From:	Tania Azara
To:	David Flynn; Martin Doyle; Ewa Babiarczyk
Cc:	historiclandfill applications; [redacted]
Subject:	Concerns Regarding Impact of Whitegate Landfill on High Arsenic Levels in Drinking Water Well
Date:	Thursday 21 November 2024 09:01:22
Attachments:	Summary Points and Conclusion.pdf Position Paper Whiregate landfill.pdf

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Dear Mr Flynn, Mr Doyle, Mrs. Babiarczyk,

We recently received water quality results from tests carried out on our well with corresponding advice from the HSE and are extremely concerned at the levels of Arsenic, Manganese and Iron ***("all more than 1000 times permitted levels")*** and Mercury ***("> 10 times permitted levels")*** that have been detected in the water from our well. The potential for significant adverse health impacts for our family is particularly worrying for us. We have a two-year old son, and I am about to give birth to my second child.

Obtaining a connection to a safe drinking water supply has become urgent for us in light of the HSE's comments that ***"this water supply would be totally unfit for human consumption".*** We cannot use the water from our well for any domestic activity including cooking or washing, not to mention drinking. We sought a connection to the Whitegate mains water supply; however, we have been advised that this is not feasible due to cost considerations.

Our friend Paula, who is experienced in the area of Environmental Science, is assisting us in understanding the risks associated with drilling another well in the proximity of our existing well for our domestic supply.

Our well is located 0.9 km from the old Whitegate Landfill site, and consequently, we have reviewed the reports/risk assessments undertaken for this landfill. As a result of this review, and a further review of the research literature into the mobilisation of arsenic at unlined legacy landfills, we have serious concerns regarding the adequacy of the risk assessments undertaken for Whitegate Landfill to quantify the risks associated with this site.

The attached 'Position Paper Regarding the Environmental Risk Assessment of Whitegate Historic Landfill' outlines these concerns in detail. We have also attached a summary of this Position Paper. These documents outline in detail our concerns regarding the risks associated with drilling another well in this location and emphasise the exceptional difficulty of our position.

We respectfully request, as a matter of urgency, that a detailed hydrological investigation is undertaken at Whitegate Landfill to assess the full impacts of leachate

from this site.

We also respectfully request, as a matter of urgency, that our family gets access to an alternative source of clean water to meet our basic drinking water and domestic supply needs.

As I am about to give birth, we would appreciate it if you could include Paula in your response to this email and she can keep us updated when I am indisposed.

Respectfully

Tania Azara and Noel O'Donnell

Position Paper – Summary Points and Conclusion

1. In July 2024, following sampling of their well by Clare County Council (CCC), Tania Azara and Noel O'Donnell were advised that Arsenic, Iron, and Manganese results were all more than 1000 times permitted levels for drinking water, and Mercury was greater than 10 times permitted levels. The values detected for Arsenic and Mercury were 1028 ppb and 5.06 ppb respectively. The HSE advised that "*this water supply would be totally unfit for human consumption and* extreme *caution should be exercised if the household propose to bore another well in this general area"*.

2. Tania and Noels' well is located 0.9 km from the historic Whitegate Landfill site, and we have reviewed the Risk Assessments undertaken for this landfill in 2009 and 2021, to understand the risks associated with using ground water in the proximity of this site for Tania and Noels' domestic supply.

3. In 2009, a **Tier 2 Exploratory Investigation** was undertaken using trial holes to collect site-specific information and reported that: waste is deposited at and below the level of the water table on the site; waste volume appears to be in direct contact with groundwater; depth of soil was not determined but depth to bedrock appears graded across the site with potential for lenses of higher permeability; peat was encountered in the subsoil of only 3 out of 10 trial holes; bedrock was encountered at two trial holes indicating extreme vulnerability; and significant volumes of leachate were encountered in four trial holes.

4. This site investigation concluded there was a direct discharge of contaminated leachate to groundwater at the site and that groundwater movement (and associated leachate movement) appeared to be from a south-west to north-east direction, based on observation of seeps in trial holes. Tania and Noels' well (Well B) is located 0.9 km along this gradient, due north-east of the landfill

5. The report concludes that "*Consideration of the presence of private wells within the 1-kilometre radius around the site makes a hydrogeological investigation imperative for the full assessment of the risk status of the site. The SPR3 linkage* (i.e. linkage to private well) *cannot be assessed without further hydrogeological investigation. A hydrogeological investigation to establish groundwater quality .. and flow direction associated with the landfill site should be included in the full Tier 2 assessment. A suitable plan of wells (including well depth and construction) and a sampling program needs to be established before this SPR linkage can be fully assessed*."

6. The report also concludes *"To evaluate the SPR9 linkage* (i.e. linkage to Special Protection Area) *investigation is required to determine the radius of influence of the landfill in groundwater and hydrogeologic separation of the aquifer from the landfill activity.*

7. The first report was followed by the **Close out of Tier 2 Risk Assessment**, also undertaken in 2009. The key concern with this RA is that **no hydrogeological investigation was undertaken**, to fully understand groundwater quality, flow direction, radius of influence and critical pathways to receptors. EPA's 'Code of Practice for Risk Assessments for Unregulated Waste Disposal Sites', requires that the main investigation (Tier 2) for the highest-risk sites (Class A) should have a sufficiently detailed site investigation programme to enable a full assessment of the risk to be made, and to confirm (or otherwise) the presence of source-pathway-receptor (S-P-R) linkages identified.

8. In the absence of this hydrogeological investigation the two potential SPR linkages were closed out prematurely including the SPR 3 linkage to a private well (Well B), and the SPR 9 linkage to the protected site adjacent to the old landfill (Slieve Aughty SPA) as follows:

    The Tier 2 RA close out report includes groundwater results for Well B showing an Arsenic concentration of 489 ppb, which is significantly greater than the limits (i.e. 10 ppb) provided in the 2007 EC (Drinking Water) Regs. This report concluded that the poor water quality in Well B was not connected with discharges to groundwater from the old landfill because "... *recharge rates to the aquifer would be quite limited and travel distances in the groundwater body would be relatively short before intersection with surface water*. *Bedrock in the area*.. is..*associated with low permeability and restrictive water flow*....and *the aquifer is classified as being poor"* and because of "*the separation distance between the old landfill site and Well B*.*"* This is not supported with site-specific data from a detailed hydrogeological investigation that establishes the radius of influence of the landfill in groundwater and does not consider the site-specific findings of the Tier 2 Exploratory Investigation cited in 3, 4, and 5 above. It also does not take account of extensive findings from the research literature describing the impacts of reduced leachate plumes associated with unlined solid waste landfills, on arsenic mobilisation in shallow groundwater systems.

    This report also concludes that based on the findings of the desk based Ecological Study for the site "*For all practical purposes the SPR 9 link (linkage to SPA) does not exist".* This does not account for the findings of the Exploratory Investigation cited in 6 above and the Ecological Study itself which is clear regarding the necessity for the hydrogeological investigation to be undertaken to draw definitive conclusions regarding linkages to the SPA.

