Groundwater (Level) Management Plan (GMP)

NZ TRANSPORT AGENCY
WAKA KOTAHI

MacKays to Peka Peka Expressway

Groundwater (Level) Management Plan (GMP) Revision History

Revision N°	Prepared By	Description	Date
Version 1.0	Ann Williams	For internal review	09.05.2013
Version 1.1	Ann Williams	Draft for GWRC Review and Comments	-
Version 1.2	Ann Williams	Final draft for GWRC review (as per Condition G.18A)	17.05.2013
Version 2.0	Ann Williams	Final for GWRC certification	20.06.2013

Independent Review

Action	Name	Signed	Date
Reviewed by	Wayne Russell		21.05.2013

Document Acceptance

Action	Name	Signed	Date
Prepared by	Ann Williams		20.06.2013
Reviewed by	Kylie Eltham/Anna Lewis		20.06.2013
Approved by	Alan Orange Alliance Project Manager		20.06.2013
on behalf of	M2PP Alliance		

Certification

Action	Name	Signed	Date
Regulatory Manager Approval	Al Cross		20/8/13
on behalf of	Greater Wellington Regional Council		

Quick Reference Guide to Conditions

Condition Number	Condition Requirement	Comments	Key Final GMP Reference
G.28A (a-c)	That there shall be no changes to the groundwater levels that shall result in a significant change to wetland hydrological conditions; and	Outcomes of the GMP	Section 2.1
	That there shall be no permanent changes to the ability of existing bore owners to abstract water from their existing water supply bores; and.		Section 2.4
	That existing bore owners shall have priority to abstract water from their existing water supply bores unless adequate replacement water supply or other agreed arrangements can be provided.		Section 2.4
G.29(a)	15 working days before submitting the Groundwater (Level) Management Plan (GMP) to the Manager for certification, the Consent Holder shall submit a copy of the draft GMP required by condition G.29 to KCDC for comment.	Draft sent to KCDC	Discussed with Brydon Hughes
G.29(b)	The Consent Holder shall submit a draft GMP to the Manager (GWRC) at least 30 working days prior to Work commencing. The final GMP will be submitted to the Manager for certification at least 15 working days prior to commencement of Work. The GMP shall be submitted with the CEMP as an appendix.	Draft sent to GWRC	Discussed with Brydon Hughes
	The purpose of the GMP is to set out the best practicable options for groundwater monitoring and management, procedures to avoid, remedy or mitigate changes in groundwater levels and wetlands and to ensure that existing bore owners have priority to abstract water from their existing water supply bores and to protect the integrity of those supplies (in terms of both quality and quantity of supply).	Purpose of the GMP	Section 1.1

G.29(c)	The GMP shall be finalised in consultation with Te Āti Awa ki Whakarongotai and Takamore Trust.	Consultation required	Appendix J and Sections 3.1
G.29(d)(i)	The schedule of groundwater monitoring bores identifying piezometer depth, screen length and geological unit;	Information required in the GMP	Appendix A
G.29(d)(ii)	The locations of groundwater monitoring bores shown on plans, including within the vicinity of the bore supplying the Harrisons Country Gardenworld;		Appendix A
G.29(d)(iii)	The locations of monitoring stations on the Wharemauku Stream and Drain 5;		Appendix A
G.29(d)(iv)	A summary of understanding of the hydrological regime in each wetland (as identified in condition G.38B) at the time of preparation of the GMP;		Section 8.1
G.29(d)(v)	Details of how the monitoring and management, including the anticipated length of time temporary effects on existing water supply wells, may occur;		Sections 5 and 10
G.29(d)(vi)	Monitoring frequency;	Monitoring	Section 5
G.29(d)(vii)	Monitoring methods including the role of Te Ati Awa ki Whakarongotai and Takamore Trust;	Role of iwi	Sections 3.1 and 5
G.29(d)(viii)	Reporting requirements;	Reporting	Section 6
G.29(d)(ix)	Consultation procedures with the owners of affected existing groundwater bores, including owners of businesses reliant on bore water;	Consultation	Section 7
G.29(d)(x)	Alert and action programmes, including the details of a range of mitigation options that can be implemented;	Alert and actions	Sections 8 and 9
G.29(d)(xi)	Response management; and	Responses	Section 9
G.29(d)(xii)	Review procedures.	Reviews	Section 12
G.29(d)	Work shall not commence until the Consent Holder has received the Manager's written certification for the GMP. The GMP shall be developed in parallel with the EMP (as required by	Certification; Development with EMP	Sections 8.4 and 9.1

	condition G.34) to ensure that the monitoring and mitigation measures are appropriate for wetland management.		
GD.2(a)	Install and maintain the groundwater monitoring boreholes shown in Appendix A of this GMP	Install and maintain boreholes for monitoring	Appendix A and Section 5.1.2
GD.2(b)	Monitor and record groundwater levels in the groundwater monitoring boreholes shown in Appendix A of the draft GMP and keep records of the water level measurement and corresponding date in accordance with the GMP and condition GD. 7 These records shall be compiled and submitted to the Manager at three monthly intervals, or upon request, for the duration of the monitoring.	Monitor, record and report on groundwater levels	Sections 5.1.3 and 6.1
GD.2(c)	Frequency for monitoring groundwater levels in existing boreholes and in newly installed monitoring boreholes shown in Appendix A of this GMP before the commencement of construction that may affect groundwater levels in the area of monitoring. Report the groundwater levels recorded over this period, together with the monitoring trends obtained during the investigation and detailed design phases, and use these to establish groundwater alert levels that will initiate actions to be undertaken when potentially adverse changes in groundwater levels occur. The proposed alert levels and supporting data shall be discussed with the KCDC and submitted to the Manager for certification 15 working days prior to submission of the GMP.	Frequency for monitoring and reporting on groundwater levels before construction. Establish proposed alert levels and actions.	Appendices A , Section 5 and discussed with Brydon Hughes
GD.2(d)	Include in the GMP the proposed actions for remediation and mitigation should alert levels (as determined in the GMP) be exceeded. These actions shall include provision for the accidental interception of artesian or spring flows in the area	Actions for remediation and mitigation. Consultation requirements	Appendices F and G, Sections 7.2 and 2.4.2

	immediately adjacent to Wetland 9 (located between the Waimeha Stream and Waikanae River) and the provision of sufficient drainage capacity to avoid land drainage or flooding problems on properties in the immediately vicinity caused by the operation of Wetland 9. The Consent Holder shall consult with property owners adjoining Wetland 9 prior to finalising proposed actions and shall include in the GMP the response to feedback obtained through the consultation.	and response to feedback.	
GD.3	Frequency of review and reporting the results of monitoring as compared with predicted effects on groundwater levels assessed from groundwater modelling and the established range of groundwater levels determined from groundwater monitoring prior to the Work. An annual report will be prepared and submitted to the Manager to cover specified information detailed in this condition. Any changes proposed to the future monitoring programme or to the alert levels and mitigation must be amended in the GMP and certified by the Manager before they can be implemented.	Frequency for review and reporting the results of monitoring. Annual report.	Sections 6.2 and 8.4.3
GD.4	Frequency for monitoring groundwater levels in each borehole listed in Appendix A of the draft GMP. Records shall be compiled and submitted to the Manager at 3 monthly intervals or upon request. Actions required in the event of an exceedance of the Alert levels specified in the GMP.	Monitoring frequency, records and actions in the event of exceedence	Appendix A, Section 5
GD.5	Review of monitoring data from bores in or adjacent to wetlands. Results of review included in 3 monthly groundwater monitoring reports under condition GD.3. Notification requirements in event of exceedence.	Review of monitoring data and notification requirements	Section 8.1

