# Turkeyland Recycling and Waste Management Ltd

## Review of 2022 waste testing and water quality monitoring data

January 2023

Waste Management Research Group

University of Southampton

# TRWM: Review of 2022 waste testing and water quality monitoring data

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| **Prepared for:** | **Turkeyland Recycling and Waste Management Ltd**<br>Broom House<br>Foxdale Road<br>Ballasalla<br>Isle of Man<br>IM9 3DW |
| **By:** | Waste Management Research Group (WMRG)<br>Faculty of Engineering and Physical Sciences<br>Highfield<br>University of Southampton<br>Southampton SO17 1BJ |

Tel: 01621 869133
email: rpb2@soton.ac.uk

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| **Author:** | **Richard Beaven** | |
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# Executive Summary

1. This document reviews environmental monitoring data for three facilities operated by Turkeyland Recycling and Waste Management Ltd (TRWM). The facilities monitored are:

    - Incinerator bottom ash (IBA) waste transfer station with treatment
    - Old Turkeyland (OTL) landfill
    - New Turkeyland (NTL) landfill

    The report covers data up to the end of 2022.

2. The IBA transfer and treatment facility currently processes ~10,000 t/a of bottom ash; the OTL landfill Cells A-C covered ~1.2ha and now contain ~30,000 tonnes of unprocessed IBA, following the processing and removal of ~80,000t to NTL in 2017.

    The NTL landfill is ~5.4 ha in area, and contains ~734,000 tonnes of wastes, of which ~190,000t is processed IBA residue. The remaining material in NTL is largely inert wastes. Approximately 1,684 tonnes of ferrous and non-ferrous metals were recovered by Meldgaard from the previously deposited IBA within NTL during 2022.

    The controls over inert wastes entering the site need to be maintained to ensure loads do not contain degradable material. This particularly relates to C&D wastes arriving in skips that have not been subjected to WACS testing nor any waste pre-treatment stage. The importance of keeping ***all*** biodegradable waste out of the site cannot be over-emphasised and has been a point made in many previous environmental monitoring reports.

    The remaining airspace in NTL at the end of 2022 is estimated at ~330,000 m$^3$. The average airspace consumption between September 2020 (previous survey) and June 2022 was 38,650 m$^3$/year. Based on this value the **operational life of the site** is estimated at approximately **8.5 years from the start of 2023**.

3. The principal areas of environmental monitoring are:
    - testing the quality of residue after processing of IBA
    - leachate monitoring at the two landfills
    - monitoring the discharges of Pad run-off and NTL leachate to marine waters
    - external environment (groundwater and surface waters)

4. The need for the secure storage of environmental data for the Turkeyland sites is highlighted. Currently, historical records resides with Colas in pdf form and with consultants in various spreadsheets. Environmental monitoring of the Turkeyland landfill sites will need to continue for many decades after the site(s) are restored and there is a risk that the continuity of the data record is at risk. It is ***recommended*** that Government considers the adoption of its own in-house data management and reporting system for environmental data for all landfills it is responsible for.

5. Compliance with the sampling and monitoring programme during 2022 was adversely affected by the unexpected death of a key member of staff responsible for the monitoring of TRWM. Colas have been unable to access all of the monitoring records that are locked into the individual's computer and this is reflected in the low compliance rates, especially for measurements of dips. (Table 2.1, p15).

   Only 25% compliance was achieved for taking of marine water samples as there were health and safety concerns raised around the safety of obtaining these samples.

6. The solid phase composition of IBA delivered to the TRWM facility has fluctuated and changed since the evaluation trials carried out during 2007-08:

   In late 2022 changes to the secondary incinerator operation resulted in "yellow bag" clinical wastes being processed via the primary incinerator. Sharp wastes are stockpiled and processed via the secondary line approximately every 6 months.

   In the Primary ash, the 2022 concentrations of all metals are within the historical range monitored since 2005.

   The Secondary ash has, over time, exhibited sustained increases in Cu, Ni, Zn, Cr and Co. These are presumed to be due to changes in waste inputs to the much smaller secondary line. Concentrations of Cu, Zn, Cr and Ni in the Secondary ash are generally higher than in the Primary ash.

7. Leaching tests indicate that the nature of the matured IBA is largely as expected, but there are large fluctuations in leaching of calcium and sulphate, both showing an inverse relationship with pH value. Tests undertaken for the first time in 2021 comparing the leaching behaviour of IBA from the surface and centre (core) of IBA windrows indicated higher pH (by between 0.5 and 2 pH units) in the inner compared to surface samples. There were some differences in leaching characteristics, but further analysis is required to assess the significance within the historical variations.

8. The formal CEN leaching test BS EN12457-4 was replaced in 2021 with a standard WAC 2-stage leaching test BS EN12457-3. The early data validates the WAC test as a suitable alternative to BS EN12457-4 and good correlation has been maintained between the site eluate tests and the WAC tests. **Confirmation is needed from Government that this alternative testing regime should be continued.**[1] Persistent differences between leaching test results for chromium between the on-site leaching test and the laboratory CEN or WAC tests continue into 2022 and is an area of ongoing concern.

9. In the **OTL Cell leachates**, the major ion composition, together with COD, was initially (in 2009) similar to the values predicted from the 2007/08 evaluation study but subsequently decreased in strength by ~50%. This decline is most likely a result of dilution by infiltrating rainfall through the uncapped surface.

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[1] This was discussed at a meeting with the Department of Infrastructure on 5th September 2023

Most heavy metals were initially similar to predicted concentrations; however, Pb and Zn were, from the start, orders of magnitude lower than predicted and remain so, whilst Sb has remained ~10 times higher than originally predicted.

Several of the heavy metals declined in strength, to well below predicted concentrations, namely: As, Cd, Cr, Cu, Ni and Se. For Mo and Sb there was no clear trend.

Reinstated monitoring in 2019 in a temporary surface water collection sump in the base of Cell A reflect an ongoing decline in major ionic strength with a superimposed seasonal effect that extended into 2020. There were no samples taken in 2022.

10. The major ion strength of the **Pad run-off** has been between ~10% and 100% of the predicted IBA leachate strength, compared with a range of 25% to 100% used in the impact modelling. In 2022 it was typically <10% to 25% of predicted IBA strength. Average concentrations of antimony (Sb) exceeded predicted IBA leachate strength by a factor of ~3. The majority of heavy metals are consistently at lower concentrations than predicted and consistently below their discharge limits. The exceptions are Cr, which often exceeds its discharge limit by a factor of ~2 to ~7, and Sb, which exceeds predictions but for which there is no limit on discharge.

11. The ambiguity over the volumes of Pad run-off discharged identified during 2021 has been resolved. The volumes of Pad run-off discharged during 2021 averaged ~14.3 $m^3$/d and ~10.3 $m^3$/d during 2022, which (as in previous years) is slightly larger than an estimate based on effective rainfall. During 2022 there was an average of 54 days when pumping exceeded the licensed maximum discharge rate of 25$m^3$ day, and 5 days when over 50 $m^3$/day was discharged. More regular monitoring or logging of the flow meter readings are required for better resolution on actual daily discharges.

12. Prior to the large scale processing and removal of IBA from ***OTL landfill, leachate levels*** fluctuated by 0.5m to 1m each year. As there is no active abstraction, this fluctuation implied there had been loss of leachate from the cells. This could be partly due to leakage into groundwater but is considered most likely to have been escape into the surface drainage system, via a low point at ~28.5mOD on the base of Cell A.

    With the reduced amount of ash remaining in OTL, surface water runoff mixed with leachate continues to flow into the surface water system, and consideration should be given to installing a sump to collect and manage contaminated run-off in a more controlled and formalised manner.

13. There were no reported **NTL licensed discharge to marine water** during 2022. Leachate levels in the site are stabilising at around 5.5 m OD and is in accordance with the long term hydrogeological conceptual flow model for the site.

14. It is ***recommended*** that at least one, preferably two at least 30 m apart, new leachate monitoring points are installed to allow monitoring of leachate levels/ quality in the areas of NTL used to deposit IBA wastes.

15. There has been little change in the chemical composition of samples taken from the NTL sump since pumping was turned off, except that there is a continued upward trend in nickel concentrations. The concentrations of nickel are higher than from the eluate tests on processed IBA, so it is unlikely that IBA is the cause of these increases. Pumped samples from the existing NTL monitoring sump are required to help confirm whether this is a real upward trend. The major ion content indicates a seawater/groundwater ingress rather than IBA, for example a higher magnesium concentration than would be expected from IBA leachate.

16. With leachate levels in NTL apparently stable, the rate of groundwater / seawater ingress into NTL will have reduced. It is anticipated that the quality of leachate samples will become less dominated by these external inputs and be more representative of the "source" term in the site, whether this is from "inert" wastes or IBA. Obtaining information on the source term is essential to i) help verify the predicted $C_0$ leachate strength (Table 4.1, p29) used in the hydrogeological risk assessment and ii) help establish whether there are any potential issues with biodegradability of any wastes deposited in the inert part of the site. Consequently, all monitoring points should be monitored routinely for leachate level (monthly) and quality (at least quarterly) throughout the year. Whilst there is no pumped discharge to the sea outfall there is less need for monthly leachate samples from NTL. However establishing a better record of leachate quality from the inert and IBA areas of the site is critical, and bi-monthly sampling (6 per year) is ***recommended*** from all monitoring points until a baseline record is generated **and** leachate levels in the site have stabilised to their natural "*equilibrium*" levels. Thereafter sampling could revert to quarterly.

17. ***Groundwater levels around OTL landfill*** undergo a regular seasonal fluctuation of from 1m to 3m. There is no evidence of any long term change. In the four bedrock wells, water levels are consistently lower than leachate elevations were in the landfill. Therefore, there was potential for downward movement of leachate. However, water levels in the single borehole in the superficial deposits (BH2 Upper) are at most times within a similar range to leachate levels, rising slightly higher than leachate levels in winter. This implies no potential for leakage of leachate into the superficial deposits, and therefore perhaps little or no actual potential for leakage into the bedrock.

18. ***Groundwater quality at OTL*** shows some variation between the different boreholes around OTL, but none shows any evidence of contamination by ash leachate from landfilled IBA. BH2 Lower has shown evidence since ~2013 of organic contamination from an unknown source. All of the OTL boreholes exhibit a high background concentration of zinc, whose source remains unknown.

19. It is ***recommended*** that the groundwater monitoring infrastructure around OTL is upgraded to provide better spatial monitoring around the site and so that it is in line with UK guidance that aims to fulfil the requirement of the Landfill Directive (1999/31/EC). This is especially important for when OTL is redeveloped as a stable non-reactive hazardous waste landfill. It is also recommended that a more extensive suite of mainly organic pollutants are added to the routine monitoring suite of OTL ground water borehole samples. The monitoring should be kept under review and altered according to the quality of the new source term when this is better characterised following landfilling in the new facility.

20. The screened horizons (monitoring zones) of the ***groundwater monitoring wells around NTL*** are not ideally located for picking up potential migration of any leachate. With the cessation of dewatering within NTL it is important that the three groundwater wells downgradient of the site are redrilled to different depths and in slightly new locations to rectify this.

21. ***Groundwater levels around NTL*** have risen in all wells other than Bh A2 (which screens different horizons than original Bh A) since 2007. The rises range from ~5.5m (Bh D) to 9m (Bh B). Water levels now range from ~10 to 12 m OD at the furthest inland locations (Bhs A2, B and C) to ~4 to 5 m OD at the boreholes nearest the shoreline (Bh D and E). All groundwater levels are currently above mean sea level, and water levels in Bh E and Bh D are lower than leachate levels in the site. This is in accordance with the hydrogeological conceptual flow model for the long term operation of the site. Water levels do not appear to be directly affected by the state of the tide in any borehole. The increased monitoring frequencies in 2021 helped establish seasonal fluctuations in water levels (with large fluctuation noted in Bh A2), but this monitoring was not continued into 2022. Water levels are generally lower in the summer than in the winter.

22. ***Groundwater quality at NTL***: BH E, prior to 2021, was clearly affected by seawater ingress, with chloride in most samples at ~50% of the concentration in seawater (~19,400 mg/l). It has corresponding elevated levels of sulphate, sodium and magnesium, all indicative of seawater. Samples during 2021 and 2022 do not exhibit evidence of significant seawater intrusion. The reasons for this are not yet understood. It may be a real effect related to the cessation in dewatering in the quarry, but may also relate to a change in monitoring protocols (e.g. the borehole may not have been properly purged prior to sampling) associated with a change in staff undertaking the monitoring. Monitoring procedures were reviewed and enhanced in September 2023 and monitoring after this date should clarify the position. Major ion strength is much lower at all the other NTL boreholes, broadly similar to those around OTL, and there is no evidence of any of them being contaminated by IBA leachate.

23. The fissure discharge entering ***Santon Burn*** has a similar major ion composition to that previously monitored in upgradient OTL groundwater borehole BH 4, and shows no evidence of long term change, nor of IBA leachate. The stream samples have much lower major ion concentrations than the fissure discharge. Downstream quality is very similar to upstream quality, indicating that the higher strength fissure discharge must be generally of a much lower flow rate than the stream. There is no evidence of IBA contamination in the stream samples.

24. ***Marine water*** samples taken near the Turkeyland outfall show no indication of any effect from IBA leachate in the licensed discharges, although only one set of samples were taken in late 2022. Previously elevated concentrations of TOC and BOD, which are not characteristic of IBA leachate and are indicative of other contamination sources have improved over the last 3 years. Four metals (Cr, Cu, Zn and Pb) regularly exceeded their EQS values, as noted in previous years. ***It is recommended that*** the monitoring protocol for taking marine samples is altered to address health and safety concerns. Consideration should be given (in consultation with Government) to the removal of

COD from the list of analyses undertaken. This is because the high concentrations of chloride interfere with the COD analysis. Better quality control of the major ion analysis by the DETS laboratory is also required, and Colas should introduce a system whereby the results are checked as soon as they are received so that any anomalies can be investigated by the laboratory before the physical sample is discarded.

25. The report makes a series of recommendations regarding the sampling and monitoring infrastructure, the scope of testing, and impact assessment/reduction. Some of these are re-statements of recommendations that were made in previous reports, that have not yet been implemented.

# 1. Introduction

This report reviews environmental monitoring data for leachate and the water environment during 2022, for three facilities operated by Turkeyland Recycling and Waste Management Ltd (TRWM).

The report covers the period when some COVID-19 control measures and restrictions on work and social contacts was mandated by the Isle of Man Government.

The three facilities operated by TRWM are:

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| Old Turkeyland IBA processing facility | Waste Disposal Licence WDL/04/2010/V1<br>NTL Discharge Licence WPA/07/2008 |
| Old Turkeyland landfill | Waste Disposal Licence WDL/05/2003/V3 |
| New Turkeyland landfill | Waste Disposal Licence WDL/04/2005/V2<br>NTL Discharge Licence WPA/07/2008 |

Brief descriptions of each facility and their environmental management follows.

## 1.1. Old Turkeyland Bottom Ash Waste Transfer Station with Treatment

The facility provides processing, interim storage and treatment, of incinerator bottom ash (IBA) from the Energy from Waste (EfW) plant at Richmond Hill, on a 7,260m$^2$ concrete pad. Approximately 1200 m$^2$ of the north-west end of the pad is currently allocated to the temporary storage of contaminated harbour silts, covered in plastic sheet, so the pad area currently available for processing of IBA is approximately 6,000m$^2$.

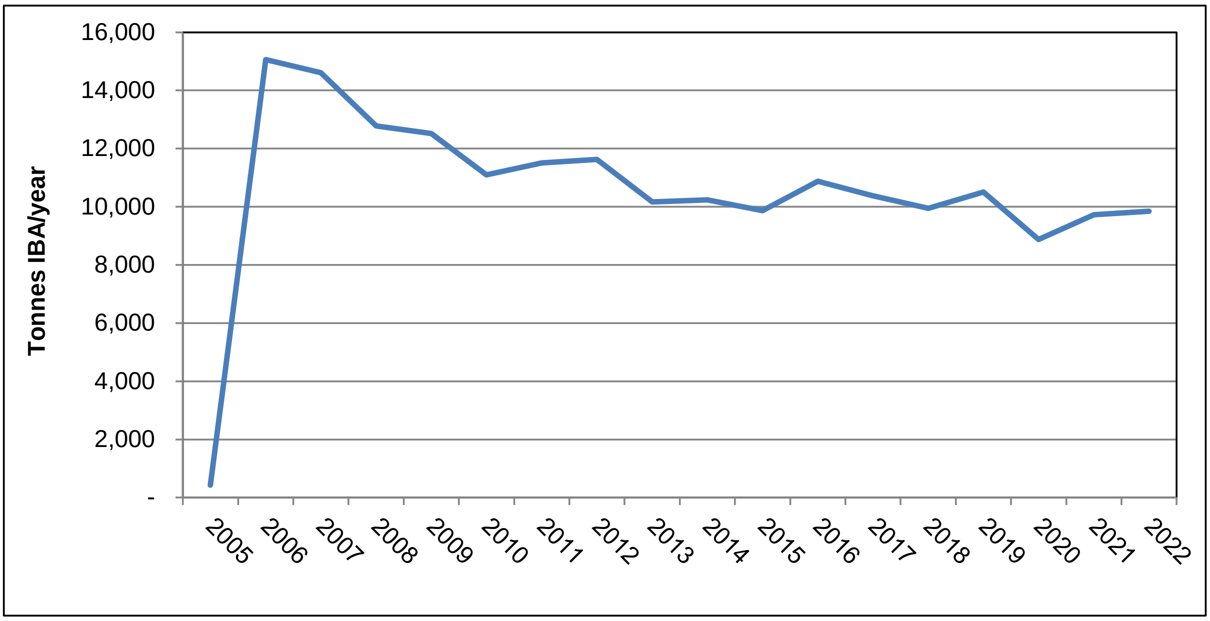
IBA was for many years subjected to screening, to remove metals and oversized objects. The metals screening is intended to produce ferrous and non-ferrous fractions that can be sold for recycling. The remaining material was then subjected to maturation by exposing it to atmospheric carbon dioxide in windrows on an open concrete pad for a minimum period of three months. This is intended to encourage reactions such as carbonation, that reduce the leaching potential of the material. During 2018 screening of the IBA was discontinued, and maturation of the unsegregated IBA in windrows occurred. After a minimum of three months, the “aged” IBA is transferred to the New Turkeyland Landfill (NTL) for storage, which may be either temporary or permanent. The intention now is to accumulate a stockpile of unsegregated bottom ash in New Turkeyland Landfill (NTL) and to bring contractors in to process it for metals when the economies of scale dictate. This occurred during 2022. The viability of this *modus operandi* was demonstrated during the excavation and processing of bottom ash from Old Turkeyland landfill during 2016-17.

**Plate 1.** Raw IBA, no metal segregation, on Old Turkeyland maturation pad. April 2019

Rain falling on the maturation pad is routed to a run-off collection sump. This is a covered concrete tank buried in the ground adjacent to the north west corner of the pad. From here it is pumped to discharge to a sea outfall, under licence.

The processing facility began operations during 2012. From then on all IBA delivered to Turkeyland has been subjected to the maturation process. The annual tonnages of IBA delivered to Turkeyland since the start of the Richmond Hill EfW plant are shown in Figure 1.1. These declined steadily by ~30% from 2006 to ~2013. This is thought to be due to an annual escalation in the gate fee, which was understood to be £165/tonne by early 2016. Between 2013 and 2022 tonnages appeared to have stabilized at ~10,000 tonnes per annum, Monthly inputs vary considerably throughout the year. In 2022 highs of over 1,000 tonnes per month occurred in January, March, May and August, whereas less than 550 tonnes was delivered in June and December and only 77 tonnes in July.

**Figure 1-1 Annual quantities of untreated incinerator bottom ash delivered to Turkeyland**



## 1.2. Old Turkeyland Landfill (OTL)

This landfill was designed to provide dedicated containment cells for the temporary storage of IBA, and a separate cell for inert wastes containing some asbestos materials. Apart from asbestos (in a separate cell), only IBA was accepted at the site. Asbestos and asbestos containing materials continue to be taken into the asbestos cell at OTL, although there were no arisings during 2022. A total of ~6,130 tonnes of asbestos and asbestos containing materials have been accepted into OTL since 2005. The main landfill was developed for the disposal of IBA in three cells, A to C, whose layout is shown in Figure 1.2. Waste placement in them began in 2005 and continued until 2012 when operation of the maturation pad began and processed IBA was then transferred to NTL landfill. After filling, Cells A, B and C contained ~80,000t of IBA. Much of this had been removed to NTL from late 2016 to late 2017.

The landfill formation was created by infilling the former OTL quarry with ~10-12m of inert material to a base formation level above that of the groundwater levels in the local bedrock. The completed cells contained ~5m of IBA above the inert formation layer. No capping was applied. A schematic cross section showing the OTL landfill in the context of the original quarry, the local geological setting and the groundwater monitoring network is shown in Figure 1.3. The approximate line of the cross section, running NW to SE is indicated on Figure 1.2.

Cells A to C were lined with bentonite-enhanced sand (BES) to minimise basal leakage. It is understood that at the design stage it was anticipated that no leachate would accumulate within the cells and that leachate discharge would not be necessary. The cell design did not include provision of basal drainage layers or abstraction sumps. There was no hydraulic separation between the cells. The base contours of each cell are graded at a fall towards the north west, of 1 in 200. Between Cells B/C and Cell A there is a step down in base level from ~30mOD in Cells B and C to the base of Cell A which grades from ~29mOD in the south east, to ~28.5mOD in the north west.[2] The base plan shows a low point in the northern corner of Cell A at ~28-28.5mOD.

From December 2016 to late 2017, processing of the OTL ash to recover metals was undertaken, by a Danish company, Meldgaard. This has resulted in ~79,000t so far having been transferred into NTL after processing. In some parts of the site IBA has been completely removed down to the BES basal layer. There is estimated to be ~30,000t remaining in OTL since the end of 2017.

**Plate 2. View of OTL cells following removal of IBA to NTL (April 2019)**

Leachate monitoring wells were installed (one per cell). Although these had the potential to be used for the abstraction of leachate, none was ever removed for disposal from the OTL landfill cells. These wells were removed or destroyed during the processing of the OTL contents, so no monitoring from them took place in 2018. A makeshift monitoring sump was installed in former Cell A during early 2019, and monthly sampling reinstated.

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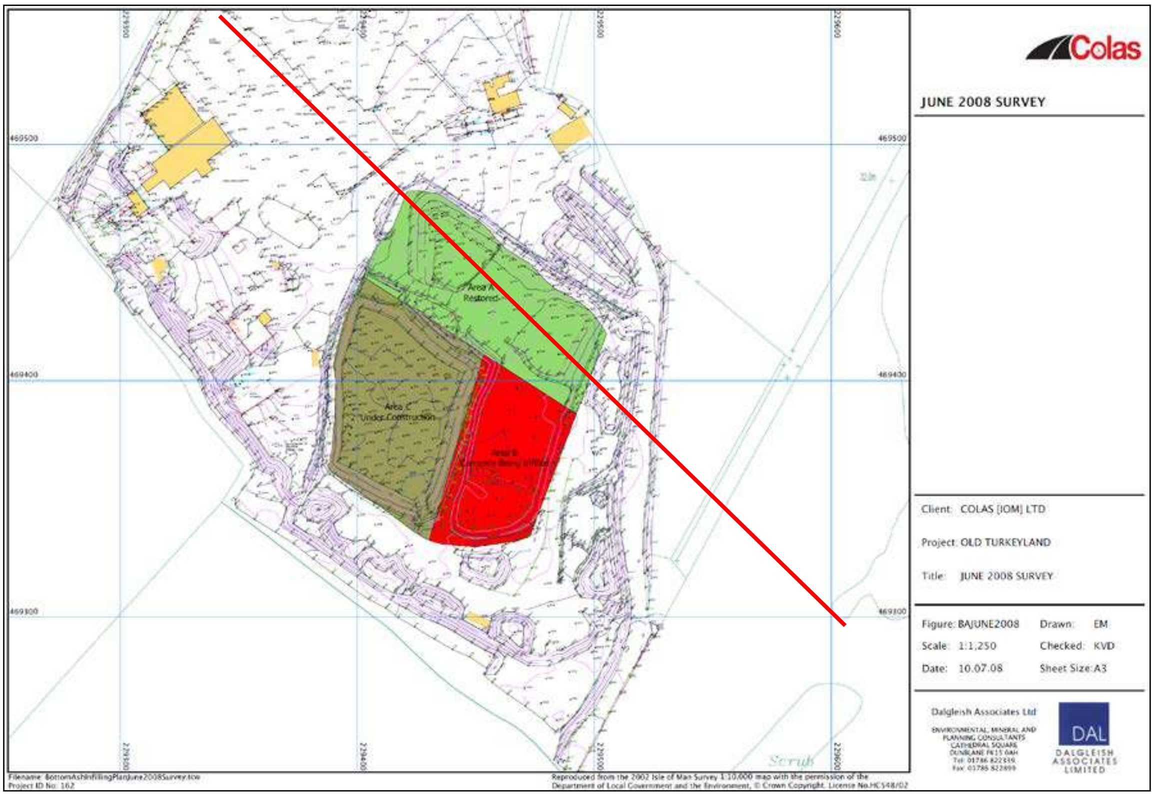
[2] Drawing BLC1 'Bottom ash infilling plan base level contours' Dalgleish Associates Ltd, 11.08.15

There are plans to completely excavate the remaining IBA to allow OTL to be developed as a new lined landfill for problematic wastes. This development, previously anticipated during late 2020 or 2021, is unlikely to occur before 2024. However, on the basis that this transfer of IBA and redevelopment of OTL does go ahead the need for any further monitoring infrastructure for IBA leachate appears unnecessary.

