KINGETT MITCHELL
& ASSOCIATES LTD.
ENVIRONMENTAL CONSULTANTS

14 December, 1994

Our Ref: 75900

The Consents Manager
Southland Regional Council
Private Bag 90116
INVERCARGILL

Attention: Mr J Engel

Dear Sir,

RE: SOUTHGAS PROJECT - WASTE WATER DISCHARGE ISSUES

We have just completed, in draft form, our report on the water quality implications of the two well test programme proposed by Southgas. A copy of this is attached for your comments.

On broader RMA matters, we have been asked by Southgas to prepare an Assessment of Environmental Effects in respect of the water and atmospheric discharges. We are preparing this now and will forward same later this week, together with resource consent applications.

A section of the AEE will address the consultation that Southgas personnel have undertaken, including the responses of the various parties. I understand this issue was discussed between you and Southgas representatives last week. In this regard, you have suggested that the Department of Conservation be contacted, and we would appreciate if you could advise the most appropriate person to approach.

Thank you for your assistance and we look forward to receiving your feedback. In the interim if you have any queries please contact us.

Yours sincerely,
KINGETT MITCHELL & ASSOCIATES LTD

PH Mitchell

P H MITCHELL

cc: Mr I T Kennedy R C Macdonald Wellington

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SOUTHGAS COALBED DEMETHANATION PROJECT

INITIAL PHASE: ASSESSMENT OF ENVIRONMENTAL EFFECTS OF WASTEWATER DISCHARGE

Prepared for

SOUTHGAS JOINT VENTURE

November 1994

1. INTRODUCTION

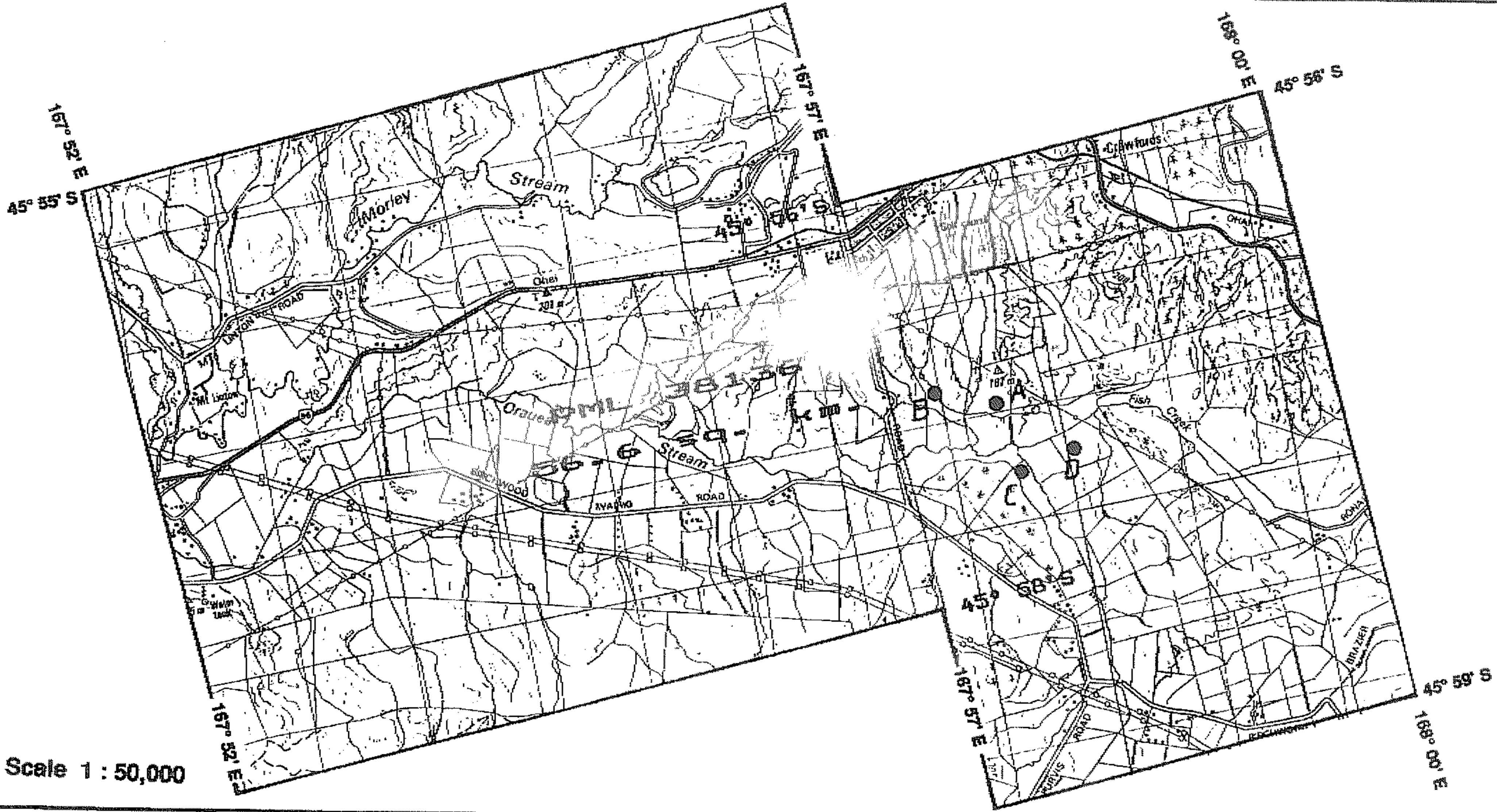
In the early 1980's, Macdonald Investments - a division of the R C Macdonald Group, formed the Southgas consortium to explore the possibility of extraction of methane gas from the Ohai Coalfield of Western Southland. Four test production wells were drilled, one well producing up to 5,600 m^3/day of gas. At that time plans for proceeding to commercial production were not pursued.

