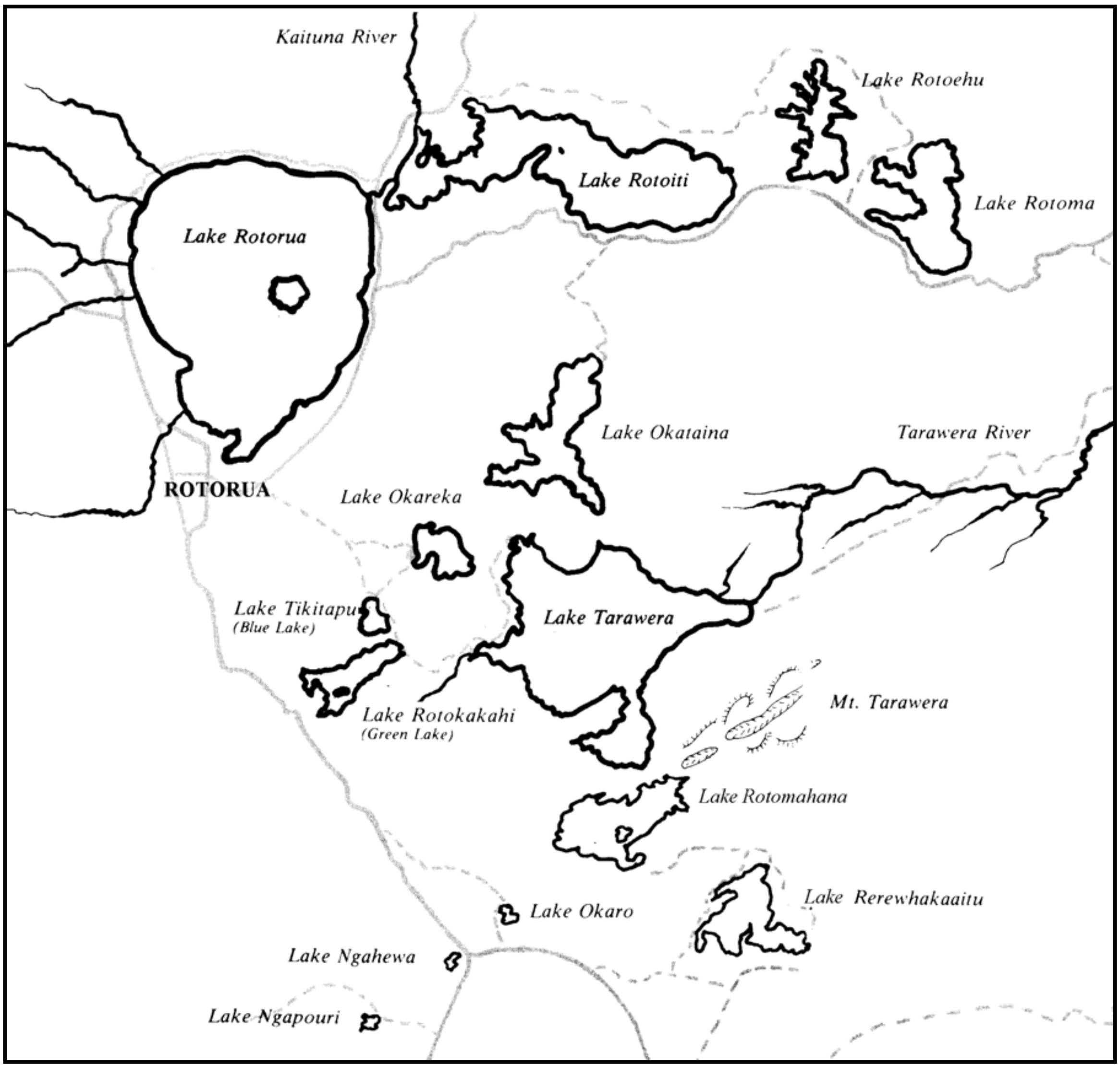
Proceedings and Report

ROTORUA LAKES 2002

A workshop on Lakeside Communities and Sewerage



Proceedings and Report

ROTORUA LAKES 2002

A workshop on Lakeside Communities and Sewerage

20 September 2002
Centra Hotel, Rotorua, New Zealand

Jointly hosted by

LakesWater Quality Society Incorporated
and
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Editors' Note

Material for the Workshop Proceedings has been received in a variety of formats, but generally as computer 'Power Point' presentations. Most presentations were fully or partly transcribed from audiotapes, and there are some inevitable gaps in this record. Preparing material from transcriptions has been a very laborious and time-consuming task. Due to the very short notice at which the Workshop was hosted, it was not possible to obtain full text versions from the presenters. Not all visual material from Power Point presentations has been included, in order to keep the file size and physical size of this document to a reasonable minimum.

The oral presentations have been edited to a limited extent, without seeking to remove all the flavour of the spoken word. Audience questions and presenter's answers have been included where available, but owing to taping problems, not all questions and answers are available for publication. The Editors are grateful to Jane Jackson who prepared the original tape transcripts for these Proceedings.

Please bear in mind that these Proceedings have been edited, proofed and assembled by volunteers, in their spare time.

Nick and Elizabeth Miller

Disclaimer: The Proceedings report the formal presentations and question sessions of the Symposium, which was designed to encourage open discussion amongst those managing, studying, or with an interest, in the Rotorua lakes. The information is <u>not</u> intended to substitute for official policy statements from parent organisations.

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Table Of Contents

Foreword

The Workshop ***Rotorua Lakes 2002 - Lakeside Communities and Sewerage*** was organised by the LakesWater Quality Society with support from the Rotorua District Council (RDC), and assisted by the Royal Society of NZ (Rotorua Branch).

This Workshop follows the successful ***Rotorua Lakes 2001*** that had been devoted to research needs for the Lakes.

The focus this time was more practical: - on specific proposals by RDC for sewerage at Mourea-Okawa Bay and for Lake Okareka. The general issues relating to sewerage for lakeside communities were also discussed.

I extend grateful thanks to all those who have prepared papers, to RDC and to the voluntary committee who carried out the major task of organizing the Symposium.

Writing a foreword after some time has elapsed has the advantage of allowing judgments to be made in hindsight. Since the Workshop RDC has decided to construct a sewerage scheme for Mourea-Okawa Bay. Considerable progress has been made in planning, but not all obstacles have been overcome as at the time of writing.

With Lake Okareka, RDC and Environment BOP are now working together and will be preparing an Action Plan together with the local community.

The more general findings of the Workshop will be of interest to other communities, both around the Rotorua Lakes and beyond.

Workshops and Symposia such as ***Rotorua Lakes 2002*** have a most useful purpose on presenting and discussing technical information. But the ultimate test of their value is action that improves the water quality in the lakes.

By this measure, the value of ***Rotorua Lakes 2002*** is still to be determined.

Ian McLean
Chairman, LakesWater Quality Society Inc.

May 2003

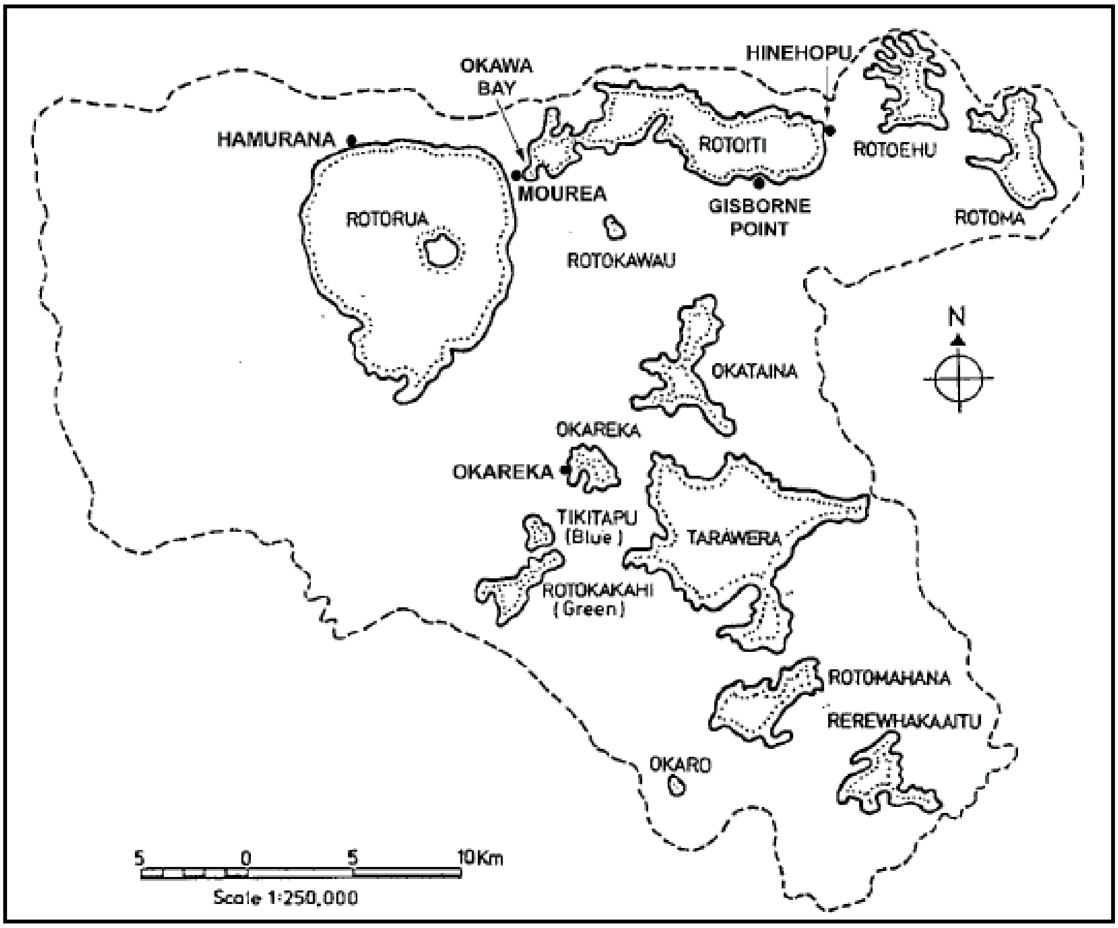
Septic tank leachate at lakeside communities - NIWA investigations

Dr David Ray, National Institute of Water and Atmosphere (NIWA)

The studies that NIWA were asked to undertake for the Rotorua District Council were to assess the effects of leachate on the Rotorua Lakes, from septic tanks in the various small communities around the Lakes, and the contaminants we've addressed have been largely pathogens (things of concern to public health) and nitrogen.

In general terms, we were firstly assessing the risk to public health presented by leachate from septic tanks and secondly, in most situations we put together a nitrogen budget which looked at the input of nitrogen from the whole catchment of the lakes, (this is the external input of nitrogen from run-off from pasture, forest, etc.), and compared that to the input of nitrogen from the septic tanks.

The map (*below*) shows the areas we've looked at: Hamurana, Mourea, Okawa Bay, Gisborne Point, Hinehopu and Okareka. I'm going to talk in the next half an hour about all of those communities, except for Okawa Bay, and Kit Rutherford, one of my colleagues from NIWA, is going to address Okawa Bay a little bit later on in a lot more detail.



Just a very brief background. As I'm sure most of you are aware, septic tanks can be a useful treatment system for single houses, provided they are not too densely located, but problems can arise with them for a number of reasons. First of all, if the ground water is too shallow there can be insufficient treatment. The septic tanks generally rely on the unsaturated soils above the groundwater table to treat the effluent that comes out of the disposal field. So if it's too shallow, it's an ineffective treatment and we can get groundwater contamination. Secondly, if the soils are too free-draining, if they are very coarse sands for example, this effluent can travel too quickly through the unsaturated soils and again we can get contamination of the groundwater. And finally, if the soils are too poorly drained, essentially the effluent can't get into the soils and you can get it surfacing on the ground surface.

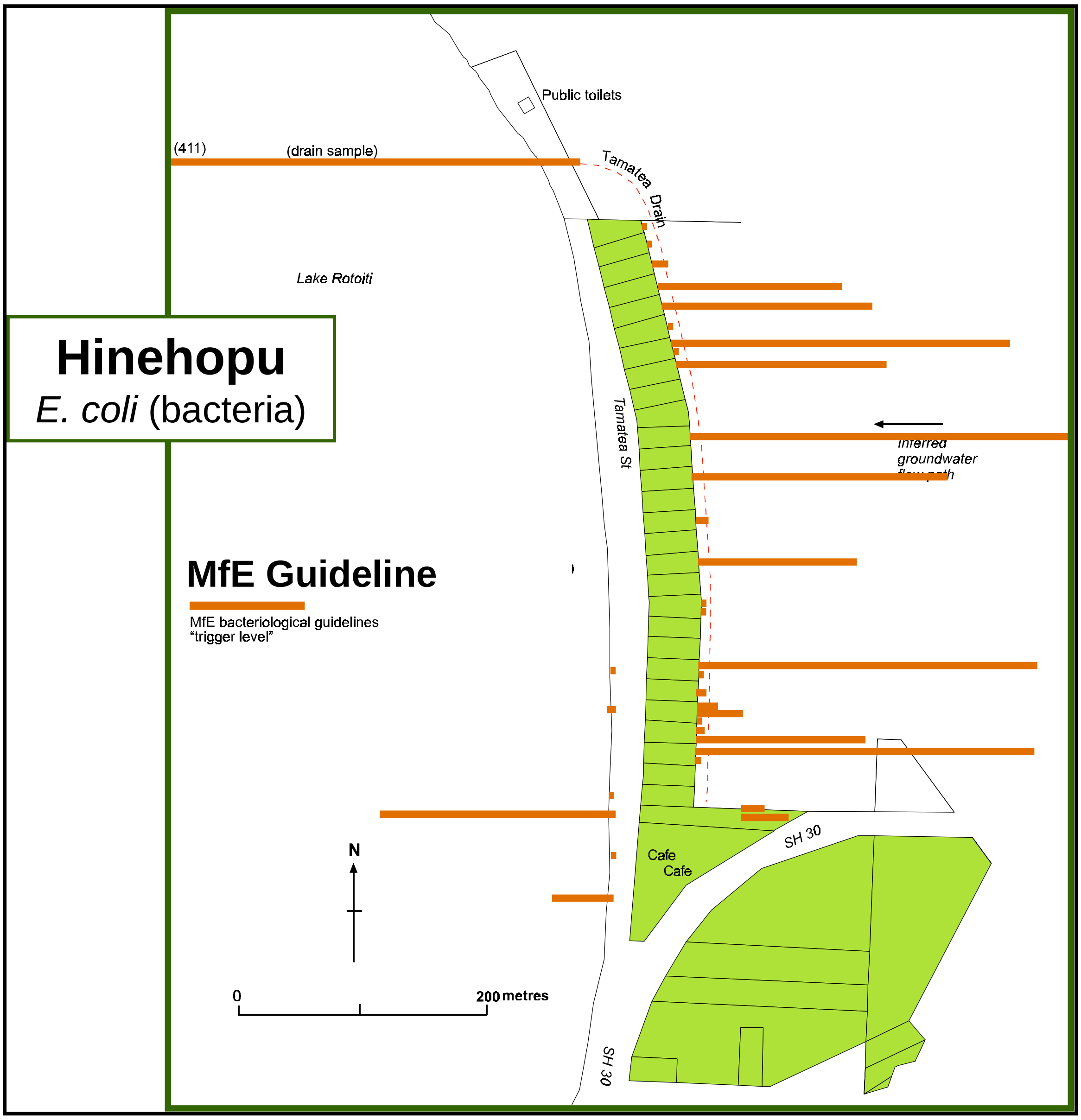
Those first two problems I'll be addressing this morning. The method we used in our study was to take shallow groundwater samples near the lake edge using a penetrometer that I'll show you in just a moment, and then we analysed those samples for pollution indicators, being nitrogen in the form of ammonia and nitrate, and also indicator bacteria – *E. coli* and in some places *Clostridium*.

First, this is a slide showing the method of sampling we used. The steel shaft is driven into the sand until you hit the top of the groundwater table and we just suck up a sample using a little vacuum pump and send it away to be analysed.

The simplest and I guess best news stories, Hamurana and Gisborne Point. We found little evidence at those two communities of any significant groundwater contamination. There were a few isolated high readings from the samples, but generally speaking no evidence of any widespread serious contamination. When the input of nitrogen from the septic tanks was compared to the input from the rest of the catchment, we found that both at Hamurana and Gisborne Point the septic tanks contributed less than 2% of all the nitrogen inputs to those lakes – to Lakes Rotorua and Rotoiti respectively.

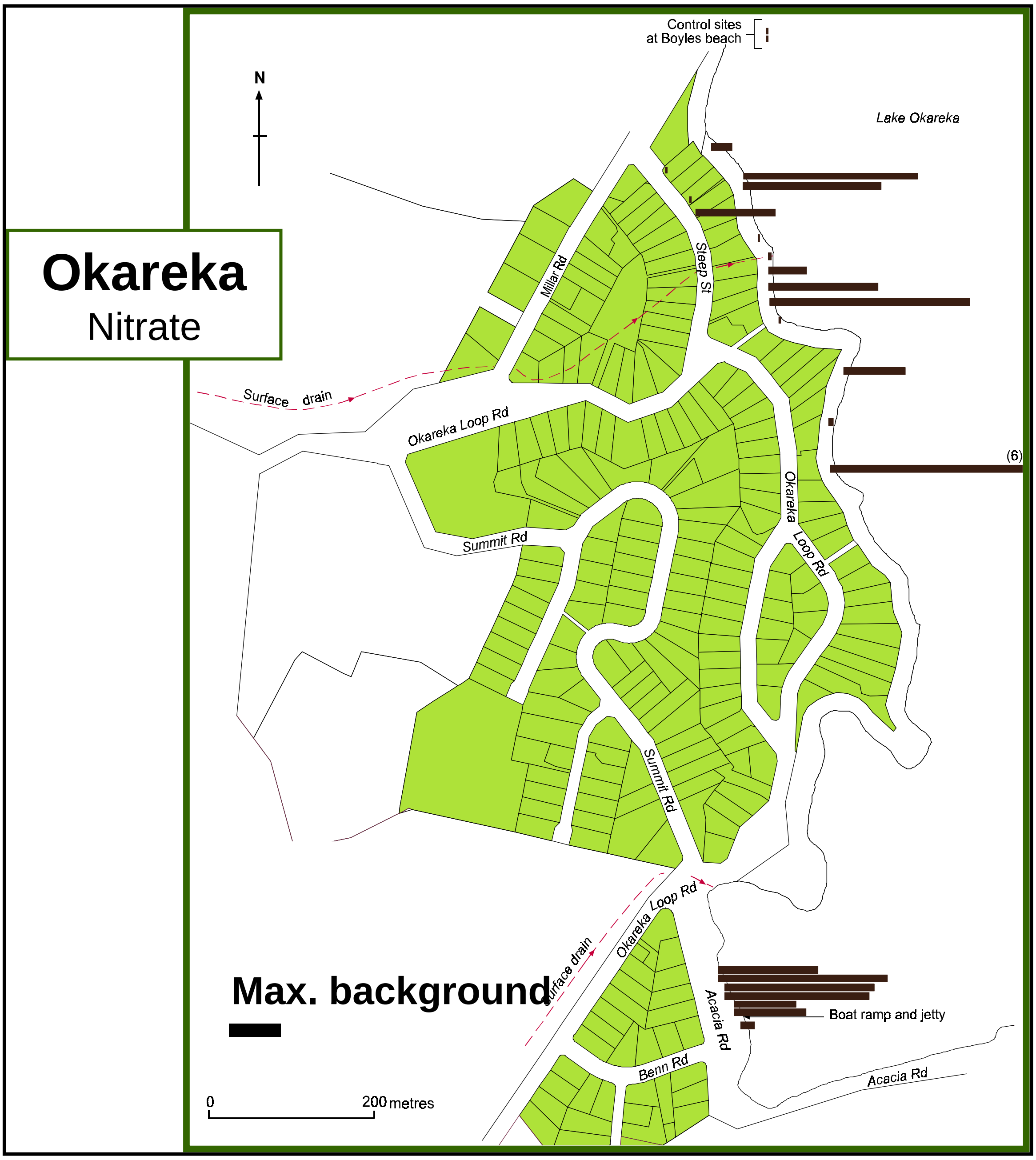
Then we looked at Hinehopu. As I'm sure most of you are aware, Hinehopu is on a very low-lying area of land and has a very shallow groundwater table, with a very small amount of unsaturated soils for treatment of the effluent. We believe that as a consequence of that, there were some very high levels of ammonia and *E. coli* indicator bacteria at the rear of some of the properties, as I'll show you on this next slide. This is a map of Hinehopu. This is Lake Rotorua and this is the lakeshore. This is State Highway 30, with Rotorua in this direction and heading off towards Whakatane around here, and that's the little café at the corner. So we focussed our efforts mainly on the houses along that little road there called Tamatea Street.

We took groundwater samples between the houses and an open drain at the rear of the properties, so we took the samples between tanks and the open drain, because that's the way the groundwater appeared to be moving. These brown bars you can see are the results that we got for *E. coli* indicator bacteria and what we've got to the left represents the Ministry for the Environment's guideline for contact recreation, which is a trigger level of 126 *E. coli* per 100ml. So basically, as a yardstick for comparison, if these bars exceed the length of that guideline figure, there's cause for concern, and as you can see a number of the samples significantly exceeded that guideline level.



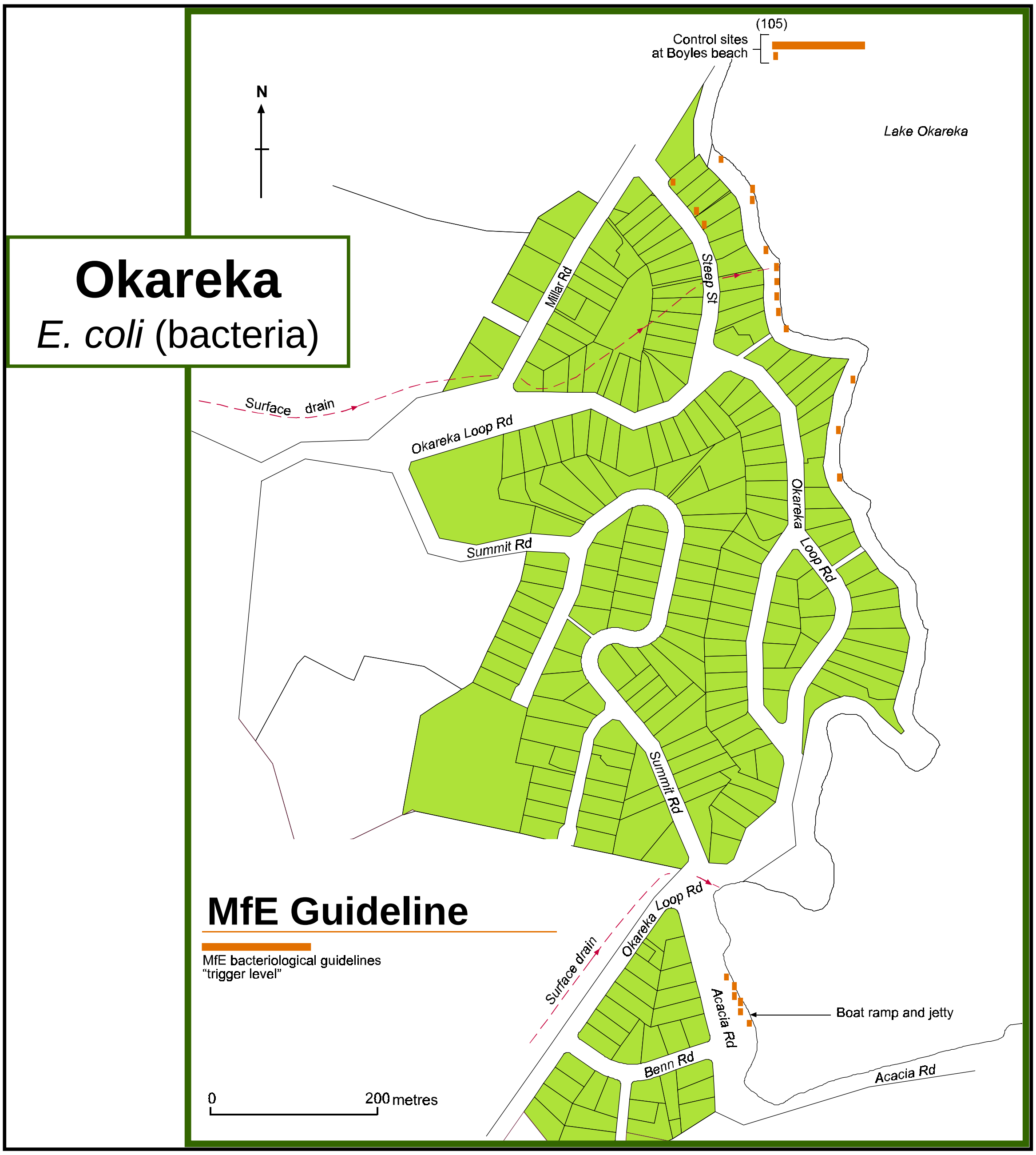
It was a very similar story for ammonia. The open drain runs down the back of the houses and then discharges into the lake. So in conclusion at Hinehopu, we believe that there is a public health risk there. Firstly, for people using shallow groundwater for their drinking water supply and secondly, there is also the potential for a public health hazard in terms of contact recreation in the vicinity of where that open drain discharges into the lake. But again, similarly to Hamurana and Gisborne Point, Hinehopu contributes less than 2% of all the external nitrogen inputs to Lake Rotoiti.

Moving on to Okareka, a similar approach was used again. Here we found some quite interesting results. We've got some very high nitrate levels at Okareka, but consistently very low *E. coli* levels, very low bacteria levels. Just showing you again on the map, this is Lake Okareka here, with the township in green, the boat ramp down the far end there and the road where you drive into Okareka from Rotorua.



In this case the black bars are representing nitrate concentrations and again as a yardstick, we have assessed that the maximum background level of nitrate that we would expect would be about 1 gram per cubic metre. So again, if these bars exceed that maximum background level of 1 gram per cubic metre, there is obviously some reasonably significant source of nitrate in the catchment. As you can see, there are some quite high nitrate levels at a number of locations.

When you look at *E. coli*, the indicator bacteria, again here's the MfE guideline level, the small brown dots are the *E. coli* results and as you can see very consistently right throughout we've got very low bacteria results. That really left the question as to what was causing these high nitrate levels, and there are two explanations that we have thought of.



The first is that the high nitrate levels weren't caused by septic tanks at all. Perhaps they were to do with another source, for example a geothermal input back in the catchment there somewhere. Or possibly the nitrate was caused by leachate from pasture elsewhere in the catchment. The third possibility is that the nitrate is in fact sourced from septic tanks, but that the *E. coli* are being filtered out as the leachate passes through the groundwater passing through the soils. We do know that *E. coli* are filtered out quite effectively by passing through soils, so I guess it's difficult to make a definitive conclusion on that, but our best judgement was that we believed it was most likely the third of those explanations; that in fact the nitrate presence is as a result of septic tank leachate.

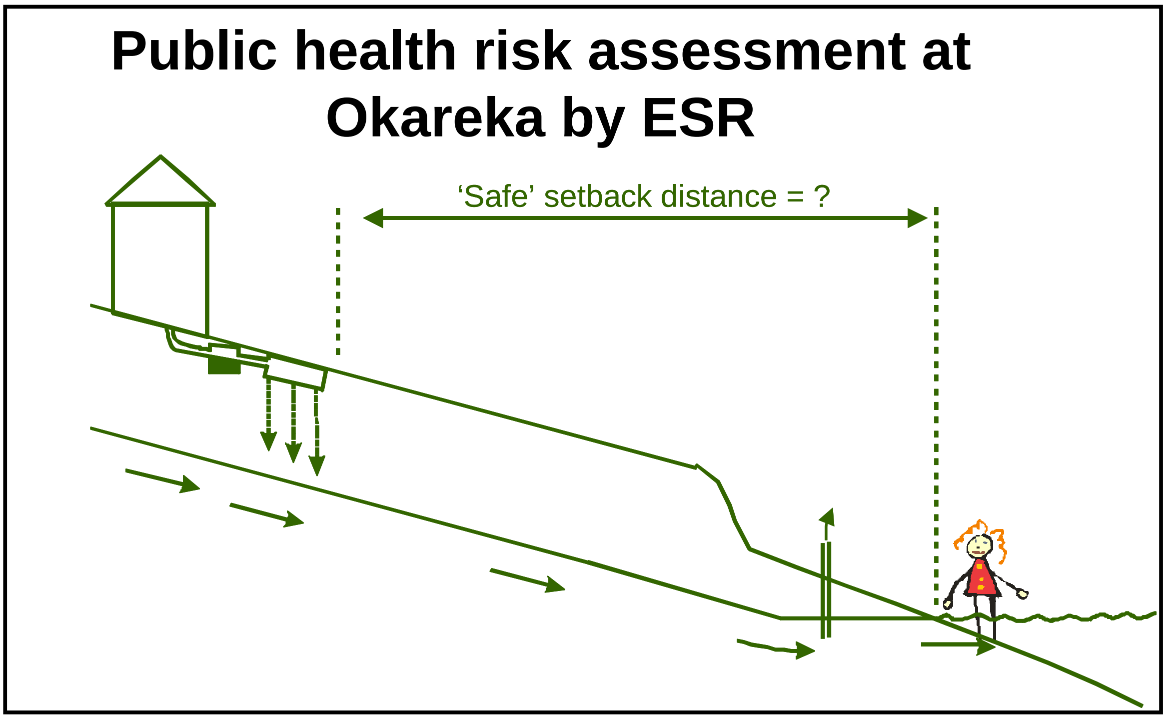
Now on to the nitrogen budget for Okareka. We took a slightly different approach at Okareka. We used a couple of different methods of assessing the importance of nitrogen from septic tanks. We used our field measurements from the groundwater samples and also looked at a range of earlier studies that had been done around the Rotorua Lakes to assess how much input of nitrogen we thought there would be from rural run-off. We used a range of different assumptions and as you are aware, assumptions are fraught with difficulties if they happen to be the wrong ones, so we took the extremities of those assumptions, a kind of best case/worst case. Having gone through that, our conclusion is that the septic tanks contribute between 16% and 44% of all the external nitrogen inputs to the lake. So the septic tanks make a fairly significant contribution to the lake in comparison to the other external inputs.

One thing that the District Council asked us to do at Okareka was to carry out a public health risk assessment and essentially what we were looking at was how far back would septic tanks have to be from the lakeshore to ensure that some kiddie paddling about on the lakeshore there is not at risk of getting sick from bugs that are coming out of the leachate, coming down with the groundwater and surfacing in that near-shore lake water. We sub-contracted this work to ESR down in Christchurch who specialise in the movement of pathogens through groundwater and how they are removed.

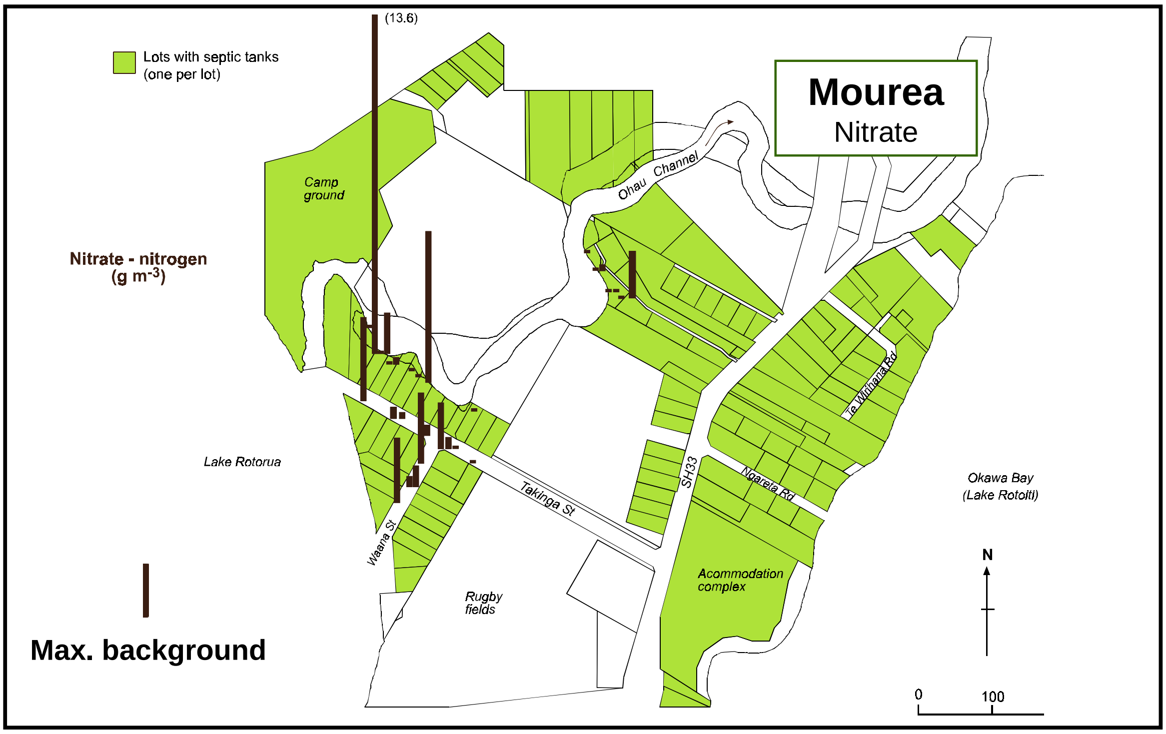
ESR made quite a comprehensive study that involved quite a range of field measurements at two properties near the boat ramp at Okareka. They carried out a range of field trials. They injected some traces into the top surface of the soils and saw how much of these traces were removed in the unsaturated soil profile at the top metre of soil. They measured what went in and what came out at the bottom. They also took some soil cores and took them back to their lab in Christchurch. They had them saturated with groundwater and they did a similar test, putting bacteriophages and *E. coli* tracers in and running those through the saturated soils.

They used all that data to build a computer model to make predictions about how the pathogens, for example viruses and bacteria, would be removed in the soil profile between the septic tank and the lakeshore. They compared the results of that model with the MfE contact recreation guidelines, and also against the New Zealand drinking water standard which is, as you can imagine, much more stringent, setting levels required for the water to be safe to drink.

It was assessed from that study that a minimum of 16 metres set back would be required to meet the MfE contact recreation guideline and 51 metres to meet the NZ drinking water standard. As perhaps is fairly obvious, you need quite a bit more set back to meet the drinking water standard. In conclusion, ESR cautioned that there were a number of assumptions used in that study, so they recommended that some sort of safety margin be applied.



Finally Mourea.   As with Hinehopu, there's a very shallow groundwater table at Mourea, so we expected to get some high pollution indicators at that site and indeed, we did get some very high ammonia and nitrate levels and also some evidence of bacterial contamination. Again here's our map, showing Lake Rotorua over here, Okawa Bay, the township in the middle, State Highway 33 running through and the Ohau Channel snaking its way through there.



We focussed our measurements mainly in the area off Takinga Street and also in the area down the right-of-way that goes to the Ohau Channel. You can see there the background level that we were comparing against for nitrate and there were some very large figures there; in fact that one there goes right off the graph. There were quite a few exceedances of that background concentration. That was for nitrate and we got something fairly similar for ammonia. I haven't got the ammonia results, but we got some very high results for ammonia.

So at Mourea we concluded similarly to Hinehopu that there is a public health risk if people are using shallow groundwater for their drinking water supply. Again similarly to a lot of these other communities, the actual contribution of nitrogen from the septic tanks to the Ohau Channel is fairly small – less than 1% of all the other inputs to Lake Rotorua. Obviously this is the science that hopefully will be able to underpin some of the management decisions that the District Council and the community will make.

Questions

Gertie Gielen - Forest Research
How did you measure the concentrations of the nitrate? How did you measure or estimate the load that would contribute to the lake on certain things?

