8 July 2015

Mr Malcolm Gillies
Wallaceville Developments Limited
Via email

Dear Mr Gillies

RE: Radioactivity Survey of former "Wallaceville Animal Research Station" at Ward Street, Upper Hutt

Our Reference: 11307.000.000

1 Introduction

ENGEO Limited (ENGEO) was requested by Wallaceville Developments Limited, to undertake a surface radioactivity survey of the former "Wallaceville Animal Research Station" site at Ward Street, Upper Hutt. This survey was intended to establish whether any residual cobalt-60 (^{60}Co), from the former use of the site as an animal research station, was present in detectable quantities either in dispersed or 'point' form (i.e. arising from 'top-dressing' of the land or from 'cobalt bullets' excreted by livestock) in the shallow soil in areas of the site formerly used as 'paddocks'.

The need to undertake this survey was established from feedback comments received from the Upper Hutt City Council (UHCC)-appointed peer reviewer (Golder Associates (NZ) Ltd) in regard to the 'Radioactivity Desk Study' letter report that was appended to the 'Submission Responses' report (ENGEO, 2015). This report was undertaken in response to the submissions made to UHCC in regard to 'Plan Change 40'.

The findings of the survey support the conclusions of the 'Radioactivity Desk Study', and provide underpinning to the evidence submitted in support of 'Plan Change 40'.

2 Site Description

The site is located at the southern end of Ward Street, Upper Hutt to the immediate east of Trentham Racecourse, approximately 1.5 km west / south-west of Upper Hutt city centre.

The site has an area of over 68 ha and currently consists of a number of disused buildings and roadways in the eastern part of the site nearest to Ward Street, and open fields, paddocks and small copses towards the western end near the racecourse.

3 Background to Survey

3.1 Brief Site History

The site was in use as the "Wallaceville Animal Research Station" for approximately 100 years from the early 1900s to 2007. During that time a wide range of research was conducted at the site into various aspects of livestock nutrition and diseases, in support of the New Zealand agricultural industry (Tenquist, 1991).

Further information can be found in the 'Radioactivity Desk Study' letter report (ENGEO, 2015).

3.2 Description of Radioactive Substances and Current Status

Review of various literature sources relating to the "Wallaceville Animal Research Station" confirmed that nine different radionuclides (hydrogen-3 (^{3}H) carbon-14 (^{14}C), phosphorus-32 (^{32}P), sulphur-35 (^{35}S), cobalt-60 (^{60}Co), selenium-75 (^{75}Se), iodine-125/131 ($^{125/131}$I) and cerium-144 (^{144}Ce)) were employed for various purposes in the course of the research activities undertaken at the site.

Table 1 below summarises the conclusions of the 'Radioactivity Desk Study' with regards to the likely current condition of radioactive substances used as part of research activities at the site:

Table 1: Current Status of Radionuclides used at Wallaceville

Radionuclide	Current Status
^{3}H	Strong biogeochemical interactions will likely have diluted and dispersed this radionuclide to negligible levels on the site and hence poses minimal risk to human health.
^{14}C	Strong biogeochemical interactions will likely have diluted and dispersed this radionuclide to negligible levels on the site and hence poses minimal risk to human health.
^{32}P	Very short half-life; this radionuclide will have decayed to negligible levels and hence poses no human health risk.
^{35}S	Very short half-life; this radionuclide will have decayed to negligible levels and hence poses no human health risk.
^{60}Co	Significant half-life and weaker biogeochemical interactions mean that this radionuclide has the potential to persist in soils at the site and may present a human health risk.
^{75}Se	Very short half-life; this radionuclide will have decayed to negligible levels and hence poses no human health risk.
$^{125/131}$I	Very short half-lives; these radionuclides will have decayed to negligible levels and hence pose no human health risk.
^{144}Ce	Very short half-life; this radionuclide will have decayed to negligible levels and hence poses no human health risk.

