Manukau City Council

MANUKAU
City Council

Assessment of Old Landfills

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GHD
MANAGEMENT
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GHD LIMITED
1st Floor, Merial Building, Putney Way, Manukau City
PO Box 760477 Manukau City
Telephone: 64 9 261 1400 Facsimile: 64 9 262 8340 Email: auckmail@ghd.co.nz

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			Name	Signature	Date
1	Ram Sharma	Ewen Skinner	Mark Goldsmith		30/06/00

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1. Background

Auckland Regional Council (ARC) has undertaken a review of the sanitary landfill operations throughout the region to ensure that all the necessary resource consents are in place. As part of this and with the assistance of territorial local authorities (TLA) throughout the region, closed landfills have also been evaluated. In this context Manukau City Council (MCC) produced an inventory of the historical landfill sites for its area.

Historical records revealed that 39 closed landfill sites existed within MCC owned property. Each site was evaluated to determine the potential for adverse environmental effects. A priority list of sites requiring further evaluation was generated for the MCC area.

In 1994 MCC began a programme of investigations to identify discharges of leachate and landfill gas from the old landfill sites that may be having an adverse effect on the environment, and where necessary and practicable to carry out remedial site works. In this regard, Manukau City is committed to finding longer term solutions to the closed landfills, and as far as possible eliminate associated risks to the general public in relation to health & safety and risks to the environment.

The programme includes carrying out assessments for each of the closed landfill sites; to elucidate which of the sites may require resource consents from the ARC. In the above context, and based on the agreed assessment criteria given below, this report has been prepared to identify Old Landfills that may require resource consents.

2. Assessment Criteria

In this report assessments of the Old Landfills have been carried out, based on agreed criteria between Manukau City Council and Auckland Regional Council. The key criteria are:

- Age of the landfill
- Type of fill
- Leachate discharge
- Proximity to water courses
- Hydraulics, water levels & rainfall
- Leachate toxicity risk factor

It was also agreed that assessments to evaluate the need for resource consents for the Old Landfills should be weighted towards assessment of environmental effects. This includes the assumption that the Landfill sites are public open spaces.

In meeting the above objectives, the following key issues were also considered to be part of the assessment process:

- Health and Safety of the General Public
- Structural Integrity
- Ecological Impacts
- Water Quality
- Sediment & Erosion Control
- Air Quality

The issue of land use and management were considered to be separate from the resource consent application process and as a consequence have not been included within this report.

3. Landfill Locations

The old landfill sites are located on MCC owned properties (with the exception of Miro Road site, which is owned by Te Puea Marae) and their names and road locations are listed below in Table 1. A map of each site is given in Appendix A of this document.

Table 1: Landfill Names and General Locations

No.	Landfill Site Name	Road Location & Suburb
1	Hills Rd	Hills Rd, Mayfield Park, Otara
2	Whitford Bridge	Whitford Road, Whitford Bridge Reserve, Whitford
3	Pah Rd	Papatoetoe Cemetery, Papatoetoe
4	Ngati Otara Park	Alexander Crescent, Ngati Otara Park, Otara
5	Riverina Ave	Riverina Ave, Pakuranga
6	Riverhills Park	Cnr Ti Rakau Dr and Gossamer Drive, Pakuranga
7	Leabank Park	Claymore Street, Manurewa
8	Miro Rd	Cnr Miro Road and Mahunga Road, Mangere Bridge
9	Dale Crescent	Dale Crescent, Pakuranga
10	Kingfisher Pl.	Kingfisher Place, Mangere
11	Coxhead Rd	Cnr Coxhead Road and Kohiwi Road, Manurewa
12	Oruarangi Rd	Oruarangi Road, Ihumatao
13	Gt. South Rd	Great South Road, South Bank, Otahuhu
14	Robert Allan Rd	Robert Allan Way, Pakuranga
15	Roscommon Rd	Cnr Roscommon & McGlaughlin Roads, Puhinui
16	Tiraumea Reserve	Tiraumea Ave, Pakuranga
17	Old Quarry Rd	Cnr Walmsely and Coronation Roads, Mangere
18	Udys Rd	Cnr Udys and Reeves Roads, Pakuranga
19	Norana Rd	Norana Ave, Favona
20	Ennis Ave	Ennis Ave, Pakuranga

