APPENDIX 3

Tier 2 Report

Clare County Council
Pilot Project on Risk Assessment on closed landfill sites

Exploratory Investigation on Whitegate Landfill
(Class A rated site from Tier 1 investigation)

(Exploratory investigation undertaken by Patricia O'Brien, Cathal Brodie, Tracey Duffy, Mary Burke)

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Appendix A: EPA COP Matrix for Moderate Risk and High Risk Unregulated Sites. (Matrix)

Appendix B: Surveillance monitoring data for Lough Allewnaghta

Appendix C: Observation logs of trial holes

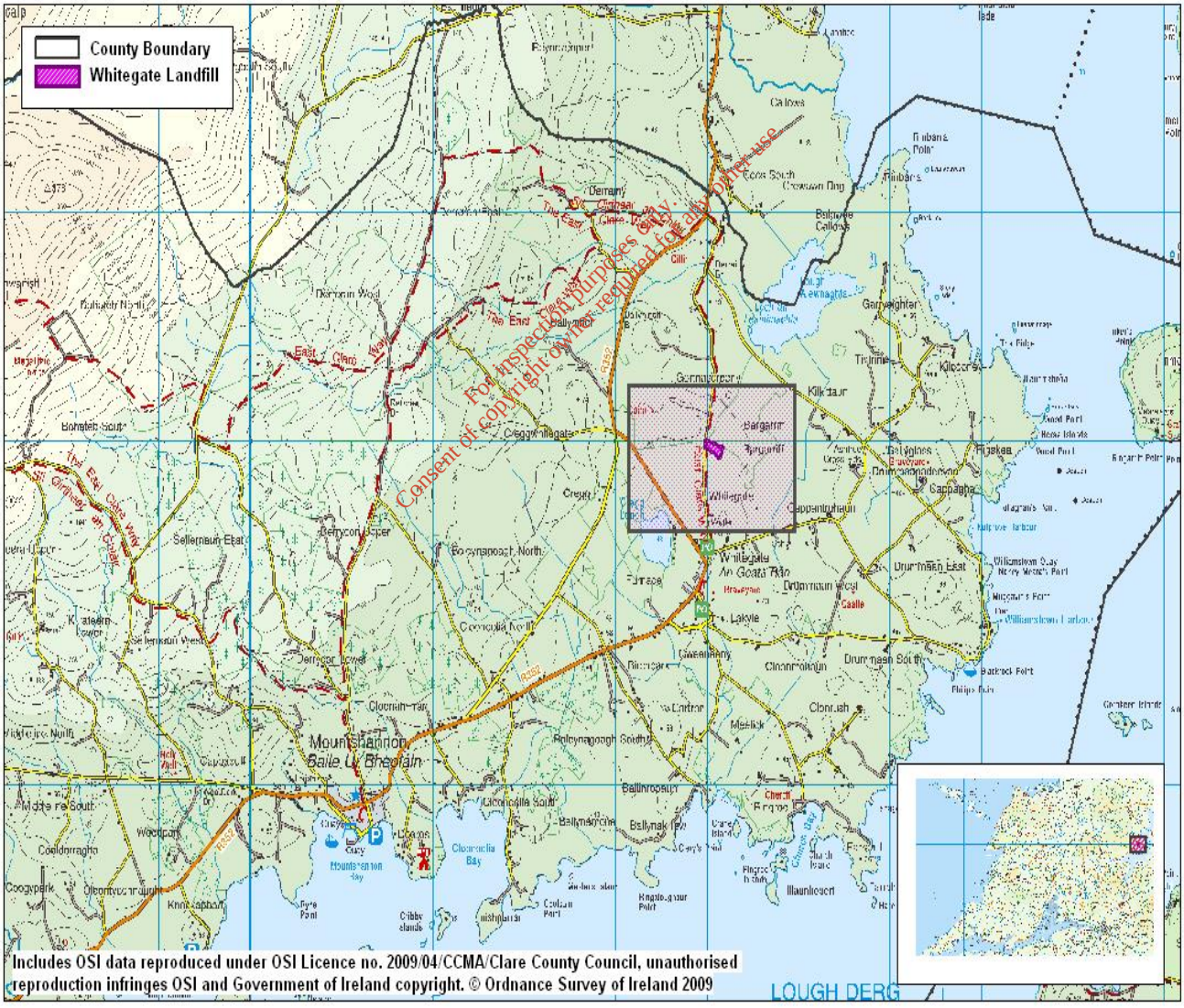
Appendix D: Photographs from Tier 2 Exploratory Investigation

1. Objective of exploratory investigation

The objective of this exploratory investigation was to determine the overall cost requirements for the full Tier 2 investigation, using the methodology recommended in the EPA matrix (see Appendix A). This exploratory work should enable the Local Authority to provide a costing for the Tier 2 investigation, and further develop the conceptual site model (CSM) for Whitegate landfill. The complete Tier 2 investigation needs to provide sufficient information to quantify the risks associated with the site, and (if necessary) determine an appropriate level of essential and technical measures to manage these risks.

2. Site Description

Figure 1 Location of Whitegate Landfill Site - County Clare



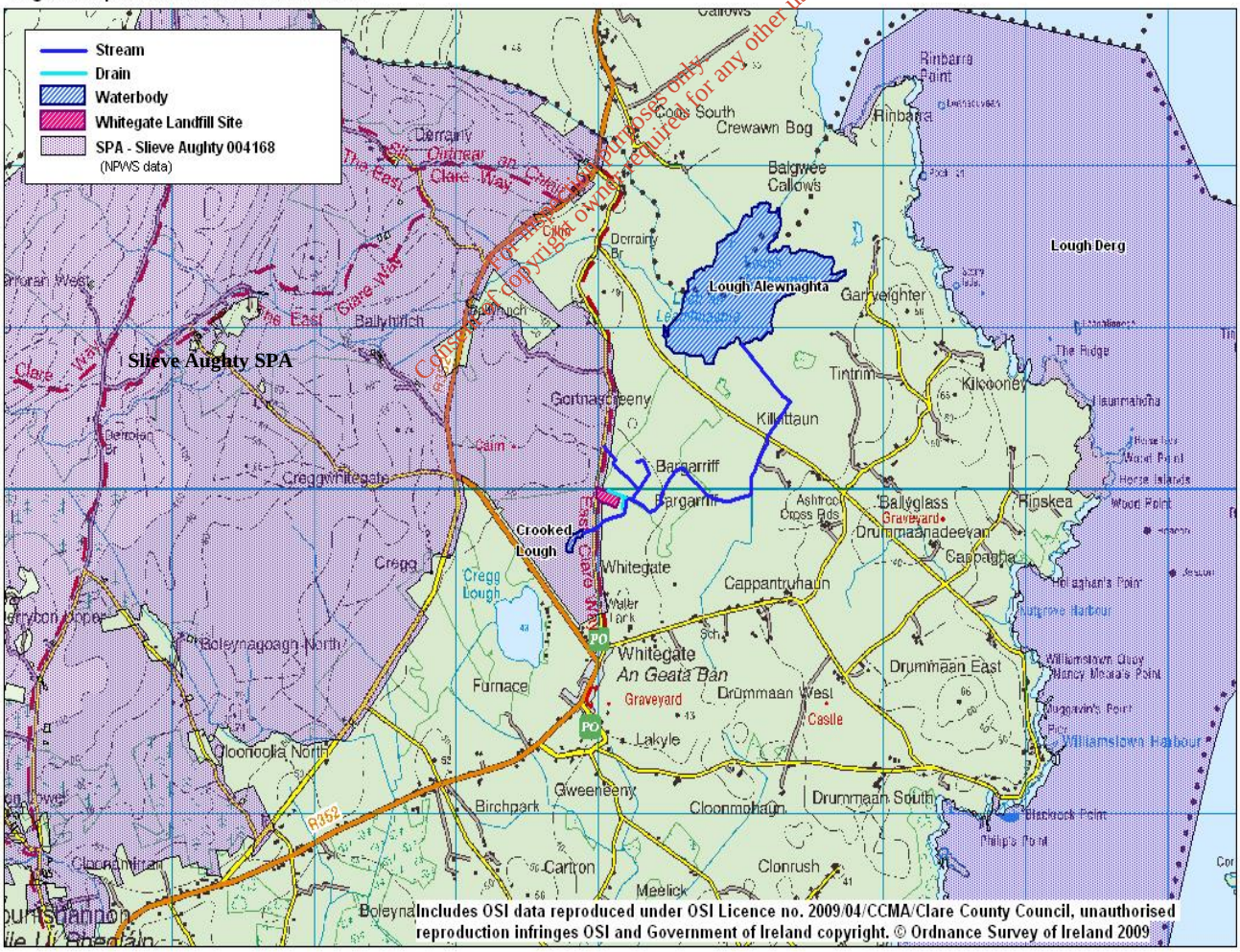
Whitegate landfill site is located on an 8 Ha site approximately 800m to the north of Whitegate village, off the R352 Scariff to Portumna road. The site is owned by Clare County Council. The lands are fenced off and are

densely covered with gorse. The landfill is bounded on all sides by forestry. On the western boundary of the site there is a local road access from Whitegate village. This road forms part of the East Clare Way, and rejoins the R352 approximately 2km to the north of the landfill. The nearest house is 600m north. The land slopes from west to east. Based on the initial exploratory work, the area of the site used for landfill is 1.19 hectares. This is based on land fill levels relative to surrounding land and trial hole data.

3. Tier 1 Assessment summary

Whitegate landfill site was rated as a Class A (high risk) site in the Tier 1 Risk Assessment, which was undertaken in accordance with the Code of Practice for Environmental Risk Assessment of Unregulated Waste Disposal Sites, EPA, 2007 (EPA CoP, 2007). The Tier 1 Risk assessment for the Whitegate site concluded that based on the SPR9 linkage between the landfill and the adjacent Slieve Aughty designated Special Protection Area (Site Code 004168**)**, via leachate migration through surface water. This assessment acknowledged that the SPA is located upstream of the landfill, and unlikely to be impacted by the landfill.

Figure 2 Special Area of Protection SPA



4. Scoping the Tier 2 Exploratory Site Investigation

This scoping exercise is based on the approach provided for the Tier 2 risk assessment methodology (set out in Chapter 5 of the EPA CoP, 2007 and the matrix entitled *EPA COP Main Site Investigation Requirements for Moderate Risk and High Risk Unregulated Sites* (See Appendix A).

The exercise also took account of

- Accessibility throughout the site to assess site area, waste depth and uniformity
- Vegetation status of the site,
- Ready availability of investigation techniques,
- Their probative value and flexibility (on site) in the time allowed for the works.

During the course of the exploratory works a potential SPR linkage was identified leading to re-assessment of the risk designation for the site. It is important to emphasise that the confirmation of risk classification can only follow a full risk screening exercise based on the information yielded in the full Tier 2 assessment.

Based on the Tier 1 assessment of waste depth (4 metres) it was decided that trial holes or trenches, using a track machine capable of providing holes to depth of 5 metres would be appropriate for the exploratory investigation and would enable an assessment be undertaken to address the questions posed in Section 5.2.1 of the EPA Code of Practice document. The main areas being addressed included the following:

- Scoping waste type, age and depth across the site
- Depth and composition of capping layers
- Leachate monitoring
- Sub soil assessment for thickness and permeability
- Water table level
- Potential for discharges to surface waters
- Potential for discharges to groundwater
- Collection of sufficient data to evaluate the SPR linkages and determine appropriate remediation if required.

5. Exploratory Site investigation

The exploratory site investigation was undertaken on November 5th 2009. There was no rain on the day, but there was significant rainfall in the area in the previous days, and ponding was evident on lands in the area. Four persons were deployed at the site throughout the day to provide for in tandem sampling of surface waters (including examination of streams for suitability for SSRS assessment), trial hole observation (capping, soil layers, waste type, depth and age and waste deposition area and water table levels), leachate sampling, and, assessment of wells in the area.

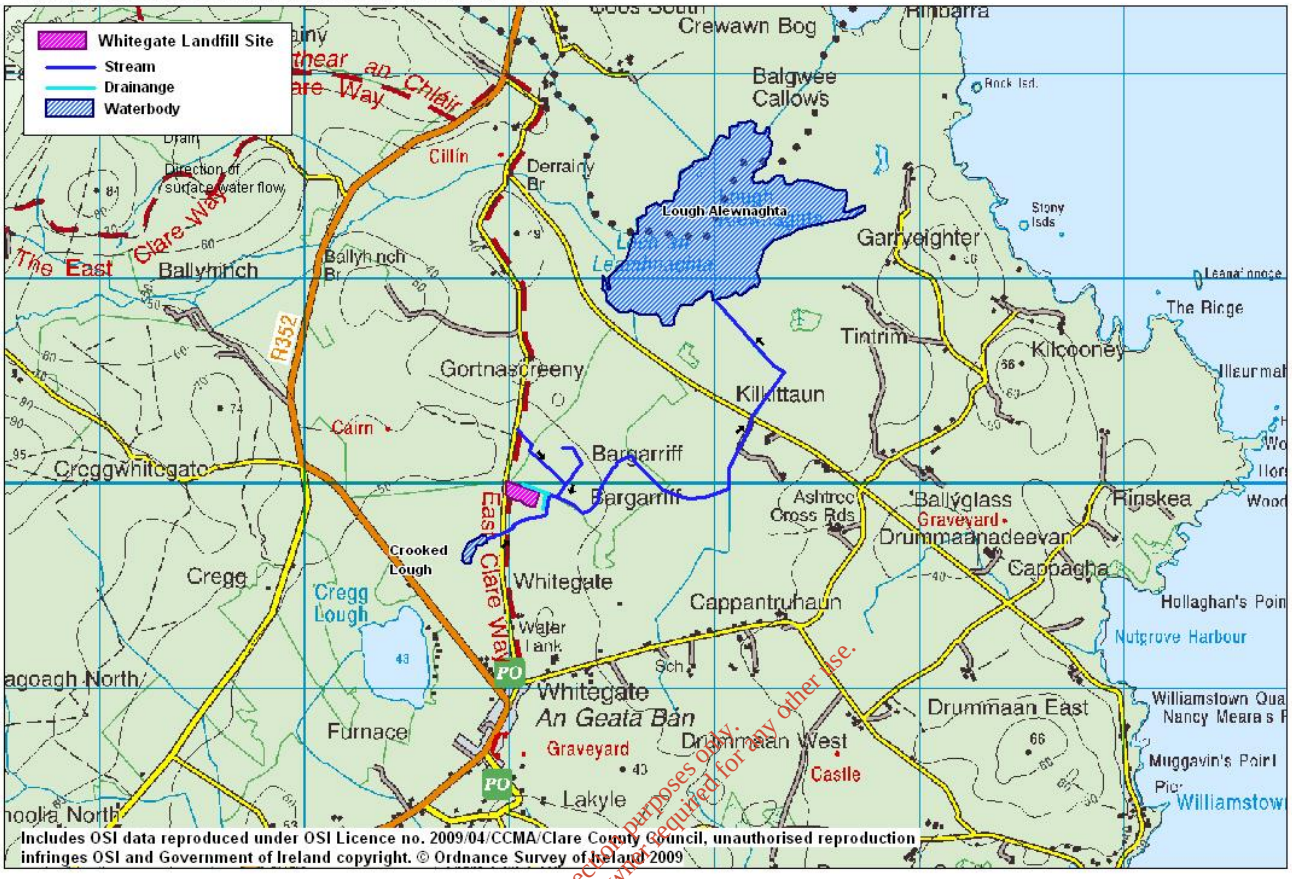
Safety considerations were also taken into account to ensure two persons were deployed at all locations on and adjacent to the landfill. One person undertook the well survey).

