Attachment I.5

Ground and /or groundwater

Locations

Schwarz Pharma Ltd.

Revised IPPCL Application

Issue No : 2

53836-003

CONTENTS

CONTENTS

1. GROUND WATER MONITORING

Groundwater monitoring is carried out by Schwarz Pharma Ltd. in accordance with the current IPC Licence, Condition 9.3 and Schedule 5(ii) –Groundwater Analysis on Site. Monitoring has been undertaken annually at eleven sampling locations, seven wells at the main site and four at Bay 130. Manufacturing operations at Bay 130 have now ceased. Monitoring Locations for the main site area are detailed in Attachment F.2. Details of GS 11 and GS 12 borehole installation are contained in appendix I.5.1, Bord Na Mona Report T104-GW and details of GS02, GS03, GS04 and GS06 installation are contained in Appendix I.5.2 Bord Na Mona Report K207/R1

Table I.4 Groundwater Monitoring Points

Well No.	Location	Direction
GS 01	Main Plant	East of the canteen
GS 02	Main Plant	South East of BPC
GS 03	Main Plant	South East of Tank Farm
GS 04	Main Plant	South of the Effluent Treatment Tank
GS 06	Main Plant	North of the Pharma Plant
GS 11	Main Plant	North of the Blower House
GS 12	Main Plant	North East of the Nitration Plant

2. GROUNDWATER QUALITY

Groundwater samples at Schwarz Pharma Ltd. are analysed for trace organics, major anions, cations, total ammonia, nitrate and individual heavy metals. Analytical results for trace organics (purgeable organic compounds by USEPA method 524.2) and non-purgeable organic compounds are below method detection limits for all groundwater samples. Analytical results for berrylium, cobalt, copper, silver, cadmium antimony, lead and mercury are reported to be < 2µg/l.

Schwarz Pharma Ltd. has included a project for 2004/5 to trend monitoring data in order to provide a comprehensive evaluation of the hydrogeological regime at the site and also the local groundwater quality. Details of groundwater quality are contained in Table I.4(i).

3. GROUNDWATER USAGE

Large volume extraction of groundwater is unlikely given that the groundwater in the soil zone is saline (elevated sodium and chloride concentrations) and not suitable for potable use. Groundwater in the bedrock aquifer is also suspected to be saline.

4. GROUNDWATER PROTECTION

Schwarz Pharma has implemented a number of measures to ensure that groundwater is protected at their facility.

- All manholes, boreholes and inspection holes are readily identified, secured and are easy to use when required. In the event of an incident occurring on site or during an emergency, it is essential to be able to readily identify the source in order to manage the impact to surface and groundwater.
- Drain surveys are conducted to ensure the integrity of all underground piping for the transfer of chemicals and contaminated water in process and foul sewers. Damaged lines are identified and the necessary remedial works completed.
- All measures have been taken to ensure adequate storage space is available in the dedicated Waste Management area and that the area is of suitable construction to prevent a risk of surface and groundwater pollution.
- Bund integrity is checked on a regular basis, with repair work being undertaken where leaks are identified. Further information on bund integrity is included in Attachment H.2.
- A firewater pump is operational on site. This ensures that firewater arising on site in the event of a fire scenario is retained and does not pose a threat to surface or groundwater sources.

5. GEOLOGY AND HYDROGEOLOGY

Bay 130 is underlain by very soft, clayey, silty, peaty soils between 5 and 6 metres thick, which are considered to be either natural estuarine muds or dredging used as in-fill material. The main Schwarz Pharma site is underlain by stiff silty clay and peat, about 2-3 meters thick. This layer overlies a meter or so of peat and broken rock fragments, including boulders. The Eastern area of the site is underlain mostly by 3 meters of clayey silt and thin beds of peat and gravel, about 3-4 meters deep. These soils overly the limestone bedrock.

The bedrock under the main Schwarz Pharma Ltd. site and Bay 130 is composed of the Ballysteen Limestone Formation, a fossiliferous dark grey muddy limestone, which underlies virtually the entire Shannon Airport area (Geological Survey of Ireland, Geology of the Shannon Estuary, GSI, 1999). The bedding planes in the Ballysteen Formation 'dip' to the north west at 10° to 35°.This limestone is ranked as a 'Locally

Important' (GSI terminology) aquifer by the GSI, however the well yields are extremely dependant on wells intersecting major fractures or not. High yields have been reported from this formation where major fracture zones have been intersected, though water quality is often poor, with high iron and manganese problems common (elevated iron and manganese are detected in the shallow groundwater samples from around Bay 130). A single high yielding well in known to exist (within a bedrock fracture zone) in the Smithstown Industrial Estate, some 2 km to the east.. Often the main zone of groundwater movement occurs in a more fractured, weathered zone a few metres thick at the top of bedrock in such situations. Details of all wells GSI records, within a 3km radius of the site, are listed in Appendix I.5.6.

The groundwater in the soil zone is saline (elevated sodium and chloride concentrations) and not suitable for potable use. Groundwater in the bedrock aquifer is also suspected to be saline, though this is unproven. Meteorological data for the site is included in appendix I.5.5

Groundwater flow is to the south and east towards the Shannon Estuary. The Piezometric Gradient under site was investigated as part of the Bord na Mona reports contained in appendix I.5.1 and 1.5.3.

6. GROUNDWATER CONTAMINATION

In the first quarter 1997, spillage occurred from an IBC in the drum store area. 1000l IBC containing Desipramine Carbamate in Xylene overturned and spilled onto the grassed area beside the drum store. The EPA where informed at the time. In April 1997, Schwarz Pharma Ltd. commissioned Bord na Mona to investigate the impact on groundwater in the vicinity of GS04. As part of the investigation 5 new groundwater monitoring borehole where installed. The borehole logs are presented in Appendix 1 of the report contained in Appendix I.5.2 to this attachment. GS04 was found to be contaminated with a wide variety of organic chemicals. A comprehensive pump and treat program was implemented at GS04 and a follow up report was completed by Bord na Mona in 1998, see Appendix I.5.3. In February 2000 Bord Na Mona considered that the isolated groundwater contamination previously recorded at the site had been effectively contained and remediated, see Appendix I.5.4.

Organic contaminants have been detected in two monitoring wells, GS03 and GS11, after a period of sampling for the presence of any contaminant had been below the detection level. The organic contaminants detected are used on site. Schwarz Pharma contracted O'Neill Ground Water Engineering to prepare a proposal to further investigate the extent of the contamination and also to develop a remediation programme. This proposal to address the ground water contamination issue at Schwarz is included in Appendix I.5.9.

7. SUBSIDENCE IN BAY 130

Subsidence of the floor slab in Bay 130 has been ongoing since Schwarz Pharma Ltd. began occupation of the unit in 1978. Schwarz Pharma Ltd. has commissioned a number of reports to determine the cause and extent of the problem.

