Investigation into the remediation of the contaminated site at Mapua

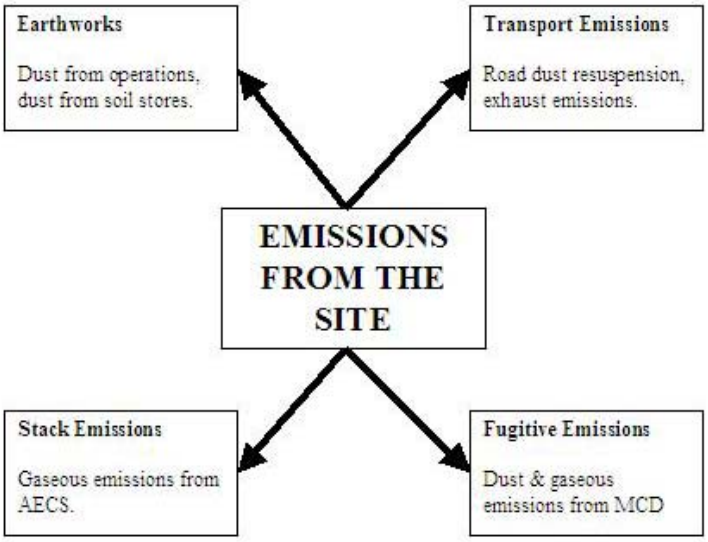
Air technical annex

Contents

Discharges to air

The clean up of the Mapua site resulted in emissions to air of dust and gases from earthworks and soil screening operations on the site and from the operation of the MCD plant. These emissions had a number of sources, including remediated and unremediated soil on the site, the EDL plant stack, fugitive emissions from the plant, and emissions from transport, see Figure 1.

Figure 1: A schematic diagram of the potential atmospheric emissions from the operation.



The resource consents granted for the clean up of the FCC site included a consent for the discharge of contaminants to air (RM030523). The consents contained a number of conditions, including limits on emissions, and controls on the plant and site activities to reduce emissions. The consents also required monitoring of the emissions from the site and monitoring of the stack emissions.

The atmospheric emissions *per se*, and the measurement and monitoring of them is crucial to be able to assess whether:

- the resource consents themselves have been breached
- the Total Hazard Index (THI, the system designed to assess the potential ill effects of the emissions on people), which depends on these measurements, has produced correct results.

Accordingly, the potential emission routes shown in Figure 1 seem a useful way to analyse the emissions from the site. After which the THI itself, as well as other cognate issues will be dealt with. The emissions from transport will not be covered in this report.

Rather than document what seem to have been numerous apparent breaches of the various consent conditions through the life of the project, this annex will deal with only those issues that seem to be the most serious.

Dust and particulates from site operations

The dust and particulate emissions include not only the particles *per se*, but also the contaminants in the particles or adsorbed onto them. Fugitive emissions from the drier will be considered in this section.

The resource consent specifies (condition 19) that dust (among other things) which is "offensive, objectionable…" must not be discharged beyond the site boundaries, and specifies (condition 20) best practicable options to "minimise" discharges of dust from the site.[1] The Remedial Action Plan does not necessarily specify what actions should be carried out but, more importantly, *how* those actions should be carried out (in terms of the management plans) to remain within the boundaries of the conditions of the resource consents. Within the resource consent conditions and in the Remedial Action Plan, operations that could reasonably be predicted to be dust generators were identified, and appropriate mitigation methods planned, such as covering inactive stockpiles, watering by water cart, control of transport movements. Employing a mix of mitigation methods according to prevailing conditions is recognised as the most effective way of minimizing dust emissions. It would not have been possible to stop dust leaving the site. Site management did deploy a range of the techniques to minimise dust, as outlined in the Remedial Action Plan.

Nonetheless, many complaints were made about dust during the works, both the amount of dust outside and in houses, onset of medical symptoms after prolonged dust episodes,[2] and the (perceived) lack of mitigation methods deployed during the very frequent dust episodes. According to PRP minutes[3] "…work stopped when the wind reaches 15 knots…". This would mean anything more than a "moderate breeze"[4] would have stopped work – this seems inconsistent with the accounts of residents.[5]

For dust mitigation methods to be as effective as possible, the management on the ground needs to be not only sensitive to changing conditions, but also able to respond with the deployment of mitigation methods appropriate to conditions, and (if necessary) to vary the rate of work to minimise dust production. Site management on the ground may have had limited room for manoeuvre to reduce the rate of work. It is also likely that the dust monitoring was compromised, not giving site management the full picture

Dust generation is generally proportional to the rate of excavation (and associated work), and is obviously worse on windy days. Plant shutdowns were more frequent than expected, and more soil was processed than originally envisaged; over the project the plant failed to meet its target contractual production rate.[6] (Overall production rates over the timescale of the project were more than 40 percent below target.[7]) If anything,

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[1] Resource Consent Conditions 19–20 of RM030523

[2] Parliamentary Commissioner for the Environment (PCE) Filenotes including FN 200/9/07

[3] Peer Review Panel minutes 6 April 2005

[4] Definition of Beaufort Scale winds 11–16 knots.

[5] PCE Filenote (CRFSW)

[6] EDL Close-out Report

[7] Investigation into the remediation of the contaminated site at Mapua, PCE (July 2008) p31.

these three factors would have given EDL incentives to work the plant harder, not slow it down.

In relation to the other dust mitigation methods employed, the deployment of the water cart can only ever have been a minor mitigation method, given the scale of the works. So, whether dust emissions from the site were actually "minimised"[8] is debatable, but seems unlikely.

Two particulate measurement methodologies were used at Mapua – one to measure Total Suspended Particulates (TSP) and one to measure total deposition. The TSP was measured by the use of high volume aerosol samplers, and the total deposition by WOK wet and dry deposition gauges. The deposition gauges literally catch what drops out of the sky onto them (including rainfall) and are used to estimate the flux of materials that deposit. The high volume aerosol samplers suck ambient air through a filter, which catches particulates in the air, and is subsequently analysed.

Both of these methods (specified in the resource consent) are acceptable for the tasks for which they were specified, but issues around their implementation as specified in the resource consent (condition 28) are problematic. The requirement to analyse only a quarter of each sample increases the uncertainties of measurement for both methods. For the TSP samples in particular, the distribution of trapped particulates is not necessarily uniform across the filter, so the quarter sampled may not be representative of the whole. For the deposition gauges, taking a quarter of the sample is likely to have resulted in under-estimation of the insoluble particulates by a factor of two to four.[9]

To further complicate the situation, in January 2005 (three months into the sampling) the high volume aerosol samplers were replaced by high volume polyurethane foam (PUF) samplers. Difference in sampling rate and architecture between the high volume sampler and the PUF samplers suggests that the PUF sampler would be likely to under-sample the larger part of the particle size spectrum,[10] but probably capture most particles less than about 10 μm.[11, 12]

Generally it is the surface of the atmospheric particulates that carry the pesticides – the pesticide molecules are adsorbed onto the surfaces of the aerosol particles. Smaller particles have proportionally much more surface area than larger particles. In terms of the particle size spectrum in the air, there are many more smaller particles than larger particles, (although most of the mass of the aerosol is contained in the larger particles). The implication of this is that smaller particles will be carrying a greater proportion of any adsorbed pesticide than the larger particles. So, when smaller particles are being

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[8] Resource consent condition 20 of RM030523.