D.R.
When we did the nitrogen budget, in fact in most situations we didn't use our sampling measurements. We actually took quite a conservative approach of taking literature values of the nitrogen export if you like from each household. So we multiplied that by the number of houses we had and we assumed that there would be no removal of nitrogen between the septic tank and the lake. So it's very much a worst-case scenario if you like, we're saying that all the nitrogen that leaves those houses gets into the lake. We use mass loads, we said there's so many kgs per day were coming out of each household, so we didn't even know the volumes of water, we just had a mass load of so many kgs per day of nitrogen from each house. I guess that might sound a little bit confusing as to why we were taking the groundwater samples. The groundwater samples were to get an indication more in terms of the public health risk, how much of the stuff was actually getting to the lake front, and we were using the nitrate and ammonia as a bit of an indicator for that public health risk, along with the *E. coli*.

Bill Holden – Lake Okareka Ratepayers & Residents Association.
We were interested in why there were no samples taken on the peninsula in Lake Okareka, which we would consider to be one of the main contributors because it protrudes into the lake. Why were no samples taken on the peninsula?

D.R.
Well we did try. We couldn't get any unfortunately. We tried at about 20 different sites, mainly on the southern side of the peninsula, but for one reason or another, I think it was just the very fine nature of the soils there. Along the beaches you've got that very coarse pumice sands, but on the peninsula you've got those much more fine sediments and it was basically difficult for that penetrometer to extract the samples.

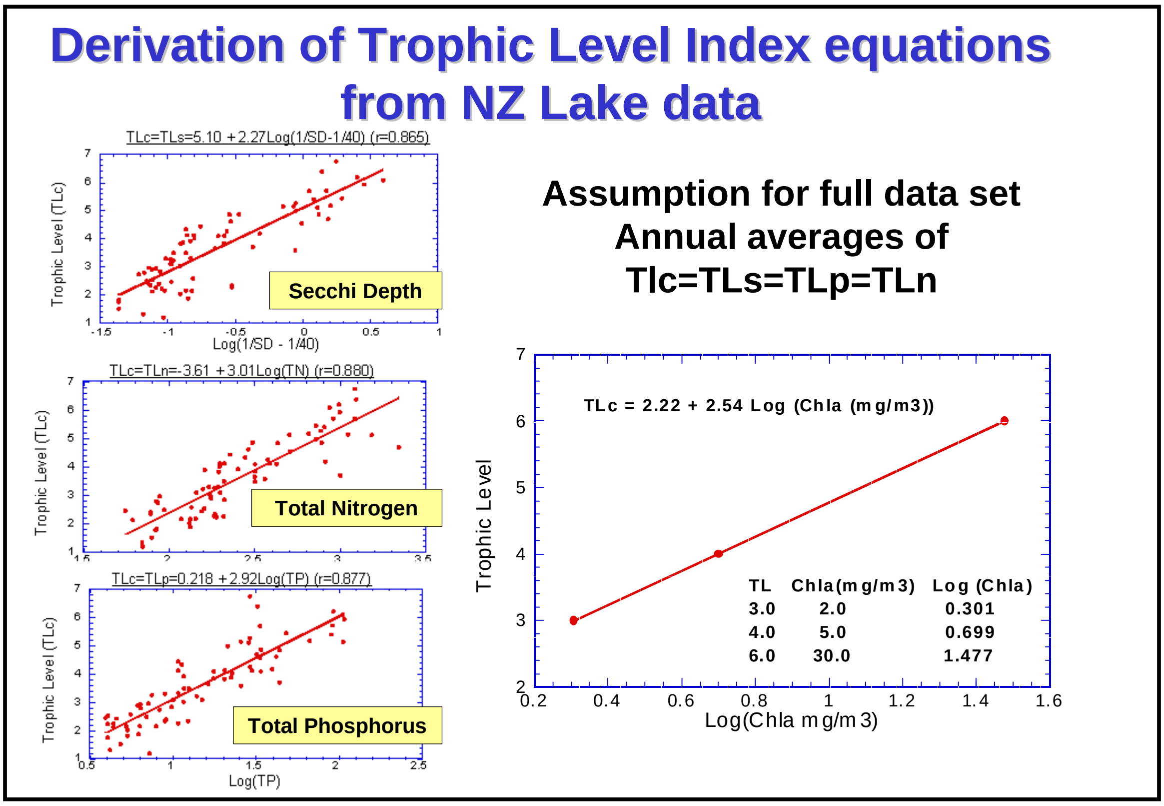
Background water quality trends in critical lakes

Dr Noel Burns, Lakes Consulting

I'm going to describe trophic level and its values obtained from 12 different Rotorua lakes and then examine some of them in a little more detail. The data has all come from the Environment B.O.P. monitoring programme and has been analysed using the computer programme Lake Watch which I am selling.

I'll just give you a little background into the concepts, because I'm going to go into them in some detail. Initially, we set up a number of trophic levels and associated them with chlorophyll concentrations. According to this little table here (*shown in chlorophyll plot in the diagram below*), the higher the chlorophyll concentration, the higher the trophic level. From that we were able to get a straight line and get an equation, so that enables us to take a chlorophyll concentration and calculate back to a trophic level. The TLc is the trophic level calculated from chlorophyll.

In New Zealand we monitored 24 lakes for a period of 4 years and obtained a lot of good quality data. From this we were able to get the annual average value of chlorophyll for each of those lakes for each year, and then from that calculate the trophic level index for each average annual chlorophyll concentration, the TLc. We plotted these against the logarithm of the corresponding annual average secchi depths, total phosphorus, and total nitrogen. Thus we were able to generate trophic level equations, from the chlorophyll average concentrations for each of the other three variables and thus values for the trophic level of phosphorus - TLp, TLn and TLs for each lake for each year.



The equations generated are shown below:

New Zealand

Regression equations

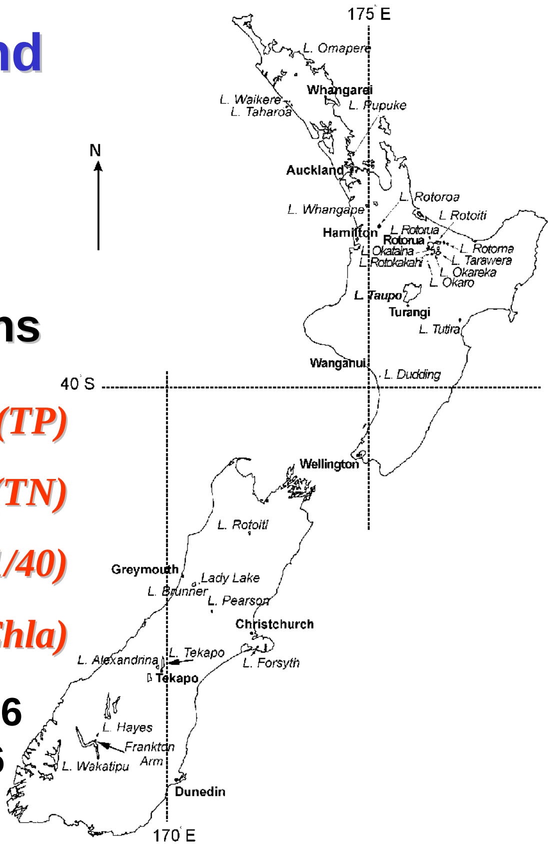
$$TLp = 0.218 + 2.92 \log (TP)$$

$$TLn = -3.61 + 3.01 \log (TN)$$

$$TLs = 5.10 + 2.27 \log (1/SD - 1/40)$$

$$TLc = 2.22 + 2.54 \log (Chla)$$

TLc=TLs=TLp=TLn=3.66
i.e. Average TLx=3.66



Because of this system, it ends up that across the 24 lakes, the average TLc equals that of TLs, TLp and TLn (collectively called TLx). For the New Zealand lakes this number is 3.66. Now this is really quite important because it enables you to compare lakes, if you compare the way the TLn or TLp is different in one lake from that of another. It enables us to develop some idea of the character of individual lakes. Here is the table of TLI (Trophic Level Index, the TLI is the average trophic level for the whole lake from the 4 indicators), and TLx values for the 12 Rotorua lakes.

Trophic Level Index values for the 12 Rotorua District Lakes, 1990 to 2001.

Lake	TLc	TLs	TLp	TLn	TLI
Okaro	5.92	5.04	6.34	5.78	5.77
Okataina	2.73	2.7	2.47	2.64	2.63
Okareka	3.77	3.16	2.71	3.48	3.28
Rotoehu	4.51	4.36	4.7	4.34	4.48
Rerewhakaaitu	3.89	3.62	2.84	4.13	3.62
Rotoiti	4.1	3.67	4.15	3.7	3.9
Rotokakahi	3.37	3.24	3.08	3.29	3.25
Rotoma	2.41	2.43	1.65	2.82	2.32
Rotomahana	3.89	3.8	4.02	3.52	3.81
Rotorua	4.89	4.44	4.92	4.3	4.64
Tarawera	2.78	3.01	2.71	2.49	2.76
Tikitapu	2.78	3.29	1.77	3.23	2.77
Averages	**3.75**	**3.56**	**3.45**	**3.64**	**3.60**
Std. Dev.	1.03	0.76	1.40	0.91	1.00

The TLc values are close to the TLI ones, while the TLp and TLn can be quite different from each other.

Starting with Tarawera, we see that the TLp and TLn are relatively close together, within 10% of each other. That's basically what I would call a balanced lake. In terms of algal needs, we have about the same amount of nitrogen operating in the system as we do phosphorus.

Now if you look at Rotoma you see quite a different situation. There the TLp is 1.65 as against the TLn of 2.82. That means that this system is very deficient in phosphorus compared to nitrogen in terms of algal needs and it's what you would term a phosphorus-limited system. The algal growth is being limited by the amount of phosphorus available to the algae.

If you look at Rotoiti you see the opposite, that now the phosphorus is in surplus at TLp of 4.15 as against the nitrogen at TLn of 3.70 and so that's what you'd term a nitrogen-limited lake.

Now it turns out that the 12 Rotorua lakes are an amazingly good sample set. We have four lakes in each of the types, and that's unusual really to be able to get something like that in one region. You usually have all your lakes in one type or the other. The interesting thing here to note is really that the TLc, that's the trophic level accordingly to the chlorophyll, is very similar to the TLI in the balanced lakes. But in the phosphorus- and nitrogen-limited lakes, the TLc can be different from the TLI.

Trophic Level values for the 3 different lake types.

Lake	TLc	TLs	TLp	TLn	TLI
Balanced	(difference between TLp, TLn < 0.4)				
Okataina	2.73	2.7	2.47	2.64	2.63
Rotoehu	4.51	4.36	4.7	4.34	4.48
Rotokakahi	3.37	3.24	3.08	3.29	3.25
Tarawera	2.78	3.01	2.71	2.49	2.76
Averages	**3.35**	**3.33**	**3.24**	**3.19**	**3.28**
Std. Dev.	0.83	0.72	1.01	0.84	0.84
P-Limited					
Okareka	3.77	3.16	2.71	3.48	3.28
Rerewhakaaitu	3.89	3.62	2.84	4.13	3.62
Rotoma	2.41	2.43	1.65	2.82	2.32
Tikitapu	2.78	3.29	1.77	3.23	2.77
Averages	**3.21**	**3.13**	**2.24**	**3.42**	**3.00**
Std. Dev.	0.73	0.50	0.62	0.55	0.57
N-Limited					
Rotoiti	4.1	3.67	4.15	3.7	3.9
Rotomahana	3.89	3.8	4.02	3.52	3.81
Rotorua	4.89	4.44	4.92	4.3	4.64
Okaro	5.92	5.04	6.34	5.78	5.77
Averages	**4.70**	**4.24**	**4.86**	**4.33**	**4.53**
Std. Dev.	0.92	0.63	1.07	1.03	0.91

Looking at each of these three lake types sequentially: if the lake type is balanced, then the TLx are all very similar. That is if you look at these values in the Table below, the TLx and TLI are relatively similar and the difference between the TLc and the TLI is very small. So you have quite a predictable system here and what actually happens I think, or I am deducing from what I've seen in the data, is that neither the phosphorus-efficient algae nor the nitrogen-efficient algae can dominate.

If the lake-type is ***balanced*** then TLx are all similar and TLc close to TLI value.

Lake	TLc	TLs	TLp	TLn	TLI	TLc-TLI	TLp-TLn
Balanced	(difference between TLp, TLn < 0.4)						abs. diff.
Okataina	2.73	2.7	2.47	2.64	2.63	0.1	0.17
Rotoehu	4.51	4.36	4.7	4.34	4.48	0.03	0.36
Rotokakahi	3.37	3.24	3.08	3.29	3.25	0.12	0.21
Tarawera	2.78	3.01	2.71	2.49	2.76	0.02	0.22
Averages	**3.35**	**3.33**	**3.24**	**3.19**	**3.28**	**0.07**	**0.24**
Std. Dev.	0.83	0.72	1.01	0.84	0.84	0.05	0.08

Neither the phosphorus-efficient nor the nitrogen-efficient algae can dominate.

At the beginning of the stratified season you notice that the dissolved phosphorus disappears very quickly in the epilimnion and the dissolved phosphorus is at very low levels but there's quite enough nitrate. But as the season progresses you see the nitrate levels come down to become very low, so at the beginning of the season you have the phosphorus-efficient algae taking dominance and at the end of the season, the nitrogen-efficient algae dominate. So you've got this seesaw dominance between the algal types in the lake.

Now if the lake is P-limited then the TLc value is closer to that of the TLn. If you look at the Table below, it's 3.21 for TLc and it's 3.42 for the TLn, but the TLp is 2.24, **so this is a phosphorus-limited system but the chlorophyll is not controlled all that predictably by the phosphorus.** What tends to happen in this system is that you have the phosphorus-efficient algae operating at the beginning of the season and then as the season progresses there is always adequate nitrate and so that type of algal community continues to dominate the whole season. The phytoplankton in this system become well-adapted to continuous low phosphorus conditions.

If the lake is P-limited, then TLc value is close to that of TLn, the surplus nutrient.

Lake	TLc	TLs	TLp	TLn	TLI	TLc-TLI	TLp-TLn
P-Limited							
Okareka	3.77	3.16	2.71	3.48	3.28	0.49	-0.77
Rerewhakaaitu	3.89	3.62	2.84	4.13	3.62	0.27	-1.29
Rotoma	2.41	2.43	1.65	2.82	2.32	0.09	-1.17
Tikitapu	2.78	3.29	1.77	3.23	2.77	0.01	-1.46
Averages	**3.21**	**3.13**	**2.24**	**3.42**	**3.00**	**0.22**	**-1.17**
Std. Dev.	0.73	0.50	0.62	0.55	0.57	0.21	0.29

The phosphorus-efficient algae dominate at all times.

In the case of the nitrogen-limited lakes (shown in the Table below), if we look at the trophic level of chlorophyll, TLc we find that it's closer to that of phosphorus which is the surplus nutrient, than it is to the nitrate which is the limiting nutrient. The difference between the chlorophyll, TLc and the TLI is not too large, but it is bigger than it is in a balanced lake. In these lakes nitrogen-efficient algae now dominate at all times, because there's always surplus phosphorus. The dissolved phosphorus is seen to decrease as the season progresses, but there is still adequate phosphorus at the end of the growth season.

If the lake is N-limited, then TLc value is close to that of TLp, the surplus nutrient.

Lake	TLc	TLs	TLp	TLn	TLI	TLc-TLI	TLp-TLn
N-Limited							
Rotoiti	4.1	3.67	4.15	3.7	3.9	0.2	0.45
Rotomahana	3.89	3.8	4.02	3.52	3.81	0.08	0.5
Rotorua	4.89	4.44	4.92	4.3	4.64	0.25	0.62
Okaro	5.92	5.04	6.34	5.78	5.77	0.15	0.56
Averages	**4.70**	**4.24**	**4.86**	**4.33**	**4.53**	**0.17**	**0.53**
Std. Dev.	0.92	0.63	1.07	1.03	0.91	0.07	0.07

The nitrogen-efficient algae dominate at all times.

The conventional lake management strategy is that you manage the nutrient that is in most short supply. In the Lake Okareka case, it's very definitely a phosphorus-limited system, so you then try to lower the availability of that limiting nutrient so as to lower the algal concentration in the lake: this system works and it's quite a good approach. The problem here is that it's quite difficult to predict the probable trophic level of the chlorophyll from the trophic level of the limiting nutrient, because of this algal adaptation capability. What this set of data for the Rotorua lakes shows **is that if you can get a balanced lake, that is your phosphorus and your nitrogen availability is about equal, then you will be able to predict your final chlorophyll concentration well, and it will be close to the TLI of the balanced lake.**

Thus in contrast to the conventional treatment concept of lowering the limiting nutrient, I say you should lower both nutrients down to the trophic level that you're trying to achieve, and this will give you the trophic level that you want with much more certainty.

Finding

- **Conventional lake management strategy is : 'control the limiting nutrient'.**
- **But TLI results for the Rotorua lakes suggest the opposite, namely:**
- **Thus, control the surplus nutrient, down to the level of the desired TLI.**

So looking at our five problem lakes in the Table below: you can see that the TLp of Okareka is 2.71 at the moment, as against 3.48 for the nitrogen, so it's quite phosphorus-limited. What I'm saying is if you were going to manage that lake, you don't have to worry about the phosphorus now, because it's below the TLI of 3.0, which is what we want. But what you need to really work on is the nitrogen. Bring it down to at least 3.0, then you've got a good margin of safety with a TLp of 2.7 and you'll have definitely a lake that will have a TLI under 3. At the moment the draft action plan is taking a very wide stance. It's saying lower both the phosphorus and the nitrogen by an average of 0.3 units, so that you end up with a TLp of 2.41 and a TLn of 3.18. I would actually be happier if that TLn was just lowered down to 3.0 and then I believe there would be a reasonable margin of safety there for managing that lake.

Proposed Management Objectives.

Lake	TLI objective	TLI 1990-2001	Proposed Stategy.
Okareka	3.0	3.28 (TLp=2.71, TLn=3.48)	ReduceTLn to 3.0 (Burns)
Okareka	3.0	3.28 (TLp=2.71, TLn=3.48)	Reduce TLp and TLn by 0.3 (TLp=2.41, TLn=3.18 Draft Action Plan)
Rotorua	4.2	4.64 (TLp=4.92, TLn=4.30)	Reduce both TLp and TLn to 4.2
Rotoehu	3.9	4.48 (TLp=4.70, TLn=4.34)	Reduce both TLp and TLn to 3.9
Rotoiti	3.5	3.90 (TLp=4.15, TLn=3.70)	Reduce both TLp and TLn to 3.5
Okaro	5.0	5.78 (TLp=6.34, TLn=5.78)	Reduce both TLp and TLn to 5.0

Now in the case of Lake Rotorua, we want a 4.2 lake. We've actually got a 4.64 at the moment, and both the phosphorus and the nitrogen are over the limit. The phosphorus a good deal more so than the nitrogen, and I think we have to do the hard work if we really want that lake at 4.2, to bring both TLp and TLn down to 4.2. Rotoehu is really a phosphorus-limited lake, but there again both of those nutrient availabilities are above what we desire, so we need to bring them both down to 3.9. Rotoiti: again we have to work on both nutrients to bring down the TLp and TLn to 3.5. In the case of Lake Okaro, we need to bring down the TLn and TLp to 5.0.

These ideas I have just put forward, about managing the surplus nutrient seriously, as well as the limiting nutrient, are radical and don't make sense unless you think about the changes which you can bring about in the algal communities of lakes by eliminating single nutrient limitation and managing the lakes to have balanced nutrient availability. If you create a balanced lake, the resultant chlorophyll level will be more predictable, because you have eliminated an adaptation to a low nutrient level, and you do not have to lower the nutrient levels to the low level required for a single limiting nutrient to be effective.

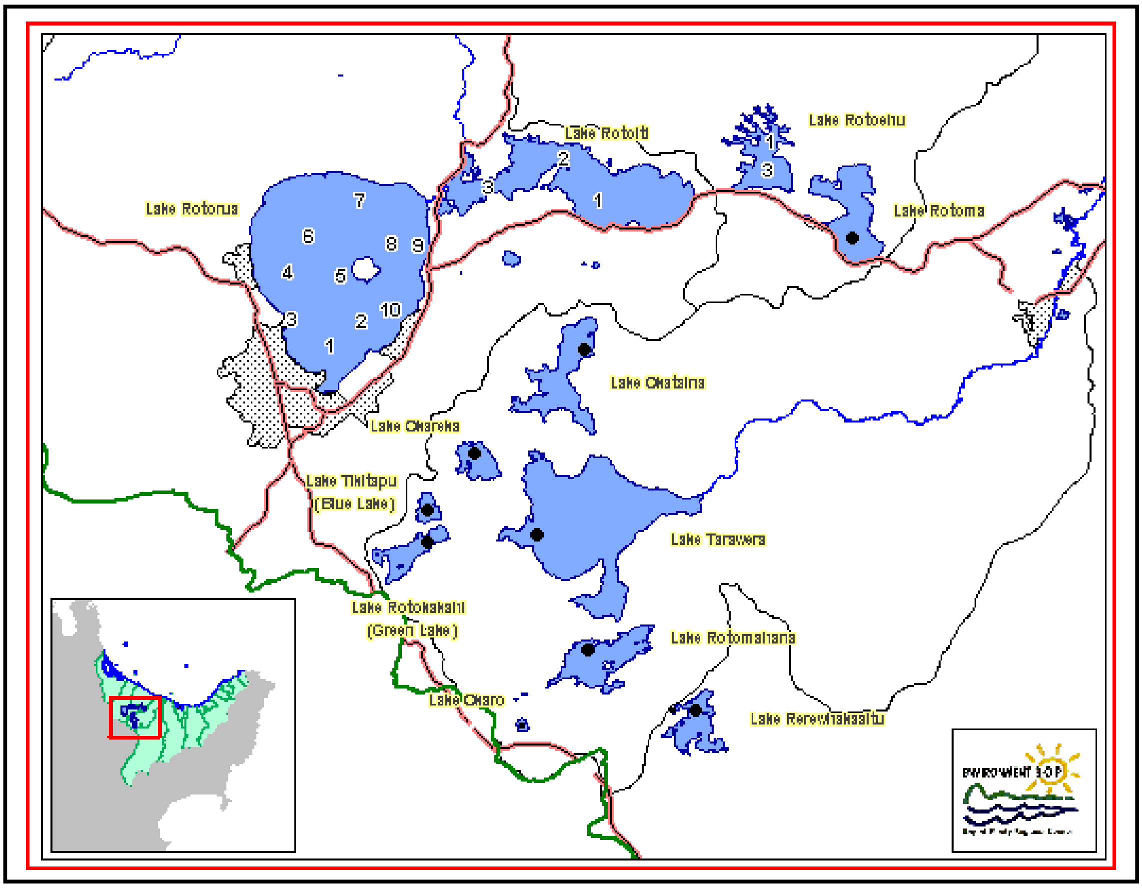
Eutrophication and the Rotorua Lakes

Thomas Wilding, Environment Bay of Plenty

(Some of the early part of this presentation not recorded)

Taking a closer look at Five lakes

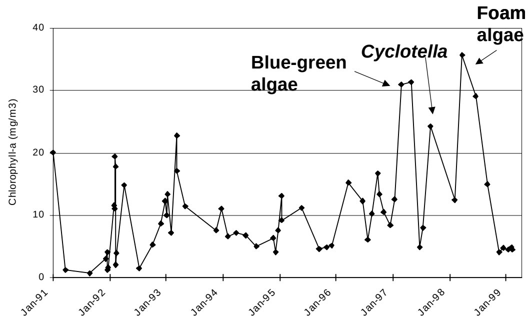
- Rotorua
- Rotoehu
- Okareka
- Rerewhakaaitu
- Okawa Bay



Lake Rotorua

- Over the decades Rotorua nutrients have increased from town sewage and land development.
- While inputs were reduced, the problems go on

Rotorua Algae Problems



Lake Foam on Rotorua. (Photo from the late Maureen Dougherty)

- 10 years ago people were drinking the water from Lake Rotoehu
- 1993 the lake turned green
- Blue green (toxic) algae now well established
- Problems with odour, appearance and likely effects on the rainbow trout fishery

Lake Rotoehu. This was another type of blue-green alga, *Microcystis*. It had quite a mustardy colour, almost yellow.

One of our soil conservators, John Douglas, retired quite a large area around the margin of the lake and in the catchment. Whether that's enough to fix a lake, we don't know. My guess would be probably not.

Rotoehu *Microcystis* bloom

- Okawa Bay followed in Rotoehu's footsteps about 5 years later
- Toxic algae blooms, smell, fish kills, messy!
- Impacts on skiers and other water users, visual appeal and property values

Moving on to of Okawa Bay: we've got deterioration in Rotorua 40 years ago, Rotoehu 10 years ago. It's only really in the last 5 years that we've had significant problems in Okawa Bay. We've got similar problems here to Rotoehu – we've got toxic algae blooms as well as the smell and the appearance, we also have fish kills probably associated with deoxygenation stratification, and it's generally quite messy. Now this has impacts on people wanting to use the lake – skiers, other water users, and it does affect property values and the views of the people in the catchment. This is a picture of Okawa Bay – most of you have probably been round there.

It's a very nice, scenic little bay, lots of bird life (*left*). But of course you get blooms like this around the shore (*right*) and it certainly detracts from the appeal. In terms of the response to these problems, for Rotorua a lot of money went in to divert the sewage to land disposal, but the improvements have been slow. With all those blooms we've had even since the sewage has been diverted we're still having problems, so while we need to start restoration as soon as possible on these systems, it's really important that we need to prevent other lakes going the same way. For those lakes that don't already have the problems, we can't afford to wait until they do. It's a lot quicker, it's a lot cheaper to prevent them going off in the first place.

- Sewage diversion and riparian management for Rotorua – improvements slow

Need to start restoration as soon as possible, but we also need to prevent other lakes going the same way

We need to predict the susceptibility of those other lakes that haven't already gone off. Common features of the fallen lakes are that they are shallow, with pasture or urban catchments.

Predicting Susceptibility of the other lakes

Common features of '*fallen*' lakes

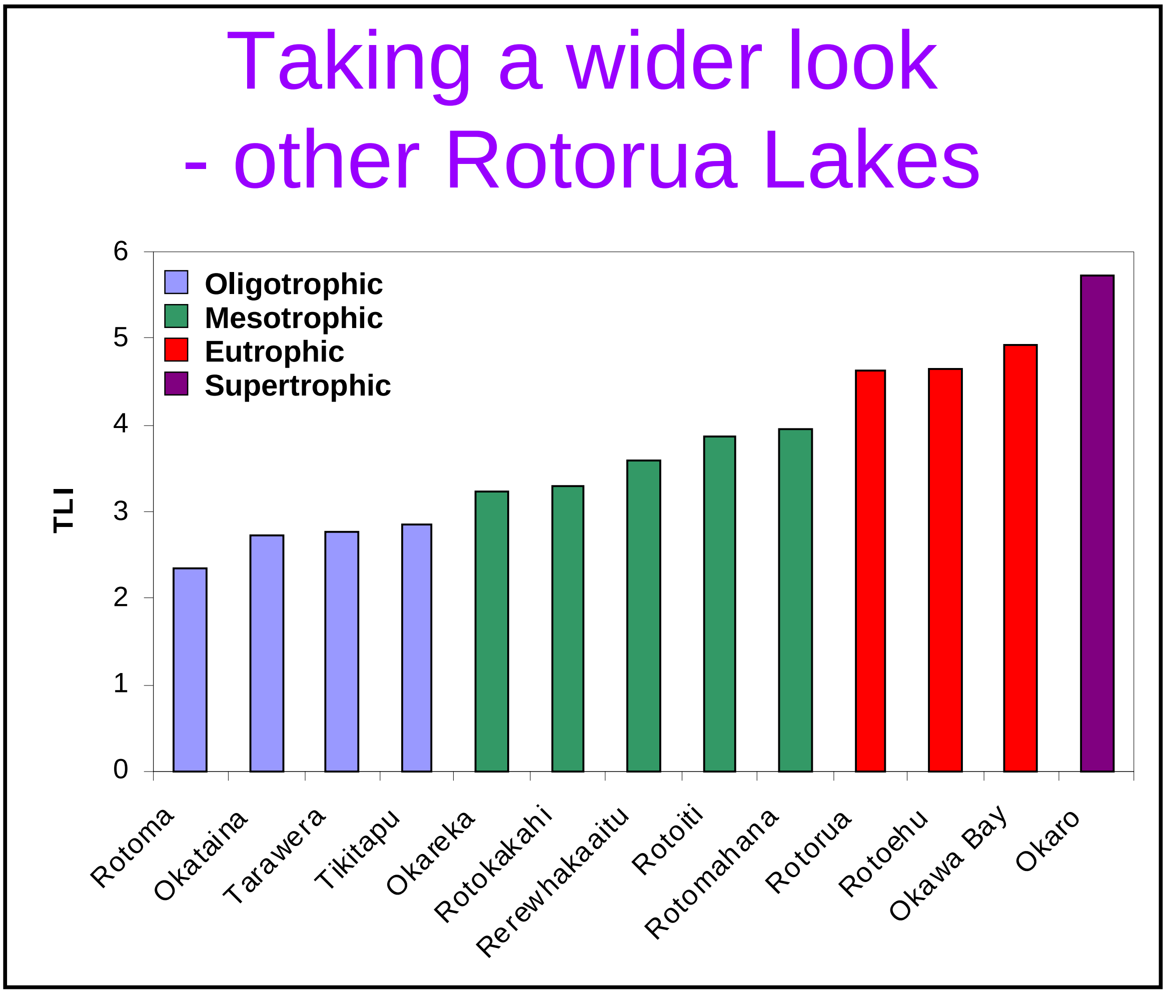
- shallow (<12m deep)
- pasture/urban catchments

Features common to Rerewhakaaitu, hence farmers and Environment B.O.P. are taking a proactive approach

They're shallow, typically less than 12 metres deep and the catchments are developed, whether that be pasture or urban. As an example, these are features of Lake Rerewhakaaitu and hence Environment BOP were taking a pro-active approach in that catchment as to finding where the nutrients are coming from and what might need to be done to prevent problems there. Here's a picture of Lake Rerewhakaaitu (*below left*).

You can see from that aerial photo that the catchment's definitely pasture. You can almost see from the photo that it's a shallow lake too. It's only 10 or so metres deep. One feature of Rerewhakaaitu is the very large macrophyte or waterweed communities growing almost right across the bed of this lake. It's very much a macrophyte-dominated system in terms of the ecology. Now if the algae take over and increase in numbers, that reduces the amount of light that gets down to the bed of the lake. What can happen then is that the macrophytes don't get enough light and they die off. When they die off they release all the nutrients within them into the water column and that produces even more algae, so that's how you can get a lake that just suddenly tips over. It reaches a threshold and goes from a macrophyte-dominated system to an algae-dominated system and that's not a move that we want to make.

Here is another lake, Okareka (*above right*), that doesn't really have many problems at the moment, but which we are concerned about, as it is showing some signs of decline. It's showing the early stages of problems developing and it's got those features. It's not really a shallow lake, but it certainly does have a well-developed catchment, about half the catchment is developed and we're worried that if we don't catch that problem now then it's going to get a lot worse.



OK, that's the conclusion of the talk. Thank you.

Questions

Gifford MacFadden – Federated Farmers
If you take those weeds at the bottom of Rerewhakaaitu out, will that remove the nutrients? I'm not talking about the cost of it, just the theory of it. Would that work or not?

T.W.
We did get a study done by NIWA that looked at removing weeds. They certainly do contain nutrients and so if you remove them you are removing nutrients from the

system, but the practicalities – it just doesn't work out. In terms of the cost I think it was working out at several hundred thousand dollars for one tonne of phosphorus, and of course you'd have to keep doing that because more nutrients are going to come in if you don't remove the source.

Bill Holden, Lake Okareka Ratepayers & Residents Association.
You mentioned that retirement of the lake edge around Rotoehu; you felt in your opinion it was ineffective in terms of the effect of algae on the lake. We've undergone a particularly stringent retirement scheme around the farmland at Lake Okareka. Are you saying that what we have actually completed there may not be that effective as well and therefore we need to take further action?

T.W.
I wouldn't say it's ineffective, in fact I'd say it's definitely the first step to take, especially if you are combining that with wetland systems that will intercept a lot of nutrients. The question is, is it enough for Rotoehu. Is it enough to take that system back to how it was, and that's really where I'd have my doubts, but it's certainly a very worthwhile exercise and probably the first step.

Nutrients and flows in Okawa Bay - would refreshment work?

Dr Kit Rutherford, National Institute of Water and Atmosphere (NIWA)

Good morning everybody. David Ray you've already met, Max Gibbs has done a lot of the lake chemistry in this study, Neil Broekhuisen has done the modelling work. I had a general overview and did a little bit of the modelling and Scott Stevens did the fluid mechanics.

Starting at the bottom (*of the diagram below*), Thomas Wilding has already given you some of the background to Okawa Bay. I think the study is largely driven by the blue-green algal blooms that have been encountered in Okawa Bay. Blue-green algal bloom monitoring only started seriously in 1997 and since then there have been well-documented blooms pretty much every summer, including some quite severe blooms which have required posting of notices warning about possible public health problems.

David started by attempting to review the available information about the quality of Okawa Bay. Much of that was anecdotal, whereas there's a lot of documented evidence on Rotorua and the main body of Rotoiti. There is only patchy information about Okawa Bay, but it's summarised there.

Past history

Prior to 1980:
- **good water clarity**
- **extensive macrophyte beds**

1980-present:
- **significant fluctuations in**
  - **clarity and**
  - **macrophyte abundance**

Blue green algae:
- **monitoring began in 1997**
- **summer blooms most years since 1997**
- **some blooms severe**

Prior to the 1980's the lake (Okawa Bay) appeared to be fairly stable and then during the mid 1980's it became unstable, with periods of low water clarity when the macrophytes collapsed and other periods when the macrophytes were quite abundant and the water was much more clear, and again Thomas Wilding alluded to this. There are no records that David could find of that sort of behaviour prior to the 1980's, so something's been happening in Okawa Bay in recent times.

The other point was the large number of blue-green algal bloom problems in Lake Rotorua, starting at about 1995/96 and as you will see later, of course, there is a physical connection between the water in Okawa Bay and the water in Rotorua, and so what goes on in Rotorua does have an effect on what's going on in Rotoiti, which has an effect on what's going on in Okawa Bay.

What the Rotorua District Council asked us to do was to give our scientific input into the questions of what would be the benefits of removing septic tanks and/or introducing a diversion flow of water that currently goes down the Ohau Channel. What if some of that was diverted into Okawa Bay? What would be the benefits of those two moves?

