TAG Oil (NZ) Limited
Sidewinder Production Station
Monitoring Programme
Biennial Report
2012-2014

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Executive summary

TAG Oil (NZ) Limited holds consents for a petrochemical production station located on Upper Durham Road at Inglewood, in the Waitara catchment. The Sidewinder Production Station processes oil and gas from the Company's adjacent Sidewinder wellsite. This report for the period July 2012-June 2014 describes the monitoring programme implemented by the Taranaki Regional Council to assess the Company's environmental performance during the period under review, and the results and environmental effects of the Company's activities.

During the monitoring period, the Company demonstrated an overall high level of environmental and administrative performance and compliance with the resource consents.

The Company holds three resource consents in relation to the Sidewinder Production Station, which include a total of 42 conditions setting out the requirements that the Company must satisfy. The Company holds one consent to discharge stormwater and treated produced water onto land, in circumstances where it may subsequently enter the Piakau Stream, and two consents to discharge emissions related to production activities into the air at this site.

The Council's monitoring programme for the period under review included 18 inspections, 12 water samples collected for physicochemical analysis, four biomonitoring surveys, and ten ambient air quality analyses. Monitoring of the stormwater discharge from the site found that all applicable conditions in the consent were complied with. There were no adverse effects found in the receiving waters of the Piakau Stream.

There were no adverse effects on the environment resulting from the exercise of the air discharge consents. The ambient air quality monitoring at the site showed that levels of carbon monoxide, combustible gases, PM_{10} particulates and nitrogen oxides were all below levels of concern at the time of sampling. No offensive or objectionable odours were detected beyond the boundary during inspections and there were no complaints in relation to odours or smoke from the site.

In the 2012-2014 period, the Council was not required to undertake significant additional investigations and interventions, or record incidents, in association with the Company's conditions in resource consents or provisions in Regional Plans. The Company demonstrated an overall high level of both environmental and administrative performance and compliance with the resource consents. The Sidewinder Production Station was well managed and maintained.

For reference, in the 2012-2013 year, 35% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of both environmental performance and compliance with their consents, while another 59% demonstrated a good level of environmental performance and compliance with their consents. In the 2013-2014 year, 60% of consent holders achieved a high level of environmental performance and compliance with their consents, while another 29% demonstrated a good level of environmental performance and compliance.

This report includes recommendations for the 2014-2015 year, including a recommendation relating to the optional review of consents 7595-1, 7777-1 and 7822-1.

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1. Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

This report is the Biennial Report for the period July 2012 – June 2014 by the Taranaki Regional Council on the monitoring programme associated with resource consents held by TAG Oil (NZ) Limited [TAG]. The Company operates a petrochemical production station situated on Upper Durham Road at Inglewood, in the Waitara catchment.

This report covers the results and findings of the monitoring programme implemented by the Council in respect of the consent held by TAG that relates to discharges of water within the Waitara catchment, and the air discharge permits held by TAG to cover emissions to air from the site.

One of the intents of the *Resource Management Act 1991* [RMA] is that environmental management should be integrated across all media, so that a consent holder's use of water, air, and land should be considered from a single comprehensive environmental perspective. Accordingly, the Taranaki Regional Council generally implements integrated environmental monitoring programmes and reports the results of the programmes jointly. This report discusses the environmental effects of the Company's use of water, land and air, and is the first combined annual report by the Taranaki Regional Council for the Sidewinder Production Station.

1.1.2 Structure of this report

Section 1 of this report is a background section. It sets out general information about compliance monitoring under the RMA and the Council's obligations and general approach to monitoring sites though annual programmes, the resource consents held by TAG in the Waitara catchment, the nature of the monitoring programme in place for the period under review, and a description of the activities and operations conducted at the Sidewinder Production Station.

Section 2 presents the results of monitoring during the period under review, including scientific and technical data.

Section 3 discusses the results, their interpretations, and their significance for the environment.

Section 4 presents recommendations to be implemented in the 2014-2015 monitoring year.

A glossary of common abbreviations and scientific terms is presented at the end of the report.

1.1.3 The Resource Management Act 1991 and monitoring

The *Resource Management Act 1991* [RMA] primarily addresses environmental 'effects' which are defined as positive or adverse, temporary or permanent, past, present or future, or cumulative. Effects may arise in relation to:

(a) the neighbourhood or the wider community around a discharger, and may include cultural and social-economic effects;
(b) physical effects on the locality, including landscape, amenity and visual effects;
(c) ecosystems, including effects on plants, animals, or habitats, whether aquatic or terrestrial;
(d) natural and physical resources having special significance (eg, recreational, cultural, or aesthetic);
(e) risks to the neighbourhood or environment.

In drafting and reviewing conditions on discharge permits, and in implementing monitoring programmes, the Taranaki Regional Council is recognising the comprehensive meaning of 'effects' inasmuch as is appropriate for each discharge source. Monitoring programmes are not only based on existing permit conditions, but also on the obligations of the RMA to assess the effects of the exercise of consents. In accordance with section 35 of the RMA, the Council undertakes compliance monitoring for consents and rules in regional plans, and maintains an overview of the performance of resource users and consent holders. Compliance monitoring, including both activity and impact monitoring, enables the Council to continually re-evaluate its approach and that of consent holders to resource management and ultimately, through the refinement of methods and considered responsible resource utilisation, to move closer to achieving sustainable development of the region's resources.

1.1.4 Evaluation of environmental and consent performance

Besides discussing the various details of the performance and extent of compliance by the consent holder/s during the period under review, this report also assigns a rating as to each Company's environmental and administrative performance.

Environmental performance is concerned with actual or likely effects on the receiving environment from the activities during the monitoring year. **Administrative performance** is concerned with the Company's approach to demonstrating consent compliance in site operations and management including the timely provision of information to Council (such as contingency plans and water take data) in accordance with consent conditions.

Events that were beyond the control of the consent holder and unforeseeable (i.e. a defence under the provisions of the *RMA* can be established) may be excluded with regard to the performance rating applied. For example loss of data due to a flood destroying deployed field equipment.

The categories used by the Council for this monitoring period, and their interpretation, are as follows:

Environmental Performance

- **High** No or inconsequential (short-term duration, less than minor in severity) breaches of consent or regional plan parameters resulting from the activity; no adverse effects of significance noted or likely in the receiving environment .The Council did not record any verified unauthorised incidents involving significant environmental impacts and was not obliged to issue any abatement notices or infringement notices in relation to such impacts.

- **Good** Likely or actual adverse effects of activities on the receiving environment were negligible or minor at most. There were some such issues noted during monitoring, from self reports, or in response to unauthorised incident reports, but these items were not critical, and follow-up inspections showed they have been dealt with. These minor issues were resolved positively, co-operatively, and quickly. The Council was not obliged to issue any abatement notices or infringement notices in relation to the minor non-compliant effects; however abatement notices may have been issued to mitigate an identified potential for an environmental effect to occur.

  For example:

  - High suspended solid values recorded in discharge samples, however the discharge was to land or to receiving waters that were in high flow at the time;
  - Strong odour beyond boundary but no residential properties or other recipient nearby.

- **Improvement required** Likely or actual adverse effects of activities on the receiving environment were more than minor, but not substantial. There were some issues noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent minor non-compliant activity could elevate a minor issue to this level. Abatement notices and infringement notices may have been issued in respect of effects.

- **Poor** Likely or actual adverse effects of activities on the receiving environment were significant. There were some items noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent moderate non-compliant activity could elevate an 'improvement required' issue to this level. Typically there were grounds for either a prosecution or an infringement notice in respect of effects.

Administrative compliance

- **High** The administrative requirements of the resource consents were met, or any failure to do this had trivial consequences and were addressed promptly and co-operatively.

- **Good** Perhaps some administrative requirements of the resource consents were not met at a particular time, however this was addressed without repeated interventions from the Council staff. Alternatively adequate reason was provided

for matters such as the no or late provision of information, interpretation of 'best practical option' for avoiding potential effects, etc.

- **Improvement required** Repeated interventions to meet the administrative requirements of the resource consents were made by Council staff. These matters took some time to resolve, or remained unresolved at the end of the period under review. The Council may have issued an abatement notice to attain compliance.

- **Poor** Material failings to meet the administrative requirements of the resource consents. Significant intervention by the Council was required. Typically there were grounds for an infringement notice.

For reference, in the 2012-2013 year, 35% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of both environmental performance and compliance with their consents, while another 59% demonstrated a good level of environmental performance and compliance with their consents. In the 2013-2014 year, 60% of consent holders achieved a high level of environmental performance and compliance with their consents, while another 29% demonstrated a good level of environmental performance and compliance.

1.2 Process description

The Sidewinder Production Station was commissioned in late 2011 following the successful drilling and testing of the Sidewinder-1, 2, 3 and 4 exploration wells, which produce gas-rich condensate. A major site expansion to the southwest of the production station was carried out over the summer of 2012/13 to allow for the drilling of three further exploration wells in 2013. Upgrades were also made to the site facilities to allow for increased throughput of oil and gas.

The facilities are designed to process up to 30 million cubic feet of gas per day, along with any associated condensate. Processed gas is exported via a 3.5 km pipeline which was constructed to provide a connection from the Sidewinder site to the North Island gas network. Condensate is exported via a truck load-out facility.

All chemical storage is contained within bunds and isolated from the stormwater system. Stormwater from these areas is directed for treatment through a three-stage API interceptor. The site's stormwater drain system consists of open culvert ring-drains which capture general surface water run-off. All stormwater passes through two lined skimmer pits before discharging to land near the Piakau Stream at the southeastern corner of the site.

Photo 1 Sidewinder Production Station and wellsite in February 2012

1.3 Resource consents

1.3.1 Water discharge permit

Section 15(1)(a) of the RMA stipulates that no person may discharge any contaminant into water, unless the activity is expressly allowed for by a resource consent or a rule in a regional plan, or by national regulations.

During the period under review, TAG held water discharge permit **7595-1** to discharge treated stormwater and production water from hydrocarbon exploration and production operations at the Sidewinder wellsite onto and into land in the vicinity of the Piakau Stream. This permit was issued by the Taranaki Regional Council on 11 February 2010 under Section 87(e) of the RMA. It was varied twice, on 14 January 2011 and 6 December 2011, to account for a site name change and an increase in the size of the catchment area, respectively. It is due to expire on 1 June 2027.

Conditions 1 and 2 require adoption of the best practicable option and place a limit on the maximum catchment area.

Conditions 3 and 4 require works notifications and provision of a contingency plan.

Conditions 5 to 7 relate to the stormwater system design and bunding of hazardous substance storage areas.

Conditions 8 to 10 stipulate limits on constituents in the discharge and effects on receiving waters.

Conditions 11 to 13 relate to site reinstatement, lapse and review.

The permit is attached to this report in Appendix I.

1.3.2 Air discharge pemits

Section 15(1)(c) of the RMA stipulates that no person may discharge any contaminant from any industrial or trade premises into air, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations.

TAG holds air discharge permit **7777-1** to discharge emissions to air associated with production activities at the Sidewinder wellsite, including flaring from well workovers, and emergency situations, and other miscellaneous activities. This permit was issued by the Taranaki Regional Council on 7 February 2011 under Section 87(e) of the RMA. It is due to expire on 1 June 2027.

Conditions 1 and 2 require notification of significant flaring events to the Council and neighbouring residents, and the maintenance of a record of all enquiries or complaints.

Conditions 3 and 4 exclude the flaring of liquid or solid hydrocarbons.

Condition 5 requires adoption of the best practicable option at all times.

Conditions 6 to 10 relate to the prevention and minimisation of emissions.

Conditions 11 and 12 require provision of an analysis of the well stream upon request and maintenance of a flaring log.

Conditions 13 and 14 are lapse and review provisions.

TAG also holds air discharge permit **7822-1** to discharge emissions into the air from the flaring of hydrocarbons arising from hydrocarbon production and processing operations, together with miscellaneous emissions, at the Sidewinder Production Station. This permit was issued by the Taranaki Regional Council on 22 June 2011 under Section 87(e) of the RMA. It is due to expire on 1 June 2027.

Condition 1 requires adoption of the best practicable option at all times.

Conditions 2 to 6 detail requirements for the recording and provision of information.

Conditions 7 and 8 require notification of site alterations and instances of continuous flaring.

Conditions 9 to 13 relate to the prevention and minimisation of emissions.

Conditions 14 and 15 are lapse and review provisions.

These permits are attached to this report in Appendix I.

1.4 Monitoring programme

1.4.1 Introduction

Section 35 of the RMA sets out obligations upon the Taranaki Regional Council to gather information, monitor, and conduct research on the exercise of resource consents, and the effects arising, within the Taranaki region and report upon these.

The Taranaki Regional Council may therefore make and record measurements of physical and chemical parameters, take samples for analysis, carry out surveys and inspections, conduct investigations, and seek information from consent holders.

The monitoring programme for the Sidewinder Production Station consisted of four primary components.

1.4.2 Programme liaison and management

There is generally a significant investment of time and resources by the Taranaki Regional Council in:

- ongoing liaison with resource consent holders over consent conditions and their interpretation and application;
- in discussion over monitoring requirements;
- preparation for any reviews;
- renewals;
- new consents;
- advice on the Council's environmental management strategies and content of regional plans; and
- consultation on associated matters.

1.4.3 Site inspections

The Sidewinder Production Station and wellsite was visited eighteen times during the monitoring period. With regards to the consent for discharges to land/water, the main points of interest were plant processes with potential or actual discharges to receiving watercourses, including contaminated stormwater and process wastewaters. Air inspections focused on plant processes with associated actual and potential emission sources and characteristics, including potential odour, dust, noxious or offensive emissions. Sources of data being collected by the consent holder were identified and accessed, so that performance in respect of operation, internal monitoring, and supervision could be reviewed by the Council. The neighbourhood was surveyed for environmental effects.

1.4.4 Chemical sampling

The Taranaki Regional Council undertook sampling of both the discharges from the site and the water quality upstream and downstream of the discharge point and mixing zone.

The Sidewinder Production Station discharge was sampled on four occasions, and the samples analysed for chlorides, conductivity, hydrocarbons, pH and suspended solids. The Piakau Stream was sampled concurrently, and the samples analysed for the same constituents.

The Council also undertook sampling of the ambient air quality outside the boundary of the site. A multi-gas meter was deployed on four occasions in the vicinity of the plant, with monitoring consisting of continuous measurements of gas concentrations for the gases of interest (carbon monoxide and combustible gases). A 'DustTrak' PM_{10}

particulate monitor was also deployed on four occasions, and nitrogen oxides (NO_x) passive absorption samplers were deployed on two occasions at three monitoring sites.

The full air monitoring reports are attached in Appendix II.

1.4.5 Biomonitoring surveys

Four biological surveys were performed in the Piakau Stream to determine whether or not the discharge of treated stormwater from the site had had a detrimental effect upon the communities of the stream.

The full survey reports are attached in Appendix III.

2. Results

2.1 Water

2.1.1 Inspections

Eighteen inspections were carried out at the Sidewinder Production Station and wellsite in the 2012-2014 period. The following was found during the inspections:

23 August 2012
The site was inspected after a period of prolonged rainfall. At the time of inspection the weather was fine. The site was tidy and well managed. The skimmer pits were full of clear water with no evidence of any contaminants. Only a pilot flare was operating. The API separator and all bunds and ring drains were clear. Everything was satisfactory.

1 November 2012
The site was inspected during fine weather with no significant rain having occurred for a week or more. The skimmer pits were clear and not discharging. The ring drains were free of contaminants and a frog was in residence at the top end of the drain. Some flaring was being undertaken, but this was very minor and no downwind effects were noted. The site was tidy and well managed. Steve Webling [TAG] was on site at the time of inspection. Everything was satisfactory.

10 January 2013
It was observed that no silt containment measures were in place along the northern side of the site extension adjacent to a small stream. It was highly likely that silt/sediment would enter the stream if it rained. The installation of silt cloth would reduce the effects caused by the runoff of this sediment into the stream. It was requested that the Company install silt cloth by the end of the following day.

22 January 2013
An inspection of the site found it to be dry. The skimmer pits were nearly empty and were not discharging. Staff on site advised that the pits would be lined with plastic in the very near future. Silt cloth had been placed along the length of the earthworks areas adjacent to the stream and grass seed had been applied to stabilise the banks.

12 February 2013
Inspection found the site to be clean and tidy. The ring drains were in good condition. The skimmer pits were not discharging at the time of inspection.

1 March 2013
Drilling was not taking place at the time of inspection. The rig was to be moved over the coming days to commence drilling another well. The skimmer pits were not discharging at the time of the visit. The site was dry, clean and tidy. A spill of drilling mud had occurred in the morning as a result of operator error. The spill was contained to a small area and immediately cleaned up. The contaminants had been removed from the site and disposed of as per normal procedure. Fresh gravel had been put in place of the removed contaminated gravel. The spill did not reach the ring drain. It appeared that the response to the spill was well managed with the appropriate action taken for the circumstances.

15 March 2013
Drilling was taking place on the site. The testing of wellheads was also about to begin. The site was clean and tidy. There were some small spills observed, including what appeared to be dried drilling mud in the ring drain. All minor spills were being cleaned up with a shovel by the on-site HSE Officer. The skimmer pits were empty after the contents had recently been pumped out to be used in the drilling operation. In general, the site appeared to be well managed and spills had been quickly attended to.

26 March 2013
The ring drains were found to be in good working order. The on-site HSE Officer was ensuring that debris was cleared from the ring drains to allow water to flow freely. Attention was being given to ensure any spills around the mud tank area were being cleaned up straight away. The Company was advised to ensure that bunded areas were clean prior to any rain occurring.

14 May 2013
No stormwater discharge was occurring at time of inspection. All bunds and ring drains were secure and clear of any debris after the recent high winds. The Rival drilling rig was on site undertaking well completion work. The wellsite area was also neat and tidy. No flaring was been undertaken at the time of inspection, although a pilot flare was evident. Everything was satisfactory.

7 June 2013
Inspection found that drilling activities had recently stopped on site due to noise constraints. The rig was still on site. The site was clean and tidy with no indication of any contaminated areas. The skimmer pits were not discharging at the time of the inspection.

13 June 2013
There were no stormwater discharges from the production station or wellsite. The ring drains and bunds were clear. There was no flaring or any notable odours. The site was neat and tidy. Everything was satisfactory.

6 August 2013
The production station site and facilities were inspected during equipment demobilisation on the adjacent exploration site. The ring drains and bunds on the production site were clear of contaminants. The skimmer pits were clear of contaminants and the discharge to the adjacent stream was not causing any effects. No flaring was being undertaken. Everything was satisfactory.

1 January 2014
The site was inspected following recent rain. The ring drains and bunds were clear. Water in the skimmer pits was very clean and not discharging at time of inspection. Minimal flaring was being undertaken with no detectable smoke or odours. The site was neat and tidy.

26 February 2014
The site was neat and tidy. A pilot flare was burning. There was no stormwater discharge off the site. The separators and bunds were clear. The site was well managed. Everything was satisfactory.

30 April 2014
The site was inspected following recent heavy rain. No effects of any stormwater discharges were noted in the receiving environment. Little or no activity was being carried out at this facility. No flaring, odours or areas of concern were noted.

15 May 2014
The site was inspected following extremely heavy rain, primarily to assess the effect of this on the stormwater system, bunds, skimmer pits and separators. The systems were coping very well. There were no silt control issues. The TAG stormwater sampling regime was discussed with the operator on site at the time. There was minimal flaring, with only a pilot flare burning at time of inspection. Everything was satisfactory.

20 June 2014
The site was inspected after heavy rainfall. It was neat and tidy. Only a pilot flare was burning with no smoke or odours. The ring drains and skimmer pits were clear of contaminants. There was no stormwater discharge at the time of inspection. The API separator was getting close to its effective capacity. The Company was advised to test and drain off the excess water as required.

30 June 2014
The stormwater discharge to the adjacent stream was clear of contaminants. No effects on the stream from this discharge were noted. The site was neat and tidy. Everything was satisfactory.

2.1.2 Results of discharge monitoring

Chemical water quality sampling of the discharge from the Sidewinder Production Station was undertaken on four occasions during the 2012-2014 period. The samples were collected on 28 May 2013, 18 June 2013, 12 June 2014 and 27 June 2014. Table 1 presents the results. The location of the sampling site (IND002050) is shown in Figure 1.

Table 1 Results for discharge monitoring from Sidewinder Production Station (site IND002050)

Parameter	Units	28 May 2013	18 June 2013	12 June 2014	27 June 2014	Consent limits
Chloride	g/m^3	9.0	7.7	0.8	2.0	50
Conductivity	mS/m	4.6	4.4	1.7	1.4	-
Hydrocarbons	g/m^3	4.6	0.8	< 0.5	< 0.5	15
Suspended solids	g/m^3	85	20	4	12	100
Temperature	Deg. C	8.2	13.0	10.1	10.7	-
pH		7.0	7.2	7.0	7.2	6.0 – 9.0

All results were in compliance with the applicable conditions of consent 7595-1 at the times of sampling.