[9] Stevenson, C. Problems with dust deposition sampling methodology. Report to Peer Review Panel. 2007.

[10] Letter from Bruce Clarke, Senior Environmental Consultant, Sinclair Knight Merz to Parliamentary Commissioner for the Environment, 18 July 2007.

[11] Stevenson, C. Problems with dust deposition sampling methodology. Report to Peer Review Panel, 2007.

[12] Graham, B., Review and Assessment of Air Monitoring and Emissions Data for the Former Fruitgrowers Chemical Company Site, Mapua. Report to the PCE, June 2007.

preferentially sampled (as in this case), there will appear to be a greater amount of pesticide per mass of aerosol than actually exists.

The samples from both of these particulate were analysed for a suite of compounds. The effects of these technical problems with the particulate sampling are that:[13]

- for the TSP samples, precision and accuracy are likely to have been affected, but not enough to mean that the results would not be useful indicators of the true position for PM_{10}. Effectively, this error has the effect of assuming that the concentration of toxins on the smaller particles is much the same as that on the larger particles. This is not likely to be the case – as described above, the larger particles are likely to have much lower concentrations of toxins. The use of this data in the Total Hazard Index (see later) would have had the effect of overestimating the doses of toxins received by people.

- for the insoluble dust fraction, the deposition gauges are likely to have significantly under-reported. During the project, this may have misled site management into assuming that the dust emissions from the site were considerably less than they might actually have been. In terms of the Total Hazard Index, this error has been factored into the calculations.[14]

Additionally, under consent RM030523 condition 25, the consent holders were required to measure PM_{10} concentrations at the beginning of the remediation. This was done. Condition 26 required them to measure the proportion of the TSP which comprised PM_{10} concentrations "...on at least ten days of maximum site remediation operations...". On the basis that the results from the initial proof-of-performance measurements were low, this was not done. The measurements taken during the proof-of-performance tests, (required by condition 25) were not during a period when the remediation was maximal (and hence do not seem to be consistent with the requirement of condition 26). This appears to be a breach of conditions.

PM_{10} is important because it contains particles that can travel further into the lungs, presenting a larger potential health problem than TSP in terms of the particles themselves, as well as anything toxic they may carry. It may be that conditions 25 and 26 are unclear or could be interpreted differently. In that case it would have been up to the consent holders to prove this and potentially use s127 of the RMA to modify them.

Fugitive emissions from drier

Figure 2 shows a schematic diagram of the Mechanico-Chemical Dehalogenation (MCD) plant and the associated Air Emissions Control System (AECS). The AECS is designed to remove toxins formed in the drier and other parts of the MCD plant from the gaseous emissions of the plant. Fugitive emissions are those emissions which are emitted into the atmosphere from the drier or other parts of the MCD not via the AECS.

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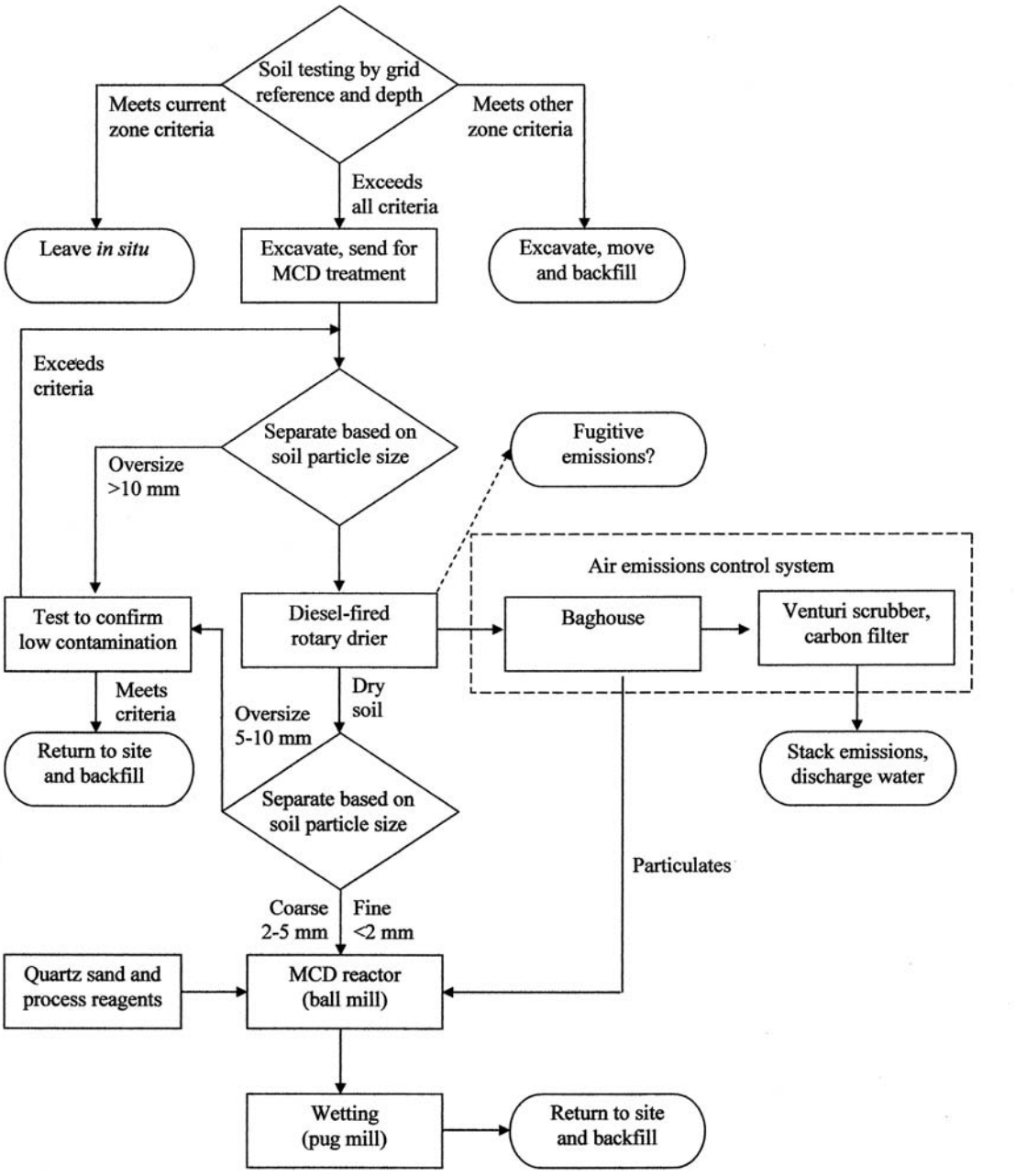
[13] C. Stevenson, Senior Consultant, AES Ltd, Problems with dust deposition sampling methodology. Report to Peer Review Panel, 2007.

