



WINSTONE
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THREE KINGS QUARRY

**MONITORING AND CONTINGENCY
PLAN FOR DEWATERING THREE
KINGS QUARRY**

SEPTEMBER 2005

Three Kings Quarry

Monitoring and Contingency Plan for Dewatering Three Kings Quarry

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Three Kings Quarry

Monitoring and Contingency Plan for Dewatering Three Kings Quarry

A monitoring and contingency plan for dewatering Three Kings Quarry is required by condition 14 of the consent to dewater Three Kings Quarry – Permit No. 12997 (attached as Appendix A).

This monitoring and condition plan must be complied with at all times [Condition 16].

Relevant conditions of consent are shown in square brackets.

1.0 Background and Definitions

The original consent to dewater Three Kings Quarry was granted by Environment Court order in March 1997. In preparation for dewatering to commence, a monitoring and contingency plan for ground subsidence was prepared and submitted to the Auckland Regional Council (Three Kings Quarry Monitoring and Contingency Plan for Ground Subsidence dated November 1998). Dewatering of Three Kings Quarry commenced in March 1999.

In April 2001 a comprehensive review of the monitoring data and predictive models was commenced to check monitoring results against predictions. A new groundwater model was developed to supplement the existing groundwater model. Settlement predictions were revised to reflect the changes to the groundwater model and settlements observed since dewatering commenced in March 1999.

In April 2003 the Auckland Regional Council issued a notice to review conditions of consent to dewater Three Kings Quarry under Section 128 of the Resource Management Act. This review was publicly notified and submissions were received. A hearing before Commissioners was held in July/August 2003. In the Commissioners decision dated 5 September 2003, changes to conditions of consent, in particular to boreholes to be monitored, ground surface level benchmarks to be surveyed, ground settlement limits and the content of the Monitoring and Contingency Plan were made. Appeals to the Commissioners

decision were lodged. These appeals were settled by an Environment Court consent order dated 15 July 2005.

An interim monitoring and contingency plan was prepared to cover the appeal period (Interim Monitoring and Contingency Plan dated February 2004).

This Monitoring and Contingency Plan is a result of and subject to the conditions of consent to dewater Three Kings Quarry granted by consent order dated 15 July 2005 – Permit No 12977 (Appendix A).

The information used in the preparation of this monitoring and contingency plan is based on information and recommendations contained within:

- The resource consent to dewater Three Kings Quarry (Permit No 12977),
- The Tonkin and Taylor report (2003a) entitled “Three Kings Quarry Dewatering – Review of Settlement Predictions” dated February 2003,
- The Tonkin and Taylor report (2003b) entitled “Three Kings Quarry Dewatering – Assessment of Supplementary Investigations of April 2003” dated July 2003,
- The Pattle Delamore report entitled “Groundwater Modelling of the Waitematas near Three Kings Quarry” dated February 2003,
- The Pattle Delamore report entitled “Three Kings Dewatering: Assessment of Groundwater Information April 2003” dated July 2003,
- The Pattle Delamore report entitled “2003/2004 Groundwater Monitoring Report, Three Kings Quarry” dated February 2005, and
- Groundwater level monitoring results and precise level survey data to July 31 2005.

Definitions

Dewatering – means the lowering of the groundwater table (as measured in the quarry reference bore).

Total Settlement – the total settlement of a surface level monitoring point is the difference between the original (baseline) level of the monitoring point and the

level recorded in the most recent precise level survey.

Differential Settlement – is the difference in total settlement between two adjacent surface level monitoring points divided by the distance between the two monitoring points.

Where a surface level monitoring point has been established subsequent to dewatering commencing, the total settlement of that monitoring point must be adjusted for any settlement occurring between the time when dewatering commenced and when the monitoring point was established. This adjustment will be determined by a linear calculation derived from the total settlements of adjacent surface level monitoring points (these may be an “adjusted” total settlement where adjacent surface level monitoring points were established subsequent to dewatering commencing).

Cessation of Settlement – means that there has been no settlement caused by dewatering, as a result of the exercise of the consent to dewater Three Kings Quarry, greater than 5mm during any continuous 12 month period at any of the surface level monitoring points required by this Monitoring and Contingency Plan.

This will be determined by comparing the survey levels of all surface level monitoring points surveyed in a 12 month period with the survey level recorded at the start of the 12 month period.