GD.6	Implement mitigation measures described in the GMP to ensure that existing groundwater users (consented users) or those identified in condition GD.2(c) who have a reduced ability to abstract their own water supply as a result of the Project receive a replacement water supply. Avoid adversely affecting KCDC's public water supply bores and ensure access to those bores for maintenance and servicing is maintained throughout the Project.	Existing bores	Sections 2.5 and 7.1
GD.7	Frequency for continued monitoring of groundwater levels in each borehole listed in Appendix A of the GMP. If the alert levels are exceeded, the Consent Holder shall follow the procedures outlined in conditions GD.2 and GD.3.	Frequency of continued monitoring of groundwater levels.	Section 5.1.3
GD.8A	Details of the pre and post construction monitoring shall also be included in the GMP.	Detail construction monitoring in GMP	Section 5
GT.1	The location, design, implementation and operation of the groundwater takes shall be in general accordance with the consent application, including the plans contained in the GMP	Groundwater takes - general	Sections 7.1 and 2.5
GT.2	The rate at which water is taken from each water supply bore shall not exceed 275,000 m3/year at a maximum of 750 m3/day and a maximum pumping rate of 35 litres/sec. The combined rate of pumping shall not exceed 1990 m3/day in total from all Project construction water supply bores pumping at any particular time.	Rate of water take	Sections 7.1 and2.5
GT.3	Install and maintain a water meter on each water supply bore	Water meter	Sections 5.1.2 and 7.1
GT.4	A stepped rate pumping test shall be carried out in each new water supply bore to determine the volume of water that can be abstracted from the bore. The stepped rate test shall be followed by a	Pumping tests	Sections 5.2, 2.5 and 7.1

	constant rate pumping test of at least 8 hours duration at the desired pumping rate. Monitoring of water levels in at least one observation bore shall be carried out during the constant rate test.		
GT.5	Within 3 months of the completion of each pumping test, the Consent Holder shall submit a report to the Manager outlining information detailed in this condition. This report must be approved by the Manager before the bore can be utilised for construction water supply purposes.	Approved report requirement prior to bores being used for construction water	Sections 2.5 and 7.1
GT.6	If so requested by the Manager, make its bores available for monitoring of water levels and water quality.	Monitoring by Council if requested	Section 7.1
WS.5	Undertake flow monitoring in the Wharemauku Stream and Drain 5 in order to determine whether there are any changes in flow levels following the construction of the flood storage areas 2, 3A and wetland 3. Details of the flow monitoring locations and methods, reporting procedures, and response procedures shall be included in the Groundwater Management Plan as set out in condition G.29.	Flow monitoring and reporting	Section 8.4

Table of Contents

Appendices

1 Introduction

1.1 Scope and purpose of Groundwater Management Plan

This Groundwater (Level) Management Plan (GMP) (the Plan) forms part of a comprehensive suite of environmental controls within the Construction Environmental Management Plan (CEMP) for the MacKays to Peka Peka Expressway Project ("the Project").

The GMP addresses the potential effects on groundwater levels associated with both the construction and long term operation of the Project, and identifies the minimum standards that must be complied with as well as best practicable options for groundwater management for the Project. It is intended as a framework for the development of groundwater level management practices and procedures to minimise impact on the environment, and to achieve compliance with resource consent conditions.

The purpose of this Groundwater (Level) Management Plan (GMP) is to fulfil the requirements of the MacKays to Peka Peka Expressway designation condition G.29(b) which states:

G.29(b) *"….The purpose of the GMP is to set out the best practicable options for groundwater monitoring and management, procedures to avoid, remedy or mitigate changes in groundwater levels and wetlands and to ensure that existing bore owners have priority to abstract water from their existing water supply bores and to protect the integrity of those supplies (in terms of both quality and quantity of supply)."*

This management plan is submitted to the Manager (GWRC) in accordance with G.29 (b) for certification.

The potential for effects on the environment to occur can be measured by recording changes in groundwater levels in piezometers installed in proximity to the works and responding with suitable actions if trigger levels are reached.

The GMP will be updated, with the necessary approval, throughout the course of the Project to reflect material changes associated with construction techniques, ground conditions and/or the longer data record in areas where construction has yet to commence. The effects of changes to the Project as a result of the detailed design process will also need to be considered. Approval from the Greater Wellington Regional Council (GWRC) will be required for any relevant revisions of a material nature to the GMP.

It should be noted that this GMP does not consider changes to groundwater quality that could be caused by the Project. Groundwater quality changes and associated monitoring requirements are

addressed in the Contaminated Soils and Groundwater Management Plan (CSGMP) also included within the CEMP.

This GMP addresses the matters in Condition G.29d (refer to the quick reference guide to conditions).

1.2 Project description

For a description of the Project, refer to the Project Description (Construction and Operation) within Part D, Chapters 7 and 8, Volume 2.

1.3 Performance standards

The CEMP identifies general legislative standards and other requirements relevant to the management of groundwater for the Project.

1.4 Environmental plans and maps

The location of relevant environmental plans and maps within the CEMP are summarised in Table 1.

Table 1 – Plans and Maps Referenced in the GMP

Plan/Map	Relevance
Settlement Effects Management Plan (SEMP)	Management of potential impact on buildings and services from settlement related to Expressway construction.
Contaminated Soils and Groundwater Management Plan (CSGMP)	Management and monitoring of potential environmental and health risks arising from changes to soil and groundwater contamination as a result of Expressway construction.
Ecological Management Plan (EMP) and Landscape Management Plan (LMP)	Management and monitoring of potential impacts on freshwater ecology caused by a reduction of groundwater flow or level in wetlands or surface water bodies.
Environmental Maps	Project alignment and receiving environments.

2 Potential effects on groundwater

Assessments of the existing groundwater regime and changes that might occur as a result of the Expressway have been made from groundwater modelling that has been calibrated to in-situ investigation data and both in-situ and laboratory testing. The groundwater models developed for the assessment serve to define the locations and ranges of groundwater changes that are expected to result from construction of the Expressway. They also serve to guide the development and

implementation of this monitoring programme (GMP) to verify these changes, and to trigger any mitigation or corrective actions that are needed to protect the environment. Because models are always limited by the available data used in their construction and calibration, the modelled effects are not, and can never be, exact. Actual effects may be larger or smaller than those predicted at some locations, especially those locations away from the areas of focus of the model. In spite of these limitations, the models do serve as the most reliable assessment of future effects that are likely to be caused by the Expressway.

It is important to check that actual changes in groundwater levels during and following construction are similar to those modelled. This can be done by:

- Recording water levels in selected piezometers adjacent to and at distance from the Expressway; and
- Monitoring water levels and base flows in wetlands and other surface water bodies.

The monitoring requirements set out in Section 5 of this GMP are designed to confirm current baseline conditions (including seasonal variations), check the validity of the modelling and allow it to be updated accordingly and to give warning of changing groundwater level conditions resulting from construction of the Expressway. The use of modelling and monitoring together provides a greater level of understanding than reliance on either modelling or monitoring alone.

Because changes to groundwater levels occur before settlement is experienced, mitigation measures can be carried out to limit groundwater drawdown if monitoring indicates potentially deleterious effects due to higher than anticipated drawdown; monitoring acts as a warning system for settlement effects. In the same way, recorded changes in water levels as compared with those anticipated, can be used as an indicator of potential effects on wetlands and other surface water bodies and mitigation measures can be applied if necessary.

Specific objectives of the GMP are (in accordance with Condition G.28A):

a. That there shall be no changes to the groundwater levels that result in a significant change to wetland hydrological conditions; and

b. That there shall be no permanent changes to the ability of existing bore owners to abstract water from their existing water supply bores; and

c. That existing bore owners shall have priority to abstract water from their existing water supply bores unless adequate replacement water supply or other agreed arrangements can be provided.