[14] PCE Filenote CRSFW; Stevenson, C., Recalculation of Hazard Indices and cancer risks for the Mapua FCC contaminated site remediation project. AES Ltd, February 2008.

Figure 2: A schematic diagram of the MCD plant and associated AECS



In mid-2006 a new Series III MCD reactor began to be used alongside the original reactor.[15] This diagram is correct for both.

Within the MCD, there are two main sources of emissions – one from the soil drier, and the second from the reactor itself. Both have short and direct paths to the atmosphere (via screw conveyors), although the reactor seems to have a design feature enabling conveyors to act as devices to relieve transitory air pressure rises in the reactor. In terms of emissions from the reactor or the drier, under expected operating conditions the design of the system would seem to minimise any emissions that could occur from the

[15] Site Management Meeting Minutes for June and July 2006.

reactor except via the AECS. Under normal operation, about 2 m^3 s^{-1} of air was passing through the system and the flow was fan forced (the fan was at the front end of the process). In addition, on the far side of the bag-house there is an additional fan to induce flow. However, in the first year of operations there were back-pressure issues within the system,[16] where the resistance of the AECS was such that the pressure within the system increased. This seems to have been caused by the substantial back pressure from the baghouse and carbon filter. In this situation, air can be forced back through the drier. Under these circumstances, it is likely that fugitive emissions from the drier could occurred. These emissions would likely have been discharged into storage shed ST120. It is also worth noting that the "effective seals"[17] between the storage shed ST130 and the drier do not mean 'pressure tested'. So some of these fugitive emissions from the drier may have been emitted into the open.

No routine measurements seem to have been taken in these areas (particularly important in the first year of operation) to be able to check the extent of these emissions.

For the MCD process to function efficiently, the soil being decontaminated must be dry. However, if contaminated soil particles in the drier come into contact with air above 250°C, organochlorine pesticides (OCPs) in the soil may be converted to form dioxin. This happened in one of the Proof of Performance trials, so specific precautions were included to prevent this situation arising during normal operations. In essence, condition 22 required the hottest part of the drier (the inlet) to be fitted with a temperature cut-off, which would shut the drier down if the temperature exceeded 120°C. This was to reduce the volatilisation of OCPs, and prevent the *de novo* formation of dioxins.

Measurements of drier inlet temperatures in February 2006 seem to indicate that these were below the specified limit of 120°C.[18] However, these measurements were inconsistent with calculations[19] that indicate that temperatures at the drier inlet must have usually have been at least 250–380°C (the temperature depends on the water content of the soil). The design of the drier was such that, had this resource consent condition[20] regarding the temperature cut-off been implemented, the soil throughput would likely have been about 15 percent of what was actually processed. This means that the plant EDL installed was not capable of complying with the temperature consent condition and functioning at the throughput envisaged. MfE and TDC failed to reach agreement about where the temperature should be measured until the works were close to completion.

At root, it could be argued that the two aspects of the design of this plant (engineering and chemistry) each had problems. Apart from the engineering flaws in the AECS system (which led to problems described above), the design of the MCD itself

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[16] Bryan Black, Managing Director, EDL, Response to PCE questions (Q25), 31 March 2007.

[17] Statement of evidence by Simon Oakley in the matter of the RMA and the applications by Thiess Services for resource consents to remediate contaminated land at the old Fruitgrowers Chemical Company site at Mapua.

[18] Peer Review Panel minutes, February 2006.

[19] Comments by C. Stevenson, Senior Consultant, AES Ltd to the Peer Review Panel on the emissions testing at the Mapua plant, 2006.

[20] Resource Consent Condition 22 of RM030523.

contributed. The use of an inappropriate type of drier[21] as part of the MCD either caused or exacerbated chemical problems, as it had to be run hotter than specified to be able to fulfil its function in the process.

From the chemical perspective, a combination of the hotter drier temperatures, insufficient characterisation and/or insufficient blending of the soils being run through the drier, and the routing of the diesel exhaust through the system probably led to the unforeseen formation of large amounts of acid gases (probably SO_2 and HCl) as well as larger amounts of volatile organic compounds VOCs than expected. All these factors, along with poor management of the plant, contributed to the likelihood and potential extent of fugitive emissions.

Stack emissions

The air emissions control system

The air emissions control system (AECS) is part of the MCD plant; its role is to control the emissions to air from the soil drying process. Consultant process engineer Simon Oakley gave evidence at the hearing, on behalf of Thiess, about the proposed plant including the AECS.

In his brief of evidence,[22] he set out that the air emissions control system was to consist of cyclone separators, a bag filter, a venturi water scrubber, a packed bed scrubber and two activated carbon filters in series.[23] The air stream from the dryer that would potentially contain toxins and dust from the soil was to be passed through the air emissions control system before release from the stack, (see Figure 2).

There are questions as to whether the AECS actually installed was as described at the hearing. It should be noted that the configuration of the AECS was changed in during July–November 2005.

When the plant with the installed AECS was put through its Proof of Performance testing, it consisted of cyclone separators, bag-house, venturi scrubber and a single carbon filter.[24] The components of the AECS were not as described by Simon Oakley, the packed bed scrubber and a carbon filter (see below) seem to be missing. It seems that the AECS was not installed in accordance with the AEE and therefore potentially breached resource consent condition 17.

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[21] Advice to the Ministry for the Environment from R. Cudmore, Director, Kingett-Mitchell Ltd, October 2005.

[22] Statement of evidence by Simon Oakley in the matter of the RMA and the applications by Thiess Services for resource consents to remediate contaminated land at the old Fruitgrowers Chemical Company site at Mapua.

[23] Cyclone separators remove larger particulates. The bag filter is designed to remove smaller particles. The packed bed scrubber and venturi scrubber also remove particulates and some gaseous compounds; the C filters remove VOCs.

[24] Advice to the Ministry for the Environment from R. Cudmore, Director, Kingett-Mitchell Ltd, October 2005. (EDL has presented contradictory evidence to the Parliamentary Commissioner for the Envirnoment on whether or not there was a packed bed scrubber.)