21	Kiwi Esplanade	Kiwi Esplanade, Mangere Bridge
22	Riverhills School	Between Gossamer Dr & La Trobe St, Pakuranga
23	Millen Ave	Millen Ave, Pakuranga
24	Ti Rakau Park	Between Cortina Place & Ti Rakau Dr, Pakuranga
25	Harania Ave	Harania Ave, Favona
26	Botany Rd	Cnr Botany and Andrew Roads, Pakuranga
27	Tanners Rd	Tanners Road, Mangere
28	Clifton Rd	Clifton Road, Beachlands
29	Bairds Rd	Bairds Road, Otara
30	Riverlea Rd	Tamaki Bay Drive, Pakuranga
31	Harania Inlet	John Fletcher Drive, Favona
32	Beach Rd	Beach Road, Favona
33	Bells Rd	Bells Road, Pakuranga
34	Elm Park	Gossamer Dr, Pakuranga
35	Hilltop Rd	Cnr Hilltop and Redoubt Roads, Manukau Heights
36	Allenby Rd	Cnr Allenby and Great South Roads, Papatoetoe
37	Manukau Yacht Club	Kiwi Esplanade, Mangere Bridge
38	Mangemangeroa Bridge	Whitford Road, Whitford
39	Omana Park	Omana Road, Papatoetoe

4. History

The history of waste disposal in Manukau City, goes back to the period when the landfills were managed by former Manukau County Councils. Some of the former local authorities, which make up the present Manukau City Council, such as the Papatoetoe Borough Council, operated their own landfills. Papatoetoe Borough Council operated the Kohuora Crater landfill, but not for an extensive period of time. The Kohuora Crater landfill has been investigated and remediated separately.

Some sites have been considered and listed in previous reports but have since been found to be outside the scope of this investigation as they are in private ownership. These are Allens Rd, Point View Drive, Ruaiti Rd and Lukes Bridge.

The information available on the history of some sites is unclear. Further monitoring has been carried out on these sites to ascertain the extent of contamination and their effects on the environment. Furthermore, there are some sites, which have no recorded history of contaminated material or domestic refuse being dumped at them.

The relevant histories of individual sites are given with other respective information in Appendix E of this document.

5. Methodology

5.1 Preliminary Investigations & Screening

The investigations and monitoring carried out for this project were generally undertaken along the ANZECC (Australia and New Zealand Environment and Conservation Council) guidelines for contaminated sites. The methodology allowed for general screening investigations on all landfill sites, leading to more targeted and detailed investigations on those sites that required further work.

The order of investigations had been adjusted in some instances to suit resources, local conditions and assess potential environmental risks associated with individual landfills. For example, initial sampling was undertaken in waterways adjacent to many of the landfills. However this was largely discontinued after results showed that there were low concentrations of contaminants in these waterways.

As part of the preliminary investigations and screening process, the methodology also included Leachate Strength Assessment as described in the ESR report "The Assessment of Ground and Surface Water Contamination at Former Landfills, Manukau City" on the Manukau landfills (July 1996). Details of the ESR report has already been described in previous MCC reports to the ARC. Nevertheless, the monitoring data for bore (B) and surface (S) water samples are given for reference in Appendix B.

In brief, the leachate strength is based on the average concentration of a set of key indicators relative to their concentrations in a typical landfill leachate. The set of indicators chosen consists of iron, manganese, zinc and ammonia. The other analytes consistently measured throughout the monitoring process have been cadmium, chromium, lead and zinc.

For each landfill site the most representative sampling locations were selected by considering the nature of the sampling location, the concentrations at that location and the consistency of results. Results from tidal pools, estuaries and streams were found to be too diluted and variable. For this reason, the decision was made to consider only springs directly out of the landfill and groundwater bores, to evaluate the leachate strength.

For each landfill site, the concentrations of each of the key indicators were averaged between the sampling locations at that site and over samples taken at different times at any one sampling location. The result is a representative average concentration of each of the key indicators at that site.

These average values were then divided by the concentration of those analytes in a typical landfill leachate. This gives for the site, the relative strength of each of the indicators.

These percentages for the individual indicators were then averaged to arrive at an overall percentage. This overall percentage gives an indication of the strength of

the leachate from the site relative to the strength of leachate from an operating landfill.

The reason that the strength of the individual indicators are considered separately is that it allows easier identification of possible outlier results and other possible anomalies in the results.

Table 2 below illustrates the methodology for deriving the Average Leachate Strength Values for individual Landfill bore (B) and surface (S) water samples.

Using the concentration of indicators in an operating landfill does not necessarily give a good indication of the potential for effects. The potential for adverse effects of each of the individual indicators may vary considerably. It is recognised that the above methodology does not take into account, the varying potential for effects from each of the individual indicators.

