PARLIAMENTARY COMMISSIONER FOR THE ENVIRONMENT INVESTIGATION INTO HYDRAULIC FRACTURING IN NEW ZEALAND SECOND SUBMISSION BY CLIMATE JUSTICE TARANAKI

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Summary

In this submission to the Parliamentary Commissioner for the Environment, Climate Justice Taranaki (CJT) examines the science, technical capacity and the current regulatory and monitoring regimes in New Zealand re the oil and gas industry. CJT concludes that there is inadequate scientific evidence and technical capacity to ensure safety at all stages of oil and gas production involving fracking. The associated risks—elevated seismic hazards, water contamination, soil degradation, air pollution, contamination of food chain and health impacts on nearby residents—are far too great to justify further expansion of the oil and gas industry involving fracking across NZ. Based on review of numerous Taranaki Regional Council documents, many revealing consent breaches and repeated non-compliances by oil and gas companies, CJT concludes that the current regulatory regime of the industry in NZ, and in particular Taranaki, cannot guarantee industry best practice, robust and objective monitoring, transparent compliance checks or effective response and remediation should incidents occur. All credible, international agencies and climatologists have agreed that to avoid catastrophic impacts from climate change, actions must now be taken to reduce greenhouse gas emission by substantially reducing fossil fuel use.

Based on the above, CJT recommends the following:

- An outright ban on fracking in NZ.
- If a ban is not possible, a moratorium on fracking in NZ until all of the following can be achieved:
  i. In-depth research into seismicity and fracking in order to identify high hazard areas where fracking and deep well injection of drilling and fracking waste must be banned.
  ii. Development and implementation of a "traffic-light" system for managing the risk of injection-induced earthquakes, involving research and deployment of adequate instruments.
  iii. A ban on disposal of drilling and fracking wastes on farms.
  iv. Obligatory accounting and minimisation of fugitive methane.
  v. Strengthening (not 'streamlining') of the current regulatory regime relating to fracking, to ensure safety, environmental protection, rights of landowners and potential affected parties, and adequate resources for disaster management, remediation and compensation.
  vi. Strengthening of the current monitoring regime relating to fracking at the regional level, to ensure adequate science, independency of data, transparent reporting and objective assessment.
- Development of an effective energy transition strategy, incorporating energy efficiencies, clean renewable energy sources, public transport systems and sustainable agriculture that do not rely heavily on fossil fuels.

1. Introduction

There is now just five months before the Parliamentary Commissioner for the Environment (PCE) releases her final report on the investigation into hydraulic fracturing (fracking) in New Zealand. Climate Justice Taranaki (CJT) makes this submission to highlight several critical issues that we hope will be thoroughly examined in the PCE's final report. We also reiterate the key points raised in our previous submission.

The three critical issues are:

- The scientific basis and technical capacity to inform planning and decisions
- The current regulatory and monitoring regimes
- Climate change

The relevance and importance of these issues, especially science, regulations and monitoring, are examined for the different stages of oil and gas production, with particular focus on waste disposal. Critical gaps of knowledge are highlighted as questions. The geographical focus, understandably, is Taranaki. Yet given industry and government intentions to use our region as a 'model' for the expansion of the industry in other regions, our findings, recommendations and questions have national relevance and implications. This submission is made in good faith, based on our analysis of published reports and other documents (underlined with hyperlinks) in the public domain.

"The petroleum industry needs clear requirements for operation, regulators must have a solid scientific basis for those requirements, and the public needs assurance that the regulations are sufficient and are being followed," Ellsworth (2013).

2. Choosing where to drill

2.1 There is inadequate scientific information on seismicity, aquifer distribution and connectivity, and impacts from flaring, to determine, in every case, whether a location is 'safe' to drill.

As explained in detail in our previous submission, Taranaki Regional Council (TRC)'s hydrogeological assessment on fracking (2012) cannot be considered independent or comprehensive (CJT submission to PCE, Nov 2012). The 2012 GNS report on the effects of fracking on seismicity is also inadequate due to *"limitations of the monitoring system"* and particularly given the planned, major expansion of the industry in coming years.

Careful site identification is especially crucial in places where oil and gas exploration, production, storage and waste disposal (notably deep well injection DWI) have all been happening for many years, or are planned, in close proximity to rural populations and farmlands. There are already adverse legacy issues in parts of Taranaki.

The google map on Taranaki's oil and gas sites developed by CJT illustrates the scale and scope of the industry to date. It also highlights current and emergent impacts on people, livestock, the environment and other economic backbones that rely on healthy, uncontaminated soil, water and air. Pertinent examples include Kapuni, Ngaere (Cheal), Tikorangi and Inglewood.

Recently, TRC commissioned a study—atmospheric dispersion modelling of discharges from flaring of fracturing fluid (Backshall 2013). The conclusion: *"the disposal of fracturing fluid by flaring should not result*

in any adverse effects beyond the well site" is based on very limited data and methodologies with admitted assumptions, discrepancies and inaccuracies. Yet it has important implications on where new wells (and associated flare pits) can be located without unacceptable impacts on landowners, occupiers and livestock. Notably, the study predicted maximum concentration of contaminants at 615 m downwind from the source, but TRC retains the *"preferred buffer separation of 300 metres between flares and residential dwellings, for flaring to be considered a controlled activity"* (TRC meeting, 11 June 2013). The report failed to provide concrete recommendations and a plan for further research to gain more robust data that could be used to really determine the safe distance, based on the precautionary principle.

A related issue is the condition or structural integrity of aging infrastructure. There are hundreds of abandoned onshore oil and gas wells across the country, half of them are in Taranaki. Several studies overseas have demonstrated the risks of groundwater contamination when drilling takes place near improperly abandoned wells (See section 8).

Is there comprehensive information available on all abandoned wells (including their integrity) and water bores in the vicinity of a proposed well site? Is such information taken into account seriously when choosing where to drill?

2.2 Landowners' rights

The PCE's interim report listed *"ease of access to the land"* and *"ease of gaining resource consents from councils"* as the key considerations for companies when determining whether and where to drill within a permit area. Although land owners and occupiers do not own the oil and gas under their land, they do have the right to deny access by not signing access arrangements proposed by companies or consents for an arbitrator to determine an access arrangement (CMA 1991, article 66). And there are restrictions on determination of access arrangements by arbitrators (CMA 1991, article 55). These, plus other landowners and occupiers' rights such as compensations (CMA 1991, article 76) and the fact that all costs are to be borne by the person desiring access (CMA 1991, article 73) should be made clear to landowners and occupiers. Understandably, companies generally offer no explanations to landowners and occupiers of their rights; on the contrary the latter are coerced into signing access and confidentiality agreements (Jury, 2012; Live Magazine, 2013).

The issue of land access and landowners and occupiers' rights should be clarified in the PCE's final report.

Re "*ease of gaining resource consents",* the fact that the vast majority of resource consents are granted non-notified by TRC precludes public review and input, notably by potential affected parties.

The lack of definition of "*minimal impact"* and *"minor adverse effects"* is a serious problem that works against an objective and transparent consenting process (EDS, 2013), as also explained in detail in our previous submission. **It also undermines the rights and safety of potential affected parties.**

Moreover, persons who have given written approval to an activity are no longer considered 'affected parties'. We challenge this notion because it contributes to under-stating the overall effects of the activity and hampers public understanding of the full extent of the activity or project.