Two other questions remain – whether the plant as proposed would have worked, and whether the plant as built did work. As to the first question, one answer is provided by the expert opinion of Simon Oakley.[25] However, another expert view of the system is that it was not best suited for the job, and did not represent best practice at the time.[26] It is clear that the carbon filters would have had to be redesigned, as happened. Beyond that though, partly due to redundancy in the original design, the system as specified, although not ideal, would probably have functioned.

The answer to the question about whether the plant as built worked is clearer. The plant as first installed had a single carbon filter rather than a pair in series. This reduced both the capacity and security of the VOC removal part of the system. It has been argued by EDL[27] that a single carbon filter was sufficient, because the plant only ran for 12 hours per day. The two carbon filters (as presented at the hearing) were necessary because at that time it was envisaged that the plant would run for 24 hours a day. This, however, is not consistent with another EDL statement on the matter.[28] It also seems clear that, on the basis of noise alone, even before the hearing it was obvious that a plant such as this could not be run for 24 hours a day in a residential area. Both high humidity and/or high temperature of the gas stream would have compromised the performance of the carbon filters. In the configuration as originally installed (even if nothing else had gone wrong), it is unlikely that the carbon filter would have worked efficiently.[29] However, as the carbon filter failed a number of times, the question is answered.

A further point concerns the lack of a packed bed scrubber. The role of this unit would be to remove gases and particulates and – possibly by increasing the volume of the system – contribute to system stability. Its absence will have affected the performance of the plant in those two ways.

In the event, the drier was run much hotter than the specified 120°C, producing hotter gases and more VOCs, and both reducing the efficiency of the carbon filter and increasing the job it had to do. In addition, the corrosive nature of the gases running through the system was much greater than anticipated, which ultimately led to the complete failure of the carbon filter on some occasions, and the plant running without it. This indicates that the system as initially installed did not work properly.

During the period July to November 2005, the system was modified, redesigning the carbon filter and moving it ahead of the venturi scrubbers. (This reduced the humidity reaching the carbon filter, increasing its efficiency). The flow through the filter was also reversed (to reduce the back pressure in the system). This then exposed it to higher

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[25] Statement of evidence by Simon Oakley in the matter of the RMA and the applications by Thiess Services for resource consents to remediate contaminated land at the old Fruitgrowers Chemical Company site at Mapua.

[26] Advice to the Ministry for the Environment from R. Cudmore, Director, Kingett-Mitchell Ltd, October 2005.

[27] Response to Site Instruction #21 – review and comment on the AECS. Memorandum from Brent Pascoe, Site Manager, EDL, to John Roosen, Site Manager, EMS, 25 July, 2005.

[28] Bryan Black, Managing Director, EDL, Response to PCE questions (Q25), 31 March 2007.

[29] Letter from R. Cudmore , Director, Kingett-Mitchell Ltd to Kim Morgan Senior Advisor, Ministry for the Environment, October 2005; Advice from T. Brady, T. Brady Consulting Ltd, to EDL, August 2005.

temperatures, which in turn impaired its efficiency.[30] In this position, the carbon filters were also exposed to dust from the bag-house, which also reduced their capacity. There is clear evidence that this dust did significantly impair the capacity and function of the carbon filters and, on some occasions, effectively disabled them.[31] For some months there is also evidence that the carbon filter did not have the capacity to continue through the period of service.[32] To address these issues:

- the carbon filter was changed monthly (from November 2005). The carbon filter did not completely fail after that, but issues relating to the efficiency of its performance were raised throughout 2006.[33]

- the size of the carbon filter increased from 250 to 300 kg (from April 2006)

- a closer management of the bag-house and carbon filter arrangement was adopted.

It seems that certainly before October 2005, the plant as installed did not function properly. From early 2006, although not problem-free, most of the problems with the plant, and more particularly its onsite management, seem to have been better addressed. Indeed by March 2007 TDC was reassured enough about the carbon filter and management arrangements that it agreed a change to resource consent conditions that effectively put more reliance on the carbon filters to work efficiently and reliably.[34]

Poor on-site maintenance, management and control[35] exacerbated the design weaknesses of the plant – certainly until late 2005. Improvements occurred after this, but problems persisted. It is also clear that MfE was aware of carbon filter issues before taking over the consent.[36]

In summary, the air emissions control system failed completely on a number of occasions and did not work effectively to control emissions during some periods of the consent. The extent of these emissions is uncertain, but is likely to have been higher than was discussed in the resource consent hearing. The effect on people and the environment cannot be readily determined from currently available data.

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[30] Letter from R. Cudmore , Director, Kingett-Mitchell Ltd to Kim Morgan Senior Advisor, Ministry for the Environment, October 2005; Advice from T. Brady, T. Brady Consulting Ltd, to EDL, August 2005.

[31] Peer Review Panel Minutes November 2006; Stevenson, C., Consideration of Recoveries of OCPs for the PUF samplers for month long sampling periods, 16 February, 2008.

[32] Peer Review Panel Minutes, 27 February 2006.

[33] Various emails from C. Stevenson, Senior Consultant, AES Ltd, 2006.

[34] Letter from Dennis Bush-King, Head of Environment & Planning, Tasman District Council to Kim Morgan, Senior Senior Advisor, Ministry for the Environment, 23 March 2007.

[35] Two examples – (note dates). Letter from Dennis Bush-King Head of Environment & Planning, Tasman District Council to Nigel Ironside, Sustainable Business Manager, Ministry for the Environment, "…Once we became aware of the situation on 15 March 2005 when the visible signs of leaking carbon were obvious…", 7 April 2005; Site Instruction #25, "...black carbon material is streaming down the main air emission control system…", 20 July 2005.

[36] Memo from Howard Ellis, Senior Adviser, Ministry for the Environment to Peter Nadebaum, Mapua site auditor, and Kim Morgan, Senior Adviser, Ministry for the Environment, 2004.

Stack monitoring

If the AECS had worked appropriately, then the stack emissions should have been satisfactory. So this section briefly examines the stack monitoring – the tests performed to check whether the stack emissions were within the limits set in the resource consent. Two types of stack measurements were carried out – the standard measurements as outlined in the resource consent conditions, and the enhanced measurements to include dioxins (in March 2007). The carbon filters were also analysed to try and establish what had been emitted from the plant.

Standard stack measurements

The resource consent required that testing of the emissions from the stack be carried out three monthly (condition 23a). The monitoring was to be carried out in accordance with ISO 9096:1992 (E) or an equivalent method. The samples collected from the testing were to be analysed for their gaseous and particulate fractions for lindane, aldrin, dieldrin, DDD, DDE, DDT, heptachlor, chromium, manganese and nickel. These measurements were carried out by K2 Environmental.