In Excess of Seasonal Variation – means that the groundwater level measured in two successive groundwater level measurements in boreholes BH37, BH38, BH39 and BH40 measured in accordance with this Monitoring and Contingency Plan is below the greater of 0.2 metres below the bottom level of the natural groundwater level range, or the bottom 99.9% probability limit calculated from the first two years of data (in accordance with Section 6 of this Monitoring and Contingency Plan).

The natural groundwater level range is obtained from determining the 99% probability limits for the groundwater monitoring data for each groundwater monitoring bore (in accordance with Section 6 of this Monitoring and Contingency Plan).

The 99% probability limits are defined by the sample mean, plus or minus the product of 2.58 times the standard deviation of the data. The 99.9% probability

limits are defined by the sample mean plus or minus the product of 3.29 times the standard deviation of the data.

2.0 Quarry Dewatering

Dewatering of Three Kings Quarry commenced in March 1999. Groundwater levels in the quarry were lowered to RL34m by October 2002 when dewatering was halted while the review of the dewatering was being undertaken. Since October 2002 the groundwater level in the quarry has been held above RL34metres.

Dewatering Procedure

The quarry groundwater level must be maintained above RL34m until the following criteria are complied with [Condition 22]. Dewatering can then only occur in a maximum of 5m drawdown steps with a period of maintenance pumping of at least 2 years at the end of each drawdown step. Dewatering can only continue following each drawdown step if criteria in 2.7 and 2.8 are met. Dewatering must cease if the criteria in 2.9 and 2.10 are exceeded [Condition 22A].

Pumping of groundwater must cease if the differential settlement between any two ground settlement points is steeper than 1:1000. Pumping of groundwater is not allowed to recommence without the permission of the Auckland Regional Council [Condition 13].

To ensure the following criteria are complied with, any lowering of the quarry groundwater level must be fully documented and communicated with the Auckland Regional Council. The Annual Report (Section 9.0) must contain all details of and actions resulting from the lowering of the quarry groundwater level.

Dewatering action plans for the initial drawdown step below RL34m and for subsequent dewatering steps are presented in Figure 1 and 2 respectively. These figures show a summary of actions outlined in more detail in Sections 2, 3, 4, 5 and 6 of this Monitoring and Contingency Plan.