Of the nine identified radionuclides, only ^{60}Co has the potential to persist to any significant degree at the site. Review of historical data sources relating to the site indicate that ^{60}Co may have been used as part of trials for 'top-dressing' of the land, i.e. spraying of chemicals labelled with the radionuclide to

the ground surface over wide areas (whole paddocks) and / or for the labelling of 'cobalt / ruminant bullets', which were hard pellets administered to animals to provide additional dietary cobalt, and which may have been excreted to the ground.

Further information can be found in the 'Radioactivity Desk Study' letter report (ENGEO, 2015).

3.3 Motivation for Survey

Tonkin and Taylor carried out ground contamination investigation, remediation and validation works at the site in 2004, 2005 and 2008 respectively, with a focus on the waste disposal pits that were located at different points around the site. The remediation included excavation of waste in the pits and disposal at a licensed landfill. Validation samples were taken to provide evidence of the suitability of the site for its proposed end use.

The reports from these phases of work describe monitoring being undertaken for the presence of radioactive substances at the ground surface in the vicinities of the pits, and also for material retrieved from the pits, using Geiger and scintillation counters. Recent liaison with Tonkin and Taylor did however confirm that no monitoring for radioactive substances was undertaken in the wider site, either on soil samples retrieved from the paddocks, or as part of wide-area surface surveys.

This lack of previous monitoring data covering the southern paddock area, combined with the findings of the 'Radioactivity Desk Study' (that ^{60}Co has greater potential to persist on the site than any of the other radionuclides known to have been used at the site) and the fact that ^{60}Co is a high-energy gamma emitter so can result in irradiation even at significant distance (up to several metres) and if embedded within a substance (i.e. soil) gave the UHCC-appointed peer reviewer cause to believe that monitoring data would be required to substantiate the conclusion that there would be negligible risk to human health from persisting radioactive substances at the site.

4 Survey Methodology

4.1 Broad Approach

The broad approach taken for this survey was a semi-quantitative demonstration of presence or absence, rather than measurement of levels or concentrations. Detailed establishment of natural background radiation conditions and acquisition of highly-sensitive instruments able to provide high-accuracy figures was not possible on the timescales required, but the use of representative numerical data and simple statistical analysis is intended to provide 'screening' of the site.

This screening was intended to robustly demonstrate whether count rates in excess of natural background levels are present in areas of the site, or not. If the screening identified any results that clearly indicated that radioactivity above natural levels were present, further work using a more refined approach and more sophisticated equipment would be necessary.

4.2 Spatial Approach

The post-and-wire fences that formerly divided the site into a large number of small paddocks have been removed, so a new system of subdivision was formulated for the purposes of the survey which divided the site up into 22 zones of varying size and shape (see Figure 1).

The survey involved personnel walking out a set of parallel straight line 'transects' spaced 5 m apart, covering the whole area of each of the zones. As the personnel walked out the transects (at normal walking pace) the Geiger counters (see Section 4.3 below) were continuously held close to the ground surface (< 10 cm, or just above the ground surface as site conditions allowed, in line with the requirements of '*Detailed inspection of radioactive contaminated land under Part 2A EPA 1990: guidance for local authorities on visual inspection and limited surveys'*, United Kingdom Environment Agency, 2006) on poles, and the reading on the counter was continuously observed.

A spacing of 5 m between transects was judged as the optimal balance between coverage of the site (i.e. will have a reasonable chance of intercepting areas where radioactivity may have been applied within the paddocks, over the whole site footprint) and practicability of the survey.

The zones were clearly marked out with degradable spray-paint on the ground surface where necessary (i.e. where existing features could not be used as a guide) and the ends of all transects were marked out with coloured cones, to give the personnel a 'target' for walking out each transect. Using this approach, investigation areas of the site were consistently monitored with no bias or omissions in coverage.

4.3 Equipment

Type and Suitability

GMC-300E Geiger counters, manufactured by GQ Electronics in the United States, were employed for this survey. These are relatively simple and inexpensive instruments but suitable for the purposes of this survey (see Section 4.1). Even using more capable instruments may not have produced superior results as the counting efficiency of Geiger counters for gamma radiation is generally low due to the relatively low ionisation potential for gamma photons (compared to alpha and beta particles), but this is an unavoidable feature of this particular technology.

