Environment B·O·P
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LAKE OKAREKA

LEVEL CONTROL

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Cover Photo: Lake Okareka (foreground) looking towards path of outlet and Lake Tarawera (background)

Executive Summary

Lake Okareka is a small land-locked lake in the Rotorua district. Since the 1960s, before which it was drained solely by underground seepage towards Lake Tarawera, an outlet pipeline and valve have been operating to control lake levels.

The pipeline capacity has always been considered too small to prevent high lake levels following extended periods of high rainfall. Several dwellings, jetties and septic tanks have been inappropriately located at low levels close to the lake, and are threatened by high lake levels. Concern has been voiced by residents of the area about this, particularly with regards to the implications for lake water quality. On the other hand, low lake levels are also of concern, particularly as flow supply to a trout nursery area downstream of the pipeline is threatened and as boat access to jetties around the lake becomes difficult.

Consent applications are to be lodged in 1999 for the outlet structure. As background to the applications, several options for lake level control have been identified and investigated in this study. Of those, two options remain for further consideration: maintaining the existing system, and enlarging the pipeline to allow greater gravity outflow.

The existing system could be improved by implementing several other measures (improved maintenance of outlet, upgrading septic tank systems directly if required, planting and fencing the lake and outlet canal margins, and implementing development restrictions more appropriate to possible lake level variations). These measures could also be implemented should the second option be adopted.

The second option is provisionally costed at $100,000. While this would reduce the duration of high lake levels, no option can guarantee that levels will always be within the desired range. Furthermore, water quality monitoring results suggest that problems associated with the current regime, particularly in times of high lake levels, may not be as poor as perceived. The community needs to weigh up the cost of this option (and its willingness/ability to pay) with the frequency and severity of the problems associated with maintaining the status quo.

Contents

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Chapter 1: Introduction

Lake Okareka is a small lake situated between Lake Tikitapu and Lake Tarawera (Figure 1). It has a surface area of 3.46 km^2, a land catchment area of 16.7 km^2 and a maximum depth of 33.5 metres. A small community is located on its western shores, although in summer the population swells with holidaymakers. The lake is regarded as mesotrophic, that is intermediate between oligotrophic (low in nutrients, generally in 'natural' condition) and eutrophic (high in nutrients, typical of a highly modified or pastoral catchment).

The lake is land-locked, and until the 1960 outflow was entirely via underground seepage to the Waitangi Stream (resurfacing at the Waitangi Springs) and Lake Tarawera. Lake Okareka residents began lobbying for additional, artificial drainage in the 1950s as lake levels rose. In 1962 lake levels rose again, and in 1963 a pump scheme was installed between Lake Okareka and the Waitangi Stream. Pumping stopped in 1964 and the current gravity pipeline was completed in 1965. Titchmarsh (1995) summarises the history of the pumping and gravity schemes.

From the lake, water drains via a set of six parallel culverts, of varying diameters and invert levels, into an outlet canal. (Figures 2 and 3). In times of high lake level, water will also overtop what is effectively a weir between the lake and the outlet canal.

The canal is approximately 250m long, passing through farmland (Playne's property). Water then enters a pipeline. The inlet structure has a grill in front to prevent debris blockage of the pipe (Figure 4), while the invert of the inlet is at a level of around 352.94m[1] to help control minimum lake levels.

The pipeline consists of 317 metres of 18 inch (450 millimetre) diameter pipe and 125 metres of 12 inch (300 millimetre) pipe, separated by a gate valve to control flow. The maximum capacity of the system was set equal to the capacity of the pump scheme – that is, just over 200 litres per second.

In 1995, the Operations & Rural Services Department of Environment B·O·P applied for resource consents for the existing pipeline draining Lake Okareka. The application was notified and submissions received. However the application stalled before a hearing was held and a decision made.

As a period of time has elapsed since the original application, and as there were several unresolved issues regarding the nature of the consents sought, it has been decided to withdraw the previous applications and submit a new set of consent applications. The revisiting of the

[1] All levels in this report given are in terms of Moturiki Datum – the datum commonly used in the Bay of Plenty, approximately equal to mean sea level

level control is particularly timely given the public concern over high lake levels of the second half of 1998.

This report describes the assessment of environmental effects of the pipeline structure. It outlines issues and options surrounding the control of the level of Lake Okareka.

Figure 1 Location of Lake Okareka

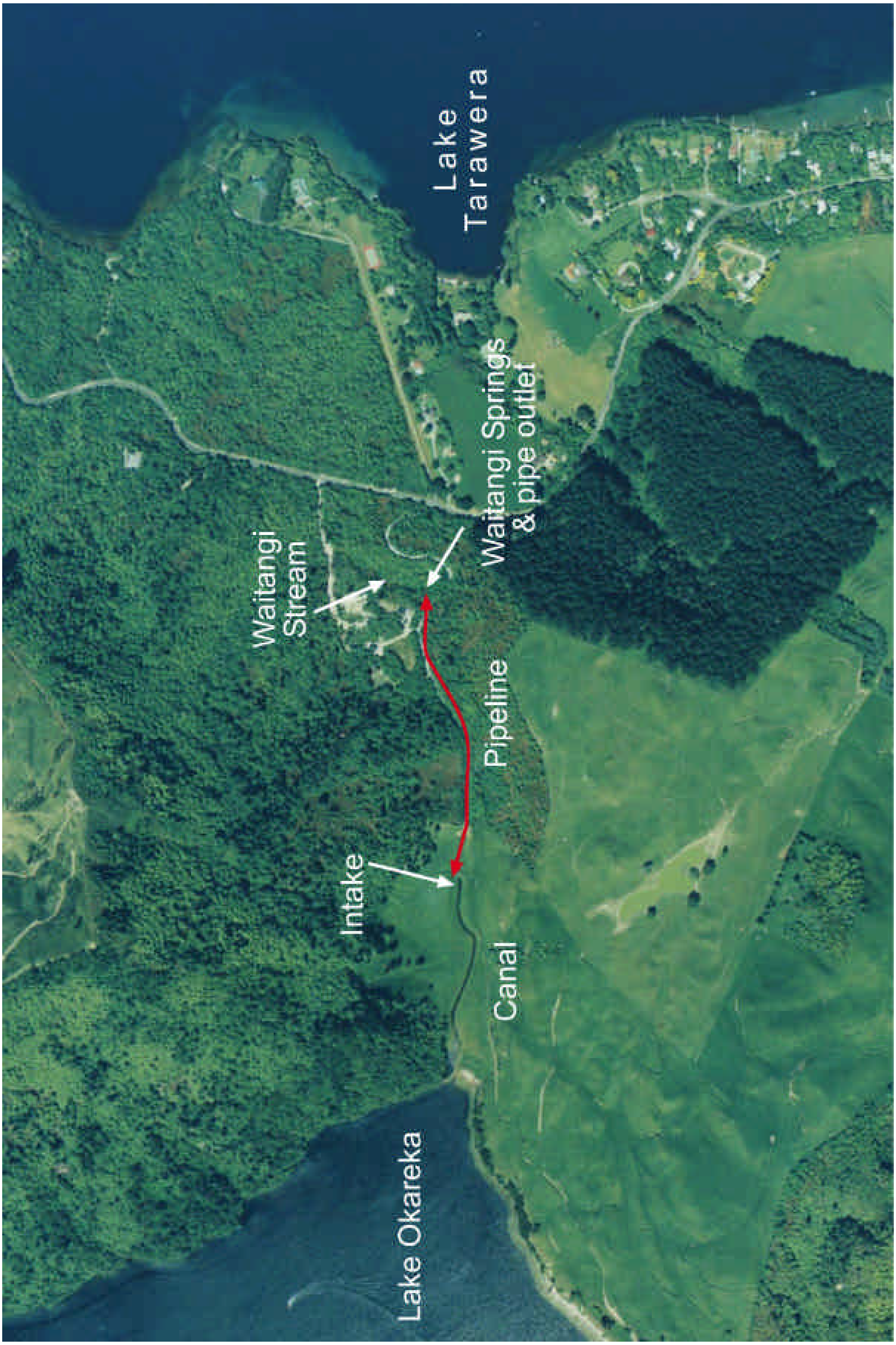


Figure 2 Lake Okareka Outlet

Figure 3 *Weir and culverts between lake and outlet canal*
Not all culverts visible in this photo. Weir has been subsequently rebuilt.

Figure 4 *Entrance to pipeline*
Upper pipe (disused) is remnant of the earlier pump scheme.

Chapter 2: Lake Levels

2.1 Current and Historical Lake Levels

A lake level recorder was first installed in Acacia Bay in 1951. The present recorder was installed in 1986 and takes readings every 30 minutes, although these are only down-loaded every two months. In addition, Rotorua District Council (RDC) contractors take levels weekly when the intake is checked and a local resident has been providing weekly readings to Environment B·O·P during the most recent period of high levels.

Figure 5 shows recorded annual minimum, maximum and median lake levels since 1955. It can be seen that lake levels since the mid 1970s have been over one metre lower than in the 1950s and around two metres lower than in the early 1960s. Even with the pump and then the gravity outlet, lake levels took several years to drop from the highs of the 1960s to levels considered acceptable.

During investigation of lake control options in the early 1960s, a maximum lake level of 354.784 metres was proposed so as to avoid damage to lakeside properties. BOPCC[2] files indicate that by the late 1970s, a target range of 353.3 metres to 353.9 metres was established. There is no record as to when and why this change was made (BOPCC letter dated 20 December 1979 to RDC, file 153/15).

Currently the valve in the pipeline is operated so as to attempt to keep lake levels between 353.5 metres and 353.9 metres. (However, heavy rain in July 1998 led to lake levels rising to a peak of 354.27 metres in August, the highest recorded since 1971. Levels since that time have steadily dropped, reaching the desired maximum towards the end of 1998. (Figure 6).

The 1995 resource consent application (Titchmarsh, 1995) proposed a larger range – from 353.4 metres to 353.9 metres – to provide more flexibility for managing the levels. Dropping the minimum would provide more storage during high rainfall periods and reduce the likelihood that the desired maximum would be exceeded. However, it appears from the earlier submissions, and from more recent public feedback, that the current range (i.e. 353.5 – 353.9 m) is still desired and this report is prepared on that basis (see Chapter 4).