R C Macdonald Ltd holds a petroleum mining licence (PML 38136) under the Petroleum Act 1937 authorising extraction of gas from those areas of interest, located in the Ohai Coalfield, Southland. It has formed the new Southgas Resources Joint Venture to pursue the Ohai Demethanation Project.

Southgas propose in the initial testing phase (Phase 3) to drill and hydraulically stimulate two test production wells to assess coal seam permeability and other geological and geochemical characteristics of the Morley Coal Measures. If the results of this assessment are favourable then a further initial investigation, referred to as Phase 3A will proceed. This would involve the drilling and stimulation of two more test wells. Location of the four proposed test wells (A, B, C, D) is shown in Figure 1.1.

To enhance gas production all test wells will be hydraulically stimulated. This procedure opens up existing fractures in the coal seams by hydraulic pressure. Extension of the fractures is achieved by a high input pumping rate of carrier fluid (water) and proppant (quartz sand) at pressures great enough to hold the fractures open. When pumping is stopped the new fracture extensions are held open by the quartz sand. Such fractures increase the effective borehole radius and provide a pathway for the gas to the well. Water is then removed from the coal seam by pumping.

This document provides an assessment of the consequences of discharge of the water removed from the coal seam (known as production water) to the nearest major stream (Orauea Stream).



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TITLE:

SOUTHGAS JOINT VENTURE LICENCE AREA SHOWING SITES OF PROPOSED TEST PRODUCTION WELLS

CLIENT:

SOUTHGAS JOINT VENTURE

DATE: DEC 1994

PROJECT NO.: 75900

FIGURE NO.: 1.1

2. ENVIRONMENTAL CONSIDERATIONS

The four wells will be located in open farmland and the Southgas Joint Venture has engaged in consultation with the landowners Southland District Council and Southland Regional Council regarding test well operations.

2.1 WATER USAGE

Consultants to the project estimate the following water usage characteristics for each well (Geosearch 1994):

(i) Drilling: Initial requirement of 50 m^3 total per well, with a maximum daily usage of up to 5 m^3.

(ii) Hydraulic Stimulation: A total requirement 380 m^3 per well.

All water used to make up drilling fluid and fraccing water would be water obtained from the Ohai township supply (Duffill Watts & King 1994). As that water has already been treated to drinking water standards there are no concerns for any environmental effects resulting from its use *per se*.

2.2 DISCHARGE WATERS

It is proposed to use only benign additives approved by Southland Regional Council in drilling fluids (Baroid EZ MUD, potassium chloride, bentonite). The cuttings from drilling would be disposed of by a local contractor in accordance with normal procedures and Council requirements.

Fraccing fluid would be made up as a thin slurry of quartz sand. A biocide (slimicide) would be used to control fungal and bacterial growth within the coal seam. It is proposed to use Halliburton BE-4 (hexahydro-1,3,5-tris(hydroxyethyl)triazine).