9. The Tier 3 Risk Assessment was completed in 2021, twelve years following the completion of the Tier 2 RA. As with the Tier 2 Close Out, **no detailed hydrogeological investigation was undertaken for the Tier 3 RA** to fully assess groundwater conditions and critical pathways to receptors. EPA's 'Code of Practice for Risk Assessments for Unregulated Waste Disposal Sites', requires the Tier 3 RA to identify the sensitivity and/or degree of uncertainty for each S-P-R linkage following a thorough risk screening exercise based on good quality information**.** A Detailed Risk Assessment approach is required in the case of a sensitive site or where there is poor information and potential for a high level of risk to the environment.

10. There are inaccuracies and inconsistencies with respect to the location and description of Well B (Tania and Noels' well) in the text and in Figure 3.2 from the Tier 3 Report.

11. The Tier 3 report refers to the elevated results for 2009 including arsenic (489 ppb) and states it is considered more likely these results originate from other potential sources than from the landfill. This statement is not supported by site-specific data from a detailed hydrogeological investigation. The results from two further CCC sampling events in May and September 2024, again show significantly elevated Arsenic results for Well B of 1028 ppb and 541 ppb respectively.

12. The surface water sampling programme for 2021 was reduced in comparison to the 2009 programme, and SW1 is the only sample taken on the landfill site. The concentrations of Ammonium, Arsenic and Iron are all higher in March 2021 when compared with values in 2009. Results from the May 2024 sampling event show the same increasing trend with results for Arsenic (55 ppb), Iron (30.246 ppb), and Mercury (4.79 ppb) significantly higher than compared with 2021.

13. An increasing trend in Arsenic concentrations for the period between 2009 and 2021 is also observable for Lough Alewnaghta from EPA's Water Framework Directive chemistry data. All 24 sampling events in 2009 and 2015 showed Arsenic concentrations were <1.0 ppb. However, in 2021, Arsenic concentrations had risen in 7 out of the 12 monthly sampling events. Lough Alewnaghta is a Special Protection Area located approximately 1 km due north-east of Whitegate Landfill along the groundwater gradient identified for the landfill (see Figure 2). Lough Alewnaghta also is approximately 300 m from Well B.

14. There was no sampling of landfill leachate undertaken in the Tier 3 RA to quantify the existing quality and rate of leakage even though the previous results were 12 years old. Research has shown that reducing conditions in landfills, driven by organic carbon, can be maintained over a substantial period of time and the leakage rate from landfills over a long time period can be several times higher than that of either a short or medium time period.

15. The Revised Conceptual Site Model (CSM) in the Tier 3 Report shows an inaccurate dimension for the depth of waste and soil beneath the waste. We recognise that the drawing entitled 'Revised Conceptual Site Model Rev 1' supplied to the EPA by CCC in Dec 2022, amends Figure 4.2 to reflect the conditions of the waste body. However, Figure 4.2 and the Revised Conceptual Site Model Rev 1' show a continuous layer of peat across the landfill underneath the entire body of waste. This is not in agreement with the findings of the Trial Hole investigation as only 3 of the 10 Trial Hole Logs refer to peat being encountered in the subsoil. The 2009 Tier 2 investigation only confirmed "*the presence of some peat underlying the waste across the site"* and the Tier 2 reports confirmed that *subsoil thickness and permeability was not assessed,* and it appeared *the waste volume was in direct contact with groundwater.*

16. The CSM depicts only minimal groundwater infiltration across the waste body. This does not consider the conclusions of the exploratory site investigation based on trial hole data: that *waste is deposited at and below the level of the water table* on the site, that the *waste volume appears to be in direct contact with groundwater*, that *depth to bedrock appears graded across the site* with *potential for lenses of higher permeability*, that the *degree of connectivity between surface water and groundwater is high,* and that *there is a direct discharge of leachate to groundwater at the site.* Also, the Tier 3 report states earlier that "*the vulnerability rating for the bedrock aquifer underlying the peat in the area is classified as Moderate… however the harvesting of peat has reduced the vulnerability rating, and the trial pit excavations indicates that the vulnerability in T-6 and T-8 is Extreme."*

17. The Conclusions in the Tier 3 Report state that "*leachate migration to the underlying bedrock is considered to be insignificant because of the presence of compacted peat underlying the waste with preferential flow laterally to the surface water drainage system"*. But, as outlined above the presence of compacted peat underneath the entire body of waste was not established and peat was not encountered in 7 of the 10 Trial Holes. The Tier 2 Exploratory Investigation report states, based on the evidence from trial hole excavations, that "*the presence of a natural geological barrier being in place was not fully assessed due to depth of waste"*.

18. The lack of a Detailed Risk Assessment and hydrogeological investigation in the Tier 3 RA limits the refinement of the Conceptual Site Model. The presence of compacted peat (i.e. a geological barrier) underlying the entire waste body was not established in Trial Hole investigations but a direct discharge of leachate to groundwater was established.

19. There is no discussion or consideration in the Tier 2 Close Out RA or the Tier 3 RA report of the extensive body of research from the literature, over several years, that describes the impacts of reduced leachate plumes associated with unlined solid waste landfills, on arsenic mobilisation in shallow groundwater systems. Information from this research is particularly relevant for Whitegate Landfill because the data from trial hole investigations, surface water sampling, and well water sampling, from 2009 to 2024, point to the conditions for mobilisation of arsenic at this site. It also reinforces the requirement for the

necessity for detailed hydrogeological investigation at this landfill as recommended in 2009.

20. Although arsenic contamination in groundwater has natural causes, human activities, such as leakage of landfill leachate, can exacerbate the release of arsenic and affect arsenic distribution and migration (Xu et al. 2018).

21. Typically, organic matter contained within landfills produces a deoxygenated or reducing environment in groundwater beneath and directly downgradient of the landfill (Lamie, 2012). This removal of oxygen is caused by the degradation of the organic matter by native microorganisms; a process that requires oxygen (Lamie, 2012). Under reducing conditions, metals such as arsenic and iron dissolve and become mobilized in groundwater. In oxidizing conditions, arsenic exists as arsenate (As(V)), while in reducing conditions, it exists as arsenite (As(III)) which is more mobile (Zhao et al., 2024). The source of metals may be natural (i.e., contained within soil and rock formations or as coatings on the surface of aquifer materials), or/and from within the landfilled waste.

22. Lamie (2012) reports that when groundwater reaches the oxidizing surface water environment, iron and arsenic in solution precipitate out as solid phase (iron and arsenic bearing floc). Orange iron flocculate deposits are commonly observed in groundwater discharge zones downgradient of unlined solid waste landfills. The extensive development of iron floc deposits at landfill sites can be attributed to strongly reducing subsurface conditions imposed by landfill leachate plumes (Parisio et al. 2006). There is evidence of orange "floc" deposits in the drainage channels around Whitegate Landfill. These flocs should be examined for the Total Arsenic concentrations.