2.2 Changes in groundwater level

Lowering of the groundwater level (drawdown) might occur as a result of:

- Drainage associated with Expressway cuts;
- Excavation and replacement of peat with more permeable sand to construct Expressway embankments;
- Permanent stormwater measures (i.e. lowering of the ground and groundwater levels for flood attenuation);
- Pumping of wells for construction water supply; and/or
- Reduced infiltration due to increasing the amount and coverage of paved surfaces.

Drawdown will result in a depression of the groundwater level that will extend outwards and decline in magnitude with distance from the activity.

A rise in the groundwater level could occur as a result of:

- Preloading or surcharging the peat resulting in reduced permeability and through flow of groundwater;
- Infiltration of run-off from (unlined) storm water devices; and / or
- Replacement of excavated sand with compacted peat (in these areas the peat may have a lower permeability than the surrounding ground and may locally act as an impediment to groundwater flow, resulting in a rise in groundwater level).

Technical Report 21, Volume 3 (Assessment of Groundwater Effects) found that assessed changes in groundwater level were generally of limited extent with effects of less than 0.3 m predicted at distances of 50 m to 70 m from the Expressway. This Plan sets out monitoring of water level changes in the area up to 200 m from the Expressway, being approximately double the distance of anticipated drawdown or mounding effects in most locations and the greatest extent of calculated ground settlement effects at any location along the route.

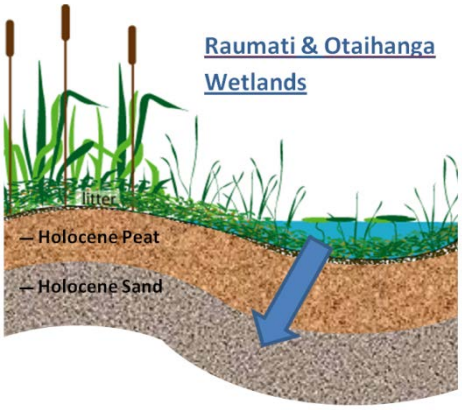
Drawdown in the aquifer pumped to supply construction water is treated separately because it is a larger temporary effect in the deeper aquifer from which the water is to be abstracted and these drawdown effects, should they prove deleterious, can be remedied in different ways to other drawdown effects on the Project.

2.3 Drawdown induced settlement

The drawdown of groundwater below its normal seasonal variation can cause settlement of the ground, which in turn may result in settlement of structures founded on or in the ground. This movement can result in damage to structures depending on the amount of settlement that is

induced and how this changes beneath the structure, and the nature of the structure and its foundations.

The settlement associated with groundwater drawdown is predicted to extend for the most part in the order of 90 m to 200 m from the Expressway embankment, though noticeable effects are likely to be limited to less than 90 m (refer to Technical Report 35, Volume 3). Monitoring and management of ground settlement is set out in the Settlement Effects Management Plan (SEMP).



2.4 Effects on wetlands and surface water bodies

Drawdown and damming of groundwater levels in the vicinity of wetlands or surface water bodies may alter the contribution of groundwater that naturally flows towards these areas; it may also increase the volume of water that naturally discharges through the bed of such areas to recharge the underlying groundwater system.

Technical Report 21, Volume 3 (Assessment of Groundwater Effects) found that in general, assessed changes in groundwater level or flows to wetlands were expected to be negligible (when considering the lining of storage areas that might have otherwise resulted in larger changes in water level).

2.4.1 Wetlands potentially at risk

The Kāpiti Coast wetlands have formed in different ways according to the local ground and groundwater conditions. This means that the water level in some wetlands will naturally vary more than in others and a small change in wetland water level will have a greater effect on some wetlands than on others. For this reason the base line monitoring data has been reviewed to identify the likely hydrogeological behaviour of each wetland, in accordance with Condition G.29 iv). These different wetland types are illustrated below.

a. Raumati Manuka Wetland

Groundwater level data indicates a downwards gradient, suggesting that rainfall is held up on the near-surface peaty soils, but slowly infiltrates through them to recharge the underlying sands and gravels. Natural water level variations of up to 0.7 m are recorded in piezometers in and adjacent to this wetland. This means that it might be less sensitive to variations in groundwater level than some other wetlands that receive water from aquifers below them.

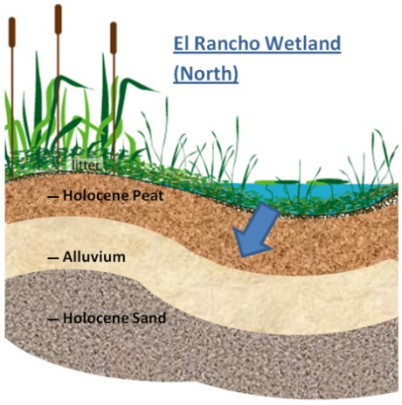
b. Otaihanga Northern and Southern Wetlands

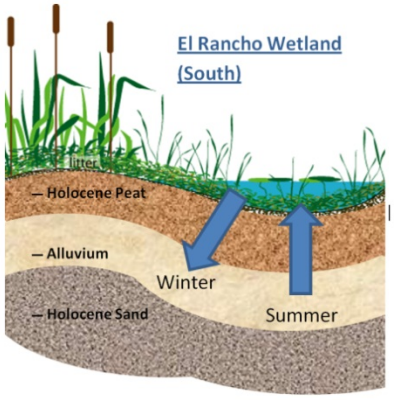
As for the Raumati Manuka Wetland, groundwater level data indicates a downwards gradient, suggesting that rainfall is held up on the near-surface peaty soils, but slowly infiltrates through them to recharge the underlying sands and gravels. This model is supported by water quality analyses reported in Technical Report 23 which record contaminants in surface water but little evidence of contamination in groundwater.

c. El Rancho Wetland (Weggery)

This wetland area is complex and exhibits different styles:

- The northern part of the wetland in the vicinity of the proposed stormwater devices exhibits a downward gradient, suggesting that rainfall is held up on the near-surface peaty soils, but slowly infiltrates through them to recharge the underlying sands and gravels.
- The southern part of the wetland also exhibits a downward gradient with recharge to the underlying soils during the winter months, but is fed by the underlying aquifer during the summer months.



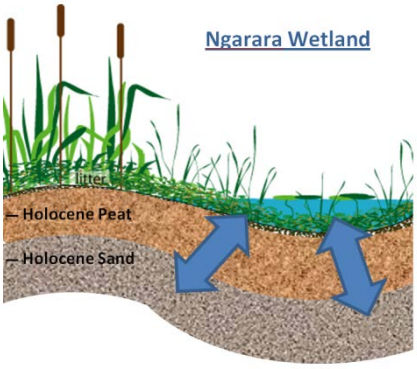


Groundwater levels recorded in shallow piezometers in and around these wetlands typically have a very small variation 0.2 to 0.4 m but up to 0.73 m. The El Rancho (South) wetland is therefore likely to be more sensitive to changes in groundwater level in the soils beneath it than the wetlands that consistently show a downward gradient.

d. Ngarara Wetland

Currently there are no piezometers installed close to or in the Ngarara Wetland. These will be installed once NZTA has ownership of the land in proximity, and well ahead of the minimum 12 month pre-construction monitoring period. However, we anticipate from piezometer data available in the broader area that groundwater both recharges and drains the aquifer beneath it here. Groundwater levels recorded in shallow piezometers in the broader Ngarara area typically have a very small variation 0.5 to 0.8 m. To date there is no clear seasonal trend.

2.4.2 Wetland 9 (Tocker's Pond)



The area around Wetland 9 currently suffers from poor drainage because it is low-lying with high groundwater levels and has no robust surface water drainage system. If the project were to result in a rise in groundwater levels in the area, this could result in surface ponding of water. As part of the construction of Wetland 9, there will be a stormwater pipe installed along the access lane at the Tocker property that will take attenuated storm runoff from the Wetland 9 outlet and discharge it to the Council pipe system in Puriri Road. That new pipe will also have capacity to convey drainage from the relatively small residual catchment areas around the wetland.