It has been determined that back-extraction of production water should initially occur at a rate of 7 - 18 m^3/day in each well (Geosearch 1994). The value of 7 m^3/day is based upon a minimum assumed (induced) permeability in the well vicinity of 1 millidarcy (md). The value of 18 m^3/day is based upon a maximum assumed (induced) permeability in the well vicinity of 3 md. These values are considered to bracket the likely induced permeability in the coal seam adjacent to the production well following fraccing. The rates of water production are estimated to reduce to 5.8 - 8.6 m^3/day per well by the end of the first year and to decline steadily thereafter (Geosearch 1994).

Production water will be produced during the initial production phase at low volumetric flow rates. This is initially composed of a mixture of residual fraccing fluid water and coal seam formation water with water quality trending over about four weeks to that characteristic of (natural) coal seam formation water.

It is proposed to discharge production water to Orauea Stream. This implies that the likely minimum quality of that water must be assessed as well as the baseline quality of water in Orauea Stream to ensure that no adverse effect on the ecological health of the stream will ensue from that discharge.

3. PROGRAMME DESCRIPTION

Figure 3.1 shows the general area where the four test wells will be located but highlights in blue the stream (Orauea Stream) to which it is proposed production water from the fraccing process will be discharged. Orauea Stream lies in a shallow valley running south-east - north-west. The valley is almost exclusively used for farming purposes - principally sheep, cattle and deer grazing.

Numerous small tributaries run into Orauea Stream and those in the vicinity of, and upstream of, the likely discharge point are highlighted in red. Of particular interest is the small tributary creek marked in yellow running north-east from Ohai township. That creek receives effluent from a small sewage treatment plant servicing the township located at the head of the creek.

Sampling for water quality was conducted at five locations (Fig. 3.1 and Table 3.1). These were:

Site 1. A groundwater seepage point 80 m below the surface in the Wairaki Coal Mine at Ohai.

Site 2. On Orauea Stream, upstream of the likely discharge point, some 40 m downstream of the Birchwood Wairio Road Bridge.

Site 3. On Orauea Stream, 50 m downstream of the likely discharge point but immediately upstream of the small tributary creek receiving sewage plant wastewater.

Site 4. On Orauea Stream, downstream of the likely discharge point and 50 m downstream of the small tributary creek receiving wastewater from the Ohai township sewage treatment plant.

Site 5. Test production well TP1 from earlier Southgas activities located near Morley Stream in the north-west portion of the Southgas mining lease on Mount Linton Station.

Sampling took place on five occasions between 31/10/94 and 15/11/94. The Orauea Stream was also gauged for volumetric flow rate at sites 2 and 4 on or about each occasion that sampling for water quality occurred. Daily rainfall data for 1994 (up to 15/11/94) for Ohai was also obtained.