5.1 Physical Observations

- The landfill site is fenced off and difficult to access from either the road or the adjacent lands
- Surrounding lands are under forestry cover, which appear to be healthy and no evidence of areas of compromised growth were observed
- The site is covered with dense gorse growth and no evidence of compromised or unhealthy growth was observed
- Access over the site was very limited due to the gorse growth. This slowed the investigation as delays were inevitable while gorse was removed by the track machine to allow access for staff, and to create safe access routes around the site itself, and to surface waters around the site.
- The site presents as an elevated ridge which runs in a west to east direction across the site. This is consistent with the anecdotal evidence on landfilling practice at the site (based on filling from the western end or the site, tipping over the face of the landfill, followed by spreading with track machine and finally compacting)
- The difference between the ground levels adjacent to the site and the capped area of the landfill was of the order of 4-5 metres. A full level survey will be undertaken in the completed Tier 2 assessment. This level difference appears to be consistent with waste depths as established using trial holes, described hereunder. The reduction in ridge height at the eastern end of the site (from the elevated ridge back to the natural ground level) was noted and investigated by trial hole to confirm the absence of waste in the lower ground areas.
- There was no characteristic landfill odour in the vicinity of the site. Interviews with residents of the area confirm that there is no ongoing or incidental issue with odour arising from the site. (Odour was observed after the capping material was removed at the majority of trial holes, as noted hereunder)
- There was no ponding of water on the landfilled area, and storm water appears to move off the landfilled ridge into surface drains around the ridge.
- Deposited waste was not evident except on the ridge at the southern end of the site. Items of waste were either projecting through the cover material, or were completely visible.
- At the base of the ridge on its southern side, there were deep ponds into which some waste has either been deposited more recently (from fly tipping) or had fallen from the main body of the waste into the area over time

5.2 Local hydrology

Figure 3 Surface Water Drianage around Whitegate Landfill



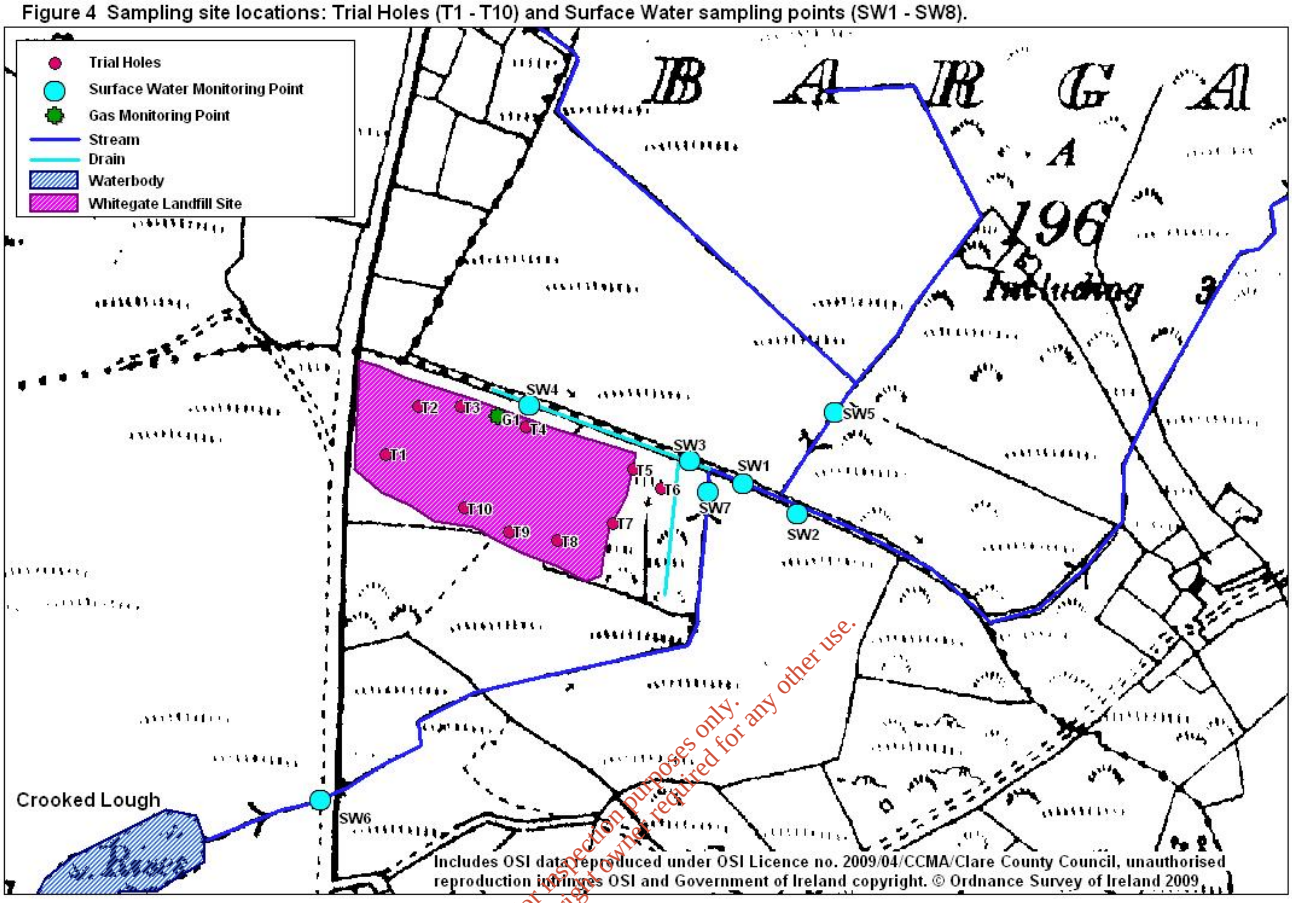
Surface and storm water flow around the site is generally in a west to east direction. Surface water features around the landfill site are marked on a map above. This shows the following features:

- Crooked Lough (wetland) lies approximately 250m to the southwest of the site (upstream of the landfill site).
- Cregg Lough lies 750m southwest and upgradient of the site. According to the river water body delineation made by the Shannon River Basin District Project there is no connection from this lough to the landfill site area.
- Lough Allewnaghta is approximately 1km to the northeast of the landfill. The surface water drains from the landfill boundary flow to Lough Allewnaghta via a first order stream.
- The northern boundary drain, which appears to be very slow moving, with max depth of 1 metre and maximum width 1.5m. The water in the drain was orange, and appeared to be impacted by leachate. This drain flows in a west to east direction along the line of the landfill site. This drain appears to be the main surface water connected with the water table and leachate in the main waste body.
- The eastern boundary drain, which probably receives flow from the water ponds on the southern boundary of the landfill (based on forestry drain connections and local topography). This drain is also fed from forestry drainage ditches. At the eastern edge of the landfill site the forestry drains showed some evidence of leachate impact.

5.3 Surface water quality.

Details of all sampling locations are marked on the surface water features map below.

Figure 4 Sampling site locations: Trial Holes (T1 - T10) and Surface Water sampling points (SW1 - SW8).



A surface water sampling program was designed to address the following areas:

- Compare upstream and downstream water quality, and determine whether significant impact has occurred
- Input further data in the Tier 1 SPR9 linkage to quantify the risk, based on the substances discharged and sensitivity of receptors
- Feed into the SPR linkages and ensure appropriate review of the SPR linkages generally
- Establish sites for future monitoring to assess future risk management measures
- Confirm the status of surface waters in the vicinity of the site, and the impact of the landfill site on these water bodies. Where possible analysis of nutrients and some anions (as defined in Table C.2 of the Landfill Manual-Tidy up reference) was undertaken by Clare County Council in the in-house laboratory. Metal and organic analysis was contracted to Alcontrol, with a standard turnaround time (10 days) for results. The turnaround time requested is a consideration for costing of the work in this project, as speedy turn around times will be more expensive, and could reduce the number of sampling points.

Water quality monitoring is undertaken on Lough Allewnaghta by the EPA, under a surveillance monitoring program associated with the Shannon River Basin Management Plan. (Results of this monitoring are attached in

Appendix C). Preliminary assessment of the analytical data for this water body does not indicate any discernible impact which could be associated with the landfill site.

Surface water samples were collected from 7 locations in the vicinity of the landfill site, as shown in Figure 4. Detailed analytical data for these samples will be included in the final report. In house laboratory results are presented in Table 1 on Page 10. Sampling point references SW1 to SW7 refer to the points marked on Figure 4. The sampling points SW5 and SW6 are both upstream of the landfill, but samples show low pH values (probably due to peaty soils) and associated low dissolved oxygen levels.

From these preliminary results, the samples taken at SW3 (the combined drains from the eastern and southern sides of the lanfill) and SW4 (from the northern boundary drain) indicate impact of leachate discharge to these waters. Until the full suite of results is available, it is premature to draw any conclusion from the data. It should also be stated that the data refer to one sampling round only. Grab sampling is best interpreted over time, when a sampling program reflects seasonal fluctuations in flow and associated assimilative capacity.

Figure 1: Surface Water Monitoring Results for samples taken November 5th 2009								
Parameter	**Units**	SW1	SW2	SW3	SW4	SW5	SW6	SW7
Description		D/S of landfill-boundary drain. (Down stream of landfill and can be compared with SW6)	D/S of landfill-boundary drain. (Down stream of landfill and can be compared with SW5)	(D/S of landfill-boundary drain -prior to streams entering the drain)	Boundary drain-mid drain	(Upstream location)	(Upstream location)	May be run off from landfill –can be compared with SW6
Time sampled	-	14:50	15:00	15:05	15:50	15:08	15:30	15:15
Appearance	-	Clear, straw yellow, no odour, No gross SS	Clear, straw yellow, no odour, No gross SS	Clear, straw yellow, no odour, No gross SS	Clear, straw yellow, no odour, No gross SS	Clear, straw yellow, no odour, No gross SS	Clear, straw yellow, no odour, No gross SS	Clear, straw yellow, no odour, No gross SS
Temperature	**°C**	9.4	9.2	9.4	9.5	9.8	9.2	9.4
Dissolved oxygen	**mg/l**	7.72	7.65	6.94	6.11	5.51	5.54	7.2
Dissolved oxygen	**%**	68.9	68	61.9	54.6	49.6	49.3	64.1
Ph	-	6.07	6.05	6.89	6.72	4.13	5.19	5.63
Conductivity	**µS/cm**	115	122	447	400	189	89	102
Total Suspended solids	**mg/l**	5	4	15	3	<2	<2	9
Ammonia	**mg/l**	0.288	0.349	4.233	2.725	0.339	0.120	0.044
TON	**mg/l**	<0.001	<0.001	0.068	<0.001	0.301	<0.001	<0.001
Nitrate	**mg/l**	<0.001	<0.001	0.074	<0.001	0.317	<0.001	<0.001
Nitrite	**mg/l**	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
BOD	**mg/l**	2	<2	4	<2	<2	<2	<2
COD	**mg/l**	103	102	26	16	104	115	105
Sulphate	**mg/l**	<0.5	<0.5	10.086	13.652	15.303	<0.5	<0.5
Chloride	**mg/l**	18.88	20.78	25.93	22.48	31.25	17.73	17.901
Ortho-phosphate	**mg/l**	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Fluoride	**mg/l**	0.017	0.017	0.043	0.049	0.037	0.016	0.023
Metals[1]	**Subcontracted (awaiting results)**							

1: Metal analysis included the following:
Toxic metals: Dissolved-As, B, Cd, Cr, Cu, Pb, Mn, Ni, Se, Zn, Hg.
Alkaline and Iron metals: Dissolved-Ca, Fe, Mg, K, Na
Unfiltered metals: Unfiltered-Cr, Phosphorus

5.4 Trial Holes

For the exploratory investigation, the use of trial holes or trenches were considered as the main approach to assess site capping, sub-soil depth as a geotechnical barrier, waste type, depth and age and waste deposition area, depth to water table and potential landfilling on bedrock or within the water table. This decision was based on time available to undertake the exploratory work, costs associated, and the level of information which would arise from the approach. This is consistent with the window sampling approach, outlined in the EPA COP matrix (See Appendix A). The locations of trial holes through the site is presented in Figure 4. Observation logs on each trial hole, and photographs are provided in Appendix C and D respectively, indicating depth of capping material, sub-soil layers (if evident), waste type, waste depth , possible waste age in each trial hole, and identification of landfilling within the water table.

After completion of the first three trial holes, it was decided to continue with trial holes at 50 meter intervals along the length of the site to define the waste deposition area. This decision was based on safety considerations and investigative value. The depth of waste established (between 4-5 metres) would be likely to render trenches unstable for a sufficient time window to undertake adequate observations and samples, without giving rise to serious risk to persons. An additional factor considered was the extent of run off arising from the disturbed leachate. This run off was observed from a number of trial holes for short periods during trial hole inspections. Minimal disturbance of leachate was considered to be the lowest risk approach to protection of local water courses. The following data was provided from the trial hole investigations:

- The area of waste deposition is 1.19 hectares.
- The maximum depth of waste deposited, based on trial hole detail is 4.8 m, (including capping)
- Waste is deposited at and below the level of the water table on the site
- In general there is some overburden above the bedrock, but the depth of overburden was not clearly established throughout the site. Decaying vegetative growth, consistent with the indigenous site vegetation (gorse) was noted below the waste deposited in several trial holes. This is obviously underlaid by some soil, but the depth of soil was not determined. This is a limitation of the trial hole approach where trail hole depth needs to address nature and depth of sub-soil below the waste volume. However, taking account of the water table level observed on the site, it would appear that the waste volume is in direct contact with groundwater, so that sub-soil investigation (for permeability) is unlikely to be an issue across the site.
- The more recent area of waste deposition is located at the eastern end of the site, but landfilling at the site appears to have taken place over the entire area of the site between 1994 and 1998.
- Significant volumes of leachate were encountered in trial holes number TH 3, 4, 5 and 8. Leachate samples were taken at trial holes TH 3,4,5 and 8 and their analysis is ongoing (see table 2 below) . Soil samples were taken from trial holes TH 1,2,3,4 and analysis of these will depend on the leachate results obtained in the coming weeks. Where soil samples were not taken this was due to the fact that the material in the trial hole was mainly waste, with no evident soil for sampling

- Groundwater movement in the overburden, (and associated leachate movement) appears to be from a south west to north east direction, based on observation of seeps in each trial hole
- Based on very preliminary observation of the level of the water table in the trial holes, and the level in the adjacent water course- it is likely that the leachate is in contact with and draining to surface waters
- Bedrock was reached in two trial holes, TH 1, near the western boundary of the site and TH 8 within a few meters of the southern boundary of the waste deposit area. No subsoil was observed between the waste deposited and the bedrock in TH 8. There was only minimal dispersed waste in TH 1.Overall discontinuity in the depth of soil on site? Potential lenses of higher permeability- can we rule these out?
- At the base of two trial holes TH 3 and TH 4 there was evidence of decomposing gorse vegetation, which suggested that there was no removal of soil or vegetation cover before landfilling. This could give rise to additional landfill gas volumes?
- Odour of landfill gas was clearly evident at Trial holes TH 2, 3, 4, 5, and 8.
- Some industrial waste was evident in the trial holes TH 4, 5, and 8. This was identified as probably coming from the Finsa facility as the waste was mainly chipboard, or chipboard products

From the perspective of characterisation of source of risk, the trial hole investigation was an extremely useful exploratory investigation tool. The approach allowed for assessment of cover material, waste depth, type and area of deposition, and for assessment of depth to water table. The sampling of leachate and (where present) sub soil was also enabled. Results of leachate analysis are set out in Table 2. A full suite of results will be available for the completed Tier 2 report.

