REPORT

OPUHA WATER LTD

Opuha Dam
Annual Dam Safety Inspection 2010

Report prepared for:

OPUHA WATER LTD

Report prepared by:

Tonkin & Taylor Ltd

Distribution:

OPUHA WATER LTD	**4 copies**
Tonkin & Taylor Ltd (FILE)	**1 copy**

May 2010

T&T Ref: 51137.004 Issue

DOCUMENT CONTROL				Prepared By: T&T
Title: Opuha Dam			OPUHA WATER LTD	Initial: TGM File name: Tgm.18.05.10.Opuha 2010 Annual Report.docx
Pages	**Date**	**Issue No**	**Description**	**Initials**
All	10 May	Draft1	Initial draft for review	TGM
All	18 May 2010	Issue	Issue	TGM

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Executive summary

The Annual Safety Inspection of Opuha Dam for 2010 was undertaken on 27th April 2010. This report incorporates the inspection on that day and a review of the dam's performance for the period between 1st April 2009 and 31st March 2010. The review is undertaken in accordance with the recommendations of NZSOLD (2000).

The inspection and monitoring data for the period suggest that the dam is operating in a generally satisfactory manner.

The Downstream Weir Overflow Embankment (DWOE) fused on 17th May 2009 during a major flood event. The peak flood flow was estimated to be approximately 180 m^3/s. The DWOE performed in accordance with expectations and the DWOE was subsequently reinstated. Commissioning of the DWOE was considered complete on 13th October 2010.

A 7.8 Moment Magnitude earthquake occurred at 9:22pm on Wednesday 15th July. The epicentre was located in Fiordland and the Geological and Nuclear Sciences website indicates that a maximum acceleration of 0.8%g (0.01g) was recorded in Fairlie during this event. Opuha Water Limited carried out a post earthquake inspection of the dam on Thursday 16th July and no effects from the modest shaking was reported in the Fairlie area. The earthquake occurred during a period of cold weather and erratic hydraulic piezometer levels were recorded at this time. It was subsequently concluded that the erratic piezometer levels were a consequence of frozen piezometer leads behind the power house. Frost protection has subsequently been placed over the exposed hydraulic piezometer lines.

There were no other significant operational incidents during the period.

The Annual Safety Inspection report for 2009[1] provided eight recommendations. These have either been actioned or are in process of being actioned and the current status of these is reported in Section 10. A further four recommendations are provided as a consequence of the 2010 inspection. The recommendations are summarised as follows:

- Review of the hydraulic piezometer installation
- Access arrangements to adjacent property insofar as this relates to dam safety matters
- Clear and maintain fuse plug triggering device clay tile pipes free from debris
- Review of the status of the Allendale pipeline in the vicinity of the dam toe and securing associated valves from tampering by vandals.

A prior recommendation of note that is yet to be resolved relates to investigation of seepage flows emerging from the upper part of the embankment close to drain D16. The seepage has been noted in the past and is not excessive but is persistent.

[1] Tonkin & Taylor; Opuha Water Limited, Opuha Dam, Annual Dam Safety Inspection 2009; May 2009; Reference 51137.002

1 Introduction

The Annual Safety Inspection of Opuha dam was undertaken on the 27th April 2009, by Tim Morris of Tonkin & Taylor (T&T), together with Ken Roberts and Denis McEntyre of Contact Energy (the Operator) and the station attendant Snow Gardner (Opuha Water Limited, OWL). The weather for the inspection was overcast with some cloud cover. Rain had preceded the inspection and in places the ground surface was wet. The reservoir water level was low (below the base of the Type 4A riprap) at 379.3 mRL.

The inspection took approximately four hours and progressed along the following route:

- Crest left bank to right bank (Tim Morris and Snow Gardner only)
- Right abutment and Service Spillway approach channel
- Exposed area of the upstream face
- Auxiliary Spillway and left abutment
- Powerhouse
- H flume drains
- Service Spillway flip bucket and service spillway
- Downstream Weir.

This report incorporates the inspection on that day and reviews the performance of the dam in the period from 1st April 2009 to 31st March 2010 in accordance with the recommendations of NZSOLD (2000). Throughout the report recommendations are made *in italics*. All recommendations are summarised in Section 10. The report covers the following:

- The Dam, comprising the embankment crest and slopes
- Dam instrumentation
- The reservoir, including the intake tower
- The service and auxiliary spillways
- The power station and tailrace
- The downstream weir
- Access roads
- Surveillance and monitoring during the period considered including consideration of any operation incidents of note that occurred during this time.

The following summary of events since 2004 provides relevant background information to the dam. In 2004 SMEC carried out a Comprehensive Safety Review of the dam. Based on the recommendations from this review, the Canterbury Regional Council (ECan) reviewed and modified Consents CRC950567 and CRC950579.1 to include additional monitoring and a requirement for remedial works to the dam. A programme of remedial design and construction for both abutments and the downstream toe was undertaken. The abutment works and toe works were completed in 2005 and 2006 respectively and the works have been signed off with ECan.

2 Dam embankment crest and slopes

Visual inspection of the embankment included:

- Upstream face, to the extent permitted by the reservoir water level
- Downstream face
- Crest.

2.1 Upstream face

The upstream slope and riprap appeared in good condition to the extent visible above the 379.3 mRL lake level (Figure 2.1).

Minimal accumulation of debris was noted with no immediate need for debris removal. We understand that periodic debris removal is undertaken and this should continue.

The riprap is robust and sound. No signs of riprap bulging were observed near the base of the Type 4A riprap.

Figure 2.1 – Upstream face from auxiliary spillway approach

2.2 Downstream face

The downstream face appears to be in a good condition (Figure 2.2, Figure 2.3 and Figure 2.4). Spraying continues to control local growth of scrub and bushes to prevent them from penetrating through the riprap into the embankment fill below.

OWL reports that the in several locations sheep have formed tracks across the face of the dam, particularly in the vicinity of promontories towards the left abutment of the dam (Figure 2.4). OWL has expressed concerns that stock tracks could lead to concentration of storm water run-off flows and OWL advises that it is in the process of investigating options to fence the downstream face to exclude stock from this area.

Figure 2.2 Downstream face from right abutment

Figure 2.3 Downstream face from left abutment

Figure 2.4 Downstream face – area where stock tracks have formed.

2.3 Embankment crest

The crest roadway and fence were generally in good condition. OWL is considering enhancing signage that is intended to assist with exclusion of motorcycles from the dam crest.