23. Ya Xu et al. (2018) examined the long-term dynamics of leachate production from landfill sites. Results showed that the leakage rate over a long time period (50-1000 years) is 10 times higher than that of either a short (0-10 years) or medium (10-50 years) period. Due to the substantial increase in leakage rate, the negative influence on groundwater quality changes from "insignificant" in the short term to "unacceptable" in the long term.

24. The USGS also reported that arsenic contamination of ground water may persist for many years after closure of a landfill because of the high organic carbon content of contaminated sediments, which maintain reducing conditions favourable for reductive dissolution of arsenic-containing iron oxides (Stollenwerk and Colman, 2004).

25. Statom et al., (2004) examined temporal changes in leachate chemistry of a solid waste landfill and determined it had an anaerobic (reducing) interior environment and reducing conditions were enhanced by capping causing the most redox sensitive metals to become more mobile. **The raises concerns regarding the implementation of remedial**

measures like capping at Whitegate Landfill without a detailed investigation to understand the long-term physico-chemical dynamics of the landfill.

26. As with Arsenic, Mercury can be mobilized into groundwater from geogenic or anthropogenic sources, including legacy sites, due to changes in redox potential, with concentrations reaching above the WHO drinking water standard of 1 μg/L (Aleku et al., 2024). The sampling event undertaken by CCC in May 2024 indicated high Mercury concentrations in Well A (4.5 ppb) and Well B (5.06 ppb). The surface water samples taken during this event also indicated very high levels of Mercury in SW1 (4.79 ppb), SW6 (4.59 ppb) and SW10 (4.83 ppb). The only sample exhibiting a lower value for Mercury was SW11 (0.45 ppb).

Conclusion

There are serious concerns regarding the adequacy of the Tier 2 and Tier 3 Risk Assessments for Whitegate Landfill to provide sufficient information to quantify the human health and environmental risks associated with this site, given the fact that a detailed hydrogeological investigation to fully assess groundwater conditions, and critical pathways to receptors, was never undertaken. The Tier 2 Exploratory Investigation concluded in 2009, that consideration of the presence of private wells and of a Special Area of Protection within the 1-kilometre radius of the site, made a detailed hydrogeological investigation imperative for the full assessment of its risk status.

Meanwhile, sampling data from 2009 to 2024 for this site show increasing trends for rising Arsenic, Mercury and Iron levels in well data and surface water samples. An increasing trend in Arsenic concentrations for the period between 2009 and 2021 is also observable for Lough Alewnaghta.

There is an extensive body of research from the literature, over several years, that describes the impacts of reduced leachate plumes associated with unlined solid waste landfills, on arsenic mobilisation in shallow groundwater systems. Understanding how landfill leachate from Whitegate Landfill affects arsenic and mercury migration and transformation in shallow groundwater at this site and its environs, is crucial for the accurate assessment of the potential ecological and human health hazards posed here.

There is an urgent need for the long-term dynamics of leachate leakage from Whitegate Landfill, and the transformation and mobilisation of arsenic in the surrounding groundwater, to be comprehensively assessed and understood to protect human health and the environment in this area.

There is also an urgent need to provide Tania and Noels' family with access to a safe drinking water supply. All of the above raise serious concerns regarding the risks associated with drilling another well in this location, and places Tania and Noel in an exceptionally difficult position. This family requires immediate access to an alternative source of clean water to meet their basic drinking water and domestic supply needs.

Position Paper Regarding the Environmental Risk Assessment of Whitegate Historic Landfill

November 2024

Prepared on behalf of: Tania Azara and Noel O'Donnell, [redacted]

Prepared by: Paula Treacy, Ph.D. Env. Sc., B.E. Civ.Eng.

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1.0 INTRODUCTION

In July 2024, Tania Azara and Noel O'Donnell received water quality results of tests undertaken that May from Clare County Council (CCC) on their domestic well near Whitegate Co. Clare. These results showed the water from their well had 1028 ppb dissolved Arsenic, 8536 ppb dissolved Iron, 1121 ppb dissolved Manganese, and 5.06 ppb dissolved Mercury. CCC forwarded these results to the HSE who subsequently highlighted the following points:

1. *Arsenic, Iron, and Manganese results are all more than 1000 times permitted levels and Mercury is > 10 times permitted levels. Several other parameters are also exceeded, and this water supply would be totally unfit for human consumption.*
2. *Extreme caution should be advised if the household propose to bore another well in this general area.*

The levels of Arsenic, Mercury, Iron and Manganese that have been detected in this well are of huge concern particularly given the significant potential health impacts for this family; Tania and Noel have a two-year old son and Tania is pregnant. They cannot use the water from this well for consumption, or for any domestic activity inside or outside their home.

Obtaining a connection to a safe drinking water supply became urgent for them in light of the HSE's comments and they requested a connection to the Whitegate mains water supply; however, they have been advised that this is not feasible due to cost considerations.

As Tania and Noel cannot avail of a connection to a mains supply they are in an extraordinarily difficult position. As outlined above, the HSE has advised extreme caution if they are to attempt to bore another well. In light of this, we reviewed available scientific material on the hydrogeologic status of the area to assess the options/implications for using groundwater for their domestic water source.

Tania and Noels' well is located 0.9 km from the historic Whitegate Landfill site, and consequently we have reviewed the reports/risk assessments undertaken for this landfill to understand the risks associated with using ground water in the proximity of this site for domestic supply.

As a result of this review, and a further review of the research literature into the mobilisation of arsenic at unlined legacy landfills, we have serious concerns regarding the efficacy of the risk assessments undertaken for Whitegate Landfill to quantify the risks associated with the site and to demonstrate the effectiveness of proposed remediation options.

These concerns are outlined in detail below.

2.0 TIER 2 AND TIER 3 RISK ASSESSMENT REPORTS

Three Risk Assessment (RA) reports were prepared for Whitegate historic landfill. The first, in 2009, covered the Tier 2 Exploratory Investigation. The second, also in 2009, covered the Close Out of the Tier 2 RA, and the third, in 2021, covered the Tier 3 RA. The findings of these reports and issues of concern are outlined below.

2.1 Findings of Report 1 – 'Tier 2 Exploratory Investigation'

Report 1 is clear regarding the requirements for the Tier 2 RA which is ***"to provide sufficient information to quantify the risks associated with the site"***. Trial holes were used as in this initial investigation to collect site-specific information on depth to water table, subsoil depth as a potential geotechnical barrier, potential landfilling on bedrock or within the water table, and leachate generation. The following findings on these topics were reported:

- *"From the perspective of characterisation of source of risk, the trial hole investigation was an extremely useful exploratory investigation tool.* ***The approach allowed for assessment … of depth to water table."*** *"Waste is deposited* ***at and below the level of the water table*** *on the site."*

- *"In general, there is some overburden above the bedrock, but the depth of overburden was not clearly established throughout the site ..****the depth of soil was not determined****. This is a limitation of the trial hole approach where trial hole depth needs to address nature and depth of sub-soil below the waste volume.* ***However, taking account of the water table level observed on the site, it would appear that the waste volume is in direct contact with groundwater, so that sub-soil investigation (for permeability) is unlikely to be an issue across the site."***

- The report raises the question of "**discontinuity in the depth of soil on site**" and the "**potential for lenses of higher permeability"**.