Figure 1: Action Plan for the Initial Dewatering Step Below RL34m

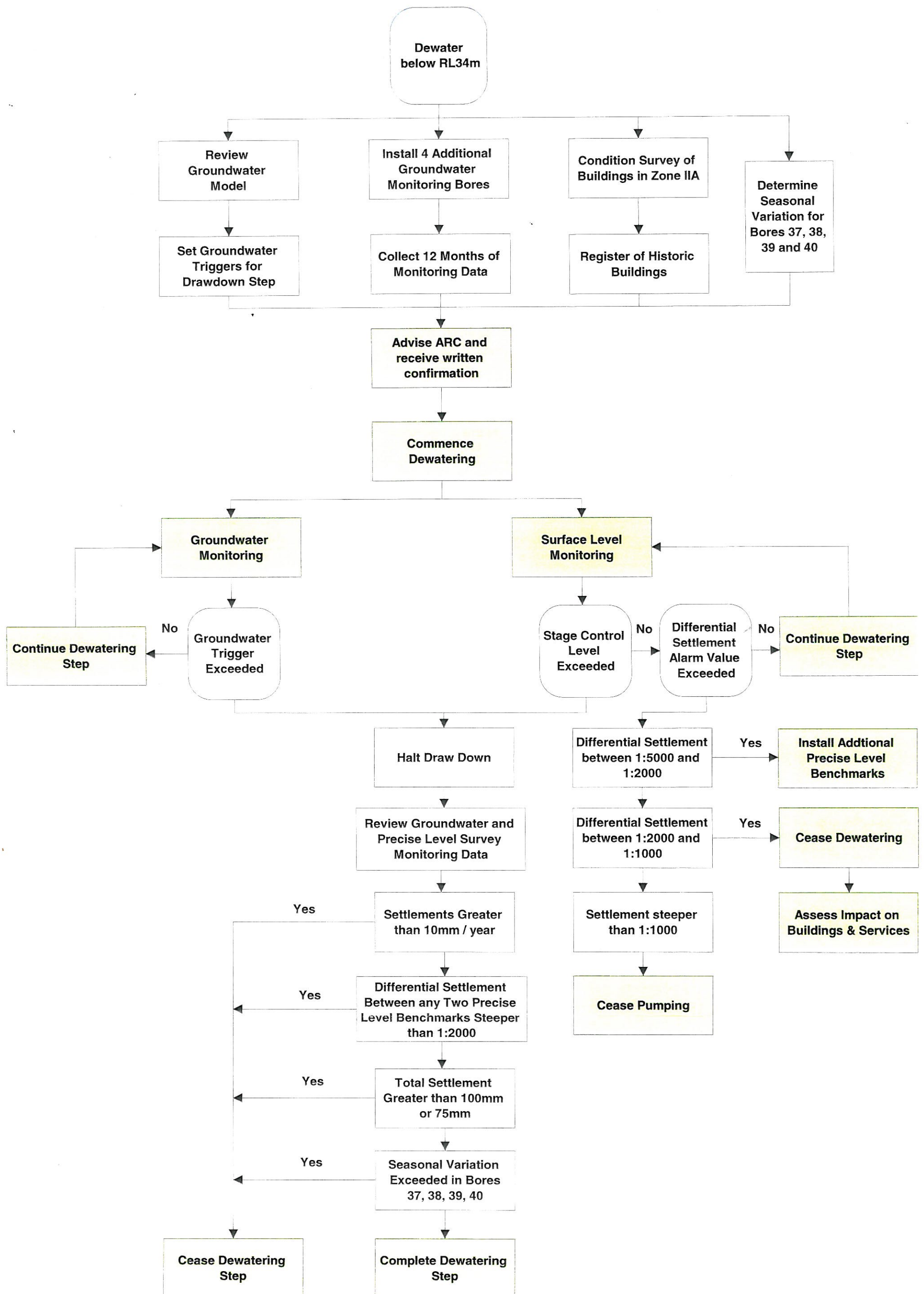
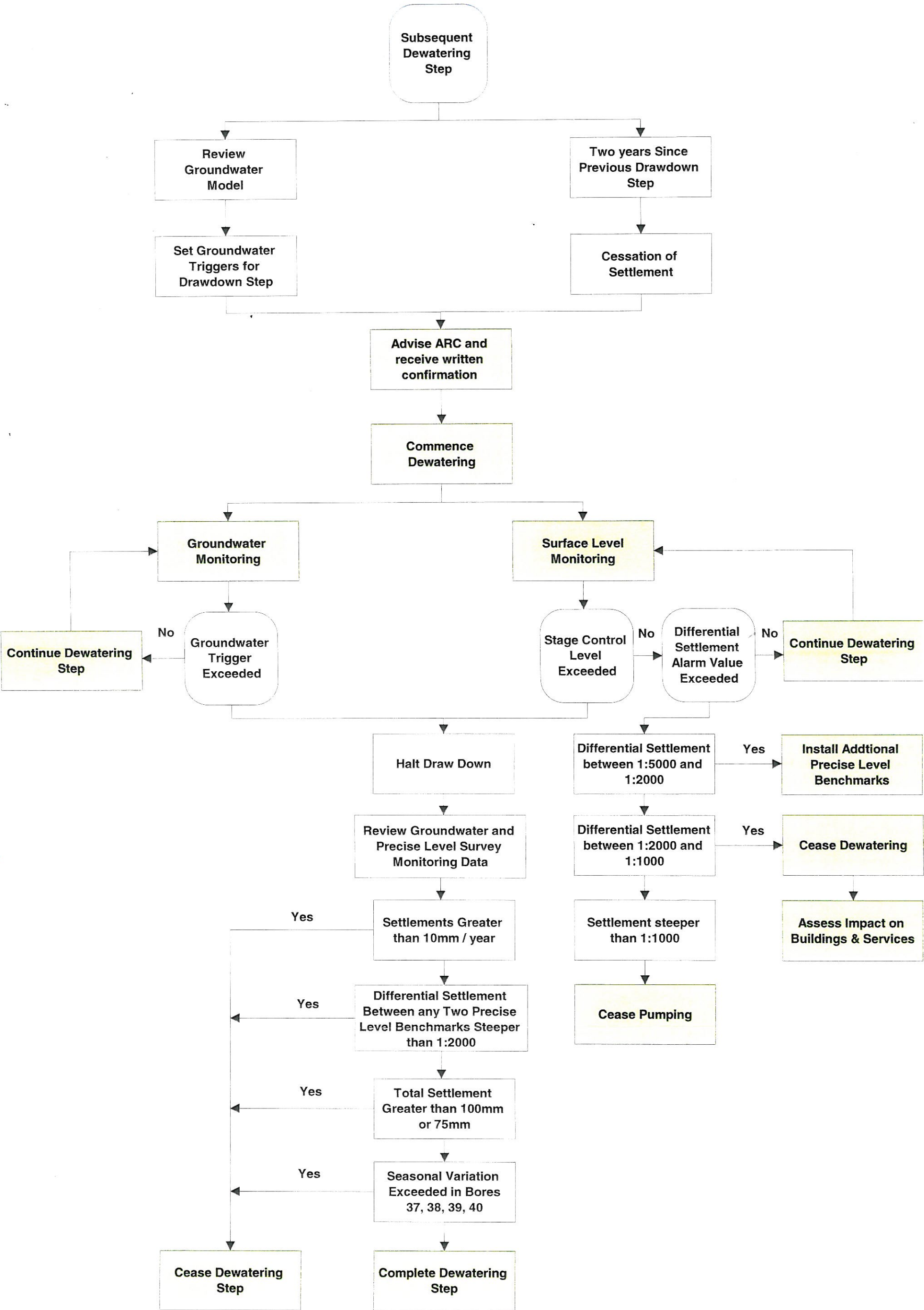