Differential subsidence of the floor slabs relative to the structural frame has occurred throughout Bay 130. Settlement is oriented parallel to the long axis of the building and is most marked in the production and stores areas, where the floor slab has locally settled by over 0.1 metres in places and drains and manholes now stand proud of the surrounding floor. The extent of the subsidence was detailed in a Gibson O'Connor report 1278 (1997). The report identified the soft underlying soils as the cause of the subsidence.

Soil and groundwater investigation work has been completed on behalf of Schwarz Pharma Ltd. by Bord Na Mona in 1996 and 1997 which detected nitrogen compound contamination of shallow groundwater in the soft, clayey, silty, peaty soils, principally by ammonia and nitrate. Three pre-existing wells were sampled and a further four shallow wells were drilled and sampled in late 1996 to obtain higher quality groundwater samples, due to deficiencies in the construction of the earlier wells.

Bord na Mona (report K207/R2) considered that the subsidence of the floors within the building may have led to damage to the subsurface drains and pipework resulting in the observed nitrogen or ammonia inputs to the subsurface. No evidence of releases to ground of volatile organics, metals or acids (monitoring well pH near neutral) was detected by Bord na Mona.

The reports were reviewed by URS in 2004 as part of the Residual Management Plan for Bay 130 (contained in Attachment K). URS identified the possibility of a fracture zone or other weak zone in the underlying bedrock as having contributed to the subsidence issue.

URS also explored the possibility of acid dissolution of the limestone bedrock due to spills of acid or leaking acid effluent drains as a possible cause of subsidence beneath the building. Low pH has never been detected in any of the wells around the perimeter of the building and saline water contained in the soil and bedrock aquifer would have a high pH buffering effect so acid release as a potential cause of subsidence was ruled out.

URS recommended that following site closure, investigations of potential source areas of chemical release should be carried out by undertaking an intrusive investigation close to areas of potential concern. The intrusive investigation would focus primarily on the bedrock zone to establish if there is potential for significant groundwater movement within the bedrock aquifer.

URS also recommended that a CCTV survey of the drains beneath the floor slab be carried out to inspect their condition and assess the likelihood of effluent releases to ground.

Appendix I.5.1

Hydrogeological Investigation of the SIFA complex Shannon Free Zone

Installation and subsequent sampling of two additional boreholes

Bord na Mona report T104-GW

BORD NA MÓNA

BORD NA MÓNA ENVIRONMENTAL LIMITED

HYDRODROGEOLOGICAL INVESTIGATION OF THE SIFA COMPLEX SHANNON FREE ZONE

INSTALLATION AND SUBSEQUENT SAMPLING OF TWO ADDITIONAL BOREHOLES

REPORT NO: T104-GW

ATTENTION: Mr. John O' Donaghue
SIFA Ltd.,
Shannon Free Zone
Co. Clare

PREPARED BY: Mr. Garrett Leech
Waste/Water Section Head

REVIEWED BY: Ms. Sarah Casey
Environmental Consultant

DATE: 13TH August 2001

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REGISTERED IN IRELAND NUMBER: 303313

Executive Summary

Bord na Mona Environmental Consultancy Ltd., were contracted by SIFA Ltd. to install an additional 2 no. groundwater monitoring boreholes within the vicinity of the new Nitration plant to the north of the complex. These additional boreholes were also sampled so as to assess the chemical quality of the groundwater. A piezometric map was generated for the facility using data obtained from all onsite-monitoring boreholes.

To this effect, 2 no. boreholes were installed upgradient and downgradient from the newly constructed Nitration plant at the facility. The underlying Quaternary deposits were identified as glacial tills with bedrock lying at between 2 m bgl (below ground level) and 3.5 m bgl.

The underlying bedrock geology is made up of the Ballysteen Formation consisting of fossiliferous dark-grey muddy limestones. Groundwater vulnerability of the facility is classified, using the criteria established by the GSI, as being of *Moderate to Extreme*.

Groundwater quality beneath the site is generally of good quality, showing little evidence of contamination originating from the activities of the SIFA Complex.

Garrett Leech

Mr. Garrett Leech
Waste/Water Section Head

Sarah Casey

Ms. Sarah Casey
Environmental Consultant

TABLE OF CONTENTS

1.0 INTRODUCTION

SIFA Ltd., manufacturers of Fine Chemicals for the pharmaceutical and chemical industry is situated in the Shannon Free Zone, Co. Clare.

SIFA LTD commissioned these investigations, to establish baseline conditions of the groundwaters underlying a new nitration plant at the facility prior to the plant going on line.

The Sifa Limited site was visited on Wednesday 4th April 2001 and the installation of 2 no. boreholes was undertaken at this time.

Following on to this Bord na Móna Environmental Ltd, sampled the two newly installed boreholes on Monday 14th May 2001 to assess groundwater quality. Groundwater samples were returned to the laboratory for subsequent analysis. In addition to this, all of the existing boreholes were measured for static water level.

This report details the information obtained from the site during the borehole installation program and the groundwater sampling event that took place including the sampling and analytical methods used. A piezometric map has been generated from the water levels obtained on the site during the field activities. A commentary on the analytical results is also included.

2.0 SITE INVESTIGATIONS

2.1 Borehole Installation

On the 4th April 2001, by the request of Bord na Mona Environmental Limited, Messrs. Glover Site Investigation Ltd. installed 2 no. groundwater monitoring boreholes at the north of the site (adjacent to the newly built Nitration Plant, see attached map in appendix 1). The boreholes were drilled by means of a truck mounted, rotary air blast drill rig and the hole diameter was 6 inch. Both boreholes had a 50mm PVC standpipe installed, with the bottom section of the standpipe slotted so as to allow entry of groundwater into the annulus. Wells were backfilled with washed pea gravel (surrounding the standpipe) and the top 1.5m was backfilled with bentonite pellets so as to grout the monitoring wells and prevent contamination emanating from the surface. Further details of the monitoring wells can be found in appendix 2 – borehole logs.

2.2 Groundwater Sampling

Groundwater in the well casing and in close proximity to the well is not considered representative of the general groundwater at a given location. In order to ensure that the groundwater samples extracted from the newly installed monitoring wells were representative of the groundwater held in the subsurface strata and not water held stagnant in the casing, it was necessary to develop the wells prior to purging and sampling. The objective of well development is to allow the settlement of the newly-installed gravel pack, to obtain the maximum well life and to cleanse the water bearing strata in the immediate vicinity of the well of fines/debris resulting from the drilling process. The newly installed wells were developed using air lifting techniques and were then allowed to settle prior to sampling.

Following development, the wells were further purged prior to sampling. A common procedure is to pump the well until between 2 and 5 bore volumes have been removed (Marsh and Lloyd 1980 and Boating 1987). The purged volumes were calculated on-site from the measured static water levels (measured using an electronic well dipper) and the total depth of the well. In order to ensure efficacy of the evacuation procedure, the pH and conductivity of the extracted water was continually monitored. Evacuation was deemed to be complete on stabilisation of both parameters.