[2] Bay of Plenty Catchment Commission – predecessor of Environment B·O·P

Figure 5 *Lake Okareka – Annual Maximum, Minimum and Mean Levels*

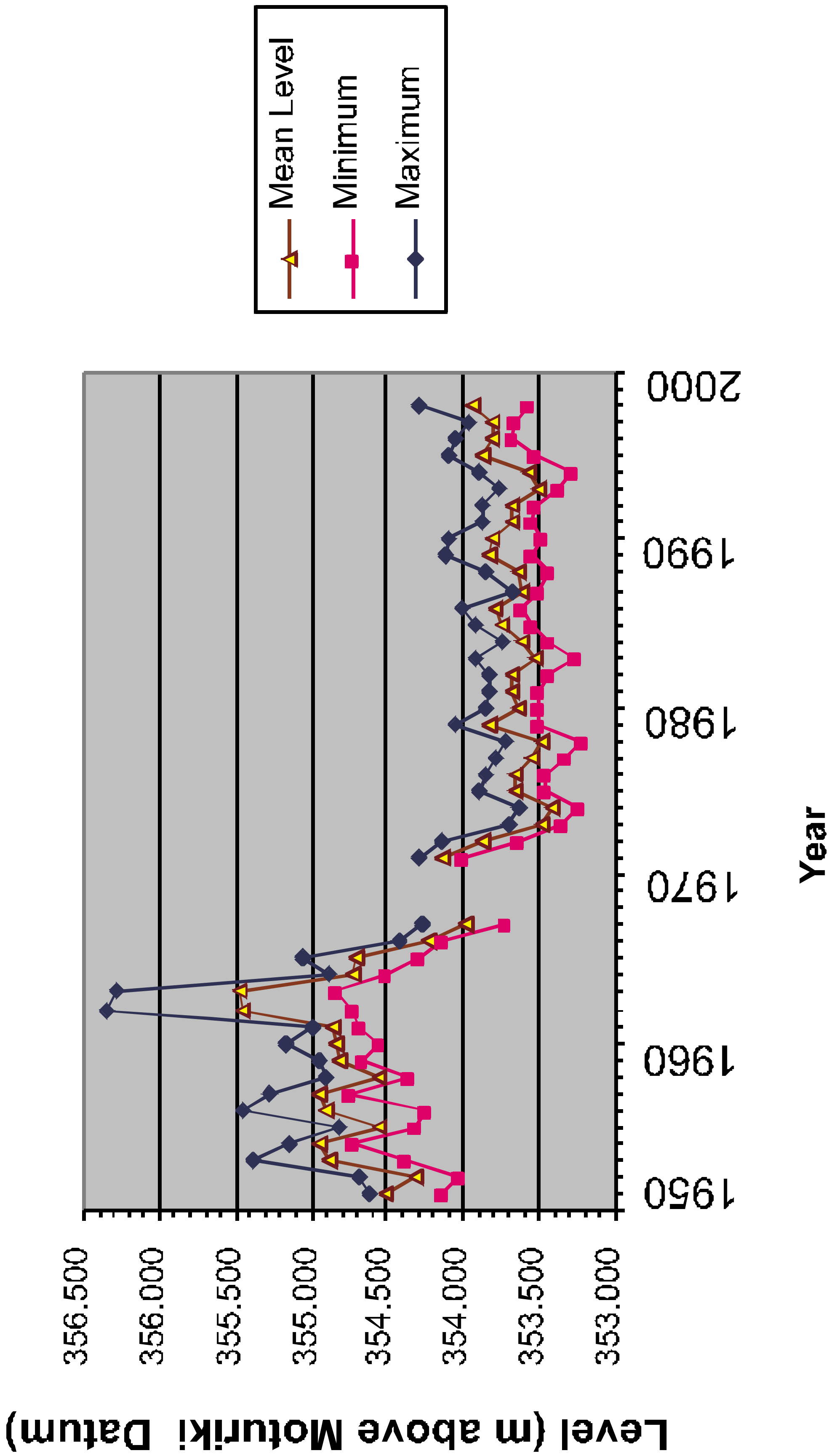
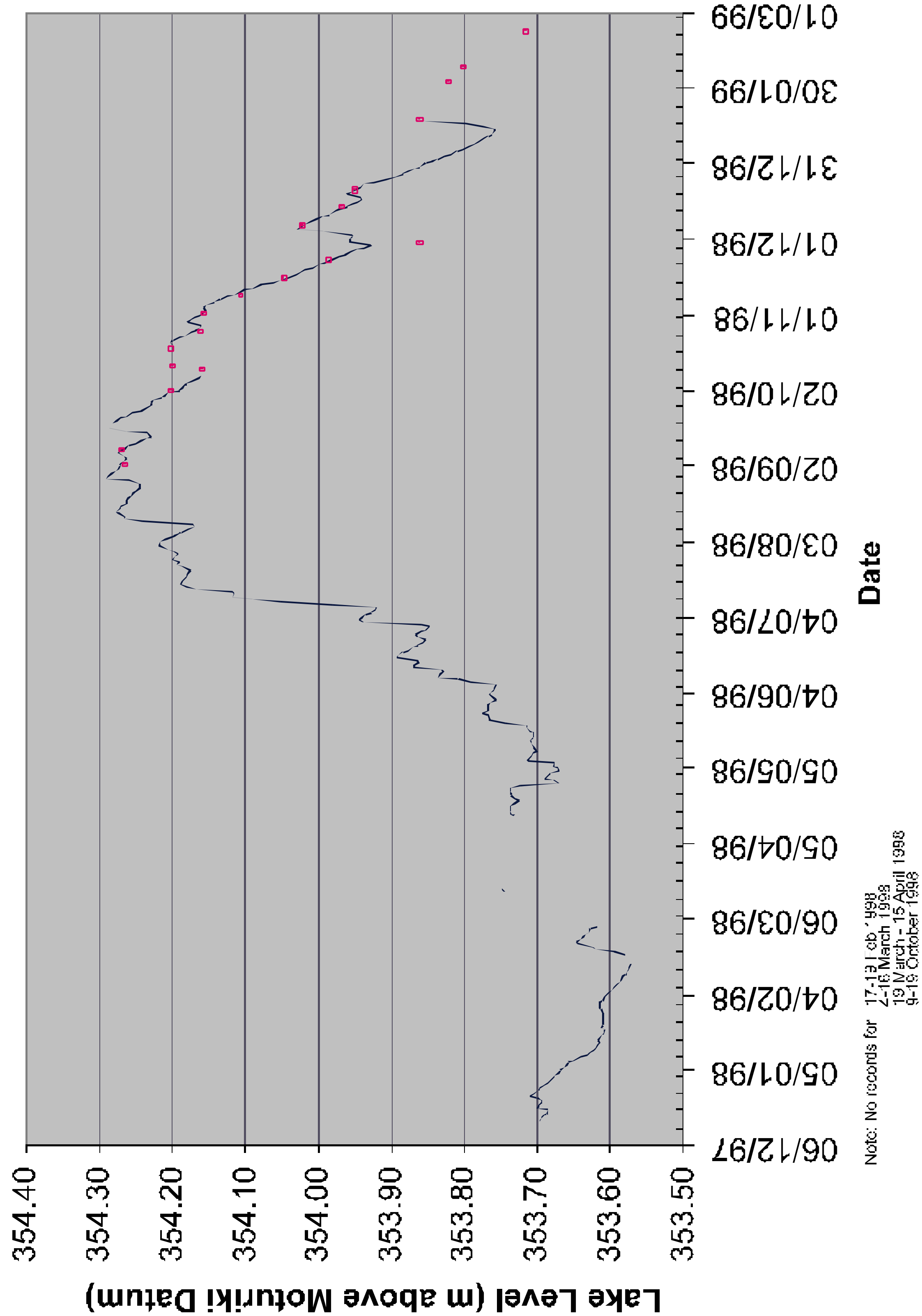


Figure 6 *Lake Okareka Levels 1998*



2.2 Predicted Lake Levels

From lake level and rain gauge records at Lake Okareka, a computer model of lake levels has been built and calibrated. Details and results are included in Appendix I. This model has been used to predict lake levels under a variety of rainfall scenarios and management regimes, in order to assist with the evaluation of management regimes.

Chapter 3: Issues

3.1 Trout Spawning

The Waitangi Stream, below the set of falls on the stream, is regarded highly as a trout-spawning fishery. In order to sustain this fishery, a minimum flow needs to be maintained in the stream, particularly during spawning periods.

Spawning takes place between April/May and October. Following this, sufficient flow is also needed to sustain habitat for juvenile fish until as late as February. Thus there are only a couple of months during each year when flow could be stopped without endangering the trout nursery. Indications from the caretaker at the site are that the base flow alone (i.e. from the Waitangi Springs) is insufficient for the nursery. In 1963, the base flow from the Waitangi Springs was estimated at around 400 litres per second. More recent measurements are given in Appendix II. These indicate that the base flow is much less today (less than 100 litres per second), presumably because the lake level (and hence the head driving the seepage) has dropped.

As the valve has been fully opened since the end of April, conditions were good during the 1998 winter and spring for the trout nursery.

Previous correspondence from the Eastern Fish and Game Council suggests that sudden increases in flow in the stream are not desirable. An appropriate maximum rate of change in flow (related to a rate of change in valve setting) may need to be developed in consultation with the Council and the site caretaker.

The RDC does inform the caretaker at the site when it is considering adjusting valve levels, and if necessary this consultation process could be formalised as part of conditions on any eventual consent for the outlet structure.

3.2 Water Quality

Water quality has been the subject of most concern from residents of both Lake Okareka and Lake Tarawera in consultation over the pipeline. Lake Okareka residents are generally concerned that the pipeline does not permit sufficient outflow in times of high lake level, perceiving that untreated effluent from septic tank systems would contaminate the lake. On the other hand, Lake Tarawera residents have expressed concern over the relatively clean (oligotrophic) Lake Tarawera receiving flow from the lower quality (mesotrophic) Lake Okareka.

3.2.1 Pastural Land Use

Stock access to the lake edge, and especially to the outlet channel between lake Okareka and the pipe, has been of concern to some residents. Lake Tarawera residents are particularly concerned that water quality of Lake Okareka will be further diminished before it flows into Lake Tarawera.

3.2.2 Septic Tanks

The Lake Okareka community disposes of its sewage by septic tank systems. Such systems consist of a tank, into which waste water discharges and solids settle, and a drain field where effluent soaks into the ground allowing treatment by the soils (Figure 7).

In order for soils to effectively treat the effluent, a septic tank drainage field should be at least 600 millimetres above the water table (or 2,000 millimetres if using a soak hole). Obviously if surface water entered the tank via the 'mushroom', the tank would also be overloaded.

Several septic tanks have been inappropriately located at low levels close to the lake, and during times of high lake levels, e.g. 1979, 1986 and 1998, residents have been concerned that untreated effluent would be reaching the lake.

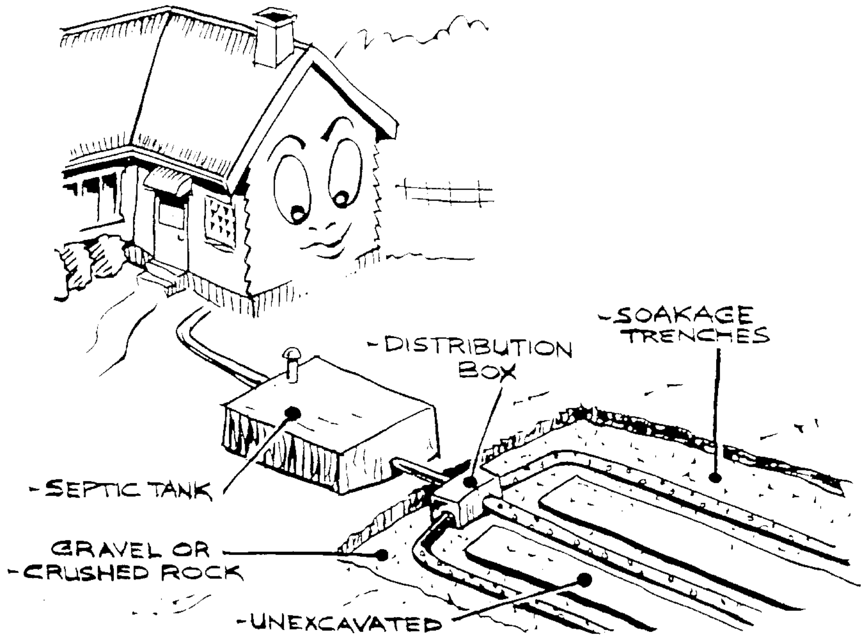


Figure 7 Typical Septic Tank System (Environment B·O·P, 1996)

3.2.3 Monitoring

The effects of septic tank effluent on surface waters in the Bay of Plenty were investigated in 1991 (Environment B·O·P, 1992). The results showed that the water of Lake Okareka met recreational guidelines for bacterial quality, although there was a tendency for the occasional high result at the Jetty site.