3. Establishing the well site

3.1 'Unbundling' of consents

The largely 'unbundled' consenting process is indeed a *"'thin end of the wedge' strategy, preventing consideration of the whole operation, and denying public participation"* (PCE interim report, 2012). In Taranaki, resource consents (discharge, land-use, water take) are often granted separately by the regional and district councils even though they are part of the same proposal on the same site. This 'unbundled' procedure fails to consider the overall or cumulative effects of the different activities consented for, and the real impacts on the environment and nearby landowners and occupiers.

One example, in Nov 2012, New Plymouth District Council (NPDC) granted landuse consent LUC12/45599 to drill up to 8 wells at Kowhai-B wellsite, despite the fact that **quantity of proposed hazardous substances far exceed the permitted effects ratio of 0.75.** The calculated fire/explosion ratio for the proposed activity is 13.3, the human health effects ratio is 129.21 and the environmental effects ratio is 349.12 (LNPDC LUC12/45599 planning report). The original application, with such high risk factors, failed to meet the requirements of District Plan Rules 69 and 93. But at the time of application, TRC has already granted water take consents and discharge consents consecutively over several months; for emission to air, including from combustion of returned frack fluids, granted on 28 Feb 2012 and discharge contaminants to water or land—fracking, granted on 29 March 2012 and deep well injection, granted on 11 May 2012. **All these activities are to take place within a 20.4 ha property. There's a dwelling on the property, about 200m from the wellsite. The nearest neighbour's home is 320m away and the local school <1km away. All the consents were granted non-notified.**

Indeed, the density of oil and gas wells in some areas of Taranaki is already very high (See google map on Taranaki's oil and gas sites). **There is an apparent paucity of research and risk assessment of the cumulative or synergistic effects of so many associated oil and gas activities in a small area over the short to long term** (Lloyd-Smith, 2012). The 'unbundled' consenting process perpetuates and takes advantage of this vacuum of information.

4. Drilling and constructing the well

4.1 The current engineering capacity cannot guarantee well integrity in the short or long term.

Industry studies (e.g. Watson and Bachu, 2009) have shown, *"about 5% of all oil and gas wells leak immediately because of integrity issues, with increasing rates of leakage over time."* In 20 years, over half of the wells will leak (Ingraffea et al. 2012). *With hundreds of thousands of new wells expected, this problem is neither negligible nor preventable with current technology... Pressures under the earth, temperature changes, ground movement from the drilling of nearby wells and shrinkage crack and damage the thin layer of brittle cement that is supposed to seal the wells. And getting the cement perfect as the drilling goes horizontally into shale is extremely challenging. Once the cement is damaged, repairing it thousands of feet underground is expensive and often unsuccessful. The gas and oil industries have been trying to solve this problem for decades"* (Ingraffea, 2013). All the above do not take into account the very high seismicity in many regions of NZ which will, with little doubt, further compromise well integrity and longevity.

Are the casing and cement used in NZ designed to withstand large ground movements? (See section 7.3)

What is there to ensure that old wells that are being redrilled have the required strength and integrity to withstand a 'second life', likely decades long, of production and/or waste disposal?

One serious consequence of well casing failure is groundwater contamination. A new (2013) study of 100 private water wells in and near the Barnett Shale, USA, showed elevated levels of potential contaminants closest to natural gas extraction sites. Arsenic and strontium were found in almost all the samples, with concentrations significantly higher in active extraction areas than historical levels. That of arsenic was also much higher than in non-extraction areas. Causes could include*: "industrial accidents such as faulty gas well casings; mechanical vibrations from natural gas drilling activity disturbing particles in neglected water well equipment; or the lowering of water tables through drought or the removal of water used for the hydraulic fracturing process. Any of these scenarios could release dangerous compounds into shallow groundwater."* The researchers argued strongly for the need of continued research. Has similar study been undertaken in NZ prior to 2011? (See section 6.2)

4.2 TRC's regulatory response in case of well failure is questionable.

In September 2009, TRC was advised by Austral (operation subsequently taken over by Cheal Petroleum) that two production wells within the Cheal-A facility, had developed leakages, and were discharging fluids to the Urenui Formation at a depth of approximately 1,400 m below ground. ***"The discharge to the Urenui Formation was occurring due to integrity issues with casing patch seals within the wells."*** The casing patch seals were installed back in April 2007 and were *"not successful in fully isolating the wellbore, and leakage of power fluids subsequently developed"* (TRC 1133945, 2013). Losses through the Cheal-A4 well from June 2010 to October 2010 averaged 45 m^3 a day. An application seeking a change to the conditions of Resource Consent 4728-1 was granted on 14 December 2009, to allow for the discharge of fluids to the Urenui Formation, and provide *"a regulatory response to the reported well leakages."* Is this the kind of "regulatory response" we're looking for?

What is needed is a thorough investigation into the case to determine responsibility or more stringent regulation and testing to avoid future issues, and ensure more timely reporting and remediation should well casing failure occur.

Why are companies not liable for compensation for environmental damage and how would the latter be assessed/calculated?

5. Fracking the well

5.1 Environmental and health impacts of fracking chemicals

There are now many peer-reviewed studies that have illustrated the serious risks involved in fracking and the numerous pathways for water contamination to occur (Resource page of CJT website), some of which have already been explored in the PCE's interim report, 2012. However, many of these studies have pointed to the need for more detailed research, especially in the area of health impacts from exposure to fracking chemicals. **At present, not enough is known about some of the chemicals, or the cumulative and synergistic effects they may have on humans, animals and soil, or water quality (**Lloyd-Smith lecture, 2012**). Many of the chemicals have not even been assessed, and some have undisclosed constituents, making it impossible to assess or monitor**.

The PCE's interim report says *"some of these [fracking] chemicals may be toxic to humans or the environment"* and refers to an appendix 2 which is a generic list of components of fracking fluids. In fact, **many of the chemicals are known to be toxic to humans and the environment, some at concentrations near or below detection limits** (e.g. Glutaraldehyde, Ethylene glycol monobutyle ether, 2,2-dibromo-3-nitrilopropionamide). The more telling documents are the appendices provided in the TRC's hydrogeological assessment on fracking (2012) and the excerpts from the material safety data sheets of the fracturing products (2012).

We reiterate our concern re the **Hazardous Substances and New Organisms Act 1996 (HSNO)** which **is far from adequate in protecting the environment from fracking impacts**. The EPA admitted in April 2012 that the majority of fracking chemicals were self assessed by companies and approved under the group standard 'additives, process chemicals and raw materials' (CJT submission, Nov 2012; CJT presentation, Aug 2012). Neither EPA or the Department of Labour seemed to have much knowledge or control about the import, storage, usage and disposal of the chemicals.

Are the regional and district councils responsible for the implementation of the HSNO Act? Do councils have the technical capacity and resources to deal with this?

In terms of science and technology, many of the issues concerning fracking are similar to those for drilling (See Sections 2–4). But because of the high pressure and particular toxic chemicals involved, the risks are even greater. There are numerous pathways that may lead to groundwater contamination when fracking is involved (Mooney, 2011).