- Trial Hole Logs (see Appendix C of Report 1) report **peat being encountered in the subsoil of 3 trial holes. Peat was not encountered in 7 of the 10 trial holes.**

- ***"Bedrock was reached in two trial holes****, TH 1, near the western boundary of the site and TH 8 within a few meters of the southern boundary of the waste deposit area.* ***No subsoil was observed between the waste deposited and the bedrock in TH 8."***

- *"In TH 8…bedrock was encountered at the base of the trial hole****. This suggests a graded depth to bedrock across the site, broadly in a west to east direction****."*

- ***Significant volumes of leachate were encountered*** *in trial holes TH 3, 4, 5 and 8.*

- ***"Groundwater movement*** *in the overburden, (and associated leachate movement) appears to be from a* ***south-west to north-east direction****, based on* ***observation of seeps*** *in each trial hole".* ***"A well along this gradient was identified, at 0.9 kilometre distance*** *due north east of the landfill* (i.e. Well B - Tania's Well).*"*

- *"...based on the information arising from the trial hole assessment of the site****, there is a direct discharge[1] of leachate to groundwater at the site.*** *Consideration of the presence of private wells within the 1-kilometre radius around the site* ***makes a hydrogeological investigation imperative for the full assessment of the risk status of the site. The SPR3 linkage*** **(i.e. linkage to private well)** ***cannot be assessed without further hydrogeological investigation."***

- ***"To evaluate the SPR9 linkage (*****i.e. linkage to Special Protection Area*****) investigation is required to determine the radius of influence of the landfill in groundwater and hydrogeologic separation of the aquifer from the landfill activity.***

2.1.1 Recommendation for Hydrogeological Investigation

Based on the above findings the initial Tier 2 Exploratory Investigation on Whitegate Landfill recommends the following:

- ***"A hydrogeological investigation to establish groundwater quality*** *(upgradient, within and downgradient of the landfill)* ***and flow direction*** *associated with the landfill site* ***should be included in the full Tier 2 assessment****.* ***A suitable plan of wells*** *(including well depth and construction)* ***and a sampling program needs to be established before this SPR linkage can be fully assessed****...The hydrogeological assessment needs to address:*
  - *Groundwater flow direction*
  - *Groundwater flow volumes*
  - *Groundwater quality*
  - *Radius of influence of the landfill in groundwater*
  - *Travel time for migration of leachate to groundwater or a potential receptor*
  - *Potential decay of contaminants over time, or during their movement through overburden..."*

  The report also states this assessment should be used to establish whether there is:

  - *"Hydrogeologic separation of the aquifer from the activity, and bedrock water quality."*

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

The overall conclusion of the report states:

> *"Based on the exploratory site investigation, and preliminary results of surface water, leachate and well water samples, **it is not possible to confirm or break the tentative SPR3 and SPR9 linkages without further investigation**. The proposed investigation will include the **development of appropriate boreholes to define the source of groundwater contamination in the area and assess any potential pathway** between the landfill site and receptor sites."*

This confirmed the situation that Whitegate landfill, a Class A site, warranted further quantitative risk assessment and the collection of sufficient data to quantify the risks associated with the site and to demonstrate the effectiveness of remediation options.

2.2 Findings of Report 2 – 'Close out of Tier 2 Risk Assessment'

Report 2 closes out the Tier 2 RA. It was undertaken following the exploratory investigation when all of the results for 2009, including Arsenic concentrations, were available for ground water and surface water samples. Table 1 outlines these results for Well B which indicate an Arsenic concentration of 489 ppb in this well, which is significantly greater than the limits (i.e. 10 ppb) provided in the EC (Drinking Water) Regulations (2007) and the Groundwater Threshold Values (i.e. 7.5 ppb) set out in the EC Env. Objectives (Groundwater) Regs (2010). The location of Well B is shown in Figure 1 (i.e. Figure 1 from Report 2.)

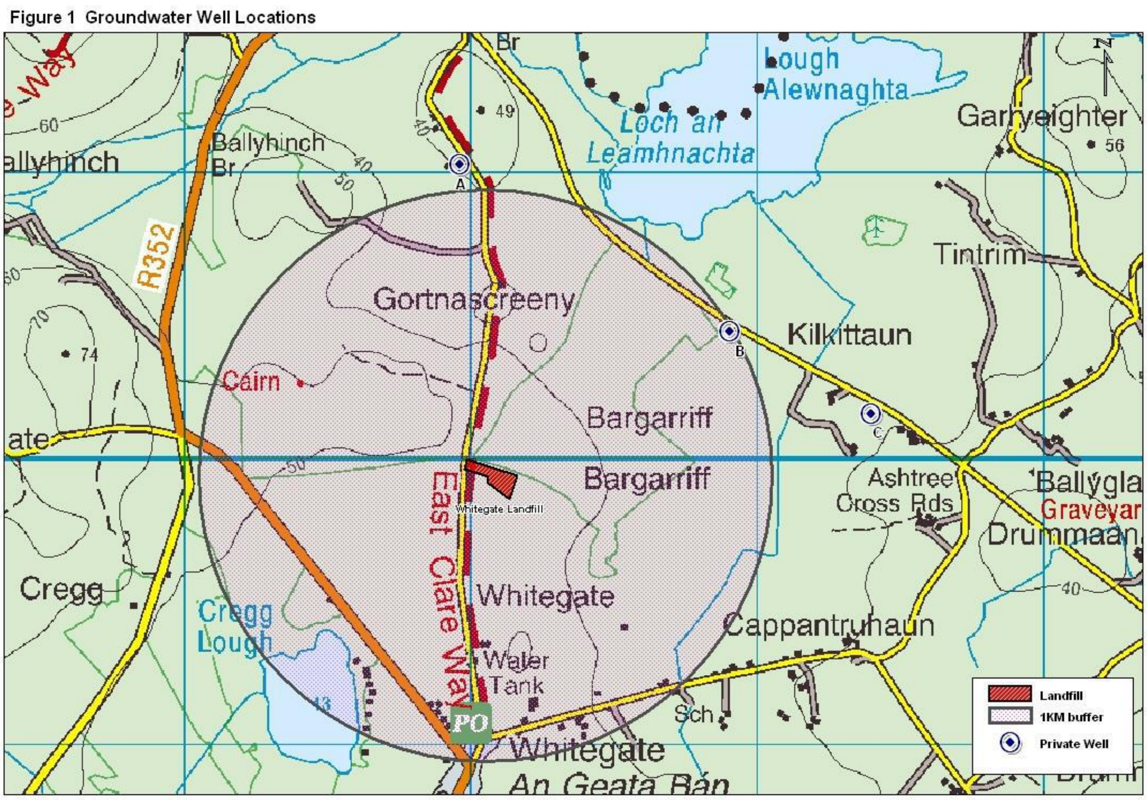

Figure 1. Location of 3 wells (Well A, B and C) which were analysed in 2009 (Well B is Tania and Noels' Well). Source: CCC, Close out of Tier 2 Risk Assessment, 2009.