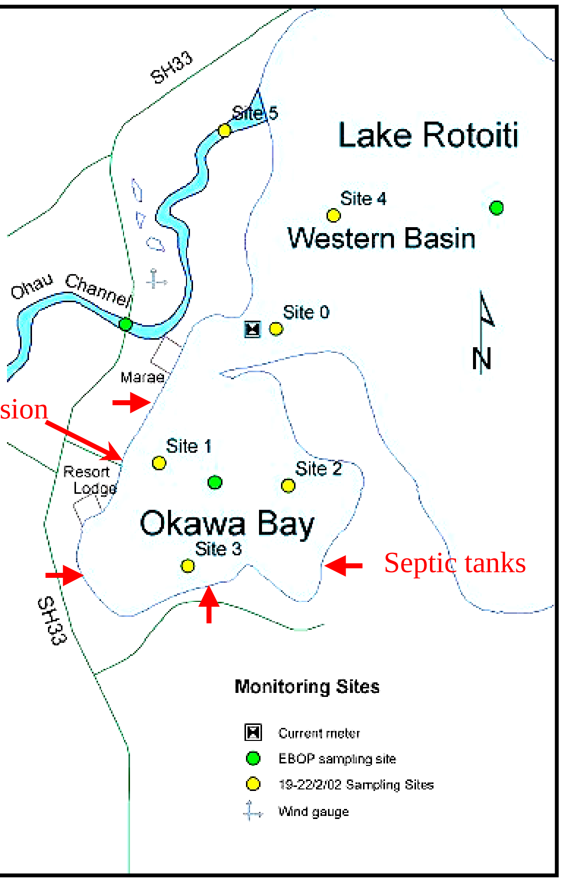
Preliminary assessment

Septic tanks
1.5 t N/yr from septic tanks
0.7 t N/yr from catchment
⇒ septic tanks make a big contribution

Diversion
~ 2 years (no exchange)
~ 18 days (with 1 m3/s diversion)
⇒ diversion increases outflow

⇒ looks promising

Missing
1. Exchange flow at the entrance
2. Nutrient release from the lake bed



So just orientating ourselves by looking at the map, reminding ourselves about the main features of Okawa Bay, a narrow entrance here, a kind of deep channel through this region and clearly the connection with the western basin of Rotoiti. The Ohau Channel is shown here. Water flows out of Rotorua as you know, collects in the western basin and thence flows out over the Okere Falls or flows into the other part of Lake Rotoiti.

Shown schematically, not in their true locations, are septic tank inputs of nutrients from the communities around Okawa Bay and the proposal, of course, is to divert water from the Ohau Channel to increase the flushing rate. We started with a preliminary assessment of the potential and David did most of this work.

The main conclusion from that was that septic tanks on average contribute a load of 1½ tonnes of nitrogen per year. By comparison the rest of the catchment, so that includes the small amount of farmland there and includes rainfall falling directly on the lake, contributes only 0.7 of a tonne of nitrogen per year. The balance is similar for phosphorus, but we believe that this system is more likely to be nitrogen-limited than phosphorus-limited. The take-home message from that is that the septic tanks make a substantial contribution to the external load of nitrogen to the lake.

The second calculation that we did was to estimate the total flows from the catchment, that's the water coming in from rain and the water coming in from the drains, and that flow is very, very small indeed. The catchment is a tiny one. And if you divide the volume of the lake by that natural inflow, the residence time of the lake is about two years, so if that were the only thing causing water to be flushed out, water would stay in the lake for a long time. Were you to put one cubic metre a second of water from the Ohau Channel into the bay, then the simple calculation suggests you would drop the residence time to about 18 days.

Now by comparison, in the middle of summer when there's lots of light and warm temperatures, algae will divide roughly every 2 days, so 18 days is 9 doubling times. If you're thinking about algal blooms, the bloom would have an opportunity to double itself 9 times. Bill Vant will tell me what 2 to the power of 9 is, but it's a number that figures in the modelling.

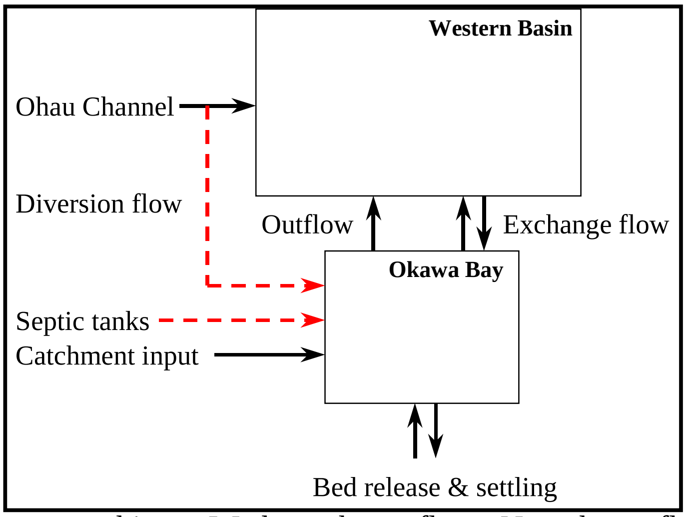
There are two things missing out of that preliminary assessment. We have no information about the exchange flow through the entrance and that is clearly important. The other thing we had no information on at that time was nutrient release from the bed. Now we know from work done in Rotorua, both before and after sewage diversion, that there are large stores of nutrient that tend to build up in the beds, especially of shallow lakes, and from time to time that nutrient is released into the water column. It normally happens in summer. When the lake stratifies the bottom waters go anoxic, and some work that was done at the time the Rotorua scheme was being designed suggested that nutrient recycling from the bed of Lake Rotorua would periodically release nutrients and that that process would go on for 10's if not 20's if not 100's of years and I think Thomas alluded to those sorts of timescales.

Field investigations
Feb & July

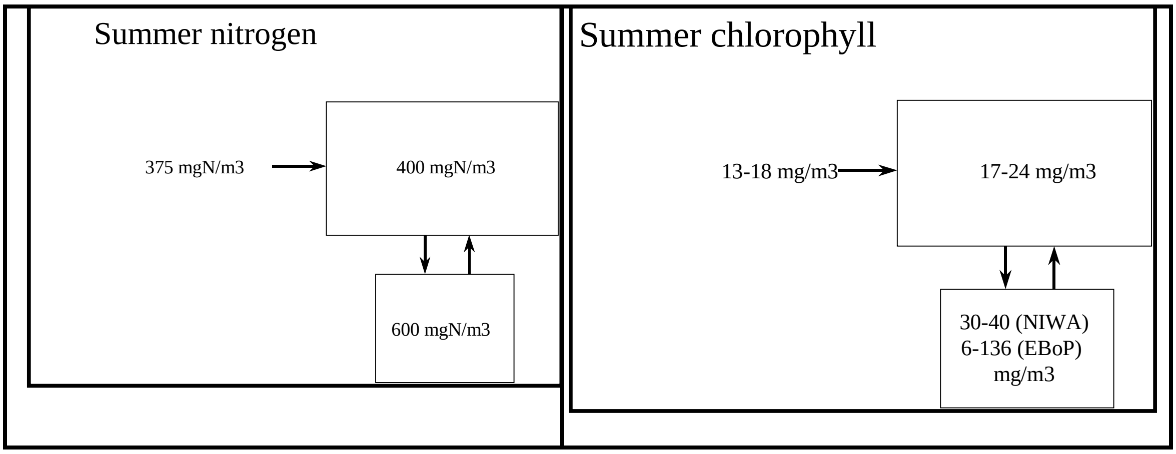
- **Water quality (nutrients, algae)**
- **Nutrient bed release**
- **Exchange flow (meters, dye, drogues)**
- **Nutrient/algae modelling using field data**

So we went back and did more detailed field investigations in the February summer period and then again in July. The first thing we measured was water quality, that's nutrient concentrations and algal concentrations, and we measured them at those yellow sampling sites, measured there. The green sampling sites are the ones routinely sampled by Environment BOP and we have been able to compare our measurements with their much longer-term record. Max deployed his chambers to measure nutrient release from the bed. Scott Stevens supervised measurements of the exchange flow.

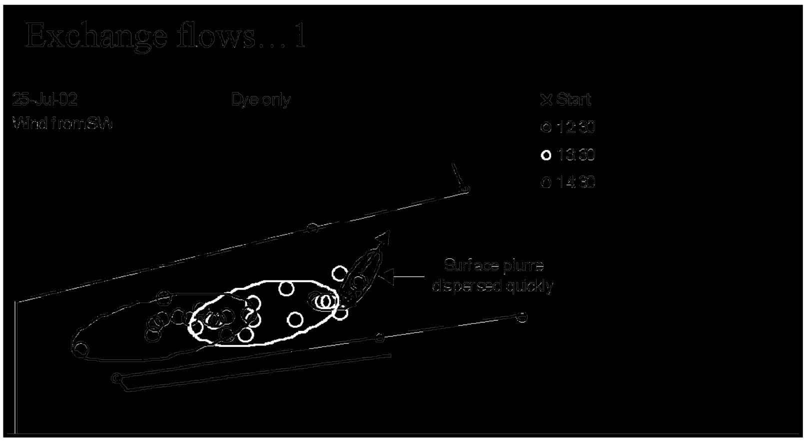
So we did those three lots of field experiments and developed a small model to predict the likely effects of diversion. And being a modeller, this is the reality of the system that we are modelling and I'll refer to this in a minute, because I'll start to put numbers on some of these exchange flows.



Clearly what I've drawn there is the western basin and Okawa Bay. The Ohau Channel flows into the western basin and the dotted line obviously is the contemplated diversion from the Ohau Channel. The septic tanks are there as a dotted line because of the possibility of them being removed, and you have the catchment input that is rainfall plus pasture. Now we have bed release and settling and we have two things. We have the outflow. Now the outflow is the steady movement of water out of the bay which goes on all the time, and that's basically driven by rainfall and catchment flow and that is as I've said already, an extremely small number. And the exchange flow is the flow of water either in or out of the bay and you'll see in a minute that that dominates the system, so you'll see that diagram again.

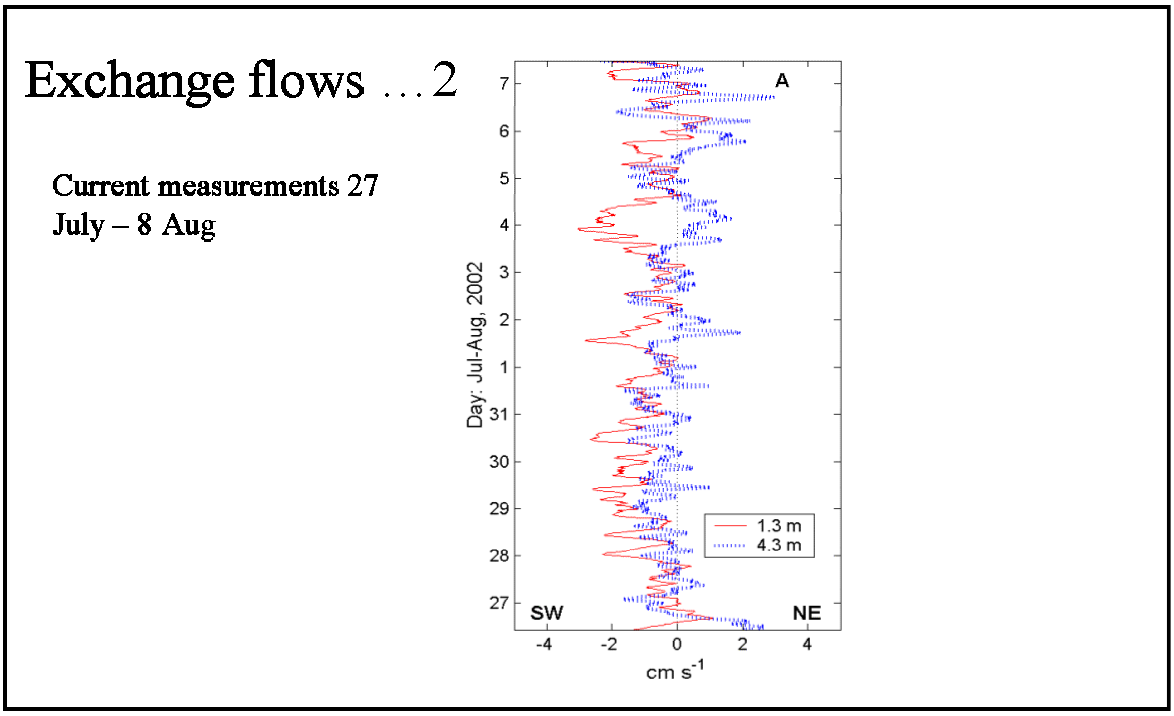


To Summarise the results of our summer water quality work, the chlorophyll concentration which is a measure of the algal content of the water, in the summer surveys, when we were there, we measured 30 to 40 parts per billion of chlorophyll in Okawa Bay. By comparison, the western basin chlorophyll concentration was somewhat lower and the concentration in the Ohau Channel was lower again. Just putting this in context with the much longer data set from Environment BOP, they have measured very high chlorophyll concentrations up to 136 parts per billion, presumably under bloom conditions. When we were there, there was not a bloom going on but there was an awful lot of chlorophyll in the water. It was quite green, but by no means the worst-case conditions that have been observed.

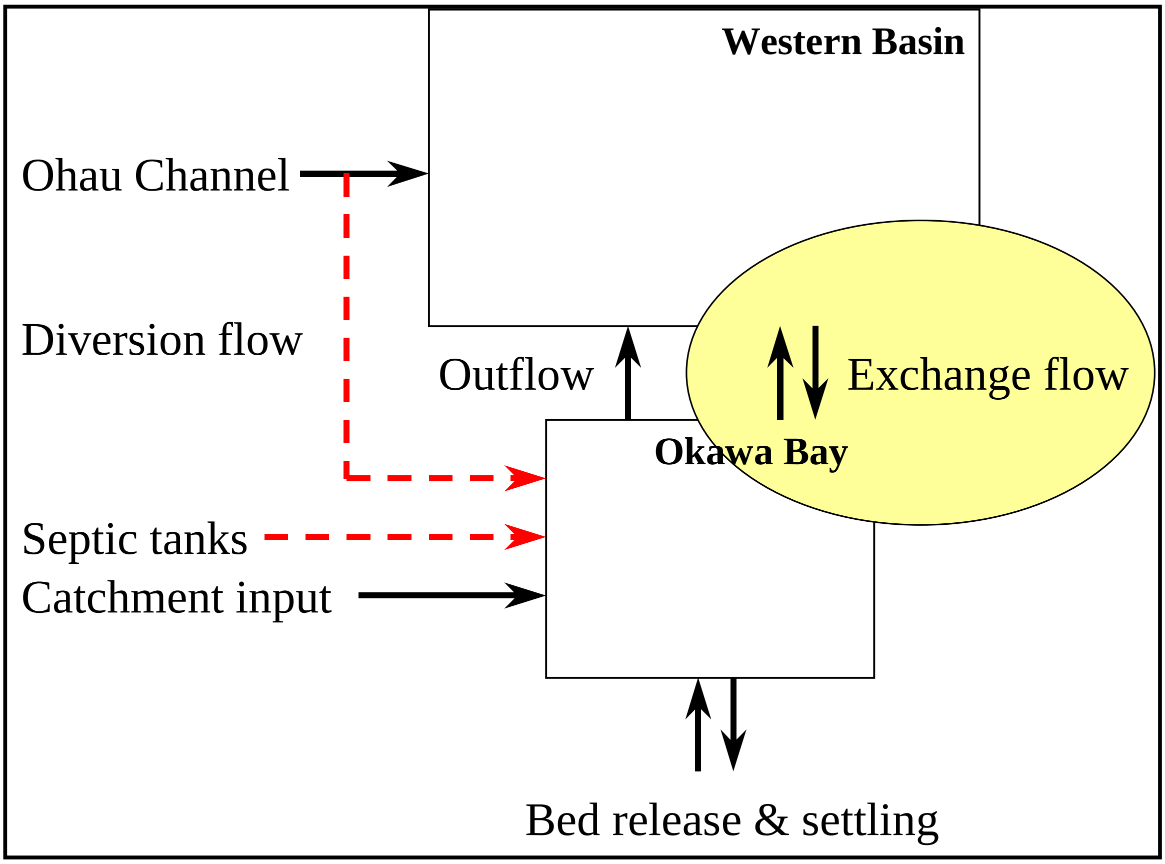


Turning to the exchange through the entrance, the straight lines define the entrance to Okawa Bay. Those circles are actually surveyed spots, the lines are just drawn in. So what we're doing here is a dye release in the deep channel between Okawa Bay and western basin, and dye was released at that point and it was distributed throughout the water column. The water is about 8 metres deep at that point. The dye at the surface followed the purple arrow, so it moved out of the bay and it dispersed and disappeared very quickly. The dye further down in the water column at 3 and 4 metres depth remained detectable and moved in the opposite direction. The wind was from the southwest at the time of this study and so the results are quite plausible that the wind was blowing the surface water out of the bay and there was a return current at depth which carried the dye back into the bay and that indeed is a feature of the current meter record.

Here over a long period of time, 27th July through to the 7th August, is the current velocity and the red is near the surface at 1.3 metres, the blue down at 4.3 metres and a negative velocity means that it's flowing in a south-west direction, in other words it's flowing into the bay. So if we look at this period here, we've got water at the surface which is flowing into the bay and we've got water down deep that is flowing out of the bay.



So exchange at the entrance is quite substantial and it occurs as a two-layer flow system. There are one or two periods in here where the currents are always flowing in the same direction, so there are times when the control gates at the Okere Falls are lifted. Lake Rotoiti fills up with water and of course there is a continual flow into Okawa Bay, and the converse happens when they lower the control gates at the Okere Falls then there'll be a mass flow of water out of the bay, and that adds to the two-layer flow system here.



But the take-home message from all that is that the exchange flows that we measured range from 3 cubic metres per second measured during our February survey and they can go as high as 10 cubic metres per second. It's possible, although we haven't actually studied a period of prolonged calm, that for short periods of time the exchange flow will be negligibly small. So we've got the three columns (*table below*). Assuming an exchange flow of zero and assuming no extra water is added to the bay, then the residence time is two years. We've already met that number. If one cubic metre of water was diverted, the residence time would drop to 18 days. We've seen those numbers before. The effects of the exchange flow though would dramatically alter that picture. We think that a long-term average exchange flow is about 5 cubic metres per second, so that's the middle line, and so currently the residence time of water in the bay would be just under 4 days and were one to divert water in there, it would drop it to just over 3 days.

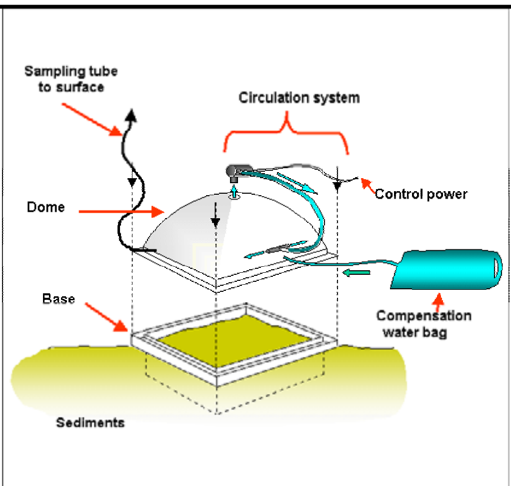
Periodically the exchange flow is 10 cubic metres per second and clearly, the residence time is about 2 days and diversion is not going to make much difference to the residence time of water.

Exchange flow & residence time

	Residence time with no Ohau Channel diversion flow	Residence time with Ohau Channel diversion flow = 1 $m^3 s^{-1}$
Exchange flow = zero	712 days	18 days
Exchange flow = 5 $m^3 s^{-1}$	3.7 days	3.1 days
Exchange flow = 10 $m^3 s^{-1}$	1.8 days	1.7 days

Max's chamber work - the way the chamber works is that divers take the base down, push it into the lake sediments, then the lid is dropped onto the base and sealed and you leave it for a little while to settle down and then stir it gently, and by measuring the rate at which the nutrient concentration increases in the chamber you can calculate how much is being released from the bed. The chamber of course measures the release rate over a very small area.

Bed nutrient release experiments



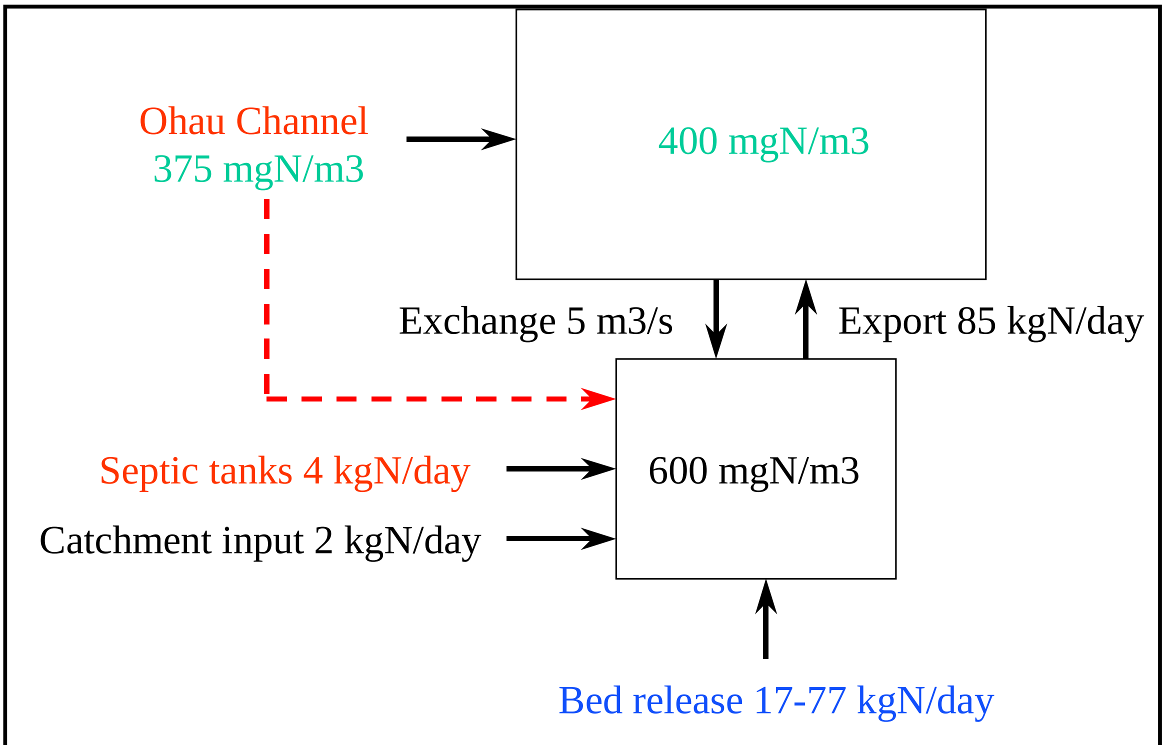
Exploded view of a stirred benthic chamber

The figures I'm going to talk about are in tonnes per year and what we do is multiply the results from this area by the area of the lake, assuming it's uniform. The other thing that Max does with these chambers is to put a small plastic bag on the side and by looking to see whether that plastic bag fills up with water, you can estimate whether there is a net flow of groundwater through the bed of the chamber into the lake. There have been some suggestions that there are hot or cold springs flowing into Okawa Bay. Max's second lot of chamber deployments failed to detect any significant inflow, but of course remember that he was sampling small areas of the bed – about the size of that table - in three places. In the summary of the deployments, from summer and winter, release rates of ammonia and reactive phosphorus levels are higher in summer because of the higher temperatures.

Bed nutrient release: summary

	Summer (from February results)	Winter (from July results)	Annual average
NH_4-N	23-124 kg N day^{-1}	11-30 kg N day^{-1}	17-77 kg N day^{-1} (6-28 t N yr^{-1})
DRP	1.2-15 kg P day^{-1}	0.2-3.6 kg P day^{-1}	0.7-9.3 kg P day^{-1} (0.3-3.5 t P yr^{-1})

The annual average nitrogen release rates of 17 to 77 will be carried through into the modelling. So what we can do then is begin to put together a nitrogen budget for Okawa Bay on the basis of our summer surveys.



Nitrogen budget

One thing to note first of all, the nitrogen concentration in Okawa Bay is about 600 mg.m^{-3} and the nitrogen concentration outside in the western basin is 400 mg.m^{-3}, so there's clearly a large source of nitrogen in Okawa Bay which maintains that concentration high, despite a substantial exchange flow through the entrance. Remember the exchange flow is about 5 cubic metres per second. So the next question is why? What is the source of nitrogen in Okawa Bay that is maintaining the concentration as high as it is. What we've got there are our best estimates of the septic load, 4kg per day, catchment input 2 and the bed release 17 to 77.

An immediate implication is that by comparison with the bed release, septic tanks are small beer and again, the implication is that the removal of septic tanks in the short-term is not going to make a huge contribution to this nutrient budget. The other really interesting implication is that given that concentration difference and given the exchange flow of 5 cubic metres per second, Okawa Bay is on average exporting 85kg of nitrogen per day out of the system and again, the immediate question that crops up is how can that be if the external load from septic tanks and catchment inputs is only 6kg per day of nitrogen?

The implication is that there must be a store of nutrient, presumably in the bed sediments, which is currently being mined by the system and that's what's driving the net export. Now the origins of that store we can only guess at. There have been extensive macrophyte growths and collapses since the 1980's as we have heard and we haven't done any work on it, but we can postulate that a large store of nutrient has built up in the bottom of Okawa Bay, possibly fuelled by those macrophyte blooms and collapses. We're not sure how big that store of nutrient is or exactly where it's come from. Nevertheless, in terms of the short-term task we were given which was to advise Environment BOP and you folk of the likely implications of diverting septic tanks, we did some modelling and the results are summarised here. Currently, under summer conditions we've got a chlorophyll algal concentration of 34 mg.m^{-3}, take the septic tanks out and it's predicted to go to 31 mg.m^{-3}. Leave the septic tanks in but divert one cubic metre from the Ohau Channel and it's predicted to go to 31 mg.m^{-3}, do both of those two things and it's predicted to go to 29 mg.m^{-3}. At the last minute we were asked what if we diverted three cubic metres per second?

	Chla mg/m3
Present	34
No septic tanks	31.2
Divert 1 m3/s	31.1
No septic tanks + 1 m3/s	29.3
Divert 3 m3/s	27.8
No septic tanks + 3 m3/s	26.5
Exchange flow	3 m3/s
Western Basin chlorophyll	19 mg/m3
Ohau Channel chlorophyll	14 mg/m3
Bed release	75 kgN/day

Model predictions

I've put those numbers in red because they're a little bit less certain. We don't know how a large diversion will interact with the exchange flow; we've assumed it has no effect, then the prediction is between 26 and 28 mg.m^{-3} – you can see those. Those numbers in blue are the numbers that we've used in the modelling. Now I realise that some of this is a bit difficult to assimilate, but all the gory detail is in here and that's posted on the website and if anybody has any technical questions, we're all at the end of an e-mail.

Conclusions… in the short-term

removal of sewage and/or a diversion flow of 1 $m^3 s^{-1}$ are unlikely to substantially reduce nutrient concentrations and algal blooms in Okawa Bay

because

(a) release from the lake bed currently dominates the nutrient load and

(b) the high exchange flow between the Bay and the Western Basin limits the effectiveness of the proposed management options

In the longer term (>>10 years)

(a) improvements in water quality in Lake Rotorua and the Western Basin are likely to benefit Okawa Bay and

(b) removal of septic tanks should help reduce nutrient release from the lake bed

(c) increasing the diversion flow from 1 to 3 m3/s may be beneficial provided this does not reduce the exchange flow

So the conclusions - in the short-term the removal of sewage and/or the diversion of one cubic metre per second from the Ohau Channel is unlikely to substantially reduce nutrients or algal blooms. And the reasons are that release from the bed currently dominates the nutrient load in combination with the fact that the very high exchange flows mean that what you see in Okawa Bay is very closely linked to what's going on in the western basin.   This means that the effects of any local initiative in Okawa Bay, are tempered by the strong physical connection between water in Okawa Bay and the western basin – so that's the bad news.

The good news is that in the long-term, because of the diversion of sewage away from Lake Rotorua, it's predicted that over 10 to 50 to 100s of years water quality in Lake Rotorua, and therefore water quality in the western basin, will improve. Given that water is flowing in and out of Okawa Bay, there will ultimately be some benefits to Okawa Bay. The second one is a bit more conjectural, but there has to be a connection between the external nutrient load to Okawa Bay and what is in the sediment. We don't know the timescale of the response in Okawa Bay, but were the external load to that system reduced, then in the long-term we would expect the lake bed nutrients to release less and less nutrient. As I say, the timescales have been studied for Rotorua, but not for Okawa Bay. The final point is that were one to squirt in more water, then there may be some slight benefits, as long as it doesn't reduce the exchange flow. So I'll leave it there and I'm happy to answer any questions.

Questions

Professor Warwick Silvester, University of Waikato.
Kit, you've got evidence of flushing at the entrance. You've got evidence of an export of 85 and regeneration of 77 ($mg.m^{-3}$.) If that's been going on all the time, there could be no net accumulation. Have you evidence that that flushing actually is not just flushing the entrance, is it flushing the whole bay?

K.R.
Thank you Warwick. We did measure concentrations at three points in the bay. There is no significant difference in concentrations between those three sites, from which we infer that the bay is reasonably well mixed and indeed Scott ran a wind-driven hydro-dynamic model, uncalibrated, of the bay and also we managed to convince ourselves

that Okawa Bay itself is reasonably well mixed. That exchange really is not just confined very close to the entrance, it is actually moving material out of the bay. But your point is well-made, that there are some questions about that nutrient budget, because the numbers don't add up completely and I think that's a function of the fact that the system is extremely dynamic.

Bill Vant, Environment Waikato
Kit, I think your model used 3 cubic metres as the exchange flow, which resulted in the chlorophyll concentrations of about 30. Now Environment B.O.P.'s record shows number like 130 ($mg.m^{-3}$) for chlorophyll and I guess your model would have to have the exchange flow very much lower to reproduce those, so there are going to be periods, as you have said, when exchange flow is going to be very low, and I guess you would agree that under those conditions diversion of only one cubic metre from the Ohau Channel would be valuable. So I guess I'm saying whilst diversion may not be much use for the average situation, do you agree it would help for those extreme peaks?

K.R.
Thanks Bill. Yes I think you're right. The reason we went with the numbers that are here was that that's what we observed during our February survey. It would be nice to have good information about the exchange flows during an algal bloom; you know we picked the wrong days to do our experimental work.

Nick Miller, Lakes Water Quality Society
A question and a comment. Firstly, of the 17 to 77 mg per litre release of nitrogen from the sediments, have you any sort of handle as to how much of that actually gets recycled back to the sediments in the form of decomposing algal material, etc.?

K.R.
The only answer I can give you, Nick, is that I've tried including settling in the models and a substantial fraction can settle back down again.

Nick Miller
And the comment – I was speaking to Lindsay Brighouse, and he reminded me that there used to be a substantially-sized sawmill on the shores of Okawa Bay back in the earlier part of last century, and anecdotal evidence from someone long familiar with the bay suggested that most of the sawdust from that mill went out into the bay and in fact this gentleman claimed that at times you could actually walk on the bay because of the thickness of sawdust. Now that must be a massive nutrient source sitting down there. I wonder if that might be part of the problem and as any gardener will tell you, wood wastes take up a lot of nitrogen in particular while they're decomposing, which might possibly be one explanation for the comparatively recent nature of the problems. Possibly until then it was all being soaked up.

K.R.
I don't know if Max Gibbs has got any comments. He's recently collected some cores. Max is in the audience. I don't know whether he's found any sawdust.

Max Gibbs, NIWA
Thanks Nick. Looking at the sediments in Okawa Bay, they are very enriched with nitrogen. Given that the soil round the Okawa Bay area has a nitrogen content of around about 0.05%, the sediments have 0.75% nitrogen.

David Hamilton, University of Waikato
Just a point of clarification more than anything else. Were the measurements that you took depth-integrated values through the water column for the very high phytoplankton concentrations, up to 40, that you got compared with Environment B.O.P. measurements of 140, which I believe may have been surface samples?

K.R.
Max can probably answer that question better than I can.

Max Gibbs
Thank you. Chlorophyll samples were in fact depth-integrated over 4 metres for our study. We took an integrated tube sample of the water through the top 4 metres of the water column.

David Hamilton
If I could just respond then. Were the Environment B.O.P. values just surface samples, or were they depth-integrated, because the two values may be comparable if that's the case?

Nick Miller
Chlorophyll samples were taken from the surface.

Roland Burdon – Forest Research
I take it that nitrogen fixation by blue-green algal blooms was not factored into the model. Is that the case, or were you able to discount that from the outset as being a consideration?

K.R.
It's not factored into the model.

Paul Dell, Environment B.O.P.
The original study suggested there may have been quite a major groundwater flow coming into the bay bringing with it the nutrient source. Has recent work possibly now discounted that and is it showing the sediments to be basically the store of that nutrient source?

K.R.
In the original study with the chambers there was no attempt to measure the physical flow. In the second set of measurements a small plastic bag was clipped to the edge of the chamber and were there a flow of groundwater into the chamber, then one would expect to see that blow up like a balloon. That was not found in the second set of samples, so I think on the basis of the second set of chambers that we would discount significant inflows at the sites that we studied, but of course springs are extremely localised so I don't think we can rule it out completely.

Mary Stanton, Lake Rotoiti
Kia ora, this is Mary Stanton. I actually live in Okawa Bay, I was born on the Ohau Channel. I would like to ask a question regarding the environment. I look at pine trees and I look at August as the time when the pine trees are actually throwing off their pollen. I have never ever seen our lakes before having to put up with something that to us was never part of our environment and I question the pollen, I see the thickness of the pollen falling on the water, I see the effects it has on our roofs. Anything that is outside is just covered in pollen. It's got that green paint-like gooey-ness about it when it hits water. I want to know could there be some effect on the water quality from the pollen? Thank you very much.

K.R.
I'd have to plead ignorance and say I have no expertise at all. Whether there's somebody in the audience who can shed any light on pollen?

Nick Miller
I think Massey University are doing a study.

RDC proposals for sewerage scheme for Mourea/Okawa Bay

Greg Manzano, Rotorua District Council

The papers that were presented earlier were more on the same theme, studies concerning the lakes. I will be talking more on the formal sewerage infrastructure for Mourea and Okawa Bay. The object of my presentation is just to present to you the progress that we have made in terms of investigations and engineering design on the proposed sewerage scheme for Mourea.

We studied this about 6 months ago, and the paper will describe in detail what we have done, what we have discovered, what is being proposed. There are three main components of a sewerage scheme. The first component is the reticulation system, which is the collection system. The second component is the treatment system, which treats the effluent before it is dispersed into the ground or into the environment. The third component is the disposal system.

I'll talk on the reticulation system first. The function of a reticulation system is to collect wastes from every individual plumbing system and convey it into a pump station, and from the pump station convey it into a treatment and disposal system.
The design approach that we took was to provide as much as possible a gravity connection to every property. This could only be attained by laying the lines towards the lowest point in the community or laying the line towards the lowest point on a group of properties. This gave us a lot of challenges and as you may see later on the proposed layout, there will be some challenges in the design and the construction.

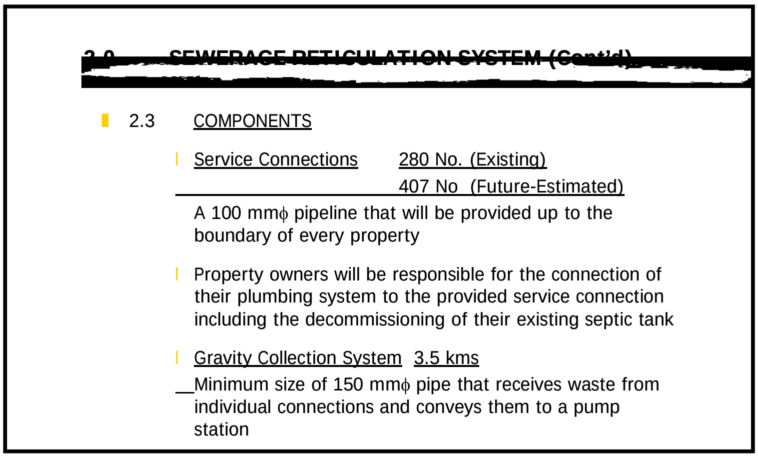
Then the reticulation system conveys the wastes into a pump station and the pump station pumps it into the treatment plant and into the final disposal system. The components of the reticulation system that we are currently designing will involve about 280 service connections for the existing properties and 407 in the ultimate development. A service connection is a 100 mm pipeline that will be laid up to the boundary of the property and is connected into the town main system. Our intention is for the property owners to connect their property into that service connection and at the same time be responsible for the decommissioning of the septic tanks.