The counters displayed data for total radiation count (measured from the point the counters are switched on), instantaneous dose rate, and continuously-recalculated counts per minute (CPM). The CPM data was the focus of the survey.

These instruments did offer data recording and download capability, but given the very large survey area of even single zones, this capability was not utilised. This was because the flash memory capacity was limited and may not have been able to record complete data sets for continuous monitoring over total transects distances of several kilometres, and the download time required at the completion of each grid would be detrimental to the practicability of the survey, given remoteness from locations suitable for undertaking computer work during much of the survey.

In lieu of using data recording, the CPM was manually monitored continuously during all stages of the survey for 'significant readings' (see Section 4.4 below), with personnel making diligent notes of readings and all other relevant information.

Calibration and 'Bump Testing'

It was not possible to carry out a full calibration of the Geiger counters, but given the intention to carry out 'screening' of the site rather than take accurate point-measurements, it was not deemed necessary to be able to demonstrate the counters were fully calibrated to a standard that would be necessary for work involving the handling of concentrated radioactive sources, or equivalent.

In lieu of carrying out a full calibration, John Futter at the National Isotope Facility (NIC, part of Geological and Nuclear Sciences) in Lower Hutt agreed to give access to radioactive sources to check the responsiveness of the counters to elevated dose rates, using radioactive sources. Both of the Geiger counters used in the survey were placed in immediate proximity to a ^{60}Co radioactive source; the response was immediate and clear, with both instruments 'alarming' (giving an audio signal to warn of a potential radiation hazard) and recording count rates of several thousand CPM.

Comparison of the more accurate numerical readings given by more sophisticated instruments held by NIC for the same radioactive source indicated that the GMC-300E counters were responding in an over-sensitive manner (by a factor of approximately 4), which gave confidence of their suitability for detecting the much lower count rates likely to be encountered at the Wallaceville Site.

The responsiveness of the counters were observed with second radioactive source (containing americium-241, ^{241}Am). A similar positive response was observed, and the readings given by the GMC-300E counters concurred with the NIC instruments' readings much more closely (they differed by a factor of approximately 2). John Futter stated that this may indicate that the GMC-300E counters had undergone factory calibration using a ^{241}Am source.

Part of the feedback given by the UHCC-appointed peer reviewer was that it would be desirable to carry out 'bump tests' on the Geiger counters i.e. test if the instruments responded to a radioactive source at intervals during the field work, to ensure that the functionality of the instruments remained good.

Given the short timescales for survey preparation and implementation, it was not feasible to obtain a licence to handle radioactive sources for this purpose, so it was deemed practicable to use rock samples of a type likely to be enriched in Naturally Occurring Radioactive Materials (NORM) that may produce beta and gamma emissions detectable by the Geiger counters above background. Igneous rocks are the most likely to contain elevations of NORM so samples of andesite and gneiss (which is often composed of metamorphosed granite) were obtained for this purpose.

'Bump testing' was carried out using these samples during the second and third days of surveying, but a positive deviation in CPM from placing the rock samples next to the counters was not reliably obtained. Given the strong response observed during the testing of the instruments at NIC, this was attributed to the fact that the rock samples were likely not sufficiently radioactive to produce a signal (only a small proportion of igneous rocks form under conditions leading to significantly elevated levels of NORM), rather than a lack of responsiveness from the instruments.

4.4 Significant Readings

Background Readings

Background readings were taken at five different locations just outside the site boundary, providing a representative picture of the surrounds of the site (see Figure 1).

These locations, rather than locations at a greater distance from the site boundary, were selected because they would be unlikely to have been affected by any potential applications of radioactivity to the ground, but would also be continuous with local geological features. Natural variability in underlying geology could potentially affect background readings, so this approach reduced this influence to a minimum.

At each of the locations the counters were placed on a fixed position at the ground surface and allowed to measure continuously. The CPM figure was noted every minute for 10 minutes at each location. These 50 data points were then used to calculate a mean average CPM figure, and a standard deviation.