5.2 Seismic risks and monitoring

Fracking is known to induce microearthquakes, although the latter are not always recorded. The conclusion that *"there is no evidence that hydraulic fracturing activities in Taranaki between 2000 and 2011 have triggered, or have had any observable effect on, natural earthquake activity"* was because of *"limitations of the monitoring system"* (GNS report on the effects of fracking on seismicity, 2012). Another consideration is the relatively small number of frack jobs in that period, compared with future proposals. In the USA, seismic monitoring capabilities in many of the areas are not capable of detecting small earthquake activity and quakes of M<3 are not always documented (Ellsworth (2013). Yet small earthquakes have the potential to cause damage to well casings and associated infra-structure and create linkages between previously unconnected subsurface ground layers, such as fractured zones and aquifers.

In the US, van der Elst et al. (2013) demonstrated that, *"areas with suspected anthropogenic earthquakes are also more susceptible to earthquake-triggering from natural transient stresses generated by the seismic waves of large remote earthquakes. Enhanced triggering susceptibility suggests the presence of critically loaded faults and potentially high fluid pressures. Sensitivity to remote triggering is most clearly seen in sites with a long delay between the start of injection and the onset of seismicity and in regions that went on to host moderate magnitude earthquakes within 6 to 20 months. Triggering in induced seismic zones could therefore be an indicator that fluid injection has brought the fault system to a critical state."* (See also section 7.3.1.)

6. Flowback and transitioning into production

6.1 Combustion of returned frack fluids

The issues of flaring has already been introduced in section 2. Notably, two years before the dispersion modelling study (Backshall 2013), TRC had already allowed temporary flaring involving fracking, at Kapuni and Turangi. And in Feb 2012, TRC issued a consent for combustion of returned fracking fluids at Kowhai-B wellsite in Tikorangi (See section 3.1). Importantly, material safety data sheets of **many fracking chemicals state clearly that they are hazardous, carcinogenic, and when heated, may release toxic gases**. **Yet flaring of returned fracking fluids is allowed to occur just 300 m from homes.** Overseas, there are many cases of serious negative health effects to people and animals living close to gas wells (McKenzie et al. 2012; Bamberger, 2012).

6.2 Groundwater contamination and implications for consent conditions

TRC recently released a groundwater monitoring report at Greymouth Petroleum's Turangi-B wellsite (TRC 1073740, 2013) whereby samples were collected from within 1 km radius of the wellsite during 2011-2013. **Five zones from 3400m to 4100m depth at Turangi-B wellsite were fracked over six events from Nov 2011 to March 2012**. In total 2572m^3 of fracking fluid was pumped into the ground, of which 2047m^3 was recovered, and 372.1 tonne of proppant was pumped into the ground, only 3% of which returned to the surface. There are neighbouring homes within 300m from the wellsite. The report revealed **the presence of toluene (a constituent of BTEX) and elevated levels of chloride in groundwater samples from two of the closest monitoring wells**. **Council attributed this finding to *"general wellsite activities",* notably discharge of returned fracking fluids into the flare pit for combustion.** Although the levels detected are below that of NZ drinking standard, it is worth noting that EPA NZ classifies toluene as "acutely toxic", "suspected human reproductive or development toxicants", "harmful to human target organs or systems", "slightly harmful in the aquatic environment…" and "harmful to terrestrial vertebrates". It is a flammable liquid of high hazard.

According to the report, *"… when there were periods of low rainfall it was observed that clear groundwater had entering the skimmer pits. While it was theoretically possible that* ***contaminants from the site might have discharged into groundwater due to the permeable nature of the pit walls****, preliminary results of groundwater monitoring around the site showed in fact that no effects were detected."* Noticeably, inspection on 27 Feb 2012 reported, *"The flare pit contained a copper coloured liquid solution. The level of the solution had dropped over the past week, indicating that it had evaporated during the dry period, or had been pumped out or discharged to ground."* **Is this "copper coloured liquid solution" some of the returned frack fluid?**

We have a number of questions relating to the monitoring findings and their implications on regulatory/consenting procedures:

- Of the 2047m^3 of returned frack fluid, how much was burnt, 'pumped out', 'discharged to ground' or 'evaporated'?
- Does the company hold consents to discharge returned frack fluid 'to ground'? And how?
- Does the consent 7855-1 for "emission to air from other miscellaneous activities" cover both combustion and evaporation of returned frack fluid?
- Is the range of tested chemicals/parameters adequate, considering the varying compositions of the fracking and drilling chemicals involved, given that some of the constituents are dangerous in concentrations below detection limit and known to be eco-toxic. **Were radioactive substances including both tracers and NORMS tested for?**
- **Should there not be a consent condition to ensure that the walls of skimmer pits (and other waste storage pits) be impermeable to prevent water and soil contamination?** If there is, why is it not enforced?

- How can TRC be so sure that there are or will be "in fact" no effects in the longterm, when the monitoring was only conducted within 12 months from the first fracking event?
- Will groundwater monitoring at other fracked wells, especially those in the same area, follow the same protocol? We believe thorough groundwater monitoring should be conducted wherever water is being used for households and animals, to ensure that there's no impact from nearby fracked wells (See section 4.1).
- Is groundwater monitoring within 1 km radius from the well in question adequate?
- **Why is this distance (1 km radius from well) not used to define/identify affected parties during consent applications?**

6.3 Water abstraction

From fracking to production, a substantial amount of water is required. In some regions, this can be a significant issue as it contributes to competition with other water users and potentially affects water security and stream health.

How are water security and fair allocation being safeguarded?

During July 2011-June 2012, Todd Taranaki exceeded its water abstraction limit to take from Mangahewa Stream for the McKee production station on nine occasions, representing a repeated non-compliance, without any legal consequence (TRC 1143821, 2013).

This appears to be the norm in respect of regulatory breaches by the industry. If this is in fact the case, is it an example of regulatory capture by the industry?

Moreover, a new study on injection induced earthquakes (Ellsworth, 2013) pointed out, *"production may also release tectonic stress. The long-term pumping of groundwater may have induced the deadly M_w 5.1 earthquake in Lorca, Spain, on 11 May 2011."*

Does GNS, TRC or oil and gas companies really know enough to assure the public that the current and projected massive expansion of oil and gas extraction is safe, in terms of seismic risk and water security?

6.4 Gas venting, flaring disturbances and non-compliances

In the US, *"…venting appears to be common industry practice, and the latest estimates from EPA (2011b)… are that 85% of flowback gas from unconventional wells is vented and less than 15% flared or captured"* (Howarth et al. 2012). **What are the comparable figures for NZ—how much of the flowback gas is vented rather than flared or captured?** (See section 9 on climate change)

In Taranaki, flaring has caused a great deal of unease among local residents due to the obvious light and air pollution. In some cases, flaring has not been conducted according to consent conditions. **In 2012, Tag Oil was found to have been flaring at Cheal-A illegally for months**, citing "unable to export gas" in its gas flare report as the reason. In December 2012, Stratford District Council gave permission for Tag Oil to continue flaring and require them to pay a sum to offset "the increased intensification of land use by an industrial activity which is out of character with the character of the surrounding area." Indeed, the rapid intensification of the industry in Taranaki is changing fast, so fast that often companies successfully argue that a rural area is already becoming semi-industrial and a new well site would not change it significantly.