The "Water inertial lift pump" system was used to evacuate all of the monitoring bores. The system comprises of three main components:

- Manual drive HDPE
- Riser tubing (HDPE or Teflon)
- Non return foot value

The required length of tubing was cut so as to allow a 1m excess above the top of the well casing. A non return stainless steel foot valve was fitted to the bottom of the tubing and inserted into the bore to the required depth. The pump was operated by vertically oscillating the tubing in the bore. A discharge rate of 2 - 3 l min-1 was achieved using the system described. Separate tubing and foot valves were used at each monitoring bore to eliminate the possibility of cross contamination.

Samples were returned to the Bord na Mona Laboratory at Newbridge and stored at 2-8°C. The appropriate analytical determinations were conducted as per table 2.2.1 below.

Table 2.2.1: Groundwater Analytical Schedule & Methods of Analysis

	Location		
	GS-11	GS-12	
Parameter			Method of Analysis
pH pH units	✓	✓	G/05
Conductivity µS/cm @ 25°C	✓	✓	G/06
Alkalinity as $CaCo_3$ mg/l	✓	✓	G/20
Ammonia as N mg/l	✓	✓	G/02
Nitrate as N mg/l	✓	✓	IC based on ASTM D 4327
Chloride mg/l	✓	✓	ASTM D 4327
Sulphate mg/l	✓	✓	G/39
Phosphate as P mg/l	✓	✓	G/39
Fluoride mg/l	✓	✓	APHA 4500F-C
Potassium mg/l	✓	✓	ICP-MS
Calcium mg/l	✓	✓	ICP-MS
Sodium mg/l	✓	✓	ICP-MS
Magnesium mg/l	✓	✓	ICP-MS
Arsenic µg/l	✓	✓	ICP-MS
Cadmium µg/l	✓	✓	ICP-MS
Lead µg/l	✓	✓	ICP-MS
Zinc µg/l	✓	✓	ICP-MS
Chromium µg/l	✓	✓	ICP-MS
Copper µg/l	✓	✓	ICP-MS
Aluminium µg/l	✓	✓	ICP-MS
Antimony µg/l	✓	✓	ICP-MS
Barium µg/l	✓	✓	ICP-MS
Nickel µg/l	✓	✓	ICP-MS
Manganese µg/l	✓	✓	ICP-MS
Iron mg/l	✓	✓	ICP-MS
Mercury µg/l	✓	✓	ICP-MS
Boron µg/l	✓	✓	ICP-MS
Beryllium µg/l	✓	✓	ICP-MS
Tin µg/l	✓	✓	ICP-MS
Silver µg/l	✓	✓	ICP-MS
Cobalt µg/l	✓	✓	ICP-MS
Selenium µg/l	✓	✓	ICP-MS
TPH's µg/l	✓	✓	GC-MS with Purge and Trap
USEPA 524.2* µg/l	✓	✓	GC-MS with Purge and Trap
Methanol mg/l	✓	✓	GC-FID
Acetonitrile mg/l	✓	✓	GC-FID
Ethanol mg/l	✓	✓	GC-FID
Acetone mg/l	✓	✓	GC-FID
Isopropanol mg/l	✓	✓	GC-FID

*Purgeable Organic's see appendix 3 for list of compounds

2.2.1 Control Chain of Custody

As part of the Quality System in place in Bord na Móna, Environmental Ltd., measures are taken to ensure controlled chain of custody. An outline of the chain of custody is given overleaf.

BORD NA MÓNA

BORD NA MÓNA ENVIRONMENTAL LIMITED

CONTROLLED CHAIN OF CUSTODY

SITE	TRANSPORT	LABORATORY
Sampling and packaging of all samples were carried out by Bord na Móna Technical Team: E. Moran & J. Marsh	Transport Document Form → Transport to laboratory by Bord na Móna Technical Team. → Sample Reception Form	Receiving of samples at Bord na Móna Environmental Laboratory complex by: M. Mc Fadden, Laboratory Manager (Secure laboratory complex access to authorised personnel only) ↓ Storage of all samples for 1 month period after report issue. ↓ Supervised Disposal

2.2.2 Quality Control

The Environmental Laboratory complex has been recommended for ILAB accreditation by the ILAB secretariat. A stringent six point quality control approach is at present implemented in the laboratories.

(i) Controlled chain of custody.

(ii) Operator competence - all analysts must be suitably qualified to carry out the required analysis.

(iii) Certified Reference Materials (CRM). The accuracy of a series of determinations is checked against known standards.

(iv) Duplicate - 10% duplication is normal.

(v) Quality Control Charts.

(vi) Inter Laboratory Testing - The Environmental Limited Laboratories are members of the WASP Interproficiency Testing Scheme and the W.R.C. Aquacheck Scheme. The Laboratory also participates in the Environmental Protection Agency's Intercalibration Programme and is listed on the Agency's Register of Quality Approved Testing Laboratories issued for 1999.

2.3 Piezometric Mapping

In order to establish the direction of groundwater migration and the associated hydraulic gradient, assessments of the ground level and SWL's at each of the 7 no. groundwater monitoring locations on the main SIFA site was conducted. This was achieved using an appropriate well depth monitoring device (electronic) and standard surveying techniques. The resulting piezometric map is presented in Appendix 1.

The resulting map shows a defined westerly gradient over the site, with the greatest gradients evident at the southerly end of the site (near car-park), where a clear tightening of the groundwater contours are evident.

3.0 GEOLOGY/HYDROGEOLOGY

The bedrock geology underlying the site is made up of Lower Carboniferous Limestones. These rocks make up part of the Ballysteen Formation (BA) and consist of fossiliferous dark-grey muddy limestones.

The installation of monitoring boreholes, as part of previous investigations undertaken around the facility indicate that the depth to bedrock ranges between 5.2 m and 6 m within the southern area of the facility. As part of these investigations 2 no. additional boreholes were drilled (in the vicinity of the Nitration Plant) within the northern area of the facility. Bedrock was encountered within both boreholes (GS 11 & GS 12) at a depth of 3.5 m bgl (below land ground level) and 2 m bgl respectively.

The boreholes drilled identified the following lithology within the underlying deposits:

Infill Material	0.0 – 0.5 m	Made-up clayey ground/concrete
Glacial Till	0.5 – 2.0/3.5 m	Stiff Sandy Silty CLAY, containing rounded to sub-rounded clasts
Bedrock	2.0/3.5	Limestone bedrock

Groundwater vulnerability has not been undertaken by the GSI for County Clare. The guidelines published by the GSI have been used to classify the area. The area is underlain by between 2 - 6 metres of moderate to low permeable Quaternary deposits and as such groundwater vulnerability is classified as *Moderate - Extreme*.