Identification of Significant Readings

The simple and well-established 'sigma' methodology was applied in assessing what constituted 'significant readings' in this survey. This methodology considers how many standard deviations above an established mean value (in a normal distribution) a reading is, with 'one sigma' (1 σ) being one standard deviation above the mean, and so on. Using this methodology, 1 σ corresponds to the 68th percentile of all the data points, 2 σ the 95th percentile and 3 σ the 99.7th percentile.

'Significant readings' in this survey corresponded to 3 σ due to the very high specific activity of ^{60}Co, i.e. if this artificial radionuclide was present in shallow soil even in low and / or dispersed quantities, it would be expected to produce count rates well outside the prevailing natural background.

Table 2: Background, Standard Deviation and *x* σ Data

Key Figure	CPM
Background Mean Average	18.4
Standard Deviation	4.1
1 σ	23
2 σ	27
3 σ	31

See Appendix 1 for the data and calculations underpinning the figures in this table.

Response to Significant Readings

All 2 σ and > 2 σ / < 3 σ readings were noted (count rate, location and any other potentially relevant information), but if ≥ 3 σ readings were encountered the surveyor immediately stopped walking out the transect and held the counter at the ground surface at the location the reading was noted, and immediately surrounding areas (within approximately 1 m of the point of interest).

If the count rate subsequently decreased (to the 2 σ figure or lower, and did not subsequently rise to the 3 σ figure again) within approximately 1-2 minutes, a note was made and the survey resumed, but if the CPM figure held steady at 3 σ (or greater) for 1 minute or longer, the location was to be immediately recorded with a coloured cone and marking with water soluble spray paint. A second set of passes over this zone would then be undertaken at right angles to the original 5 m-spaced transect at a spacing of 0.5 m, covering a square 25 m per side, centred on the area where the high readings were recorded.

If this secondary, high-intensity survey were to identify an area with consistently higher readings, potentially indicating residual concentrations of ^{60}Co in surface or shallow soil then it will have a GPS location recorded, will be marked with a stake in the ground, and representative soil samples will be taken from the surface and undisturbed depth (approximately 0.2 m below ground level) and sent for analysis

5 Results for Each Zone

Zone	Brief Description	Significant Readings	Other Notes
1	Small irregularly-shaped zone in the south-eastern part of the site adjacent to Trentham Racecourse land. Transects undertaken on east-west alignment.	No readings ≥ 2 σ.	No elevated readings recorded in the vicinity of the landfill to the east of the Zone (outside the site boundary).
2	Mid-sized irregularly-shaped zone in the southern part of the site adjacent to Trentham Racecourse land. Transects undertaken on east-west alignment.	2 readings > 2 σ / < 3 σ recorded: 2 x 29 CPM. In both cases the CPM figures were observed to decrease rapidly to levels below 'significant readings' during stationary observation.	No elevated readings recorded in the vicinity of the landfill to the south of the zone (outside the site boundary).
3	Large rectangular zone in the southern part of the site adjacent to Trentham Racecourse land. Transects undertaken on east-west alignment.	1 reading ≥ 3 σ recorded: 32 CPM. This CPM figure was observed to decrease rapidly to levels below 'significant readings' during stationary observation.	No additional notes.
4	Mid-sized triangular-shaped zone in the southern part of the site adjacent to the linear part of Trentham Racecourse. Transects undertaken on east-west alignment.	No readings ≥ 2 σ.	No additional notes.
5	Large rectangular zone in the south-eastern part of the site adjacent to Alexander Road. Transects undertaken on east-west alignment.	4 readings > 2 σ / < 3 σ recorded: 2 x 27, 28 and 29 CPM. In all cases the CPM figures were observed to decrease rapidly to levels below 'significant readings' during stationary observation.	No additional notes.
6	Large rectangular zone in the south-eastern part of the site adjacent to Alexander Road. Transects undertaken on east-west alignment.	No readings ≥ 2 σ.	Drainage ditches were present in the northern part of the zone, and necessitated partial subdivision of a number of transects.
7	Large irregularly-shaped zone in eastern part of the site adjacent to Alexander Road. Transects undertaken on east-west alignment.	4 readings > 2 σ / < 3 σ / ≥ 3 σ recorded: 2 x 27, 2 x 31 CPM. In all cases the CPM figures were observed to decrease rapidly to levels below 'significant readings' during stationary observation.	Drainage ditches were present in various parts of the zone, and necessitated partial subdivision of a number of transects.
8	Large rectangular zone in the western part of the site adjacent to the Wairarapa Railway and land undergoing residential development. Transects undertaken on north-south alignment.	No readings ≥ 2 σ.	No additional notes.
9	Large rectangular zone in the western part of the site adjacent to the Wairarapa Railway. Transects undertaken on north-south alignment.	No readings ≥ 2 σ.	No additional notes.
10	Large rectangular zone in the north-western part of the site adjacent to the Wairarapa Railway and the operational National Biosecurity Centre. Transects undertaken on north-south alignment.	2 readings ≥ 3 σ recorded: 2 x 34 CPM. In both cases the CPM figures were observed to decrease rapidly to levels below 'significant readings' during stationary observation. *See additional notes.*	The high readings encountered in this zone were noted to coincide with chimney smoke from nearby residences drifting over the technician undertaking the surveys. The CPM rose as the smoke was encountered, and was found to rise to the reading of 34 CPM if the counter was raised into the air. It is feasible that the smoke contained combustion products with low levels of entrained, naturally-occurring radionuclides, if fossil fuel