Analysis of subsurface flows showed that urban sites around Lake Okareka had higher levels of bacterial contamination than rural sites. The most highly impacted site was the Jetty site. The bacterial pathogen *Clostridium perfringens* was found at highest density around the Jetty. Bacteriophage (bacterial viruses) were found in sediment samples from subsurface septic tank seepage zones near the Jetty and at Steep St, which indicates that viral pathogens could survive transport to the lake water.

Under summer conditions with normal lake levels the results indicated that septic tanks posed a threat to the recreational quality of the lake-shore waters at Okareka. Subsequent bathing suitability surveys have highlighted the threat to bathing quality at the Jetty site.

A report on recent monitoring of water quality in Lake Okareka, the outlet and Lake Tarawera, was commissioned to investigate the validity of concerns about the effect of inundation of septic tanks on lake water quality (Deely, 1998). Results indicate that during high lake levels, bacterial contaminants were not entering the lake in numbers high enough to cause bathing guidelines to be breached. However, there were ponding areas around the lake foreshore that had high bacterial concentrations. The overall assessment at this time was that the high lake level resulted in a contamination threat at the immediate disposal site but that the hydraulic pressure of the lake water meant that the problem area was confined on land. The most serious contamination was likely to be in summer at normal lake levels when full occupancy would occur.

The water quality of Lake Tarawera did not appear to be adversely affected by Okareka inflows. The Waitangi Springs contributed more nutrients that the pipeline outflow, and water quality in Waitangi Bay met bathing guidelines.

Further monitoring of water quality has continued this summer (1998/99). Generally, bathing guidelines have been met.

3.3 Erosion

High lake levels are likely to lead to increased erosion of lake margins. This is a concern of some Lake Okareka residents, although little comment has been received during the high water levels of this year. The degree of the potential erosion has not been assessed, but it would seem to be a less important issue than that of water quality as discussed above.

Conversely, increased outflows could lead to erosion of the Waitangi Stream, particularly if the outflows are variable.

3.4 Access

In its submission to the original consent application, the Department of Conservation was concerned that high lake levels would reduce access to lake margin strips, and requested that a maximum level be set to minimise any access problems. The Department has been approached to clarify the significance of this issue.

3.5 Jetties

Jetties around the lake, mostly private, have been built to cope with normal lake levels i.e. 353.5 – 353.9 metres. If lake levels drop, boats can run aground short of the jetties, particularly with the shallow lake bed on the eastern side of the peninsula. A submission to the original consent applications from the Lake Okareka Residents Association opposed the lowering of the minimum level for this reason.

Similarly if lake levels rise, the jetties become submerged and cannot be used, as was been the case during the 1998 winter and spring.

3.6 Building Floor Levels

A small number of dwellings, mainly on the eastern side of the peninsula, have been built close to the lake with low floor levels. The risk posed to these houses by high lake levels needs to be considered in any assessment of options.

No houses were flooded during the period of high water levels during 1998. Available freeboard at the peak lake level appeared to be of the order of 500mm, although no actual measurements were made.

3.7 Water Supply

A Lake Tarawera resident has commented that additional water volume input into Lake Okareka has resulted from the change of water supply from lake to mains in the Okareka settlement and that this has been responsible, in small part, for the recent rise in lake levels. However, if a typical consumption of 500 litres per day per person is assumed[3] and multiplied by the population of 258[4], and making the very conservative assumption that all of that use ends up in the lake, it can be seen that such usage would only result in a rise of 0.04 millimetres per day. This is negligible.

3.8 Maintenance

Environment B·O·P is applying for and will hold the consents. For reasons of efficiency Rotorua District Council is to operate the valve and maintain the inlet. In turn, the District Council contracts this work to CastleCorp, a Rotorua District Council-owned company.

Flow is regulated through the pipeline by a valve. This valve needs 24 turns to turn it on and off. NIWA was commissioned by the Rotorua District Council to measure the outflow at various valve settings. The findings were as in the following table.

[3] Based on average Wellington city consumption of 187 000 litres per person per year in 1996 (WCC, 1997).
[4] From On-Site Effluent Treatment Plan (Environment B·O·P, 1996).

Setting	Flow (litres per second)
Valve fully open	239
Valve ¾ open	237
Valve ½ open	233
Valve ¼ open	202

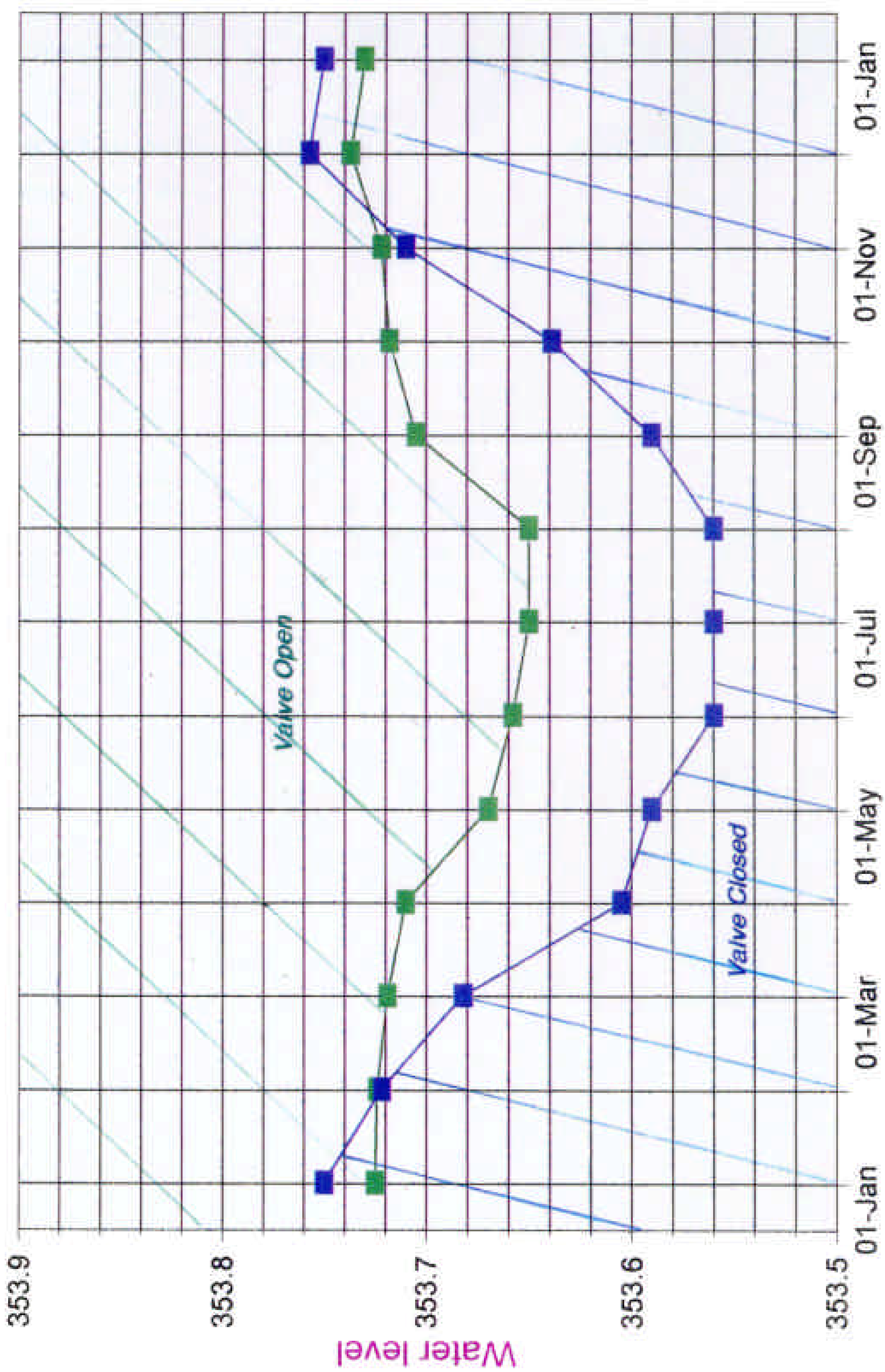
(RDC, 1996)

Hence there is little difference between ¼ open and fully open. Flow can be regulated at lesser openings, however in practice the valve is either fully open or fully shut. The guidelines used for regulating the valve are as shown in Figure 8.

Suggestions that the valve be improved to allow more fine-tuning of outflows have been received from members of the public. However, the modelling of lake levels, as presented in Appendix I, indicate that the current practice and guidelines do allow the lake levels to be maintained largely within desired limits.

Several members of the public have also observed that the entrance to the pipeline is often blocked with debris collecting on the screen and have expressed concern that the pipe flow is being impeded. Although the precise impact of such blockage has not been quantified in these investigations, the suggestion that the entrance be cleared more frequently than at present (weekly inspections) does appear to have some merit.

Figure 8 Valve Control for Existing Pipeline



3.9 Funding

Current operational costs of the outlet system are met by Rotorua District Council. The capital cost of any upgrade would most likely be met by Rotorua District Council and Environment B·O·P. How each organisation would raise this capital and also fund the ongoing maintenance has not been explored at this stage. However, the organisations would need to fulfil their obligations under s.122 of the Local Government Act, including having consideration of who the beneficiaries of the works would be, before setting the funding policy.

Chapter 4: Options

Options for controlling the lake levels include

(i) No control – block off the pipeline and allow the lake to drain naturally via evaporation and seepage.

(ii) Maintain existing pipeline

- with current operating guidelines
- with current guidelines but maintaining a minimum outflow
- with a pump to increase outflows in times of high flows.

(iii) Enlarge the pipeline

- with current operating guidelines
- with current guidelines but maintaining a minimum outflow

Each of these is discussed below. The implications for lake levels are summarised at the end of this chapter.

4.1 No Control

This could be achieved simply by shutting the valve in the pipe, although it would probably be more desirable to place a bund in front of the intake, drain the pipe and block off the entrance.

The principal advantages of this option are

- no ongoing maintenance costs for the pipeline and only a low construction cost to implement
- avoiding the possibility of lower quality Lake Okareka water having adverse effects on Waitangi Stream and Lake Tarawera.

However, this option would lead to higher lake levels generally and is unlikely to be acceptable because

- current concerns of Lake Okareka residents about high lake levels would be increased

- lake margins would be more likely to be inaccessible due to high levels
- Waitangi Stream would be more likely to experience low flows, affecting the viability of trout spawning (although higher lake levels would probably lead to an increased seepage flow feeding the Waitangi Springs).

4.2 Maintain Existing Pipeline

4.2.1 Current Guidelines

The existing pipeline appears to cope with most conditions, with lake levels being within the desired range 78% of the time between January 1978 and August 1998. Lake levels were in excess of the maximum 10% of the time, and below the minimum for 12% of the time.

The principal advantage of this status quo option is that no additional capital outlay is required, while the disadvantages are that the concerns outlined in the preceding chapter remain.

The perceived limitations of this option could be reduced by implementing one or more of the following measures:

- Clear the inlet screen more frequently

  Increasing the frequency of maintenance inspections to say twice-weekly when lake levels are above a certain height – 353.8m for instance – would ensure that any problems with the pipe inlet are reduced.