4.0 GROUNDWATER QUALITY RESULTS

The results of the investigations carried out by Bord na Móna, Environmental Ltd., are presented as follows:

Table 4.1: Results of Field Measurements taken at Groundwater Monitoring Borehole

Table 4.2: Chemical Analysis of Groundwater Sample
The Dutch VFR Guidelines Values and MACs (Maximum Acceptable Concentration (98/83/EC) are listed on the right hand margin for of table comparison purposes.

TABLE 4.2 CHEMICAL ANALYSIS OF GROUND WATER SAMPLES			
Parameter	GS 11	GS 12	MAC values
pH pH units	7.9	7.5	6.5 – 9.5
Conductivity µS/cm @ 25°C	1476	1202	2,500
Alkalinity as $CaCo_3$ mg/l	550	435	-
Ammonia as N mg/l	0.6	<0.2	0.23
Nitrate as N mg/l	<0.04	0.3	11.3
Chloride mg/l	49.8	29.1	250
Sulphate mg/l	222.6	203.4	250
Phosphate as P mg/l	<0.16	<0.16	
Fluoride mg/l	0.2	<0.1	1.5
Potassium mg/l	7	<2	
Calcium mg/l	105	166	
Sodium mg/l	70	8	200
Magnesium mg/l	28	7	
Arsenic µg/l	4	<2	10/60[1]
Cadmium µg/l	<2	<2	0.4/6[1]
Lead µg/l	<2	<2	15/75[1]
Zinc µg/l	0.20	0.26	65/800[1]
Chromium µg/l	<2	<2	1/30[1]
Copper µg/l	3	3	15/75[1]
Aluminium µg/l	<2	<2	200
Antimony µg/l	<2	<2	5
Barium µg/l	149	295	50/625[1]
Nickel µg/l	<2	<2	15/75[1]
Manganese µg/l	753	11	50
Iron mg/l	<0.1	<0.1	200
Mercury µg/l	<1	<1	0.05/0.3[1]
Boron µg/l	30	579	1000
Beryllium µg/l	<2	<2	
Tin µg/l	<2	<2	
Silver µg/l	<2	<2	
Cobalt µg/l	<2	<2	20/100[1]
Selenium µg/l	<2	<2	10
USEPA 524.2* µg/l	<10	<10	
Methanol mg/l	<0.5	<0.5	
Acetonitrile mg/l	<0.5	<0.5	
Ethanol mg/l	<0.5	<0.5	
Acetone mg/l	<0.5	<0.5	
Isopropanol mg/l	<0.5	<0.5	

[1]Dutch VFR Groundwater Quality Guidelines: Target Values "S"/ Intervention Values "I"
Values in Bold exceed the Maximum Admissible Concentrations as per the water drinking water directive 98/83/EEC or the Dutch Intervention Values
*See Appendix III for USEPA 524.2 parameter list

5.0 DISSCUSSION & CONCLUSION

The groundwater parameters are compared water drinking water directive 98/83/EC (Quality of water intended for Human Consumption) and the Dutch VFR groundwater quality guidelines. The Dutch "S" value or reference value can be considered as indicative of clean material. The Dutch "I" value is that above which the natural function of groundwater is significantly compromised.

The groundwater quality at the site is, in general, what would be expected from a limestone aquifer of this nature, however the elevated conductivity and sodium (particularly in GS-11) levels recorded is most likely as a result of saline intrusion.

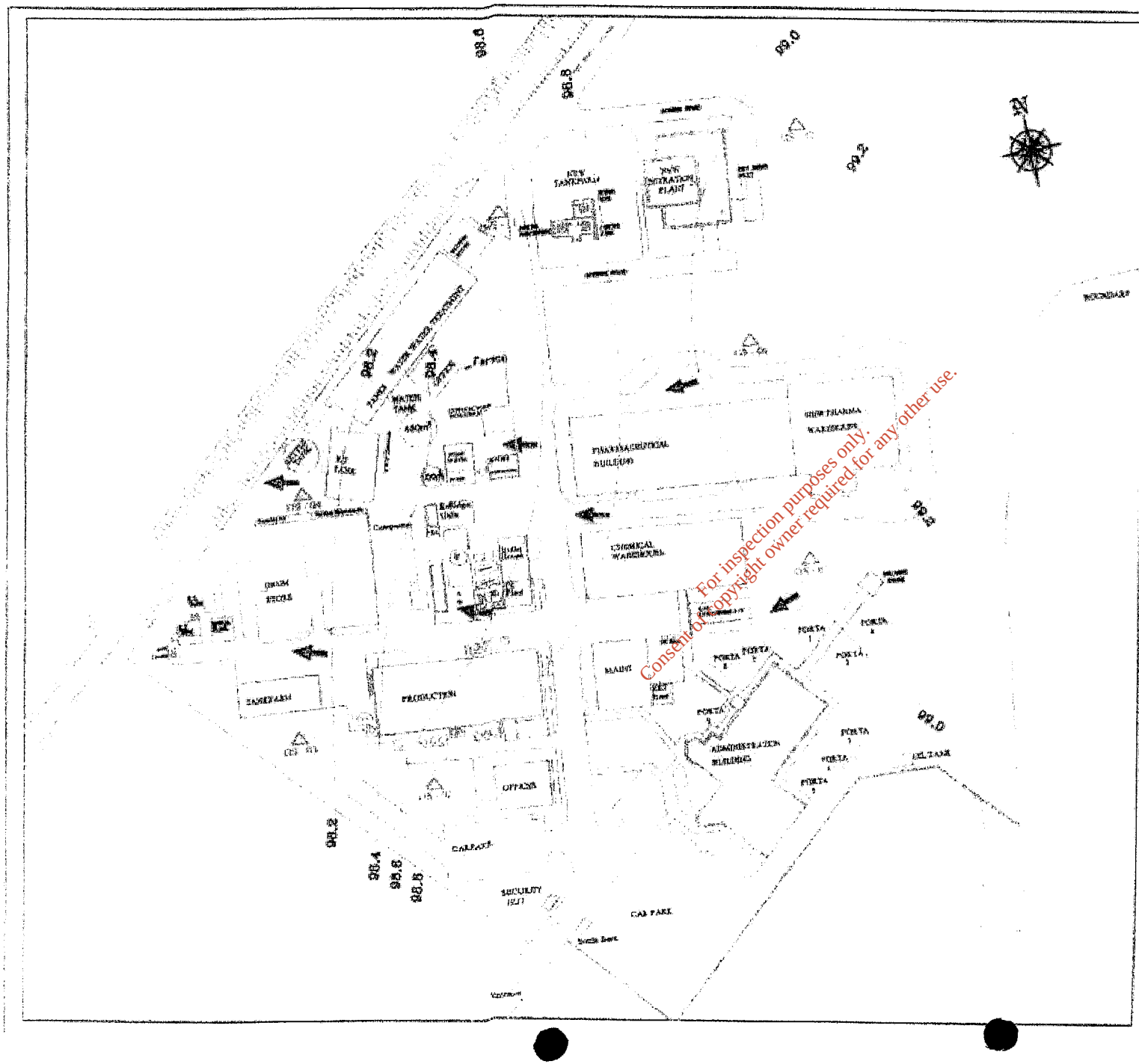
The analytical results obtained from the US EPA 542.2 scan for a range of organic chemical contaminants (Appendix III) indicate that there have been no inputs of these chemicals from the area adjacent to the Nitration plant into the underlying groundwater.