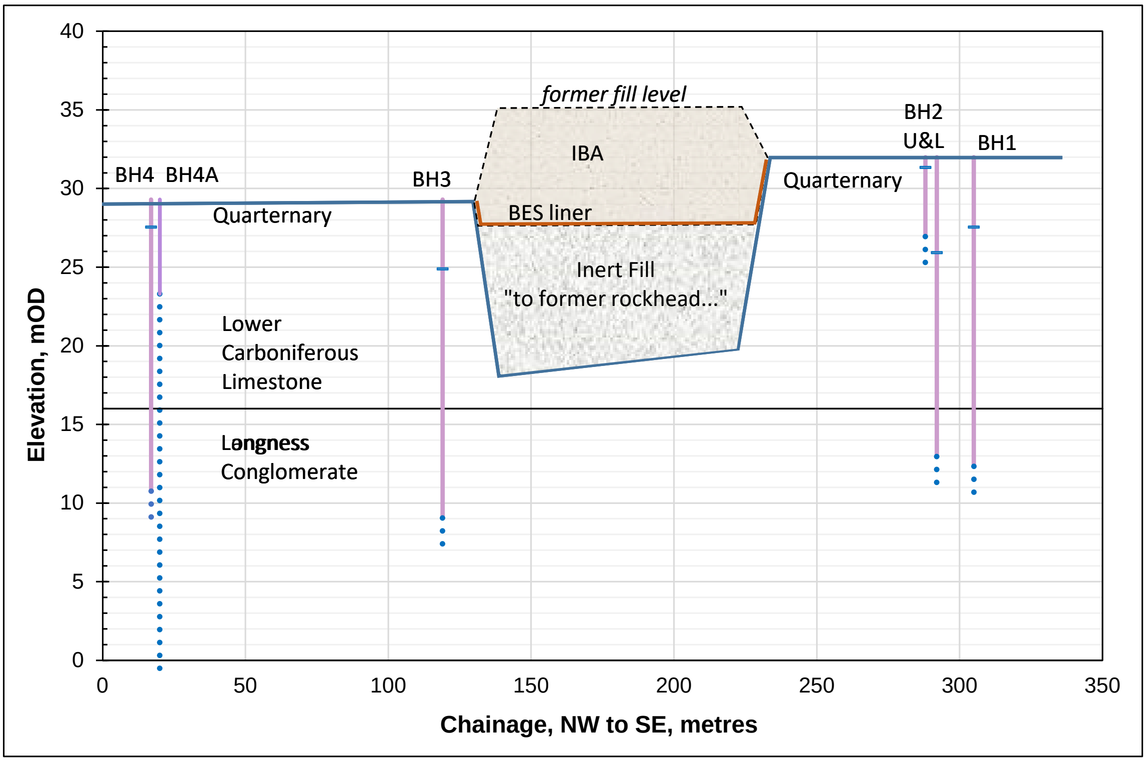
While the monitoring wells were in use, leachate levels rose and fell seasonally in each cell: it was noted above that there is a low point in the northern corner of Cell A, at ~28 - 28.5mOD, whilst the Cell B and C bases grade towards Cell A without any impediment. It therefore appears likely that seasonally accumulated leachate may have been able to drain slowly from the three cells via a low point on Cell A. From there it would have had the potential to contaminate surface waters. The removal of much of the ash means that this risk should have been reduced. Nevertheless if IBA remains in place in OTL it is ***recommended*** that a more formal leachate collection sump is installed and operated to reduce any uncontrolled seepage.

**Figure 1-2 Layout of OTL landfill cells A to C, for IBA disposal, as at June 2008**



[Source Dalgleish Associates Limited]; approximate line of section shown in red

**Figure 1-3 Schematic cross section of OTL landfill and groundwater boreholes NW to SE**



## 1.3. NTL Landfill

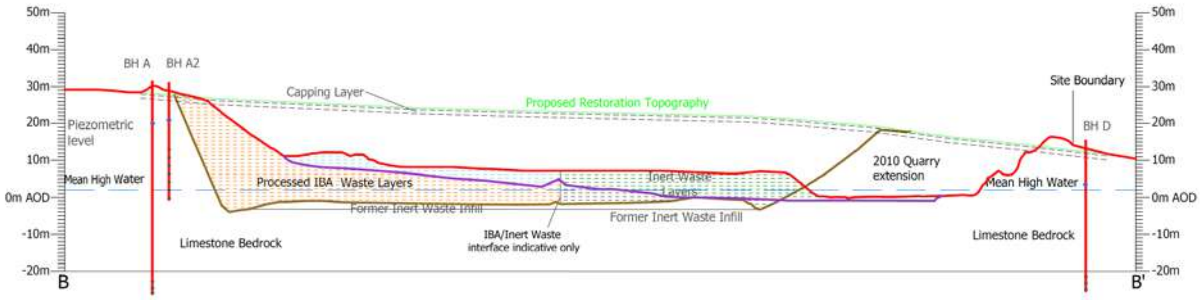
This is an unlined quarry located in fissured limestone. The deepest part of the quarry base lies at -4 mOD, which is well below the inferred rest water level for the local groundwater system. The quarry has been maintained in an un-flooded condition by dewatering. It is understood that under rest conditions, when hydraulic equilibrium has re-established, groundwater in the vicinity of the quarry is likely to discharge into the marine waters to the east of the quarry. A cross section from the survey carried out in September 2020 is shown as Figure 1.4, with annotations showing the waste profile at that time, the inferred original quarry base level and current piezometric levels from Boreholes A and A2 up-gradient and D down-gradient of the quarry. In 2004 the original useable airspace for wastes to approved final contours was calculated to be 641,994 m$^3$. This includes an allowance for 5% settlement and excludes volumes of soil to create a 0.5 m thick cover layer.

It is understood that the quarry has been in use for disposal of inert wastes since 2005. Between 2008 and 2010 additional rock was removed from the eastern side of the quarry and used in the construction of a runway extension at the adjacent Ronaldsway airport. This increased the final landfill surface area from 4.67 ha to 5.42 ha and the overall airspace for waste from 642,000 m$^3$ to 752,000 m$^3$. A modification of the Waste Disposal Licence to allow it to be used also for the disposal of pre-treated IBA, from the facility at Old Turkeyland, was issued in 2010. The issuing of this modification was based on a risk assessment which showed that the additional impact on marine water quality, via migrating groundwater and/or controlled discharges of leachate from the NTL landfill dewatering sump, would remain within acceptable limits. Pre-treated IBA residues have been transferred from the maturation facility at OTL into the NTL landfill since 2012. Additional quantities of matured IBA were transferred into NTL from the OTL landfill in 2017, following processing to remove metals.

Placement of IBA is confined to approximately one third of the quarry area, towards its NW edge. Here, the IBA is placed on top of previously deposited inert wastes. During 2017 OTL IBA processed by Meldgaard was deposited directly into the top of the quarry from the road running along the north west edge of the site. A topographic survey of NTL from September 2022 is reproduced as Figure 1.5. Remaining airspace at the time of the survey was 353,879 $m^3$.

During late 2022 Meldgaard mobilised plant into NTL to recover metals from the already deposited ash by digging out and redistributing the material. The provisional values are that 958 tonnes of non-ferrous metals and 726 tonnes of ferrous metal were recovered up until mid-December. Final confirmation of these data is awaiting confirmation from the off-island re-processing contractors.

**Figure 1-4 Schematic cross section of NTL landfill, approximately NW to SE**



[Source: Dalgleish Associates Limited; Cross-section adapted for this report]

**Plate 3. View of NTL from north-west edge of quarry (April 2019)**

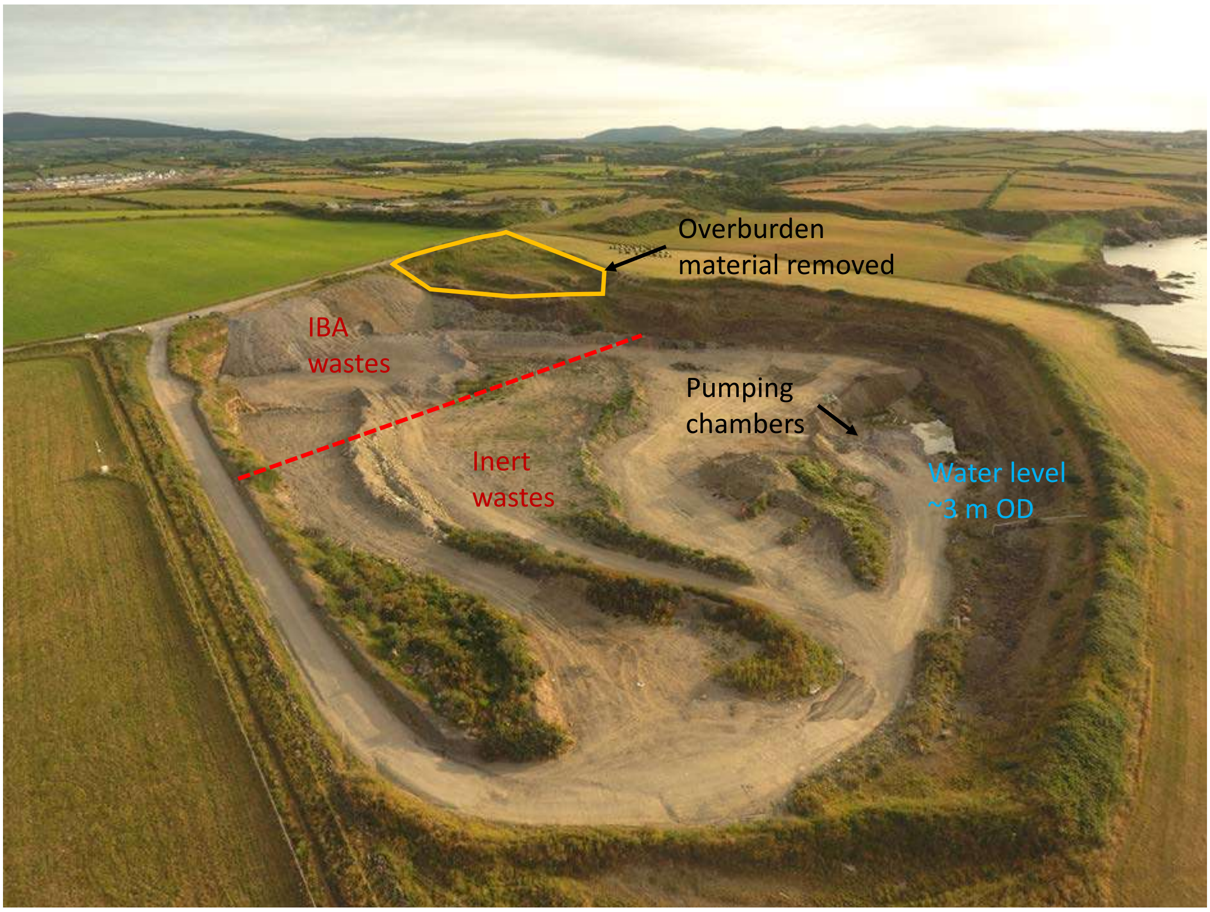
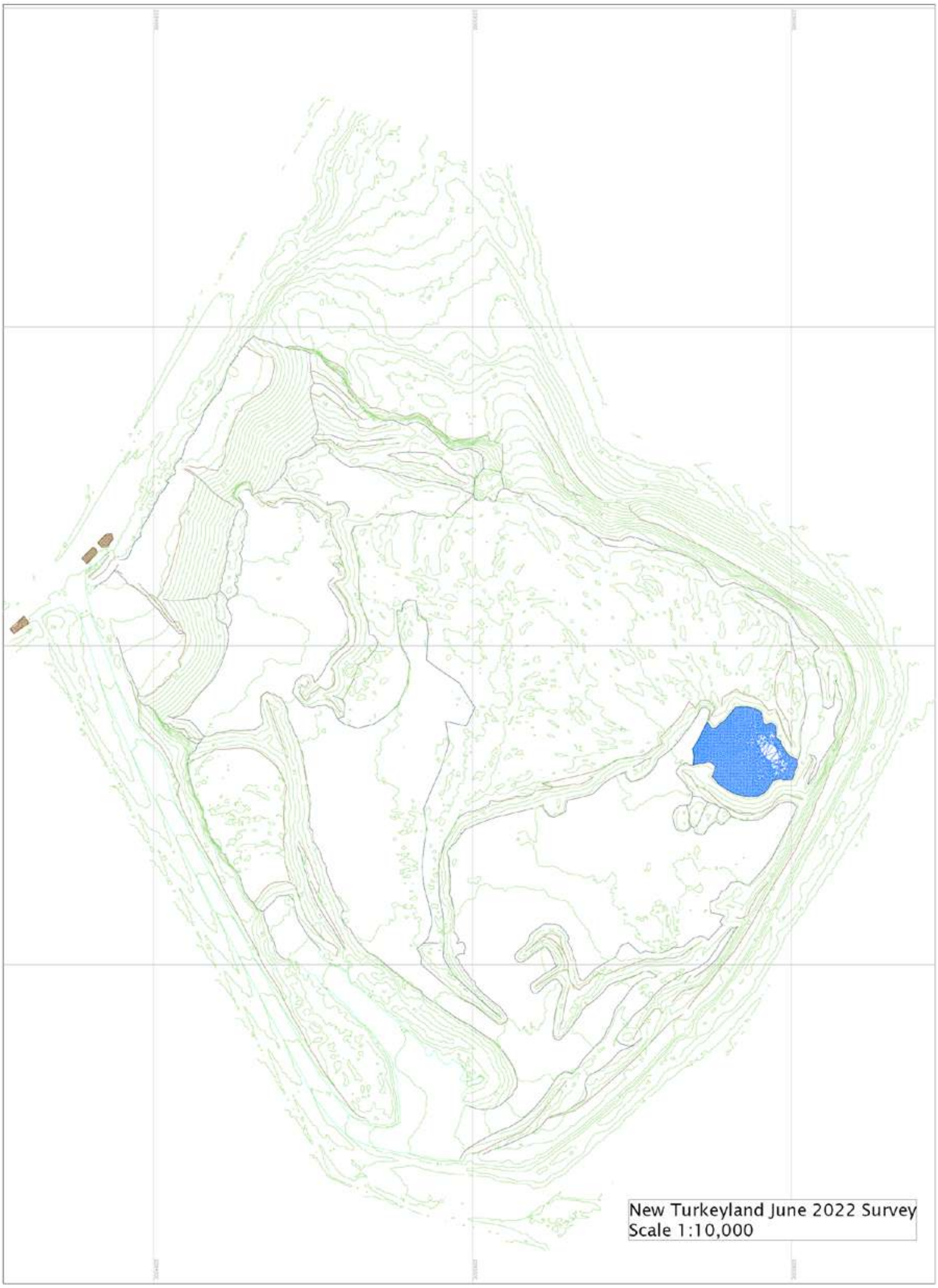


**Plate 4. Aerial view of NTL from south (July 2021)**

**Figure 1-5 Topographic survey of NTL landfill as at June 2022**



[Source: Dalgleish Associates Ltd Dwg ‘Site Survey June 2022]

The quantities of processed IBA and other wastes deposited in NTL during 2022 are shown in Figure 1.6. These can be considered in the context of long term IBA deliveries to Turkeyland (Figure 1.1) and long term inputs of IBA and other wastes into NTL landfill (Figure 1.7), which has taken into account the 1684 tonnes of ferrous and non-ferrous metals recovered and removed from NTL in 2022.

**Figure 1-6 Quantities and types of waste deposited in NTL landfill during 2022**

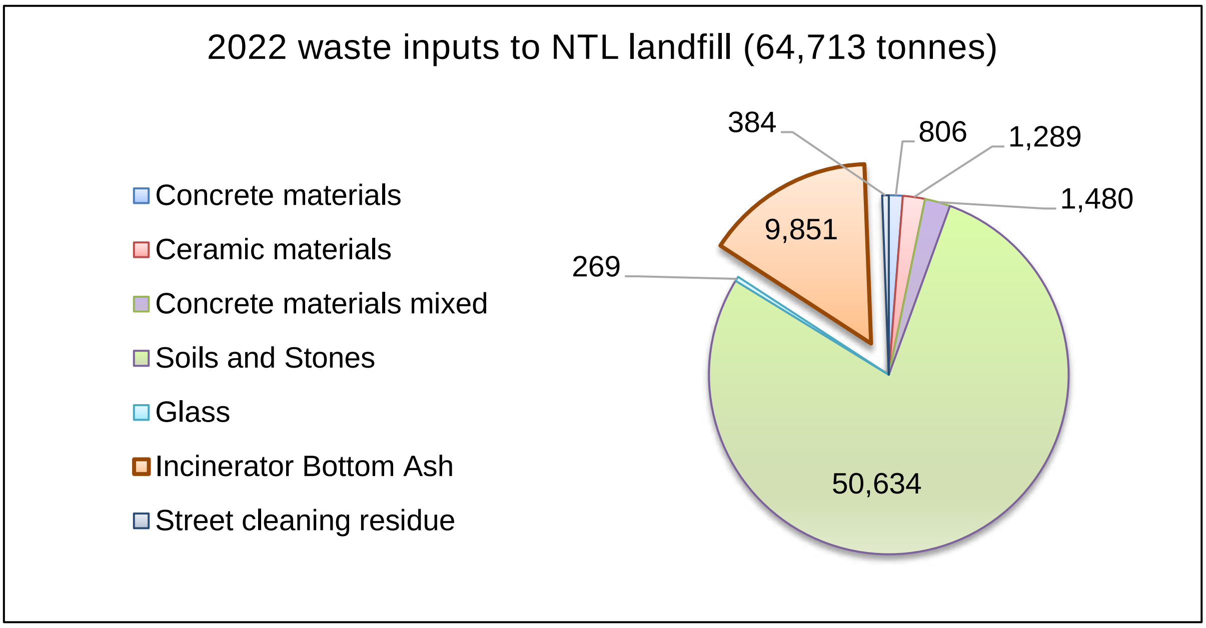
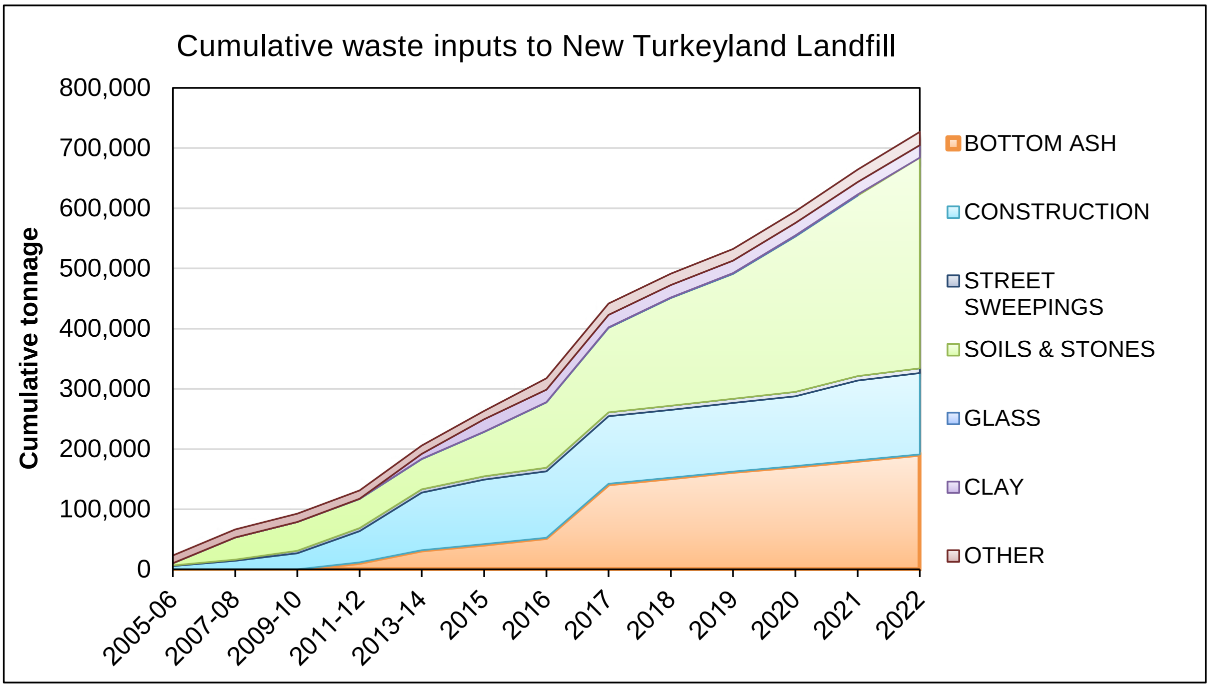


**Figure 1-7 Cumulative deposits of all wastes into New Turkeyland Landfill**



Deposits of 9,851t of processed IBA deposited in 2022 constituted ~15% of the ~64,713t total deposits of new wastes into NTL landfill that year. With the transfer of much of the OTL ash during 2017 the total amount of IBA in NTL as a proportion of the total was ~26% by the end of 2022.

Inputs of soil like materials and construction wastes during 2022 totalled ~53,000 tonnes, and is the highest yearly input to date. Although there is some considerable fluctuation year on year there has been a an average increase in inputs of over 1,500 tonnes per year since 2009/10.

Dalgleish re-examined the original airspace survey undertaken in 2005 with surveys undertaken in 2010 after additional rock was taken out of NTL for the Ronaldsway runway extension. The total airspace of NTL was recalculated as 752,200 m$^3$ of which 330,750 m$^3$ has been utilised (to September 2020). With reference to figure 1.7, the average bulk density of all materials disposed into NTL is calculated as 1.79 t/m$^3$.

The useable void remaining in NTL quarry as of a survey in June 2022 was 353,879m$^3$. The calculated bulk density of the deposited waste since the last survey is calculated as 1.66 t/ m$^3$. Since then until the end of 2022 an additional ~ 40,000 tonnes have been landfilled, giving an estimate of the useable void at the end of 2022 as ~330,000 m$^3$. The average airspace consumption between September 2020 (previous survey) and June 2022 is 38,650 m$^3$/year. Based on this value the operational life of the site is estimated at approximately 8.5 years from the start of 2023.

Another noteworthy input to the *cumulative* deposits in NTL was ~13,500 tonnes of rejects from a materials recycling facility that were deposited during 2014[3]. Testing showed that the material contained sufficient organic content to present a risk of biological degradation processes occurring and its disposal was therefore discontinued. Subsequently, a test protocol has been adopted to screen wastes against (i) EU Waste Acceptance Criteria (WAC) for Inert waste landfills, and (ii) previously established leaching behaviour of matured IBA. The IOM Government made a number of requests during 2019 for the deposit of new waste streams into NTL, including 40,000 m$^3$ of heavy metal contaminated dredged silts from Peel Marina. The organic content of these silts made them unsuitable for deposit into NTL as their presence would have risked the mobilisation of currently stabilised contaminants within the deposited IBA.

Colas expressed concerns in 2021 that skip waste coming into NTL may contain fines with a significant organic content. There appear to be a lack of Island-wide controls that requires waste producers bringing inert wastes into the site to ensure and/or demonstrate that all wastes are non-biodegradable. This applies mainly to C&D wastes arriving in skips that have not been subjected to WACS testing or any waste pre-treatment stage.

The importance of keeping ***all*** biodegradable waste out of the site cannot be over-emphasised. Organic material in the landfill will change the leaching characteristics of the IBA ash potentially leading to off-site pollution outside the parameters of the hydrological risk assessment that supports the current operation of the site. The potential generation of landfill gas from the biodegradation of organic material would be a further serious consequence as the ability to control methane and potentially hydrogen sulphide gas migration in this unlined landfill quarry in fissured rocks will be exceedingly difficult.

A Discharge Licence allows leachate to be abstracted from a dewatering sump in the landfill and discharged to sea via a purpose-built outfall. This discharge was intended to ensure that the operational area of NTL can be kept in an un-flooded condition, by countering the effect of groundwater ingress, until the wastes reach a level above the rest water level of the natural groundwater system. Waste levels are now at or above this level and no pumping has occurred since August 2021. The volume of the discharge has been metered or estimated from pump hours since the start of 2015.