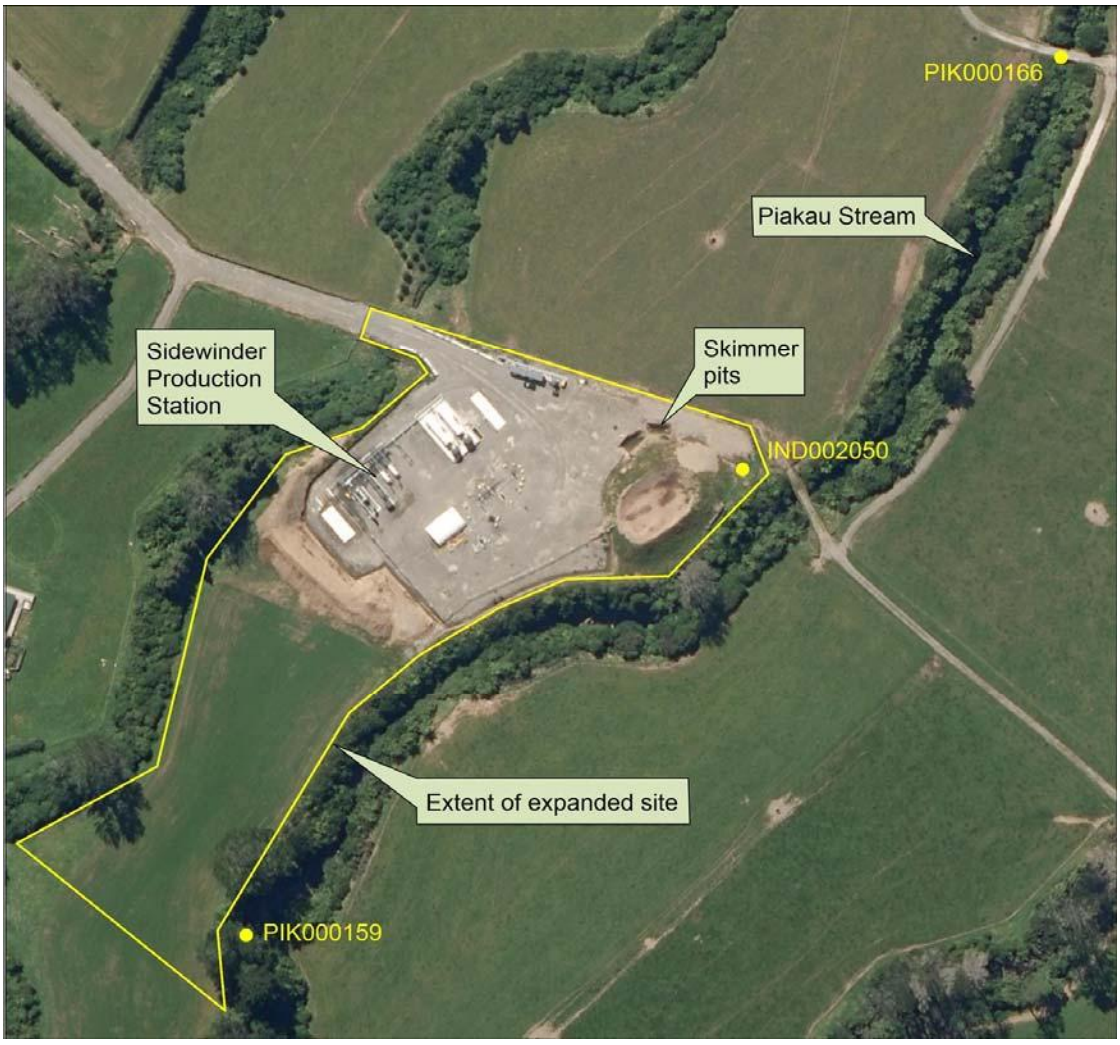

Figure 1 Sidewinder Production Station and associated water quality sampling sites

2.1.3 Results of receiving environment monitoring

Chemical

Receiving water quality sampling was undertaken in conjunction with discharge sampling at points upstream (PIK000159) and downstream (PIK000166) of the discharge. The results are presented in Table 2 and the sampling sites are shown in Figure 1 above. These sites were chosen because they provide safe access to the stream during periods of rain and are outside of the discharge mixing zone. The stretch of the Piakau Stream between these two points has very high, steep banks which would not permit easy escape in the event of rising waters.

The results indicate that the discharge was not affecting the water quality of the Piakau Stream and was in compliance with all applicable consent conditions for receiving waters at the times of sampling.

Table 2 Results of receiving environment monitoring in relation to Sidewinder Production Station

Date	Parameter	Chloride	Conductivity	Hydrocarbons	Suspended solids	Temperature	**pH**
	Unit	g/m^3	mS/m	g/m^3	g/m^3	Deg. C	
28 May 2013	Upstream site PIK000159	8.1	7.1	< 0.5	2	8.6	7.4
	Downstream site PIK000166	8.4	7.2	< 0.5	2	8.7	7.5
18 Jun 2013	Upstream site PIK000159	6.4	4.2	< 0.5	5	11.1	7.2
	Downstream site PIK000166	6.1	4.4	< 0.5	6	11.3	7.2
12 Jun 2014	Upstream site PIK000159	7.4	6.8	4.0	3	10.4	7.4
	Downstream site PIK000166	7.4	7.0	< 0.5	3	10.5	7.4
27 Jun 2014	Upstream site PIK000159	7.9	6.0	< 0.5	< 2	10.6	7.3
	Downstream site PIK000166	7.6	6.2	< 0.5	4	10.7	7.4

Biomonitoring

The Council's standard 'kick-sampling' technique was used at three established sites on four occasions to collect streambed macroinvertebrates from the Piakau Stream, to assess whether discharges from the Sidewinder Production Station had had any detrimental effects on the macroinvertebrate communities of this stream. The sites are shown in Figure 2. Site 1 (PIK000160) is 60 m upstream of the Sidewinder Production Station discharge. Site 2 (PIK000162) is 25 m downstream and site 3 (PIK000165) 100 m downstream of the discharge. This section of the stream can be safely accessed for biomonitoring because the work is undertaken in fine weather. Samples were sorted and identified to provide the number of taxa (richness) and MCI and $SQMCI_S$ scores for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects or organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The $SQMCI_S$ takes into account taxa abundance as well as sensitivity to pollution, and may reveal more subtle changes in communities, particularly if non-organic impacts are occurring. Significant differences in either the MCI or the $SQMCI_S$ between sites may indicate the degree of adverse effects (if any) of the discharges being monitored.

Figure 2 Biomonitoring sites in the Piakau Stream adjacent to the Sidewinder Production Station

29 November 2012

This late spring macroinvertebrate survey indicated that the discharge of treated stormwater and production water to land and to water from the recently established Sidewinder Production Station site had not had any recent detrimental effects on the macroinvertebrate communities of the Piakau Stream. The MCI scores for each site were all significantly higher than their respective predictive scores for equivalent sites in the upper mid-reaches of ringplain streams. No significant changes in the macroinvertebrate communities were recorded between sites and $SQMCI_S$ scores were not significantly different between sites.

The macroinvertebrate communities of the stream contained very high proportions of 'sensitive' taxa at all sites. In addition, communities at all sites had a number of common dominant taxa (they shared four of the seven dominant taxa through the surveyed reach). There were no significant changes in MCI values between sites, coincident with very similar habitat at all sites. In addition, taxonomic richness (numbers of taxa) was relatively consistent across all three sites. The MCI scores indicated that the stream communities were of very good 'health', and better than typical conditions in comparison with predictive values recorded from equivalent ringplain stream sites. The absence of significant differences between the three sites indicated no recent impacts from any of the Sidewinder Production Station discharges to land and/or run-off to the adjacent Piakau Stream.

15 February 2013
This late summer macroinvertebrate survey indicated that the discharge of treated stormwater and production water to land and to water from the recently established Sidewinder Production Station site had not had any recent detrimental effects on the macroinvertebrate communities of the Piakau Stream. The MCI scores for each site were all higher than their respective predictive scores for equivalent sites in the upper mid-reaches of ringplain streams. No significant changes in the macroinvertebrate communities were recorded between sites and $SQMCI_S$ scores were not significantly different between sites.

Lower MCI scores were recorded at all sites by this late summer survey in comparison with the earlier (and only) previous survey in late spring which is a typical seasonal trend in ringplain streams.

The macroinvertebrate communities of the stream contained very high proportions of 'sensitive' taxa at all sites. In addition, communities at all sites had a number of common dominant taxa (they shared seven of the eight dominant taxa through the surveyed reach). There were no significant changes in MCI values between sites, coincident with very similar habitat at all sites. In addition, taxonomic richness (numbers of taxa) was relatively consistent across all three sites. The MCI scores indicated that the stream communities were of good 'health', and better than typical conditions in comparison with predictive values recorded from equivalent ringplain stream sites. The absence of significant differences between the three sites indicated no recent impacts from any of the Sidewinder Production Station discharges to land and/or run-off to the adjacent Piakau Stream.

18 December 2013
This early summer macroinvertebrate survey indicated that the discharge of treated stormwater and production water to land and to water from the Sidewinder Production Station site had not had any recent detrimental effects on the macroinvertebrate communities of the Piakau Stream. The MCI scores for each site were all higher than their respective predictive scores for equivalent sites in the upper mid-reaches of ringplain streams. No significant changes in the macroinvertebrate communities were recorded between sites and $SQMCI_S$ scores were not significantly different between sites.

Higher MCI scores were recorded at sites 2 and 3 in this early summer survey in comparison with the previous survey conducted in late summer which is a typical seasonal trend in ringplain streams. The MCI score for site 1 remained the same.

The macroinvertebrate communities of the stream contained very high proportions of 'sensitive' taxa at all sites. In addition, communities at all sites had a number of common dominant taxa (they shared five of the nine dominant taxa through the surveyed reach). There were no significant changes in MCI values between sites, coincident with very similar habitat at all sites. In addition, taxonomic richness (numbers of taxa) was relatively consistent across all three sites. The MCI scores indicated that the stream communities were of good to very good 'health', and better than typical conditions in comparison with predictive values recorded from equivalent ringplain stream sites. The absence of significant differences between the three sites indicated no recent impacts from any of the Sidewinder Production Station discharges to land and/or run-off to the adjacent Piakau Stream.

11 February 2014
This summer macroinvertebrate survey indicated that the discharge of treated stormwater and production water to land and to water from the Sidewinder Production Station site had not had any recent detrimental effects on the macroinvertebrate communities of the Piakau Stream. At the time of this survey, it was noted that a significant portion of the steep bank near the point of discharge had collapsed into the stream. It was possible that the discharge, which ponds between the outlet of the final skimmer pit and the stream, had saturated the soil and destabilised the bank. The Company was instructed to investigate and remedy this issue.

The MCI scores for each site were all higher or similar to their respective predictive scores for equivalent sites in the upper mid-reaches of ringplain streams. The reduction in MCI score recorded from the upstream site to the two downstream sites was due almost entirely to the presence/absence of a number of taxa only found as rarities (less than 5 individuals/site).

The macroinvertebrate communities of the stream contained very high proportions of 'sensitive' taxa at all sites. In addition, communities at all sites had a number of common dominant taxa (they shared four of the eight dominant taxa through the surveyed reach). There were no significant changes in $SQMCI_S$ scores between sites, coincident with very similar habitat at all sites. In addition, taxonomic richness (numbers of taxa) was relatively consistent across all three sites.

The MCI scores indicated that the stream communities were of good to very good 'health', and similar or better than typical conditions in comparison with predictive values recorded from equivalent ringplain stream sites. The results of this survey indicated no recent impacts from any of the Sidewinder Production Station discharges to land and/or run-off to the adjacent Piakau Stream.

2.2 Air

2.2.1 Inspections

Air inspections were carried out in conjunction with site inspections as discussed in section 2.1.1 above. No issues regarding air quality were noted during the monitoring period.

2.2.2 Results of receiving environment monitoring

During the period under review, a multi-gas meter and a DustTrak PM_{10} particulate monitor were deployed concurrently on four occasions in the vicinity of the plant. Nitrogen oxide [NO_x] passive absorption samplers were deployed on two occasions at three monitoring sites. These sites are shown in Figure 3.

Carbon monoxide and combustible gases

A multi-gas meter was deployed on 20 November 2012, 23 January 2013, 15 August 2013 and 11 December 2013. The deployments lasted from 46 to 90 hours, with the instrument placed in a downwind position at the start of the deployment. Monitoring consisted of continual measurements of concentrations for carbon monoxide [CO] and combustible gases.

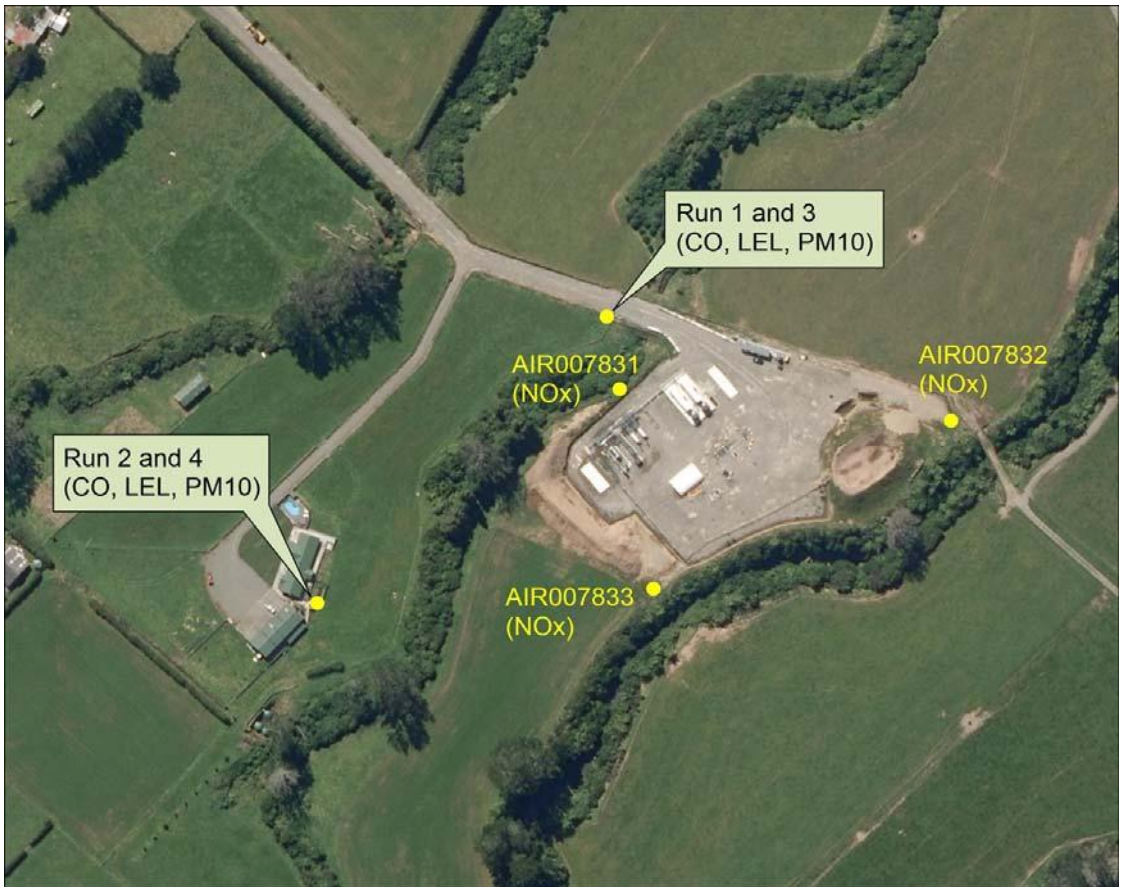

Figure 3 Air quality sampling sites in relation to the Sidewinder Production Station

Because of the nature of the activities on the site, it was considered that the primary information of interest in respect of gases potentially emitted from the site was the average downwind concentration, rather than any instantaneous peak value. That is, the long-term exposure levels, rather than short-term maxima, are of most interest. The gas meter was therefore set up to create a data set based on recording the average concentration measured during each minute as raw data. A summary of the results is shown in Table 3.

The consents for air discharges from the Sidewinder Production Station and wellsite have specific limits for particular gases. Special condition 11 of consent 7822-1 sets a limit on the CO concentration at or beyond the production station site boundary at 10 mg/m^3 (eight-hour average exposure), or 30 mg/m^3 (one-hour average exposure). The maximum concentration of CO found during the monitoring period was 10.4 ppm, equivalent to 8.8 mg/m^3. The average concentration across all the monitoring runs was only 0.05 ppm, equivalent to 0.04 mg/m^3, which complies with the consent condition.

The concentration of combustible gases detected in the sampled air is expressed as a percentage of the lower explosive limit [LEL%] of methane. The sensor in the instrument reacts to gases and vapours such as acetone, benzene, butane, methane, propane, carbon monoxide, ethanol and higher alkanes and alkenes with varying degrees of sensitivity. The Council's Regional Air Quality Plan has a general requirement that no discharge shall result in a dangerous level of airborne contaminants, including risk of explosion. This is also expressed in special condition 10 of consent 7822-1 which prohibits hazardous, toxic or noxious levels of contaminants at

or beyond the site boundary. At no time did the level of explosive gases downwind of the Sidewinder Production Station reach any more than a trivial level.

Table 3 Summary of ambient gas monitoring results at Sidewinder Production Station

Run number		1	2	3	4	Average
Deployed	From	20 Nov 2012 13:27	23 Jan 2013 13:00	15 Aug 2013 15:06	11 Dec 2013 13:25	
	To	22 Nov 2012 11:28	25 Jan 2013 15:16	19 Aug 2013 08:14	14 Dec 2013 20:04	
Maximum	CO (ppm)	1.90	10.4	0.30	7.40	5.00
	LEL (%)	0.10	0.20	0.20	0.20	0.18
Mean	CO (ppm)	0.00	0.10	0.00	0.10	0.05
	LEL (%)	0.00	0.00	0.00	0.00	0.00
Minimum	CO (ppm)	0.00	0.00	0.00	0.00	0.00
	LEL (%)	0.00	0.00	0.00	0.00	0.00

PM_{10} particulates

Particulates can be derived from many sources, including motor vehicles (particularly diesel engines), solid and oil-burning processes for industry and power generation, incineration and waste burning, photochemical processes, and natural sources such as pollen and sea spray. PM_{10} particulates are linked to adverse health effects that arise primarily from the ability of particles of this size to penetrate deep into the lungs and inhibit their function. In 2004, the Ministry for the Environment introduced a National Environmental Standard [NES] for certain air pollutants. The NES for PM_{10} is 50 $\mu g/m^3$ (24-hour average). Background levels of PM_{10} in Taranaki have been found to be around 11 $\mu g/m^3$.

During the monitoring period, a DustTrak PM_{10} monitor was deployed on four occasions in the vicinity of the site, with the instrument placed in a downwind position at the start of the deployment. Monitoring consisted of continual measurement of PM_{10} concentrations. The sites are shown in Figure 3.

The average recorded PM_{10} concentration was 10.3 $\mu g/m^3$ for the first two runs, and 6.2 $\mu g/m^3$ for the last two runs. These equate to 21 and 12 percent, respectively, of the NES for a 24-hour average. The maximum recorded PM_{10} concentration over the monitoring period was 220 $\mu g/m^3$. This short term spike may have been caused by local traffic movements on adjacent unsealed roads.

Nitrogen oxides

Nitrogen oxides [NO_x] are potential products of fossil fuel combustion. Exposure to elevated levels of NO_x in humans can affect breathing and impair immune system functioning. Nitrogen oxides are toxic to plants and can contribute to brown haze and petrochemical smog.

Photo 2 Clean burning flare at the Sidewinder Production Station

The Council has been monitoring NO_x in the region since 1993 using passive absorption discs which capture target gases from the air. The length of time the disc is exposed to the atmosphere and the amount of NO_x absorbed can be used to calculate theoretical maximum 1 and 24-hour average concentrations that may have occurred during the deployment period. The Council uses the most conservative corrective factor in this calculation to produce a 'worst case scenario' result.

Table 4 Summary of nitrogen oxides monitoring results at Sidewinder Production Station

Site	Date	NO_x laboratory result µg/m^3	NO_x 24-hour average (theoretical maximum) µg/m^3	NO_x 1-hour average (theoretical maximum) µg/m^3
AIR007831	Nov-Dec 2012	1.0	1.9	3.6
	Aug-Sep 2013	1.6	2.9	5.4
AIR007832	Nov-Dec 2012	1.2	2.3	4.3
	Aug-Sep 2013	1.0	1.8	3.4
AIR007833	Nov-Dec 2012	3.8	7.2	13.5
	Aug-Sep 2013	1.6	2.9	5.4
Consent limits			*100*	*200*

During the monitoring period, passive absorption discs were deployed at three sites around the boundary of the production station on two separate occasions, for periods of 24 and 19 days respectively. The sites are shown in Figure 3. The results and the calculated maxima are presented in Table 4, along with the limits imposed by condition 12 of consent 7822-1.

The results indicate that concentrations of nitrogen oxides in the vicinity of the Sidewinder Production Station were in compliance with all applicable consent conditions and far below levels of concern during the period under review.

2.3 Investigations, interventions, and incidents

The monitoring programme for the period was based on what was considered to be an appropriate level of monitoring, review of data, and liaison with the consent holder. During the period matters may arise which require additional activity by the Council, for example provision of advice and information, or investigation of potential or actual courses of non-compliance or failure to maintain good practices. A pro-active approach that in the first instance avoids issues occurring is favoured.

The Taranaki Regional Council operates and maintains a register of all complaints or reported and discovered excursions from acceptable limits and practices, including non-compliance with consents, which may damage the environment. The Incident Register [UIR] includes events where the company concerned has itself notified the Council. The register contains details of any investigation and corrective action taken.

Complaints may be alleged to be associated with a particular site. If there is potentially an issue of legal liability, the Council must be able to prove by investigation that the identified company is indeed the source of the incident (or that the allegation cannot be proven).

In the 2012-2014 period, the Council was not required to undertake significant additional investigations and interventions, or record incidents, in association with the Company's conditions in resource consents or provisions in Regional Plans relating to the Sidewinder Production Station.

3. Discussion

3.1 Discussion of site performance

Monitoring the Sidewinder Production Station during the 2012-2014 period found that the site was well managed. All consent conditions relating to site operations and management were complied with. Any issues identified during inspections were quickly resolved.

3.2 Environmental effects of exercise of consents

Monitoring of the stormwater discharge from the site found that all applicable conditions in the consent were complied with. There were no adverse effects found in the receiving waters of the Piakau Stream.

There were no adverse effects on the environment resulting from the exercise of the air discharge consents. The ambient air quality monitoring at the site showed that levels of carbon monoxide, combustible gases, PM_{10} particulates and nitrogen oxides were all below levels of concern at the time of sampling. No offensive or objectionable odours were detected beyond the boundary during inspections and there were no complaints in relation to odours or smoke from the site.

3.3 Evaluation of performance

A tabular summary of the consent holder's compliance record for the period under review is set out in Tables 5-7.

