Environmental Impact Statement for Ballymurtagh Landfill

Volume 3: Appendices

November 2009

Table of Contents

Appendix A

List of Organisations and Individuals contacted during Scoping Phase of EIS

Ms. Deirdre French, Inspector, Environmental Management and Planning, Environmental Protection Agency Headquarters, P.O. Box 3000, Johnstown Castle Estate, Co. Wexford

Ms. Grace Fraher, General Manager, Dublin Mid Leinster Health Board (Area 10), Glenside Road, Wicklow Town

Mr Pat Doherty, Chief Executive Officer, Eastern Regional Fisheries Board, 15A Main Street, Blackrock

Mr. Ian Lumley, Heritage Officer, An Taisce, Tailors Hall, Backlane

Mr. Paul Galvin, Site and Habitats Protection, Bird Watch Ireland, P.O. Box 12, Greystones

Mr. Donal Guilfoyle, Manager, Environmental and Regional Coordination, Failte Eireann, Baggott Street Bridge, Dublin 2

Ms. Marie Merrigan, Vale of Avoca Development Association, Avoca, Co. Wicklow

The Secretary, The Development Applications Unit, The Department of the Environment, Heritage, Customs House, Dublin 2

Ms. Caitriona Douglas, National Parks and Wildlife 7 Ely Place, Dublin 2

The Secretary, National Monuments and Historic Properties Division, Dun Sceine, Harcourt Lane Dublin 2

Mr. Sylvester Murphy, Environment Section Department of Agriculture and Food, Johnstown Castle Estate, Co. Wexford

Regional Development, Irish Farmers Association Livestock Market, Barrack Street Kilkenny

Ms. Caren LeVine, Development Officer, Irish Wildlife Trust, Sigmund Business Centre 93A Lagan Road

Mr. John Lee, Head of Centre, Teagasc, Research and Development, Iohnstown Castle, Co. Wexford

Mr. Paddy Mathews, Planning Officer, The Heritage Council, Rothe House, Kilkenny

Mr. Martin Critchley, Chairperson The Mining Heritage Trust of Ireland, 36 Dame Street Dublin 2

Mr. Michael McNamara, Shareridge Ltd. Thomas Street, Castlebar Co. Mayo

Brenda Brannigan	Avoca Cottage Tigroney West Avoca	12/12/2008
Greg Brannigan,	Avoca Cottage Tigroney West Avoca	12/12/2008
Brigid Byrne	Tigroney West Avoca Co. Wicklow	12/12/2008
Patrick Clark ,	The Studio River Lodge Tigroney West Avoca	12/12/2008
Anthony Cullen	Robin Dale Tigroney West Avoca	12/12/2008
Elizabeth Cullen.	Robin Dale Tigroney West Avoca	12/12/2008
Denise Doyle	White Bridge Tigroney West Avoca	12/12/2008
Dermot Doyle.	White Bridge Tigroney West Avoca	12/12/2008
James Doyle	White Bridge Tigroney West Avoca	Not sent at the request of S.I
Lucy Doyle.	Riverside Tigroney West Avoca	12/12/2008
Myles Doyle	Riverside Tigroney West Avoca	12/12/2008
Peter Doyle,	White Bridge Tigroney West Avoca	12/12/2008
Sandra Doyle	Riverside Tigroney West Avoca	12/12/2008
Sarah Doyle,	White Bridge Tigroney West Avoca	12/12/2008
Una Doyle	White Bridge Tigroney West Avoca	12/12/2008
David Ennis	Kestrel Lodge Tigroney West Avoca	12/12/2008
George Ennis	Kestrel Lodge Tigroney West Avoca	12/12/2008
John Foley ,	Tigroney West Avoca Co. Wicklow	12/12/2008
Anthony Gilvarry	Tigroney West Avoca Co. Wicklow	12/12/2008
Bridie Gilvarry .	Tigroney West Avoca Co. Wicklow	12/12/2008
John Gilvany	Tigroney West Avoca Co. Wicklow	12/12/2008
Joseph Gilvarry	Tigroney West Avoca Co. Wicklow	12/12/2008
Joseph (Jnr) Gilvany	Tigroney West Avoca Co. Wicklow	12/12/2008
Tracy J Gilvarry,	Tigroney West Avoca Co. Wicklow	12/12/2008
Catriona Gray	Tigroney West Avoca Co. Wicklow	12/12/2008
Lucy Gray.	Tigroney West Avoca Co. Wicklow	12/12/2008
Nicholas Gray	Tigroney West Avoca Co. Wicklow	12/12/2008
Rebecca Gray.	Tigroney West Avoca Co. Wicklow	12/12/2008
Michael Hamilton	Tigroney West Avoca Co. Wicklow	12/12/2008
Sandra Hamilton	Tigroney Wes t Avoca Co. Wicklow	12/12/2008
Bridget Heffernan	Teach Na Blath Tigroney West Avoca	12/12/2008
Gail Heffernan	Teach Na Blath Tigroney West Avoca	12/12/2008
John J. Heffernan	Mine View House Tigroney West Avoca	12/12/2008
John jnr. Heffernan	Teach Na Blath Tigroney West Avoca	12/12/2008
John Joseph Heffernan	Teach Na Blath Tigroney West Avoca	12/12/2008
Philomena Heffernan	Mine View House Tigroney West Avoca	12/12/2008
Edward Kearns.	Tigroney West Avoca Co. Wicklow	12/12/2008
Gerald Kearns	Tigroney West Avoca Co. Wicklow	12/12/2008
Jeffrey Kearns .	Tigroney West Avoca Co. Wicklow	12/12/2008
Judy Kearns	Tigroney West Avoca Co. Wicklow	12/12/2008
Antony Dermot Kew,	Terra Cotta Tigroney West Avoca	12/12/2008
Rachel Kew	Terra Cotta Tigroney West Avoca	12/12/2008
Jamie William Klyne ,	Whitebridge House Tigroney West Avoca	12/12/2008
Maria Anne Klyne	Whitebridge House Tigroney West Avoca	12/12/2008
Michael Klyne,	Whitebridge House Tigroney West Avoca	12/12/2008
Mairead Meehan	Alora Tigroney West Avoca	12/12/2008
Philip Moore.	Tigroney West Avoca Co. Wicklow	12/12/2008
Susan Moore	Tigroney West Avoca *Co.* Wicklow	12/12/2008
Vera Moore,	Linvar Tigroney West Avoca	12/12/2008
Brigid O'Grady	Inisfree Tigroney West Avoca	12/12/2008
Emmet O'Grady,	Inisfree Tigroney West Avoca	12/12/2008

Eoin O'Grady	Inisfree Tigroney West Avoca	12/12/2008
Clothilde Walenne ,	Tigroney West Avoca Co. Wicklow	12/12/2008
Jacqueline P. Whelan	Tigroney West Avoca Co. Wicklow	12/12/2008
John A. Whelan	Tigroney West Avoca Co. Wicklow	12/12/2008
Sean Whelan	Tigroney West Avoca Co. Wicklow	12/12/2008
Sheila Whelan	Tigroney West Avoca Co. Wicklow	12/12/2008
David Hughes	Tigroney West Avoca Co. Wicklow	12/12/2008
Frank Cardiff	Tara Ballygahan Lower Avoca	12/12/2008
Joseph Carter	Ballygahan Lower Avoca Co. Wicklow	12/12/2008
Donald Clarke	Ballyhagan House Ballygahan Lower j\ voca	12/12/2008
Evan Cleak,	The Old Stables Bellrock	12/12/2008
Ian Cleak,	The Old Stables Bellrock	12/12/2008
Barbara Cooney	Tara Ballygahan Lower Avoca	12/12/2008
Jennifer Cooney,	Tara Ballygahan Lower Avoca	12/12/2008
Natasha Cooney	Tara Ballygahan Lower Avoca	12/12/2008
Bred a Fitzpatrick .	Ballygahan Lower Avoca Co. Wicklow	12/12/2008
John Fitzpatrick	Ballygahan Lower Avoca Co. Wicklow	12/12/2008
Leonard Fitzpatrick,	Ballygahan Lower Avoca Co. Wicklow	12/12/2008
Jacqueline Heffernan	Coppervale Cottage Ballygahan Lower Avoca	12/12/2008
Samantha Heffernan ,	Coppervale Cottage Ballygahan Lower Avoca	12/12/2008
Seamus Heffernan	Coppervale Cottage Ballygahan Lower Avoca	12/12/2008
Sinead Heffernan -	Coppervale Cottage Ballygahan Lower Avoca	12/12/2008
Audrey Kavanagh	Lorien Ballygahan Lower Avoca	12/12/2008
Joanne Keogh,	Dale House Ballygahan Lower Avoca	12/12/2008
John Keogh	Dale House Ballygahan Lower Avoca	12/12/2008
Pauline McMahon .	Riverdance Ballygahan Lower Avoca	12/12/2008
Gina Mullins	Rivendale Ballygahan Lower Avoca	12/12/2008
John Mullins,	Rivendale Ballygahan Lower Avoca	12/12/2008
Alida O'Rourke	The Lodge Ballygahan Lower Avoca	12/12/2008
Fergus O'Rourke	The Lodge Ballygahan Lower Avoca	12/12/2008
Victoria Smith	The Pines Ballygahan Lower Avoca	12/12/2008
Luke Smyth,	The Pines Ballygahan Lower Avoca	12/12/2008
Sonya Twohig	Ballygahan House Ballygahan Lower Avoca	12/12/2008
Sinea d Fitzgerald	No.3 Ballygahan Lower Avoca	12/12/2008
Mary Pender	No.3 Ballygahan Lower Avoca	12/12/2008
Rachel Pender	No.3 Ballygahan Lower Avoca	12/12/2008
Sarah Pender	No.3 Ballygahan Lower Avoca	12/12/2008
Thomas Pender'	No.3 Ballygahan Lower Avoca	12/12/2008
William Stanfield	No.4 Ballygahan Lower Avoca	Not sent at the request of S.I
Jane Clavin	No.5 Ballygahan Lower Avoca	12/12/2008
Shane Harrison	No.5 Ballygahan Lower Avoca	12/12/2008
Paul Doyle.	Burnt Oak No.6 Ballygahan Lower	12/12/2008
Carla Glynn	Burnt Oak No.6 Ballygahan Lower	12/12/2008
Mary Doran.	Ballygahan Lower Avoca Co. Wicklow	12/12/2008
Noel Doran	Ballygahan Lower Avoca Co. Wicklow	12/12/2008
Charles Fleming.	Ballygahan Upper Avoca	12/12/2008
John Fleming	Ballygahan Upper Avoca	12/12/2008
Luke Fleming,	Ballygahan Upper Avoca	12/12/2008
Nicola Fleming	Ballygahan Upper Avoca	12/12/2008
Pauline Fleming,	Ballygahan Upper Avoca	12/12/2008
Hugh Garavan	Bell Rock Cottage Ballygahan Upper	12/12/2008

Kevin Harper.	Ballygahan Upper Avoca	12/12/2008
Andrew Kennedy	Ballygahan Upper Avoca	12/12/2008
Samantha Kennedy .	Ballygahan Upper Avoca	12/12/2008
Michael O'Rourke	Ballygahan Upper Avoca	12/12/2008
Catriona Reddy .	Ballygahan Upper Avoca	12/12/2008
Rebecca Rouiller	Bell Rock Cottage Ballygahan Upper	12/12/2008
Martin Hughes,	No.1 Ballygagan Upper Avoca	12/12/2008
Aisling O'Leary	No.2 Ballygagan Upper Avoca	12/12/2008
Anne Marie O'Leary.	No.2 Ballygagan Upper Avoca	12/12/2008
Donal O'Leary	No.2 Ballygagan Upper Avoca	12/12/2008
Emma Langton '	No.4 Ballygahan Upper Avoca	12/12/2008
Mark Langton	No.4 Ballygahan Upper Avoca	12/12/2008
David Allen,	Ballygahan Upper Avoca	12/12/2008
June Allen	Ballygahan Upper Avoca	12/12/2008
John Doody '	Ballygahan Upper Avoca	12/12/2008
John Doody	Ballygahan Upper Avoca	12/12/2008
Katrina Doody	Ballygahan Upper Avoca	12/12/2008
Morag Doody	Ballygahan Upper Avoca	12/12/2008
Margaret Greene.	Ballygahan Upper Avoca	12/12/2008
William Randall	Ballymurtagh Avoca	12/12/2008
Andrea Merrigan,	Ballymurtagh Avoca	12/12/2008
Louise Merrigan	Ballymurtagh Avoca	12/12/2008
Mary Merrigan,	Ballymurtagh Avoca	12/12/2008
Thomas Merrigan	Ballymurtagh Avoca	12/12/2008
Colm Caomhanach .	An Sean-mhuileann Tinnahinch	12/12/2008
Margaret Caswell	Tinnahinch Avoca	12/12/2008
May Caswell ,	Tinnahinch Avoca	12/12/2008
Declan Crangle	Tinnahinch Avoca	12/12/2008
Margaret Crangle,	Tinnahinch Avoca	12/12/2008
Marie Soledad Royo Erausquin	Ama Lur Tinnahinch	12/12/2008
Niall Fanning.	Tinnahinch Avoca	12/12/2008
Tassie Fanning	Tinnahinch Avoca	12/12/2008
Marcella Gaffney ·	Orchard Cottage Tinnahinch	12/12/2008
William Gaffney	Orchard Cottage Tinnahinch	12/12/2008
Dominic Gunshenan ·	No.2 Greenwood Tinnahinch	12/12/2008
Aileen Moran	Tinnahinch Avoca	12/12/2008
Eileen Moran .	Tinnahinch Avoca	12/12/2008
Gavin Moran	Tinnahinch Avoca	12/12/2008
Robyn Moran .	Tinnahinch Avoca	12/12/2008
Stephen Moran	Tinnahinch Avoca	12/12/2008
Suzanne Moran .	Tinnahinch Avoc a	12/12/2008
William Moran	Tinnahinch Avoca	12/12/2008
Dolly Murtagh .	Tig na H-Inse Tinnahinch	12/12/2008
Eoin Murtagh	Tig na H-Inse Tinnahinch	12/12/2008
Nigel Murtagh .	Tig na H-Inse Tinnahinch	12/12/2008
Stephen Murtagh	Tig na H-Inse Tinnahinch	12/12/2008
Barry O'Callaghan	Ama Lur Tinnahinch	12/12/2008
Ann Christine O'Loughlin	Tinnahinch Avoca	12/12/2008
Clare O' Loughlin .	Tinnahinch Avoca	12/12/2008
Edward J. O'Loughlin	Tinnahinch Avoca	12/12/2008
James O'Loughlin .	Tinnahinch Avoca	12/12/2008

Kerry Smith	Riverview House Tinnahinch	12/12/2008
Sian Smith	Riverview House Tinnahinch	12/12/2008
Mary Stinson	Timberline House Tinnahinch	12/12/2008
Terry Stinson .	Timberline House Tinnahinch	12/12/2008
Ean Wallace	Riverview House Tinnahinch	12/12/2008
Lesley J . Wallace .	Riverview House Tinnahinch	12/12/2008
Eddie Conway	Kilcashel Lane Avoca	16/12/2008
Jeffrey Green	Kilcashel Lane Avoca	16/12/2008

Appendix B

Submissions received during Scoping Phase of EIS

THE DEPARTMENT OF
AGRICULTURE, FISHERIES & FOOD
AN ROINN TALMHAÍOCHTA, IASCAIGH & BIA

23rd December, 2008.

Mr. Philip Duffy
Water & Environmental Services Section
Wicklow County Council
County Buildings
Wicklow

Re: Environmental Impact Statement For Ballymurtagh Landfill

Dear Mr. Duffy,

I refer to your letter of 11th December, 2008 concerning the above matter.

I recommend that Wicklow County Council should consider the likely impact, if any, of Ballymurtagh Landfill on agriculture/agricultural activities in the locality as part of the environment impact assessment. Aspects that should be considered include the following:

- Impact on local water supplies (quality).
- Impact of traffic (safety).
- Impact of scavenging birds, vermin (possibility of disease transmission).
- Impact of dust generated.
- Impact of litter.
- Odour impacts.
- Methane emissions
- Impact of noise.

Yours sincerely,

pp Joan Stone
Michael MacCarthy
Environment Section

Tel: 053 9163400 Fax: 053 9142839

www.agriculture.gov.ie VAT Reg. IE4773186Q

Johnstown Castle Estate,
Co. Wexford, Ireland.

Eastát Chaisleán Bhaile Sheonaigh,
Chontae Loch Garman, Éire.

Eastern Regional Fisheries Board
Bord Iascaigh Réigiúnach an Oirthir

Fisheries Ireland
Inland Natural Heritage

Philip Duffy
Senior Executive Officer
Water & Environmental Services Section
Wicklow County Council
County Buildings
Wicklow Town

28 January 2009

Re: Environmental Impact Statement for an extension of time of the Planning Permission for Ballymurtagh Landfill

Dear Sir,

With reference to the Ballymurtagh Landfill site, there are no containment / collection measures for landfill leachate which continues to be generated from this now closed facility. The leachate from this site discharges from the Avoca River through the Ballymurtagh / Road adit, after mixing with the Acid Mine discharge from the abandoned Ballymurtagh mine site. Evidence of significant landfill leachate contamination of the mine discharges was noted by elevated ammonia concentrations in sampling carried out by the Board in the past.

The Avoca system is an important salmonid water with excellent populations of salmon, sea trout and brown trout. It is a large (approx. 232 sq. mile) mainly upland catchment, with many varying habitats for fish, excellent species diversity and a good fishery potential. According to the Central Fisheries Boards report "The Quantification of the Freshwater Salmon Habitat Asset in Ireland" a total of 261 discrete migratory salmonid "fishery systems" were identified nationally of which 179 are recorded as "salmon & sea trout" and 88 as sea trout only. Of these Rivers the Avoca system ranked 17th overall with regard to the fluvial habitat accessible to salmon.

As part of a catchment management programme the Eastern Regional Fisheries Board commissioned a scoping study by the University of Newcastle to identify and develop costings for remediation measures to restore the Avoca River to a salmonid fishery. This study recommended an active treatment plant to treat the Acid Mine Drainage coming from the abandoned Avoca mine site. The Eastern Regional Fisheries Board are working with Wicklow County Council, the EPA, the National Parks & Wildlife Service, Dept. of the Environment and the Dept. of Communications, Marine & Natural Resources to bring about a solution to the pollution problem from the abandoned Avoca mine site and we are confident that this can be brought about in the near future. A pilot treatment plant study was commissioned by the Eastern Board to develop costing for a full scale plant and this treatment plant demonstrated the mine discharges could easily be treated to a very high level.

Wicklow County Council are currently proposing a significant abstraction from the upper reaches of the Avoca system, close to Rathdrum, Wicklow County Council also operate an abstraction from the Vartry River with proposals for significant extractions from groundwater

The Eastern Regional Fisheries Board
15a Main Street
Blackrock
Co. Dublin
T: (01) 278 7022
F: (01) 278 7025
E: info@erfb.ie
www.fishingireland.net

boreholes within the Vartry catchment. In both cases the abstractions will represent a net loss of water from these systems and the Board has serious concerns regarding the sustainability of the proposals.

Given the responsibility upon the State to improve water quality in the Avoca River to at least Q4 status by 2015, it is the opinion of this Board, an active treatment plant to treat the AMD discharges from the abandoned Avoca mine site should be commissioned as soon as possible. The ideal location for water abstraction would then be the Avoca River just upstream of the tidal / freshwater boundary. A very large volume abstraction (greater than that could be generated by the combined Vartry borehole and Avonmore River abstractions, both of which we believe to be unsustainable) sufficient for any expected growth in the Arklow and Wicklow town areas could take place here with minimal effect upon the potential recreational & salmon & sea trout angling resource of the Avoca which the Newcastle Report estimates could generate up to 750,000 euro per annum.

The ECJ Judjement against Ireland related to the fact that the discharges from Ballymurtagh Landfill are not confined to the groundwater on site and contributes to pollution of the lower reaches of the Avoca River. As mentioned above the Board have demonstrated that the commissioning of a full scale treatment plant will remove the metals in the mine water discharging from the abandoned mine site by altering the pH of these discharges. This treatment is unlikely to be effective in relation to many of the constituents of landfill leachate. With the commissioning of a treatment plant for the Mine water discharges at the abandoned Avoca Mine site the lower reaches of the Avoca will represent a sustainable source of potable adequate to supply the requirements for growth throughout much of County Wicklow. The Board requests that landfill leachate contamination of the Avoca River be quantified by this EIS, the impact that this leachate dicharge is likely to have upon the recreational resource of the Avoca River and as a potable water supply and that the length of time which leachate production is expected to continue at the Ballymurtagh landfill also be addressed.

Yours Faithfully

Pat Doherty
Chief Executive Officer

DICK ROCHE T.D.
MINISTER FOR EUROPEAN AFFAIRS

2009/25/4

28 January, 2009

Bryan Dyk

Mr. Des O'Brien
Director of Services
Planning & Economic Development
Wicklow County Council
County Buildings
Wicklow

Please quote our ref: IH 02/ 567

Re: Ballymurtagh Landfill

Dear Des.

I note with interest that the Council is preparing an Environmental Impact Statement for the Ballymurtagh Landfill. This, as I understand it, arises as a result of a European Court of Justice decision.

As you may be aware, some years back, I wrote to Wicklow County Council following a conversation which I had with a former employee of the mines. He suggested that there were large caverns under the Ballymurtagh Landfill and that these were filled with water. He suggested, further, that methane gas was being "sucked" into these spaces from Ballymurtagh Pit. The Council subsequently took steps to prevent a problem arising from gas build-up and as I understand it being flaring gas in the vicinity of the Ballymurtagh Landfill.

I trust that this matter will be referenced in the Environmental Impact Statement.

A further point that struck me when I revisited my correspondence on this was that a significant amount of gas is still being flared off at Ballymurtagh. I was wondering would it not be economically viable for the Council to consider a small scale electricity generation from the gas. It may be that the gas deposits are not big enough to justify this but I know that this issue has been looked at elsewhere in particular with some of the larger civic amenity sites. It might provide the Council with some form of economic return if it were a viable proposition.

I look forward to hearing from you on this.

Yours sincerely,

Dick Roche. T.D.
Minister for European Affairs

FIANNA FÁIL
Constituency office
2 Herbert Terrace, Herbert Road,
Bray, Co Wicklow
Tel: 08 353 (0) 1 286 5211
Fax: 00 353 (0) 1 286 7866

Department of Foreign Affairs
Iveagh House, St Stephen's Green, Dublin 2
Tel: 00 353 (0) 1 408 2605
Fax: 00 353 (0) 1 408 2090

Department of the Taoiseach
Government Buildings,
Dublin 2
Tel: 00 353 (0) 1 619 4534

WATER & ENVIRONMENTAL SERVICES

MEMO

FROM: Helena Dennehy **Administrative Officer** **Date: 13th February 2009** **Our Ref: 2009/25/04**	**TO: Breege Kilkenny** **Senior Executive Engineer**

Re: Ballymurtagh Landfill

Breege

Please find attached correspondence received from Dick Roche T.D. in respect of the above for your attention.

I look forward to receiving a report on same.

Helena Dennehy

HELENA DENNEHY
ADMINISTRATIVE OFFICER,
WATER AND ENVIRONMENTAL SERVICES SECTION.

30 December 2008.

Mr. Ian Lumley
Heritage Officer,
An Taisce – The National Trust for Ireland
Tailor's Hall,
Back Lane,
Dublin 8

RE: Environmental Impact Statement for Ballymurtagh Landfill

Dear Mr. Lumley,
Thank you for your response letter of 17th December 2008. As requested we have outlined below more detailed background information and proposed scope of works of the EIS to address the ECJ decision regarding Ballymurtagh Landfill.