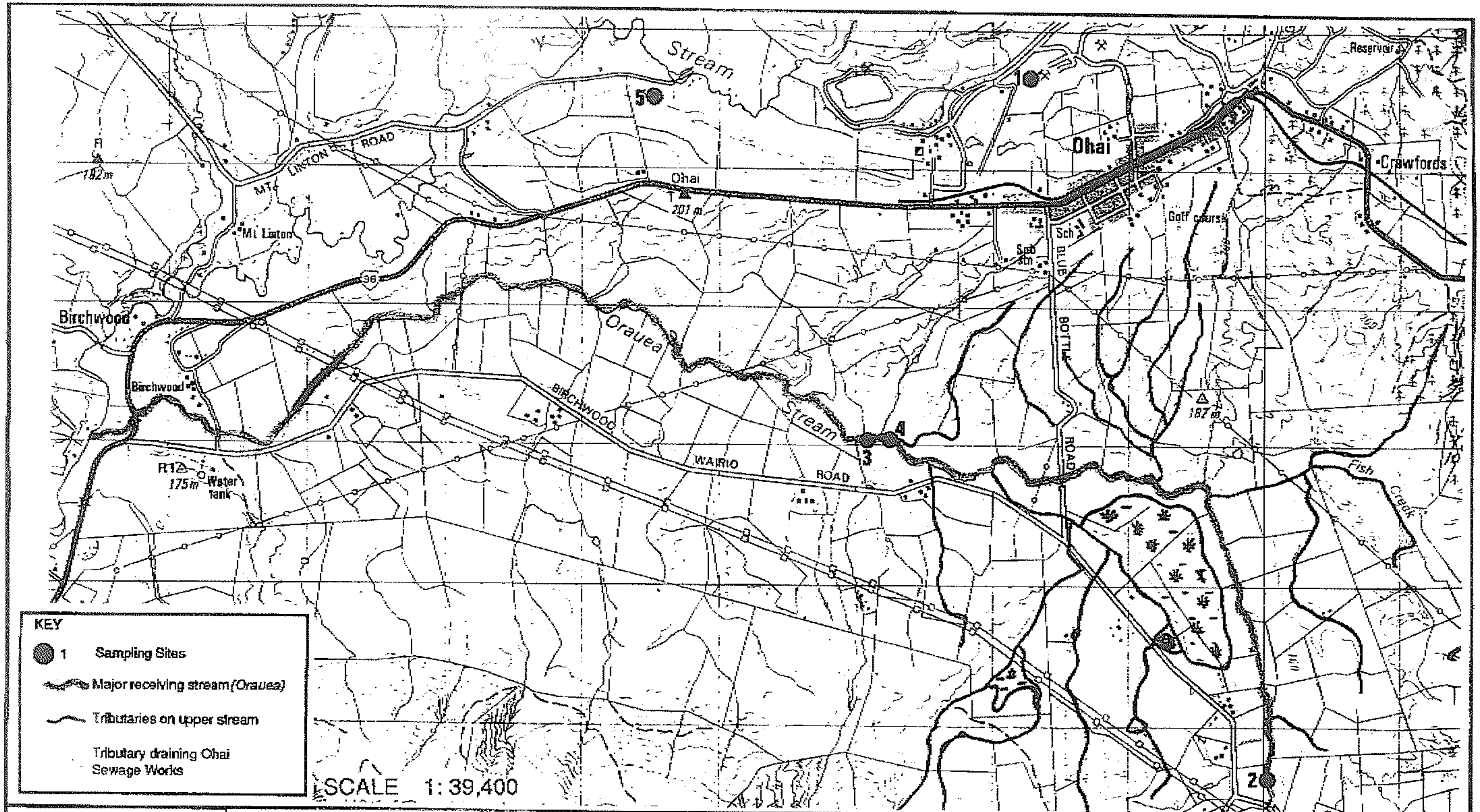
Sites 2 and 3 were sampled for water quality essentially to ascertain Orauea Stream baseline water quality above and below the likely point of discharge. Site 4 was included to determine whether treated water discharges from the Ohai Sewage Treatment Plant have a detectable impact upon Orauea Stream against which discharge of demethanation project water could be benchmarked. Sites 1 and 5 were sampled to ascertain likely water quality of back-extracted fraccing water and coal seam formation water respectively.

TABLE 3.1: Description of water quality sampling sites.

Sampling Site No.	Surface Water Sites
2	Orauea Stream upstream of proposed discharge point (40 m downstream of Birchwood Wairio roadbridge over Orauea Creek)
3	Orauea Stream downstream of proposed discharge point and downstream of small tributary creek taking Ohai sewage plant wastewater
4	Orauea Stream downstream of proposed discharge point but upstream of small tributary creek taking Ohai sewage plant wastewater
	Groundwater Sites
1	Wairaki Mine Sump Water
5	Bore TP1 on Mount Linton Station

A list of the chosen water quality parameters tested at these locations and the limit of detection tested-to is shown in Table 3.2.

Analyses for dissolved constituents were generally conducted in the usual manner by filtration through a 0.45 µm cellulose nitrate / acetate membrane filter. Groundwater is naturally filtered during passage through underground strata and any suspended solids load (including constituent elements of that load) is an artifact of the water injection or extraction process and well construction. Suspended solids in back-extracted fraccing water and production water would be overwhelmingly composed (where present) of silica sand proppant. It was concluded that analyses conducted for the baseline survey should not be biased by suspended sediment naturally present in the stream or present in the groundwater samples as an artifact of the point of sampling (well corrosion etc).



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TITLE:

DEMETHANATION PROJECT BASELINE WATER QUALITY SAMPLING SITES

DATE: DEC 1994

PROJECT NO.: 75900

CLIENT:

SOUTHGAS JOINT VENTURE

FIGURE NO.: 3.1

TABLE 3.2: Water quality parameters tested and detection limits of analysis.