Analytical leachate data available for the samples taken on November 5th 2009 are summarised below in Table 2. Detailed results will be included in the final report

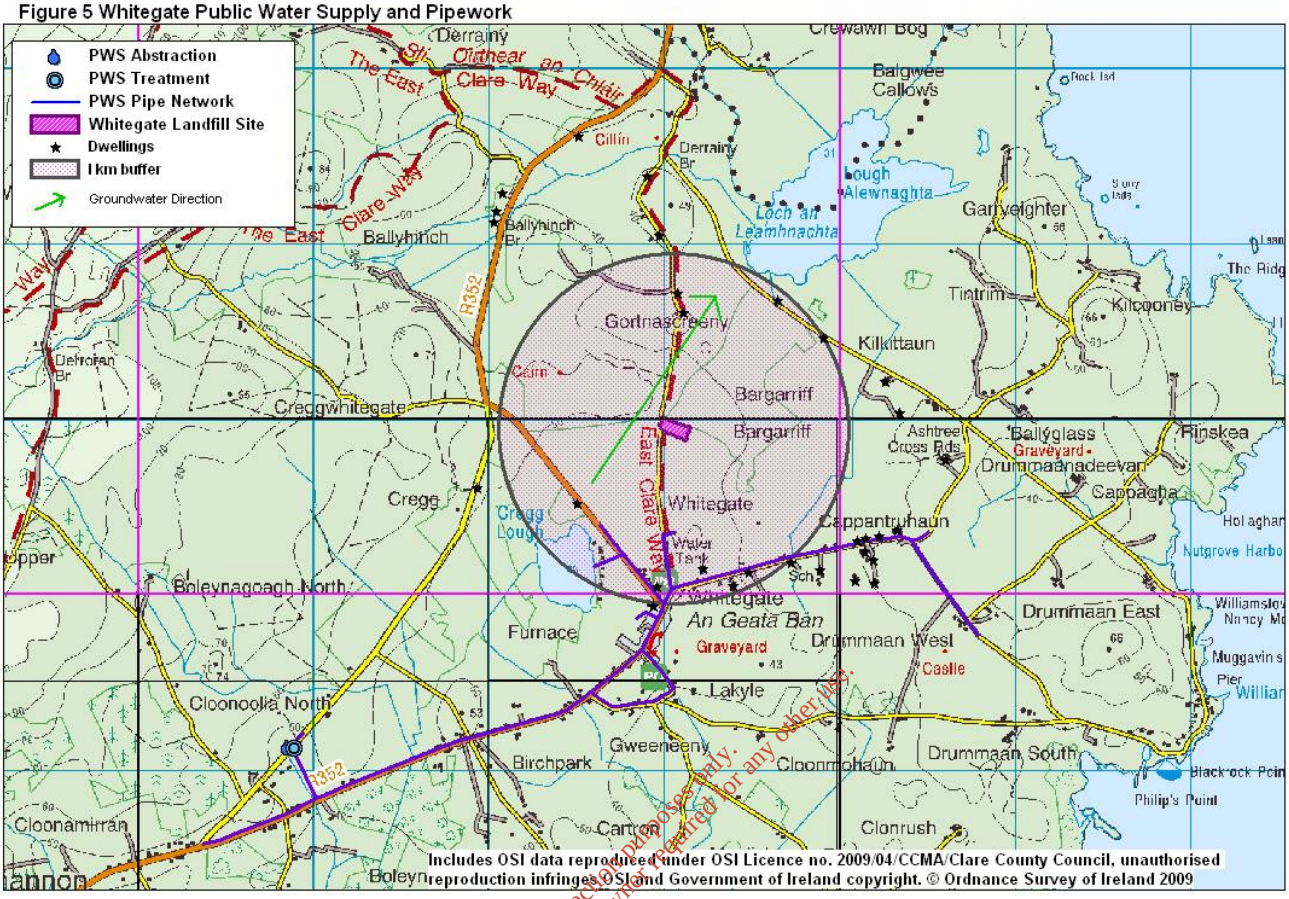
Table 2: Leachate Monitoring Results for samples taken November 5th 2009

Parameter	Units	Leachate 3	Leachate 4	Leachate 5	Leachate 8
Description		Taken from trial hole 3	Taken from trial hole 4	Taken from trial hole 5	Taken from trial hole 8
Time sampled	-	11:20	12:20	13:30	15:45
Temperature	**°C**	9.2	9.3	9.2	9.2
Ph	**Ph Units**	6.89	6.78	6.88	6.86
Conductivity	**µS/cm**	2400	2600	4000	2200
Total Suspended solids	**mg/l**	14,108	2,840	8,812	41,736
Ammonia[2]	**mg/l**	34.8	98.36	193.35	81.27
TON[2]	**mg/l**	<0.001	<0.001	<0.001	<0.001
Nitrate[2]	**mg/l**	<0.001	<0.001	<0.001	<0.001
Nitrite[2]	**mg/l**	<0.00025	<0.00025	<0.00025	<0.00025
BOD[1]	**mg/l**	15	80	186	36
COD	**mg/l**	349	831	1333	659
Sulphate[2]	**mg/l**	61.38	8.302	109.522	7.157
Chloride[2]	**mg/l**	72.89	222.40	70.81	43.96
Ortho-phosphate[2]	**mg/l**	<0.001	<0.001	<0.001	<0.001
Fluoride	**mg/l**	0.030	0.027	0.50	0.025
Cyanide	**Subcontracted (awaiting results)**				
Toxic Metals[3]	**Subcontracted (awaiting results)**				
Alkaline and Iron metals[4]	**Subcontracted (awaiting results)**				
Unfiltered metals[5]	**Subcontracted (awaiting results)**				
Anions[6]	**Subcontracted (awaiting results)**				
Trace organic substances[7]	**Subcontracted (awaiting results)**				

1.cBOD
2. Filtered sample through 0.45µm
3: Toxic metals (Dissolved-As, B, Cd, Cr, Cu, Pb, Mn, Ni, Se, Zn, Hg)
4.Alkaline and Iron metals (Dissolved-Ca, Fe, Mg, K, Na)
5.Unfiltered metals (Chromium, Phosphorus)
6.Anions (Total Alkalinity as Caco3, So4, Cl, Phosphate (ortho as PO4), F, Total Cyanide)
7. Trace organic Subs as VOC's target list by GC MS modified by US EPA 8260
SVOC's target list by GC MS modified by US EPA 8270
Organochlorine Pesticides suite
Herbacides-Atrazine and Simaz

Groundwater assessment

Figure 5 Whitegate Public Water Supply and Pipework



The Whitegate public water supply is from a spring source at Cloonoolia North, located approx. 1.76km southwest of the landfill site. The pipe line for this public supply is shown (by a purple line) on the map provided in Figure 5 above. A survey of the 1 kilometer radius around the landfill site indicates a number of dwellings using private wells. These wells are located due north and north east of the landfill site. The nearest house is 600 metres to the North of the landfill. However, based on the observations of surface water movement, local topography and movement of seeps in the trail holes it was considered that groundwater was likely to be moving from south west to north east. A well along this gradient was identified, at 0.9 kilometre distance due north east of the landfill. However, other significant anthropogenic pollution sources were also identified in the immediate catchment of this well. A large piggery is located within one kilometre metres of the well, as is a large dairy farm (both due south east of the well). No detail of well construction is available, other than the householder's indication that the well is 50ft deep. The householder indicated that well water quality is highly variable, and has recently installed an in-house treatment system (ion exchange resin). A sample of the well water prior to installation of the system was provided to the Council. The analytical data (one sample) indicates that the well water quality is poor, with elevated iron, manganese, colour, turbidity and ammoniacal nitrogen, but without coliforms. Analytical results on this sample indicate exceedence of MAC levels for ammoniacal nitrogen (List 2 substance). Based on the results provided by the householder, follow up sampling of both the untreated and treated water supply in the premises was undertaken on the following day (November 6th 2009). The preliminary results for the untreated well water

corroborate the ammoniacal nitrogen results. Additional monitoring of wells in the one kilometre catchment area will be progressed during the investigation.

Table 3: Well Water Monitoring Results.

Parameter	**Units**	**BHP sample (date 18/06/09)**	**CCC 6/11/09**		**Limit**	**Comment**
			Pre treatment	**Post treatment**		
Colour	Hazen	800	-	-	20	
Turbidity	NTU	285	-	-	10	
AmmoniumNH_3	mg/l	3.16	3.628	0.283	0.23	
Anions[1]			Subcontracted-results to follow		-	
Metals[1]			Subcontracted-results to follow		-	

1:Toxic metals (Dissolved-As, B, Cd, Cr, Cu, Pb, Mn, Ni, Se, Zn, Hg)
Alkaline and Iron metals (Dissolved-Ca, Fe, Mg, K, Na)
Unfiltered metals (Chromium, Phosphorus)
Anions (Total Alkalinity as Caco3, So4, Cl, Phosphate (ortho as PO4), F, Total Cyanide)

Direction of groundwater flow will need to be confirmed by further investigation. No other data on baseline groundwater quality is available for the area. The Whitegate public supply source is located in excess of 2 kilometres upgradient of the site, and apparently in the same bedrock aquifer.

A hydrogeological investigation to establish groundwater quality (upgradient, within and downgradient of the landfill) and flow direction associated with the landfill site should be included in the full Tier 2 assessment. A suitable plan of wells (including well depth and construction) and a sampling program needs to be established before this SPR linkage can be fully assessed. This should determine the radius of influence of the landfill, hydrogeologic separation of the aquifer from the activity, and bedrock water quality. However, it is may not be possible to undertake a full assessment in the time frame of the pilot project (before December 2009). A pragmatic assessment of the data arising from samples taken during the pilot project may enable a provisional assessment of the SPR 3 linkage. The hydrogeological assessment needs to address

- Groundwater flow direction
- Groundwater flow volumes
- Groundwater quality
- Radius of influence of the landfill in groundwater
- Travel time for migration of leachate to groundwater or a potential receptor
- Potential decay of contaminants over time, or during their movement through overburden

5.5 Landfill gas

Cover material on the landfill consists of relatively impermeable material which is well consolidated. Attempts were made in several locations to introduce a searcher bar to assess landfill gas across the site. One round of monitoring was undertaken in the mid section of the site. Other attempts to penetrate the cover material using the searcher bar were not successful.

Results of the sample taken at G1 (between T3 and T4 - see marked on Figure4):

Table 4: Landfill gas sampling results on 5/11/09	
Gas	**% V/v**
Methane CH_4	12.2
Carbon dioxide	4
Oxygen	0
Pressure	1000mBar

6. SPR linkages

6.1 SPR 9 linkage to Special Protected Area

Source: The waste type, depth and area were established during the exploratory investigation. Non hazardous municipal waste appears to comprise the main volume of deposited material, with significant levels of black plastic (presumably arising from agricultural sources). Some limited amount of timber processing waste was observed (probably from the Finsa facility in Scariff, but this company operated an on-site landfill, so volumes of waste coming to the Whitegate landfill would be very limited. An estimated volume of waste material was provided from the exploratory investigation.

Pathway: The movement of leachate into surface waters by is the pathway identified for any potential hazardous substances dissolved in water. The topography of the site, preliminary level observations and observations on movements of water /leachate in the trial holes suggests that the movement of a contaminant plume is likely to be towards surface waters located around the site on the northern and eastern boundaries. Preliminary results of analysis of surface water samples indicates elevated ammoniacal nitrogen in the northern boundary drain (see SW4 location on Figure 4), which suggests a link between leachate in the overburden and the adjacent surface water drain. Preliminary results of analysis of the downstream surface water sample (at SW2 location in Figure 4) suggests that this impact is local. Further downstream data from Lough Allewnaghta does not indicate any perceptible impact from the landfill on surface water.

Receptor: The Whitegate landfill site categorised as a high-risk site in the Tier 1 assessment because of its proximity to a the Slieve Aughty Special Protection Area (Site Code 004168). The site is of national importance for hen harrier pairs and merlin (both Annex 1 species), and for Red Grouse (Red listed species). The highest SPR linkage score obtained in the Tier 1 assessment was for leachate migration through surface water to a protected area (SPA). The theoretical impact on the protected site is due to potential for surface water contamination from

leachate. However, the protected site is located to the west of the site, upstream of the direction of surface water flow. Preliminary analysis of the surface waters adjacent to the site has been undertaken , and indicates some contamination of these waters. Sampling of the surface waters (SW1 to SW7) as described in Section 5.3 above, and analysis based on Table C.2 of the Landfill Manual (EPA publication) has been commenced. Results of this investigation are pending. It remains for an ecologist to comment on the extent which could give rise to a threat to the conservation objectives or conservation status of any species in the special protection area.

6.2 SPR 3 linkage to private wells

Source: As for 6.1 above

Pathway: The groundwater vulnerability rating for the site is "high" and the aquifer category is Pl (generally unproductive except in local zones). Sub soils mapped for the area indicate Slieve Aughty peats (to the east and north east of the site) and Puckane-Slieveragh Complexes (to the north of the site), as indicated in Figure 6.. These sub-soils would generally provide protection for the underlying aquifer. No evidence of removal of sub-soil during landfill was noted. Sandy sub-soil at the base of some trial holes suggests that preferential pathways may exist for movement of leachate through indigenous overburden on the site. This would probably favour movement into surface water rather than groundwater, due to the low permeability of the bedrock (Old Red Sandstone). The groundwater vulnerability is rated as "high" at the site location itself, but moderate in the adjacent areas (See Figure 7) . This is indicative of depths of greater than 3 metres of subsoil. The area was mapped and intensively surveyed in the latter years of the 1990s. In Trial Hole TH 8, closer to the western boundary of the site, bedrock was encountered at the base of the trial hole. All other trial holes indicated a depth of decaying vegetative material, below the landfilled material (which appeared to be typical of the indigenous gorse growth throughout the site). This suggests a graded depth to bedrock across the site, broadly in a west to east direction. To evaluate the SPR9 linkage anr investigation is required to determine the radius of influence of the landfill in groundwater and hydrogeologic separation of the aquifer from the landfill activity

Receptor: There are private wells within the 1 kilometre radius of the site. Preliminary investigation of water quality in an (apparent) downgradient well has given rise to concern due to elevated levels of ammoniacal nitrogen. A more complete investigation of the wells within the 1 kilometre catchment will be undertaken in the project. In any event, based on the information arising from the trial hole assessment of the site, there is a direct discharge[1] of leachate to groundwater at the site. Consideration of the presence of private wells within the 1 kilometre radius around the site makes a hydrogeological investigation imperative for the full assessment of the risk status of the site. The SPR3 linkage cannot be assessed without further hydrogeological investigation.