7. Handling the waste

During analysis of a recent (May 2013), routine groundwater (spring) monitoring sampling in the Onaero catchment, TRC detected the presence of barium above background levels, though below drinking water standard. Following soil sampling, TRC attributed it to *"possibly from historic drilling wastes disposal"* (Unauthorised incident register no. 13-603). We fully support further investigation to pinpoint the cause of the contamination. We are also eager to hear about the progress on Shell Todd's remediation and removal of contaminated soil from four Kapuni well sites. Assessment at the first site revealed about 300m^3 of contaminated soil, 50m^3 of which had to be taken to Wellington for 'stabilisation' before it'd be safely land filled (South Taranaki District Council, 7 August 2012).

7.1 Landfarming

7.1.1 In terms of science, there is not enough information to assure us that the practice is safe.

Little is known of the impacts that the practice may have on the environment, soil health, animal health and food safety, especially the **cumulative and synergistic effects** in the longterm. With the rapid expansion of the oil and gas industry, potential for negative ramifications is huge. Adverse impacts may become irreversible. Surely, a responsible regulator should take a precautionary approach, and not allow this to happen until safety can be proven. Yet it seems our government is allowing an uncontrolled experiment to manifest itself across our region.

TRC's own technical report (Oct 2011) – Land farming of drilling wastes: Impacts on soil biota within sandy soils in Taranaki (Year 1 of 3) – admitted that *"At present, there is a* ***paucity of information on "safe" concentrations and practices for land spreading in relation to soil ecosystems and biodiversity under different field conditions"*** and ***"there is a lack of information to inform local authorities' decisions regarding the granting of resource consents, the surrender of consents and the formulation of consents."*** The first year of the study did not reach any definitive conclusion.

Previous studies *"suggested that earthworm populations had been impacted upon by drilling waste application but that they were making a slow recovery."* **None of these studies investigated the potential effects on other invertebrates, wildlife, livestock or food products** derived from them, so there's no way of detecting any potential flow-on effects. **Fracking wastes were not included**. The chemicals involved in fracking are numerous, many have not been tested adequately, some are not even known because of trade secrets (See section 5.1).

On 19 June 2013, Fonterra announced it'd not receive milk from new landfarms, citing costs ($80,000 per year) for milk testing being an issue. This is good news to consumers, but what about the other landfarms where dry stock graze? Presumably, the animals will move onto other pastures and either produce milk or meat for consumers. Are these products tested specifically for chemical residues?

7.1.2 In terms of monitoring and regulatory processes, a great deal of improvement is needed.

NZ Ministry of Environment guidelines emphasize that monitoring information should include: *"the nature of the probable / possible contamination (petrol, diesel, petrochemicals etc.) including list of chemicals used on site"*.

Does TRC actually know all the chemicals being landfarmed?

Some fracking chemicals are proprietary. Of those with material safety data sheets, many are hazardous and/or carcinogenic, some at or below level of detection (See section 5 on Fracking the Well). How exactly are these monitored?

"Section 35 of the Resource Management Act sets out an obligation for 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," TRC report 322550 (2008). Yet TRC rely heavily on the companies themselves, or their hired consultants, to do much of the monitoring. Indeed, TRC compliance monitoring programmes on oil and gas operations rely largely on visual inspections, few (often single) samples and company data.

Is this appropriate in respect of independence of the monitoring regime? Why doesn't TRC conduct all the monitoring? If it is too costly, as was indicated by Fonterra who did seek to undertake independent tests, then one would expect that TRC would charge a fee to the companies to cover TRC's monitoring costs, rather than relying on the companies to monitor their own performance.

Often company data are not provided in full. Unauthorized incidences and breaches of consent conditions are common. In some cases, council lowered or removed the conditions altogether after companies failed to comply. Note most discharge consents are valid for well over a decade, often with multiple revisions offering change in conditions.

7.1.2.1 Geary, Schrider and Spence Road (Kakaramea) Landfarms

TRC's monitoring program (2005-06) of the Geary Road landfarm, Manutahi, was based on 12 inspections, 2 soil samples (collected by TRC) and data provided by the consent holder (TRC report 169501). The inspector commented on 10 Nov 2005, "***Recent spreading had taken place near the new pits. Stock were grazing the new areas- G32 and G33***". On 13 Feb 2006, the inspector reported, *"Areas G30 to G34 had been grassed and were being grazed by heifers. A drilling rig was onsite at Kauri E."* Analyses of many disposal areas, including some where stock were grazing, showed that **further degradation of TPH (total petroleum hydrocarbons) was required**. For reasons unknown, analytical results concerning levels of highly toxic hydrocarbons (e.g. BTEX and Naphthalene), and metals (e.g. arsenic and cadmium), were not presented in the report.

Likewise, a 2011 report on the Geary, Schrider and Spence Road (Kakaramea) landfarms said, "***Most disposal areas comply with the limits specified in the consent but not all areas have been tested for all parameters***." Why not? Nitrogen loading for three disposal areas exceeded the consent limit. On 4 February 2010, the chloride loading limit was removed from the consent. To quote from the above report: *"No chloride results were provided for the H65 and H62 wastes which were landfarmed prior to the consent change.* ***The three disposals for which nitrogen results were provided all exceeded the loading limit. Previous monitoring at landfarming sites has shown that loading limits were seldom complied with.*** *In coastal locations, adverse effects on groundwater due to leaching of chloride and nitrogen are expected to be minimal. The* ***Council allowed landfarm operators at such sites to vary their consent conditions****, but has implemented a programme of biological soil monitoring to determine the effects of high loadings (particularly chloride) on soil health."*

So is TRC effectively saying that excessive chloride and nitrogen are ok to be leached into coastal environments?

How will excess nitrogen affect coastal ecosystems, marine life and kaimoana?

Excess nitrogen loading presumably would have resulted from heavy application of fertilisers to enhance grass growth. Nitrogen is a well known water pollutant and greenhouse gas (NO_2). Strict limits on fertiliser use to avoid excess nitrogen should be applied.

What about other chemicals that were not tested for? Are they ok to be leached into coastal environments?

7.1.2.2 BTW Brown Road (Waitara) Landfarm

BTW's Brown Road (Waitara) landfarm, TRC report 987702w, March 2012 (replaced by a 1141122 "corrected version" in Jan 2013) said, *"Concentrations of contaminants in the surface soil meet the required consent conditions, with the **exception of hydrocarbons** for recent disposals. Further monitoring of the site will ensure that any consent limits exceeded, are complied with prior to surrender…."* Note discharge consents 6867-1 and 7670-1 do not expire till 2020 and 2027 respectively.

Yet inspection on 20 August 2010 reported, "*Grass regrowth for the recent application area looked well established, and bulls were grazing the pasture…."*

So it seems cattle may be grazing onsite before consent limits comply, when hydrocarbon concentrations are above limits?

BTW company annual report (Appendix II of the above TRC report 987702w) had a Table 1: Stockpiling and landfarming records which stated that **384m^3 of "Frac" waste was spread** on 9 July 2010. In Table 1, under the heading 'Treatment applied': *"The facture water was landfarmed after being stockpiled for a minimum of two months. Over this time the water was diluted by stormwater and subject to UV treatment by sunlight. Fracture water was not tested upon arrival to the site. Prior to landfarming, testing concluded the water was appropriate for landfarm."*

Importantly, pre-disposal results in Appendix III from a Nov 2010 report 778400 revealed the presence of **Gluteraldehyde in "Frac water" pits** A and E. There were no testing results of other contaminants such as heavy metal, BTEX, total hydrocarbons or PAH listed. Gluteraldehyde is highly toxic and is dangerous at concentrations at or below chemical detection limits. If released to soil, it may metabolise and is expected to leach to groundwater.

