard management and contractual procedures.

8.9.2 Traffic

All heavy vehicles will access the site from the south using either of the access roads from Masterton-Martinborough Road. It is intended that the western-most of the two access roads will be used predominantly, which will minimise effects on neighbours.

Vehicle movements to the treatment plant site will increase marginally during the construction period, however the majority of the construction traffic will be within the MWTP site, including the transport of soil and removal of material from the borrow area on the terraces of the 107 ha site. During the first few weeks of the contract, the contractor will establish the site facilities (including huts, workshop, construction equipment etc). These facilities and construction equipment will be removed at the end of the contract.

Increased traffic in the morning and evening will also occur because of workforce and supply vehicle movements.

Material needed for the pond and border strip construction will be mainly sourced from the 107 ha site, thus minimising bulk cartage from offsite, but rock for the outlet diffuser constructed in the river bed will need to be carted to the site.

8.9.3 Noise and Vibration

Heavy machinery will be required for the removal, stockpiling and re-compaction of pond construction materials. While these activities will likely be intermittent and of relatively short duration, some vibration and noise nuisance from the use of heavy machinery at the site could potentially affect neighbouring properties during the construction period.

The contractor will be responsible for the selection of machinery, which will likely include light commercial vehicles, off-road trucks, bulldozers, excavators, motor scrapers and compaction equipment.

Best practice measures, which will be contractual requirements and a condition of the designation, will include:

- Restricting construction activities to daylight hours between Monday and Saturday, and not working on public holidays (except in an emergency).
- Adequate muffling of all machinery used on site.
- Locating the machinery warm-up areas and site facilities well away from neighbours.
- Complying with the noise construction standards in NZS6803:1999 “Acoustic – Construction Noise”.

8.9.4 Dust

Dust may be generated at the site, particularly during dry, windy conditions, because of earthworks associated with the construction activity and increased vehicle movements within the site. Finer portions of the sandy/clay loams could be transported by high winds to neighbouring properties, during dry conditions.

Best practice measures, which will be contractual requirements and a condition of the designation, will include:

- Regular watering of exposed surfaces within the site, particularly during dry windy conditions, and ceasing operation if necessary until the site is sufficiently wetted to suppress dust.
- Restricting traffic speeds within the site.
- Where possible, covering loads of excavated soil when conditions dictate.
- Locating stockpiles of soil on the eastern portion of the construction site and at least 50 m from boundaries.
- Restoration of exposed land areas as soon as possible after work is completed.
- Minimising areas of exposed land

8.9.5 Sediment Runoff Control

Sediment-laden stormwater runoff can be generated as a result of earthworks and groundwater control associated with construction. Any runoff from the irrigation construction site could discharge to Makoura Stream or the Ruamahanga River. However, the potential for sediment runoff will be mitigated to a large extent by natural factors including a relatively low summer/autumn rainfall with infrequent high intensity events, and a relatively flat terrain.

The contractor will be required to prepare an Erosion and Sediment Control Plan, using standard best practice techniques, and submit this to MDC and the Engineer for approval prior to commencement of construction.

Best practice measures, which will be contractual requirements and a condition of the designation, will include:

- Construction of temporary bunds to contain any stormwater runoff to the stream or river.
- Use of sediment traps and other appropriate stormwater treatment devices.
- Avoiding earthworks during wetter periods.
- Techniques for minimising disturbance of existing vegetation as well as weed control.
- Rehabilitation of site after construction is complete.

It is worth noting that the new ponds will cover a significant area of the construction site and any rainfall will be effectively contained within the banks of the ponds.

8.9.6 Hazardous Substances and Construction Wastes

The transport, storage and use of hazardous substances and the generation of wastes during construction could have potential adverse public health and environmental effects. Best practice measures, which will be contractual requirements and a condition of the designation, will include:

- Bulk fuel storage (i.e. petrol, diesel, oil), if required on site, will be limited to one location and will need to be sited at least 20 m from a watercourse or external boundary. The fuel/oil storage area will be provided with an impervious bund with a volume of 120% of the largest container.
- Sealed waste bins will be provided for the collection of oil rags, oil filters, etc. Waste drums will be transported offsite to an appropriate receiving facility.
- The storage of hazardous substances will comply with the requirements of the Hazardous Substances and New Organisms Act and the requirements of the Proposed Wairarapa Combined District Plan.
- A Spill Emergency Response Plan will be prepared by the contractor prior to the commencement of construction.
- Covered rubbish and recycling bins will be provided for general refuse. These bins will be regularly emptied and moved offsite to an approved facility. No burning of waste materials will be permitted.
- Portable toilet facilities will be located away from traffic areas and further than 10 m from a watercourse and external site boundaries.

8.9.7 Archaeological Artefacts

No items of cultural or historic significance have been noted, during consultation or in the Cultural Impact Assessment, that could be directly affected by the construction of the ponds and irrigation scheme.

The Contractor will be required to provide for the accidental discovery of taonga and koiwi in the CMP.

8.10 Conclusions

The main conclusions of the assessment of environmental effects are as follows:

8.10.1 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.

  The construction of new silt-clay lined ponds will significantly reduce leakage.

- **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.

8.10.2 Pathogens and Microbiology

- **Reduced 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.

8.10.3 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 at certain 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, as 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.

8.10.4 Colour and Clarity

- **Improved colour and clarity in the river**

  The proposed quality of effluent and the intermittent nature of the 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 (300 m) when discharge does occur. The reasonable mixing and full mixing zones will be moved upstream of Wardells Bridge.

8.10.5 Nutrients and Algal Growth

- **Reduction in the build-up of undesirable biological growths in waterways**

  The proposed upgrade will result in a significant reduction in the contribution of nutrients to 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.

8.10.6 Aquatic Ecosystems

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

  While the river ecosystem is generally in a healthy condition in 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.

8.10.7 Recreational and Aesthetic Amenity Values

- **Improvement of the river's recreational values**

  The proposed effluent discharge regime will improve the 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. There will be no discharges to the river during those times when the river is used for recreational purposes.

- **Enhancement 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 in warm summer periods when the river is most valued for visiting.

- **Diversion of Makoura Stream**

  No significant adverse effects on recreational or amenity values are anticipated to occur from the diversion of the Makoura Stream. The Makoura Stream is not recognised as being of any significant recreational value, and is generally contained within private property. Comprehensive stream, embankment and riparian revegetation works are proposed along the diverted part of the stream to ensure the existing natural stream systems are maintained. Indeed, the proposed riparian planting will enhance the ecological and amenity values of this section of the stream, which is presently open to cattle grazing.

  The proposed upgrade is located entirely on private land and will not limit access to any public spaces or water bodies. As a council-owned property, provision for public access could be made in the future, insofar as it did not affect the operational and safety requirements of the Masterton Wastewater Treatment Plant.

- **Irrigation**

  Effects on aesthetic and amenity values from the proposed land-based disposal system are comparable with other rural irrigation systems. Sections 8.5.2 addresses the potential odour issues, concluding that the proposed irrigation system would create no off-site odour, and would be carefully managed and monitored to identify and promptly address any potential problems. No odour issues have occurred at similar irrigation schemes in New Zealand.

Visually, the effects of the proposed border strip irrigation system would be minor, and would not be inconsistent with the visual effects of pasture cropping for baleage that occurs in many rural locations. From off-site, the irrigation area would appear as pasture, with the low 30 cm high grassed dykes providing a broadly spaced geometric pattern. Only parts of the land disposal area would be visible from off-site, and only from a few properties in the vicinity, as topography and existing vegetation screen most of the area.