Figure 2: Action Plan for Subsequent Dewatering Steps



Dewatering Below RL34m

Prior to dewatering below RL34m, the following is required to be undertaken:

- 2.1 Installation of four additional groundwater monitoring bores generally located at the intersection of Mt Eden and Landscape Roads, the intersection of Landscape and St Andrews Roads, the intersection of McCullough and Duke Streets and to the south of BH27 in Settlement Zone IIB (Drawing 18670-04, Appendix D). These bores must be monitored for not less than 12 months prior to the commencement of drawdown below RL34m. The exact locations of the bores are to be fixed in consultation with the Auckland Regional Council [Condition 8].
- 2.2 The owners of properties in Settlement Zone IIA (Drawing 18670-04, Appendix D) are to be consulted and, subject to the owners approval, a detailed condition survey of buildings in Zone IIA in accordance with this Monitoring and Contingency Plan (Section 5.0) is to be undertaken to confirm their existing condition and to enable the magnitude of allowable effects from changes in groundwater pressures and ground movements to be accurately determined [Condition 23].
- 2.3 The groundwater model is to be reviewed and groundwater triggers determined for a drawdown to RL29m in accordance with this Monitoring and Contingency Plan (Section 6.0). The groundwater model review and groundwater triggers are to be reported to the Auckland Regional Council.
- 2.4 The seasonal variation of bores 37, 38, 39 and 40 are to be determined in accordance with this Monitoring and Contingency Plan (Section 6.0).
- 2.5 A register of historic buildings in the area of dewatering protected by the District Plan or the Historic Places Act is to be compiled in accordance with this Monitoring and Contingency Plan (Section 5.0).

- 2.6 The Auckland Region Council must be notified that dewatering below RL34m is to commence. Dewatering of a 5m drawdown step can only commence if the Auckland Regional Council confirms in writing that the criteria in section 2.7 have been complied with [Condition 22B].

In addition, when notice of drawdown below RL34m is given, the Auckland Regional Council may request an additional condition survey on any building in the dewatering zone for the purpose of checking for damage and for following up on any subsequent report of damage to that building [Condition 24].

Dewatering of a Drawdown Step

Prior to commencing a 5m drawdown step, the following criteria must be met:

- 2.7 Dewatering of a 5m drawdown step can only commence if the Auckland Regional Council confirms in writing that the time since the end of the last 5m drawdown step is at least 2 years; measured settlement, caused by the exercise of the consent to dewater Three Kings Quarry, has ceased at all settlement points for a period of 1 year; and the criteria in 2.10 have not been exceeded [Condition 22B].
- 2.8 The groundwater model is to be reviewed and groundwater triggers determined for the drawdown step as defined in Section 6.0. The groundwater model review and groundwater triggers are to be reported to the Auckland Regional Council.