A elevation of ammonia was recorded in GS-11 (0.6 mg/l) of which the source is not currently known, however it is possible that it could have originated from a nearby surface water drain which flows through the adjacent industrial estate.

In summary, the groundwater quality recorded (from the parameters analysed) from GS-11 and GS-12 was of relatively good quality. A minor elevation of ammonia was recorded in GS-11 of which the origin is unknown but is most likely to be of a localised nature. Both monitoring wells displayed elevated conductivity levels which may be as a result of saline intrusion.

Appendix 1

Site Layout/Location of Boreholes and Piezometric Contour Map



Piezometric Gradient

	LEGEND
98.2	Water Table Contours (metres)
	Flow Direction
BH-03	Borehole Locations

BORD NA MÓNA
ENVIRONMENTAL LIMITED
NEWBRIDGE, CO. KILDARE

Client: EPA Limited
Shannon
Co. Clare

Project: Borehole Installation and Piezometric Survey

Title: Groundwater Contour Map

SCALE: 1 – 500

Drawn: O. Leech | Checked: S. Carey

Date: June 2001 | Proj. 2102

Appendix 2

Borehole Logs

BORD NA MÓNA

BORD NA MÓNA ENVIRONMENTAL LIMITED

Log of Borehole: GS-11

Project No: T104

Client: Sifa Limited

Site: Shannon Ind. Est.

Location: West of Nitration Plant

Date: 04-04-01

Logged by: Jonathan Daly

SUBSURFACE PROFILE				SAMPLE				
Depth	Symbol	Description	Depth/ Elev.	Number	Sample Interval	TOV (ppm)	Well Data	Remarks
0		*Fill Material* Made-up ground - loose hardcore	0.5				Lockable steel cover	Lockable steel cover
1								Bentonite grout
2		*Dark Grey Till* Sandy/ silty matrix supported till. Contained 30% clasts, rounded in nature, max diameter 1cm						50mm PVC plain standpipe
3			3.5					Bentonite grout
4		*Dark Grey Limestone* Fine grained Limestone						Approximate water entry 3.5-4m
5								Washed pea gravel backfill
6								50mm PVC slotted standpipe
7								
8			8					
		End of Borehole						
9								
10								
11								
12								

Drilled By: Glovers Site Investigation

Drill Method: Rotary Percussion

Drill Date: 4th April 2001

Bord na Móna
Environmental Limited
Main Street
Newbridge
Co. Kildare

Hole Size (mm): 6"

Datum (m AOD):

Sheet: 1 of 1

BORD NA MÓNA

BORD NA MÓNA ENVIRONMENTAL LIMITED

Log of Borehole: GS-12

Project No: T104

Client: Sita Limited

Site: Shannon Ind. Est.

Location: East of Nitration Plant

Date: 04-04-01

Logged by: Jonathan Daly

SUBSURFACE PROFILE				SAMPLE			Well Data	Remarks
Depth	Symbol	Description	Depth/ Elev.	Number	Sample Interval	TOV (ppm)		
		Clay layer Loose clay, recently dug	0.5					Lockable steel cover
1		*Grey Till* Pale grey clayey sand containing 25% pebbles. Clast size 5-20 mm						Bentonite grout
2			2					
3				—				50mm PVC plain standpipe
4								Washed pea gravel backfill
5								
6		*Dark Grey Limestone* Fine Grained Limestone						Approximate water entry 6 m
7								
8								50mm PVC slotted standpipe
9								
			10					
10		End of Borehole		—				
11								
12								

Drilled By: Glovers Site Investigation Ltd

Drill Method: Rotary Percussion

Drill Date: 4th April 2001

Bord na Móna
Environmental Limited
Main Street
Newbridge
Co. Kildare

Hole Size (mm): 6"

Datum (m AOD):

Sheet: 1 of 1

Appendix 3

List of USEPA 524.3 Compounds

List of Compounds analysed for as per USEPA Method 524.2

Dichlorodiflouromethane.	Chloromethane
Vinyl chloride	Bromoethane
Chloroethane	Trichloroflourmethane
1,1-Dichloroethene	Methylene Chloride
trans-1,2-Dichloroethene	1,1-Dichloroethane
cis-1,2-Dichloroethene	2,2-Dichloropropane
Bromochloromethane	Chloroform
1,1,1-Trichloroethane	Carbon tetrachloride
1,1-Dichloropropene	Benzene
1,2-Dichloroethane	Trichloroethene
1,2-Dichloropropane	Dibromoethane
Bromodichloromethane	cis-1,3-Dichloropropene
Toluene	trans-1,3-Dichloropropene
1,1,2-Trichloroethane	Tetrachloroethene
1,3-Dichloropropane	Dibromochloromethane
1,2-Dibromoethane	Chlorobenzene
1,1,2,2-Tetrachloroethane	Ethylbenzene
m-Xylene	p-Xylene
o-Xylene	Styrene
Bromoform	Isopropylbenzene
Bromobenzene	1,2,3-Trichloropropane
n-propylbenzene	2-Chlorotoluene
1,3,5-Trimethylbenzene	4-Chlorotoluene
tert-Butylbenzene	1,2,4-Trimethylbenzene
sec-Butylbenzene	1,3-Dichlorobenzene
n-Butylbenzene	1,2-Dichlorobenzene
1,2-Dibromo-3-chloropropane	1,2,4-Trichlorobenzene
Hexachlorobutadiene	Naphthalene
1,2,3 Trichlorobenzene	

Appendix I.5.2

The installation, Sampling and Analysis of a number of Groundwater boreholes for IPC compliance monitoring at the SIFA complex.

Bord na Mona report K207/R1

BORD NA MÓNA

ENVIRONMENTAL DIVISION

The Installation, Sampling and Analysis of a number of Groundwater Boreholes for IPC compliance monitoring at the SIFA Complex Shannon Free Zone.

Report No: K207/R1

Attention: Mr. John O'Donaghue
SIFA Ltd.,
Shannon Free Zone
Co. Clare

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Senior Environmental Consultant

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Date: April 1997

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CONTENTS

1.0 INTRODUCTION

SIFA Ltd., manufacturers of Fine Chemicals and Phamaceuticals for the chemical industry is situated in the Shannon Free Zone, Co. Clare. contracted Bord na Mona Environmental Division to sample and carry out the required analysis for the annual IPC Licence compliance monitoring programme.