5 Results for Each Zone

Zone	Brief Description	Significant Readings	Other Notes
			products were being burned to produce the smoke.
11	Large irregularly-shaped zone in the southern-central part of the site adjacent to the linear part of Trentham Racecourse. Transects undertaken on north-south alignment.	5 readings > 2 σ / < 3 σ recorded: 4 x 27 and 28 CPM. In all cases the CPM figures were observed to decrease rapidly to levels below 'significant readings' during stationary observation.	The pit and adjoining rubbish pile at the north-eastern end of the zone was monitored for approximately 2 minutes. CPM varied between 17 and 20 CPM. The burning of wood and other rubbish had recently been undertaken, and parts of the rubbish pile were still smouldering at the time monitoring was undertaken.
12	Large rectangular zone in the central part of the site to the south of the forestry block. Transects undertaken on north-south alignment.	2 readings > 2 σ / < 3 σ recorded: 27 and 30 CPM. In both cases the CPM figures were observed to decrease rapidly to levels below 'significant readings' during stationary observation.	The spoil pile in the south-eastern part of the zone (possibly associated with one of the former disposal pits) was monitored for approximately 2 minutes. CPM varied between 20 and 24 CPM.
13	Large triangular-shaped zone in eastern-central part of the site adjacent to the linear part of Trentham Racecourse and Alexander Road. Transects undertaken on east-west alignment.	No readings ≥ 2 σ.	No additional notes.
14	Large rectangular zone in the eastern part of the site to the east of the forestry block and adjacent to Alexander Road. Transects undertaken on east-west alignment.	2 readings > 2 σ / < 3 σ recorded: 2 x 27 CPM. In both cases the CPM figures were observed to decrease rapidly to levels below 'significant readings' during stationary observation.	No additional notes.
15	Mid-sized irregularly-shaped zone in north-eastern part of the site adjacent to Alexander Road. Transects undertaken on east-west alignment.	5 readings > 2 σ / < 3 σ / ≥ 3 σ recorded: 27, 28, 2 x 29 and 31 CPM. In all cases the CPM figures were observed to decrease rapidly to levels below 'significant readings' during stationary observation.	Two of the higher readings (2 x 29 CPM) were noted to occur over the sealed (with tarmacadam) roadway in the area adjacent to the buildings in the western part of the zone. It is feasible that the tar content used in the tarmacadam was derived from fossil fuel products and so may contain localised areas of slightly elevated levels of naturally occurring radionuclides.
16	Mid-sized irregularly-shaped zone in the north-western part of the site adjacent to operational National Biosecurity Centre. Transects undertaken on east-west alignment.	3 readings > 2 σ / < 3 σ / ≥ 3 σ recorded: 2 x 27 and 32 CPM. In all cases the CPM figures were observed to decrease rapidly to levels below 'significant readings' during stationary observation.	The 32 CPM location was marked following stationary observation during the survey, and re-monitored approximately 1 hour later. Readings at the location were found to be only slightly elevated above the mean average background level.
17	Small rectangular zone in the north-western part of the site adjacent to operational National Biosecurity Centre. Transects undertaken on east-west alignment.	No readings ≥ 2 σ.	No additional notes.
18	Small irregularly-shaped zone in the north-eastern part of the site adjacent to Alexander Road. Transects undertaken on north-south alignment.	1 reading > 2 σ / < 3 σ recorded: 30 CPM. This CPM figure was observed to decrease rapidly to levels below 'significant readings' during stationary observation.	It was noted that several buildings shown on the aerial map have been removed; the footprints of the former buildings were however clearly visible. See photographs.
19	Mid-sized triangular-shaped zone to the east of the main site, between Alexander Road and the Rimutaka foothills.	3 readings > 2 σ / < 3 σ recorded: 28 and 2 x 30 CPM. In all cases the CPM figures were observed to decrease rapidly to levels below 'significant readings' during stationary observation.	No additional notes