Dewatering of any drawdown step will cease if:

- 2.9 Ground settlement, caused by the exercise of the consent to dewater Three Kings Quarry, as measured at any settlement monitoring point required by this monitoring and contingency plan exceeds 10mm per year. Dewatering will not recommence until the criteria in 2.7 are met [Condition 22C].

- 2.10 The differential settlement between any two settlement monitoring points required by this monitoring and contingency plan is steeper than 1:2000; or the total settlement at any settlement monitoring point established before 30 September 2002 is greater than 100mm; or the total settlement at any monitoring point established after 30 September 2002 is greater than 75mm; or groundwater drawdown, caused by the exercise of the consent to dewater Three Kings Quarry is in excess of the seasonal variation in any one of bores 37, 38, 39 or 40; or if the groundwater level in the quarry is at or below RL0m [Condition 22D].

3.0 Groundwater Monitoring

Piezometers are used to monitor changes in groundwater level within Three Kings Quarry and in the surrounding area. The location and general details for each piezometer monitoring changes in groundwater levels, including those monitoring groundwater levels in Tauranga Group Sediments, are contained within Appendix B.

- 3.1 Groundwater levels will be monitored in bores 2B, 6, 7, 10, 11, 12, 13, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37, 38, 39, 40 and in any other bore required by this monitoring and contingency plan [Condition 7].
- 3.2 Groundwater levels will be measured in all piezometer levels at each bore location [Condition 7].
- 3.3 The groundwater level in bore 2B will represent the quarry water level (the quarry reference bore).
- 3.4 In the event that a bore is destroyed or becomes inoperable, that bore will be substituted with another [Condition 7].
- 3.5 The approval of the Auckland Regional Council will be gained prior to the substitution of any bore with another [Condition 7].
- 3.6 Monitoring of groundwater levels in all piezometers will be

undertaken monthly [Condition 7].

- 3.7 The date of monitoring and the water level in each piezometer is to be recorded and a groundwater monitoring database will be maintained by Winstone Aggregates [Condition 7].
- 3.8 The water level monitoring results for the preceding quarter will be submitted to the Auckland Regional Council no later than 10 working days after 28 February, 31 May, 31 August and 30 November [Condition 7].
- 3.9 A meter to measure the total quantity of groundwater being taken from beneath Three Kings Quarry must be maintained on the outlet of the pump [Condition 5].
- 3.10 The water meter must be read at weekly intervals and a record kept of the date and water meter reading [Condition 6].
- 3.11 The water meter results for the preceding quarter will be submitted to the Auckland Regional Council no later than 10 working days after 28 February, 31 May, 31 August and 30 November [Condition 6].

4.0 Surface Level Monitoring

Surface level monitoring points are used to determine change in surface level in the area surrounding Three Kings Quarry. The location and original (baseline) level for surface level monitoring points used in determining changes in surface level are contained within Appendix C. [The following all are requirements of Condition 12.]

- 4.1 The network of surface level monitoring points listed in Appendix C will be maintained.
- 4.2 If any part of the monitoring network becomes inoperative, or if a surface level monitoring point is destroyed, it will be replaced as soon as practicable.

- 4.3 Additional surface level monitoring points to those contained within Appendix C will be installed taking into account the geology, accessibility to survey points and risk of damage from ground settlement.
- 4.4 The distance between surface level monitoring points added to the existing network will be no more than 100metres.
- 4.5 The distance between surface level monitoring points in Settlement Zone IIA (Drawing 18670-04, Appendix D) will be no greater than 25metres.
- 4.6 Two transects of surface level monitoring points at approximately right angles to Hillsborough Road will be maintained in Settlement Zone IIA (along Mt Albert Road and Budock Road, Drawing 18670-04, Appendix D).
- 4.7 Surface level monitoring points will be installed to provide a spacing of not more than 50m at locations in the survey network where observed differential settlements exceed 1:5000 and at a spacing of not more than 25m at locations in the survey network where observed differential settlements exceed 1:2000
- 4.8 All surface level monitoring points will be surveyed once every six months while no dewatering is taking place and every three months during periods of dewatering. In addition, all surface level monitoring points in Settlement Zone IIA (Drawing 18670-04, Appendix D) will be surveyed three monthly.
- 4.9 The frequency of monitoring will increase to three monthly in those areas where differential settlement exceeds 1:2000.
- 4.10 When dewatering has ceased for more than 2 years and there has been a cessation of settlement, then all ground surface monitoring will be conducted by annual survey provided that if dewatering re-

commences, the frequency of survey monitoring will revert to that set out in 4.8.