In June 2013, two abatement notices were issued to BTW for not operating within resource consent conditions. ***"The inspection found that a perforated drainage pipe had been uncovered which originated from the area where drilling wastes had been stored and spread. The discharge flowed overland and into/onto the beach, beyond the boundary of the site.*** *Samples and photographs were taken. The results of the samples found that **very low levels of benzene (below drinking water standard) were present** in the discharge at the site boundary. The resource consent for the site states that no elevation of background levels are allowed"* (UIR no.13-606 in TRC consents regulatory meeting, 23 July 2013).

There seems to be few disincentives to deter breaches of consent conditions. The company received an infringement notice of $750. TRC recommended *"no further action at this stage / costs recovered*". Is this adequate, considering the obvious consent breaches and that it has likely been occurring for months, as documented by a number of local residents?

7.1.3 Are TRC's landfarm monitoring programmes statistically rigorous and independent?

Given the highly toxic nature of some chemicals involved, and the fact that landfarms, through grazing, effectively become part of the food chain, it is crucial that monitoring is rigorous. Yet there is no mention of pilot studies for chemical testing in any of the soil chemical monitoring reports. These determine the number of samples necessary to detect a specific 'environmental effect'. TRC refer to NZ Ministry of Environment guidelines which highlight importance of 'analytical precision and accuracy'. But no statistical analyses of precision or accuracy are provided by TRC. Indeed there are no estimates of soil sample variance at all. These are necessary to assess statistical power, a crucial aspect of rigorous monitoring. Without them, there is no way of knowing whether sampling was adequate.

Again from a statistical perspective, it is typical that multiple 'replicate' samples are taken, to get a mathematical estimate of the variation around the mean (average) result. This variation is typically expressed as a 'standard error' or 'standard deviation' around the mean or average value of the replicate samples.

In some cases TRC results are based on one 'composite' soil sample from one transect across a large paddock spread with drilling wastes. In the few cases where results are graphically presented, no variance estimates (error bars) around the mean values are displayed. Although the raw data (from which such estimates could be obtained if replicate samples were taken) are meant to be in report appendices, in many reports the relevant appendices are not included. So there is no way of checking.

Generally it should be possible, based on information provided in a report, for an independent researcher to repeat and validate the study. This is not the case in many of the TRC monitoring programmes.

As introduced in section 7.1.2 above, the RMA section 35 obliges TRC to monitor effects of resource consents, yet TRC relies on the companies exercising to provide data, effectively allowing the companies to monitor themselves.

In many cases, the companies do not even provide the required data, as illustrated in many examples herein. Is it a suitable standard of independence between regulator and industry?

7.1.4 Lack of consistency in inter-annual monitoring

In at least one case—the Greymouth Hawera landfarm (part of an experimental farm owned by Fonterra) in close proximity to the regionally significant Nowell Lakes—TRC did not follow their own recommendations from one year's monitoring report to the next. In the 2005-2006 monitoring report, *"It is now proposed that for 2006-2007, **soil samples be taken 8 times during the monitoring year**. This is to take account of the fact that a number of wastes have now been applied at the site and require on-going monitoring as well as monitoring of any new wastes applied during the year. A recommendation to this effect is attached to this report".*

Yet the 2006-2007 monitoring included just 5 inspections and **2 soil samples**. There were new disposals from Moturoa 5, Ngatoro 13, Goldie 2 and Moturoa 6. During that period, there were **nine non-compliances**, many of which related to inadequate sampling or results not supplied, ***"Greymouth failed to provide any results of post disposal sampling to demonstrate compliance with consent conditions. These results are also a requirement of the Compliance Monitoring Programme and the Site Management Plan."***

"Few comments can be made about the environmental effects of the operation due to the lack of receiving environment monitoring conducted by the Company. The two disposal areas sampled by the Council complied

with the consent for the parameters analysed. Exceedances of loading limits for chloride and nitrogen indicate that future disposals may need to be applied over a larger area to comply. ***No sampling of groundwater was carried out to assess effects****."*

Yet the 2006-07 report recommended, *"THAT monitoring of treatment areas at the Greymouth landfarm in the 2007-2008 year continue at the same level as in 2006-2007".*

What happened to the 8 times per year soil sampling recommended in the 2005-06 report?

The2009-2010 monitoring period did include 8 soil samples, one water sample and four inspections. And the 2010-2011 monitoring period included just one soil sample, one water sample and three inspections. Disposal appeared to have ceased since 2009. On 23 June 2011, the inspector commented, *"The Moturoa 6#2 area still had very little pasture. The Moturoa 5C/Ngatoro 3/Goldie 7 area was covered by broom. Pasture in other areas appeared poor-average, with erosion damage by stock visible in places."* The 2011-2012 monitoring included *"two inspections, data review and on-going liaison with the Company"*.

Establishment of permanent pasture over part of the site remains an issue. *"While not a breach of consent conditions, the permanent establishment of pasture is an expected outcome of landfarming activities…"* (2011-2012 monitoring report). It is apparent, at least in this case, that landfarming does not always achieve the desirable outcome.

7.2 Mix-Bury-Cover (MBC)

TRC's mix-bury-cover monitoring program report (2010) listed 55 consents for MBC held by 12 companies, although not all consents have been exercised. *"It is unclear whether some of the older consents in Table 4 which have been renewed (-2 suffix) were originally exercised or not,* ***in some cases sumps containing drilling waste may remain buried on site****."*

If council doesn't know whether the consents had been exercised, who does?

Is TRC's monitoring and regulatory regime adequate?

Where is the safety assurance for people who may be using or purchasing this potentially contaminated land for food production?

TRC's 2012 significant activities report lists 9 deepwell injection operations (17 consents) and 29 drilling waste operations (63 consents) including 20 MBC and 2 stockpiling sites which had 'tailored compliance monitoring programmes' in 2011/2012 (Appendix III). **Were the other sites monitored and if so, what kind of monitoring was conducted?**

TRC's miscellaneous mix-bury-cover monitoring programme triennial report (2008) assessed the performance of ten companies in their MBC operations. During that period, TRC conducted 28 site inspections and collected 24 soil samples from 9 MBC areas. **The report revealed a nitrogen loading of 1,120 kg at Tag Oil's Cheal-B MBC site which exceeded the consent limit. The failure to provide pre-disposal analyses and discharge records was also non-compliant. Yet Tag Oil was granted a "good" rating** for its performance and compliance.

An inspection commented, *"A soil sample was collected from the MBC area, which had been reinstated, it had good pasture cover and was* ***back in grazing****"* (TRC doc 350614, 2008).

Again, **it seems animals were grazing before consent conditions had been met. Does such grazing comply with consent conditions? Is this safe?**

Below are some more excerpts from the same report, but regarding Bridge (now taken over by Greymouth) which obtained an *"improvement is desirable"* performance and compliance rating. *"An evaluation of performance for consent 6641 (Richmond-1) is not possible. A well was drilled at the site in 2005 and muds were disposed of via MBC.* ***The location of the disposal area cannot be accurately determined following reinstatement works. The MBC operation was not inspected by the Council and despite requests by the Council, the Company has failed to provide any information relating to the disposal."***

Inspector's comment at Hursthouse MBC site: *"21 June 2007 - The landowner was not happy with reinstatement of the site. The weather was very wet at the time MBC was carried out in the sump. Mud was mixed with soil, then cover was applied but when compacted the mud came to the surface up the sides of the sump. This mud was spread out on the southern side of the sump. A soil sample was collected from this area and* ***mud was evident a few inches below the surface****."* So drilling mud is not always buried 1m below ground as claimed by Fonterra (Radio NZ, 9 July 2013).