Table 2: Examples of Leachate Strength Assessment

Site	Site Type	Fe %	Mn %	Zn %	NH4+ %	Leachate Strength	Average Strength
Oruarangi 1	B	10.84	6.69	0.24	0	4.44	
Oruarangi 1	B	7.53	0	0.08	0.1	2.57	3.51
Coxhead Rd	B	33.13	4.46	4.65	1.4	10.91	
Coxhead Rd	B	26.2	0	3.38	1.24	10.28	10.59
Elm Park 1	S	1.3	3.5	0.08	0.06	1.24	
Elm Park 1	S	231.93	0.51	0	0.93	77.79	15.91
Gt Sth 3	B	30.12	0	0.18	0.15	10.15	
Gt Sth 4	B	11.14	0	1.03	5.11	5.76	7.96
Coronation Rd 3	S	12.65	7.64	0.28	0.2	5.19	
Coronation Rd 4	S	8.13	5.73	0.01	0.29	3.54	
Coronation Rd 3	S	10.54	7.01	0.14	0.16	4.46	
Coronation Rd 4	S	9.04	5.1	0.01	0.27	3.6	
Old Quarry 3	S	13.86	5.1	0.12	0.12	4.8	
Old Quarry 3	S	0.63	2.23	0.06	0.04	0.74	
Old Quarry 7	B	15.96	0	1.83	0.02	5.94	
Old Quarry 3	S	25	0	0.06	0.1	8.39	4.58
Harania 4	S	0.54	0.48	0.2	0.02	0.31	
Harania 2	B	0.11	0.25	0.1	0.03	0.12	
Harania 3	B	1.45	8.28	0.06	1.58	2.84	
Harania 5	B	1.99	0.57	0.07	0	0.66	
Harania 2	S	0.25	1.27	0.17	0.36	0.51	
Harania 2	B	3.92	0	0.05	0.11	1.36	
Harania 3	B	37.65	0	0.15	1.22	13.01	
Harania 5	B	6.93	0	0.21	0.05	2.4	2.39

The method assumes that the potential for effects for each of the indicators is equal at the concentrations in the typical landfill and varies exactly in proportion to the concentration of the indicator in the typical landfill. This is known not to be the case. For example, iron does not have a significant adverse effect on the environment relative to its concentration.

Nevertheless, the leachate strength values are useful as one of the screening tools for determining which of the old landfills could be considered as not likely to have any significant adverse effect on the environment, public health and safety.

In general, the methodology for assessing the old landfills also included, site descriptions, which take into account the physical setting and history of development, landfill operations and closures. Wherever possible, attempts have been made to measure the discharges of the landfills to streams adjacent or passing through the sites, by sampling at monitoring points immediately upstream and downstream of the sites, and at springs that migrate from the best known location of the filled areas.

Some of the old landfills, which have no recorded history of contaminated material or domestic refuse being dumped at them (i.e. have primarily clean-fill), were considered to pose no significant risk to the environment. Hence, no leachate monitoring was considered to be necessary for these sites.

The preliminary prioritisation was based on data such as the landfill size, age, the type of fill and the sensitivity of the surrounding environment. Detailed information on individual landfills is given in Appendix E of this report. The methodology for evaluation included other key factors such as:

- landfill capping & ground cover
- landfill stability
- public health & safety issues
- landfill status - closed or operational
- landfill maintenance
- proximity to water courses
- landfill gas
- landfill odour levels

Table 3 below provides a list of landfills, which are considered to be of no significant risk to the environment or to public health and safety. This was established at an early stage of the investigations and hence as a consequence no detailed monitoring was carried out for these landfills.

Table 3: Landfills considered not to be of significant risk to the environment after preliminary assessments

No.	Landfill Site Name	Road Location & Suburb
15	Roscommon Rd	Cnr Roscommon & McGlaughlin Roads, Puhinui
16	Tiraumea Reserve	Tiraumea Ave, Pakuranga
18	Udys Rd	Cnr Udys and Reeves Roads, Pakuranga
19	Norana Rd	Norana Ave, Favona
23	Millen Ave	Millen Ave, Pakuranga
25	Harania Ave	Harania Ave, Favona
26	Botany Rd	Cnr Botany and Andrew Roads, Pakuranga
27	Tanners Rd	Tanners Road, Mangere
28	Clifton Rd	Clifton Road, Beachlands
29	Bairds Rd	Bairds Road, Otara
30	Riverlea Rd	Tamaki Bay drive, Pakuranga
31	Harania Inlet	John Fletcher Drive, Favona
32	Beach Rd	Beach Road, Favona
33	Bells Rd	Bells Road, Pakuranga
34	Elm Park	Gossamer Dr, Pakuranga
35	Hilltop Rd	Cnr Hilltop and Redoubt Roads, Manukau Heights
36	Allenby Rd	Cnr Allenby and Great South Roads, Papatoetoe
37	Manukau Yacht Club	Kiwi Esplanade, Mangere Bridge
38	Mangemangeroa Bridge	Whitford Road, Whitford
39	Omana Park	Omana Road, Papatoetoe

Following this initial prioritisation exercise undertaken in July 1995, boreholes were drilled on the higher priority landfill sites and groundwater quality assessments undertaken. Where relevant, surface water quality assessments were also carried out.