1. Direct discharges are "*the introduction into groundwater of substances in Lists I or II (or pollutants) without percolation through the ground or sub-soil*

Figure 6 Soil Type overlay on OS 50K

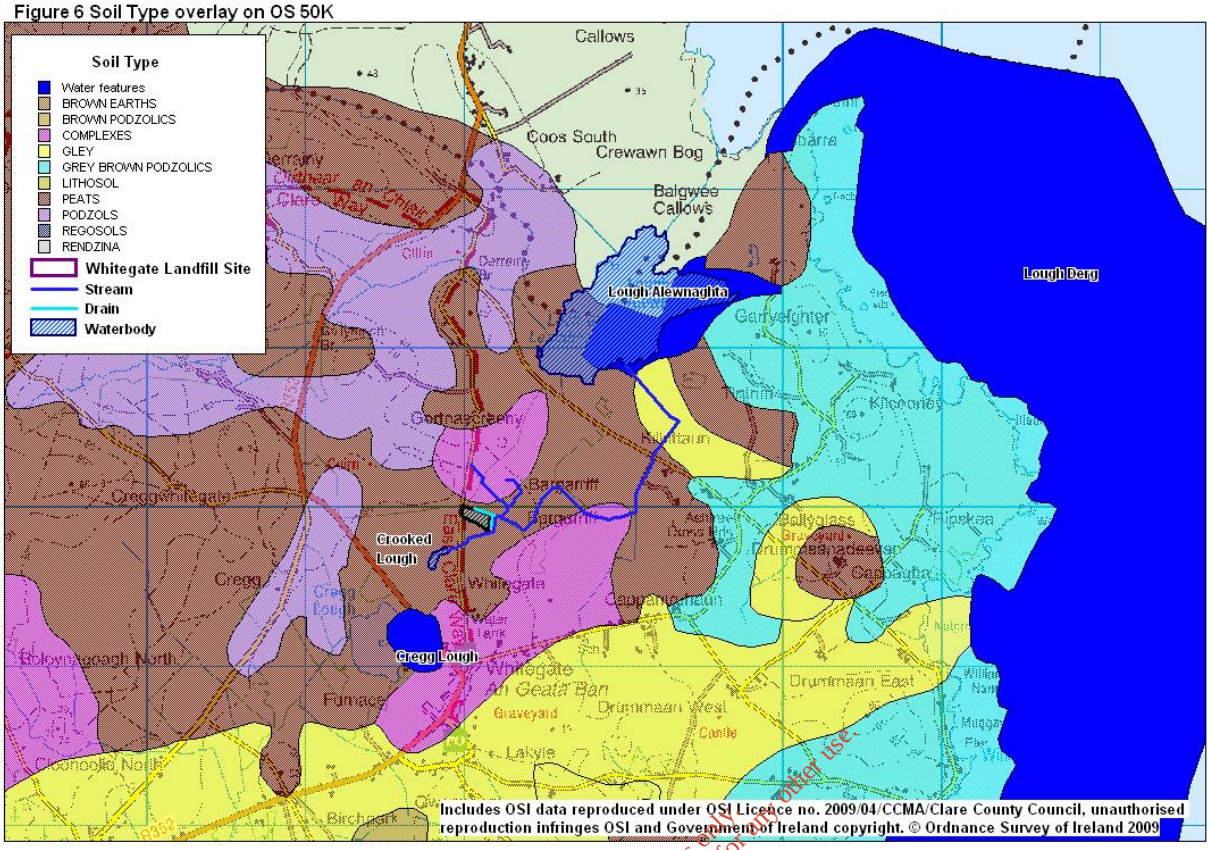
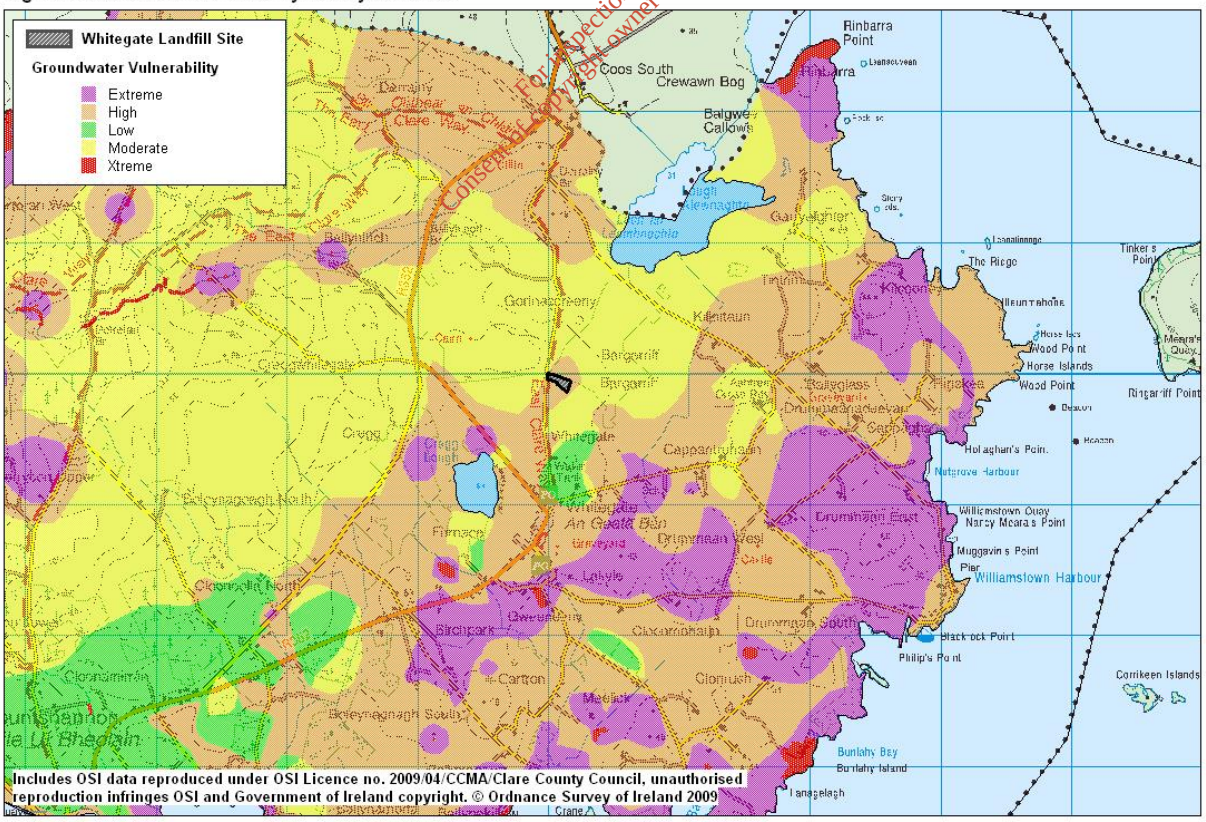


Figure 7 Groundwater Vulnerability overlay on OS 50k



7. Check list of questions from Section 5.2 of the EPA Manual for High Risk sites

Waste type and age across the site: Has been assessed

Depth of waste: Has been assessed

Depth and composition of capping: Has been assessed

Leachate monitoring: Has been undertaken

Sub-soil thickness and permeability: Has not been assessed

Bedrock type: Old Red Sandstone

Aquifer type and groundwater flow regime: Pl, flow regime estimated, not validated

Establish groundwater trigger levels: Need upgradient well, and based on the presence of private wells in the area, trigger levels will be based on Drinking Water MAC values

Location and hydrological setting of surface water drainage, including details of levels and flows; see Section 5.3 for local hydrology and sampling. Assimilative capacity and flow not assessed

Surface water classification: Not feasible due to season and SSRS not suitable for peaty substrate

Ecological survey: Ecological advice required regarding impact of dissolved substances in water on receptors

Requirements of compliance points to be defined for monitoring (including landfill gas, surface water, leachate, groundwater): To be decided at end of Tier 2

Are the data that were used in the CSM and risk screening exercise valid and accurate? Yes,

Is there a need for specialist input? Hydrogeologist and possible ecologist (as outlined above)

Is there biodegradable or hazardous waste present? Biodegradable (probably) Yes, but well degraded.. Hazardous waste-Not evident in trial holes examined throughout the site. No sources of hazardous waste in the landfill catchment

What is the potential for landfill gas migration? Considered low potential due to the site being surrounded by water and saturated peaty subsoils. Interview with local people indicated no odour issue in the area

Is there a natural geological barrier in place? Probably yes, but not fully assessed due to depth of waste

Is there possibility of direct discharge to groundwater? Yes

What is the degree of connectivity between surface water and groundwater? Probably high

Are there impacts evident? Yes, based on physical observations, early results of monitoring events. Await full suite of results from sampling rounds undertaken on November 5th 2009.

What remediation measures are required? Not yet decided until Tier 2 is completed

Have any remediation measures been put in place and have they been effective. Some capping.

8. Conclusion

Based on the exploratory site investigation, and preliminary results of surface water, leachate and well water samples, it is not possible to confim or break the tentative SPR3 and SPR9 linkages (as described above) without further investigation. The proposed investigation will include the development of appropriate boreholes to define the source of groundwater contamination in the area and assess any potential pathway between the landfill site and receptor sites. The investigation will also assess any potential impact of surface water discharges on the

conservation objectives of the Slieve Aughty SPA and associated protected species. Costs associated with the proposed full Tier 2 investigation are outlined in Section 9 hereunder.

9. Costing for completion of Tier 2 assessment

Using matrix of costs provided for the project, a revised cost estimate is set out hereunder:

Item	Lower estimate	Higher estimate	Cost per item
Trial pitting (2 days)	€1000	€2000	€1500
Drilling (5 GW wells, 2 OB wells)	€7500	€9000	€8250
Leachate testing (per sample) 4 samples	€400	€575	€475 **€1900**
Groundwater monitoring (2 DW,5 BR, 2OB wells)	€225	€350	€275 **€2475**
Surface water samples (7 samples)	€250	€375	€300 **€2100**
Soil samples (3 samples)	€400	€575	€475 **€1425**
Topographic survey	€900	€2000	€1500
Reporting	€2000	€4000	€3000
Ecological survey	€4500		€4500
Hydrogeolist survey	€2000		€2000
Gas monitoring	€700		€700
Total projected cost estimate			**€29,350**

Appendix A

EPA CoP Matrix for Moderate and High Risk sites

Appendix B

Surveillance monitoring data on Lough Allewnaghta

Appendix C

Observation logs on trial holes at Whitegate site

Appendix C

Trial hole profiles.

Trial Hole Number	**1**
Grid Coordinates	E174998; N189951
Depth to bedrock	2.2 metres
Capping composition	200mm of rubble and topsoil
Waste observations	800-1000 mm of mixed refuse, plastic,bottles and cans.
Subsoil	Clean sandy subsoil at 1 m depth, no staining, sand colour
Leachate	None
Water table	None
Odour	None

Trial Hole Number	**2**
Grid Coordinates	E175017; N189979
Depth to bedrock	4.2 metres
Capping composition	300-500mm of impermeable subsoil and rubble
Waste observations	A lot of black plastic at about 1.5m bgl. Also, bottles and some furniture and a small car engine or similar
Subsoil	From 2.5m down the material consisted mainly of stained sand and some rubble, with plastic intermingled.
Leachate	None
Water table	None
Odour	Land fill gas smell on breaking through cover material.

Trial Hole Number	**3**
Grid Coordinates	E175042; N189979
Depth to bedrock	Bedrock not observed
Capping composition	500-700 mm of impermeable subsoil and rubble
Waste observations	Refuse extended to 4.8m at which point underlying peat was encountered. The waste consisted of bottles, a number of oil drums or similar containers. Some animal medicine bottles and newspaper with July 19th 1993 date.
Subsoil	From 2.5m down the material consisted mainly of stained sand and some rubble, with plastic intermingled.
Leachate	Leachate present and sampled
Water table	Groundwater entered the hole from the SW corner at a depth of 4.5m bgl.
Odour	Land fill gas smell on breaking through cover material.

Trial Hole Number	**4**
Grid Coordinates	E175081; N189967
Depth to bedrock	Bedrock not observed at 5.0m
Capping composition	500-700 mm of impermeable subsoil and rubble
Waste observations	Refuse extended to 4.8m at which point. Waste similar to TH3, with chipboard and sawdust at 1.5m blg. A newspaper dated April 1994 was taken from the spoil..
Subsoil	Underlying peat was encountered at 4.8m blg
Leachate	Leachate present and sampled
Water table	Groundwater entered the hole from the SW corner at a depth of 4.5m bgl.
Odour	Land fill gas smell on breaking through cover material.

Trial Hole Number	**5**
Grid Coordinates	E175140; N189931
Depth to bedrock	Bedrock not observed at 4.5m
Capping composition	700 mm of impermeable subsoil and rubble
Waste observations	Trial hole was at the tip of the ridge on the eastern side of the site. Refuse consisted of a high percentage of black silage plastic and bale wrapping. There was also some chipboard, a fridge, bottles and small quantities of domestic refuse. A best before date of August 1998 was observed on a crisp package. Refuse extend to the full depth of the hole.
Subsoil	No subsoil encountered
Leachate	Leachate present and sampled
Water table	No observation of seepage, waste sitting in leachate/water mix
Odour	Land fill gas smell on breaking through cover material.

Trial Hole Number	**6**
Grid Coordinates	E175161; N189931
Depth to bedrock	1.8m to bedrock
Capping composition	Not applicable
Waste observations	This trial hole was at the base of the ridge on the eastern side of the site and apparently marks the NE boundary of the landfill. The profile consisted of 1m of sand and rubble followed by 0.8m of peat above bedrock. There was no evidence of refuse
Subsoil	1m of sand and rubble, with peat beneath, extending to bedrock at 1.8m blg
Leachate	No leachate
Water table	Some water at base of hole, appears to be surface water ingress from nearby drain
Odour	None

.

Trial Hole Number	**7**
Grid Coordinates	E175132; N189910
Depth to bedrock	1.5m to bedrock
Capping composition	Not applicable
Waste observations	None
Subsoil	Sand and small boulders. Sand colour
Leachate	No leachate
Water table	None
Odour	None

Trial Hole Number	**8**
Grid Coordinates	E175099; N189900
Depth to bedrock	3.0m to bedrock
Capping composition	Similar to TH4
Waste observations	Waste content was similar to TH3 and TH4., with some plywood type sheeting present. A domestic wrapper had a 1997 best before date
Subsoil	1m of sand and rubble, with peat beneath, extending to bedrock at 1.8m blg
Leachate	Leachate sampled
Water table	Water flow into hole from SW direction within the waste deposit
Odour	Noted

.

Trial Hole Number	**9**
Grid Coordinates	E175071; N189905
Depth to bedrock	Not encountered
Capping composition	Limited
Waste observations	This hole was dug at the base of the slope adjoining the wet marshy area. The area was probed with the digger to determine if refuse was present. This ridge appears to be the extent of the land fill on the SW side. Some refuse appears to have spilled down the slope and in to the marshy area. Car battery noted at surface level
Subsoil	None observed
Leachate	Mostly surface water in the area
Water table	
Odour	None noted

Trial Hole Number	**10**
Grid Coordinates	E175044; N189919
Depth to bedrock	Not encountered
Capping composition	Limited
Waste observations	Partially down the Southern ridge. Refuse present. The embankment tapers down to the marsh which adjoins the Southern boundary. This slope can be taken as the extent of land-filling on the south/south west side.
Subsoil	None observed
Leachate	Mostly surface water in the area
Water table	
Odour	None noted

Appendix D

Photographs from Tier 2 Exploratory Investigation

Clare County Council
Pilot Project on Risk Assessment on closed landfill sites

Exploratory Investigation on Whitegate Landfill
(Class A rated site from Tier 1 investigation)

Close out of Tier 2 Risk Assessment.

(Exploratory investigation undertaken by Patricia O'Brien, Cathal Brodie, Tracey Duffy, Mary Burke)

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Addendum to Tier 2 Investigation Report- Whitegate Landfill

Arising out of the Tier 2 Exploratory Investigation, two possible SPR linkages were identified. A potential SPR 3 linkage due to vertical and horizontal groundwater migration of leachate impacting on a private well, and an SPR 9 linkage due to leachate contaminated surface water impacting on a protected area adjacent to the old landfill. To examine these linkages further specialist surveys were required, the results of which are discussed below.