Parameter	Detection Limit
Field Measurements	
pH	0.01 units
Temperature	0.1 °C
Dissolved Oxygen	0.1 g m^{-3}
Conductivity	0.01 mS cm^{-1}
Laboratory Measurements	
pH	0.01 pH units
Alkalinity (as $CaCO_3$)	1 g m^{-3}
Hardness (as $CaCO_3$)	2 g m^{-3}
Suspended solids[1]	1.0 g m^{-3}
Absorbance (270 nm)	0.002
Absorbance (420 nm)	0.002
Chloride	1.0 g m^{-3}
Boron	0.05 g m^{-3}
Sulphate	5.0 g m^{-3}
Fluoride	0.05 g m^{-3}
Dissolved calcium	0.4 g m^{-3}
Dissolved magnesium	0.2 g m^{-3}
Dissolved potassium	0.02 g m^{-3}
Dissolved sodium	0.02 g m^{-3}
Dissolved barium	0.02 g m^{-3}
Sulphide[2]	0.5 g m^{-3}
Total dissolved phosphorus	0.004 g m^{-3}
Total dissolved Kjeldahl nitrogen[3]	0.01 g m^{-3}
Total Oxidised Nitrogen[4]	0.01 g m^{-3}
Total dissolved organic carbon	0.1 g m^{-3}
Dissolved iron	0.04 g m^{-3}
Dissolved manganese	0.02 g m^{-3}
Dissolved aluminium	0.02 g m^{-3}
Dissolved copper	0.4 mg m^{-3}
Dissolved zinc	1 mg m^{-3}
Dissolved chromium	0.2 mg m^{-3}
Dissolved nickel	0.5 mg m^{-3}
Dissolved lead	0.1 mg m^{-3}
Dissolved cadmium	0.1 mg m^{-3}
Dissolved arsenic	1 mg m^{-3}
Dissolved selenium	1 mg m^{-3}

Notes:
1. **Surface waters only (sampling sites 2, 3 and 4)**
2. **Groundwaters only (sampling sites 1 and 5).**
3. **Kjeldahl nitrogen measures organic nitrogen plus ammonium ion (NH_4^+) nitrogen.**
4. **Oxidised nitrogen measures nitrate ion (NO_3^-) plus nitrite ion (NO_2^-) nitrogen.**

4. RESULTS

As noted above each designated sampling site was sampled on five occasions. In each case it was observed that water quality parameters showed very similar values, giving confidence in the results. In addition, a field blank returned for analysis from the collection on 14/11/94 showed all parameters measured below detection limits. This indicates that the method of sample collection, bottles used, and filtration procedures in the receiving laboratories did not introduce any artifacts to the analyses.

October experienced 58 mm rainfall at this site - a minimum level of rainfall. Antecedent rainfall in the Ohai area in the week prior to the first sampling date (31/10/94) was 16 mm. Rainfall during the whole sampling period totalled 37 mm. Rainfall in the week antecedent to the final sampling date (15/11/94) totalled 15 mm. Volumetric flow rates at the two Orauea Stream sites above and below the proposed discharge point are shown in Table 4.1.

It is concluded from this data that baseflow at site 2 is of the order of 0.175 $m^3 s^{-1}$ and at site 3 of the order of 0.250 $m^3 s^{-1}$. From this it is concluded that baseflow in the vicinity of the proposed discharge point is of the order of 0.225 $m^3 s^{-1}$ (19440 m^3/day). This value was used in all subsequent computations of maximum possible discharge rates to Orauea Stream.

TABLE 4.1: Orauea Stream gauging during water quality sampling period.

Date	Site 2	Site 3
1/11/94	0.229	0.315
7/11/94	0.229	0.275
9/11/94	0.203	0.300
11/11/94	0.206	0.290
15/11/94	0.186	0.258

Note: All rates in $m^3 s^{-1}$.

Mean values for all significant water quality parameters at the five sampling sites are shown in Table 4.2. Of note are the following features of the analytical data:

- Waters in Orauea Stream (sites 2, 3 and 4) and in well TP1 (site 5) exhibit a mean pH of the order of 8.2. This is the pH to be expected for water in equilibrium with calcite / dolomite in the presence of low partial pressures of carbon dioxide. This result is in accord with local surface and subsurface geology (N.Z. Geological Survey 1964), as calcareous concretions in bands up to 65 cm thick or isolated have been observed in the Morley Valley.