For these landfills the leachate monitoring was carried out to ascertain the levels of contaminants and their potential adverse impact on the environment. Table 4 below provides list of landfills where boreholes were drilled.

Table 4: Landfills where more detailed investigations were carried out including leachate monitoring

No.	Landfill Site Name	Road Location & Suburb
1	Hills Rd	Hills Rd, Mayfield Park, Otara
2	Whitford Bridge	Whitford Road, Whitford Bridge Reserve, Whitford
3	Pah Rd	Papatoetoe Cemetery, Papatoetoe
4	Ngati Otara Park	Alexander Crescent, Ngati Otara Park, Otara
5	Riverina Ave	Riverina Ave, Pakuranga
6	Riverhills Park	Cnr Ti Rakau Dr and Gossamer Drive, Pakuranga
7	Leabank Park	Claymore Street, Manurewa
8	Miro Rd	Cnr Miro Road and Mahunga Road, Mangere Bridge
9	Dale Crescent	Dale Crescent, Pakuranga
10	Kingfisher Pl.	Kingfisher Place, Mangere
11	Coxhead Rd	Cnr Coxhead Road and Kohiwi Road, Manurewa
12	Oruarangi Rd	Oruarangi Road, Ihumatao
13	Gt. South Rd	Great South Road, South Bank, Otahuhu
14	Robert Allan Rd	Robert Allan Way, Pakuranga
17	Old Quarry Rd	Cnr Walmsely and Coronation Roads, Mangere
20	Ennis Ave	Ennis Ave, Pakuranga
21	Kiwi Esplanade	Kiwi Esplanade, Mangere Bridge
22	Riverhills School	Between Gossamer Dr & La Trobe St, Pakuranga
24	Ti Rakau Park	Between Cortina Place & Ti Rakau Dr, Pakuranga

5.2 Standards & Guidelines

To assess the relative risks to the environment from landfill discharges, the leachate and water quality data obtained, are expressed as a ratio of the relevant standard or guideline.

Some of the contaminant guideline values used are those from the U.S. Environmental Protection Agency for the Toxic Characteristic Leaching Procedure (TCLP) Tests. Other guideline values, which are not given for the TCLP Test, are from the Australia and New Zealand Environment and Conservation Council (ANZECC) Guidelines for Fresh & Marine Water Quality. These ANZECC standards / guidelines have been developed as part of the national water quality management strategy for New Zealand and Australia.

Hence the standards / guidelines are considered to be relevant for use in the assessment of relative risks to the environment from discharges of the leachate.

5.3 Leachate Risk Factor (LRF)

To assess the level of risk to the environment from contaminants in landfill leachates, the basic principles used is similar to that used in the assessment of contaminants in drinking water for monitoring & grading of water quality. The methodology is simple and yet effective in comparing the level of contaminant in the leachate to the respective environmental standard or guideline.

For example, the drinking water standard (Drinking Water Standard of New Zealand 1995) for Boron is 0.3 mg /L. If the levels of Boron in drinking water supply is below 50% of the guideline value (i.e. less than 0.15 mg / L), then the **risk of contamination** is considered to be **not significant** and no regular monitoring is required for Boron.

On the other hand, if the level of Boron is measured at levels between 0.15 and 0.3 mg / L, then even though the contaminant level is below the guideline, the **potential risk** of contamination is considered to be significant and the monitoring must be carried out on a regular basis.

Of course if the contaminant level is above the guideline value then the water supply is in non-compliance and the risk to consumers from the contaminant is considered to be significant.

Similarly, as an example, the TCLP regulatory threshold level for Cadmium in landfill leachate is 1.0 mg / L. Hence concentration of Cadmium in the leachate at levels above 1.0 mg / L, would be considered to be of significant risk to the receiving environment. This would require regulatory consent for discharge of the leachate into the environment under specific conditions.