1.0 SPR 9 linkage to Special Protected Area.

The exploratory investigations determined that the adjacent protected area (SPA Site Code 004168) was located hydrologically up stream of the old landfill and that there was no possibility of a direct hydrological connection. The other potential connection between the old landfill and the protected area was through the feeding habits of the birds, particularly protected Annex 11 species, which are included in the site description. A desk top ecological survey was undertaken by Conservation Services and Biosphere Environmental Services to assess the likely impact of the landfill on these protected species, namely the Hen Harrier and the Merlin. The report, which is attached in full in Appendix 1, identifies three potential pathways whereby leachate contamination might significantly impact on the adjacent SPA. .

1. Direct movement via groundwater
2. Direct movement via surfacewater
3. Contamination of bird and other biota in the SPA via food chains based on contaminated flora/fauna downstream of the landfill.

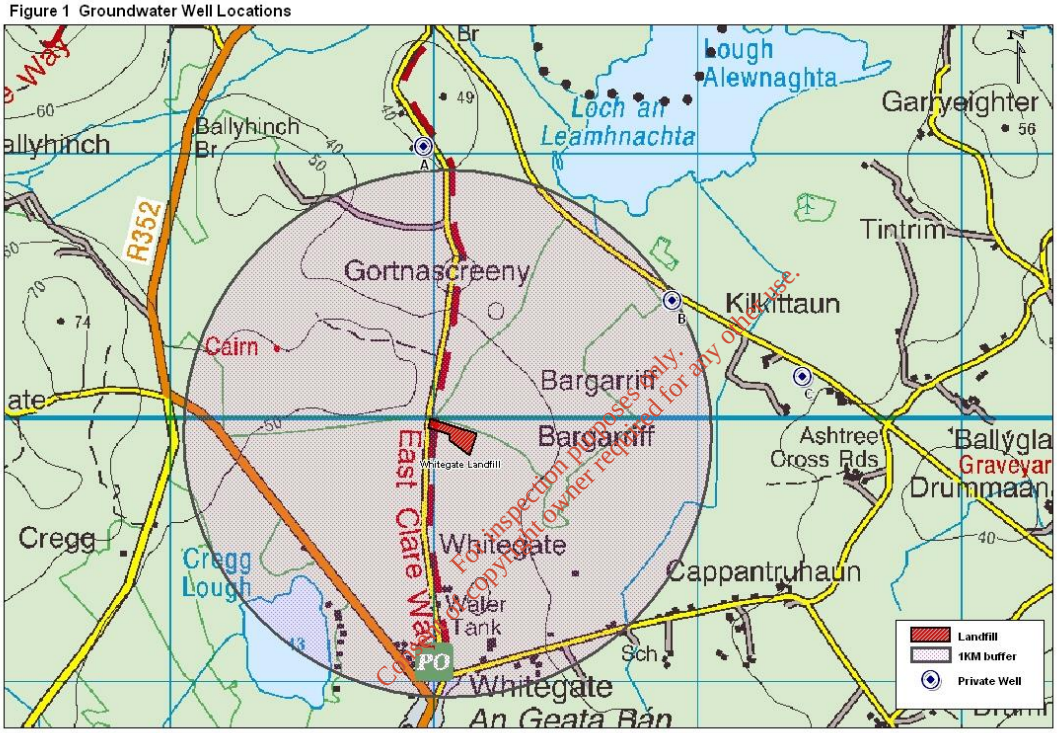
Direct movement via groundwater and surface water had been addressed by Clare County Council in the exploratory investigations and was concluded to be moving in a southwest to northeast direction away from the SPA. The ecological report supports the assertion that direct impact on the SPA via groundwater or surface water is not a significant likelihood.

The report further concludes that as the feeding habits of Merlins and Hen Harriers are not significantly aquatic/riparian food chains the likelihood of any significant impact on these species and any other species of conservation interest of the Slieve Aughty Mountains SPA biota, from the landfill, can be ruled out.

In the SPR risk calculations, SPR 9 obtained a 70% score. This high rating was due to the proximity of the landfill to the SPA. Clearly, this separation distance cannot be changed, but it is considered logical that when there is no discernible impact on the SPA from the landfill, the scoring would take account of this fact, and the classification of the landfill as being high risk should be adjusted downwards to low risk. For all practical purposes the SPR 9 link does not exist.

2.0 SPR 3 Linkage to private wells

Figure 1 Groundwater Well Locations



Three bore wells were analysed to investigate the potential SPR 3 linkage. These wells were located up gradient (Well A) and down gradient (Well B & Well C) of the landfill. The location of the wells are shown on Figure. 1. Analytical data for groundwater in the area indicates that the waters are generally not suitable for human consumption without treatment, by reason of naturally occurring high levels of iron and manganese therein. Dwellings whose potable water source is from local groundwater usually have on site treatment to deal with this matter. However, it was noted that the treatment systems installed are not reducing all parameter levels to EC (Drinking Water) Regulation limits and consumers were advised on this matter.

Well B was found to have ammonia and arsenic concentrations significantly greater than the appropriate limits provided in EC (Drinking Water) Regulation. The results for these parameters in Well B are also significantly greater than the concentration in the landfill leachate (by a factor of up to 100 times). Based on a number of significant factors, it is considered that the poor water quality in the well is not connected with discharges to groundwater from the old landfill. The factors considered in reaching this conclusion are set out hereunder:

1. The disused landfill is located over a poor aquifer and in an area surrounded by surface water drains. The recharge rates to the aquifer would be quite limited and travel distances in the groundwater body would be relatively short before intersection with surface water. Well B is located approximately 980m down gradient from the landfill, both hydrogeologically and topographically. This conclusion was reached in consultation with Advisory Consultant for the EPA project (Darragh Musgrave, Whyte Young Green).
2. Well C is also considered to be a downgradient well and does not show any elevated levels of these parameters.
3. Bedrock in the area is Old Red Sandstone, which has associated low permeability and restrictive water flow.
4. The aquifer is classified as being poor, meaning that it is only productive in local zones.
5. The concentration of arsenic in the well is significantly greater than the concentration in the leachate samples. This is inconsistent with the separation distance between the old landfill site and Well B and dilution of leachate if discharge to the groundwater body was a significant consideration
6. Well B is approximately 15m deep and is located on a hillock surrounded by peat and gley overburden. The well was also considered to be susceptible to surface water ingress. It was therefore concluded that a local source, or a naturally occurring vein of arsenate was responsible for the observations made at Well B.
7. The level of manganese and iron in Well B were 18 and 39 times respectively above the maximum level recommended for potable water.
8. No other well in the area and no surface water in the area were found to have similar high arsenic levels.

Elevated Ammonia, Phosphorus and Sulphate were detected in the two down gradient bore wells (Wells B and C). These disturbances in groundwater chemistry are more likely to be

attributable to farming practices, forestry, the high humic content of the soil strata, and the natural high iron content. It should be noted that there is an intensive pig farming activity located within 1 kilometre of the Wells B and C. Based on the analytical data for leachate from the landfill itself, and data for samples taken from the adjoining surface water drains, it was concluded that the landfill is unlikely to be the contributory factor to the elevated results for the same reasons outlined above.

3.0 Conclusion.

The Tier 2 assessment, undertaken in accordance with the EPA prescribed methodology, and in consultation with the Agency, does not support an SPR 9 or SPR 3 linkage. It is recommended therefore that the landfill classification be reduced to Class C, or low risk. As the site is considered to be low risk no Tier 3 assessment is required and the next phase is to move directly to remediation.

Appendix 1.

A DESK STUDY INVESTIGATION OF POTENTIAL ECOLOGICAL IMPACTS FROM THE WHITEGATE LANDFILL, COUNTY CLARE, ON THE CONSERVATION STATUS OF SPECIES AND HABITATS IN THE SLIEVE AUGHTY MOUNTAINS SPECIAL PROTECTION AREA

December 2009

CONSERVATION SERVICES
&
BIOSPHERE ENVIRONMENTAL SERVICES

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INTRODUCTION

A Tier 1 Risk Assessment of Whitegate Landfill County Clare was undertaken by Clare County Council in accordance with the Code of Practice for Environmental Risk Assessment

of Unregulated Waste Disposal Sites, EPA, 2007 (EPA CoP, 2007). Based on the SPR9 linkage between the landfill and the adjacent Slieve Aughty Mountains designated Special Protection Area (Site Code 004168), via leachate migration through surface water, Whitegate landfill site was rated as a Class A (high risk) site.

Subsequent to the Tier 1 Risk Assessment, an Exploratory Investigation on Whitegate Landfill was carried out to determine the overall cost requirements for the full Tier 2 investigation (using the methodology recommended in the EPA matrix), and to further develop the conceptual site model (CSM) for Whitegate landfill.

The Exploratory Investigation at Whitegate Landfill concluded that ecological advice was required regarding potential impact of waterborne pollutants on the conservation objectives or conservation status of any species in the special protection area.

The present desk study report assesses the potential for a significant impact from the Whitegate Landfill on the Slieve Aughty Mountains SPA. The report utilises the "Source-Pathway-Receptor (S-P-R)" conceptual model for environmental management recommended by EPA in its Code of Practice - Environmental Risk Assessment for Unregulated Waste Disposal Sites (EPA CoP, 2007). The report is presented in the following sections:

1. Source – An assessment of the polluting potential of the Whitegate Landfill

2. Receptor – An assessment of the Slieve Aughty Mountains SPA with particular reference to Annex bird species for which the site has been designated

3. Pathway – An assessment of potential pathways whereby pollutants from Whitegate Landfill might impact on the biota and habitats of the SPA

AN ASSESSMENT OF THE POLLUTING POTENTIAL OF WHITEGATE LANDFILL

COMPOSITION OF LEACHATE IN LANDFILLS

One of the consequences of the disposal of wastes in landfills is the generation of leachate, which is the noxious liquid that is produced as a result of the interactions in the waste as water passes through it.

The concentration of various potentially polluting substances in leachate varies depending on a variety of factors such as water content of the waste, rainfall, design and operation of the site, the age of the waste and the type of waste being disposed.

Many organic compounds which may be found in landfill leachate are of environmental significance in very low concentrations - parts per billion (ppb) or parts per trillion (ppt) quantities. Consequently very small amounts can cause severe pollution (Daly 1991). Of particular concern are compounds which are fat-soluble and biologically stable so that they accumulate in body fats. Such compounds may biomagnify along food chains and in some ecosystems concentration factors from water to top predators may be as high as 10 to the power of 7 (Mason 1996).

Thornton *et al* (1999) after Robinson (1986) list 3 acid organics (e.g. Phenol), 23 volatile organics (e.g. Methylene chloride, Toluene, 1,1-Dichloroethane, Trans-1,2-Dichloroethene, Ethylbenzene, Chloroform), 8 base-neutral organics (e.g. Bis(2-ethylhexyl)Phthalate, Diethylphthalate, Dibutylphthalate), 1 chlorinated pesticide, and 1 PCB in landfill leachate. The Robinson 1986 data suggest that methylene chloride and Trans-1,2-Dichloroethene are the most common synthetic organic chemicals in leachate.

WASTE ELECTRICAL & ELECTRONIC EQUIPMENT (WEEE)

According to the Commission of the European Communities (2000) the most environmentally problematic substances contained in WEEE include heavy metals, such as mercury, lead, cadmium and chromium, halogenated substances, such as chloroflourocarbons (CFCs), polychlorinated biphenols (PCBs), polyvinyl chloride (PVC) and brominated flame retardants as well as asbestos and arsenic.

ENDOCRINE DISRUPTING CHEMICALS (EDCS)

Endocrine disrupters, also known as oestrogen mimicking chemicals, are substances which interfere with the hormonal systems of animals and humans. "*A range of chemical substances, designed for use in industry, agriculture and consumer products, are suspected of interfering with endocrine (hormonal) systems of humans and wildlife*". (European Union Commission Communication COM (2001) 262). Landfill leachate has been identified as a potential source of EDC pollution, in Ireland (Dempsey & Costello 1998) and abroad (Daughton et al 1999).

In October 2000 the European Parliament adopted a resolution on endocrine disrupters emphasising the application of the precautionary principle and calling on the Commission to identify substances for immediate action.

A research team at Cork Institute of Technology has drawn a list of endocrine disruptors most likely to be present in surface and waste waters in the Irish aquatic environment. Included in the list are the following phthalates (Dr H. Tarrant, Cork Institute of Technology, pers. comm.):

Dimethyl Phthalate	Plasticiser
Diethyl Phthalate	Plasticiser
Di-n-butyl Phthalate	Plasticiser
Butyl Benzyl Phthalate	Plasticiser
Bis 2-(ethylhexyl) Phthalate	Plasticiser
Di-n-octyl phthalate	Plasticiser

Phthalates are probably the most important group of endocrine disrupting chemicals which may be present in landfill leachate. Phthalates are a major component in PVC, of which they form up to 60% of the total volume (European Commission 2000). About 50% of the total consumption of phthalates is bis(2-ethylhexyl) phthalate DEHP (Cadogen *et al* 1993 quoted in European Commission 2000). PVC forms approx. 2.5% of landfilled municipal waste in Europe (European Commission 2000).

The Final Report to the European Commission: *The Behaviour of PVC in Landfill* (European Commission 2000) indicates that a significant proportion of phthalates are degraded within landfills and are therefore not released to the environment. However, the report also states:

"*Essential information is still lacking for an assessment of quantitative phthalate emission from landfills. … Emissions of phthalates to landfill leachates and to the aquatic environment cannot be excluded, DEHP in particular is considered to be persistent and to accumulate in sediments. …. According to the findings from the literature survey and from our own analysis with regard to emissions resulting from the disposal of PVC in landfills, a contribution to the contamination of leachate … occurs. … As there is evidence that phthalates, DEHP mainly, are not fully eliminated through current leachate treatment .. emission to aquatic ecosystems cannot be excluded. …Technical solutions for leachate treatment are feasible.*" (European Commission 2000).

Tarrant *et al* (2005) conclude that "*with the caveat that estrogenic 'hotspots' are more likely in densely populated urban and/or industrialised areas …. Irish rivers and lakes do not appear to be at general risk from significant concentrations of environmental estrogens. ….In general, wild fish populations do not appear to be at risk from estrogenic chemicals.*"

RISKS FROM OTHER CHEMICALS AND PRODUCTS WHICH ARE PERMITTED IN THE LANDFILL

All biodegradable organic wastes which enter the landfill such as food waste, garden waste, paper and cardboard products, animal products, and a range of commercial and industrial wastes will ultimately decompose; leachate produced during this decomposition process typically has levels of B.O.D. and ammonia which are potentially lethal (in the absence of adequate treatment) to most aquatic animals and plants. Likewise decomposition of organic material frequently results in the production of phosphorus containing compounds, which if released to the aquatic environment may result in eutrophication of the receiving waters. Non organic phosphorus containing compounds disposed at the landfill may also result in phosphorus in the leachate, which if not removed by leachate treatment could result in eutrophication of receiving waters.

In addition to such well documented pollutants in landfills, a wide range of compounds enter landfill, the environmental effects of which are not known. The number of chemicals now on the market is very large and growing (Royal Commission on Environmental Pollution 2003; EU MEMO 03/213). "*Extensive national, EU and international legislation and agreements prescribe requirements for testing and assessing chemicals for their potential to cause harm*

in the environment, but only a small proportion of chemicals on the market have been the subject of risk assessment." (Royal Commission on Environmental Pollution 2003*).* To redress this situation the European Commission has brought in a new EU regulatory framework for chemicals called REACH (Registration, Evaluation and Authorisation of Chemicals).