- More closely monitoring lake levels

  Lake Okareka residents, both in a submission to the original application and more recently, have called for a telemetered lake level recorder, so as to be able to respond more quickly to changes in levels. An estimated cost for such a system is $10,000.

  However, given that readings are also made weekly by RDC and that levels do not vary significantly over a week, the benefits of a telemetered system are not great.

  If after further discussion it is still considered desirable to track levels more closely, it may be more appropriate to get a resident to take more regular readings during times of extreme levels, as was suggested as an alternative by the Lake Okareka Residents Association.

- Preventing stock access to the lake and outlet canal, and intercepting pastoral runoff with lakeside planting.

  Both the Rotorua District Council and Environment B·O·P have worked on proposals to fence off the lake edge or to plant riparian vegetation over the last few years. Implementing these proposals will go some way to alleviating the concerns of Lake Tarawera and Lake Okareka residents. Rotorua District Council has assumed responsibility for developing these proposals, but

Environment B·O·P can offer assistance. Rotorua District Council has made progress on securing agreement to develop a walkway for Acacia Bay Road and to fence off the wetland to the south-west of the lake outlet. Environment B·O·P could also provide assistance (financial and technical) to fence off and plant the canal riparian edges, via the "Environmental Plans" mechanism (Appendix III). Furthermore, a group of Lake Tarawera residents have offered to assist with any planting.

Regardless, the Proposed Regional Plan for the Tarawera River Catchment deems uncontrolled grazing of stock on lake beds to be prohibited from 1 July 2005 (Rule 13.2.5(l)).

- Sewage treatment options

A sub-option of maintaining the current outflow structure and operating guidelines would be to remove the septic tanks most vulnerable to inundation. It may be possible to pipe and pump effluent from the affected houses to elsewhere on the properties or off-site to a communal septic tank system. Estimates of the number of properties whose tanks are vulnerable vary, but the numbers are not likely to be more than twenty. These are mostly located along the eastern side of the peninsula on Acacia Road and on Steep Street. However, by December 1999, septic tanks in the Bay of Plenty region will need to be inspected and certified (Rule 6.4.4 of the On-Site Effluent Treatment Regional Plan). This process should help clarify the nature of the risk presented by septic tanks.

While the cost of any septic tank remedial work identified as necessary following inspection could be paid for by the community in lieu of funding an upgrade to the pipeline, some consideration would need to given as to what precedent this would set for landowners elsewhere in the region who are required to have tanks certified.

RDC are also currently investigating options for unsewered communities in the District, and are expected to report back in 1999. A range of alternatives for sewage treatment and disposal are likely to be considered.

While this sub-option does not deal with other problems associated with lake levels going outside of the desired range, implementing other options to control lake levels would still leave some risk posed by the septic tanks.

- Restrictions on future development

It is important that problems not be exacerbated or repeated, by ensuring that future development (including sewage treatment measures) allows for water level variations. The Building Act requires that dwellings not be inundated in a 2%AEP[5] flood event. Applying the same standard, floors should be above the 2%AEP lake level. From the modelling in Appendix I, it is suggested that development be above a level of 355.0m above Moturiki Datum (notwithstanding any other restrictions on development or on granting of building and resource consents). This restriction is likely to be implemented via

[5] Annual Exceedence Probability – there is a 2% (1 in 50) chance of there being a flood of this size or larger in any given year. Also known as a 50 year return period event

a provision in the Regional Water Plan (in preparation), as well as the Building Act.

It would also seem sensible for jetties to be stepped or allowed to float up and down so as to allow for possible lake level variations. Advice to such effect should be given to applicants for building consents for such structures.

Nevertheless, the outlet pipeline is over 30 years old and is perhaps half-way through its economic life. If this option is selected, it will need to be reassessed at some point in the future as the pipe nears the end of its life. (This also holds for the pump option below).

4.2.2 Current Guidelines Plus Minimum Flow

As noted in section 4.1 above, the residual flow in the Waitangi Stream when the pipe valve is closed is not considered sufficient to maintain the trout fishery. The effect of maintaining of a minimum flow in the pipeline, and hence in the stream, has been assessed in the modelling described in Appendix I. An arbitrary 100 litre/s pipe flow has been modelled. Results show that in most instances maintaining such a flow should not significantly affect the ability to maintain lake levels within the desired range in years of normal or high rainfall. However, in extreme dry years, the lake levels would be lower with this option than if the pipe was completely closed. It is not possible to maintain such an outflow at all times - if the lake level dropped below the level of the sill at the pipe inlet, no outflow would be possible.

Even in this scenario, nevertheless, the possibility of low levels could be minimised with the aid of long term weather forecasts and manipulating the valve appropriately

4.2.3 Pump

A pump could be installed at the pipe inlet to force additional flow through. For this report, an option of installing a submersible pump capable of pumping 400 litres per second at the required head has been assumed. This would upgrade the capacity of the first section of the pipe to equal that of the second section.

In addition to the pump and control cabinet, a pump well chamber, debris screen, flapgate (to allow gravity flow under normal lake level conditions) and manhole access would be needed. A power supply would also be required. The total cost of this option is estimated to be around $90,000.

Maintenance costs of this option would be the highest of any of the options. In addition, power costs would be around $40 per day.

Prior to installing such a pump, the capacity of the pipeline would probably need to be checked to ensure that there were no irregularities that would prevent the proposed pump delivering 400 litres per second.

A further option would be to construct a separate pumped pipeline. However this would obviously be more expensive than pressurising the existing pipeline, and it has not been pursued here.

4.3 Enlarge the Pipeline

4.3.1 Current Guidelines

The capacity of the outlet is limited by the low gradient of the 18 inch diameter pipe. Calculations show that the capacity is approximately 200 litres per second. (As noted in section 4.6, flow measurements taken by NIWA show that the actual capacity is 239 litres per second.)

Calculations indicate that the capacity of the 12 inch diameter pipe, which lies at a much steeper gradient, is around 400 litres per second. In order to provide this capacity for the entire length of the pipe, the 18 inch (450 millimetre) pipe could be replaced by a 600 millimetre concrete pipe, or a second 450 millimetre pipe installed parallel to the first. (As with the pump option, a check of the remaining steeper section pipe would be needed to ensure that there were no irregularities that would prevent the passage of the required flow).

Total costs of excavating a trench and installing a new pipe would be of the order of $100,000.

As the pipeline is around 4 metres underground over much of its length, installing a new pipe by drilling as opposed to trenching has been considered also. Costs of installing a 450 millimetre HDPE[6] pipe in this manner are likely to be between $450 per metre and $600 per metre. Thus, for the 317 metres that needs additional capacity, costs would be of the order of $150,000 – $200,000.

Conveying the flow by means of a siphon, and so avoiding the need to excavate or trench a new line, is also possible. However, no clear advantage can be seen with this method as a pump would be needed to initiate the siphon flow, and it has not been considered further.

To increase the capacity of the pipe to greater than 400 litres per second (under gravity flow) would require the entire length of pipeline to be replaced (or an additional pipe installed in parallel). This has not been investigated due to the higher cost, and as Appendix I shows that a 400 litre per second capacity would offer a significant improvement over the existing situation.

4.3.2 Current Guidelines Plus Minimum Flow

As with the "maintain existing pipe" option (section 5.2.2), modelling of lake levels (Appendix I) shows that the sub-option of providing a minimum flow does not vary significantly from that of operating according to current guidelines, except during drought years. Again, it must also be appreciated that it may not always be possible to provide a minimum flow, and that the ability to keep lake levels within the target range would be compromised.

[6] High Density Polyethylene – a common material for small and medium diameter pipes.

4.4 Discussion

The impact of these options on lake levels under a variety of conditions has been modelled, with results presented in Appendix I (Figures 9-17). Results indicate that

- The no-control option would lead to steadily increasing lake levels, at least until seepage from the lake increased to allow an approximate equilibrium
- In normal rainfall years the existing pipe system and guidelines are adequate to keep levels within the desired range, and no advantage is obtained from enlarging the pipe or adding a pump
- In high rainfall years, the larger pipe option would reduce the duration over which maximum lake levels are exceeded. The pump option offers no advantage over the larger pipe in such scenarios.
- In low rainfall years, no advantage is obtained from enlarging the pipe or adding a pump
- Requiring a minimum flow of 100 l/s would lead to lake levels falling below the desired minimum in dry years, and in extreme drought scenarios it may not be physically possible to provide the flow without the aid of a pump.

For all of the options apart from the first (decommissioning the outlet), funding for decline in service potential (depreciation) would need to be obtained, in addition to funding normal maintenance costs. No estimates have been made of this depreciation funding in this study – this is a matter for asset management planning.

The no-control option is unlikely to be acceptable, and can reasonably be eliminated. The pump option can also be eliminated, despite it having the lowest capital cost of the upgrade options. Additional maintenance costs would be required, and there is no advantage over the enlarged pipe option in maintaining lake levels within the desired range.

For either the existing or the larger pipe options, a minimum flow sub-option could be implemented. However, by maintaining a minimum flow, there is an increased risk that it will not be possible to supply any flow should lake levels drop too low at a later date. It may be appropriate to define a minimum flow subject to the lake being above a set level. Further discussions could take place between the Environment B·O·P, RDC and fishery interests regarding this, perhaps with a view to developing appropriate consent conditions.

Under the existing pipe and operating guidelines, the desired maximum lake level has been exceeded 12% of the time over the last 21 years. No estimate has been made of the exceedance percentage had a larger pipe (as per section 4.3.1) been installed, but it would be somewhat less than 12%. Not withstanding this, evidence to date does not suggest that any significant ill-effects have been caused by high lake levels.

By implementing the sub-options identified in Section 5.2.1 of this report (more frequent checking and clearing of the inlet screen, upgrading septic tank systems directly if required, planting and fencing the lake and outlet canal margins, and implementing development restrictions more appropriate to possible lake level variations) the risk posed by the current management regime could be reduced. (It would also be prudent to implement such measures even if the pipe were to be enlarged). Furthermore, by making use of longer-term weather forecasts, it is possible to better manage the valve than was assumed in the modelling described in Appendix I.

It must be stressed that no option can guarantee that lake levels will always stay within the desired range, and the degree of acceptable risk needs to be assessed against the willingness and ability of the community (regional or local) to pay for a solution.

Chapter 5: Conclusions

The existing pipeline appears to cope with most conditions, with lake levels being within the desired range 76% of the time between January 1978 and January 1999. Lake levels were in excess of the maximum 12% of the time, and below the minimum for 12% of the time.

It is accepted that the existing pipe does not always allow control of lake levels within the currently adopted desired range in periods of extreme (high or low) rainfall. Options for the lake level control system have been investigated, and of these, two are practicable:

- maintaining the existing pipeline, and
- enlarging the first section of pipe to allow 400 l/s outflow.

For either option, further discussion with interested parties prior to deliberations on the consent applications is expected to provide proposed consent conditions to formalise operating (minimum flows, valve change trigger levels, rate of change of valve settings etc) and consultation guidelines.

While no option can guarantee that levels will always be within the desired range, by increasing pipe capacity the duration during which lake levels exceed the maximum should be reduced.

The indicative costing for the enlargement option is $100,000. However, no detailed design or costings have yet been developed, as the community needs to weigh up the cost of this option (and its willingness/ability to pay) with the frequency and severity of the problems associated with maintaining the status quo. Water quality monitoring results suggest that problems associated with the current regime, particularly in times of high lake levels, may not be as bad as perceived. The problems could be further reduced by adopting other measures.