5 Results for Each Zone

Zone	Brief Description	Significant Readings	Other Notes
	Transects undertaken on east-west alignment.		
20	Large rectangular zone in the south-eastern part of the site adjacent to Trentham Racecourse land and Alexander Road. Transects undertaken on east-west alignment.	4 readings > 2 σ / < 3 σ recorded: 4 x 27 CPM. In all cases the CPM figures were observed to decrease rapidly to levels below 'significant readings' during stationary observation.	No additional notes.
21	Large rectangular zone in the south-eastern part of the site adjacent to Trentham Racecourse land and Alexander Road. Transects undertaken on east-west alignment.	1 reading > 2 σ / < 3 σ recorded: 29 CPM. This CPM figure was observed to decrease rapidly to levels below 'significant readings' during stationary observation.	No additional notes.
22	Small rectangular zone in the far north-eastern part of the site adjacent to the junction between Alexander Road and Ward Street. Transects undertaken on east-west alignment.	No readings ≥ 2 σ.	This zone was not originally intended to form part of the survey, but it was added opportunistically due to its small size, ease of access, and potential for having previously been used as a paddock. Surface was partially sealed, partially compacted soil and partially open grassed soil.

6 Discussion and Conclusions

The surface radioactivity survey of the former "Wallaceville Animal Research Station" site at Ward Street, Upper Hutt involved the monitoring of all areas of the 68 hectare (divided into 22 separate 'zones') site formerly used as paddocks with a consistent methodology, using Geiger counters. The survey was intended to identify whether any areas of the site registered levels of radioactivity significantly above background, due to residual quantities of ^{60}Co remaining within the soil from 'top-dressing' and 'cobalt bullets' trials carried out when the research facility was active.

During the course of surveying the site CPM levels were observed to be elevated above the average measured natural background CPM level in a statistically significant manner (> 2 σ / < 3 σ or ≥ 3 σ) at a total of 39 point-locations scattered around 14 of the zones.

However, further scrutiny of each of the locations where these results were observed demonstrated that the high count rates did not persist; at each location the CPM level was observed to decrease below statistically significant levels, and then did not rise again to 'significant reading' CPM levels within a timeframe of approximately 1-2 minutes.

This behaviour is not consistent with there being concentrations of ^{60}Co present in the ground; if that were the case then the elevated CPM rate would be expected to be steady. Radioactive decay is a continuous process that doesn't vary in intensity up and down over short time periods; the only change will be the steady decrease in activity according to the half-life which in the case of ^{60}Co is 5.27 years, and hence would not be observable on the scale of minutes. The signal from a single radionuclide would not produce any interference or mixed readings as could be the case with several different nuclides present in the soil, and which could potentially give the appearance of varying count rate.