2.4 Drain D16 area on the downstream face

The Operator reports that the small wet area on the upper part of the embankment dam face, on the access road and near the D16 drain outlet, has remained unchanged throughout the period. During the inspection it was not possible to observe the extent of the persistently wet area because the ground was wet from recent rain. This seepage is not excessive or extensive and has been noted in the past over a long period.

Drain D16 is a high level connection to the true right base of the thickened chimney drain at 383mRL. The drain exit is adjacent to the dam access road. Prior reports note a wet patch slightly above the drain outlet. The patch is located on the upstream side of the road edge near the outlet to Drain D16. The wet patch is not formally monitored. Nonetheless, anecdotal observations suggest that the damp spot to be generally persistent over a long period (years).

The 2008 inspection report recommended that Drain D16 be investigated by video camera. This investigation was carried out on 31st August 2008 and the video did not identify any discontinuities with the 170mm OD PE drain pipe. However, a low spot is apparent in the pipe close to the upstream end of the pipe. Here there is standing water in the pipe invert.

It is understood that there is no significant response of the damp spot to either heavy rain or reservoir level. It has been suggested that grading the road and road condition changes may obscure the wet patch from time to time. At present the source of this water remains unresolved. It may related to one or more of the following:

- seepage from the chimney drain may be tracking along the outside of the D16 drain pipe
- surface water infiltrating the embankment and exiting at this location
- leakage from the D16 drain pipe.

The 2008 report also recommended a short investigation trench in this area. The objective of this work is to investigate the source of the damp area and install a means to collect and monitor seepage flows. Alternatives to this approach should be considered. Investigation of the source of this seepage was a recommendation of the 2009 report and this recommendation is repeated below.

RCM2009-01: Develop and implement an investigation procedure to determine the source of seepage emerging at the embankment face near Drain D16.

3 Dam instrumentation

This section reviews the data for the dam instrumentation for the period 1st April 2009 to 31st March 2010. The layout of the dam instrumentation is presented in Figure 3.1. In general, the dam and spillway instrumentation continues to operate satisfactorily.

The instrumentation consists of a series of:

- Drains – H Flumes with water level recorders for flow measurements from selected drains
- Hydraulic piezometers, with gauges in the power house
- Pneumatic piezometers, located under the Service Spillway and read when the Service Spillway operates
- Stand pipes
- Rain gauge
- Deformation surveys – not undertaken in this reporting period.

3.1 Drains

There is a continuous flow monitoring system for the seepage flows from drains D7, D8, D9, D10 and D21. Water levels are recorded by data logger and the data is transmitted to Clyde Power Station hourly. Also, drain flows are manually read monthly by recording the time taken to fill a container of known volume. The surveillance regime is currently under review and the review is close to completion.

Measured drain flows provide generally consistent and satisfactory results, responding to fluctuations in reservoir level. Of the twenty-one drainage outflow measuring points, nine have had measurable flows since the 2009 report:

- the 350mRL conduit drain (D4)
- the base drainage outlet (D7)
- the outlet from the second diversion channel (D17)
- from the three chimney drain sumps (D8, D9, D10)
- Service Spillway drainage outlet (D11)
- Auxiliary Spillway fuse plug base (D18)
- the seepage cut off wall drain (D21).

Graphs of flow readings since March 2005 are provided in Appendix A, for:

- drains D7, D8, D9, D10 and D21 on Sheet A1/1 (manual data)
- the sum of D7-D10 on Sheet A1/2
- D4, D17, and D18 on Sheet A1/3.
- drains D7, D8, D9, D10 and D21 on Sheet A1/4 (water level recorder data)

D11 flows are not provided in graphical format because this drain only responds to spillway flows for a short time period.

Review of flow rates derived from water level recorder data over the period has highlighted that the water levels in the H flumes are sensitive to the accumulation of algae and other debris. Algae causes water levels to increase and thus incorrectly over estimates flow rates. The recent Surveillance and Monitoring Regime review has shown that flow rates derived from the manual readings and water level recorders are in good agreement when the

flumes are clean. Recorded flow rates diverge when the flumes become dirty. An anti fouling coating is currently being trialled in the D9 H flume and results appear promising. The H flumes are regularly cleaned. Recommendations regarding this matter are set out in the Surveillance and Monitoring Plan review that is reported separately.

Recorded drain flows were within historical bounds during the period. Very high D21 flows were recorded on 17th May 2009 and are attributed to the Downstream weir pond overtopping the H flume prior to fusing of the Overflow Embankment rather than high actual drain flows.

Figure 3.1 Instrumentation layout

3.2 Drain D18 inspection

D18 is located at the base of the auxiliary spillway fuse plugs and only flows when reservoir levels exceed 390 mRL. Flows measured during the past year were reported to be clear and within historic ranges. This level corresponds to the base of the right hand side auxiliary spillway channel. The Operator advises that an investigation may be undertaken in the near future to better understand the source of D18 drain flows. We understand that this will not involve any excavation. It is noted that this matter has been investigated in the past and based on historical drain flow records and recent inspection observations this is not considered a dam safety matter at this time.

Figure 3.3 D18 outlet.

The outlet from Drain D18 has recently been upgraded to improve measurement of flow rates. Once measured flows are now diverted into a pipe line below the invert of the auxiliary spillway (Figure 3.3). OWL confirms that the height of the new concrete work is consistent with the earlier structure to avoid any drain surcharge effect.

3.3 Other drains

Flows from D4 and D17 were small and within their typical historic ranges.

D6 flows are recorded as dripping and are too small to accurately measure.

Flows from Service Spillway drain D11 were recorded during the May 2009 flood when the spillway was operative (4.1 l/s on 17th May and 1.53 l/s on 18th May 2009). No flow was recorded from spillway drains D12, D13 and D14. The May 2009 D11 flows were higher than previously recorded. The next highest recorded flow was 0.74 l/s on 14th January 2002. It is noted that the 17th May spillway flows were higher than previously recorded, however.

3.4 Drain flow turbidity meter

A turbidity meter was installed on the H flumes to detect changes in sediment concentrations in the drain discharges. However, it is understood that turbulence and the consequent entrainment of air into the flow provided false readings. Thus upon review by the Operator, the use of the turbidity meter has cessed. Operations staff assess drainage flows for potential discolouration at the time of the manual flow rate recordings by way of a qualitative assessment of drain flows. At which time, the appropriate action can be taken if required.

3.5 Drain D17 inspection observations

The outlet area for drain D17 was upgraded in June 2008, in accordance with the recommendation of the 2008 report (Figure 3.2). There was a modest increase in the D17 flow rates following this work that may be attributed to the improved flow measurement.