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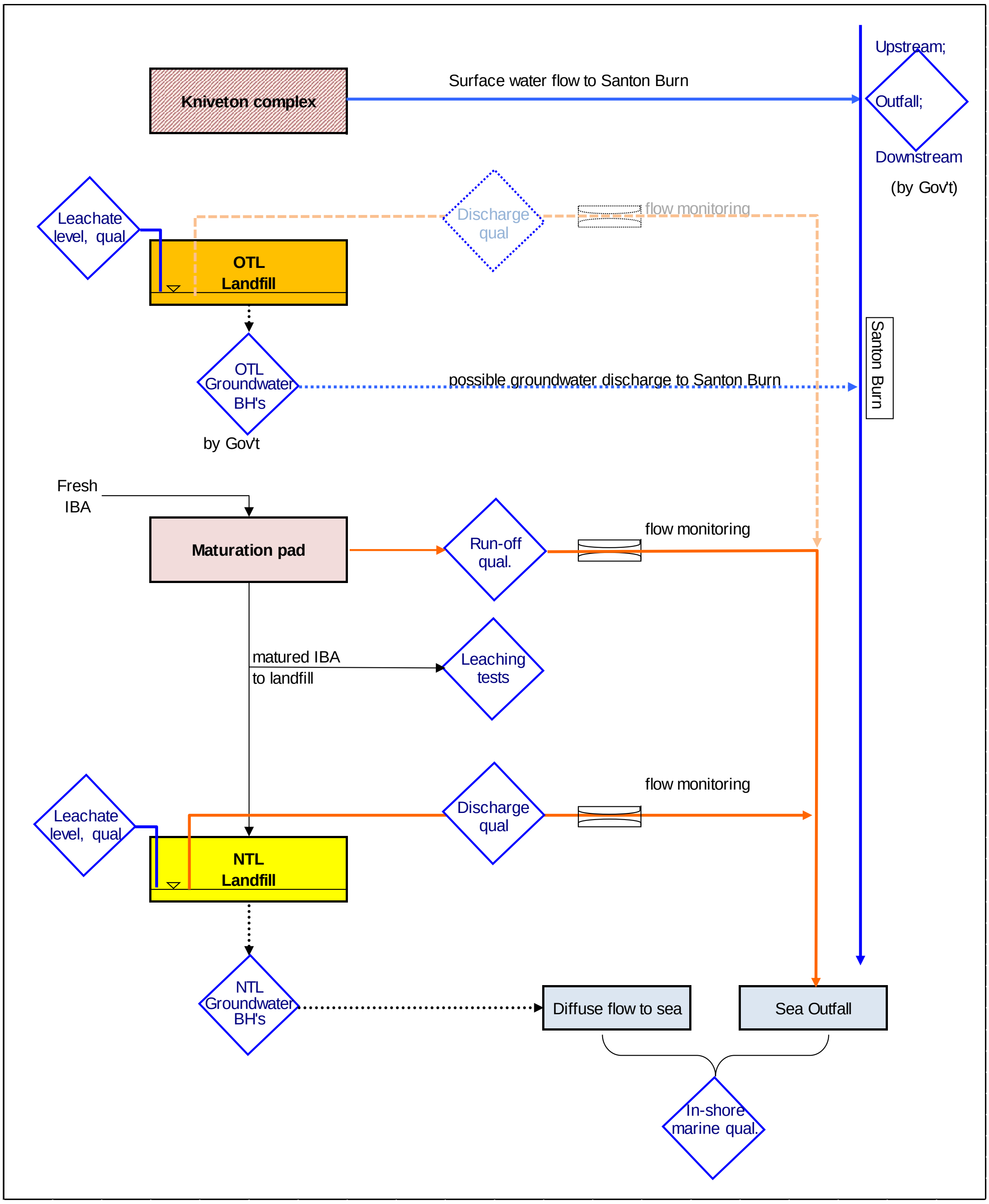
[3] Email from Colas, 11.4.16: 9,453t in 2014 and 3,994t in 2015.

# 2. Monitoring Programme for leachate and water systems

Monitoring of leachate and water environments at the TRWM facilities has evolved over several years. The first formalised programme was prepared in 2013 at the initiative of TRWM Ltd, to ensure that sufficient information is collected to monitor potential and actual environmental impacts of the various waste management operations. The overall organization and scope of the waste, leachate and water monitoring programme are shown schematically in Figure 2.1.

**Figure 2-1 Schematic showing scope of overall environmental monitoring programme**



The formal description of the programme in its current form is reproduced at Appendix 1. The formal description includes testing that is carried out by Government, and covers the key aspects of the programme, namely:

- Range of waste, leachate and water domains to be monitored
- Scope of monitoring tests to be done within each domain
- Frequency of monitoring tests within each domain

A summary of actual monitoring undertaken in each domain during 2022 is recorded in Table 2.1, showing the percentage compliance achieved against the current objectives.

Late in 2022 a key staff member responsible for monitoring of TRWM died unexpectedly. Colas has been unable to access all of the monitoring records that are locked into the individual's computer and regrettably this is affecting some of the compliance levels reported here.

This event has brought into focus the need for the secure storage of environmental data for the Turkeyland sites. Currently, historical records resides with Colas in pdf form and with consultants in various spreadsheets. Environmental monitoring of the Turkeyland landfill sites will need to continue for many decades after the site(s) are restored and there is a risk that the continuity of the data record is at risk. It is ***recommended*** that Government considers the adoption of its own in-house data management and reporting system for environmental data for all the landfills it is responsible for.

The locations of monitoring points are shown in Figure 2.2. Monitoring of individual components of the programme is described below.

## 2.1. Waste testing

A waste acceptance protocol for the IBA inputs to the TRWM facilities was initiated in 2010 and has undergone periodic updating and improvement. The current version is reproduced at Appendix 3. The acceptance protocol includes a monthly leaching test at a liquid:solid (L/S) ratio of 10:1 (LS10), to be carried out on site, on samples of matured residual IBA from the windrows. The procedure for this test is included in Appendix 3. In addition to the on-site leaching test, a replicate sample is sent every six months to an external laboratory for a leaching test according to the standard European procedure, BS EN12457-4, also carried out at LS10. This is intended to provide a cross check of the on-site leaching test.

The purposes of the leaching tests are:

(i) To compare on-going eluate quality from the matured IBA, for consistency with expectations from extensive leaching tests carried out over a period of several years prior to the construction of the maturation facility, thereby confirming the continued effectiveness of the maturation process, and the validity of the risk assessment that was carried out.

(ii) To accumulate a database of full-scale leaching test results, to compare against quality of the run-off from the pad and the leachate from the landfilled IBA.

On-site leaching tests began in October 2012. During 2013 a series of increasingly atypical results raised concerns over the reliability of the external laboratory analysis. An inter-laboratory comparison in December 2013 revealed that the laboratory had, incorrectly, begun analysing total metals, including significant amounts of suspended solids in the site eluates, and had also been using an incorrect test for the 6-monthly external check. This was corrected by early 2014.

During 2021 and throughout 2022 solid waste samples were sent for WAC testing according to EN12457-3 rather than BS EN12457-4. The difference is that EN12457-3 is a two stage leaching test that produces eluate data at LS2 and then on a second leaching stage at LS8. EN12457-4 is a single stage leaching test at LS10. The initial leaching stage at LS2 in EN12457-3 provides additional useful information of potential higher leachate concentrations that could arise from IBA ash, and consequently has benefits over EN12457-4. The original concept of demonstrating that the on-site leaching tests provided similar results to EN12457-4 on which the original risk assessment was undertaken has already been demonstrated, so it is ***recommended***, subject to Government approval, that the two stage WAC test becomes the normal test for demonstrating that the on-site leaching test continues to provide robust results.

The waste acceptance protocol requires Government to provide TRWM with the results of quarterly analysis of the IBA, carried out by the EfW plant operator, to ensure that the composition of the IBA delivered to TRWM remains consistent with samples tested for the impact assessments for the maturation facility and for the NTL landfill.

Nine internal leaching tests were undertaken in 2022 giving an overall 75 % compliance. Two external leaching tests were undertaken according to the monitoring schedule.

**Figure 2-2 Locations of leachate and water sampling points**

**Notes:** Based on drawing SLP 170620.tcw Dalgleish Associates
Positions of Bh D and Bh E in ***previous*** Environmental Monitoring Reports were plotted incorrectly.
Recommendations for a new Bh F are made in Section 2.3, page 16.

**Table 2.1 TRWM environmental monitoring compliance summary, 2022**

| | Number of locations | Frequency per year | Intended number per year | Actual number in year | % compliance |
|---|---|---|---|---|---|
| **Chemical analysis** | | | | | |
| **Wastes** | | | | | |
| Fresh IBA solids (Suez) | 1 | 4 | 4 (x2 sub-samples) | 4 | 100 |
| Matured IBA external CEN test | 1 | 2 | 2 | 2 | 100 |
| Matured IBA on-site eluate | 1 | 12 | 12 | 9 | 75 |
| **Leachates** | | | | | |
| Pad run-off, in sump | 1 | 12 | 12 | 10 | 83 |
| OTL landfill cells A-C | 3 (destroyed)[1] | 2 | no target | 0 | no target |
| NTL sump | 1 | 12[2] | 12 | 9 | 75 |
| **Groundwaters** | | | | | |
| OTL boreholes | 5 | 4[3] | 20 | 15 | 75 |
| NTL boreholes | 5 | 4 | 20 | 12 | 60 |
| **Surface waters** | | | | | |
| Santon Burn | 3[4] | 4 | 12 | 9 | 75 |
| Marine water samples | 3[5] | 4 | 12 | 3 | 25[6] |
| **Water level dips** | | | | | |
| OTL leachate wells A-C | 3 (destroyed) | 12 | no target | 0 | no target |
| NTL sump | 1[7] | 12 | 12 | 4 | 33[8] |
| OTL groundwater b/h | 5 | 4 | 20 | 20 | 100 |
| NTL groundwater b/h | 5 | 12[9] | 60 | 18 | 30[8] |
| **Flow rate, volume** | | | | | |
| Pad discharge | 1 | All discharges | 52[10] | 41[11] | 71 |
| NTL sump discharge | 1 | All discharges | | N/R | 100 |

**Notes to Table 2.1:**

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[1] *New sampling location for runoff from OTL Cell A*

[2] *NTL sump increased to monthly from 2015 onwards because not easy to sample actual discharge from NTL*

[3] *OTL GW done by government: 4 locations, one has upper and lower b/h, so five samples in all.*

[4] *Three locations: fissure discharge, upstream, downstream. Undertaken by Colas, at Government laboratory*

[5] *Comprise outfall, plus 1 north and 1 south location. [ Changed during 2014 from 2 north, 2 south]*

[6] *H&S of marine sampling protocol under review*

[7] *Changes to elevation of dipping point to ordnance datum needs to be maintained over time*

[8] *Additional monitoring probably undertaken, records inaccessible – see section 2, page 12*

[9] *Agreed that frequency of dipping should increase to monthly for period of at least 2 years following 2018 Environmental Monitoring Review meeting with Government on 21 May 2019*

[10] *Based on an average of at least one meter reading per week*

[11] *Number of meter readings taken in year*

## 2.2. Leachate quality monitoring

Leachate has been sampled at five locations, as shown in Table 2.1 and Figure 2.2. These correspond to the three sources that do, or could, contribute to the licensed discharge to the marine environment.

The two landfill sources, OTL and NTL, also have the potential to adversely affect groundwater quality directly, and thereby indirectly affect surface water quality via migration of groundwater. Therefore, their characterization as a source term is necessary. They are, or have been, sampled from sumps in each landfill – three (A, B and C) at OTL and one at NTL.

The third source, run-off from the maturation pad, is sampled from the collection tank into which it flows by gravity, prior to being pumped to discharge to sea. This is sampled monthly throughout the year.

The leachate from OTL landfill cells was sampled twice per year up to the end of 2016. No further samples have been obtained from wells A to C because they were destroyed during the large scale processing of the majority of ash present in OTL during 2017. An informal sump exists that intercepts surface water that collects in the northern part of OTL Cell A before it seeps through a surface drain onto the general Turkeyland site. This sump was sampled three times early in 2021, but thereafter was dry on each sampling occasion. The reasons causing the lack of sampling need further investigation, as the temporary sump may need some remediation work. There has been no abstraction and discharge of leachate from OTL. As a quantity of ash is to remain in OTL for an indeterminate period until the new cell is engineered, re-instatement of some more formal monitoring should be considered.

The leachate in the NTL landfill sump is sampled monthly, i.e. more frequently than was OTL leachate, because there is continuity with the groundwater and thereby the sea, and because NTL was abstracted routinely for discharge. In 2022, 9 samples were taken, giving 75% compliance. Since dewatering of the quarry stopped in August 2021 the ability to easily obtain pumped samples has been removed.

Table 2.1 shows the Maturation Pad run-off as having been sampled 10 times in 2022, giving 83% compliance.

## 2.3. Groundwater quality

The locations and screened depths of the OTL and NTL boreholes are shown in Table 2.2.

Groundwater at OTL is monitored via five boreholes. Two of these are at the same location but monitor different depth horizons (BH2 upper and lower). Inaccessible BH4 was replaced by a newly drilled well (BH4A) in December 2018, although the screened horizons are different.

A review[12] of groundwater monitoring infrastructure around OTL in July 2020 concluded there was a need for further groundwater monitoring boreholes to improve the spatial coverage of monitoring and to "*bring the level of monitoring around the site in line with UK guidance that aims to fulfil the requirement of the landfill directive*". The report made recommendations for new ground water monitoring points at four locations, one up the hydraulic gradient and three down the hydraulic gradient from the landfill. At most locations two vertically separate monitoring zones were recommended for installation.

It was also recommended that a more extensive suite of mainly organic pollutants are added to the routine monitoring suite of OTL ground water borehole samples. The monitoring should be kept under review and altered according to the quality of the source term when this is better characterised following landfilling in the proposed stable non-reactive hazardous waste landfill.

At NTL, groundwater was originally monitored in seven boreholes, two of which (originally named bh4 and bh8) became unserviceable between 1999 and 2007. A decision was taken after the 2013 review to re-name the NTL boreholes, to avoid confusion with identically named boreholes around OTL landfill. Old and new names are shown in Table 2.2. A further two boreholes (originally named bh5 and bh6) were abandoned during drilling. Two of the remaining five extant boreholes have piezometers installed at two different depths (boreholes A and B, original names bh6A and bh7 respectively). These are the two up-gradient boreholes. In late 2018 a new borehole (BH A2) was installed adjacent to NTL BH A, which was producing unreliable results when monitoring restarted in 2017. The screened horizons of BH A2 is at a higher elevation than the original BH A (Table 2.2 and Fig 1.4). Borehole D was lost during 2021 but was rediscovered under thick vegetation in 2023. At a similar time it was realised that the locations of Bhs D and E had been incorrectly plotted on Figure 2-2 in ***previous*** Environmental monitoring reports. Borehole E was incorrectly located on the NE corner of the site, and Borehole D was labelled as being in the actual position of Borehole E.

Other than BH A2 the screened horizons of the NTL groundwater monitoring wells are at an elevation of between -26 and -22 m OD and are not ideally located for picking up potential migration of any leachate. Although the risk of migration prior to 2020 was negligible due to the overall inward hydraulic gradient into NTL caused by the dewatering, this situation is starting to reverse as leachate levels in the site are allowed to reach their natural equilibrium. This increases the potential for migration to occur, according to the long term conceptual hydrogeological flow model for the site. It is ***recommended*** that new groundwater monitoring wells are installed down-gradient of the site with a monitoring response zone between approximately -5 m and +5 m OD. It is suggested that boreholes D and E should be redrilled and that a new borehole F is installed on the NE corner of the site as shown on Figure 2-2, page 14.

Monitoring of OTL groundwaters is undertaken by Government. For OTL groundwater boreholes, sampling is scheduled at quarterly intervals and this has generally occurred

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[12] University of Southampton (2020). Review of ground water monitoring in the context of proposed development of OTL as a stable non-reactive hazardous waste landfill. Consultant report to Turkeyland Recycling and Waste Management Ltd 14 July 2020

since installation in late 2005. In 2022 75% compliance was achieved with the monitoring schedule.

**Table 2.2 Details of groundwater monitoring boreholes at OTL and NTL landfills**

| Site and Borehole | Old name | Date installed | Easting | Northing | Ground elevation | Screened interval | Screened interval | Screen diameter (ID) | Casing material |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | mAOD | mbg | mAOD | mm | |
| | **OTL** | | | | | | | | |
| BH1 | | 2005 | 229493 | 469242 | 31.34 | 19-21 | 12.3 to 10.3 | | |
| BH2 upper | | 2005 | 229582 | 469412 | 31.95 | 5-7 | 26.95 to 24.95 | | |
| BH2 lower | | 2005 | 229582 | 469412 | 31.95 | 19-21 | 12.95 to 10.95 | | |
| BH3 | | 2005 | 229473 | 469563 | 27.05 | 24-26 | 3.05 to 1.05 | | |
| BH4 | | 2005 | 229351 | 469579 | 28.75 | 18-20 | 10.75 to 8.75 | | |
| BH4a | RBH02[3] | 2018 | 229355 | 469570 | 27.24 | 6-30 | 21.24 to -2.76 | 50 | hdpe |
| | **NTL** | | | | | | | | |
| A | BH6A | 1999 | 229428 | 469110 | 29.35 | | -22.15 to -25.65 | 50 | hdpe |
| | | | | | | | 27.35 to -4.65 | 19 | hdpe |
| A2 | RBH01[3] | 2018 | 229423 | 469103 | 28.89 | | 13.39 to -1.11 | 50 | hdpe |
| B | BH7 | 1999 | 229374 | 469004 | 25.85 | | -22.15 to -25.65 | 50 | hdpe |
| | | | | | | | 23.85 to 3.35 | 19 | hdpe |
| C | BH2 | 1999 | 229480 | 468824 | 13.82 | | -22.68 to -26.18 | 50 | hdpe |
| D | BH1 | 1999 | 229543 | 468847 | 13.44 | | -22.06 to -25.56 | 50 | hdpe |
| E | BH3 | 1999 | 229588 | 468883 | 14.00 | | -21.5 to -26.0 | 50 | hdpe |

**Notes**

1. OTL borehole details taken from column headers in Government spreadsheet of groundwater monitoring data for OTL.
2. NTL borehole details are taken from original borehole logs and from MJ Carter report, IOM/TQ/DH/1057/02, March 2000, prepared for Department of Local Government and Environment. The ‘old’ borehole names are those used in the logs. The ‘new’ names have been applied to avoid any confusion between OTL boreholes and NTL boreholes.
3. Driller’s log Bh name.

For NTL, no groundwater sampling or level monitoring was undertaken from 2007 until late in 2016. Sampling was reinstated in 2017.

In 2022 60% compliance was achieved with the monitoring schedule for NTL groundwater quality.

## 2.4. Surface water quality

Santon Burn passes ~200m to the east of OTL landfill and the Maturation Pad, and discharges to sea a further ~200m downstream to the south east. It is monitored for two reasons:

(i) The direction of groundwater movement around OTL could take potentially contaminated groundwater eastwards towards Santon Burn, where it could discharge into the burn.

(ii) There is a discharge of surface drainage from the Kniveton block-making complex via fissures in the bedrock into Santon Burn at a location ~350m to the north east of the complex. It is possible that this discharge could become contaminated by IBA leachate or overflow of run-off from the maturation pad, and thereby affect water quality in Santon Burn.

Quality in the burn is currently monitored at quarterly intervals by the Government laboratory at three locations. Two are upstream and downstream of the surface water discharge and one is at the point where the fissure discharges into the burn. There was 75% compliance with the programme in 2022.

Inshore marine waters are monitored at quarterly intervals by Colas, at three locations: level with the outfall of the combined Pad/NTL discharge, and at locations 50m north and 50m south of the outfall. In 2022 only 25% compliance was achieved for the taking of marine water samples as there were health and safety concerns raised around the safety of obtaining these samples. ***It is recommended that*** the monitoring protocol for taking marine samples is altered to address these concerns.

## 2.5. Leachate and groundwater levels; leachate volumes

Leachate levels were historically monitored each month in OTL landfill up to the end of 2016, in order to track short term, seasonal and long term accumulation or loss of leachate and to be able to compare leachate elevations with those of the surrounding groundwater. This was necessary in order to be able to assess the potential risk to groundwater quality and the potential for ingress of groundwater into the landfills. The programme could not be implemented in 2017 due to the destruction of the monitoring wells and inaccessibility to OTL during the re-processing of IBA by Meldgaard. No leachate monitoring points have been reinstated even though Meldgaard did not remove all the IBA from OTL. A makeshift monitoring sump has been installed in the area of Cell A, and 3 samples were obtained and analysed during the first quarter of 2021; thereafter the sump was dry on all sampling occasions. It is ***recommended*** that the reasons for the sump being dry are investigated and that regular monitoring of quality continues from this sump as long as some IBA remains in OTL.

Level monitoring is also an intended requirement for NTL landfill. Following recommendations in the 2018 annual monitoring review two large diameter (1.2 metres) concrete stacking pipes were installed into inert infill adjacent to the open body of water from which pumping occurs to keep NTL dewatered. The pipes, perforated with approximately twenty 50mm diameter holes per metre length, are wrapped in a geotextile material to stop the ingress of silts into the pipes. Since dewatering of NTL stopped in August 2021 these sumps have been used to monitoring leachate level and quality from the inert part of NTL. The **elevation (to ordnance datum) and location (for plotting on plans) of each point needs to be obtained through regular surveying**, and a record maintained of how these elevations change through time as the chambers are raised. Finally it is ***recommended*** that at least one, preferably two at least 30 m apart, additional dedicated leachate monitoring points in the IBA are installed further to the north west. The monitoring of leachate level and quality from the IBA part of the site will be important for characterising leachate flow and the source term of IBA leachate in NTL. See also s4.3.

Groundwater levels around OTL are monitored at the time of their quarterly sampling, to be able to understand the likely direction of groundwater movement, the relationship between leachate and groundwater levels, and to monitor any evidence of a change in the groundwater regime that could increase or decrease any potential risk to water quality

In 2022 50% compliance was achieved with the monitoring schedule.

At NTL monitoring of groundwater levels should normally occur at the same time as sampling, and from May 2019 following a recommendation in the 2018 annual monitoring review, levels were to be obtained monthly. The relationship between ground water levels around NTL and the level of leachate in the site will become more important as leachate levels in NTL are allowed to rise, reversing the hydraulic gradient into the site. This has now started to happen.

The total number of water levels reported from NTL boreholes in 2022 gives a compliance rate of 13%. This is probably a reflection of the inaccessibility of the monitoring records rather than the monitoring not being undertaken.

The volumes of the consented discharges to the sea outfall are monitored in order to ensure compliance with the consent limits and to help assess any impact on marine water quality. From 2015 onwards flowmeters for the pad discharge and the NTL sump have been in place and hours run for the respective pumps are also recorded.

For the ***Pad discharge***, no metered flow data were recorded from August to December 2015 and meter values obtained for 2016 were not regarded as reliable, due to software problems, despite repeated attempts to rectify these. Flow estimates for these periods are based on hours run. An impeller flowmeter was installed in this discharge line early in 2017 and was operational from 20th March 2017, as back-up to the ultra-sonic flowmeter and associated software. During 2022 41 meter readings were recorded and the opportunity was taken to correct the recorded readings for 2021.

For the ***NTL landfill discharge***, flow is metered by a mechanical in-line impeller totaliser. The times and duration of all discharges has also been recorded. A record of all discharges has been obtained until pumping stopped on 6 August 2021.

No flow monitoring from NTL landfill took place in 2022 because there was no pumped discharge.