To get a useful picture of how the plant was performing, the measurements were designed to be done when the plant was working normally (and had been for three days before the tests). "Normally" in this context meant that the plant was treating a normal amount of soil, contaminated to the level typically and usually encountered, and the operating conditions of the plant were typical of how it was being run. It has been very difficult to determine whether the testing always occurred under standard operating conditions. It seems that while the tests themselves may have been performed appropriately, there is some doubt as to whether they were carried out under normal plant operations.[37] As discussed below, it also seems that the suite of substances tested for was inadequate.

As tested, emissions generally seemed to be at levels similar to those encountered in the Proof of Performance tests. At various points in the project (e.g. at times during 2005) they were good indicators of problems occurring – so rising levels of OCPs (in large excess of those encountered in the Proof of Performance) in February 2005 indicated problems with the AECS.

The enhanced stack measurements

Between May and December 2005, the Peer Review Panel and TDC seem to have become increasingly concerned about the potential for dioxin formation in the drier. So much so that they requested that dioxin measurements be added to the standard stack measurement round due in November 2005 (at TDC's expense). After initially agreeing, MfE then subsequently refused permission.[38] After unsuccessful pressure through 2006

[37] C. Stevenson, Senior Consultant, AES Ltd, Record of Drier Temperatures, 2007.

[38] Peer Review Panel minutes, December 2005

from TDC for this measurement to be done, eventually the PCE formally requested[39] that MfE allow TDC to do these measurements, which were carried out in March 2007.

The results of this test showed very low dioxin levels. However there are doubts over the representativeness of the results. The drier temperature is the most likely driver of dioxin production. From August 2006 until the works ended in July 2007, the average chamber[40] temperature was 310°C, with a maximum of 390°C. When the dioxin measurement was taken, the chamber temperature was very low (240°C), lower in fact than it had been since August 2006, and lower than it would be until the works ended in July 2007.

The amount of dioxin measured in a stack test such as this is the result of the dioxin produced in the drier, (which in the case of this particular test would have been low), minus the dioxin adsorbed by the bag house and carbon filters.

Carbon filter testing

During 2006, in the face of MfE's refusal to allow dioxin stack testing, TDC asked MfE whether it (TDC) could test the carbon filters for dioxin. Although not perfect, the filters should have been able to give an indication of whether dioxins had been emitted. TDC's first request to do this was declined by MfE in June 2006, and finally agreed to in September 2006. The results were reassuringly low.

The carbon filters themselves are a good indicator of their effectiveness in dealing with the total emission profile. Analysis of the filters showed that, on occasions, the capacity of the filter was insufficient, and that the efficiency in some months was low enough to impair their function. The increase in carbon filter capacity in April 2006 addressed some of these shortcomings, but these concerns continued through most of 2006 before being finally resolved.

In summary, the stack testing was useful as a diagnostic and, with the carbon filter analysis, provided a useful check on the system for the compounds in the THI. For other substances that were not measured, however, the carbon filter tests were not useful. For dioxin, in the absence of tests on the bag-house dust, the carbon filter data indicates that it is likely that emissions were probably low, but this cannot be proved. MfE's responses over the dioxin sampling show a lack of appreciation of the potentially serious nature of the problem.

Monitoring site data

Monitoring site (rather than stack) data consisted of the Wok deposition gauges and, for most of the project, the PUF samplers. The detail and limitations of the sampling methodologies have been discussed above, and the robustness of the data from the site

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[39] Letter from Parliamentary Commissioner for the Environment Dr Morgan Williams, to Hugh Logan, Chief Executive, Ministry for the Environment, 26 February 2007.

[40] The chamber temperature is higher than the drier inlet temperature, but only by some tens of degrees. From Peer Review Panel Minutes, 27 February 2006: Set Temperature 160-170; Chamber Temperature 169-210; Drier Inlet Temperature – under discussion; Drier Outlet temperature 97-108. From Peer Review Panel Minutes 7 December 2005: Set temperature 350-380 during Nov 2005 stack tests, and 270 on 7th Dec 2005 Peer Review Panel Meeting site visit.

monitoring is examined below. So it remains to discuss the analytical results *per se,* as well as the plume dispersion modelling.

The monitoring site locations were designed to fulfil the resource consent requirements, being on the site boundaries (condition 24). There were, however, supposed to be background measurements taken, in an area largely unaffected by site operations. Background measurements were then to be subtracted from the main measurements so that the increase due to the site operations could be readily determined. This is common practice for dust samples, but not for TSP. The consent level appears to be taken from an MfE good practice guide[41] where 80 $\mu g\ m^{-3}$ is an absolute value, not an "above background" value.

In this case, the monitoring site chosen as background (31 Tahi Street) is 130 metres away from the site and was found[42] to have been affected by site operations. The implication is that a larger concentration of toxins is subtracted from the measurements, so lowering the apparent measurement.

For the TSP results, this choice of background monitoring site resulted in occasional negative TSP results. It is not clear either why MfE did not move the site, or why TDC did not require MfE to move the site rather than potentially produce compromised data. Contractors Sinclair Knight Merz (SKM), however, (who undertook the TSP) gave both raw and uncorrected data in their reports, and the PCE understands that uncorrected data was used in the THI, adding confidence to the THI results from this perspective. For the OCP monitoring, the levels measured at 31 Tahi St were, in most cases, low enough to make little difference.

The fact that a THI has been used at the Mapua site means at some level the actual concentrations measured (of the substances included in the THI) are only relevant in terms of their effect on the THI. The values of the concentrations measured are therefore of academic interest only and should only be interpreted as part of the THI calculation.

Plume dispersion modelling (using AUSPLUME) was carried out in tandem with the stack monitoring to establish where the plume[43] from the stack "on average" ended up. It would be difficult to use the results of the modelling for management purposes (the results were available after the event), and given the coastal situation it might be that a Gaussian model (which AUSPLUME is) would have been less able to deal with the meteorological situation than an advanced model (e.g. CALPUFF).

In general this exercise did not identify anything unexpected – but did indicate in general terms for a given period where stack emissions might be deposited. It resulted, for instance, in the stack height being increased in 2005.

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[41] Good practice guide for assessing and managing the environmental effects of dust emissions. Ministry for the Environment, September 2001.

[42] Peer Review Panel Minutes, 2 August 2005.

[43] The "plume" is the parcel of air and emissions from the stack.

The analytical suites

Inadequacy of range

The resource consent specified the same suite of substances to be analysed in the dust samples and stack testing. Discharges to air from windblown (untreated) soil could be expected to include contaminants known to be present in the soil (which persisted). Discharges to air from the MCD process could be expected to consist of those above not destroyed by the process, plus those possibly formed during the process itself (especially those detected in the Proof of Performance trials) and obvious breakdown products.

From the resource consent,[44] 10 substances were required to be tested for in the particulate samples, representing a reasonable suite of OCPs and three metals. Appendix 1 of the Air technical Annex examines the compounds are known to have been on the site, their persistence, the amount dumped and implications of that for persistence. It then goes on to infer what compounds might reasonably be expected to be among the emissions from the site. The conclusion is that the suite required to be tested for was very narrow, given both the known history of the site, and what had been discovered, for example, drums and large amounts of pure substances.