Following a site audit it was contended that the design of the existing boreholes GS 01, 02, 03, 04, were unsound with the result that the original analysis obtained from previous monitoring events may be unreliable. Accordingly it was proposed to reinstall the four bores, within 1.5 m of their original positions. In addition in order to comply with an EPA request that the existing borehole GS 05 be replaced, renamed, and resited, a new borehole was installed in an agreed location. next to the new Pharma building.

This report presents a detailed account of the installation, development, sampling and analysis of 5 No. groundwater monitoring boreholes at the SIFA main site.

2.0 METHODOLOGIES

The site was visited by a member of the technical staff from Bord na Móna Environmental Division and two drilling teams from Irish Geotechnical Services Limited (IGSL) on 12-18/12/96. Installation and development of 5 groundwater monitoring boreholes was carried out over the following 4 day period. The site was revisited, by an Environmental Consultant on the 16-17/1/97 to carry out the sampling of the bores in accordance with standard methods.

2.1 Borehole installation

A total of 5 No. groundwater monitoring boreholes were installed at the site. A Tripod shell and auger drilling rig was used in the installation. All boreholes (200 mm diameter) were advanced to a suitable depth below the vadose zone. 55mm high density polyethylene (HDPE) piezometers were installed. A graded gravel envelope was then packed in around the casing and a 1.0m deep bentonite seal was installed over the gravel packer to prevent surface infiltration. A concrete surface base with a painted, lockable mild steel pipe (0.5m above ground level) was then installed as a surface finish.

2.2 Representative Groundwater Sampling

It is well established that the groundwater in the well casing and indeed that in close proximity to the well is not representative of the general groundwater at a given location. In order to ensure that the groundwater samples extracted from the monitoring bores were representative of the water held in the subsurface strata and not water held stagnant in the borehole casing it was necessary to evacuate the monitoring bores prior to sampling.

The procedure used was to pump the wells until between 3 and 5 bore volumes have been removed (Marsh and Lloyd, 1980 and Boateng, 1987). The total bore depths and the static water level of each borehole were measured insitu using an electronic well dipper. This information was then used to carry out on-site calculations to establish the necessary purge volumes.

The monitoring bores were evacuated using the "Waterra inertial lift pump" system. This system comprises of three main components:

a. High Density Polyehtylene (HDPE) Riser tubing
b. Stainless steel non return foot value
c. Drive system - Mechanical

The required length of tubing was cut to allow a 1m excess above the top of the well casing. The stainless steel non return foot valve was fitted to the bottom of the tubing and inserted into the borehole to the required depth. The pumping operation, carried out by oscillating the tubing vertically in the borehole, can achieve discharge rates of up to 5 litres/minute.To eliminate any possibilty of cross contamination, separate tubing and foot valves were used at each monitoring borehole.

After purging the required volumes from each of the monitoring bores samples were extracted for both non-volatile and volatile organic analysis. All non-volatile samples were taken in 1 litre polypropylene containers and returned to the laboratory at 2-4°C for analysis. Traditional methods used for the sampling of organics include the use of Teflon bailers or various forms of vacuum pumps. However, excessive turbulence, negative pressures or vigorous mixing in the presence of air will purge off volatile organic compounds. As a result, specially designed Waterra volatile organic sampling kits were used for sampling of organics. The inertial pump system does not subject the sample to vacuum or excessive turbulence and so loss of volatiles is minimised.

The methodology for sampling of the boreholes for organics was as follows:

(i) A 2.5m long narrow diameter Waterra organic sampling tube was partially inserted (2.0m) into the wider diameter riser tubing.

(ii) Pumping of the riser tube was conducted.

(iii) Pumping ceased and groundwater continued to flow from the narrow bore inner tubing due to a siphon effect (this siphon effect is a result of gravity and not by suction therefore loss of volatile is minimised).

(iv) Sample from the narrow bore tubing was filled directly into a 250ml Glass Duran sampling bottle with a PTFE stoppered lid. The sampling bottles were brim filled.

(v) Separate VOC sampling kits were used at each monitoring borehole.

(vi) Samples were stored at 2-4°C and transported to Bord na Móna Environmental Laboratories.

2.3 Analysis

All samples returned to the laboratory were stored at 4°C. Subsequent analysis of all samples was carried out in strict accordance with recognised standard methods as detailed in the Table 2.1 below.

TABLE 2.1. CHEMICAL ANALYSIS OF WATER SAMPLES

Parameter	Method of analysis
pH	APHA 4500H^+ B
Conductivity	APHA 2510 B
Alkalinity	APHA 2320 B
Chloride	APHA 4500 ClB
Ammonia-N	APHA 4500 NH_3F
Nitrate-N	APHA 4500 NO_3 D
Sulphate	ASTM D 519-90
Calcium	ASTM D 511-88
Magnesium	ASTM D 511-88
Sodium	ASTM D 4191-87
Potassium	ASTM D 4192-82
Purgable organic compounds	US EPA Method 524.2*

* See Appendix 3 for list of compounds included in this method

2.4 Quality Control

The Environmental Division Laboratory complex is at present actively pursuing an ILAB accreditation status. A stringent six point quality control approach is at present implemented in the laboratories.

(i) Controlled chain of custody.

(ii) Operator competence - all analysts must be suitably qualified to carry out the required analysis.

(iii) Certified Reference Materials (CRM). The accuracy of a series of determinations is checked against known standards.

(iv) Duplicate - 10% duplication is normal.

(v) Quality Control Charts.

(vi) Inter Laboratory Testing - The Environmental Division Laboratories are members of the W.R.C. Aquacheck scheme.

BORD NA MÓNA
ENVIRONMENTAL DIVISION

Figure 1

CONTROLLED CHAIN OF CUSTODY

SITE

Sampling and packaging of all samples carried out by Bord na Móna Technical Team:
S.Jones

Transport Document Form

→

TRANSPORT

Transport to laboratory by Bord na Móna Technical Team.

Sample Reception Form

→

LABORATORY

Receiving of samples at Bord na Móna Environmental Laboratory complex by:
Dr. M. Donlon, S. McGuinness. (Secure laboratory complex access to authorised personnel only)

↓

Storage of all samples for 1 month period after report issue.

3.0 RESULTS

The results of the investigations carried out by Bord Na Móna Environmental Division are presented as follows:

Table 3.1 Borehole Identification

Table 3.2 Results of Field Measurements Taken at Each Monitoring Borehole

Table 3.3 Results of Metal Analysis of Groundwater Samples

Table 3.4 Results of Chemical Analysis of Groundwater Samples

Table 3.5 Results of Organic Analysis of Groundwater Samples

TABLE 3.1: SAMPLE IDENTIFICATION

Borehole ID	Location
GS 01	Open Space adjacent to Admin Building
GS O2	Open space between car park and Production Building
GS 03	Adjacent to Tank Farm
GS 04	Open space adjacent to Balancing Tanks
GS 06	North of New Pharma Building

TABLE 3.2: FIELD MEASUREMENTS OF MONITORING BOREHOLES

Borehole I.D.	Cond. (mS/cm)	Temp. (°C)	Actual Well Depth(m)	Static Water Level(m)	Recharge Rate (cm/min)
GS 01	0.899	10.1	2.81	0.88	300
GS 02	0.872	11.9	3.01	1.11	30
GS 03	0.996	10.1	2.49	1.67	<1
GS 04	12.86	10.7	4.44	1.88	immediate
GS 06	0.819	10.4	4.49	0.80	immediate

Note: As the original location of the borehole GS 05 has been incorporated into the factory extension, this unit no longer exists. Consequently the 'GS 05' identification number has been replaced with GS 06.