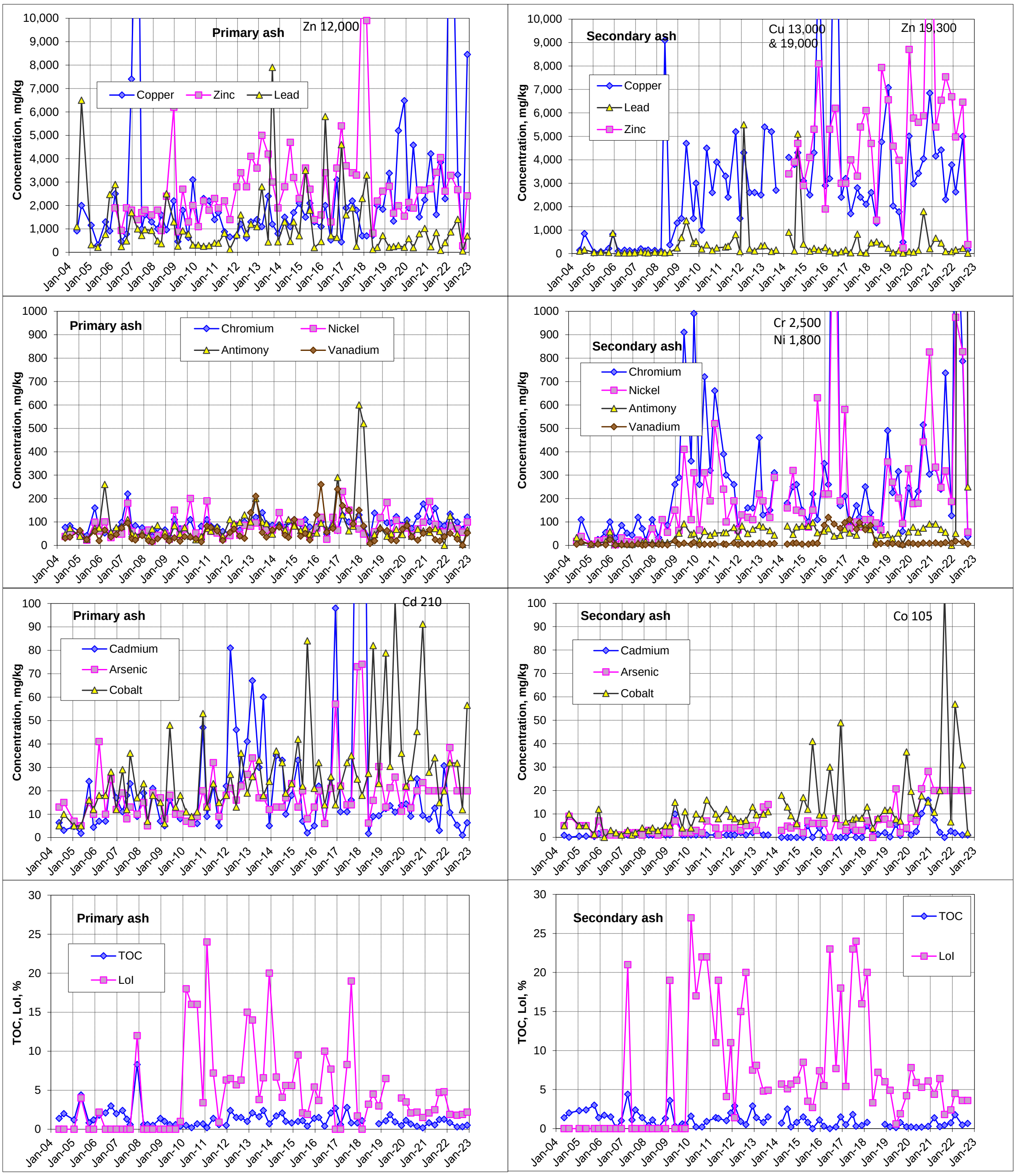
No flow monitoring from OTL landfill took place in 2022 because there was no pumped discharge.

# 3. Waste characterization

## 3.1. Solid IBA analysis results

The analyses of solid IBA samples from the EfW plant received from Suez up to the end of 2022 are shown as time series graphs for key determinands in Figure 3.1.

**Figure 3-1 Time series graphs of analyses of Richmond Hill EfW bottom ash solids**



The EfW plant has two combustion lines The Primary line has a capacity of ~70,000t/a, receives the bulk of the Island's wastes and is able to accommodate discarded tyres. The Secondary line has only ~5,000t/a capacity, and is designed to accommodate clinical, animal and oil wastes. Waste inputs are believed to be ~250t/a of clinical waste, although actual throughput data for each line has not been provided. Data are shown separately in Figure 3.1 for each combustion line. In late 2022 the operation of the secondary incinerator was altered. "Yellow" bag clinical wastes are now sent to the primary line, whereas clinical sharp wastes are stockpiled and processed in the secondary line as a batch process every ~6 months. The overall composition of IBA received at Turkeyland will be dominated by the much larger primary line. APCR (air pollution control residues) are also analysed but as these are not sent to Turkeyland for disposal, these data are not included in this review.

Figure 3.1 shows that both sources of IBA have undergone some significant fluctuations and some longer lasting changes in bulk composition since the evaluation work in 2007-08 (wheelie bin tests etc.) on which the processing facility at OTL was based. Aspects of particular note are:

- Loss on ignition (LoI) has been elevated in both sources since ~2010, reaching as high as 25%. If genuine, this high unburnt organic content could lead to significant biological activity, which would be expected to contribute increased COD in the leachate, possibly lead to lower pH due to acid formation, and possibly create soluble complexing ligands that could increase metal leaching. In contrast to LoI, total organic carbon (TOC) data have not risen, and are consistent with LoI values of <5%. Therefore one or other of the test methods appears unreliable. It is possible that calcination of slaked lime [$Ca(OH)_2$] during the test may contribute to elevated LoI results but is unlikely to account for all of the discrepancy. Previous reviews have ***recommended*** that the inconsistency between TOC and LoI data be investigated, via Government. This recommendation is re-iterated.

- In the Primary ash, the elevated concentration of zinc and cadmium noted in the December 2017 and February 2018 samples were not replicated in any of the samples in 2022.

- Significant increases in concentrations of copper and cobalt in the Primary ash were noted in the last two samples of 2019 leading to the highest average annual concentration for Co (in 2019) with Cu also being the highest since 2007. The data for 2020 and 2021 showed considerable variations in concentrations for both metals, with average concentration of copper falling across both years. This trend is reversed in 2022 caused by a peak of 19,000 mg/kg from the Q2 sample and 8,450 mg/kg in Q4. There does not appear to be any direct correlation between concentrations of Cu and Co. It is not known the cause for these high values.

- Average concentrations of zinc in the Primary ash, which were slightly increased in 2021, reduced to below the historical average in 2022.

- The elevated concentrations of copper has reversed previously seen trends in the Primary ash, where zinc > copper ≈ lead were the dominant metals, followed by Ni, Cr, Sb and V. In 2019 copper > zinc > lead followed by Ni = Cr, Co = Sb and V. In 2021and 2022 copper > zinc> lead followed by Cr>N>Sb, and V>Co.

- In the Secondary ash, large increases occurred in some metals from ~2008/09 onwards, which have generally persisted: Cu, Ni, Cr, Sb and Co have all increased, and possibly Zn. Cu, Ni and Cr have often been at significantly higher concentrations than in the Primary ash. Two metals in particular – Zn and Cu – reached noticeably high concentrations in 2016, with copper reaching 1.3% and 1.9%, and zinc ~0.8%.

- The average 2022 concentrations of Zn and Cu are similar to the average values since 2016.

- Since 2019 there has been an upward trend in the secondary bottom ash concentrations of nickel and chromium. The previously high concentrations of cobalt in the August 2021 reduced during the course of 2022. The concentrations of all three of these metals vary considerably from sample to sample. It is not known which waste streams cause these high levels of certain metals in the Secondary ash.

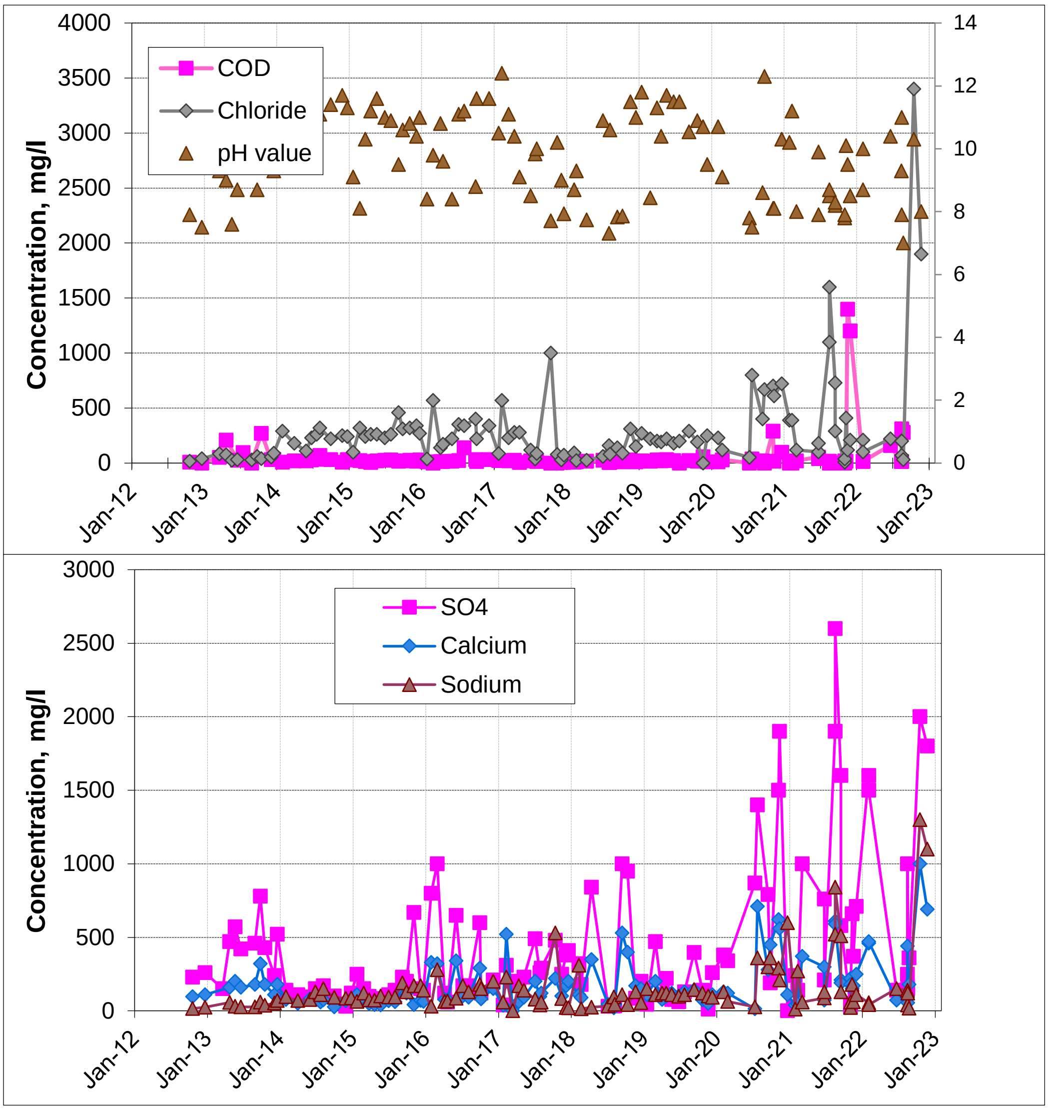
Whilst it remains important to monitor for changes in the bulk composition of the IBA there is not necessarily a direct correlation between heavy metal abundance in the ash and their concentrations in leachate: this is because their concentrations in leachate are usually limited by their solubility at the prevailing pH conditions and chemical environment, not by their abundance.

## 3.2. Leaching test results

Results for LS10 eluate concentrations from on-site leaching tests at the maturation facility are tabulated in full in Appendix 4. Results for selected parameters are shown as time series graphs in Figures 3.2, to 3.5 as follows:

| | |
|---|---|
| Figure 3.2 | Major ions and pH value |
| Figure 3.3 | Heavy metals (linear concentration scale) |
| Figure 3.4 | Heavy metals (logarithmic concentration scale) |
| Figure 3.5 | Additional heavy metals (logarithmic scale) |

**Figure 3-2 Results for major ions in LS10 eluates from on-site tests on matured OTL IBA**



The major ions are dominated by chloride, sodium, sulphate and calcium:

- The last 2 samples in 2022 indicate significantly elevated concentrations of chloride, sodium and EC (not graphed). This coincided with a change in monitoring personnel undertaking the on-site leachate tests, and it is possible these elevated results were from an incorrect interpretation of the “laboratory” procedure. ***It is recommended that*** Colas reviews their internal procedures and undertakes staff training where appropriate.

- The pH values from samples in 2022 varied considerably in the range pH 6.9 to pH 11.2 in the onsite leach tests, which is slightly less than historical variations. The pH of samples is a good indicator of the extent to which the maturation process has progressed. Elevated pH may indicate that sampling is not occurring from windrows that have had sufficient maturation time, or that the windrows would benefit from more active turning to allow better access of atmospheric $CO_2$ to the core of the pile. A ***recommendation*** from the 2018 monitoring report was that the sampling methodology is reviewed to ensure that the oldest windrow on the pad is routinely the one being analysed and that the approximate age of the windrow is recorded at the time of sampling. During 2021 samples were always taken from the oldest windrow on the pad and 4 sets of samples were taken at the same time from both the outer surface of the windrow (to match previous practice) and from within the core of the windrow. The difference in pH units from pairs of samples varied between 0.5 and 2 pH units, with the inner sample always having a higher pH. There were some differences in leaching characteristics, but further analysis is required to assess the significance within the historical variations seen.

- Calcium and sulphate continued similar to recent years, fluctuating largely and showing a general inverse relationship with pH. The last two samples of 2022 lie outside this historical trend. Ca and $SO_4$ concentrations are strongly correlated with each other, consistent with their being derived from dissolution of $CaSO_4$.

- Similar to the August 2021 samples where distinctive peaks of selenium and molybdenum correlated with high sulphate and chloride concentrations, the last two samples of 2022 repeat this trend.

For the heavy metals, the linear scale in Figure 3-3 is most helpful for Mo, Se and Hg, while the logarithmic scale in Figure 3-4 is more helpful for remaining metals.

Large concentration peaks for heavy metals during 2013 into early 2014 may be disregarded due an analytical error discussed in the 2013 report.

Previous monitoring reports show that data from the site eluate tests follow a similar trend to those obtained from the formal CEN leaching test, replaced in 2021 with a standard WAC test. The early data validates the site test as a suitable alternative to the CEN test. Good correlation has been maintained between the site eluate tests and the WAC tests.

However, for chromium, results between early 2015 and early 2018 have shown a significant difference between the two, with the CEN test leading to approximately an order of magnitude higher concentrations. Although formal CEN leaching tests undertaken (one in 2018, three in 2019 and one in 2020) yielded much closer results for the two methods, the WAC test results from 2021 and the one result from 2022 again indicate that this is an area for ongoing concern.

**Figure 3-3** LS10 Eluate metal concentrations from on-site and external leaching tests [concentrations are shown on linear scales; period of unreliable laboratory data shaded]

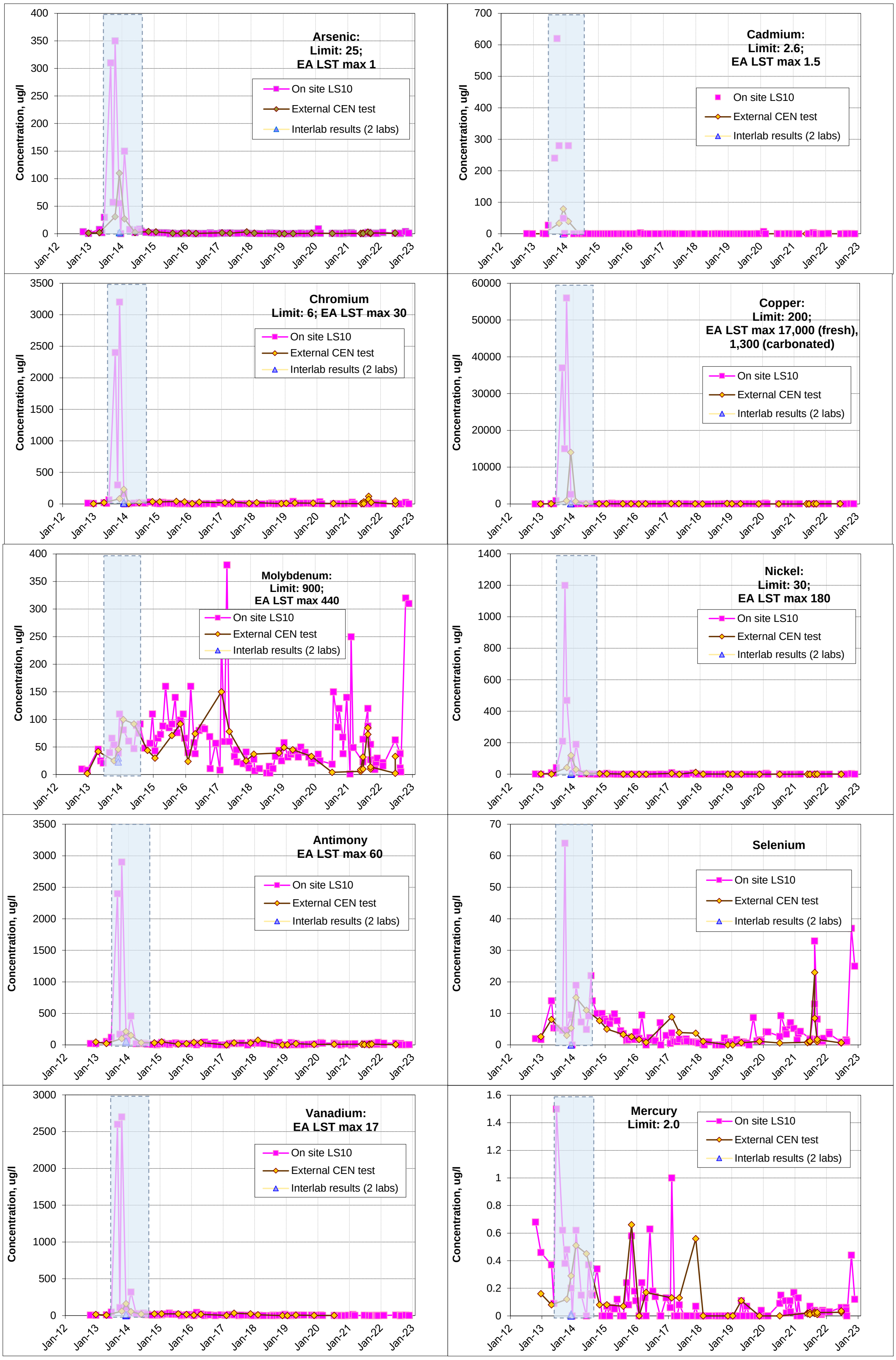


Figure 3-4 LS10 Eluate metal concentrations from on-site and external leaching tests [concentrations are shown on log scales; period of unreliable laboratory data shaded]

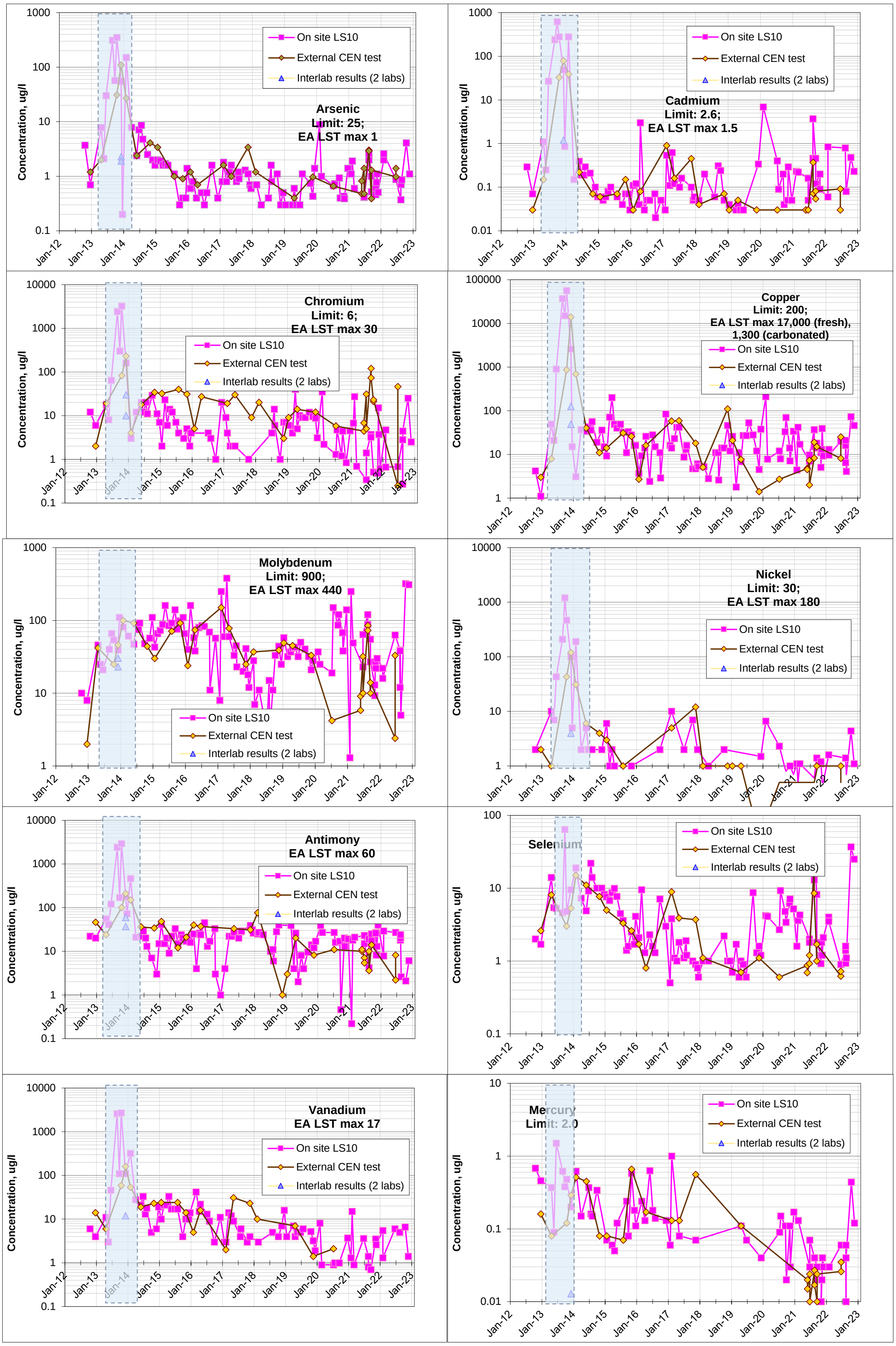
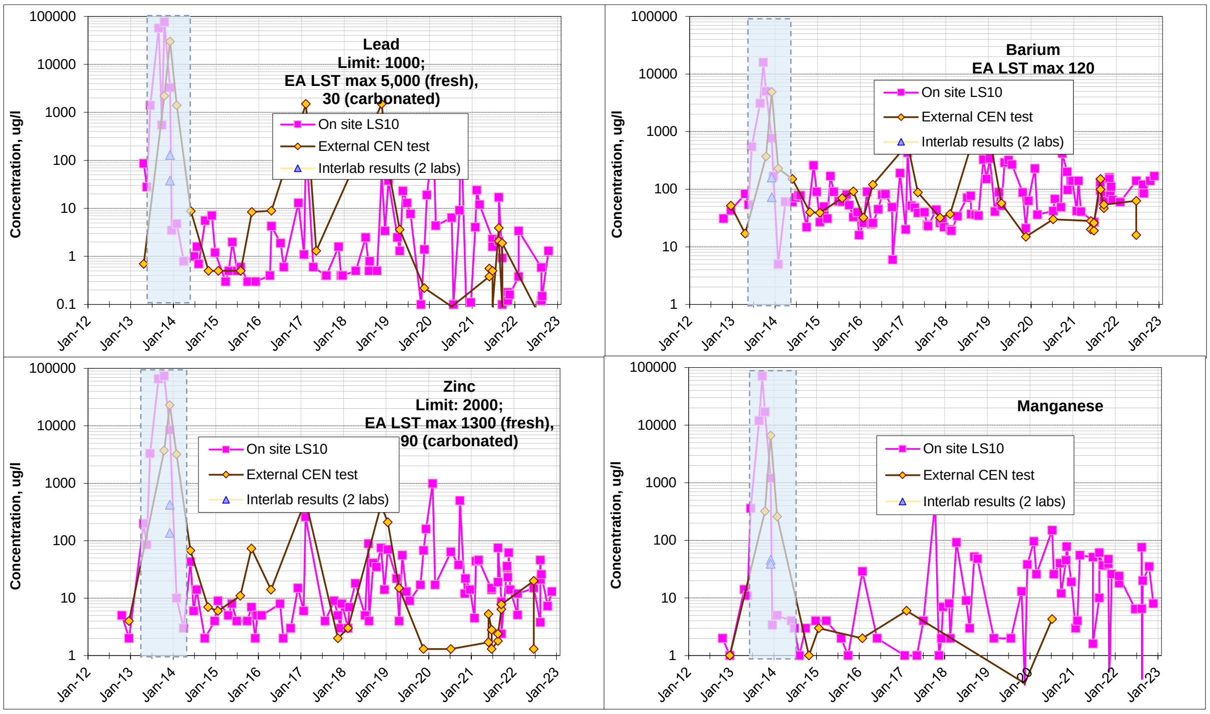


**Figure 3-5 Additional LS10 eluate results from leaching tests: Pb, Zn, Ba and Mn**



The on-site and CEN test eluates have sometimes had very different pH values, and this may account for some of the differences in metals concentrations.