Table 5 Summary of performance for Consent 7595-1 to discharge treated stormwater and production water from hydrocarbon exploration and production operations onto and into land in the vicinity of the Piakau Stream

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Adoption of the best practicable option	Inspection and liaison with consent holder	Yes
2. Maximum stormwater catchment area	Inspection and company records	Yes
3. Notification to Council seven days prior to site works and well drilling	Notifications received	Yes
4. Maintenance of a contingency plan	Latest update received 17 July 2013	Yes
5. Design and maintenance of stormwater system in accordance application documentation	Inspection and liaison with consent holder	Yes
6. All stormwater and produced water discharged through treatment system	Inspection	Yes
7. Bunding and containment of hazardous substances	Inspection	Yes
8. Limits on constituents in the discharge	Sampling	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
9. Temperature increase of not more than 2 degrees Celsius in receiving waters	Sampling	Yes
10. Limits on effects in receiving waters	Inspection and sampling	Yes
11. 48 hrs notice prior to reinstatement	Site still active	N/A
12. Lapse provision	Consent exercised	N/A
13. Optional review provision	Option for review in June 2015 not recommended	N/A
Overall assessment of environmental performance and compliance in respect of this consent		High
Overall assessment of administrative performance in respect of this consent		High

N/A = not applicable

Table 6 Summary of performance for Consent 7777-1 to discharge emissions to air associated with production activities at the Sidewinder wellsite, including flaring from well workovers, and emergency situations, and other miscellaneous activities

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Notification prior to continuous flaring	Notifications received	Yes
2. Notification of neighbours prior to flaring	No complaints received	Yes
3. Effective liquid and solid separation prior to flaring	Inspection and notifications	Yes
4. Only gaseous hydrocarbons to be flared	Inspection and notifications	Yes
5. Adoption of best practicable option to minimise effects from the flare	Inspection and air monitoring	Yes
6. No offensive odour or smoke beyond boundary	Inspection and public notification	Yes
7. Hydrocarbon storage vessels to have vapour recovery systems	Inspection	Yes
8. Control of carbon monoxide emissions	Air monitoring	Yes
9. Control of nitrogen oxide emissions	Air monitoring	Yes
10. Control of emissions to meet WES limits for other contaminants	Explosive gases and PM10 levels also monitored	Yes
11. Analysis of typical gas and condensate stream	Analysis not requested	N/A
12. Keep and maintain a flaring log	Inspection and annual flaring report	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
13. Lapse provision	Consent exercised	N/A
14. Optional review provision	Option for review in June 2015 not recommended	N/A
Overall assessment of environmental performance and compliance in respect of this consent		High
Overall assessment of administrative performance in respect of this consent		High

N/A = not applicable

Table 7 Summary of performance for Consent 7822-1 to discharge emissions into the air from the flaring of hydrocarbons arising from hydrocarbon production and processing operations, together with miscellaneous emissions, at the Sidewinder Production Station

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Adoption of best practicable option to minimise effects from the flare	Inspection and air monitoring	Yes
2. Keep and maintain a flaring log	Inspection and annual flaring report	Yes
3. Monthly flaring information supplied	Information received	Yes
4. Provision of annual flaring and air emissions report	Report received	Yes
5. Keep and maintain a record of smoke emitting incidents	Inspection and annual flaring report	Yes
6. Analysis of typical gas and condensate stream	Analysis not requested	N/A
7. Consultation prior to plant alterations which may alter flare emissions	Inspection and liaison with consent holder	Yes
8. Notification of continuous flaring	Notifications received	Yes
9. No offensive odour, dust or smoke beyond boundary	Inspection and public notification	Yes
10. No hazardous/toxic/noxious contaminants beyond boundary	Inspections and air monitoring	Yes
11. Control of carbon monoxide emissions	Air monitoring	Yes
12. Control of nitrogen oxide emissions	Air monitoring	Yes
13. Control of emissions to meet WES limits for other contaminants	Explosive gases and PM10 levels also monitored	Yes
14. Lapse provision	Consent exercised	N/A
15. Optional review provision	Option for review in June 2015 not recommended	N/A
Overall assessment of environmental performance and compliance in respect of this consent		High
Overall assessment of administrative performance in respect of this consent		High

N/A = not applicable

During the period under review, the Company demonstrated an overall high level of both environmental performance and administrative compliance with the resource consents as defined in Section 1.1.4. The Sidewinder Production Station was well managed and maintained.

3.4 Alterations to monitoring programmes for 2014-2015

In designing and implementing the monitoring programmes for air/water discharges in the region, the Taranaki Regional Council has taken into account the extent of information made available by previous authorities, its relevance under the RMA, the obligations of the Act in terms of monitoring emissions/discharges and effects, and subsequently reporting to the regional community. The Council also takes into account the scope of assessments required at the time of renewal of permits, and the need to maintain a sound understanding of industrial processes within Taranaki emitting to the atmosphere/discharging to the environment.

It is proposed that for 2014-2015 the monitoring programme is amended to reflect the Council's changes to the structure of all monitoring programmes, primarily to provide for amended health and safety requirements. A recommendation to this effect is attached to this report.

3.5 Exercise of optional review of consents

Resource consents 7595-1, 7777-1 and 7822-1 provide for optional review in June 2015. Conditions 13, 14 and 15, respectively, allow the Council to review the consents for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of these resource consents, which were either not foreseen at the time the applications were considered or which it was not appropriate to deal with at the time.

Based on the results of monitoring in the period under review, it is considered that there are no grounds that require a review to be pursued or grounds to exercise the review option for any of these consents.

A recommendation to this effect is presented in Section 4 of this report.

4. Recommendations

1. THAT monitoring of consented activities at the Sidewinder Production Station in the 2014-2015 year be amended from that undertaken in 2012-2014 to reflect the Council's changes to the structure of all monitoring programmes.

1. THAT the option for review of resource consents in June 2015, as set out in conditions 13, 14 and 15 of consents 7595-1, 7777-1 and 7822-1, respectively, not be exercised on the grounds that the current conditions are considered adequate to deal with any adverse effects on the environment arising from the exercise of these resource consents.

Glossary of common terms and abbreviations

The following abbreviations and terms may be used within this report:

Al*	Aluminium.
As*	Arsenic.
Biomonitoring	Assessing the health of the environment using aquatic organisms.
BOD	Biochemical oxygen demand. A measure of the presence of degradable organic matter, taking into account the biological conversion of ammonia to nitrate.
BODF	Biochemical oxygen demand of a filtered sample.
Bund	A wall around a tank to contain its contents in the case of a leak.
CBOD	Carbonaceous biochemical oxygen demand. A measure of the presence of degradable organic matter, excluding the biological conversion of ammonia to nitrate.
cfu	Colony forming units. A measure of the concentration of bacteria usually expressed as per 100 millilitre sample.
COD	Chemical oxygen demand. A measure of the oxygen required to oxidise all matter in a sample by chemical reaction.
Condy	Conductivity, an indication of the level of dissolved salts in a sample, usually measured at 20°C and expressed in mS/m.
Cu*	copper.
Cumec	A volumetric measure of flow- 1 cubic metre per second (1 m^3s^{-1}).
DO	Dissolved oxygen.
DRP	Dissolved reactive phosphorus.
E.coli	Escherichia coli, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample.
Ent	Enterococci, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre of sample.
F	Fluoride.
FC	Faecal coliforms, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample.
Fresh	Elevated flow in a stream, such as after heavy rainfall.
g/m^3	Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures.
Incident	An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred.
Intervention	Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring.
Investigation	Action taken by Council to establish what were the circumstances/events surrounding an incident including any allegations of an incident.

l/s	Litres per second.
MCI	Macroinvertebrate community index; a numerical indication of the state of biological life in a stream that takes into account the sensitivity of the taxa present to organic pollution in stony habitats.
mS/m	Millisiemens per metre.
Mixing zone	The zone below a discharge point where the discharge is not fully mixed with the receiving environment. For a stream, conventionally taken as a length equivalent to 7 times the width of the stream at the discharge point.
NH_4	Ammonium, normally expressed in terms of the mass of nitrogen (N).
NH_3	Unionised ammonia, normally expressed in terms of the mass of nitrogen (N).
NO_3	Nitrate, normally expressed in terms of the mass of nitrogen (N.)
NTU	Nephelometric Turbidity Unit, a measure of the turbidity of water.
O&G	Oil and grease, defined as anything that will dissolve into a particular organic solvent (e.g. hexane). May include both animal material (fats) and mineral matter (hydrocarbons).
Pb*	Lead.
pH	A numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline. The scale is logarithmic i.e. a change of 1 represents a ten-fold change in strength. For example, a pH of 4 is ten times more acidic than a pH of 5.
Physicochemical	Measurement of both physical properties (e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment.
PM_{10}	Relatively fine airborne particles (less than 10 micrometre diameter).
Resource consent	Refer Section 87 of the RMA. Resource consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15).
RMA	*Resource Management Act* 1991 and including all subsequent amendments.
SS	Suspended solids.
SQMCI	Semi quantitative macroinvertebrate community index.
Temp	Temperature, measured in °C (degrees Celsius).
Turb	Turbidity, expressed in NTU.
UI	Unauthorised Incident.
UIR	Unauthorised Incident Register – contains a list of events recorded by the Council on the basis that they may have the potential or actual environmental consequences that may represent a breach of a consent or provision in a Regional Plan.
Zn*	Zinc.

*an abbreviation for a metal or other analyte may be followed by the letters 'As', to denote the amount of metal recoverable in acidic conditions. This is taken as indicating the total amount of metal that might be solubilised under extreme environmental conditions. The abbreviation may alternatively be followed by the letter 'D', denoting the amount of the metal present in dissolved form rather than in particulate or solid form. For further information on analytical methods, contact the Council's laboratory.

Appendix I

Resource consents held by TAG Oil (NZ) Limited

TARANAKI REGIONAL COUNCIL
CHIEF EXECUTIVE
PRIVATE BAG 713
47 CLOTEN ROAD
STRATFORD
NEW ZEALAND
PHONE: 06-765 7127
FAX: 06-765 5097
www.trc.govt.nz
Please quote our file number on all correspondence

Discharge Permit

Pursuant to the Resource Management Act 1991 a resource consent is hereby granted by the Taranaki Regional Council

Name of Consent Holder:	TAG Oil (NZ) Limited P O Box 262 STRATFORD 4352	**New Address:** P O Box 402 New Plymouth 434 0
Decision Date:	22 June 2011	
Commencement Date:	22 June 2011	

Conditions of Consent

Consent Granted:	To discharge emissions into the air from the flaring of hydrocarbons arising form hydrocarbon production and processing operations, together with miscellaneous emissions, at the Sidewinder Production Station at or about (NZTM) 1703971E-5659277N
Expiry Date:	1 June 2027
Review Date(s):	June 2015, June 2021
Site Location:	Sidewinder wellsite, 323 Upper Durham Road, Inglewood [Property owner: B.F.F Limited]
Legal Description:	Lot 4 DP 420600 [Discharge source & site]

For General, Standard and Special conditions pertaining to this consent please see reverse side of this document

General condition

a. The consent holder shall pay to the Taranaki Regional Council [the Council] all the administration, monitoring and supervision costs of this consent, fixed in accordance to section 36 of the Resource Management Act.

Special conditions

Exercise of consent

1. The consent holder shall at all times adopt the best practicable option [as defined in section 2 of the Resource Management Act 1991] to prevent or minimise any actual or likely adverse effects on the environment associated with the discharge of contaminants into the environment arising from the emissions to air from the flare.

Recording and submitting information

2. The consent holder shall keep and maintain a log of all continuous flaring incidents lasting longer than 5 minutes and any intermittent flaring lasting for an aggregate of 10 minutes or longer in any 60-minute period. The log shall contain the date, the start and finish times, the quantity and type of material flared, and the reason for flaring. The log shall be made available to the Chief Executive, Taranaki Regional Council, upon request, and summarised annually in the report required under condition 4. Flaring, under normal operation in the low pressure flare, of rich mono-ethylene glycol degasser vapour, condensate tank vapours, non-condensibles from tri-ethylene glycol/mono-ethylene glycol regeneration and purge gas shall be excluded from this requirement.

3. The consent holder shall supply to the Taranaki Regional Council each month a copy of flaring information comprising: the type and amount of material flared [including any gas used to maintain a pilot flame], the date this was flared, the reason why flaring was undertaken, and an indication of whether smoke was produced from such flaring events.

4. The consent holder shall provide to the Taranaki Regional Council during May of each year, for the duration of this consent, a report:

    a) detailing gas combustion at the production station flare, including but not restricted to routine operational flaring and flaring logged in accordance with condition 2;
    b) detailing any measures that have been undertaken by the consent holder to improve the energy efficiency of the production station;
    c) detailing any measures to reduce smoke emissions;
    d) detailing any measures to reduce flaring,
    e) addressing any other issue relevant to the minimisation or mitigation of emissions from the production station flare; and
    f) detailing any complaints received and any measures undertaken to address complaints.

5. The consent holder shall keep and make available to the Chief Executive, Taranaki Regional Council, upon request, a record of all smoke emitting incidents, noting time, duration and cause. The consent holder shall also keep, and make available to the Chief Executive, upon request, a record of all complaints received as a result of the exercise of this consent.

Information and notification

6. The consent holder shall make available to the Chief Executive, Taranaki Regional Council upon request, an analysis of a typical gas and/or condensate stream from the Mt Messenger Formation, covering sulphur compound content and the content of compounds containing six or more carbon atoms in their molecular structure.

7. Prior to undertaking any alterations to the plant equipment, processes or operations, which may substantially alter the nature or quantity of flare emissions other than as described in the consent application, the consent holder shall first consult with the Chief Executive, Taranaki Regional Council, and shall obtain any necessary approvals under the Resource Management Act 1991.

8. The consent holder shall notify the Chief Executive, Taranaki Regional Council, as soon as practicable, whenever the continuous flaring of hydrocarbons [other than the flaring of rich mono-ethylene glycol degasser vapour, condensate tank vapours, non-condensibles from tri-ethylene glycol/mono-ethylene glycol regeneration and purge gas] is expected to occur for more than five minutes in duration.

Preventing and minimising emissions

9. The discharges authorised by this consent shall not, whether alone or in conjunction with any other emissions from the site arising, give rise to any levels of odour or dust or smoke that are offensive or obnoxious or objectionable at or beyond the boundary of the site as shown on attached aerial photograph [figure 1].

10. The consent holder shall not discharge any contaminant to air from the site at a rate or a quantity such that the contaminant, whether alone or in combination with other contaminants, is or is liable to be hazardous or toxic or noxious at or beyond the boundary of the site as shown on attached aerial photograph.

11. The consent holder shall control all discharges of carbon monoxide to the atmosphere from the flare, whether alone or in conjunction with any other emissions from the site, in order that the maximum ground level concentration of carbon monoxide arising from the exercise of this consent measured under ambient conditions does not exceed 10 milligrams per cubic metre [eight-hour average exposure], or 30 milligrams per cubic metre [one-hour average exposure] at or beyond the boundary of the site as shown on attached aerial photograph.

12. The consent holder shall control all discharges of nitrogen dioxide or its precursors to the atmosphere from the flare, whether alone or in conjunction with any other discharges to the atmosphere from the site, in order that the maximum ground level concentration of nitrogen dioxide arising from the exercise of this consent measured under ambient conditions does not exceed 200 micrograms per cubic metre [one hour average exposure], or 100 micrograms per cubic metre [twenty-four hour average exposure], at or beyond the boundary of the site as shown on attached aerial photograph [figure 1].

13. The consent holder shall control discharges to the atmosphere from the flare of contaminants other than carbon dioxide, carbon monoxide, and nitrogen oxides, whether alone or in conjunction with any other emissions from the site, in order that the maximum ground level concentration for any particular contaminant arising from the exercise of this consent, measured at or beyond the boundary of the site as shown on attached aerial photograph, is not increased above background levels:

    a) by more than 1/30th of the relevant Workplace Exposure Standard-Time Weighted Average [exposure averaged over a duration as specified for the Workplace Exposure Standard-Time Weighted Average], or by more than 1/10th of the Workplace Exposure Standard-Short Term Exposure Limit over any short period of time [all terms as defined in Workplace Exposure Standards, 2002, Department of Labour]; or

    b) if no Short Term Exposure Limit is set, by more than the General Excursion Limit at any time [all terms as defined in Workplace Exposure Standards, 2002, Department of Labour].

Lapse and Review

14. This consent shall lapse on 30 June 2016, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

15. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2015 and/or June 2021, for the purposes of:

    a) dealing with any significant adverse effect on the environment arising from the exercise of the consent which was not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or

    b) requiring the consent holder to adopt the best practicable option to remove or reduce any adverse effect on the environment caused by the discharge; and/or

c) to alter, add or delete limits on mass discharge quantities or discharge or ambient concentrations of any contaminant or contaminants.

Signed at Stratford on 22 June 2011

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Figure 1

Aerial photograph showing site boundary [white line]

TARANAKI REGIONAL COUNCIL
CHIEF EXECUTIVE
PRIVATE BAG 713
47 CLOTEN ROAD
STRATFORD
NEW ZEALAND
PHONE: 06-765 7127
FAX: 06-765 5097
www.trc.govt.nz
Please quote our file number on all correspondence

Discharge Permit

Pursuant to the Resource Management Act 1991 a resource consent is hereby granted by the Taranaki Regional Council

Name of Consent Holder:	TAG Oil (NZ) Limited P O Box 262 STRATFORD 4352	**New Address:** P O Box 402 New Plymouth 4340
Decision Date:	7 February 2011	
Commencement Date:	7 February 2011	

Conditions of Consent

Consent Granted:	To discharge emissions to air associated with production activities at the Sidewinder wellsite, including flaring from well workovers, and emergency situations, and other miscellaneous activities at or about (NZTM) 1703906E-5659287N
Expiry Date:	1 June 2027
Review Date(s):	June 2015, June 2021
Site Location:	Sidewinder wellsite, 323 Upper Durham Road, Inglewood [Property owner: B.F.F Limited]
Legal Description:	Lot 4 DP 420600 [Discharge source & site]
Catchment:	Waitara

For General, Standard and Special conditions pertaining to this consent please see reverse side of this document

General condition

a. The consent holder shall pay to the Taranaki Regional Council [the Council] all the administration, monitoring and supervision costs of this consent, fixed in accordance to section 36 of the Resource Management Act.

Special conditions

1. Other than in emergencies, the consent holder shall notify the Chief Executive, Taranaki Regional Council, whenever the continuous flaring of hydrocarbons [other than purge gas] is expected to occur for more than five minutes in duration. Notification shall be no less than 24 hours before the flaring commences. Notification shall include the consent number and be emailed to worknotification@trc.govt.nz.

2. At least 24 hours before any flaring, other than in emergencies, the consent holder shall provide notification to all residents within 300 metres of the wellsite of the commencement of flaring. The consent holder shall include in the notification a 24-hour contact telephone number for a representative of the consent holder, and shall keep and make available to the Chief Executive, Taranaki Regional Council, a record of all queries and complaints received in respect of any flaring activity.

3. To the greatest extent possible, all gas that is flared must first be treated by effective liquid and solid separation and recovery.

4. Only gaseous hydrocarbons originating from the well stream shall be combusted within the flare pit.

5. The consent holder shall adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimise any actual or potential effect on the environment arising from any emission to air from the flare, including, but not limited to having regard to the prevailing and predicted wind speed and direction at the time of initiation of, and throughout, any episode of flaring so as to minimise offsite effects [other than for the maintenance of a pilot flare flame].

6. The discharge shall not cause any objectionable or offensive odour or smoke at or beyond the boundary of the property where the wellsite is located.

7. All permanent tanks used as hydrocarbon storage vessels, shall be fitted with vapour recovery systems.

8. The consent holder shall control all emissions of carbon monoxide to the atmosphere from the flare so that, whether alone or in conjunction with any other emissions from the wellsite, the maximum ground level concentration of carbon monoxide arising from the exercise of this consent measured under ambient conditions does not exceed 10 milligrams per cubic metre [mg/m^3] [eight-hour average exposure], or 30 mg/m^3 one-hour average exposure] at or beyond the boundary of the property where the wellsite is located.

9. The consent holder shall control all emissions of nitrogen oxides to the atmosphere from the flare so that, whether alone or in conjunction with any other emissions from the wellsite, the maximum ground level concentration of nitrogen dioxide arising from the exercise of this consent measured under ambient conditions does not exceed 100 micrograms per cubic metre [$\mu g/m^3$] [24-hour average exposure], or 200 $\mu g/m^3$ [1-hour average exposure] at or beyond the boundary of the of the property where the wellsite is located.

10. The consent holder shall control emissions to the atmosphere from the wellsite and flare of contaminants other than carbon dioxide, carbon monoxide, and nitrogen oxides so that, whether alone or in conjunction with any emissions from the flare, the maximum ground level concentration for any particular contaminant arising from the exercise of this consent measured at or beyond the boundary of the property where the wellsite is located, is not increased above background levels:

    a) by more than $1/30^{th}$ of the relevant Occupational Threshold Value-Time Weighted Average, or by more than the Short Term Exposure Limit at any time [all terms as defined in Workplace Exposure Standards, 2002, Department of Labour]; or

    b) if no Short Term Exposure Limit is set, by more than three times the Time Weighted Average at any time [all terms as defined in Workplace Exposure Standards, 2002, Department of Labour].

11. The consent holder shall make available to the Chief Executive, Taranaki Regional Council, upon request, an analysis of a typical gas and condensate stream from the field, covering sulphur compound content and the content of carbon compounds of structure C_6 or higher number of compounds.

12. The consent holder shall record and make available to the Chief Executive, Taranaki Regional Council, a 'flaring log' that includes:

    a) the date, time and duration of all flaring episodes;

    b) the zone from which flaring occurred;

    c) the volume of substances flared;

    d) whether there was smoke at any time during the flaring episode and if there was, the time, duration and cause of each 'smoke event'.

13. This consent shall lapse on 31 March 2016, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

14. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2015 and/or June 2021, for any of the following purposes:

    a) dealing with any significant adverse effect on the environment arising from the exercise of the consent which was not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or

    b) requiring the consent holder to adopt specific practices in order to achieve the best practicable option to remove or reduce any adverse effect on the environment caused by the discharge; and/or

    c) to alter, add or delete limits on mass discharge quantities or discharge or ambient concentrations of any contaminant.

Signed at Stratford on 7 February 2011

For and on behalf of
Taranaki Regional Council

Director-Resource Management

TARANAKI REGIONAL COUNCIL
CHIEF EXECUTIVE
PRIVATE BAG 713
47 CLOTEN ROAD
STRATFORD
NEW ZEALAND
PHONE: 06-765 7127
FAX: 06-765 5097
www.trc.govt.nz
Please quote our file number on all correspondence

Discharge Permit

Pursuant to the Resource Management Act 1991 a resource consent is hereby granted by the Taranaki Regional Council

Name of Consent Holder:	TAG Oil (NZ) Limited P O Box 402 NEW PLYMOUTH 4340
Decision Date [Change]:	6 December 2011
Commencement Date [Change]:	6 December 2011 [Granted: 11 February 2010]

Conditions of Consent

Consent Granted:	To discharge treated stormwater and production water from hydrocarbon exploration and production operations at the Sidewinder wellsite onto and into land in the vicinity of Piakau Stream at or about (NZTM) 1703906E-5659287N
Expiry Date:	1 June 2027
Review Date(s):	June 2015, June 2021
Site Location:	Sidewinder wellsite, 323 Upper Durham Road, Inglewood [Property owner: BFF Limited]
Legal Description:	Lot 4 DP 420600 [Discharge source & site]
Catchment:	Waitara
Tributary:	Manganui Ngatoro Maketawa Piakau

For General, Standard and Special conditions pertaining to this consent please see reverse side of this document

General condition

a. The consent holder shall pay to the Taranaki Regional Council all the administration, monitoring and supervision costs of this consent, fixed in accordance to section 36 of the Resource Management Act.

Special conditions

1. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimise any actual or likely adverse effect on the environment associated with the discharge of contaminants from the site.

2. Stormwater discharged shall be collected from a catchment area of no more than 1.85 ha.

3. The Chief Executive, Taranaki Regional Council, shall be notified in writing at least 7 days prior to any site works commencing, and again in writing at least 7 days prior to any well drilling operation commencing. Notification shall include the consent number and a brief description of the activity consented and be emailed to worknotification@trc.govt.nz.

4. The consent holder shall maintain a contingency plan that, to the satisfaction of the Chief Executive, Taranaki Regional Council, details measures and procedures to be undertaken to prevent spillage or accidental discharge of contaminants not authorised by this consent and measures to avoid, remedy or mitigate the environmental effects of such a spillage or discharge.