BACKGROUND
The outcome of the ECJ Case 248/05 against Ireland was such that the Court declared that Ireland had failed to fulfil its obligations under the provisions of the Groundwater Directive (80/68/EC) in the planning for, operation and subsequent licensing of the Ballymurtagh Landfill (EPA Licence Register P0011-01)

Consequently the EPA have instructed Wicklow County Council to apply for a review of the Ballymurtagh Landfill Waste Licence. Such a review has necessitated an Environmental Impact Assessment (EIA) of the landfill and an Environmental Impact Statement (EIS) will be prepared to accompany the Waste Licence Review Application to the EPA in due course.

HISTORY
Wicklow County Council operated a landfill at Ballymurtagh in an area of the abandoned and polluted West Avoca Mines site in Avoca, Co. Wicklow between the years of 1989 and 2002. The landfill was designed on a dilute and disperse principle with no leachate containment measures. At the time this was considered BATNEEC for this site.

The landfill occupies an area of 5 hectares within the old mine workings of West Avoca. Landfilling occurred in a former open pit that had been used by the mine operator for the storage of mine tailings. A layer of these tailings underlies the body of the waste which is estimated at 480,000m3 of mainly domestic waste.

CURRENT SITUATION
A Waste Licence for Ballymurtagh Landfill was granted by the EPA to Wicklow County Council in April 2001 (EPA Licence Register P0011-01). Restoration of the Landfill commenced in 2004 and landscape works was completed in 2006. Under the

terms of the Waste Licence, the landfill is subject to on-going environmental monitoring.

REVIEW OF EXISTING INFORMATION

Following the ECJ ruling, a particular emphasis regarding Article 4 and Article 5 of the Groundwater Directive with a comprehensive assessment of the risks of pollution from List I and List II families and groups of substances is underway.

In assessing the impact of the landfill on the area it is important to understand the environmental setting and conditions that existed at the site prior to the commencement of landfilling.

Mining in the Avoca Valley has been recorded as far back as the 15th Century. Pollution of the Avoca River as a result of the mining processes has been well documented and Acid Mine Drainage (AMD) from both the East and West Avoca Mines area continues to this day.

A review of available information pertaining to the environmental impact of the mines going back over the last 30 years is being carried out for the EIS. Collation of monitoring data specifically in relation to List I and List II substances prior to and subsequent to landfilling is being examined.

Furthermore a Feasibility Study for the Management and Remediation of the Avoca Mining Area is currently being lead by international consultants, CDM. Wicklow County Council is one of the stakeholders of the study. This work is funded by the Department of Communications, Energy and Natural Resources and is managed by the Geological Survey of Ireland (GSI). Site investigations of surface run-off, rivers, discharges, adits, springs and groundwater as well as investigations of spoil heaps and sediments have already been carried out. Assessment of all this raw data, which is contained in a number of large volumes, has also been the subject of the EIS preparation and Waste Licence Review procedure for Ballymurtagh Landfill.

A conceptual model of the hydrogeology of the West Avoca Mines area is being developed using all of the reviewed data. This model was presented in schematic format to the EPA on November 21st 2008 and formed the basis of the discussions for the scoping of the proposed EIS. In addition a review of the statutory and EU legislative requirements for the preparation of the E.I.S. and Waste Licence Review has also been carried out.

A further review of additional environmental monitoring data pertaining to the East Avoca mining area will also be undertaken during the coming months. This data has much information on List I and List II substances associated with mine workings without the presence of a landfill leachate component. This will provide valuable assistance to establishing an indication of the environmental setting of the area before landfilling commenced.

The ECJ decision specifically referred to groundwater and surface water only. However, because an EIS and Waste Licence Review is governed by Irish and EU

legislative procedures, all other environmental impacts in relation to the landfill will also require impact assessment.

SCOPE OF PROPOSED EIS

The E.I.S. currently in progress is being conducted in accordance with the following legislation framework:-

- Guidelines on the information to be contained in an EIS issued by Environmental Protection Agency (March 2002)
- Advice notes on the current practice in the preparation of an EIS issued by the Environmental Protection Agency (1995)
- European Communities Environmental Impact Assessment (Amendment) Regulations 1999 (SI No. 93 of 1999)
- The Planning & Development Regulations (2001)
- EU Landfill Directive (1999/31/EC)
- Groundwater Directive (1980/68/EEC)
- New Groundwater Directive (2006/118/EC)
- Water Framework Directive (2000/60/EC)
- Dangerous Substances Directive (1976/464/EEC)
- Habitats Directive (1992/43/EEC)

The Environmental Impact Statement (EIS) will include the following:

1. Background to the E.I.S.

2. Historical Setting

3. Project Description

4. Aspects of the Environment with potential impacts from the landfill.

a. Human Beings
b. Fauna
c. Flora
d. Soils & Geology
e. Water. The movement of groundwater with a particular emphasis on the potential impact of List I and List II substances on the receiving waters will be a specific focus of this chapter of the EIS.
f. Air
g. Climate
h. Landscape
i. Material Assets
j. Cultural Heritage
k. Cumulative Impacts

5.0 Mitigation Measures

6.0 Alternatives

EIS SCOPING

The meeting with the EPA on 21st November 2008 constituted a formal EIS scoping meeting. A follow-on scoping exercise is under way by contacting other Statutory Bodies, as well as non Governmental Organisations, interested parties and the local community to ascertain any other significant environmental impacts that may need to be addressed in the EIS.

We hope that the above information is helpful and look forward to any further observations you may have.

Yours Sincerely,

PHILIP DUFFY
SENIOR EXECUTIVE OFFICER
WATER AND ENVIRONMENTAL SERVICES SECTION

Appendix C

Water Quality Data

Ballymurtagh Landfill, Co. Wicklow
Surface Water Quality
Quarterly Samples - November 2008

Parameter	Units	Surface Water Regulations 1989	SW1 Whitesbridge s/w sample	SW2 Upstream adit s/w sample	SW3 B'murtagh Adit s/w sample	SW4 Coal Yard s/w sample	SW5 Avoca Bridge s/w sample
			Sampled: 11/11/08	Sampled: 11/11/08	Sampled: 11/11/08	Sampled: 11/11/08	Sampled: 11/11/08
		Max. Admissable Conc.	Analysed: 12/11/08	Analysed: 12/11/08	Analysed: 12/11/08	Analysed: 12/11/08	Analysed: 12/11/08
pH		**5.5 < pH < 8.5**	6.9	6.6	4.2	6.2	6.4
Temperature (on site)	^{o}C	**25**	6	6	11	7	6
Conductivity	uS/cm at 20^{o}C	**1,000**	58	57	1870	90	61
C.O.D.	mg/l O_2	**40**	20	16	18	16	17
B.O.D.	mg/l O_2	**5**	<3	<3	15	<3	<3
Dissolved Oxygen (on site)	mg/l O_2	**<5**	7.5	8.0	4.9	7.7	7.7
Total Suspended Solids	mg/l SS	**35**	4	5	6	3	4
Total Oxidised Nitrogen	mg/l N	**5**	0.9	0.9	0.5	0.8	0.9
Total Alkalinity	mg/l HCO_3		12	12	<5	9	11
Ammonium	mg/l NH_4	**0.2**	<0.08	<0.08	2.4	0.12	<0.08
Calcium	mg/l Ca		5	5	184	5	5
Cadmium	mg/l Cd	**0.005**	<0.0002	<0.0005	0.019	0.001	0.00038
Chromium	mg/l Cr	**0.05**	<0.001	<0.001	<0.001	<0.001	<0.001
Chloride	mg/l Cl	**250**	8	8	37	8	8
Copper	mg/l Cu	**0.05**	0.0094	0.017	0.035	0.012	0.008
Iron	mg/l Fe	**0.2**	0.27	0.31	156	0.8	0.41
Lead	mg/l Pb	**0.05**	<0.004	<0.01	0.355	0.007	0.006
Magnesium	mg/l Mg		2	2	123	3	2
Manganese	mg/l Mn	**0.05**	0.03	0.05	11	0.07	0.05
Mercury	mg/l Hg	**0.001**	<0.000012	<0.000012	<0.000012	<0.000012	<0.000012
Total Phosphorus as P	mg/l P	**-**	0.06	<0.05	0.08	0.05	0.05
Phosphate	mg/l P_2O_5	**0.5**	<1	<1	<1	<1	<1
Potassium	mg/l K		<1	<1	10	<1	<1
Sodium	mg/l Na		5	5	21	5	5
Sulphate	mg/l SO_4	**200**	5	7	1275	12	8
Zinc	mg/l Zn	**3**	0.06	0.06	13	0.15	0.11

Ballymurtagh Landfill, Co. Wicklow
Surface Water Quality
Quarterly Samples - August 2008

Parameter	Units	Surface Water Regulations 1989	Environmental Quality Standards (proposed by EPA, 1997)	SW1 Whitesbridge s/w sample	SW2 Upstream adit s/w sample	SW3 B'murtagh Adit s/w sample	SW4 Coal Yard s/w sample	SW5 Avoca Bridge s/w sample
				Sampled: 07/08/08	Sampled: 07/08/08	Sampled: 07/08/08	Sampled: 07/08/08	Sampled: 07/08/08
		Max. Admissable Conc.	Proposed Limits	Analysed: 07/08/08	Analysed: 07/08/08	Analysed: 07/08/08	Analysed: 07/08/08	Analysed: 07/08/08
pH		5.5 < pH < 8.5	5.5 <pH < 9.0	7.0	6.9	4.3	6.6	6.8
Temperature (on site)	^{o}C	25		14	14	15	14	14
Conductivity	uS/cm at 20^{o}C	1,000	1,000	55	63	2150	71	61
C.O.D.	mg/l O_2	40	None	26	22	24	19	17
B.O.D.	mg/l O_2	5	5	<5	<5	21	<3	<3
Dissolved Oxygen (on site)	mg/l O_2	<5	<9 (@ 50% of the time)	9.3	9.3	7.3	8.7	9.6
Total Suspended Solids	mg/l SS	35		3	2	7	3	2
Total Oxidised Nitrogen	mg/l N	5	11.36					
Total Alkalinity	mg/l HCO_3		None					
Ammonium	mg/l NH_4	0.2	20ug/l NH_3 un-ionised Ammonia	<0.08	<0.08	7.9	0.08	<0.08
Calcium	mg/l Ca		None					
Cadmium	mg/l Cd	0.005	0.005					
Chromium	mg/l Cr	0.05	0.05					
Chloride	mg/l Cl	250	250	8	9	38	8	8
Copper	mg/l Cu	0.05	0.005 - 0.112					
Iron	mg/l Fe	0.2	-					
Lead	mg/l Pb	0.05	0.05					
Magnesium	mg/l Mg		None					
Manganese	mg/l Mn	0.05	0.3					
Mercury	mg/l Hg	0.001	0.001					
Total Phosphorus as P	mg/l P	-	-					
Phosphate	mg/l P_2O_5	0.5	0.07 mg/l P (0.32 mg/l P_2O_5) (for Seriously polluted river (Q<2)					
Potassium	mg/l K		None					
Sodium	mg/l Na		None					
Sulphate	mg/l SO_4	200	200	5	7	1456	13	8
Zinc	mg/l Zn	3	0.03 - 0.5					

Ballymurtagh Landfill, Co. Wicklow
Surface Water Quality
Quarterly Samples - May 2008

Parameter	Units	Surface Water Regulations 1989	Environmental Quality Standards (proposed by EPA, 1997)	SW1 Whitesbridge s/w sample	SW2 Upstream adit s/w sample	SW3 B'murtagh Adit s/w sample	SW4 Coal Yard s/w sample	SW5 Avoca Bridge s/w sample
				Sampled: 19/5/08	Sampled: 19/5/08	Sampled: 19/5/08	Sampled: 19/5/08	Sampled: 19/5/08
		Max. Admissable Conc.	Proposed Limits	Analysed: 19/5/08	Analysed:19/5/08	Analysed:19/5/08	Analysed:19/5/08	Analysed: 19/5/08
pH		5.5 < pH < 8.5	5.5 <pH < 9.0	7.2	6.7	3.8	6.2	6.6
Temperature (on site)	^{o}C	25		11	11	13	11	11
Conductivity	uS/cm at 20^{o}C	1,000	1,000	86	94	1941	127	110
C.O.D.	mg/l O_2	40	None	32	19	24	22	18
B.O.D.	mg/l O_2	5	5	8	4	14	7	<3
Dissolved Oxygen (on site)	mg/l O_2	<5	<9 (@ 50% of the time)	13.6	12.1	6.0	12.3	10.7
Total Suspended Solids	mg/l SS	35		4	3	4	9	3
Total Oxidised Nitrogen	mg/l N	5	11.36					
Total Alkalinity	mg/l HCO_3		None					
Ammonium	mg/l NH_4	0.2	20ug/l NH_3 un-ionised Ammonia	<0.08	<0.08	9.4	<0.08	0.15
Calcium	mg/l Ca		None					
Cadmium	mg/l Cd	0.005	0.005					
Chromium	mg/l Cr	0.05	0.05					
Chloride	mg/l Cl	250	250	10	10	44	11	11
Copper	mg/l Cu	0.05	0.005 - 0.112					
Iron	mg/l Fe	0.2	-					
Lead	mg/l Pb	0.05	0.05					
Magnesium	mg/l Mg		None					
Manganese	mg/l Mn	0.05	0.3					
Mercury	mg/l Hg	0.001	0.001					
Total Phosphorus as P	mg/l P	-	-					
Phosphate	mg/l P_2O_5	0.5	0.07 mg/l P (0.32 mg/l P_2O_5) (for Seriously polluted river (Q<2)					
Potassium	mg/l K		None					
Sodium	mg/l Na		None					
Sulphate	mg/l SO_4	200	200	9	15	1211	31	22
Zinc	mg/l Zn	3	0.03 - 0.5					

Ballymurtagh Landfill, Co. Wicklow
Surface Water Quality
Quarterly Samples - February 2008

Parameter	Units	Surface Water Regulations 1989 Max. Admissable Conc.	Environmental Quality Standards (proposed by EPA, 1997) Proposed Limits	SW1 Whitesbridge s/w sample Sampled: 5/2/08 Analysed: 5/2/08	SW2 Upstream adit s/w sample Sampled: 5/2/08 Analysed: 5/2/08	SW3 B'murtagh Adit s/w sample Sampled: 5/2/08 Analysed: 5/2/08	SW4 Coal Yard s/w sample Sampled: 5/2/08 Analysed: 5/2/08	SW5 Avoca Bridge s/w sample Sampled: 5/2/08 Analysed: 5/2/08
pH		**5.5 < pH < 8.5**	**5.5 <pH < 9.0**	6.9	6.5	4.0	6.1	6.4
Temperature (on site)	^{o}C	**25**		8	8	12	8	8
Conductivity	uS/cm at 20^{o}C	**1,000**	**1,000**	59	61	2080	75	64
C.O.D.	mg/l O_2	**40**	**None**	9	16	22	<4	<4
B.O.D.	mg/l O_2	**5**	**5**	<2	<3	<3	<2	<2
Dissolved Oxygen (on site)	mg/l O_2	**<5**	**<9 (@ 50% of the time)**	9.7	10.1	6.1	8.4	7.6
Total Suspended Solids	mg/l SS	**35**		6	8	12	6	7
Total Oxidised Nitrogen	mg/l N	**5**	**11.36**					
Total Alkalinity	mg/l HCO_3		**None**					
Ammonium	mg/l NH_4	**0.2**	**20ug/l NH_3 un-ionised Ammonia**	<0.08	<0.08	10.0	<0.08	<0.08
Calcium	mg/l Ca		**None**					
Cadmium	mg/l Cd	**0.005**	**0.005**					
Chromium	mg/l Cr	**0.05**	**0.05**					
Chloride	mg/l Cl	**250**	**250**	10	10	43	10	10
Copper	mg/l Cu	**0.05**	**0.005 - 0.112**					
Iron	mg/l Fe	**0.2**						
Lead	mg/l Pb	**0.05**	**0.05**					
Magnesium	mg/l Mg		**None**					
Manganese	mg/l Mn	**0.05**	**0.3**					
Mercury	mg/l Hg	**0.001**	**0.001**					
Total Phosphorus as P	mg/l P	**-**	**-**					
Phosphate	mg/l P_2O_5	**0.5**	**0.07 mg/l P (0.32 mg/l P_2O_5) (for Seriously polluted river (Q<2)**					
Potassium	mg/l K		**None**					
Sodium	mg/l Na		**None**					
Sulphate	mg/l SO_4	**200**	**200**	6	7	1515	14	9
Zinc	mg/l Zn	**3**	**0.03 - 0.5**					

Parameter	Units	Surface Water Regulations 1989 Max. Admissable Conc.	Environmental Quality Standards (proposed by EPA, 1997) Proposed Limits	SW6 Civic Amenity 2006 Sampled: 21/09/06 Analysed: 21/09/06	SW6 Civic Amenity 2007 Sampled: 21/09/07 Analysed: 21/09/07
pH		**5.5 < pH < 8.5**	**5.5 <pH < 9.0**	7.6	7.9
Temperature (on site)	^{o}C	**25**		8	6
Conductivity	uS/cm at 20^{o}C	**1,000**	**1,000**	629	483
C.O.D.	mg/l O_2	**40**	**None**	19	22
B.O.D.	mg/l O_2	**5**	**5**	<3	<2
Dissolved Oxygen (on site)	mg/l O_2	**<5**	**<9 (@ 50% of the time)**	6.8	9.3
Total Suspended Solids	mg/l SS	**35**		1	1
Total Oxidised Nitrogen	mg/l N	**5**	**11.36**	0.2	
Total Alkalinity	mg/l HCO_3		**None**	250	
Ammonium	mg/l NH_4	**0.2**	**20ug/l NH_3 un-ionised Ammonia**	<0.08	0.90
Calcium	mg/l Ca		**None**	144	
Cadmium	mg/l Cd	**0.005**	**0.005**	<0.03	
Chromium	mg/l Cr	**0.05**	**0.05**	<0.05	
Chloride	mg/l Cl	**250**	**250**	8	11
Copper	mg/l Cu	**0.05**	**0.005 - 0.112**	<0.05	
Iron	mg/l Fe	**0.2**	**1**	0.150	
Lead	mg/l Pb	**0.05**	**0.05**	<0.2	
Magnesium	mg/l Mg		**None**	11	
Manganese	mg/l Mn	**0.05**	**0.3**	0.100	
Mercury	mg/l Hg	**0.001**	**0.001**	<.00002	
Total Phosphorus as P	mg/l P	**-**	**-**	0.05	
Phosphate	mg/l P_2O_5	**0.5**	**0.07 mg/l P (0.32 mg/l P_2O_5) (for Seriously polluted river (Q<2)**	<1	
Potassium	mg/l K		**None**	2	
Sodium	mg/l Na		**None**	16	
Sulphate	mg/l SO_4	**200**	**200**	122	84
Zinc	mg/l Zn	**3**	**0.03 - 0.5**	0.03	

Appendix D

Principal Component Analysis (PCA)

Principal Component Analysis (PCA) has been used widely in cases and situations where scientists seek to be able to assign a chemical fingerprint to a specific source area of contamination. Practical applications include contaminated land scenarios as well as remediation of disused mines.

This Appendix briefly explains the methodology used to undertake the PCA carried out for this EIS and discusses the dataset used for the analysis.

Briefly, PCA is a data analysis method conducted in order to assist the environmental scientist with the identification and/or recognition of correlation patterns or structure among multiple samples and multiple variables (analytical constituents). The basic idea is that such correlation patterns, if present, define a distinctive dataset geometry shaped by the underlying environmental factors affecting the particular environment under study. When the shaping factors are due to sources of contamination, for example, the patterns produced by PCA should reflect these sources of contamination.

Davis (2002), Manly (2000), and Shaw (2003) present very understandable and practical introductions to PCA with minimal mathematical details, while Jackson (2003), Jolliffe (2002), Johnson & Wichern (1998), and Legendre and Legendre (1998) present the mathematical details.

In short, PCA transforms a dataset containing p variables, interrelated or correlated to various degrees, to a new dataset containing p orthogonal, uncorrelated variables called principal components (PCs). Note for our evaluations, 17 variables (constituents) were used (p = 17). The set of p PCs are linear functions of the original variables such that the sum of their variances is equal to that of the original variables, ordered from largest variance (PC1), to next largest variance (PC2), etc. Algebraically, for p original variables, x1, x2, … xp,

$$PC1 = a_{11}x_1 + a_{12}x_2 + \ldots + a_{1p}x_p = \sum_{j=1}^{p} a_{1j}x_j$$

$$PC2 = a_{21}x_1 + a_{22}x_2 + \ldots + a_{2p}x_p = \sum_{j=1}^{p} a_{2j}x_j$$

and so on for all p PCs. The variances of the PCs are the eigenvalues and the constants or weights, ajj, are the eigenvectors extracted from the covariance or correlation matrix (in this study, the correlation matrix was used in all cases). The hope is that the first few or k PCs (k << p) will retain most of the information in all of the p original variables, thus reducing the practical dimensionality of the dataset. In other words, if the correlations are high among many of the original variables, the first few PCs will tend to contain (or explain) a large percentage of the total variance and may be used to describe multivariate patterns or variation in water quality across the study area, almost as well as does the complete set of p original variables. Often these patterns are related to specific sources of contamination. The coefficients that project the data onto the PCs are called component loadings (l) and are calculated by multiplying the eigenvector (v) for the j-th variable and k-th PC by the square root of the corresponding eigenvalue [$l_{jk} = v_{jk}\sqrt{\lambda_k}$], thus resulting in a variable x PC loadings matrix. The loadings represent the importance of each original variable to the particular PC, and hence often can provide insight into the relationship of a given PC with a given source of contamination. Furthermore, the sum of the products of the loadings and the standardized data values produces a new set of data values called scores ($u_{ij} = \sum_{k=1}^{j} z_{ij}l_{kj}$), which may be analysed or interpreted.

All PCA results were obtained using the commercial computer program SYSTAT version 10 from SPSS Inc. The PCA was conducted such that samples were included if at least 14 of the 17 variables were complete (i.e., only three variables were allowed to have missing data). The missing data or "holes" in the dataset matrix were handled in the PCA by a method called pairwise deletion. Pairwise deletion calculates correlation coefficients separately for each pair of variables, ignoring only those samples with a missing value for one or both of the variables comprising the pair. Hence the number of samples used in constructing the correlation matrix varies from pair to pair but overall the information contained in the entire dataset is used. However, in calculating the PC scores, since the holes in the dataset remain, values of z_{ij} = 0 (standardized means) were substituted for the missing values to derive scores for all 312

samples. The scores for samples with missing values represent estimated scores but typically do not affect the overall interpretation of the evaluations.

PCs occurring above the broken stick random model were further rotated to improve their usefulness using Kaiser's varimax method (Kaiser 1958). The varimax rotation maximizes variable loadings along the PCs such that their values are either higher or lower. In other words, the varimax method seeks to maximize the separation of the data along the PC.

Data Compilation

The first step in the PCA was extraction of all analytical data for available water samples collected by Wicklow County Council (e.g., environmental monitoring from 1998 to present), Geological Survey of Ireland (GSI, 2006 and 2007), and CDM for the GSI (2007 and 2008).