2.0 SEWERAGE RETICULATION SYSTEM (Cont'd)

- 2.2 DESIGN APPROACH
  - Provide as much as possible gravity connection to every individual property
  - Attained by laying a gravity collection pipeline towards the lowest point in the community or group of properties in the community
  - A pump station receives the waste from the collection system and conveys it to the treatment plant or to another pump station thru a pressure main system

The gravity collection system, which is also called the public sewer main, will be about 3.5 km in length and the minimum size will be about 150mm and it receives the waste from every individual household and conveys it into the pump station. There will be about 58 manholes. The manholes are inspection or maintenance accessories, so that you can get into the system and remove the blockages or do inspections for maintenance.

There will be two major pump stations and nine minor pump stations. We call major pump stations those that will be serving the trunk main. The trunk main is the main that will convey the whole community waste into the treatment plant and there will be nine small pump stations that will pump every group of properties into a rising main or into a pressure main, which will in turn transfer it into a tank pump station. The pressure main being proposed is about 3 km in length, so that's mostly along the length of State Highway 33.


3.0 SEWERAGE RETICULATION SYSTEM (Cont'd)

2.3 COMPONENTS

- Service Connections 280 No. (Existing) 407 No (Future-Estimated)
  A 100 mmϕ pipeline that will be provided up to the boundary of every property
- Property owners will be responsible for the connection of their plumbing system to the provided service connection including the decommissioning of their existing septic tank
- Gravity Collection System 3.5 kms
  Minimum size of 150 mmϕ pipe that receives waste from individual connections and conveys them to a pump station

Specific details

The Marama Point resort will be connected to the scheme through a pipeline crossing underneath the Ohau Channel. Our intention is to site the pump stations as much as possible on road reserves or public land, but there may be cases where because of difficulty of siting we may have about 1 or 3 pump stations on private land, but that's still being investigated in detail at the moment. We have sent letters to at least three properties I think, telling them about our intentions, and we will be consulting with every property owner before we finalise the design.

The construction of the pipeline, considering that Okawa Bay has most of the properties on the lakeside and some are on the upper side as well, will be built using both conventional or open trench system and directional drilling. We may use directional drilling on the lakeside properties where we have a high water table and where we could probably experience difficulty in open trench excavation. The material that we are looking at could either be PVC or polyethylene. Again pipelines will be sited as much as possible on the road reserves if we can, but there will be cases again that because of the difficulty of siting, of providing a gravity connection to every property, we may cross private properties. We will consult with the property owners that will be affected before finalising the design.

Progress to date

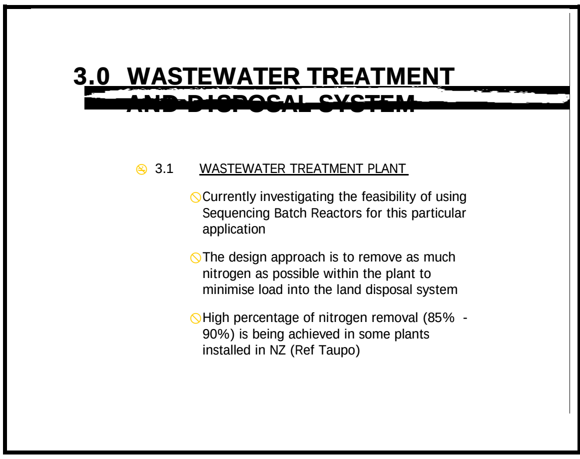
We have completed the pipeline conceptual designs. As you may see we've got the layout there, including the locations of the pump stations. There's still a lot of work needing to be done. We still need to consult with property owners who will be affected by the pump station siting. We still have to do a more detailed survey of the pipeline location and pipeline route, and the pump station locations as well. After consulting with the community, we still have to do the detailed design of the reticulation system based on the conceptual design. Then we still have to do the resource consenting works.

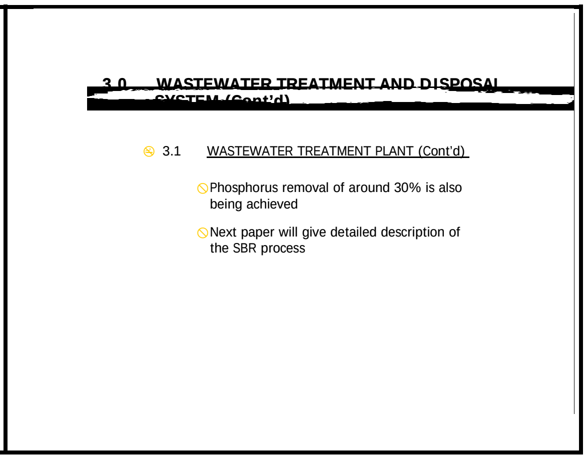
I'll show you the layout. (*Large-scale plan displayed – not included here*) As you can see, that's the Marama Point resort there. The proposed closing will be to the side and Mourea is down there, that's the State Highway 33 bridge there. We're looking at connecting the river properties there, coming up here and that's the Waana Street trunk pump station, one of the big pump stations that takes all the waste from these properties here. The Okawa Bay Resort will be connected to the pump station there and also the Okawa Bay properties. Public toilet is shown and the rising main comes all the way through there into the State Highway 33 down here.

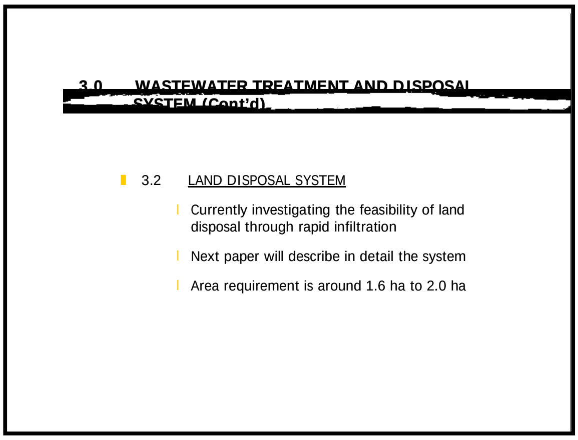
So that's the concept layout that we have now, and after we have consulted with the community we will then finalise it. There may be some cases where the locations of the pump stations may change or siting of the trunk mains or the gravity mains may change.

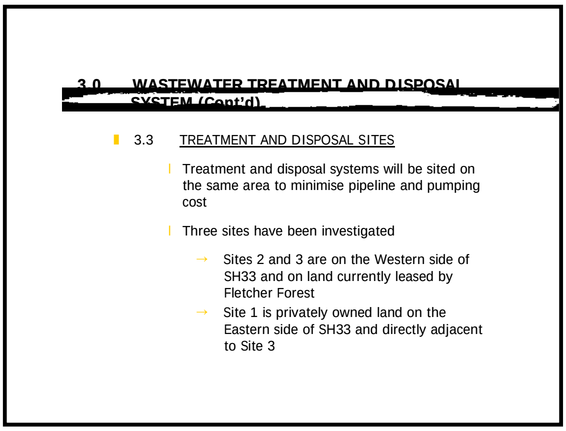
<u>The wastewater treatment and disposal system.</u>
We are looking at the moment at using a VRSD main trunking system, as we are interested in a sequencing batch reactor similar to those that have been installed in Taupo and in some other areas in New Zealand. Our design approach at the moment is to remove as much nitrogen as we can in the treatment plant before we dispose of it into the environment. We know that we need to remove high percentages of nitrogen, between 85 to 90%. They are achieving that in Taupo, and 30% of phosphorus removal. The next paper which will be presented by Steve Couper from Harrison Grierson will describe in detail the SBR technology.

<u>The land disposal system</u>
We are currently investigating the possibility of land disposal through rapid infiltration. Again, the next paper will describe in detail what rapid infiltration is. We have done preliminary calculations of the land area requirement and we have established that about 1.6 hectares to 2 hectares of land would be needed for the land disposal.









Our approach for the treatment and disposal system is to site them in the same land so that we will minimise pumping and pipeline costs. Three sites have been investigated. I will show you later on the locations of those three sites. Sites 2 and 3 are on land being used by Fletcher Forestry for their forestry, it's on the western side of State Highway 33. Site 1 which is in the same area is on the eastern side of State Highway 33 and is owned by Paehinahina Mourea Trust. We have consulted with the Trust and they have been very cooperative and we would like to thank them for that.

We are in the process of doing some more investigations on one of the sites, which you will see later on.

The progress to date

We are in the process of completing the process design and the treatment system and the disposal system concept design at the moment. We have completed, as I mentioned earlier, initial investigations of the three sites and yes, we have consulted with the property owners. There is still a lot of work to be done. We still need to make up our mind and select the most suitable site and that would only be achieved by undertaking some more geotechnical investigation on the initially selected site and are certain that the site parameters that we have used in the initial design are correct. Then we still need to consult with the property owners and finalise an arrangement wherein we could use the site and then finalise the process disposal system design and resource consenting works.

Those are the disposal sites. Site 1 is owned by the Paehinahina Mourea Trust. It's adjacent to State Highway 33 on the eastern side. Site 2 is owned by the Ruahine Trust – it's on the western side of State Highway 33 and site 3 is right on the same block of land on the western side of State Highway 33. At the moment it looks as though site 3 is the most preferable site, but we still have to confirm that after we have completed all our geotechnical and hydrologic investigations. Thank you.

Questions

Martin Hawke, AgResearch and local resident

In terms of your sites 3 and 1 and the fact that you're going to put all the septic tanks into the treatment, do you envisage connecting those to Brunswick Park?

G.M.

No I don't think so.

Max Gibbs, NIWA
Greg, on the proposal of the three sites that you've got, site 3, just as an observation, looks as though it may be the only one that doesn't drain back into the Okawa Bay catchment. Any comments?

G.M.
We found out that site 2, although it has the best absorption capability, is more on the higher scale so we thought if you do some sort of a dye trace analysis and it goes back into Okawa Bay as well, we would have concerns that there might not be enough treatment before it reaches Okawa Bay, so it could be that site 3 would be the best site at the moment, but yes we still have to confirm that with further investigations. The profile of site 3 as well is very flat; it's flatter than site 2, so it has been intended for the purpose.

Brentleigh Bond, LWQS

What is happening about the flushing option for Okawa Bay – is it on hold, in the meantime at least?

G.M.
My brief was to complete the sewerage system design first because we will need a lot of resource consents for this one and as soon as we complete all the concept design, then we can put in the applications to Environment B.O.P. and then we will carry on with the flushing system design.

Jim Stanton, Lake Rotoiti Ratepayers & Residents Association
Greg, we know that the District Council undertook to have the resource consents ready by the end of July and that you have been delayed by the problems of waiting for the report from NIWA, so what is your current projection to get these resource consents ready for putting in an application?

G.M.
Before the end of the year! Our intention is still to construct the scheme by construction season next year, so if we have to do a fast track at a later date, we'll do it.

Jim Pringle, Environment B.O.P.
Have you got any costings that are running along or estimates of costings of the system on a per property basis or anything like that?

G.M.
Jim, I think later on this afternoon Glenys will be answering those questions. I think we'll do that.

Gertie Gielen, Forest Research
You were talking about rapid infiltration as part of your final disposal system. Have you considered normal land treatment as part of that rapid infiltration and what are your reasons to go for rapid infiltration?

G.M.
We've gone for rapid infiltration because it requires less area. The intention of the Land Disposal System is to remove part of the nitrogen that comes out from the

treatment plant. Our intention is to remove most of the nitrogen from the treatment plant and use the rapid infiltration just as a disposal system, not a treatment system.

Bill Vant, Environment Waikato
This is just an observation regarding the disposal. It is true that sequencing batch reactors can remove very large quantities of nitrogen, and you mentioned 85 to 90%, but the experience of Acacia Bay in Taupo has been that the remaining 10 to 15% of what is after all a very concentrated source of nitrogen still does reach the lake and does in the Acacia Bay situation cause slimes at the lake edge, so you’re going to achieve some improvement, but there still may be issues to worry about.

Examples of treatment technology in proposed sewerage scheme

Steve Couper, Harrison Grierson Consultants Ltd.

Introduction

- Evolution of sewerage systems
- Treatment process fundamentals
- Centralised and decentralised schemes
- Treatment process selection - Rotorua community
- Sequencing batch reactors and activated sludge
- Submerged aerated filters
- Membrane bio reactors
- Disposal and reuse options
- Summary

I will make a lot more detailed comment on the SBR (sequential batch reactor) systems at Taupo and SBR systems in general as we go through. What I thought I'd do by way of introduction is to quickly go through what I'll be talking about. I'd like to talk about what I call the evolution of sewerage systems and how we've come today as a society to have them in, and the reason for having these higher and higher rate treatment processes like SBR that people talk about. I'll touch quickly on centralised/decentralised systems, talk about treatment process selection in the Rotorua context and then talk in some more detail about sequencing batch reactors, which are an activated sludge process variant, what we call submerged aerated filters, quickly talk about membrane bio-reactors which is a relatively recent innovation in the wastewater field. I'll talk about disposal, reuse options and finally do a quick summing up.

For the first 40,000 years or so of human history on the globe, we were pretty much nomads constantly moving settlements, so I guess when things got a bit too smelly in one place we'd just move on to the next. Around 3,000 BC they think the first drainage systems started to enter towns and in the developments that we humans have made and by the time the Romans came along we had quite sophisticated and well-defined water supply systems and also drainage systems, although some people hypothesise that it was the lead poisoning from the pipes that killed the Romans off.

Evolution of Sewerage Systems

Nomads	-	Constantly moving settlements
3000 BC	-	Indus valley and drainage systems in towns
100 AD	-	Rome. Well defined water supply system and drainage
16C	-	Pump invented
17C	-	Piping systems designed for water supply
1840	-	Concept of sewerage systems
1893	-	Rock or trickling filters
Early 1900s	-	Sludge digestion - Biogas use
1914	-	Activated sludge - Manchester Experiments
1960s-1970s	-	First biological nutrient removal process
1970s	-	Ozone/UV
1980s	-	Membranes
1990s	-	High rate processes

By the 16th century the pump had been invented and by the 17th century the concept of designed water supply systems was starting to take place, particularly on the European continent. By 1840 the concept, especially in the UK and the European continent, of a sewerage system was relatively well-defined and of course in these days the concept was really just transportation as opposed to transformation, so it was getting the waste away from the people and probably into the Thames or into the sea. Around 1893 people started to use what we call trickling filters, and there are still a number of those in service today around New Zealand and around the world, which are effectively a large stack of rocks that we run the waste water through, bugs grow on the rocks and simply break down the pollutants and the waste water.

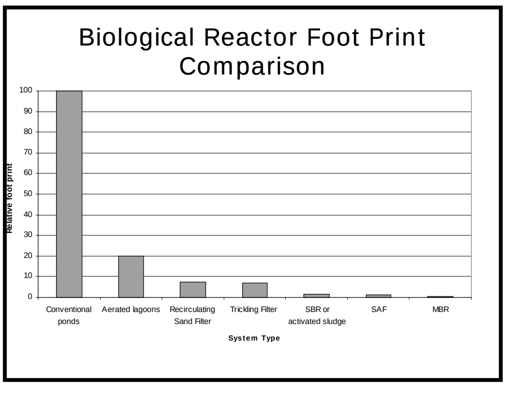
In the early part of the 20th century anaerobic sludge digestion at sewerage plants was starting to be used and we were reusing the biogas to regain energy from the waste. 1914 saw the advent of activated sludge, which was quite a big turning point and it's defined by the Manchester experiments. Two researchers called Arden & Lockhart discovered that if they bubbled air through a mixture of primary sewage, you'd actually get a bio-floc that would start to form in the bottom of the beaker. They found that if they tipped off the top water, kept the biomass in the bottom and then reintroduced some more biomass, the biomass would continue to grow and it was quite active, hence the name activated sludge. And it was actually the first sequencing batch reactor development, except they called it a fill-in drawer, what we call a fill-in drawer activated sludge plant.

This has led to a number of innovations throughout the latter half of this century, in particular first biological nutrient removal plants around the 1960's and 1970's, of which Rotorua probably had the first one in New Zealand, and then other innovations such as ozone and UV used for disinfection, and membrane plants in the 1980's. Throughout the 90's we've had a number of higher rate treatment processes that have been developed and come onto the market. Just to quickly run you through some of the fundamentals, when we talk of biological processes all we're talking about really is enhancing the natural organisms that are out in the environment all the time, so we're talking about jamming that bio-mass into smaller and smaller reactor tanks to treat the waste faster and faster. So there's nothing essentially new in it, it's just the technology to make the reactions go faster.

There are obviously also physical and what we call chemical treatment processes, and I'll quickly run through some of those. Physical processes – we're talking solids/liquids separation or else disinfection, for which we have UV filtration. Chemical treatment processes – the oldest one is probably the chlorination of our water supplies to ensure that public health is OK, but there are also a number of others.

Today we're really going to focus on biological treatment and in particular, what we call aerobic biological treatment. As I said, when we're talking aerobic biological treatment, there are essentially two main areas. There's what we call fixed film systems and suspended growth systems.

Suspended growth systems relate to ponds and aerated lagoons that are commonly seen throughout New Zealand and are what we call relatively low technology systems, and activated sludge from the Manchester experiments has brought up this whole host of other higher rate and really compact treatment systems. To put it into perspective, if you have a relative footprint of a treatment process, which is the land area that it would take up, if a pond was 100 a typical SBR would be something in the order of about 1, so you can see there's almost 100 to 1 turn down in terms of the actual land that it takes. This is because with a pond system we essentially rely on all of the natural processes, which are very low in energy requirements, whereas this is very high in energy requirements, but when you're talking areas



of land, it takes up a lot less land. In Europe especially and places like Japan where land is very expensive they've tended to develop these higher rate treatment systems to save on cost.

In process selection, when you're looking at selecting the appropriate treatment process there are obviously a number of drivers that we need to consider. We're talking of a decentralised approach here, of a number of outlying communities, and we've got clusters of development. Quite an important aspect with decentralised systems (and this is the case in Taupo where they've got 4 or 5 plants dotted around the lake), there's the centralised management of those systems.

Treatment Process Selection – Rotorua Communities

Drivers

- Decentralised approach
- Clusters of development
- Centralised management – automation and control
- Public health issues – disposal method / quality
- Environmental issues - nutrients

So in other words, it's not up to the householder to manage their own septic tank system or little aerated plant on site, they're collected in a little cluster plant and it's the local authority or other wastewater service provider that actually runs the plant, which frees the householder from that responsibility. Obviously we've got to consider public health issues, disposal methods as Greg alluded to earlier, and environmental issues which are of particular importance in this area, such as nutrients - and in particular nitrogen. I'm going to talk in a bit more detail about the three technologies that I spoke of earlier.

Modern Decentralised Systems

- Improved effluent quality
- Potential for beneficial reuse
- Centralised management regimes – eg USEPA level 3 – 5.
- Service provision is the same as a centralised scheme – freedom from householder responsibility

The first one is **Submerged Aerated Filters**. This is a fixed film process where the bugs are essentially attached to a plastic or sometimes a rock medium that's submerged within a tank. I've got some examples here. The medium can be random packed, so you could have 100's of 1000's of these stacked in a big tank, or it can be tubular medium for example, that can be just stacked and you can just imagine a really large tank that's full of that sort of stuff. What happens is that the bugs adhere to this and as the air bubbles through and the wastewater flows through, it breaks down all of the pollutants.

Submerged Aerated Filters
SAF Technology

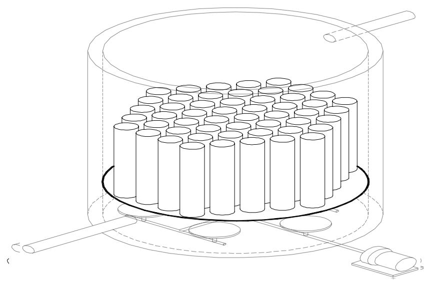
- Fixed film but high rate process
- Combines advantages of both activated sludge and trickling filters
- Compact (modular), Proven, Robust
- Cost effective

So some of the features of that system are the high voidage medium. We obviously have to input air which is usually some sort of blower system; we have an enclosure which is a tank

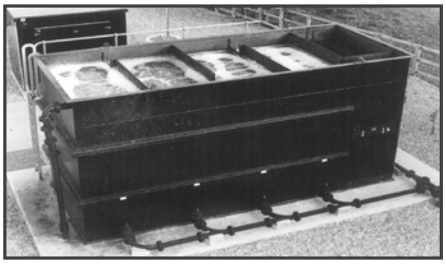
SAF System - Features

- High voidage media
- Aeration
- Enclosure
- Solids liquid seperation

and we need a solids/liquids separation device to get rid of the bugs at the end.
The system is built up like this where for a very small community it could be as simple as a couple of concrete manhole tanks; for a large community there would be a bigger tank, so we need an enclosure and we have some sort of aeration system or diffuser array on the bottom. We need some sort of grating to hold the media and then the media simply sits on top, and then we have a solids/liquids separation device. So you can imagine the wastewater is pumped in here, flows along and up through the media where there's lots of air and mixing, flows into a clarifier, the treated effluent flows out the top and the sludge to be disposed off comes out the bottom. Pretty simple stuff really.



SAF System

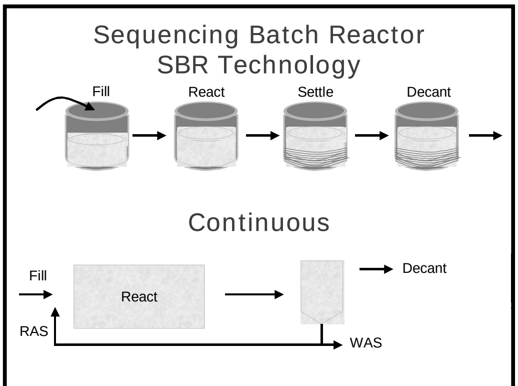


SAF Example

This is a photograph of a proprietary SAF system. It's got three reactor cells; the wastewater comes probably in the bottom and up, goes through the cells and then we've got a clarifier at the end here. There's a blower hooked up here and this is the diffuser and the air input. Obviously highly energy intensive, but also a very very small footprint when you consider this probably treats the wastewater from 400-500 persons.

Sequencing Batch Reactor technology

In the late 1980's Taupo embarked on a project of putting a number of these units around Lake Taupo and one of the advantages of sequencing batch reactors over the continuous form of activated sludge is that we have a clarifier and a reactor tank, and all of the process takes place in a single tank. What we do is we vary the conditions throughout time, rather than throughout space in the continuous plant. As the name would imply, the wastewater is typically fed into the reactor as a batch or a single slug, so we usually need to have two of these systems in parallel or we need some sort of balance tank to take the flow when the wastewater is not coming in.



It's very similar to brewing beer, you just chuck in some bugs, which is like the yeast, you chuck in some sugar which is like the wastewater, and then for beer you mix it and here we just chuck some air in the bottom. So effectively we fill up the tank, we've got an established biomass that's sitting within the tank, the air mixes it all up, the bugs break down the pollutants. At the end of the cycle we switch off the air, the bugs settle to the bottom and then we simply decant the effluent off and the cycle begins again.

SBR Concepts and Models

- Batch inputs provide for unsteady state or Plug Flow (PF) conditions
- Target pollutant removal e.g. nitrogen
- Selection of specific groups of micro-organisms
- SBR process can be manipulated to suit pollutant removal requirements
- Operational flexibility

One of the advantages of using this batch process is that it allows us to create what we call unsteady state conditions, so effectively the conditions within the reactor are changing throughout time and this allows us to select specific groups of micro-organisms which in turn allows us to target the removal of certain pollutants, and nitrogen and phosphorus are probably the key pollutants we're talking about here. Most treatment processes are very good at removing what we call the organic load or BOD (Biochemical Oxygen Demand) in suspended solids, but the effective removal of nitrogen and phosphorus is more problematic.

There was a comment before about the Acacia Bay plant, which does have difficulty with that final residual nitrate content. This can also be overcome by the addition of more readily degradable carbon, which is usually the problem with these plants, and I understand Rotorua at the moment is putting in a methanol dosing plant at the main treatment system, and these sorts of things can be put in place as well. At the end of the day it just boils down to cost and the amount of money that you're willing to throw at it.

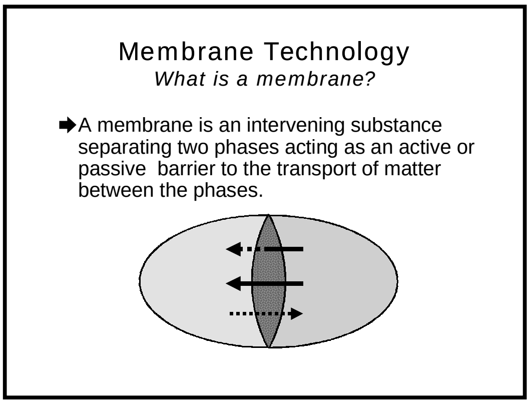
SBR Tank

This is a photograph of an SBR treating poultry-processing wastewater. About 650,000 litres a day goes through this plant and removes about 80% of the nitrogen load before discharge into the upper Manukau Harbour.

SBR Process

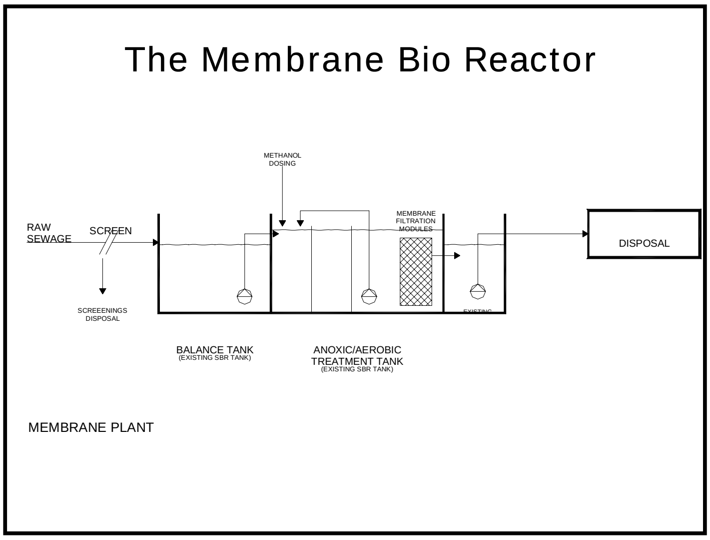
This is a photograph of the Acacia Bay SBR plant aeration basin while it's mixing. You can see the very brown mixed liquor, a nice healthy mixed liquor with lots of air. There's a bit of scum on top. This is the decant pipe. So at the end of the cycle the air will be turned off, solids will simply settle to the bottom and the wastewater will be decanted from the top.

This is a shot of another larger SBR plant. You can see the decant pipe here is lifted out of the water while the reaction takes place. Once the solids settle down, then again the liquid flows off the top.



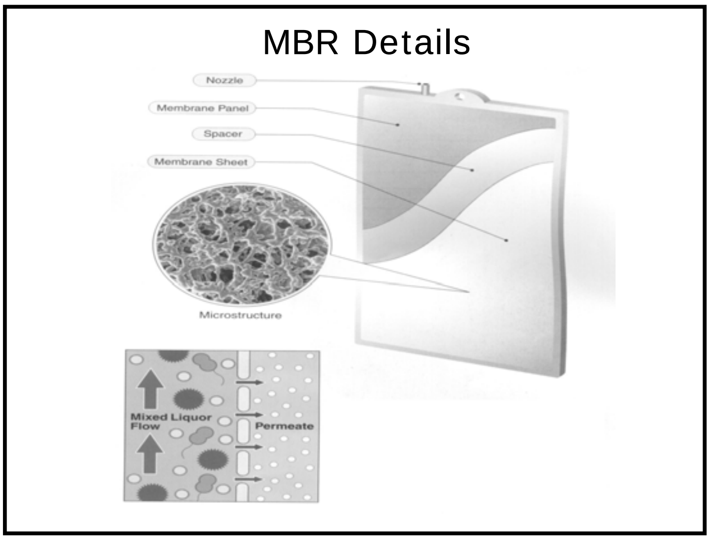
Membrane Technology

I want to quickly go through another technology that's relatively recent in wastewater treatment and that's membrane processors. Basically a membrane is just an intervening substance between two phases that allows for the transport in this case of water across a semi-permeable barrier. Throughout nature and in engineering and production and sciences, there are a number of applications of membrane technology as you can see up there.

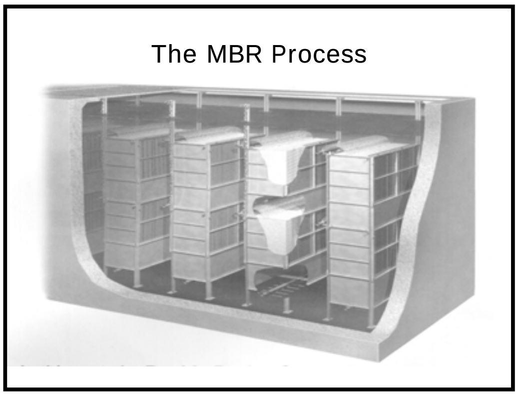


In terms of the membrane bioreactor process, which has probably come to light in the last 5 to 10 years, what we do is instead of having a clarifier and then activate as such, we effectively submerge a membrane filter within the reactor tanks. In an SBR tank we've got our blowers blowing air in, we've got recycle pumps in different zones that are removing the pollutants, the bugs are all in there. But what this membrane does is create a physical barrier to the solids from getting out and only the treated effluent can get into our final chamber and to the disposal system.

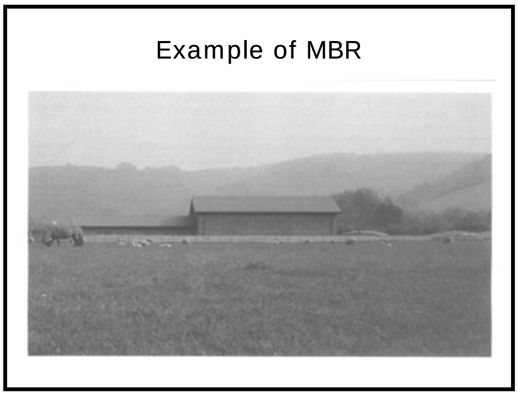
To show it in a bit more detail, the membranes are simply a whole heap of these sheets that are stacked vertically within the reactor, and you can see that's a microscopic view of it where we have these tiny little pores that not even bugs can get through. So this is a mixed liquor side or the biological reaction side, where you've got air and bugs and all the pollutants being broken down, and only the water can get through the membrane



sheets. The advantage of this sort of process is that the pressure that you need to drive across the membrane has gone down remarkably, the cost of the membrane sheets has come down remarkably and the effluent quality that you can get out of here from a bacteriological point of view is almost to drinking water standard.



Just to show you what it looks like, you effectively have a big tank, you have a suspended growth of the bugs that just move around here freely with air blowing through, and these membrane sheets – 1000's of them are stacked up and the water slowly flows through out this manifold in the top and into the disposal system.



That's a picture of a membrane plant in the south of England treating wastewater from a reasonable-sized town. As you can see, because they're so compact and small they're really easy to hide and can even be aesthetically pleasing.

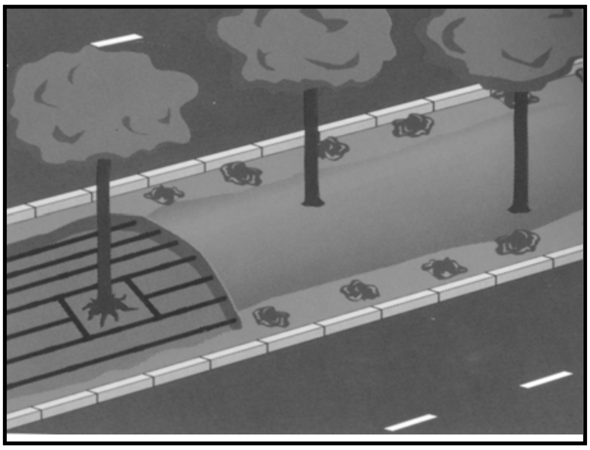
Disposal systems

Obviously if we're going to dispose of wastewater we've got to work out where we're going to put it and there's a real need to establish the assimilative capacity of the environment. This obviously feeds back into what sort of treatment process we're going to select. If we're relying on the land to provide some of the treatment and the quality, then the quality that we have to treat it to doesn't need to be as high, so obviously we wouldn't be looking at a membrane plant if we're going to spray it on a land disposal scheme and crop the hay, for example.

If we're going to go for rapid infiltration or discharge it straight into the groundwater or into a small inland waterway, then certainly the quality has to be quite a lot higher.

If discharging to land, we've got to think about whether we look at rapid infiltration, surface irrigation, sub-surface drainage, discharging to water, whether it will it be to a small waterway, or perhaps to a marine environment. Then there are a number of reuse options that most of you are probably familiar with, such as aquifer recharge, horticultural or agricultural reuse. Water supply augmentation is one that's used a lot overseas, especially in drier countries where it's simply just sprayed into the water catchment. Industrial reuse is coming into play a lot more where low-grade water can be used for cleaning processes, for example, and some people even talk about direct potable reuse.

I've got a few slides to show examples. This is simply a sub-surface drainage system similar to some of the existing septic tank systems that are probably around (*not shown*).



This is a bit more innovative, it's watering a road berm with a mound. Obviously rapid infiltration is similar to this, but you tend to have beds where the wastewater is just pumped over the bed and infiltrates quickly into the ground.

This is an example of a pop-up sprinkler on a golf course (*not shown*). We've got a nice little bit of turf on top, so when the sprinkler goes down you can't even see it. Obviously if you're going to spray it on the surface and people are playing golf, they are liable to touch their ball, so you'll need a lot higher effluent quality than you would from a bacteriological point of view anyway, than if you're putting it under the ground.

This is an example of agricultural reuse (*not shown*) where we've got drippers up on poles in an Asian country and we're dripping it onto crops in the field.

This final shot is of the Taupo land disposal system. In Taupo they've not got SBR's that would discharge into ground and effectively into the waterway: the main pollution control plant is a trickling filter plant and doesn't remove the nitrogen; they actually use the land treatment system effectively as the nitrogen sink. So they spray the wastewater onto the land all year round, they grow hay (and you can see a number of hay bales that they've cropped here) and then that's sold to farmers, which helps to fund the land disposal system. Obviously you need to have a lot of land to be able to do this.

Summarising then, biological treatment processes are well established and it's important to remember that it's simply just an acceleration of the natural treatment systems that are inherent in the environment. Modern decentralised systems can be high rate and they can produce a very high effluent quality as well. Process selection tends to be driven by effluent quality and by the disposal requirements.   Obviously the economics of the system are quite important as well.

Summary

- Biological treatment processes are well established and are simply an acceleration of natural processes
- Modern decentralised systems are high rate, compact and can produce a high effluent quality
- Process selection is driven by, effluent quality, disposal requirements and economics

Submerged aerated filters, SBRs and membrane bio-reactors are three high rate compact biological processors that are potentially suited to communities like Rotorua where you have this nutrient removal issue and it's of prime importance. Careful consideration obviously needs to be given to the disposal and reuse options when also selecting your treatment system and this includes consideration of the environmental effects and the reuse applications.

And finally, Rotorua District Council has been doing feasibility studies and investigations, which are an important way of identifying the most appropriate treatment and disposal system to ensure that the economics are there and that we meet with the environmental requirements. Thanks very much.

Summary

- SAF, SBR and MBR are 3 high rate, compact biological processes potentially suited to the requirements of Rotorua
- Careful consideration should be given to disposal and potential reuse options
- Environmental effects need to be considered when selecting treatment and disposal/reuse applications
- Feasability investigations can be used to identify the most appropriate system

Questions

David Ray, NIWA

Just a couple of quick questions, Steve. What about odour for SBR – if you could just comment on potential for odour generation and secondly, you may not want to get into the specifics, but RDC's talked about using an SBR in conjunction with rapid infiltration. Presumably there's no disinfection in that. Do you want to just talk a little bit about the potential for pathogens, where they go, what happens to them?

S.C.