As noted in the 2008 report, the current D17 flows are discharged directly onto the fill embankment below the drain outlet. This fill is spoil placed of as part of the Toe Remedial works in 2006 and is not part of the dam structural embankment. However, any displacement of the fill could affect Gooseberry Stream. Thus, the 2008 report recommended that the discharge be piped to Gooseberry Stream (*RCM 2008-07*).

The fill continues to appear stable with no adverse effect from the drain discharge observed at this time. Given the performance to date, it is suggested that observation of the fill continues in lieu of the pipework previously suggested.

3.6 Piezometers

Graphs of the data since May 2004 are provided in Appendix A2 on 3 sheets. The locations of the three lines of piezometers are shown in Figure 3.1 and the positions of each piezometer in Figure 3.3.

The 2006 remedial works disrupted the piezometer monitoring. The background to these effects is detailed in the 2007 report and are summarised as follows:

- Piezometers P2-5, P3-3 and P3-5 have been decommissioned because they are unresponsive. The readings are still recorded on site but are not reported.
- The gauges for piezometers P1-2, P1-3, P2-6, P2-7, P3-4, P1-4 and P2-8 were being repaired or replaced during early 2007 and readings were restarted on 8th August 2007.
- The remaining piezometers P1-1, P2-1, P2-4, P2-2 and P2-3 recommenced readings on 5th March 2007.

The Surveillance and Monitoring manual indicates that the hydraulic piezometers are to be read monthly.

The pneumatic piezometers under the service spillway were read following spillway operation and no concerns were identified.

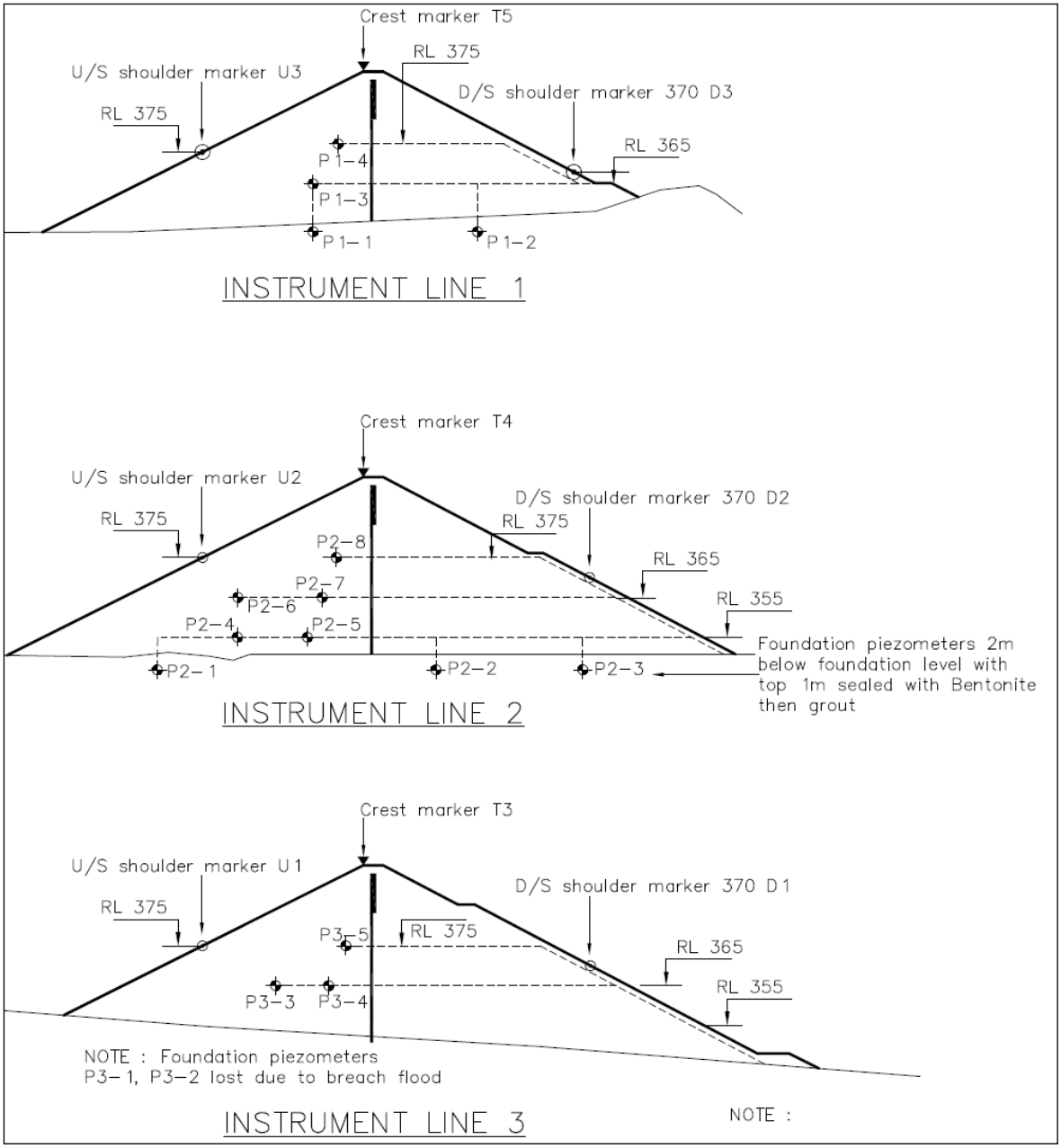

Figure 3.4 Piezometer positions (note P2-5, P3-3 & P3-5 are decommissioned)

3.6.1 Piezometer data

The piezometers were de-aired by Opus over the period between late November and early December 2008[2]. Since March 2009 piezometer levels have returned to more stable behaviour following a period during which erratic levels were recorded (excluding recordings deemed effected by freezing fluid as noted below).

The poorly protected piezometer leads referred to in the 2008 report behind the power house were encased in a length of HDPE pipe prior to the 2009 winter. Following the post earthquake inspection on Thursday 16th July, OWL reported irregular and variable hydraulic piezometer readings. Five additional sets of readings were taken between 16th July and 22nd July 2009 from piezometers P1-1, P1-2, P1-4, P2-1, P2-2, P2-3, & P2-4. The piezometers readings were erratic with high differential pressures. This period coincided with a period of freezing overnight temperatures. The piezometer readings stabilised at the end of the period as the ambient temperature increased. At the time it was considered that the cause of these erratic readings was unlikely to be the earthquake and is more likely to be freezing of the piezometer fluid. OWL has subsequently placed frost protection cover material over the exposed hydraulic piezometer leads (Figure 3.5).