Section 8.11.3 describes how remedial and screen landscape planting will be carried out to mitigate potential adverse effects on visual aesthetic and amenity values. Commonly, wastewater plants have a buffer of trees planted around the perimeter of a site, which was originally proposed for this scheme. However, consultation with neighbours indicates a preference for screen planting to occur well within the site, around the perimeter of the irrigation area, to avoid shading and potential loss of other views and vistas. Given the nature of the irrigation areas, and their distance from neighbouring properties, such planting need not require large trees or thick belts, but can be in the form of a narrow “hedge” of low shrubs and plants (such as toetoe). The exact location and form of planting is expected to be determined as a condition of the designation.

Overall, the effects of the use of the additional area of land for the proposed irrigation system are considered to be less than minor, and mitigated through targeted planting and by implementation of the measures described in Section 8.5 to minimise odour issues.

- **Effects on neighbouring land**

  There may be negative perceptions associated with the treatment plant for neighbouring land. However, the actual adverse effects of the proposed upgrade on the neighbouring amenity values are considered to be minor.

  A number of private properties are located in the vicinity of the treatment plant as indicated on the Distance To Immediate Neighbours Plan in Appendix C, which shows the distances between the nearest houses and the nearest part of the irrigation area. It also shows the nearest distances from neighbouring dwellings to the proposed ponds. The majority of these properties will actually have little, if any, views of the treatment ponds and irrigation areas. This is because of the intervening vegetation and differences in elevation.

  The Distance To Immediate Neighbours Plan in Appendix C also shows the location of the groundwater bores in the vicinity, showing that the bores are either upstream from the irrigation area (in terms of the north-to-south groundwater flow), or are hydrologically separated by the river. As discussed in section 8.3.3, no existing bores would be affected by the proposed scheme.

  As detailed in Section 11, consultation has been carried out with the immediate neighbours and aspects of the upgrade proposal have been incorporated in response to concerns raised by these neighbours, including:

  - Retention of a minimum 50 m buffer area around the perimeter of the irrigation area that would be used as part of the farming operation of the land not required for the plant
  - A wider buffer area at the northern end of the site, near the end of Pokohiwi Road
  - Retention of prominent indigenous vegetation, including the 3 ha stand of remnant kahikatea, and some copses of totara and other remnant indigenous trees
  - Significant native planting along that part of the Makoura Stream to be diverted, and protection of the existing vegetation along the other sections of the stream
  - Potential for the provision of public access through the site to the Ruamahanga River and along the Makoura Stream

Cumulatively, the potential adverse effects of the scheme on the neighbouring properties are considered to be minor, and, subject to some mitigation measures, would generally maintain existing rural amenity values. The aerial photograph below is of the Taupo Sewerage Land Treatment and Effluent Disposal Scheme, which is a similar irrigation system to that proposed for the subject upgrade. The aerial photo indicates how the land based irrigation system maintains the rural character of the pastoral environment.

Aerial Photo of the Taupo Sewerage Land Treatment and Effluent Disposal Scheme (Huka Falls to the top right)

8.10.8 Tangata Whenua Values

- **Discharge of effluent on the mauri of the river**

  Tangata whenua, as kaitiaki of the Ruamahanga River, consider that the discharge of effluent directly into the Ruamahanga River affects the river's mauri. The proposed upgrade will result in the ceasing of direct discharges into the Ruamahanga River during low flows, and therefore the proposed scheme is considered to align closely with the aspirations of tangata whenua to enhance the mauri of the Ruamahanga River.

  The proposed diversion of the Makoura Stream has been designed to retain the stream's natural values and to continue to provide habitat to indigenous fauna through extensive riparian replanting. Conditions are proposed that will ensure freshwater fish species are manually transferred into the newly formed stream channel immediately following diversion. Refilling of the old stream channel will start at the north and move south to enable freshwater fauna to move downstream back to the main channel.

8.11 Proposed Mitigation Measures

8.11.1 Overview

The proposed mitigation methods are in summary:

- Improved microbiological treatment
- Significant reduction in pond leakage
- 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, which will minimise the potential for adverse environmental effects occuring during the operation of the upgraded MWTP, as discussed in following sections 8.11.2 to 8.11.4.

8.11.2 Management Plans

A management plan for the operation and maintenance of the oxidation ponds will be developed to address ongoing environmental and health risks. This plan will address the irrigation rates, storage and discharge regime, and routine operational, maintenance and monitoring activities. It will include measures to minimise risks associated with:

- Odour
- Noise
- Health
- Discharge quality (for ecosystem effects)
- Discharge to river outside of proposed discharge rules.

The pond management plan will provide a framework for MDC operators to proactively minimise the risk of nuisance odour releases or in extreme cases, a pond "crash". The plan will require the regular measurement of dissolved oxygen (DO) concentrations and chlorophyll-a (as measures of deteriorating pond performance) as well as visual inspection on a daily basis. From this information, an "index of pond health" could be derived. Regular updating of trend plots could identify abnormal changes such that potential problems could be resolved before nuisance odour was created. The Odour Complaint Response strategy will also be continued.

Recommended key pond operational parameters are as follows:

- Chlorophyll-a should normally be > 500g/m^3 and always > 300g/m^3 as an indicator of adequate algae numbers,
- DO should be normally > 4 g/m^3 and always > 2 g/m^3, when measured between 1100 and 1400 hours,
- DO be allowed to reduce to close to zero overnight, in primary ponds, to prevent grazer growth, which can consume the oxygen-producing algae, and
- Mechanical aerators should be used when DO is low or during calm, cloudy periods.

MDC already has 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 new ponds. In addition, a *Land Treatment Management Plan* has been 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 (refer Appendix F).

8.11.3 Landscape and Visual Effects

The land treatment area will contain a planted buffer zone, with the exception of the boundary with the Ruamahanga River, which already has an existing willow buffer. This buffer area is shown on Drawing C600 in Appendix D, and to be consistent with existing landscape plantings, will include the planting of predominantly willow trees around the perimeter of the border strip irrigation area to reduce the visibility of the area from neighbouring residents properties.

In addition, the riparian planting proposed along the diverted section of the Makoura Stream will be consistent with the broader Makoura Stream Care Project that has recently been established.

8.11.4 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 at the new ponds. If insects become a problem, there are a range 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 was 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[68].

If waterfowl were to become a nuisance, the MDC will work with F&G and affected landowners to address the problem. Based on experience with the existing plant, it is unlikely, however, that such measures will be required.

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[68] 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 RMA
- Consistency with Policy and Plan provisions
- Designation considerations.

9.2 Purpose and Principles of the RMA

The 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 RMA states that the purpose of the RMA 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;
- Maintain if not enhance the life-supporting capacity of the air, water, soil and ecosystems; and
- Remedy or mitigate the existing adverse effects from the MWTP 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 RMA 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 the 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 of the regional policy statement, and regional and district plans
- Other matters that the consent authority considers relevant and reasonable necessary to determine the application.

In addition, the consent authority must not grant resource consent contrary to sections 107 and 107A.

Section 8 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.

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 at present).

9.3 Policy and Plan Provisions

The District and Regional plans set out the requirements with respect to the 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 MDP 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 MDP recognises that land use activities have both direct and indirect adverse effects on the natural and physical resources of the district. The most relevant objectives and policies in the MDP relate to Infrastructure and Water Resources.