The most notable omissions included dioxins, mercury compounds and possibly PCBs. They may also include arsenic, atrazine and pentachlorophenol, although these are less likely. The concern is that these other substances were neither measured nor included in the THI, so it is impossible to work out what exposure (if any) people had to them. This is the case especially up to November 2005.

It is not possible to know for certain whether toxins other than those measured were emitted from the site. If there were such emissions, the THI will under-represent the dose of toxins have received from the site. This is a significant concern.

Robustness and validity of data

Particulate sampling

Three months into the sampling (January 2005), new air quality consultants realised that sampling of gases as well as sampling of particulates would be needed to better describe the emissions to air. To achieve this, the standard aerosol samplers (which measure particulates) were replaced by polyurethane foam (PUF) samplers.

However, while the PUF samplers can be effective for monitoring volatile organics, they are not as effective for monitoring particulates.[45] For technical reasons, the PUF samplers were likely to have sampled very few particulates larger than 10 microns in diameter, that is, the majority of the particulate mass. The likely outcome of this inadequate sampling of particulates by the PUF samplers is an *over-estimation* of contaminant loads (see earlier discussion).

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[44] Resource Consent Condition 28 of RM030523.

[45] The US specifications for the PUF method state “airborne particles may also be collected, but the sampling efficiency is not known”.

By changing the samplers from aerosol samplers to PUF samplers, rather than using both types of samplers, it appears that the consent holders breached their conditions because they did not measure TSP as required[46] and potentially compromised the results produced by THI. However, the result would have been to make the THI higher and therefore more protective for the substances measured. This does not affect the problem of the substances not measured.

Under consent condition 25,[47] the consent holders were required to measure PM_{10} concentrations at the beginning of the remediation. This was done. Condition 26 required them to measure PM_{10} "...on at least ten days of maximum site remediation operations…"[48] and, contingent on the results, potentially further measurements. (See discussion under dust and particulates from site operations.)

Gaseous sampling

It appears that the PUF samplers were used over an extended period – for periods of about a month, as opposed to the design period of 24 hours. By using them in this way, it is possible the pesticides adsorbed on the sampler may have subsequently desorbed over the period so, when analysed, the sampler would have indicated lower average concentrations than were actually present in the atmosphere over the period of the monitoring.

To test whether this was the case, TDC asked MfE to commission radioactively labelled 'spike tests' on the samplers. This involves adding a known amount of a mix of radioactively labelled pesticide to the sampler, then running the sampler for an extended period of time (comparable to that for which the samplers were actually deployed), and assessing how much of the labelled pesticides remained on the sampler.

This was a reasonable request as samplers pre-loaded with labelled pesticides are available in New Zealand. In August 2007, SKM carried out a spiking exercise without radioactive labels – a decision was made to use a non-labelled native standard, rather than a partial but labelled standard.[49] Without radioactive labelling, it is not possible to subtract background concentrations of pesticides. The results of that exercise were of very limited use in addressing the question, giving inconsistent recoveries of 0.08 percent to 80 percent for different pesticides in the mix (with the more volatile pesticides having the poorest recoveries), so the recovery efficiency of the samplers is not known.

In the absence of reliable spike testing, two other methods were used to shed light on the efficiencies of the PUF samplers:

(1) comparing the ratios of pesticides on the carbon filters of the MCD plant to those on the PUF filters. If these were similar, then this gives confidence that the results from the monthly PUF samplers were not unreasonable.

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[46] Resource Consent Condition 24 of RM030523.

[47] Resource Consent Condition 23 of RM030523.

[48] Resource Consent Condition 26 of RM030523.

[49] Letter from Matthew Newby, Air Quality Scientist, SKM, to Tracey Morgan, Advisor, Ministry for the Environment, 2 February 2008.

Using the carbon from two months (March and April 2006) when the filters seemed to be working well, the comparison is mixed, with about half of the pesticides being present at very different ratios between the samplers and the carbon.

(2) comparing the results of a one-day deployment (in July 2007) with those obtained from monthly deployments – if pro-rota the amounts trapped of each pesticide are comparable, then again this would give confidence that the results from the monthly PUF samplers were not unreasonable. For four of the 14 pesticides, this was definitely not the case, with very much higher amounts than would be expected. A further seven of the 14 had amounts more consistent with the median values. The results of the comparison are somewhat mixed.

The data to hand means the recovery efficiency of the PUF samplers deployed for monthly sampling cannot be unequivocally assessed. However, the degree of correspondence between the different methods suggests that the data has some credibility, although is likely to be under-sampled. This, in turn, implies that the THI calculations based on this data are probably a little lower than they should be, so the THI slightly underestimates the doses that people received.

There are methodological shortcomings in both the particulate and gaseous sampling undertaken at the site. While some of these deficiencies have been estimated (allowing adjustment of the THI), the gaseous samples, in particular, do not seem correctable with any degree of certainty. However, as the maximum average range of the THI values (this is the worst case) is 0.25 to 0.46, this does not suggest that the THI is fatally compromised from this direction. Once again, this does not include any substances not measured.

Total Hazard Index (THI)

The THI was designed to assess the likely dose of toxins received by persons on and around the site. The THI was calculated using measured data from the site, as well as external reference data. If the value of the THI exceeded 1.0 for any period, then work had to cease until the situation was resolved. The characteristics of the THI were specified in the resource consent. SKM implemented the THI calculation regime.

To effectively protect people exposed to emissions to air, the THI must:

- **include all the relevant exposure pathways.** The THI did not initially include all relevant exposure pathways. MfE, on the advice of the Peer Review Panel, funded some work to improve the THI. This was completed in May 2007. TDC and Nelson Marlborough District health Board have since funded further work to add additional exposure pathways and correct other deficiencies. The methodology for the calculation of the THI, in terms of exposure pathways and adjustments to allow for deficiencies in monitoring data, is now on a firmer footing.

- **include all the relevant toxins** (discussed above). The suite required to be tested for was narrow, given the known history of the site. The most notable omissions included dioxins and mercury compounds. The very serious concern

is that these other substances were neither measured, nor included in the THI, so it is impossible to work out what exposure (if any) people had to them.

- **be calculated with input data that is robust and valid** (discussed above). There are methodological shortcomings in both the particulate and gaseous sampling undertaken at the site. While some of these deficiencies have been estimated (allowing adjustment of the THI), the gaseous samples, in particular, do not seem correctable with any degree of certainty. However, given the maximum average range (this is the worst case) of the THI was 0.25 to 0.46, the THI probably remained below the protective value of 1.0 for the substances measured. Again, this does not include any substances not measured.