There is an inherent difficulty in taking representative samples from a fairly heterogeneous material. This is more likely to affect the WAC test, which uses a 100g sample, than the on-site test, which uses 1 to 2 kg.

Other than the last two samples of 2022 that showed atypical peaks in many parameters, on-site eluate tests show concentrations remaining within the range of previously seen values for each element.

Therefore, overall, the 2022 results show no evidence of a significant change in leaching behaviour of the IBA.

# 4. Leachate source term quality results

Tabulated results for all parameters analysed are included in Appendix 4. Time series graphs for major ions, COD, BOD and heavy metals are shown in Figures 4.1 to 4.4 as follows:

Figure 4.1 Major ions, BOD and COD in OTL Cell A leachate

Figure 4.2 to 4.4 Heavy metals in OTL Cell A, B and C leachates

Figure 4.5 Major ions and heavy metals in Pad sump leachate

Figure 4.6 Major ions and heavy metals in NTL sump leachate

Representative summary values from these time series graphs are shown in Table 4.1 where they are compared with the leachate concentrations predicted from evaluation studies, as used in the application for the discharge licence.

**Table 4.1 Comparison of Turkeyland leachates in 2022 with predicted concentrations**

| | Predicted $C_0$, PDF 'most likely' | OTL Cell A initial 2009/10 | OTL Cell A pre-2016 | OTL Cell A 2020 | Colas Discharge limit µg/l | Pad sump 2022 | NTL sump 2022 |
|---|---|---|---|---|---|---|---|
| Sodium (mg/l) | 1400 | 2700 | 1000 | 107<br>(73-220) | | 130<br>(29-410) | 271 |
| Potassium (mg/l) | 1000 | 1700 | 500 | 50<br>(29-88) | | 74<br>(20-250) | 54 |
| Calcium (mg/l) | 1400 | | 20 | 34<br>(4-140) | | 51<br>(30-93) | 378 |
| Magnesium (mg/l) | <1 | <5 | <2 | <2 | | 7 | 81 |
| Chloride (mg/l) | 3200 | 5000 | 1000 | 58<br>(19-130) | | 220<br>(34-830) | 940<br>(320-4100) |
| sulphate, as $SO_4$ (mg/l) | 2400 | 2200 | 1000 | 134<br>(66-220) | | 183<br>(43-390) | 2270<br>(920-12000) |
| Alkalinity (mg/l) | 1100 | | 200 | 109<br>(30-160) | | 214 | 521<br>(340-1000) |
| Conductivity (µS/cm) | 18000 | 12000 | 4000 | 894<br>(552-1880) | | 1261 | 3909<br>(3480-4400) |
| COD (mg/l) | 400 | >500 | 80 | 36 | | 187 | 241<br>(20-1400) |
| As (µg/l) | 20 | 20 - 80 | 10 - 30 | 0.8<br>(0.3-2.3) | 25 | 2.2<br>(1.8-3.6) | 3.2<br>(0.7– 8.8) |
| Cd (µg/l) | 2.3 | 2 - 4 | ~0.5 | <0.03 | 2.6 | 0.1<br>(0.05 – 0.15) | 0.06<br>(0.04 – 0.07) |
| Sb (µg/l) | 4 | 20 - 40 | 30 -50 | 5<br>(2-14) | | 10<br>(4-25) | 0.6<br>(0.27 – 1.0) |
| Pb (µg/l) | 440 | 15 | 1 - 8 | <0.9 | 1000 | 0.3 | 0.31<br>(0.13 – 0.5) |
| Zn, Total (µg/l) | 900 | 35 | 30 | 12<br>(3-31) | 2000 | 273<br>(31-1400) | 42<br>(6 – 160) |
| Zn, dissolved (µg/l) | | | | | | 18 | 22<br>(4-45) |
| Ni (µg/l) | 20 | 40 - 100 | 10 - 80 | 1.2<br>(0.5-2) | 30 | 1.4<br>(0.6-2.5) | 27<br>(17 – 41) |
| Mo (µg/l) | 850 | 500 - 900 | 350 | 22<br>(8-75) | 900 | 30<br>(7-100) | 14<br>(8 – 19) |
| Cu (µg/l) | 125 | 100 - 200 | 100 | 6<br>(2-22) | 200 | 17<br>(10-37) | 2.5<br>(0.7-3.4) |
| Se (µg/l) | 80 | 100 - 300 | 5 - 50 | 1<br>(<0.25–2.3) | | 1.1 | 0.8<br>(0.3 – 1.3) |
| Cr (µg/l) | 3.6 | 6 - 8 | 0 - 7 | < 1<br>(dt – 0.5) | 6 | 8<br>(1.8-22) | 3.1<br>(0.3– 7.2) |
| Hg (µg/l) | 1.4 | 3.3 | 2.3 | <0.3 | 2 | 0.03<br>(0.01-0.12) | 0.01 |

Highlighted yellow values exceed discharge consent limits, blue values the predicted $C_0$ values.

Predicted $C_o$ values in Table 4.1 were from log-triangular Probability Density Functions (PDF) derived from test results, and show the most likely values from these predictions. The values chosen were from either fresh or matured ash, whichever was the greater for each parameter.[16]

## 4.1. OTL cell leachates (Table 4.1; Figures 4.1 to 4.4)

In OTL, the first samples were taken from Cell A, in 2009, approximately 5 years after deposit of IBA started. Landfilling in Cells B and C began several years later, continuing up to 2012; the first samples from Cells B and C were taken in October 2013 and the last in 2016. No samples were obtained from monitoring wells within the IBA of Cells A to C since 2017, although surface water drainage containing seepages from Cell A were captured in a new monitoring sump. The following discussion maintains a record of previously collected data.

The following observations can be made on the initial and recent composition of OTL leachates:

- The ionic strength and composition, together with COD, were similar in 2009/10 in Cell A to the values predicted from the 2007-08 evaluation study.

- Subsequently, major ion strength declined by more than 50% in Cell A, most likely as a result of flushing by infiltrating rainfall through the uncapped surface. A decline is also evident in the limited data set for Cells B and C, suggesting they underwent a similar flushing. All three had similar major ion composition by 2016, at approximately 30-50% of predicted. The 2017 sample indicates a continuing further dilution.

- COD has also declined, by at least as much as the major ions, the 2017 sample being only 23mg/l.

- The first samples showed most of the heavy metals to be present at similar to, or occasionally higher than, predicted concentrations, the most notable elevation above expectation being antimony, Sb. In contrast, Pb and Zn were far lower than predicted.

- In the years since 2009/10, concentrations of several of the heavy metals have fallen considerably in Cell A e.g. As, Cd, Cr, Cu, Ni and Se, to well below predictions. Pb and Zn remain also far lower than predicted but relatively unchanged over the years, despite the dilution of major ions. For Mo and Sb, concentrations have varied over a wide range and there is no clear trend.

- Up to 2016 metals concentrations in Cells B and C were generally at similar levels to those in Cell A.

- pH values of the cell leachates have been alkaline, as expected for ash, but have spanned a wide range, from ~8 to ~12 and showed no discernible trend with time.

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[16] See Knox Associates spreadsheet *‘Values for discharge application.xls’*

- There were no samples of OTL leachates taken directly from any monitoring point within the IBA since 2019. However, a temporary sump in the base of Cell A collects runoff and base flow arising from the residual IBA before it leaves the site under gravity drainage and provides an indication of the source term. A total of 7 samples were taken in 2020, and results have been plotted on Figures 4.1 and 4.2. Only 3 samples were taken in the first quarter of 2021 with the temporary sump being reported as being dry on each subsequent sampling occasion. There were no samples taken in 2022.

- The recent samples reflect an ongoing decline in major ionic strength. Previously seen superimposed seasonal effects were less apparent in 2020. Mo, Cr, Ni and Sb were all detected at concentrations well below the original source term values. It is noted that runoff from Cell A is not part of the formal consented discharge from the site, but nevertheless concentrations are all well below the Colas discharge limits where set. It is ***recommended*** that a more formalised arrangement is made to deal with the contaminated runoff from OTL landfills.

## 4.2. Pad sump leachate (Table 4.1; Figure 4-5)

Historically, the Pad sump samples were only analysed for the metals that are limited in the discharge licence. This was changed after the 2015 review, and a more comprehensive analysis suite was used from April 2016 onwards.

- Major ion strength in the Pad run-off during 2022 averaged ~3.5-25% of predicted leachate strength (as indicated in Table 4.1, $C_o$) for all parameters other than magnesium (discussed below). Maximum concentrations of major ions (other than Mg) were at most 55 % of the predicted $C_0$ strength. This variability is likely to reflect the patterns of rainfall and run-off generation. Magnesium concentrations averaged 7 mg/l (down from 47 mg/l in 2021) and is greater than the predicted $C_0$ concentration of less than 1 mg/l, as has been reported in recent Environmental monitoring reviews. The absolute concentration of magnesium has no cause for environmental concern as a discharge to the sea, but the reason for the increase needs to be understood. The eluate and CEN leaching tests show no increase in Mg concentration at LS:10 indicating that there is no change in the composition of the ash. It is possible that the source of this Mg is from percolation into and runoff from the temporary storage of contaminated harbour silts.

- 2022 pH values in the pad leachate have been alkaline averaging a pH value of 7.7 with a maximum value of 8.6. This is very similar to previous years

- The observed range of ~<5% to ~55% of predicted leachate strength compares with a range of 25% (high rainfall) to 100% (low rainfall) used in predictions for the Pad discharge application.

- The average total suspended solids (TSS) concentrations (not graphed) was 139 mg/l (down from 1500 mg/l in 2021). 2 out of 9 samples exceeded the discharge licence limit of 100 mg/l. However, as samples are taken manually from the sump, TSS may be affected by the level of water in the cell at the time of sampling and the amount of disturbance caused and may not reflect concentrations actually discharged. It is ***recommended*** that the sampling methodology for the sump is reviewed.

- Heavy metal concentrations in the Pad run-off are not always pro rata with the major ions, being also affected by solubility, which is often pH dependent. Heavy metal concentrations may be evaluated as follows:
- Maximum in Pad leachate, ***compared with the predicted $C_o$ values*** (Table 4.1):

| | |
|---|---|
| Lower: | As, Cd, Pb, Zn (dissolved), Ni, Se, Cu, Mo, Hg |
| Same: | None |
| Higher: | Sb, Cr |
| | |

Average concentrations in Pad leachate ***compared with discharge limits***:

| | |
|---|---|
| Very much lower (>x10): | As, Cd, Mo, Pb, Zn (dissolved) |
| Lower: | Zn (Total), Cu, Ni, Hg |
| Similar: | None |
| Higher: | Cr |

- Thus, the majority of heavy metals are at lower concentrations than predicted and consistently below their discharge limits.

- The under-prediction of Sb concentrations in the original Colas lysimeter studies is matched by the OTL leachate results, which also consistently exceeded the predicted $C_o$ for Sb.
- In contrast, the under-prediction of Cr concentrations in the Pad run-off appears anomalous: the OTL cell leachates had similar Cr concentrations to the predicted $C_o$ strength (Table 4.1).
- The consequence of the higher than predicted Cr concentrations is that it consistently exceeds the discharge limit for this metal.
- Chromium is the only substance for which the discharge limit is consistently exceeded.
- Most metals show no trend with time, although there is evidence of some seasonal variation presumably related to dilution.

## 4.3. NTL sump leachate (Table 4.1; Figure 4.6)

- Dewatering activities in NTL stopped on 6th August 2021. Samples taken subsequent to this date were from the NTL monitoring sump. Samples were obtained by a bailer. It is ***recommended*** that future samples are recovered using a borehole pump and that ~ 3 x the bore volume of the sump is removed prior to sampling. Since the sumps are constructed from large diameter (1.2 metres) concrete stacking pipes the volume of water that needs to be removed prior to sampling is considerable. As an indication, a 5-metre saturated depth would require pumping of ~17,000 Litres, and a pump rated at approximately 5m$^3$ /hr (1.4 L/sec) is likely to be needed.

- Previous reviews identified that major ion concentrations had declined during 2013 and 2014 and then remained relatively unchanging since late 2014 at ~25% of their concentrations in the predicted leachate source term. It also identified that the discharge had a relatively high magnesium content, with a Na:Mg ratio of 4.6:1, whereas Mg is virtually absent in the IBA leachate. The ratio of Na:Mg in seawater is 8.2:1, with Na concentrations in seawater ~10,200 mg/l.[17]

- It was therefore inferred that the water was predominantly affected by a mixture of seawater, groundwater and leaching from other wastes, with only a minor contribution from ash leaching. A seawater contribution was consistent with the fractured nature of the local limestone and the water level in the sump typically being at or below mean sea level. However, with average Na concentrations being less than 400 mg/l in 2019, less than 250 mg/l in 2020, and less than 200 mg/l in 2021 the predominant source of the NTL leachate was probably from groundwater entering the quarry as a result of the ongoing dewatering. The average Na concentration in 2022 was 271 mg/l and this continues to support this conceptual model.

  The pH of the leachate samples averaged 7.4 with a range from 7.2 to 7.5. A sulphate concentration of 12,000 mg/l was recorded for the sample taken on 13 December 2022. As this is approximately an order of magnitude higher than sulphate in both seawater and from IBA leaching tests, this is assumed to be a laboratory dilution error.

- During the period in 2021 when NTL was being dewatered (prior to August 2021) heavy metals concentrations, including chromium, remained well below discharge limits and within previously seen variations.

- Since the cessation of dewatering there is some limited evidence in an upward trend in certain metals, particularly nickel. Concentrations of nickel exceeded the discharge consent limit of 30 $\mu$g/l at the end of 2021 with a general upward trend continuing into 2022, although no pumped discharges were made. The concentrations of nickel are higher than from the eluate tests on processed IBA, so it is unlikely that IBA is the cause of these increases. Pumped samples from the existing NTL monitoring sump are required to help confirm whether this is a real upward trend.

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[17] It is also noted that seawater has elevated concentrations of Br and Sr, which are currently not included in routine analyses of leachates and groundwaters. See also Table 7.1 Typical chemistry of seawater

Following the installation of new pumping sumps in the area of NTL used for disposal of inert wastes, it is **recommended** that at least one (preferably two, at least 30 m apart) dedicated leachate monitoring point(s) are installed in the IBA waste zone of NTL landfill. As the rate of groundwater and seawater flow into NTL diminishes, in response to the cessation of dewatering and rising leachate levels, it is anticipated that the quality of leachate samples will become less dominated by the external inputs and be more representative of the "source" term in the site, whether this is from "inert" wastes or IBA. This information is essential to 1) help verify the predicted $C_0$ leachate strength (Table 4.1) used in the hydrogeological risk assessment and 2) help establish whether there are any potential issues with biodegradability of any wastes deposited in the inert part of the site. All monitoring points should be monitored routinely for leachate level (monthly) and quality (at least quarterly) throughout the year. Whilst there is no pumped discharge to the sea outfall there is less need for monthly leachate samples from NTL. However establishing a better record of leachate quality from the inert and IBA areas of the site is critical, and bi-monthly sampling (6 per year) is ***recommended*** from all monitoring points until a baseline record is generated **and** leachate levels in the site have stabilised to their natural "*in equilibrium*" levels. Thereafter sampling could revert to quarterly.

## 4.4. pH values in leachates

The pH values are included in Figures 4.2 to 4.4 and may be summarized as follows, with a comparison of the on-site eluates from matured ash:

| Location | pH range | pH mean | comment |
|---|---|---|---|
| On site eluate tests | 7.5 – 12.3 | 9.1 | More alkaline in CEN 2020 tests |
| OTL Cells (historic) | 7.1 – 12.6 | 10.0 | Cell A shows large fluctuations |
| Pad sump | 6.6 – 8.6 | 7.7 | All values in 2022 were below 8.6 |
| NTL sump (up to 2016) | 7.1 – 8.3 | 8.0 | Most values in narrow range 7.6-8.3 |
| NTL sump 2017 | 7.6 – 8.6<br>(+10.4, 11.1) | 7.9<br>(8.4) | Mean and range excluding outliers<br>Including outliers |
| NTL sump 2018 | 7.1 – 8.3 | 7.7 | Limited evidence of IBA influence |
| NTL sump 2019 | 7.4 – 7.9. | 7.6 | Limited evidence of IBA influence |
| NTL sump 2020 | 7.0 – 7.8 | 7.3 | Limited evidence of IBA influence |
| NTL sump 2021 | 7.1 – 8.1 | 7.6 | Limited evidence of IBA influence |
| NTL sump 2022 | 7.2 – 7.5 | 7.4 | Limited evidence of IBA influence |

The results show a gradation of pH values, which may be expected to affect some heavy metal concentrations. The eluate tests have exhibited consistently the most strongly alkaline pH values, followed by the OTL Cell leachates. The Pad sump has lower pH values but still consistently alkaline and clearly affected to a degree by the alkaline nature of the ash. In the NTL sump, results up to 2016 had little clear evidence of being affected by leachate from IBA, but 2017 results included at least two occasions when there was clearly an impact from IBA leachate. In 2018 through to 2022, the evidence is that there is still an influence of IBA on the NTL leachate quality, as expected, but this was more diluted than in 2017.

**Figure 4-1 Time trend of major ions, COD and BOD in OTL cell leachate samples**

NO SAMPLES FROM OTL LMP A in 2022

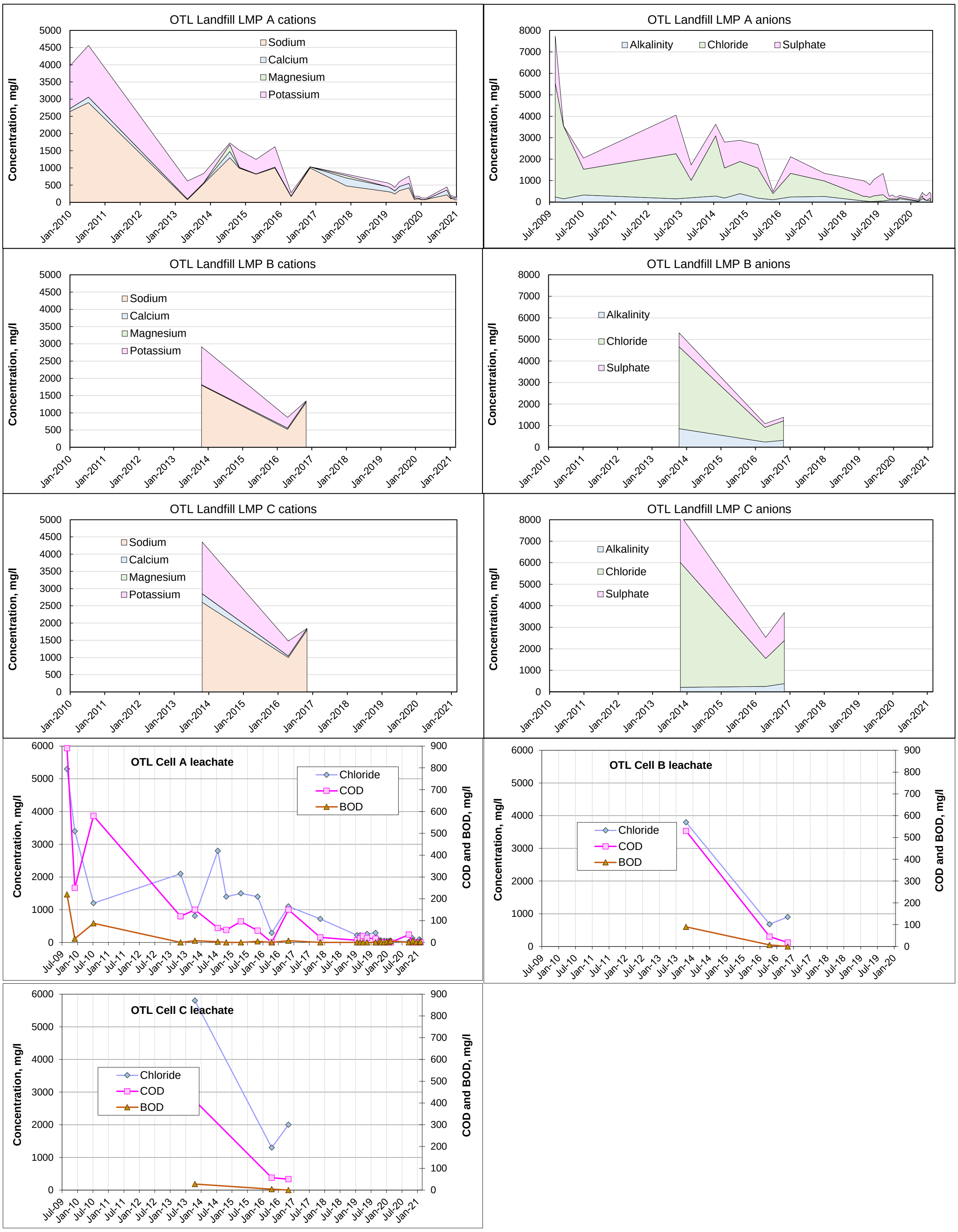
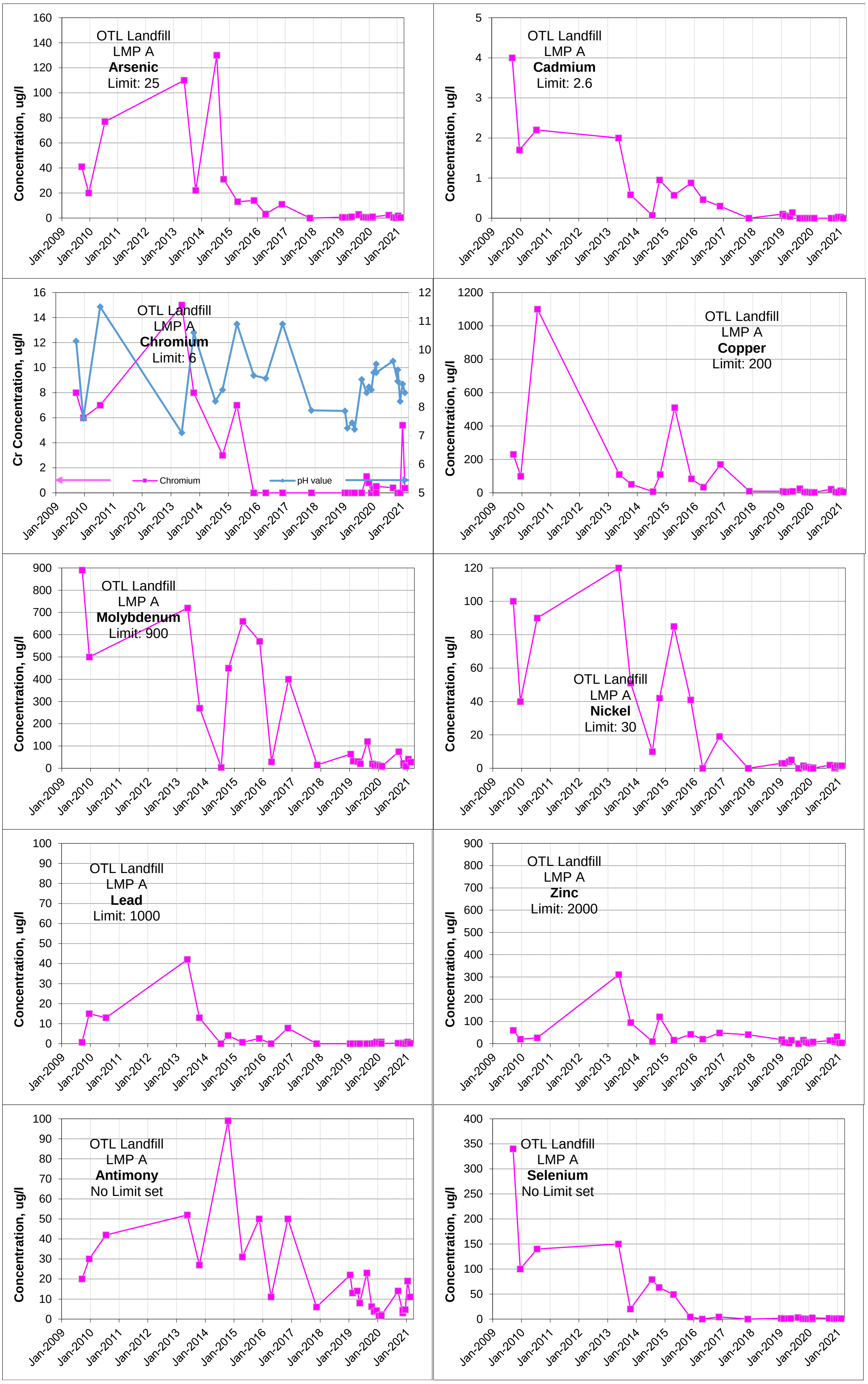