Monitoring of piezometers installed in bores 2007/BH-R, 2012/BH25(E) and 2012/BH25(W), 2011/BH215, 2012/BH15(N) and 2012/BH15(S), 2012/BH16(E) and 2012/BH16(W) will allow checking of the effects of the project and allow mitigation should exacerbation of existing flooding issues be identified.

To this end, an Accidental Artesian Aquifer Interception Plan has been prepared in accordance with Condition GD.2 and attached as Appendix G to ensure that artesian aquifer interception is managed effectively such that undesirable effects on the aquifers and discharge of water to the adjacent land are avoided.

2.4.3 Wharemauku Stream

Lowering the groundwater level around flood storage areas 2, 3A and wetland 3 reduces the amount of groundwater which naturally discharges to the Wharemauku Stream (a reduction of about 17 %) and Drain 7 (a reduction of about 13 %) over a length of some 600 m. The groundwater that would have naturally discharged to the stream instead discharges to the flood offset area, and is then redirected to the stream further down gradient such that down gradient flows are not affected. Flow gauges will be established on the Wharemauku Stream and Drain 5 to monitor stream flows.

2.5 Effects on existing bores

Groundwater drawdown effects associated with pumping from construction water supply wells will result in drawdown of the groundwater level in the aquifer from which the abstraction is taking place. Any one construction water supply bore will operate over a period while construction takes place close by. Once construction passes, a new closer bore will be used and take from the preceding bore will reduce and then cease.

These temporary drawdown effects could affect the water level in existing bores in the vicinity abstracting water from the same or a shallower aquifer. For this reason, pumping testing of each new bore will be carried out with monitoring of water levels in nearby shallow and deeper bores to assess effects. As set out in Conditions GT.5, a report detailing potential effects as determined from the testing and any mitigation measures needed, will be provided to GWRC and must be approved by the Manager before the bore water can be used.

This GMP will be updated to include these assessments as they are completed.

3 Managing groundwater - roles and responsibilities

Roles and responsibilities for the Project are described in the CEMP. Specific roles and responsibilities relating to managing groundwater are described below.

The Expressway Project team[1] will manage and monitor the effects associated with groundwater level changes including:

- Extent of settlement and the resulting effects on buildings, services, and retaining walls (refer to the CEMP);
- Reduction of flows or levels in surface water bodies and wetlands; and
- Reporting to the Consent Authority (Greater Wellington Regional Council).

The Project team will monitor the effects on the groundwater regime and wetlands by comparing the results of monitoring with modelled values.

If groundwater effects beyond those estimated occur then the Project team will pass on the findings and coordinate any discussions with the affected party. The Project team will implement measures to limit groundwater drawdown, effects on surface water bodies and ground settlement, and carry out remedial actions on affected buildings and services, with the agreement of GWRC. This will include consideration of actual geology encountered as compared with modelled geology and updating the relevant model if necessary.

All personnel working on the Project including Project team employees and subcontractors have the responsibility for following the requirements of this GMP.

[1] This Plan refers to the Project team as carrying out works on behalf of and as contracted by the NZTA. The NZTA is the requiring authority and the consent holder.

3.1 Role of Te Ati Awa ki Whakarongotai and Takamore

Freshwater is an issue of the utmost importance to Te Ati Awa ki Whakarongotai due to the significant status of water to the Iwi. Water plays an important role in the cultural identity and traditions of Te Ati Awa ki Whakarongotai. It sustains life and provides resources critical to the customary practice of mahinga kai. Te Ati Awa ki Whakarongotai have historic and contemporary concerns over the degradation of water environments and the erosion of traditional relationships with water within their tribal jurisdiction, particularly with regard to customary rights, access and management.

Measuring the health water environments within the iwi's tribal rohe is a vital component to maintaining and improving water quality under future management regimes for freshwater.

Te Ati Awa ki Whakarongotai will be provided an opportunity to develop methodologies for the cultural monitoring of groundwater sources affected throughout the construction phase of the M2PP project. The iwi has nominated its water working group to assist in this regard. The Te Ati Awa ki Whakarongotai water working group comprising Mr Bill Carter, Mr Ra Higgott and Mr Mahutonga Blenkinsopp will provide advice and undertake site inspections as well as cultural monitoring services where required.

Their role will include:

- Opportunities to discuss the proposed monitoring programme at the early stages of design;
- Invitation to participate in monitoring round;
- Invitation to participate in wetland observation visits required should an alert trigger be confirmed.

4 Training

Environmental training for all relevant staff will be undertaken as part of the site induction programme as described in the CEMP.

The Environmental Induction will include information on the following aspects of this Plan:

- Information about the activities and stages of construction that may cause impacts on groundwater within the construction area;
- Consent requirements;
- Complaints management procedures;
- Groundwater monitoring and management procedures; and
- Roles and responsibilities for management of groundwater on the Project.

5 Monitoring requirements

This section details the monitoring programme for the measurement of groundwater levels during and after the construction period.

Changes in groundwater level give an indication of the potential for drawdown-induced settlements and interactions with surface water bodies. Differences between modelled and actual changes in groundwater level can be expected, and will need to be considered in terms of the actual geological sequence encountered compared with that modelled and the impact this might have (if any) on potential effects.

5.1 Monitoring of groundwater levels (other than associated with construction water abstraction)

Monitoring will be undertaken by a specifically identified and trained team. Review and reporting of collected monitoring data will be undertaken by a specialist hydrogeologist. In the case of water level data recorded in piezometers in or adjacent to wetlands (piezometers listed in Appendix A1), review of data will be made jointly by a hydrogeologist and a suitably qualified fresh water ecologist.

Groundwater levels will be recorded in monitoring bores that will include piezometers already installed along the alignment, as well as bores drilled specifically to allow monitoring of water levels in proximity to the Project or to particular natural features that could be affected, such as wetlands (Appendix A).

5.1.1 Location of groundwater monitoring bores

Monitoring bore sets have been established along the alignment with a particular focus on sensitive areas such as where natural wetlands occur, where significant man made ponds / wetlands are proposed or in areas already susceptible to high groundwater levels / surface flooding.

Each monitoring bore set comprises a suite of one, two or three separate bores (according to the geological profile at that location), each monitoring a separate geological horizon.

Groundwater level monitoring will be carried out in the boreholes shown on the plans attached as Appendix A. Monitoring boreholes have been installed approximately 12 months ahead of commencement of construction works that could potentially affect groundwater, to collect data on seasonal variations in groundwater level. Boreholes to monitor effects on the Ngarara wetland will be installed once access to desired sites is available.

Using telemetered reference GWRC piezometers that have been continuously monitored since 2001, expected minimum and maximum water levels in the monitored boreholes have also been established. This “base line” data is attached in Appendix B.

5.1.2 Construction of groundwater monitoring bores

Piezometers have been installed so that the screened interval of each piezometer targets a separate geological unit. Piezometers have been 'developed' immediately following construction. Typical installation details are attached in Appendix C.

Monitoring will consist of the recording of:

- Piezometer name, screened geological unit, date and time of monitoring;
- Depth to groundwater (as both a depth below ground surface and as a reduced level); and
- Any damage to the piezometer or ponding of water or other change at the bore head.

An example field recording sheet is attached in Appendix D.