The THI would provide a reasonable estimate of the doses of toxins received by people **if** it included all the toxins they were exposed to. It is not possible to know for certain whether toxins other than those measured were emitted from the site. If there were such emissions, the THI will under-represent the dose of toxins people have received from the site. This is a significant concern.

Conclusions

Two matters stand out as being of serious significance:

1. The limited range of the substances measured means that we cannot rule out the fact that people may have been exposed to a range of toxins, most notably dioxins as well as mercury compounds, especially between September 2004 and November 2005.

2. The design and management of the plant meant that from June 2004 until November 2004, the risk of the generation and emission of a range of toxins, most notably dioxins, was elevated.

Some of the resource consent conditions around discharges to air contained significant problems which made compliance difficult. Clear, measurable and enforceable resource consent conditions were required. It seems that TDC, for whatever reason, did not have sufficient expertise on hand to deliver these.

For different reasons, much of the atmospheric monitoring data cannot be relied upon. There have been failures by EDL, MfE, MfE's consultants and TDC in this regard. We simply do not have good enough data to determine whether there have been emissions to air from the site beyond those included in the THI.

With respect to emissions to air, it appears that TDC failed to enforce the resource consent conditions. However, it should be noted that the Peer Review Panel was instrumental in getting key measurements carried out.

MfE did not appear to have appropriate expertise in its project team to safely and appropriately manage this project (even with EMS in place). They also did not appear to have the capability to identify serious issues and take a precautionary approach in those circumstances.

We have found it difficult to get consistent information from EDL. It seems that EDL learnt many lessons from the Mapua remediation that they have used to refine and develop the MCD technology.

[Appendix 1 to this Annex comprises Former Fruitgrowers Chemical Company Site, Mapua: Assessment of the Possible Releases to Air during Soil Processing, Report to the Parliamentary Commissioner for the Environment, prepared by Dr Bruce Graham of Graham Environmental Consulting Ltd, February 2008.]

Glossary and acronyms

2,4-D	An organochlorine pesticide
abatement notice	A formal order, issued by a regional council or local territorial authority, requiring compliance with resource consent conditions within the time specified in the notice
activated carbon	An amorphous form of carbon. Its chemical nature, high surface area and porosity make it an ideal medium for the removal of organic pollutants from liquid or gas streams.
ADL	A collective term for aldrin, dieldrin and lindane, three organochlorine pesticides
adsorbed	Gathering of gas, liquid or a dissolved substance on a surface in a condensed layer
AECS	Air Emissions Control System
AEE	Assessment of Environmental Effects: a report outlining the effects that a proposed activity might have on the environment, required under the RMA for resource consent applications
aerosol sampler	Device used to collect samples, which are analysed for specific liquid or solid particles in the air
AES Ltd.	Air quality and environmental consultants
aldrin	An organochlorine pesticide.
ambient air	The air surrounding an object or the air outside
ammoniacal nitrogen	Nitrogen combined with hydrogen
analytical suite	The compounds found within a sample by chemical analysis
aquifer	Any geological formation containing or conducting groundwater
arsenical compounds	Arsenic bonded with various other elements
atrazine	A herbicide
AUSPLUME	A model for measuring plume dispersal
background concentrations	Level at which substances are naturally present in the environment
back pressure	The resistance to the flow of gas through the exhaust
bag filter	A device designed to remove small particles from the contaminated soil
bag-house	A structure or machine designed to capture pollutants or waste under low pressure through a bag, which acts as a filter
belt and braces	To have additional levels of protection
breakdown products	Product resulting from a chemical breaking apart into smaller pieces
bund wall	A wall erected to prevent the escape of stored liquids into the surrounding environment
cadmium	A heavy metal
CALPUFF	A model for measuring plume dispersal
capping	Placement of a covering (cap) of one or more layers of sand, silt, rock or synthetic fabric over an established layer of

	contaminated earth. This cap is designed to prevent pollutants from migrating into surrounding waters by providing a physical and chemical seal.
carbon filter	A filter employing activated carbon to remove particles from the air
chlorophenoxyacetic acid herbicides	A class of pesticides that mimic plant hormones
CH2M Hill	Environmental and engineering consultants
clay bunding	Construction of a bund wall using clay
cleanup	Remediation of a contaminated site
Close-out Report	A report compiled at the end of a project, which determines if the expectations established as the project outcome were met
CMPS&F	Environmental consultants
containment	The process of keeping hazardous wastes confined to a particular location, so as to prevent their accidental release into the surrounding environment
contaminated land	Land identified as posing a significant possibility of significant harm to human health or the environment due to substances present in, or under, the ground
copper sulphate	A copper salt
cut-off wall	A collar (metal, concrete etc.) placed around a culvert to prevent water flowing around the outside of the culvert
cyclone separators	A device designed to remove larger particulates from the contaminated soil
DAP	diammonium phosphate
DDD	A breakdown product of DDT
DDE	A breakdown product of DDT
DDT	An organochlorine pesticide
DDX	The sum of DDT and its primary breakdown products
dehalogenation	The reduction or removal of halogens from a chemical compound. Halogens are various non-metallic elements that readily combine with metals. Halogenated compounds are more likely to be toxic.
de novo	Latin: to make anew
deposition	The laying down of particles carried by air or water
desorbed	To remove condensate from a surface upon which a gas, liquid or dissolved substance has been adsorbed
destruction efficiency target	The agreed percentage destruction of OCP contaminants in treated soil; also known as the Destruction / Removal Efficiency (DRE) target
dieldrin	An organochlorine pesticide
dioxin	Any of a group of toxic chlorinated compounds known chemically as dibenzo-p-dioxins. They are produced as a by-product of chemical production or combustion and are widespread pollutants in the environment.
discharge stack	A walled enclosure extending upward to direct exhaust air