- **Importance of Physical Resources**

  The MDP 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 discharge regime, maximising the existing investment in public infrastructure, with consequential improvements in the receiving water quality and flow-on benefits for the community.

- **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 MDP 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.

- **Protection of the Land Resource**

  Objective 1 (and associated policies) seeks to maintain the productive potential of the district's 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 MDP 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 be contrary to the outcomes sought for the rural area.

- **Kaitiakitanga**

  Objective 3 of the MDP 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 has 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.

- **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 MDP contains details of flood hazard areas, including the flood potential for the Ruamahanga River.

  The MDP 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 included in 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 Wairarapa Combined District Plan

The decisions on the Proposed Wairarapa Combined District Plan (WCDP) were notified on 29 March 2008, with appeals from 14 parties received. 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 those contained within the MDP, including issues relating to the maintenance and enhancement of amenity values and the quality of the environment. Section 12 of the WCDP 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 WRFP 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 that the wastewater be disposed of totally to land, this option cannot 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 fail to achieve contact recreation guidelines (at times that will not occur because 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 will be 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 300-500 m (400 m is suggested) is considerably shorter than present and is consistent with the policy.

Policy 5.2.12 (Discharges Containing Sewage) is particularly relevant to the project. It proposes that discharges of sewage should pass through land or artificial wetlands, unless a discharge direct to water better meets the purpose of the RMA, 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 will not satisfy Maori cultural values, while a full treatment wetland will 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 of the WRFP; 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 section8.2.7.

Overall, it is considered that 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.

In addition, a number of policies contained in Chapter 6 of the WRFP specifically relate to the diversion of surface water (Objectives 6.1.1, 6.14, and Policy 6.2.15, as well as broader Policies 4.2.7 (encouragement of stream restoration and remedial works to the stream banks), 4.2.3 (working with other agencies to enable integrated management of freshwater), 4.2.33 (enabling activities with no more than minor adverse environmental effects), and 4.2.34 – 4.2.36 (avoiding, remedying and mitigating adverse effects of activities on freshwater, and consent conditions).

Upon assessment, it is considered that the proposed diversion of the Makoura Stream is in accordance with these additional provisions as:

- Makoura Stream is not recognised as containing any significant natural, cultural, recreational or heritage value and the proposed diversion will only affect part of the lower reaches of the stream, contained within land owned by MDC and not accessible to the general public;
- The proposed stream diversion is necessary to construct the proposed new treatment ponds;
- Public access could be enhanced along the stream margins;
- MDC has consulted with tangata whenua and this consultation is on-going;
- The effects of the diversion on water flow and natural ecology will be limited to the temporary effects associated with the construction activity, and the short period within which habitat becomes established in the new stream channel. These temporary effects are considered minor and can be managed through conditions of resource consent.
- The stream will be permanently retired from grazing and restored with remedial embankments to improve habitat values and water quality. This will be undertaken in consultation with the Makoura Stream Care Project, and with representatives of interested parties, such as Sustainable Wairarapa and the New Zealand Fish and Game Council, to ensure the integrated management of the restoration works with other upstream restoration projects; and
- Any effects on natural character and amenity will be temporary and the stream protection and restoration outlined above will have long-term benefits to natural character and amenity as well as habitat values.

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 became operative on 1 September 2003.

The RAQMP 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 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 RMA 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 RDLP 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 8.3 of this report provides an assessment of effects of discharges to 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 area, 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 upgrade of the MWTP is given under Section 168A of the RMA, 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 RMA.

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 8), 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 3, 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
- It 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
- 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 consents could be sought from MDC. 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 consents will not be able to clearly identify the location and purpose of the MWTP within the MDP, 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 more effectively achieved by way of a comprehensive designation.

Designation

The advantages of 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
- Is used for the existing MWTP that adjoins the additional land to be designated
- 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 and affordable treatment and disposal of sewage, and 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 3.2.5).

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. The WWP 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 an advanced 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 MDC 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 purchase of the 107 ha site by MDC in March 2007 created alternative options, which were not viable with only the 91 ha site. Construction of new ponds has been carefully considered in the past and was found not to be feasible because new ponds on the 91 ha site would have reduced the irrigation area from 75 to 42 ha. With the purchase of the 107 ha site, Council decided to re-evaluate options for new ponds and the extent of the irrigation area. The availability of gravelly fill material in the terraces at the west of the 107 ha site allows the construction of new ponds at significantly lower costs compared to hauling fill material from further away. Seven options were considered for the construction of new oxidation ponds, either on the 91 or the 107 ha sites, with various permutations developed on the sites. The options are reported in detail in Masterton Wastewater Upgrade Project: Review of Pond Irrigation Options Incorporating Additional Land (Beca January 2008). In December 2007, Councillors unanimously selected the option of constructing new clay lined ponds on the 91 ha site and developing a land treatment scheme on the remainder of the 91 ha site, with the 107 ha site being partially developed for irrigation.

The principal reasons for choosing the preferred option (Scheme 1a) were that:

- It meets Council's objectives (set out in section 3.2.5 of this report) for the upgrade project
- It is considered to be consistent with the Regional Policy Statement and the WRFP
- It will meet national receiving water quality guidelines
- It is consistent with Part 2 of the RMA, and in particular:
    - 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).
- There are a number of distinct advantages relating to retaining the use of oxidation ponds within the current WWTP site including:
    - Oxidation ponds are low energy users, have low complexity, are robust, here low operator input, and can handle peak flows from inflow and infiltration (I/I)
    - It will build upon the existing community's invested capital
    - The relatively short distance from the Masterton urban area
    - 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

- Wastewater treatment
- Sludge disposal
- Effluent disposal

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.

The high rates of infiltration / inflow to the Masterton sewerage system have a strong influence on the costs of "in-tank" type treatment options and this was the main reason for not adopting "in-tank" treatment methods. The alternative of reducing infiltration and inflow in the sewerage system is discussed in Section 10.4.4.

10.2.1 Dissolved Air Floatation (DAF) to Achieve Full Time 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 would 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 would 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.

There is one DAF plant used for tertiary treatment of domestic wastewater in New Zealand, to remove phosphorus from the Waihi oxidation pond discharge to the Ohinemuri River, which has very low flows in dry summers. This DAF unit also removes algae, which is recycled to the oxidation ponds. 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 of 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 side stream 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. 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 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 the ponds themselves provide excellent bacterial and pathogen reduction, and therefore UV disinfection would 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 treatment typically removing 95-99% of bacteria during transport through the top 1 m of soil.

UV capital costs are estimated at $1.7 million with annual operting and maintenance costs of $0.2million.

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 will 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 will provide minimal treatment benefit, but it was considered that the land passage, wildlife habitat, and landscape enhancement might provide some wider environmental benefits. However, there will 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 were 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.

10.2.5 Diversion of the Makoura Stream

Following concerns expressed by iwi about the maturation ponds being constructed over Makoura Stream and the need to divert the stream around the ponds, an alternative pond layout was considered. This involved constructing maturation Ponds 2 and 3 within the boundary of the stream and constructing Ponds 4, 5, and 6 within the decommissioned pond areas. This would have involved a two-stage construction of the ponds over two summer periods and a temporary direct discharge from Pond No. 3 to Makoura Stream until the remaining ponds were constructed following the existing oxidation ponds being decommissioned. This option was estimated to cost an additional $1 million.

10.3 Alternative Methods of Sludge Disposal

The ponds and maturation cells will typically require desludging once every 20 to 30 years. As part of the construction of new ponds, the existing ponds will be decommissioned and the sludge air dried in place.