- 4.11 The survey will be to an accuracy range achieved by best practice precise levelling, which in any given survey means within a range of +/- 2mm between adjacent surface level monitoring points.
- 4.12 A database of precise level survey measurements will be maintained by Winstone Aggregates.
- 4.13 The results of each survey will be forwarded to the Auckland Regional Council and the Three Kings United Group within 10 working days of the completion of the survey.

5.0 Building Condition Survey

Settlement Zone IIA

A detailed building condition survey of buildings within Settlement Zone IIA (Drawing 18670-04, Appendix D) will be undertaken prior to drawdown of groundwater in the quarry below RL34m [Condition 23]. This building condition survey will be undertaken in consultation with the owners of the properties and will be subject to the owner's approval. It will include but not necessarily be limited to the following:

- The type and capacity of foundations
- Existing levels of aesthetic damage
- Existing levels of structural distress
- Assessment of structural ductility
- Susceptibility to further foundation movements
- Assessment of waterproofness of basements

The survey will be undertaken by an independent experienced engineer approved by the Auckland Regional Council. A certificate will be issued by a Chartered Engineer within one month of the completion of the survey that certifies that the survey has been completed in a professional manner and is an accurate assessment of the condition of the buildings concerned.

The procedure for undertaking the building condition surveys will be as follows:

1. The owners of building in Zone IIA will be identified and consulted with regarding the purpose and extent of building conditions surveys proposed.
2. Only those buildings with the owner's approval will be surveyed.
3. An independent experienced engineer will be identified to undertake the surveys and that persons details will be submitted to the Auckland Regional Council for approval.
4. Subject to the owner's written approval the building survey will be undertaken and may include a photographic record of the building.
5. A report for each building will be prepared.
6. A certificate will be issued by a Chartered Engineer within one month of the completion of the survey that certifies that the survey has been completed in a professional manner and is an accurate assessment of the condition of the buildings concerned.

Historic Buildings

Prior to dewatering below RL34m, a register of historic buildings within the area of dewatering protected by the District Plan or the Historic Places Act will be compiled and their locations plotted on a map of the Three Kings area together with surface level monitoring points. An appraisal of their condition together with existing and predicted settlements in the immediate vicinity of each building will be undertaken to ensure that dewatering authorised by the consent to dewater Three Kings Quarry does not result in damage to any historic building [Condition 25].

6.0 Groundwater Monitoring Action Plan

Groundwater levels will be monitored in and around Three Kings Quarry in accordance with Section 3.0 of this Monitoring and Contingency Plan. The groundwater level in the quarry is currently being held above RL34m. The

procedures and criteria for drawing the quarry groundwater level below RL34m are detailed in Section 2.0 of this Monitoring and Contingency Plan.

Trigger levels are required for the early warning of excessive ground settlement based on the difference between predicted and actual groundwater level changes, and the calculated seasonal variation in bores 37, 38, 39 and 40.

Groundwater Triggers

For each drawdown step, groundwater triggers will be determined as follows:

- 6.1 The groundwater model will be reviewed prior to a groundwater drawdown step to track calibration accuracy, to validate drawdown predictions and to ensure recharge estimates are reasonable.
- 6.2 A prediction of groundwater levels in each of the monitoring bores will be made prior to each groundwater drawdown step. These predictions will be compared with those used to determine the settlement values in Table 1 (Section 7).
- 6.3 Groundwater triggers will be set to ensure that settlements greater than those values in Table 1 are not exceeded.
- 6.4 The results of the prediction review at each drawdown step will be forwarded to the Auckland Regional Council prior to that drawdown step being commenced.
- 6.5 Dewatering will cease (by halting the drawdown of groundwater levels in the quarry) if groundwater triggers in any dewatering step are exceeded. A review of the groundwater levels and precise level survey data will be undertaken. Dewatering can only be recommenced if the review of precise level survey data demonstrates that criteria in section 2.9 and 2.10 will not be exceeded.
- 6.6 The results of the review will be forwarded to the Auckland Regional Council prior to dewatering recommencing.