The ≥ 3 σ CPM figures that were encountered for brief periods of time (before dropping down to lower figures within 1-2 minutes) at several locations around the site are judged to be within the statistical variability of the natural background radiation levels at the site (from geologic or cosmogenic sources).

When the survey was designed it was judged that 50 datapoints would be sufficient to establish the natural background count rate for the site in a reliable and statistically robust manner. However, observation of the variability of the count rate during the course of the surveying indicates that the actual standard deviation of the background may be significantly more than that applied during the survey.

The CPM level ranged between 9-10 CPM in large areas of the site through to approximately 30-32 CPM at a number of the 'elevated reading' points (see Section 5). The fact that this range is larger than that recorded during the course of taking background readings lends support to the statistical variation at the site being large and the 'significant readings' actually being within that range, and most importantly that these elevated CPM rates were highly unlikely to be due to residual concentrations of ^{60}Co.

If more extensive background data (either at a larger number of spatial locations, or recorded over a longer period of time, or both) had been obtained then an appropriate standard deviation could have been applied, and any statistically significant figures may then have been more meaningful.

The testing of the counters with radioactive sources at the NIC indicated that they were overly sensitive to signals. As such, it is possible that some or all of the > 2 σ / < 3 σ or ≥ 3 σ events were 'false positives' and were not indicative of or proportional to actual radioactive emissions, whether part of natural background (i.e. naturally-occurring radionuclides in soil / rock), or otherwise.

Overall, it can be robustly concluded that the radioactivity survey carried out at the Wallaceville Site did not gather data to indicate that residual concentrations of ^{60}Co, either in dispersed form from 'top-dressing' of the paddocks, or from excretion of cobalt bullets by animals held within the paddocks, are likely to be present on the site.

The 5m-spaced transects and linear scanning (sweeping around each transect was deemed impractical with the equipment available) used in the survey are estimated to have systematically surveyed approximately 10-15% of the available soil area in the former paddock areas. The lack of significant readings indicates that the soils within the areas not directly surveyed are unlikely to contain a substantial number of point sources or large hotspots. If ^{60}Co is present on the site the data indicates that any residual radiation present is highly likely to be at a level which poses negligible risk to human health.

The findings also support the hypothesis that cobalt bullets were used only at the secondary Kaitoke Site, and not at the primary Wallaceville Site. This has been inferred from annotated photographic evidence found as part of the historical review which shows personnel using radiation detectors to search for ^{60}Co labelled bullets in the ground at the Kaitoke Site.

The Geiger counters used in the survey provided a continuous dose rate figure in addition to the CPM figure. The highest figure at the ground surface (not counting the anomalous readings obtained in Zone 10, see Table 2) was 32 CPM, which corresponded on the counters to a dose rate of 0.16 µSv/hr. Even if it were assumed that the counters were under-sensitive (testing at the NIC demonstrated that the opposite was in fact the case) by an order of magnitude (factor of 10; which would be very conservative) this would correspond to a dose rate of 1.6 µSv/hr / 0.0016 mSv/hr.

Taking the global average background radiation dose rate of 3.02 mSv/yr (United Nations, 2008) as applicable to New Zealand, this would correspond to approximately 0.35 mSv/hr / 350 µSv/hr. The radiation dose detected at the Wallaceville Site, even if attributable to residual ^{60}Co in soil, would therefore contribute approximately only an additional 0.5% of the natural background dose rate to a permanent user of the site. This also indicates that it is highly unlikely that there is an increased risk from any ^{60}Co at the site to the end users.