5.1.3 Monitoring frequency

Groundwater monitoring bores will be monitored for twelve (12) months (where practicable) before the commencement of construction that may affect groundwater levels in the area of monitoring, during construction, and for at least twelve (12) months, but up to three (3) years, after construction is complete. In cases where post-construction mitigation is implemented, monitoring specific to such mitigation may be continued for a longer period if the collected data do not indicate a return to pre-construction groundwater levels or establishment of a new equilibrium. The frequency and type of monitoring will vary depending on the stage of construction.

a. Prior to construction

In the 12 months (where practicable) prior to construction that may affect groundwater levels in the area of monitoring, groundwater level monitoring will be undertaken at monthly intervals. For the final month before construction, the frequency of groundwater level monitoring will be increased to weekly intervals. Data-loggers will be installed in piezometers located in proximity to sensitive wetlands (those set out in Table 2 of Section 8.1) to allow more frequent collection of water level data (hourly as far as practicable) that might aid understanding of wetland behaviour.

b. During construction

As the active construction stage starts to affect the relevant section, the frequency of groundwater level monitoring will be increased to twice weekly. Active construction is defined as beginning when the advancing construction face comes within 200 m of the section and ending when earthworks are complete and / or no dewatering is occurring within 200 m of the section. Where data-loggers have been installed in piezometers, these will continue to record water levels at hourly intervals (as far as practicable).

c. Post construction

Monitoring will continue on a monthly basis for a period of twelve (12) months after construction of the Expressway is complete. Following this twelve month period, the frequency of monitoring will reduce to 3 monthly for a further 24 months, or a lesser period approved by the Manager. An application to the manager to cease monitoring will be made if records indicate that changes in groundwater level have stabilized, or reversed approximately in accordance with predictions.

Piezometers located in or adjacent to the wetlands identified in Condition G.38B (Raumati Manuka wetland, Otaihanga Northern wetland, Otaihanga Southern wetland, El Rancho wetland (Weggery), Ngarara wetland) shall continue to be monitored for 48 months following the initial 12 month period.

5.2 Monitoring of groundwater levels (construction water abstraction)

Monitoring of groundwater levels in at least one observation bore will be carried out during the pumping testing of each construction water supply bore in accordance with Condition GT.4.

In addition monitoring of selected existing bores in proximity to each construction bore water supply bore will be carried out as agreed with the bore owners and where feasible (depending on bore construction and pump set up it may not be possible to install a monitoring probe in a bore). The bores to be monitored will be agreed with GWRC for each construction water supply well in the bore completion report required by Condition GT.5.

6 Reporting requirements

Data collected in monitoring will be collated, plotted, evaluated and reported. The reporting requirements vary through the life of the project.

6.1 Three-monthly reports

Reporting is required at 3-monthly intervals through the pre-construction period and during construction. The frequency of reporting may be reduced to 6-monthly following completion of construction.

6.1.1 Pre-construction and during construction

A Groundwater Monitoring Report compiling the records of groundwater monitoring data and setting out interpretation of the data will be prepared by the Project team's Environmental Manager and forwarded to the Manager (Greater Wellington Regional Council) at quarter-yearly (once every three months) intervals, or upon request, for the duration of the monitoring period.

The Groundwater Monitoring Report presenting the monitoring results will be submitted to the Greater Wellington Regional Council within one (1) week of the final monitoring round within any 3 month period.

The Monitoring report will include:

- Groundwater levels recorded in each piezometer over the 3-month period
- Monitoring trends plotted from the outset of monitoring (pre-construction), updated to reflect the new data
- 'Departure' of recorded water levels from background water levels for piezometers set out in Table 2 (those located in proximity to sensitive wetlands)
- Results of flow monitoring at stream gauges established in the Wharemauku Stream and Drain 5 (once such gauges have been established)
- Established alert levels and any recommended changes to these (updated correlations with GWRC wells) based on the longer monitoring record prior to works being carried out that could affect a particular area
- A comparison with predicted effects on groundwater levels assessed from groundwater modelling and the established range of groundwater levels determined from groundwater monitoring prior to the work
- Commentary from the Project fresh water ecologist on water levels in piezometers listed in Appendix A1, located in and around the wetlands described in section 2.3.1 of this Plan (and in Condition G.38B) in accordance with Condition GD.5
- Consider the findings in the light of construction progress
- Any actions undertaken in response to exceedance of alert levels during the reporting period.

6.1.2 Post construction

The frequency of reporting may be extended to 6 monthly following completion of construction if approved in writing by the Manager (GWRC).

6.2 Annual reports

An annual report will be prepared and submitted to the Manager (Greater Wellington Regional Council) by 1 May each year that, as set out in Condition GD.3, describes:

- Groundwater monitoring undertaken since commencement of the works
- Actual and potential effects arising from the groundwater level changes
- Any remedial or mitigation measures that have been implemented

- Any changes to proposed remedial or mitigation measures
- And changes proposed to construction methods that might influence groundwater levels
- Any changes proposed for the future monitoring programme or to alert levels.

The GMP will be amended to address and such approved changes and certified by the Manager (GWRC) before being implemented.

6.3 Final report

After 36 months of post-construction monitoring reporting, or a lesser period approved by the Manager, a final monitoring report will be prepared. The report will:

- Provide an assessment of any groundwater level effects caused by the Project based on a review of all the data collected prior to, during and following the project
- Provide an assessment of the range of impacts of these effects
- Demonstrate that effective measures are in place to address any adverse effects.

On acceptance of the final report by the Manager (GWRC), reporting may cease.

7 Consultation procedures

7.1 Construction water bores

The take and use of groundwater for construction water supply is addressed in Conditions GT.1 to GT.6. These Conditions set out the investigation and testing work required at each site prior to taking water.

At each site, existing bores within 500 m of the proposed abstraction site will be identified and visited with permission of the bore owners. As far as possible, the location of each identified bore will be confirmed by GPS and bore depth checked using a dip meter. Bore owners will be asked to refrain from pumping their bores during the pumping testing of the construction water supply bore.

Selected bores able to have a monitoring probe installed in them will be used to monitor effects during the required pumping test phase (Condition GT.5), from which the effects of the construction water abstraction will be calculated.

Once the likely effects are ascertained, any potentially deleteriously affected landowners will be consulted to agree a strategy for provision of an alternative water supply during the period of construction water abstraction.

This GMP will be updated to include details of parties consulted with as consultation is completed.

7.2 Wetland 9

An Accidental Artesian Aquifer Interception Plan has been prepared in accordance with Condition GD.2 and is attached in Appendix G. A flooding mitigation concept design is set out in Appendix F. This design is to be discussed with owners or occupiers of properties adjoining Tocker's Pond, specifically:

- 29, 31, 33, 39, 53, 55, 57, 59, 61 and 63 Puriri Road
- 8 Greenaway Road.

8 Groundwater alert levels and action levels

The natural variation of groundwater levels in each piezometer is established using all data collected from that bore over the 12 month pre-construction period (or greater period if available). This data has been used to identify natural seasonal groundwater level variations and groundwater monitoring trigger levels.

The purpose of the **Alert** level is to initiate a check of changes in water level and compare them with modelled levels and if exceeded, increase the frequency of data collection.

The purpose of the **Action** level is to avoid the occurrence of adverse effects that might result from groundwater drawdown (or mounding) in excess of modelled levels.

Trigger levels for each individual piezometer have been set as a reduction below the lowest recorded naturally occurring low level or above the highest recorded naturally occurring high level for the piezometer as set out in the schedule below.

Recommendations for amendments to the monitoring program and the adopted trigger levels will be included in the annual monitoring report that will be submitted to GWRC.

8.1 Monitoring of water levels in or in proximity to sensitive wetlands

Monitoring of changes to water levels in wetlands will be accomplished by recording groundwater levels in piezometers installed between the Expressway and the wetlands.

In parallel, the Project fresh water ecologist will undertake wetland condition surveys bi-annually as set out in Condition G.38B, to record the ecological condition of the key wetlands and undertake other monitoring as set out in the EMP. The Project fresh water ecologist will also review the groundwater level data recorded in the piezometers listed in Appendix A1 on a monthly basis from the commencement of works that could have an effect on groundwater levels in accordance with Condition GD.5. By monitoring groundwater levels the potential for effects on water levels in wetlands can be identified.