References

Titchmarsh, B R (1995); Lake Okareka – Report on Technical Issues to be considered in the Application for a Resource Consent. Environment B·O·P Operations Report 95/3.

Environment B·O·P (1996); On-Site Effluent Treatment Regional Plan. Resource Planning Publication 96/3.

Environment B·O·P (1996); Proposed Regional Plan for the Tarawera River Catchment (Redline/Strikeout Copy). Resource Planning Publication 93/7.

Environment B·O·P, (1992): Investigation of Septic Tank Effluent Disposal in the Bay of Plenty. Technical Publication No 6 Prepared by J McIntosh.

Wellington City Council (1997); Right Here Right Now – A Public Summary of Wellington's State of the City Report.

Rotorua District Council (1996); Submission on Resource Consent Applications 02 4488 and 05 0662, Environment B·O·P.

Appendices

Appendix I – Lake Level Model

A simple model of lake levels has been developed to help assess the effect of various rainfall distributions and outflow management strategies. The model is in an Excel spreadsheet and stored in the Environment B·O·P computer directory 'designgroup', file r:\phil\lake okareka\lake level model 2.xls.

The model calculates daily water levels based on the equation

$$\text{water level} = \text{water level on preceding day} + \frac{\text{(volume of inflow – volume of outflow) in preceding 24 hours}}{\text{area of lake}}$$

Inflows are

- rainfall on lake surface
- rainfall on remainder of catchment x runoff coefficient
- seepage into lake

Outflows are

- seepage from lake
- outflow from pipe
- evaporation from lake surface

Rainfall data have been obtained from the Mercer/Wilson manual rain gauge in the Okareka settlement where readings are taken daily.

The model has been calibrated over the period 16 December 1997 to 7 January 1999, as during this time one of the above variables – pipe outflow – was known precisely. From 16 December 1997 until 29 April 1998 the valve was closed and hence pipe outflow was zero, while after 29 April the valve was fully opened – implying a pipe outflow of 239 litres per second. The valve was partially closed on 8 January 1999.

The variables that were used for calibrating the model were

- runoff coefficient
- seepage from lake
- seepage into lake
- evaporation

A runoff coefficient of 0.2 was assumed, as also assumed by M Thomas of the Rotorua District Council (Appendix 2 of Titchmarsh (1995)). However this was increased by 25 percent (i.e. giving a runoff coefficient of 0.25) for the period from June 1998 due to high rainfalls and hence expected wetter ground conditions.

Seepage to the lake has been assumed to be a constant 100 litres per second, although for the verification (see below) period 1993/94 it has been reduced to account for the dry conditions. Seepage from the lake has been assumed at 160 litres per second. Note that this is more than the inferred flow from the Waitangi Springs – it can be expected that some seepage from the lake goes elsewhere.

Evaporation has been estimated by month, based on average monthly records for Rotorua (Environment B·O·P, 1996). It is expected the calibration and verification of the model would be improved by using actual evaporation figures, but these data were not available.

Figure 9 shows the results of the calibration.

Verification was attempted for the period 22 September 1993 to 26 July 1994, when the pipe valve was closed. However a good match with observed lake levels was not possible, unless the seepage inflow was reduced to zero (i.e. net seepage outflow = 160 litres per second). 1993 was a particularly dry year, with rainfall at Whakarewarewa being 75 percent of mean annual and at Okareka being 72 percent of mean annual. (1997 rainfall was close to mean annual.) Groundwater seepage into the lake could therefore be expected to be reduced during the verification period. Reducing the seepage inflow to 70 litres per second (i.e. 70 percent of 100 litres per second) still did not provide a verification of the model, but was assumed nonetheless in the final version of the model. Figure 10 shows the results of the verification.

Nonetheless, the model is still considered useful for comparing various scenarios. Scenarios modelled include

- Drought conditions

  –1914 rainfall at Whakarewarewa (driest year on record) (Figure 11)

  –driest February on record with average rainfalls for other months (Figure 11)

  –1000mm annual rainfall (approximately the 2%AEP annual low rainfall) (distributed evenly) (Figure 12)

- average rainfall for each month (distributed evenly over the month) (Figure 13)

- High rainfall conditions

  –2%AEP 30 day high rainfall (distributed evenly over the 30 days) with average rainfall for remainder (Figure 14)

  –2%AEP annual high rainfall (distributed evenly) (Figure 15)

  –10%AEP 30 day high rainfall (distributed evenly over the 30 days) with average rainfall for remainder (Figure 16)

  –1998 rainfall (Figure 17)

Each scenario was modelled for one year, with rainfall data coming from Whakarewarewa (being similar in distribution to Okareka, but with a much longer record).

Management scenarios modelled include

- current regime and guidelines
- current regime and guidelines plus 100 l/s minimum pipe flow
- no outlet (pipeline blocked up)
- larger pipe capacity (400 litres per second)
- larger pipe capacity (400 litres per second) plus 100 l/s minimum pipe flow
- current pipe capacity (239 litres per second) plus pump

In the case of the 100 l/s minimum flow options, no gravity pipe flow was assumed possible when lake levels dropped below 352.94m – the level of the invert of the outlet.

Two pump operation alternatives were initially modelled in the 2%AEP 30 day rainfall scenario. The first assumed the pump was on whenever lake levels were greater than 353.90m. The second assumed that the pump would be started when water levels were above 353.80m and rising, and stopped when levels fell back below 353.90m. However, the difference proved insignificant (Figure 15) and the first was assumed in the remaining scenarios.

Further assumptions made were that the pipe was either fully open or fully closed (except in the minimum flow options), and that the pipe valve was only adjusted weekly. However, the pump was turned on or off daily as required.

In the exercise, the decision to shut or open the valve was based on a simplification of the RDC guidelines of Figure 8. The pipe was closed if lake levels were below those shown in the following table, otherwise the pipe was open.

Month	Level
January	353.750m
February	353.730m
March	353.660m
April	353.600m
May	353.590m
June	353.560m
July	353.560m
August	353.560m
September	353.590m
October	353.640m
November	353.710m
December	353.760m

In practice, more flexibility is available to open or close the valve in accordance with rainfall forecasts or longer-term weather predictions.

Two qualifications need to be made about the results that follow. Firstly, the no-outlet option results become less reliable as the lake levels, since observations prior to the construction of the outlet suggest that the seepage from the lake is likely to increase. This effect has not been modelled.

Secondly, the drought year predictions should be read with more caution than the high rainfall predictions, given that the calibration in high rainfall conditions was more successful than the verification in drought conditions.