7 References

United Nations Scientific Committee on the Effects of Atomic Radiation (2008) UNSCEAR Report Volume 1, Sources of Ionising Radiation

United Kingdom Environment Agency (2006) Detailed inspection of radioactive contaminated land under Part 2A EPA 1990: guidance for local authorities on visual inspection and limited surveys

8 Limitations

i. We have prepared this report in accordance with the brief as provided. This report has been prepared for the use of our client, Wallaceville Developments Ltd, their professional advisers and the relevant Territorial Authorities in relation to the specified project brief described in this report. No liability is accepted for the use of any part of the report for any other purpose or by any other person or entity.

ii. The recommendations in this report are based on the ground conditions indicated from published sources, site inspections and subsurface investigations described in this report based on accepted normal methods of site investigations. Only a limited amount of information has been collected to meet the specific financial and technical requirements of the Client's brief and this report does not purport to completely describe all the site characteristics and properties. The nature and continuity of the ground between test locations has been inferred using experience and judgement and it must be appreciated that actual conditions could vary from the assumed model.

iii. Subsurface conditions relevant to construction works should be assessed by contractors who can make their own interpretation of the factual data provided. They should perform any additional tests as necessary for their own purposes.

iv. This Limitation should be read in conjunction with the IPENZ/ACENZ Standard Terms of Engagement.

v. This report is not to be reproduced either wholly or in part without our prior written permission.

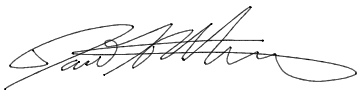
We trust that this information meets your current requirements. Please do not hesitate to contact the undersigned on 04 472 0820 if you require any further information.

Report prepared by

Nick King

Project Environmental Consultant

Reviewed by



David Robotham

Associate Environmental Consultant

FIGURE 1

Map of Zones, Background Measurement Points and Locations of Statistically Significant Readings

ENGEO
Expect Excellence

Date	July-15	**Client**	**Wallaceville Developments Ltd**		
Drawn by	CM	**Project**	**Wallaceville Submission Response**		
Approved by	DR	**Description**	**Zone Division & Background and Significant Readings Map**		
Scale	NTS	**Figure Number**	1	**Project Number**	11307

APPENDIX 1

Background Readings and Calculations

Location	Reading Number	CPM	Dose Rate (µSv/hr)
1	1	14	0.07
	2	15	0.08
	3	20	0.1
	4	19	0.1
	5	16	0.08
	6	18	0.09
	7	16	0.08
	8	21	0.11
	9	16	0.08
	10	20	0.1
2	1	21	0.11
	2	13	0.06
	3	14	0.07
	4	25	0.13
	5	20	0.1
	6	22	0.11
	7	19	0.1
	8	16	0.08
	9	25	0.13
	10	18	0.09
3	1	22	0.11
	2	15	0.08
	3	17	0.09
	4	20	0.1
	5	13	0.07
	6	17	0.09

Location	Reading Number	CPM	Dose Rate (µSv/hr)
	7	21	0.11
	8	18	0.09
	9	25	0.013
	10	21	0.11
4	1	21	0.11
	2	14	0.07
	3	24	0.12
	4	21	0.11
	5	17	0.09
	6	25	0.12
	7	24	0.12
	8	14	0.07
	9	23	0.12
	10	28	0.14
5	1	10	0.05
	2	17	0.09
	3	14	0.07
	4	15	0.08
	5	17	0.1
	6	18	0.09
	7	15	0.07
	8	18	0.09
	9	12	0.06
	10	23	0.12
Mean Average		18.4	0.095
Standard Deviation		4.1	0.021

Location	Reading Number	CPM	Dose Rate (µSv/hr)
1 σ		23	0.12
2 σ		27	0.14
3 σ		31	0.16

APPENDIX 2

Site Photographs (Note zones are only partially shown in some photographs)

Photo A: Background Reading (front of site)

Photo B: Background Reading (Zone 1)

Photo C: Background Reading (Zone 9)

Photo D: Background Reading (Zone 20)

Photo E: Background Reading (Zone 19)

Photo F: Zone 1

Photo G: Zones 2, 3 and 4

Photo H: Zones 4 and 6

Photo I: Zone 5, 6 and 7

Photo J: Zones 8 and 9

Photo K: Zone 10 (incl. Weather Station)

Photo L: Zones 11, 12 and 13

Photo M: Zones 14 and 15

Photo N: Zone 16

Photo O: Zone 17

Photo P: Zone 19

Photo Q: Zones 20 and 21

Photo R: Zone 22