**Figure 4-2 Time trends of heavy metals in OTL landfill monitoring point A**

NO SAMPLES FROM OTL LMP A in 2022



## Figure 4-3 Time trends of heavy metals in OTL landfill monitoring point B

NOT UPDATED BECAUSE MP DESTROYED

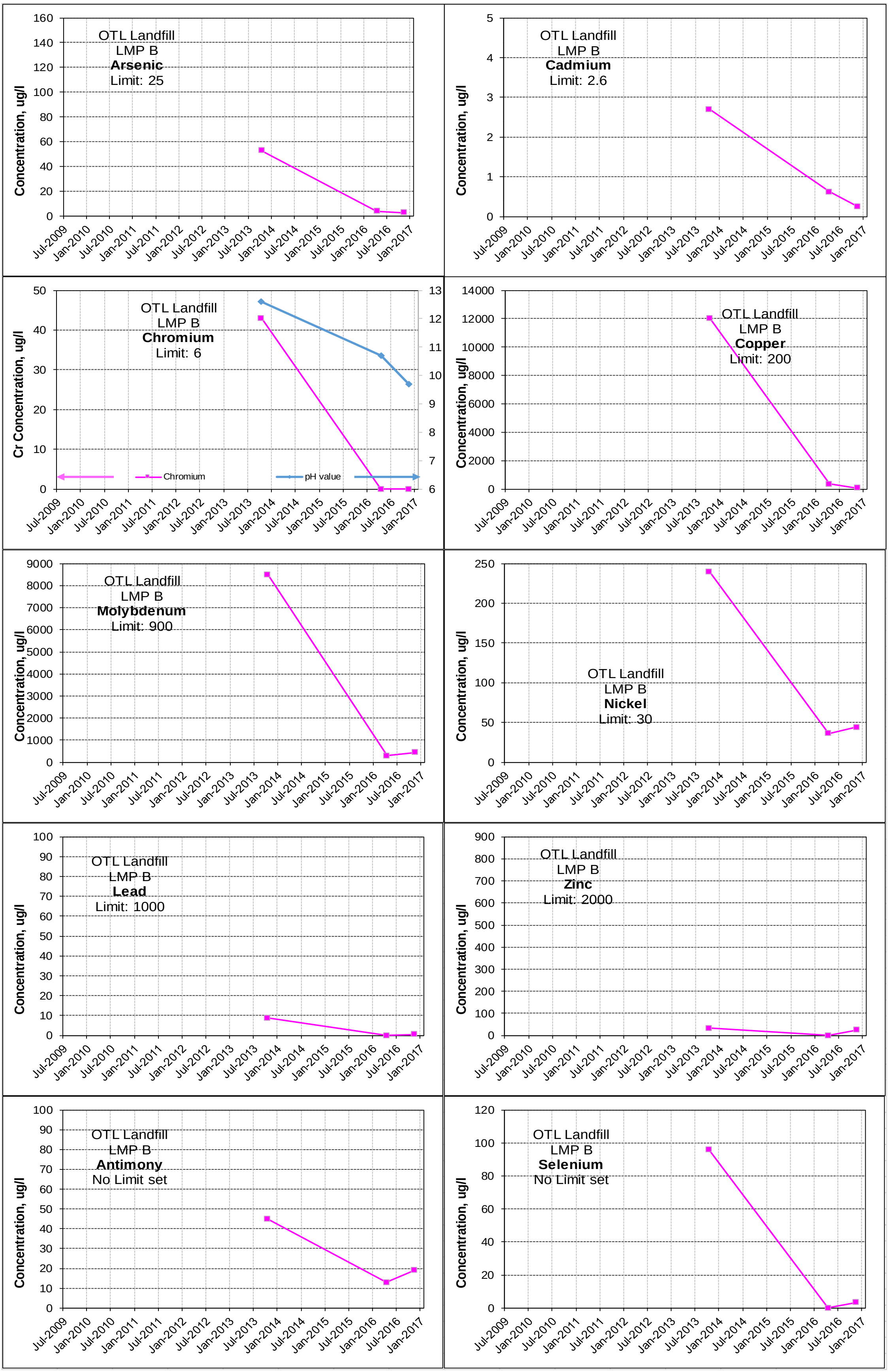
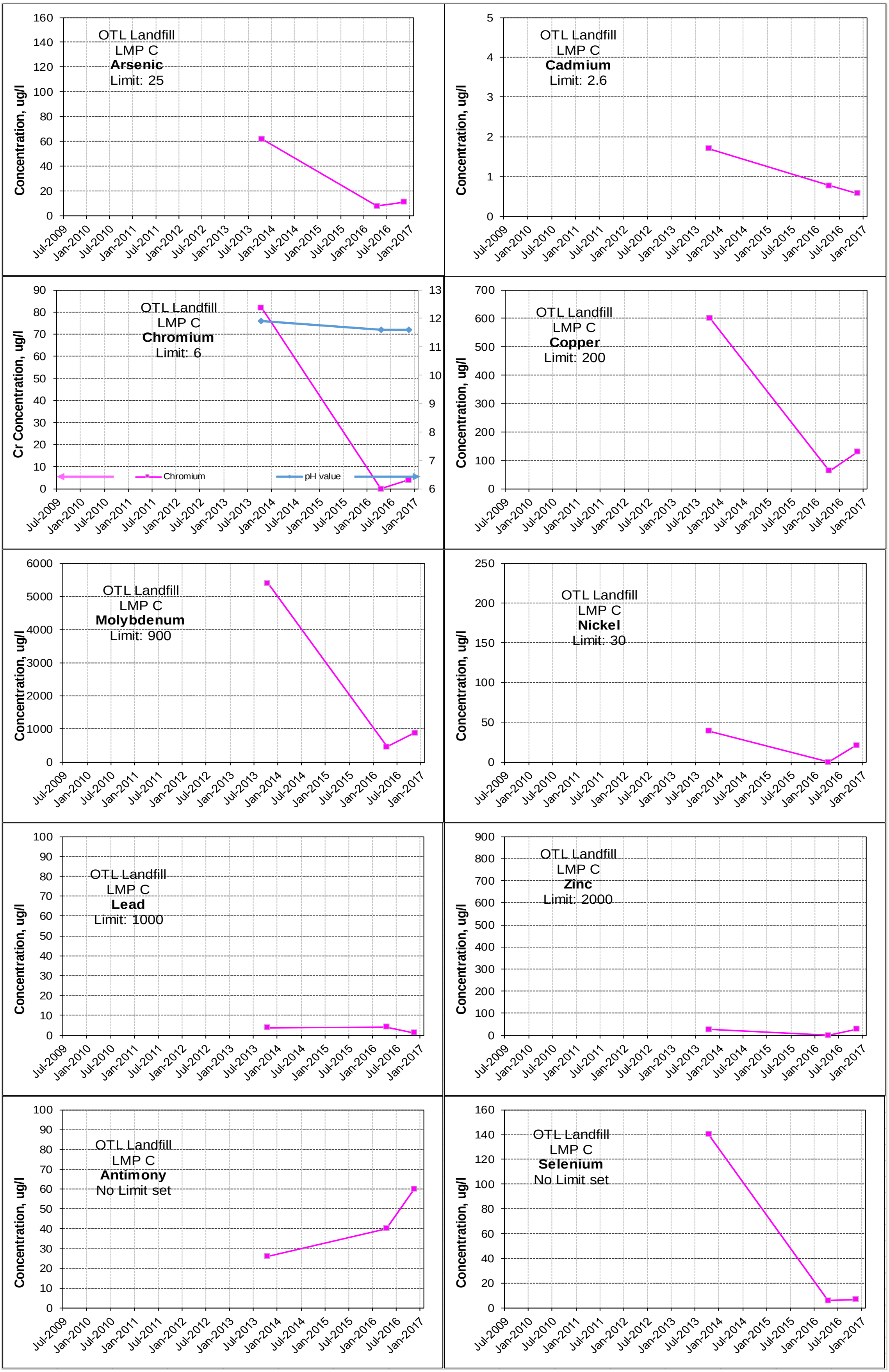
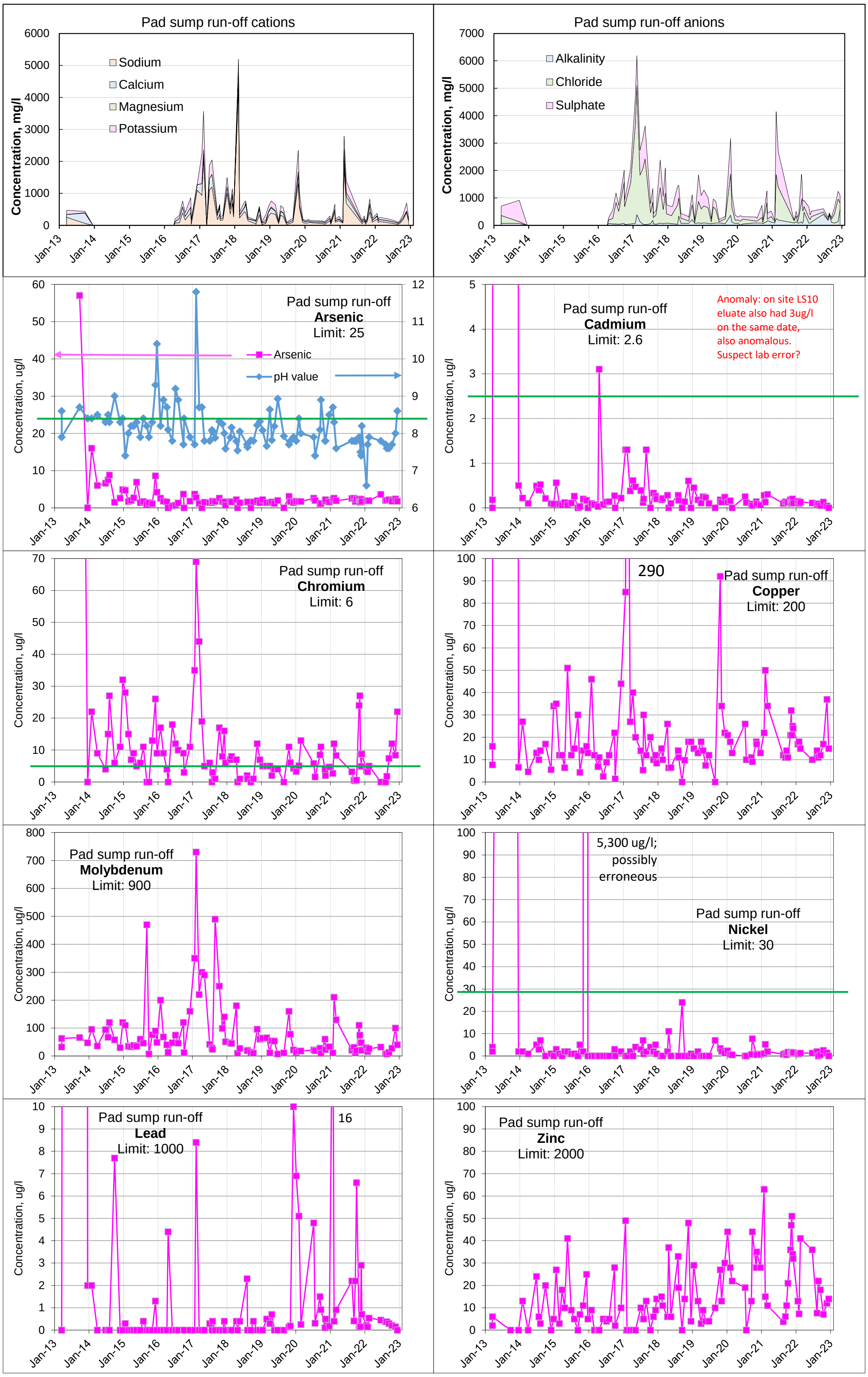


**Figure 4-4 Time trends of heavy metals in OTL landfill monitoring point C**

NOT UPDATED BECAUSE MP DESTROYED

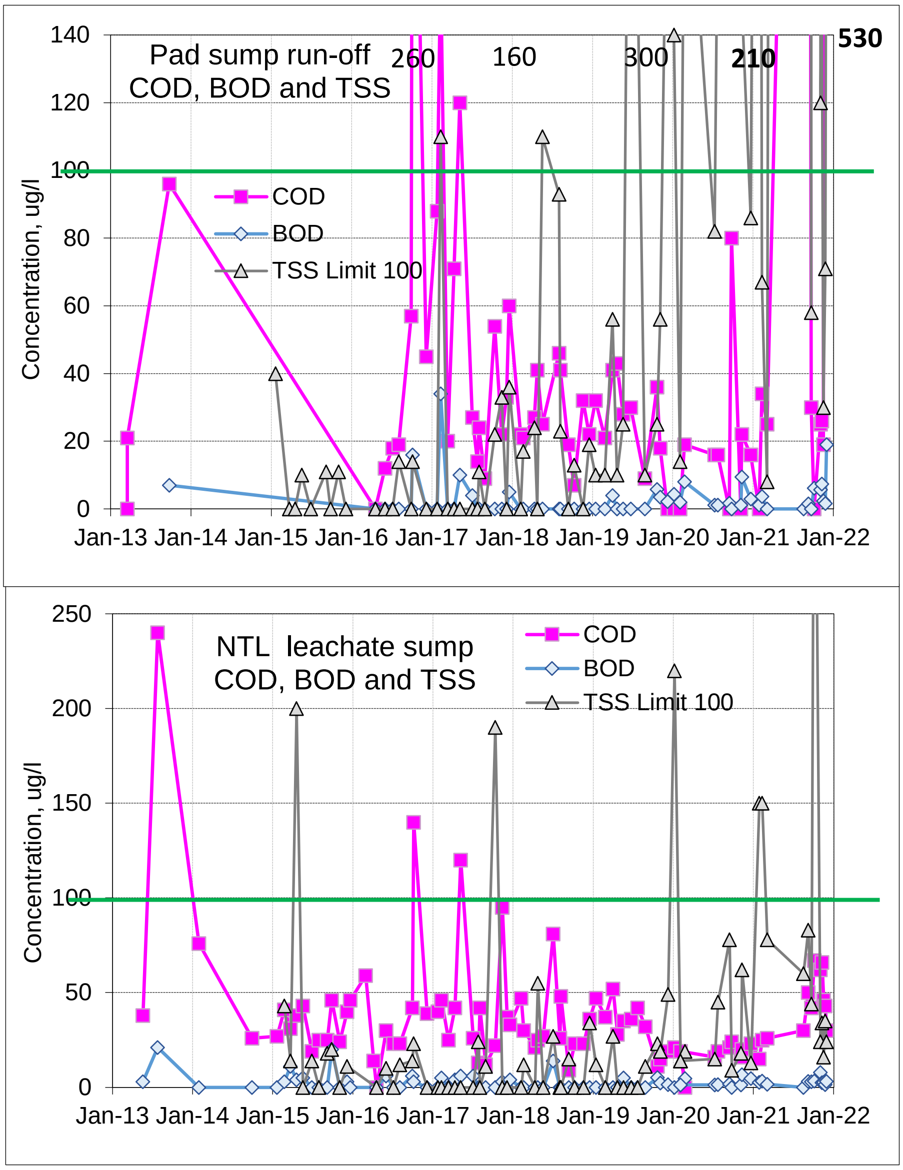


## Figure 4-5 Time series of leachate parameters in Maturation Pad run-off sump



## Figure 4-6 Time trends of key leachate quality parameters for NTL leachate sump

Figure 4-7 Time series trend of organic indicators and TSS in Pad and NTL sumps



# 5. Leachate levels and volumes

## 5.1. Leachate levels at OTL landfill

Leachate levels were monitored routinely in one monitoring well in each of the three cells, A, B and C at OTL landfill, up to the end of 2016. The MPs were removed during early 2017 as part of the Meldgaard re-processing operations, which removed most of the waste from the cells.

Details of the monitoring wells' construction and elevations were presented in earlier annual reviews. Data for leachate level and elevation in Cells A, B and C up to the final data in late 2016 are shown as time series graphs in Figure 5.1.

The monitoring data up to 2016 showed a consistent pattern of seasonal fluctuation that is typical of those occurring at many landfills:

- Levels fall to a seasonal low, usually in late summer (early August in 2016, mid-October in 2015).
- They then rise in response to winter rainfall, peaking in early Spring.
- The seasonal fluctuations at OTL were ~400-700mm in Cell A, 300-500mm in Cell B and 900-1,000mm in Cell C.
- At the peak, there appeared to be ~0.9m leachate in Cell A,~2.2m in Cell B and ~1.7m in Cell C.

The occurrence of regular seasonal fluctuations in level, in cells from which no leachate was actively abstracted, implies that the winter surplus leachate was either evaporating during summer months, or was escaping from the cells. Escape could have occurred either via infiltration through the base into groundwater or via the low point of Cell A, at ~28.5mOD. There were no bunds to prevent leachate from all three cells flowing towards this low point and onto the ground surface.

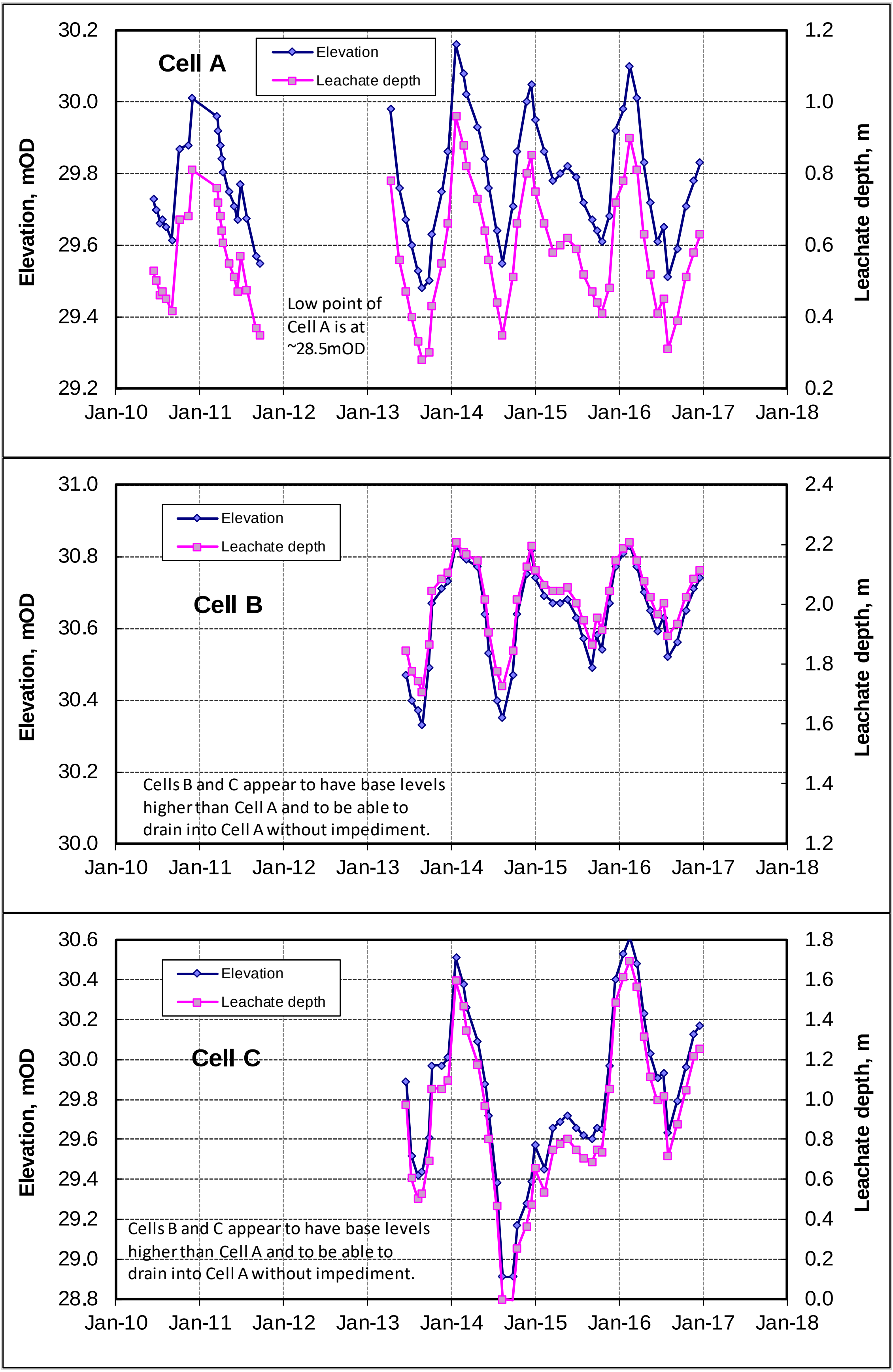
The potential for leakage to have occurred into groundwater during the period when OTL contained IBA underlines the importance of the groundwater monitoring around OTL landfill, to detect any evidence of leakage via this route.

However, it is more likely that the seasonal loss of leachate was via surface flow out of the cells. If this is the case the impact of this on surface waters needs to be assessed. Prior to the start of processing and removal of the IBA an assessment was carried out in November 2016 of the potential impact on marine water quality if the leachate were to be collected and discharged. A modification to the discharge licence was subsequently sought by Colas, to include this leachate in the existing discharge to sea. This component may remain relevant if a significant quantity of ash is to remain in OTL.

Calculations comparing the potential volumes equivalent to (i) the annual fluctuations in leachate level and (ii) the estimated capture of effective rainfall, were presented in the 2016 review. The level fluctuations indicated an annual volume on the order of ~800 to ~2,400 $m^3$/a (equivalent to a daily average of ~2 to ~6$m^3$/d).

**Figure 5-1 Time series graphs of leachate level in OTL Cells A, B and C**

NOT UPDATED BECAUSE MPs DESTROYED



Low point of Cell A is at ~28.5mOD

Cells B and C appear to have base levels higher than Cell A and to be able to drain into Cell A without impediment.

Cells B and C appear to have base levels higher than Cell A and to be able to drain into Cell A without impediment.

Estimated effective rainfall of 391 mm in 2022 and a surface area of ~1.2 ha of the three OTL cells indicate that ~4,700 m$^3$ of potentially contaminated surface water may be generated from OTL, equivalent to an average flow of ~13 m$^3$/day.

Since the transferring of processed ash into NTL, the remaining waste is too dispersed and irregular for it to be practicable to measure leachate levels. If the remaining ash is not to be transferred into NTL it may be prudent to try to re-instate at least one monitoring point.

## 5.2. Leachate levels at NTL landfill

Prior to the installation of the concrete ring pumping sump and its associated monitoring point located in the area previously backfilled with inert wastes there was no routine monitoring of leachate levels in NTL.

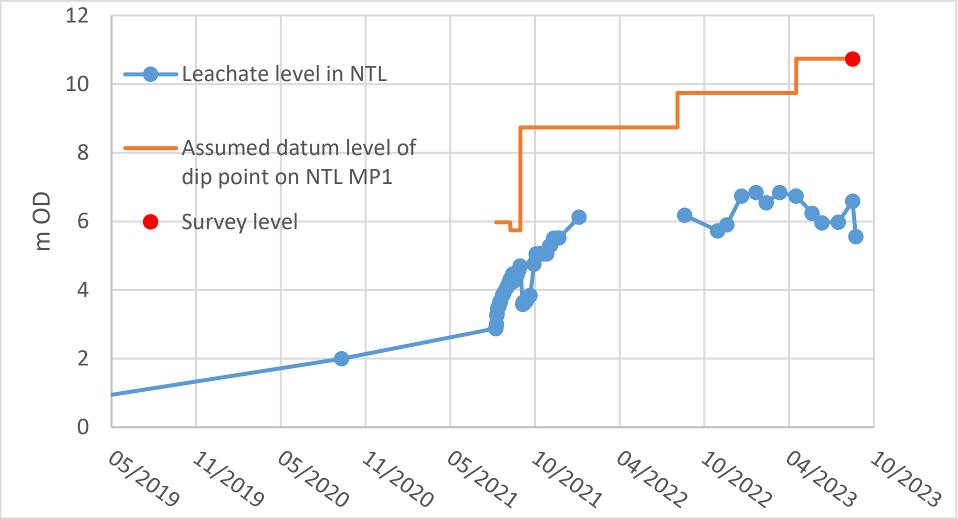
Estimates of water level in the open water area taken from site surveys are as follows:

| | |
|---|---|
| 16th February 2015: | - 3.5 mOD |
| December 2015: | +0.25 mOD |
| January 2018 | - 0.1 mOD |
| September 2020 | + 2.0 mOD |

The concrete ring pumping sump was installed onto a concrete pad with a surveyed elevation of 0.05 m OD. The elevation of the top of the sumps has changed over time as more concrete rings have been added. The datum level of the top of the sump was surveyed at 10.74 m OD in September 2023. It is ***recommended*** that the elevation of the dipping point on all leachate monitoring points are surveyed at least annually. A record should be also kept of any changes over time to the elevation of the top of each point.

Figure 5-2 graphs leachate levels in the NTL leachate monitoring sump and indicates that after a rapid rise in levels during the second half of 2021 following cessation of pumping, there is evidence from the monitoring in 2022 and into 2023 that leachate levels have stabilised at between approximately 5.5 to 6.5 m AOD. This is broadly in accordance with the conceptual flow model for the site.