5. The design, management and maintenance of the stormwater system shall be undertaken in accordance with the information submitted in support of the consent application [application 6415], in particular, section 8.1 of the Assessment of Environmental Effects.

6. All stormwater and produced water shall be directed for treatment through the stormwater treatment system identified in condition 5 before being discharged.

7. Any significant volumes of hazardous substances [e.g. bulk fuel, oil, drilling fluid] on site shall be:

   a) contained in a double skinned tank, or

   b) stored in a dedicated bunded area with drainage to sumps, or to other appropriate recovery systems, and not directly to the site stormwater system.

8. Constituents in the discharge shall meet the standards shown in the following table.

Constituent	Standard
pH	Within the range 6.0 to 9.0
suspended solids	Concentration not greater than 100 gm^{-3}
total recoverable hydrocarbons	Concentration not greater than 15 gm^{-3}
chloride	Concentration not greater than 50 gm^{-3}

This condition shall apply prior to the entry of the treated stormwater into the receiving waters of the Piakau Stream at a designated sampling point approved by the Chief Executive, Taranaki Regional Council.

9. After allowing for a mixing zone of 25 metres, the discharge shall not give rise to an increase in temperature of more than 2 degrees Celsius.

10. After allowing for a mixing zone of 25 metres, the discharge shall not give rise to any of the following effects in the receiving water:

a) the production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials;
b) any conspicuous change in the colour or visual clarity;
c) any emission of objectionable odour;
d) the rendering of fresh water unsuitable for consumption by farm animals;
e) any significant adverse effects on aquatic life.

11. The consent holder shall advise the Chief Executive, Taranaki Regional Council, in writing at least 48 hours prior to the reinstatement of the site and the reinstatement shall be carried out so as to minimise adverse effects on stormwater quality. Notification shall include the consent number and a brief description of the activity consented and be emailed to worknotification@trc.govt.nz.

12. This consent shall lapse on 31 March 2015, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

13. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2015 and/or June 2021, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Signed at Stratford on 6 December 2011

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Appendix II

Air monitoring reports

Memorandum

To Job Manager, Callum MacKenzie
From Scientific Officer - Air Quality, Brian Cheyne
File Spordmon315, 7822-1, FRODO# 1378962
Date July 23, 2014

Ambient air quality monitoring at Sidewinder Production Station (2013-14)

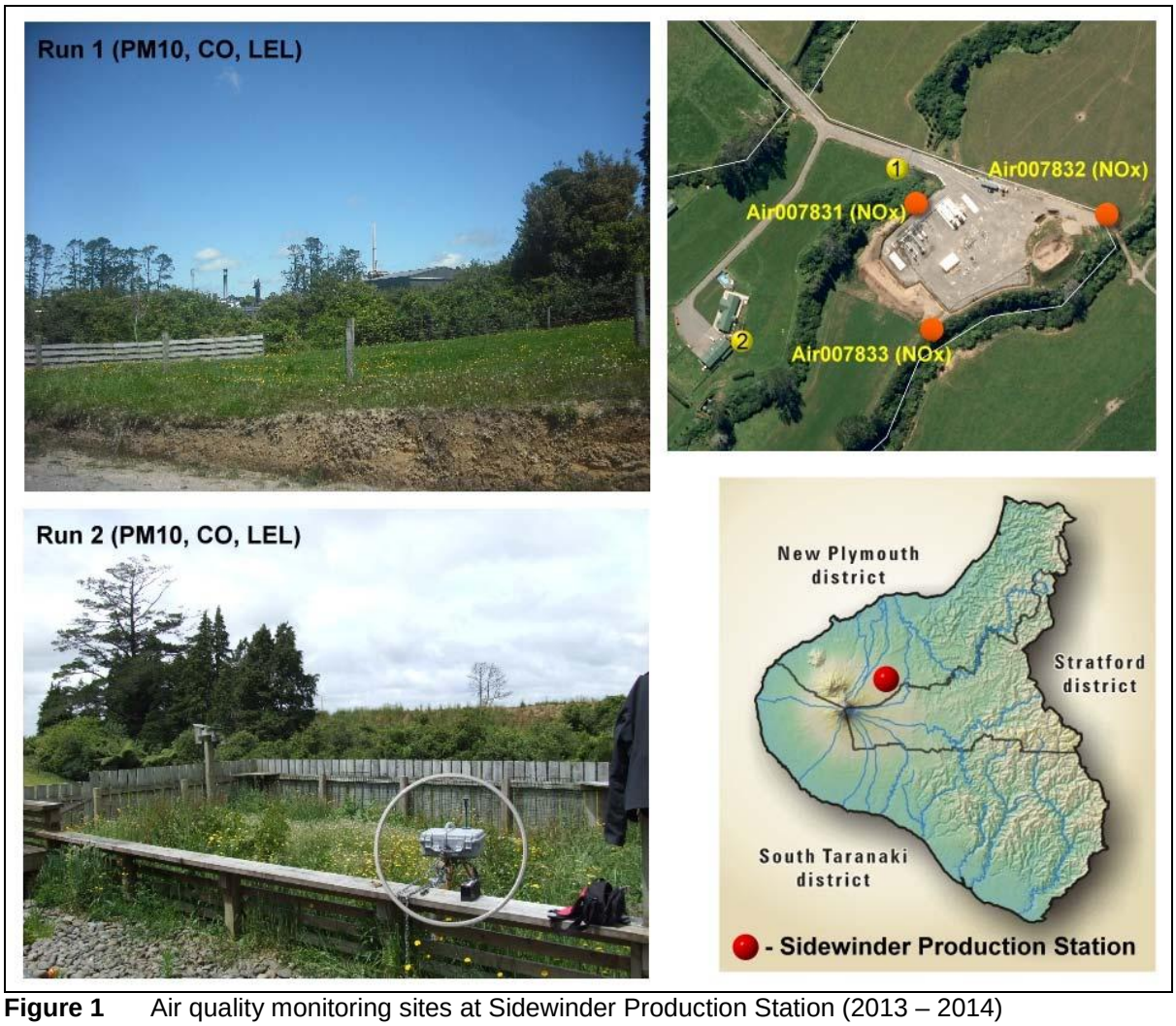

Figure 1 Air quality monitoring sites at Sidewinder Production Station (2013 – 2014)

QRae -multi gas analyser:

During the July 2013 – 30 June 2014 monitoring period, a multi-gas meter was deployed on two occasions in the vicinity of the Sidewinder Production Station. Both deployments lasted approximately seventy-two hours, with the instrument placed in a down-wind position. Monitoring consisted of continual measurements of gas concentration for carbon monoxide and combustible gases.

The location of the air quality monitoring sites is shown in Figure 1. The results of monitoring undertaken are summarized in Table 1 and the data presented graphically in Figure 2.

Because of the nature of the activities on the site, it was considered that the primary information of interest in respect of gases potentially emitted from the site was the average downwind concentration, rather than any instantaneous peak value. That is, the long-term exposure levels, rather than short-term maxima, are of most interest. The gas meter was therefore set up to create a data set based on recording the average concentration measured during each minute as raw data.

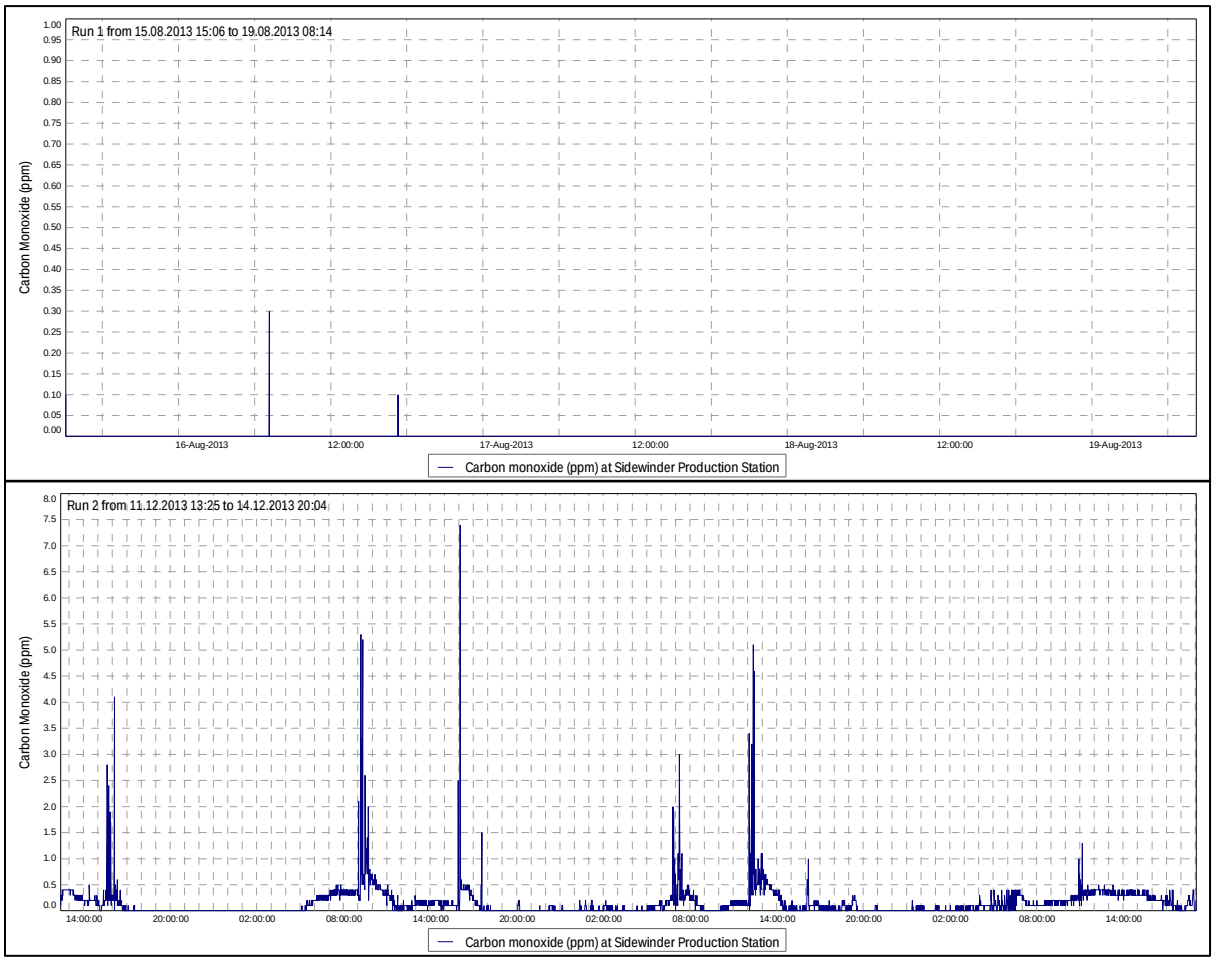

Figure 2 Graphs of ambient gas levels in the vicinity of the Sidewinder Production Station (2013-14)

Table 1 Summary of ambient gas monitoring results at Sidewinder Production Station (2013-14)

Run		1	2	Average
Period (from-to)		15.08.2013 15:06 19.08.2013 08:14	11.12.2013 13:25 14.12.2013 20:04	
Max	CO(ppm)	0.30	7.40	3.85
	LEL(%)	0.20	0.20	0.20
Mean	CO(ppm)	0.00	0.10	0.05
	LEL(%)	0.00	0.00	0.00
Min	CO(ppm)	0.00	0.00	0.00
	LEL(%)	0.00	0.00	0.00

Note: (1) the instrument records in units of ppm. At 15°C
1ppm CO = 0.85 mg/m^3

(2) See text for explanation of LEL. Because the LEL of methane is equivalent to a mixture of approximately 5% methane in air, then the actual concentration of methane in air can be obtained by dividing the % LEL by 20.

Carbon Monoxide (CO)

The consents covering air discharges from the Sidewinder Production Station have specific limits related to particular gases. Special condition 11 of consent 7822-1 set a limit on the carbon monoxide concentration at or beyond the production station's boundary.

> *"The consent holder shall control all discharges of carbon monoxide to the atmosphere from the flare, whether alone or in conjunction with any other emissions from the site, in order that the maximum ground level concentration of carbon monoxide arising from the exercise of this consent measured under ambient conditions does not exceed 10 milligrams per cubic metre [eight-hour average exposure], or 30 milligrams per cubic metre [one-hour average exposure] at or beyond the boundary of the site…"*

The maximum concentration of carbon monoxide found during the monitoring run was 7.40 ppm or 6.3 mg/m^3 and average concentration was only 0.05 ppm which complies with the consent condition

Lower Explosive Limit (LEL)

LEL% gives the percentage of the lower explosive limit, expressed as methane, that is detected in the air sampled. The sensor on the instrument reacts to gases and vapours such as acetone, benzene, butane, methane, propane, carbon monoxide, ethanol, and higher alkanes and alkenes, with varying degrees of sensitivity. The Council's Regional Air Quality Plan has a typical requirement that no discharge shall result in a dangerous level of airborne contaminants, including any risk of explosion. This is also expressed in special condition 10 on discharge permit 7822-1.

> *"The consent holder shall not discharge any contaminant to air from the site at a rate or a quantity such that the contaminant, whether alone or in combination with other contaminants, is or is liable to be hazardous or toxic or noxious at or beyond the boundary of the site…"*

At no time did the level of explosive gases downwind of the Sidewinder Production Station reach any more than a trivial level.

PM-10 monitoring (DustTrak)

In September 2004 the Ministry for the Environment promulgated the National Environmental Standards (NES) relating to certain air pollutants. The (NES) for PM10 is 50 µg/m^3 (24-hour average).

Particulutes can be derived from many sources, including motor vehicles (particularly diesels), solid and oil-burning processes for industry and power generation, incineration and waste burning, photochemical processes, and natural sources such as pollen, abrasion, and sea spray.

PM10 particles are linked to adverse health effects that arise primarily from the ability of particles of this size to penetrate the defences of the human body and enter deep into the

lungs significantly reducing the exchange of gases across the lung walls. Health effects from inhaling PM10 include increased mortality and the aggravation of existing respiratory and cardiovascular conditions such as asthma and chronic pulmonary diseases.

During the reporting period, a "DustTrak" PM10 monitor was deployed on two occasions in the vicinity of the plant. The deployments lasted approximately seventy-two hours, with the instrument placed in a down-wind position at the start of the deployment. Monitoring consisted of continual measurements of PM 10 concentrations. The locations of the PM10 monitor during the sampling runs are shown in Figure 1.

The details of the sample runs are graphically presented in Figure 3.

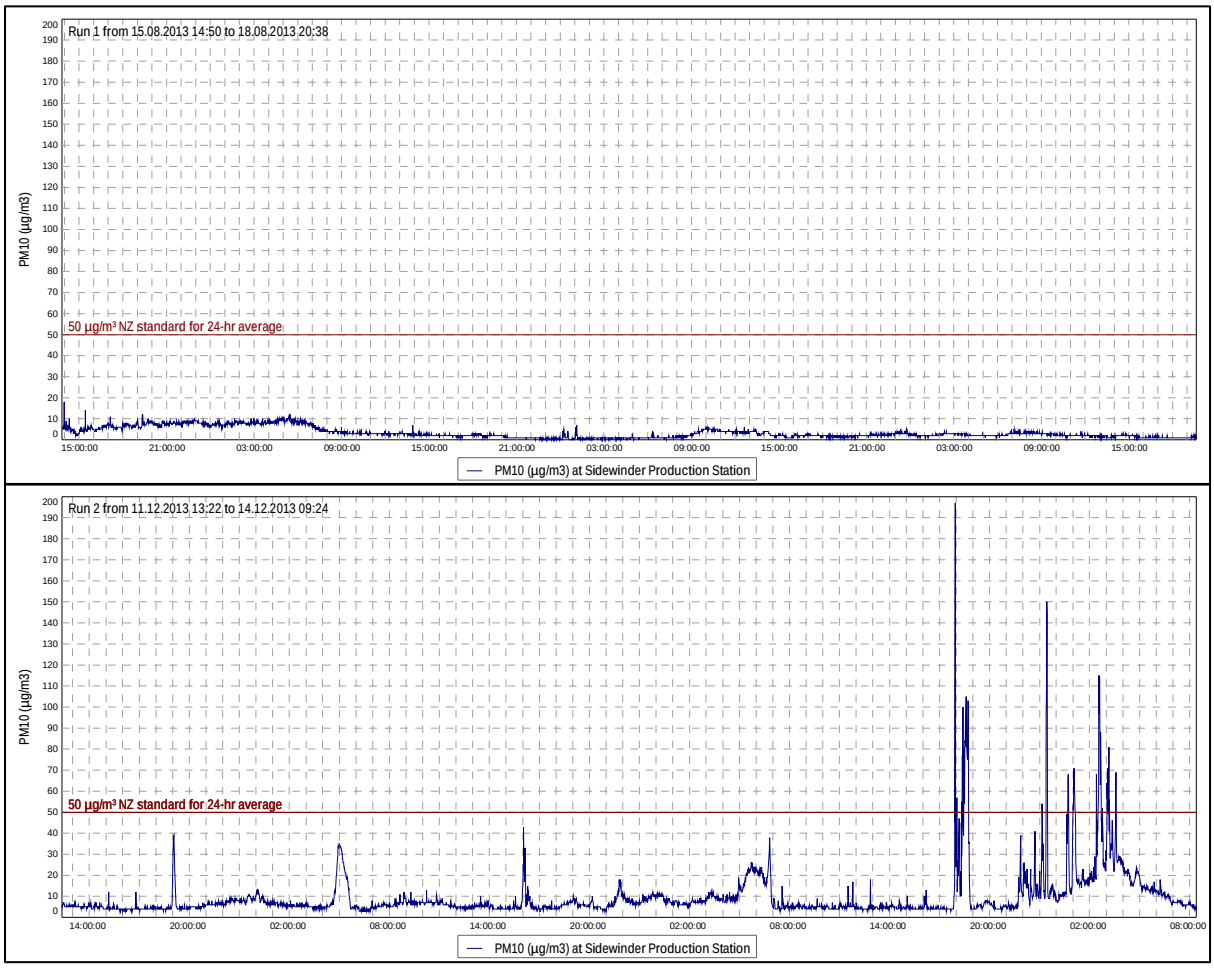

Figure 3 PM10 concentration (µg/m³) at the Sidewinder Production Station (2013-14)

Findings

The average recorded PM10 concentration for the entire 144 hours dataset was 6.2 µg/m³. This equates to 12 % of the National Environmental Standard for a 24-hour period of 50 µg/m³. The maximum recorded PM_{10} concentration over the entire monitoring period was 197 µg/m³. This short term spike may be caused by local traffic movement on the unsealed areas of the property.

Background levels of PM_{10} in the region have been found to be around 11 µg/m³.

Nitrogen (NOx) oxides monitoring

Nitrogen oxides are products of fossil fuel combustion. In humans they can reduce the body's resistance to infections and affect breathing. Nitrogen oxides are toxic to plants and can contribute to brown haze and petrochemical smog.

Special conditions 12 of air consent 7822-1 set limits for nitrogen dioxide at or beyond the boundary of the site.

> *"The consent holder shall control all discharges of nitrogen dioxide or its precursors to the atmosphere from the flare, whether alone or in conjunction with any other discharges to the atmosphere from the site, in order that the maximum ground level concentration of nitrogen dioxide arising from the exercise of this consent measured under ambient conditions does not exceed 200 micrograms per cubic metre [one hour average exposure], or 100 micrograms per cubic metre [twenty-four hour average exposure], at or beyond the boundary of the site…"*

The Taranaki Regional Council has been monitoring nitrogen oxides (NOx) in the Taranaki region since 1993 using passive absorption discs. These discs are placed at the nominated sites, in the vicinity of the industry concerned. The gases diffuse into the discs and any target gases (nitrogen dioxide) are captured. Passive absorption discs were placed at three sites, staked about two metres off the ground for a period 19 days. The location of the monitoring sites is shown in Figure 1.

From the average concentration measured, it is possible to calculate a theoretical maximum daily concentration that may have occurred during the exposure period. Council data on NOx is gathered over a time period other than exactly 1-hour or 24-hours. There are mathematical equations used by air quality scientists to predict the maximum concentrations over varying time periods. These are somewhat empirical, in that they take little account of local topography, micro-climates, diurnal variation, etc. Nevertheless, they are applied conservatively and have some recognition of validity.
One formula in general use is of the form:

$$C(t_2) = C(t_1) \times \left(\frac{t_1}{t_2}\right)^P$$

where C(t) = the average concentration during the time interval t, and p = a factor lying between 0.17 and 0.20. When converting from longer time periods to shorter time periods, using p = 0.20 gives the most conservative estimate (i.e. the highest calculated result for time period t_2 given a measured concentration for time period t_1). Using the 'worst case' factor of p = 0.20, the monitoring data reported above has been converted to equivalent 'maximum' 24-hour exposure levels.

Table 3 presents the actual levels found, theoretical maximum 1-hour and 24-hours concentration of NOx, and consent 7822-1 limits.

Table 3 Ambient NOx results from around the Sidewinder Production Station (15/08/2013 to 09/09/2013)

Site	NOx µg/m³ Laboratory	NOx - 24 hour average µg/m³ (Theoretical maximum)	NOx - 1 hour average µg/m³ (Theoretical maximum)
Limits		***100 (Consent)***	***200 (Consent)***
AIR007831	1.6	2.9	5.4
AIR007832	1.0	1.8	3.4
AIR007833	1.6	2.9	5.4

Discussions

The calculated 24-hour and 1-hour average concentrations (using a power law exponent of 0.2) ranged from 1.8 mg/m³ to 2.9 mg/m³ and from 3.4 mg/m³ to 5.4 mg/m³ for nitrogen oxides respectively. These values were all within the consent limits of 100 and 200 mg/m³.

Conclusions

Levels of the emission of interest were all measured at levels well below NES or Taranaki Regional Council consent levels.