The following wetlands are specifically monitored (the piezometers are listed in Appendix A1):

- Raumati Manuka Wetlands, CH3700 to CH4100 – 5 piezometers;
- Otaihanga Northern Wetland, CH8700 to CH9100 – 3 piezometers;
- Otaihanga Southern Wetland, CH8700 to CH9100 – 3 piezometers;
- El Rancho Wetland (Weggery), CH10900 to CH11600 – 8 piezometers;
- Ngarara Wetland, CH to CH – 3 piezometers.

Because even small changes in groundwater level outside the normal seasonal variation for the above listed wetlands may have a deleterious effect on the wetland and the limited number of measurements that are available to date for the establishment and understanding of the normal wetland water levels, the drawdown and high water trigger levels for piezometers located in and around the above wetlands are set as follows:

Alert Level	Using GWRC reference piezometers that are telemetered and are located in the same materials outside the project area, the 'expected' water level will be calculated for each monitored piezometer based on simple linear regression for each reading. A 0.1 m variation, increased by the margin of error of the 80 % confidence prediction interval outside the expected water level, will trigger the alert for the piezometer.
Action Level	Generally a further 0.05 m variation, however in some cases where the wetland is in proximity to a temporary construction water abstraction site that could have a short term effect on levels, a larger variation may be tolerated

The proposed methodology will be used during construction for monitoring the effect of the project on the sensitive wetlands set out in Condition G.38B a) as recorded in the piezometers listed in Table 2.

Table 2 – Correlation of Piezometers and Wetlands

Piezometer ID	Wetland Monitored
2012/BH01 GW E	Raumati Manuka
2012/BH01 GW W	Raumati Manuka
2011/BH301 E	Raumati Manuka
2011/BH301 W	Raumati Manuka
2011/ HA WM02	Raumati Manuka
2012/BH11 GW	Otaihanga Northern
2012/BH10 GW	Otaihanga Southern
2011/BH307 N	Otaihanga Northern

Piezometer ID	Wetland Monitored
2011/BH307 S	Otaihanga Northern
2011/BH305 N	Otaihanga Southern
2011/BH305 S	Otaihanga Southern
2007/BH-O	El Rancho Wetland
2011/HA WM05	El Rancho Wetland
2012/BH15 GW (N)	El Rancho Wetland
2012/BH15 GW (S)	El Rancho Wetland
2012/BH25 GW (E)	Wetland 9
2012/BH25 GW (W)	Wetland 9
2012/BH16 GW (E)	Wetland 9
2012/BH16 GW (W)	Wetland 9
2012/BH28	Ngarara Wetland
2013/BH361	Ngarara Wetland
2013/BH362	Ngarara Wetland

At the end of the construction period, the alert and action levels will be re-evaluated on the basis of the longer term construction monitoring record and will be replaced with single values for each monitoring location. Approval of the revised triggers will be obtained from GWRC before implementation of this change to in accordance with Section 13 of this Plan.

8.2 Other wetlands

The drawdown and high water trigger levels in the remaining wetlands have been set as follows:

Alert Level	0.2 m variation outside the recorded level for the piezometer
Action Level	Using GWRC reference piezometers that are telemetered and are screened in the same materials but situated outside the project area, the 'expected' water level will be calculated for each monitored piezometer based on simple linear regression. A 0.2 m variation increased by the margin of error of the 80 % confidence prediction interval outside the expected water level will trigger the action procedures for the piezometer. In some cases where the wetland is in proximity to a temporary construction water abstraction site that could have a short term effect on levels, a larger variation may be tolerated

Alert levels for individual piezometers in proximity to non-critical wetlands are set out in Table 3.

Table 3 - Alert Levels for all Wetlands other than those addressed in Section 8.1

Piezometer ID	Recorded Levels (mRL)			Low Trigger Levels (mRL)		High Trigger Levels (mRL)		Piezometer Location
	Low	High	Average	Alert	Action	Alert	Action	
2011/BH302 N	5.23	5.45	5.33	5.03	-	5.65	-	Wetland OA
2011/BH302 S	4.61	4.99	4.81	4.41	-	5.19	-	Wetland OA
2007/BH-C	3.56	4.04	3.71	3.36	-	4.24	-	Wetland 3
2012/BH21 GW	4.37	4.69	4.52	4.17	-	4.89	-	Wetland
2007/BH-L	2.68	3.27	2.98	2.48	-	3.47	-	Wetland
2011/HA WM04	1.86	2.32	2.10	1.66	-	2.52	-	Wetland
2011/BH306 N	7.34	7.57	7.49	7.14	-	7.77	-	Otaihanga Central
2011/BH306 S	6.26	6.66	6.46	6.06	-	6.86	-	Otaihanga Central
2012/BH18 GW	4.60	4.81	4.70	4.40	-	5.01	-	Wetland
2011/BH209	4.53	6.29	6.16	4.33	-	6.49	-	Wetland
2012/BH19 GW	5.21	5.47	5.33	5.01	-	5.67	-	Wetland

Action levels will be calculated based on all data available up to the date the Alert trigger was activated, using the detailed approach described above.

8.3 Monitoring of water levels – ground settlement

A buffer distance of 200 m has been selected for monitoring of water level changes near the Expressway. This distance is approximately double the distance of anticipated drawdown or mounding effects in most locations and the greatest extent of calculated ground settlement effects at any location along the route.

The main purpose of groundwater level monitoring in these areas is to avoid the potential for deleterious ground settlement. The predicted groundwater drawdowns set out in Technical Report 21 are not expected to result in deleterious ground settlements, as described in Technical Report 35. Therefore the groundwater level alerts have been set at the lowest recorded level minus the predicted drawdown, reduced by 25 % or 200 mm, whichever is the larger.

High level triggers have been set to check against the potential for surface ponding of water, in particular on the upgradient side of the Expressway. These triggers have been set as a maximum of 200 mm below ground surface, except where existing groundwater level already reaches higher than this.

Alert and alarm levels for individual piezometers are:

Alert Level	Lowest recorded level – (predicted drawdown x 0.75 %) or Lowest recorded level - 200 mm, whichever is the greater
Action Level	A further 0.1 m variation, however in some cases where the piezometer is in proximity to a temporary construction water abstraction site that could have a short term effect on levels, a larger variation may be tolerated

Monitoring Alert and Action Levels for ground settlement and flooding are defined in Table 4. No alert or action level is established for piezometers that are located in greenfields areas or more than 200 m from the Project works, however these piezometers will continue to be monitored and will be considered should an alert level the vicinity be triggered.