- Conversely, waters in the Wairaki Mine, Ohai, groundwater seep (site 1) exhibit a mean pH of the order of 7.3 and other characteristics indicating that water has had limited residence time in contact with subsurface minerals. This water largely reflects nearby meteoric infiltration, possibly that collected in the large depression excavated beside the mine entrance. Consequently it was concluded that analyses of Wairaki Mine groundwater were of limited utility, other than to confirm that subsurface water becomes enriched in chloride, sulphide, chromium, phosphorus and nitrogen species.

- Coal seam formation water from well TP1 (site 5) averages 2486 g m^{-3} chloride whereas water in Orauea Stream (site 2, 3 and 4) averages only 11 g m^{-3}.

- Water from TP1 (site 5) averaged 3.52 g m^{-3} total dissolved phosphorus and 4.7 g m^{-3} total dissolved Kjeldahl nitrogen (which being groundwater would be mostly present in the ammonium ion form). Total oxidised nitrogen (nitrate / nitrite) was undetectable (<0.010 g m^{-3}).

- Water in Orauea Stream immediately downstream of the proposed discharge point (site 4) averaged 0.028 g m^{-3} total dissolved phosphorus, 0.21 g m^{-3} total dissolved Kjeldahl nitrogen, and 0.05 g m^{-3} total oxidised nitrogen.

- Chromium, which was present at an average concentration of 76 mg m^{-3} in coal seam formation water from well TP1 (site 5) exceeds the ANZECC guideline concentration of 10 mg m^{-3} for protection of freshwater ecosystems (ANZECC 1992).

- Sulphide, which was present at an average concentration of 1.2 g m^{-3} in coal seam formation water from well TP1 (site 5) exceeds the ANZECC guideline concentration of 0.002 g m^{-3} (for undissociated sulphide) for protection of freshwater ecosystems (ANZECC 1992).

- Concentrations of all other potentially ecotoxic trace elements (aluminium, arsenic, barium, boron, cadmium, copper, nickel, lead, selenium and zinc) in coal seam formation water as obtained from well TP1 (site 5) were well below ANZECC guidelines regarding water suitable for protection of aquatic ecosystems (ANZECC 1992).

TABLE 4.2: Selected mean water quality parameter values.

Site No.	pH	Chloride	Diss. Chromium	Sulphide	Total Diss. Phosphorus	Total Diss. Kjeldahl Nitrogen	Total Oxidised Nitrogen
1.	7.34 ± 0.09	22 ± 0	4.3 ± 1.1	0.6 ± 0.8	0.080 ± 0.007	1.34 ± 0.11	<0.010
2.	8.22 ± 0.28	11 ± 0	1.2 ± 0.5	-	0.031 ± 0.015	0.144 ± 0.030	0.081 ± 0.015
3.	8.04 ± 0.31	11 ± 0	1.1 ± 0.3	-	0.034 ± 0.005	0.196 ± 0.042	0.193 ± 0.235
4.	8.08 ± 0.35	11 ± 0	1.0 ± 0.3	-	0.028 ± 0.003	0.208 ± 0.055	0.052 ± 0.026
5.	8.22 ± 0.04	2486 ± 30	76 ± 4	1.2 ± 0.6	3.52 ± 0.52	4.68 ± 0.26	<0.010

Note:
1. **All other parameters in units of g m^{-3} except dissolved chromium (mg m^{-3}).**
2. **Sulphide not tested for in surface waters (not present).**
3. **Values following ± symbol represent one standard deviation.**

5. ENVIRONMENTAL ISSUES WITH RESPECT TO WATER QUALITY

The biocide Halliburton BE-4 which would be added to fraccing fluid is of low toxicity. About 95 litres would be used per well and therefore would be subject to a dilution factor of at least 4000 (assuming the product is 100 % pure - the commercial product is certified > 60 %). Further dilution would occur as back-extracted fraccing water becomes diluted by formation water. The maximum possible concentration of BE-4 in discharged production water is therefore 250 g m^{-3}. Data supplied shows that the 48 hour EC_{50} for *Daphia* sp. (water fleas) is 26.1 g m^{-3} and the 96 hour LC_{50} for Rainbow Trout is >119 g m^{-3} (Halliburton Energy Services 1994). As the discharged production water would also be subject to a further **minimum** dilution factor of 270 (based upon four wells simultaneously discharging 18 m^3/day each) in Orauea Stream residual concentrations of BE-4 in the stream would be, at most, 0.9 g m^{-3}. This concentration poses no threat to the ecological health of stream biota. Concentrations of the principal breakdown product formaldehyde would not need to be monitored in early back-extracted production water over the three weeks of back-extraction of fraccing water as the half-time ($t_{1/2}$) for decomposition of BE-4 to formaldehyde is well in excess of 30 days above pH 8.0.