The results of over 100 different sampling locations are contained in the data. A list and description of all the locations used in the final evaluation are provided in **Appendix E**. As shown, the locations include samples from both groundwater (monitoring wells, leachate wells, private wells, mine adit discharges, springs) and surface water (Avoca River, other tributaries, pit lakes, seeps, runoff water, drainage ditches). Figures with the locations identified in the area of the Ballymurtagh Landfill are also provided in **Appendix E.**

The extracted data, which included surface water and groundwater samples, were placed into a master database provided in **Appendix E**. A cross-tabulation was performed on the master database to determine the number of variables (analytical constituents) measured for each sample, and likewise the number of samples with measurements for each variable. All concentration data were converted to consistent units. Selected dissolved metals data (filtered samples) were converted to total metals data (unfiltered samples) in cases where total metals results were missing. Selected TDS (total dissolved solids) data were converted to conductivity (COND) data using COND = 0.64 x TDS where appropriate. This conversion was based on the relationship between conductivity and TDS for samples with both constituents measured. From the cross-tabulation, 17 variables were selected for the PCA dataset (see **Table D-1**) based on the following criteria:

Percentage completeness: The variable had to be analysed and reported in most of the samples retained for evaluation. Samples without a nearly full suite of the variables cannot be used in the evaluation as accurate evaluations cannot be completed (as described in **Section 7.5**). As shown on **Table D-1**, Number of Samples, the variables selected typically had results for 100 (or near 100) percent of the variables in the samples. The exceptions were chloride, ammonia and pH (reported in 82 percent of the samples).

Percentage of data above analytical detection limits: This criterion assures that the evaluation is meaningful because a range of concentrations are reported and available for evaluation. The PCA evaluation essentially depends upon the variability of different constituents from different sources (see **Sections 7.5 and 7.5.3.1** for more discussion). If a constituent has a large amount of reported results below the analytical detection limit (nondetect data), little variability is present (many identical values) and the constituent is not useful in evaluating differences observed in concentrations. As shown in **Table D-1**, Number of Detections, most of the constituents had a large percentage of detected values. For example, sulphate was detected above the analytical detection limit in 311 of the 312 samples (99.7 %). All constituents selected had over 50 percent of the values above the detection limit except for alkalinity (48 %), cadmium (41 %) and chromium (33 %). The low percentage for alkalinity would be anticipated because many of the samples had low pH values with no alkalinity. Cadmium and chromium are typically present only at small concentrations near the analytical detection limits. Typically a constituent with only 33 % detections would not be useful in the evaluation. However, sensitivity analyses have shown that if only one or two constituents have low amount of detections, the evaluation results are not substantially affected.

As a result of the above criteria, the total size of the dataset is: 17 variables x 312 samples = 5,304. The number of missing data values is 166 (3.1%) and the number of nondetects is 1,055 (20.5%) – see **Table D-1**.

Table D-1: Summary of Ballymurtagh PCA Database

Variable	Symbol	Number of Samples [1]	Number of Detections [2]
Alkalinity	ALK	312	146
Cadmium [3]	CD	312	128
Calcium [3]	CA	312	308
Chloride	CL	262	258
Chromium [3]	CR	312	102
Conductivity	COND	312	312
Copper [3]	CU	311	196
Iron [3]	FE	312	282
Lead [3]	PB	312	165
Magnesium [3]	MG	311	309
Manganese [3]	MN	311	283
Ammonia	NH3	257	156
pH	PH	256	256
Potassium [3]	K	312	260
Sulphate	SO4	312	311
Sodium [3]	NA	312	302
Zinc [3]	ZN	310	309
TOTAL		5,138	4,083

[1] Number of samples in the dataset with an analytical result. [2] Number of results above analytical detection limits. [3] Total concentration (unfiltered samples).

Data Treatment

The PCA dataset (as summarized in **Table D-1**) was treated prior to the PCA by first converting all non-detects to one-half the value of the reported detection limit. All data values except those for pH were then log transformed to minimized distortion due to highly skewed distributions. Environmental data are typically log normal distributed (Davis 2002) and transformation results in distributions that are typically normal (note: this is not a requirement of evaluations). Since the PCA was conducted on a correlation matrix (see **Section 7.5** for further details), the log transformed data were also inherently standardized.

Results of the PCA

Data Variance Explained

The eigenvalues extracted in PCA provide the percentage of the total variance in the dataset corresponding to each principal component (PC) and are typically examined visually via a scree plot (see **Figure D-1**). As shown in **Figure D-1**, PC1 explains 46.3% of the variance (40.3 after varimax rotation), PC2 explains 22.3% (28.3% after varimax rotation), and PC3 explains 8.5% (not rotated by varimax). As shown, PC1 and PC2 explain most of the total variance (68.6 %). A completely random PC with none of the 17 variables related would explain 5.88 % (100 %/17).

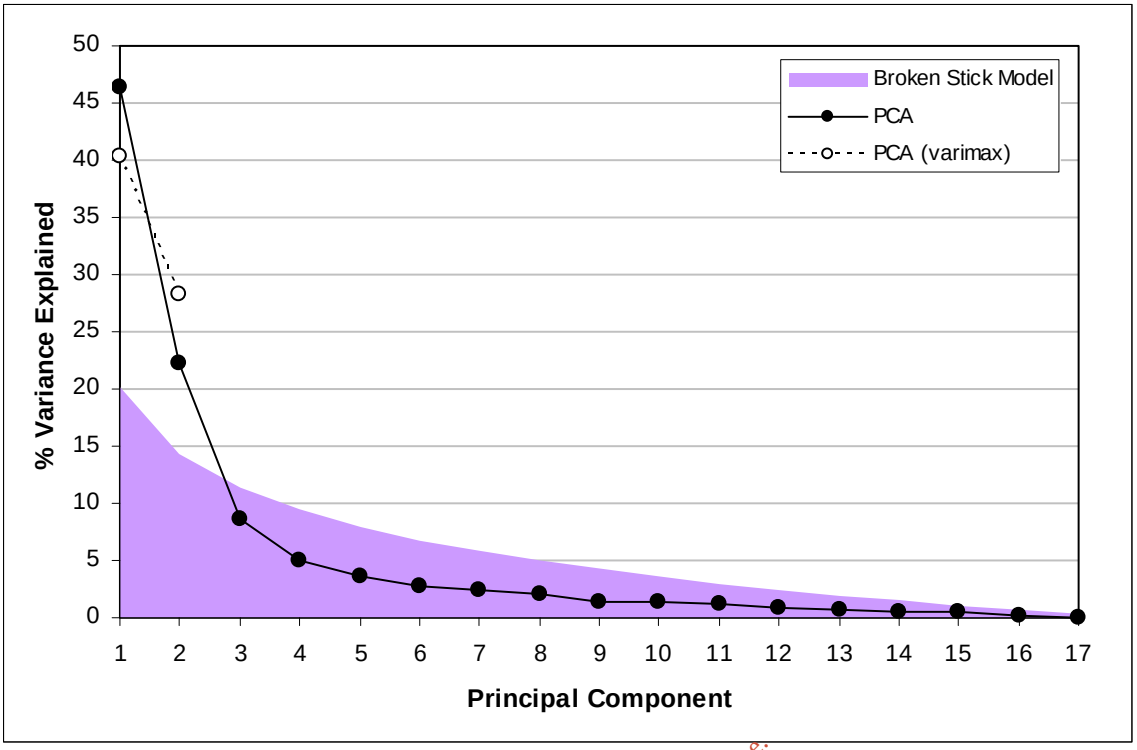


Figure D-1: Scree plot showing percent variance explained for the 17 PCs in the Ballymurtagh PCA, along with the broken stick random model.

Although no formal statistical tests exist with which to definitively select which, if any, of the resulting PCs are nontrivial and hence may be considered important or useful for interpretation, comparison to a hypothetical random model referred to as the "broken stick" model is a commonly used method. Given a dataset devoid of correlation structure, i.e., no interrelationships between the **variables**, the resulting eigenvalues should be distributed according to the p pieces broken at random from a stick of unit length:

$$L_j = \frac{1}{p}\sum_{i=j}^{p}\frac{1}{i}$$

This led Frontier (1976) to propose selecting as important those PCs with corresponding eigenvalues exceeding the broken stick model. Frontier (1976) and others (e.g., Jackson 1993, Jolliffe 2002, Legendre and Legendre 1998) indicate that this method accurately selects the appropriate number of PCs.

As shown in **Figure D-1,** the broken stick model selects the first two PCs (PC1 and PC2) as non-trivial, which accounts for (or explains) 68.6% of the total variance in the dataset.

The broken stick model threshold was also used as the cutoff for additional rotation of the PCs. Hence the first two PCs (PC1 and PC2) were rotated using the varimax method to improve their usefulness. The varimax method is the most commonly used rotation method in environmental science, tending to align the loadings better with the PCs and making them have either higher or lower values. Note that the percent variance explained after rotating the two PCs remains the same as before rotation (68,6%) but is distributed slightly differently as shown in **Figure D-1**.

Component Loadings

The eigenvalues and eigenvectors extracted via PCA are used to calculate a variable x PC matrix of component loadings, i.e., the coefficients for projecting the data (standardized and transformed) for each variable onto the PC axes. Since the data are z standardized, the loadings are constrained between -1 and +1 and represent the correlations between the variables and the PCs. The higher the absolute loading, the higher is the correlation and contribution of the variable to the PC. Interpretation involves evaluating the association of the loadings in terms of

environmental phenomena related to underlying geochemical processes and/or sources of contamination.

A simple way to display and compare component loadings is via a bar graph. **Figures 7-6** and **7-7** of the Main EIS Document provide bar graphs for PC1 and PC2, respectively. The loadings displayed are those following the varimax rotation method. A variable is considered to be an important contributor to a PC if its absolute loading exceeds about 0.75 (solid bars), moderately important if between about 0.50 and 0.75 (hachured bars), and unimportant if less than about 0.5 (open bars). Note that pH is < -0.75; i.e., highly correlated negatively with metals such as Zn and Cu (> 0.75); that is, at low pH values, the metals have high concentrations.

Appendix E

Surface Water and Groundwater Monitoring Data used in PCA

Table E-1
Principal Component Analysis (PCA)
Sample Locations and Categories

Sample	Description	Category
Arklow_Bridge:02/08/2007	Avoca R at Bridge in Arklow Town	SW - Stream
Arklow_LB:03/08/2007	Left Bank of Avoca R in Arklow below discharge	SW - Stream
Arklow_RB:03/08/2007	Right Bank of Avoca R in Arklow below discharge	SW - Stream
AVO-06-W001:20/11/2006	Vale view stream	SW - Stream
AVO-06-W003:15/02/2007	Deep adit runoff	SW - Runoff/Drainage
AVO-06-W004:15/02/2007	Deep adit discharge	SW - ARD
AVO-06-W005:20/11/2006	Deep adit discharge near Avoca R	SW - ARD
AVO-06-W006:20/11/2006	Avoca River mixing zone deep adit discharge	SW - Stream
AVO-06-W007:20/11/2006	Avoca River mixing zone road adit	SW - Stream
AVO-06-W008:15/02/2007	Road adit discharge	SW - ARD
AVO-06-W009:22/11/2006	Avonmore River	SW - Stream - Reference
AVO-06-W010:20/11/2006	Red Road Stream	SW - Stream
AVO-06-W011:22/11/2006	Avoca River above sulfur Brook	SW - Stream
AVO-06-W012:22/11/2006	Sulfur Brook near confluence with Avoca R	SW - Stream
AVO-06-W013:22/11/2006	Sulfur Brook midway	SW - Stream
AVO-06-W015:15/02/2007	Connary adit discharge	SW - ARD
AVO-06-W016:20/11/2006	Avoca R above Avoca Town Bridge	SW - Stream
AVO-06-W018:22/11/2006	Avoca R at Shelton Abbey	SW - Stream
AVO-06-W019:22/11/2006	Avoca R below Shelton Abbey	SW - Stream
AVO-06-W020:20/11/2006	Drainage near Emergency tailings	SW - Runoff/Drainage
AVO-06-W021:20/11/2006	Avoca R below emergency tailings	SW - Stream
AVO-06-W022:20/11/2006	Spoil runoff -Avoca R mixing zone	SW - Runoff/Drainage
AVO-06-W024:15/02/2007	Cronebane Shallow Adit discharge	SW - ARD
AVO-06-W025:22/11/2006	Castlehoward area drainage ditch	SW - Runoff/Drainage
AVO-06-W026:22/11/2006	Run off, NE end of Mt Platt	SW - Runoff/Drainage
AVO-06-W027:22/11/2006	Run off, SW-central of Mt. Platt	SW - Runoff/Drainage
AVO-06-W029:22/11/2006	Mrs Tracey's spring	GW - Spring
AVO-06-W030:20/11/2006	P Clarke's spring	GW - Spring
AVO-06-W032:27/11/2006	Avoca R, downstream Shelton Abbey	SW - Stream
AVO-06-W033:27/11/2006	Shelton Abbey Surface drainage ditch	SW - Runoff/Drainage
AVO-06-W035:15/02/2007	Surface runoff below Deep adit near river	SW - Runoff/Drainage
AVO-07-W002:14/06/2007	Avoca River Below Vale View Stream	SW - Stream
Avoca_D/S_Aughrim:02/08/2007	Avoca R down stream of Aughrim R confluence	SW - Stream
Avoca_U/S_Aughrim:02/08/2007	Avoca R up stream of Aughrim R confluence	SW - Stream
Ballinacleish_Bridge:02/08/2007	Ballinacleish Bridge, Avonbeg R	SW - Stream - Reference
Ballygahan_Adit:31/07/2007	Ballygahan Adit	SW - ARD
BH86/9:01/12/1999	Borehole 86/9	GW - Leachate
BH96/3:Q4/2008	Borehole 96/3	GW - Leachate
BH96/4B:2/19/1999	Borehole 96/4B	GW - Borehole
BH96/5A:?/2000	Borehole 96/5A	GW - Borehole
Cosgroves_Well:04/08/07	Cosgroves Well	GW - Well - Private
Cronebane_Intermediate_Adit:31/7/07	Cronebane Shallow Adit discharge	SW - ARD
Cronebane_Pit_Lake:14/11/2007	Cronebane pit lake	SW - ARD
Cronebane_Seeps:31/07/2007	Cronebane seeps	SW - ARD
Cronebane_Shallow_Adit:14/11/2007	Cronebane Shallow Adit discharge	SW - ARD
D/S_Fertilizer_Plant:02/08/2007	Avoca R down stream of Fertilizer Plant	SW - Stream
D/S_Landfill:02/08/2007	Avoca R down stream of Landfill below Fertilizer Plant	SW - Stream
Deep_Adit:14/11/2007	Deep adit discharge	SW - ARD
Deep_Adit_Confluence:31/07/2007	Avoca River at confluence with Deep Adit discharge	SW - Stream
Donald_OLeary:Q2/2007	Donald Oleary well	GW - Well - Private
Drews_Discharge:04/08/2007	Drainage ditch	SW - Runoff/Drainage
East_Avoca_Pit_Lake:02/08/2007	East Avoca Pit Lake	SW - ARD
Eddie_Coleman:Q2/2007	Eddie Coleman Well	GW - Well - Private
G1/04:Q4/2004	Monitoring well G1/04 (deep, 26.8)	GW - MW
G1/05:Q4/2005	Monitoring well G1/05 (deep, 25-31)	GW - MW
G1NSL2:03/08/07	Monitoring well G1NSL2 (deep, 22)	GW - MW
G2/04:Q4/2004	Monitoring well G2/04	GW - MW
G2/05:Q4/2005	Monitoring well G2/05 (shallow, 4-10)	GW - MW
GW1/05:03/08/07	Monitoring well GW1	GW - MW
GW2/05:03/08/07	Monitoring well GW2	GW - MW
Heffernans_Well:03/08/07	Heffernans Well	GW - Well - Private

Table E-1
Principal Component Analysis (PCA)
Sample Locations and Categories

Sample	Description	Category
Holy_Well:04/08/07	Holy Well Spring	GW - Spring
Jeffery_Green:Q2/2007	Jeffery Green Well	GW - Well - Private
Kerins_Well:03/08/07	Kerins Well	GW - Well - Private
Kilmacoo:31/07/2007	Kilmacoo adit discharge	SW - ARD
L03/1:Q1/2003	Leachate well 03/1	GW - Leachate
L05/10:Q4/2005	Leachate well 05/10	GW - Leachate
L05/16:Q4/2005	Leachate well 05/16	GW - Leachate
Lions_Bridge:02/08/2007	Lions Bridge, Avonmore R	SW - Stream - Reference
Meehans_Well:04/08/07	Meehans well	GW - Well - Private
Monitoring_Well:01/12/1999	Monitoring well	GW - MW
MWDA1:15/11/07	Monitoring well 1 Deep Adit (shallow, 9-12)	GW - MW
MWDA2:20/02/08	Monitoring well 2 Deep Adit (deep, 22-25)	GW - MW
MWET1:15/11/07	Monitoring well 1 Emergency Tailings (shallow, 7.8-10.6)	GW - MW
MWET2:20/02/08	Monitoring well 2 Emergency Tailings (deep, 17-20)	GW - MW
MWPF1:16/11/07	Monitoring well Patty Fuller property (shallow, 4.7-7.7)	GW - MW
MWSA2:15/11/07	Monitoring well Shelton Abbey (shallow, 8-10)	GW - MW
Radio_Tower_Spring:02/08/2007	Radio Tower Spring	GW - Spring
RC6:Q4/2004	Monitoring well RC6	GW - MW
Red_Road:14/11/2007	Red Road Stream	SW - Stream
Richards_Well:03/08/07	Richards well	GW - Well - Private
Road_Adit:21/02/2008	Road adit discharge	SW - ARD
Road_Adit_Confluence:31/07/2007	Avoca River at confluence with Road Adit discharge	SW - Stream
SG1/04:21/02/08	Monitoring well SG104-G1/04 (deep, 26.8)	GW - MW
Shelton_Abbey_Base_Pond:15/11/2007	Base Pond at Shelton Abbey	SW - ARD
Shelton_Abbey_Downgradient:02/08/2007	Avoca River down stream of Shelton Abbey	SW - Stream
Shelton_Abbey_Upstream:02/08/2007	Avoca River up stream of Shtelton Abbey	SW - Stream
Spa_Adit:31/07/2007	Spa Adit discharge	SW - ARD
Sulfur_Brook:31/07/2007	Sulfur Brook	SW - Stream
SW1:Q4/2008	Avoca R at Whites Bridge	SW - Stream
SW1_Whitesbridge:01/12/1999	Avoca R at Whites Bridge	SW - Stream
SW2:Q4/2008	Avoca R Ustream of Ballygahan adit	SW - Stream
SW2_Upstream_Adit:01/12/1999	Avoca R Ustream of Ballygahan adit	SW - Stream
SW3:Q2/2009	Road Adit Discharge	SW - ARD
SW3_Ballymurtagh_Adit:01/12/1999	Road adit discharge	SW - ARD
SW4:Q4/2008	Avoca River at Coal Yard	SW - Stream
SW4_Coal_Yard:01/12/1999	Avoca River at Coal Yard	SW - Stream
SW5:Q4/2008	Avoca River at Avoca Town Bridge	SW - Stream
SW5_Avoca_Bridge:01/12/1999	Avoca River at Avoca Town Bridge	SW - Stream
T1:30/07/2007	Avoca River Transect 1-below Meeting of the Waters	SW - Stream
T2-Comp:30/07/2007	Avoca River Transect 2-below Deep Adit discharge	SW - Stream
T3:30/07/2007	Avoca River Transect 3-below Coal Yard	SW - Stream
T4:30/07/2007	Avoca River Transect 4-below Avoca Town Bridge	SW - Stream
T5:21/02/2008	Avoca River Transect 5-upgradient of T3	SW - Stream
Thomas_Merrigan:Q2/2007	Thomas Merrigan Well	GW - Well - Private
Twin_Shafts:01/06/2000	Twin Shafts	GW - Twin Shafts
Unknown_Trib:31/07/2007	Unknown Tributary to Sulfur Brook	SW - Stream
Vale_View:31/07/2007	Vale view stream	SW - Stream

Figure E-1

Groundwater Monitoring Points in the Avoca Mining Area

Groundwater Monitoring Points

- GW - Borehole
- GW - Spring
- Ballymurtagh Landfill Site
- GW - Leachate
- GW - Twin Shafts
- GW - MW
- GW - Well - Private

0 25 50 100 150 200 250 Meters

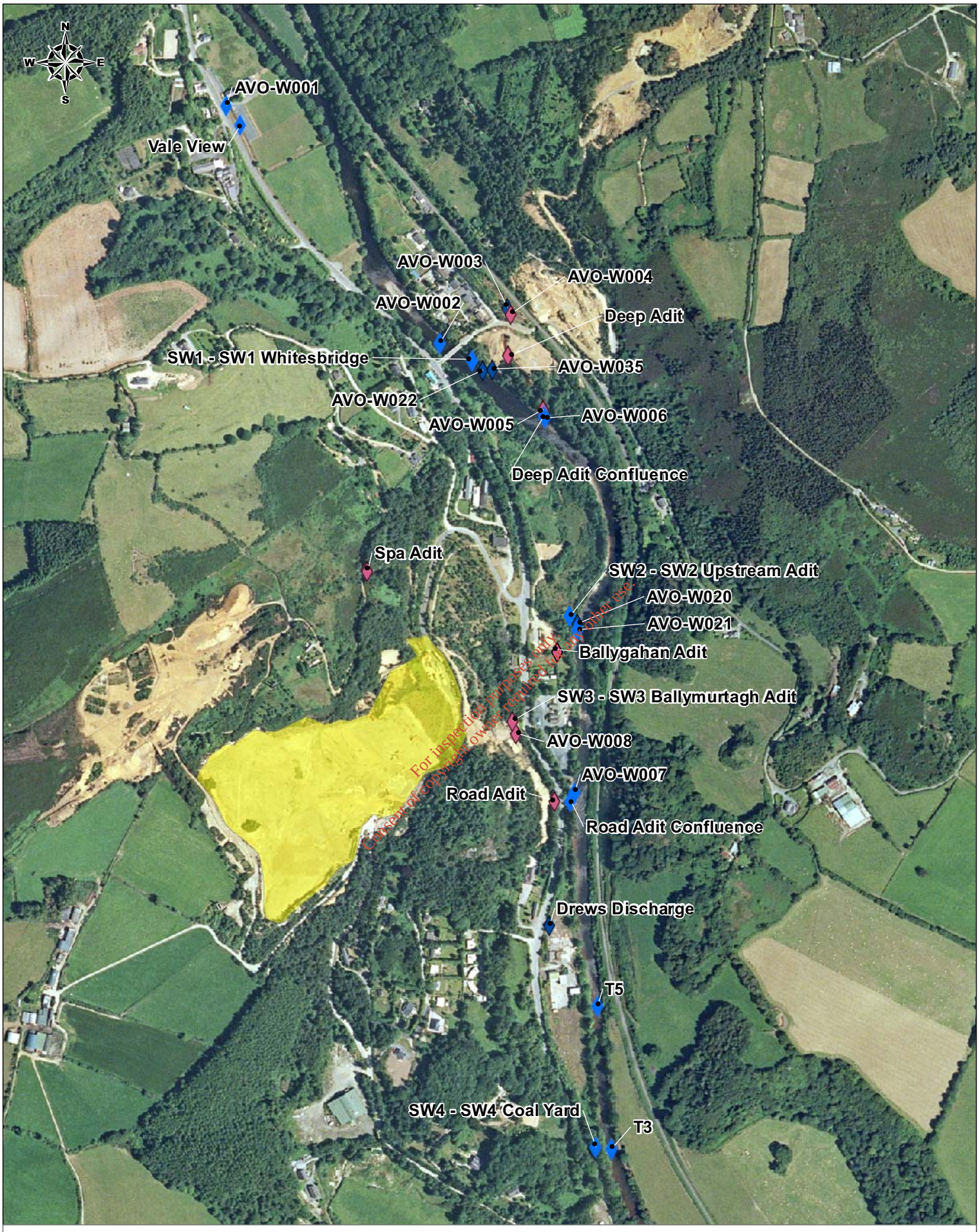


Figure E-2

Surface Water Monitoring Points in the Avoca Mining Area

Surface Water Monitoring Points

- SW - ARD
- SW - Runoff/Drainage
- SW - Stream
- Ballymurtagh Landfill Site

0 25 50 100 150 200 250 Meters

Table E-2
Principal Component Analysis (PCA) Master Database
Surface Water and Groundwater Monitoring Data