Parameter	Units	2009 Well B		2021 Well B (GW1)		2024 Well B		IGV*	GTV**
		Before Treatment	After Treatment	March	April	May	Sept.		
Ammonium	mg/l	4.63	0.48	3.18	2.69	3.36	NT	0.15	0.175
Arsenic Dissolved	µg/l	489	461	6.78	6.41	1028	541	NE	7.5
Conductivity	µS/cm	595	772	581	585	601	NT	1,000	1,875
Iron Dissolved	µg/l	7880	96.7	9.47	<5.00	8536	6320	200	NE
Manganese Dissolved	µg/l	897	7.4	781	784	1121	783	50	NE
Mercury	µg/l	<0.01	<0.01	<0.5	<0.5	5.06	NT	NE	0.75
Sulphate	µg/l	6600	9100	7300	1700	11800	NT	200	187.5

Table 1. Groundwater results for Well B in 2009, 2021 (GW1) and 2024.

IGV* - Interim Guideline Values for groundwater published by EPA as cited in Tier 3 Report
GTV** – Groundwater Threshold Values, EC Environmental Objectives (Groundwater) Regs (S.I. 9 of 2010)
NS – Not tested
Data from Close out of Tier 2 and Tier 3 Risk Assessment Reports and from CCC sampling in 2024.

2.2.1 *Issues Arising from the Close Out of the Tier 2 Risk Assessment*

The key issue arising from the close out of the Tier 2 RA is that **no hydrogeological investigation was undertaken** as called for in the Exploratory Investigation, to fully understand groundwater quality, flow direction, radius of influence and critical pathways to receptors. EPA's 'Code of Practice for Risk Assessments for Unregulated Waste Disposal Sites', requires that the main investigation (Tier 2) for the highest-risk sites (Class A) should **have a sufficiently detailed site investigation programme** to enable a full assessment of the risk to be made, and to confirm (or otherwise) the presence of source-pathway-receptor (S-P-R) linkages identified in the preliminary investigation, as well as informing the quantitative risk assessment to be undertaken as part of Tier 3 RA and subsequent recommendations for remediation.

In the absence of this hydrogeological investigation **the two potential SPR linkages were closed out prematurely** including the SPR 3 linkage to a private well (Well B), and the SPR 9 linkage to the protected site adjacent to the old landfill (Slieve Aughty SPA) as discussed below:

- **SP3 Linkage to Private Wells**

  Report 2 concluded that the poor water quality in Well B was not connected with discharges to groundwater from the old landfill for the following reasons:

  1. Because it "... *is located over a poor aquifer... the recharge rates to the aquifer would be quite limited and travel distances in the groundwater body would be relatively short before intersection with surface water*. *Bedrock in the area*.. is... *associated with low permeability and restrictive water flow*....and *the aquifer is classified as being poor, meaning that it is only productive in local zones."*

     This is not supported with site-specific data from a detailed hydrogeological investigation that establishes the radius of influence of the landfill in groundwater. The Tier 3 report states for this aquifer type "G*roundwater flow paths are typically 10s* ***to 100s*** *of metres*... The above statement does not consider the movement of shallow groundwater over 100s of metres and the results of the exploratory site investigation: that waste is deposited **at and below the level of the water table** on the site, **that the waste volume appears to be in direct contact with groundwater and that depth to bedrock appears graded across the site** with **potential for lenses of higher permeability**. It is also inconsistent with the information from the trial holes which noted that bedrock was encountered at T1 and T8 **indicating extreme vulnerability.**

  2. Because "*the concentration of arsenic in the well is significantly greater than the concentration in the leachate samples. This is inconsistent with the separation distance between the old landfill site and Well B and dilution of leachate if discharge to the groundwater body was a significant consideration."*

     This comment does not take account of extensive findings from the research literature describing the impacts of reduced leachate plumes associated with unlined solid waste landfills, on arsenic mobilisation in shallow groundwater systems. This is discussed in detail below in Section 3.0. The exploratory site investigation reported **there was a direct discharge of contaminated leachate to groundwater at the site and that groundwater movement** (and associated leachate movement) appeared to be from a **south-west to north-east direction**, based on **observation of seeps** in each trial hole. Well B is located 0.9 km along this gradient, due north-east of the landfill (see Figure 1).

3. Because *"well C is also considered to be a downgradient well and does not show any elevated levels of these parameters."*

   Well C is not located on the same north-east gradient line from the landfill as Well B and is not identified as a shallow well.

- **SP9 Linkage to Special Protection Area**

Report 2 includes the desk top Ecological Study that was undertaken to assess the likely impact of the landfill on the adjacent SPA including direct movement via groundwater and direct movement via surface water. Report 2 ultimately concludes that based on the findings of this Ecological Study "*For all practical purposes the SPR 9 link does not exist".*

However, the Exploratory Investigation (Report 1) concluded that ***"to evaluate the SPR9 linkage (*i.e. linkage to SPA*) investigation is required to determine the radius of influence of the landfill in groundwater and hydrogeologic separation of the aquifer from the landfill activity"*** and the desk based Ecological Study is clear regarding the necessity for this investigation to be undertaken to draw definitive conclusions regarding linkages to the SPA as cited below:

> *"Initial investigations by Clare County Council indicate that leachate movement within the landfill is in a south west to north east direction i.e. away from the adjacent SPA, and furthermore that leachate contamination moves into surface waters adjacent to the landfill.* ***The Council however qualifies this conclusion by highlighting the need for further, more detailed investigations."***
>
> and
>
> *"On the basis of the groundwater and surface water investigations carried out by Clare County Council* ***and subject to the requirement for more detailed investigations****, it is concluded that direct significant impact on the SPA via groundwater or surface water is not a significant likelihood."*

The statement – "*For all practical purposes the SPR 9 link does not exist"*- is not justified based on the requirement for further investigation outlined in the exploratory investigation, which did not occur, and based on the qualified statements from the Ecological Report outlined above.

In conclusion, the source-pathway-receptor linkages and their relative importance should have been confirmed by further site investigations in the Tier 2 risk assessment as recommended in the conclusion of Report 1.

2.3 Findings of Report 3 – 'Tier 3 Environmental Risk Assessment'

The Tier 3 RA was completed in 2021, twelve years following the completion of the Tier 2 RA. As with the Tier 2 RA, **no detailed hydrogeological investigation was undertaken for the Tier 3 RA** to fully assess groundwater conditions and critical pathways to receptors as discussed above. EPA's 'Code of Practice for Risk Assessments for Unregulated Waste Disposal Sites' requires the Tier 3 RA to identify the sensitivity and/or degree of uncertainty for each S-P-R linkage. Confirmation of the risk classification is assigned only following a thorough risk screening exercise based on good quality information. This allows a decision as to the nature and extent of the risk assessment to be completed and to determine whether a Generic Risk Assessment or a Detailed Risk Assessment needs to be carried out. A Generic Risk Assessment may be used at less sensitive locations and/or where the information is available to suggest that the level of risk is low. In the case of a sensitive site or where there is poor information and potential for high level of risk to the environment, a Detailed Risk Assessment approach is required.