Figure 9 Lake Level Model Calibration

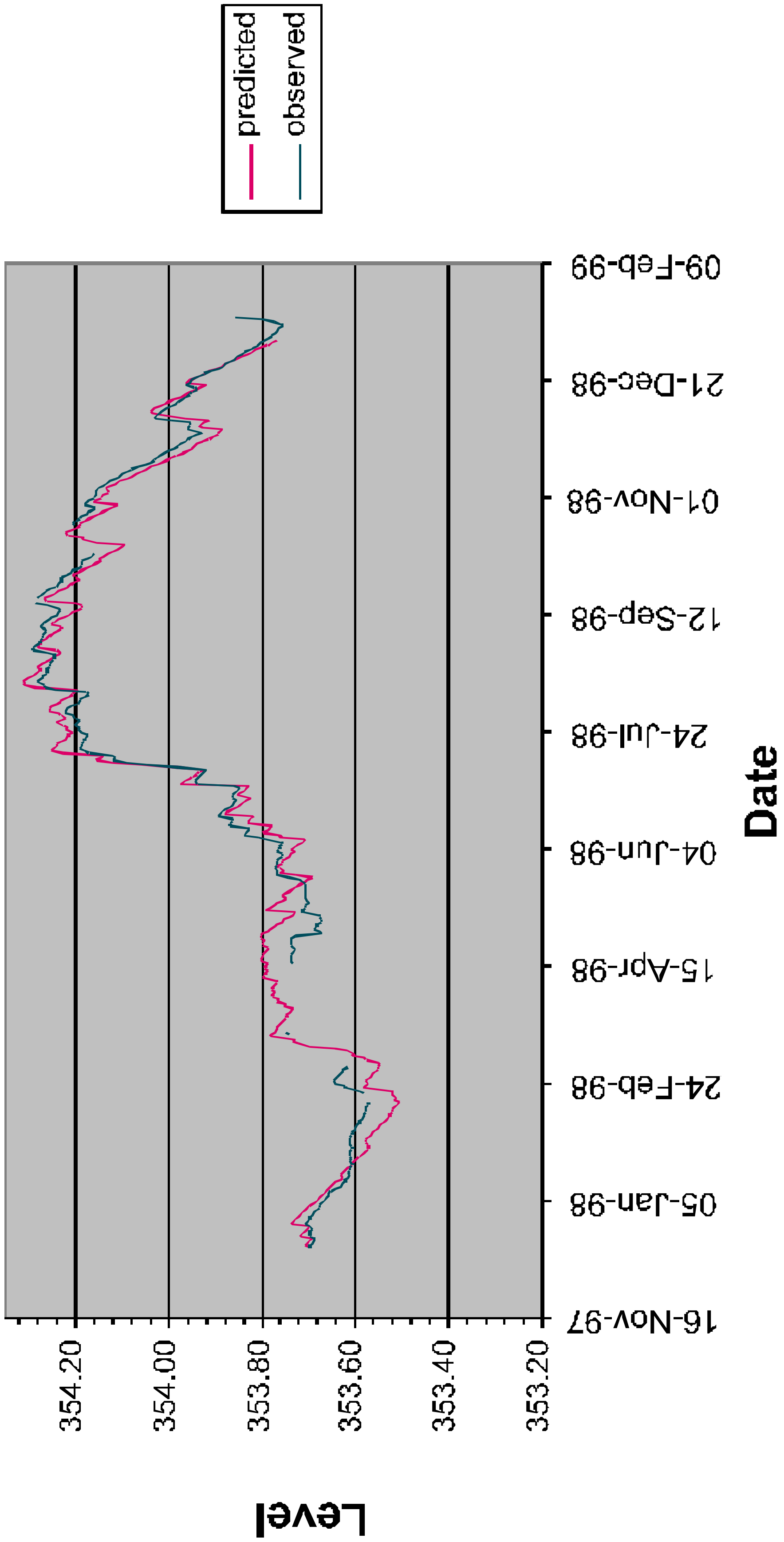


Figure 10 *Lake Level Model Verification*

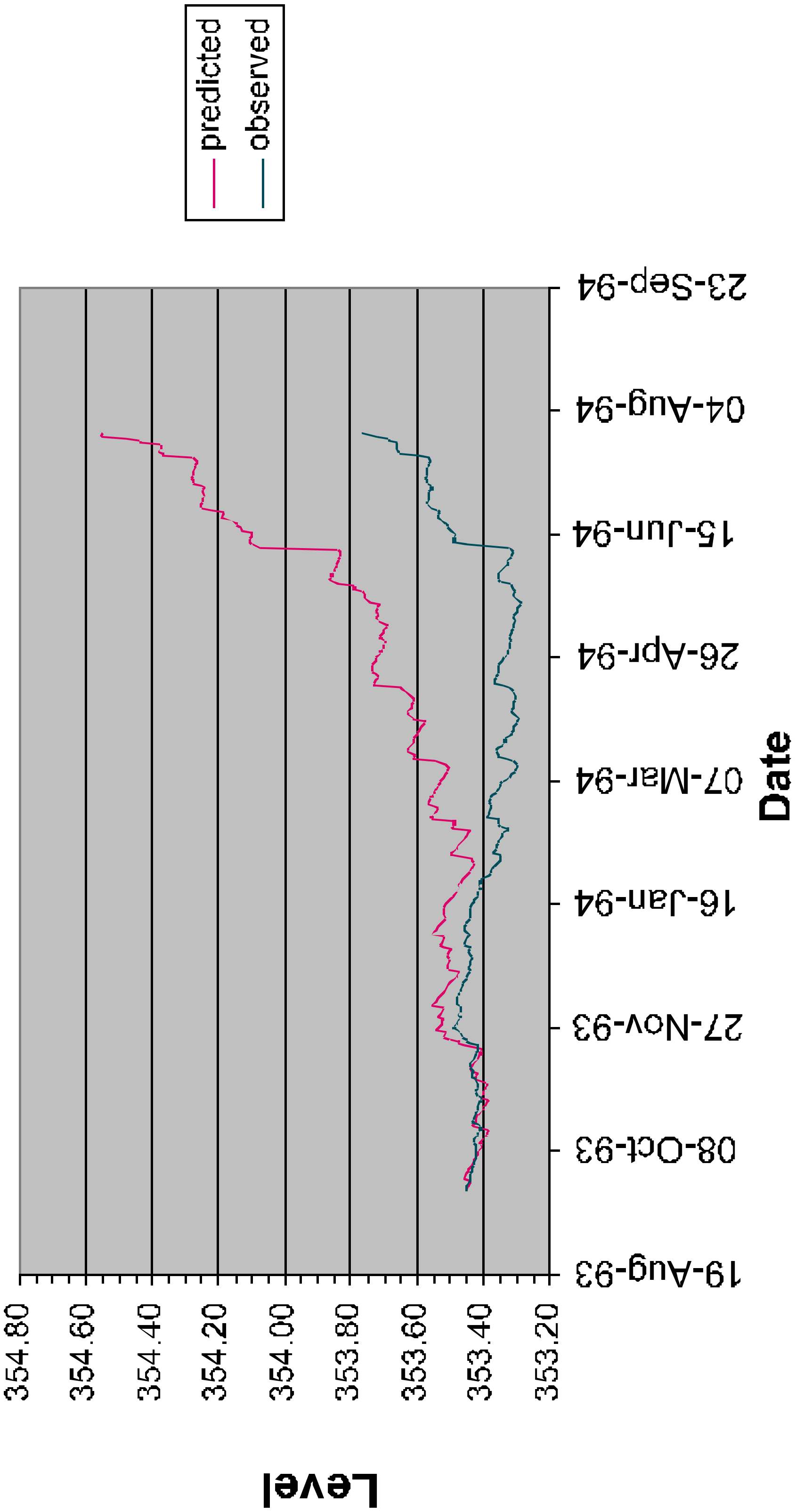


Figure 11 Predicted Lake Levels – minimum recorded annual and monthly rainfalls

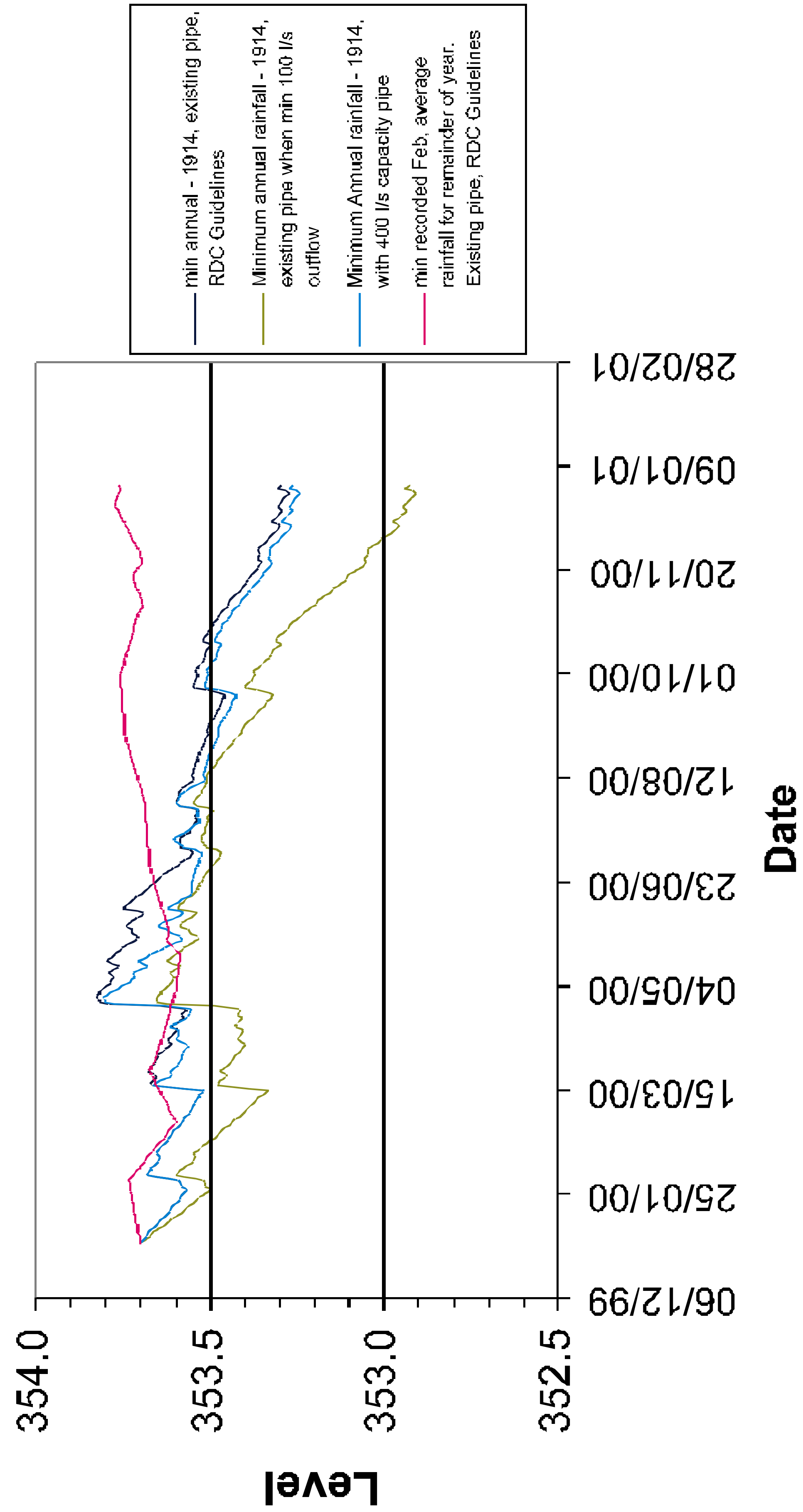


Figure 12 Predicted Lake Levels – 1000mm annual rainfall

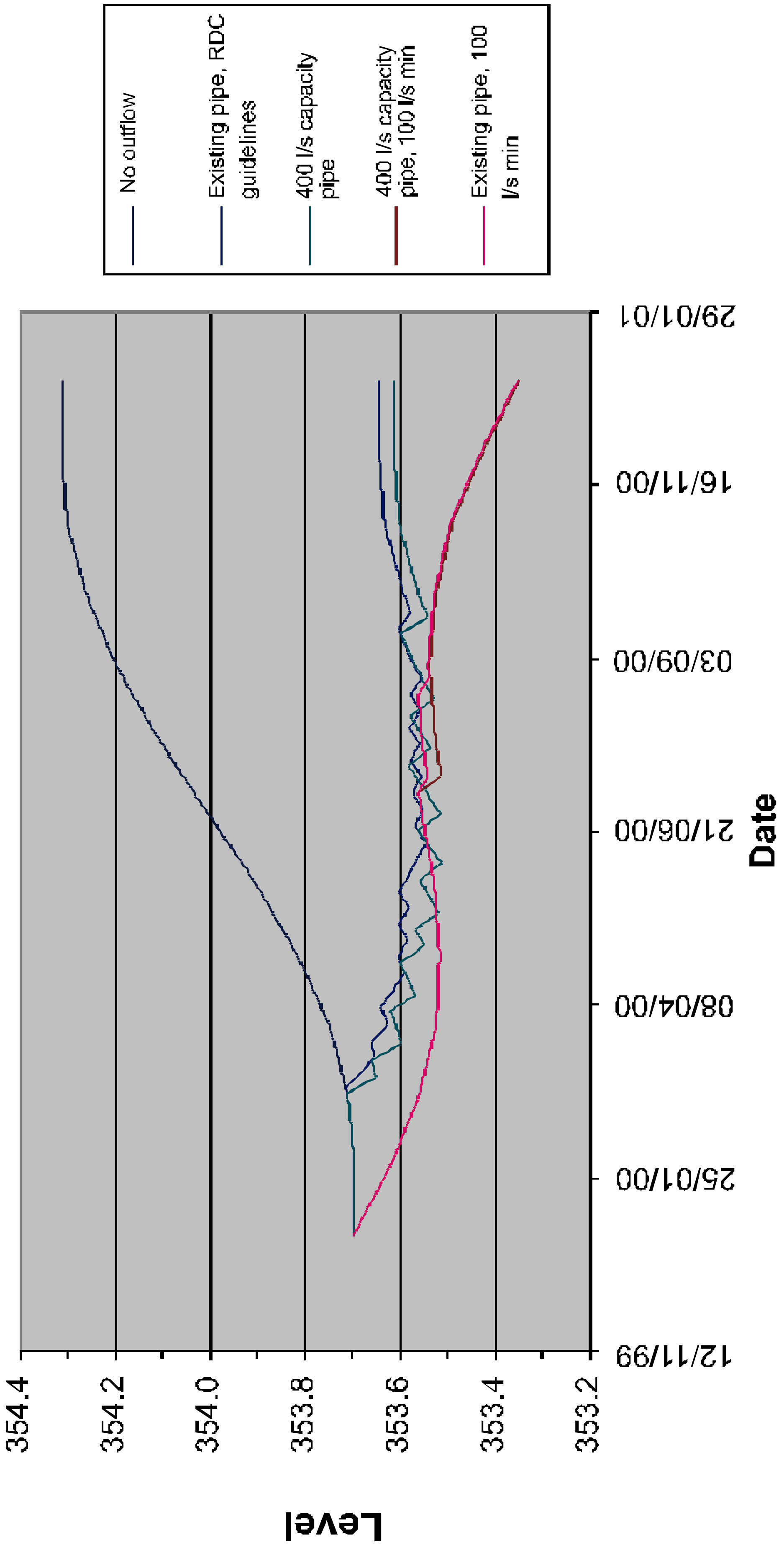


Figure 13 Predicted Lake Levels – average rainfall

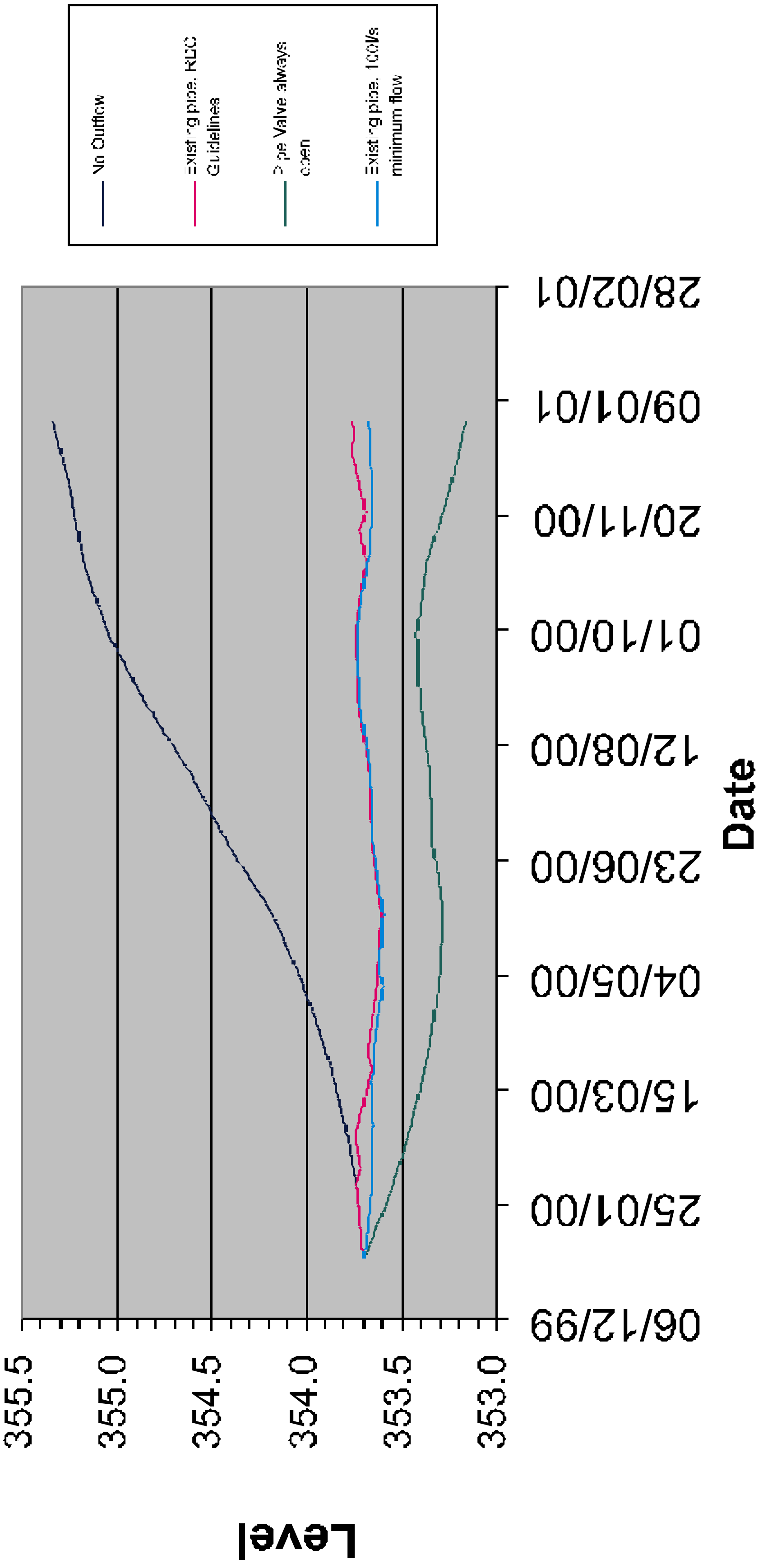


Figure 14 *Predicted Lake Levels – 30 day 50 year rainfall in August, average monthly rainfall for remainder of year*