Average of Value	Variable								
Sample	ALKALINITY	CADMIUM_T	CALCIUM_T	CHLORIDE	CHROMIUM_T	COND	COPPER_T	IRON_T	LEAD_T
Arklow_Bridge:02/08/2007	5	0.0005	30.8	11	0.004	39.68	0.047	0.707	0.004
Arklow_LB:03/08/2007	30	0.0005	74.2	2441	0.005	3014.4	0.035	0.677	0.01
Arklow_RB:03/08/2007	23	0.0005	58.17	1231	0.004	1781.76	0.043	0.627	0.006
AVO-06-W001:20/11/2006	0.25	0.00025	15.94	.	0.003	150	0.005	0.149	0.002
AVO-06-W003:15/02/2007	0.25	0.008	27.97	.	0.005	580	2.3	1.46	0.287
AVO-06-W003:20/11/2006	0.25	0.037	24.37	.	0.019	1480	8.266	19.33	0.394
AVO-06-W004:15/02/2007	0.25	0.139	25.11	.	0.004	1860	1.416	19.36	1.483
AVO-06-W004:20/11/2006	0.25	0.148	9.954	.	0.109	1680	1.471	22.37	2.113
AVO-06-W005:20/11/2006	0.25	0.15	9.293	.	0.005	1670	1.457	21.84	2.021
AVO-06-W006:20/11/2006	0.25	0.003	3.727	.	0.005	50	0.041	1.194	0.04
AVO-06-W007:20/11/2006	0.25	0.005	58.43	.	0.019	1100	0.169	16.6	0.152
AVO-06-W008:15/02/2007	0.25	0.011	158.2	.	0.002	2320	0.301	102.3	0.305
AVO-06-W008:20/11/2006	0.25	0.011	155.8	.	0.00025	2480	0.364	159.6	0.372
AVO-06-W009:22/11/2006	0.25	0.00025	3.774	.	0.003	40	0.00025	0.199	0.004
AVO-06-W010:20/11/2006	0.25	0.00025	14.34	.	0.014	150	0.025	0.47	0.007
AVO-06-W011:22/11/2006	0.25	0.00025	4.17	.	0.028	50	0.011	0.662	0.006
AVO-06-W012:22/11/2006	0.25	0.00025	9.74	.	0.00025	140	0.018	0.042	0.004
AVO-06-W013:22/11/2006	0.25	0.00025	11.2	.	0.024	200	0.064	0.179	0.026
AVO-06-W015:15/02/2007	0.25	0.01	25.63	.	0.005	260	0.227	0.742	1.552
AVO-06-W015:22/11/2006	0.25	0.012	9.381	.	0.001	240	0.287	0.546	1.705
AVO-06-W016:20/11/2006	10.4	0.00025	4.184	.	0.002	20	0.006	0.421	0.015
AVO-06-W018:22/11/2006	0.25	0.00025	6.043	.	0.00025	40	0.009	0.319	0.003
AVO-06-W019:22/11/2006	0.25	0.003	264.1	.	0.122	1700	0.244	3.559	0.014
AVO-06-W020:20/11/2006	0.25	0.004	67.87	.	0.039	580	1.578	0.464	0.028
AVO-06-W021:20/11/2006	9.2	0.00025	3.938	.	0.014	40	0.027	0.294	0.008
AVO-06-W022:20/11/2006	0.25	0.00025	3.742	.	0.037	40	0.029	0.38	0.011
AVO-06-W024:15/02/2007	0.25	0.251	24.6	.	0.014	1960	10.72	146.9	0.835
AVO-06-W024:22/11/2006	0.25	0.242	8.316	.	0.019	3220	10.52	128.4	0.975
AVO-06-W025:22/11/2006	0.25	0.00025	7.989	.	0.001	110	0.003	0.034	0.002
AVO-06-W026:22/11/2006	0.25	0.073	0.73	.	0.008	2030	7.072	104.3	0.471
AVO-06-W027:22/11/2006	0.25	0.28	1.967	.	0.234	3760	30.83	303.6	0.433
AVO-06-W029:22/11/2006	0.25	0.00025	17.84	.	0.005	160	0.008	0.078	0.00025
AVO-06-W030:20/11/2006	0.25	0.00025	1.195	.	0.003	40	0.012	0.237	0.003
AVO-06-W032:27/11/2006	0.25	0.00025	5.405	.	0.004	20	0.009	3.113	0.035
AVO-06-W033:27/11/2006	0.25	0.00025	2.777	.	0.00025	40	0.00025	0.584	0.002
AVO-06-W035:15/02/2007	0.25	0.005	21.68	.	0.008	1100	4.725	32.77	0.092
AVO-07-W001:14/06/2007	0.25	0.00025	41.29	.	0.003	140	0.115	0.55	0.003
AVO-07-W002:14/06/2007	0.25	0.00025	30.84	.	0.012	60	0.097	0.51	0.005
AVO-07-W004:13/06/2007	0.25	0.105	28.11	.	0.003	1760	1.154	20.23	1.272
AVO-07-W005:13/06/2007	0.25	0.102	30.59	.	0.005	1770	1.188	18.8	1.227
AVO-07-W006:13/06/2007	0.25	0.022	30.68	.	0.005	380	0.323	1.842	0.237
AVO-07-W007:13/06/2007	0.25	0.002	35.59	.	0.005	150	0.089	7.812	0.029
AVO-07-W008b:13/06/2007	0.25	0.012	221.7	.	0.004	2440	0.234	96.2	0.278
AVO-07-W009:14/06/2007	0.25	0.00025	32.29	.	0.003	50	0.124	0.392	0.003
AVO-07-W010:14/06/2007	0.25	0.002	41.87	.	0.007	100	0.17	2.193	0.022
AVO-07-W011:14/06/2007	0.25	0.001	24.87	.	0.004	80	0.058	1.205	0.012
AVO-07-W012:14/06/2007	0.25	0.00025	27.59	.	0.006	150	0.036	0.578	0.007
AVO-07-W013:14/06/2007	0.25	0.001	29.07	.	0.004	150	0.081	0.393	0.017
AVO-07-W016:14/06/2007	0.25	0.001	21.51	.	0.005	90	0.055	1.189	0.011
AVO-07-W018:13/06/2007	0.25	0.00025	23.84	.	0.005	100	0.038	0.818	0.006
AVO-07-W022:14/06/2007	0.25	0.002	30.09	.	0.004	70	0.187	1.031	0.009
AVO-07-W024:13/06/2007	0.25	0.317	35.37	.	0.014	4560	8.361	151.8	1.197
AVO-07-W029:14/06/2007	0.25	0.0005	31.35	.	0.005	170	0.019	0.39	0.003

Table E-2
Principal Component Analysis (PCA) Master Database
Surface Water and Groundwater Monitoring Data

Average of Value	Variable							
Sample	MAGNESIUM_T	MANGANESE_T	NH3	PH_T	POTASSIUM_T	SO4	SODIUM_T	ZINC_T
Arklow_Bridge:02/08/2007	6.828	0.025	0.15	.	1	15	7.75	0.177
Arklow_LB:03/08/2007	163	0.089	0.15	.	57.5	344	1500	0.167
Arklow_RB:03/08/2007	92.25	0.087	0.15	.	34.5	212	775	0.222
AVO-06-W001:20/11/2006	3.47	0.019	.	6.86	2.6	17	7	0.047
AVO-06-W003:15/02/2007	12.92	0.571	.	3.18	0.7	156000	14.5	2.182
AVO-06-W003:20/11/2006	53.79	2.495	.	2.66	1.2	710000	5	10.57
AVO-06-W004:15/02/2007	91.79	3.464	.	3.33	1.7	1205000	7.5	37.95
AVO-06-W004:20/11/2006	91.02	4.216	.	3.3	1.8	1161000	8.5	49.31
AVO-06-W005:20/11/2006	89.27	4.167	.	3.12	1.8	1153000	11	48.87
AVO-06-W006:20/11/2006	2.934	0.144	.	5.05	0.7	24	6	0.997
AVO-06-W007:20/11/2006	57.72	5.663	.	4.3	4.4	618	13.5	6.361
AVO-06-W008:15/02/2007	117.4	9.404	.	3.93	10.4	1401000	22	8.716
AVO-06-W008:20/11/2006	158.9	15.08	.	3.74	10.4	1580000	31.5	15.88
AVO-06-W009:22/11/2006	1.756	0.013	.	6.73	0.7	11	6.5	0.058
AVO-06-W010:20/11/2006	6.425	0.291	.	6.86	2.5	24	10	0.232
AVO-06-W011:22/11/2006	2.114	0.059	.	6.71	0.7	13	6	0.179
AVO-06-W012:22/11/2006	5.339	0.017	.	7.05	2.1	8	10.5	0.074
AVO-06-W013:22/11/2006	5.186	0.051	.	6.64	2.4	12	10	0.166
AVO-06-W015:15/02/2007	7.361	0.309	.	3.74	2.6	65000	11.5	2.286
AVO-06-W015:22/11/2006	5.038	0.219	.	3.66	2.6	63000	9.5	2.969
AVO-06-W016:20/11/2006	1.834	0.06	.	6.25	0.6	44	5	0.208
AVO-06-W018:22/11/2006	2.876	0.054	.	6.7	0.9	11	7	0.135
AVO-06-W019:22/11/2006	64.81	15.54	.	3.65	5.6	1062	11.5	2.186
AVO-06-W020:20/11/2006	13.51	1.876	.	4.33	0.8	271000	4	1.491
AVO-06-W021:20/11/2006	1.68	0.057	.	5.97	0.6	10	5	0.126
AVO-06-W022:20/11/2006	1.57	0.038	.	5.71	0.6	8	5	0.131
AVO-06-W024:15/02/2007	175.5	6.611	.	3.87	0.4	3510000	7	62.01
AVO-06-W024:22/11/2006	155.1	6.68	.	2.59	0.4	2767000	8	71.25
AVO-06-W025:22/11/2006	4.146	0.019	.	6.05	3.1	11	8.5	0.064
AVO-06-W026:22/11/2006	35.17	0.746	.	2.36	0.1	880000	3.5	14.17
AVO-06-W027:22/11/2006	82.27	3.349	.	2.19	0.1	2606000	4.5	80.99
AVO-06-W029:22/11/2006	5.853	0.006	.	6.3	1	10000	11.5	0.037
AVO-06-W030:20/11/2006	1.823	0.008	.	5.54	2.8	5000	8	0.082
AVO-06-W032:27/11/2006	2.291	0.272	.	6.76	1	6	4.5	0.101
AVO-06-W033:27/11/2006	1.31	0.166	.	5.91	3	1500	3.5	0.032
AVO-06-W035:15/02/2007	18.58	0.459	.	2.17	0.2	404000	10	1.454
AVO-07-W001:14/06/2007	7.916	0.037	.	6.63	1.8	28	7.5	0.121
AVO-07-W002:14/06/2007	5.233	0.032	.	6.88	1.1	10	7.5	0.162
AVO-07-W004:13/06/2007	93.15	3.734	.	3.06	2	1111000	9	39.13
AVO-07-W005:13/06/2007	91.74	3.713	.	3.03	2	1111000	8.5	38.71
AVO-07-W006:13/06/2007	22.82	0.802	.	3.75	1.2	133	8	8.306
AVO-07-W007:13/06/2007	13.29	0.762	.	5.29	1.7	105	9.5	1.053
AVO-07-W008b:13/06/2007	127.9	10.14	.	3.8	11.4	1652000	27	9.374
AVO-07-W009:14/06/2007	5.245	0.015	.	7	1	9	8	0.139
AVO-07-W010:14/06/2007	12.16	0.634	.	6.43	3.3	44	9.5	0.769
AVO-07-W011:14/06/2007	5.87	0.144	.	6.08	1.3	23	8.5	0.48
AVO-07-W012:14/06/2007	8.513	0.037	.	6.56	2.3	13	10	0.167
AVO-07-W013:14/06/2007	8.457	0.087	.	5.88	2.4	16	10	0.347
AVO-07-W016:14/06/2007	5.546	0.141	.	6.38	1.2	24	7.5	0.457
AVO-07-W018:13/06/2007	6.274	0.159	.	6.15	1.1	23	8.5	0.284
AVO-07-W022:14/06/2007	6.049	0.145	.	6.21	1.1	23	8	0.575
AVO-07-W024:13/06/2007	238.5	9.841	.	2.6	0.7	4901000	6.5	102.4
AVO-07-W029:14/06/2007	7.682	0.013	.	6.34	0.8	10000	10	0.116

Table E-2
Principal Component Analysis (PCA) Master Database
Surface Water and Groundwater Monitoring Data

Average of Value	Variable								
Sample	ALKALINITY	CADMIUM_T	CALCIUM_T	CHLORIDE	CHROMIUM_T	COND	COPPER_T	IRON_T	LEAD_T
Avoca_D/S_Aughrim:02/08/2007	10	0.0005	28.22	10	0.006	26.88	0.047	0.699	0.006
Avoca_U/S_Aughrim:02/08/2007	5	0.0005	27.75	9	0.006	21.76	0.048	0.789	0.007
Ballinacleish_Bridge:02/08/2007	5	0.0005	21.88	16	0.003	44.8	0.031	0.405	0.005
Ballygahan_Adit:31/07/2007	5	0.044	127.5	49	0.005	2445	5.266	32.64	0.191
BH86/9:01/12/1999	524.5901639	0.015	199	166	0.04	1980	0.04	8.32	0.125
BH86/9:02/06/1998	0.008196721	0.005	236	530	0.025	4370	0.005	0.72	0.05
BH86/9:06/03/2000	508.1967213	0.015	119	119	0.04	2020	0.04	0.41	0.125
BH86/9:09/10/2000	106.557377	0.015	298	48	0.04	2300	0.04	19.5	0.125
BH86/9:11/06/1998	0.008196721	0.005	197	530	0.025	4940	0.005	2.2	0.05
BH86/9:17/02/1999	581.9672131	0.015	150	138.9	0.04	2340	0.04	1	0.125
BH86/9:23/09/1999	139.3442623	0.015	207	257	0.04	2830	0.04	12.28	0.125
BH86/9:27/05/1998	0.016393443	0.005	150	461	0.025	4080	0.01	0.46	0.05
BH86/9:27/10/1998	606.557377	0.005	180	101	0.025	2280	0.005	1.8	0.125
BH86/9:31/05/2000	1516.393443	0.015	221	130	0.04	3080	0.04	0.24	0.125
BH96/3:2/19/1999	21.80327869	0.015	192	41.6	0.04	6190	0.71	176.6	0.41
BH96/3:Q4/2004	360.6557377	0.015	468	32	0.025	4040	0.025	441	0.1
BH96/3:Q4/2005	1262.295082	0.015	364	61	0.025	4520	0.025	112	0.1
BH96/3:Q4/2006	434.4262295	0.015	429	44	0.025	3870	0.025	194	0.1
BH96/3:Q4/2007	1393.442623	0.015	441	49	0.025	4020	0.00039	9.95	0.0001
BH96/3:Q4/2008	1524.590164	0.00005	432	46	0.5	3620	0.0085	22	0.001
BH96/4B:2/19/1999	36.8852459	0.05	49	73	0.04	2880	4.63	31.8	0.35
BH96/5A:?/2000	4.098360656	0.005	381	0.5	0.025	2490	0.005	1.3	0.83
BH96/5A:01/12/1999	4.098360656	0.1	385	8.3	0.04	2920	31.37	71	1.05
BH96/5A:02/06/1998	8.196721311	0.14	3150	1.5	0.025	3770	100	96	2.5
BH96/5A:08/03/2000	4.098360656	0.06	453	8	0.04	2490	22	7.7	0.83
BH96/5A:09/10/2000	4.098360656	0.12	526	10	0.04	2300	45	53	1.41
BH96/5A:11/06/1998	4.098360656	0.12	550	0.5	0.025	4510	30.5	26	1.6
BH96/5A:23/09/1999	4.098360656	0.07	381	7.6	0.04	2630	26.26	10.9	1.08
BH96/5A:27/05/1998	4.098360656	0.13	600	9	0.025	3700	60	1.3	3.1
Cosgroves_Well:04/08/07	23	0.0005	27.23	19	0.003	92.16	0.043	0.331	0.002
Cronebane_Intermediate_Adit:31/7/07	5	0.107	27.03	12	0.004	1093	2.569	28.15	1.109
Cronebane_Pit_Lake:14/11/2007	5	0.0141	3.694	7	0.0005	592	32.76	1.145	0.742
Cronebane_Pit_Lake:31/07/2007	5	0.013	24.15	7	0.004	551	3.435	2.532	0.416
Cronebane_Seeps:31/07/2007	5	0.016	23.96	8	0.003	680	4.988	2.577	0.901
Cronebane_Shallow_Adit:14/11/2007	5	0.3326	14.17	11	0.005	4277	9.218	193	1.301
Cronebane_Shallow_Adit:31/07/2007	5	0.248	27.07	12	0.014	2805	8.809	130.6	1.11
D/S_Fertilizer_Plant:02/08/2007	10	0.0005	26.12	15	0.003	39.68	0.043	0.67	0.005
D/S_Landfill:02/08/2007	12	0.0005	26.57	10	0.002	48.64	0.038	0.61	0.004
Deep_Adit:14/11/2007	5	0.0914	8.913	12	0.0005	1555	1.133	49.22	1.339
Deep_Adit:19/02/2008	5	0.12	11.05	13	0.025	1369.6	1.32	17.49	1.54
Deep_Adit_Confluence:31/07/2007	5	0.099	29.23	13	0.009	1397	0.83	17.3	1.534
Donald_OLeary:Q2/2007	32.78688525	0.0001	6	14	0.5	135	0.025	0.025	0.001
Donald_OLeary:Q4/2007	44.26229508	0.0001	9	14	0.00005	134	0.025	0.004	0.001
Donald_OLeary:Q4/2008	44.26229508	0.00013	9	14	0.0005	149	0.067	0.025	0.001
Drews_Discharge:04/08/2007	18	0.014	50.41	20	0.002	296.96	0.052	0.417	0.003
East_Avoca_Pit_Lake:02/08/2007	5	0.106	28.68	12	0.004	1280	2.531	28.73	1.101
Eddie_Coleman:Q2/2007	11.47540984	0.0002	10	13	0.5	137	0.025	0.025	0.005
Eddie_Coleman:Q4/2007	13.1147541	0.0002	11	13	0.00005	132	0.025	0.004	0.004
Eddie_Coleman:Q4/2008	18.03278689	0.00025	10	11	0.0005	136	0.094	0.025	0.002
G1/04:Q4/2004	4.098360656	0.87	309	11	0.22	11240	201	255	0.45
G1/04:Q4/2005	4.098360656	1.41	289	23	0.00005	11830	135	134	0.51
G1/04:Q4/2006	0.409836066	0.77	310	39	0.2	9250	171	146	0.42
G1/04:Q4/2007	0.409836066	0.93	274	40	0.86	10480	62.23	163.69	1.097

Table E-2
Principal Component Analysis (PCA) Master Database
Surface Water and Groundwater Monitoring Data

Average of Value	Variable							
Sample	MAGNESIUM_T	MANGANESE_T	NH3	PH_T	POTASSIUM_T	SO4	SODIUM_T	ZINC_T
Avoca_D/S_Aughrim:02/08/2007	6.039	0.05	0.15	.	0.9	13	6.75	0.277
Avoca_U/S_Aughrim:02/08/2007	6.01	0.075	0.15	.	0.85	16	6.5	0.257
Ballinacleish_Bridge:02/08/2007	4.025	0.013	0.15	.	0.5	8	5.35	0.073
Ballygahan_Adit:31/07/2007	191.8	13.67	9.04	3.8	14.5	2072	34.75	19.21
BH86/9:01/12/1999	69	1.75	38.88888889	6.6	60	760	117	0.03
BH86/9:02/06/1998	87	0.06	126	7.3	140	680	230	1.8
BH86/9:06/03/2000	90	0.27	62.84444444	7.7	77	750	110	0.01
BH86/9:09/10/2000	99	5.8	48.84444444	6.6	52	155	50	3.05
BH86/9:11/06/1998	89	5	134.5555556	7	140	780	675	1.8
BH86/9:17/02/1999	76	1.47	50.55555556	7.3	55.2	845	230	0.04
BH86/9:23/09/1999	78	3.03	78.55555556	6.4	150	1062	184	0.05
BH86/9:27/05/1998	61	1.04	129.1111111	7.4	1500	553	75	1.8
BH86/9:27/10/1998	65	0.005	34.22222222	6.6	40	713	78	0.41
BH86/9:31/05/2000	91	3.45	93.8	6.9	78	712	135	0.04
BH96/3:2/19/1999	618	25.93	27.22222222	3.3	16.9	5931	28.6	4.02
BH96/3:Q4/2004	263	17	51.33333333	6.1	35	3043	36	0.07
BH96/3:Q4/2005	408	13	157.1111111	6.7	73	2884	62	0.02
BH96/3:Q4/2006	355	13	5.288888889	7.2	56	2306	45	0.08
BH96/3:Q4/2007	278	12.96	106.5555556	7.1	55	2219	43	0.0071
BH96/3:Q4/2008	236	12	95.66666667	6.6	51	1742	39	0.02
BH96/4B:2/19/1999	150	9.96	14.54444444	3.1	9.7	1626	47.4	5.43
BH96/5A:?/2000	82	2.25	0.622222222	3	0.4	2285	6	12
BH96/5A:01/12/1999	166	8.86	1.244444444	4.4	0.4	3174	18	27.5
BH96/5A:02/06/1998	217	2.25	1.944444444	4.3	2.8	2840	20	80
BH96/5A:08/03/2000	82	4.2	0.622222222	4.1	0.5	2446	6	12
BH96/5A:09/10/2000	188	9.7	48.84444444	7	0.5	3419	7	37
BH96/5A:11/06/1998	205	13.5	1.477777778	3	0.64	2870	12.25	43
BH96/5A:23/09/1999	115	5.58	0.933333333	4.2	3.86	2285	19	19
BH96/5A:27/05/1998	219	13.8	1.4	4.1	0.61	2635	6	46.5
Cosgroves_Well:04/08/07	9.883	0.007	0.4	.	2.45	25	12.25	0.091
Cronebane_Intermediate_Adit:31/7/07	54.18	2.568	0.33	4.31	3.05	799	7.75	28.8
Cronebane_Pit_Lake:14/11/2007	10.22	5.65	0.31	3.33	0.9	160	5	5.015
Cronebane_Pit_Lake:31/07/2007	11.53	0.494	0.11	3.62	0.6	167	4.4	4.39
Cronebane_Seeps:31/07/2007	15.85	0.753	0.08	3.55	0.6	228	4.95	5.728
Cronebane_Shallow_Adit:14/11/2007	241	14.92	0.54	3.13	0.7	3691	7	110.2
Cronebane_Shallow_Adit:31/07/2007	179.4	7.44	0.78	3.92	0.6	3215	6.25	76.38
D/S_Fertilizer_Plant:02/08/2007	6.026	0.133	0.15	.	0.95	18	7.25	0.169
D/S_Landfill:02/08/2007	6.049	0.074	0.15	.	0.95	16	7	0.195
Deep_Adit:14/11/2007	77.46	4.28	0.27	3.55	2.2	963	8.5	48.63
Deep_Adit:19/02/2008	74.72	3.35	0.28	.	1.1	1047	8.3	.
Deep_Adit_Confluence:31/07/2007	84.19	3.573	0.33	3.47	2.15	1362	8	39.29
Donald_OLeary:Q2/2007	6	0.015	0.031111111	6.6	2	14	10	0.07
Donald_OLeary:Q4/2007	7	0.0419	0.031111111	6.6	2	17	11	0.04
Donald_OLeary:Q4/2008	7	0.015	0.031111111	6.3	2	12	11	0.09
Drews_Discharge:04/08/2007	26.03	1.357	3.7	.	5.4	192	19.25	4.518
East_Avoca_Pit_Lake:02/08/2007	54.67	2.571	0.15	3.41	3	796	7.75	28.45
Eddie_Coleman:Q2/2007	4	0.05	0.031111111	5.9	2	20	7	0.08
Eddie_Coleman:Q4/2007	5	0.0515	0.031111111	5.5	2	21	9	0.08
Eddie_Coleman:Q4/2008	5	0.04	0.031111111	6	2	22	8	0.07
G1/04:Q4/2004	1521	69	0.077777778	2.8	2.5	18068	7	288
G1/04:Q4/2005	1927	82	0.005	3	2.5	19940	6	398
G1/04:Q4/2006	1487	50	1.244444444	3	2.5	14521	6	200
G1/04:Q4/2007	1776	58.683	0.637777778	3.5	2.5	15553	12	229.1