On the other hand, if the level of Cadmium is measured at levels between 0.5 and 1.0 mg / L, then even though the contaminant level is below the guideline, the potential risk of contamination is considered to be significant and the monitoring must be carried out on a regular basis. In such cases, a regulatory consent for discharge of the leachate into the environment may be required depending on other factors such as the sensitivity of the receiving waters and toxicity characteristics of the contaminant.

However, if the level of Cadmium in the leachate is below 50% of the guideline value (i.e. less than 0.5 mg / L), then the risk of any actual or potential adverse environmental effects is considered to be not significant and no regular monitoring is required. In this case there would be no requirement for discharge consent.

Hence the measured concentrations of contaminants in the leachate, are expressed as a ratio of relevant standard or guideline, to assess the relative risks to the environment from the landfill discharges. These ratios have been used as

part of the methodology in determining which of the MCC Old Landfills may require resource consent from the ARC.

It should be noted that the leachate risk factors (LRF) derived are only one of the key issues for consideration in deciding whether there is a need for resource consent. Other factors, such as relative significance of individual contaminants and sensitivity of the receiving environment may also be a key indicator as to whether resource consent for the specific landfill is required.

5.4 LRF Parameters for MCC Old Landfills

In case of MCC Old Landfills, five contaminant parameters have been used for calculation of the LRF. These parameters are Cadmium, Chromium, Lead, Ammonia-Nitrogen, and Total Nitrate levels. The criteria for selection of these parameters are based on the fact that:

- they are indicators of leachate toxicity to the environment and public health
- reliable standards or guidelines are available for these contaminants
- the borehole leachate data for these parameters were available for the assessments in this report

The LRF values obtained for the five individual contaminants are combined and expressed as a sum in Table 5 below. In terms of LRF, those landfill sites with relatively high values are highlighted and more detailed review carried out.

Note:

For ANZECC Guidelines (mg/L), allowance has been made for dilution factor of 100 times. This is necessary as these Guidelines are for levels in the receiving waters and need to be adjusted for comparable concentrations in the landfill leachate itself.

It should also be noted that the dilution factor in the receiving water is likely to be significantly greater with tidal influences at many sites.

The US EPA Guidelines are for levels in the landfill leachate in mg/L.

Combined LRF >5 - Significant.

Table 5: Calculation of Leachate Risk Factors for MCC Old Landfills

	Leachate Toxicity Risk Factors					
Landfill	Cd	Cr	Pb	NH_4 - N	Nitrate	Totals
Hills Rd	0.07	0.118	0.24	60	0.95	61.38
Whitford Bridge	0.01	0.058	0.236	0.64	0.49	1.43
Pah Rd	0.086	0.48	1.86	26	0.18	28.61
Ngati Otara	0.029	0.028	0.104	4.6	0.52	5.28
Riverina Ave	0.01	0.44	0.184	0.028	0.03	0.69
Riverhills	0.01	0.004	0.0086	0.72	0.04	0.78
Leabank		0.0138	0.0104	0.002	0.24	0.27
Miro Rd	0.027	0.6	0.74	6.4	0.14	7.91
Dale Cres	0.038	0.02	0.0172	7.4	0.02	7.50
Kingfisher Place	0.01	0.024	0.034	0.158	0.05	0.28
Coxhead Rd	0.01	0.014	0.11	1.26	0.03	1.42
Oruarangi Rd		0.007	0.0094	0.086	0.085	0.19
Great South Road	0.06	0.014	0.09	5.8	0.0017	5.97
Robert Allan Rd	0.01	0.0062	0.017	18.8	0.11	18.94
Old Quarry Rd	0.01	0.032	0.22	0.26		0.52
Ennis Ave	0.01	0.002	0.004	0.094	0.037	0.15
Kiwi Esplanade	0.01	0.14	0.4	0.138		0.69
Riverhills School	0.01	0.002	0.02	0.0036	0.0003	0.04
Ti Rakau Dr	0.01	0.0016	0.0148	0.058	0.042	0.13
Harania Rd	0.01	2.8	0.6	1.42	0.0061	4.84
Bairds Rd	0.01	0.006	0.04	0.054		0.11
US EPA Guideline	1.0	5.0	5.0			
ANZECC Guideline				5.0	10	

The concentration values used for calculation of LRF for each of the chosen parameters are based on worst case scenario. That is, using the highest measured concentration of the contaminant in any of the leachate sample obtained from the respective landfill.

5.5 Criteria for Application of LRF

For an individual contaminant, a LRF value of over 0.5 is considered to be significant in relation to **potential** adverse effect on the environment. Hence,

the combined LRF value for five contaminants would need to be over 2.5 to be considered as being significant.