Thank you. The odour one first. In a well-operated SBR there tends to be no odour problems unless there's a process upset or some sort of shock loads come down the sewer. There is the potential for odour generation during some of the anoxic phases of the SBR system, but I think it's for a very short duration, like a minute or two when the air first blows back on, if the anoxic phase has gone too far. In other words, if all the oxygen has been degraded to a point where you're going to get an odorous release. My experience with them is that odour isn't generally a major issue beyond the boundary of the site. In terms of the bugs, that's true, you could always add a final balance tank and a disinfection system on it, and I guess really it depends on the requirements of the disposal environment. If there's a risk of human contact and disinfection is necessary, then at the end of the day that's probably what you have to do. An SBR system will typically give you a one-log reduction in terms of the pathogens coming in.

Ian McLean, Lakes Water Quality Society
What are the relative economics of the three systems?

S.C.
An SBR and a SAF system, probably much the same, not too dissimilar. It's probably true to say that an SBR is more established in terms of its ability to remove nitrogen, and certainly an SAF system won't be able to remove phosphorus biologically, because it's a fixed film process. Membrane plants are still more expensive, but their price has come down five-fold in the last 10 years, which shows you where the trend is going. The oldest membrane bioreactor is only 6 years old and that's the Wessex Water installation. So the membrane thing, that's what we're going to be looking at 5 to 10 years out from now. It'll be more standard practice.

Nick Miller, LWQS
Am I right in thinking that with an SBR you can plump for high nitrogen removal efficiency or high phosphorus removal efficiency, but not both in the one tank?

S.C.
You should be able to do both in the one tank. Certainly the design theories say that you can. There aren't really any practical examples in New Zealand of SBRs removing both P and also N. There is quite a lot of literature and some operational examples overseas. I think to really make the thing work you would need some sort of supplemental carbon dosing for it, in other words you'd have to have methanol or maybe acetic acid. At Noosa Heads on their plant they've got molasses dosing I understand, they use a sugar by-product and dose that in. Basically as I said, it's like brewing beer. With sewerage you've got to take what you get down the drain, so if you can supplement it and put in the extra yummy stuff when you need it, then the bugs will certainly respond.

Nitrogen removal at the Rotorua Land Treatment Site

Kit Rutherford and David Ray, National Institute of Water and Atmosphere (NIWA)

Acknowledgement is given of extensive use of the results of studies by Forest Research, Landcare Research & Rotorua District Council.

We've made extensive use of work by colleagues, particularly those in Forest Research. If I've made any mistakes and misrepresented their information, there are enough of them here to defend themselves. NIWA was involved in the design of the land treatment system back in 1990 and what I've summarised down here are the design limits which we contributed to with help from various colleagues at Forest Research.

Roughly 80 tonnes per year of nitrogen was anticipated to leave the treatment plant. Some nitrogen is removed at the treatment plant, the balance of about 80 would make its way up to the forest, and it was anticipated that some would be removed by the pine trees, some would be removed by the forest soils, some would be removed by the wetlands and these were the best guesses that could be made at that time of the likely rates of removal. And the take home story was that if the wind was behind us and we added up all the right numbers and took it off here, then we'd reach this target here.

Forest Nitrogen Renovation

'Target' load to lake	30 t y^{-1}	
Applied wastewater	~80 t y^{-1}	
	Design[A]	Actual
Removal by:		
pines	0-10 t y^{-1}	1-2 t y^{-1} [B]
forest soils	5-15 t y^{-1}	0 t y^{-1} [C]
wetlands	10-30 t y^{-1}	4-8 t y^{-1} [D]

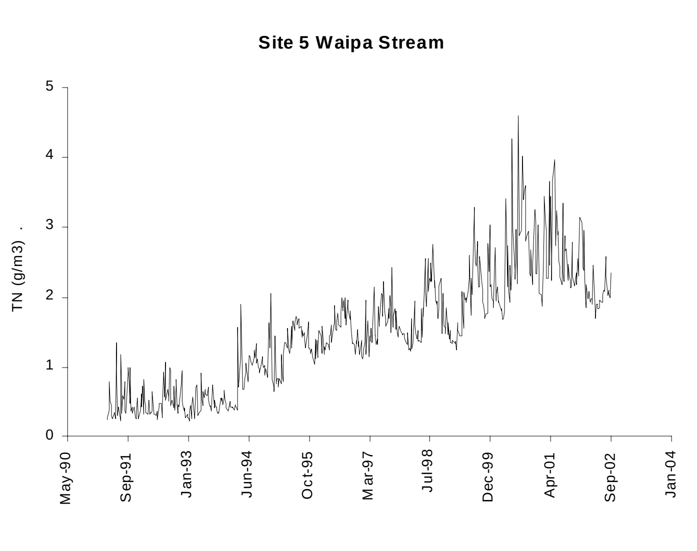
[A] Cooper & Cooke (1990)
[B] Tomer et al. (1997)
[C] Barton et al. (1999)
[D] Nguyen et al. (2001)

But there was considerable uncertainty, even at the design stage, about the ability of the Whakarewarewa soils to remove nitrogen, and in particular, there was quite strong dependence on the wetlands for nitrogen removal, the natural wetlands present in that system.

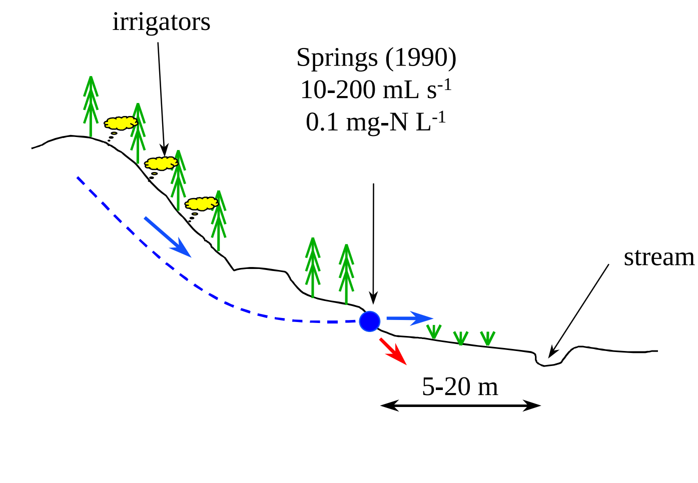
Now we have the benefit of hindsight and the work that's gone on since then. Louise Barton in particular did her PhD study on nitrogen removal by the forest soils and got about that much. She found the reasons were that the soils at Whaka were extremely free-draining and were largely aerobic. A lot of these figures came from slightly tighter soils, which were much less free-draining, in which either the soils themselves were anaerobic or there were anaerobic micro-sites. And you need those anaerobic micro-sites to support the denitrifying bacteria that take the nitrate and convert it to nitrogen gas. So there is a pretty good understanding of why the forest soils are reasonably low in nitrogen removal.

I'm not too familiar with the details of the pine studies, but my understanding is that there's a lot of work going on at Forest Research and indeed, there is nitrogen uptake by pines and it's certainly within the range that was forecast. The one I'm much more familiar with is the role of the wetlands, because Long Nguyen and I have done some work there.

The work by Rotorua District Council – this is measurements of nitrogen concentration in parts per million in the Waipa Stream. The Waipa Stream is the stream at the bottom of Whakarewarewa that collects all the effluent that's been sprayed on. The spray irrigation started in 1991; clearly nothing much happened for a while. These are the background levels that had been measured prior to the scheme. After about two years there was a steady increase in nitrogen concentration, a very strong seasonality in it, much higher nitrogen concentrations in the winter than in the summer, but an alarming trend. Slight reduction in recent times, which I think is associated with slight differences in loading to the system.



Source: Rotorua District Council



Peacock et al. (1998) Water, nitrate and chloride budgets of a wetland receiving land-treated municipal wastewater. *Proceedings of the Land Treatment Collective*, Taupo 1998.

Looking in a little bit more detail at the way the system works – sewage is treated in Rotorua at the treatment plant on the side of the lake. A substantial fraction of the nitrogen and phosphorus is removed by that treatment process. There's a fair amount of nitrogen left in the system when it gets up to the soils. It's sprayed in the forest on the slopes. These soils are extremely free-draining and the water certainly percolates into those soils very quickly and then makes its way down-slope and emerges as springs.

Now one thing that's been observed to happen and was forecast to happen is that the flow out of these springs has increased quite substantially, because effectively in the spray irrigation area you are increasing the rainfall by a factor of between 2½ and 3. The water's got to go somewhere and it comes out in these springs, which are scattered around on the flood plain.

Below the springs are a number of natural wetlands, varying in size from here to the back of the room to somewhat smaller, and these wetlands have got quite a lot of plants on them. The soils are highly organic and it was these wetlands that were anticipated to do the final mopping up of the nitrogen.

Briefly summarising the phosphorus story, during the design phase some phosphorus removal in the treatment plant was factored in and the capacity of the soils up here to absorb phosphorus was investigated, and the short answer is that any surplus phosphorus being spray-irrigated was likely in the medium- to long-term to be mopped up by the soil. So phosphorus is not a concern, it's principally nitrogen, and indeed nitrate in particular is found to be much more mobile than phosphorus.

Forest Soils

Barton et al. (1999): forest soils

- free draining
- aerobic
- low denitrification rates

Cooper & Cooke (1990): riparian & wetland soils

- less permeable
- anaerobic
- some high denitrification rates

Just summarising the forest and wetland soils: I've said this already before, summarising Louise Barton's studies: – the soil is extremely free-draining, aerobic, with very low denitrification rates. The work that Bryce Cooper and Jim Cook did on the riparian wetland soils, those soils which are at the bottom of those slopes, they are much less permeable and that's why the stream is there, because of course you've got impermeable clays. They were anaerobic and they had extremely high denitrification rates, and that's why those two folk forecast sizable nitrogen renovation in the wetlands.

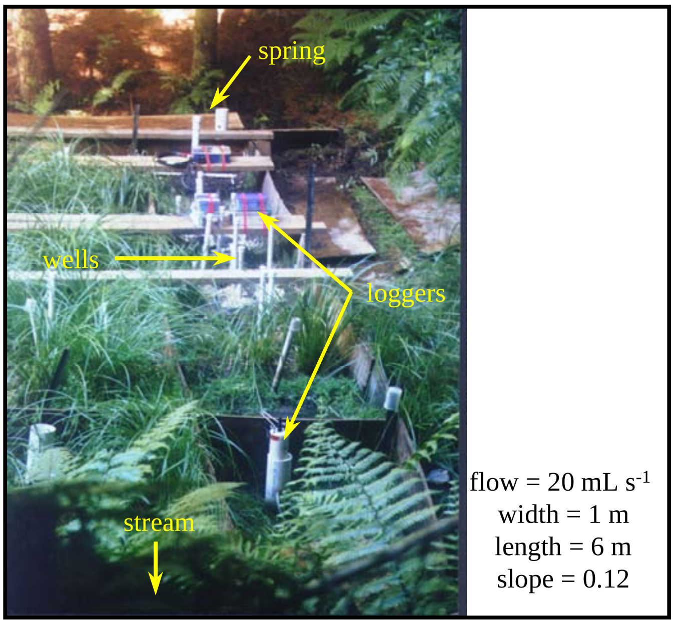
What's happened in the springs: I've already mentioned the fact that the flow was forecast to go up by a factor of 2 to 3 times, but what was surprising to find was that the nitrate concentration has increased. This is the typical concentration pre-irrigation. Alison Peacock did a masters study and she measured concentrations of 6 to 10 and now Long Nguyen and I have done a little bit of work just recently, and concentrations are comparable with those that Alison Peacock found.

Springs

Flow increased by ~2-3 times

Nitrate increased by ~100 times

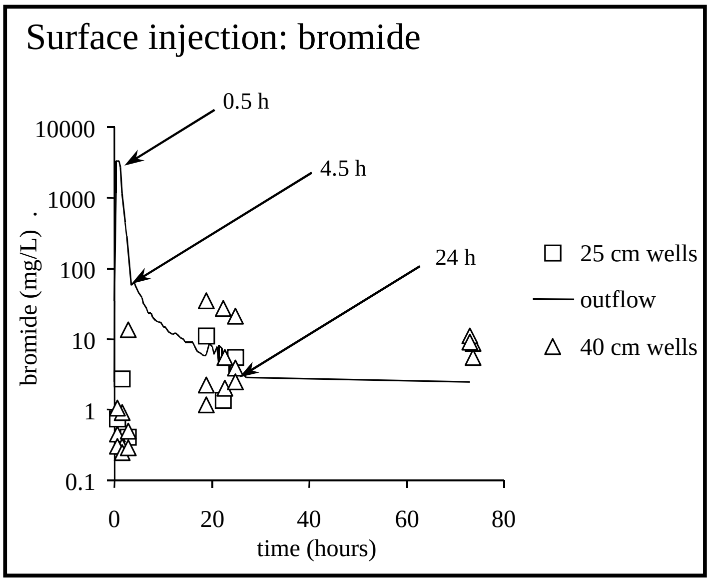
1990	0.1 mgN/m3	Peacock et al. (1998)
1997-1998	6-10 mgN/m3	
2000-2001	8-10 mgN/m3	Nguyen et al. (2001)



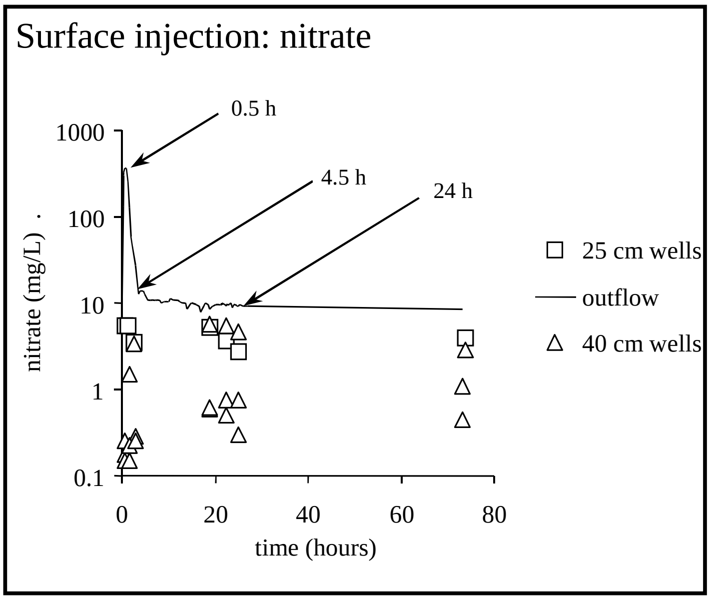
So these are the springs at the top of these wetlands. We also studied the ability of the wetland soils to remove nitrogen and there's no question that those soils have a huge potential to remove nitrogen, which indeed was what Jim Cook and Bryce Cooper had found. The work reported there - the take home message - was that were water to be in contact with these wetland soils for about a day, all the nitrogen would have been removed from those soils. They're that active.

So we set out to address the question: in that case why aren't these wetlands working better? This is the typical sort of situation (*above*). Here is a steep bank. There's a road just about where that black bar is and then the hillside behind is being spray-irrigated, and tucked in here is a spring, water bubbling out of the ground. What we've done is enclose it with plywood sheets, but effectively the water from that spring trickles down through our little chamber in a narrow, confined channel.

We put a number of sub-surface wells in here, we also had a number of surface collection pot points – here's one at the bottom where we could measure conductivity continuously - and we did some tracer experiments introducing an inert tracer to tell us how quickly the water was flowing and then spiked that with nitrogen to look to see how much of the nitrogen was removed.



I've got two lots of results. This is an inert tracer, bromide, and it's a log scale somewhat distorted. What we did is we injected a pulse of this at the surface and then measured it at the down-stream end of the channel, and the important feature of this is that the vast majority of the tracer came out in the first half an hour. You can see this big pulse and don't forget this is a log scale. But, and this is a very interesting point, there is some tracer which came out over the period 4½ to 24 hours, so there's evidence that some tracer was being retained within the wetland soils there and coming out after 24 hours. Remember what I said earlier about the denitrification rate, it takes about 12 hours of contact time to strip all the nitrogen out.

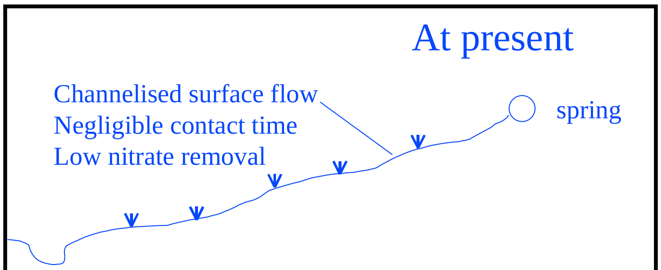


Now if we look at what happened when we put nitrogen in as well – same experiment – but just looking at the nitrogen that we added, same sort of thing. The vast majority of the nitrogen came out in the first half an hour, but in this period 4½ to 24 hours, whereas there were very strongly elevated bromide concentrations, there's hardly any nitrogen and that's because the small amount of tracer nitrogen in this period here has been stripped out. This just confirms the fact there's nothing wrong with the soils. If there is anything wrong it's with the flow patterns, and the problem is that the vast majority of the spring flow is travelling across the surface of those wetlands in preferred flow paths.

- surface horizontal flow >90%
- residence time ~ 0.2 hour
- removal low
- sub-surface horizontal flow <10%
- residence time ~ 1-2 days
- removal c. 100%
- vertical exchange flow c. 5-10%
- residence time c. 6-24 hour

Overall nitrate removal 5-10%

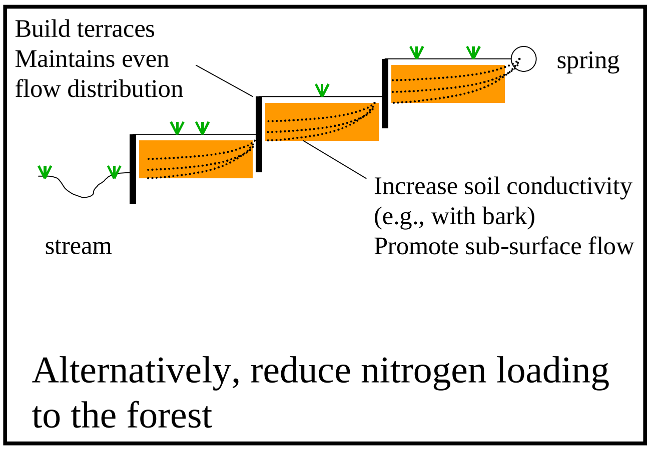
So the summary from the work that we did was that about 90% of the spring flow is going across the surface of the wetlands and it's got a residence time of a few minutes. There is a very small amount of horizontal sub-surface flow and there is some vertical exchange and so overall, about 5 to 10% of the nitrogen entering those wetlands is being removed and that was considerably lower than the design figure.



Could wetland nitrogen removal be increased?

- Redistribute flow evenly
- Reduce surface & increase sub-surface flow

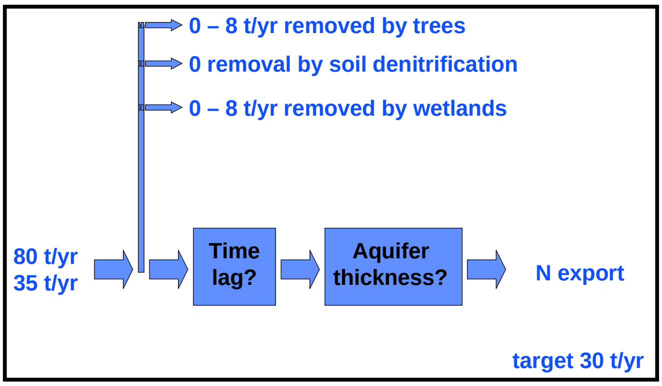
So could wetland nitrogen removal be improved? If one was aiming to do that, then the important thing would be to redistribute the flow evenly across the surface. At the moment there's a spring here, there's a spring over there, there's a spring over there, and then each of these springs just flows in a narrow band.



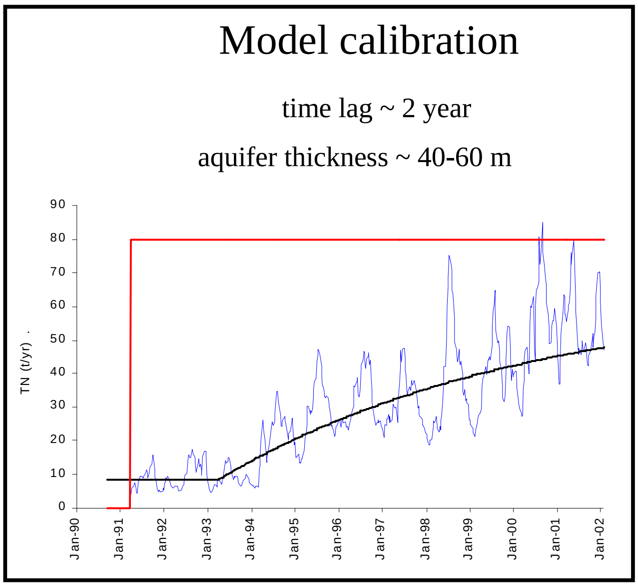
If one were to distribute the flow evenly across the surface, that would improve it, and particularly if you could increase the sub-surface flow. Long Nguyen is Vietnamese; they have rice paddies in Vietnam, so one possibility which hasn't been investigated in any detail would be to terrace those wetlands, perhaps increase the permeability taking a leaf out of Louis Schipper's book, perhaps backfill them with bark. This alternative has not been proceeded with because the other alternative of course is to minimise the nitrogen that's applied and this indeed is the option that Rotorua District Council have decided to run with, to take the nitrogen out in the treatment plant where you've got a bit more control of it, and reduce the loading.

So the final point of my talk here is the question that Paul asked us, which is what would happen if the nitrogen loading remained constant at its current high level and what would happen if the nitrogen load was reduced by advanced treatment on the lake edge.

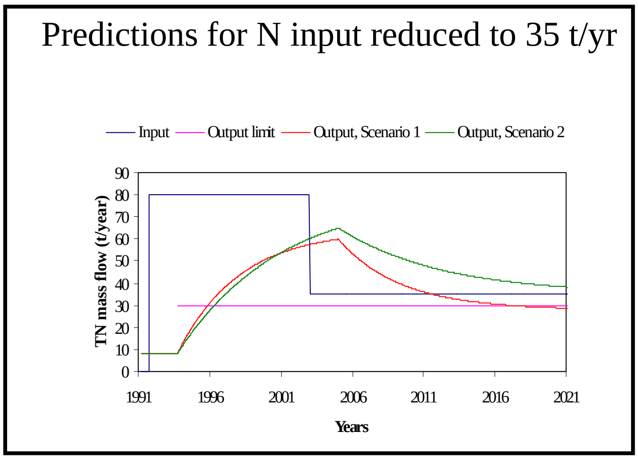
To do that we constructed a very simple computer model and the computer model basically says let's assume that there is an aquifer underlying the spray-irrigation area whose thickness we don't know, that's a model coefficient. The water enters this aquifer, is fully mixed within the aquifer, but we don't know the thickness of it. We know from looking at that graph of the Waipa Stream data, that there's a time lag in the system, so let's put a time lag in the system and again we don't know what that is.



We have information for the 15 years of monitoring data at a loading of 80 tonnes a year, so let's use the measurements of nitrate concentration in the Waipa River to calibrate up this little model, and then let's use it to predict the effects of reducing the nitrogen load to 35 tonnes a year.



Now here is the monitoring data that I plotted before and here is the loading of 80 tonnes a year and here is the calibrated model, and in order to get that fit I've played around with the time lag and the aquifer thickness until I’ve managed to get the black line to go through the middle of the blue line. Having done that you can then ask what happens if we now at this point change the nitrogen loading on the system from 80 tonnes a year to 35 tonnes a year, and what I’ve got here is an upper and a lower bound prediction.



There is some uncertainty in the model calibration, so the standard trick is you take a likely upper bound and a likely lower bound and you hope that reality will lie somewhere in between. And the predictions say that, first of all this time lag of two years turns up again, nothing’s predicted to happen for two years, in the same way that nothing happened for two years when the irrigation started. Thereafter it will drop and eventually in the worst case you’ll get back to 35 tonnes a year coming off, i.e. zero renovation within the system, so what comes out is exactly what you put on, that’s the worst case prediction.

The best-case prediction is where something like 16% of the nitrogen you put on will be retained, and this tells you something about the timescale, so you know were this to happen tomorrow my children would see it.

Conclusions…1

Negligible soil removal because
- soils drain well
- remain aerobic
- do not support denitrifiers

Low wetland removal because
- high hydraulic loading
- channelised surface flow

To meet target load for lake (30 t/yr), need to reduce nitrogen loading to the forest from 80 to 35 t/yr by improved treatment

So the conclusions – negligible soil removal in the forest soils for those reasons, less wetland removal than we expected – largely because of the high hydraulic loading which hadn't been factored fully into the design and the fact that the high hydraulic loading produced channelised surface flows.

A reduction of nitrogen loading to 35 tonnes a year is our best guess of the input to the system that would still allow the lake target of 30 tonnes a year to be met. Just generalising, putting these into context with studies elsewhere, high soil removals of nitrogen have been measured. Colleagues in Landcare and Lincoln University are studying nitrogen renovation in New Zealand soils and it would be fair to say that the soils in the Whaka Forest are atypical of many New Zealand soils where nitrogen removals from irrigated effluent are much higher and there, tight soils which go anaerobic are much more likely to remove nitrogen that the free-draining ones at Whaka.

Conclusions…2

High soil removal is measured elsewhere in New Zealand where the soils drain more slowly

High wetland removal is measured elsewhere in New Zealand where hydraulic loadings are lower and flow is more evenly distributed

Again, wetland removal: what's atypical about the natural wetlands in the Whaka Forest is that they are comparatively small and they've got an extremely high hydraulic loading. Again, larger natural wetlands in other parts of the country with lower hydraulic loadings have been able to renovate and remove nitrogen from waste streams that are discharged through them. So Whaka Forest is a bit atypical.

Chair
Thank you very much Kit, I think that explained it very clearly to us all.

Questions

Gertie Gielen, Forest Research
It's more like a comment I think than a question. The Rotorua District Council in the last couple of months have changed their irrigation schedule from a weekly schedule to a daily schedule in order to address concerns that Kit had about large hydraulic loadings to the wetlands. I can't pre-empt data from the Rotorua District Council, but from the little peek that I had at it, it looked pretty promising.

Professor Warwick Silvester, University of Waikato
The uptake into the forest soils, Kit - I take it you're talking just about denitrification. Is that right? Because the litter drop that goes on in the pine forest has fairly high

carbon to nitrogen ratio and has the ability to immobilise quite significant amounts of nitrogen.

K.R.
Louise did just measure denitrification and we did have another student at the University who looked at the soil absorption and the amounts retained in the soil over time, and there were some increases in soil nitrogen. In terms of total nitrogen it was so variable it was difficult to see differences from control treatments and where the effluent had been applied, but there was an indication, there was some. That's held as a master's thesis at University of Waikato. You might like to pick that up as well.

Mary Stanton
Kia ora. The wetlands have always been very precious to us Maori and when I look at the situation I can understand the wetlands would be vital in your seeping of water, because naturally it has the right vegetation like wiwi for instance. It is part of the wetland, it is a drainage. Now, I come back to the location that we're looking at, Okawa Bay/Mourea and we know where the wetlands are, and my question is: I know our people's feeling because when you are taking anything into our wetlands you would be gradually moving into the lake and we've always said the lakes are our food bowl, so to mix something that we may see as not very tasteful to our waters, there could be some different reasoning as to using the wetlands. This is where I would like to say from the Maori's perspective, culturally the wetlands are very vital to us. Kia ora.

K.R.
Thank you Mary.

Lake Okareka: an environmental catchment study

Paul Sampson, District Engineer, Rotorua District Council

Thank you Madam Chair. Up to now the discussion has been a lot on the science and the engineering. In my role as a District Engineer it's a matter of looking at a raft of things and trying to then at the end of the day come up with some solutions or options that we can put to the Council, so they can make a value judgement. You've heard today from Kit about the investment that the Council has put in, in terms of the land treatment system. To get the end results what we've had to do is take the science, take some of the engineering and try and get a solution.

Now whilst this is called an environment catchment study, what I was really doing with this was taking a lot of the information we had and taking the word 'environmental' in its widest sense - that it's not just the science, it's also got to take into account the fact that people wish to live in the environment. And the basic concept of the environmental catchment study is the total environment – the economic environment, the human environment and what is usually sort of known as the 'green' environment.

I must say it's been quite interesting that, as you can see, we've been investing money with NIWA and in conjunction with Environment B.O.P. I know a lot of people think we come from different points and sometimes we've had some tension, but I've got to say that it's actually been quite good in the sense that now we are working very collaboratively together. It was interesting that I produced this paper for the Council Works Committee and about the same time Environment B.O.P were producing a like report – in other words in terms of the philosophy, the only difference between us in this one is that I had some dollars and our experience in the sewerage schemes, and the other thing is that I have personally had quite a bit of experience in 1982 when I was the County Engineer in Taupo.

I was sent to the States by the County and the Tuwharetoa Trust Board to look at solutions for sewerage around Lake Taupo. From those discussions with the US EPA we actually brought the SBR (sequential batch reactor) technology into New Zealand and the Acacia Bay Plant was basically the smallest plant or the first plant of that size ever produced in the world. It's been interesting to see even 10 years later that that technology is still being used and is actually producing what that original concept was.

But back to the Okareka study. As I said, we've got some sites, we've got some engineering, we've got some funding, and we want a sustainable environment in that wider context. So from my point of view, what's the best value for money? One of the other aspects on this is of course that you've got the District Council, you've got Environment B.O.P., and what are our respective responsibilities and therefore at the end of the day, who pays?

I guess Rotorua District Council's prime responsibility is public health. We are obviously very interested in the environment, otherwise we wouldn't be doing what we are; but in terms of a fundamental sort of statutory process, in broad terms RDC has got that primary responsibility for public health, and Environment B.O.P. has got the same for the environment and at the end of the day you'll see why I think this is a good idea.

What we've done there is the land use around Lake Okareka. (*Slide not included.*) The reason we chose Lake Okareka was because it was a confined catchment, we knew there were some issues in there, we knew there were some issues in terms of public health. In the papers you've heard this morning from David Ray and the team on Lake Okareka, we were looking for a public health perspective on septic tanks, what they are doing and also what are they doing from an environmental basis? Of course the thing that drops out of that, as you've heard from David, is in terms of the separation distance and things like that; but the other aspect of course is the land use and how much the septic tanks contribute as against the total nutrient loading.

So proceeding in a fairly pragmatic way, if you look at the map of Lake Okareka the different colours there represent the different land use, you can see the yellow is the indigenous forest, you've got farmland, planted forest and the urban areas. Now from those individual land uses you can see the nitrogen loading. Bearing in mind the discussions before about using nitrogen as the limiting factor, you can see from that what the different land uses generate in terms of the nutrient loading.

Now one of the other aspects we've looked at is that you've got a total nitrogen loading on the lake, but basically if you've virtually converted the lake back to natural forest, you are still always going to have the 7.85 tonne coming into the lake. So therefore the top part which takes up the balance of the loading up to the 19 tonnes gives you an indication of what you might say is the convertible loadings: in other words by changing various things in that top box we could in actual fact reduce the nutrient loading.

The first one is obviously the option of sewerage: 2.9 tonnes. We can put in a plant there, remove 2.9 tonnes of nitrogen, and maybe remove about 30% of phosphorus at the same time. The other options are for us to start converting land use, and you can see from that you can drop down in terms of the convertible load. Now throwing some sums at this, suggesting that changing the whole of the pastoral land to forestry, (now we're not suggesting you do this), we're just saying if you were to do it you'd get rid of about 45% of the convertible nitrogen load and it costs about $300,000 per tonne to do that conversion.

If you go to the sewage treatment system, and I've covered a couple of those points, you start looking at the capital cost of about $3 million to put a sewerage system into Okareka. You've got about $280,000 for operational costs and if you take it on a net present value over a 20-year period, you spend about $6 million and you've removed 2.9 tonnes per annum, so overall you're about $2.1 million per tonne for a sewerage scheme and you've only removed 15%.

Another aspect we've looked at is the public health. David Ray and his colleagues have already covered the ESR report, because what we were looking at there was with the public health issue of septic tanks, if we were to actually remove them how far back we could go and still rely on septic tanks. You've seen the figures there of 16 metres for bathing water standards.

Now there are about 17 tanks that are inside that zone. We could remove them for say $60,000. So then you say to yourself what's the risk if we move those tanks back? From work we've had a look at from the US EPA, there's often a higher risk of cross-contamination between bathers. So if you get a lot of people swimming in the same area, you're more likely to get cross-contamination than you are to get it from the ground water.

What about the wildlife impact? From information we've got, there are about 685 birds, but when you start looking at the faecal coliform and the streptococci that those discharge, you suddenly come to the point that they are a significant contributor. When you see the duck is five times that of a human, it looks as if water birds are equivalent to about 3,500 people, or 27,000 people with respect to streptococci.

Now when you look at the human population there, you find there are only 50 people who are likely to be in that 16-metre zone, so what's the public health risk there? Is it the wildlife? Is it the septic tanks?

One of the other things is land use. You can change the range of land uses and depending on what you chose, you could actually reduce the amount of nitrogen in terms of the pastoral discharge – so we don't necessarily have to convert the whole lake or catchment: I've covered that before.

In terms of value for money, if it's only $300,000 per tonne to remove nitrogen by conversion to plantation and $2.1 million for sewerage, we need to determine in actual fact what are the options out there, rather than just rushing in and spending that sort of money on sewerage given some of these uncertainties. I think there needs to be that debate and it needs to be very much for the landowners and the public. With the sewerage schemes you've got an ongoing cost of $280,000 to $300,000 per year for operational costs.

This then raises the question of possible scenarios. As you can see there in the black line heading straight up, from the work that has been done, if we do nothing you can see the TLI just keeps on climbing. OK, you can argue that that's at no cost. If you look at where we are now (about the 2000) you can see there the target TLI and you say well what we really need to do is to make a decision on what's the best way to get down to this target TLI?

If we went for a total land conversion and sewerage, you might be spending something like $9 million, but there may be some other options out there. In other words, with some land conversion and some sewerage, or maybe with just some land conversion you don't need to do the sewerage. You can see there's a range of options out there. I guess the other interesting thing is the Environment B.O.P. report talks in terms of having to remove something like 2.32 tonnes per year to bring it back on to the appropriate TLI, so from that point of view you can see that our target should be looking at bringing down 2.32 tonnes, and there's a range of options and I guess that's where, from our perspective, there's still work to do. We, with Environment B.O.P. and their document, will work together in the future to find what the final solution out there is. But the decisions are still to be made. Thank you.

Chair
Thank you very much Paul and I'm sure you've given us all a lot to think about, and I think we already have some questions and I'd like to be really brief so we can get back on time a little.

Questions

Amanda Hunt, Environment B.O.P.
Paul, I'm just wondering if you could let us know what the source of nutrient export co-efficients was please.

P.S.
We used the tables from NIWA and also from the Bioresearches data.
Sorry, I'm not aware of whether there are actually any cattle in the local Okareka catchment at present.

Noel Burns, Lakes Consulting
Paul, I was just wondering, in the land conversion are you removing nitrate and ammonia, because the trouble is a lot of these budgets when we do them, we are doing them in terms of total nitrogen. Much of that is inactive nitrogen material and if you take it out it doesn't do much improvement to the lake at all. You've really got to remove the soluble ammonia and nitrate, and we need to be very careful how we do these budgets to ensure that.

P.S.
I totally agree. I guess this is not a scientific paper. What I've tried to do here is to raise the awareness that just rushing in and doing a sewerage scheme and the ongoing costs of that, is that really the best dollar that we could invest? There is still obviously work to be done because we've just taken some data, put it together and said look at this as a concept, instead of just saying we are going to solve the problem like at Okawa Bay, by putting in a sewerage scheme. The end result we've seen today is – well it might be 50 years before you see any benefit. So we've got some money and the Council has provided about $3 million for the likes of Lake Okareka in the longer term, but is that the best value for the money, would we get a better return and get the lakes back quicker, or are there some other options there? That was the concept.