Table E-2
Principal Component Analysis (PCA) Master Database
Surface Water and Groundwater Monitoring Data

Average of Value	Variable								
Sample	ALKALINITY	CADMIUM_T	CALCIUM_T	CHLORIDE	CHROMIUM_T	COND	COPPER_T	IRON_T	LEAD_T
G1/04:Q4/2008	4.098360656	0.833	341	21	0.133	9270	140	84	0.343
G1/05:Q4/2005	4.098360656	0.03	122	23	0.025	1482	9.9	0.4	0.1
G1/05:Q4/2006	0.409836066	0.03	127	19	0.025	1482	9.2	0.45	0.1
G1/05:Q4/2007	0.409836066	0.07	190	17	0.025	2000	14.1	31.325	0.366
G1/05:Q4/2008	4.098360656	0.057	207	15	0.0025	2020	11.8	25	0.279
G1NSL2:03/08/07	5	0.001	28.47	14	0.004	101.12	0.602	1.058	0.01
G2/04:Q4/2004	4.098360656	0.12	151	12	0.06	3360	57	2.8	0.27
G2/04:Q4/2005	4.098360656	0.09	121	11	0.00005	3100	51	11	0.0001
G2/04:Q4/2008	4.098360656	0.118	204	16	0.044	159	57	28	0.242
G2/05:Q4/2005	4.098360656	0.015	130	26	0.025	1140	5.8	1.56	0.1
G2/05:Q4/2006	122.9508197	0.015	116	26	0.00005	1064	6.2	0.89	0.1
G2/05:Q4/2007	0.409836066	0.03	126	17	0.025	1276	7.5	0.0836	0.005
G2/05:Q4/2008	4.098360656	0.029	160	15	0.0005	1393	7.7	0.45	0.001
GW1/05:03/08/07	5	0.03	141.2	14	0.002	1095.68	8.028	0.452	0.004
GW1/05:16/11/07	5	0.0311	110.9	15	0.0005	1100.8	10.01	0.186	0.0005
GW1/05:19/02/08	5	0.025	144.2	15	0.025	1228.8	9.33	0.025	0.025
GW2/05:03/08/07	5	0.018	117.8	18	0.002	1080.32	5.336	0.63	0.003
GW2/05:16/11/07	5	0.025	97.59	15	0.0005	908.8	8.736	0.156	0.0005
GW2/05:19/02/08	5	0.025	134.5	19	0.025	921.6	7.01	0.025	0.025
Heffernans_Well:03/08/07	5	0.0002	18.95	11	0.004	11.52	0.031	0.296	0.001
Holy_Well:04/08/07	27	0.0005	27.03	15	0.004	126.72	0.027	0.324	0.001
Jeffery_Green:Q2/2007	14.75409836	0.0002	76	13	0.5	128	0.025	0.21	0.001
Jeffery_Green:Q4/2007	18.03278689	0.0002	111	12	0.00005	128	0.025	0.004	0.002
Jeffery_Green:Q4/2008	26.2295082	0.00025	11	10	0.0005	134	0.057	0.1	0.001
Kerins_Well:03/08/07	5	0.0005	21.495	18	0.0035	54.4	0.0795	0.3855	0.0025
Kerins_Well:21/02/08	5	0.025	3.91	19	0.025	51.2	0.15	0.025	0.025
Kilmacoo:31/07/2007	5	0.01	26.2	15	0.003	211	0.29	0.696	1.944
L03/1:Q1/2003	2131.147541	0.015	205	204	0.025	3090	0.025	4.87	0.1
L03/1:Q4/2003	5327.868852	0.015	143	677	0.025	7420	0.025	1.06	0.1
L03/2:Q4/2003	2704.918033	0.015	262	569	0.025	6800	0.025	58	0.1
L03/2:Q4/2004	4098.360656	0.015	156	515	0.025	5430	0.025	2.27	0.1
L03/2:Q4/2005	3688.52459	0.015	101	342	0.025	6130	0.025	1.39	0.1
L03/2:Q4/2006	2049.180328	0.015	189	265	0.025	3040	0.025	3.37	0.1
L05/10:Q4/2005	8606.557377	0.015	37	44	0.05	10700	0.025	5	0.1
L05/10:Q4/2006	8688.52459	0.015	53	946	0.025	10190	0.025	4.96	0.1
L05/10:Q4/2007	9672.131148	0.015	47	969	0.05	11220	0.0059	5.18	0.015
L05/10:Q4/2008	4500	0.0018	77	682	41	8240	0.021	6.4	7.2
L05/16:Q4/2005	1663.934426	0.015	164	101	0.025	2620	0.025	1.08	0.1
L05/16:Q4/2006	1065.57377	0.015	289	24	0.025	1638	0.025	22	0.1
L05/16:Q4/2007	2459.016393	0.015	238	102	0.025	2530	0.0014	0.057	0.0001
L05/16:Q4/2008	538	0.00023	197	15	0.5	1162	0.158	14	0.002
Lions_Bridge:02/08/2007	5	0.0005	24.75	9	0.003	96	0.045	0.477	0.005
Meehans_Well:04/08/07	5	0.0005	23.48	36	0.004	60.16	0.063	0.413	0.003
Monitoring_Well:01/12/1999	4.098360656	0.05	26	73	0.04	2430	3.23	103.6	1.02
Monitoring_Well:02/06/1998	3081.967213	0.04	0.05	71	0.025	2460	3.9	15.5	0.33
Monitoring_Well:06/03/2000	4.098360656	0.05	121	67	0.04	3800	26	276	0.125
Monitoring_Well:09/10/2000	4.098360656	0.06	131	62	0.04	3830	26.2	248	0.125
Monitoring_Well:11/06/1998	4.098360656	0.04	96	83	0.025	2930	2.25	74	0.21
Monitoring_Well:12/03/2001	4.098360656	0.06	100	0.25	0.025	3300	16.2	140	0.23
Monitoring_Well:17/02/1999	4.098360656	0.05	49	73	0.04	2880	4.63	31.8	0.35
Monitoring_Well:23/09/1999	4.098360656	0.06	47	61	0.04	3260	15.2	145	0.125
Monitoring_Well:27/05/1998	4.098360656	0.07	21	66	0.025	2790	2.6	0.39	0.32
Monitoring_Well:31/05/2000	4.098360656	0.04	26	69	0.04	2860	7.6	50	0.125

Table E-2
Principal Component Analysis (PCA) Master Database
Surface Water and Groundwater Monitoring Data

Average of Value	Variable							
Sample	MAGNESIUM_T	MANGANESE_T	NH3	PH_T	POTASSIUM_T	SO4	SODIUM_T	ZINC_T
G1/04:Q4/2008	1248	55	0.303333333	2.9	2.5	12460	6	207
G1/05:Q4/2005	76	5.3	0.031111111	3.8	3	1025	21	10
G1/05:Q4/2006	101	5.9	0.005	3.7	3	1107	15	12
G1/05:Q4/2007	152	9.436	0.031111111	4.1	2	4522	13	23.4
G1/05:Q4/2008	140	8.2	0.031111111	3.8	2	1596	12	21
G1NSL2:03/08/07	15.7	0.464	0.15	.	2.9	85	8.5	0.533
G2/04:Q4/2004	345	15	0.07	3.5	2.5	3635	6	40
G2/04:Q4/2005	305	12	0.777777778	4	0.5	3364	5	29
G2/04:Q4/2008	375	20	1.322222222	3.2	1	4074	11	37
G2/05:Q4/2005	59	4.6	0.031111111	4.4	3	757	17	6.3
G2/05:Q4/2006	72	3.9	0.233333333	4.1	3	715	20	6.8
G2/05:Q4/2007	78	4.781	0.031111111	4.1	2	859	12	8.8
G2/05:Q4/2008	81	4.7	0.031111111	3.8	2	993	11	9
GW1/05:03/08/07	97.58	5.537	0.15	.	2.2	1121	11.75	9.855
GW1/05:16/11/07	94.13	6.704	0.04	.	1.25	855	5.7625	13.83
GW1/05:19/02/08	101.9	5.93	0.06	.	2.1	1254	13.4	.
GW2/05:03/08/07	59.15	3.354	0.15	.	2.45	753	12	5.863
GW2/05:16/11/07	72.14	5.507	0.06	.	1.3	21	5.7625	10.45
GW2/05:19/02/08	76.89	4.44	0.11	.	2.2	942	16.6	8.601
Heffernans_Well:03/08/07	4.733	0.006	0.15	.	5.2	5	4.5125	0.081
Holy_Well:04/08/07	9.848	0.006	0.4	.	2.75	14	13.75	0.047
Jeffery_Green:Q2/2007	6	0.25	0.031111111	6.2	1.4	26	8	0.19
Jeffery_Green:Q4/2007	5	2.567	0.031111111	5.9	2	25	9	0.09
Jeffery_Green:Q4/2008	4	0.13	0.031111111	5.6	2	26	8	0.22
Kerins_Well:03/08/07	5.4765	0.024	0.15	.	3	7	11.75	0.115
Kerins_Well:21/02/08	2.47	0.07	0.04	.	2	8	11.7	0.065
Kilmacoo:31/07/2007	7.629	0.309	0.03	4.62	3	63	8.5	2.339
L03/1:Q1/2003	40	1.46	125.2222222	7	129	253	179	0.04
L03/1:Q4/2003	84	0.53	450.3333333	7.4	400	296	487	0.02
L03/2:Q4/2003	160	2.7	376.4444444	7	352	1741	401	0.02
L03/2:Q4/2004	59	0.72	235.6666667	7.5	280	303	407	0.01
L03/2:Q4/2005	174	1.11	386.5555556	7.4	222	1890	294	0.02
L03/2:Q4/2006	44	1.3	112	7.1	157	270	264	0.03
L05/10:Q4/2005	60	0.27	956.6666667	7.8	609	78	763	0.03
L05/10:Q4/2006	60	0.19	12.44444444	7.7	573	3	735	0.04
L05/10:Q4/2007	65	0.093	748.2222222	7.9	527	18	726	0.015
L05/10:Q4/2008	53	0.17	10.11111111	7.5	427	41	545	0.02
L05/16:Q4/2005	56	5.8	89.44444444	7	80	491	135	0.01
L05/16:Q4/2006	50	8	17.11111111	6.7	28	430	81	0.03
L05/16:Q4/2007	55	5.637	86.33333333	7.3	73	66	106	0.005
L05/16:Q4/2008	37	4.4	10.11111111	6.2	14	212	29	0.02
Lions_Bridge:02/08/2007	4.658	0.013	0.15	.	0.75	5	6.25	0.108
Meehans_Well:04/08/07	5.893	0.008	0.15	.	4.25	10	11.75	0.108
Monitoring_Well:01/12/1999	166	10.16	10.11111111	3.4	13	1694	56	21.5
Monitoring_Well:02/06/1998	156	9.25	10.5	2.9	12	1400	53	24.5
Monitoring_Well:06/03/2000	231	13	14.31111111	2.9	1.4	3131	45	22
Monitoring_Well:09/10/2000	233	14.7	11.04444444	3	10	4664	42	21
Monitoring_Well:11/06/1998	165	9.5	11.04444444	3.4	12	1480	46	21.5
Monitoring_Well:12/03/2001	223	14	15.00333333	3	12	3042	43	25
Monitoring_Well:17/02/1999	150	9.96	14.54444444	3.1	9.7	1626	47.4	22.55
Monitoring_Well:23/09/1999	205	12.8	9.1	3	9.63	2549	40.2	23
Monitoring_Well:27/05/1998	415	12	10.26666667	2.8	30	1425	10	23.7
Monitoring_Well:31/05/2000	129	9.5	14	3.4	13	1782	49	18

Table E-2
Principal Component Analysis (PCA) Master Database
Surface Water and Groundwater Monitoring Data

Average of Value	Variable								
Sample	ALKALINITY	CADMIUM_T	CALCIUM_T	CHLORIDE	CHROMIUM_T	COND	COPPER_T	IRON_T	LEAD_T
MWDA1:15/11/07	5	0.0486	12.62	14	0.007	1664	8.821	16.09	0.231
MWDA1:20/02/08	5	0.14	18.62	13	0.025	2662.4	18.03	49.98	0.16
MWDA2:15/11/07	5	0.0589	39.22	48	0.0005	140.8	7.746	38.69	0.203
MWDA2:20/02/08	5	0.06	29.03	15	0.025	947.2	6.52	5.48	0.06
MWET1:15/11/07	5	0.0042	103.8	17	0.0005	896	0.358	87.26	0.001
MWET1:19/02/08	5	0.025	109.4	24	0.025	1472	8.37	38.38	0.025
MWET2:15/11/07	18	0.0005	9.533	21	0.0005	102.4	0.015	0.477	0.029
MWET2:20/02/08	5	0.025	426.2	13	0.025	2240	0.025	1.02	0.025
MWPF1:16/11/07	10	0.0007	14.34	16	0.0005	115.2	0.095	0.064	0.0005
MWPF1:20/02/08	5	0.025	17.43	15	0.025	64	0.06	0.025	0.025
MWSA2:15/11/07	5	0.0044	323.8	17	0.0005	1728	0.158	65.31	0.0005
MWSA2:20/02/08	5	0.025	340.2	19	0.025	1497.6	0.15	7.83	0.025
Radio_Tower_Spring:02/08/2007	5	0.0005	19.32	13	0.003	95	0.065	0.323	0.002
RC6:Q4/2004	4.098360656	0.14	140	7	0.11	6430	76	279	0.25
RC6:Q4/2006	0.409836066	0.2	201	21	0.07	5490	77	82	0.23
Red_Road:14/11/2007	14	0.0131	3.699	14	0.0005	64	31.95	0.951	0.63
Red_Road:19/02/2008	12	0.025	12.88	18	0.025	89.6	0.07	0.025	0.025
Red_Road:31/07/2007	18	0.0005	32.24	13	0.006	75.52	0.043	0.623	0.017
Richards_Well:03/08/07	44	0.0005	24.63	17	0.004	52.48	0.027	0.502	0.003
Road_Adit:21/02/2008	5	0.025	142.4	2171	0.025	1369.6	0.025	77.11	0.24
Road_Adit_Confluence:31/07/2007	5	0.01	224.3	40	0.003	1557.76	0.311	111.5	0.27
SG1/04:21/02/08	5	0.59	1992	16	0.17	16524.8	160.7	72.77	0.62
Shelton_Abbey_Base_Pond:15/11/2007	5	0.0005	10.45	15	0.0005	921.6	0.016	0.508	0.028
Shelton_Abbey_Downgradient:02/08/2007	10	0.0005	28.6	11	0.003	37.12	0.045	0.776	0.014
Shelton_Abbey_Upstream:02/08/2007	10	0.0005	29.1	11	0.005	55.04	0.053	0.78	0.008
Spa_Adit:31/07/2007	5	0.048	33.86	10	0.008	2244	8.212	104.5	0.088
Sulfur_Brook:31/07/2007	22	0.0005	28.35	15	0.003	80.64	0.063	0.33	0.01
SW1:Q4/2008	19.67213115	0.0001	5	8	0.0005	58	0.0094	0.27	0.002
SW1_Whitesbridge:01/12/1999	15	0.015	1.6	2	0.04	52	0.04	0.33	0.125
SW1_Whitesbridge:02/06/1998	2.5	0.005	3	2	0.025	102	0.005	0.13	0.05
SW1_Whitesbridge:06/03/2000	30	0.015	7	10	0.04	102	0.04	0.05	0.125
SW1_Whitesbridge:08/05/2001	20	0.015	3	12	0.025	84	0.025	0.89	0.1
SW1_Whitesbridge:09/10/2000	20	0.015	4	7	0.04	54	0.04	0.19	0.125
SW1_Whitesbridge:11/06/1998	2.5	0.005	38	10	0.025	72.5	1.1	0.14	0.05
SW1_Whitesbridge:12/03/2001	25	0.015	8	10	0.025	67	0.025	0.11	0.1
SW1_Whitesbridge:16/02/1999	5	0.015	8	10	0.04	77	0.04	0.05	0.125
SW1_Whitesbridge:23/09/1999	6.1	0.015	1.8	8.2	0.04	54	0.04	0.24	0.125
SW1_Whitesbridge:26/05/1998	2.5	0.17	20.5	17	0.025	137	0.05	69.8	1.62
SW1_Whitesbridge:27/10/1998	5	0.005	2.1	25.4	0.025	47	0.005	0.35	0.125
SW1_Whitesbridge:31/05/2000	20	0.015	3.03	11	0.04	96	0.04	0.05	0.125
SW1_Whitesbridge:Q4/2001	15	0.015	4	9	0.025	60	0.025	0.14	0.01
SW1_Whitesbridge:Q4/2003	25	0.015	5	9	0.025	72	0.025	0.17	0.1
SW1_Whitesbridge:Q4/2004	11	0.015	3	8	0.025	51	0.025	0.25	0.1
SW1_Whitesbridge:Q4/2005	10	0.015	4	9	0.025	64	0.025	0.35	0.1
SW1_Whitesbridge:Q4/2006	10	0.015	6	9	0.025	73	0.025	0.35	0.1
SW1_Whitesbridge:Q4/2007	12	0.015	5	9	0.025	66	0.025	0.046	0.001
SW2:Q4/2008	19.67213115	0.00025	5	8	0.0005	57	0.017	0.31	0.005
SW2_Upstream_Adit:01/12/1999	15	0.015	1.7	8.5	0.04	60	0.04	0.34	0.125
SW2_Upstream_Adit:02/06/1998	2.5	0.05	0.05	76	0.025	2540	4.4	30	0.34
SW2_Upstream_Adit:06/03/2000	20	0.015	5	10	0.04	90	0.04	0.31	0.125
SW2_Upstream_Adit:08/05/2001	10	0.015	4	12	0.025	89	0.025	0.45	0.1
SW2_Upstream_Adit:09/10/2000	20	0.015	3	6	0.04	46	0.04	0.26	0.125
SW2_Upstream_Adit:11/06/1998	2.5	0.06	86	74	0.025	3200	2.5	40	0.34

Table E-2
Principal Component Analysis (PCA) Master Database
Surface Water and Groundwater Monitoring Data

Average of Value	Variable							
Sample	MAGNESIUM_T	MANGANESE_T	NH3	PH_T	POTASSIUM_T	SO4	SODIUM_T	ZINC_T
MWDA1:15/11/07	67.43	5.427	0.11	.	0.45	784	4.2625	21.99
MWDA1:20/02/08	200.1	15.07	0.63	.	0.3	2060	10.4	59.96
MWDA2:15/11/07	109.5	13.81	0.1	.	2.4	1240	7.2625	42.12
MWDA2:20/02/08	99.86	8.37	0.09	.	2.8	1060	13.4	27.3
MWET1:15/11/07	60.98	9.92	0.65	.	1.15	1636	7.0125	15.24
MWET1:19/02/08	93.8	7.81	0.6	.	1.6	1426	16.3	12.31
MWET2:15/11/07	3.92	0.157	0.05	.	0.5	26	5.5125	0.161
MWET2:20/02/08	234.1	36.6	0.15	.	12.3	2515	26.5	4.899
MWPF1:16/11/07	2.887	0.067	0.04	.	0.65	33	4.7625	0.095
MWPF1:20/02/08	2.95	0.08	0.02	.	0.8	36	10.1	0.085
MWSA2:15/11/07	85.02	23.89	1.57	.	4.05	1658	5.5125	4.475
MWSA2:20/02/08	80.07	17.38	1.36	.	7.4	1551	12.5	3.68
Radio_Tower_Spring:02/08/2007	.	.	0.15	5.4	3.2	4	8.25	0.117
RC6:Q4/2004	542	19	0.031111111	2.5	2.5	8121	2.5	47
RC6:Q4/2006	614	24	0.147777778	2.9	0.5	7227	6	55
Red_Road:14/11/2007	9.142	5.48	0.03	.	3.8	13	10	5.026
Red_Road:19/02/2008	6.08	0.05	0.06	.	2.2	97	9.1	0.107
Red_Road:31/07/2007	9.477	0.317	0.04	.	2.5	29	9	0.272
Richards_Well:03/08/07	5.095	0.02	0.15	.	6.15	2	14.75	0.234
Road_Adit:21/02/2008	108.4	9.74	7.09	.	12.1	2171	28.7	11.06
Road_Adit_Confluence:31/07/2007	126.6	11.04	6.59	.	11.95	1539	26.75	9.48
SG1/04:21/02/08	792.2	45.56	3.26	.	0.1	5863	7.1	136.8
Shelton_Abbey_Base_Pond:15/11/2007	4.17	0.184	0.63	.	4.5	930	10.5	0.177
Shelton_Abbey_Downgradient:02/08/2007	6.498	0.064	1.3	.	0.9	15	7	0.167
Shelton_Abbey_Upstream:02/08/2007	6.153	0.056	0.15	.	0.9	14	7	0.201
Spa_Adit:31/07/2007	132.5	8.596	1.22	3.5	0.7	2044	6	13.71
Sulfur_Brook:31/07/2007	7.634	0.042	0.01	.	2.2	14	10	0.165
SW1:Q4/2008	2	0.03	0.031111111	6.9	0.5	5	5	0.06
SW1_Whitesbridge:01/12/1999	1.2	0.025	0.038888889	6.1	0.6	4	23	0.05
SW1_Whitesbridge:02/06/1998	1	0.005	0.038888889	6.5	0.76	6	20	0.05
SW1_Whitesbridge:06/03/2000	2	0.025	0.038888889	6.6	1	5	9	0.02
SW1_Whitesbridge:08/05/2001	3	0.03	.	6.8	1	7	18	0.03
SW1_Whitesbridge:09/10/2000	1	0.025	0.038888889	6.8	0.5	4	6	0.03
SW1_Whitesbridge:11/06/1998	4.3	0.005	0.038888889	6.3	0.61	18	7.75	0.04
SW1_Whitesbridge:12/03/2001	2	0.04	0.038888889	7.6	0.5	7	6	0.04
SW1_Whitesbridge:16/02/1999	1.3	0.025	0.038888889	7.2	0.6	5	12	0.03
SW1_Whitesbridge:23/09/1999	1.5	0.025	0.038888889	7	0.71	4.7	19	0.05
SW1_Whitesbridge:26/05/1998	97	3.86	0.7	2.8	1.57	1253	10	66.4
SW1_Whitesbridge:27/10/1998	0.9	0.07	0.038888889	6.5	0.4	18.2	3	0.04
SW1_Whitesbridge:31/05/2000	2.5	0.1	0.038888889	5.9	0.7	19	11	0.26
SW1_Whitesbridge:Q4/2001	0.5	0.03	0.039666667	6.3	0.5	8	5	0.04
SW1_Whitesbridge:Q4/2003	2	0.015	0.031111111	7.1	0.5	8	7	0.03
SW1_Whitesbridge:Q4/2004	2	0.015	0.031111111	6.7	0.5	5	6	0.03
SW1_Whitesbridge:Q4/2005	2	0.015	0.031111111	6.7	0.5	3	6	0.03
SW1_Whitesbridge:Q4/2006	3	0.015	0.031111111	6.7	0.5	8	6	0.09
SW1_Whitesbridge:Q4/2007	3	0.0111	0.031111111	7	0.5	7	7	0.08
SW2:Q4/2008	2	0.05	0.031111111	6.6	0.5	7	5	0.06
SW2_Upstream_Adit:01/12/1999	1.1	0.025	0.038888889	6.1	0.6	5	23	0.05
SW2_Upstream_Adit:02/06/1998	179	11.5	12.21111111	2.9	13	1590	70	30.5
SW2_Upstream_Adit:06/03/2000	2	0.025	0.038888889	6.1	1	8	10	0.11
SW2_Upstream_Adit:08/05/2001	3	0.06	.	6.3	1	13	14	0.17
SW2_Upstream_Adit:09/10/2000	0.5	0.025	0.038888889	6.7	0.5	4	5	0.02
SW2_Upstream_Adit:11/06/1998	185	12	11.35555556	3	13	1660	49.5	24