TABLE 3.3: METAL ANALYSIS OF GROUNDWATER SAMPLES											
Sample ID	Ca (mg/l)	Mg (mg/l)	K (mg/l)	Na (mg/l)	Fe (mg/l)	Pb (mg/l)	Ni (mg/l)	Cr (mg/l)	Cd (mg/l)	Cu (mg/l)	Zn (mg/l)
GS 01	169	12	2.6	26	<0.04	<0.01	<0.04	<0.04	<0.01	<0.03	0.44
GS 02	80	44	15	26	<0.04	<0.01	<0.04	<0.04	<0.01	<0.03	0.27
GS 03	126	26	4.4	29	<0.04	<0.01	<0.04	<0.04	<0.01	<0.03	0.26
GS 04	157	31	58	3306	0.20	<0.01	<0.04	<0.04	<0.01	<0.03	0.42
GS 06	138	12	3.1	17	<0.04	<0.01	<0.04	<0.04	<0.01	<0.03	0.15

TABLE 3.4: CHEMICAL ANALYSIS OF GROUNDWATER SAMPLES										
Sample ID	pH (pH units)	Cond. (mS/cm)	TDS (mg/l)	Tot. Alkalinity as $CaCO_3$ (mg/l)	NH_3-N (mg/l)	NO_3-N (mg/l)	SO_4 (mg/l)	F (mg/l)	Br (mg/l)	Cl (mg/l)
GS 01	8.2	0.913	499	422	<0.1	3.2	29.9	0.2	0.5	12.5
GS 02	8.5	0.896	503	395	0.4	ND	39.6	0.3	0.5	10.6
GS 03	8.3	1.012	765	330	0.7	0.7	55.3	0.5	0.6	11.1
GS 04	7.8	13.0	11851	5625	9.5	110.2	244.8	0.6	232.7	615.8
GS 06	8.1	0.833	441	362	<0.1	2.1	30.7	0.2	0.5	12.7

TABLE 3.5: ORGANIC ANALYSIS OF GROUNDWATER SAMPLES	
Sample ID	USEPA 524.2 (µg/l)
GS 01	<5
GS 02	<5
GS 03	<5
GS 04	Sample contaminated (see Table 3.6)
GS 06	<5

TABLE 3.6:ORGANIC CHEMICAL CONTAMINANTS GS 04 US EPA 524.2	
Compound	Concentration μgl^{-1}
Bromochloroethane	2421.2
Chloroform/Tetrahydrofuran	1098.1
Carbon tetrachloride/1,1 dichloropropene	16.7
1,1 Trichloroethene	14.9
1,2 Dichloropropane	92.2
Bromodichloromethane	128.3
cis 1,3 Dichloropropene	72329.1
Toluene	124.3
Trans 1,3 Dichloropropene	6058.1
Tetrachloroethene	13.5
Dibromochloroethane	39.0
m xylene	10.3
p xylene	42.8
o xylene	17.8
Styrene	30.1
isopropylbenzene	23.9
1,1,2,2 Tetrachloroethane	40.5
Bromobenzene/ 1,2,3, Trichloropropane	5.9
1,4 Dichlorobenzene	7.1

GC-FID	
Compound	Concentration mg/l
Methanol	49.87
Acetonitrile	2.70
Ethanol	679.63
Acetone	117.7
IPA	93.0
1-Propanol	17.8
MEK	4.3

4.0 DISCUSSION

Three of the four existing boreholes which were scheduled to be reinstalled, i.e. GS 01, GS 02, and GS 03 were relocated within 1.5m of there original positions. Due to encountering bedrock at 1.8m from the surface installation problems were encountered at GS 04. It was, therefore, necessary to remove the existing casing and install an new appropriate configured unit. It is stressed that GS 04 was designed and installed in an identical manner to the other boreholes.

Borehole GS 05 had been decommissioned due to plant extensions. A new borehole, GS 06, was subsequently installed as a replacement to the north of the new plant extension. The design and location of same was previously agreed with the EPA inspectorate.

The locations of the groundwater monitoring boreholes and sampling stations are described in Table 3.1. The results of the field measurements and the chemical analysis of the groundwaters are presented in Tables 3.2, 3.3, 3.4 and 3.5.

The actual depths of the boreholes sampled (Table 3.2) ranged from 3.65 (GS-03) to 4.60m (GS-01) while static water levels in the boreholes ranged from depths of 0.88m to 1.88m.

The results of the investigation confirmed that the design and installation of the existing boreholes was unsound and that the results obtained previously may not have been truly representative of the groundwater underlying the site. This is evidenced from the analytical results obtained from Borehole GS 04 i.e. it is recorded that contamination with a variety of organic chemicals has occurred at this location (Table 3.6).

The fact that personnel at the site could not recall using many of the organic chemicals detected in the past number of years, together with the fact that the borehole is located in close proximity to the drum storage area, (which houses a great range of organic chemicals), may indicate that the source of the organic inputs, is (or was), associated with a leak from same.

The elevated levels and the large variety of contaminants recorded in GS 04 would appear to confirm this observation.

A notable difference in the hydrogeology of the GS 04 setting is that the bore actually penetrates the rock and that the static water level is within this bedrock strata.

Furthermore, it is noted that the soil cover and hence the attenuative barrier available is at its shallowest in this location.

The presence of significant saline intrusion is evidenced by the elevated Conductivity, TDS, sodium, and chloride levels recorded. One important consequence of this observation is that the degree and extent of contamination present (GS 04) may vary considerably with changing tidal cycles, an important consideration when extracting samples.

In general, the results of all other boreholes demonstrate that the groundwater beneath the site is of good chemical quality. However, the cause of the slightly elevated zinc levels recorded in all samples is, at present, unclear. Similar zinc values were recorded in an investigation of the Bay 130 plant. Further investigation into the source of this anomoly is recommended.

It is concluded that, with the exception of GS 04, the activities on site are not impacting on the quality of the underlying groundwaters. The extensive organic chemical contamination recorded would appear to indicate inputs from a point source such as the drum storage area.