With the previous option to upgrade the existing ponds, consideration was given to drying the sludge in geotextile bags and using it as landfill cover at the Nursery Road landfill when it is closed.

Another alternative option considered, was to screen the dredged sludge to remove debris and then directly discharge it 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 proposed method of disposal is for the sludge to be stored in a lined landfill in the decommissioned pond area, which is the lowest cost option and avoids the need to cart the sludge off site.

10.4 Alternative Methods of Wastewater Disposal

A number of alternative methods of effluent disposal were considered, including:

- Full time land treatment
- Alternative irrigation methods
- Full time river discharge
- Reducing the discharge to the river: By reducing I/I; or Buying more land ; or Higher trigger flow for discharge.

10.4.1 Full Time Land Discharge

Full time discharge to land is an alternative method of discharge, and 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 as well as others in the community, and MDC carefully considered this option. However, these full time 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 full time irrigation. However, for an average winter influent flow of approximately 17,000 m^3/day, a full time 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 MDC's property on Manaia Road or a new site to be purchased or leased by MDC. The Manaia Road site has approximately 30 ha of land potentially available for irrigation, and, assuming an application rate of 2 mm/d, an effluent volume of 600 m^3/d could be irrigated on the site. In combination with the current area at Homebush proposed for irrigation, the Manaia Block would still not provide an adequate area for a full time land disposal system. In addition, a significant disadvantage of using another site like the Manaia Road block for effluent disposal, is the additional pipeline 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 near the treatment plant is not considered 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 purchase of 107 ha of land on the west side of the Makoura Stream, the total area available for irrigation will 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 will be approximately $6.3 million. There would then be further substantial costs associated with site infrastructure and ongoing operational costs.

It should be noted that the 340 hectares would be able to cope with the average winter flows of 17,000 m³/ day. Peak wet weather flows would need to be discharged to the river or a total area of approximately 800 hectares would be needed if all effluent was to be discharged to land.

In addition, piping and pumping the wastewater to another irrigation site would present a significant capital 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 full time land disposal unaffordable for the community, and therefore not a best practicable option (BPO) for Masterton.

As outlined in Section 7, a full time land treatment scheme is also not necessary as the effluent can be discharged to the river at times of higher flows with minimal effects on the environment. However, an additional 52 ha (net area) of irrigation land (refer Potential Future Land Treatment Area on Drawing C600 in Appendix D) could be added in the future. 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 Alternative Irrigation Methods

The choice of border strip irrigation instead of spray irrigation was made after consideration of a range of factors as outlined below. While spray irrigation has advantages in some situations, border strip irrigation was the preferred method for this effluent irrigation scheme.

When spray irrigation of effluent is proposed, there are typically a number of submissions that raise concern about spray drift and aerosols causing effects on neighbours' health (in this regard, some submissions on the 2007 Masterton consent applications mentioned the effects of "spray drift" even though spray irrigation was not proposed). To allay such concerns, applicants for spray irrigation schemes typically propose additional mitigation measures such as; UV lamp disinfection, larger separation distances, and/or to stop spraying when the wind direction could carry aerosols onto residential properties, roads or recreational areas. Based on other decisions elsewhere in New Zealand, if the applicant does not offer such mitigation measures the consent authority is likely to impose such conditions.

While technical justifications can demonstrate that the risk to public health might be minor, the perceived effect of effluent sprays (which are visible) has been recognised elsewhere as a valid adverse effect. The public is familiar with how far the spray will travel from a lawn sprinkler or a farm irrigator under strong winds, and members of the public do not accept the difference in potential effects between low vs. medium vs. high-pressure sprays.

Submission 30 (to the 2007 AEE and consent applications) refers to "the lay of the land with humps hollows and changing gradients" and to "areas of heavy soil in hollows" on the Homebush site. With a spray irrigation scheme, it is not usual practice to re-grade the site to uniform slopes, because the costs for spray irrigators and distribution pipework are already significant. For clean water irrigation, the consequences of runoff to hollows and ponding are minor, and, if needed, the application rate can be readily reduced (as has been required for the spray irrigation system operated by the previous landowner). However, for effluent irrigation, runoff to hollows and ponding may lead to odour emissions, as the ponded effluent decays. This effect would be exacerbated by a more rapid build-up of algae solids in the hollows, which would increase the ponding volume and duration. One of the benefits of a border strip system, is that algae solids are well distributed down the length of the strips and do not clog the topsoil due to the alternating wetting and drying cycles and biological activity in the topsoil.

Accordingly, for these reasons, and where the topography is suitable (as is the case at Masterton), it is preferable where pond effluent is irrigated, to grade the land to uniform slopes so that ponding does not occur. The re-grading also allows runoff to be collected and directed to enhanced infiltration areas within the wipe-off drains, with surplus first-flush volumes pumped to the ponds. Such a management system would not be possible for a spray application scheme where the land is not re-graded.

A key advantage of border strip irrigation is that effluent can move down the strips and percolate into the soil at the localised rate, as dictated by topsoil moisture demand and underlying drainage characteristics, therefore this process is inherently self-correcting. Hence, it is not possible to apply more effluent than the soil's hydraulic capacity to accept, as is possible with other spray systems. Thus, hydraulic loading rates can be maximised in keeping with the key objective for this scheme that seeks to divert effluent away from the river, particularly at low river flows. Effects on groundwater in terms of nutrient breakthrough will be monitored and application rates can be adjusted for specific areas based on operating experience.

Border strip systems have been criticised because of the difficulties in automating the distribution system and measuring the flows in open headrace channels. In addition, gates to individual border strips can often leak creating permanently wet areas with anaerobic soils. To avoid these problems, a piped distribution system would be installed with bubble-up valves to individual strips which are leak-tight when shut, and actuated valves to groups of strips. This would allow the system to be largely automated, with overview inspections by an operator.

Effluent application to land systems elsewhere in New Zealand have generally been designed to the site-specific constraints of topography and soil infiltration rates. Spray systems have been used for steeper slopes (Rotorua, Levin, Whangamata and Whitianga) or where the soils are very free draining (Taupo on pumice soils). Border strip irrigation systems have been used successfully for up to 40 years, for alluvial plain locations similar to Masterton: at Templeton, Burnham, Waimate and Leeston.

A very large system has operated at Werribee (southwest of Melbourne) for over 100 years. This system handles a flow from 1.6 million people using some 4,200 ha of the 11,000 ha total area, and uses the flood irrigation method with check borders (similar to border strip). Effluent percolates slowly through the permeable soil and is collected by a network of deep open drains. The typical soil profile is a red-brown silty clay loam, with 35 % clay, 45 % silt and 20% sand. Thus, the Werribee soil profile is less permeable than at Masterton where the underlying gravel strata and proximity to the river allows for adequate sub-drainage.

Buried drip-lines would mitigate the health concerns, but application rates would be restricted and the topsoil uptake of moisture and nutrients would be reduced. In addition, the long-term performance of drip-lines handling pond effluent is uncertain. Clogging of the sub-surface soils close to the emitters would occur with higher application rates. Removal of algae prior to drip-lines would be prohibitively expensive. However, it is justified to install driplines in the perimeter buffer planted areas because the "visible effluent" effect is avoided. In addition, it would not be a major cost if the buffer area driplines had to be replaced at a future date, if clogging of the subsoil occurred.