Table E-2
Principal Component Analysis (PCA) Master Database
Surface Water and Groundwater Monitoring Data

Average of Value	Variable								
Sample	ALKALINITY	CADMIUM_T	CALCIUM_T	CHLORIDE	CHROMIUM_T	COND	COPPER_T	IRON_T	LEAD_T
SW2_Upstream_Adit:12/03/2001	25	0.0015	7	10	0.015	66	0.025	0.16	0.1
SW2_Upstream_Adit:16/02/1999	2.5	0.07	41	77	0.04	2720	4.19	65.1	0.3
SW2_Upstream_Adit:23/09/1999	6.1	0.015	1.8	8	0.04	53	0.04	0.2	0.125
SW2_Upstream_Adit:26/05/1998	2.5	0.08	44	70	0.025	2750	2.6	32	0.38
SW2_Upstream_Adit:27/10/1998	5	0.005	1	28	0.025	48.8	0.005	0.28	0.125
SW2_Upstream_Adit:31/05/2000	15	0.015	2.3	10	0.04	89	0.04	0.23	0.125
SW2_Upstream_Adit:Q4/2001	2.5	0.015	7	10	0.025	179	0.28	0.31	0.01
SW2_Upstream_Adit:Q4/2003	20	0.015	5	9	0.025	76	0.025	0.25	0.1
SW2_Upstream_Adit:Q4/2004	10	0.015	4	8	0.025	53	0.025	0.26	0.1
SW2_Upstream_Adit:Q4/2005	105	0.015	4	9	0.025	64	0.025	0.35	0.1
SW2_Upstream_Adit:Q4/2006	10	0.015	5	9	0.025	68	0.025	0.29	0.1
SW2_Upstream_Adit:Q4/2007	10	0.015	5	9	0.025	72	0.025	0.004	0.0032
SW3:Q2/2009	0.25	0.018	253	21.5	0.5	1009	0.37	106	0.351
SW3:Q4/2008	4.098360656	0.019	184	37	0.0005	1870	0.035	156	0.355
SW3_Ballymurtagh_Adit:01/12/1999	2.5	0.04	61	15	0.04	2260	1.1	151.1	0.53
SW3_Ballymurtagh_Adit:02/06/1998	2.5	0.04	14	70	0.025	2380	1.3	104	0.6
SW3_Ballymurtagh_Adit:06/03/2000	2.5	0.03	123	74	0.04	2490	0.91	200	0.41
SW3_Ballymurtagh_Adit:08/05/2001	2.5	0.015	61	84	0.025	2310	0.025	163	0.46
SW3_Ballymurtagh_Adit:09/10/2000	2.5	0.05	131	63	0.04	2490	1.97	172	0.57
SW3_Ballymurtagh_Adit:11/06/1998	2.5	0.05	106	84	0.025	2600	0.005	79	0.66
SW3_Ballymurtagh_Adit:12/03/2001	2.5	0.04	112	89	0.025	2370	1.05	169	0.51
SW3_Ballymurtagh_Adit:16/02/1999	2.5	0.04	69	80	0.04	2440	1.16	96	0.53
SW3_Ballymurtagh_Adit:23/09/1999	2.5	0.05	51	65	0.04	522	1.36	120.4	0.52
SW3_Ballymurtagh_Adit:26/05/1998	5	0.05	61	74	0.025	2560	1.3	101	0.68
SW3_Ballymurtagh_Adit:27/10/1998	2.5	0.005	105	20.7	0.025	2760	0.005	128	0.75
SW3_Ballymurtagh_Adit:31/05/2000	2.5	0.04	60	70	0.04	2210	1.02	83	0.49
SW3_Ballymurtagh_Adit:Q4/2001	2.5	0.04	179	87	0.025	2390	0.83	195	0.01
SW3_Ballymurtagh_Adit:Q4/2003	2.5	0.015	167	67	0.025	2480	0.89	178	0.42
SW3_Ballymurtagh_Adit:Q4/2004	2.5	0.03	170	53	0.025	2380	0.9	171	0.57
SW3_Ballymurtagh_Adit:Q4/2005	2.5	0.015	210	40	0.025	2880	0.71	330	0.46
SW3_Ballymurtagh_Adit:Q4/2006	0.25	0.015	175	39	0.025	2400	.	224	0.42
SW3_Ballymurtagh_Adit:Q4/2007	0.25	0.015	211	45	0.025	2030	0.38	140.34	0.353
SW4:Q4/2008	14.75409836	0.001	5	8	0.0005	90	0.012	0.8	0.007
SW4_Coal_Yard:01/12/1999	10	0.015	1.6	8	0.04	63	0.04	0.69	0.125
SW4_Coal_Yard:02/06/1998	2.5	0.005	0.05	12	0.025	102	0.02	0.95	0.05
SW4_Coal_Yard:06/03/2000	15	0.015	9	11	0.04	122	0.04	0.42	0.125
SW4_Coal_Yard:08/05/2001	5	0.015	5	12	0.025	140	0.05	1.68	0.1
SW4_Coal_Yard:09/10/2000	15	0.015	4	7	0.04	58	0.04	0.38	0.125
SW4_Coal_Yard:11/06/1998	25	0.005	1.84	20	0.025	95	0.01	0.24	0.05
SW4_Coal_Yard:12/03/2001	30	0.015	4	10	0.025	88	0.025	0.91	0.1
SW4_Coal_Yard:16/02/1999	5	0.015	16	12	0.04	115	0.04	1.1	0.125
SW4_Coal_Yard:23/09/1999	12	0.015	27	8.2	0.04	55	0.04	0.46	0.125
SW4_Coal_Yard:26/05/1998	15	0.005	3.4	15	0.025	176	0.04	0.1	0.05
SW4_Coal_Yard:27/10/1998	5	0.005	3	27.7	0.025	51.1	0.005	0.33	0.125
SW4_Coal_Yard:31/05/2000	5	0.015	3.54	13	0.04	130	0.04	0.05	0.125
SW4_Coal_Yard:Q4/2001	5	0.015	4	9	0.025	94	0.025	1.39	0.01
SW4_Coal_Yard:Q4/2003	25	0.015	5	10	0.025	88	0.025	0.73	0.1
SW4_Coal_Yard:Q4/2004	27	0.03	4	8	0.025	62	0.025	0.66	0.1
SW4_Coal_Yard:Q4/2005	10	0.015	4	9	0.025	72	0.025	0.9	0.1
SW4_Coal_Yard:Q4/2006	8	0.015	6	9	0.025	86	0.025	1.2	0.1
SW4_Coal_Yard:Q4/2007	7	0.015	8	10	0.025	103	0.025	0.029	0.0048
SW5:Q4/2008	18.03278689	0.00038	5	8	0.0005	61	0.008	0.41	0.006
SW5_Avoca_Bridge:01/12/1999	20	0.015	1.8	8.5	0.04	63	0.04	0.42	0.125

Table E-2
Principal Component Analysis (PCA) Master Database
Surface Water and Groundwater Monitoring Data

Average of Value	Variable							
Sample	MAGNESIUM_T	MANGANESE_T	NH3	PH_T	POTASSIUM_T	SO4	SODIUM_T	ZINC_T
SW2_Upstream_Adit:12/03/2001	2	0.04	0.038888889	7.3	0.5	9	6	0.07
SW2_Upstream_Adit:16/02/1999	130	10.8	14.77777778	3.3	12	1726	39	25.9
SW2_Upstream_Adit:23/09/1999	1.5	0.025	0.038888889	6.9	0.8	5.3	18	0.06
SW2_Upstream_Adit:26/05/1998	162	13	11.12222222	2.8	12	1586	70	25
SW2_Upstream_Adit:27/10/1998	0.7	0.06	0.077777778	6.2	0.4	18.8	2.8	0.03
SW2_Upstream_Adit:31/05/2000	2.9	0.07	0.038888889	6.3	0.6	15	12	0.17
SW2_Upstream_Adit:Q4/2001	5	0.36	0.299444444	4.5	0.5	46	6	0.68
SW2_Upstream_Adit:Q4/2003	2	0.015	0.031111111	6.8	0.5	9	6	0.06
SW2_Upstream_Adit:Q4/2004	2	0.04	0.031111111	6.5	1	8	6	0.06
SW2_Upstream_Adit:Q4/2005	2	0.04	0.031111111	6.6	0.5	7	6	0.04
SW2_Upstream_Adit:Q4/2006	3	0.05	0.031111111	6.5	0.5	9	6	0.12
SW2_Upstream_Adit:Q4/2007	3	0.0499	0.031111111	6.6	0.5	12	7	0.19
SW3:Q2/2009	98	8.8	3.330833333	6.033333333	10	637.25	20	12
SW3:Q4/2008	123	11	1.866666667	4.2	10	1275	21	13
SW3_Ballymurtagh_Adit:01/12/1999	172	14.2	11.66666667	3.8	15	1642	64	23.5
SW3_Ballymurtagh_Adit:02/06/1998	144	10	12.28888889	3.6	12.5	1425	35	23.5
SW3_Ballymurtagh_Adit:06/03/2000	177	14	16.02222222	3.8	13	1689	47	29
SW3_Ballymurtagh_Adit:08/05/2001	171	12	.	4.2	18	1887	84	25
SW3_Ballymurtagh_Adit:09/10/2000	195	7.88	12.05555556	3.9	15	1934	43	25
SW3_Ballymurtagh_Adit:11/06/1998	150	10	12.67777778	3.4	15	1270	52.5	19
SW3_Ballymurtagh_Adit:12/03/2001	170	14	4.977777778	4.1	16	1728	49	28
SW3_Ballymurtagh_Adit:16/02/1999	119	10.1	14.77777778	3.8	12	1546	44	20.8
SW3_Ballymurtagh_Adit:23/09/1999	155	12	9.722222222	3.9	12.2	1567	44	20.6
SW3_Ballymurtagh_Adit:26/05/1998	148	0.16	10.26666667	3.5	13	1433	34	24
SW3_Ballymurtagh_Adit:27/10/1998	150	8.4	14.62222222	3.7	13	1638	54	24.3
SW3_Ballymurtagh_Adit:31/05/2000	115	9.83	13.45555556	4	15	1310	11	17
SW3_Ballymurtagh_Adit:Q4/2001	175	14.8	21.99555556	4.1	17	1776	52	23
SW3_Ballymurtagh_Adit:Q4/2003	166	13	18.66666667	4.3	17	1709	40	17
SW3_Ballymurtagh_Adit:Q4/2004	178	14	11.66666667	4	16	1899	37	20
SW3_Ballymurtagh_Adit:Q4/2005	286	25	8.555555556	4.2	12	2517	27	31
SW3_Ballymurtagh_Adit:Q4/2006	171	15	9.333333333	4.3	11	1799	22	17
SW3_Ballymurtagh_Adit:Q4/2007	136	11.119	7.622222222	4.3	13	1400	25	13
SW4:Q4/2008	3	0.07	0.093333333	6.2	0.5	12	5	0.15
SW4_Coal_Yard:01/12/1999	1.8	0.09	0.038888889	5.5	0.7	9.5	20	0.12
SW4_Coal_Yard:02/06/1998	2.5	0.1	0.155555556	5.3	12	57	7.5	0.42
SW4_Coal_Yard:06/03/2000	3	0.14	0.155555556	5.2	1	23	10	0.3
SW4_Coal_Yard:08/05/2001	5	0.22	.	5.5	1	45	16	0.58
SW4_Coal_Yard:09/10/2000	1	0.025	0.038888889	6.2	0.5	6	5	0.04
SW4_Coal_Yard:11/06/1998	4.2	0.1	0.7	6	0.73	15	8.5	0.25
SW4_Coal_Yard:12/03/2001	3	0.08	0.116666667	5.9	0.5	29	7	0.25
SW4_Coal_Yard:16/02/1999	3.5	0.17	0.155555556	5.2	0.7	28	11	0.4
SW4_Coal_Yard:23/09/1999	1.4	0.07	0.038888889	7.4	0.8	7	13	0.12
SW4_Coal_Yard:26/05/1998	5.2	0.26	0.155555556	5.7	1.08	64	16	0.69
SW4_Coal_Yard:27/10/1998	1.2	0.005	0.077777778	10.6	0.4	0.5	3	0.07
SW4_Coal_Yard:31/05/2000	3.6	0.17	0.155555556	5.2	0.8	28	12	0.35
SW4_Coal_Yard:Q4/2001	2	0.15	0.199888889	5.6	0.5	25	6	0.28
SW4_Coal_Yard:Q4/2003	3	0.08	0.07	6.2	1	15	7	0.16
SW4_Coal_Yard:Q4/2004	2	0.07	0.031111111	6.3	1	12	6	0.13
SW4_Coal_Yard:Q4/2005	3	0.11	0.031111111	6.2	0.5	12	6	0.14
SW4_Coal_Yard:Q4/2006	3	0.12	0.077777778	5.9	0.5	17	6	0.21
SW4_Coal_Yard:Q4/2007	4	0.173	0.077777778	5.9	0.5	27	8	0.36
SW5:Q4/2008	2	0.05	0.031111111	6.4	0.5	8	5	0.11
SW5_Avoca_Bridge:01/12/1999	1.4	0.06	0.038888889	5.5	0.6	8	20	0.07

Table E-2
Principal Component Analysis (PCA) Master Database
Surface Water and Groundwater Monitoring Data

Average of Value	Variable								
Sample	ALKALINITY	CADMIUM_T	CALCIUM_T	CHLORIDE	CHROMIUM_T	COND	COPPER_T	IRON_T	LEAD_T
SW5_Avoca_Bridge:02/06/1998	2.5	0.005	0.05	11	0.025	111	0.02	0.34	0.05
SW5_Avoca_Bridge:06/03/2000	35	0.015	5	10	0.04	91	0.04	0.36	0.125
SW5_Avoca_Bridge:08/05/2001	5	0.015	4	11	0.025	105	0.015	0.13	0.1
SW5_Avoca_Bridge:09/10/2000	20	0.015	5	9	0.04	72	0.04	0.41	0.125
SW5_Avoca_Bridge:11/06/1998	2.5	0.005	44	10	0.025	82	0.005	0.32	0.05
SW5_Avoca_Bridge:12/03/2001	20	0.015	5	9	0.025	76	0.025	0.44	0.1
SW5_Avoca_Bridge:16/02/1999	5	0.015	2	11	0.04	95	0.04	0.46	0.125
SW5_Avoca_Bridge:23/09/1999	6.1	0.015	2	8.1	0.04	54	0.04	0.33	0.125
SW5_Avoca_Bridge:26/05/1998	5	0.005	3.1	15	0.025	153	0.04	0.07	0.05
SW5_Avoca_Bridge:27/10/1998	5	0.005	2	24.4	0.025	55.3	0.005	0.26	0.125
SW5_Avoca_Bridge:31/05/2000	20	0.015	2.67	11	0.04	96	0.04	0.34	0.125
SW5_Avoca_Bridge:Q4/2001	10	0.015	3	9	0.025	71	0.025	0.54	0.01
SW5_Avoca_Bridge:Q4/2003	15	0.015	5	9	0.025	79	0.025	0.37	0.1
SW5_Avoca_Bridge:Q4/2004	9	0.015	4	8	0.025	54	0.025	0.36	0.1
SW5_Avoca_Bridge:Q4/2005	10	0.015	4	9	0.025	65	0.025	0.44	0.1
SW5_Avoca_Bridge:Q4/2006	11	0.015	5	9	0.025	75	0.025	0.49	0.1
SW5_Avoca_Bridge:Q4/2007	11	0.015	6	9	0.025	85	0.025	0.013	0.002
T1:30/07/2007	5	0.0005	26.72	8	0.005	103.68	0.037	0.521	0.004
T2-Comp:30/07/2007	5	0.0005	25.79	8	0.003	12.8	0.043	0.589	0.008
T2-Grab:30/07/2007	5	0.002	22.92	8	0.003	227.84	0.053	0.41	0.014
T3:30/07/2007	5	0.0005	26.25	8	0.003	154.88	0.051	0.96	0.012
T4:30/07/2007	5	0.0005	30.04	10	0.004	49.92	0.055	1.028	0.01
T5:21/02/2008	5	0.025	9.22	10	0.025	12.8	0.025	0.025	0.025
T5:31/07/2007	5	0.0005	27.5	9	0.006	42.24	0.052	1.073	0.015
Thomas_Merrigan:Q2/2007	40.98360656	0.00005	19	12	0.5	165	0.025	0.025	0.001
Thomas_Merrigan:Q4/2007	47.54098361	0.0001	20	11	0.00005	157	0.025	0.004	0.001
Thomas_Merrigan:Q4/2008	55.73770492	0.0001	23	10	0.0005	174	0.037	0.025	0.001
Twin_Shafts:01/06/2000	65.57377049	0.015	40	25	0.04	454	0.04	0.05	0.125
Twin_Shafts:01/12/1999	65.57377049	0.015	47	26	0.04	420	0.04	0.11	0.125
Twin_Shafts:02/06/1998	57.37704918	0.04	30	22	0.025	421	0.005	0.09	0.05
Twin_Shafts:06/03/2000	65.57377049	0.015	41	26	0.04	396	0.04	0.05	0.125
Twin_Shafts:07/12/2001	65.57377049	0.015	54	29	0.025	438	0.025	0.22	0.01
Twin_Shafts:09/10/2000	106.557377	0.015	56	28	0.04	467	0.04	0.05	0.125
Twin_Shafts:11/06/1998	73.7704918	0.01	74	30	0.025	477	0.005	0.025	0.05
Twin_Shafts:12/03/2001	49.18032787	0.015	40	26	0.025	351	0.00025	0.004	0.1
Twin_Shafts:17/02/1999	57.37704918	0.015	40	26	0.04	374	0.04	0.005	0.125
Twin_Shafts:23/09/1999	73.7704918	0.015	59	27	0.04	439	0.04	0.05	0.125
Twin_Shafts:27/05/1998	4.098360656	0.01	30.5	23	0.025	426	0.01	0.025	0.1
Twin_Shafts:27/10/1998	65.57377049	0.005	56	41.2	0.025	565	0.005	0.1	0.125
Twin_Shafts:Q4/2003	90.16393443	0.015	47	28	0.025	428	0.025	0.08	0.1
Twin_Shafts:Q4/2004	81.96721311	0.015	54	30	0.025	434	0.025	0.09	0.1
Twin_Shafts:Q4/2005	55.73770492	0.015	53	34	0.025	440	0.025	0.1	0.1
Twin_Shafts:Q4/2006	72.13114754	0.015	54	29	0.025	402	0.025	0.15	0.1
Twin_Shafts:Q4/2007	75.40983607	0.015	55	31	0.025	423	0.025	0.004	0.002
Twin_Shafts:Q4/2008	68.85245902	0.009	3890	26	0.0005	360	0.018	0.15	0.002
Unknown_Trib:31/07/2007	17	0.0005	30.27	16	0.006	72.96	0.04	0.465	0.002
Vale_View:31/07/2007	26	0.0005	42.04	13	0.006	208.64	0.038	0.445	0.004

Table E-2
Principal Component Analysis (PCA) Master Database
Surface Water and Groundwater Monitoring Data

Average of Value	Variable							
Sample	MAGNESIUM_T	MANGANESE_T	NH3	PH_T	POTASSIUM_T	SO4	SODIUM_T	ZINC_T
SW5_Avoca_Bridge:02/06/1998	2.1	0.06	0.311111111	5.8	0.76	150	1.5	0.31
SW5_Avoca_Bridge:06/03/2000	2	0.025	0.038888889	6.4	1	9	9	0.12
SW5_Avoca_Bridge:08/05/2001	4	0.12	.	6	0.81	24	13	0.37
SW5_Avoca_Bridge:09/10/2000	2	0.025	0.038888889	6.6	0.5	7	7	0.07
SW5_Avoca_Bridge:11/06/1998	2	0.04	0.038888889	6	0.6	185	12.25	0.14
SW5_Avoca_Bridge:12/03/2001	2	0.05	0.038888889	6.5	0.5	12	6	0.13
SW5_Avoca_Bridge:16/02/1999	2.3	0.08	0.038888889	5.8	0.6	16	10	0.23
SW5_Avoca_Bridge:23/09/1999	1.5	0.08	0.038888889	7.1	0.68	5.9	11	0.1
SW5_Avoca_Bridge:26/05/1998	3.9	12.5	0.155555556	5.8	0.88	37	11	0.49
SW5_Avoca_Bridge:27/10/1998	1	2.6	0.077777778	5.6	0.6	19.8	3	0.06
SW5_Avoca_Bridge:31/05/2000	2.9	0.08	0.311111111	6.2	0.7	16	6	0.21
SW5_Avoca_Bridge:Q4/2001	1	0.07	0.039666667	6	0.5	13	5	0.15
SW5_Avoca_Bridge:Q4/2003	2	0.015	0.031111111	6.5	1	11	7	0.11
SW5_Avoca_Bridge:Q4/2004	2	0.03	0.031111111	6.5	1	8	6	0.08
SW5_Avoca_Bridge:Q4/2005	2	0.06	0.031111111	6.3	0.5	8	6	0.08
SW5_Avoca_Bridge:Q4/2006	3	0.05	0.031111111	6.3	0.5	11	6	0.14
SW5_Avoca_Bridge:Q4/2007	4	0.096	0.031111111	6.3	0.5	18	7	0.26
T1:30/07/2007	4.822	0.011	0.15	.	0.6	5	5.75	0.093
T2-Comp:30/07/2007	4.949	0.035	0.03	.	0.65	9	5.75	0.208
T2-Grab:30/07/2007	5.625	0.085	0.06	.	0.7	23	6	0.741
T3:30/07/2007	5.448	0.074	0.05	.	0.7	12	6.5	0.3
T4:30/07/2007	6.146	0.068	0.04	.	0.8	14	6.25	0.245
T5:21/02/2008	3.77	0.17	0.16	.	0.7	24	8.4	0.15
T5:31/07/2007	5.715	0.091	0.05	.	0.7	31	6	0.302
Thomas_Merrigan:Q2/2007	4	0.015	0.031111111	6.3	1	24	6	0.01
Thomas_Merrigan:Q4/2007	4	0.0013	0.031111111	7.1	1	26	7	0.02
Thomas_Merrigan:Q4/2008	4	0.015	0.031111111	5.9	0.5	26	7	0.01
Twin_Shafts:01/06/2000	20	0.23	0.21	6.7	5	125	14	1.2
Twin_Shafts:01/12/1999	19	0.26	0.038888889	6.3	5	143	16	1.36
Twin_Shafts:02/06/1998	14	0.18	0.233333333	6.9	5.1	125	93	1.3
Twin_Shafts:06/03/2000	14	0.025	0.038888889	6.2	7	110	10	1
Twin_Shafts:07/12/2001	17	0.18	0.031111111	7.2	5	127	11	1
Twin_Shafts:09/10/2000	19	0.22	0.116666667	6.9	4	155	11	3
Twin_Shafts:11/06/1998	18	0.29	0.077777778	6.7	4	240	12.5	1.04
Twin_Shafts:12/03/2001	13	0.005	0.077777778	7	8	99	12	2
Twin_Shafts:17/02/1999	13	0.19	0.038888889	6.5	6.5	98.4	13.3	0.09
Twin_Shafts:23/09/1999	19	0.23	0.038888889	6.7	8.9	146	18	3.63
Twin_Shafts:27/05/1998	14	0.29	0.077777778	7.3	6.5	140	7	0.92
Twin_Shafts:27/10/1998	20	0.35	0.155555556	6.5	3.2	161	6.6	1.8
Twin_Shafts:Q4/2003	16	0.17	0.031111111	6.7	6	130	10	1.6
Twin_Shafts:Q4/2004	17	0.18	0.031111111	7	7	130	11	1.7
Twin_Shafts:Q4/2005	17	0.17	0.077777778	6.8	11	128	13	1.5
Twin_Shafts:Q4/2006	16	0.17	0.031111111	6.6	9	118	11	1.4
Twin_Shafts:Q4/2007	17	0.1623	0.031111111	7.1	6	133	11	14
Twin_Shafts:Q4/2008	12	0.17	0.031111111	6.8	11	95	11	1
Unknown_Trib:31/07/2007	8.178	0.01	0.02	.	1.85	9	10	0.082
Vale_View:31/07/2007	6.864	0.013	0.02	.	1.95	16	6.5	0.409

Appendix F

Annual Environmental Report 2008

Ballymurtagh Landfill
W0011-01

Annual Environmental Report
2008

DOCUMENT CONTROL SHEET

Client	Wicklow County Council					
Project Title	Ballymurtagh Landfill Licence Compliance – Waste Licence W0011-01					
Document Title	Annual Environmental Report 2008					
Document No.	MDE0046Rp0049					
This Document Comprises	DCS	TOC	Text	List of Tables	List of Figures	No. of Appendices
	1	1	18	1	1	4

Rev.	Status	Author(s)	Reviewed By	Approved By	Office of Origin	Issue Date
F01	Final	Paddy Lambe	Cathriona Cahill		West Pier	June 2009

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

APPENDICES

1 INTRODUCTION

This Annual Environmental Report (AER) summarises the environmental performance of Ballymurtagh landfill between January and December 2008 and outlines proposals for the 2009 reporting period to help minimise environmental impacts. RPS have prepared this AER on behalf of Wicklow County Council in accordance with the conditions of waste licence W0011-01, the Environmental Protection Agency (EPA) "Draft Guidance on Environmental Management Systems and Reporting to the Agency" and the EPA "Landfill Manuals – Landfill Monitoring 2nd Edition".