Table 4 – Low and High Trigger levels (Ground Settlement)

Piezometer ID	Low Trigger Levels (mRL)		High Trigger Levels (mRL)		Piezometer Location
	Alert	Action	Alert	Action	
2011/BH206 NE	3.67	3.52			Alignment
2011/BH206 SW	4.66	4.51			Alignment
2011/BH204 E	3.74	3.54			Alignment
2011/BH204 W	3.56	3.36			Alignment
2010/BH05	4.93	4.83			Alignment
2012/CPT14 E	2.81	2.71			Alignment
2012/CPT14 W	4.43	4.33			Alignment
2011/BH205	-	-			Peripheral
2010/BH04	-	-			Peripheral
2012/BH02 GW E	3.84	3.74	5.17	5.27	Alignment
2012/BH02 GW W	6.23	6.13	-	-	Alignment
2007/BH-A	3.88	3.68	5.04	5.14	Alignment
2012/BH03 E	4.22	4.02	7.00	7.10	Alignment
2012/BH03 W	3.47	3.27	4.64	4.74	Alignment
2012/BH03 GW	2.50	2.40	4.12	4.22	Alignment
2012/BH04 GW	1.95	1.85	3.55	3.65	OSA 3A
2011/BH213 N	2.35	2.25	4.50	4.60	Alignment
2011/BH213 S	3.60	3.50	-	-	Alignment
2011/BH303 N	2.04	1.94	-	-	OSA 2

Piezometer ID	Low Trigger Levels (mRL)		High Trigger Levels (mRL)		Piezometer Location
	Alert	Action	Alert	Action	
2011/BH303 S	2.02	1.92	-	-	OSA 2
2011/HA WM10	-	-	-	-	OSA 2
2011/HA WM09	dry	dry	-	-	OSA 2
2012/BH24 GW	2.42	2.32	4.34	4.44	Alignment
2012/BH06 GW	1.00	0.90	4.05	4.15	Alignment
2011/HA WM08	-	-	-	-	OSA 3A
2012/BH05 GW	0.74	0.64	4.14	4.24	Alignment
2007/BH-B	-	-			Peripheral
2012/BH07 GW (N)	3.92	3.72	5.31	5.41	Alignment
2012/BH07 GW (S)	dry	dry	8.23	8.33	Alignment
2007/BH-U	3.42	3.32	4.87	4.97	Alignment
2007/BH-E	3.93	3.73	5.53	5.63	Alignment
2007/BH-D	-	-			Peripheral
2007/BH-T	4.35	4.25	5.79	5.89	Alignment
2012/BH09 GW	4.52	4.32	6.23	6.33	Alignment
2007/BH-J	5.23	4.88			Alignment
2012/HA25	-	-			Alignment
2007/BH-I	-	-	7.57	7.67	Peripheral
2011/BH214	-	-			Peripheral
2007/BH-K	4.38	4.28			Alignment
2008/BH202	-	-			Peripheral
2007/BH-M	1.39	1.19			Alignment
2012/BH14 GW	0.97	0.77			Alignment
2011/BH216	5.13	5.03	7.05	7.15	Alignment
2007/BH-V	5.34	5.24	7.01	7.11	Alignment
2012/BH20 N	1.61	1.51	2.91	3.01	Alignment
2012/BH20 S	2.06	1.96	2.77	2.87	Alignment
2007/BH-N(A)	1.78	1.68	2.86	2.96	Alignment
2007/BH-N	2.05	1.95	2.94	3.04	Alignment
2008/BH204	3.09	2.99	4.68	4.78	Alignment
2011/BH215	2.61	2.51	3.10	3.20	Alignment
2008/BH205	-	-			Peripheral

Piezometer ID	Low Trigger Levels (mRL)		High Trigger Levels (mRL)		Piezometer Location
	Alert	Action	Alert	Action	
2007/BH-R	2.84	2.74	3.59	3.69	Alignment
2012/BH22 GW (E)	2.15	2.05	3.10	3.20	Alignment
2012/BH22 GW (W)	2.19	2.09	3.14	3.24	Alignment
2010/BH07	1.93	1.83	2.85	2.95	Alignment
2012/BH26	0.41	0.31	2.40	2.50	Alignment
2011/BH207 E	1.96	1.76	2.75	2.85	Alignment
2011/BH207 W	1.26	1.06			Alignment
2007/BH-S	-	-			Peripheral
2007/BH-Q	-	-			Peripheral
2012/BH17 GW	dry	dry			Alignment
2011/BH208	4.06	3.86			Alignment
2010/BH12	4.85	4.75			Alignment
2011/BH211	3.70	3.55			Alignment
2011/BH211A	3.82	3.72			Alignment
2012/BH 20 GW	4.62	4.52			Alignment
2012/BH23 GW	3.77	3.67			Alignment
2011/BH210	4.21	4.11			Alignment
2010/BH13 N	5.80	-			Alignment
2010/BH13 S	5.94	5.84			Alignment
2011/BH309 N	6.82	6.72	-	-	Alignment
2011/BH309 S	6.61	6.51	-	-	Alignment
2011/BH308 N	5.98	5.88	-	-	Alignment
2011/BH308 S	5.94	5.84	-	-	Alignment
2012/BH37 E	-	-	-	-	Alignment
2012/BH37 W	-	-	-	-	Alignment
2011/BH310 E	-	-	-	-	Alignment
2011/BH310 W	-	-	-	-	Alignment
2010/BH16	8.77	8.67			Alignment

8.4 Monitoring of stream flows

Gauges will be established at the following locations (marked on plan GT-GW-104 in Appendix A and plan GT-GW-104, CEMP Appendix I, Management Plan Appendices, Volume 5) in order to determine whether there are any changes in flow levels following the construction of the flood storage areas 2, 3A and wetland 3, in accordance with Condition WS.5:

- Up-stream of the Wharemauku Stream crossing;
- Down-stream of the Wharemauku Stream crossing; and
- Drain 5.

The actual location of gauges will be dependent on stream bed conditions. Where possible, gauges will be placed in locations such that they are able to record the full range of flows (very low to very high) and be in proximity to groundwater level monitoring wells.

Baseline surveys will be required a year in advance of construction of the structures that could potentially affect stream flows in order to establish seasonal flow ranges (i.e. lowest naturally and highest naturally occurring flows due to seasonal influences).

Where surface water is ephemeral, shallow standpipes should be installed in the place of permanent gauging stations.

8.4.1 Monitoring records

The flow gauging (continuous if feasible) will provide a raw data record of in-stream flow and its variations over time. The raw data will be separated into base flow (that derived from storage within surface water bodies) and quick flow (that resulting from rainfall, storm water runoff etcetera).

Consideration will be given to recordings at an established upstream flow site on the Wharemauku Stream (Coastlands site) in interpretation of the data.

8.4.2 Monitoring frequency

Where continuous monitoring gauges are able to be established, monitoring will be recorded at 15 minute intervals for one (1) year prior to commencement of excavation of flood offset storage areas 2, 3A and wetland 3, continuing through the construction period and for one (1) year following construction, or for a shorter period if no effect on flows has been recorded and it is agreed by the Manager. Prior to construction, these records will be downloaded for processing every 3 months. During and for a period of 12 months following construction, the data will be downloaded monthly.

If it is not feasible to install continuous flow gauges, spot gauging will be carried out at monthly intervals for one (1) year prior to commencement of construction, continuing through the construction period and for one (1) year following construction, or for a shorter period if no effect on flows has been recorded.

8.4.3 Reporting

Results of surface water flow monitoring will be downloaded and analysed monthly. The data and assessment of the data will be presented three (3) monthly as an appendix to the groundwater (level) monitoring reports, required in condition GD.3, issued at the same time.

8.5 Monitoring of inflows to excavations

Actual groundwater inflow to the excavations shall be monitored where practical and compared with modelled inflows.

Where groundwater inflows are sufficient to warrant pumping and removal, discharged volumes shall be monitored and recorded on a daily basis. This flow monitoring will be carried out in conjunction with monitoring as described in the monitoring section of the Erosion and Sediment Control Plan (ESCP) and/or the Contaminated Soils and Groundwater Management Plan (CSGMP).

8.6 Monitoring of ground conditions

Actual ground conditions encountered in excavation of stormwater storage areas and wetlands will be recorded by a geologist or geotechnical engineer. Where these differ noticeably from modelled ground conditions, the relevant model will be updated to reflect actual conditions and the effects checked against those anticipated to determine whether any further mitigative action by design is needed.

9 Alert or action trigger response

9.1 During construction

Where an **Alert trigger** level is exceeded, the Project team's Project Manager and the Consenting Authority (Greater Wellington Regional Council) will be notified by the Environmental Management Team, in writing, within 3 working days with details of actions to be undertaken.