Memorandum

To Job Manager, Callum MacKenzie
From Scientific Officer - Air Quality, Brian Cheyne
File Spordmon315, 7822-1, FRODO# 1328640
Date March 28, 2014

Ambient air quality monitoring at Sidewinder Production Station

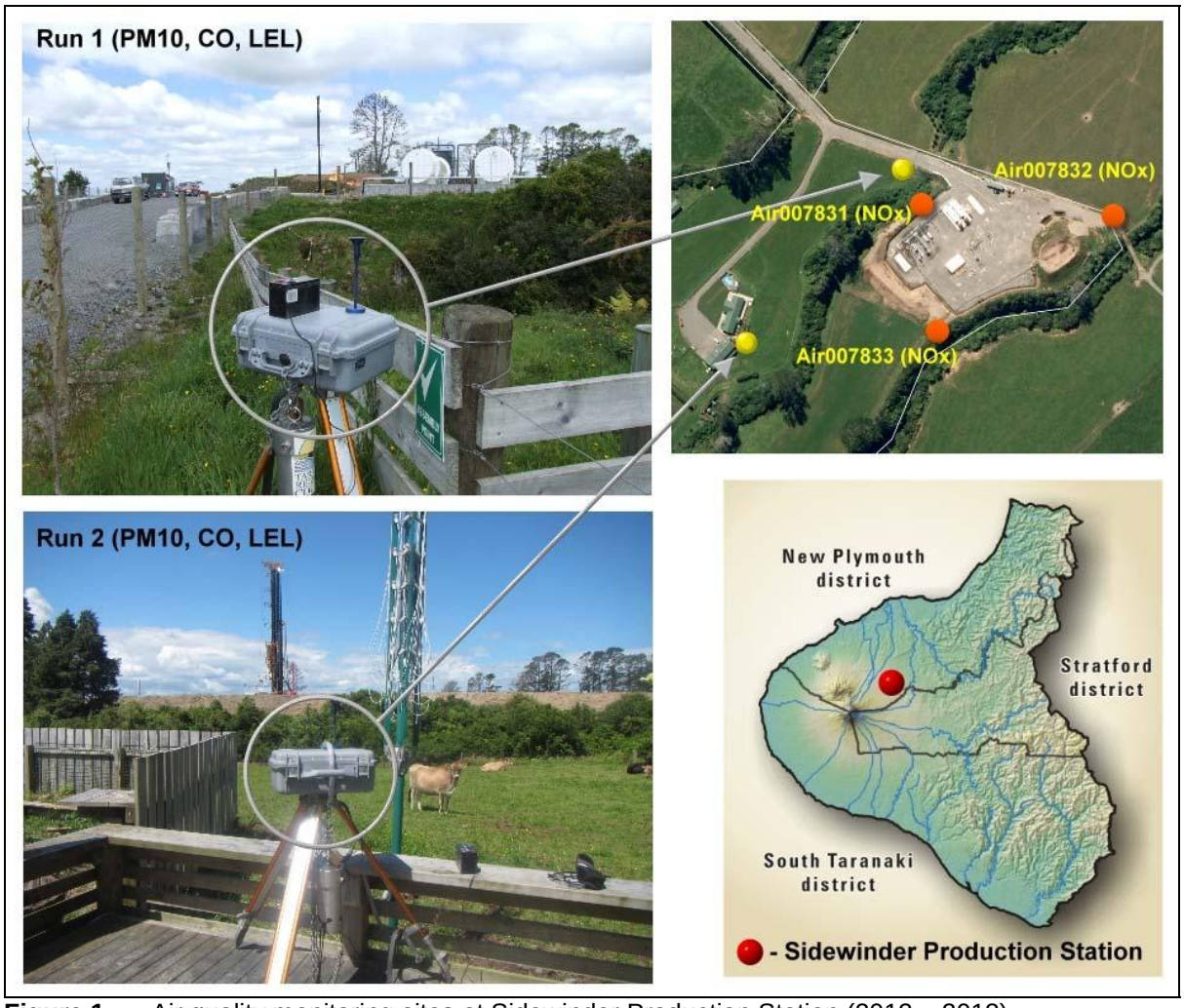

Figure 1 Air quality monitoring sites at Sidewinder Production Station (2012 – 2013)

QRae -multi gas analyser:

During the July 2012 – 30 June 2013 monitoring period, a multi-gas meter was deployed on two occasions in the vicinity of the Sidewinder Production Station. Both deployments lasted approximately forty-eight hours, with the instrument placed in a down-wind position. Monitoring consisted of continual measurements of gas concentration for carbon monoxide and combustible gases.

The location of the air quality monitoring sites is shown in Figure 1. The results of monitoring undertaken are summarized in Table 1 and the data presented graphically in Figure 2.

Because of the nature of the activities on the site, it was considered that the primary information of interest in respect of gases potentially emitted from the site was the average downwind concentration, rather than any instantaneous peak value. That is, the long-term exposure levels, rather than short-term maxima, are of most interest. The gas meter was therefore set up to create a data set based on recording the average concentration measured during each minute as raw data.

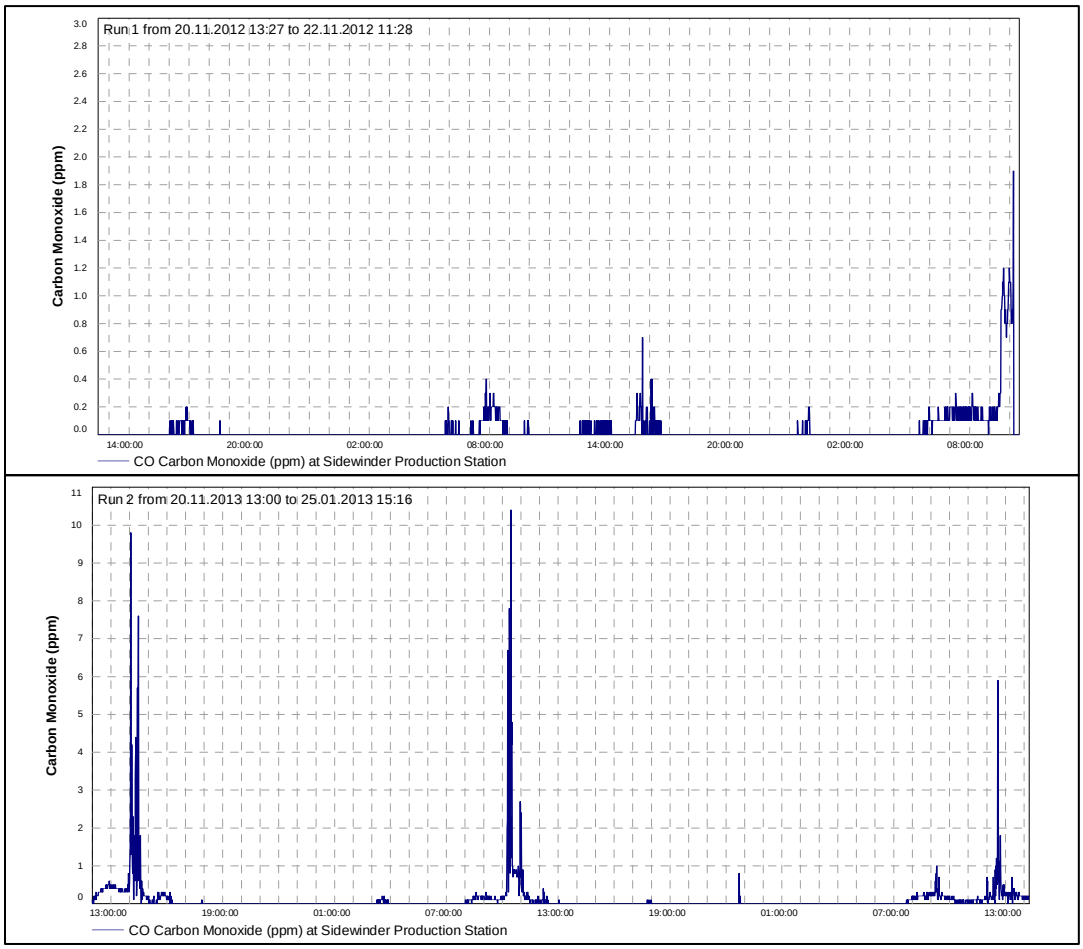

Figure 2 Graphs of ambient gas levels in the vicinity of the Sidewinder Production Station

Table 1 Summary of ambient gas monitoring results at Sidewinder Production Station

Run		1	2	Average
Period (from-to)		20.11.2012 13:27 22.11.2012 11:28	23.01.2013 13:00 25.01.2013 15:16	
Max	CO(ppm)	1.90	10.4	6.15
	LEL(%)	0.10	0.20	0.15
Mean	CO(ppm)	0.00	0.10	0.05
	LEL(%)	0.00	0.00	0.00
Min	CO(ppm)	0.00	0.00	0.00
	LEL(%)	0.00	0.00	0.00

Note: (1) the instrument records in units of ppm. At 15°C
1ppm CO = 0.85 mg/m^3

(2) See text for explanation of LEL. Because the LEL of methane is equivalent to a mixture of approximately 5% methane in air, then the actual concentration of methane in air can be obtained by dividing the % LEL by 20.

Carbon Monoxide (CO)

The consents covering air discharges from the Sidewinder Production Station have specific limits related to particular gases. Special condition 11 of consent 7822-1 set a limit on the carbon monoxide concentration at or beyond the production station's boundary.

> *"The consent holder shall control all discharges of carbon monoxide to the atmosphere from the flare, whether alone or in conjunction with any other emissions from the site, in order that the maximum ground level concentration of carbon monoxide arising from the exercise of this consent measured under ambient conditions does not exceed 10 milligrams per cubic metre [eight-hour average exposure], or 30 milligrams per cubic metre [one-hour average exposure] at or beyond the boundary of the site…"*

The maximum concentration of carbon monoxide found during the monitoring run was 10.4 ppm or 8.8 mg/m^3 and average concentration was only 0.05 ppm which complies with the consent condition

Lower Explosive Limit (LEL)

LEL% gives the percentage of the lower explosive limit, expressed as methane, that is detected in the air sampled. The sensor on the instrument reacts to gases and vapours such as acetone, benzene, butane, methane, propane, carbon monoxide, ethanol, and higher alkanes and alkenes, with varying degrees of sensitivity. The Council's Regional Air Quality Plan has a typical requirement that no discharge shall result in a dangerous level of airborne contaminants, including any risk of explosion. This is also expressed in special condition 10 on discharge permit 7822-1.

> *"The consent holder shall not discharge any contaminant to air from the site at a rate or a quantity such that the contaminant, whether alone or in combination with other contaminants, is or is liable to be hazardous or toxic or noxious at or beyond the boundary of the site…"*

At no time did the level of explosive gases downwind of the Sidewinder Production Station reach any more than a trivial level.

PM-10 monitoring (DustTrak)

In September 2004 the Ministry for the Environment promulgated the National Environmental Standards (NES) relating to certain air pollutants. The (NES) for PM10 is 50 µg/m^3 (24-hour average).

Particulutes can be derived from many sources, including motor vehicles (particularly diesels), solid and oil-burning processes for industry and power generation, incineration and waste burning, photochemical processes, and natural sources such as pollen, abrasion, and sea spray.

PM10 particles are linked to adverse health effects that arise primarily from the ability of particles of this size to penetrate the defences of the human body and enter deep into the

lungs significantly reducing the exchange of gases across the lung walls. Health effects from inhaling PM10 include increased mortality and the aggravation of existing respiratory and cardiovascular conditions such as asthma and chronic pulmonary diseases.

During the reporting period, a "DustTrak" PM10 monitor was deployed on two occasions in the vicinity of the plant. The deployments lasted approximately forty-eight hours, with the instrument placed in a down-wind position at the start of the deployment. Monitoring consisted of continual measurements of PM 10 concentrations. The locations of the PM10 monitor during the sampling runs are shown in Figure 1.

The details of the sample runs are graphically presented in Figure 3.

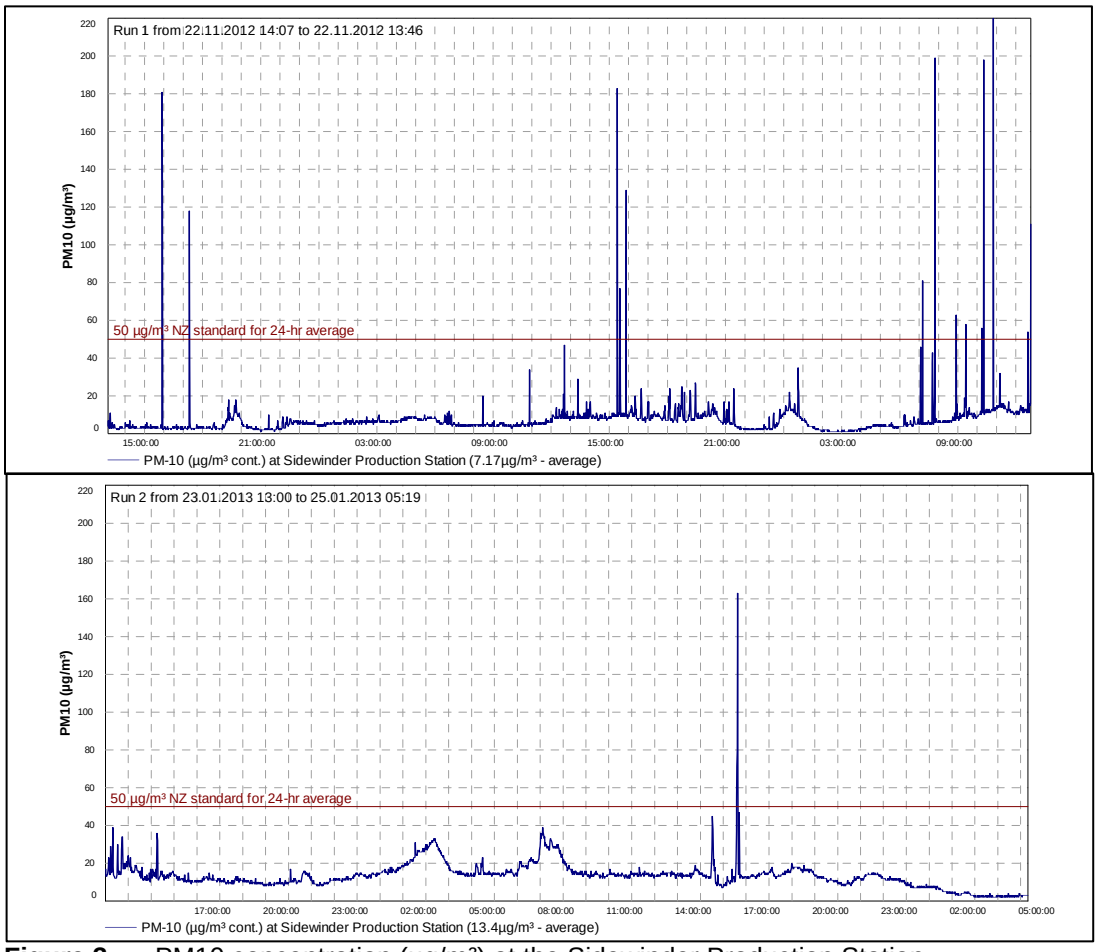

Figure 3 PM10 concentration (µg/m³) at the Sidewinder Production Station

Findings

The average recorded PM10 concentration for the entire 88 hours dataset was 10.3 µg/m³. This equates to 21% of the National Environmental Standard for a 24-hour period of 50 µg/m³. The maximum recorded PM_{10} concentration over the entire monitoring period was 220 µg/m³. This short term spike may be caused by traffic movement as the monitor was located adjacent to the site entrance.

Background levels of PM_{10} in the region have been found to be around 11 µg/m^3.

Nitrogen (NOx) oxides monitoring

Nitrogen oxides are products of fossil fuel combustion. In humans they can reduce the body's resistance to infections and affect breathing. Nitrogen oxides are toxic to plants and can contribute to brown haze and petrochemical smog.

Special conditions 12 of air consent 7822-1 set limits for nitrogen dioxide at or beyond the boundary of the site.

> *"The consent holder shall control all discharges of nitrogen dioxide or its precursors to the atmosphere from the flare, whether alone or in conjunction with any other discharges to the atmosphere from the site, in order that the maximum ground level concentration of nitrogen dioxide arising from the exercise of this consent measured under ambient conditions does not exceed 200 micrograms per cubic metre [one hour average exposure], or 100 micrograms per cubic metre [twenty-four hour average exposure], at or beyond the boundary of the site…"*

The Taranaki Regional Council has been monitoring nitrogen oxides (NOx) in the Taranaki region since 1993 using passive absorption discs. These discs are placed at the nominated sites, in the vicinity of the industry concerned. The gases diffuse into the discs and any target gases (nitrogen dioxide) are captured. Passive absorption discs were placed at three sites, staked about two metres off the ground for a period 24 days. The location of the monitoring sites is shown in Figure 1.

From the average concentration measured, it is possible to calculate a theoretical maximum daily concentration that may have occurred during the exposure period. Council data on NOx is gathered over a time period other than exactly 1-hour or 24-hours. There are mathematical equations used by air quality scientists to predict the maximum concentrations over varying time periods. These are somewhat empirical, in that they take little account of local topography, micro-climates, diurnal variation, etc. Nevertheless, they are applied conservatively and have some recognition of validity.
One formula in general use is of the form:

$$C(t_2) = C(t_1) \times \left(\frac{t_1}{t_2}\right)^P$$

where C(t) = the average concentration during the time interval t, and p = a factor lying between 0.17 and 0.20. When converting from longer time periods to shorter time periods, using p = 0.20 gives the most conservative estimate (i.e. the highest calculated result for time period t_2 given a measured concentration for time period t_1). Using the 'worst case' factor of p = 0.20, the monitoring data reported above has been converted to equivalent 'maximum' 24-hour exposure levels.

Table 3 presents the actual levels found, theoretical maximum 1-hour and 24-hours concentration of NOx, and consent 7822-1 limits.

Table 3 Ambient NOx results from around the Sidewinder Production Station (20/11/2012 to 14/12/2012)

Site	NOx µg/m³ Laboratory	NOx - 24 hour average µg/m³ (Theoretical maximum)	NOx - 1 hour average µg/m³ (Theoretical maximum)
Limits		***100 (Consent)***	***200 (Consent)***
AIR007831	1.0	1.9	3.6
AIR007832	1.2	2.3	4.3
AIR007833	3.8	7.2	13.5

Discussions

The calculated 24-hour and 1-hour average concentrations (using a power law exponent of 0.2) ranged from 1.9 mg/m³ to 7.2 mg/m³ and from 3.6 mg/m³ to 13.5 mg/m³ for nitrogen oxides respectively. These values were all within the consent limits of 100 and 200 mg/m³.

Conclusions

Levels of the emission of interest were all measured at levels well below NES or Taranaki Regional Council consent levels and provide a reference benchmark in an area where several other petrochemical processes plants discharge to air.

Appendix III

Biomonitoring reports

To Job Manager, Callum McKenzie
From Scientific Officer, B Thomas
Report No BT019
Doc No 1379223
Date July 2014

Biomonitoring of the Piakau Stream in relation to the Sidewinder Production Station, December 2013

Introduction

This was the first survey completed of the two scheduled biomonitoring surveys relating to the Sidewinder Production Station of TAG Oil New Zealand Ltd for the 2013-2014 monitoring year.

The production Station discharges stormwater and treated production water to land where they may enter the Piakau Stream. Two stage skimmer pits in the northeast corner of the site collect and treat water from the production and wellsite areas. The discharge from the second skimmer pit ponds in the adjacent grassed area. Overflow from this area flows down the bank and enters the Piakau Stream. [Note: The consent provides for discharge onto land in the vicinity of the stream and includes conditions related to instream effects and allows for a 25 m mixing zone in the stream].

The purpose of this survey was to determine whether this discharge from the Production Station has resulted in any detrimental effects on the macroinvertebrate communities in the Piakau Stream downstream of the discharge.

Two previous surveys have been performed at these three sites which were established specifically for the purpose of monitoring the Sidewinder Production Station in the Piakau Stream sub-catchment of the Waitara River catchment.

Methods

The standard '400 ml kick-sampling' technique was used to collect streambed macroinvertebrates from three established sites in the Piakau Stream (Table 1, Figure 1) on 18 December 2013. The 'kick-sampling' technique is very similar to Protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark et al, 2001).

Table 1 Biomonitoring sites in the Piakau Stream surveyed in association with the Sidewinder Production Station

Site No.	Site code	GPS reference	Location	Distance from National Park (km)	Elevation (mask)
1	PIK000160	E1703959 N5659234	60 m upstream of Sidewinder Production Station discharge	6.27	295
2	PIK000162	E1704023 N5659300	25 m downstream of Sidewinder Production Station discharge	6.35	295
3	PIK000165	E1704062 N5659354	100 m downstream of Sidewinder Production Station discharge	6.43	285

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al. 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= estimated 20-99 individuals;
VA (very abundant)	= estimated 100-499 individuals;
XA (extremely abundant)	= estimated 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly `sensitive' taxa were assigned the highest scores of 9 or 10, while the most `tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience. By averaging the scores obtained from a list of taxa collected from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

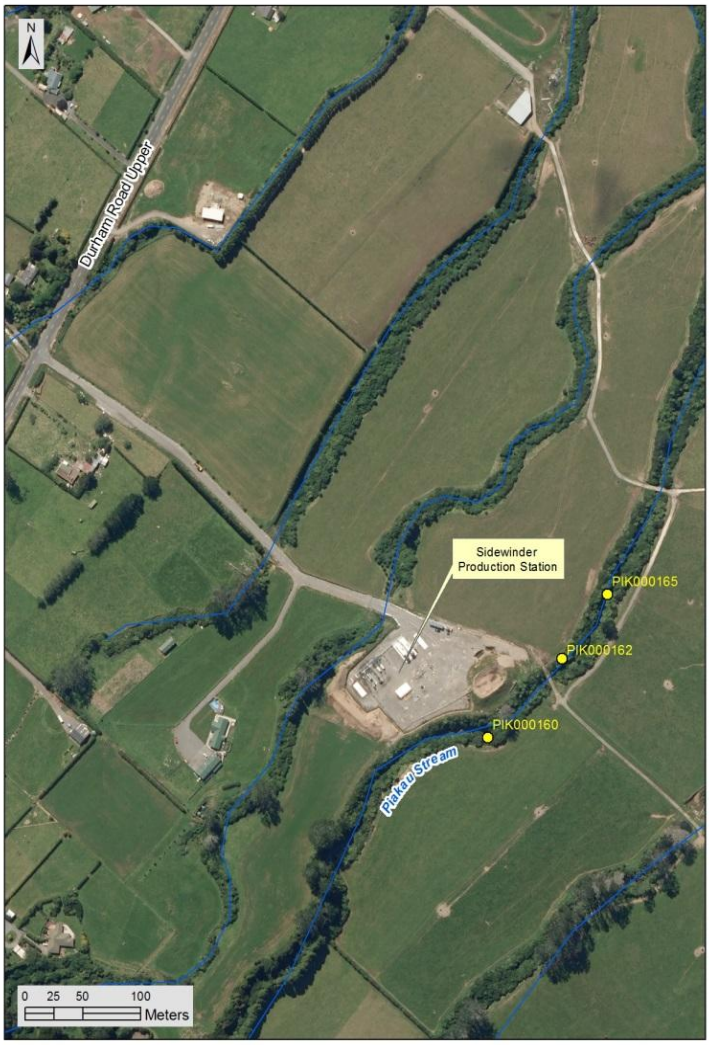

Figure 1 Biological sampling sites in the Piakau Stream related to the Sidewinder Production Station

The MCI was designed as a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. MCI results can also reflect the effects of warm temperatures, slow current speeds and low dissolved oxygen levels, because the taxa capable of tolerating these conditions generally have low sensitivity scores. Usually more 'sensitive' communities (with higher MCI values) inhabit less polluted waterways. The use of this index in non-stony streams is possible if results are related to physical habitat (e.g., good quality muddy/weedy sites tend to produce lower MCI values than good quality stony sites). Weedy stream macroinvertebrate communities tend to be dominated by more 'tolerant' taxa than is the case in stony stream communities. It may therefore require more severe organic pollution to cause a significant decline in MCI value in weedy streams.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, therefore $SQMCI_s$ values range from 1 to 10.