Natural water quality as measured for coal seam formation water in well TP1 (site 5) was used to estimate "worst case" dilutions required for discharge to Orauea Stream.

As noted above, chromium, present at an average concentration of 76 mg m^{-3} in coal seam formation water as measured in well TP1 (site 5) exceeds the ANZECC guideline concentration of 10 mg m^{-3} for protection of freshwater ecosystems (ANZECC 1991). However, a dilution factor of discharged water of only 8 would be sufficient to bring the chromium concentration (in Orauea Stream) within ANZECC guidelines.

As noted, sulphide, present at an average concentration of 1.2 g m^{-3} in coal seam formation water as measured in well TP1 (site 5) exceeds the concentration of **undissociated hydrogen sulphide** (H_2S) recommended (2 mg m^{-3}) as the limit for the protection of freshwater ecosystems (ANZECC 1992). The most toxic form of sulphide is hydrogen sulphide (H_2S) which is the predominant form (99 %) at pH 5, but conversion to sulphide anion (HS^-) increases rapidly with increasing pH (USEPA 1986). As discharged production water is subject to a **minimum** dilution factor of 270 upon discharge to Orauea Stream (see above), residual concentrations of total sulphide could be no more than 4.4 mg m^{-3}. As the pH of both Orauea Stream and any coal seam formation which would be discharged to it is ~ 8.2 it can be shown by speciation modelling (USEPA 1991) that residual concentrations of **undissociated** H_2S would be at least 10 times less than 4 mg m^{-3} (i.e., ≤ 0.4 mg m^{-3}) and therefore well below levels hazardous to fish and other aquatic wildlife.

As noted earlier, coal seam formation water as measured in well TP1 (site 5) averages 2486 g m^{-3} chloride. This is some 226 times more saline than water in Orauea Stream (averaging 11 g m^{-3}). ANZECC guidelines (ANZECC 1992) specify a maximum salinity of fresh waters of 1000 g m^{-3} (equivalent to a conductivity of ~ 1.5 mS cm^{-1}), although it is noted (in the Guidelines) that this concentration may need to be reduced depending on water uses. Orauea Stream (as measured at sites 2, 3 and 5) has a conductivity of ~ 0.2 mS cm^{-1} and is known to support (for example) a viable trout population. On grounds of salinity alone, discharge of coal seam formation water (the "worst case" possible water quality following back-extraction of water from test production wells) should be subjected to a dilution of at least 8 times.

However, the issue of dissolved phosphorus requires to be addressed due to the concentration of total dissolved phosphorus (TDP) observed in water from well TP1 (averaging 3.52 g m^{-3}) and the fact that algal growth in freshwater streams is commonly phosphorus limited. Phosphorus concentrations were also elevated (over typical surface water values) in the groundwater seep in the Wairaki Mine, Ohai (site 1). The concentration of total dissolved phosphorus as measured in well TP1 (site 5) is some 126 times more concentrated than at site 4 immediately downstream of the proposed discharge point on Orauea Stream. Further testing requested showed that 85 % of the inorganic phosphorus is present as free reactive phosphorus (FRP), i.e., forms of inorganic phosphate ion. This is the form of phosphorus which is immediately available biologically to stimulate algal growth in receiving stream(s). Further testing requested also showed that, on average, under baseflow conditions, 61 % of TDP is present as readily available FRP in Orauea Stream. Immediately downstream of the confluence with the small tributary contributing wastewater from the Ohai sewage plant FRP occurs at a mean concentration (under baseflow conditions) of ~ 0.019 g m^{-3}. For a baseflow of 0.225 m^3 s^{-1}, this implies a daily available phosphorus load passing this point of 369 g.

For two wells discharging production water at 18 m^3/day each the maximum possible extra load of FRP added to the stream would be 108 g/day. This would raise FRP concentration in the stream to (at the most) 0.024 g m^{-3}. This is less than the limiting value of 0.030 g m^{-3} suggested by Quinn (1991), above which undesirable changes in trophic status would occur. Chessman & Hutton (1989) have shown that a similar limit can probably be used for south-east Australian rivers and streams. A limit of ~ 0.025 g m^{-3} is generally accepted in the United States (e.g., Thomann & Mueller 1987).