RISKS FROM CHEMICALS AND PRODUCTS WHICH ARE PROHIBITED IN THE LANDFILL

Evidence from Britain (Royal Commission on Environmental Pollution Report 2003) indicates that significant quantities of domestic pesticides may still be disposed of illegally to landfill in Britain. Thornton *et al* (1999) also highlight the significant potential for hazardous waste disposed of by small commercial enterprises without contracts with waste disposal companies to make its way to non hazardous waste landfills.

TIMESCALE FOR LEACHATE GENERATION

The sequence of microbiological breakdown processes which occurs in landfills is now well established, in that the landfill progresses through the aerobic, acetogenic, methanogenic and finally semi-aerobic phases. Whilst these phases will ensure that organic matter is eventually completely broken down and the carbon is released in the form of methane and carbon dioxide gases, some of the end products of these degradation processes remain as soluble components of leachate. Thus, waste components which constitute pollutants in the solid phase are gradually transposed into a liquid phase and can only be eliminated from a landfill providing waste encapsulation by the removal and treatment of the leachate. Robinson and Gronow (1993) state that a large, deep, high-density domestic waste landfill, operated in a typical manner as at present in the UK, will continue to produce strong and polluting leachates well in excess of values considered acceptable for discharge to surface or ground water for a large number of decades, and possibly over timescales in excess of a century.

Investigations into potential polluting effects of PVCs in landfills (see section 2.1.1.2 above) are described in "The Final Report to the European Commission: *The Behaviour of PVC in Landfill* - European Commission 2000". This report states that; "*There is no evidence that*

the release of additives will come to a standstill. Thus it is expected that this process will last for a very long time …Nowadays the technical guarantee for landfill bottom liners and pipes for leachate collection is restricted to 80 years. Emissions resulting from the presence of PVC in landfills are likely to last longer than the guarantee of the technical barrier."

One of the most difficult components of leachate to eliminate is ammonia, since this is the soluble end product of the anaerobic breakdown of nitrogenous components of wastes. Typically the ammonia content of leachates is 1000 mg/l, and for direct discharge to controlled waters a limit of say perhaps 1 mg/l would be required. Thus a dilution ratio of 1000:1 would be required for all leachate contained within a site. Walker (1993) calculates that if an engineered landfill site were capped over a depth of refuse of 10m with an average drained moisture content of 40%, then the hydraulic retention time (HRT) for the infiltration rate of 50mm per annum is given by: 10m x 0.4 ÷ 0.05m/a = 80 years. Knox (1990) calculates that for a hydraulic retention time of 80 years, the time to reduce the concentration of ammonia from 1000 mg/l to 1 mg/l is 552 years. Krumpelbeck and Ehrig (1999) report that in a study of 50 German landfills, ammonia concentrations did not show a significant decrease thirty years after closure. Thus extremely protracted time scales may be involved for the operation of leachate control measures at fully engineered sites. This conclusion is supported by Freeze and Cherry (1979) who state that "in some cases leachate production may continue for many decades or even hundreds of years". The concept of very protracted time scales for leachate control is discussed in more detail by Belvi and Baccini (1989).

WHITEGATE LANDFILL – GENERAL INFORMATION

The Exploratory Investigation on Whitegate Landfill by Clare County Council has established the following:

1. The area of waste deposition is 1.19 hectares.

2. The maximum depth of waste deposited, based on trial hole detail is 4.8 m, (including capping)

3. Waste is deposited at and below the level of the water table on the site

4. In general there is some overburden above the bedrock, but the depth of overburden was not clearly established throughout the site.

5. Taking account of the water table level observed on the site, it would appear that the waste volume is in direct contact with groundwater, so that sub-soil investigation (for permeability) is unlikely to be an issue across the site.

6. The more recent area of waste deposition is located at the eastern end of the site, but landfilling at the site appears to have taken place over the entire area of the site between 1994 and 1998.

7. Significant volumes of leachate were encountered in trial holes

8. Groundwater movement in the overburden, (and associated leachate movement) appears to be from a south west to north east direction, based on observation of seeps in each trial hole

9. Based on very preliminary observation of the level of the water table in the trial holes, and the level in the adjacent water course- it is likely that the leachate is in contact with and draining to surface waters

10. The movement of leachate into surface waters is the pathway identified for any potential hazardous substances dissolved in water. The topography of the site, preliminary level observations and observations on movements of water /leachate in the trial holes suggests that the movement of a contaminant plume is likely to be towards surface waters located around the site on the northern and eastern boundaries.

11. Preliminary results of analysis of surface water samples indicates elevated ammoniacal nitrogen in the northern boundary drain, which suggests a link between leachate in the overburden and the adjacent surface water drain.

12. Non hazardous municipal waste appears to comprise the main volume of deposited material, with significant levels of black plastic (presumably arising from agricultural sources).

13. Some industrial waste was evident in the trial holes. This was identified as probably coming from the Finsa facility as the waste was mainly chipboard, or chipboard products

In summary the results of the investigation indicate a small (1.19ha) landfill with maximum depth of 4.8m, which operated during the 1990s. The main volume of deposited material was non-hazardous municipal waste. The landfill was unlined and leachate is dispersed beyond the site by surface water (rather than groundwater) flow, which is via boundary drains, which connect with an adjacent stream which flows in a north east direction for c.2.5km to 1km long Lough Allewnaghta, which in turn discharges via a c. 0.6km stream to Lough Derg.

WHITEGATE LANDFILL - POLLUTANTS IN LEACHATE

As part of the Exploratory Investigation on Whitegate Landfill by Clare County Council, leachate samples were taken at four locations at the landfill and analysed for a large suite of organic and inorganic pollutants. Results are presented in Appendix 1. The range of concentrations recorded for a number of important pollutants are presented in Table 1 below alongside typical concentrations found in leachate from recent and aged landfill waste.

Table 1

	Range of concentrations (mg/l) recorded at Whitegate Landfill (untreated leachate)	**Typical Composition (mg/l) of untreated leachates from domestic wastes in Britain D.O.E. data reproduced in Daly (1987)**	

Parameter		Untreated Leachate Recent Waste	Untreated Leachate Aged Waste	Maximum Admissible Concentration in receiving waters
pH	6.78 – 6.89	6.2	7.5	6.0 - 9.0 (Salmonid Waters Regulations)
C.O.D.	349 – 1333 mg/l	23,800 mg/l	1,160 mg/l	
B.O.D.	15 – 186 mg/l	11,900 mg/l	260 mg/l	<5 (Salmonid Waters Regulations)
Ammon-iacal N	35 – 193 mg/l	790 mg/l	370 mg/l	1.0 mg/l total ammonium subject to complying with standard of 0.02 mg/l for non-ionised ammonia NH_3 (Salmonid Waters Regulations)
Chloride	44 – 222 mg/l	1315 mg/l	2080 mg/l	250 mg/l (Surface Water Regulations)
Magnesium	50 – 95 mg/l	252 mg/l	185 mg/l	50 (Drinking Water Regulations)
Potassium	44 – 272	780	590	12
Manganese	1.7 – 2.2 mg/l	27 mg/l	2.1 mg/l	0.05 mg/l (Surface Waters Regulations)
Iron	1.3 – 22.8 mg/l	540 mg/l	23 mg/l	0.2 mg/l (Surface Waters Regulations)
Nickel	<0.001 mg/l	0.6 mg/l	0.1 mg/l	0.05 mg/l (Drinking Water Regulations)

	Range of concentrations (mg/l) recorded at Whitegate Landfill (untreated leachate)	Typical Composition (mg/l) of untreated leachates from domestic wastes in Britain D.O.E. data reproduced in Daly (1987)		
Parameter		**Untreated Leachate Recent Waste**	**Untreated Leachate Aged Waste**	**Maximum Admissible Concentration in receiving waters**
Chromium (unfiltered)	0.025 – 0.730 µg/l			0.032 µg/l (Environmental Objectives Surface Water Regulations 2009)
Di (2-ethylhexyl)-phthalate (DEHP)	4.64 - 54.6 µg/l			1.3 µg/l max annual average (Environmental Objectives Surface Water Regulations 2009)
Phenol	<1.00 – 14.6 µg/l			46 µg/l (Environmental Objectives Surface Water Regulations 2009)

(Sources for leachate concentrations: Daly (1987), & Leachate monitoring data for Whitegate Landfill provided by Clare County Council)

The analysis establishes that for a range of major indicators of leachate pollutant concentration such as ammonia, BOD, and COD, the concentration recorded in the Whitegate leachate was substantially lower than would be typical of aged landfill waste. For example ammonia concentrations of 35 – 193 mg/l were recorded comparing favourably with typical concentrations of in leachate from aged waste of 370mg/l and in leachate from recent waste of 790 mg/l (Daly 1987). This relatively low concentration of pollutants in the leachate may be due to a combination of:

i. The age of the waste

ii. The shallow depth of the waste

iii. The uncontained nature of the landfill

iv. High rainfall levels

v. Rapid water infiltration rate

vi. Short hydraulic retention time

However, as the assessment was carried out on only one sampling date, further investigation would be required to establish the condition of the landfill leachate with more certainty.

Nevertheless the leachate assessment indicates pollutants at concentrations which would be damaging to aquatic flora and fauna. Pesticides were all below the detection level of the analysis methods used. A range of volatile organic compounds (SVOCs) and volatile organic compounds (VOCs) were detected in the leachate. Notably the phthalate DEHP was detected at over 40 times the maximum allowable annual average concentration acceptable in surface water under the Environmental Objectives Surface Water Regulations 2009.

WHITEGATE LANDFILL - POLLUTANTS IN DOWNSTREAM SURFACE WATERS

Surface water samples were taken by Clare County Council at seven stream sites adjacent to the landfill on 5th November 2009. Results are tabulated in Appendix 1. At downstream sites the assessment indicated elevated levels of a number of pollutants particularly ammonia. At Site SW3, which is immediately downstream of the confluence with the landfill drains, ammonia concentration of 4.23 mg/l was recorded (the maximum admissible concentration

under the Salmonid Waters Regulations is 1.0 mg/l total ammonium, subject to complying with standard of 0.02 mg/l for non-ionised ammonia NH_3).

Results of monitoring carried out by EPA in 2007 & 2008 at Lough Alewnaghta (c. 2.5 km downstream of the landfill) are presented in Appendix 2. The results of the monitoring show no indication of contamination from the landfill, apart from a possible landfill effect indicated by an elevated ammonia level on one of the ten sampling dates. The level of ammonium NH_4 was 1.6 mg/l on 1/10/08 as compared with an average of 0.081 mg/l over the other sampling dates.

An assessment of the Slieve Aughty Mountains SPA

SPA SELECTION CRITERIA

The Slieve Aughty Mountains SPA is designated under the EU Birds Directive (Council Directive 79/409/EEC). The site qualifies for designation under Article 4.1 of the Directive by supporting a population of European importance of **Hen Harrier** *Circus cyaneus*, a species listed on Annex I of the Directive. In 2005, 27 breeding pairs (24 confirmed, 3 possible) were recorded, representing 17.6% of the estimated breeding population in the Republic of Ireland.

Site also supports a population of the Annex I species **Merlin** *Falco columbarius*, that is likely to exceed with ease the threshold for national importance - probably 5 pairs but further survey required.

SITE DESCRIPITON

The Slieve Aughty Mountains SPA is a very large site (61,127 ha) that extends from just south of Lough Rea (Co. Galway) in the north to as far south as Scariff in Co. Clare (and close to the village to Whitegate in the south-east). The peaks are not notably high or indeed pronounced, with a maximum of 378 m near Cappaghabaun Mountain. The site includes many small and medium sized lakes, notably Lough Graney and Lough Atorick. Important rivers which rise in the site include the Owendalulleegh and Graney. Lough Derg occurs

immediately to the south-east of the site. The Slieve Aughty hills are predominantly comprised of Old Red Sandstone. Outliers of Lower Palaeozoic provide occasional outcrops capping the hills.

The site consists of a variety of upland habitats, though approximately half is afforested. The coniferous forests include first and second rotation plantations, with both pre-thicket and post-thicket stands present. Substantial areas of clearfell are also present at any one time. The principal trees are sitka spruce and lodgepole pine. Almost one-third of the site is unplanted blanket bog and heath, with both wet and dry heath present. Well developed blanket bog occurs at several locations, notably Sonnagh, Loughatorick South and Glendree. The vegetation is characterised by such species as ling heather, bilberry, common cottongrass, hare's-tail cottongrass, deergrass and especially purple moor grass. Bog mosses (*Sphagnum* spp.) are well represented. The remainder of the site is largely rough grassland that is used for hill farming. This varies in composition, with some wet areas with rushes (*Juncus* spp.) and some areas with scrub encroachment.

The main threat to the long-term survival of Hen Harriers within this site is further afforestation which would reduce the amount of foraging habitat, with a possible reduction in breeding density and productivity.

Overall this site provides excellent nesting and foraging habitat for breeding Hen Harriers and is considered among the top two sites in the country for the species.

HEN HARRIER – BACKGROUND INFORMATION

The principal interest of the SPA is the population of nesting Hen Harriers, supporting the second largest concentration in the country. The mix of forestry and open areas provides optimum habitat conditions for this rare bird. The early stages of new and second-rotation conifer plantations are the most frequently used nesting sites, though some pairs may still nest in tall heather of unplanted bogs and heath.

Hen Harriers will forage up to c. 5 km from the nest site, utilising open bog and moorland, young conifer plantations and hill farmland that is not too rank. Birds will often forage in openings and gaps within forests. In Ireland, small birds and small mammals appear to be the most frequently taken prey. Meadow pipits and bank voles are considered the principal avian and mammalian prey items but harriers will take a wide range of small birds, including warblers, finches, thrushes and even larger prey such as snipe and grouse (an extensive list of prey items is given in Watson 1977).

In its most usual type of hunting flight, the Hen Harrier flies low, flapping and gliding at an average of less than 3 metres above the ground. The technique of low-level flight, varied pace and use of local topography enables a harrier to exploit its long legs to maximum effect in striking at prey on, or close to, the ground. Harriers will also patrol over low scrub or along the margins of forests, using the element of surprise to pick off small birds.

Hen Harriers return to the breeding grounds during March and are usually present until July or August. After that, adults and juveniles disperse widely, mostly to low-lying areas where the winter climate is less harsh. Research on Irish Hen Harriers by Mr Barry O'Donoghue has recorded a young female wing tagged in Co. Clare on an island in Wales, which proves that some birds travel abroad. Some harriers may visit the uplands during winter or at least linger on into early winter.

MERLIN - BACKGROUND INFORMATION

Little is known about the Slieve Aughty breeding population of Merlin, a further Annex I listed species. Merlin is a difficult species to census but is typically found in mosaics of forestry and open bog. The birds nest mostly in trees, utilising the old nests of crows.

The merlin is a small falcon and uses its speed and agility to chase down prey items, mainly small birds and small mammals but also larger insects.

Like the hen harrier, the merlin population largely vacates the uplands in winter and spends the winter in more hospitable lowland areas often along coastal strips.

SPA CONSERVATION PLAN

A Conservation Plan for the Slieve Aughty Mountains SPA has not yet been prepared by the Department of the Environment, Heritage & Local Government. However, it is understood that the principal nature conservation objectives for the site are to maintain the population of the species (hen harrier & merlin) for which the site is selected, and to maintain and, where possible, enhance, the habitats on which the harriers are dependant.

An assessment of potential pathways whereby pollutants from Whitegate Landfill MIGHT impact on the biota and habitats of the SLIEVE AUGHTY MOUNTAINS SPA

Three potential pathways for leachate pollutants to impact on the Slieve Aughty Mountains SPA are considered (1) Groundwater movement, (2) Surface water movement, (3) Contamination of birds and other biota in the SPA via food chains based on contaminated flora/fauna downstream of the landfill.