Figure 3.5 Frost protection placed over hydraulic piezometer leads behind the Power Station.

Piezometer alert criteria are currently under review.

3.6.2 Piezometer inspection observations

Bourbon gauges are located at the base of the power station to read the hydraulic piezometer tip pressures. It is noted that these gauges have not been calibrated since 2nd April 1999. Prior to 2nd April 1999 the gauges were calibrated at the end of construction. Based on the time since the last calibration and changes in the bourbon gauge calibration factors between 2nd April and the end of construction, it is recommended that the hydraulic piezometer bourbon gauges are recalibrated. Often hydraulic piezometer gauges are configured to include a control gauge to assist with gauge calibration. It is noted that the Opuha Dam installation does not include a control gauge. Opus[2] also report that the bladder requires replacement and various other minor upgrades are also suggested. Given all of these matters it is recommended that the hydraulic gauge arrangement is inspected by a specialist and a comprehensive assessment completed to identify all matters where the system could be improved (for example installation of a control gauge) as well as all necessary maintenance works. We understand that the Operator has programmed hydraulic piezometer maintenance works for November 2011.

[2] Opus International Consultants, Opuha Dam Hydraulic Piezometers Maintenance, 1 January 2009.

RCM2010-01: Complete a comprehensive review of the hydraulic piezometer system and identify necessary upgrade and maintenance works. For example: gauge calibration, consideration of a requirement for a control gauge, review of bladder and the like.

3.7 Observation wells

The ten observation wells are all read monthly. These are:

- three in the left abutment area of the dam (OW1 – OW3)
- one near the downstream toe near the power station (OW4)
- six along the sides of the main spillway (OW5 – OW10).

Graphs of these readings since March 2005 are attached at Appendix A in three sheets. The graphs show the 2 or 3 levels at which readings are taken, in individual tubes, for the purpose of checking discrete ground water levels at a range of selected locations and elevations.

Observation well readings for the reviewed period are generally in keeping with historical readings.

As part of the review of the Surveillance and Monitoring Plan, rising or falling head tests were carried out on each of the observation wells. This work was carried out by the Operator on 11th and 12th February 2008. The purpose of this testing was to ensure that they were hydraulically connected to the surrounding ground and therefore capable of responding to changes in local groundwater pressures. All wells showed response to the addition or extraction of water, although the response rate was quite variable. Based on these tests it appears that the wells are recording in-situ ground water levels and therefore should remain in service.

3.8 Rain gauge

Rain gauge data is available from the Environmental Consultancy Services website. Figures A1/1 through A1/4 included in Appendix A illustrate rainfall recorded at the intake tower throughout the period.

3.9 Deformation survey

The bi-annual Type B Deformation Survey was scheduled for February 2010. However, the Operator advises that a deformation survey has not as yet been undertaken because of issues related to access to the survey pillar which is on land adjacent to the site owned by others. We understand that these matters are in the process of being resolved and that the Type B Deformation Survey will follow soon thereafter.

Access to survey pillars is necessary to fulfil both dam safety compliance obligations and on unpredictable occasions such as immediately following an earthquake. For these reasons it important that OWL and/or the Operator has reasonable rights of access to the survey pillars. The agreed access should anticipate all times that access may be required (including access for planned surveys as well as emergency or unusual occurrence situations).

RCM2010-02 Formalise access requirements to all areas of adjacent land where formal access agreements do not exist and access may be necessary for routine activities (eg deformation surveys) as well as during unusual or emergency situations.

The downstream row of survey markers, D1, D2 and D3 were replaced in June 2008. The locations of these survey markers will be picked up during the course of the next deformation survey.

A deformation marker has been installed on the conduit anchor block since the last deformation survey. This will be included in the next Type B deformation survey and will provide additional information on the integrity and performance of the anchors.

The 2008 report recommendation RCM2008-15 relates to amending the Surveillance and Monitoring Plan and the Emergency Action Plan to include an additional deformation survey following a significant earthquake event. The Surveillance and Monitoring Plan is in the process of being updated.

Such an event would typically be felt locally or would have triggered an operational response or otherwise be reported upon. The need for a survey should be confirmed with the Dam Safety Consultant following the earthquake event.

4 Reservoir

4.1 General

The reservoir margin and adjacent slopes in the immediate vicinity of the dam was visually inspected from the dam crest and both abutments. The reservoir level was 379.3 mRL at the time of the inspection. Based on the extent of visual inspection from these locations there is no apparent sign of slope instability at the margin of the reservoir. In addition, the Operator has not reported any slope instability at the reservoir margin in the period.

Figure 4.1 Intake tower

4.2 Elver pass

The elver pass is reported to be in good condition.

4.3 Intake Tower

Figures 4.1 and 4.2 illustrate the Intake Tower to the extent that the structure was visible from the dam upstream face of the dam.

A dive inspection of the intake tower was not undertaken during the 2009-20010 year. Diver inspections are scheduled every two years and the next diver inspection is scheduled for May 2010. The imminent dive inspection will provide an opportunity to undertake a more thorough inspection of the intake tower structure. A section of access ladder hoop is loose (Figure 4.2). As-built drawings indicate that the ladder hoops are hinged to allow access to the ladder at varying reservoir levels and that the hinged sections are restrained by chains. It is presumed that the loose hoops are due to the lashing chain coming loose. This matter will be investigated at the time of the upcoming dive inspection.

Figure 4.2 Intake tower

A number of recommendations from the 2008 report remain outstanding:

- RCM2008-18 – Clarification of the labelling of the guide ropes from the South West tower leg.
- RCM2008-19 - The Operator reports that it is believed that the bulkhead valve handle is located in the powerhouse. This is to be confirmed at the time of the next divers' inspection

- RCM2008-20 - The loose steel bar/plate at the NE tower leg splice should be investigated during the 2009-2010 diver inspection.

5 Service spillway

The spillway operated during May 2009. This was the first time that the Service Spillway has been required since January 2007. The 17th May 2009 maximum spillway flow was estimated to be 180 m^3/s and it is understood that this is the highest flow that the service spillway has conveyed thus far.

Figure 5.1 Service spillway approach

Figure 5.2 shows that the approach is relatively clear of significant debris. The approach to the service spillway was inspected and was in good condition. No erosion damage was evident adjacent to the true left approach training wall where dirty water was evident during the May 2009 high spillway flows (Figure 5.3).