**Figure 5-2 Time series graphs of leachate level in NTL**



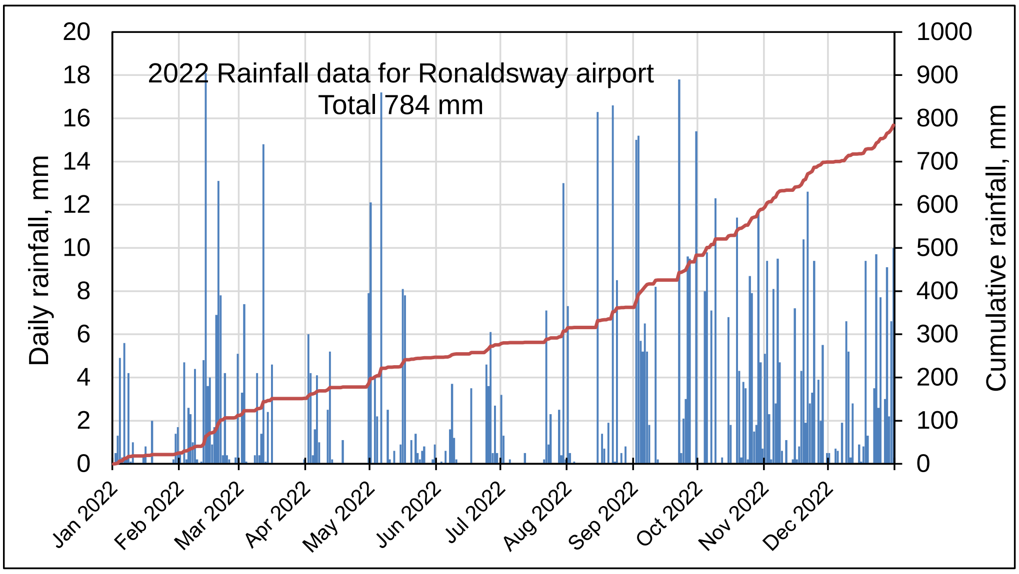
## 5.3. Leachate and run-off volumes discharged to sea outfall

Recording of discharged volumes began at the start of 2015. Details and results from the two licensed discharges are set out below.

### 5.3.1. Rainfall data

There is a direct correlation between the volume of runoff from the maturation pad with rainfall and hydrologically effective rainfall estimates. Annual rainfall (784 mm) in 2022 was 85% of the average for the preceding 10 years. (Figure 5.3). An estimate of the hydrologically effective rainfall for 2022 is 391mm.

**Figure 5-3 Daily and cumulative rainfall data for 2022**



Data source: Isle of Man Meteorological Office

Annual rainfall (1023 mm) in 2021 was 111% of the average for the preceding 10 years. An estimate of the Hydrologically effective rainfall for 2021 is 630mm.

### 5.3.2. Maturation Pad discharge

There was an ambiguity in the pad's monitoring record from 2021, which is resolved in this report. Consequently, data for 2021 and 2022 are reported.

Since 20th March 2017 an impeller totaliser flow meter has been in place. There is currently no means to accurately record the number of hours the pump has been operating, so a cross check of the pump discharge rate is not possible. During 2021 the meter readings were reported with a decimal point and at the time of writing the 2021 annual report it was not clear whether it was the 2021 data that were erroneous or data from previous years. It is now clear that the 2021 data was reported incorrectly.

Available flow data are shown in Figure 5.2, with data since March 2017 being based on the totalizer.

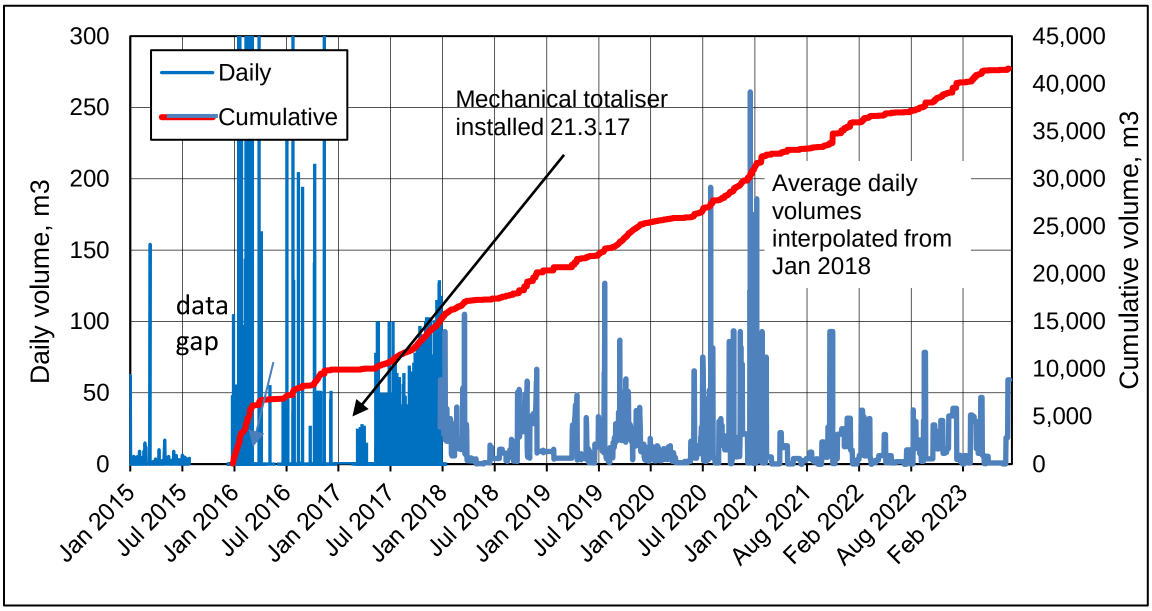
The total volume of runoff from the pad discharge that was discharged to the sea outfall was 5214 $m^3$ in 2021 and 3710 $m^3$ in 2022. These discharge volumes are comparable to previous years (see Table 5.1).

The licensed discharge amount (see Appendix 1) is 9 $m^3$/day continuously, with a maximum of 25 $m^3$ /day for up to 2 days per week. The average discharge rate over the year was 14 $m^3$/day in 2021 and 10.3 $m^3$/day in 2022. There was on average of 47 days in 2021 and 54 days in 2022 when the discharge volume exceeded 25 $m^3$/day.

| Year | 2019 | 2020 | 2021 | 2022 |
|---|---|---|---|---|
| Number of meter readings | 60 | 112 | 55 | 41 |
| Average daily discharge ($m^3$/d) | 13.5 | 13.0 | 14 | 10.3 |
| Number of days pumping over 25 $m^3$/d | 50 | 46 | 47 | 54 |
| Number of days pumping over 50 $m^3$/d | 8 | 19 | 26 | 5 |
| Max daily discharge ($m^3$/d) | 127 | 194 | 261 | 78 |
| Volume discharged ($m^3$) | 4,948 | 4,728 | 5,214 | 3,710 |
| Estimated volume based on pad area and hydrologically effective rainfall | 4,494 | 4,342 | 4,574 | 2,839 |
| Metered volume as percent of estimated volume | 110% | 109% | 115% | 130% |

**Table 5.1 Summary of Maturation Pad run-off discharge data**

**Figure 5-4 Turkeyland Maturation Pad run-off discharge volume data**



The volume metered from the Pad discharge for 2021 is compared below with the expectation for the area of the pad and effective rainfall in this location, as shown by the following calculation:

***Expectation:***

Pad area 7,260 m$^2$ (including area used for harbour silts)

Effective Rainfall (2021) ~630 mm/a *[from Met Office data]*

So, expected run-off [area x ER] 4,574 m$^3$

Equivalent daily average from ER 12.5 m$^3$/d

***Measured volumes:***

Total recorded discharge in 2021 5214 m$^3$

Equivalent daily recorded average 14.3 m$^3$/d

The 2021 metered volume is ~115 % of the estimated volume.

The volume metered from the Pad discharge for 2022 is compared below with the expectation for the area of the pad and effective rainfall in this location, as shown by the following calculation:

***Expectation:***

Pad area 7,260 m$^2$ (including area used for harbour silts)

Effective Rainfall (2022) ~391 mm/a *[from Met Office data]*

So, expected run-off [area x ER] 2,839 m$^3$

Equivalent daily average from ER 7.8 m$^3$/d

***Measured volumes:***

Total recorded discharge in 2021 3,710 m$^3$

Equivalent daily recorded average 10.2 m$^3$/d

The 2021 metered volume is ~130 % of the estimated volume.

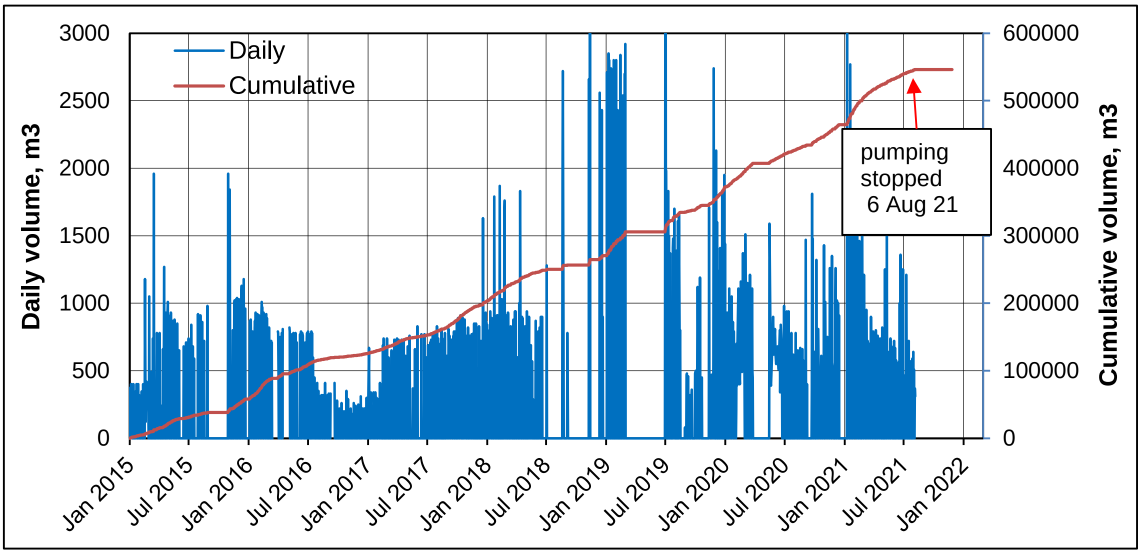
As in previous environmental monitoring reports it is ***recommended*** that the whole of the IBA pad's discharge to outfall arrangements are reviewed. This should include whether any areas outside the pad are contributing to its catchment area. Logging of the flow meter output should be considered, to confirm that discharge is occurring at high tide according to the operating requirements of the system. The installation of a physical "hours run" meter into the control panel of the pump, so that the actual run time of the pump is recorded would provide a useful check on flow rates. The pump's flow meter should continue to be manually recorded at least weekly and preferably more often to provide better resolution on the daily volumes being discharged off site.

### 5.3.3. NTL quarry discharge

There were no reported discharges of leachate from NTL during 2022.

For the record, the historical pumping of leachate from NTL is shown in Figure 5-5.

**Figure 5-5 NTL quarry sump discharge volumes**



# 6. Monitoring of the external environment: groundwater

## 6.1. Groundwater at OTL landfill

### 6.1.1. Groundwater levels

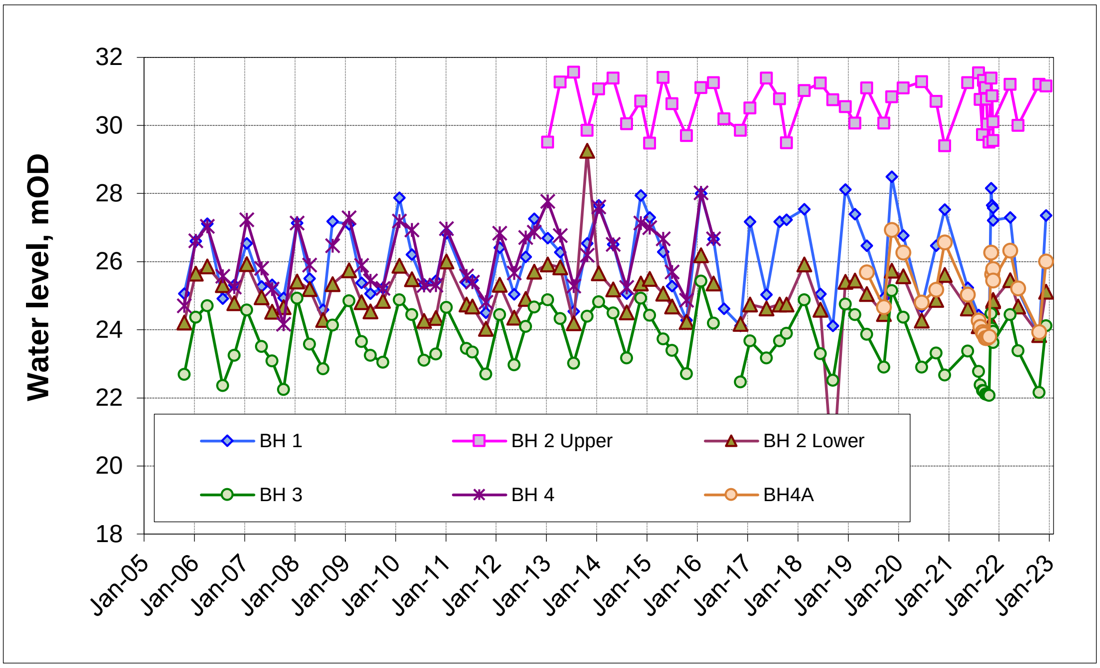
Time series data for water level in the OTL groundwater monitoring boreholes are shown in Figure 6.1, dating from 2005 onwards. Occasional misallocation since 2012 of some level and quality data between Boreholes 2 Upper and Lower has now been corrected.

A new borehole (4A) was drilled in 2019 to replace original borehole 4 which became inoperable during 2016. The replacement borehole is screened at a different elevation to the original (see Table 2.2 and Figure 1.3). Levels in all five boreholes undergo a regular seasonal fluctuation of 1m to 3m, the greatest being at BH3 (which also has the lowest groundwater levels) and the least at BH2 Lower. Levels fall to their minimum typically in late summer, and their maximum usually around the turn of the year. Water level fluctuations in 2022 followed this normal trend, including levels in Bh4A.

Over the long term, there is little change in groundwater levels, although levels in BH1 may have increased by about 1 metre over the last 15 years. Water levels recorded in 2022 are within the seasonal variation seen for each individual borehole.

Levels in BH2 Upper are considerably higher than in the other wells. This borehole is screened at a shallower depth (~5-7m below ground) than the other three original boreholes (~19-21m below ground) and is likely to be monitoring the glacial till materials, whilst the others are monitoring the bedrock of the Langness Conglomerate. Bh4A screens a much longer interval, so it is difficult to infer which geological formation is dominating the water level results.

**Figure 6-1 Time series water level data for groundwater boreholes at OTL landfill**



In the bedrock, the highest groundwater levels are in the two westernmost boreholes, BH1 and BH4 (whilst in operation) and the lowest at BH3 to the northeast of OTL. The level data therefore imply a piezometric gradient in an approximately north easterly direction, towards Santon Burn. There is no obvious effect of dewatering of NTL quarry (at times over the historical period down to -3mOD) on levels at BH1 which is nearest to NTL quarry.

Groundwater levels in the four bedrock boreholes are all lower than leachate levels used to be in the OTL landfill (Figure 5.1), which fluctuated between ~29.4mOD and ~30.8mOD until the ash was largely removed. Therefore the potential existed for downward migration of leachate leaking through the basal liner. Conversely, groundwater levels in the superficial deposits (BH2 upper) are at most times within a similar range to the historic OTL leachate levels, rising slightly higher than leachate levels did in the winter, so little potential existed for contamination from OTL leachate.

### 6.1.2. Groundwater quality

Time series graphs of groundwater quality are shown in Figures 6.2 (inorganic indicators) and 6.3 (heavy metals and sanitary parameters).

Borehole BH4, whilst in operation until 2016, appears to indicate 'background' upgradient groundwater quality in the bedrock, with the lowest and most unvarying concentrations of most major ions (Figure 6.2). It also had the lowest concentrations of key organic indicators COD and $NH_4$-N. In contrast, it had consistently higher nitrate concentrations than other boreholes (Figure 6.3), although BH3 has recently seen increases in $NO_3$ starting in during 2018 and extending into the first sample in 2022; this may indicate an effect from application of inorganic fertilizer further upgradient. Replacement BH4A does not replicate these results, as it is screened over a much longer horizon, and its quality appears to be more akin to the shallower boreholes. Consequently there is no longer a borehole representative of 'background' upgradient groundwater quality.

For many inorganic parameters, the quality of samples from BH4A are within the range seen in other boreholes. This includes sodium, magnesium, chloride and alkalinity. Concentrations of potassium and sulphate remain elevated compared to other borehole samples. The concentrations detected are not cause for inherent concern.

Quality in BH2 Lower has undergone some noteworthy changes at times, not shown by any other borehole:

- It had anomalously high conductivity, sulphate, chloride and sodium for the first two years of the data record. After that they became consistent with other boreholes but appear to be undergoing a long term slow decline. There is no obvious explanation for these initial higher concentrations of some inorganic ions nor their subsequent decline.

- From mid-2014 onwards BH2 Lower has shown several changes consistent with contamination by organic matter, namely: elevated $NH_4$-N and Mn (and occasionally Fe, BOD, COD and phosphate) and falling $SO_4$. These changes would be consistent with an organic source such as sewage or animal waste causing anaerobic conditions. BH2

Upper has also seen similar occasional elevated concentrations since 2017, with a spike of 5 mg/l NH4-N in September 2019, not repeated in 2020 through to 2022.

- It is possible that this contamination has occurred from the land surface directly around the borehole via the wellhead, rather than representing contamination of the aquifer itself from further upgradient. A note on the government spreadsheet recorded the presence of a considerable amount of cow excrement very close to the borehole in late 2013. It is ***recommended*** that a concrete ring be placed around the borehole cover to prevent access by livestock.

- It has been confirmed that samples from BH2 Lower are taken after pumped evacuation of water. Provided this matches normal practice in UK guidance to evacuate at least two bore volumes, then the samples should be representative. However it is ***recommended*** that the approximate volume of water pumped prior to any sample being taken is recorded as a matter of course.

The 2013, 2014-15 and 2016 reviews recommended that three heavy metals associated with IBA leachate (Mo, Sb, and Se) be added to the analytical suite for groundwater samples. Results for these parameters have been provided for all samples taken since 2021. Only antimony (Sb) was found above detection limits (of 5µg/l for Mo and Se) and averaged 1.1µg/l (range 0.6 to 1.44µg/l) across all boreholes, which was very similar to 2021.

For the heavy metals Pb, Ni, Cu and Cr, all results continue to be below detection limits in 2022.

Mercury has not been analysed since 2010. It is ***recommended*** that Hg should be included in the list of metals analysed by Government for all samples.

Only one metal, zinc, has been detected consistently in groundwater samples. It is present in all samples, including the upgradient borehole BH4 and BH4A. Concentrations of zinc across all boreholes and time have ranged between 20µg/l and 163µg/l (Bh2 Lower December 2022). Overall peak concentrations were recorded in 2008 and appear to show a slight long term decline until 2017. Since then, fluctuations in concentrations have increased, with more of a divergence between results in individual boreholes.

Ammoniacal nitrogen and COD concentrations are generally higher in Boreholes 1, 2 and 3 than in the ‘upgradient’ borehole BH4 and in replacement BH4A. There is no long term change in either parameter in any borehole, with the exception of the recent rises in some parameters in BH2 Lower, noted above.

Concentration of nitrate in BH3 have increased over time (since 2010), but is almost certainly related to use of agricultural fertilisers.

Overall, there is no long term increase in most parameters in any borehole except BH2 Lower, and no evidence of any effect on groundwater quality in any borehole by IBA leachate from the OTL landfill.

## Figure 6-2 Groundwater quality trends at OTL: inorganic indicators

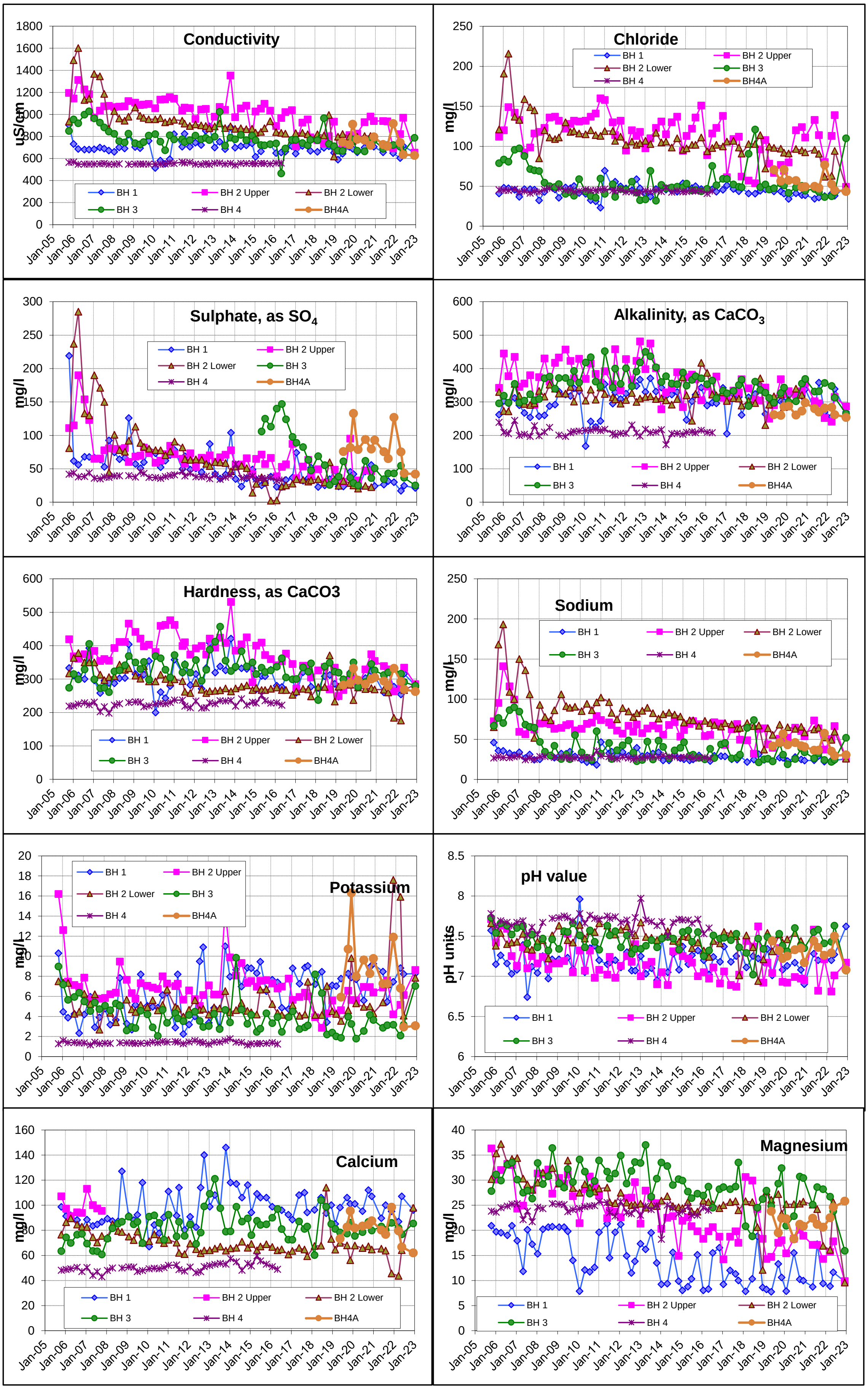
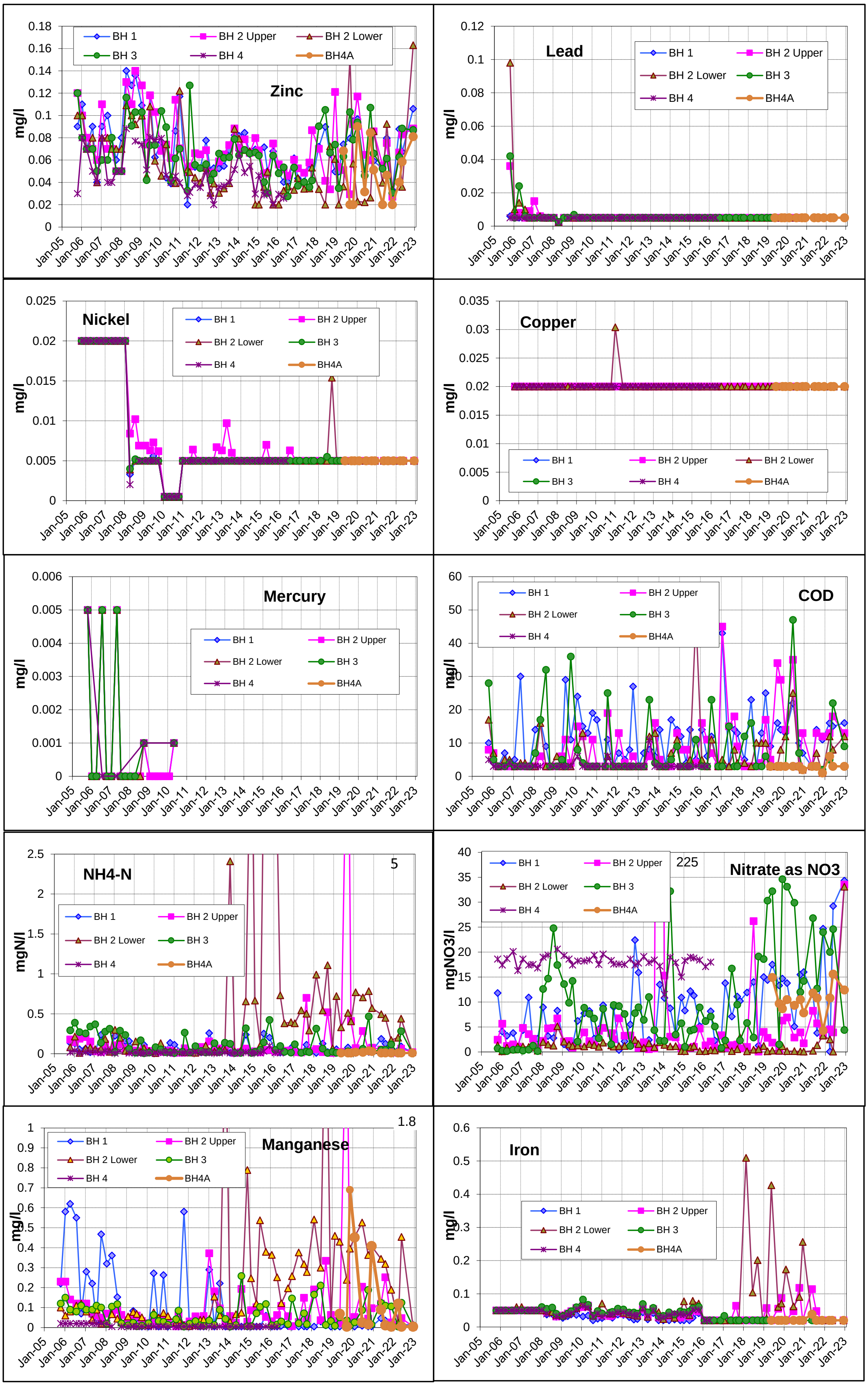