5.0 RECOMMENDATIONS

In order to ascertain the extent and source of the contamination recorded in Bore GS 04 we recommend that the following actions are taken:

1. Initiate a series of extended pumping tests to generate the maximum draw down in GS 04 well bore.

2. Generate a maximum cone of depression around this borehole.

3. Resample and analyse borehole GS 04 on completion of the extended pumping test .

4. Conduct a detailed piezometric mapping assessment of the site in order to establish the directional groundwater flow.

5. Initiate a detailed bund integrity assessment of the current chemical storage area.

6 Conduct a comprehensive hydrogeological survey of the site using standard pumping test techniques. This investigation should be designed to establish the permeabilities and behaviours of the basic groundwater bearing units beneath present.

APPENDIX 1

BORING RECORD

I.G.S.L.

Contract: SIFA
No. 3752
Location: LIMERICK
Client: BORD NA MONA
Dates: 18.12.96

Borehole No. GS01
Sheet No. 1 of 1
Method Cable Tool
Dia. 200mm
Ground Level m.O.D

Description	Red. Level	Legend	Depth m	samples Ref. No.	samples Type	samples Depth	Field Tests
Firm grey SILT with angular stone, made ground							
			1.50				
Grey SILT and rock fragments							
			2.80				
ROCK (Limestone)							

Remarks

Installed 50mm pipe - 1m slotted , 1.8m plain
Installed 1m bentonite seal and cover

Chiselling at 2.80 for 45 minutes
Placed 1.0 x 1.0 x 100mm concrete slab

Water level observations

Date	Hole Depth	Cased Depth	Water Depth	Remarks

Driller:

Sample/Test Key : U - tube sample. D - disturbed sample. W - water sample. S - SPT. C - CPT. R - Refusal. V- vane.

BORING RECORD

I.G.S.L.

Contract:	SIFA	Borehole No.	GS02
No.	3752	Sheet No.	1 of 1
Location:	LIMERICK	Method	Cable Tool
Client:	BORD NA MONA	Dia.	200mm
Dates:	17.12.96	Ground Level m.O.D	

Description	Red. Level	Legend	Depth m	samples Ref. No.	samples Type	samples Depth	Field Tests
Firm grey SILT							
			2.00				
Firm grey SILT with traces of peat							
			3.20				
Presumed ROCK							

Remarks

Chiselling 2.80 - 3.20 = 30mins

Installed 50mm pipe
Installed bentonite seal and cover
Placed 1.0 x 1.0 x 150mm concrete slab

Water level observations

Date	Hole Depth	Cased Depth	Water Depth	Remarks

Driller:

Sample/Test Key : U - tube sample. D - disturbed sample. W - water sample. S - SPT C - CPT R - Refusal. V- vane.

BORING RECORD

I.G.S.L.

Contract:	SIFA	Borehole No.	GS03
No.	3752	Sheet No.	1 of 1
Location:	LIMERICK	Method	Cable Tool
Client:	BORD NA MONA	Dia.	200mm
Dates:	16.12.96	Ground Level m.O.D	

Description	Red. Level	Legend	Depth m	samples Ref. No.	samples Type	samples Depth	Field Tests
Firm grey brown SILT			1.00				
Firm to stiff grey brown SILT			2.40				
ROCK at 2.40							

Remarks

Chiselling at 2.40m = 30mins

Installed 50mm pipe
Installed bentonite seal and cover
Concrete pad 1.0 x 1.0 x 150mm placed

Water level observations

Date	Hole Depth	Cased Depth	Water Depth	Remarks

Driller:

Sample/Test Key : U - tube sample. D - disturbed sample. W - water sample. S - SPT. C - CPT. R - Refusal. V- vane.

BORING RECORD

I.G.S.L.

Contract: SIFA
No. 3752
Location: LIMERICK
Client: BORD NA MONA
Dates: 16.12.96

Borehole No. GS04
Sheet No. 1 of 1
Method Cable Tool
Dia. 200mm
Ground Level m.O.D

Description	Red. Level	Legend	Depth m	samples Ref. No.	samples Type	samples Depth	Field Tests
Two attempts at boring 0 - 1.7m abortive (Presumed Rock)			1.70				

Remarks

Pulled existing shell casing
Inserted 4.20 metres PVC (slotted)
Installed bentonite seal and cover
Concrete cover 1.00 x 1.00 x 150mm placed
Chiselling bedrock for 30 minutes at each abortive location

Water level observations

Date	Hole Depth	Cased Depth	Water Depth	Remarks

Driller:

Sample/Test Key : U - tube sample. D - disturbed sample. W - water sample. S - SPT. C - CPT. R - Refusal. V- vane.

BORING RECORD

I.G.S.L.

Contract:	SIFA .	Borehole No.	GS06
No.	3752	Sheet No.	1 of 1
Location:	LIMERICK	Method	Cable Tool
Client:	BORD NA MONA	Dia.	200mm
Dates:	16.12.96	Ground Level m.O.D	

Description	Red. Level	Legend	Depth m	samples Ref. No.	samples Type	samples Depth	Field Tests
TOPSOIL			0.20				
Brown/grey silty CLAY			1.20				
Grey SILT			4.60				
ROCK at 4.60							

Remarks

Installed 50mm pipe - 2m slotted , 2.6m plain
Installed bentonite seal and cover
Concrete base 1.00 x 1.00 x 160mm placed
Chiselling in rock for 30 mins.

Water level observations

Date	Hole Depth	Cased Depth	Water Depth	Remarks

Driller:

Sample/Test Key : U - tube sample. D - disturbed sample. W - water sample. S - SPT. C - CPT. R - Refusal. V- vane.

APPENDIX 2

List of Compounds analysed for as per USEPA Method 524.2.

Dichlorodiflouromethane.	Chloromethane
Vinyl chloride	Bromoethane
Chloroethane	Trichloroflourmethane
1,1-Dichloroethene	Methylene Chloride
trans-1,2-Dichloroethene	1,1-Dichloroethane
cis-1,2-Dichloroethene	2,2-Dichloropropane
Bromochloromethane	Chloroform
1,1,1-Trichloroethane	Carbon tetrachloride
1,1-Dichloropropene	Benzene
1,2-Dichloroethane	Trichloroethene
1,2-Dichloropropane	Dibromoethane
Bromodichloromethane	cis-1,3-Dichloropropene
Toluene	trans-1,3-Dichloropropene
1,1,2-Trichloroethane	Tetrachloroethene
1,3-Dichloropropane	Dibromochloromethane
1,2-Dibromoethane	Chlorobenzene
1,1,2,2-Tetrachloroethane	Ethylbenzene
m-Xylene	p-Xylene
o-Xylene	Styrene
Bromoform	Isopropylbenzene
Bromobenzene	1,2,3-Trichloropropane
n-propylbenzene	2-Chlorotoluene
1,3,5-Trimethylbenzene	4-Chlorotoluene
tert-Butylbenzene	1,2,4-Trimethylbenzene
sec-Butylbenzene	1,3-Dichlorobenzene
n-Butylbenzene	1,2-Dichlorobenzene
1,2-Dibromo-3-chloropropane	1,2,4-Trichlorobenzene
Hexachlorobutadiene	Naphthalene
1,2,3 Trichlorobenzene