The repair to the shotcrete coating on the rock on the right hand side of the spillway is in good order.

The structural concrete spillway approach walls are in good condition. The previously recorded 10 mm displacement of the vertical joint between the spillway left side approach wall and mass concrete bridge abutment appears unaltered since the last inspection (refer to the 2006, 2007, 2008 and 2009 Annual Safety Inspection Reports for background detail).

5.1 Obermeyer gates

The Obermeyer gates appear to be in sound condition.

The Operator advises that the procedures for operation of the Obermeyer gates during flood events have recently been reviewed and clarified. Also, the Operator advises that the compressor that operates the Obermeyer gates has been replaced in the last few months. It is understood that the old compressor will be serviced and retained as a standby unit.

Figure 5.2 Obermeyer gates from RHS of spillway approach

Figure 5.3 Base of true left hand side approach channel

5.2 Stepped spillway chute

The spillway steps appeared in satisfactory condition. The number of stones on the steps is less than last year because the May 2009 flood event removed debris that had accumulated prior to this time. As noted previously, in isolated locations step edges have been broken off by the impact of larger rocks thrown from the spillway bridge. It is understood that the Obermeyer gates are also targeted.

In the past rocks thrown onto the spillway have previously been washed into the basin at the toe of the spillway. It is believed that the May 2009 flows have flushed most of this material from the stilling basin.

A pine tree has established at the top of the shotcrete above the true right hand side of the stepped chute. The Operator advises that this has recently been sprayed so that the tree roots do not damage the shotcrete.

OWL advise that the 22nd January 2010 high intensity rain event (Section 9.2) caused storm water to concentrate and infiltrate in the vicinity of the bridge right abutment backfill. A dirty discharge was subsequently reported emerging for a short time from the adjacent subsoil drain outlet onto the service spillway. Figure 5.4 illustrates the drain outlet at the time of the inspection. Regarding works have subsequently been undertaken to divert storm water away from the top of the Service Spillway as outlined in Section 9.2.

Figure 5.4 Small slip opposite Service Spillway

5.3 Tailrace and Stilling basin

A small slip of minor significance was noted on the left bank of the tail race, opposite the spillway (Figure 5.5)

Figure 5.5 Small slip opposite Service Spillway

The tailrace water level was low enough this year to see the spillway basin rock sill during the inspection. There is minor erosion of the rock sill at the downstream edge of the basin (Figures 5.6 and 5.7). Indications are that a negligible amount of additional rock was eroded during the May 2009 event.

The upper rock cover to the dowel bars had been lost prior to the May 2009 flood. This damage is concentrated at both ends of the sill over a length of approximately 2m on the right and 10m on the left side. In some areas the concrete cover is undermined (Figure 5.7). The sill performed well during the May 2009 event, and as a result damage was limited to the loss of a minor amount of rock. Close monitoring of the sill will continue. Consequently, the Operator has indicated that works associated with 2008 report recommendation RCM2008-28 will be postponed for the time

being. The Operator advises that repair works will be implemented as deemed necessary by the ongoing inspection regime. Based on recent performance this approach is considered to be appropriate.

Figure 5.6 Minor erosion – spillway stilling basin sill

Figure 5.7 Minor erosion – spillway stilling basin sill

6 Auxiliary spillway

6.1 Fuse plug and channel

The auxiliary spillway appeared to be in a satisfactory condition. The riprap and approach are sound.

One of the right hand side fuse plug triggering device clay tile pipes is partially blocked. It is recommended that this is cleared and any future blockages removed as they may arise (Figure 6.2).

RCM2010-03: Clear fuse plug triggering device clay tile outlet pipes and maintain these pipes free from blockage.

Routine spraying will continue to prevent establishment of vegetation on the fuse plug fill, particularly in the vicinity of the drain outlets.

There was a small puddle on the invert of the auxiliary spillway channel similar in extent to prior years.

Work to improve collection and measurement of the Drain D18 outlet flows has been completed (Figure 3.3). The drain discharge has been piped below the invert of the Auxiliary spillway channel to its downstream extent. The concentrated drain discharge onto the slope below the auxiliary spillway does not present any concerns at present.

OWL advises that a surveillance camera may be installed on the left abutment to allow real time remote monitoring of the dam and reservoir water level during an emergency or unusual occurrence situation.

6.2 Left abutment cut slope

The left abutment cut, above the auxiliary spillway, is in good condition. The historical wedge failure downstream of the fuse plug shows no sign of recent movement. Apart from this, there are no signs of any significant movement on the slope. No cracking or

Figure 6.1 Auxiliary fuse plug and approach channel viewed from left hand side cut slope.

Figure 6.2 Partially blocked fuseplug triggering device clay tile outlet pipe

Figure 6.3 Left abutment cut slope drainage

significant deformation was obvserved at the top of the cut face.

Recent works have been undertaken to regrade the cut slope benches to divert storm water and prevent concentrated storm water flows affecting the auxiliary spillway fuse plug.

In addition, OWL has undertaken considerable works to form tacks to access the cut slope benches from the downstream end of auxiliary spillway (Figure 6.5). These works are of a good standard and will facilitate future maintenance works in this area.

Figure 6.4 Concentrated cut erosion and debris fan viewed from bench above

Figure 6.5 Left abutment cut slope drainage

7 Power station and tailrace

7.1 Powerhouse

The external and internal structure appeared to be in satisfactory and tidy condition. The powerhouse was viewed from the access platform and from around the base of the generator and turbine. No seepage was observed around the penstock pipe penetration through the station wall. Also no other internal leakage into the structure was observed.

The Operator advises that an auxiliary generator is currently being investigated. It is intended that this will allow water to be pumped from the sump at the base of the power station, operation of the lifting equipment and other miscellaneous activities in the event of a power failure.

7.2 Switchyard

Fencing and security appeared to be in a satisfactory condition.

As noted in the 2006 and 2007 inspections, the recently installed water pipe offtake and other valving for farm water supply near the switchyard needs to be added to the As Built drawings (*recommendation RCM2009-07*). At the time of writing the Operator is in the process of instructing T&T to update these drawings.

There are two valves adjacent to the power station that control small diameter pressurised pipelines. The respective pipe alignments are close to the power station and across the dam toe (water supplies to Mr Dave Williams and Allendale stock water supply). These valves are covered by timber lids that are not vandal proof.