2.3.1 *Issues Arising from the Tier 3 Risk Assessment*

The following issues arise from the close out of the Tier 3 RA and the refinement of the Conceptual Site Model (CSM):

- There are anomalies in this report with respect to the location and description of Well B (identified in Report 1 as Tania and Noels' well) which is located 0.9 Km due north-east of the Landfill (see Figure 1 from the 2009 Tier 2 report). The Tier 3 report refers to Well B as:

  > *"The closest down hydraulic gradient well identified by GSI is c1.5km to the east of the site in Killkittuan townland and is an agricultural and domestic well installed in 2002 with an abstraction rate of 32m3/day (Well B). ..This is also the closest well to the site identified by the Council during the Tier 2 investigations."*

  While also referring to a separate well (Tania and Noels' well) as follows:

  > *"The Council identified a well c900m to the northeast of the site which was sampled as part of the Tier 2 investigations."*

  Fig. 3.2, from the Tier 3 report does not show the correct location of Well B (Tania and Noels' well) as shown in Figure 1. It also does not indicate what well is 1.5 km away from the landfill.

- The groundwater sampling results for Well B from 2009 and those for Well B (GW-1) from 2021 are grouped together. The report refers to the elevated results for Well B in 2009 including Arsenic (489 ppb) and states it is considered more likely these results originate from other potential sources than from the landfill. This statement is not supported by site-specific data from a detailed hydrogeological investigation. The results from two further CCC sampling events in May and September 2024, again **show significantly elevated Arsenic results for Well B** (Tania's Well) **of 1028 ppb and 541 ppb** respectively (see Table 1).

- The surface water sampling programme for 2021 was reduced in comparison to the 2009 programme, specifically with regard to samples taken on the landfill site. Surface water sampling locations are shown on Figure 3.3 in the Tier 3 Report. In 2009 Surface water samples were taken from locations SW-1, SW-2, SW-3, SW-4, SW-5, SW-6 and SW-7. In 2021 samples were taken again for SW-1 and SW-6 and from two new locations upstream and downstream from the landfill SW-10 and SW-11. SW-1 is the only sample taken on the landfill site.

  Table 2 outlines the results for SW1 in 2009, 2021 and 2024. The concentrations of Ammonium, Arsenic and Iron are all higher in March 2021 when compared with values in 2009. Results from the May 2024 sampling event show **the same increasing trend** with **results for Arsenic (55 ppb), Iron (30.246 ppb), and Mercury (4.79 ppb) significantly higher** than compared with 2021.

  An increasing trend in Arsenic concentrations for the period between 2009 and 2021 **is also observable for Lough Alewnaghta** from EPA's Water Framework Directive chemistry data (**www.catchments.ie**). Table 3 outlines Arsenic concentrations in samples from this lake over 12-month periods in 2009, 2015 and 2021 (sampling is due to be repeated in 2027). All 24 sampling events in 2009 and 2015 showed Arsenic concentrations were <1.0 ppb. However, in 2021, Arsenic concentrations had risen in 7 out of the 12 monthly sampling events (see Table 3). Lough Alewnaghta is part of the Lough Derg Special Protection Area and is located approximately 1 km due north-east of Whitegate Landfill, along the groundwater gradient identified for the landfill (see Figure 1). Lough Alewnaghta also is approximately 300 m from Well B.

- There was no sampling of landfill leachate undertaken in the Tier 3 RA to quantify the existing quality and rate of leakage even though the previous results were 12 years old. Research has shown that reducing conditions in landfills, driven by organic carbon, can be maintained over a substantial period of time. Ya Xu et al. (2018) showed the leakage rate from landfills over a long time period (50-1000 years) is 10 times higher than that of either a short (0-10 years) or medium (10-50 years) period. This is discussed further in Section 3.0.

Parameter	Units	2009 SW1	2021 SW1		2023 SW1	2024 SW1 Downstream	AA-EQS	EU-MAC
		Nov.	March	April	Nov.	May		
Ammonia	mg/l	0.288	5.19	10.82	0.73	7.2	0.065	NE
Arsenic Dissolved	µg/l	10.6	14.68	7.47	NS	55	25	10
Conductivity	µS/cm	115	340	551	276	496	1000	NE
Iron Dissolved	µg/l	1630	3065	1938	NS	30,246	NE	NE
Manganese Dissolved	µg/l	197	529	1010	1575	746	20	20
Mercury	µg/l	<0.01	<0.05	<0.05	<0.06	4.79	0.05	0.07
Sulphate	µg/l	103,000	5300	<0.05	NS	21,800	NE	NE

Table 2. Surface Water results for Sampling Point SW1 in 2009, 2021, 2023 and 2024.

AA EQS – 2009 Surface Water Regulations Environmental Quality Standards as cited in Tier 3 Report.
MAC EQS – As cited in Tier 3 Report.
Purple shading indicates samples above thresholds for Iron (200 µg/l) and sulphate (250 µg/l) from the 2007 EC Drinking Water Regs as cited in Tier 2 Report.
Data from Close out of Tier 2 and Tier 3 Risk Assessment Reports and from CCC sampling in 2023 and 2024.

	2009		2015		2021	
Arsenic µg/l (Filtered in 2015 and 2021)	19/03/2009	<1.0	12/03/2015	<1.0	20/01/2021	3.9
	13/05/2009	<1.0	09/07/2015	<1.0	09/02/2021	4.4
	06/07/2009	<1.0	05/11/2015	<1.0	08/04/2021	2.2
	10/11/2009	<1.0	11/06/2015	<1.0	05/05/2021	<1.0
	27/01/2009	<1.0	17/02/2015	<1.0	21/09/2021	1.8
	10/09/2009	<1.0	14/05/2015	<1.0	03/06/2021	<1.0
	11/02/2009	<1.0	10/09/2015	<1.0	04/11/2021	<1.0
	08/04/2009	<1.0	15/10/2015	<1.0	08/07/2021	<1.0
	16/06/2009	<1.0	21/01/2015	<1.0	05/08/2021	2.6
	08/12/2009	<1.0	01/04/2015	<1.0	02/12/2021	4.5
	17/08/2009	<1.0	20/08/2015	<1.0	11/03/2021	4.3
	06/10/2009	<1.0	16/12/2015	<1.0	06/10/2021	<1.0

Table 3. Sampling data for Arsenic in Lough Alewnaghta in 2009, 2015 and 2021.

Data from EPA Water Framework Directive chemistry monitoring data www.catchments.ie.