On 3 June 2008, the inspector commented, ***"the site was inspected and was in use as a feed pad.*** *The site was metalled, making it too difficult to collect a representative soil sample from the MBC area."*

How can an assurance be given that the area is safe for grazing when no representative soil samples had been tested (See 7.1.3)? No analytical results provided to council or additional monitoring were included in the report. Why not?

7.3 Deep Well Injection (DWI)

7.3.1 Seismic hazards

While fracking is known to routinely cause microearthquakes, wastewater disposal by DWI poses a higher risk because this practice can induce larger earthquakes. *"Several of the largest earthquakes in the U.S. midcontinent in 2011 and 2012 may have been triggered by nearby disposal wells. The largest of these was a magnitude 5.6 event in central Oklahoma that destroyed 14 homes and injured two people. The mechanism responsible for inducing these events appears to be the well-understood process of weakening a preexisting fault by elevating the fluid pressure. …* ***Injection-induced earthquakes, such as those that struck in 2011, clearly contribute to the seismic hazard****"* (Ellsworth, 2013). Of sites that dispose of very large volumes of water, the Paradox Valley in southwestern Colorado illustrates well, *"how long-term, high-volume injection can lead to the continued expansion of the seismically activated region and the triggering of large-magnitude events many kilometres from the injection well more than 15 years after observation of the initial seismic response" and " the challenges for managing the risk once seismicity has been induced."* (See also section 5.2)

Ellsworth (2013) also pointed out that **current regulatory frameworks were designed to protect drinking water from contamination, not address seismic safety**. *"One consequence is that both the quantity and timeliness of information on injection volumes and pressures reported to regulatory agencies are far from ideal for managing earthquake risk from injection activities. In addition, seismic monitoring capabilities in many of the areas in which wastewater injection activities have increased are not capable of detecting small earthquake activity that may presage larger seismic events … One approach for managing the risk of injection-induced earthquakes involves setting seismic activity thresholds that prompt a reduction in injection rate or pressure or, if seismic activity increases, further suspension of injection. Such "traffic-light" systems*

have been used selectively [in the US], going back to … 1966…" (Ellsworth, 2013). **These points are all relevant to NZ.**

We strongly recommend that the PCE investigation carefully consider the short and long-term risks of injection-induced seismic hazards.

7.3.2 Well integrity issues

Regarding well integrity, Lustgarten (2012) noted (in the US) that *"review of well records, case histories, and government summaries... (from) more than 220,000 well inspections... found that structural failures inside injection wells are routine"* and that *"from late 2007 to late 2010"* there was ***"one well integrity violation... issued for every six deep injection wells examined*** *- more than 17,000 violations nationally ... more than 7,000 wells showed signs that their walls were leaking".*

The 2013 GNS review on DWI authored by Zemansky recognised that the Department of Labour 1999 regulations is *"passive"* and in essence, *"calls for self-regulation".* Notably, the **regulations *"do not cover all important aspects of well integrity****… there are no requirements for mechanical integrity testing or submittal and review of plans such as an 'Injection Operation Management Plan.'"* This is of great concern given that *"purpose-built disposal wells are constructed to meet lower engineering specifications than exploration and production wells"* (TRC 158502, 2006).

The above significant concern is further compounded by the fact that *"Cements commonly used in Taranaki wells to isolate zones are Portland based (Class-G or Class-A).* ***These cement types are not resistant to carbonation****. While zonal isolation in many existing disposal wells has been achieved with Class-G or Class-A Portland based cement, the Taranaki Regional Council requires the use of acid resistant cement (ie. Thermalock, POZMIX, or LATEX 2000) in any new disposal wells,"* TRC monitoring report on Todd Taranaki's DWI programme (2010). Has this requirement been followed through? In any case, **most active DWI operations are taking place in old wells, presumably with non-acid-resistant cement casing.**

What measures are there to safeguard the integrity and zonal isolation of these old wells? Is there a national standard that companies must comply with?

7.3.3 In Taranaki, regulation and monitoring re DWI is far from adequate.

The 2013 GNS review on DWI revealed that in 2005, TRC staff prepared a paper with discussions and guidelines for DWI, with reference to USEPA requirements including those for Class I (hazardous waste disposal wells), with the intension *"to ensure that TRC requirements were more stringent than those in the US for Class II wells applicable for injection of fluids associated with oil and gas production".* These requirements include the information required from companies applying for consents, such as the **maximum volume of materials to be disposed of over the lifetime of the well** and the ***"modelled radius of influence of the contaminant plume"*** expected. Yet few of these guidelines have been implemented in the many DWI consents issued or modified since 2005.

There is little evidence that companies have clear expectation of the maximum volume of materials to be disposed of (per day or over the lifetime), as seen in the numerous change of consent conditions at many sites. An example is the case of Todd Taranaki's DWI programme, consent TRK965052-1 originally granted in

1996 to Fletcher Challenge Energy Taranaki to discharge up to 750 m^3/day of water and/or produced water by DWI into the McKee Formation via two wells at the McKee-B wellsite. This was changed in 1999 to allow an increase of discharge volume to 3200 m^3/day. The consent was altered again in 2000 for discharge of up to 3000 m^3/day of produced water via McKee-4. Then following the transfer of the consent to STOS in 2002 and to Todd Taranaki in 2006, the consent (now 5052) was further altered in 2007 ***"to allow for the discharge of waste drilling and fraccing fluids … in addition to 3000 cubic meters per day via the McKee-4 well at the McKee-B wellsite."*** From July 2007 to June 2009, 218,629 m^3 of waste was discharged into McKee-4 well via DWI (TRC report 800543, 2010). A subsequent monitoring report (2013) revealed that **McKee-4 well was perforated between 798 metres true vertical depth sub-sea (TVDSS) and 970 m TVDSS for injection**. This depth was not reported in the 2010 report and at less than 1km deep, is much shallower and closer to freshwater aquifers than industry typically acknowledges.

Similarly, consent TRK924182 was initially held by Petrocorp to "*discharge up to 1021 m^3/day of produced water and treated stream water by DWI into McKee Formation for reservoir water-flooding purposes*". It was revised in 1999 to allow a maximum injection volume of 4000 m^3/day. The latest version (consent 4182-2) granted in 2009 allows Todd Taranaki to "*discharge waste drilling fluids, fraccing fluids, water, produced water, storm water and production sludges … at the McKee-A wellsite."* It appears this consent (also 3895) now sets "**no limits for daily discharge volumes or injection pressures**" (TRC report 1108053, 2013). Consent 3895 covered in the same report, originally specified Tuhua-5 as the disposal well, now allows for **discharge at any well** drilled on that wellsite, despite known errors in recording during the monitoring period, and the opportunity to review the consent in June 2009. TRC concluded, *"the consent conditions were adequate to deal with the potential adverse effects of the activity".*

But how is it possible to regulate or monitor effectively if the disposal well is not even specified?