Gifford McFadden, Federated Farmers
The question I have for you is, that you've talked about using sewerage in regard to nitrogen reduction, but what is the likelihood you'll have to put a sewerage system in there anyway at a later date for public health reasons, because that then would alter the formula quite substantially wouldn't it?

P.S.
Well I guess that's what it comes back to on that land use, I mean one of the options could well be, say, for Lake Okareka to be converted into lifestyle blocks, and with that low density and some limitations on the stocking rates, it may well be that you can achieve that. It's that sort of question that I think we've got to answer.

Gifford McFadden
Sorry, that's not what the question was. The question was: will you have to at some future date put a sewerage system in for public health reasons, pending water purity or whatever. In other words you haven't in any way been purely delaying it?

P.S.
Well no, that's why we got NIWA and ESR to have a look at the separation distance to put the public health aspect into its right position and that result showed that if you were about 16 to 20 metres back with the septic tanks, the pathogens and viruses are retained, so they don't get into the receiving waters. With the soils around Okareka and places like that, maybe there is sufficient soil underneath that we don't have a problem, even if you carry on with the current septic tanks there. If there was to be increased development, that would change the picture, but that's what we are trying to suggest – that you've got to look at that land use and what it's contributing, but I don't know that you just want to put in a sewerage scheme for public health unless you can actually prove there is a public health issue there.

Chair
Our final question will be from Mark, because unfortunately it's lunchtime, but I'm sure all our speakers will be available for discussions during lunchtime and there's the forum later on when we'll all be able to have our say. Mark.

Mark Collet, Lake Okareka Ratepayers & Residents Association
Paul, you talked about retiring agricultural land. Would wetlands filter out the nutrients from the agricultural land equally effectively?

P.S.
I guess you've seen from Kit's work just before my presentation that there are potentials there for that, and I guess again that is what I believe has been a little bit addressed in the Environment B.O.P. report, that we've got to look at all of those land uses and see what we can achieve. I do remind you again though, of the number of water birds and the amount of pollutants that are coming out from there, and I know in the US there have been situations where they've had to close beaches because they've introduced wetlands. There is a need to look at the impact of that on the recreational use of our lake, so I think there's some trading there to be done to make sure that what we do does leave us with that sustainable lake.

Role of Environment B.O.P. regarding wastewater disposal issues in the lakeside communities.

Paul Dell, Group Manager Regulation & Resource Management,
Environment Bay of Plenty

Introduction

It was 1990 when Environment Bay of Plenty hosted a one-day seminar in Whakatane to discuss the concern over septic tank contamination in parts of the Region. The catalyst for the meeting was concerns expressed by the Medical Officer of Health, over contamination levels in water and shellfish. Omokoroa and Waihi Beach were two areas where monitoring had shown increased bacterial levels in streams, and drains, particularly after periods of rain.

I was not overly surprised that Waihi Beach was having problems, as in 1977 when I first started work for the Hauraki Catchment Board I undertook regular sampling of the streams at Waihi Beach. The levels of bacterial contamination back then were already high.

The 1990 seminar then was a good opportunity to bring together both the staff and politicians of the Regional Council and Territorial Local Authorities, along with health experts, and Professor Ian Gunn (an expert in on-site effluent treatment) from Auckland University to discuss the issue.

As a result of the meeting it was agreed that Environment Bay of Plenty would undertake a study into septic tank effluent contamination throughout the Region.

The study resulted in the report "Investigation of Septic Tank Effluent Disposal in the Bay of Plenty" which was completed in August 1992. The report concluded:

> *"From the initial focus on water quality it could be seen that generally the water quality of the unsewered areas of the Bay of Plenty is excellent. If septic tank effluents had a localised adverse effect then the diluting action of the estuarine or lake water was effective in reducing the impact to acceptable levels within a short distance. However as the margins of estuaries and lakes are highly utilised by the public …, these localised impacts can be important"*.

Waihi Beach was identified as an area that required urgent action. I am pleased that in the summer of 2001/2002 a new system was commissioned to service Waihi Beach, Athenree and Pio Shores/Bowentown.

In late 1992 Environment Bay of Plenty commenced preparation of a Plan to deal with on-site effluent treatment.

Operative On-Site Effluent Treatment Regional Plan

Environment Bay of Plenty's On-site Effluent Treatment Regional Plan became operative on 1 December 1996. It must be said that the "birth" of this Plan was not easy and was thwart with difficulty. At the start of the process the team were buoyed by expectations of being able to "make a difference". It was always expected that the plan would allow the TLAs to become proactive in managing the clean out and inspection regime in the identified sites. One reason for the high expectation of this approach was the positive feedback that was received from Ian Gunn. Ian considered the approach in the plan to be "proactive" for New Zealand as it was becoming more common overseas. As with any "new product" further improvement can be made over time and this is in fact what is being done. The first Plan Change has already made some amendments, particularly recognising the changing technology for on-site effluent treatment.

The response by the District Councils has been variable. None of the District Councils have wanted to take on the "managed clean out and inspection regime" that the plan promoted. However the reasons for this have been quite variable. One Council has wanted Environment B·O·P to implement the clean out and inspection regime while they dealt with the community on assessing long-term options. This same Council sees Environment Bay of Plenty's approach as assisting them in reaching their own goal. On the other hand another Council does not consider the clean out and inspection regime to be of any benefit.

The implementation methods require that property owners in the identified areas must upgrade their systems to comply with the permitted activity conditions of the On-site Effluent Treatment Regional Plan by December 2004. Also if consents are lodged for a community system by December 2001 then the three-yearly clean out inspection regime and upgrades can be deferred. Clean out and inspection can also be moved to a six-year cycle if an effluent filter is added at the end of the septic tank to prevent solids from clogging the soakage field.

It has, however, also been Environment B·O·P's position that at some point contamination will still result even if systems are upgraded to the permitted activity standard due to a number of other issues, including density of dwellings. Septic tanks were never seen as a long-term option for high-density housing. This has been an evolving issue where over time infill housing, home upgrades and full-time occupancy have conspired to increase housing density and septic tank usage at lakeside and estuarine settlements.

It would be appropriate at this time to review the actions to date on the 14 identified communities, identified as exhibiting increased septic tank contamination in the receiving environment.

Waihi Beach	-	reticulated system: remove from Plan
Athenree	-	reticulated system: remove from Plan
Omokoroa	-	Pipeline proposal
Maketu	-	Options being evaluated
Little Waihi		
Tanners Point	-	Upgrades/inspections
Woodlands (Opotiki)	-	Upgrades/inspections
Okareka	-	Options being evaluated
Tarawera	-	Upgrades/inspections/further monitoring
Hamurana	-	Upgrades – remove from Plan
Hinehopu	-	Options being evaluated
Okawa Bay	-	Further investigation/options being investigated
Mourea		
Gisborne Point	-	Further monitoring/upgrades/inspections

It should also be noted that Te Puna and Ongare Point are to be added at the next Plan change.

Environment Bay of Plenty's Role

Under the Resource Management Act (RMA), Environment Bay of Plenty is responsible for the management of discharges to water or land where it may enter water. This in turn places a duty on Environment Bay of Plenty to assess the impact of such discharges on the wider environment and therefore the wider community. There are clearly liability issues for Council. For on-site effluent treatment systems, the wider environmental monitoring will assess cumulative impacts on the receiving environments, however Council also needs to be able to assess the suitability in an efficient way of individual systems.

Whereas the District Council may approve an on-site effluent treatment system under the Building Act, this approval does not authorise the discharge. This is the responsibility of Environment Bay of Plenty and as such there is a duty on Environment Bay of Plenty to ensure that systems either meet quality criteria or the specified Best Practical Option (BPO). Environment Bay of Plenty has an operative On-site Effluent Treatment Regional Plan to authorise these discharges.

Due to the large number of on-site effluent systems and the fact that they do not have their own individual environmental monitoring system, Environment Bay of Plenty has adopted the B.P.O. approach in the On-site Effluent Treatment Regional Plan. To assess compliance with this approach the clean out and inspection regime has been introduced. The results of the inspections have shown many systems fail to meet the necessary criteria (Table 1). The two major problems have been undersized tanks and shallow groundwater.

Maintenance of on-site treatment systems is essential to ensure the integrity of the system for its long-term use, by minimising the opportunities for failure and consequential adverse environmental effects. However, most residents in the Bay of Plenty region do not maintain their septic tanks to keep them in good working order, mainly through ignorance of the need to do so, or of the existence of the system at all. There is very much an "out of sight, out of mind" attitude.

Managed clean out and certification is also being done in other parts of New Zealand by District Councils. These are New Plymouth and South Taranaki District Councils and Waitakere City Council.

Matters to be addressed

I consider there are three components to be considered when addressing the issue of septic tank contamination. These are:

Interpretation of environmental data;
Individual system constraints;
Funding.

(i) <u>Interpretation of environmental data</u>

One of the issues to be resolved is whether the community is willing to accept contaminated seepage areas around lake margins if bathing suitability standards are met. Bathing suitability is assessed at the depth of a person's calf where dilution will lower contaminant levels. However young children often play around the edges of water where contaminated seepages occur with consequent higher bacterial levels. Increased nutrient levels can also impact lake margins although they may be only a small component of the wider lake nutrient budget.

A further issue is whether the community feels comfortable with increased levels of contamination as long as it is below certain levels.

(ii) Individual system constraints

The following will impact on how well an individual system will operate.

Pre-treatment level (tank)
Groundwater depth
Soil category
Restrictive soil horizon
Barrier to horizontal soakage/flow
Proximity to surface water
Soakage system type
Density of development

At this point it is important to reinforce that on-site effluent treatment involves two components, the tank and the soakage system. The tank can be considered pre-treatment, with much of the remediation of the effluent occurring in the soil. It will be noted in the above table that many of the constraints will impact on the soakage system. It is the soil that will remove the bacteria and phosphorus. Unfortunately the nitrogen once below the root zone will predominantly be lost to groundwater and eventually therefore to the lake or estuary.

In many of the lake and estuarine communities, shallow groundwater and the use of soak holes results in minimal renovation of effluent by the soil. Essentially soak holes are designed to soak effluent away and not treat it.

(iii) Funding

I accept there is a range of funding philosophies to consider when assessing the upgrade of septic tank systems. However I contrast the issue of lakeside community wastewater disposal with dairy shed effluent treatment.

Over the last decade the majority of farmers have moved to land-based dairy effluent treatment systems. The advantage of this has been the reduction in bacteriological and nutrient contamination in most lake catchments. Some of the spray irrigation systems have cost farmers in the order of $35,000. These costs have been born solely by the individual landowner. In contrast there appears to be a different view as to the need or justification for urban property owners to pay the cost of treating their effluent to reduce the impact on the receiving environment. Under the RMA a septic tank discharge is no different to a dairy effluent discharge in that it is a point source and requires authorisation. It is also relevant that in some cases individual upgrade costs could be very expensive, and therefore a community solution may be more affordable.

Summary

Under the Resource Management Act Environment Bay of Plenty is responsible for authorising the discharge of contaminants to the environment from on-site effluent treatment systems. It has chosen a B.P.O. approach and as part of its duty to monitor compliance with this approach it has implemented a clean out and inspection regime. This regime has been applied in a number of communities within the region where monitoring has shown increased levels of contamination in groundwater seepage. Similar programmes exist in other parts of New Zealand.

The clean out and inspection regime is also considered an important component for the maintenance of on-site effluent treatment systems and ensures that individual property owners better understand the need to maintain their system.

Environment Bay of Plenty is responsible for wider environmental management and to a large degree must act as the conscience to District Councils and communities on this issue. District Councils do have differing functions from that of the Regional Council and may therefore approach such issues as septic tank contamination from a different viewpoint.

Table 1: Analysis of Septic Tank Inspection Programme Results

Town	**Passed**	**Failed**	**Failed on Tank Size**	*Demerit Point Range*				**Number Inspected**
				5-9	**10-14**	**15-19**	**>20**	
Athenree	26%	74%	77%	93%	6%	0%	1%	208
Waihi Beach	24%	76%	75%	93%	6%	1%	1%	680
Tanners Point	44% 37	56% 47	77% 36	91% 43	6% 3	0% 0	2% 1	84
Omokoroa	47% 328	53% 375	44% 165	86% 323	10% 37	3% 10	1% 5	703
Maketu	50% 167	50% 165	48% 79	83% 137	13% 22	3% 5	1% 1	332
Little Waihi	26% 11	74% 31	45% 14	68% 21	23% 7	6% 2	3% 1	42
Woodlands	41% 118	59% 171	43% 74	94% 160	5% 9	1% 1	1% 1	289
Hamurana	46% 54	54% 63	60% 38	90% 57	6% 4	2% 1	2% 1	117
Hinehopu	15% 6	85% 35	31% 11	60% 21	26% 9	6% 2	9% 3	41
Gisborne Point	21% 24	79% 91	46% 42	76% 69	15% 14	7% 6	2% 2	115
Okareka	27% 64	73% 169	64% 108	81% 137	15% 26	2% 3	2% 3	233
Tarawera	40% 121	60% 178	51% 90	74% 132	21% 37	3% 5	2% 4	299
Mourea/Okawa Bay	36% 39	66% 71		80% 57	13% 9	4% 3	0% 0	108
Overall inc. Waihi & Athenree								3251
Overall exc. Waihi & Athenree	41% 969	59% 1394	50% 657	83% 1157	13% 177	3% 38	2% 22	2363

A number of identified communities will be removed from the programme as the result of a partial or full community system being implemented or individual upgrades being undertaken. In some instances more detailed monitoring may be required to determine the best outcome. Additional communities have also been identified for inclusion in the programme.

This (*table above*) shows you some of the results from the clean out programme from our first round. If you look, for example, at some of the catchments near Lake Okareka, you'll see that about 64% of the systems failed there because of tank size – but that still means that about 36% of the failures are because of other reasons and that could be problems with shallow groundwater and so forth. So across the board there is variability throughout the area. In one area (at Omokoroa) only 44% failed on tank size. In fact they hold the record for a tank where we put dye in the bath, let the bath out, it went into the tank, there was no bottom in the tank and it turned up through a drain in the harbour very, very quickly; so again these things are very real and we've been able to pick up a lot of these things through the inspection regime and sort out what has to be done.

Funding I think is a difficult one and it's not for me to tell you how these things will be funded, but in my paper I do make the comment that on-site effluent treatment discharges are a point source and in that point of view it is no different from a dairy farm point source, from a dairy cow shed effluent that are all regulated by Environment B·O·P as consents. All of the farmers are moving to land-based systems and most farmers are spending about $35,000 to do that, and that is a cost that they are having to pay for their point discharge.

So I just thought I'd make that point that an on-site effluent treatment to me is no different in that it is a point discharge at the end of the day. There's a tank and there's a pipe and it is coming out of it. At the same time, Environment B·O·P does have a project to evaluate if there's justification for our Council to contribute to sewerage schemes. It's really an economic environmental analysis, our Consultant is going round all the District Councils and consulting with them, the information to be reported back to Environment B·O·P.

And so there is something there, but again if you look at the government's policy - and Paul Sampson and I have both looked at it and talked about it - we recognise that the government has written it in such a way that it's going to be very difficult to lever many dollars out of central government. We don't know what our report will say when it goes back to Council or what our Council may do. The only thing I'd say is I wouldn't hang our hat on Okawa Bay necessarily being the first one off the block at this stage.

In summary, there's no doubt that on-site effluent discharges are impacting parts of the environment in the Bay of Plenty. We see this in a number of areas and whether it's bacteria or nutrient does vary, because we've seen in Okareka that nitrogen could be an important issue, we've seen at Hinehopu that bacteria is an important issue, so we've got to understand what the drivers are in different areas. The majority of these areas are lakeside and estuarine communities. The contaminants of concern are the bacteria and the nutrients. I believe that in the Bay of Plenty context at this time the lakes are more susceptible to nutrients than estuaries.

In the estuarine environment we've more or less focussed on bacterial problems rather than the nutrient, because we haven't seen a big nutrient issue, but in the lakes we do think that there are areas where nutrients will be important. Increased development is likely to cause contamination problems and we're seeing communities where people are moving away – Waihi Beach was a good example. It started off as mining cottages, it's now become million dollar homes where people have retired, and at Christmas 30 people visit, tents on the lawn or staying in the house, and the toilets, basically they just hang a rock on the flush part because it's basically a continual system. There are so many people loading into those systems.

Under the RMA Environment BOP does have a duty to authorise on site effluent discharges and we therefore have a duty to monitor compliance. There are liabilities for our Council if we don't do that. In the identified areas compliance for us involves assessing BPO (Best practical Options) and we believe it's been a very successful way of bringing not just the community awareness up, but ensuring that good practice is being put into play. Under the RMA we also have a duty to manage and monitor that wider environment and being regional, we take, I think, a wider perspective for not just the local community, but for a far wider community.

I believe actions are being taken to address the contaminant issues and a lot of those have been talked about today, but it's going to be the communities that are an important part of that decision-making. That's why I think the work that both Paul and my own team have done in looking at Okareka, is now going to be about talking to the community and saying that there are a whole lot of options, these are the dollars against those options, what are we willing to spend, what are we hoping to achieve? And that is going to be very important.

I'll leave you with the last one: that it's not easy to define at what point on-site effluent treatment systems are no longer viable. Back in 1982 I was in the Environment Court in Hamilton for a rural lifestyle sub-division and that very question was posed at that time about clusters. At what point would on-site effluent no longer be sustainable? And we had to basically say at that time to the Court, that there is no simple answer, but you do find there comes a point where you monitor and find contamination levels increasing and therefore you have a problem. So, in closing we must ask ourselves at what point are septic tank systems no longer viable. Thank you.

Chair
Thanks very much for those points Paul. Your concluding comment – at what point are septic tank systems no longer viable – is a controversial point to finish your presentation on. What I propose is to just take any questions of clarification.

Questions

Bill Holden, Lake Okareka Ratepayers' and Residents' Association
From a layman's perspective, and we're basically looking back at the Lake Okareka situation again, it seems to me that both the Council and Environment B.O.P. seem to try to look confused, but from my perspective it actually seems a lot simpler and you might be able to help me untangle this. From where I'm sitting, it seems to me that the septic tank problems or the effluent disposal of the built-up areas is really the responsibility of the Council; and that the effluent disposal of the rural areas seems to me should fall on Environment B.O.P.'s side. So when each of you are sort of saying well, there's no funding for this and there's no funding for that, surely one of you can fund one part and the other one can fund the other. Am I being a bit simplistic or not?

P.D.
I think if you look at my paper, I don't pay, or my Council doesn't pay, the farmer $35,000 to put in his spray irrigation system, so I think what I was saying in there was as a community you are contributing with a point discharge into the environment. If it's determined that's having an unacceptable impact and something has to be done, then you have to weigh up who should pay for that, and I think that is the issue because we deal with a lot of industries. Tasman Pulp & Paper have spent $10 million cleaning up their effluent. I am sure you wouldn't want as a ratepayer to be paying $10 million to clean up Tasman Pulp & Paper's effluent, just as you wouldn't want to be paying to clean up farmers' effluent. So you have to look at where the contaminants are coming from and that's a big decision to be discussed. That's where I don't think there's confusion between the district and the region, I think we are now presenting a very similar presentation to the community, but decisions are going to have to be made because I am not sure if there is someone with a chequebook just hiding round the corner at the moment.

Chair
I think we'll draw this section to a close. So again thanks very much for your participation.

The next session is the panel, chaired by Professor David Hamilton who holds the new chair of Lakes Management and Restoration at the University of Waikato. We are doing three things in this: David's going to bring the issues together and lay them out for us. Secondly, we have had one contributed presentation, which will be very brief, on alternative sewage treatment. Then we're going to bring all the presenters and any other scientists and engineers to the front for the Technical Panel Session. Professor David Hamilton – thank you very much.

Technical panel session

Chaired by Professor David Hamilton, Chair of Lake Management and Restoration, University of Waikato

Thanks Ian. You've pretty well introduced what I was going to say. The format of the session will be that I'll give a very brief introduction to it. What I don't intend to do is to actually draw conclusions. I'll leave that for Warwick Silvester later in the day, but what I do intend to do is to raise issues more than anything else and intend to put those issues as starting points to the panel, which will consist largely of the speakers from this morning and we'll also have a talk from Peter Gearing and Gujja Magesan.

Paul Dell made the point that our dispersed population has been one of our blessings and indeed it has, but it also presents some fairly unique problems, and one of those is that we are currently dealing obviously with a lot of septic tank issues and issues of relatively diffused sources of pollution, and that in itself presents some special difficulties that we are now encountering. We are encountering them more and more as our population obviously expands, and we're starting to deal with some of the issues relating to nutrient inputs to the lakes.

We also know that there's no 'silver bullet' in terms of fixing these lakes and so what we're looking at is basically incremental changes to, in particular, nutrient inputs from the catchment in order to be able to, hopefully, incrementally change and improve and restore the water quality of the lakes. It's also quite evident that a holistic approach is going to be quite essential and it's a point that was made by Arapeta Tahana, that we need to interconnect the catchment and the components of the catchment, being forestry, pastoral and urban land use for example, with the lakes themselves, and also the wetlands that surround the lakes.

I'm not going to talk so much about the pathogen issue at this stage, only in the knowledge that improved treatment processes are obviously going to reduce the likely incidence of pathogens, with the possible exception as mentioned this morning of birds in particular, and potentially wetland restoration. But in general the assumption will be that nutrient removal is going to mostly favour pathogen removal.

So to deal sequentially with some of the topics here, and I've listed them as three main topics, one has been the wastewater treatment process, another one has been Okawa Bay and the final one is Lake Okareka. Let's deal sequentially with those topics. Technologies for wastewater treatment we know are evolving very rapidly and the real challenge here is that we need to take into account these evolving technologies, looking into the future, and also to take account of what the likely limiting nutrients are in some of these systems.

If we take Lake Okareka for example, we still are relatively uncertain of which nutrient exactly to target because as Noel explained this morning, it appears that phosphorus may be the limiting nutrient in that lake and yet most of our target at this stage has been to try and limit nitrogen. Obviously what we want to do is concurrently to be able to control nitrogen and phosphorus, but there are certainly different treatment technologies for both of those nutrients and in particular if you look at treating for nitrogen using denitrification, that's quite a different process to being able to treat either biologically or chemically for phosphorus. So we really need to make decisions fairly soon that will have far-reaching implications in terms of nutrient removal and which nutrient we're going to target.

Another aspect is we need to be able to start to balance the capacities of forests versus soils versus wetlands in terms of nutrient removal processes. We are obviously overloading some of these systems under current scenarios with excess nutrients, and so we're really going to have to evolve, I suppose relatively rapidly, knowledge of the absorption capacity of these systems in relation to the nutrients that are applied to them.

Before I go on to Okawa Bay, just a point that Kit raised which I think is quite important – if we look at the wetland systems we know they've got a response time and Kit estimated a response time in the order of two years. Each one of these systems is obviously going to have a response time that the presenters may want to take into consideration in the panel discussion. Now if Kit's working with a response time of two years for the wetlands, then we can assume that the bigger the system is, and for example Lake Rotoiti, the greater the response time is going to be, and so this has to be also built in to a public perception of just how quickly the systems will respond and what the public sees in terms of changes and improvements to the lake.

OK, Okawa Bay. As we've seen there's been some excellent scientific work done on Okawa Bay, and knowledge scientifically for the system is still evolving; I suppose that's one of the challenges of science in many ways at present. Some of the ecosystems and lakes in particular are changing so rapidly that we actually need to evolve the science to more rapidly generate some answers in terms of management applications. So we need to have informed decision-making on the basis of the science that exists at the present point in time, and on that point I guess we can commend Ian and the Lakes Water Quality Society for basically the purpose of this workshop, which is to communicate the best available knowledge of the engineering and science that exists at the present time.

On the point about rapid changes in systems, I've been having a look back over Hilary Jolly's work in the 1950s on Lake Rotoiti. Lake Rotoiti really had very limited deoxygenation, in other words oxygen levels were still moderate right throughout the summer in that lake. Lake Rotoiti currently is completely depleted and devoid of oxygen for about 7 or 8 months of the year over a large part of its water column. In fact more than 50% of the depth of the water column has no oxygen. So that's the current situation and that's evolved over a period of about 40 years, and that's still within what we'd say is one generation, so we have seen rapid deterioration of these systems and hopefully the response times are fast enough that we can also see rapid improvements in the systems.

The options to manage nutrients in Okawa Bay are perhaps fairly limited in terms of catchment inputs and as I said, there are most likely going to be small and incremental changes to the water quality of Okawa Bay. It's obvious too that there is potential and there are still very wide limits in terms of nutrient release of sediment from sediments in Okawa Bay. Here we have perhaps the potential to target one mechanism that is a very large component of the deterioration of water quality in Okawa Bay, and that is the sediments. There are management techniques that have been used very successfully and unsuccessfully for targeting nutrient release from bottom sediments of lakes and particularly in smaller lakes. So on that point I'll introduce our speakers.

Subsurface drip irrigation – appropriate technology for on-site disposal

Peter Gearing, URS New Zealand

Thank you David. We're late runners for this symposium. We're environmental engineers and we work very closely with Forest Research, and we've been asked to just give a quick presentation on some of the projects that we're involved with and some of the techniques that we're using, as they may well have application in this region. We also work very closely with Paul and his team and we are quite pleased to see that he's given us a reasonable good vote of confidence on our solution at Omokoroa, and we're also working very closely with him at Waihi Beach.

Prior to lunch there was a statement made that there's no sequential batch reactor in New Zealand that was removing both phosphorus and nitrogen. We've designed one which is about to be built at Pauanui, so we have quite an intimate knowledge of both wastewater treatment systems and disposal, but there's always a high cost associated with the capital equipment of sophisticated treatment, so one of the key areas that we're investing heavily in is looking at sophisticated land treatment to hopefully reduce a lot of the capital cost and the burden on small communities.

Also before lunch the Taupo scheme was mentioned. That was a scheme that we designed in the early 90's and that was one of the first places in New Zealand where a trial was done with sub-surface drip. We looked at that as one of the options for the Taupo system, which is in effect about 150 hectares of land being irrigated there. From there we became quite interested in sub-surface drip and that's really one of the key things that we'll be just quickly running through today, so in essence we're talking about a lattice work of sophisticated pipes and design below the ground where there's no human contact with the wastewater.

So some of the key advantages are that there are health advantages, environmental advantages. In terms of straight irrigation it's quite often a superior method to sprinklers. There's now a significant amount of research both within New Zealand and internationally being undertaken with sub-surface drip, but with the specialist techniques to make it work. In terms of health advantages there's no human contact with the wastewater, because clearly it's being put below the ground if the design has been done correctly and the rates are all organised correctly. Conversely there are no aerosols, also no smells and no risk of viral contamination typically, if everything's been designed correctly and the pathogens are neutralised prior to ground water, again if you've got your act together.

Environmentally no cross-contamination of surface rain run-off, which is important I guess in the lake environment and the stream. You're putting the nutrient right at the root zone for maximum uptake of the plants, groundwater is protected, disposal area can be used safely and productively, where you like to think that the wastewater can be used as a resource not a liability. We'll show you some examples of that, and we've had a very positive feedback on most consent applications we have been involved with from the Tangata Whenua who see that it meets many of their cultural demands in putting effluent back through Mother Earth.

Sub-surface drip has several important characteristics. Organised correctly you can get a very uniform distribution across the total disposal area, giving a very even application. The surface remains dry and there's typically less running costs compared to sprinkler systems such as in smaller pumping, smaller power charges and typically less maintenance costs.

However there are important things that we've found that need to be considered. Typically, sophisticated systems are impregnated to stop root intrusion, methods of injecting chemicals probably will not comply in the very near future, tubes lined with bactericide are more reliable, compensating emitters allow you to get a longer run length, wide internal pathways help avoid blockage and so on. Another key advantage is that by putting it below the ground you wet up a larger soil volume that you do if you put the irrigation on the surface, and that means that you have a more oxygenated environment for breaking down the wastewater and also the area is less saturated, meaning you can get your rates higher.

This is one of the first systems ever done in the southern hemisphere. This is one I did for Oakley in Melbourne. It's a landfill leachate system, that's the bright green area with the typical half dead Aussie grass around it. This is actually on one of the most prestigious baseball diamonds in Melbourne, so it's used quite extensively.

This is a 5-hectare project at the New Zealand Aluminium Smelters – that's actually on Department of Conservation land. Those of you who know the site will recognise the spent cathode liner pyramid out the back there. This system is accepting about 300 cubic metres a day and actually sits above the aquifer that they take their drinking water from. It has operated since 1998 now, effectively trouble-free and won an Environment Southland's Corporate Award for Excellence in the year 2000.

This is a project that we've had involvement with over years just north of Auckland, which may have many of the characteristics similar to what you people are involved in with your lakes. This is Omaha where it is a peninsula out here which is effectively houses from there down and a developer has now put another series of houses down here, about 400 of them. Sub-surface drip was used originally for crop-growing here and the Council had its own area of short-rotation eucalyptus here. There's also a neighbour who actually purchased the wastewater and used it for growing crops, and that's an example of it there. Those were actually exported, those crops. Recently part of a new residential development was to extend the existing 9-hole golf course to an 18-hole golf course. We have all under the fairways here sub-surface drip and that's going to take about 600 cubic metres a day when the system is fully developed, and there's about another 1200 cubic metres a day going out onto the short-rotation eucalyptus.

Like we say, root intrusion is quite important. This is an example of a product that wasn't protected against it – it didn't have the internal impregnation, and what actually happens is that the roots grow through the outlet orifice. This is inside the pipeline. So here's the roots, they're very fine hair-like roots inside it and they effectively cause the system to die.

This is a pipe chopped open – this is from the aluminium smelter after about 18 months worth of use, so you can see the little internal pathways up here are all perfectly clean and the pipeline with the bactericide lining has effectively accumulated nothing.

Buoyed on by our success with treated wastewater, we have now moved to an experiment at Waihi Beach where we're using effectively untreated wastewater, so this project takes raw effluent from the community. Well that was the theory, we've been doing that for about 18 months, but now we're drawing from the main pond on the new treatment plant where the levels are a lot lower than they told us that they were and we're effectively working with activated sludge, but are still treating it very inexpensively and putting it through underneath a short rotation forest with sub-surface drip. We're working very closely with Forest Research in terms of monitoring this and Gujja will give you a bit more of an outline on what's happening there.

Gujja Magesan, Forest Research
You can see from the sketch, the development of this site and this was taken very recently, where you can see very healthy trees. Because of the time, I will just briefly mention what we are involved in and what results we have found. Forest Research is looking at the soil water quality, groundwater quality and the tree crop monitoring.

Here is a sample of groundwater concentrations of nitrate. There are two nutrients, as we all know, which affect water quality. One is phosphate and the other is nitrate. Phosphate, in the concentrations we have found, was very negligible, almost zero, so I have not made a graph, and as you can see the nitrate concentration in the groundwater is less than 2 ppm. We conclude that the land application of effluent used in sub-surface irrigation in the past two years has not affected groundwater quality. Thank you very much. If you have any questions, these should go to Peter. Thank you.
(*No slides were available for this presentation – Editors*)

Technical Panel (continued)

Professor David Hamilton

The Okawa Bay issue and Lake Okareka. I thought I'd begin with the wastewater treatment process and what I'd do is encourage one of the experts here to contribute and start by reiterating one of the questions that I asked before, which was: do we target nitrogen or phosphorus in the wastewater treatment process and do we potentially have a series of different treatment processes operating for different catchments, so that we can target each one of those? So perhaps if one of our speakers from this morning would like to begin with a consideration of that.

Steve Couper

As we've discussed, it does depend on what the requirements of the disposal environment are, so if the requirement is to remove phosphorus as the key nutrient, well then we obviously need to gear our treatment systems for that, and there's a number of biological and both chemical and physical processes. If it's nitrogen, then obviously we've got to gear them for that. There are options to have a number of processes within a plant or within a system train, so we can achieve both nitrogen and phosphorus removal, and indeed the biological treatment plant at the main Rotorua system tends to do that as well, so the technology is there. I guess it ultimately comes down to the cost and the dollars and the benefits that you're going to get out it, and that was what Paul tried to allude to in his talk a little bit. We've got to get some perspective in terms of what money we put in versus what environmental benefits or values we actually get out from it.

Paul Sampson

One of the things with the wastewater treatment plant down here was we tried to balance the two and get N and P out at the same time, and we found that we weren't achieving optimum on both. Therefore when we went through this last upgrade with the resource consent, we looked at the fact that up in the land treatment system there was a high potential up there for it to retain phosphorus. That's when we made the decision, given the fact that the nitrogen wasn't coming out up in the forest, to optimise the design of the plant for nitrogen removal with the addition of the carbon source. So I'm just reiterating that we can play around with the techniques, but we found that when you're trying to optimise for both, you don't get the best. The SBR from the Taupo experience was shown to be great in getting rid of the nitrogen. We did find when we first commissioned that plant that we were actually removing a high percentage also of phosphorus. I don't know how the technology has changed since then, that was 10 years ago, but in a low-loaded SBR we actually found that we were getting a very high phosphorus removal also, so it is horses for courses.

D.H.

Based on Noel Burns' talk this morning, it's pretty evident that some of these systems are fairly finely balanced and it would appear that having some flexibility in terms of treatment, whether we target phosphorus or nitrogen, is perhaps going to be fairly important. On that point Noel, I just wondered whether where nitrogen fixation potentially comes into considerations here, we've talked about targeting both nutrients, but evidently if we target nitrogen at the expense of phosphorus we do run the risk of increasing the potential for nitrogen-fixing blue-green algae to actually increase nitrogen concentrations within the lakes.

Noel Burns
I'm just speaking now from instinct, rather than knowledge, but if you actually have a balanced lake where you are altering the limited algae from the nitrogen to the phosphorus type, I think you have probably minimised the opportunity for nitrogen fixers to establish themselves, because if this nitrogen limitation is beginning to evolve into dominance, then the nitrogen becomes available and the phosphorus runs out, so they lose their position and the other type come in. So I think a balanced type of lake would probably indirectly minimise the nitrogen fixation problem.

D.H.
My next question is probably directed more to Kit, and that is to what extent have we been successful in quantifying the overall nutrient loads to the lakes and partitioning sources, and I guess it also relates perhaps to David's talk earlier this morning in which he looked at the septic tank nutrient inputs and if we are to perhaps target those we are looking at relatively small fractions of the overall nutrient budget. So where perhaps should we be directing a lot of our attention?

Kit Rutherford
Yes, I mean the external loads, things that you can often get reasonable numbers for, I think the discussion this morning was focussed on the fact that there is a lot of information available about how much nitrogen enters septic tank systems. There's a certain amount of information about how much of that nutrient is retained within septic tanks and finds its way out into leachate fields. There's been a lot of work on nitrogen yields from various land uses, so external loads on lakes are reasonably quantifiable. I think the major difficulty with forecasting the fate of these Rotorua lakes is that internal nutrient load, the large stores of nutrient which we know are present in the lake sediments, but we have very incomplete understanding about the processes by which those are either buried and permanently lost from the system, or recycled back into the system.

I'm a modeller, so I feel reasonably confident about putting first order estimates on those external loads. Noel raised a very important point that most of the measurements that are made of nutrients loads in streams are in terms of total nutrients. One component of that is in particulate form, and one of the big debates which, when I was a young scientist without grey hair, was discussed extensively in respect of Rotorua, was what fraction of the catchment load is bio-available. In other words, it actually influences the algae in the lake. What fraction goes in as particulates, disappears into the sediments and plays no role. I think Noel sounded a warning this morning in respect of Paul's talk, but it's true that probably in all of our estimates of loads we have to assess the bioavailability of the loads that are coming. And that is a very difficult area where the plant physiologists probably need to engage in the debate, because I think there are some unanswered questions there, just about the nutrient needs for plankton and whether the engineering-type approaches that we make to nutrient budgets were appropriate.