Similarly, for an individual contaminant, a LRF value of over 1.0 is considered to be significant in relation to actual adverse effect on the environment. Hence, the combined LRF value for five contaminants would need to be over 5.0 to be considered as being significant. Clearly in these cases there is a key indicator that shows that resource consent may be required for discharge of leachate to the receiving environment.

Hence, the Maximum Acceptable Value (MAV) for combined effects of five contaminants is considered to be 5.0 (i.e. combined LRF values of the five contaminants).

In relation to landfills with LRF values between 2.5 to 5.0, they may or may not have any significant adverse effect on the environment. In these cases other factors, such as landfill size, type of fill, receiving environment, etc., have also been taken into consideration in assessing whether these landfills require any resource consent.

5.6 Consideration of Other Factors

The methodology for evaluation includes other key factors such as:

- landfill capping & ground cover
- landfill stability
- public health & safety issues
- landfill status - closed or operational
- landfill maintenance
- proximity to water courses
- landfill gas
- landfill odour levels

The process involved site visits and assessments based on above factors, of all MCC Old Landfills (39 in total). Other details of individual landfills are given in Appendix E of this report. A summary of the information obtained is tabulated in Section 8.2.

6. Sources of Information

Information for this report has been drawn from a variety of sources. This includes information on the history, location and extent of the sites, which has been largely obtained from the recollections of long serving council staff. Furthermore, such information has been supplemented in places by the memories of the public who either worked on some of the sites, or lived near them at the time of filling.

Another source of information has been through an article in local papers (Manukau Courier and Eastern Courier), that asked former employees and residents to contact a nominated staff member. This drew a number of responses and provided historical information about some of the old landfills.

Information about the catchments of various streams flowing through or close proximity to the landfills, has been drawn from MCC Stormwater Catchment Management Plans.

The underlying geological information for Coxhead Rd and Pah Rd has been drawn from the Geological Map of New Zealand for the Auckland urban area (Kermode L.0. 1992). The remainder of the information has been drawn from the Geological Map of New Zealand, 1:25000 (Industrial Series). The sheets used were Sheet N42/5 (Eden) L.O.Kermode & E..J.Searle 1966 DSIR, Sheet N42/6 (Howick) L.O.Kermode 1975, Sheet N42/8 (Mangere) L.O.Kermode 1966, Sheet N42/9 (Whitford)) L.O.Kermode 1986.

Background information for the Pah Rd site was supplemented by information from the "Preliminary Site Investigation for the South Auckland Cemetery", January 1995 by Pattle Delamore Partners Ltd.

Chemical analysis results, interpretation and some background information regarding leachates, have been obtained from the MCC "Old Landfill Leachates" report and subsequent reports prepared by Environmental Science and Research Ltd.

Information from Bore logs, with the exception of Miro Rd, have been obtained from the MCC "Landfill Drilling Logs" report prepared by Groundsearch EES. The bore hole logs for the three groundwater monitoring bores installed at Miro Rd have been prepared by Manukau City Council staff.

Information relating to visual assessments and descriptions of the existing site surface, observable contamination, site stability, risk to public health and safety, and maintenance of the Old Landfill sites, are based on site visits by relevant GHD consultant and Manukau City Council staff. These are discussed in Section 8 of this report.

7. Monitoring Data

7.1 Initial Investigations & Monitoring

The initial investigations involved surface water sampling only. Samples were taken at drains running through the sites, springs coming out of the sites and the adjacent surface water bodies.

Surface water samples were taken in two rounds between August and October 1994. Further surface water samples were taken in February, April and September 1995.

Both surface and groundwater samples were taken from selected sites in December 1995. A full round of surface and groundwater sampling was undertaken in March to May 1996, and October / November 1996.

Some of the old landfill sites may have an impact on nearby streams. These sites include:

- Riverina Ave
- Kingfisher Place
- Pah Road
- Robert Allan Park
- Hills Road-Mayfield Park
- Oruarangi Road
- Harania Ave
- Elm Park
- Bairds Road
- Coxhead Park
- Old Quarry Road

At each of these sites, upstream and downstream water samples were taken and analysed. The detailed analytical data is shown in Appendix C.

Review of the surface water sampling results indicated that generally the landfills had no significant impact on the contaminant levels in surface waters flowing over the landfills or those adjacent to the sites. A discussion of the individual analytical data is given in Appendix E.

7.2 Data for Priority Landfills

After the preliminary investigations and screening process, the high priority landfills were selected for the drilling investigation programme. Bores were drilled on the sites in December 1995 and February 1996. The testing programme was progressively refined as more knowledge was gained of the sites and the concentrations of substances being found at or around the sites.