7.3.4 How can the regulator be sure that there have not been any impacts on groundwater quality when groundwater monitoring has not been implemented?

TRC's own report on Swift Energy's DWI programme (TRC 158502, 2006) said, *"...in order to show whether or not the discharge has adversely affected a freshwater aquifer, the aquifer itself should be tested. A potentially suitable site would be a deep bore that taps a freshwater aquifer that directly overlies the discharge plume in the injection zone."* **No aquifer was tested because *"there are no such sites at this time"*, despite the fact that much higher maximum injection pressures and concentration of contaminants in the injectate were involved than originally applied for in the consent, and *"hydro-fracturing of the injection zone is likely to have occurred"*.** Over the three year period, 671,013 m^3 of waste material was discharged via Waihapa-7A well. Disposal at this well has continued since, with **Origin now holding the revised consent (4094) which allows a higher maximum injection pressure (85 bars), sufficient to initiate hydro-fracturing of the injection zone** (TRC 158502, 2006; TRC 1114242, 2013). From Oct 2010-June 2012, 86,932 m^3 was injected via Waihapa-7A well into a saline aquifer in the Matemateaonga Formation, at 1126-1176 m below ground. A **spike in injection pressure of 89 bar** was reached for *"less than 15 seconds"* on 3 August 2011, exceeding the specified limit. Interestingly, the 2013 report noted the freshwater-saline water interface at 809 m TVD whereas the **2006 report noted freshwater at 1029 m at Waihapa, less than 100 m above the injection zone**. Nonetheless, no groundwater testing was conducted to check for potential contamination in the overlying freshwater aquifer.

In fact, with the exception of Cheal Petroleum (Tag Oil)'s DWI programme (2009-2012), **none of the recent DWI monitoring reports we have reviewed indicated that groundwater monitoring had been implemented**. The typical section of these reports read like this: *"The monitoring programme also included an option to sample up to three water bores in the vicinity of any active disposal wells(s), or to install a monitoring well specifically for this purpose, where there were any concerns relating to the integrity of the injection well, injection zone or confining geological formations. … The groundwater monitoring provision of the programme was not implemented during the period under review as analysis of injection and well operation data did not indicate any potential injection well or geological integrity issues."* (TRC 717351, 2010 on Cheal; TRC 1119464, 2013 on Greymouth; TRC 1114242, 2013 on Origin; TRC 1108053, 2013 and TRC 800543, 2010 on Todd Taranaki).

Shell Todd's DWI monitoring at Kapuni did not include groundwater testing either. Its latest report (TRC 1126526, 2013) said, *"The conditions attached to consent 1336-3 prohibit any form of groundwater contamination as a result of DWI activities. Compliance with this key consent condition is difficult to assess as there are no sites to directly monitor deep freshwater aquifers in the area of any of the Company's disposal wells.* ***Compliance with this condition was assessed indirectly, based on the well discharge and formation characterisation data provided by the Company and the Council's complaints register****..."*

7.3.5 Non-compliances in DWI operations

Companies do not always submit complete or timely injection data and reports. The latest DWI monitoring reports on Cheal Petroleum (TRC 1133945, 2013), Greymouth (TRC 1119464, 2013) and Todd Taranaki (TRC 1108053, 2013) all revealed non-compliances in this regard.

Of the above operations, Cheal is perhaps the most concerning, in part due to the intensity of exploration, production and disposal, all in a small area. Report TRC 717351, 2010 indicated that TRC did not even have a clear understanding of the injection depth, *"some discrepancies have occurred regarding the true depth of the receiving formation. … Council needed to know more precisely the depth of the injection interval. It was recommended then that a formal application for a change of condition/purpose was submitted which was subsequently made and later approved…"* Yet, **two producing wells on site had been *"loosing[sic.] power fluids into deep formations"* since 2007, due to *"suspected integrity issues with casing patches",* yet TRC was only informed of this in September 2009** (TRC 717351, 2010). Still, no groundwater was tested during that monitoring period.

Furthermore, in the subsequent monitoring period, TRC had to enter **two unauthorised incidents** against the company for consent non-compliances (TRC 1133945, 2013): *"The first noncompliance issue identified related to the submission of incomplete injection records and the late submission of an "Injection Well Operation Management Plan," and annual written reports. … An additional incident was also entered when it was discovered that the consent holder had continued to operate under the conditions of consent 4728-1, following the granting of revised consent 4728-2, on 25 May 2012."* **So for nearly a whole year, Cheal Petroleum (Tag Oil) was discharging drilling mud wastes, waste drill water and produced water when it was consented to inject only saline groundwater. Yet within weeks from the issuance of the abatement notices, TRC granted the company several new consents for discharge to land, water and air, at Cheal-E wellsite.**

Such a regulatory and monitoring regime can hardly be considered adequate. The whole resource consenting process would appear futile if new consents are routinely issued to meet companies' requests, disregarding their previous non-compliances and poor performance.

If councils are not performing as regulators, then the likelihood of another Pike River type disaster is inevitable, with no blame or consequence on anyone through the system from councils to the ministries, yet the workers and environment suffer. This is not acceptable.

7.3.6 Designation of 'Area of Review'

TRC recently commissioned GNS Science to conduct a review on the regulation on DWI under the RMA (Zemansky, 2013). According to the report, *"most of the regulatory requirements of agencies in North America pertinent to the DWI discharge are already incorporated in proposed TRC consent conditions"* as are some well integrity requirements. But the review only examined the DWI consent application for Greymouth Petroleum's Turangi-A wellsite, not any of the others mentioned above. There's also no mention of the many non-compliances reported or consideration re injection-induced earthquakes.

However, the review did offer a few important recommendations, notably the **designation of an *"Area of Review (AoR) when assessing applications for proposed injection wells"*. The AoR in the US and Canada is 1.6 km radius from the bottom-hole location of the injection well.** Currently in Taranaki, some DWI wells are located much closer to homes than 1.6 km, posing risks to landowners, occupiers and their water resources.

We strongly recommend an AoR be incorporated into NZ's resource consenting process, with appropriate designation of affected parties and notification of consents.

7.4 Other waste disposal

In addition to landfarms and MBC sites, there are **numerous other sites where discharge consents have been issued for drilling wastes to be introduced into the environment**; emissions to air, discharges on/into land, on land in the vicinity of rivers or directly into tributaries and streams (See TRC non-notified consents issued each quarter/month). Basically, every wellsite (with its multiple wells) has a suite of discharge consents (to air, land and water) associated with it. E.g. Origin Energy holds 36 discharge consents for its wellsites associated with the Rimu Production Station in Mokoia alone.

Are TRC's current monitoring programmes robust and independent enough to detect environmental effects from the discharge of treated and untreated produced water, stormwater and surplus drill water on stream health?