Seasonal Variation Calculation

- 6.7 Groundwater monitoring data for boreholes BH37, BH38, BH39 and BH40 for the first 12 month period will be analysed and the natural groundwater level range, including seasonal fluctuations, will be determined for each borehole by determining the 99% probability limits for the data. The 99% probability limits are defined by the sample mean, plus or minus the product of 2.58 times the standard deviation of the data. Data from the second 12 months of monitoring will be used to recalculate the natural groundwater level range if the 95% confidence limits of the second 12 month monitoring data set overlap with the 95% confidence limits of the first 12 month monitoring data set. The calculated natural range will not be altered after the first 2 years of monitoring.
- 6.8 Dewatering will cease (by halting the drawdown of groundwater levels in the quarry) if groundwater drawdown caused by the consent to dewater Three Kings Quarry is in excess of seasonal variation in any one of bores 37, 38, 39 or 40.
- 6.9 The calculated natural groundwater level range and the 99.9% probably limit in bores 37, 38, 39 and 40 will be forwarded to the Auckland Regional Council by 31 March 2006 and 31 March 2007 following the first and second anniversary respectively of monitoring water levels in bores 37, 38, 39 and 40.

7.0 Surface Level Monitoring Action Plan

Ground surface levels will be monitored by precise level survey of surface level monitoring points as detailed in Section 4. Precise level settlement triggers for both total settlement and differential settlement will be established.

Total Settlement

Settlements for surface level monitoring points in the zones shown in Drawing No

18670-04 (Appendix D) have been calculated for various stages of drawdown of quarry groundwater levels. These Stage Control Levels are presented in Table 1.

Should settlements greater than the Stage Control Levels be measured, the following actions will be undertaken:

- 7.1 Dewatering will cease (by halting the drawdown of groundwater levels in the quarry) if groundwater drawdown caused by the exercise of the consent to dewater Three Kings Quarry is in excess of any Stage Control Level (Table 1).
- 7.2 A review of groundwater levels and precise level survey data will be undertaken. Dewatering can only be recommenced if the review demonstrates that criteria in section 2.9 and 2.10 will not be exceeded with any further drawdown.
- 7.3 The results of the review will be forwarded to the Auckland Regional Council prior to dewatering recommencing.

Table 1 Stage Control Levels for Total Settlement									
	Intermediate Trigger (mm) for Settlement Zones								
	I	II	IIA	IIB	III	IV	V	IIIA	IIIB
Quarry Drawdown to RL30m	10	20	45	15	10	10	5	25	20
Quarry Drawdown to RL15m	15	25	55	35	15	10	5	35	30
Quarry Drawdown to RL0m	20	30	65	45	20	15	5	45	40
Steady State Water Level (at RL0m)	20	35	75	50	25	20	5	65	60

Differential Settlement

Differential settlements between adjacent surface level monitoring points will be calculated following each precise level survey. Differential Settlement Alarm Values are defined as set out in Table 2.

Table 2 Differential Settlement Alarm Values	
Trigger Status	Measured Differential Settlement
Trigger for Installation of Additional Survey Marks	1:5,000
Trigger to Halt Dewatering and Assess Impact of Settlement on Buildings and Services	1:2,000
Trigger to Cease Pumping	1: 1000

Where differential settlements between surface level monitoring points exceed Differential Settlement Alarm Values as a result of the exercise of the consent to dewater Three Kings Quarry, the following will be implemented:

At a differential settlement steeper than 1 in 5,000, in the area affected:

- a) Install additional surface level monitoring points at 50metre centres between existing survey marks.
- b) Report the settlements to the Quarry Manager and the Auckland Regional Council.

At a differential settlement steeper than 1 in 2000, cease lowering the groundwater (as measured in the quarry reference bore) and, in the area affected:

- a) Install additional survey marks at 25metre centres between existing survey marks.
- b) Report settlements to the Quarry Manager, the Auckland Regional Council, affected property owners and the following Community Groups and Community Boards: South Epsom Planning, Three Kings United, Epsom Environmental Effects, Mt Roskill Community Board, and Eden-Albert Community Board.
- c) Assess the potential impact of ongoing settlement on buildings and services.
- d) Undertake a review of the groundwater model and settlement predictions.