Results and discussion

At the time of this early afternoon survey there was a low, steady, clear, uncoloured flow in the Piakau Stream at all three sites. During this survey water temperature ranged from 14.2°C to 14.5°C Substrate was similar at the three sites in the Piakau Stream and comprised mainly of cobbles, gravels, and boulders, with some sand. Periphyton mats were very thin, with no filamentous algae at all sites. Moss was widespread at site 1 and site 2 and patchy at site 3. All sites were partially shaded by native vegetation. This survey was undertaken following a period of flow recession, during early summer 11 days after the latest fresh in excess of 3x and 7x median flows. No discharge from the skimmer pits was occurring at the time of the survey.

Macroinvertebrate communities

Two surveys have been performed of the three sites in the Piakau Stream, prior to the current survey. These results and results of the current survey are summarised in Table 2.

Table 2 Number of taxa, MCI, and $SQMCI_s$ values for the Piakau Stream, sampled in relation to the Sidewinder Production site on 18 December 2013 and a summary of historical data for these sites and predicted MCI scores (from Stark and Fowles, 2009)

Site No	Number of previous surveys	Numbers of taxa			MCI values			$SQMCI_s$ values			Predicted MCI scores	
		Median	Range	Current	Median	Range	Current	Median	Range	Current	Altitude	Distance
1	2	26	25-26	23	124	121-126	121	7.5	7.4-7.6	7.6	114	111
2	2	25	23-27	23	124	115-132	123	7.0	6.7-7.3	6.9	114	111
3	2	23	22-24	26	124	116-132	118	7.6	7.5-7.6	7.0	113	111

The macroinvertebrate fauna recorded by the current survey at each of the three sites are presented in Table 3.

Table 3 Macroinvertebrate fauna of the Piakau Stream in relation to Sidewinder Production Station sampled on 18 December 2013

Taxa List	Site Number	MCI score	Site 1	Site 2	Site 3
	Site Code		PIK000160	PIK000162	PIK000165
	Sample Number		FWB13406	FWB13407	FWB13408
ANNELIDA (WORMS)	Oligochaeta	1	C	C	R
EPHEMEROPTERA (MAYFLIES)	*Ameletopsis*	10	R	R	-
	Austroclima	7	A	C	C
	Coloburiscus	7	VA	A	XA
	Deleatidium	8	XA	VA	VA
	Ichthybotus	8	-	-	R
	Nesameletus	9	C	C	-
	Oniscigaster	10	-	R	-
	Zephlebia group	7	R	R	R
PLECOPTERA (STONEFLIES)	*Acroperla*	5	R	-	-
	Megaleptoperla	9	-	R	-
	Zelandobius	5	-	-	R
	Zelandoperla	8	R	-	R
COLEOPTERA (BEETLES)	Elmidae	6	VA	VA	VA
	Hydraenidae	8	R	R	R
	Hydrophilidae	5	-	-	R
	Ptilodactylidae	8	-	-	R
MEGALOPTERA (DOBSONFLIES)	*Archichauliodes*	7	A	A	A
TRICHOPTERA (CADDISFLIES)	*Aoteapsyche*	4	A	R	A
	Costachorema	7	-	-	R
	Hydrobiosis	5	R	R	C
	Plectrocnemia	8	-	C	-
	Beraeoptera	8	XA	A	VA
	Confluens	5	R	-	-
	Helicopsyche	10	R	-	R
	Olinga	9	-	-	R
	Pycnocentrodes	5	A	C	C
	Triplectides	5	-	R	-
DIPTERA (TRUE FLIES)	*Aphrophila*	5	C	R	A
	Eriopterini	5	R	R	R
	Orthocladiinae	2	-	R	R
	Polypedilum	3	R	-	R
	Empididae	3	R	C	R
	Austrosimulium	3	R	R	R
		No of taxa	23	23	26
		MCI	121	123	118
		SQMCIs	7.6	6.9	7.0
		EPT (taxa)	14	14	14
		%EPT (taxa)	61	61	54

'Tolerant' taxa | 'Moderately sensitive' taxa | 'Highly sensitive' taxa

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

Site 1 (upstream of Production Station discharge)

A moderately high richness of 23 taxa was recorded, which was very similar to the median number (25 taxa) and well below the maximum (36 taxa) found by the 170 previous surveys of National Park-sourced streams at 'control' sites between 250 and 299 m asl (TRC, 1999 (updated 2013)). This richness was two taxa less than that found previously at this site.

The community was comprised of a very high proportion (78 %) of 'sensitive' taxa, seven of which were 'highly sensitive' taxa. The community was characterised by two 'highly sensitive' taxa [mayfly (*Deleatidium*) and cased caddisfly (*Beraeoptera*)]; five 'moderately sensitive' taxa [mayfly (*Coloburiscus*), elmid beetles, dobsonfly (*Archichauliodes*), mayfly (*Austroclima*) and stony cased caddisfly (*Pycnocentrodes*)]; and one 'tolerant' taxon [net-building caddisfly (*Aoteapsyche*)].

The numerical dominance by 'sensitive' taxa (particularly two 'highly sensitive' and two 'moderately sensitive' taxa), resulted in the very high $SQMCI_s$ value of 7.6 units, which was the same as the maximum $SQMCI_s$ score to date (Table 2) and more typical of $SQMCI_s$ scores at sites closer to the National Park boundary (TRC, 2013). This was indicative of good physical habitat and preceding physicochemical water quality, typical of the upper mid-reaches of ringplain streams.

The high proportion of 'sensitive' taxa comprising the community resulted in the relatively high MCI score (121 units) which was the same as what was recorded for the previous survey and 6 units above the median MCI score recorded by the 170 surveys of 'control' sites in National Park-sourced rivers and streams between 250 and 299 m asl (TRC, 1999 (updated 2013)). It was also 7 and 10 units above predicted (Stark and Fowles, 2009) altitude and distance scores respectively (Table 2) and categorized this site as having 'very good' generic stream health and 'better than expected' predictive health (TRC, 2013) for a site in the upper mid-reaches of a ringplain stream.

Site 2 (25 m downstream of Production Station discharge)

A moderately high richness of 23 taxa was found at this site, the same number of taxa as the site upstream of the discharge area, and within three taxa of the median richness recorded by the 170 previous surveys at similar 'control' sites (see above and TRC, 1999 (updated, 2013)).

The community was comprised mainly of 'sensitive' taxa (78% of richness), two of which were 'highly sensitive' taxa. The community was characterised by all of the same dominant taxa as at the upstream 'control' site, with the absence of two 'moderately sensitive' taxa [mayfly (*Austroclima*) and stony cased caddisfly (*Pycnocentrodes*)], and one 'tolerant' taxon [net-building caddisfly (*Aoteapsyche*)].

The continued numerical dominance by 'sensitive' taxa (one 'highly sensitive' and one 'moderately sensitive' taxon in particular) resulted in a high $SQMCI_s$ value of 6.9 units, which was 0.2 unit above that recorded by the previous survey and 0.7 unit lower than the score at the upstream site (Table 3). This was also indicative of good physical habitat and preceding physicochemical water quality, typical of the upper, mid-reaches of ringplain streams, and coincidental with minimal periphyton substrate cover.

The relatively high proportion of 'sensitive' taxa in the composition of the community was reflected in the moderately high MCI score of 123 units, an insignificant two units above that

found at the 'control' site upstream of the discharge area, and an insignificant 8 units above the score recorded by the previous survey and also the median score recorded by more the 170 previous surveys at similar sites (TRC, 1999 (updated, 2013)). The score was also nine and twelve units above predicted altitude and distance scores respectively (Stark and Fowles, 2009; Table 2). This categorised the site as having 'very good' generic stream health and 'better than expected' predictive health (TRC, 2013) for a site in the upper mid reaches of a ringplain stream.

Site 3 (100 m downstream of Production Station discharge)

Taxa richness (26) was moderately high for a site in the upper mid-reaches of a ringplain stream and one taxon above the median richness found to date by the 170 surveys of 'control' sites in National Park-sourced streams at altitudes between 250 and 299 m asl (TRC, 1999 (updated, 2013)). This richness was four taxa above the richness found by the previous survey at this site.

The community was comprised of a high proportion (77%) of 'sensitive' taxa, two of which were 'highly sensitive' taxa. It was characterised by all of the same 'highly sensitive' and 'moderately sensitive' taxa also dominant at site 2, plus one additional 'moderately sensitive' taxon [tipulid cranefly (*Aphrophila*)] and one 'tolerant' taxon [net-building caddisfly (*Aoteapsyche*)].

The continued numerical dominance by 'sensitive' taxa resulted in a high $SQMCI_s$ value of 7.0 units which was an insignificant 0.5 unit below the score found by the previous survey and 0.6 unit below that recorded at the upstream 'control' site (1). This was an indication of relatively good physical habitat and preceding physicochemical water quality, and better than typical of the upper mid-reaches of ringplain stream, coincidental with minimal periphyton substrate cover at this partially shaded site.

The relatively high proportion of 'sensitive' taxa comprising this community resulted in a moderately high MCI value of 118 units, which was only 3 units lower than the score recorded upstream of the Production Station discharge area and 2 units higher than recorded by the previous survey at this site. This current score was also an insignificant three units above the median score recorded by the 170 previous surveys at similar sites (see above and TRC, 1999 (updated, 2013)) , and 5 to 7 units above predicted altitude and distance from the National Park boundary scores respectively (Stark and Fowles, 2009; Table 2). This score characterised the site as having 'good' generic stream health and 'better than expected' predictive health (TRC, 2013) for a site in the mid-reaches of a ringplain stream.

Conclusions and summary

The Council's standard 'kick-sampling' technique was used at three established sites to collect streambed macroinvertebrates from the Piakau Stream, to assess whether discharges from the Sidewinder Production Station had had any detrimental effects on the macroinvertebrate communities of this stream. This early summer survey was the first of two surveys programmed for the 2013-2014 monitoring period. Samples were sorted and identified to provide the number of taxa (richness) and MCI and $SQMCI_S$ scores for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects or organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The $SQMCI_S$ takes into account taxa abundance as well as sensitivity to pollution, and may reveal more subtle changes in communities, particularly if non-organic impacts are occurring. Significant differences in either the MCI or the $SQMCI_S$ between sites may indicate the degree of adverse effects (if any) of the discharges being monitored.

This early summer macroinvertebrate survey indicated that the discharge of treated stormwater and production water to land and to water from the Sidewinder Production Station site had not had any recent detrimental effects on the macroinvertebrate communities of the Piakau Stream. The MCI scores for each site were all higher than their respective predictive scores for equivalent sites in the upper mid-reaches of ringplain streams. No significant changes in the macroinvertebrate communities were recorded between sites and $SQMCI_S$ scores were not significantly different between sites.

Higher MCI scores were recorded at sites 2 and 3 in this early summer survey in comparison with the previous survey conducted in late summer which is a typical seasonal trend in ringplain streams (TRC, 2013). The MCI score for site 1 remained the same.

The macroinvertebrate communities of the stream contained very high proportions of 'sensitive' taxa at all sites. In addition, communities at all sites had a number of common dominant taxa (they shared five of the nine dominant taxa through the surveyed reach). There were no significant changes in MCI values between sites, coincident with very similar habitat at all sites. In addition, taxonomic richness (numbers of taxa) was relatively consistent across all three sites. The MCI scores indicated that the stream communities were of good to very good 'health', and better than typical conditions in comparison with predictive values recorded from equivalent ringplain stream sites. The absence of significant differences between the three sites indicated no recent impacts from any of the Sidewinder Production Station discharges to land and/or run-off to the adjacent Piakau Stream.

References

Fowles CR and Smith KL, 2013: Biomonitoring of the Piakau Stream in relation to the Sidewinder Production Station, November 2012. TRC Report CF586.

Fowles CR and Smith KL, 2013: Biomonitoring of the Piakau Stream in relation to the Sidewinder Production Station, February 2013. TRC Report CF587.

Stark JD, 1985: A macroinvertebrate community index of water quality for stony streams. *Water and Soil* Miscellaneous Publication No. 87.

Stark JD, 1998: SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. *New Zealand Journal of Marine and Freshwater Research 32(1)*: 55-66.

Stark JD, 1999: An evaluation of Taranaki Regional Council' SQMCI biomonitoring index. Cawthron Institute, Nelson. Cawthron Report No. 472.

Stark JD, Boothroyd IKG, Harding JS, Maxted JR, Scarsbrook MR, 2001: Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment. Sustainable Management Fund Project No. 5103. 57p.

Stark JD and Maxted JR, 2004. Macroinvertebrate community indices for Auckland's soft-bottomed streams and applications to SOE reporting. Prepared for Auckland Regional Council. Cawthron Report No. 970. Cawthron Institute, Nelson. ARC Technical Publication 303. 59p.

Stark JD and Maxted JR, 2007. A biotic index for New Zealand's soft bottomed streams. New Zealand Journal of Marine and Freshwater Research 41(1).

Stark JD and Maxted JR, 2007a. A user guide for the macroinvertebrate community index. Cawthron Institute, Nelson. Cawthron Report No. 1166.

Stark JD and Fowles CR, 2009. Relationships between MCI, site altitude, and distance from source Taranaki ring plain streams. Stark Environmental report No. 2009-01

TRC, 1999: Some statistics from the Taranaki Regional Council database (FWB) of freshwater macroinvertebrate surveys performed during the period from January 1980 to 31 December 1998 (Updated October 2013). Technical Report 99-17.

TRC, 2013: Freshwater macroinvertebrate fauna biological monitoring programme Annual SEM Report 2011-2012. Technical Report 2012-18.

To Job Manager, Callum McKenzie
From Scientific Officer, B Thomas
Report No BT024
Doc No 1392205
Date August 2014

Biomonitoring of the Piakau Stream in relation to the Sidewinder Production Station, February 2014

Introduction

This was the second survey completed of the two scheduled biomonitoring surveys relating to the Sidewinder Production Station of TAG Oil New Zealand Ltd for the 2013-2014 monitoring year.

The production Station discharges stormwater and treated production water to land where they may enter the Piakau Stream. Two stage skimmer pits in the northeast corner of the site collect and treat water from the production and wellsite areas. The discharge from the second skimmer pit ponds in the adjacent grassed area. Overflow from this area flows down the bank and enters the Piakau Stream. [Note: The consent provides for discharge onto land in the vicinity of the stream and includes conditions related to instream effects and allows for a 25 m mixing zone in the stream]. At the time of this survey, it was noted that a significant portion of the steep bank at the point of discharge had collapsed into the stream. It appeared that the discharge, which ponds between the outlet of the final skimmer pit and the bank, had saturated the soil and destabilised the bankside.

The purpose of this survey was to determine whether this discharge from the Production Station has resulted in any detrimental effects on the macroinvertebrate communities in the Piakau Stream downstream of the discharge.

Three previous surveys have been performed at these three sites which were established specifically for the purpose of monitoring the Sidewinder Production Station in the Piakau Stream sub-catchment of the Waitara River catchment.

Methods

The standard '400 ml kick-sampling' technique was used to collect streambed macroinvertebrates from three established sites in the Piakau Stream (Table 1, Figure 1) on 11 February 2014. The 'kick-sampling' technique is very similar to Protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark et al, 2001).

Table 1 Biomonitoring sites in the Piakau Stream surveyed in association with the Sidewinder Production Station

Site No.	Site code	GPS reference	Location	Distance from National Park (km)	Elevation (mask)
1	PIK000160	E1703959 N5659234	60 m upstream of Sidewinder Production Station discharge	6.27	295
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3	PIK000165	E1704062 N5659354	100 m downstream of Sidewinder Production Station discharge	6.43	285

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al. 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= estimated 20-99 individuals;
VA (very abundant)	= estimated 100-499 individuals;
XA (extremely abundant)	= estimated 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly `sensitive' taxa were assigned the highest scores of 9 or 10, while the most `tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience. By averaging the scores obtained from a list of taxa collected from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

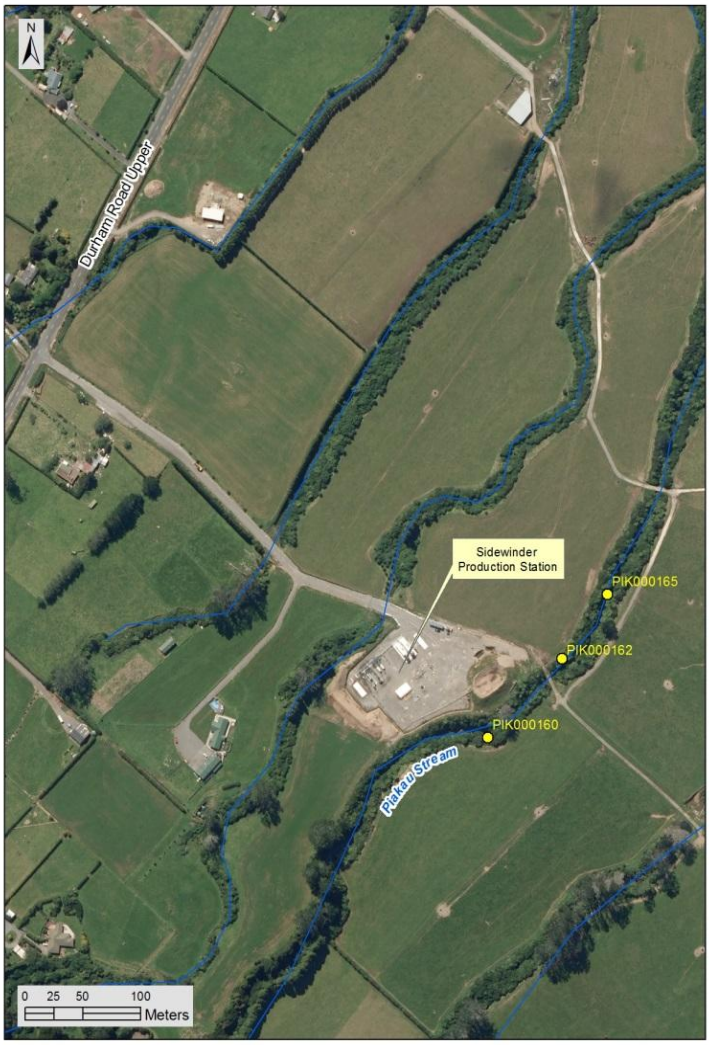

Figure 1 Biological sampling sites in the Piakau Stream related to the Sidewinder Production Station

The MCI was designed as a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. MCI results can also reflect the effects of warm temperatures, slow current speeds and low dissolved oxygen levels, because the taxa capable of tolerating these conditions generally have low sensitivity scores. Usually more 'sensitive' communities (with higher MCI values) inhabit less polluted waterways. The use of this index in non-stony streams is possible if results are related to physical habitat (e.g., good quality muddy/weedy sites tend to produce lower MCI values than good quality stony sites). Weedy stream macroinvertebrate communities tend to be dominated by more 'tolerant' taxa than is the case in stony stream communities. It may therefore require more severe organic pollution to cause a significant decline in MCI value in weedy streams.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, therefore $SQMCI_s$ values range from 1 to 10.

Results and discussion

At the time of this midday survey there was a low, steady, clear, uncoloured flow in the Piakau Stream at all three sites. During this survey water temperature ranged from 13.7°C to 14.0°C. Substrate was similar at the three sites in the Piakau Stream and comprised mainly of cobbles, gravels, and boulders, with some silt and sand. Periphyton mats were very thin, with no filamentous algae at all sites. Moss was patchy at all sites. All sites were partially shaded by native vegetation. This survey was undertaken following a period of flow recession, 15 days after the latest fresh in excess of 3x median flow.

Macroinvertebrate communities

Three surveys have been performed at the three sites in the Piakau Stream, prior to the current survey. These results and results of the current survey are summarised in Table 2.

Table 2 Number of taxa, MCI, and $SQMCI_s$ values for the Piakau Stream, sampled in relation to the Sidewinder Production site on 11 February 2014 and a summary of historical data for these sites and predicted MCI scores (from Stark and Fowles, 2009)

Site No	Number of previous surveys	Numbers of taxa			MCI values			$SQMCI_s$ values			Predicted MCI scores	
		Median	Range	Current	Median	Range	Current	Median	Range	Current	Altitude	Distance
1	3	25	23-26	21	121	121-126	132	7.6	7.4-7.6	7.1	114	111
2	3	23	23-27	18	123	115-132	112	6.9	6.7-7.3	6.9	114	111
3	3	24	22-26	26	118	116-132	114	7.5	7.0-7.6	7.0	113	111

The macroinvertebrate fauna recorded by the current survey at each of the three sites are presented in Table 3.

Table 3 Macroinvertebrate fauna of the Piakau Stream in relation to Sidewinder Production Station sampled on 11 February 2014

Taxa List	Site Number	MCI score	Site 1	Site 2	Site 3
	Site Code		PIK000160	PIK000162	PIK000165
	Sample Number		FWB14081	FWB14082	FWB14083
ANNELIDA (WORMS)	Oligochaeta	1	-	R	R
	Lumbricidae	5	-	-	R
EPHEMEROPTERA (MAYFLIES)	*Ameletopsis*	10	R	-	-
	Austroclima	7	C	C	C
	Coloburiscus	7	VA	C	XA
	Deleatidium	8	VA	VA	VA
	Ichthybotus	8	R	-	R
	Nesameletus	9	C	C	A
	Zephlebia group	7	R	C	C
PLECOPTERA (STONEFLIES)	*Zelandobius*	5	R	-	-
	Zelandoperla	8	R	-	R
COLEOPTERA (BEETLES)	Elmidae	6	VA	VA	VA
	Hydraenidae	8	R	R	C
MEGALOPTERA (DOBSONFLIES)	*Archichauliodes*	7	A	A	A
TRICHOPTERA (CADDISFLIES)	*Aoteapsyche*	4	C	C	A
	Costachorema	7	R	-	-
	Hydrobiosis	5	-	R	C
	Orthopsyche	9	-	-	R
	Plectrocnemia	8	R	-	-
	Beraeoptera	8	VA	A	VA
	Confluens	5	-	-	R
	Pycnocentria	7	R	-	-
	Pycnocentrodes	5	R	C	R
DIPTERA (TRUE FLIES)	*Aphrophila*	5	C	R	A
	Eriopterini	5	-	R	R
	Harrisius	6	-	-	R
	Orthocladiinae	2	C	-	C
	Polypedilum	3	-	R	R
	Empididae	3	-	R	R
	Austrosimulium	3	C	R	R
	Tanyderidae	4	-	-	R
		No of taxa	21	18	26
		MCI	132	112	114
		SQMCIs	7.1	6.9	7.0
		EPT (taxa)	15	9	13
		%EPT (taxa)	71	50	50

'Tolerant' taxa | 'Moderately sensitive' taxa | 'Highly sensitive' taxa

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

Site 1 (upstream of Production Station discharge)

A moderately high richness of 21 taxa was recorded at this site, which was similar to the median number of 25 taxa previously found at this site. This richness was two taxa less than that recorded in the previous survey at this site (Thomas, 2014).