It has been identified that there is uncertainty regarding the status of the Allendale stock water pipeline. As-built drawings indicate that the Allendale stock water supply comprises a 100 mm diameter ABS pipeline running along the toe of the dam (length of ABS and other materials unclear). The pipe is connected to the conduit in the vicinity of the Power Station and passes under the lower portion of the Service Spillway. There is at least one break in the line that is understood to have occurred as a consequence of frost action. The leak is visible on the cut slope to the south west of the service spillway when the valve adjacent to the power station is opened (ie the identified leak does not pose an erosion risk to the toe of the dam). This valve is usually shut and it is understood that the line is not currently used. It is recommended that the status of the pipe crossing the toe of the dam is clarified. Subject to the review, recommended outcomes could include repair, decommissioning, or clarification of maintenance responsibility. Additionally, it is recommended that all valves in the vicinity of the power station are secured against tampering by vandals.

RCM2010-04 Review status of Allendale water supply pipe line and ensure all valves in the vicinity of the power station are secured against tampering by vandals.

7.3 Stoplog

The 2007 report recommended that the stoplog seals be replaced prior to their next scheduled use. The Operator reported that the stoplog seals have been reviewed and are considered to be serviceable at present.

7.4 Conduit anchor block

The conduit anchor block stressed anchor bars are discussed in the 2006, 2007 and 2008 reports (RCM2008-32). The Operator advises that BBR Contech will complete this testing at a suitable time in the near future when the reservoir is near to an annual low. At the time of writing the Operator advises that these works are programmed for 25th May 2010.

A deformation marker has recently been installed on the conduit anchor block.

We recommend that if practical, the anchor block location markers should be surveyed for position prior to undertaking the anchor testing.

8 Downstream weir

8.1 General

The crest, part of the upstream face and downstream face of the right hand closure embankment were inspected. There is no monitoring instrumentation on the downstream weir and appurtenant structures.

The small and isolated areas of gorse that had previously been reported as becoming established on the upstream face of the closure embankment above normal water levels have been sprayed. OWL maintains an ongoing spraying regime to ensure that gorse does not become established on, or in the vicinity or water retaining structures. The downstream face appears to be even and is in a satisfactory condition.

Figure 8.1 Downstream Weir Enclosure Embankment – sprayed gorse

8.2 Downstream Weir Overflow Embankment

The DWOE is designed to fuse during a five year or greater Average Recurrence Interval (ARI) flood. The estimated five year ARI routed dam outflow is 100 m^3/s. The Downstream Weir Overflow Embankment (DWOE) fused early in the morning of 17th May 2009 during a significant flood event. The flood peak was estimated to be approximately 180 m^3/s. The DWOE fused as intended.

OWL subsequently engaged T&T to provide specifications[3] for the reinstatement works and Rooney Earthmoving Ltd. were contracted to reinstate the DWOE. Some minor

Figure 8.2 Downstream Weir Overflow Embankment

Figure 8.3 Downstream Weir Overflow Embankment

[3]Tonkin & Taylor; Specification, Opuha Water Limited, Opuha Dam Downstream Weir Overflow Embankment Reinstatement Earthworks Specification; June 2009; T&T Reference 51137.005.

leakage through the DWOE was anticipated following initial filling as similar performance was also recorded following initial filling of the previous two DWOE structures. Some minor leakage near the toe of the DWOE was observed following first filling and was well within pre construction expectations. The leakage ceased in early October 2009. Ongoing monitoring has not identified any subsequent DWOE leakage. The Operator has prepared a comprehensive report[4] describing the 2009 reinstatement works. This report covers matters relating to resource consent compliance, investigations and material sources, as well as design, construction, construction verification and commissioning. Commissioning of the reinstated DWOE was considered complete on 13th October 2009. No signs of seepage in the vicinity of the DWOE downstream face were visible and the reinstated fusible section of the left embankment was in good condition at the time of the inspection (Figures 8.2 and 8.3).

OWL reports that the DWOE crest has recently been dressed and regarded to suit the as-built crest levels outlined in the completion report (crest varies from 341.85 mRL to 341.90 mRL). It is understood that this work was done to remove oversize material and ensure a low point to concentrate overflows to promote embankment fusing. We note that T&T recommended a level crest at 341.95 mRL to suit maximising gate outflows. We understand that OWL has adopted a lower crest level for operational reasons to provide additional security that the DWOE will fuse in the manner anticipated given actual Enclosure Embankment crest levels.

8.3 Downstream erosion

The concrete and stone armouring on both banks and under the right side training wall is generally in satisfactory condition.

It was previously noted that the mass concrete at the end of the left training wall (beyond the toe of the ogee weir) is at least partially undermined. While not a dam safety issue, we suggest that reasonable measures be undertaken to keep people off this area for their safety.

8.4 Weir and control structure

The structure was generally in good condition. Figure 8.4 illustrates the area in the vicinity of the weir and gate structure.

OWL advises that the damaged fence downstream of the radial gate structure on the true right hand side will be reinstated soon. The ground level was reinstated in this area and additional rock armour protection placed at the time of the 2009 DWOE reconstruction works (Figure 8.4).

Figure 8.4 Downstream gate structure and ogee weir

[4]Contact Energy; Opuha Water Partnership, Completion Report Overflow Embankment Reinstatement, May – August 2009; December 2009; Contact Energy references NP11880 & Opuha/37-002

Gabion baskets originally supported the true left hand side of the radial gate approach channel. It was identified that the basket mesh had almost entirely disappeared when the pond drained following the May 2009 DWOE breach. A repair used large diameter rock armour at the time of the DWOE reinstatement. The repaired area was not visible at the time of the inspection because of the high pond level. OWL advises that the repair is performing well.

Recommendations RCM2008-35, 36 and *37* in the 2008 report related to inspection of the radial gate, concrete downstream of the gate, and a gabion training wall on the true right upstream of the gate. These relate to routine maintenance matters to be considered by the dam Owner. OWL advises that these inspections were carried out in May 2009 when river flows were diverted through the DWOE breach and that the concrete and gate structure were in a satisfactory condition.

The concrete weir spillway is in a satisfactory condition. Inspections of previous years identified a number of small continuous horizontal cracks in the spillway face, as well as occasional small surficial spalls. These features do not appear to have significantly changed in the last year.

9 Access roads

9.1 Access to dam

The maintenance of the access road to the dam is the responsibility of the District Council, including removal of slumps from the batters on the west side of the access road leading to the dam. Road access was clear at the time of the inspection.

9.2 Dam road

The dam crest road has a safety barrier on the upstream edge. In addition public access is restricted by a locked chain with signage.

Access to the powerhouse and the downstream weir was clear at the time of the inspection.