To summarise, the border strip method has the key advantage for the Masterton site of the surface undulations being removed during the re-grading of the site. It would also avoid the common community concerns associated with spray irrigation due to spray drift. The border-strip irrigation method for oxidation pond effluent disposal has the longest successful operational history, both in New Zealand and Australia, even in soils with less favourable filtration characteristics than those at the Homebush site.

A detailed report was prepared which evaluated centre pivot irrigation for crop production, in relation to the proposed border strip irrigation scheme – refer to "Masterton Land Treatment of Wastewater" (Beca, May 2008) which is provided as a background report. This report concludes the following;

- The principal objective of the proposed effluent irrigation system, is to maximise the sustainable treatment of wastewater by passage through land, not to maximise revenue earning ability from cropping.
- A much greater proportion of treated effluent (at least three times as much during the summer months and seven times as much on an annual basis) will be applied to land by the border strip scheme, than by centre pivot irrigation for crop production.
- Centre pivot spray irrigation and cropping is not supported because it would greatly diminish the scheme's ability to reduce effluent and therefore nutrient discharges to the Ruamahanga River. That would be contrary to the stated MDC objective of maximising discharge to land.
- Permanent pasture, rather than other cropping, is strongly recommended because pasture would allow the formation of stable topsoil aggregation and high infiltration capacity required for the high wastewater application rates. Also permanent pasture is more effective at assimilating the applied nutrients and being able to accept wastewater on a year round basis.

- Baleage, or other similar "cut and carry" pasture harvesting methods, would provide useful returns to MDC. Based on the Taupo wastewater irrigation example, the Masterton wastewater-irrigated area is likely to have a gross return of about $300,000 per year. This does not include returns from crops grown on the western portion of the property, which initially will not be irrigated with wastewater.
- Border strip application is recommended as the best method of achieving the land treatment objectives of the proposed wastewater treatment scheme, because relatively large volumes of treated wastewater can be applied to land at 7 to 10 day intervals, which will allow the soil to drain and re-aerate.
- Standard centre pivot irrigators for an 84 ha operation would handle about 60 litres/sec and would result in almost daily applications of effluent. The border strip scheme is designed for twin 300 litres/sec delivery mains – 600 litres/sec total. The cost of the proposed land treatment scheme reflects the much greater delivery capacity. Standard on-farm irrigator costs, cannot be compared to the much higher capacity land treatment proposal.
- For irrigation of pond effluent containing algae, the land should be re-graded to eliminate hollows where algae would accumulate and blind the surface (applies to spray systems as well as border strip).
- If a spray irrigation system was to be used to apply pond effluent, it is possible that the Hearing Panel could impose a requirement to install UV lamp disinfection to mitigate concerns regarding health effects due to aerosols in spray drift. This would have an additional capital cost of $1.7 million and additional annual costs of $0.2 million.
- Extraction of groundwater from the MDC land and supply to private farms in the vicinity (if there is a demand) is recommended as a more sustainable and safer way of increasing crop production, rather than supplying treated wastewater directly. This concept is "flagged" at this stage for future consideration and is not part of the 2008 consent application package.

10.4.3 Full Time River Discharge

A full time 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 full time 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, would use significantly more energy, and would have an annual operating cost of $1.7 million.

These costs, relative to the benefits of a primary discharge to land, mean that full time discharge to the river is not considered to be the BPO for Masterton. Furthermore, a full time discharge to the river is unacceptable to many in the community, irrespective of the quality of wastewater.

10.4.4 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 underperforming because 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 because 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 would only result in a minor reduction in construction costs of $150,000. In addition, sustained levels of high expenditure on I/I, which could reduce inflow to the MWTP, would not provide significant "value" to Masterton over the longer term in regard to relative benefits for the costs.

The analysis on the reduction of I/I showed that even with an expenditure of $2 million per year over the next 20 years, it 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.

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.

In summary, MDC has undertaken ongoing work to reduce the amount of I/I into the Masterton sewer network since the mid 1990's. This /I/ reduction work includes:

- A number of flow monitoring studies to attempt to identify the worst performing parts of the network in terms of I/I
- An extensive sewer grout sealing contract in the Bentley Street catchment
- Grout sealing of sewers in Lansdowne catchment
- The repair of leaking manholes

- CCTV covering approximately 30% of the 130km Masterton sewer network to further define poorly performing sewers in terms of I/I
- Condition inspections of approximately 25% of the manholes in the Masterton sewer network to identify leaks
- Private property I/I 'source detection' inspections of approximately 2,300 properties of the total number of 7,500 properties in Masterton
- Enforcement programmes to compel property owners found to have defects in their private laterals to repair them
- Substantial sewer maintenance work to further arrest deterioriation
- The replacement of the Cockburn Street sewer. The Cockburn Street sewer had been demonstrated to have particularly high I/I, and the project included replacement of approximately 2.4km total length of mains, the lower sections of laterals and 16 manholes.

In addition to the above projects, MDC has engaged consultants to investigate the nature of the Masterton I/I problem, idenitify its causes and potential solutions, and recommend impovement works to reduce I/I. This extensive ongoing work programme demonstrates the high priority MDC has placed on the reduction of I/I into the Masterton wastewater network.

In conclusion, the reduction of I/I will provide benefits to the MWTP, but the benefit of accelerating I/I reduction expenditure above the currently proposed level, would not achieve the overall project objectives. Accordinagly, the use of additional land for the disposal of effluent is a more efficient method for reducing the discharge to the river, than I/I reduction.

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, would not reduce the annual volume of discharge to the river. It would only serve to postpone the period when it would need to be discharged. This would require a greater amount of storage to hold wastewater until it could be discharged and noticeably increases 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 conservative since little primary contact recreation occurs at higher flows.

It should also be noted that the very rapid rise and fall of the river flow rates during freshes, means that the time interval between the median trigger and a higher trigger flow value, is typically very short – less than 2 hours. Thus in practice, different river flow trigger values will not change the effects on the river.

Purchase of additional land for irrigation

In the June 2005 Council resolution to adopt the preferred scheme, Council also resolved to seek to acquire additional land for effluent disposal. The 2007 purchase of the 107 ha site is the first implementation of that resolution. Purchasing additional land for the disposal of effluent is an option, providing it can be acquired cost effectively. There is further potential to apply effluent to the western portion of the 107 ha site that was purchased in 2007. This application does not extend to irrigation of this additional land. Whilst that is an option which will remain available, the additional irrigation would add further cost for little if any environmental benefit.

Retaining the existing ponds and increasing the area of land irrigation.

One option which was considered was to retain the existing ponds and maintain the ability to use as much as possible of the 107 ha block for future irrigation. After weighing all of the options for the total land area, the Council decided that the best option was to decommission the existing ponds to largely eliminate pond leakage. At the same time it has maintained the same ability to irrigate as was in the 2007 proposal, and there is the option of further increasing the irrigation area if that is required in the future. The options are reported in detail in Masterton Wastewater Upgrade Project: Review of Pond Irrigation Options Incorporating Additional Land (Beca January 2008).

11 Consultation

Masterton District Council has undertaken an extensive public and stakeholder consultation programme on the issues and options for upgrading the wastewater system since 2003, including a comprehensive consultation process regarding the revised Scheme in mid-2008, prior to lodgement of the Resource Consent Applications and Notice of Requirement.