Actions are outlined below (bullets 1 and 2 will be implemented in all cases, followed by bullet 3 if the exceedance is confirmed):

- Repeat monitoring of piezometer exceeded and closest piezometers in the vicinity;
- Analyse expected water level using regression method set out in Section 8.1 if not already done;
- Increase frequency of groundwater level monitoring to daily for all bores within 200 m radius of the affected monitoring bore.

Where an **Action trigger** level for a monitoring bore is exceeded, activities that have the potential to cause adverse effects (such as increasing drawdown) will be ceased or mitigated (such as by reinjection of abstracted water). The following people will be notified:

- The Project and Site Managers;
- The Consenting Authority (Greater Wellington Regional Council); and
- The Environmental Management Team.

Works may recommence without mitigation once groundwater levels return to sub-Action levels. Alternatively, works may recommence if written notice is received from the Consenting Authority (Greater Wellington Regional Council) indicating that they are satisfied that damage to buildings, structures and services, or impacts on wetlands are unlikely.

9.2 Ground settlement indicator

Apply actions set out in section 3.3 of the Settlement Effects Management Plan (SEMP).

9.3 Ponding groundwater indicator

Visit the site to assess the potential for the raised water level to result in ponding of groundwater above the ground surface. Identify mitigation opportunities (section 10.3) in consultation with NZTA, KCDC and the potentially affected party.

Should surface ponding occur in an area where monitoring indicates raised water levels in piezometers, the extent of the surface ponding will be mapped on a weekly basis until such ponding, if found to be a result of project works, is mitigated.

9.4 Wetland indicator

Apply actions set out in section 8 of the Ecological Management Plan (EMP) and section 5.3 of the EMP Technical Attachment 5: Wetland Monitoring and Management Plan.

10 Mitigation measures

This section describes potential mitigation measures available; a variety of measures are available and the most appropriate measure will be determined by the Project team's Engineer for each specific case should it be required. Measures shall be implemented in accordance with the Conditions and in agreement with the Consenting Authority (GWRC).

The procedures for regular monitoring of groundwater levels during the construction phase are given in Section 5 and Appendix D of this GMP. The Alert and Action Levels used to trigger any of the mitigation measures listed below are specified in Section 8 of this GMP.

10.1 Groundwater drawdown contingency measures (other than associated with construction water abstraction)

A small amount of drawdown is expected within the designation resulting from temporary excavations, peat replacement and groundwater lowering for flood management. In the event of groundwater drawdown exceeding the anticipated levels away from the immediate works, the following actions will be considered.

Changes to construction methodology i.e.:

- Alternative peat treatment (surcharge);
- Lining (temporary and / or permanent) of cuts below the groundwater level; or
- Limit the length and drained duration of temporary excavations.
- Local cut off (clay bund or slurry wall);
- Recharge water through trenches or well; or
- Where drawdown is found to affect private well use, water from the construction supply wells could be provided via tanker truck to affected users (short term) or it might be necessary to deepen the private pump or well. Should monitoring indicate that excessive groundwater drawdown begins after the completion of the Expressway, any of the mitigation options listed above (except for changes to construction methodology) could be implemented. However, the predicted drawdowns in the aquifers supplying water to most wells in the areas away from the Expressway and associated construction are small, 0.2 to 0.5 m in the most-affected wells and less than 0.2 m in most others. These relatively small changes are unlikely to be noticed by well water users away from the Expressway designation.

10.2 Groundwater drawdown contingency measures (construction water abstraction)

Because the effect of groundwater drawdown associated with construction water abstraction will be temporary, temporary solutions will be agreed with the affected party.

These are likely to be provision of tankered water, lowering of existing pump in the bore, or provision of a temporary submersible pump.

10.3 Groundwater damming and mounding contingency measures

A small amount of groundwater damming is expected within the designation resulting from surcharging and compression of the peat. Groundwater mounding is also likely in the short term from infiltration at the base of swales and unlined stormwater devices. In the event that groundwater damming or mounding exceeds the anticipated levels the following actions could be taken:

Changes to construction methodology i.e.:

- Alternative peat treatment (excavate and replace);
- Increase permeability of starter drainage layer in embankment (to act as drainage blanket) to transfer groundwater from outside of the Project;
- Introduce active drainage measures (e.g. sub-soil drains beneath embankment).

10.4 Site specific measures

10.4.1 Wetland 9

The area around Wetland 9 currently suffers from poor drainage because it is low-lying with high groundwater levels and has no robust surface water drainage system. If the project were to result in a rise in groundwater levels in the area, this could result in surface ponding of water. As part of the construction of Wetland 9, there will be a stormwater pipe installed along the access lane at the Tocker property that will take attenuated storm runoff from the Wetland 9 outlet and discharge it to the Council pipe system in Puriri Road. That new pipe will also have capacity to convey drainage from the relatively small residual catchment areas around the wetland.

In the event that there is additional surface ponding, private connections could be provided for surface runoff, to drain that ponded water.

A further enhancement, if needed, would be to allow for shallow depth private subsoil drainage to also connect to this pipe, to assist in the management of high groundwater levels and wet ground, in the event that the existing problems are exacerbated by the Project.

11 Transition phase

At the end of construction, all monitoring data will be handed over to the NZTA to allow monitoring to continue through the post-construction stage. As far as possible, continuity of personnel should be maintained through this phase of the monitoring, at least for the up to 3-year period following Project completion.

12 Review procedures

This section describes how the Plan will be reviewed, including considering the environmental controls and procedures to make sure that they are still applicable to the activities being carried out.

The GMP will be reviewed by the Project team after confirmation of the resource consent and designation conditions and will be revised in accordance with these conditions. The GMP will be updated, with the necessary approval, throughout the course of the Project to reflect material

changes associated with changes to construction techniques or the natural environment. Approval from GWRC will be required for any relevant revisions of a material nature to the GMP.

A management review of the GMP will be undertaken at least annually by the Project team Project Management team. The management review will be organised by the Environmental Manager and the Project team will be informed of any changes to this Plan through the regular Project communications processes. The review will take into consideration:

- Significant changes to construction activities or methods;
- Significant change in the volume or nature of groundwater encountered;
- Key changes to roles and responsibilities within the Project;
- Changes in industry best practice standards or recommended pollution controls ;
- Changes in legal or other requirements (social and environmental legal requirements, the NZTA objectives and relevant policies, plans, standards, specifications and guidelines);
- Results of monitoring, inspection and maintenance programmes, logs of incidents, corrective actions, internal or external assessments; and
- Public complaints.

Reasons for making changes to the GMP will be documented. A copy of the original GMP document and subsequent versions will be kept for the Project records, and marked as obsolete. Each new/updated version of the GMP documentation will be issued with a version number and date to eliminate obsolete GMP documentation being used.

13 References

Coe, L. Assessment of Ground Settlement Effects: Technical Report 35: MacKays to Peka Peka Expressway Project AEE.

Coe, L. Settlement Effects Management Plan (SEMP): Appended to the Construction Environmental Management Plan (CEMP) for the MacKays to Peka Peka Expressway Project.

Construction Environmental Management Plan (CEMP): MacKays to Peka Peka Expressway Project.

France, S. and Michaelsen, J. Assessment of Groundwater Effects: Technical Report 21: MacKays to Peka Peka Expressway Project AEE.

Park, M. Ecological Impact Assessment: Technical Report 26: MacKays to Peka Peka Expressway Project AEE.

Ridley, G. Erosion and Sediment Control Plan (ESCP): Appended to the Construction Environmental Management Plan (CEMP) for the MacKays to Peka Peka Expressway Project.

Smith, G. Contaminated Soils and Groundwater Management Plan (CSGMP): Appended to the Construction Environmental Management Plan (CEMP) for the MacKays to Peka Peka Expressway Project.