It is prudent to check the dissolved inorganic nitrogen (DIN = NH_4-N + oxidised N) to FRP ratio induced in Orauea Stream below the discharges vis-a-vis the "Redfield Composition" ratio for algal biomass of 7.2 (Redfield 1958). At site 3 (below the confluence with the small tributary contributing wastewater from the Ohai sewage plant) baseflow DIN is estimated to be about 0.291 g m^{-3}. This assumes that about 50 % of total dissolved Kjeldahl nitrogen in the stream is inorganic (i.e., ammonium ion) and therefore available for algal utilisation. This suggests a DIN load in the stream under baseflow conditions at this point of about 5.66 kg/day. Addition of 36 m^3/day of coal seam formation water would contribute only about 0.17 kg extra. This would raise the DIN concentration in the stream to about 0.299 g m^{-3}. DIN/FRP ratio in the stream could only change from 15.3 to 12.5. This is not a significant shift in terms of any increased tendency to encourage algal growth and eutrophication of the stream. The shift would be even less during and following rainy periods.

Should the estimate of maximum permeability in test production wells prove too conservative, or should a situation arise where four wells are discharging production water simultaneously, in excess of a total of 36 m^3/day, then it is proposed to analyse water discharged to Orauea Stream on a monthly basis for total nitrogen and total dissolved phosphorus. Although the possibility is considered remote, should such testing show that rates of discharge of production water to the stream were significant in terms of potential to induce algal growth, consideration would be given to treating water prior to discharge. This would be easily achieved with a small "skip-mounted" unit based upon iron salt dosing, flocculation and filtration.

Note that the maximum suggested total discharge rate of ~ 36 m^3/day of water is an **initial** rate, applying only at commencement of production. Average maximum water production per well over the first year is estimated to be only ~ 13 m^3/day. Furthermore, we have assumed only baseflow conditions in Orauea Stream apply at all times. As the impact of increased or altered nutrient status of freshwater streams is manifested over timescales of one month to ten years (Hvitvied-Jacobsen 1985) it is considered unlikely that production water would require such treatment (to remove phosphorus).

It should be noted that the analyses undertaken for this study show that concentrations of these parameters measured expected to exist in stream water immediately downstream of the proposed discharge are still well within ANZECC Guidelines for water suitable for stock watering purposes or as a raw water for human drinking water supply (ANZECC 1992).

6. CONCLUSIONS

- Detailed water quality testing of water at various locations in Orauea Stream, at a groundwater seep in the Wairaki Mine, Ohai and at an abandoned test production well (TP1 on Morton Station) has been performed.

- The water quality of coal seam formation water (as measured in TP1) has been used as the "**worse case**" for production water back-extracted from the proposed four test production wells.

- Volumetric baseflow rate at the proposed point of discharge in Orauea Stream has been determined to enable **minimum** rates of dilution achievable by discharge to that stream under dry weather conditions. Over longer timescales (one month to 10 years) higher dilution rates would apply.

- No significant ecotoxicological risk is posed to the aquatic biota of Orauea Stream by the discharge of trace concentrations of the slimicide Halliburton BE-4 which would be added to injected fraccing water.

- Testing has established that no significant ecotoxicological risk is posed to the aquatic biota of Orauea Stream by the salinity or trace element composition of any coal seam formation water that may be discharged to it as test well production water.

- Dissolved phosphorus has been established as the limiting constituent of Ohai Coalfield coal seam formation water controlling maximum rates of discharge of test well production water to Orauea Stream.

- Maximum estimated rates of discharge of back-extracted production water of up to ~ 36 m^3/day do not pose a threat to Orauea Stream with respect to eutrophication.

- Should total discharge rates to Orauea Stream exceed 36 m^3/day, routine testing on a weekly basis, of dissolved phosphorus and nitrogen concentrations would be performed on discharged production water to continuously assess the potential of discharge to affect the trophic status of the Stream.

- No constituent of production water discharged to Orauea Stream produces a change in concentration of that parameter in the stream, downstream of the discharge site, which compromises the suitability of stream water for stock watering purposes or as a source of raw water for human drinking purposes.

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