11.1 Initial Consultation Process 2004-2006

The initial programme of consultation is outlined in the *Technical Report on the Recommended Scheme* (Beca 2005), which was 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 (CTG) was established with the function of facilitating an effective consultation process. The CTG included specific industry and sector group representatives, including:

- Rangitaane O Wairarapa
- Ngati Kahungunu Ki Wairarapa
- Dairy Farmers of New Zealand (Wairarapa)
- Industry
- Recreational Users – Wellington Fish and Game Council
- Masterton District Council.

The CTG was responsible for facilitating the consultation process and included specific industry and sector group representatives, including Rangitaane O Wairarapa,; Ngati Kahungunu Ki Wairarapa, Dairy Farmers of New Zealand (Wairarapa), Industry; Recreational Users – Wellington Fish and Game Council, and Masterton District Council. There has also been consultation outside of the Consultation Task Group, with other interested parties and the community in general.

Formal feedback was received from Rangitaane O Wairarapa, Ngati Kahungunu Ki Wairarapa, Department of Conservation, Fish and Game New Zealand and the DHB: this feedback is included in the Appendices to the Technical Report.

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 groups have expressed residual concerns regarding any ongoing discharge to the river. These concerns have also been echoed to a degree by other submitters.

A range of concerns has been expressed by those consulted, and these are summarised and discussed below.

The initial consultation process identified a number of issues, which, in summary, were:

- Cultural concerns including whether there should be fulltime land-based disposal
- Nature of treatment – pond technology and nutrient removal
- Pond leakage volume and effects
- Erosion risks to ponds
- Discharge regime (median or half median)
- River water quality – standards/targets, including metals, attached algae
- Health impacts/risk
- Fonterra's requirements (in relation to wastewater discharges)
- Sludge volume in ponds
- Blue green algae impacts from oxidation ponds
- Land treatment/disposal
- Aerosols
- Application method
- High irrigation rates
- Effect on soils
- Nutrient removal
- Ground water effects
- Discharge to the Ruamahanga River vs. Makoura Stream
- Reticulation – addressing high inflows
- Removal of indigenous vegetation
- Diversion of the Makoura Stream.

The CTG considered these issues and, in December 2004, confirmed what it considered the "Top 5" issues:

- Wastewater and river water quality
- Risks to the existing treatment plant from natural hazards
- Leakage from the existing treatment plant
- Inflow and Infiltration to the reticulation network
- Future-proofing of the treatment process

A summary of how these and other relevant issues have been addressed is contained in Table 53 below with further detail to be found in section 11.2.

Table 53 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 a cost-effective manner while also addressing concerns over pond leakage and river erosion effects on the pond bunds • 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
Concen about about abstracting water from the Ruamahanga River now that the discharge will be moved upstream of the abstraction point	• Options for the Ternent's stock water supply are being discussed and will be agreed with them.
Risks to the treatment plant from natural hazards	• The construction of new oxidation pond with engineered banks will mitigate the siesmic and liquefaction risks • The new ponds are set back from the river allowing for natural meander movements and erosion
Diversion of the Makoura Stream	• Stream diversion to be consistent with natural meander and flow of existing channel • Riparian planting to be established
Loss of native trees	• Design of new ponds and irrigation area adjusted to retain a large group of kahikatea and other native species near Makoura Stream and Ruamahanga River • Diversion of Makoura Stream will allow kowhai and cabbage trees to be retained
Effects on construction of new ponds during high/artesian groundwater conditions at the site	• Modelling by PDP indicates that pumping from a groundwater cut-off trench at a rate of 50 litres/sec can control high groundwater levels during flooding events.
Inflow and infiltration (I/I) to the reticulation system	• The new ponds will 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 (for example, higher receiving water quality). The proposed system can be readily upgraded to produce higher quality effluent. The Council has additional irrigation land on the 107 ha site which may allow for future expansion of the scheme. • 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

Issue	**How the issue has been addressed**
Why not irrigate the full 107 ha site	• This is a potential future irrigation area and could be developed in the future depending on affordability and other considerations
Concern about buffer planting on the west boundary of the 107 ha site obstructing views	• Planting will only be established if agreed with the adjacent neighbour
Concern about irrigation of river berm area and erosion/flooding	• There will be on-going river edge maintenance as part of the GWRC river scheme • Each irrigation area is self-contained with its own wipe off drain and can be operated independently in the event of erosion to another irrigation area. The trunk main is on the west side of the stopbank and is therefore protected.
High groundwater table around the Manga-akuta Steam that joins Makoura Stream at the north of the site	• The northern part of the site will have a buffer with no irrigation (refer Drg C600) and a new drain will be constructed to the west of the irrigation area which will improve under-drainage.
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 floodwater over private land and when the Lower Ruamahanga Barrage Gates are opened	• The discharge to the river will be suspended at peak river flows of 300 m^3/s. This flow is less than the 2-year return period flow of 460 m^3/s at which flow the river flows over private properties.
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 will 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 • Dried sludge will now be stored in a lined landfill constructed in the area of the decommissioned ponds
Concern over outbreaks of Blue Green Algal Blooms because of discharge	• This issue can be prevented through strategy to identify times of risk during certain weather conditions, and to respond by increasing mixing to the relevant ponds at the appropriate times to prevent the conditions occurring within the ponds that could cause an outbreak of Blue Green algae • In addition, the fact that there will not be any direct discharges to the river in summer low flows (the time of greatest risk of Blue Green algal blooms) provides a significant reduction in the risk to community health
Concern about trucks using the northern and western access routes to the site	• Heavy trucks and machinery will only access the site at the two access routes from Martinborough Masterton Road on the southern side of the site.

11.2 Upgrade Scheme Consultation 2006-2007

Prior to submitting the Resource Consent Applications and Notice of Requirements in 2007, a thorough and extensive consultation process was 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 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 were clearly articulated and investigated, with a number of additional studies and assessment undertaken in response to some concerns and suggestions. As a consequence, the proposed upgrade option took into account a number of key issues raised by the 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 proposal for which resource consents were sought provided for these outcomes. Nevertheless, most of the submissions received on the notice of requirement and resource consent applications opposed the proposed upgrade, with the principal issues focused on the discharges into the Ruamahanga River, the existing ponds and their ongoing leakage, and the risks from flooding and erosion.

After submissions were received on the resource consent applications and Notice of Requirement, the Regional Council convened a Pre-Hearing meeting with submitters, at which the MDC and its technical advisers responded to the issues raised by submitters. Separately, the MDC held a briefing for iwi representatives at which the technical advisers responded to questions.

As outlined earlier in this report, in late 2007, before the resource consent applications went to a hearing, the MDC undertook a review of the options that became available with the acquisition of the adjoining 107 ha of land. The MDC decided to amend the scheme to provide for new treatment ponds located further away from the river, allowing for the decommissioning of the existing ponds, and the development of the underlying land for additional border-strip land disposal. The revised scheme will also see the use of additional pasture land on the western side of the Makoura Stream for border-strip irrigation, providing a total of 97 ha (refer to Table 23) of land treatment of effluent (compared with 75 ha under the 2007 scheme). The revised scheme would address a number of concerns raised in submissions, particularly those issues relating to the existing treatment ponds.

11.3 Revised Upgrade Scheme Consultation 2008

Following the Council's decision in December 2007, and some further detailed analysis and design, a number of specific meetings were held with submitters/neighbouring landowners, iwi, DoC, and Fish & Game, to inform them of the recent changes to the design of the proposed upgrade.