GROUNDWATER

The Clare County Council report on the Exploratory Investigation on Whitegate Landfill (2009) states:

i. "*Groundwater movement in the overburden, (and associated leachate movement) appears to be from a south west to north east direction, based on observation of seeps in each trial hole*."

ii. "*The movement of leachate into surface waters ...is the pathway identified for any potential hazardous substances dissolved in water. The topography of the site,*

preliminary level observations and observations on movements of water /leachate in the trial holes suggests that the movement of a contaminant plume is likely to be towards surface waters located around the site on the northern and eastern boundaries. Preliminary results of analysis of surface water samples indicates elevated ammoniacal nitrogen in the northern boundary drain … which suggests a link between leachate in the overburden and the adjacent surface water drain."

The conclusion of the County Council report is that leachate movement within the landfill is in a south west to north east direction i.e. away from the adjacent SPA, and furthermore that leachate contamination enters surface waters adjacent to the landfill. This conclusion is however qualified as the Council also states in the report:

i. "*To evaluate the SPR9 linkage an investigation is required to determine the radius of influence of the landfill in groundwater and hydrogeologic separation of the aquifer from the landfill activity*."

ii. "*A hydrogeological investigation to establish groundwater quality (upgradient, within and downgradient of the landfill) and flow direction associated with the landfill site should be included in the full Tier 2 assessment*."

If the conclusion of the Exploratory Investigation on Whitegate Landfill that "*movement of leachate into surface waters …is the pathway identified for any potential hazardous substances dissolved in water"* is borne out by the further investigations proposed, then a significant direct impact on the SPA via groundwater can be ruled out.

SURFACE WATER

The Exploratory Investigation on Whitegate Landfill (2009) states that:

- *"The protected site is located to the west of the site, upstream of the direction of surface water flow."*

- *"Crooked Lough (wetland) lies approximately 250m to the southwest of the site (upstream of the landfill site)."*

- *"Cregg Lough lies 750m southwest and upgradient of the site. According to the river water body delineation made by the Shannon River Basin District Project there is no connection from this lough to the landfill site area."*

- *"Lough Allewnaghta is approximately 1km to the northeast of the landfill. The surface water drains from the landfill boundary flow to Lough Allewnaghta via a first order stream."*

- *"The northern boundary drain, which appears to be very slow moving, with max depth of 1 metre and maximum width 1.5m. The water in the drain was orange, and appeared to be impacted by leachate. This drain flows in a west to east direction along the line of the landfill site. This drain appears to be the main surface water connected with the water table and leachate in the main waste body."*

- *"The eastern boundary drain, which probably receives flow from the water ponds on the southern boundary of the landfill (based on forestry drain connections and local topography). This drain is also fed from forestry drainage ditches. At the eastern edge of the landfill site the forestry drains showed some evidence of leachate impact."*

On this basis a significant direct impact on the SPA via surface water can be ruled out.

FOOD CHAIN

The assessment carried out by Clare County Council establishes that there is a significant level of leachate contamination of surface watercourses evident in the immediate vicinity of the landfill (albeit at a considerably lower level than might be expected). The concentration

of ammonia (a reliable indicator of leachate contamination) in Lough Allewnaghta (c. 2.5 km downstream of the landfill) was unsatisfactory on one sampling date out of ten over a two year period. Rigorously applying the precautionary principle, one could conclude that Lough Allewnaghta and the 2.5km of stream between it and the landfill could be exposed to significant landfill contamination, taking into account the fact that some pollutants that may be in landfill leachate can bio-accumulate and bio-magnify as they pass along ecological food chains.

The main components of the stream and lake ecosystems are aquatic plants, invertebrate animals (insects, molluscs, worms etc), fish, birds which feed largely on the aquatic food chain e.g. dipper, grey wagtail, duck, swans etc., and mammals which feed largely on the aquatic food chain such as otter and mink.

The two species for which the SPA is selected, hen harrier and merlin, are at the top of the food chain and are therefore theoretically susceptible to bio-accumulation of chemicals contained in substances such as leachate. The drastic effect on the Peregrine population during the 1960s due to accumulation of organochlorine pesticides and other synthetic chemicals is well documented (see Ratcliffe 1980). The effects not only included death of adult birds but also poor reproduction with high losses of eggs and hatched chicks.

As already noted, hen harriers are adapted for hunting over open country and during the nesting season hunt almost entirely over open bog/heath, rough grassland and in pre-thicket forests. In winter, they often forage over open wetland habitats such as reed-beds and marshes but will also forage over agricultural lands. Hen harriers are not adapted for feeding along rivers or streams on riparian species such as dippers or kingfishers (and it is not known if such species even occur on the streams below the landfill) and there appears to be no instances in the literature where there is evidence of hen harriers taking these bird species. Lough Allewnaghta may support wetland birds such as wildfowl, moorhen, coot and possible waders such as lapwing and curlew. Whilst there are records of hen harriers taking wildfowl and waders (lapwing, young curlew, snipe etc.) these are very occasional and would be taken mainly outside the nesting season (Watson 1977).

It is concluded that there is no real risk to the hen harrier population from preying upon birds and/or mammals that may have been contaminated from leachate originating from the landfill for the following reasons:

(i) It is highly improbable that hen harriers from the Slieve Aughty Mountains SPA would predate riparian birds along the streams below the landfill

(ii) It is also improbable that hen harriers from the Slieve Aughty Mountains SPA would predate wetland birds at Lough Allewnaghta as such seldom feature in their diet (and especially during the nesting season)

Merlin is also generally a species associated with hunting over open countryside and is not normally associated with hunting along riparian habitats. However, Tyler & Ormerod (1994) note that kestrels, merlins and peregrines occasionally take Dippers. They observe that it is likely that the close proximity of breeding merlins to dippers in some upland valleys result in dippers being taken as prey. On the other hand, they note that Colin Bibby analysed bird remains at 66 merlin sites in Wales and of over 1,600 individual bird prey items, none were dippers.

As with hen harriers, it is considered that it is highly improbable that merlins from the Slieve Aughty Mountains SPA (with a population of perhaps less than 10 pairs) would predate riparian birds along the streams below the landfill. Even if a merlin was to take riparian prey, this would likely be an opportunistic event. Similarly, merlins would not be expected to predate wildfowl or waders such as lapwing (due to their size) which may occur on Lough Allewnaghta. It is concluded that there is no risk to the merlin population by preying upon birds and/or mammals that have been contaminated from leachate originating from the landfill.

CONCLUSIONS

Preliminary investigations by Clare County Council indicate that the leachate of Whitegate landfill contains pollutants with the potential to cause significant ecological impacts. The

concentration of pollutants recorded are however lower than might be expected in aged landfill wastes. It is conjectured that this may be due to the relatively shallow depth of refuse, the age of the landfill and short hydraulic retention time, resulting in a declining concentration of pollutants in the leachate. However, as the assessment was carried out on only one sampling date, further investigation would be required to establish the condition of the landfill leachate with more certainty.

Three potential pathways whereby leachate contamination might significantly impact on the adjacent SPA are considered:

1. Direct movement via groundwater

2. Direct movement via surface water

3. Contamination of birds and other biota in the SPA via food chains based on contaminated flora/fauna downstream of the landfill

Initial investigations by Clare County Council indicate that leachate movement within the landfill is in a south west to north east direction i.e. away from the adjacent SPA, and furthermore that leachate contamination moves into surface waters adjacent to the landfill. The Council however qualifies this conclusion by highlighting the need for further more detailed investigations.

The SPA is located to the west of the landfill site, upstream of the direction of surface water flow. Preliminary investigations by Clare County Council of surface water adjacent to the landfill indicated elevated levels of a number of pollutants, particularly ammonia, immediately downstream of the landfill. Results of monitoring carried out by EPA in 2007 & 2008 at Lough Alewnaghta (c. 2.5 km downstream of the landfill) show no indication of contamination from the landfill apart from a possible landfill effect indicated by an elevated ammonia level on one of the ten sampling dates.

On the basis of the groundwater and surface water investigations carried out by Clare County Council and subject to the requirement for more detailed investigations, it is concluded that

direct significant impact on the SPA via groundwater or surface water is not a significant likelihood.

Based on the findings of the County Council and EPA investigations, and rigorously applying the precautionary principle, one could conclude that Lough Allewnaghta and the 2.5km of stream between it and the landfill could be exposed to significant landfill contamination, taking into account the fact that some pollutants that may be in landfill leachate can bio-accumulate and bio-magnify as they pass along ecological food chains. However, hen harrier and merlin are the two species for which the Slieve Aughty Mountains SPA was selected. A detailed consideration of the feeding habits of Merlins and Hen Harriers presented in this reports indicates that the proportion of the diet of these birds derived from aquatic/riparian food chains is insignificant, thereby ruling out any significant likelihood of a food chain impact on these species (or indeed any other element of the Slieve Aughty Mountains SPA biota) from the landfill.

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APPENDIX 1

LEACHATE AND SURFACE WATER MONITORING DATA

(Data provided by Clare County Council)

		Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**	SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	-	09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
		(u/s location)	***U/s location***	***May be run off from landfill***	***D/S of landfill Ds of Sw6***	***D/S of landfill-boundary drain. D/s of SW5)***	***Boundary drain-mid drain***	***(D/S of landfill***				
Temperature	**°C**	9.2	9.8	9.4	9.4	9.2	9.5	9.4	9.2	9.3	9.2	9.2
Dissolved oxygen	**mg/l**	5.54	5.51	7.2	7.72	7.65	6.11	6.94				
Dissolved oxygen	**%**	49.3	49.6	64.1	68.9	68	54.6	61.9				
Ph	-	5.19	4.13	5.63	6.07	6.05	6.72	6.89	6.89	6.78	6.88	6.86
Conductivity	**µS/cm**	89	189	102	115	122	400	447	2400	2600	4000	2200
Total Suspended solids	**mg/l**	<2	<2	9	5	4	3	15	14,108	2,840	8,812	41,736
Ammonia	**mg/l**	0.120	0.339	0.044	0.288	0.349	2.725	4.233	34.8	98.36	193.35	81.27
TON	**mg/l**	<0.001	0.301	<0.001	<0.001	<0.001	<0.001	0.068	<0.001	<0.001	<0.001	<0.001
Nitrate	**mg/l**	<0.001	0.317	<0.001	<0.001	<0.001	<0.001	0.074	<0.001	<0.001	<0.001	<0.001
Nitrite	**mg/l**	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025	<0.00025
BOD	**mg/l**	<2	<2	<2	2	<2	<2	4	15	80	186	36

		Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**	SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	-	09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
COD	**mg/l**	115	104	105	103	102	16	26	349	831	1333	659
Sulphate	**mg/l**	<0.5	15.303	<0.5	<0.5	<0.5	13.652	10.086	61.38	8.302	109.522	7.157
Chloride	**mg/l**	17.73	31.25	17.901	18.88	20.78	22.48	25.93	72.89	222.40	70.81	43.96
Ortho-phosphate	**mg/l**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.001	<0.01	<0.01	<0.01	<0.01
Fluoride	**mg/l**	0.016	0.037	0.023	0.017	0.017	0.049	0.043	0.030	0.027	0.50	0.025
Total Alkalinity	**mg/l**								1210	2320	4300	1440
Arsenic[1]	**µg/l**	**18.1**	**17.0**	**13.3**	**10.6**	**12.6**	5.45	8.95	4.46	6.31	**16.8**	6.46
Arsenic[3]	**µg/l**	-		-	-	-	-	-	-	-	-	-
Boron[1]	**µg/l**	<18	<18.0	<18	<18	<18	74.1	132	**1090**	939	776	618
Boron[1]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-
Cadmium[1]	**µg/l**	<0.220	<0.220	<0.220	<0.220	<0.220	<0.220	<0.220	<0.22	<0.22	<0.22	<0.22
Cadmium[3]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-
Chromium[3]	**µg/l**	<0.700	2.86	<0.770	<0.7	<0.7	<0.7	<0.700	8.90	22.3	**38.5**	11.1
Copper[1]	**µg/l**	<1.60	<1.60	<1.60	14.2	17.2	8.71	<1.60	2.27	<1.6	<1.6	<1.6
Copper[3]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-
Lead[1]	**µg/l**	3.21	2.05	2.85	2.50	2.47	1.83	2.14	2.35	2.10	1.64	1.88
Lead[3]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-

		Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**	SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	-	09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
Manganese[1]	**µg/l**	**396**	**734**	**237**	**197**	**284**	**458**	**470**	**1730**	**1380**	**2130**	**2230**
Nickel[1]	**µg/l**	<1.50	2.08	<1.50	1.65	2.15	2.56	2.62	<1	<1	<1	<1
Selenium[1]	**µg/l**	<1.00	<1.00	<1.00	1.17	1.07	<1.00	<1.00	<1	<1	<1	<1
Selenium[3]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-
Zinc[1]	**µg/l**	**12.7**	**11.9**	**12.2**	**9.18**	**17.7**	**20.6**	**15.8**	<0.01	<0.01	<0.01	<0.01
Zinc[3]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-
Mercury[1]	**µg/l**	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Mercury[3]	**µg/l**	-	-	-	-	-	-	-	-	-	-	-
Sulphate	**mg/l**	-	-	-	-	-	-	-	118	19.5	166	55.4
Chloride	**mg/l**	-	-	-	-	-	-	-	**75.3**	**72.4**	**213**	**43.0**
Orthophosphate	**mg/l**	-	-	-	-	-	-	-	<0.08	<0.08	<0.08	<0.08
Chromium	**µg/l**	<3.00	<3.00	<3.00	SW1	<3.00	<3.00	<3.00	25.7	**223**	**730**	**48.4**
Phosphorus[3]	**mg/l**	30.1	21.5	30.7	<3.00	54.8	35.3	58.6	1710	5720	11600	3640
Total Cyanide	**mg/l**	-	-	-	-	-	-	-	<0.05	<0.05	<0.05	<0.05
Calcium[1]	**mg/l**	7.34	7.92	8.48	11.1	11.1	51.4	16.4	**236**	195	**271**	**206**
Calcium[3]	**mg/l**	-	-	-	-	-	-	-	-	-	-	-
Sodium[1]	**mg/l**	11.1	17.7	10.4	11.2	11.1	13.4	12.5	60.8	76.9	133	37.0
Sodium[3]	**mg/l**	-	-	-	-	-	-	-	-	-	-	-