Following the installation of groundwater bores, sampling was largely discontinued in all of the surface water sampling locations except the springs coming out of some sites. The environmental parameters that have consistently been monitored are listed below:

- Cadmium
- Chromium
- Copper
- Manganese
- Iron
- Lead
- Zinc
- Ammonia Nitrogen
- Total Nitrate
- dissolved oxygen
- pH
- electrical conductivity
- salinity
- temperature

Assessment on-site:

- odour
- clarity
- colour

Boron has been monitored for most of the programme. Nitrite, nitrate, nitrite + nitrate nitrogen and total nitrogen have all been measured at varying times.

The analytes initially monitored but discontinued following the first review were aluminium, arsenic, cobalt, mercury, molybdenum, nickel, phosphorus, sulphur, selenium and strontium. Potassium, magnesium, sodium and calcium were also measured but subsequently excluded.

The detailed analytical data is shown in Appendix B.

7.3 Groundwater Bore Location

The placement of the groundwater bores on the sites varied from site to site depending on the topography of the site, the location of surface water, the type of material found in the bores and whether they contained groundwater.

On many sites drilling was undertaken at many locations throughout the sites. Piezometers were installed only in those bores thought likely to provide good samples of the site groundwater and / or where it was thought likely leachate was being produced.

For those sites where groundwater was encountered above the bottom of the fill the piezometers were installed at the location(s) where it was thought most likely to intercept groundwater that has passed through the body of the fill. This is usually at the downhill end of the original profile prior to the placement of fill, through or close to the bed of former streams (prior to the placement of fill) and / or where the groundwater level is lowest. If the available information was inconclusive, piezometers were placed where the fill was deepest and at the downhill end of the current surface.

7.4 Sampling Procedures

Normal procedures have been followed regarding the cleaning of equipment to prevent cross-contamination of samples.

To ensure comparability of results, samples at any one site have been taken at the same time in the tidal cycle, at all marine and estuarine sites for different sampling rounds. (e.g. samples at Harania Ave would be taken within the time range of 1 to 2 hours before low tide). In most cases, the level of groundwater in the bores has been largely independent of the level of the tide.

At sampling locations other than in the sea, or in a flowing estuary or stream, the sampling site was prepared to ensure that the sample taken was as free from sediment as possible.

Where springs were sampled, the sampling procedure ensured that the water gathered was fresh spring water rather than water that had potentially been pooled at the site for some time. To achieve this all vegetation was cleared away from immediately around the sampling area and where necessary, the sampling location was dug out to remove any stagnant water and mud to allow flow of fresh spring water into the sampling location. The site was left to stand for a minimum period of one hour to allow settling of sediment before taking the water samples.

For bores which do not dry, the purging was continued until at least three well volumes had been removed before sampling. For bores that did dry, pumping was continued until the well was dry. The bore would then be re-sampled when the water level had recovered sufficiently.

For each sampling run, one field blank for both ground and surface water was taken per day.

For each sampling run, extra samples or replicates were taken for quality control purposes. This required that at least one sample was replicated, or 5% of the total number of samples, whichever was the greater, for both groundwater and surface water. Furthermore, one trip blank was taken per sampling round.

7.5 Subsurface Investigations

The drilling investigations commenced in August 1995 with three boreholes being dug on the Miro Rd (Te Puea Marae) site. Drilling was undertaken on Hills Rd, Ngati Otara, Whitford Bridge, Old Quarry Rd and Elm Park in December 1995. Bores were drilled on more of the sites in January 1996. A brief summary of the borehole results is presented in Table 6. A more detailed discussion of the local site conditions and the results is presented in the individual site reports in Appendix E of this document.

The landfill drilling logs have been presented to the ARC as part of previous report to the ARC. The site maps are presented as Appendix A of this report.

Out of the 'original' set of sites, bores were drilled on the greater priority sites. The priority for these sites was based on the preliminary prioritisation exercise undertaken in July 1995 and described above in Section 7.4 of this document.

The method of drilling used was by rotary auger on most sites. A hammer drill was used on Miro Rd and for part of the Oruarangi Rd site.

It is also noted that borehole and surface water samples were generally turbid and were not filtered prior to laboratory analysis. This is likely to provide higher contaminant values than that actually present in the soluble form. The contaminants bound to the suspended solids generally have low bio-availability. Hence the contaminant concentrations obtained are total levels in the sample and not just the soluble fraction. This issues adds to the worst case scenario methodology used for calculation of the LRF values in Section 5.4 of this report.