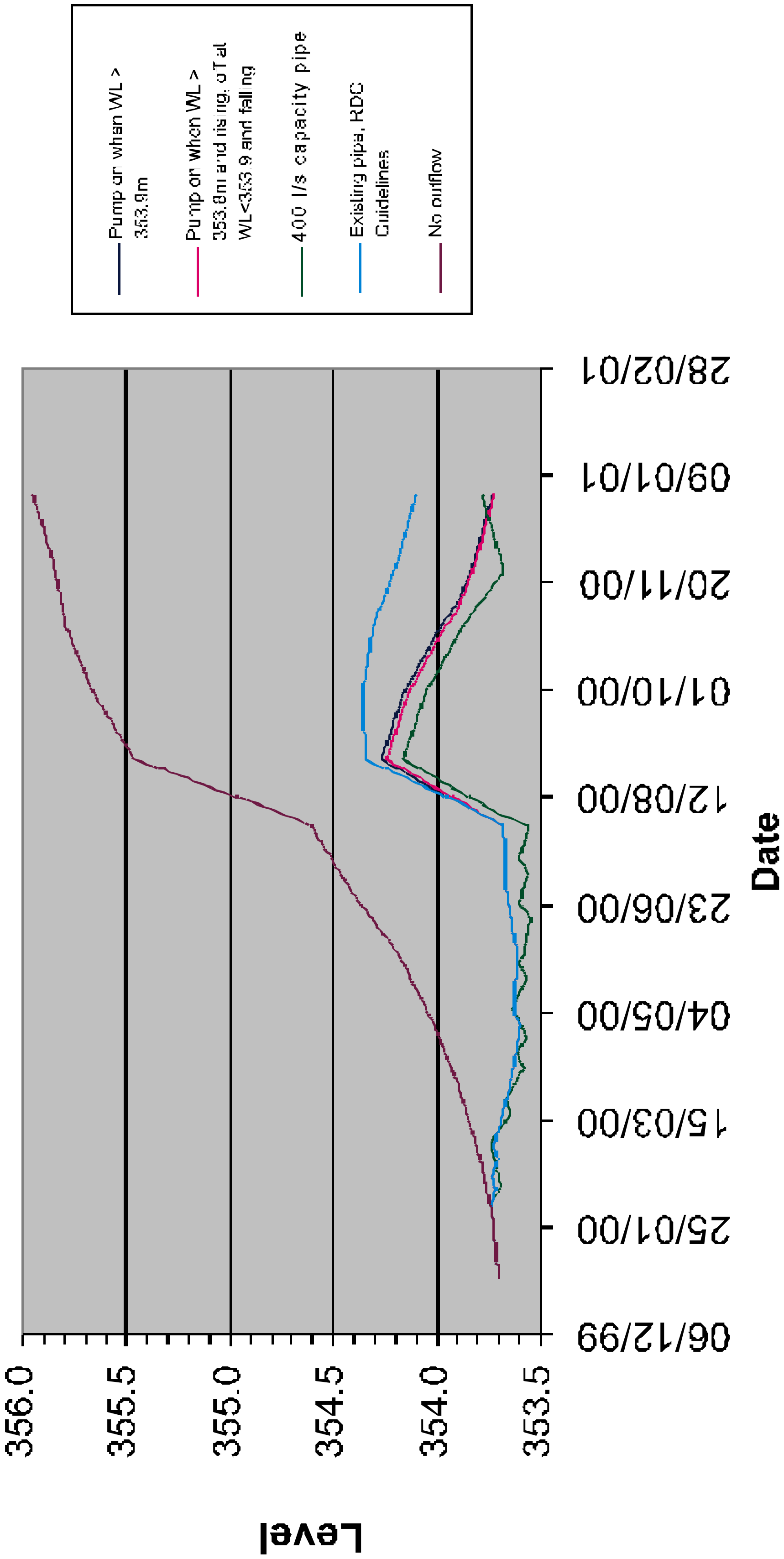


Figure 15 *Predicted Lake Levels – 50 year annual rainfall*

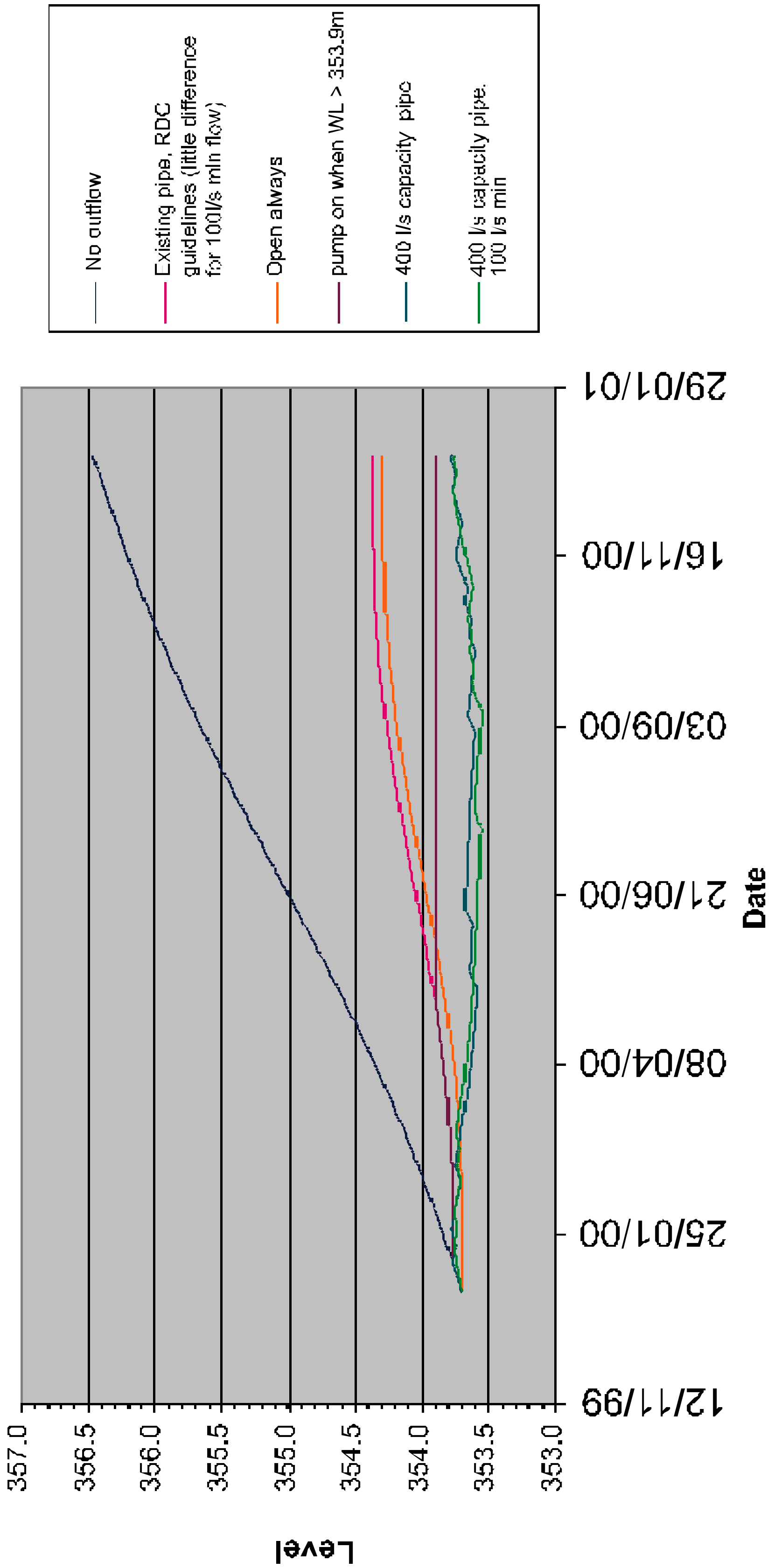


Figure 16 Predicted Lake Levels – 10 year 30 day rainfall

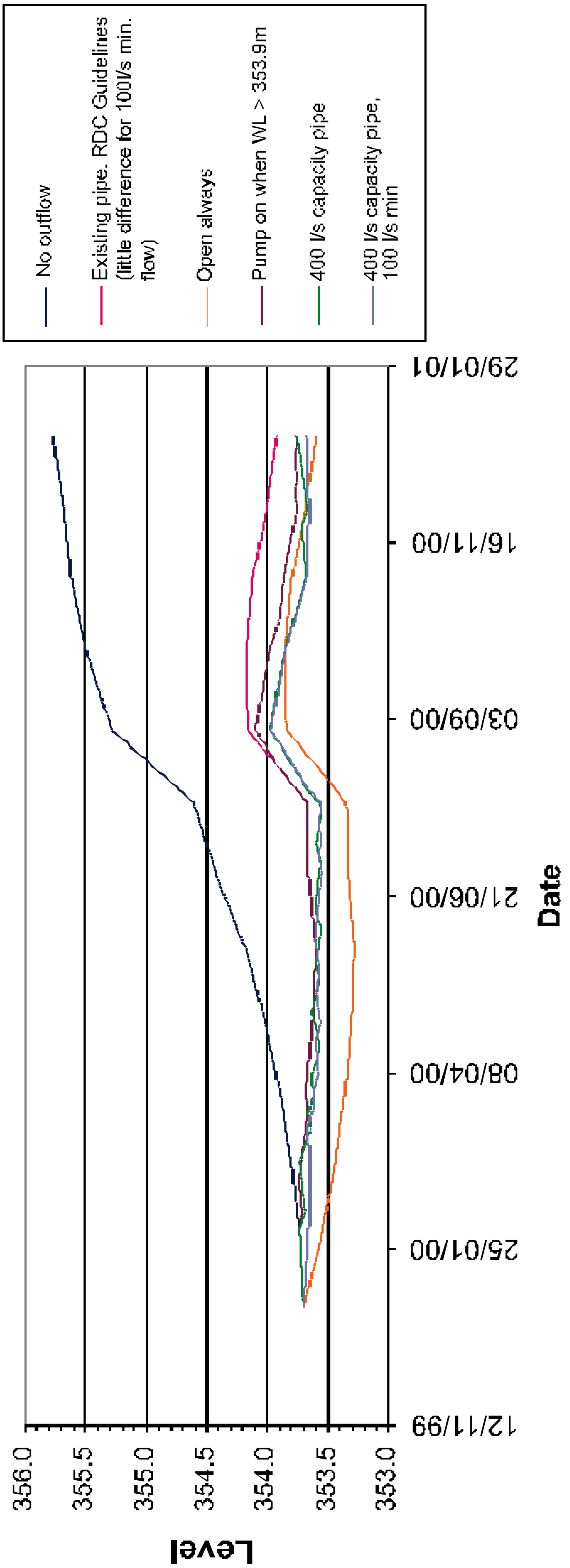
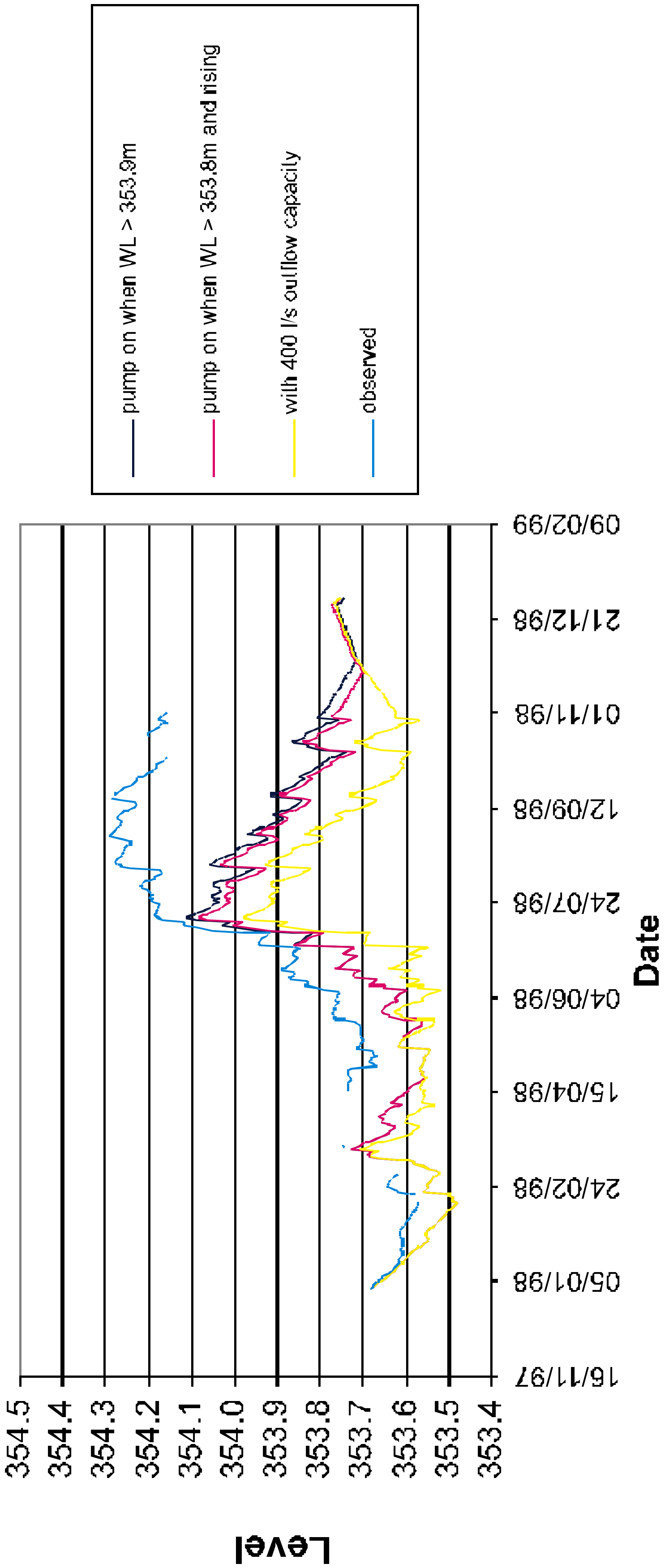


Figure 17 Predicted Lake Levels – if alternative options were in place for the July 1998 events



Appendix II – Waitangi Stream Baseflow

Gaugings have been performed as follows:

27 November 1998

Lake Okareka Outflow at U/S of leftbank tributary 315l/s

(Other readings L/B trib at Lake Okareka Outflow confluence dry
Lake Okareka Outflow at U/S Culvert 328 l/s)

Valve open fully at the time – i.e. 239 l/s from pipe according to NIWA measurements. Hence baseflow is approximately 76 l/s.

24 April 1996

At upstream of upstream of road culvert 227 l/s
Left tributary dry.

Valve open 3 turns at the time – flow unknown, but from NIWA measurements (Section 4.8 of this report) one-quarter open (i.e. 6 turns) equates to 202 l/s. Therefore contribution from pipe is between 0 and 200 l/s. Thus baseflow in the stream is between 27 l/s and 227 l/s.

Neither of these readings are conclusive, but both suggest that the baseflow is typically of the order of 100 l/s.

Appendix III – Environmental Plans

Soil Conservation Practice

ENVIRONMENTAL PLANS

Fact Sheet SC01/98

Introduction

The established approach for dealing with on farm erosion issues is the Soil Conservation Property Plan. This details the physical problems and resources of a farm property, and an appropriate programme of erosion control works. More recently in the Bay of Plenty, Environmental Plans have been introduced which address a broader range of environmental issues at the farm scale.

Environmental Plans can improve water quality, deal with farm effluent and rubbish disposal, and add to the natural beauty of the area. This approach not only improves the farm environment but also has benefits for the downstream catchment.

In the Ngongotaha Stream catchment near Rotorua for example, a 1990 DSIR survey found real improvements in water quality after protecting streambanks from grazing on individual properties.

- Erosion of streambanks decreased from 30% to 4%.
- Sediment carried downstream to Lake Rotorua reduced by 85%.
- Particulate nitrogen and phosphorus entering the stream reduced by 33%.

Streambank protection has improved the quality of Lake Rotorua while more soil and nutrients have been retained on local farms.

Environmental Plans promote water quality and landscape values.

The Development of Environmental Plans

The concept was first proposed by Federated Farmers branches in Rotorua and Taupo. It was then expanded by a working group of Federated Farmers, Rotorua District Council, Department of Conservation, Environment Waikato and Environment B·O·P.

Environmental Plans are voluntary for landowners and are based on a partnership between the landowners and organisations such as Environment B·O·P, District Councils and the Department of Conservation.

What is involved in an Environmental Plan?

The first step in the presentation of an Environmental Plan is the identification of environmental issues and resources on the property, including:

- streambank protection
- erosion and farm runoff
- protection of springs/wetland
- water supply and quality
- plant and animal pests
- use of chemicals
- farm dumps and offal holes
- disposal of effluents
- protection of landscape and heritage values
- protection of forested remnants and other natural features