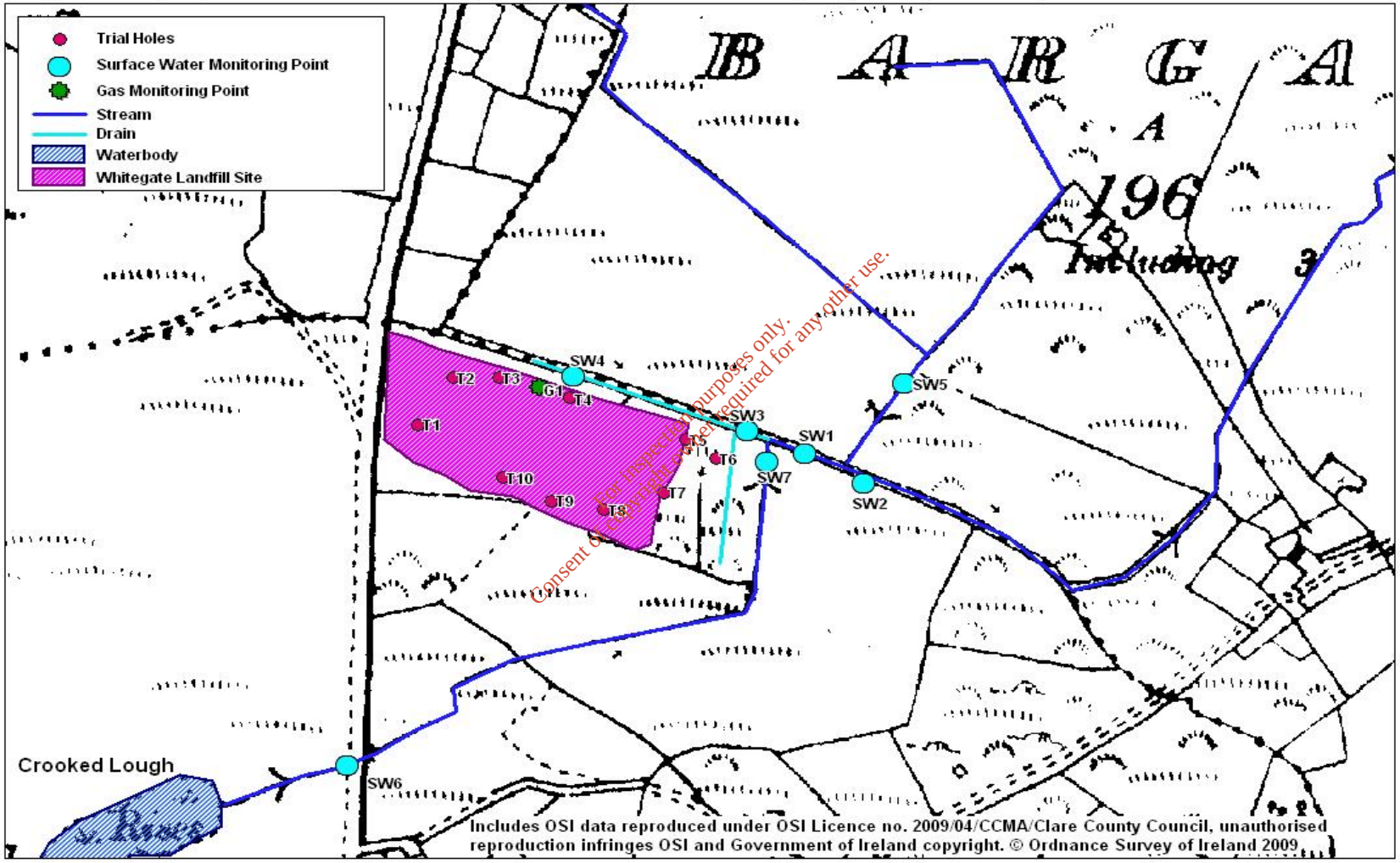
			Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**		SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	-		09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
Magnesium[1]	**mg/l**		1.62	1.83	1.49	2.16	2.11	10.6	11.8	**94.9**	**77.9**	**74.7**	49.6
Magnesium[3]	**mg/l**		-	-	-	-	-	-	-				
Potassium[1]	**mg/l**		<2.34	<2.34	<2.34	<2.34	<2.34	**9.15**	**7.76**	**109**	**119**	**272**	**44.0**
Potassium[3]	**mg/l**		-	-	-	-	-		-				
Iron[1]	**mg/l**		**2.23**	**3.49**	**1.69**	**1.63**	**1.96**	**3.26**		**1.25**	**11.4**	**22.8**	**14.2**
Iron[3]	**mg/l**		-	-	-	-	-	-	-				
Pesticides/Herbicides	**Atrazine**	**µg/l**	-	-	-	-	-	-	-	<1	<1	<1	<1
	Simazine	**µg/l**	-	-	-	-	-	-	-	<1	<1	<1	<1
	Remainder	**µg/l**	-	-	-	-	-	-	-	<0.01	<0.01	<0.01	<0.01
SVOC's	**4-Methylphenol**	**µg/l**	-	-	-	-	-	-	-	<1.00	46.5	159	2.62

			Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**		SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	-		09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
	Bis (2-ethylhexyl) phthalate	**µg/l**	-	-	-	-	-	-	-	21.1	7.03	54.6	4.64
	Di-n-butyl phthalate	**µg/l**	-	-	-	-	-	-	-	<1.00	1.77	**6.42**	<1.00
	Fluorene	**µg/l**	-	-	-	-	-	-	-	1.11	<1	<1	<1
	Phenol	**µg/l**	-	-	-	-	-	-	-	<1.00	**9.89**	**14.6**	<1.00
	Naphthalene	**µg/l**	-	-	-	-	-	-	-	1.17	<1	1.12	<1.00
	Diethyl phthalate	**µg/l**	-	-	-	-	-	-	-	1.48	<1.00	<1.00	<1.00
	DI-n-Octyl phthalate	**µg/l**	-	-	-	-	-	-	-	<5	<5	<5	<5

			Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**		SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	-		09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
	Remainder of SVOC's	**µg/l**	-	-	-	-	-	-	-	<1.00	<1.00	<1.00	<1.00
VOC's	**Benzene**	**µg/l**	-	-	-	-	-	-	-	<1.30	<1.30	**1.82**	<1.30
	Chlorobenzene	**µg/l**	-	-	-	-	-		-	**<3.50**	**<3.50**	**24.7**	**<3.50**
	P/m-Xylene	**µg/l**	-	-	-	-		-	-	<2.50	4.76	**19.0**	24.5
	o-xylene	**µg/l**	-	-	-	-	-	-	-	<1.70	<1.70	2.99	<1.70
	1,3,5-Trimethyl-benzene	**µg/l**	-	-	-	-	-	-	-	<1.80	<1.80	4.78	<1.80

			Upstream samples		Downstream samples					Leachate samples			
Parameter	**Units**		SW6	SW 5	SW7	SW1	SW2	SW4	SW3	L3	L4	L5	L8
Lab code	-		09-2692	09-2691	09-2693	09-2687	09-2688	09-2690	09-2689	09-2682	09-2684	09-2685	09-2686
	1,2,4-Trimethyl-benzene	**µg/l**	-	-	-	-	-	-	-	<1.70	4.51	18.5	5.25
	4-Isopropyltoluene	**µg/l**	-	-	-	-	-	-	-	<2.60	<2.60	14.1	<2.60
	Remainder of VOC's [2]	**µg/l**	-	-	-	-		-	-	<LOD[2]	<LOD[2]	<LOD[2]	<LOD[2]

Figure 4 Sampling site locations: Trial Holes (T1 - T10) and Surface Water sampling points (SW1 - SW8).



APPENDIX 2

LOUGH ALLEWNAGHTA MONITORING DATA

(Data provided by Clare County Council derived from EPA Surveillance Monitoring Programme and Clare County Council)

Waterbody	Sampling date	Alkalinity mg/l CaCO3	Ammonium mg/l NH4	Calcium mg/l CaCO3	Chloride mg/l	Chlorophyll mg/l	Conductivity uS/cm @ 20°C	Dissolved Oxygen Surface mg/l O2	Dissolved Oxygen Surface %Sat	Magnesium
Alewnaghta	30/04/2007	100.0	0.100	31.4	23.00	5.84	210.9	10.00	105.0	2.78
Alewnaghta	18/06/2007	90.0	0.100			17.53	203.6	9.10	92.0	
Alewnaghta	13/08/2007	80.0	0.100			16.42	158.8	10.10	103.0	
Alewnaghta	28/08/2007	102.0	0.021		15.34		150.0	12.10	131.0	
Alewnaghta	21/09/2007	172.0	0.084		14.92		159.7	8.70	86.0	
Alewnaghta	23/10/2007	110.0	0.260			7.42	186.2	7.30	71.0	
Alewnaghta	04/04/2008	51.0	0.034		20.10	3.10		10.80	99.0	
Alewnaghta	04/04/2008					3.10				
Alewnaghta	20/06/2008	45.0	0.005		19.51	4.00	237.0	9.84	101.0	
Alewnaghta	20/06/2008					4.00				
Alewnaghta	01/10/2008	62.0	1.600	23.7	15.20	0.90	191.0	10.10	97.0	2.47
Alewnaghta	25/08/2008	60.0	0.026	21.0	14.80	5.20	168.0	8.60	88.2	2.22

Waterbody	Sampling date	pH 2	Potassium	Secchi m	Silica mg/l SiO2	Sodium mg/l	Sulphate mg/l	Temp surface ºC	Total Oxidised Nitrogen mg/l N	Total Phosphorus mg/l P	True Colour
Alewnaghta	30/04/2007	7.6		2.80		11.0	9.00	14.20	0.300	0.025	22
Alewnaghta	18/06/2007	7.7		1.86				16.50	0.150	0.025	25
Alewnaghta	13/08/2007	7.4		1.70				16.30	0.150	0.025	64
Alewnaghta	28/08/2007	7.5			0.3490		10.64	19.20	0.050	0.041	83
Alewnaghta	21/09/2007	7.5			1.7400		7.65	14.90	0.050	0.047	35
Alewnaghta	23/10/2007	7.2		2.00				13.90	0.150	0.005	77
Alewnaghta	04/04/2008	7.6			2.06		7.66	11.00	0.390	0.038	16
Alewnaghta	04/04/2008										
Alewnaghta	20/06/2008	7.7			0.72		8.08	16.50	0.050	0.012	15
Alewnaghta	20/06/2008										
Alewnaghta	01/10/2008	7.8	1.34			9.90	5.00	17.60	0.210	0.017	
Alewnaghta	25/08/2008	7.6	1.38			9.45	5.61	16.40	0.120	0.027	

Waterbody	Sampling date	Alkalinity mg/l CaCO3	Ammonium mg/l NH4	Calcium mg/l CaCO3	Chloride mg/l	Chlorophyll mg/l	Conductivity uS/cm @ 20°C	Dissolved Oxygen Surface mg/l O2	Dissolved Oxygen Surface %Sat	Magnesium
Alewnaghta	30/04/2007	100.0	0.100	31.4	23.00	5.84	210.9	10.00	105.0	2.78
Alewnaghta	18/06/2007	90.0	0.100			17.53	203.6	9.10	92.0	
Alewnaghta	13/08/2007	80.0	0.100			16.42	158.8	10.10	103.0	
Alewnaghta	28/08/2007	102.0	0.021		15.34		150.0	12.10	131.0	
Alewnaghta	21/09/2007	172.0	0.084		14.92		159.7	8.70	86.0	
Alewnaghta	23/10/2007	110.0	0.260			7.42	186.2	7.30	71.0	
Alewnaghta	04/04/2008	51.0	0.034		20.10	3.10		10.80	99.0	
Alewnaghta	04/04/2008					3.10				
Alewnaghta	20/06/2008	45.0	0.005		19.51	4.00	237.0	9.84	101.0	
Alewnaghta	20/06/2008					4.00				
Alewnaghta	01/10/2008	62.0	1.600	23.7	15.20	0.90	191.0	10.10	97.0	2.47
Alewnaghta	25/08/2008	60.0	0.026	21.0	14.80	5.20	168.0	8.60	88.2	2.22

Waterbody	Sampling date	pH 2	Potassium	Secchi m	Silica mg/l SiO2	Sodium mg/l	Sulphate mg/l	Temp surface ºC	Total Oxidised Nitrogen mg/l N	Total Phosphorus mg/l P	True Colour
Alewnaghta	30/04/2007	7.6		2.80		11.0	9.00	14.20	0.300	0.025	22
Alewnaghta	18/06/2007	7.7		1.86				16.50	0.150	0.025	25
Alewnaghta	13/08/2007	7.4		1.70				16.30	0.150	0.025	64
Alewnaghta	28/08/2007	7.5			0.3490		10.64	19.20	0.050	0.041	83
Alewnaghta	21/09/2007	7.5			1.7400		7.65	14.90	0.050	0.047	35
Alewnaghta	23/10/2007	7.2		2.00				13.90	0.150	0.005	77
Alewnaghta	04/04/2008	7.6			2.06		7.66	11.00	0.390	0.038	16
Alewnaghta	04/04/2008										
Alewnaghta	20/06/2008	7.7			0.72		8.08	16.50	0.050	0.012	15
Alewnaghta	20/06/2008										
Alewnaghta	01/10/2008	7.8	1.34			9.90	5.00	17.60	0.210	0.017	
Alewnaghta	25/08/2008	7.6	1.38			9.45	5.61	16.40	0.120	0.027	

Appendix 2.

Whitegate Groundwater Results – December 2009

Parameter	LOD	Parametric Value – EC(Drinking Water) Regulations, 2007	Sample No.			
			09-2995	09-2996	09-2997	09-2998
			Up Gradient of Landfill **Well A**	*Before treatment* ***Down gradient*** **Well B**	***After treatment Down gradient*** **Well B**	***Down Gradient*** **Well C**
Turbidity		No abnormal change	18.4	>4000	1.71	0.187
Colour		No abnormal change	129	>500	28	<5
pH		6.5 - 9.5	6.85	7.07	7.66	7.97
Conductivity		2500 $uScm^{-1}$	357	595	772	465
Ammonium		0.30mg/l	0.012	4.631	0.479	0.177
Nitrite		0.50mg/l	<0.0025	<0.0025	<0.0025	<0.0025
Chloride		250mg/l	11.33	22.19	37.24	22.56
E. coli		0 cfu	0	0	0	0

Coliform Bacteria		0 cfu	4	0	0	0
Total Alkalinity as CaCO3	<2 mg/l	None	155	300	400	225
Fluoride	<0.5 mg/l	1000mg/l	<0.5	<0.5	<0.5	<0.5
Arsenic Dissolved	<0.12 µg/l	10ug/l	1.24	489	461	1.1
Boron Dissolved	<9.4 µg/l	1000ug/l	112	<9.4	<9.4	<9.4
Cadmium Dissolved	<10 µg/l	5ug/l	<10	<10	<10	<10
Chromium Dissolved	<0.22 µg/l	50ug/l	1	1.54	2.01	1.24
Copper Dissolved	<0.85 µg/l	2000ug/l	1.23	4.54	3.15	22
Lead Dissolved	<0.02 µg/l	10ug/l	0.14	2.35	0.673	1.51
Manganese Dissolved	<0.04 µg/l	50ug/l	16.2	897	7.4	28
Nickel Dissolved	<0.15 µg/l	20ug/l	0.404	1.84	0.768	1.34
Selenium Dissolved	<0.39 µg/l	10ug/l	<0.39	0.435	1.14	0.857
Zinc Dissolved	<0.41 µg/l	None	2.26	16.6	6.79	42.9
Mercury	<0.01 µg/l	1ug/l	<0.01	<0.01	<0.01	<0.01

Dissolved						
Sulphate (soluble)	3000ug/l	250ug/l	17000	6600	9100	15700
Chloride	<2 mg/l	None	12.6	22.4	39	24.1
Phosphate (ortho as PO4)	<0.08 mg/l	None	<0.08	<0.08	0.529	<0.08
Chromium (Unfiltered)	<3 µg/l	50ug/l	3.93	<3	<3	<3
Phosphorus (Unfiltered)	<18.3 µg/l	None	31.8	108	40.2	<18.3
Total Cyanide	<50 mg/l	50ug/l	<50	<50	<50	<50
Calcium Dissolved	0.012 mg/l	None	23	118	1.26	69.1
Sodium Dissolved	0.076 mg/l	None	83.8	17	231	10.7
Magnesium Dissolved	0.036 mg/l	None	7.57	6.75	<0.036	3.8
Potassium Dissolved	2.335 mg/l	None	4.92	<2.34	<2.34	3.78
Iron Dissolved	19ug/l	200ug/l	<19	7880	96.7	<19