OWL reported localised storm water damage in the vicinity of the elver pass adjacent to the service spillway true left abutment during high intensity rainfall on 22nd January 2010. The damage was caused by storm water originating south west of the Service Spillway Bridge crossing the bridge and over topping the left hand side (western) bridge abutment. Figure 9.1 illustrates the repaired area.

Figure 9.1 Storm water erosion repairs

OWL has subsequently undertaken works to divert storm water away from the bridge right hand side abutment. The measures include an open drain at the toe of the access road cut slope (Figure 9.2) and an open drain channelling storm water south east from the Service Spillway (Figure 9.3). The reformed channel at the cut slope toe diverts storm water towards the boat ram area and prevents flow across the dam access road towards the bridge and the spillway gate control building (Figure 9.2).

Figure 9.2 Cut slope drain works

Figure 9.3 New drain diverting storm water away from the Service Spillway

10 Recommendations

10.1 2010 Annual Review recommendations

Recommendations arising from the inspection of 2010 are collected in Table 10.1. The recommendations for action on each component of the project are numbered, referenced to the section in this report where they arise and categorised as:

- N (Necessary) to be done as a priority (within 12 months) or regularly
- D (Desirable) to be done at a suitable time before the next Comprehensive Safety Review (CSR).

Table 10.1 Opuha Dam 2010 Annual Review recommendations

Reference	Report section	Recommendation	Category
RCM2010-01	3.6.2	Complete a comprehensive review of the hydraulic piezometer system and identify necessary upgrade and maintenance works. For example: gauge calibration, consideration of a requirement for a control gauge, review of bladder and the like.	D
RCM2010-02	3.10	Formalise access requirements to all areas of adjacent land where formal access agreements do not exist and access may be necessary for routine activities (eg deformation surveys) as well as during unusual or emergency situations.	N
RCM2010-03	6.1	Clear fuse plug triggering device clay tile outlet pipes and maintain these pipes free from blockage.	N
RCM2010-04	7.2	Review status of Allendale water supply pipe line and ensure all valves in the vicinity of the power station are secured against tampering by vandals.	D

10.2 2008 and 2009 recommendations

Table 10.2 summaries progress with the eight recommendations in the 2009 report (based on advice provided by the Operator 27/4/10). Table 10.3 summaries progress with the thirty nine recommendations in the 2008 report.

Considerable progress has been made in undertaking and completing the recommendations of 2008 and 2009. The progress is noted in the column under “Current status”. Where relevant, outstanding recommendations are discussed in the text of this report. Unresolved matters that are not close to completion are highlighted in bold text.

Table 10.2 Opuha Dam 2009 Annual Review recommendations

Reference	Recommendation	Category	Current status
RCM2009-01	**Develop and implement an investigation procedure to determine the source of seepage emerging at the embankment face near Drain D16.**	**N**	**To be completed**

RCM2009-02	The accuracy of the D7 drain flow rate measurements collected using the data logger and manual technique warrants review. Subject to the outcome of this exercise, the alert criteria may require re-evaluation.	N	Completion imminent as at May 2010
RCM2009-03	The accuracy of the D8, 9 and10 drain flow rate measurements collected using the data logger and manual technique warrants review. Subject to the outcome of this exercise, the alert criteria may require re-evaluation (D8 & 10).	N	Completion imminent as at May 2010
RCM2009-04	Review the accuracy of the D21 drain flow rate measurements collected using the data logger and manual techniques and review alert levels given the data now available.	N	Completion imminent as at May 2010
RCM2009-05	Review the de-airing methodology against the erratic behaviour observed and determine if further maintenance is warranted.	N	Completed
RCM2009-06	Investigate and then undertake works to prevent avoidable surface water impinging on the fuse plug embankment as well as prevent progressive damage to the abutment cut slopes.	D	Recently Completed
RCM2009-07	Arrangements for the water pipe offtake and valving for farm water supply, near the switchyard, should be added to the As Built drawings.	D	To be completed May 2010
RCM2009-08	Spray gorse on the Downstream weir closure embankment	N	Completed. Maintenance spraying ongoing

Table 10.3 Opuha Dam 2008 Annual Review recommendations

Dam			**Current status**
RCM2008-01	The chain across the crest road should be extended along the downstream side of the crest to make access more difficult for trail bikes and signage should be erected on the chain. (2.2)	D	Complete November 2008
RCM2008-02	The D16 drain pipe should be videoed to check the integrity of the pipe. If the pipe has no visible leakage a short investigation trench should be excavated into the face at the location of the wet patch to try and indentify its source and a drain installed to allow monitoring of the water flow. (2.2)	D	Camera inspection completed June 2008. Refer RCM2009-01.
RCM2008-03	The discrepancy between the manual and automatic H flume flow measurements from drains should be investigated and additional on site correlation work carried out. (2.3.2.2)	N	Refer RCM2009-3,4&5.

Dam			Current status
RCM2008-04	The automatic monitoring system should be checked to ensure that it incorporates the correct alert values and, if necessary, changed to reflect the S&M Plan values. (2.3.2.2)	N	Completion imminent as at May 2010
RCM2008-05	The D18 drain outlet should be cleaned out and a small concrete bund constructed on the uphill side. (2.3.2.3)	D	Complete June 2008
RCM2008-06	The adjacent seepage flows should be directed into the D17 drain by constructing a concrete wall at the rock/ fill interface. The combined flow should then be recorded as D17. (2.3.2.3)	N	Complete June 2008
RCM2008-07	The D17 flow should be piped from the current outlet to discharge at the base of the fill embankment into Gooseberry Stream.(2.3.2.3)	D	No action warranted, flow drains ok as is, continue to monitor fill for any change - June 2008
RCM2008-08	All drains should be identified by attaching plaques or by painting the drain numbers on headwalls to ensure consistent use of references. (2.3.2.3)	N	October 2008 – substantially complete. Ongoing
RCM2008-09	The H flumes should be regularly cleaned of algae to ensure the depth to flow rate calibration remains applicable. (2.3.2.3)	N	Complete October 2008
RCM2008-10	All weir boards should be kept in a secure location (e.g. the power station). (2.3.2.3)	D	Complete August 2008
RCM2008-11	The leak in the elver pass pipe should be repaired (we understand that this is programmed to take place soon). (2.3.2.3)	N	Complete June 2008
RCM2008-12	The damaged section of piezometer lead pipe should be repaired with a more robust solution (e.g. a split length of PVC pipe between the grey and orange PVC pipes and held together with stainless steel bands and wrapped in Densotape). (2.3.3.3)	D	Complete June 2008
RCM2008-13	The downstream toe deformation markers should be replaced. (2.4.2)	D	Complete June 2008
RCM2008-14	The Opus report includes some recommendations regarding the scope of the surveys which should be considered in the review process. (2.4.4)	D	Complete August 2008
RCM2008-15	**The Surveillance and Monitoring Plan and the Emergency Action Plan (EAP) should be amended to include the recommendation for an additional survey of the dam following a significant earthquake event. (2.4.4)**	**D**	**Completion of Surveillance and Monitoring Plan imminent, EAP to be completed.**