- tree planting

Staff from the Environment B·O·P Land Resources Section assist landowners with this process and draw up a specific Environmental Plan for the property. This plan will include a description of soils and land use capability types, the management goals and environmental concerns of the landowner, plus a programme of works to address these concerns.

Environmental Plan Assistance

Environment B·O·P provides the following assistance for the preparation and implementation of Environmental Plans.

Sustainable Options

Caring for the Bay of Plenty

- Administrative, professional and technical support.
- Resource support —aerial photos, maps, etc.
- Financial support (see below).
- Help in organising and implementing the programme of works.
- Ongoing monitoring programme.

District councils can assist by providing specialist advice (e.g. on landscape issues) and may provide financial support. The Department of Conservation can advise on habitat and wildlife values and may also assist fencing and planting programmes. Support for Maori initiatives to preserve native flora is also available through Nga Whenua Rahui.

To cement the partnership with the landowner, Environment B·O·P offers grant rate funding. For works with a high downstream benefit a grant rate of up to 50 percent is applicable to the following costs.

- Retirement fencing (steep gullies, at-risk headwaters, streambanks, lake and estuary margins).
- Protection plantings of trees/shrubs within retired areas.
- Construction of erosion control structures

Degraded wetlands can be restored and protected under an Environmental Plan

For works associated with a lesser downstream benefit, a grant rate of 25 percent is applicable to the following costs.

- Catchment protection woodlots.
- Stock water supply (where retirement has excluded access to natural water).
- Pole planting and other accepted soil conservation practices.

Grants are paid out upon completion of works and the signing of a suitable covenant where land is retired from stock grazing. This is an agreement to preserve the retirement and is registered against the title of the property concerned. Such covenants can include Conservation Covenants, Queen Elizabeth II National Trust Open Space Covenants, or Land improvement Agreements.

All areas retired from stock grazing, and other on-farm works carried out under an Environmental Plan, remain the property of the landowner. Environment B·O·P undertakes to regularly monitor the condition of works and provide some support for ongoing tasks, such as plant and animal pest control. Routine maintenance of works is otherwise the responsibility of the landowner.

For further information and advice contact your local Soil Conservator at the following Environment B·O·P offices:

WHAKATANE	**Tel**	**07 307 2545**
	Fax	**07 307 2544**
ROTORUA	**Tel**	**07 349 5070**
	Fax	**07 349 5074**
TAURANGA	**Tel**	**07 574 8810**
	Fax	**07 574 8814**

Further reading

The Sustainable Agriculture Manual , published by Waikato Federated Farmers, P O Box 3341, Hamilton

Native Forest Restoration , by T Porteous, published by QEII National Trust, P O Box 3341, Wellington

Managing Riparian Zones, Vol I and II, by K J Collier et al (eds), published by Department of Conservation, P O Box 10420, Wellington

Reducing the Impact of Agricultural Runoff on Water Quality, published by Ministry for the Environment, Wellington

This fact sheet was prepared by Colin Stace
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