Wicklow County Council operate Ballymurtagh Landfill in accordance with Waste Licence Register No. W0011-01.

It is the policy of Wicklow County Council to comply fully with the conditions of this waste licence, to minimise impact on the environment and ensure that members of staff are aware of the environmental impacts associated with their work on the landfill.

1.1 WASTE MANAGEMENT POLICY

The County Wicklow Waste Management Plan outlines the following policy;

"*..to move quickly to a 'maximum recycling' scenario, which will meet the wishes of the public and also meet the mandatory targets for recycling set out by government… The Council aims to arrest and counteract the current trend of waste growth through concerted measures aimed at waste minimisation and prevention".*

1.2 SITE DESCRIPTION

Ballymurtagh Landfill is located in the townlands of Ballymurtagh, Ballygahan Upper, Ballygahan Lower, and Tinnahnich in the Vale of Avoca approximately 1.5 km north-west of the village of Avoca in County Wicklow. It is situated in the catchment of the Avoca River, which rises in the Wicklow Mountains and enters the Irish Sea at Arklow. The landfill is located within a disused Open Lode pit of the former Avoca Mines. Prior to landfilling the pit was used for the settlement of mine tailings, a layer of which underlies the body of waste. The bedrock underlying the landfill consists of volcanic rock, which is part of the Avoca Formation. The lithologies based on drilling carried out by the Geological Survey of Ireland consists of light greenish grey, fine grained, well foliated metavolcanic rock.

The principal activity between 1989 to 2002, was to 'deposit in, on or under land', Waste acceptance ceased for landfilling on the 31st December 2002 and recycling is now the principal activity. It is estimated that approximately 480,000m^3 of waste were deposited at the site since it commenced operation in 1989. The Civic Waste Facility was opened in February 2003. The layout of the facility is shown on Figure 2.2.

Restoration works in accordance with the Waste Licence commenced in October 2004 and were completed in November 2005. The site has been landscaped and vegetation was successfully established during 2006.

1.3 WASTE ACCEPTANCE

A procedure for the acceptance of waste at the Civic Waste Facility has been developed and is outlined in the Environmental Management Plan (EMP).

2 ENVIRONMENTAL MONITORING

The following sections summarise the monitoring undertaken at Ballymurtagh during the 2008 reporting period. More detailed interpretations can be found within the quarterly monitoring reports, which were submitted to the Agency throughout 2008.

2.1 SURFACE WATER

TE Laboratories (TelLabs), Co Carlow collected and analysed samples from 5 monitoring locations (including the Civic Waste Site) (see Figure 2.1) specified in the waste licence. Samples were collected in February, May, August and November. Parameters requiring annual analysis were monitored in November. Results were compared with the European Community (Quality of Surface Water intended for Abstraction of Drinking Water) Regulations, 1989 (S.I. No. 294 of 1989) and the EPA's Environmental Quality Objectives and Environmental Quality Standards (a discussion document, from 1997).

Section 2.1.1 summarises the overall surface water quality at the landfill. However, it should be noted that the Ballygahan Adit and Ballymurtagh Road Adit carry acid mine drainage (AMD). Surface water quality monitoring points SW2 and SW3 respectively are located in close proximity to these adits. Parameters which would mainly originate from acid mine drainage include sulphate, copper, lead, iron, manganese and zinc along with low pH and elevated electrical conductivities.

Full copies of all results can be found in Appendix A.

2.1.1 Interpretation

Surface water quality upstream of the facility (at SW1 and SW2) was generally of good quality during the 2008 monitoring period with no quarterly limits exceeded. Iron was recorded during the annual round of monitoring and was elevated at both monitoring points. SW1 recorded a level of 0.27mg/lFe at SW1 and SW2 recorded a level of 0.31mg/lFe. Manganese was also elevated at SW2 at 0.05mg/lMn.

Surface water quality at SW3 (Ballymurtagh Road Adit) shows evidence of Acid Mine Drainage in the form of low pH (range 3.8 – 4.3) (see Figure 2.1), elevated conductivity (ranging from 1870µS/cm to 2150µS/cm), and elevated sulphate (1363mg/l – 1535mg/l). Sulphate concentrations were elevated throughout the year and remain similar to those recorded in previous years as shown in Figure 2.3. Elevated concentrations of iron, cadmium, manganese, lead and zinc were also detected in the annual sample. Low dissolved oxygen concentrations were recorded in the 4th quarter (4.9mg/l) and this is likely due to seasonal variances. BOD levels were elevated in comparison to 2007 (<3mg/l – 21mg/l). Ammonium levels were also high at SW3 (2.4mg/l NH_4 to 10mg/l NH_4), however they are gradually decreasing as can be seen in Figure 2.2. Since the site was capped ammonium levels have gradually decreased.

Surface water quality at SW4 and SW5, (approx 300-400m downstream of SW3) is generally of good quality and similar to that of 2007. Manganese was elevated at 0.07mg/l at SW4 and 0.05mg/l at SW5 during the annual round of monitoring which is lower than the result for manganese recorded in 2007. Iron was also slightly elevated. All other parameters were within recommended limits.

Figure 2.3: pH concentrations at all surface water monitoring locations from February 2005 to November 2008

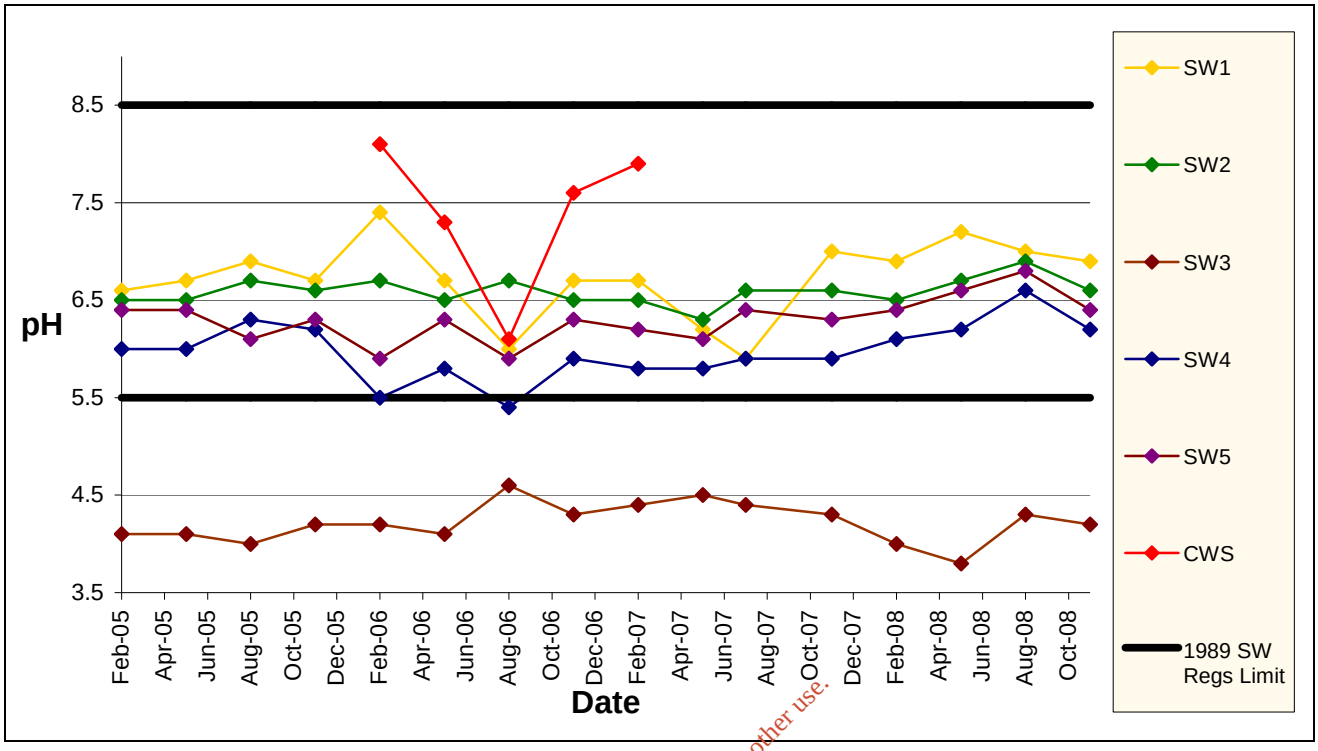


Figure 2.4: Ammoniun concentrations at SW3 **from…**

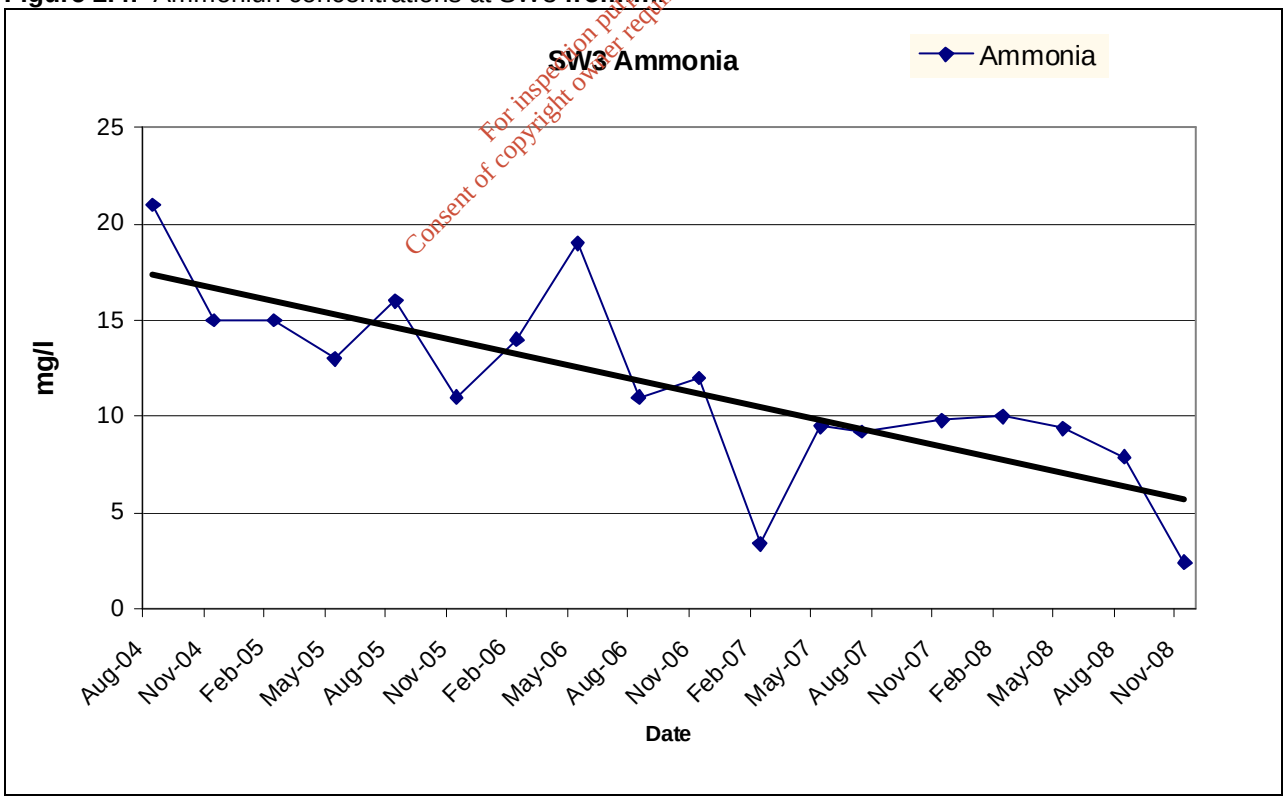
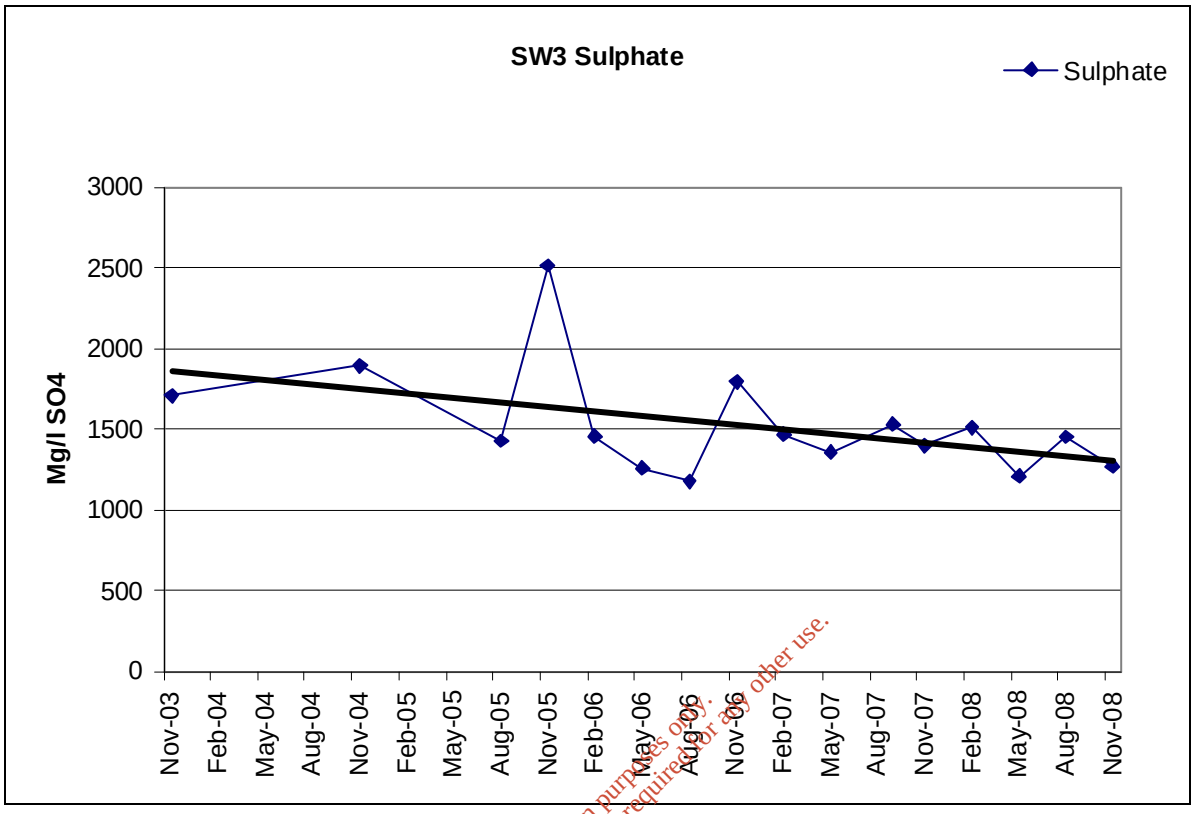


Figure 2.5: Sulphate concentrations at SW3 **from November 03 to November 08**



2.1.2 ELV Compliance

There is a surface water discharge limit of 35mg/l suspended solids. No exceedances of this limit were recorded during 2008.

2.2 GROUNDWATER

TelLabs took groundwater samples in February, May, August and November 2008, the results of which are contained within Appendix A. Four private groundwater wells (Thomas Merrigan, Donal O' Leary, Eddie Coleman and Jeffery Green) were also monitored in 2008. Parameters that require analysis on an annual basis were sampled in November.

As discussed in the 'Monitoring Infrastructure Assessment Report' and the 'Groundwater Flow and Contaminant Transport Modelling Study', Ballymurtagh Landfill is located within a disused open mine pit, which is underlain by 6 - 16.5m of mine tailings and an underground mine. This underground mine was allowed to flood after closing and overflows mainly at the Ballymurtagh Road Adit (SW3) and on occasion at the Deep Ballygahan Adit (SW2). Therefore, any leachate generated within the body of waste seeps into the underground tailings and subsequently into the underground mine. Therefore, any landfill leachate contamination would be observed at the Ballymurtagh Road Adit (SW3).

RC6 was dry for all rounds of monitoring in 2008. G2/04 has been dry for all rounds of monitoring since November 2005, it was however possible to obtain a sample from G2/04 in November 2008, likely due to increased rainfall.

The following interpretations summarise the overall groundwater quality. More detailed interpretations can be found within the quarterly monitoring reports, which were submitted to the Agency throughout the reporting period.

2.2.1 Interpretation

The groundwater up-gradient of the landfill (Twin Shafts) is generally of good quality, however during analysis of annual parameters in the fourth quarter high concentrations of zinc (1mg/l), manganese (0.17mg/l), cadmium (0.009mg/l) and calcium (3809mg/l) were recorded. Bacteriological quality is generally poor and high concentrations of coliforms are likely to originate from local agricultural practices.

BH96/3 is located down gradient but adjacent to the main body of waste and is therefore more representative of leachate than groundwater. Samples taken at BH96/3 are of poor quality with conductivity, ammonia, iron, potassium, total coliforms and sulphate exceeding the relevant EU MAC limits on all sampling occasions. Faecal coliforms exceeded concentrations for the 3rd and 4th quarters. Calcium, manganese and magnesium were also elevated in the 4th quarter for the annual round of monitoring.

Groundwater quality at other down-gradient (G1/04, G1/05 and G2/05) monitoring points is also considered poor with low pH concentrations, incidences of high conductivity, iron and sulphate concentrations. Exceedances for ammonium were recorded at G1/04. The limits for copper, magnesium, manganese, zinc, iron, lead, fluoride, chromium, and cadmium were also exceeded at most of the sampling wells during monitoring of annual parameters. Incidents of high total coliforms were recorded throughout the year indicating poor bacteriological quality.

Water quality at the private wells is generally good. However the pH concentrations were outside the recommended range in all wells throughout the year. The only exception to this is Donal O'Learys well recording a pH of 6.5 in the 3rd quarter. Elevated total coliforms were detected in all wells; O'Learys well in the 1st Quarter, all wells in the 3rd quarter and all except Greens well in the 4th quarter. Feacal coliforms were also high at O'Learys well in the 1st & 3rd quarter and at Merrigans well in the 3rd quarter. Iron and manganese were elevated in the 2nd and 4th quarters in Greens Well Interpretations and results ere provided to each well owner after each quarter.

As discussed above in Section 2.2, it is considered that SW3 (Ballymurtagh Road Adit) is representative of down-gradient conditions, details of which are outlined in Section 2.1.1.

2.3 LEACHATE

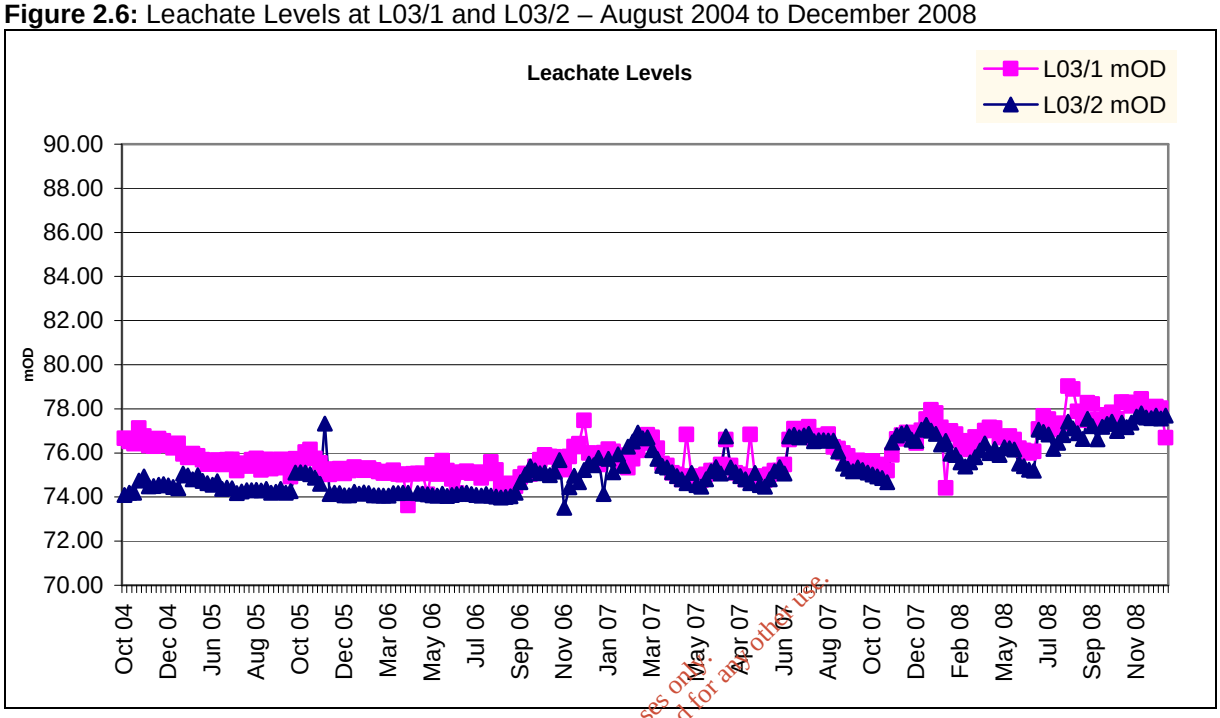
Leachate samples were taken from leachate monitoring points L05/10 and L05/16 in all quarters of this monitoring period. Samples were not obtained from the remainder of the wells (i.e. L03/1, RC3, RC4, RC5, V9 and SP9) as they were dry throughout 2008. The samples obtained in November were analysed for a broader range of parameters to comply with the annual monitoring requirements of the licence. The results were compared with typical leachate compositions of 30 samples from UK/Irish landfills (EPA, 1997).