Dam			Current status
RCM2008-16	A new deformation marker should be installed on the conduit anchor block to allow monitoring of this structure. (2.4.4)	D	Complete June 2008
The Reservoir			
RCM2008-17	The service spillway debris boom should be repaired. (3.1)	N	Complete June 2008
RCM2008-18	The guide rope between the SW tower leg and the bypass valve should be reinstated and the bypass valve then inspected. (3.2)	D	In progress, refer Section 3.2 of the 2009 annual report
RCM2008-19	The location of the bulkhead valve handle should be established or a new handle obtained (3.2)	D	In progress, handle located, to be checked at the time of the next diver inspection
RCM2008-20	The loose steel bar/plate at the NE tower leg splice should be further investigated during the next diver inspection in 2010. (3.2)	D	To be undertaken at the time of the diver inspection scheduled for May 2010.
Service and Auxiliary Spillways			
RCM2008-21	The undermined shotcrete on the right hand side of the spillway approach should be repaired with concrete to prevent the loss of this protective layer. (4.1)	D	Complete August 2008
RCM2008-22	The gauging board on the right hand side of the spillway approach wall should be repaired. (4.1)	N	Complete June 2008
RCM2008-23	The rust on the Obermeyer gate studs and nuts should be treated before it causes them to seize and the missing nut should be replaced. (4.1)	D	Nuts replaced August 2008 (not painted).
RCM2008-24	The rust spots on the steel gates should be treated and painted. (4.1)	D	Gate now painted
RCM2008-25	The upper nut on the water level bubbler should be tightened and the lower nut should be replaced with a stainless steel nut. (4.1)	N	Complete June 2008
RCM2008-26	The Obermeyer gate operation should be reviewed so that all parties are aware of the system set up and operational responsibilities. (4.1)	D	Complete September 2008
RCM2008-27	The spillway basin should be drained and inspected and if damage has occurred, the rocks should be removed from the basin. (4.1)	N	Complete June 2008
RCM2008-28	**The damage to the spillway basin downstream sill should be repaired with concrete. The use of mesh reinforcement or alternatively fibre reinforced concrete is recommended to reduce the chance of further damage, preceded by clearing off all loose rock and growth. (4.1)**	**N**	**Repair works deferred pending inspection regime.**
RCM2008-29	The small tree on the left side of the auxiliary spillway should be removed. (4.2)	N	Complete June 2008

Dam			Current status
RCM2008-30	The fuse plug crests should be converted back to loose granular material by breaking up the crust and raking back to a smooth even surface. (4.2)	N	Work undertaken June 2008. Refer 2009 Section 4.2.1 for discussion on fuse plug construction.
RCM2008-31	The outlet ends of the two buried pipes should be exposed and all four pipes should be **carefully** rodded to check for and remove any blockages. (4.2)	N	Complete June 2008.
Powerhouse and Tailrace			
RCM2008-32	The damage to the tailbay concrete should be investigated in greater detail to assess the effects and consequences and determine whether immediate repairs are required. (5.3)	N	To be inspected by divers on 25 May 2010
RCM2008-33	The conduit anchor block anchors should be tested. (5.5)	N	Testing scheduled for 25 May 2010
Downstream Weir			
RCM2008-34	The weir raising should be extended towards the centre of the structure to improve protection to the gate hydraulic systems (e.g. by metal plates). (6.3)	D	Complete June 2008
RCM2008-35	As noted in the 2007 report, the gate should be cleaned to allow observation of the state of the components and the need for any maintenance. (6.3)	D	Completed.
RCM2008-36	The gate should be closed to allow inspection of the concrete downstream. (6.3)	D	Completed by OWL May 2009.
RCM2008-37	Debris should be regularly removed to prevent it from becoming stuck in the gate. (6.3)	N	Debris removed August 2008. Monitoring ongoing
RCM2008-38	The gabion wall just upstream of the gate should be inspected during a low pond level and, if necessary, repaired or replaced. (6.3)	N	Inspected May 2009 and gabions subsequently replaced by rockfill June 2009
RCM2008-39	The void in the instrument shed gabion wall should be filled to prevent the upper basket from settling further and the wall monitored in the 2009 inspection (6.3)	D	Complete August 2008. Void filled with AP20.

11 Conclusions

The Annual Safety Inspection for Ophua dam was undertaken on the 27th April 2010 in accordance with the NZSOLD Dam Safety Guidelines (2000). The inspection was undertaken by Tonkin & Taylor and accompanied by the Operator. The dam is in a satisfactory condition.

Many of the recommendations from last year's report have been actioned or are in the process of being implemented.

The report also reviews the data gathered in the last year from the dam monitoring instruments.

The four recommendations provided in this report result from the annual inspection and a review of the monitoring data for the last year. These recommendations primarily relate to:

- Review of the hydraulic piezometer installation
- Access arrangements to adjacent property insofar as this relates to dam safety matters
- Clear and maintain fuse plug triggering device clay tile pipes free from debris
- Review of the status of the Allendale pipeline in the vicinity of the dam toe and securing associated valves from tampering by vandals.

12 Applicability

This report has been prepared for the benefit of Opuha Water Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

TONKIN & TAYLOR LTD

Environmental and Engineering Consultants

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Appendix A: Instrumentation Records

- **A1/1 - Seepage Drains D7, D8, D9 D10 & 21 – manual data**
- **A1/2 - Seepage sum of Drains D7 – D10**
- **A1/3 - Seepage Drains D4, D17, & D18**
- **A1/4 -Seepage Drains D7, D8, D9 D10 & 21 – water level recorder data**
- **A2/1 - Hydraulic Piezometers -2m & RL 355 tips**
- **A2/2 - Hydraulic Piezometers RL 365 tips**
- **A2/3 - Hydraulic Piezometers RL 375 tips**
- **A3/1 – Observation Wells OW1, 2, 3 & 4**
- **A3/2 – Observation Wells OW5, 6 & 7**
- **A3/3 – Observation Wells OW8, 9 & 10**