- e) Report assessment to the Quarry Manager, the Auckland Regional Council and property owners.
- f) The frequency of survey monitoring will be increased to 3-monthly until no further settlements are recorded.

At a differential settlement steeper than 1 in 1,000:

- a) The taking of groundwater authorised by the consent to dewater Three Kings Quarry will cease immediately. Pumping of groundwater will not recommence without the permission of the Auckland Regional Council.
- b) Report settlements to the Quarry Manager, the Auckland Regional Council, property owners in the area affected and the following Community Groups and Community Boards: South Epsom Planning, Three Kings United, Epsom Environmental Effects, Mt Roskill Community Board, and Eden-Albert Community Board.
- c) Assess the potential impact of ongoing settlement on affected structures.
- d) If settlements cause damage in breach of special condition 11 of the consent to dewater Three Kings Quarry, then any damage will be assessed and repaired in accordance with special condition 21B.

8.0 Measures to Control Groundwater Induced Settlement

If differential settlements induced by quarry dewatering exceed 1:1000, the following contingency measures will be considered:

- i) Allow or assist parts of the groundwater system to recharge, either naturally or by injection of water into the groundwater system in the vicinity of any location identified as affected
- ii) Monitoring of potentially affected structures (condition assessment monitoring)
- iii) Remediation of any affected structures (i.e. underpinning and/or strengthening works).

9.0 Reporting

All groundwater triggers, settlement alarms, reviews of monitoring data and any subsequent actions will be documented. Where a review indicates that a change to a groundwater trigger, settlement alarm, groundwater/settlement models or pumping strategy is required, the Auckland Regional Council will be notified. This may result in a change to the monitoring and contingency plan.

The results of groundwater level monitoring and water meter readings will be forwarded to the Auckland Regional Council at quarterly intervals no later than 10 working days after 28 February, 31 May, 31 August and 30 November [Conditions 6 and 7] .

Precise level survey results will be forwarded to the Auckland Regional Council and the Three Kings United Group within 10 working days of the completion of the precise level survey [Condition 12].

An annual Three Kings Quarry Monitoring Report will be prepared by 30 April for the year ending 31 March compiling all data and documenting any groundwater triggers, settlement alarm value events, reviews and remedial action required by this monitoring and contingency plan or any lowering of the groundwater level within the quarry undertaken during that year. This report will be forwarded to the Auckland Regional Council and the following Community Groups and Community Boards: South Epsom Planning, Three Kings United, Epsom Environmental Effects, Mt Roskill Community Board, and Eden-Albert Community Board.

10.0 Personnel

The Three Kings Quarry Manager has overall responsibility for the operation at Three Kings Quarry. The Quarry Manager is assisted by site personnel, specialist Winstone staff, and the Winstone Aggregates Management Team.

The responsibility for this Monitoring and Contingency Plan has been delegated

to the Resource and Environment Team of Winstone Aggregates, specifically the Three Kings Quarry Dewatering Monitoring Manager. This position is currently held by Michael Harris.

The Three Kings Quarry Dewatering Monitoring Manager has responsibility to maintain and ensure compliance with this Monitoring and Contingency Plan, and for the collection, recording and reporting of monitoring data as detailed within this Monitoring and Contingency Plan.

The collection of groundwater and precise level survey data is currently undertaken by consultants as follows:

- Groundwater Monitoring – Environmental and Earth Sciences Ltd (standpipe piezometers), Tonkin and Taylor Ltd (pneumatic piezometers)
- Precise level Surveys – Harrison Grierson Consultants Limited

Monitoring results will be forwarded to the Three Kings Quarry Dewatering Monitoring Manager as the information is collected. The Three Kings Quarry Dewatering Monitoring Manager will maintain a database of the monitoring information and report to the Auckland Regional Council, the Three Kings Quarry Manager and community groups as required by this Monitoring and Contingency Plan.

The validation of the groundwater model and any groundwater prediction reviews are currently undertaken by groundwater consultants Pattle Delamore Partners Ltd. The assessment and review of surface settlements is currently being undertaken by environmental and engineering consultants Tonkin and Taylor Ltd. Additional specialist consultants may be engaged to review the dewatering of Three Kings Quarry.