The concentrations of most of the indicator parameters, including all the metals for most of the samples taken, are within the typical/average values for landfill leachate.

2.3.1 Leachate Levels

Leachate levels fluctuate throughout the year as shown in Figure 2.4.

Figure 2.6: Leachate Levels at L03/1 and L03/2 – August 2004 to December 2008



2.4 NOISE

Noise monitoring was undertaken by Euro Environmental at 2 monitoring locations (NSL1 and NSL4) (see Figure 2.1) in March 2009. The 55dB(A) day limit was not exceeded at monitoring point NSL4. NSL 1 exceeded the recommended daytime limits of 55dB(A) at 57dB(A), although this was attributed to traffic on the main road. No noise could be heard from operations at the landfill at NSL1 at the time of monitoring. No noise emanating from the flare was audible at NSL1, the nearest noise sensitive location to the flare.

2.5 GAS

Wicklow County Council undertook landfill gas monitoring during 2008 at those monitoring locations shown on Figure 2.1, summary results of which are contained in Appendix A.

CO_2 levels exceeded the limit of 1.5 %v/v at G6 (2.0% - 4.6%) and at G7 (3.0% - 5.3%) throughout the reporting period. Exceedances of CO_2 were recorded at other wells on occasion during the reporting period as shown in Appendix A. CH_4 levels did not exceed the Emission Limit Value at any of the points monitored during the reporting period.

2.5.1 Investigation into Elevated CO_2 levels

RPS carried out a Phase 1 desk study review of the available and relevant geological, hydrogeological and geochemical information for the area including the landfill itself and the mine workings. This report was forwarded to the agency on 5th December 2007.

2.6 LANDFILL GAS FLARE

Irish Power Systems Ltd undertook monitoring of the landfill gas flare and gas abstraction sampling points throughout 2008. Methane levels averaged at 24%, carbon dioxide at 28% and oxygen at 1.3%. Although the methane content is low and decreasing, this is indicative of the stage of the microbial degradation. The remaining % is most likely made up of hydrogen, nitrogen, carbon monoxide and water vapour derived from the atmosphere. The methane, carbon dioxide and oxygen levels recorded at the flare have decreased proportionately. O_2 levels have increased slightly in comparison to 2007.

RPS undertook the flare outlet monitoring in September to comply with the bi-annual requirements, results of which are included in Appendix A.

2.6.1 Gas Flare Unit Efficiency

Gas monitoring reports are included in Appendix A. Recently the availability of gas required to operate the flare has reduced. This may result in the flare being turned off at specific times to allow gas to build up. This will be monitored throughout 2009.

2.7 METEOROLOGICAL DATA

No meteorological data was obtained on-site during the reporting period, however data is provided by the weather station at Casement Aerodrome/Poulaphouca.

2.8 SITE SURVEY

A site survey was undertaken in July 2008 and is attached in appendix B**.**

2.9 ECOLOGY

An assessment of the ecology of the restored landfill and adjoining habitats was carried out in May 2009 and is included in Appendix C.

WASTE TYPES

The landfill ceased disposal of waste in December 2002. In total 480,000 tonnes of waste was disposed of at the facility.

Table 3.2 provides summary information on wastes received at the Civic Waste Facility and which was subsequently sent off-site for recovery during 2008.

Table 3.1: Approximate Total Quantities of Waste Accepted at the Civic Waste Facility during 2008

Waste Type	EWC Code	Approx. Monthly Quantities	Materials transported Off-site
Aluminium cans	19 12 03	472 Kg	5663 Kg
Steel Cans	20 01 40	1345 Kg	16140 Kg
Paper / Cardboard packaging / tetrapak	20 01 01	21816 Kg	261792 Kg
Fluorescent tubes / Bulbs	20 01 21	45 Kg	543 Kg
Fridges / Freezers	20 01 23	1183 Kg	14195 Kg
WEE small: Photocopiers, Keyboards, TVs, Videos, Monitors, Printers, PCs, Scanners, Smoke alarms	20 01 36	3171 Kg	38050 Kg
Plastics	20 01 39	5755 Kg	69063 Kg
Batteries	20 01 33/34	537 Kg	6441 Kg
Mixed Municipal Waste	20 03 01	853 Kg	10240 Kg
Waste Oils	20 01 25/26	275 Kg	3300 Kg
Ink jet cartridges,	08 03 13	26 Units	308 Units
Glass	20 01 02	7043 Kg	84519 Kg
WEE large: Cookers, Washing machines, Dryers	19 12 02	2618 Kg	31421 Kg
Textiles, Clothes	20 01 10/11	2110 Kg	25320 Kg
Scrap Metal	20 01 40	1682 Kg	20180 Kg
Mobile Phones		17 Units	204 Units

Quantities of waste accepted at the facility have remained similar to that of 2007. There was an increase in plastics accepted at the site from 47,721 kg in 2007 to 69,063Kg in 2008 and textiles from 2,786Kg in 2007 to 25,320Kg in 2008. Glass and bulbs also showed a significant increase of 14,460Kg and 131Kg respectively. Most of the other materials collected remained at similar levels to 2007. Overall, the Civic Waste Site is very busy with a large portion of the community making use of the facility.

4 MASS BALANCE OF SPECIFIED SUBSTANCES (MBSS)

According to the Agency's 'Waste Licensing, Draft Guidance on Environmental Management Systems and Reporting to the Agency', the purpose of a MBSS is to produce a detailed analysis of the facility in order to itemise and quantify all material flows i.e. Inputs = Output + Accumulation + Consumption - Generation. As activities at the landfill ceased in December 2002, the main inputs during 2008 relate to incoming waste to the Civic Amenity Site. The main outputs are leachate (see section 4.4), air emissions, i.e. landfill gas (see section 4.3), noise (see section 2.4) and waste departing the Civic Waste Facility (see section 3). In terms of generation, leachate and air emissions (mainly landfill gas) are generated because of the decomposition of waste, which result in their output. However, as the site was restored during 2005 and 2006, it is expected that these emissions will continue to reduce over time. The main activity at the Civic Waste Facility is the transfer of the waste disposed of at the site to suitable recovery/recycling facilities.

4.1 EPRTR REQUIREMENTS

As part of the requirements of the European Pollutant Release and Transfer Register, Ballymurtagh Landfill uploaded the results of emissions on the 22nd June 2009. Further details can be seen in Appendix D.

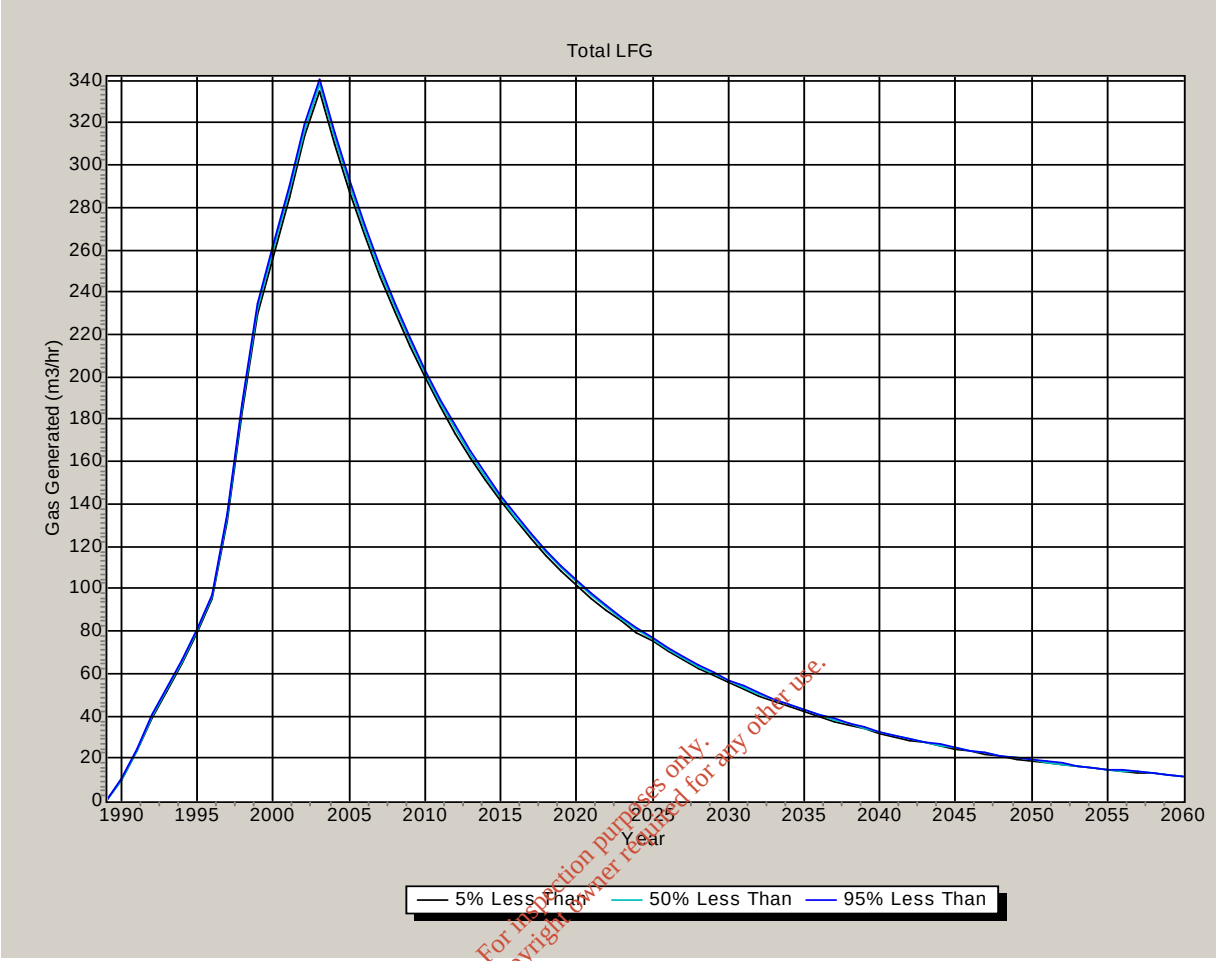
4.2 RESOURCE AND ENERGY CONSUMPTION SUMMARY

The operation of the landfill required 55,113 units of electricity, 2,800L of diesel (to operate the generator at the civic amenity site) and 6,221L of water during 2008.

4.3 ESTIMATED & CUMULATIVE QUANTITES OF LANDFILL GAS

GasSim, a landfill gas modeling software package (developed by the UK Environmental Agency), was used to simulate the expected production of landfill gas at Ballymurtagh Landfill based on the input information (see Table 3.1). Figure 4.1 shows the average hourly rate of landfill gas generation for each year for Ballymurtagh landfill.

Figure 4.1: Average hourly rate of landfill gas generated at the facility for each year 1995 to 2030**.**

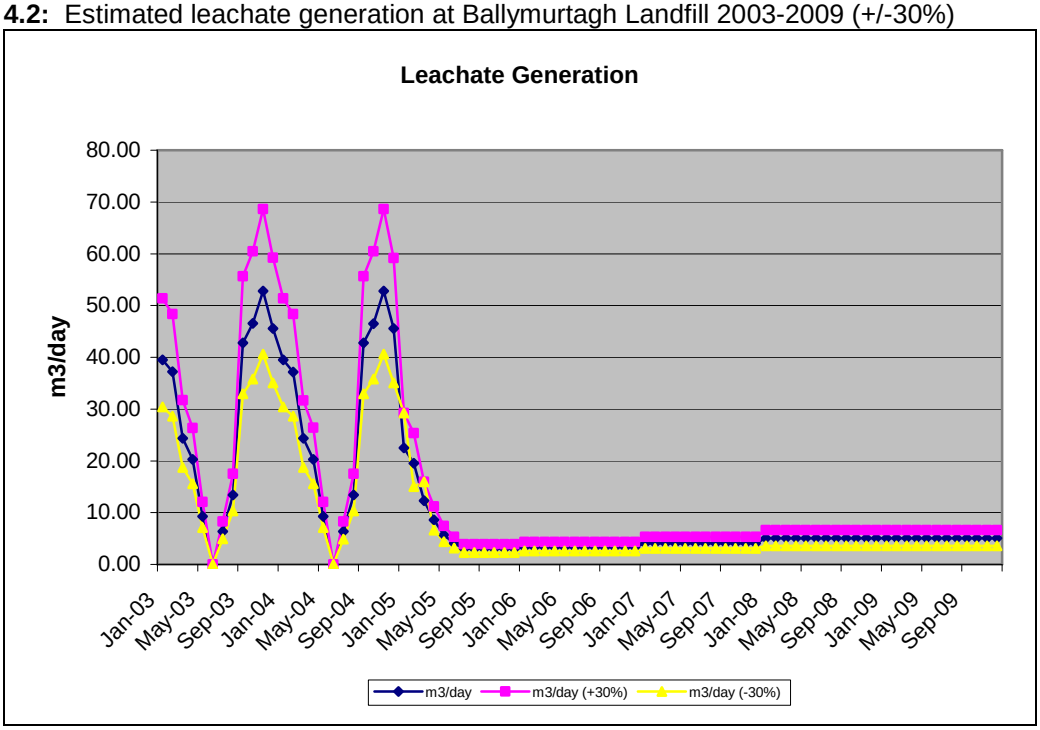


The flare at Ballymurtagh has a capacity of 500m^3/hr.

4.4 MONTHLY WATER BALANCE CALCULATION AND INTERPRETATION

Monthly rainfall data obtained from the nearest Met Eireann weather station at Poulaphouca, Co. Wicklow recorded a total of approximately 1110.3mm of rainfall in 2008. This is significantly higher than that recorded in previous years. Evapotranspiration data was obtained from Met Éireann's weather station at the Casement Aerodrome as it was not available from the weather station at Poulaphouca. The total estimated amount of rainfall lost to evapotranspiration is estimated at 546mm. Monthly volumes of leachate were calculated for the entire landfill area based on monthly rainfall, area and the stage at which the area is at i.e. completely filled and permanently capped. The water balance calculations are outlined in Appendix E. Figure 4.2 shows the estimated leachate generation for the reporting period and projections for 2009.

Figure 4.2: Estimated leachate generation at Ballymurtagh Landfill 2003-2009 (+/-30%)



It is estimated that up to 1876 m^3 of leachate were generated during the reporting period, 156m^3/month. This amount is high when compared to the estimated figure of 91m^3/month as calculated before capping. This is due to high rainfall in 2008. Evapotranspiration was slightly higher than 2007 however did not compensate for increased rainfall during the 2008 period.

4.5 EMISSIONS TO GROUNDWATER

The landfill was designed on a 'dilute and disperse' principle with no leachate containment measures put in place. The leachate, which is attenuated by the underlying soil and groundwater, drains naturally to the Avoca River.

5 SITE DEVELOPMENT WORKS

5.1 DEVELOPMENT WORKS UNDERTAKEN DURING 2008

A new shed for the storage of WEEE was erected in June 2008.

5.2 PROPOSED DEVELOPMENT WORKS

There are currently no proposals for any side development works.

6 ENVIRONMENTAL MANAGEMENT

The Facility Manager, assisted by the Senior Engineer, is responsible for achieving the schedule of objectives and targets, which are set out in the EMP. The responsibilities and time scales for achieving the objectives and targets for 2009 - 2013 are outlined in Table 6.1. As waste acceptance ceased in 2002, the objectives and targets mainly relate to the protection of the receiving environment and the aftercare of the facility.

Table 6.2 discusses the % completion of the Schedule of Objective & Targets set for 2008 - 2012.

6.1 ENVIRONMENTAL INCIDENTS

Corrective Action Report Forms relating to incidents occurring in 2008 are included in in quarterly reports forwarded to the agency throughout the year. There were no complaints in 2008.

6.2 PROCEDURES

The updated Environmental Management Plan and associated procedures was forwarded to the Agency in August 2008.

6.3 REPORTS ON FINANCIAL PROVISIONS

Wicklow County Council allocates funding on an annual basis from its revenue sources. The fund will be maintained in an amount always sufficient to underwrite the current Restoration and Aftercare Plan in accordance with Condition 11 of the Waste Licence.

Table 6.1: Schedule of Environmental Objectives and Targets for 2009 - 2013

SCHEDULE OF OBJECTIVES AND TARGETS 2009 - 2013			
Objective	**Target**	**Responsible Party**	**Completion Date**
Improve the environmental performance of the facility	Undertake regular reviews of Facility to assess compliance of site with Waste Licence	Facility Manager	Ongoing
	Submit Application for Review of Waste Licence (and accompanying EIS)	Director of Services	2009
Reduce potential odour at the facility	Minimise the number of landfill gas flare shutdowns and ensure that the flare is operating as near to 100% of the time as possible.	Facility Manager	Ongoing
Encourage public to recycle their waste	To inform the public of the waste accepted at the civic waste facility by issuing information at the civic waste facility office to members of the public, radio and newspaper advertisements	CWF Supervisor Facility Manager	Ongoing
Provide for the protection of the receiving environment.	Wicklow County Council will support any remedial action taken to improve the quality of the Avoca River. A report into the investigation of treatment of groundwater discharges from the adits was completed in February 2007. (University of Newcastle)	Senior Engineer	Ongoing
Accept additional waste materials at the Civic Waste Facility	Source further recycling/re-use opportunities	CWF Supervisor Facility Manager	Ongoing

Table 6.2. % Completion of Schedule of Objectives & Targets for 2008

SCHEDULE OF OBJECTIVES AND TARGETS 2008				
Objective	**Target**	**Responsible Party**	**% Completion**	**Comment**
Improve the environmental performance of the facility	Undertake regular reviews of conditions of Waste Licence to assess compliance of site	Facility Manager	100	Compliance of the facility is discussed on a regular basis.
Reduce potential odour at the facility	Clearly identify the source of any carbon dioxide trigger level exceedences recorded at perimeter boreholes	Facility Manager	100	A Phase 1 desk study report on the investigation into elevated carbon dioxide levels was submitted to the Agency in December 2007.
Encourage public to recycle their waste	To inform the public of the waste accepted at the civic waste facility by issuing information at the civic waste facility office to members of the public, radio and newspaper advertisements	CWF Supervisor Facility Manager	Ongoing	
Provide for the protection of the receiving environment.	Wicklow County Council will support any remedial action taken to improve the quality of the Avoca River	Senior Engineer	Ongoing	A report into the investigation of treatment of groundwater discharges from the adits was completed in February 2007. An EIS for Ballymurtagh will be prepared in 2009.
	Actively participate in the identification and implementation of appropriate measures to minimise the impact of the landfill on groundwater and surface water in the area	Facility Manager		
Reduce the potential for long-term environmental impacts	Implement the Landscaping Plan	Facility Manager	100%	Landscaping is now complete.
	Minimise the number of landfill gas flare shutdowns and ensure that the flare is operating as near to 100% of the time as possible	Facility Manager	Ongoing	
Accept additional waste materials at the Civic Waste Facility	Source further recycling/re-use opportunities	CWF Supervisor Facility Manager	Ongoing	

7 STAFFING AT BALLYMURTAGH LANDFILL

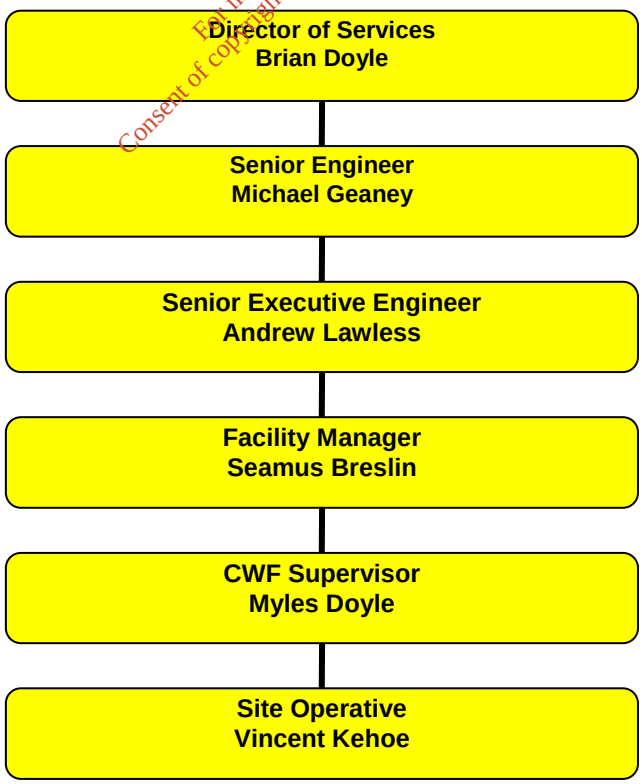
The site is under the overall operational control of the Director of Services and the Senior Engineer who provide office support as required. The Facility Manager is responsible for the day-to-day supervision and management of the site. The Facility Manager maintains regular contact with County Buildings, with regular site visits from the Senior Executive Engineer. RPS Consulting Engineers advises Wicklow County Council on operations at the facility and waste licence compliance issues. Table 7.1 provides details of the management as at June 2008.

Table 7.1: Managerial Staff

Position	Contact details
Mr Brian Doyle, Director of Services (Environmental & Sanitary Services)	Wicklow County Council, County Buildings, Wicklow. Telephone No: 0404 20100 Fax No: 0404-67792
Mr Michael Geaney, Senior Engineer (Environmental & Sanitary Services)	Wicklow County Council, County Buildings, Wicklow.
Mr Andrew Lawless, Senior Executive Engineer (Environmental & Sanitary Services)	Wicklow County Council, County Buildings, Wicklow.
Mr Seamus Breslin, Facility Manager	Wicklow County Council, County Buildings, Wicklow.

Figure 7.1 outlines the management structure for the site. A supervisor is also employed to run the civic waste facility. Any changes to this structure will be submitted to the Agency for agreement in accordance with Condition 2.6 of Waste Licence Reg. No. W0011-1.

Figure 7.1: Management Structure & Organisational Chart



7.1 ECONOMIC CONTRIBUTION

The operation of the landfill employed 4 local employees when it was in operation. Since closing in December 2002, one employee has taken the position of site supervisor at the Civic Waste Facility and another employee as Civic Waste Facility operator.

8 NUISANCE CONTROL

Wicklow County Council undertake weekly inspections of the landfill and civic waste facility to identify any environmental nuisances caused by litter, dust, odour and vermin. An inspection form is outlined in the EMP and forms part of the Corrective Action Procedure.

8.1 LITTER

The Facility Manager ensures that the facility is kept free from litter. In the event of fly tipping, the Facility Manager notifies and organises for the proper disposal of the waste.

8.2 ODOUR

In the event of odour detection, the Facility Manager has regard to the Corrective Action Procedure.

Irish Power Systems (IPS) visit the site on a weekly basis to maintain the gas extraction system so as to minimise flare failure which may lead to landfill gas migration and subsequent odour complaints.

8.3 VERMIN CONTROL

The Procedure for the Control of Vermin (set out in the EMP) outlines measures to ensure that vermin do not give rise to nuisance at the landfill and civic waste facility.

The Facility Manager oversees the implementation of the procedure for the control and eradication of pests. However, since waste acceptance has ceased at the landfill facility, the potential for vermin, pests, birds, etc has been much reduced.