The community was comprised of a very high proportion (86%) of 'sensitive' taxa, eight of which were 'highly sensitive' taxa. The community was characterised by two 'highly sensitive' taxa [mayfly (*Deleatidium*) and cased caddisfly (*Beraeoptera*)], and three 'moderately sensitive' taxa, [mayfly (*Coloburiscus*), elmid beetles and dobsonfly (*Archichauliodes*)].

The high proportion of 'sensitive' taxa comprising the community resulted in 'very good' MCI score of 132 units, which was a significant 11 units higher than that recorded in the previous survey and 18 and 21 units above predicted (Stark and Fowles, 2009) altitude and distance scores respectively (Table 2). This categorized this site as having 'very good' generic stream health and 'better than expected' predictive health (TRC, 2013) for a site in the upper mid-reaches of a ringplain stream.

The numerical dominance by 'sensitive' taxa (particularly two 'highly sensitive' and two 'moderately sensitive' taxa), resulted in the very high $SQMCI_s$ value of 7.1 units, an insignificant 0.5 unit less than the maximum $SQMCI_s$ score to date (Table 2) and typical of $SQMCI_s$ scores at sites closer to the National Park boundary (TRC, 2013). This was indicative of good physical habitat and preceding physicochemical water quality, typical of the upper mid-reaches of ringplain streams.

Site 2 (25 m downstream of Production Station discharge)

A moderately high richness (18 taxa) was found at this site, three taxa less than the site upstream of the discharge area, and three taxa less than that recorded in the previous survey.

The community was comprised of a high proportion of 'sensitive' taxa (72% of richness), four of which were 'highly sensitive' taxa. The community was characterised by all of the same dominant taxa as at the upstream 'control' site, with the absence of one 'moderately sensitive' taxon [mayfly (*Coloburiscus*)].The continued numerical dominance by 'sensitive' taxa (one 'highly sensitive' and one 'moderately sensitive' taxon in particular) resulted in a high $SQMCI_s$ value of 6.9 units, which was the same as that recorded by the previous survey and 0.2 unit lower than the score at the upstream site (Table 3). This was also indicative of good physical habitat and preceding physicochemical water quality, typical of the upper, mid-reaches of ringplain streams, and coincidental with minimal periphyton substrate cover.

The moderately high proportion of 'sensitive' taxa in the composition of the community was reflected in the moderately high MCI score of 112 units. This score was a significant twenty units less than that found at the 'control' site upstream of the discharge area, and a significant 11 units below the score recorded by the previous survey (Thomas, 2014). The significant reduction in MCI score was due almost entirely to the presence/absence of a number of taxa only found as rarities (less than 5 individuals/site). In particular, the reduction in MCI score can be attributed to the absence of seven 'sensitive' taxa and addition of three 'tolerant' taxa recorded at this site. The MCI score was two units below the

predicted altitude score and 1 unit above the predicted distance score (Stark and Fowles, 2009; Table 2). This categorised the site as having 'good' generic stream health and a similar predictive health (TRC, 2013) for a site in the upper mid reaches of a ringplain stream.

Site 3 (100 m downstream of Production Station discharge)

Taxa richness (26) was moderately high for a site in the upper mid-reaches of a ringplain stream and one taxon above the median richness found to date by the 170 surveys of 'control' sites in National Park-sourced streams at altitudes between 250 and 299 m asl (TRC, 1999 (updated, 2013)). This richness was the same as the richness found by the previous survey at this site.

The community was comprised of a high proportion (73%) of 'sensitive' taxa, seven of which were 'highly sensitive' taxa. It was characterised by all of the same 'highly sensitive' and 'moderately sensitive' taxa also dominant at site 2, plus one additional 'highly sensitive' taxon [mayfly (*Nesameletus*)], two 'moderately sensitive' taxa [tipulid cranefly (*Aphrophila*) and mayfly (*Coloburiscus*)] and one 'tolerant' taxon [net-building caddisfly (*Aoteapsyche*)].

The continued numerical dominance by 'sensitive' taxa resulted in a high $SQMCI_s$ value of 7.0 units which was the same as that found by the previous survey and 0.1 unit below that recorded at the upstream 'control' site (1). This was an indication of relatively good physical habitat and preceding physicochemical water quality, and better than typical of the upper mid-reaches of ringplain stream, coincidental with minimal periphyton substrate cover at this partially shaded site.

The relatively high proportion of 'sensitive' taxa comprising this community resulted in a moderately high MCI value of 114 units, which was a significant 18 units lower than the score recorded upstream of the Production Station discharge area and 4 units lower than recorded by the previous survey at this site. Again, the significant reduction in MCI score recorded from the upstream control site was due almost entirely to the presence/absence of a number of taxa only found as rarities (less than 5 individuals/site). In particular, the reduction in MCI score can be attributed to the absence of five 'sensitive' taxa and addition of four 'tolerant' taxa recorded at this site. This current score was also 1 and 3 units above predicted altitude and distance from the National Park boundary scores respectively (Stark and Fowles, 2009; Table 2). This score characterised the site as having 'good' generic stream health and similar predictive health (TRC, 2013) for a site in the mid-reaches of a ringplain stream.

Conclusions and summary

The Council's standard 'kick-sampling' technique was used at three established sites to collect streambed macroinvertebrates from the Piakau Stream, to assess whether discharges from the Sidewinder Production Station had had any detrimental effects on the macroinvertebrate communities of this stream. This summer survey was the second of two surveys programmed for the 2013-2014 monitoring period. Samples were sorted and identified to provide the number of taxa (richness) and MCI and $SQMCI_S$ scores for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects or organic pollution in stony streams. It is based on the presence/absence of taxa

with varying degrees of sensitivity to environmental conditions. The $SQMCI_S$ takes into account taxa abundance as well as sensitivity to pollution, and may reveal more subtle changes in communities, particularly if non-organic impacts are occurring. Significant differences in either the MCI or the $SQMCI_S$ between sites may indicate the degree of adverse effects (if any) of the discharges being monitored.

This summer macroinvertebrate survey indicated that the discharge of treated stormwater and production water to land and to water from the Sidewinder Production Station site had not had any recent detrimental effects on the macroinvertebrate communities of the Piakau Stream.

The MCI scores for each site were all higher or similar their respective predictive scores for equivalent sites in the upper mid-reaches of ringplain streams. The reduction in MCI score recorded from the upstream site to the two downstream sites was due almost entirely to the presence/absence of a number of taxa only found as rarities (less than 5 individuals/site).

The macroinvertebrate communities of the stream contained very high proportions of 'sensitive' taxa at all sites. In addition, communities at all sites had a number of common dominant taxa (they shared four of the eight dominant taxa through the surveyed reach). There were no significant changes in $SQMCI_S$ scores between sites, coincident with very similar habitat at all sites. In addition, taxonomic richness (numbers of taxa) was relatively consistent across all three sites.

The MCI scores indicated that the stream communities were of good to very good 'health', and similar or better than typical conditions in comparison with predictive values recorded from equivalent ringplain stream sites. The results of this survey indicated no recent impacts from any of the Sidewinder Production Station discharges to land and/or run-off to the adjacent Piakau Stream.

Since the current survey, plans have since been put into place to change the location of the operational stormwater discharge point in response to the slump/slip which may have been caused by the existing stormwater discharge from the Sidewinder Production Station. It was proposed a new 6m length of pipe be installed at the end of the existing swale drain with a sock traversing the steep bank to control the stormwater until it discharges into the Piakau Stream. The current consent will need to be changed to reflect the fact that the discharge will now flow directly into the Piakau Stream.

References

Fowles CR and Smith KL, 2013: Biomonitoring of the Piakau Stream in relation to the Sidewinder Production Station, November 2012. TRC Report CF586.

Fowles CR and Smith KL, 2013: Biomonitoring of the Piakau Stream in relation to the Sidewinder Production Station, February 2013. TRC Report CF587.

Stark JD, 1985: A macroinvertebrate community index of water quality for stony streams. *Water and Soil* Miscellaneous Publication No. 87.

Stark JD, 1998: SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. *New Zealand Journal of Marine and Freshwater Research 32(1*): 55-66.

Stark JD, 1999: An evaluation of Taranaki Regional Council' SQMCI biomonitoring index. Cawthron Institute, Nelson. Cawthron Report No. 472.

Stark JD, Boothroyd IKG, Harding JS, Maxted JR, Scarsbrook MR, 2001: Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment. Sustainable Management Fund Project No. 5103. 57p.

Stark JD and Maxted JR, 2004. Macroinvertebrate community indices for Auckland's soft-bottomed streams and applications to SOE reporting. Prepared for Auckland Regional Council. Cawthron Report No. 970. Cawthron Institute, Nelson. ARC Technical Publication 303. 59p.

Stark JD and Maxted JR, 2007. A biotic index for New Zealand's soft bottomed streams. New Zealand Journal of Marine and Freshwater Research 41(1).

Stark JD and Maxted JR, 2007a. A user guide for the macroinvertebrate community index. Cawthron Institute, Nelson. Cawthron Report No. 1166.

Stark JD and Fowles CR, 2009. Relationships between MCI, site altitude, and distance from source Taranaki ring plain streams. Stark Environmental report No. 2009-01.

Thomas, 2014: Biomonitoring of the Piakau Stream in relation to the Sidewinder Production Station, December 2013. TRC Report BT019.

TRC, 1999: Some statistics from the Taranaki Regional Council database (FWB) of freshwater macroinvertebrate surveys performed during the period from January 1980 to 31 December 1998 (Updated October 2013). Technical Report 99-17.

TRC, 2013: Freshwater macroinvertebrate fauna biological monitoring programme Annual SEM Report 2011-2012. Technical Report 2012-18.

To Job Manager, Callum McKenzie
From Scientific Officers, C R Fowles and K L Smith
Report No CF587
Doc No 1246903
Date September 2013

Biomonitoring of the Piakau Stream in relation to the Sidewinder Production Station, February 2013

Introduction

This was the second survey completed of the two scheduled biomonitoring surveys relating to the Sidewinder Production Station of TAG Oil New Zealand Ltd for the 2012-2013 monitoring year.

The production Station discharges stormwater and treated production water to land where they may enter the Piakau Stream. Two stage skimmer pits in the northeast corner of the site collect and treat water from the production and wellsite areas. The discharge from the second skimmer pit ponds in the adjacent grassed area. Overflow from this area flows down the bank and enters the Paikau Stream. [Note: The consent provides for discharge onto land in the vicinity of the stream and includes conditions related to instream effects and allows for a 25 m mixing zone in the stream].

The purpose of this survey was to determine whether this discharge from the Production Station has resulted in any detrimental effects on the macroinvertebrate communities in the Piakau Stream downstream of the discharge.

One previous survey had been performed at these three sites which were established specifically for the purpose of monitoring the recently established Sidewinder Production Station in the Piakau Stream sub-catchment of the Waitara River catchment.

Methods

The standard '400 ml kick-sampling' technique was used to collect streambed macroinvertebrates from three recently established sites in the Piakau Stream (Table 1, Figure 1) on 15 February 2013. The 'kick-sampling' technique is very similar to Protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark et al, 2001).

Table 1 Biomonitoring sites in the Piakau Stream surveyed in association with the Sidewinder Production Station

Site No.	Site code	GPS reference	Location	Distance from National Park (km)	Elevation (mask)
1	PIK000160	E1703959 N5659234	60 m upstream of Sidewinder Production Station discharge	6.27	295
2	PIK000162	E1704023 N5659300	25 m downstream of Sidewinder Production Station discharge	6.35	295
3	PIK000165	E1704062 N5659354	100 m downstream of Sidewinder Production Station discharge	6.43	285

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al. 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= estimated 20-99 individuals;
VA (very abundant)	= estimated 100-499 individuals;
XA (extremely abundant)	= estimated 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly `sensitive' taxa were assigned the highest scores of 9 or 10, while the most `tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience. By averaging the scores obtained from a list of taxa collected from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

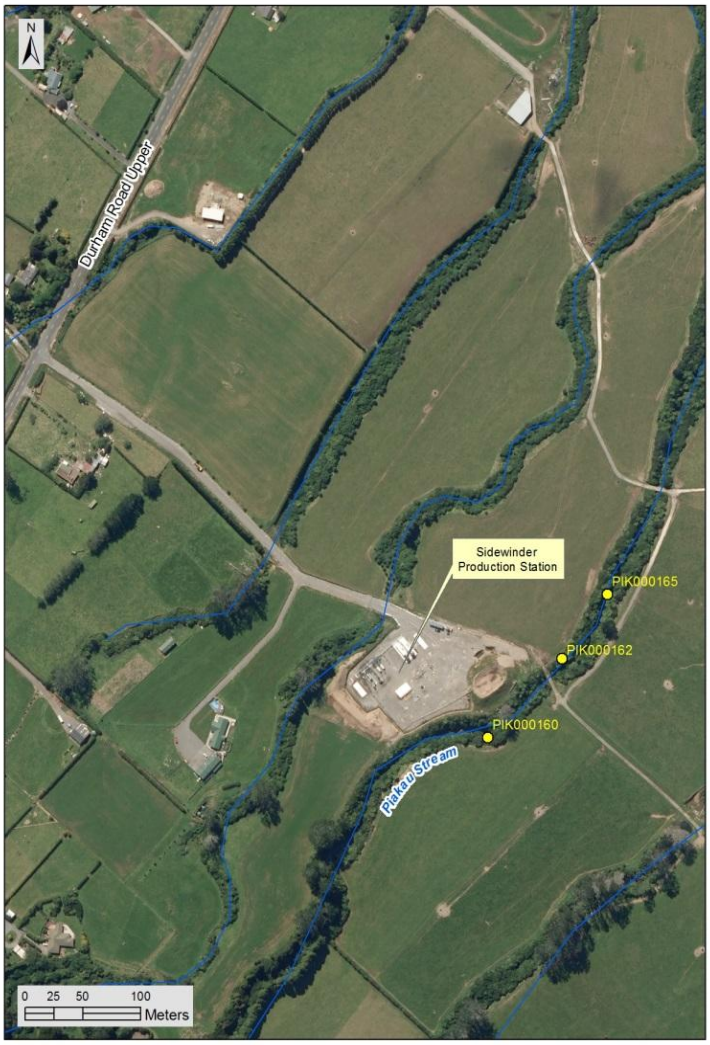

Figure 1 Biological sampling sites in the Piakau Stream related to the Sidewinder Production Station

The MCI was designed as a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. MCI results can also reflect the effects of warm temperatures, slow current speeds and low dissolved oxygen levels, because the taxa capable of tolerating these conditions generally have low sensitivity scores. Usually more 'sensitive' communities (with higher MCI values) inhabit less polluted waterways. The use of this index in non-stony streams is possible if results are related to physical habitat (e.g., good quality muddy/weedy sites tend to produce lower MCI values than good quality stony sites). Weedy stream macroinvertebrate communities tend to be dominated by more 'tolerant' taxa than is the case in stony stream communities. It may therefore require more severe organic pollution to cause a significant decline in MCI value in weedy streams.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, therefore $SQMCI_s$ values range from 1 to 10.

Results and discussion

At the time of this mid morning survey there was a low, swift, clear, uncoloured flow in the Piakau Stream at all three sites. Water temperature ranged from 12.6°C to 13.0°C during this survey. Substrate was similar at the three sites in the Piakau Stream and comprised mainly cobbles, gravels, and boulders, with some sand also present. Periphyton mats were very thin, with no filamentous algae at all sites. Moss was patchy at all sites which were partially to completely shaded by native vegetation. This survey was undertaken following a period of flow recession, during late summer 10 days after the latest fresh in excess of 3x and 7x median flows. No discharge from the skimmer pits was occurring at the time of the survey.

Macroinvertebrate communities

One previous of survey had been performed to date of the three sites in the Piakau Stream. These results and results of the current survey are summarised in Table 2.

Table 2 Number of taxa, MCI, and $SQMCI_s$ values for the Piakau Stream, sampled in relation to the Sidewinder Production site on 15 February 2013 and a summary of historical data for these sites (Nov 2012), and predicted MCI scores (from Stark and Fowles, 2009)

Site No	N	No of taxa			MCI value			$SQMCI_s$ value			Predicted MCI scores	
		Median	Range	Feb 2013	Median	Range	Feb 2013	Median	Range	Feb 2013	Altitude	Distance
1	1	-	26	25	-	126	121	-	7.6	7.4	114	111
2	1	-	27	23	-	132	115	-	7.3	6.7	114	111
3	1	-	24	22	-	132	116	-	7.6	7.5	113	111

The macroinvertebrate fauna recorded by the current survey at each of the three sites are presented in Table 3.

Table 3 Macroinvertebrate fauna of the Piakau Stream in relation to Sidewinder Production Station sampled on 15 February 2013

Taxa List	Site Number	MCI score	1	2	3
	Site Code		PIK000160	PIK000162	PIK000165
	Sample Number		FWB13076	FWB13077	FWB13078
PLATYHELMINTHES (FLATWORMS)	*Neppia*	6	-	-	R
ANNELIDA (WORMS)	Oligochaeta	1	-	R	R
EPHEMEROPTERA (MAYFLIES)	*Austroclima*	7	C	C	R
	Coloburiscus	7	VA	VA	VA
	Deleatidium	8	XA	VA	XA
	Nesameletus	9	A	A	VA
	Zephlebia group	7	R	C	-
PLECOPTERA (STONEFLIES)	*Austroperla*	9	R	-	-
	Megaleptoperla	9	R	-	-
	Zelandoperla	8	R	-	R
COLEOPTERA (BEETLES)	Elmidae	6	VA	VA	VA
	Hydraenidae	8	C	-	R
	Ptilodactylidae	8	-	-	R
MEGALOPTERA (DOBSONFLIES)	*Archichauliodes*	7	A	A	A
TRICHOPTERA (CADDISFLIES)	*Aoteapsyche*	4	A	A	A
	Costachorema	7	-	R	C
	Hydrobiosis	5	R	R	R
	Neurochorema	6	R	R	-
	Psilochorema	6	R	-	-
	Beraeoptera	8	A	C	A
	Confluens	5	R	R	R
	Helicopsyche	10	-	R	-
	Pycnocentria	7	C	C	-
	Pycnocentrodes	5	C	R	R
DIPTERA (TRUE FLIES)	*Aphrophila*	5	A	A	A
	Eriopterini	5	-	-	R
	Harrisius	6	-	R	-
	Orthocladiinae	2	R	C	R
	Polypedilum	3	R	C	C
	Empididae	3	R	-	-
	Austrosimulium	3	R	R	-
	Tanyderidae	4	R	R	R
		No of taxa	25	23	22
		MCI	121	115	116
		SQMCIs	7.4	6.7	7.5
		EPT (taxa)	16	14	11
		%EPT (taxa)	64	61	50
'Tolerant' taxa	'Moderately sensitive' taxa	'Highly sensitive' taxa			

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

Site 1 (upstream of Production Station discharge)

A moderately high richness (25 taxa) was recorded, very similar to the median number (26 taxa) and well below the maximum (36 taxa) found by more than 165 previous surveys of National Park-sources streams at 'control' sites between 250 and 299 m asl (TRC, 1999 (updated 2012)). This richness was one taxon less than found by the single previous survey performed at this site. The community was comprised of a very high proportion (76%) of

'sensitive' taxa, seven of which were 'highly sensitive' taxa. The community was characterised by three 'highly sensitive' taxa [mayfly (extremely abundant *Deleatidium;* and *Nesameletus)* and cased caddisfly (*Beraeoptera*)]; four 'moderately sensitive' [mayfly (very abundant *Coloburiscus*), elmid beetles, dobsonfly (*Archichauliodes*), and cranefly (*Aphrophila*)]; and one 'tolerant' taxon [net-building caddisfly (*Aoteapsyche*)]. The numerical dominance by 'sensitive' taxa (particularly one 'highly sensitive' and two 'moderately sensitive' taxa), resulted in the very high $SQMCI_s$ value of 7.4 units, within 0.2 of the value recorded by the single previous survey (Table 2) and more typical of $SQMCI_s$ scores at sites closer to the National Park boundary (TRC, 2013). This was indicative of good physical habitat and preceding physicochemical water quality, typical of the upper mid-reaches of ringplain streams.

The high proportion of 'sensitive' taxa comprising the community resulted in the relatively high MCI score (121 units) which was 5 units lower than recorded by the single previous (late spring) survey and 6 units above the median MCI score recorded by more than 155 surveys of 'control' sites in National Park-sourced rivers and streams between 250 and 299 m asl (TRC, 1999 (updated 2012)). It was also 7 and 10 units above predicted (Stark and Fowles, 2009) altitude and distance scores respectively (Table 2) and categorized this site as having 'very good' generic stream health and 'better than expected' predictive health (TRC, 2013) for a site in the upper mid-reaches of a ringplain stream.

Site 2 (25 m downstream of Production Station discharge)

A moderately high richness (23 taxa) also was found at this site, two taxa fewer than at the site upstream of the discharge area, and within three taxa of the median richness recorded by more than 155 previous surveys at similar 'control' sites (see above and TRC, 1999 (updated, 2012)). This was four taxa fewer than the richness recorded by the single previous survey at this site (Table 2) with a community composition mainly comprised of 'sensitive' taxa (74% of richness), four of which were 'highly sensitive' taxa. The community was characterised by all but one of the same eight dominant taxa as at the upstream 'control' site, the exception being one 'highly sensitive' taxon [flare-cased caddisfly (*Beraeoptera*)]. The continued numerical dominance by 'sensitive' taxa (one 'highly sensitive' and two 'moderately sensitive' taxa in particular) resulted in a high $SQMCI_s$ value of 6.7 units, which was 0.6 unit lower than recorded by the previous single (late spring) survey (Table 2) and 0.7 unit lower than the score at the upstream site (Table 3). This was also indicative of good physical habitat and preceding physicochemical water quality, typical of the upper, mid-reaches of ringplain streams, and coincidental with minimal periphyton substrate cover.

The relatively high proportion of 'sensitive' taxa in the composition of the community was reflected in the moderately high MCI score (115 units), an insignificant six units above that found at the 'control' site upstream of the discharge area, but 17 units below the score recorded by the single previous survey. However, it was equal with the median score recorded by more than 155 previous surveys at similar sites (see above and TRC, 1999 (updated, 2012)). The score was also one and four units above predicted altitude and distance scores respectively (Stark and Fowles, 2009; Table 2). This categorised the site as having 'good' generic stream health and 'better than expected' predictive health (TRC, 2013) for a site in the upper mid reaches of a ringplain stream.