8. Well Abandonment

The issues of abandoned wells and their degradation over time and risks to the surrounding environments are huge, though not much talked about. According to a GNS study on geothermal energy(Reyes, 2007), there were 349 abandoned onshore oil and gas wells in NZ then, 140 were in Taranaki. The study revealed,

*"**Abandoned wells are plugged. In most cases liners are not installed or are pulled out upon abandonment. Hence cave-ins may occur in some older wells. Permeability is apparently present in most of the wells** as indicated by the discharge of water from some wells; however the water level in the wells is unknown. In Taranaki, there is a widespread zone of over pressuring with respect to the hydrostatic gradient at >3000m (King and Thrasher, 1996) indicating that these wells may be artesian (Figure 10) and hence will flow without the need for downhole heat pumps."*

Critically, ***"Inadequate sealing of a well could potentially result in subsurface pathways for contaminant migration leading to groundwater pollution, and potentially surface water pollution**. Experience in the US to date is that the risks posed by poorly controlled and logged historical wells far outweigh the risks posed by wells designed and constructed to current standards. … **The chemical constituents of hydraulic fracturing fluids remain an area of uncertainty pending the development of a more extensive database of behaviour of fluids in shale formations over time."*** (AEA report to the European Commission DG Environment, 2012). Studies in the USA re deep well injection have shown that water contamination had resulted when *"injected brines travelled up... improperly... abandoned wells in the vicinity of the injection wells and entered drinking water through cracks in these old wells"* (Hembra et al. 1989 in Zemansky, 2013). Often, the contamination was **not discovered *"until water supplies became too salty to drink or crops were ruined."***

With the rapid increase in oil and gas exploration activities across many regions of the country, the number of abandoned wells, many with permeability issues, would have greatly increased in recent years. The PCE's interim report gave examples of nine wells in Moturoa alone, as having 'siginificant risk' of hydrocarbon leakages. The report raised the important issues of *"costs and responsibility for closing down the well, cleaning up the well site, and providing for its future safe maintenance".*

What exactly is in place currently to ensure safe maintenance of abandoned well sites once companies have completed production and abandoned the wells?

Are all historical wells carefully logged with detailed information relevant to their integrity and maintenance?

Is such information readily available and considered by drilling companies and councils responsible for assessing resource consents?

9. Climate Change

"Global warming isn't a prediction. It is happening. The evidence for human-made climate change is overwhelming," Dr James Hansen at Columbia University Earth Institute, the world's leading climatologist. In fact all credible, international agencies from the British Royal Society to the American Association for the Advancement of Science, Intergovernmental Panel on Climate Change, International Energy Agency and the World Bank have agreed that the world is experiencing unprecedented rates of climate change, driven by the burning of fossil fuels, and that actions must be taken now to avoid catastrophic impacts on societies.

The PCE's statement of intent (2011-2014) stated, *"climate change is the most important environmental issue facing the world and will remain an area where the office will be active. Connections to climate change policies will continue to feature in reports and advice."* Her interim report on fracking (2012) concluded, *"when it comes to the interaction between fracking and the biggest environmental challenge of all – climate change – it is not possible to reach any firm conclusions,"* but did not recommend further investigation into

this subject. This is at odds with the scale of the challenge and her priority of work. CJT hereby reiterate our grave concerns over the looming threat of climate change to humanity and the social injustice it is causing (CJT submission to PCE, Nov 2012).

We strongly urge that the PCE examines the climate change impact from escalating oil and gas extraction enabled by fracking in NZ, and provides concrete policy guidance on this matter.

Numerous studies and authorities have already concluded that natural gas is not a clean fuel or transition energy source. Rather, it is a *"gangplank to more warming and away from clean energy investments"*, as described by Dr Anthony Ingraffea, an engineer who was influential in developing the technology of fracking. As is well known, methane is a far more powerful greenhouse gas than carbon dioxide, *"…over a 20-year period, one pound of it traps as much heat as at least 72 pounds of carbon dioxide. Its potency declines, but even after a century, it is at least 25 times as powerful as carbon dioxide,"* Ingraffea (2013).

Substantial methane venting occurs during well completion and flowback (See section 6.4) and fugitive methane from leakages is widespread. A 2011 study by researchers at the National Center for Atmospheric Research (NCAR) concluded, ***"unless leakage rates for new methane can be kept below 2%, substituting gas for coal is not an effective means for reducing the magnitude of future climate change"*** (Wigley, 2011). Yet several studies have revealed much higher leakage rates, including two Cornell University studies Howarth et al. 2011 and 2012, and a 2013 NOAA study in Utah which revealed *"losses of up to 9% … nearly double the cumulative loss rates estimated from industry data"* (Tollefson in *Nature*, Jan 2013).

"Using all available information and the latest climate science, we conclude that for most uses, the GHG footprint of shale gas is greater than that of other fossil fuels on time scales of up to 100 years. When used to generate electricity, the shale-gas footprint is still significantly greater than that of coal at decadal time scales but is less at the century scale. … shale gas is not a suitable bridge fuel for the 21st Century. …the decadal scale is critical, given the urgent need to avoid climate-system tipping points" Howarth et al. (2012).

To date there is no study in New Zealand on fugitive (vented or leaked) methane from the oil and gas industry, without which there is no ground for arguing that expansion of the gas industry here is a transition to a low-carbon future.

10. Conclusions and Recommendations

There is inadequate scientific evidence and technical capacity to ensure safety at all stages of oil and gas production involving fracking; from site identification to production, waste disposal and post well abandonment. The associated risks—elevated seismic hazards, water contamination, soil degradation, air pollution, contamination of food chain and health impacts on nearby residents—are far too great to justify further expansion of the oil and gas industry involving fracking across NZ.

A responsible regulator should take the precautionary approach, and not allow this to happen until safety can be ensured. Yet it seems our government is allowing an uncontrolled experiment to manifest itself across our region. It's a mockery of the precautionary principle when companies, and often the government, ask concerned groups and individuals to prove that harm has been made before they'd stop their risky practices!

The current regulatory regime of the oil and gas industry in NZ, and in particular Taranaki, cannot guarantee industry best practice, robust and objective monitoring, transparent compliance checks or effective response and remediation should incidents occur.

All credible, international agencies and climatologists have agreed that to avoid catastrophic impacts from climate change, actions must now be taken to reduce greenhouse gas emission by substantially reducing fossil fuel use. The PCE herself has said, *"climate change is the most important environmental issue facing the world."* Globally known fossil fuel reserves already account for much more than can safely be used, if catastrophic climate change impacts are to be avoided (McKibben,2012; Do the Math, 2012). CJT is gravely concerned about the looming threat of climate change to humanity, the social injustice it is causing and the urgent need to transition onto clean renewable energy sources. Every year that we continue with business as usual makes this transition more unlikely to succeed.

Based on the above, we urge the PCE to consider the following:

- An outright ban on fracking in NZ.
- If a ban is not possible, a moratorium on fracking in NZ until all of the following can be achieved:
  vii. In-depth research into seismicity and fracking in order to identify high hazard areas where fracking and deep well injection of drilling and fracking waste must be banned.
  viii. Development and implementation of a "traffic-light" system for managing the risk of injection-induced earthquakes, involving research and deployment of adequate instruments.
  ix. A ban on disposal of drilling and fracking wastes on farms.
  x. Obligatory accounting and minimisation of fugitive methane.
  xi. Strengthening (not 'streamlining') the current regulatory regime relating to fracking, to ensure safety, environmental protection, rights of landowners and potential affected parties, and adequate resources for disaster management, remediation and compensation. Focus on the CMA, HSNO, RMA and resource consenting processes.
  xii. Strengthening the current monitoring regime relating to fracking at the regional level, to ensure adequate science, independency of data, transparent reporting and objective assessment.
- Advise and support the government in developing an effective energy transition strategy incorporating energy efficiencies, clean renewable energy sources, public transport systems and sustainable agriculture that do not rely heavily on fossil fuels.

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