The additional meetings with iwi and neighbours identified additional concerns, including:

- The necessity and cultural offensiveness of diverting the Makoura Stream
- The relationship of the stream diversion with the work being undertaken by the Makoura Stream Restoration Group
- The effects of new land based discharges on river water and groundwater quality, including neighbouring bores
- Additional erosion and flood risk associated with the raised ponds and additional irrigated areas, including the suitability of existing stopbanks and effects of flooding of the irrigation area
- Effects on existing vegetation within the site, including the stand of remnant kahikatea
- The cost of the project to ratepayers, which discourages potential alternative schemes to be developed in the future
- Odour from the desludging process and additional irrigation
- Dust from earthworks during construction
- General effects on amenity values and the need for a planted buffer area
- Loss of access across the land to the Ruamahanga River
- Concern over the suitability of the scheme design in general, including:
    - Questions why centre pivot irrigation is not being used[69]
    - Flood risk
    - Effects on water levels from removing clay capping layers on the adjoining land
    - The need to use on site materials (gravel and clay) as much as possible
    - Concern the effluent treatment is not as good as other systems operating in New Zealand (for example Palmerston North).

These concerns are addressed in the relevant sections of this AEE. Overall, the upgrade scheme as now proposed, and for which consent is sought, is considered to address most of the concerns raised during consultation, and delivers the Best Practicable Option for the long-term improvement of the treatment and disposal of Masterton's wastewater in accordance with the Project's objectives.

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[69] In response to this concern, the MDC commissioned a separate technical report to evaluate the options for land treatment, after a neighbouring landowner advocated a centre-pivot irrigation system. The evaluation concluded that, as outlined earlier in this report, a border-strip system was superior in terms of maximising effluent application to land, and for reducing the discharge to the river or avoiding having to increase pond storage capacity.

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

NOTE: Changes in this section from the 2007 AEE, are to provide corrections to Table 46 and to provide additional information relating to effluent quality compliance and the proposed diversion and restoration of Makoura Stream.

12.1.1 Discharge to Water

The proposed effluent quality compliance standards have been developed in accordance with the New Zealand Municipal Wastewater Monitoring Guidelines, 2002 Chapter 13 and Table 13.2. The method uses proportional compliance conditions as outlined in the Guidelines and uses a permissible number of exceedances of a percentile limit in a batch of samples, when also considering the risk of sampling errors. The compliance monitoring method is not intended to be "intuitive" in terms of a typical percentile standard, and the discussion in the Guidelines needs to be read to gain an understanding of the method.

The choice of a percentile for a given standard and use for compliance is arbitrary: a 90%ile standard has been chosen for most parameters while E.coli, metals TPH, PAHs, SVOCs, VOCs use the higher performance standard of 95%ile, as these parameters have higher ecological or health risks.

The compliance period is generally 1 year except for ammoniacal-nitrogen and E.coli that have seasonal compliance periods.

The Guidelines are regarded as good practice, and have been developed by a working group with representatives from district and regional councils, as well as from NIWA and the Ministry for the Environment.

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 1,200 litres/second.
- Frequency and compliance calculation shall be in accordance from New Zealand Municipal Wastewater Monitoring Guidelines (NZWWA 2002) as indicated in Table 54 and based on the monitoring frequency given in Table 55. 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 is 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 the summer period E.coli.

Table 54 Proposed Effluent Quality Compliance

Parameter	**Geometric Mean**	**Percentile compliance standard**	**Sampling frequency/ Number of samples**	**Compliance (Exceedances over period)**
BOD5 (g/m^3)	21	42 90%ile	Monthly/12	No more than 3 over 1 year
Filtered BOD (g/m^3)	10	28 90%ile	Monthly/12	No more than 3 over 1 year
Suspended solids (g/m^3)	32	91 90%ile	Monthly/12	No more than 3 over 1 year
Dissolved reactive phosphorus (g/m^3)	3.0	4.0 90%ile	Monthly/12	No more than 3 over 1 year
Total Nitrogen (g/m^3)	13	20 90%ile	Monthly/12	No more than 3 over 1 year
Nitrate Nitrogen (g/m^3)	1.0	7.5 90%ile	Monthly/12	No more than 3 over 1 year
Nitrite Nitrogen (g/m^3)	0.5	2.0 90%ile	Monthly/12	No more than 3 over 1 year
Ammonia-Nitrogen (g/m^3)	2.0 (summer) 6.0 (winter)	11 90%ile 11 90%ile	Monthly/6 Monthly/6	No more than 2 over 6 months No more than 2 over 6 months
E.coli (cfu/100 mL)	300 (summer)	330 median 1800 95%ile	Monthly/6	No more than 5 above 330 over 6 months No more than 1 above 1800 over 6 months
E.coli (cfu/100 mL)	1,000 (winter)	1,000 median	Monthly/6	No more than 5 above 1000 over 6 months
Metals		ANZECC (2000)	Annually	95%ile trigger values
TPH, PAHs, SVOCs, VOCs		ANZECC (2000)	Annually	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 55:

Table 55 Proposed Effluent Monitoring Requirements

Constituent	Monitoring Frequency	Detection Limit
Flow (influent and effluent)	Continuously	10%
PH	As per E.coli	0.1 pH
Temperature	Monthly	0.1 Degrees Celsius
Colour and Clarity:		
– Suspended Solid	Monthly	0.1 g/m^3
– Total Solids	Monthly	0.1 g/m^3
– Colour	Monthly	
– Foam and Scum	Monthly	
Oxygen Demand:		
– Dissolved Oxygen	Weekly	0.2 g/m^3
– BOD5	Monthly	0.1 g/m^3
Nutrients:		
– Total Nitrogen	Monthly	0.1 g/m^3
– Nitrite-N	Monthly	0.1 g/m^3
– Nitrate-N	Monthly	0.1 g/m^3
– Total Kjeldahl Nitrogen	Monthly	0.1 g/m^3
– Ammonia-N	Monthly	0.1 g/m^3
– Dissolved Reactive Phosphorus	Monthly	0.1 g/m^3
– Total Phosphorus	Monthly	0.1 g/m^3
Metals and Metalloids:		
– Cd, Cu, Ni, Pb, Zn, Hg, As, Ag, Cr	Annually	0.001 g/m^3
– Alkalinity and hardness	Annually	0.1 g/m^3
Organics:		
– TPH (Total Petroleum Hydrocarbons) PAH (Poly Aromatic Hydrocarbons) SVOC (Semi volatile Organic Hydrocarbons) VOC (Volatile Organic Hydrocarbons)	Annual	0.001 g/m^3
Pathogens and Indicators		
– E.coli	Monthly	10 Cfu/100mL

Receiving Surface Water Monitoring

It is proposed that the surface water monitoring requirements shall be as set out in Table 56:

Table 56 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/m^3	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/m^3	0.01	Monthly
Nitrite-N	g/m^3	0.002	Monthly
Nitrate-N	g/m^3	0.002	Monthly
Total Kjeldahl Nitrogen	g/m^3	0.1	Monthly
Total Nitrogen (by calculation)	g/m^3	0.1	Monthly
Total Phosphorus	g/m^3	0.004	Monthly
Dissolved Reactive Phosphorus	g/m^3	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/m^3	0.5	Monthly

The sites sampled shall be Ruamahanga River sites; the upstream monitoring point is proposed to be shifted to the northern boundary of the irrigation site to avoid effects of groundwater recharge on the river and Rua2 (downstream).

Note 1; Sampling frequency for the first year of operation. Frequency to be reduced following the first year in consultation with GWRC.

12.1.2 Discharge to Land

The discharge will be managed in accordance with the Land Treatment Management Plan (refer Appendix F for a draft plan).