- The Revised Conceptual Site Model (CSM), as illustrated in Figure 4.2 of the Tier 3 Report has the following anomalies:
    - An inaccurate dimension of 3m is shown on the left-hand side of the CSM diagram encompassing the depth of waste and the depth of peat underneath the waste but the Tier 3 Report states earlier that the waste body ***is on average 4.5m thick and is c5m at its deepest***. We recognise that the drawing entitled 'Revised Conceptual Site Model Rev 1' supplied to the EPA by CCC in Dec 2022, amends Figure 4.2 to reflect the conditions of the waste body. However, Figure 4.2 and the Revised Conceptual Site Model Rev 1' show a continuous layer of peat across the landfill underneath the entire body of waste. This is not in agreement with the findings of the Trial Hole investigation as **only 3 of the 10 Trial Hole Logs** (see Appendix C of Report 1) **refer to peat being encountered in the subsoil. Peat was not encountered in 7 of the 10 trial holes.** The Tier 3 Report states earlier that the 2009 Tier 2 investigations only confirmed "*the presence* ***of some peat*** *underlying the waste across the site"* and "***the thickness of the peat and underlying subsoil was not established".*** The Tier 2 Reports also confirm that ***subsoil thickness and permeability was not assessed,*** and it appeared ***the waste volume is in direct contact with groundwater.***
    - The CSM depicts only minimal groundwater infiltration across the waste body. This does not consider the results of the exploratory site investigation based on Trial Hole data: that *waste is deposited* ***at and below the level of the water table*** on the site, that the *waste volume* ***appears to be in direct contact with groundwater***, that ***depth to bedrock appears graded across the site*** with ***potential for lenses of higher permeability***, that the *degree of* ***connectivity between surface water and groundwater is high***, and that ***there is a direct discharge of leachate to groundwater at the site.***

Also, the Tier 3 report states earlier that "*the vulnerability rating for the bedrock aquifer underlying the peat in the area is classified as Moderate… **however the harvesting of peat has reduced the vulnerability rating, and the trial pit excavations indicates that the vulnerability in T-6 and T-8 is Extreme.**"*

- The discussion on the revised Conceptual Site Model and the Conclusions in the Tier 3 Report state that "*leachate migration to the underlying bedrock is considered to be insignificant because of the presence of compacted peat underlying the waste with preferential flow laterally to the surface water drainage system*". As outlined above the presence of compacted peat underneath the entire body of waste was not established in the trial hole investigation; **peat was not encountered in 7 of the 10 Trial Holes.** The Tier 2 Exploratory Investigation report states, based on the evidence from trial hole excavations, that "***the presence of a natural geological barrier being in place was not fully assessed due to depth of waste".***

  '**EPA's Code of Practice for Risk Assessments for Unregulated Waste Disposal Sites'** states "*Where a landfill is on peat, the vulnerability rating can be taken as low, as the peat has a low permeability and is usually underlain by clays, unless there is evidence* **(see above)** *that the depth to rock is shallow, or the peat has been extracted prior to the landfilling having taken place. In the case of a site where the waste is placed directly on bedrock… then the vulnerability should always be defined as extreme.. This reflects the loss of any protective subsoil.*"

In conclusion, the lack of a Detailed Risk Assessment and hydrogeological investigation in the Tier 3 RA limits the refinement of the Conceptual Site Model. The presence of compacted peat (i.e. a geological barrier) underlying the entire waste body was not established in Trial Hole investigations but a direct discharge of leachate to groundwater was established.

There is no discussion or consideration in the Tier 3 RA report of the extensive body of research from the literature describing the impacts of reduced leachate plumes associated with unlined solid waste landfills, on arsenic mobilisation in shallow groundwater systems. This is extremely relevant for this site and is discussed below.

3.0 SCIENTIFIC LITERATURE ON MOBILISATION OF ARSENIC FROM LANDFILLS

There is an extensive body of research conducted over the past 20 years describing the impacts of reduced leachate plumes, associated with unlined solid waste landfills, on arsenic mobilisation in shallow groundwater. **Information from this research is summarised below and is particularly relevant for Whitegate Landfill. It is relevant because the data from trial hole investigations, surface water sampling, and well water sampling, from 2009 to 2024, point to the conditions for mobilisation of arsenic at this site. It also reinforces the requirement for the necessity for detailed hydrogeological investigation at this landfill as recommended in 2009.**

3.1 Background - Mobilisation Methods of As from Landfills

Arsenic contamination of groundwater has affected human health and environmental safety in multiple countries around the world (Zhao et al., 2024). Although arsenic contamination in groundwater has natural causes, human activities, such as leakage of landfill leachate, can exacerbate the release of arsenic and affect arsenic distribution and migration (Xu et al. 2018).

Typically, organic matter contained within landfills produces a deoxygenated or reducing environment in groundwater beneath and directly downgradient of the landfill (Lamie, 2012). This removal of oxygen is caused by the degradation of the organic matter by native microorganisms; a process that requires oxygen (Lamie, 2012). Under reducing conditions, metals such as arsenic and iron dissolve and become mobilized in groundwater. In oxidizing conditions, arsenic exists as arsenate (As(V)), while in reducing conditions, it exists as arsenite (As(III)) which is more mobile (Zhao et al., 2024). The source of metals may be natural (i.e., contained within soil and rock formations or as coatings on the surface of aquifer materials), or/and from within the landfilled waste.

In 2024, based on a comprehensive literature review, Zhao et al., examined the impact of leachate generated by municipal waste landfills on the migration and transformation of arsenic in groundwater. These authors concluded that a variety of compounds in landfill leachate and environmental conditions can influence the migration and transformation of arsenic in groundwater. Among them:

- the organic matter in the landfill leachate changes the form of arsenic through complex reactions and redox reactions, reducing its adsorption capacity on minerals and accelerating its release;

- inorganic ions can interact with arsenic through substitution and competitive adsorption, competing for the surface sites of adsorbed minerals to promote the release of arsenic;

- microorganisms change the form of arsenic through oxidation, reduction, methylation, and other processes, so that the adsorption capacity of arsenic changes and affects the migration and release of arsenic in groundwater;

- changes of pH value and redox potential of groundwater caused by the physical and chemical properties of landfill leachate will also affect the migration behaviour of arsenic in groundwater (Zhao et al., 2024).

Understanding if and how landfill leachate from Whitegate Landfill affects arsenic's migration and transformation in shallow groundwater at this site and its environs is crucial for the accurate assessment of the potential ecological and human health hazards posed by arsenic here.

3.2 Legacy Landfills and 'Flocs' Identified as sources of As Contamination

Several researchers have identified that landfills are significant sources of reducing capacity and identified a number of landfill sites where arsenic mobilization occurred under reducing conditions as follows:

- In 2004, researchers from the United States Geological Survey (USGS) described the effects of landfill leachate on arsenic concentration in ground water at a landfill in Maine where ground-water contamination extended away from the landfill in the direction of ground-water flow, forming a leachate plume that resulted in the release of naturally occurring arsenic (Stollenwerk and Colman, 2004).
- Ford et al. (2011) examined how the discharge of contaminated ground water served as a primary and on-going source of contamination to surface water from a closed landfill. Their field investigation defined the locus of contaminant flux… for arsenic contamination in a pond abutting a closed landfill by employing a network of wells to delineate the spatial and temporal variability in subsurface conditions. Comparison of the spatial distribution of chemical signatures at depth within the water column demonstrated that direct discharge of leachate-impacted ground water was the source of highest arsenic concentrations observed (Ford et al., 2011).
- In addition, in 2012, researchers in New Hampshire discovered that anthropogenic carbon sources from landfill leachate can encourage in situ reductive dissolution of arsenic and increase arsenic mobility in groundwater (Harte et al. 2012).