D.H.
The other aspect that I raised during my talk was, (and perhaps there are several speakers who would like to address this, ranging from the application through to forests, through to wetland treatment and so on), do we understand enough now to be able to balance the assimilative capacity of these systems, whether they be the forest or the wetland, against the actual nutrient inputs that we're putting onto the land? So

perhaps if someone would like to lead away, in particular with regard to the forests perhaps, do we understand what sort of application rates, in relation to the forest type, the soil type will bring about sufficient decrease in, for example, nitrogen concentrations?

Gertie Gielen
Currently we do some research in different soil types and the effect of effluent irrigation. The rate of effluent irrigation has a similar capacity of the soils. The experiment is ongoing so I can't give you any definite answers yet, but we do have some ideas that from previous work there is a lot of nitrogen being stored in the soil, as compared to taken up by the trees or leached away. I can give you an example – at the moment the amount of nitrogen that's being put into the land treatment system in Whaka forest takes about 1-2% of the total nitrogen that's being stored in the soil for a whole year. The application in a whole year is only 1-2% of what's already available in the top one metre of soil, so with a little increase in the soil storage the soil can take a lot of nitrogen.

Professor Warwick Silvester
I think I can add a few things to what Gertie's said from some basic physiological principles. Forests have the capacity to assimilate nitrogen, which is largely based on two things. One is the amount of immobilisation which occurs in the trees themselves and this of course has got to be in the wood because the foliage recycles every year. If you look at general productivity and how much nitrogen goes into wood, it's actually quite small because wood has a very low nitrogen content and what we're really talking about here is immobilisation of nitrogen. We talk about getting rid of it or it disappearing – the biological processes are very well known. Immobilisation into wood simply means that it sits in the wood and stays there at a very low level and the amounts that you can get rid of into a forest which has canopy closure is in the order of about 20kg to a maximum of 50kg per hectare per year. The other big side in the soil is actually also in organic material and that depends on its C:N ratio - the carbon to nitrogen ratio. If you have a high carbon to nitrogen ratio then the bugs that are decaying that will in fact take up the nitrogen as part of their process and immobilise that. The other major component is immobilisation into microbes and recalcitrant organic matter in the soil, and that immobilisation process is quite significant and much more than what would be immobilised into the growing wood, and we're talking of probably in the order of 100kg of nitrogen per hectare per year at max. So those are the levels that can be immobilised in that way and I think those numbers from overseas work and from some local work are generally quantifiable, at least in theory. The practice gets difficult actually measuring small changes in nitrogen against a big background of nitrogen – it's very, very difficult.

D.H.
I just wanted to finish with perhaps one last question for our panel here and after that I'll put it open to the audience. Members of the audience may wish to comment too of course, because there are many people sitting amongst the audience, of course, who also have specialist knowledge in certain areas. My final question relates to Okawa Bay and the release of nutrients from the sediments of Okawa Bay, and it seems that this bay isn't fitting many of the traditional models of deoxygenation or severe deoxygenation and then nutrient release. There seems to be a fairly steady stream of nutrients coming out of the sediments of Okawa Bay and it's not directly related necessarily to ground water as such, but appears to be a chemically- driven process

perhaps also related to the thermal structure of the water column and perhaps moderate, but not severe deoxygenation. So perhaps Max Gibbs might want to comment on this.

Max Gibbs, NIWA

The measurements that were done in Okawa Bay show a typical cycle of nutrient release from the sediments in terms of high summer release rates versus low winter release rates, in other words there is a temperature-derived cycle. The measurements that we made were in fact oxic release of nutrients and they weren't anaerobic conditions, in fact despite the chambers being in there on one occasion for up to 100 hours, we didn't achieve anaerobic conditions within the chamber. We had low oxygen levels, but this was not anaerobic. The difference between aerobic and anaerobic release is that under anaerobic conditions as you would get in the bottom of Lake Rotoiti you get a very sudden release of ammoniacal nitrogen, the ammonia form, which is reasonably readily taken up by plants, particularly phytoplankton. The biological process confirms that it can convert that to nitrate in the water column. In Okawa Bay we see a lot of ammonia coming out of the sediments, which is the form that you would see it in. There's no indication of anaerobic conditions changing or causing a very rapid release of that nutrient at any occasion, except in the Environment B.O.P. data there are pulses when anaerobic conditions obviously occur and you get a very much higher release rate.

D.H.

I think that largely covers the question I was asking, that there certainly appear to be sediments that do pulse nutrients occasionally, but also have sustained periods of release of nutrients, particularly nitrogen, on an almost continuous or, at least during the summer period, on an almost continuous basis. At this stage I thought I'd open up some questions for the audience. If you'd like to make them primarily of a technical nature and address them to specific people on the panel, that would be the best means of doing it.

Rowland Burdon, Forest Research

A question to Gertie or to Warwick. Regarding the form of nitrogen stored in the soil or in the trees, I understand that when you plant conifers you go to a system of considerable absorption of ammonium in the soil colloids. What sort of amounts of ammonium per hectare can you get stored?

Gertie Gielen

(*short gap in transcript – reconstructed from brief notes*)

Ammonium in the soil is not significantly leached, but it may be oxidised to nitrate, which is leached. In terms of trees, I think trees can take up ammonia and nitrate, so ..

Professor Warwick Silvester

Yes, I think one thing is that most of what's going on the forest of course at the moment is nitrate. Because of the nature of the reactor system, there is a small amount of ammonia going in, but for ammonia of course there are going to be two processes that will take in ammonia. One is into the cation exchange complex and the amount taken up there of course is dependent on the extent of mineralisation of the soil and also the organic matter, but much of the ammonia, as Gertie says, is going to be very quickly assimilated by either bacteria or the fungi or the trees themselves, or be very rapidly converted to nitrate and that nitrate becomes part of the general nitrate pool which is very mobile. So I think much of the ammonia that goes on is very quickly converted to nitrate.

Don Atkinson, Okawa Bay
The science that's been presented today shows quite a conflict in relationship to the nutrient bank and the inconclusive discussion associated with the inflows and outflows from Okawa Bay and how that is reflected. The NIWA report in actual fact relies on some relatively inconclusive statements and as stated by the Doctor, that it is not understood, but I would like to see that issue debated by the panel, seeing that we've got all the experts in front of us, and that is why the maths are effectively not adding up at the moment in respect to the presentation that we had this morning.

D.H.
Maybe I can make a brief comment on that before perhaps Kit makes a comment. I think one of the difficulties is trying to quantify the exchange between Rotoiti and the embayment itself. While we do have some record of currents at two depths through the NIWA study, it still is very difficult in trying to actually work out the water masses exchanged between the bay and between Rotoiti, and that is potentially I suppose a source of error that may lead to quite large variations in the nutrient loads between the two systems.

Kit Rutherford.
Yes, David's sort of half-answered the question for me. Unfortunately the behaviour of a small embayment like Okawa Bay connected to Rotoiti is an incredibly dynamic situation because the wind blows and then the wind stops blowing, and so you've got water sloshing in and out of the bay and the nature of all scientific investigations is you can't be there all the time and so you know, we've been there on two occasions and we measured what we measured. Unfortunately what we've measured is always influenced by what's happened in the weeks beforehand, about which we have incomplete information and so that unfortunately is the nature of the beast.

There is an immediate contrast between the work that I described this morning on Okawa Bay and the work that was done on Rotorua in the 1990s leading up to the decision to treat and spray-irrigate the sewage treatment, because there we had a data set going back to the 1950s when Hilary Jolly first started doing some work, and then when Geoff Fish came here he spent his entire professional life gathering data on the lake and that long data set included all the dynamics that I'm talking about. But of course because those dynamics had been studied for a long period of time, you were able to see some trends that are very difficult to pick up in the short-term studies of the nature that we've described. So what we've attempted to do to help this debate is to combine the insights that we've gained from long-term studies on other lakes with a couple of snapshot studies that we've had on Okawa Bay. Of course being scientists, we're always very quick to point out the uncertainties in the information.

I am half an engineer and half a scientist –the basic principles I think are there in that diverting septic tank effluents or reducing external nutrient loads on a lake must in the long-term result in the tragic state of the lake improving, but sounding the warning that on the basis of what we've seen in the short-term, please don't expect to see the thing turn into a Lake Taupo overnight if the septic tanks go.

Michelle Goethe, Rotorua Girls' High School
I've got an interest in involving students and the community – have all the options actually been looked at and have you looked at things overseas, for example with nutrient recycling? Is there some way we could set up some floating gardens or hydroponics that we could involve kids in, that could uptake some of the nutrients and generate some money and just be another one of these possible inputs that will help reduce the nutrients. Any ideas like that?

D.H.
I think you can be fairly confident that the work that's been done up until now is very much state of the art and is certainly based on the best available knowledge by the researchers that have undertaken that. As for environmental education, I don't know whether Paul Dell would want to make any comments on that?

Paul Dell
John McIntosh went overseas last year to look at a whole wide range of international experiences with lake management and one thing that was clear to us was that communities have to be engaged and understand what is happening with nutrients in their environment. John gave a very good presentation here in Rotorua some time ago on that, showing display boards around lakes explaining to people the nutrient cycle so they may better understand their interaction with that environment. In terms of the hydroponic aspect, we've actually looked at harvesting lake weeds and the report has just come to us and that will be presented shortly, which basically shows that the sort of return for the amount of effort, whether you put it in dollars or people, is so horrendous for what you're getting back out of it – it's not realistic. I think we are taking a holistic approach. Also the LakesWater Quality Society takes a very wide approach and with them we hope to look at some form of education module for the wider community about lake management and that may be going into schools, coming about within the next maybe 18 months if we can nail the money down. So there are quite a lot of those aspects being looked at as well.

Thomas Wilding
Just going back to the previous discussion on Okawa Bay, I'll contribute from my experience with monitoring the algae that for most of the time the bay does behave as a separate system to Lake Rotoiti. For most of the time you go to Okawa Bay and there'll be a prolific bloom there – you head over to Lake Rotoiti or Okareka and the water is clear, and I think that for at least summer and autumn they are behaving as separate systems. I have heard examples where the bay appears to empty out into Rotoiti and that happens occasionally, but I certainly would encourage a closer look at the exchange rate between Rotoiti and Okawa Bay before we assume that there is high mixing between the two.

D.H.
I think just following up on Thomas's point, we can expect it to be very different because one of the points made in the NIWA report was that the depth is only 3, 4 or 5 metres typically through which mixing is occurring, as opposed to Rotoiti where in summer the phytoplankton and the algae in particular are being mixed through perhaps 20 metres or so, so it's a very different environment physically in the embayment to what it is in Rotoiti itself.

John McIntosh
Can I just add to that – Thomas has referred to the biological communities in Okawa Bay being different to the biological communities in the rest of Rotoiti, but just commenting on our data from Okawa Bay where we sampled, we looked at when the lake was stratified and it was during that occasion that Max mentioned when the bottom waters ran out of oxygen that there was a large pulse of nutrients came into the lake, and a couple of weeks later it had completely disappeared. I would have looked at data like that and said we must have made a mistake, the high result was wrong, but I think to explain that – Kit's 5 cubic metres of water being exchanged (although I would have thought that was unlikely beforehand), is how that is explained. There is that big exchange, we did get a big release of nutrients, but it was quickly diluted out of Okawa Bay, presumably by this large exchange.

Chair
OK, we've got one last question in order to adhere to time.

Alan Jones, Okawa Bay
One comment that I would make on the Okawa Bay uniqueness, if that's what it is, is that it is a designated ski lane and on many, many occasions you can be there watching a dozen or more boats roaring around, and its like a washing-machine. Now what influence does that have in the middle of summer just prior to an algae bloom or in cutting the weed?

D.H.
Do we have any takers? You've put me on the spot now. One interesting aspect I guess of *Anabaena* in particular, which is the prominent blue-green alga that causes most of the problems, is that it does tend to like relatively static, still conditions and it's under those conditions that it can actually control its position in the water column quite successfully, and that's often the reason for the scums which you would have noticed would often form when the wind blows and it often blows those surface scums into embayments. My thoughts would be that water-skiing might even stir up those sorts of scums and create conditions that were less ideal for the *Anabaena*, but I guess there are other issues that we would need to consider.

Lindsay Brighouse, Lake Rotoiti
It was earlier referred to that there was quite a massive sawmill on the side of Okawa Bay, apparently from 1927 to 1942. It milled all the timber from around the Hinehopu area, which was mainly rimu with some totara, and the logs were taken up and put through this big old mill, and you can imagine the cuts were about that wide. Apparently the sawdust from the mill was disposed of into Okawa Bay by a sluice method, and I've talked to a couple of the old people who worked on the mill and they said there was literally hundreds of tonnes of sawdust, probably thousands of tonnes, dumped into Okawa Bay. I'm just wondering, did the NIWA people find anything freakish about the sediment there that could have pointed to a great layer of sawdust in there?

Max Gibbs
There was no obvious indication of the sort of carbon levels that you might expect with sawdust of that sort of magnitude in the lake and it may be that since 1942 to now you've had 60 years, and decomposition may have got rid of the majority of that. What I did look at was the isotopic ratio of the nitrogen levels in the surficial

sediments in the lake. The levels of nitrogen, the value for $C:N_{15}$ the heavy isotope of nitrogen was around about 1, which is close to atmospheric level of 0, and my interpretation is that this is probably due to nitrogen fixation by the *Anabaena* in the water column, and that material sedimenting onto the surface. There is a layer of about 2½ cm thick of this flocculent material that has a carbon to nitrogen ratio of 8.6, which indicates it's probably phytoplankton material. It's not a detrital material, which would have a C:N ratio of around about 3 to 4, so what we are currently seeing is the biological deposition of material onto the surface of the sediment in winter. How that changes and releases nutrients in summer, I am not sure because we didn't look at that aspect in summer, but it doesn't have the signature of sawdust at this stage.

D.H.
I think I'll draw this to a close, perhaps making a final comment that scientifically there is still a lot that remains to be understood about the sediments of Okawa Bay. However, we know enough to know that they are obviously a very prominent source of nitrogen in particular and are obviously influencing the eutrophication of Okawa Bay. Please join with me in thanking the panel for the session and also the audience who have contributed the questions. Thank you.

Chair
Well thank you to David and the panel. In a moment we'll move into open forum. Thank you.

Open Forum

Chair
In the open forum, this is entirely your session. We are not trying to manage it in any way. There are only two considerations – the first one is the normal consideration of courtesy and the second one is as much brevity as possible. The floor is open to you.

Mary Stanton, Okawa Bay
Kia ora. I would like to continue with Okawa Bay regarding water quality. I work up towards the Urupa which continues from the Okawa Bay Marina and I've been watching these questions being fired to certain people, but I believe too that people who live in the area do have knowledge of that particular area, and I want to share some of my views with people who are trying to help save our lakes. At Okawa Bay on the western side, which is looking towards Okawa Bay Resort, there are times when the water quality is totally different to what is on the eastern side facing out to towards Hinehopu. We have got Urupa Road, in fact we call it the peninsula that juts out and it's very high and it looks on the whole of Mourea, so you have a situation there where the peninsula goes right out and on both sides you have water, which is quite unique. You don't often have water on two sides, so whilst I'm working in between I can look at one side and see the wind blowing, I can see the water deteriorating and take for example if it's in the summer, I would go in to the opposite direction. You will find facing out to Hinehopu could be totally opposite. The water could be pure, clean, calm and I can even jump in and have a swim when I'm feeling hot, whereas I can't do that on the Okawa Bay side. It can be totally different in water quality, the whole complex, the water when it comes to where it's like a washing-machine and this is why I have had people come down and say wouldn't it be a good idea to dig a drain right across that peninsula and empty out your problem water from Okawa Bay out into the other side. I've made this comment and I'm not afraid to repeat it, no. I don't think that is being fair, because what you are virtually doing is taking sewerage and you are crossing through our land. There are times, you know, we don't mind giving land to help, but in this case I don't see it a very good reason, because what you would be doing is pumping that water into what is clean water heading out to Hinehopu – so you are just taking sewage water from one area and pushing it into another waterway. Kia ora.

Chair
Kia ora, Mary.

Richard Wilson, Otaramarae
I'll try this question to Paul Dell. Can you please tell me Paul, with your septic tank regime on Lake Rotoiti, why you are just targeting Gisborne Point and Mourea/Okawa Bay areas and possibly the Hinehopu area, and you are not targeting the rest of the lake? Could you tell me that please? Thank you.

Paul Dell
If you look at the on-site effluent treatment plan, what's happened at the moment is we have flagged that Hamurana will come off the plan and we are also flagging that some other communities, particularly in the Western Bay, will be added to the plan. I think what we have said is we have tried from our early monitoring to identify priority areas and over time as we do more monitoring, more communities may well be identified and put into the system. So, we are not saying that those are the only communities, but those are the ones in an initial first round that we saw as being the more critical ones. I

would say that in due course when we do more monitoring, and John McIntosh here runs the ongoing programme, we may well then put more communities in there. So it's about a staged issue, I think, like anything, so therefore we shouldn't say that others are not contributing, but we have tried to prioritise it based on that 1992 work and also some other work we've done since then.

Martin Hawke, AgResearch
To do with Okawa Bay and probably the question might be directed at Kit, my observations are that it's a small catchment and about 30% of the catchment is covered in nitrogen-fixing gorse, of which some of it is quite steep. Over the last 30 years I think I've seen it cleared 2 or 3 times. Twice it's been burnt and once with a bulldozer. Have any measurements been made in terms of what effect that has had in terms of the nitrates or going down into the sediments? It seems to me that it's quite a big area that hasn't been talked about, but it could have quite an impact.

Kit Rutherford, NIWA
The short answer, Martin, is that I'm not aware of any studies that have been done in that catchment itself. We based our estimates of catchment load on a range of measurements made elsewhere on similar sorts of soils, but I guess the take home message is we felt we put upper and lower bounds on the catchment load in the first cut and you saw the results. I think the conclusion is reasonably robust that the catchment nitrogen load is relatively small by comparison with septic tanks and certainly in comparison with our measurements of nutrient release.

Chair
Thank you, I promised Kim next.

Kim Young, Department of Conservation.
Kia ora. I have two questions with the permission of the Chair. Both of them are ecologically-based and the first comment that I would just like to make is I sat through the workshop and I commend the organisers of the workshop for the purpose of looking at the lakeside sewerage issues with regard to the lake's water quality. One of the concerns that I always have at these types of forums is we often reduce down the issues into nitrogen, phosphorus and bacteria, and we often forget about the wider ecological issues associated with the management of the lakes. I realise that a lot of that is because of the time constraints that we have associated with the types of forums that we run and the quite clear outcomes that we want to receive, so I will try to couch my questions succinctly, and the first one really is to Paul Sampson. I listened with a little bit of concern regarding your environmental accounting exercise regarding the Lake Okareka model, and I hope that the forum doesn't mind us turning our attention to Lake Okareka at this point in time.

I think we've got to be really careful when we start doing environmental accounting exercises that we actually consider the components of what we are going to compare in the proper context, and I think it's really dangerous to start comparing the contributions that some of the naturally-occurring components of the ecosystem might make against some of the human disturbance contributions that are added to a system that disturb the stability of a particular system. I speak really about that in ecological terms, and I ask you the question whether in your environmental accounting exercise you might give further consideration to separating out in future deliberations the naturally-occurring components from the human disturbance-contributing components.

Paul Sampson
The short answer is yes. I think what I was trying to do in that paper of mine was pull a whole pile of other threads in. I think in some respects I am saying yes, I agree with you in the sense that we often say "Oh sewerage, we'll go and fix the sewerage," but we don't know what that really means, and what I was trying to do was bring in the whole environment and say "you've got money, you've got people wanting to live there, you've got land use" and I threw in the wild birds because I've never heard anybody else talk about it and when I saw the data I thought, well we talk about public health, why don't we throw that into the equation?

And I think the whole thrust of what I was trying to say is exactly what you are saying – we should be looking at these lakes in total, looking at all the contributing things and making, if you like, what Paul Dell's action plan is all about. Putting all of the parameters on the table and not just saying "oh, here's an engineering solution". In throwing the money at it, again it's the same sort of thing – we really want to have a sustainable development at the lowest cost that the community can afford and I think you've got to take all of those parameters. I think I was actually doing what I think you were asking would I do. Thanks.

Chair
Kim, well since you are a member of the Lakes Water Quality Society, you can have the second question – so if there is anybody else who wants the second question, it'll only cost you $5!

Kim Young
My second question is along the same themes and it's to Kit, John McIntosh and Max Gibbs. It's really regarding the use of already-established wetlands for the purpose of sewage treatment policy at the end of a treatment system. I noted, Kit, in your presentation about the use of the Whakarewarewa wetlands prior to discharge to the Waipa Stream, and I'm really just wondering to what extent you actually consider the wetlands a natural functioning ecosystem that already is performing to ecologically stable equilibrium levels in terms of its nitrogen uptake, and how you might consider the response of the wetlands systems as a recipient to added nutrients, how long a period of time you might think that a naturally occurring wetland with already a stable state might take to come back to equilibrium with additional nutrient levels to perform to the level that you are wanting it to do to polish up final effluent. I guess really I have that concern about the use of other natural wetlands around lake margins as mitigation or remediation measures for forest, rural catchments, etc.

Kit.Rutherford.
I think the wetlands were considered because they were there and I really can't comment on what natural values were ascribed to those wetlands at the time the planning studies were done. I mean, I've sloshed around in those wetlands and I would venture to suggest that the natural values may not have been ranked particularly highly, in that some of those wetlands were actually created by forestry roads, and you probably know the wetlands well. As a general point, clearly out of the planning process, before using a natural wetland for waste disposal there must be an assessment of their ecological values, and if wastewater is going to adversely affect those values, then that would be part of the equation. Does that answer your question?

Kim Young
It partially answers my question Kit, but I wasn't actually talking about the ecological values, I was more talking about the ecological responses and how you would expect that there would be a period of instability associated with added nutrient loadings or disturbance to an already existing regime, so it may be that there is quite a time lag behind that wetland being able to come up to the performance targets that you are expecting it to come up to.

Kit Rutherford
Yes, I think that's a good point. What's happened at Whaka is that a series of springs have broken out at the foot of the hill and the soils where those springs emerge are actually highly oxidised with very low organic carbons. Now possibly over time those soils will change and it could well be that their denitrification potential will improve and maybe the nitrogen removal in that wetland system will gradually increase over time, but the flip side of course is that we are engaged in a lot of work on riparian buffer zones where there is a lot of discussion about exactly the opposite process, that you fence off a riparian margin on the edge of the stream, let the grass grow or the blackberry grow. In the short term it may be a very efficient sink particularly for particulate nutrients and one of the big unanswered questions is what happens over time in terms of whether that becomes saturated and gets to the point where it is no longer acting as a trap.

John McIntosh
What Kit was referring to was in the action plan proposed for Lake Okareka. We had put various options and one of them was wetland establishment. It wasn't to treat waste, it was to treat natural stream inflows and we also raised the point that where the lake edge has been retired along the edge of Okareka, in the future lake edge wetlands could well establish there which could give additional nutrient renovation. But in catchments like Rotoehu there is very little we can do to treat catchment loads, as the major nutrient inputs are through the streams and there are reasonable levels of nitrogen in those streams so that if we created a wetland, we could possibly treat that nutrient level. That would be the only way we could reduce the nutrient levels going to that particular lake, but we would also address the issue of there being few wetlands in the Bay of Plenty and we would be going some way to increasing that.

Ian Johnstone, Landward Management
Noel told us that Lake Rotoiti was nitrogen limited and Kit gave some data that showed that nitrogen levels in Okawa Bay were unbelievably high, so I wonder whether Okawa Bay is still nitrogen limited? Also, Thomas told us that we get blooms of *Anabaena* that fixes nitrogen in Okawa Bay, but if in fact we have these very, very high levels of nitrogen in Okawa Bay, I am wondering why do we need it to be a bloom of a nitrogen-fixing alga. Does that make sense?

Thomas Wilding.
I couldn't speak in terms of the nitrogen. I haven't really seen many instances, or case studies, where nitrogen-fixing algae have been found to contribute significantly to the nitrogen load of a lake, but this doesn't mean it doesn't happen, I just haven't come across it. Nitrogen-fixing algae, that's one feature of their biology I guess, but generally they'll do well when the nutrients are high, regardless of nitrogen/phosphorus conditions a lot of the time, especially where they are usually fairly well balanced.

Chair
This question will also get responses from Professor David Hamilton and Professor Warwick Silvester.

David Hamilton
Just on the presence of blue-green algae, there are probably several things. One of them is that not all blue-green algae fix atmospheric nitrogen, that is free nitrogen that's within the water column. *Anabaena* is a genus that does, but it doesn't always do it and it's actually energetically inefficient for it to do it. It'll only switch to nitrogen fixation when nitrogen is in very short supply, and it actually grows at substantially slower rates when it is fixing nitrogen.

Warwick Silvester
One of the points I was going to make later on and I might as well make it now, is that blue-green algae are not just blue-green algae. They are everything. Blue-green algae have the widest range of physiological capability of any microorganism. Photosynthetic, non-photosynthetic, nitrogen fixing and not, toxic and not – there is an enormous range and so we must be careful when we talk about blue-green algae. They represent an enormous range of capacity and one of them is nitrogen fixation and as David said, they don't necessarily have to fix nitrogen. They will grow extremely well at very high nutrient levels and also at very low nutrient levels; they have gas vacuoles and they'll float and form blooms. They have an amazing ecology and they represent some extremely diverse and very interesting capacities. Nitrogen fixation – some things about that just very quickly – I tend to agree with Thomas that the contribution of blue-green algae to fixation and the total nitrogen budget of lakes is very, very small. They'll fix nitrogen very actively for a very short period of time and then sediment out, and that will go into the detritus stream. The nitrogen fixed does not become available immediately for any other organism, it actually is immobilised. It may be recycled and I think what Max was saying about recycling off the surfaces is quite important, but that instantaneous fixation does not go into the water column, it goes into the organism and is sedimented out and may be recycled. This is a quick response to a whole lot of things.

Sam Dinford, Lake Okareka
Mr Chairman, I am speaking about Okareka pollution. I am concerned and confused. This morning NIWA said septic tanks could contribute between 16 and 44% of the pollution going in and a previous report from Mr Sampson suggested 2.61%. I wonder if there is anyone who could explain the big divergence. Is there a variation of opinion?

Chair
Can we just check the numbers?

David Ray.
The NIWA numbers are correct, I'm not sure about the RDC one - perhaps Paul could clarify that.

Paul Sampson
I thought it was using your data! I've not come up with any Paul Sampson research – we've commissioned these people, and what my paper was doing was trying to pull the

information together. We have had some debate with David Ray in terms of 14 to 44 and how robust is the literature research up against the actual data that was done, and we also had debates about the occupancy rate in these areas as distinct from using three people against 2.26 or something like that, so there will be some variations in terms of where we've picked it from, but fundamentally there shouldn't be any difference.

Bill Vant
What we are saying is that the difference between 14 and 44% seems to us to be great, so Paul seems to be hanging on the lower end of the scale and yet we still are confused as to whether perhaps sewerage isn't responsible for a greater amount than this, because your figures were 16 to 44% - that's a big difference from 15%. That's where we are confused. There is one point that I would like to make and that is how important is it that the lake level … (*transcript interrupted*)

Bill Holden, Lake Okareka Ratepayers & Residents Association
My question is, does Okareka have sufficient wetlands at present to make a healthy, balanced lake, because there is considerable debate going around in our community at the moment about the lake level being raised. Now I presume that the argument for the lake level being raised, and back to its natural level, in other words blocking off the man-made control valve at the end, centres around the argument that we need more wetlands. What I am saying is, can we actually accept that there is settlement to the extent that it is at the lake at the moment, and improve the health of the lake with the amount of wetlands that we do have available at present levels?

Paul Dell
In our action plan, what we have commented on and I think John McIntosh has touched on it is that Miller Stream carries (from our nutrient budget) about a tonne of nitrogen a year into the lake. We felt that one of the options was to possibly have a constructed wetland for part of the flow to bring about a reduction in the total balance coming into the Okareka catchment, and that's in our action plan for discussion with the community as "hey, here's a possible option, is it possible, are there fishery issues, are there ecological issues as Kim has raised?" So it's basically, if you like, a part of our toolkit, just one of the many things we can do to try and bring about a reduction in the nutrient load to the lake. John has also said, though, that with the new retirement areas that are going in, and Rotorua District Council has been working hard in this area, there may be new natural wetlands being able to be established around the lake fringes, so we are simply saying that there are a number of other things that can be done. Could I also just comment on that previous thing about the 16% of the septic tank contribution, whether it be 2.6 tonnes or whatever. It's probably fair comment that there has been some refinement since that earlier work to the nutrient budget and so as we work through the process we will actually start getting a better handle on what are the actual contributory processes. So again I think we've just got to be careful that we don't grab hold of figures. There is a lot more work going on and I think Paul and I are going to be presenting a more refined indication of what we now think those different levels are.

Brentleigh Bond, Okawa Bay
There seems to be general consensus that Okawa Bay is getting worse. Is there a consensus here today that sewerage diversion is the best first step to at least stopping the rot?

Max Gibbs
A lot of us are looking at what's going into the lake in terms of a nutrient budget based on time. Can I throw the question back and look at the perspective of what the average annual release of nutrients from the centre of the bay is (40 kg/yr) and from the data that you saw from Okawa Bay the septic tank effluent is estimated to give a loading of 4kg per year. Now the difference is that the material that is released from the sediment theoretically can go up and return to the sediment to be released in another year. So if we don't take out the septic tanks, in ten years time you have doubled the amount of stored nutrient within the bay, assuming no flushing or loss from denitrification or anything else. So over ten years you have the potential to double that loading, so the obvious answer is – stop it?

Chair
Is there any disagreement from the panel on whether we should just stop putting in that nutrient?

Bill Vant
As well as going in, that septic tank nutrient is also being buried and your suggestion that it's being stored and therefore is all available presupposes that it's not just the top couple of centimetres of sediment that's releasing nutrient. I don't think we know one way or the other.

Chair
That doesn't help; it just says it's complicated. Anybody else on the panel? Warwick, thank you.

Warwick Silvester
I think Max summarised things very nicely there and it's certainly my position on this matter that when we are comparing the inputs from septic tank with what's recycled, we are not comparing the same thing. Inputs are nett inputs that are freely available and they mix through the lake. The others are measured from a chamber on the bottom and a lot of that is recycled continuously. What we are talking about is an input which is a continuing annual input, which is adding to the burden, which is going to keep priming that recycling pump – and as you put it in, that recycling pump is being pushed harder and harder, so if you want to stop that recycling the best way to do that is actually to take off the priming which is the septic tank. That's one way of looking it and what brought this to mind was the sawdust thing, because if that was sawdust in there I believe a model we could develop is that (and one of the reasons this happened suddenly) is that the sawdust represents a sink for nitrogen into which nitrogen went for some time, until such time as the C:N ratio of that dropped as it started recycling and at that point the input of sewage effluent, that freely available nitrogen, primes that pump and drives the recycling, so they are different but they are very tightly interlocked. I believe that one of the first things that need to be done is to withdraw that priming.

Nick Miller
Can I follow on with a slightly philosophical viewpoint here? We've just seen a NIWA report in the last few days, most of us, suggesting that diversion of sewage from Okawa Bay wouldn't really have any major impact on the bay in the short term, which they suggested might be ten years, might be more. I think that when we are dealing

with lakes perhaps it's in our long-term best interests to actually take the long-term view.

David Ray
I'm just going to quote directly from our report which is available on the website. Obviously we're all clear that we're saying that we don't expect any dramatic short-term improvements, but we do say in our executive summary (and Kit talked about this in his presentation) that improvements in Lake Rotorua should flow through to Okawa Bay in the long-term and we also say that the removal of sewage should also result in reduced nutrient release from the lake bed. I'm actually reading this directly from the report, so I don't want us to appear too vague in our conclusions.

Chair
I think you have a clear-cut answer.

Kit Rutherford
A couple of people chipped in and answered the question for me. I am old enough to remember the discussions about Lake Rotorua and therefore, I have been at pains to point out (and I've said it once and I'm quite happy to say it again), I think the removal of septic tanks in the long-term will be considerably beneficial. But, and it's a big but, we must not expect the lake to turn into a Lake Taupo overnight. It would be most unwise to suggest to Paul and others who are managing this whole process that that will happen; I mean look at what has happened in Rotorua.

As Thomas's presentation this morning showed, there are still problems in Lake Rotorua and if you dredge back through the literature from the time the planning was made, we were trying to sound those warnings then. Yes, the removal of sewage from Lake Rotorua in the long-term will have some benefit, but there was an immediate short-term benefit to the removal of sewage from Rotorua, but because of the way the lake-bed works we forecast ongoing problems and we are beginning to see some of them at the moment. They will come and they will go, there will be good years and there will be bad years in Rotorua and I imagine the same will be true with Okawa Bay, but in terms of the long-term, taking the sewage out must be beneficial.

Chair
Because of the importance of this question, can I just ask if there is any dissenting view on the panel? No – thank you.

Jim Stanton, Lake Rotoiti Ratepayers & Residents Association
That's exactly the same question as I was going to ask and seeing as we now have five members of the panel who appear to agree that the long-term benefits of removing sewerage from Okawa Bay perhaps outweigh any dissent in the other direction, I think we should perhaps ask Paul Sampson or someone from the District Council to give us some definitive answer on whether they intend to go ahead and put in the sewerage scheme at Okawa Bay, in light of the fact that right up until now they have suggested that they require to make that ultimate decision based on information which has been provided at this workshop. It would appear to us, and is our understanding, that any further research and investigatory work will only have a very small contribution to making that decision from hereon in. Thanks.

Chair

Can I just say two things Jim; firstly this workshop is obviously going to be significant in influencing RDC thinking, hopefully, and the second thing is that RDC actually has the sewerage scheme in its forward plan.

Paul Sampson
No that is correct, I mean we've been paying for this research for the idea of being able to give an informed opinion. We were very happy to actually have the Lake Society here today, because we wanted to have a very well informed public in terms of when the Council makes its decision. It's got scientific, engineering and public awareness in front of it and I guess it's going to be a political decision on when it proceeds – it's not my decision at all. I mean, as an engineer I love building things and I love spending your rates, so I haven't got a problem with building a sewerage scheme, it would be quite fun to put a new SBR plant out there.

We are proceeding on the basis that ultimately one will be there, but I do go back to what I said in my paper, which was to look at the value and make sure that the public who ultimately pay for this - because it's not the Council – it's you as ratepayers pay, it's your money and if you don't get a bang for your buck then, you know, we don't want any criticism on the basis that "you still haven't improved our lake". As I say, it's a political decision and I think now the Councillors will have all the information in front of them as to where do we go, who pays and how do we pay?

I still think there's a question there on what's the environmental benefit, and as Paul has already mentioned, Environment B.O.P. are looking at contributions where there are environmental benefits and obviously sewerage is a driver, we all know that, and there's no dissention that if you take it out there is obviously going to be some benefit. So I don't think there's ever really been that argument - it's just being fully informed and making that decision, because it is big money and one of our concerns (and Councillor Searancke will cover this later on) is the ability for people to continue to pay.

It's all very well to sit here and say "yes we'll do this", but you're talking about an $X million dollar scheme of so much per annum and I think that's always going to have to be a consideration. One positive thing I would like to say is that with that new membrane system, it might be an idea if we got a sewage plant in, that we could put the membrane in and we could solve the water supply problem at the same time!

Mark Collet, Lake Okareka
My question is addressed to Paul Sampson. We have approximately 200 houses at Lake Okareka, though I know the Council wants to have many more, and each of those is probably worth on average something like $300,000. That makes $60 million. We may have spent a million dollars on our sewage up till now; I think we have had our sewage treatment on the cheap. We are damaging the lake. You are talking of spending $3 million as if this was an unconscionable amount to spend. If the community is worth $60 million, then surely a sewage treatment plant should be included in the community.