Site 3 (100 m downstream of Production Station discharge)

Taxa richness (22) was moderately high for a site in the upper mid-reaches of a ringplain stream and four taxa below the median richness found to date by more than 155 surveys of

'control' sites in National Park-sourced streams at altitudes between 250 and 299 m asl (TRC, 1999 (updated, 2012)). This richness was two taxa fewer than the richness found by the only previous survey at this site (Table 2). The community was comprised of a high proportion (77%) of 'sensitive' taxa, six of which were 'highly sensitive' taxa. It was characterised by all of the same 'highly sensitive' and 'moderately sensitive' taxa also dominant at site 2, plus one additional 'highly sensitive' taxon [flare-cased caddisfly (*Beraeoptera*)]. The continued numerical dominance by 'sensitive' taxa resulted in a high $SQMCI_s$ value of 7.5 units which was within 0.1 unit of the score found by the only previous survey (Table 2) and 0.1 unit higher than recorded at the upstream 'control' site (1). This was an indication of relatively good physical habitat and preceding physicochemical water quality, and better than typical of the upper mid-reaches of ringplain stream, coincidental with minimal periphyton substrate cover at this completely shaded site.

The relatively high proportion of 'sensitive' taxa comprising this community resulted in a moderately high MCI value of 116 units, which was only 5 units lower than the score recorded upstream of the Production Station discharge area but 16 units lower than recorded by the only previous (late spring) survey at this site. This current score was also an insignificant one unit above the median score recorded by more than 155 previous surveys at similar sites (see above and TRC, 1999 (updated, 2012)) and 3 to 5 units above predicted altitude and distance from the National Park boundary scores respectively (Stark and Fowles, 2009; Table 2). This score characterised the site as having 'good' generic stream health and 'better than expected' predictive health (TRC, 2013) for a site in the mid-reaches of a ringplain stream.

Conclusions and summary

The Council's standard 'kick-sampling' technique was used at three newly established sites to collect streambed macroinvertebrates from the Piakau Stream, to assess whether discharges from the Sidewinder Production Station had had any detrimental effects on the macroinvertebrate communities of this stream. This late summer survey was the second of two surveys programmed for the 2012-2013 monitoring period. Samples were sorted and identified to provide the number of taxa (richness) and MCI and $SQMCI_S$ scores for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects or organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The $SQMCI_S$ takes into account taxa abundance as well as sensitivity to pollution, and may reveal more subtle changes in communities, particularly if non-organic impacts are occurring. Significant differences in either the MCI or the $SQMCI_S$ between sites may indicate the degree of adverse effects (if any) of the discharges being monitored.

This late summer macroinvertebrate survey indicated that the discharge of treated stormwater and production water to land and to water from the recently established Sidewinder Production Station site had not had any recent detrimental effects on the macroinvertebrate communities of the Piakau Stream. The MCI scores for each site were all higher than their respective predictive scores for equivalent sites in the upper mid-reaches of ringplain streams. No significant changes in the macroinvertebrate communities were recorded between sites and $SQMCI_S$ scores were not significantly different between sites.

Lower MCI scores were recorded at all sites by this late summer survey in comparison with the earlier (and only) previous survey in late spring which is a typical seasonal trend in ringplain streams (TRC, 2013).

The macroinvertebrate communities of the stream contained very high proportions of 'sensitive' taxa at all sites. In addition, communities at all sites had a number of common dominant taxa (they shared seven of the eight dominant taxa through the surveyed reach). There were no significant changes in MCI values between sites, coincident with very similar habitat at all sites. In addition, taxonomic richness (numbers of taxa) was relatively consistent across all three sites. The MCI scores indicated that the stream communities were of good 'health', and better than typical conditions in comparison with predictive values recorded from equivalent ringplain stream sites. The absence of significant differences between the three sites indicated no recent impacts from any of the Sidewinder Production Station discharges to land and/or run-off to the adjacent Piakau Stream.

References

Fowles CR and Smith KL, 2013: Biomonitoring of the Piakau Stream in relation to the Sidewinder Production Station, November 2012. TRC Report CF586.

Stark JD, 1985: A macroinvertebrate community index of water quality for stony streams. *Water and Soil* Miscellaneous Publication No. 87.

Stark JD, 1998: SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. *New Zealand Journal of Marine and Freshwater Research 32(1*): 55-66.

Stark JD, 1999: An evaluation of Taranaki Regional Council' SQMCI biomonitoring index. Cawthron Institute, Nelson. Cawthron Report No. 472.

Stark JD, Boothroyd IKG, Harding JS, Maxted JR, Scarsbrook MR, 2001: Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment. Sustainable Management Fund Project No. 5103. 57p.

Stark JD and Maxted JR, 2004. Macroinvertebrate community indices for Auckland's soft-bottomed streams and applications to SOE reporting. Prepared for Auckland Regional Council. Cawthron Report No. 970. Cawthron Institute, Nelson. ARC Technical Publication 303. 59p.

Stark JD and Maxted JR, 2007. A biotic index for New Zealand's soft bottomed streams. New Zealand Journal of Marine and Freshwater Research 41(1).

Stark JD and Maxted JR, 2007a. A user guide for the macroinvertebrate community index. Cawthron Institute, Nelson. Cawthron Report No. 1166.

Stark JD and Fowles CR, 2009. Relationships between MCI, site altitude, and distance from source Taranaki ring plain streams. Stark Environmental report No. 2009-01

TRC, 1999: Some statistics from the Taranaki Regional Council database (FWB) of freshwater macroinvertebrate surveys performed during the period from January 1980 to 31 December 1998. Technical Report 99-17.

TRC, 2013: Freshwater macroinvertebrate fauna biological monitoring programme Annual SEM Report 2011-2012. Technical Report 2012-18.

To Job Manager, Callum McKenzie
From Scientific Officers, C R Fowles and K L Smith
Report No CF586
Doc No 1246175
Date September 2013

Biomonitoring of the Piakau Stream in relation to the Sidewinder Production Station, November 2012

Introduction

This was the first survey completed of the two scheduled biomonitoring surveys relating to the Sidewinder Production Station of TAG Oil New Zealand Ltd for the 2012-2013 monitoring year.

The Production Station discharges stormwater and treated production water to land where they may enter the Piakau Stream. Two stage skimmer pits in the northeast corner of the site collect and treat water from the production and wellsite areas. The discharge from the second skimmer pit ponds in the adjacent grassed area. Overflow from this area flows down the bank and enters the Piakau Stream. [Note: The consent provides for discharge onto land in the vicinity of the stream and includes conditions related to instream effects and allows for a 25 m mixing zone in the stream].

The purpose of this survey was to determine whether this discharge from the Production Station had resulted in any detrimental effects on the macroinvertebrate communities in the Piakau Stream downstream of the discharge.

No previous surveys had been performed at any of these three sites which were established specifically for the purpose of monitoring the recently established Sidewinder Production Station in the Piakau Stream sub-catchment of the Waitara River catchment.

Methods

The standard '400 ml kick-sampling' technique was used to collect streambed macroinvertebrates from three newly established sites in the Piakau Stream (Table 1, Figure 1) on 29 November 2012. The 'kick-sampling' technique is very similar to Protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark et al, 2001).

Table 1 Biomonitoring sites in the Ngaere Stream surveyed in association with the Waihapa Production Station

Site No.	Site code	GPS reference	Location	Distance from National Park (km)	Elevation (masl)
1	PIK000160	E1703959 N5659234	60 m upstream of Sidewinder Production Station discharge	6.27	295
2	PIK000162	E1704023 N5659300	25 m downstream of Sidewinder Production Station discharge	6.35	295
3	PIK000165	E1704062 N5659354	100 m downstream of Sidewinder Production Station discharge	6.43	285

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al. 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= estimated 20-99 individuals;
VA (very abundant)	= estimated 100-499 individuals;
XA (extremely abundant)	= estimated 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly `sensitive' taxa were assigned the highest scores of 9 or 10, while the most `tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience. By averaging the scores obtained from a list of taxa collected from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways.

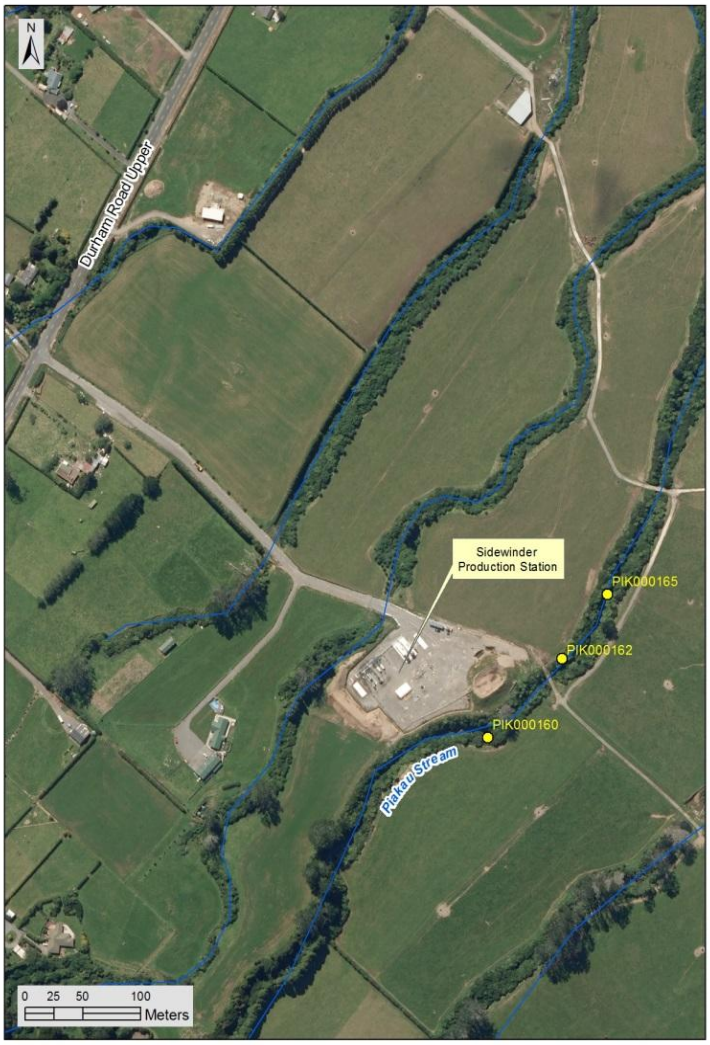

Figure 1 Biological sampling sites in the Piakau Stream related to the Sidewinder Production Station

The MCI was designed as a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. MCI results can also reflect the effects of warm temperatures, slow current speeds and low dissolved oxygen levels, because the taxa capable of tolerating these conditions generally have low sensitivity scores. Usually more 'sensitive' communities (with higher MCI values) inhabit less polluted waterways. The use of this index in non-stony streams is possible if results are related to physical habitat (e.g., good quality muddy/weedy sites tend to produce lower MCI values than good quality stony sites). Weedy stream macroinvertebrate communities tend to be dominated by more 'tolerant' taxa than is the case in stony stream communities. It may therefore require more severe organic pollution to cause a significant decline in MCI value in weedy streams.

A semi-quantitative MCI value ($SQMCI_s$) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the $SQMCI_s$ is not multiplied by a scaling factor of 20, therefore $SQMCI_s$ values range from 1 to 10.

Results and discussion

At the time of this midday survey there was a low, swift, clear, uncoloured flow in the Piakau Stream at all three sites. Water temperature ranged from 13.0°C to 14.0°C during this survey. Substrate was similar at the three sites in the Piakau Stream and comprised mainly cobbles, gravels, and boulders, with some sand also present. Periphyton mats were very thin, with no filamentous algae at all sites. Moss was patchy at all sites which were all partially shaded by native vegetation. This survey was undertaken following a period of flow recession during late spring, 12 days after the latest fresh in excess of 3x median flow and 27 days after a fresh in excess of 7X median flow. No discharge from the skimmer pits was occurring at the time of the survey.

Macroinvertebrate communities

No previous surveys have been performed to date at any of the three sites in the Piakau Stream. The results of the current survey are summarised in Table 2.

Table 2 Results of the survey of 2012 in relation to the Sidewinder Production Station, and predicted MCI scores (from Stark and Fowles (2009)) for these sites

Site No	Results			Predicted MCI scores	
	No of taxa	MCI	$SQMCI_s$	Altitude	Distance
1	26	126	7.6	114	111
2	27	132	7.3	114	111
3	24	132	7.6	113	111

The macroinvertebrate fauna recorded by the current survey at each of the three sites are presented in Table 3.

Table 3 Macroinvertebrate fauna of the Piakau Stream in relation to Sidewinder Production Station sampled on 29 November 2012

Taxa List	Site Number	MCI score	1	2	3
	Site Code		PIK000160	PIK000162	PIK000165
	Sample Number		FWB12471	FWB12472	FWB12473
EPHEMEROPTERA (MAYFLIES)	*Ameletopsis*	10	-	R	-
	Austroclima	7	C	C	C
	Coloburiscus	7	VA	VA	VA
	Deleatidium	8	XA	VA	XA
	Nesameletus	9	C	C	C
	Zephlebia group	7	C	C	C
PLECOPTERA (STONEFLIES)	*Acroperla*	5	C	R	-
	Megaleptoperla	9	R	R	C
	Spaniocerca	8	-	R	-
	Zelandobius	5	R	-	R
	Zelandoperla	8	R	-	C
COLEOPTERA (BEETLES)	Elmidae	6	VA	A	VA
	Hydraenidae	8	R	R	C
	Ptilodactylidae	8	-	R	R
MEGALOPTERA (DOBSONFLIES)	*Archichauliodes*	7	C	C	A
TRICHOPTERA (CADDISFLIES)	*Aoteapsyche*	4	C	C	A
	Costachorema	7	-	-	R
	Hydrobiosis	5	R	R	C
	Neurochorema	6	R	R	-
	Plectrocnemia	8	R	R	-
	Beraeoptera	8	XA	A	XA
	Confluens	5	R	R	-
	Helicopsyche	10	R	C	R
	Olinga	9	R	R	R
	Pycnocentrodes	5	C	R	C
DIPTERA (TRUE FLIES)	*Aphrophila*	5	A	C	A
	Eriopterini	5	R	-	C
	Harrisius	6	-	R	R
	Orthocladiinae	2	C	R	R
	Polypedilum	3	-	R	-
	Empididae	3	R	-	R
	Austrosimulium	3	R	R	-
		No of taxa	26	27	24
		MCI	126	132	132
		SQMCIs	7.6	7.3	7.6
		EPT (taxa)	18	18	15
		%EPT (taxa)	69	67	63
'Tolerant' taxa	'Moderately sensitive' taxa	'Highly sensitive' taxa			

R = Rare C = Common A = Abundant VA = Very Abundant XA = Extremely Abundant

Site 1 (upstream of Production Station discharge)

A moderately high richness (26 taxa) was recorded, identical with the median number (26 taxa) and well below the maximum (36 taxa) found by more than 155 previous surveys of National Park-sources streams at 'control' sites between 250 and 299 m asl (TRC, 1999 (updated 2012)). The community was comprised of a very high proportion (85%) of

'sensitive' taxa, nine of which were 'highly sensitive' taxa. The community was characterised by two 'highly sensitive' taxa [mayfly (extremely abundant *Deleatidium*) and extremely abundant cased-caddisfly (*Beraeoptera*); three 'moderately sensitive' taxa [mayfly (*Coloburiscus*), elmid beetles, and cranefly (*Aphrophila*)]; but no 'tolerant' taxa. The numerical dominance by 'sensitive' taxa (particularly two 'highly sensitive' taxa) resulted in the very high $SQMCI_s$ value of 7.6 units more typical of scores at sites close to the National park boundary (TRC, 2013). This was indicative of good physical habitat and preceding physicochemical water quality, typical of the upper mid-reaches of ringplain streams.

The high proportion of 'sensitive' taxa comprising the community resulted in the relatively high MCI score (126 units) which was a significant (Stark, 1998) 11 units above the median MCI score recorded by more than 155 surveys of 'control' sites in National Park-sourced rivers and streams between 250 and 299 m asl (TRC, 1999 (updated 2012)). It was also significantly 12 and 15 units above predicted (Stark and Fowles, 2009) altitude and distance scores respectively (Table 2) and categorized this site as having 'very good' generic stream health and 'better than expected' predictive health (TRC, 2013) for a site in the upper mid-reaches of a ringplain stream.

Site 2 (25 m downstream of Production Station discharge

A moderately high richness (27 taxa) also was found at this site, one taxon more than at the site upstream of the discharge area and one taxon more than the median richness recorded by more than 155 previous surveys at similar 'control' sites (see above and TRC, 1999 (updated, 2012)). The community composition was mainly comprised of 'sensitive' taxa (85 of richness), 11 of which were 'highly sensitive' taxa. The community was characterised by four of the same five dominant taxa as at the upstream 'control' site, the exception being one 'moderately sensitive' taxon [cranefly (*Aphrophila*)]. The continued numerical dominance by 'sensitive' taxa (one 'highly sensitive' and one 'moderately sensitive' taxa in particular) resulted in a high $SQMCI_s$ value of 7.3 units, only 0.3 units lower than the score at the upstream site (Table 3). This was also indicative of good physical habitat and preceding physicochemical water quality, typical of the upper, mid-reaches of ringplain streams, and coincidental with minimal periphyton substrate cover.

The high proportion of 'sensitive' taxa in the composition of the community was reflected in the high MCI score (132 units), an insignificant six units above that found at the 'control' site upstream of the discharge area, and a significant (Stark, 1998) 17 units above the median score recorded by more than 155 previous surveys at similar sites (see above and TRC, 1999 (updated, 2012)). The score was also significantly 18 and 21 units above predicted altitude and distance scores respectively (Stark and Fowles, 2009; Table 2). This categorized the site as having 'very good' generic stream health and 'well above expected' predictive health (TRC, 2013) for a site in the upper mid reaches of a ringplain stream.

Site 3 (100 m downstream of Production Station discharge)

Taxa richness (24) was moderately high for a site in the upper mid-reaches of a ringplain stream and two taxa below the median richness found to date by more than 155 surveys of 'control' sites in National Park-sourced streams at altitudes between 250 and 299 m asl (TRC, 1999 (updated, 2012)). The community was comprised of a high proportion (87%) of 'sensitive' taxa, nine of which were 'highly sensitive' taxa. It was characterised by all of the same 'highly sensitive' and 'moderately sensitive' taxa also dominant at site 2 plus two additional 'moderately sensitive' taxa [dobsonfly (*Archichauliodes*) and cranefly (*Aphrophila*)], and one 'tolerant' taxon [net-spinning caddisfly (*Aoteapsyche*)]. The continued numerical dominance by 'sensitive' taxa resulted in a high $SQMCI_s$ value of 7.6 units which was identical with the

score recorded at the upstream 'control' site (1). This was an indication of good physical habitat and preceding physicochemical water quality and better than typical of the upper mid-reaches of ringplains treams, coincidental with minimal periphyton substrate cover.

The high proportion of 'sensitive' taxa comprising this community resulted in a high MCI value of 132 units, which was six units above the score upstream of the Production Station discharge area. This score was also a significant 17 units above the median score recorded by more than 155 previous surveys at similar sites (see above and TRC, 1999 (updated, 2012)) and 19 to 21 units above predicted altitude and distance from the national Park boundary scores respectively (Stark and Fowles, 2009; Table 2). This score characterised the site as having 'very good' generic stream health and 'well above expected' predictive health (TRC, 2013) for a site in the mid-reaches of a ringplain stream.

Conclusions and summary

The Council's standard 'kick-sampling' technique was used at three newly established sites to collect streambed macroinvertebrates from the Piakau Stream, to assess whether discharges from the Sidewinder Production Station had had any detrimental effects on the macroinvertebrate communities of this stream. This late spring survey was the first of two surveys programmed for the 2012-2013 monitoring period. Samples were sorted and identified to provide the number of taxa (richness) and MCI and $SQMCI_S$ scores for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects or organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The $SQMCI_S$ takes into account taxa abundance as well as sensitivity to pollution, and may reveal more subtle changes in communities, particularly if non-organic impacts are occurring. Significant differences in either the MCI or the $SQMCI_S$ between sites may indicate the degree of adverse effects (if any) of the discharges being monitored.

This late spring macroinvertebrate survey indicated that the discharge of treated stormwater and production water to land and to water from the recently established Sidewinder Production Station site had not had any recent detrimental effects on the macroinvertebrate communities of the Piakau Stream. The MCI scores for each site were all significantly higher than their respective predictive scores for equivalent sites in the upper mid-reaches of ringplain streams. No significant changes in the macroinvertebrate communities were recorded between sites and $SQMCI_S$ scores were not significantly different between sites.

The macroinvertebrate communities of the stream contained very high proportions of 'sensitive' taxa at all sites. In addition, communities at all sites had a number of common dominant taxa (they shared four of the seven dominant taxa through the surveyed reach). There were no significant changes in MCI values between sites, coincident with very similar habitat at all sites. In addition, taxonomic richness (numbers of taxa) was relatively consistent across all three sites. The MCI scores indicated that the stream communities were of 'very good' health, and better than typical conditions in comparison with predictive values recorded from equivalent ringplain stream sites . The absence of significant differences between the three sites indicated no recent impacts from any of the Sidewinder Production Station discharges to land and/or run-off to the adjacent Piakau Stream.

References

Stark JD, 1985: A macroinvertebrate community index of water quality for stony streams. *Water and Soil* Miscellaneous Publication No. 87.

Stark JD, 1998: SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. *New Zealand Journal of Marine and Freshwater Research 32(1*): 55-66.

Stark JD, 1999: An evaluation of Taranaki Regional Council' SQMCI biomonitoring index. Cawthron Institute, Nelson. Cawthron Report No. 472.

Stark JD, Boothroyd IKG, Harding JS, Maxted JR, Scarsbrook MR, 2001: Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment. Sustainable Management Fund Project No. 5103. 57p.

Stark JD and Maxted JR, 2004. Macroinvertebrate community indices for Auckland's soft-bottomed streams and applications to SOE reporting. Prepared for Auckland Regional Council. Cawthron Report No. 970. Cawthron Institute, Nelson. ARC Technical Publication 303. 59p.

Stark JD and Maxted JR, 2007. A biotic index for New Zealand's soft bottomed streams. New Zealand Journal of Marine and Freshwater Research 41(1).

Stark JD and Maxted JR, 2007a. A user guide for the macroinvertebrate community index. Cawthron Institute, Nelson. Cawthron Report No. 1166.

Stark JD and Fowles CR, 2009. Relationships between MCI, site altitude, and distance from source for Taranaki ring plain streams. Stark Environmental report No. 2009-01

TRC, 1999: Some statistics from the Taranaki Regional Council database (FWB) of freshwater macroinvertebrate surveys performed during the period from January 1980 to 31 December 1998. Technical Report 99-17.

TRC, 2013: Freshwater macroinvertebrate fauna biological monitoring programme Annual SEM Report 2011-2012. Technical Report 2012-18.