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 57.

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 samples 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 six monthly. The first six months should include data collection for January or February and June or July.

Table 57 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/m^3	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/m^3	0.01	3 monthly (inc from Jan)
Nitrite-N	g/m^3	0.002	3 monthly (inc from Jan)
Nitrate-N	g/m^3	0.002	3 monthly (inc from Jan)
Total Kjeldahl Nitrogen	g/m^3	0.1	3 monthly (inc from Jan)
Total Nitrogen (by calculation)	g/m^3	0.1	3 monthly (inc from Jan)
Dissolved Reactive Phosphorus	g/m^3	0.004	3 monthly (inc from Jan)
Total Phosphorus	g/m^3	0.004	3 monthly (inc from Jan)
Miscellaneous:			
Total Organic Carbon	g/m^3	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 B.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 the 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 50 m from the boundary of the designated site.

12.1.4 Makoura Stream Diversion

It is submitted that conditions of resource consent be developed to ensure that the proposed water diversion activity (construction and associated remedial works) are undertaken in accordance with Greater Wellington Regional Council best practice sediment management guidelines to ensure, among other things, the following:

- That the new stream channel is designed and constructed in conjunction with an ecologist to maintain the existing hydrology of the Makoura Stream, and ensure that fish passage is maintained as part of the new stream diversion
- A minimum riparian buffer of 5 metres surrounding the new stream channel shall be permanently retired from farming and riparian planting undertaken consistent with the conceptual planting diagram attached in Appendix C, unless constrained by embankment and flood protection works)
- A riparian management plan shall be prepared by a suitably qualified ecologist for the new stream channel, to guide the stream replanting and ongoing management
- A suitably qualified ecologist shall be required to sign off the new stream channel prior to final stream diversion
- The construction activity is undertaken during appropriate climate and water flow conditions using Greater Wellington Regional Council best practice sediment management guidelines
- A suitably qualified ecologist shall be on site to assist with relocation of any freshwater fish species that may remain in the diverted stream
- Upon completion of the new stream channel, the territorial and regional authorities will inspect the works and confirm that the earthworks and site remediation works have been carried out in accordance with the conditions of the resource consent and relevant plans

12.2 Designation Conditions

The principal environmental issues and the measures to avoid, remedy or mitigate any potential adverse effects on the environment from the operation of the proposed upgrade scheme are primarily addressed through the resource consents sought and through any conditions imposed thereon.

However, conditions are recommended to ensure a buffer area is provided around the perimeter of the irrigation areas, suitable planting design, and to manage construction activities as outlined below.

Activities within the Buffer Area

- A condition of the designation is recommended to provide assurance to neighbours, that no surface irrigation of effluent would be located outside the identified buffer area and not within:
  - 50 m of any private property boundary
  - 20 m of any public road adjoining the designation area
- However, this condition should be worded to ensure buried dripline irrigation of effluent can be carried out within the buffer areas to supply water to plantings.

Existing and Proposed Vegetation

- To ensure the proposed planting design is sympathetic to potential concerns of neighbours, a planting plan should be developed on behalf of the Council so neighbours and interested parties can comment on the planting design before its implementation. A designation condition could ensure that, prior to the use of land based irrigation, a Landscape Treatment Plan is prepared and distributed to neighbouring landowners for comment.
- The Landscape Treatment Plan should detail:
  - The location and type of vegetation to be planted around the perimeter of the land treatment area
  - The timing of planting and anticipated size after 5, 10, 15 and 20 years
  - How the landscape treatment will be designed to screen the land treatment area
  - The riparian planting along the sides of the diverted section of Makoura Stream
  - The existing vegetation to be retained and long term management of remnant vegetation

Construction Management Plan

- It is anticipated that, prior to carrying out any construction activities associated with the proposed upgrade, a Construction Management Plan will be prepared on behalf of Masterton District Council, to be distributed to neighbouring landowners and available for members of the public.
- The Construction Management Plan would identify the anticipated construction programme, including timeframes as well as measures to be taken to avoid and/or minimise potentially adverse effects associated with construction activities as described in Section 8.9 and listed below:

Vibration and Noise

- Restricting construction activities to daylight hours between Monday and Saturday, and not working on public holidays (except in an emergency).
- Adequate muffling of all machinery used on site.
- Locating the machinery warm-up areas and site facilities well away from neighbours.
- Complying with the noise construction standards in NZS6803:1999 “Acoustic – Construction Noise”.

Dust

- Regular watering of exposed surfaces within the site, particularly during dry windy conditions and ceasing operation if necessary until the site is sufficiently wetted to suppress dust.
- Restricting traffic speeds within the site.
- Where possible, covering loads of excavated soil when conditions dictate.
- Locating stockpiles of soil on the eastern portion of the construction site and at least 50 m from boundaries.
- Restoration of exposed land areas as soon as possible after work is completed.
- Minimising areas of exposed land

Sediment Control

- Construction of temporary bunds to contain any stormwater runoff to the stream or river.
- Use of sediment traps and other appropriate stormwater treatment devices.
- Avoiding earthworks during wetter periods.
- Techniques for minimising disturbance of existing vegetation as well as weed control.
- Rehabilitation of site after construction is complete.

Hazardous Substances & Waste

- Bulk fuel storage (i.e. petrol, diesel, oil), if required on site, will be limited to one location and will need to be sited at least 20 m from a watercourse or external boundary. The fuel/oil storage area will be provided with an impervious bund with a volume of 120% of the largest container.
- Sealed waste bins will be provided for the collection of oil rags, oil filters, etc. Waste drums will be transported offsite to an appropriate receiving facility.
- The storage of hazardous substances will comply with the requirements of the Hazardous Substances and New Organisms Act and the requirements of the Proposed Wairarapa Combined District Plan.
- A Spill Emergency Response Plan will be prepared by the contractor prior to the commencement of construction.
- Covered rubbish and recycling bins will be provided for general refuse. These bins will be regularly emptied and moved offsite to an approved facility. No burning of waste materials will be permitted.
- Portable toilet facilities will be located away from traffic areas and further than 10 m from a watercourse and external site boundaries.

Archaeological Items

- The Contractor will be required to provide for the accidental discovery of taonga and koiwi in the CMP.

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Note: Documents provided as Background Reports denoted 'B'

Documents provided as Technical reports denoted 'T'

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Appendices

Masterton Wastewater Treatment Plant and Disposal System Long-Term Upgrade

Masterton District Council

15 August 2008

Appendix A	**Gazette Notice & Certificates of Title**
Appendix B	**Water Quality & Water Quality Guidelines**
Appendix C	**Plans showing Distances from Scheme to Immediate Neighbours & Conceptual Stream Remedial Planting Design**
Appendix D	**Designation Plan & Scheme Drawings**
Appendix E	**Aerial Photo’s showing the Upper Ruamahanga Te Ore Ore River Management Scheme**
Appendix F	**Draft Land Treatment Management Plan**

Appendix A

Gazette Notice & Certificates of Title

Appendix B

Water Quality & Water Quality Guidelines

Appendix C

Plans showing Distances from Scheme to Immediate Neighbours & Conceptual Stream Remedial Planting Design

Appendix D

Designation Plan & Scheme Drawings

Aerial photos show the design channel with the outer lines representing the buffer zones.

Appendix E

Aerial Photo’s or the Upper Ruamahanga Te Ore Ore River Management Scheme

Appendix F

Draft Land Treatment Management Plan