Table 6: Drilling Investigations Summary

No.	Site Name	No. of Bores	Refuse in #Bores	Gas (> 10% LEL) in #Bores	Ground water in #Bores	Ground -water Depth (m)	# Piezo's
1	Hills Rd	4	4	4	4	1.5	4
2	Whitford Br.	11	2	2	9	1.2	6
3	Pah Rd	3	3	0	3	2	3
4	Ngati Otara	3	3	1	3	1.2	3
5	Riverina Ave.	5	0	0	2	2	1
6	Riverhills Pk.	3	0	0	1	2	1
7	Leabank Pk	9	0	0	1	2	1
8	Miro Rd	3					3
8	Udys Rd	2	0	0	2	2.5	1
9	Dale Crescent	4	0	4	3	2	1
11	Coxhead Rd	4	3	1	2	2	1
12	Oruarangi	7	1	0	1	2.5 - 12.0	3
13	Gt. Sth Rd	4	4	1	2	5	4
14	Robert Allan	4	1	2	3	1.5	2
16	Tiraumea Ave.	3	0	0	1	1.7	0
17	Old Quarry	7	2	5	1	2.3	1
20	Ennis Ave.	3	1	0	0	-	1
23	Millen Rd	2	0	1	2	1.5	0
24	Ti Rakau Pk	7	0	0	3	2-3	1
25	Harania Ave.	5	1	0	5	1.2-2	3
34	Elm Park	6	0	0	1	1.6	0

8. Environmental Effects

The MCC old landfill sites have been investigated and indicative parameters monitored for a considerable period of time since 1994. This has also included physical observations, monitoring of contaminant levels in surface water samples and landfill leachates, particularly for signs of any significant effect on the environment and / or risk to the health of respective neighbouring communities. In this context a large collection of scientific data has been considered, assessed and presented as part of this report.

8.1 General Characteristics of the Landfills

The landfill sites are relatively young (< 40 years) and a large proportion of them are relatively small in size in terms of either volume of waste and/or ground area covered. The largest site under consideration, Hills Rd (Mayfield Park), is less than three hectares. Most sites are less than 0.5 hectare.

Many of the larger old landfill sites in Manukau have been covered over and are now used as open space recreational areas. Some of these open spaces are also used for contact sports. Many of the smaller sites are drainage or esplanade reserves. The main use of these sites is therefore for recreation or to provide a buffer area.

The history of the old landfill sites is varied. For example, Hills Rd, Ngati Otara and Pah Rd were operated as municipal refuse dumps. Whereas Miro Rd and Whitford Bridge, largely took materials from inorganic collections. But it is likely that household refuse would have been diverted to each of these sites on occasions. Many of the remaining sites reportedly took a mixture of materials ranging from clean-fill to illegal household refuse. For some sites it is thought that they took clean-fill only.

A majority of landfills were reclamations, such as in-fill of small stream gullies and banks or estuarine inlets. They are generally very low lying with nearly all of them being close to the coast. These sites themselves are mostly flat or gently rolling. Only the Mangemangeroa Bridge, Pah Rd, Kingfisher Place, Riverhills Park and Riverina Ave sites have steep side slopes.

8.2 Site Inspections & Assessments

There is no record of any of the landfills having a specifically engineered clay liner or base. Anecdotal evidence suggests that the landfills were established on top of existing ground. This has largely been confirmed by the drilling investigations. The landfills are generally underlain to a variable depth and with variable quality of silt or clay type medium and unknown permeability.

The integrity and value of this material as a seal is likely to be low. None of the landfills have a leachate collection system.

The sites, which are now recreational parks, have had cover but this was more to provide a physical barrier and contoured surface rather than designed to limit water ingress. The cover on the sites generally consist of reasonably permeable materials such as topsoil. There is no evidence that a specifically engineered clay cap has been placed over any of the sites.

All of the sites are covered with some form of grass with sporadic native and exotic trees. The majority of sites are well maintained by MCC Parks. A summary of site inspection report is given in Table 7.

Stormwater drains cross many of the old landfill sites in urban areas. Sewers also cross a few sites. Searches of records have shown that there are other utility services around the fringes of many sites, but they do not actually cross the sites.

There are residential or commercial buildings just beyond the edge of the filled area at the following sites:

- Riverhills School - houses
- Hills Rd - houses
- Ngati Otara - marae buildings and houses
- Great South Rd - commercial buildings
- Miro Rd - marae buildings
- Harania Rd - houses
- Kingfisher Pl. - houses
- Dale Crescent - houses
- Riverina Ave. - houses
- Riverhills Park – clubhouse

The sites, which are major recreational parks, have a positive visual impact on the environment in their present form. The rest of the sites are largely not visible to the public.