Chair
Well you're getting a strong reaction from the community there Paul.

Paul Sampson
Well I think later on there is the next session and I think you can answer that Glenys. Got to give her something to do for the day!

Rod Stace, Lake Okareka
I would like to explore the options for Lake Okareka in a bit more depth. Paul Sampson in his paper presented the solutions for farmland input and septic tanks almost as if they are alternatives, whereas I would have thought that both are significant. From my reading of the literature, it seems that the proportion of nutrients that are contributed by septic tanks is more like 25% than 15%, so isn't the best solution addressing both these problems at once if possible? Surely it doesn't need the sort of drastic solutions that were proposed. As a matter or argument, instead of the total conversion of farmland to forest and the total reticulation of the settlement, is it not possible to have partial solutions to both which will take out the greater part of the nutrient that is input and for much less cost. This will, of course, change the whole cost benefit relationship between those solutions. Thank you.

Paul Sampson
I could be quick and just say "yes", because that's basically what I was trying to portray in the graph at the end. We're saying that if you've got the targeted TLI, what we should be doing is looking at the most cost-effective way to get the TLI down to the target levels so we have that sustainability of the lake, and there's a range of options. All I'm saying is: yes we can go and jump in and do a sewerage scheme, but if it's not really got a public health benefit and it's from an environmental point of view, and you're paying $2 million a tonne to take that N out, we may be able to find by discussing with landowners and so forth some options that are acceptable to them. At the end of the day the cost may be only $2 million against a maximum of $9 million. It just seems to me that that's what we should be doing for sustainable environment, not just the green environment, if you like, but the human environment and the ability of the community to pay. Trying to wrap all of those together so we all come out winners.

Rod Stace
It's not just the District Council that would have to be funding these solutions - is it that we can expect the solutions on farmland to be funded by Environment B.O.P.?

Chair
Paul Dell, do you want to respond?

Paul Dell
I think, Rod, the reality is that Environment B.O.P. has put out the draft action plan for discussion with the community and the Regional Council may, for example, be willing to contribute to a wetland on the basis that the Regional Council wishes to establish an enhanced wetland at that place. We are also involved in riparian planting where we offer subsidy, and also there are possibilities that they may look at something like regional park retiring land. So there are a whole lot of different options, but again, and I think as Paul said this afternoon when you talked about funding, when you start talking of private good versus public good, then you start looking at who are the exacerbators and who should pay, and I think that that's an issue which will have to be worked through. In our action plan at the moment we've said that's all on the table for

discussion. We just want the community to look and think about the options, and, using Paul's expertise, put dollars against those.

Chair
Thank you Paul. We'll have Rowland now with the last question. I'm told afternoon tea's ready.

Rowland Burdon
My question is regarding the septic tanks. To what extent are coliform counts an indicator of likely phosphorus leakage? If in fact those coliform counts, say in Okawa Bay, are a pointer to a phosphorus problem, then we have got something that can be attacked not only through the sewerage or even improving the septic tanks, but something that may be attacked by other avenues, in a rather shorter time-frame than has been projected for responses to attacking the nitrogen problem there.

David Ray
I'm not sure if I totally understand the question actually. The coliforms, are you talking about faecal coliforms, bacteria in other words? They are obviously quite separate to the nutrients, but where you have septic tank leachate obviously you have bacteria alongside nutrients, so the two are connected but I'm not quite sure I understand the question.

Rowland Burdon
Well, one of the things is that you can get nitrogen leaching out of septic tanks without any coliforms getting away, but if you've got coliforms, is that a likely indication that you're going to get phosphorus leaking out into the lake?

David Ray
Oh, OK. Possibly, yes. I mean bacteria are generally filtered out in the soil and I guess by the same token phosphorus is often absorbed onto the soil, so possibly the two are linked I suppose – if you have coliforms you may have phosphorus. Actually just while I'm on this point, there was one thing I wanted to clarify about my presentation with the setback distance that I discussed about Okareka. We are not saying that every house that's further than 16 metres or even 50 metres from the lakeshore definitely does not have the potential of causing a public health problem. As Paul Dell covered in his presentation, there are a number of faulty septic tank systems and if you have a septic tank that is overflowing for example, or is being short-circuited somehow to a nearby stream or drain, you still have a mechanism by which pathogens can get into the lakeshore even if the system is 100-200 metres back from the lakeshore. So it's not quite as simple as just saying we need to be 16 metres back or we need to be 50 metres back.

Chair
Thanks David. Just before we close this, Noel Burns wants to contribute on Okawa Bay.

Noel Burns
Ian, I just want to comment on a question you raised about how can we have these nitrogen-limited algae in Okawa Bay when we're getting these huge release rates of ammonia off by them? Well, I think the problem is simply that we don't know what the phosphorus release rates are, because phosphorus and ammonia used to get released

simultaneously and I'm sure there was a large amount of phosphorus coming off to the point that it created nitrogen limitation.

Chair
Would you show your appreciation to the panel for their very valuable contributions please. Thank you. Now I'll hand you over to the very capable hands of Glenys Searancke again.

RDC Charging Policy

Glenys Searancke, Chair of Works Committee, Rotorua District Council

Financing of sewerage schemes – I want to break it into two sections, the Capital cost and the Operating cost, but they aren't related. Can I assure Okawa Bay that we have no intention of not doing the sewerage scheme; it is a matter of when and that will be when we've got the information all together. You've heard Greg today – he's making very good progress on the physical scheme itself and there is no intention of not doing the sewerage scheme, so I give you that assurance. If there is a plan out there, I certainly don't know about it.

Now, the other thing I would just like to say about the whole issue of Okawa Bay, because that is the one that we are about to put the first sewerage scheme in, is that when it first came to Council it did not come to Council as a concern for Okawa Bay itself, but as a concern for Mourea and it was a health problem and it still is a health problem for Mourea. That is the real worry and that is Council's responsibility, to clear up that health issue, and that as much as the problems of Okawa Bay itself is driving the sewerage scheme.

So that's just a little bit on the side because as you know, and you people all know, it's been on the books for a long time and it is time we got some finality about it, but we've got to do it the right way.

OK, so let's talk about Capital cost. Originally Council (and they have put aside in this year's budget $3 million for Okawa Bay/Mourea sewerage system) had an agreement that they would meet the full capital cost; however this is where it ties in with the operating costs, because if we did that and then left the operating costs to Mourea and Okawa Bay, they would be looking at something between $650 to $800 a year in operating costs. That is an impossibility for some people and so what we've tried to do is come up with a practical solution.

This is not set in concrete, this is just being discussed at Works Committee meetings and it has met favour with the politicians, and the fact of the matter is we are talking of equalising sewerage operating costs. By that I mean that in town I think the figure is $288 a year for 1 to 4 pans for a residential house and what it would do if we went to such a costing regime is add $10 to $12 onto everybody's sewerage charge right across the district. Anyone who was on sewerage. That would be the people of Okawa Bay and Mourea and further down the track, if so be it, Okareka. Everybody would be paying the same operating costs.

Now to compensate for that, at a cost at Okawa Bay/Mourea of $12,000 to $15,000 a property to connect to the sewerage, to get it through and get the whole plant up, we believe that there should be a capital contribution from the beneficiary of the scheme, which is the property owner. So we are saying we now believe that we will treat all schemes on a case-by-case basis, with a contribution from each property towards the capital cost.

Now talking about costs and paying, there are two issues and both Pauls have touched on it briefly. There are two issues when it comes to lakeside sewerage schemes. We have the public health issue that I have talked about, which is definitely Rotorua District Council's responsibility, and then we have the environmental issues and the benefits to the environment, which are definitely Environment B.O.P.'s responsibility. I was very pleased in Paul's paper to hear him say that they are looking and can see the rationale behind that. So we could have a tri-sided sort of agreement whereby there is a capital contribution from Rotorua District Council, from Environmnent B.O.P. and from the property owner. The proportions have not been really finalised.

There is, of course, a government fund of $15 million per annum which is not able to be applied for until January and isn't actually in policy yet. But it has been promised, and one of the parameters for that (and I have read the paper on it) is a socio-economic factor, which means if we're talking Mourea/Okawa Bay, then we would definitely, surely, be able to get some contribution out of that $15 million towards the Mourea component of the scheme, so that is something we cannot apply for until January. That covers that little piece there.

We've covered operating costs and we've covered the increase that would result for everybody, and the political rationale for such a decision was undoubtedly the benefit to the district, and this is no different than when the sewerage scheme went in Rotorua, when the rural people who lived out at Okawa Bay and Reporoa, people who live in all rural areas who were not on sewerage, made a small contribution towards the capital cost. Be mindful that it was the huge government grant of $21 million towards that scheme. So in the scheme of things it was not an expensive scheme for the ratepayers of Rotorua. I don't really think that we need to go down any other track.

The other area of sewerage reticulation that was on the books at the same time as Mourea and Okawa Bay was of course Reporoa, but there the problem has been Reporoa village. There the problem has been solved by some excellent engineering work, whereby stormwater and all drainage was absolutely improved, the water level was dropped and now, of course, we have septic tanks that are functioning properly. So that was one huge cost to the district that was able to be done in a much cheaper and more practical manner. I think that is probably about all I really want to cover. I am sure there will be some questions. Councillor Oppatt here from Lake Okareka, Councillor Martin was here earlier – both on the Works Committee, so if you do have any questions I am only too happy to try and answer them.

Questions

Jim Stanton, Lake Rotorua Ratepayers & Residents Association
Glenys thanks very much for the presentation, we are well aware of what Council's funding policy is and we've been through all the issues with you in the past. We certainly hope to have an opportunity within our community to debate those issues with you – you have undertaken to do so and I don't think you have met that undertaking just yet and I believe you are still to do that.

This may be an opportunity to put our issues across once again, because we were the proponents of equalising the operational costs across the board and we are very pleased to see that you have taken that on board and have taken the points that we made in respect of that and agreed with those. We fundamentally oppose any capital charge on the community for sewerage schemes. The reason is not that we disagree because the amount is unreasonable, because it probably isn't. You've talked about a maximum ceiling of $5,000 and you may be talking about $1,500 to $2,000 in Okawa Bay.

We are aware that there are some residents within Mourea/Okawa Bay and probably most of those are in Okawa Bay, who feel quite happy and comfortable about paying that amount and see it as being reasonable, but I guess too that they would have to admit that the alternative to doing that is perhaps paying up the $15,000 for some highly sophisticated septic tank treatment system.

However, what we are really talking about is the overall Mourea/Okawa Bay scheme and we are talking about the overall community and the ability of many, many people within that community, especially within Mourea, of the difficulties in contributing to a sewerage scheme, bearing in mind that they will already have the operational costs included in their rating, and capital cost will just be an extra burden upon them in this particular instance. However, our fundamental opposition is based on issues of principle and theories, and the reason I say that is that if we go back to the urban scheme, no one in this district has yet paid an individual capital contribution to a sewerage scheme.

The urban scheme cost $32 million of which you rightly said the government provided $21 million. The balance of $11 million has been funded through a loan across the district paid for out of general rates from day one and as you rightly pointed out that has been paid by everyone, including those in rural districts who we are discussing today. In 1999 you changed the funding policy, because prior to that you were funding sewerage schemes 100% from general rates. You changed the policy whereby you split the outstanding urban loan 70% to the urban users and 30% to the rest of the community, so in fact 30% is still being paid by the rest of the community at this time. The urban sewerage rate at that time went up by about $40 a year to $250 or something like that, and the offset of that was that you decided that you would put a charge on any new community schemes up to a maximum of $5,000. At the same time, within that funding review, you increased the rural differential from 51.5% to 60%, which effectively was also part of the overall review in determining the equalisation of costs, in consideration of taking out some of that percentage from the outstanding urban loan for the sewerage scheme, I believe. In implementing the equalisation of the operational cost, it will effectively mean that everyone who has a sewerage scheme will pay the same operational cost. Therefore, everyone will be contributing back into the outstanding urban loan, so we will all be paying for the total sewerage costs across the district. That’s one point.

The $5,000 that you determined would be the capital contribution, up to $5,000, in 1999 was based on the premise that a basic septic tank system, if you had to put one in, would cost about that amount. Of course that ignores the fact that most of the people that we are talking about in our particular area, and I’m sure Okareka will be same, already have a system and have already spent that money on a system. It can well be argued that the research done via the on-site effluent treatment plan has highlighted the fact that quite a number of the septic systems don’t work very well and that people in the normal course of events would have to upgrade them and it would probably cost them that sort of money anyway. However, if we look at the specific figures and you look at Mourea for example, the research done by District Council in 1998, which went across over 100 properties in Mourea, suggested that the majority of them had satisfactory operating septic systems, excepting for the size of the septic tank which Paul Dell has highlighted today in his talk.

However, a great many, we understand, of those septic tanks are only marginally below the new standards, so that, for example, in the old days when the septic tank was allowed to be something around 2,000 litres, we now have a new standard set where it has to be 2,700 litres, but there is no suggestion that the 2,000 litre tank is not performing satisfactorily and the drainage fields are performing satisfactorily for a great many people within the community. So we are suggesting that that argument, in fact, is perhaps only a small part of the equation.

So at the end of the day, we believe if you equalise the operational cost because of the overall benefit to the district, the top priority in this district was determined through the strategic planning process as being the maintenance and the enhancement of the lakes and the lake water quality in this district. So it follows that most of the people within the district would be quite happy to see any schemes or implementation of schemes such as sewerage schemes which might bring about the enhancement of lake water quality as being of benefit to everyone within the district. OK, you've equalised the operational cost in that respect; we would suggest to you that by doing the same with the capital cost that that also reflects the same desire of the people within the district.

Ian, I've nearly finished and I think it's important that you hear the whole of our argument, because it would form the basis of any debate or discussion on the matter. Sorry, just bear with me. I think one of the other issues that we need to remember is that (and it has been alluded to today in a number of speeches) Rotoiti probably historically has suffered from the inputs of Lake Rotorua over a great number of years and still continues to suffer in that way. Whilst we might accept that Okawa Bay is perhaps now determined to be a small issue on its own, we have to be cognisant that the western basin in particular of Lake Rotoiti has deteriorated quite markedly over the last 30-40 years and I'm sure that everyone will agree that this in no small way is due to the inputs of Lake Rotorua. So that is another reason why we might suggest to you that the whole of the district has contributed to this problem, and the whole of the district may benefit from any enhancement that we make to fix it.

The other thing I would just like to say to you about the new government proposed subsidy scheme is that part of the criteria that they are using in that scheme also talks about the high measured rates of water-borne communicable disease. I am sure that can be applied to Okawa Bay, particularly where the counts have all been made over there in the last 3 or 4 years from the algae blooms. It also talks about significant health inadequacies and those significant health inadequacies can perhaps be applied to quite a number of those properties within the centre of Mourea who are afflicted by high ground water and do not have the capacity to take on the septic tanks operating correctly.

So given all that together, we believe that that strongly supports our opposition, as a matter of principle and fairness, to applying a capital charge, and I just repeat that we are not talking about dollars, we are talking about the principle of the matter. I would just like that to be put into the forum and debated to see whether in fact we do have some other consensus on that. Thank you.

Glenys Searancke
Jim, the Councillors are certainly well aware of Rotoiti Ratepayers Association's feelings, I think the submission came through the annual plan process. Personally speaking, I guess I can go out to Ngakuru and if I suggested to them that they were

paying for your capital costs for your sewerage scheme and for say Lake Okareka's sewerage scheme, they wouldn't be very happy either. So it's a matter of trying to reach some kind of balanced stance on the matter.

Now Council has said if you are prepared to pay the full operating costs as we and all urban areas have done over the years, then certainly we would pay for the capital, but we can see that you cannot sustain it. A lot of the people out there would not be able to sustain such a cost, I mean I'm saying $600 to $800 – it might be $900 – I don't know. We haven't got to those final figures yet, so I'm not going to say <u>this</u> is what it will cost – as I'm saying, between $12,000 and $15,000 a property. Once again, we don't know until we get the final details when Greg gets right down that path. So it is a philosophical argument, there's no doubt about that.

You have contributed, but the rural people did contribute to some of the capital cost servicing the loan for the sewerage treatment plan and that was on the grounds that you have said yourself Jim, that it was deemed to be of environment benefit to the whole district. That is the same philosophy that we are taking with the operating costs. We are saying to clean up Okawa Bay and Mourea is of benefit to our lake and the lakes are our jewels, so that is the philosophy we are taking. It has and it will be debated again - I am sure it will be, but we have to reach agreement on it, we don't want to hold up the scheme for argument's sake, for the sake of who's going to pay.

If in the long run you look at operating costs over 20 years at say $800, that's a lot of money and as far as capital costs are concerned, for some people in Mourea there will be assistance from the likes of WINZ for that cost, I am absolutely sure of that. So I guess we'll continue to debate the matter and I don't know if other people have got other views. The thing is, we want to get the scheme in and we are going to work our way through those problems Jim, one way or the other.

Don Atkinson, Okawa Bay.
Just from my own personal point of view I would hate to see the scheme delayed simply because we couldn't work out a practical solution to the dollars, and I think that that's something that can be quite comfortably handled through appropriate discussions and negotiations.

Gifford MacFadden, Federated Farmers
As a rural person from another catchment and one of the people that are going to pay, I would have to support what Glenys is saying, that while I understand you all want to go to heaven but you don't want to die, in other words you don't want to pay for the scheme, there are other political pressures on the Council that have to bring in a balance to it. We are sympathetic, but you know there is going to be a limit to it.

Chair
It's my privilege to invite Professor Silvester to take the floor and to sum up for us.

Workshop Summary

Professor Warwick Silvester, University of Waikato

I want to precede my comments by saying what a brilliant day it's been for a whole lot of reasons and I'll just keep that in view. I think one of the most interesting, well-crafted and productive day symposiums that I've ever been to. I think the LakesWater Quality Society should be very strongly congratulated for not just thinking of doing this, but for the way it's been put together to bring together different points of view and to give them airing and to allow people to have their say. I believe that you, the community of Rotorua, are incredibly well served by that Society.

Today's been a bit like an onion to me – not because I've wept all day, not at all, but because of the layer upon layer that has emerged as we've discussed things, and I want to talk about and summarise in terms of those layers as I see it, because I think we've had five layers of the problem. We've had the technology layer, the science layer, the management layer, the sociology layer and we've had the philosophy layer.

They have layered and built from a core of technology which provides us with the data, to the science which provides us with the understanding, to the management which takes the understanding and attempts to implement it, to the sociology which brings in the community, to the philosophy which actually bears upon the whole thing and says why are we doing this and where do we come from to do that? I think today we have been served well because we've brought all of those things together and I just want to bring together for you a few of the highlights in terms of those five different layers of the onion.

Some of the things I've already talked about in trying to integrate some of the information. Starting with the technology, I was greatly encouraged to hear of the developments in batch technology, and particularly in filter technology, which I've been hearing about in little bits and pieces, and it seems like things are moving ahead much faster than I had anticipated. Certainly there's some very good news out there about the way in which we can develop these systems to better and more effectively and economically implement waste disposal.

Also to hear that question that Nick put, which I think was a very important one, can these systems look at both nitrogen and phosphorus and deal with them? Not optimally perhaps yet, but certainly both can be managed within the systems, whereas previously you optimise for one and you very sub-optimise for the other, but now those seem to be coming together.

In terms of the technology, one point that I think was well-made and we have not actually taken it into the equation yet, is that not every septic tank is the same. They vary enormously and Paul brought this out very well for that survey that they did. Something like less than half of them meet any modern standard and so I don't think we can say we've got 150 septic tanks here and they all do that – they don't. Some do what they do very well and some don't do anything at all, and so I think in analysing what their systems do we need to take that into account. Certainly, however, we've heard today that the technology and handling of human waste is developing rapidly and New Zealand appears to be taking those things on board.

It's been interesting to hear, not so much at the conference here, but talking with people, about the role of wetlands now. I remember 15-20 years ago we thought wetlands were going to be the answer to at least the polishing of effluent, but that may be not the case. That's something to do with the carbon that a wetland can store, because it needs the carbon to do the job and sometimes that's just not met.

Just going on to the science, then, and we've been very well served by our scientific presentations and the data that they've been able to assemble. I think those inputs have been incredibly valuable. Attempting to integrate the information that we have on lakes represents a very real problem, not just for what we see here, it's a worldwide interesting problem. We were discussing at afternoon tea - what controls an algal bloom? The scientists have been working on this for many decades and biological systems are inherently both very difficult to understand and often very unstable, and trying to get the definitive answers to questions like that is very difficult.

This brings me to 'TLI's. In fact this has been a symposium of acronyms hasn't it, we've heard about 'RDC's and 'OET's and 'TLc's and 'TLn's and 'SBR's and 'NBR's and 'STI's – I'm very much in favour of 'TLC' – I need a lot of it! Noel talked about 'TLI's and he's actually given us an approach, which really on the one hand worries me – it's intuitively totally counter-intuitive, but I believe he's got something and I really want to talk to you about that, Noel. We really need to try and get to the bottom of that. How is it you can take something that is not limiting, work on it to bring down your TLI and do something for the lake for your TLc.

So we need to talk a lot more about TLc, and TLC for our lakes is very important. I really think we need to get together and talk about that and try to come to some understanding of how we can use that magnificent data set that you put together to work for the good of the lakes.

We've talked a lot about nitrogen and I've tried to impress on people that not all nitrogen is the same, in fact it is very, very different. We can talk about nitrogen: on the one hand that stuff that actually comes from the septic tank into the lake as nitrate – that is most labile – it is readily available. At the other end of the scale I have my shoes. Now those are made of nitrogen – that's protein – and that is readily unavailable. It is totally unavailable. It is tanned. It is so tanned that it will never (well, except if you've got some very bad feet) decompose, so nitrogen is not all the same.

This is one thing that's come through – we keep on talking about nitrogen, but must be careful to talk about what sort of nitrogen and that brings me to the sediment in the bottom of the lakes, which is the great big black box, it seems to me at the moment - it seems to me the big unknown. So we know a lot about inputs, we are starting to get some feeling of turnovers, but what we don't know about is what is happening in the sediment.

We now realise that it is a very big contributor, but the point I would have to emphasise is it's a big contributor because the lakes are great integrators of what's been happening over the last 20, 30, 50 years. They've been sitting there acting like a big incubator and what we've been doing is putting in all the time. It has been accumulating, some has been going out, but we've got this reactor sitting in the bottom, about which we know not very much. We don't even know how much is there, let alone do we know what forms of nitrogen and how recalcitrant some of that nitrogen may be, compared with how quickly it can turn over. I believe we need to know more about that black box.

The point I would just emphasise again, which is going to be one of my main points, is that because the lake is the integrator of everything, those inputs continue to drive the sediment, because they contribute to it and have contributed to it and I've tried to give the image of a pump. That nutrient that's going in –not just the nitrogen, but we are concentrating on that – that is the primer to the pump, that's what's been accumulating and that's what's driving it now, and not in a very subtle way – in quite a major way.

So I believe that's one of the important lessons we can learn. Of course what I'm saying is a bit idiosyncratic because I work a lot on nitrogen and I believe that some of these lessons can be well-learned. So as far as the science is concerned, we are starting to get some of the very good numbers and I believe that that black box of the sediment, which is generating perhaps the major amount of nitrogen, we need to know more about.

Then we come to the third layer of the onion which is the management side and I think this is one of the very good things that this conference has done; it's brought managers together with different perspectives and we learnt today from Paul squared, (or was it Paul plus Paul?) that the RDC and Environment B.O.P. have different roles, which their statutory roles certainly are, and that they end here and we've got someone working here and someone working over here.

I hope the conference actually has perhaps helped to bring the roles together a bit and certainly, I hope that we all appreciate that the two authorities do have a different role and that we've actually had a coming together and a meeting of minds which I think has been very positive and successful. We learnt about the stress that's been there for a while, but I don't detect that that's been a particularly negative thing. I think today we've learnt that actually it has a positive outcome.

And then Paul asked the question (won't say which Paul 'cos I forget), at what point do septic tanks become intolerable or unsustainable or whatever? I believe we actually had a very common view on that, that certainly the panel along the front were of the view that septic tank effluent had to go, despite the fact that the figures seem to point to it being a minor input. We certainly, I think, had a unanimous view about that.

Then there's the sociology side and the bringing together of the public, and this is where a value system becomes very important, because we hear from time to time of the single bottom line, but we're now talking about the triple bottom line and I think many of the people who have spoken from the floor have attempted to put the fact that the environment has a value, that perhaps you can't put a dollar on it, but to many people that has a value which is over and above the cost of doing anything, and this is where of course perception and reality tend to meet.

Finally we have the philosophical one and this one I could spend a lot of time on. We've heard that there are cultural matters, and very strong cultural matters, to do with the disposal of waste, and we have to put a value on those, and increasingly society is putting a high value on the cultural side of the perception of these matters, and philosophically as well, I believe, we are doing that.

Finally I have to put sort of a personal view, which is the nature of the scientific input to some of these matters. It's unfortunate, I believe, that science these days has become divided and managed to the point where the economic model drives science and much of what is being done is being done in isolation. We've had a bringing together of certain things here and I've heard things from my colleagues across the road that I had no idea they were doing, which I think is a pity, but the economic model driving science is actually driving scientists into their laboratories, not out into the community or into a co-operative model.

We seem to have moved well away from the co-operative model of doing these things and I think that's very unfortunate, and I think I made the comment at the last conference that much of the science we are doing seems to be done as client research and very little of it seems to be getting into the scientific literature. I had to review some work on this whole matter and was absolutely staggered to find that virtually every bit of work that had been done on the subject was actually done as an internal report, a client report or was done for a particular organisation. It had excellent science in it, but didn't seem to be getting into the real scientific literature. I had no access to it, unless I went and sometimes had to pay for it. I went to an organisation and had to ask for it. I could find very little of it in the peer-reviewed scientific literature.

So there we are, those are my rather idiosyncratic views of what's gone on today. I have to say I have been stimulated to think about an awful lot of things and hopefully to discuss them with a lot of people and let me repeat how perhaps on behalf of the people of Rotorua, how well served you are by this conference that has taken this issue, taken it by the throat, rattled it and got the people here to talk about it and to face the real issues. Thanks very much for inviting me along and I hope this is just the beginning of a lot of fruitful discussion. Thank you.

Ian McLean, Chairman, LWQS
Thank you very much indeed, Warwick.
I really want to thank those who made this workshop successful – to all those who are on the stage, chairing, presenting papers, all the work in preparing the presentations, for summing up, for the mihi, for all those – thank you very much. I'm not going to go through the names, but we do appreciate it very much. To the hotel, to the people who did the technology, to our web master, the RDC staff who provided technical help, and all of those who gave great amounts of time to organise the workshop.

Thanks to Rotorua District Council for the excellent financial support, to the Royal Society for their continued encouragement and support and website. What I want to do now is just to get the people who did the actual organisation to stand up. Lindsay Brighouse, Liz Miller, Nick Miller, Brentleigh Bond and Greg Manzano from the District Council. These are the people who did most of the work, will you please show your appreciation.

And now just before I close, it is a Chairman's privilege to say the last word and I intend to do that – it'll be brief. During the day today we look back on it and we say what a great day we've had and how much progress we've made – and we have, but while we've been here some of the lakes have stayed the same as they were, one or two of them have got a bit worse, one might possibly have got a little better, but the test of this workshop is what happens outside and I've got to congratulate both Rotorua

District Council and Environment Bay of Plenty for following one of the basic laws of sewage, right at the source. They have recognised that it is time to pass water or get off the pot! Thank you very much.

Thank you all for attending and for the contributions you have made.

Post-workshop reflection – a summary

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I would like to acknowledge LWQS for planning one of the best-structured and organised Workshops I have attended. The meeting was constructed to present the best technical and scientific information, to set the political and management issues and to give the public opportunity to voice concerns of a social and cultural nature. LWQS, along with RDC and Environment B.O.P, who have hosted and supported the day, should be congratulated on a timely meeting.

In summarising the important points made I must acknowledge that one's own perspective is bound to creep in and as such I need to declare this must be a subjective and idiosyncratic view of the day's proceedings.

The day's meeting was, to quote Shrek, like the onion, a many-layered one. These layers ran all the way from the technical to the philosophical at the two extremes while in between we had the scientific, management, political and sociological. At times the layers overlap, but each represents a distinctive and important perspective on the problem.

Technology

The two technology papers on reticulation and treatment left us in no doubt that there are no major problems that sufficient money cannot solve. It was most encouraging to hear the progress made in small-sized high-rate systems. The incremental improvement in SBR (Sequential Batch Reactor) design means that they can remove at least 90% of N and have a footprint of no more than 1% of a pond treatment system. Similar rapid improvements in membrane construction and price will bring further improvements in effluent quality, potentially to drinking water standard. The above news is particularly topical in view of the reported overloading of the land treatment system in Whakarewarewa forest.

Two contrasting points of view about treatment of septic tank effluent illustrate the tension that exists between various advocates. On the one hand it was stated many times and is included in the commissioned reports that the contribution of septic tanks may be less than 1% of a N budget of a lake and is therefore insignificant. On the other hand it was strongly put that the 10% of nutrients that might be left after treatment in a high-rate system, is still too much to be putting into a lake. These contrasting points of view highlight the dilemma facing managers and politicians in this debate.

A major limitation to the high-rate process of sewage treatment is the shortage of soluble carbon substrate to process the material. Methanol and molasses have been used, but access to this sort of material may be a limiting factor in the application of that technology.

Science

Scientific studies on the lakes started with the pioneering work first by Hilary Jolly, then by Geoff Fish. However it is true that much of the work represents snapshots of existing conditions rather than long-term understanding of the environmental and biological variability. Water quality monitoring initiated by Environment B·O·P has now set a systematic framework on which to build some deep scientific appreciation of how these lakes operate. This approach is applauded as only by taking many snapshots can the movie be made that will tell the dynamic story of Lake Decline and Renewal.

A major confusion for me, and I am sure for many listeners, was the assumption that all septic tanks are the same, all nitrogen (N) is the same and all blue-green algae (cyanobacteria) are the same. Everything has a place in space/time and all are different. Thus we heard from Paul Dell that some 59% of septic tanks do not meet minimum standards. Therefore some will perhaps represent a health hazard while others, operating properly, will simply represent a nutrient enrichment source. Given that there is a required set-back from the lake edge, a suitable-sized tank and vertical separation of drainage field from water table, it was agreed that the major contribution from septic tanks is of nitrogen and they do not constitute a primary health hazard. The Workshop, then, centred its attention on the contribution of septic tanks to the N economy of lakes.

Considerable confusion is created, I believe, when nutrient element levels, such as N are quoted without context. Nitrogen exists in many states of availability in the lake environment and it is essential to recognise its biological availability, lability and concentration. The nitrate that flows from septic tank drainage fields will be liberated to lake margins during flood events, will give transitional high N concentrations at margins and may result in local scums and blooms, especially in isolated bays. At least initially this N is exceptionally available as it is released into the photic zone and is in contrast to N released during anaerobic decay from sediments, which is returned to top water on mixing. Thus the immediate environmental effect of septic tank effluent N and that recycled from sediments may be entirely different.

Available data for Okawa Bay and for Lake Okareka indicate that the likely N inputs from septic tanks are in the order of 1.5 tonnes (Okawa Bay) to 2.9 tonnes (Lake Okareka). Data was also presented that other inputs into these systems far exceed the projected septic tank inputs. In the case of Okawa Bay the NIWA data shows 17-77 kg N day^{-1} being generated from the sediments compared with about 5 kgNday^{-1} from septic tanks. Similarly for Okareka, over 19 tonnes N yr^{-1} comes from the land. Implicit in this data is the conclusion that septic tanks are a minor source of N and can be ignored in the bigger scheme of things.

Okawa Bay represents a microcosm of the problem. It is a small, enclosed bay with significant algal bloom problems. The NIWA study showed that there may be as much as 77 kg N day^{-1} recycled from the bottom of the Bay while septic tank inputs are 5 kg Nday^{-1} and as much as 85 kg Nday^{-1} may be leaving the Bay. This set of figures became a test case at the meeting and an important question was put to the technical panel during question time paraphrased as follows: "If the septic tank N is such a small part of the input should we ignore it?" The panel all agreed that the septic tank N is not insignificant and cannot be compared with the recycled N from sediment. The incoming N was likened to the priming of a pump. This N is immediately available and is the ultimate driving force of the recycled N.

The sediment recycling results for Okawa Bay were based on short-term analyses and extrapolations to long-term, annual averages are dangerous to say the least. While we have reasonable measures of some of the external inputs into lakes there are very few measures of the long-term role of sediments in nutrient regeneration and recycling. As sediments build up in lakes they impose increasing oxygen demand, they release nutrients that increase primary production, which again increases the oxygen demand when those organisms settle into the sediment.

Good evidence was presented that there is a large reservoir of nutrients in the sediments of Okawa Bay and other lakes, and this is increasingly being returned to the photic zone. Anecdotal evidence was presented that sawdust from a local sawmill was dumped in the Bay in large quantities, could this be a part of the local problem?

Management

Regional Council, District Council and Health Authorities are grappling with the management difficulties of lakes that do not meet the expectations of local citizens, and offer an embarrassment to the tourist industry. We were told of the increasing need to declare whole lakes and parts of lakes off-limits for bathing and other water sports. The disturbing news is that many of the Rotorua lakes have annual cyanobacterial blooms. These changes have taken place apparently quite suddenly and apparently without any change in TLI over the past few years. Local citizens will not be blamed for expecting managers, technologists and scientists to come up with both an understanding of the problems and some answers.

A survey of over 3000 septic tanks in the Environment B·O·P area shows that over 59% do not currently comply with local standards of size and water-table levels. The costs of compliance are large, but the costs of non-compliance to ground water quality and lake quality, are perhaps higher.

Paul Sampson of RDC put the wider picture of understanding a lake by understanding the catchment. This approach is of course part of the proposed Regional Water and Land Plan. Nutrients ultimately come from the land and land-use can reasonably predict the amount of nutrient produced. For Okareka it was shown that 19 tonnes N yr^{-1} is added to the lake from the catchment, 2.9 tonnes of which originates from septic tanks and 12.5 tonnes from pastoral farming. The costs of removing the septic tank N was said to be \$M2.10 $tonne^{-1}$ while the cost of reducing the pastoral input by conversion to forest may be as low as \$M0.3 $tonne^{-1}$. From a District Council, and ratepayer point of view the economic analysis is compelling and poses a real problem in lake management.

Political

A certain tension exists between the roles of District and Regional Councils in managing water, and water bodies. An example of this was given in the permitting and monitoring of septic tanks. District Council may approve an on-site effluent treatment system under the Building Act, but this does not authorise a discharge, as this is a Regional Council responsibility. While it may be self-evident that both Councils wish to achieve the best outcomes from their ratepayers, it was evident that the management of discharges under the RMA (a Regional Council concern) imposes different and separate responsibilities on it.
These political concerns are ongoing but the tone of the meeting indicated that there is a large degree of agreement as to the nature and provenance of the problems while there is healthy debate on the solutions.

The Workshop was remarkable for the level of concern and of willingness to look for both understanding and answers. While the focus of the meeting was on septic tanks it was forced to look at many of the wider issues of lake eutrophication and management. The major management tool of TLI has apparently been accepted, though perhaps not well understood by all. There appears to be a consensus that while septic tanks may not be the major contributor to N in the TLI, other methods of sewage disposal must be implemented. The big question is who pays? This debate was entered but not resolved. On the one hand it was pointed out that the obligation of farmers to meet effluent standards is met by the individual farmer, while in urban areas it is a ratepayer obligation.

This Workshop has been most successful for the following reasons:

- It has raised awareness of the role of nutrient inputs into lakes as major determinants of their current state.
- It has highlighted the poor state of rural effluent disposal systems.
- It has opened the debate on how best to ameliorate the problems.
- It has brought Regional and District Councils together to discuss their roles.

I congratulate the organiser and participants on a most successful and stimulating meeting.