	vertically away from fans
down-gradient	Areas in an aquifer with lower water levels
drier	A device used to heat and dry the contaminated soil.
East Area	The eastern area of the Mapua contaminated site
ecotoxic	Substances that may present immediate or delayed risks to one or more parts of the environment
EDL	Environmental Decontamination Limited
Egis Consulting	An environmental consultancy
elemental sulphur	A chemical that is a very strong acidification agent
EMS	Effective Management Service Limited
enforcement order	An order issued by the Environment Court requiring a consent holder to comply with resource consent conditions within the time specified in the order
entrained	Carried along in a current
estuarine	Found in estuaries (the mouth of a river)
eutrophication	The process by which a body of water acquires a high concentration of plant nutrients, especially nitrates or phosphates, resulting in algae growth and depletion of dissolved oxygen in the water. This natural process can be greatly accelerated by human activities.
FCC	Fruitgrowers Chemical Company
FCC East	Eastern part of the Mapua contaminated site.
FCC West	Western part of the Mapua contaminated site
French drains	A perforated pipe placed in a gravel-filled pit, where liquid is poured into the drain and then permeates through into gravel
fugitive emissions	Emissions not caught by a capture system (due to factors such as equipment leaks, evaporative processes and/or wind)
groundwater	All water which is below the surface of the ground in a saturated zone and in direct contact with the subsoil
heavy metals	Metallic elements with high atomic weights or density, such as mercury, cadmium, arsenic and lead. Many heavy metals are toxic and, since they do not easily break down, tend to accumulate in the food chain
heptachlor	An organochlorine pesticide
herbicide	Any pesticide used to destroy or inhibit plant growth
hotspots	Localised areas where the concentration of contaminants is high relative to the surrounding area
hydrocarbons	Organic compounds that contain only carbon and hydrogen
impoundment pond	An area with bunding, designed to prevent the escape of stored liquids into the surrounding environment
in situ	Latin: present at the site, in place. Refers here to the treatment of hazardous waste on site, without removing them to another location.
K2 Environmental	Company specialising in air quality testing
labelled standard	A compound that has had one of its atoms replaced by a

	radioactive isotope
landfill	A site used for the disposal of solid waste
leachable	Able to be removed by the action of a percolating liquid
Lime and Marble	A mineral processing company, later known as Mintech
lindane	An organochlorine pesticide
$m^3 s^{-1}$	Cubic metres per second
Manco Environmental Ltd.	Manufacturer, importer and distributor of waste collection equipment; associate company of EDL
MCD	Mechano-Chemical Dehalogenation
metabolites	A substance that is the product of biological (metabolic) changes to a chemical
MfE	Ministry for the Environment
micron	1/1,000 of a millimetre or 1/1,000,000 of a metre
microniser	Device designed to reduce a substance to particles that are only a few microns in diameter
Mintech	A mineral processing company, formerly known as Lime and Marble
MWH	Montgomery Watson Harza Limited
National Environmental Standard	Tool provided for by the RMA; used to set nationwide standards for the state of a national resource.
Nelson Marlborough District Health Board (NMDHB)	An organisation established to protect, promote and improve the health and independence of the population in the Nelson Marlborough District.
non-labelled native standard	Standard compounds in which an atom has not been replaced by a radioactive isotope
OCPs	organochlorine pesticides
organics	Natural organic materials of waste or non-waste origin, including petroleum products, pesticides, herbicides, solvents, and chemicals from decaying plants and animals
organochoride pesticides	Synthetic organic compounds containing chlorine; also known as chlorinated hydrocarbons. Includes pesticides such as DDT, aldrin, dieldrin and lindane. Found to be toxic to non-target species, persist in the environment, and have a propensity to accumulate in the food chain.
organomercury compounds	Mercury bonded with carbon; organic mercury compounds are also called organomercurials
organophosphate	A group of organic compounds consisting of phosphorus bonded with carbon. Organophosphate pesticides break down rapidly when exposed to sunlight, air and soil.
orphaned site	Contaminated site where either no party can be fixed with legal liability, or the liable party is unable to fully fund the remediation
packed bed scrubber	A device designed to remove particulates and some gaseous compounds from the contaminated soil.
paraquat	An organochlorine pesticide
particulates	Sum of all microscopic liquid and solid particles, of human and

	natural origin, that remain suspended in a medium such as air for some time. Particulate matter may be in the form of fog, fumes, dust, soot or fly ash.
PCBs	polychlorinated biphenyls
PCE	Parliamentary Commissioner for the Environment
pentachlorophenol	A manufactured organic biocide also known as PCP
pesticide	Chemicals used to kill, control, repel or mitigate any pest; includes herbicides (to control weeds and plants), insecticides (to control insects), fungicides (to control fungi), rodenticides (to control rodents) and germicides (to control bacteria)
pentachlorophenol	A chemical, also known as PCP, historically used as an anti-sapstain fungicide for short-term protection of sawn timber surfaces
phenoxy herbicides	A group of herbicides derived from phenoxy-acetic acid
PM_{10}	Particulate matter classified as 'coarse and fine' based on the size of their aerodynamic particles
polychlorinated biphenyls	A class of chemical compounds containing benzene and chlorine atoms. Some are used for pesticides and fire-resistant coatings.
PRP	Peer Review Panel
PUF	polyurethane foam sampler
pug mill	A device that mixes and grinds clay or other materials to a desired texture, using rotating paddles or blades
rainfall recharge	The process of adding water to an aquifer
reagent	A substance used to react with another substance
remediation	The clean-up or mitigation of risks from contaminants in soil
resource consent	Permission granted by a consent authority for an activity that might affect the environment and is not permitted 'as of right' in a District or Regional Plan
RMA	Resource Management Act 1991
rotary-type drier	A mixing apparatus using rotation, as opposed to other options such as kneading, pulverising or stirring
run-off	That element of precipitation that finds its way into streams and rivers
screw conveyors	Mechanical device for conveying material via a revolving shaft with continuous or broken flighting
SKM	Sinclair Knight Merz, consultants
slag	Waste product formed from the heating of ore in a furnace
soakhole	An excavated pit where holes have been driven into the rock and then covered over, without being filled, so that stormwater can drain into the ground
soil drier	A device used to heat and dry the contaminated soil
spike tests	Identification of the amount of pesticides remaining on a sampler after extended use through the use of radioactively labelled samples
stack emissions	Emissions to the atmosphere from a chimney or stack

stack test	A quantitative examination of air samples taken from the stacks or chimneys of a facility
stormwater	Precipitation that accumulates in natural and/or constructed storage and drainage systems during and immediately following a storm event
stormwater drains	Openings leading to underground pipes or open ditches for carrying surface run-off.
TDC	Tasman District Council
Thiess Services	A specialist remediation contractor
THI	Total Hazard Index
topsoil	The fertile, upper part of the soil
triazines	A group of herbicides typically used on field crops; they have a relatively high solubility and slower degradation time compared to other types of herbicide.
TSPs	Total Suspended Particulates
unitary authority	A territorial authority carrying out the roles of both regional and district councils under the RMA
up-gradient	Areas in an aquifer with higher water levels
Validation Report	A site validation report; assesses the results of post-remediation testing against clean-up criteria for a contaminated site
venturi	A short tube with a constricted throat used to determine fluid pressures and velocities by measurement of differential pressures generated at the throat as a fluid traverses the tube
venturi scrubber	An air pollution control device in which the liquid injected at the throat is used to scrub particulate matter from the gas flowing through the tube
VOCs	Volatile Organic Compounds
volatile organics	Organics that will evaporate into the air naturally from water
West Area	The western area of the Mapua contaminated site.
Wok deposition gauge	A device to measure deposition
Woodward-Clyde (NZ) Ltd	Environmental consultants, now known as URS Corporation New Zealand