3.2.1 Iron and Arsenic Flocs associated with Landfills

As outlined above, research carried out at municipal landfills in New England indicates that arsenic is frequently associated with reduced iron and mobilised as a dissolved constituent in leachate-impacted groundwaters at these sites.

Lamie (2012) also reports that when groundwater reaches the oxidizing surface water environment, iron and arsenic in solution precipitate as solid phase iron oxyhydroxides containing arsenic (an iron and arsenic bearing floc). Bright orange iron flocculate or "floc" deposits are commonly observed in groundwater discharge zones (e.g. seeps, stream margins) downgradient of unlined solid waste landfills (Parisio et al. 2006). The high frequency and extensive development of iron floc deposits at landfill sites can be attributed to strongly reducing subsurface conditions imposed by landfill leachate plumes (Parisio et al. 2006).

Parisio et al. (2006) examined if arsenic co-precipitates with iron in these discharge zones where reduced groundwaters are exposed to atmospheric oxygen. Floc samples from several landfills in New England were analysed and arsenic concentrations in these flocs exceeded the severe effects level for aquatic life as outlined in the relevant guidance document for screening contaminated sediments (Parisio et al. 2006).

These results indicate that arsenic contamination is of potential concern downgradient of landfills wherever iron-stained leachate discharges are observed (Parisio et al. 2006). Sampling and analysis of iron flocs could also provide a means of identifying landfills that may present risks of arsenic contamination to downgradient water supply wells, especially in cases where groundwater monitoring wells are not available for sampling (Parisio et al. 2006).

There is evidence of bright orange “floc” deposits in the drainage channels around Whitegate Landfill. These flocs also have dark green/black floc deposits (see Figure 4). These flocs should be examined for the presence of arsenic. Sampling parameters must include Total Arsenic, as the sample value for dissolved As will only indicate the dissolved species (i.e. As (III)) and will not indicate the precipitated species of As.

3.3 Temporal effects on Landfill Leachate

In 2018, Ya Xu et al. examined the long-term dynamics of leachate production and leakage from hazardous waste landfill sites, and its impact on groundwater quality and human health. Results showed that the leakage rate over a long time period (50-1000 years) is 10 times higher than that of either a short (0-10 years) or medium (10-50 years) period. Due to the substantial increase in leakage rate, the negative influence on regional groundwater quality and human health changes from "insignificant" in the short term to "slight but acceptable" in the medium term, and finally to "substantial and unacceptable" in the long term. Studies also reveal that the uncertainty of risk increases over time (Ya Xu et al., in 2018).

The USGS also reported that arsenic contamination of ground water may persist for many years after closure of a landfill because of the high organic carbon content of contaminated sediments, which maintain reducing conditions favourable for reductive dissolution of arsenic-containing iron oxides (Stollenwerk and Colman, 2004).

In a further study, Statom et al., (2004) examined temporal changes in leachate chemistry of a municipal solid waste landfill cell in Florida and determined the landfill cell had an anaerobic (reducing) interior environment and **reducing conditions were enhanced by capping** causing the most redox sensitive metals to become more mobile.

The above raises concerns regarding the implementation of remedial measures like capping without a detailed investigation to understand the physico-chemical dynamics of the landfill. The long-term impacts of leachate leakage from Whitegate Landfill and its influence on surrounding groundwater and on human health requires detailed assessment for long-term management and risk control at this site.

Figure 4. Iron floc deposit in northern drain adjacent to Whitegate Landfill.

4.0 MOBILISATION OF MERCURY IN GROUNDWATER

As with Arsenic, Mercury can be mobilized into groundwater from geogenic or anthropogenic sources, including legacy sites, due to changes in redox potential, with concentrations reaching above the WHO drinking water standard of 1 μg/L (Aleku et al., 2024).

Under reducing conditions, microbial activity facilitates the reductive dissolution of iron oxyhydroxides, causing the release of sorbed Mercury into groundwater. The released Hg^{2+} may be reduced to Hg^0 by either dissolved organic matter or Fe^{2+}. The stability of Mercury species (Hg^0, Hg_2^{2+}, Hg^{2+}, MeHg) in groundwater is controlled by oxidation-reduction potential (Eh) and pH.

The sampling event undertaken by CCC in May 2024 indicated high mercury concentrations in Well A (4.5 ppb) and Well B (5.06 ppb). The surface water samples taken during this event also indicated very high levels of mercury in SW1 (4.79 ppb), SW6 (4.59 ppb) and SW10 (4.83 ppb). The only sample exhibiting a lower value for Mercury was SW11 (0.45 ppb).

Understanding if and how landfill leachate from Whitegate Landfill affects Mercury's migration in shallow groundwater at this site and its environs is crucial to accurately assess the potential ecological and human health hazards posed by Mercury here.

5.0 CONCLUSION

There are serious concerns regarding the adequacy of the Tier 2 and Tier 3 Risk Assessments for Whitegate Landfill to provide sufficient information to quantify the human health and environmental risks associated with this site, given the fact that a detailed hydrogeological investigation to fully assess groundwater conditions, and critical pathways to receptors, was never undertaken. The Tier 2 Exploratory Investigation concluded in 2009, that consideration of the presence of private wells and of a Special Area of Protection within the 1-kilometre radius of the site, made a detailed hydrogeological investigation imperative for the full assessment of its risk status.

Meanwhile, sampling data from 2009 to 2024 in groundwater and surface water samples show increasing trends for rising Arsenic, Mercury and Iron. An increasing trend in Arsenic concentrations for the period between 2009 and 2021 is also observable for Lough Alewnaghta.

There is an extensive body of research from the literature, over more than 20 years, that describes the impacts of reduced leachate plumes associated with unlined solid waste landfills, on arsenic mobilisation in shallow groundwater systems. Information from this research is particularly relevant for Whitegate Landfill because the data from trial hole investigations, in addition to groundwater and surface water sampling from 2009 to 2024, point to the conditions for the mobilisation of arsenic at this site. Evidence from this research reinforces the necessity for detailed hydrogeological investigation at Whitegate landfill as recommended in 2009.

There is an urgent need for the long-term dynamics of leachate leakage from Whitegate Landfill and the transformation and mobilisation of arsenic in the surrounding groundwater, to be comprehensively assessed and understood to protect human health and the environment in this area.

There is also an urgent need to provide Tania and Noels' family with access to a safe drinking water supply. All the above raises serious concerns regarding the risks associated with drilling another well in this location, and places them in an exceptionally difficult position. This family requires immediate access to an alternative source of clean water to meet their basic drinking water and domestic supply needs.

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