**Figure 6-3 Groundwater quality trends at OTL: metals and sanitary parameters**



## 6.2. Groundwater at NTL landfill

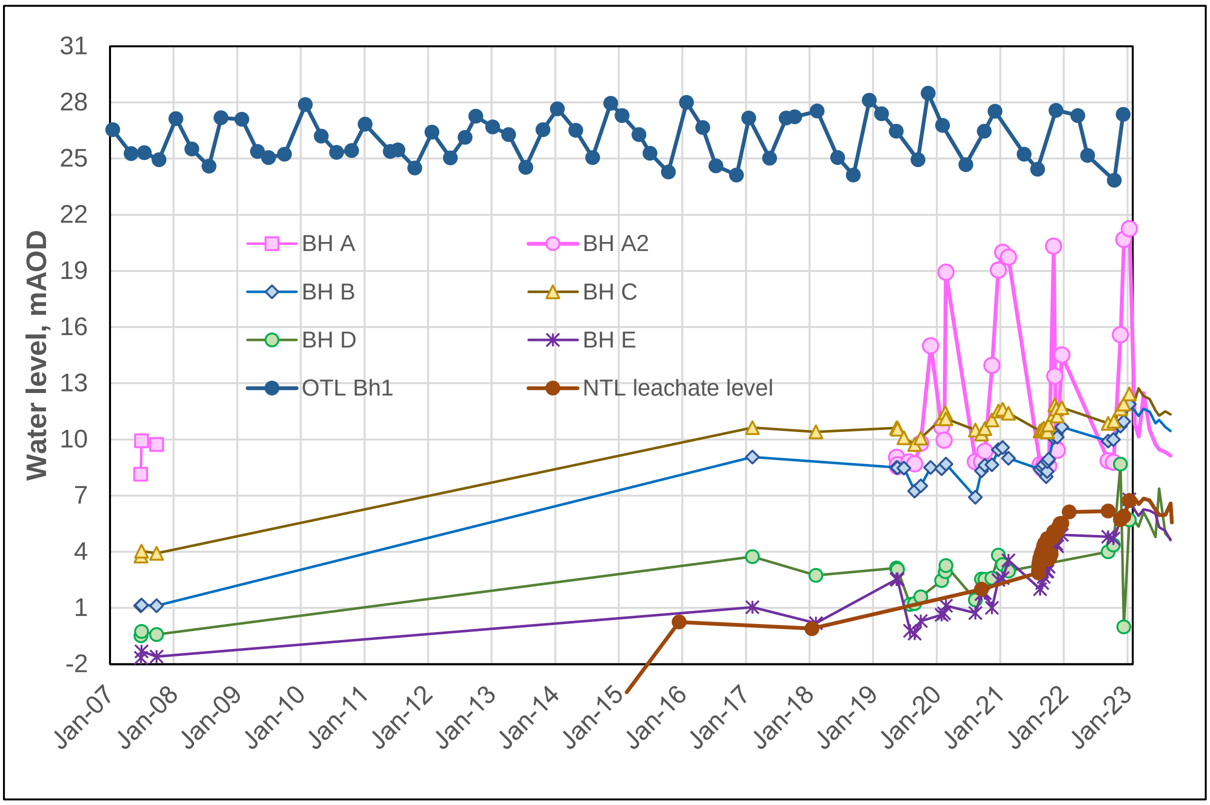
### 6.2.1. Groundwater levels at NTL

Time series data for water level in the NTL groundwater monitoring boreholes are shown in Figure 6.4, alongside water levels from OTL Bh1 for comparison. The record for NTL comprises three readings in 2007, one to two readings in 2017/18 with more frequent readings up until 2022. With the drilling of new borehole A2, a previously recorded 2017 water level in BH A of ~21 m AOD has been deleted from the record as being erroneous. Borehole D was lost, originally presumed destroyed during early 2021, although it was rediscovered under vegetation at the end of 2022.

Some interesting observations may be made from Figure 6.4:

- All water levels are significantly lower than those recorded in OTL Bh1.
- The data show a significant rise in groundwater levels in all NTL boreholes other than Bh A2 (which screens different horizons than original Bh A) since 2007. The rises range from ~5.5m (Bh D) to 9m (Bh B). This is consistent with reduced pumping over the time and the maintenance of the water level in the quarry at a higher level over time.
- With the benefit of increased monitoring frequencies since 2021 seasonal fluctuations in water levels are becoming more apparent. Water levels are generally lower in the summer than in the winter. Water level changes in excess of 13 metres were recorded in BHA2 throughout 2020 and this trend extended into 2021, but lack of a monitoring record into 2022 means it is difficult to be certain about the cause for these changes. The potential impact of water sampling on water levels needs to be investigated (e.g. water levels after a sampling event need to be monitored to see how quickly levels recover). Although there has been increased monitoring in recent years there is still not a complete annual record with readings having been taken at least once per month. It is ***recommended*** that groundwater level monitoring continues at a monthly interval.
- A water level reading or -5.3 m AOD from Bh D in December 2022 is assumed to be erroneous (and is not plotted).
- All groundwater levels are currently above mean sea level, but water levels in Bh D and E are now at or below leachate levels in the site. This is in accordance with the conceptual hydrogeological model for the long term operation of the site.
- Previous investigations during 2019 indicated that no water levels appear to be significantly affected by the state of the tide, with a much stronger correlation to the main water level in NTL quarry consistent with there being some seawater ingress into the quarry.
- A surprising finding is that the water level at BH B, near the site entrance, is lower than that at BH C, which is closer to the sea shore.
- Water levels in fractured limestone may be influenced by the spatial distribution of major fissures in the rock, so may not be solely related to their topography and position.

**Figure 6-4 Water level data for NTL groundwater boreholes**



### 6.2.2. Groundwater quality at NTL

Time series graphs of groundwater quality in the NTL boreholes are shown in Figures 6.5 & 6.6 (inorganic parameters) and 6.7 (heavy metals and sanitary parameters). Figures 6.5 and 6.6 are shown with two different Y axes for clearer presentation of lower concentrations. Similar to recommendations provided for OTL borehole sampling, at least 3 bore volumes should be removed prior to sampling and it is ***recommended*** that the approximate volume of water pumped prior to any sample being taken is recorded as a matter of course.

Although the data record is limited, the following comments can be made:

- BH E, prior to 2021, is clearly affected by seawater ingress, with chloride in most samples at ~50% of the concentration in seawater (~19,400 mg/l). It has corresponding elevated levels of sulphate, sodium and magnesium, all indicative of seawater. This quality is consistent with its low water levels. Samples during 2021 and 2022 do not exhibit evidence of significant seawater intrusion. The reasons for this are not yet understood. It may be a real effect related to the cessation in dewatering in the quarry, but may also relate to a change in monitoring protocols (e.g. the borehole may not have been properly purged prior to sampling) associated with a change in staff undertaking the monitoring. Monitoring procedures were reviewed and enhanced in September 2023 and monitoring after this date should clarify the position.
- Previously seen elevated concentrations of sulphate and calcium in BH A compared with B, C and D, were not replicated in any samples since 2019. The previous

explanation was that samples might have been influenced by a localised deposit of gypsum in the rock. It is understood that better purging of NTL wells prior to sampling has occurred since 2019, and this would have the effect of negating any localised "contamination" sources and result in more representative ground water samples

- The alkalinity of all borehole samples taken in December 2022 are approximately double compared to the historical records. No other major ions are elevated in this way. Future monitoring in 2023 will determine whether this is part of a real ongoing trend, or analytical error.
- Other than alkalinity, the inorganic composition of ground water samples shows no obvious effect from IBA leachate in any of the boreholes.
- Slightly elevated concentrations of zinc occurred again in 2022, but within the historical trend seen in these boreholes. Nickel was elevated in samples from borehole E but there appears to have been a slight reduction from the elevated concentrations seen in 2021. Other heavy metals, including copper, zinc and chromium were detected at generally low concentrations. Antimony is consistently detected at between approximately 1 - 2 µg/l (similar to OTL boreholes). Ongoing monitoring is required to establish whether the detection of these metals at low concentrations can be attributed to leachate from within NTL.
- Concentrations of nitrate are mostly lower than in the OTL groundwater boreholes. Slightly elevated concentrations of $NH_4$-N occurred in all boreholes (up to 1.5 mg/l in Bh E) in the samples taken late in 2022. Further monitoring is required to ascertain whether this represent a real upward trend.

As previously discussed, the screened horizons of the downgradient NTL groundwater boreholes are not located at an optimum elevation for identifying future impact of NTL on groundwater quality. It is ***recommended*** that Bhs D and E are redrilled and that a new Bh F is drilled on the NE corner of the NTL quarry.

**Figure 6-5 Groundwater quality trends at NTL: inorganic parameters** (standard Y axis)

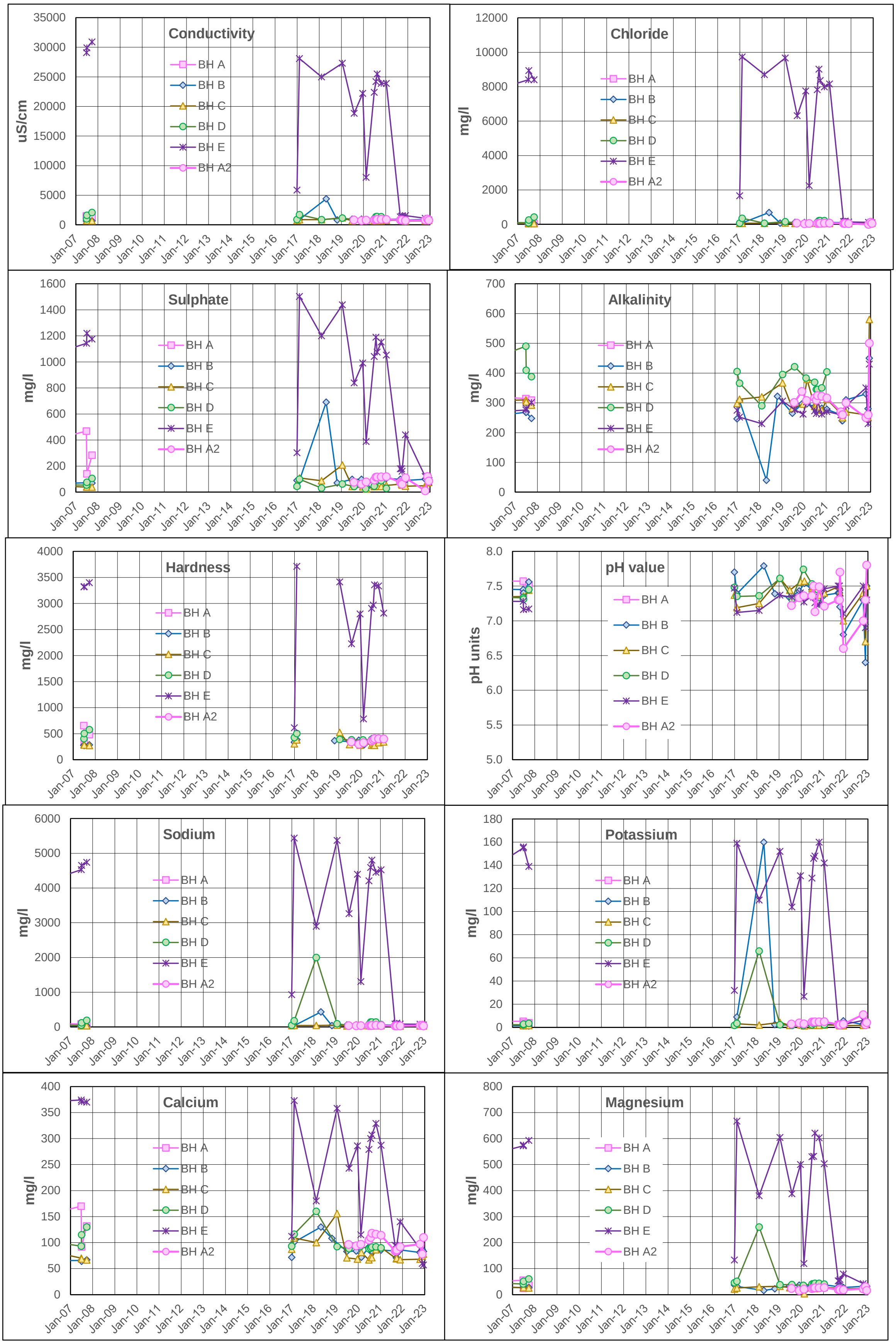
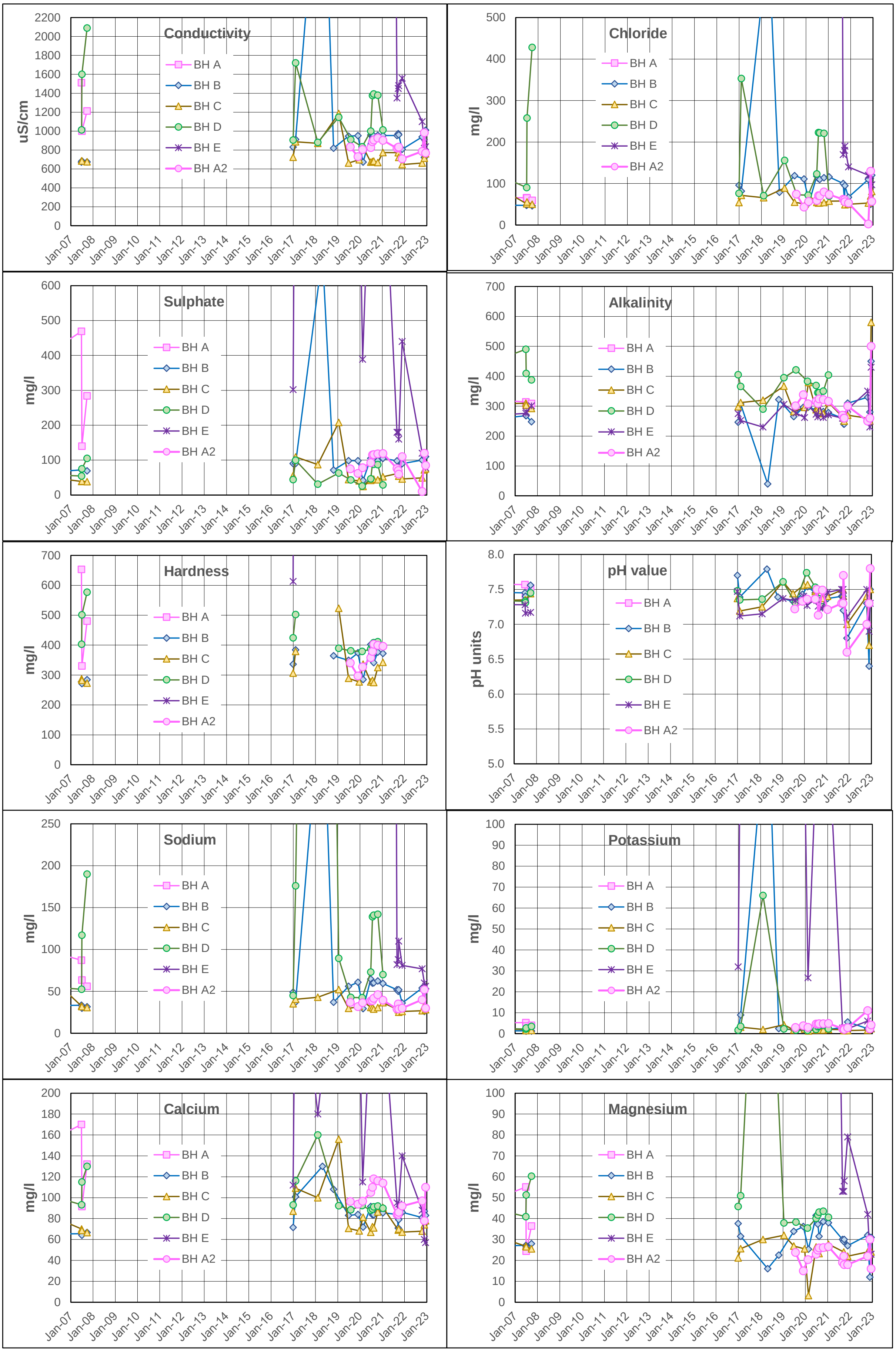
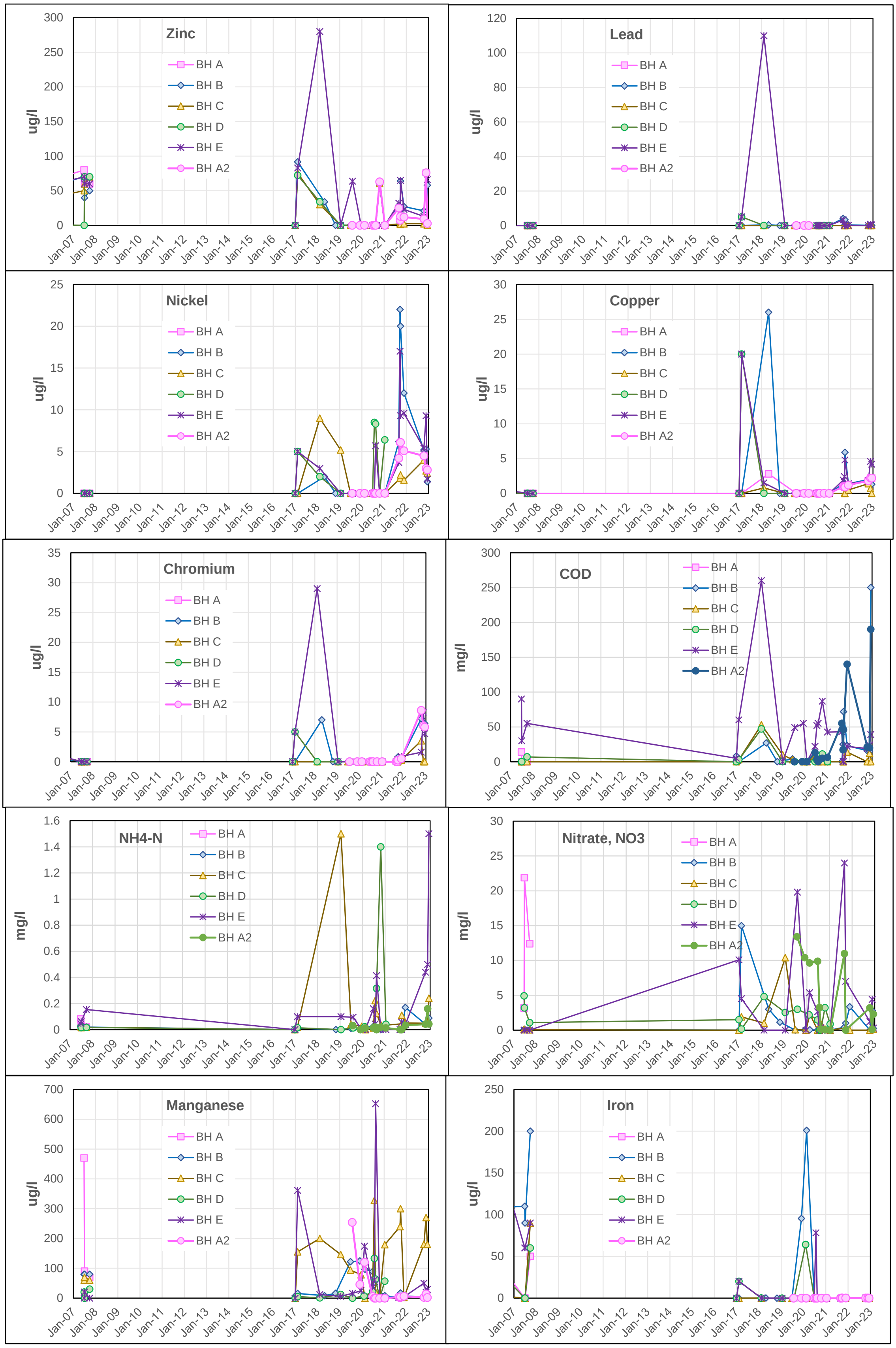


**Figure 6-6 Groundwater quality trends at NTL: inorganic parameters (expanded Y axis)**



## Figure 6-7 Groundwater quality trends at NTL: metals and sanitary parameters



# 7. Monitoring of the external environment: surface waters

## 7.1. Santon Burn water quality

Time series data for a range of determinands in Santon Burn are shown in Figures 7.1 (inorganic indicators) and 7.2 (heavy metals and sanitary indicators). The graphs include data for the fissure discharge into Santon Burn. The stream samples are taken upstream and downstream of the discharge, to determine whether it is affecting water quality. Their locations are indicated in Figure 2.2.

In the ***fissure discharge***, the concentrations of dissolved inorganic salts are considerably greater than those in the stream samples. They have exhibited no long term change since monitoring began in 2007. The major ion composition of the discharge is similar to that previously monitored in OTL groundwater borehole BH4 (Figure 6.2), identified earlier as probably indicating upstream background quality in the groundwater. The fissure water is predominantly a calcium bicarbonate water, with the relative magnitude of major ions as follows: Ca>Na>Mg>K; Bicarbonate>Cl>$SO_4$>$NO_3$.

One significant difference in the major ion composition between the fissure discharge and the groundwater at BH4 is that BH4 has lower calcium and higher magnesium concentrations than in the fissure discharge.

Concentrations of Ca, Mg, alkalinity and hardness exhibit a seasonal fluctuation in most years, becoming considerably weaker in the winter samples. There is a corresponding fall in pH values to less alkaline values at these times. Chloride undergoes no significant seasonal change.

Overall, the major ions show no evidence of the presence of IBA leachate in the discharge.

Upstream and downstream ***samples in Santon Burn*** have a much lower major ion strength than the discharge. At most times, the major ion strength downstream is virtually identical to the upstream samples, indicating that stream flow is considerably greater than the discharge flow.

However, there have been occasions when an increase can be observed for most ions in the downstream samples. These invariably occur in mid-winter samples but are not apparent every year and did not occur in 2018. The occurrence of these peaks may indicate that the fissure flow sometimes undergoes large winter increases in flow rate compared with those in Santon Burn.

As in the groundwaters, most ***heavy metals*** are below their detection limits in most fissure and stream samples. The exception is zinc: its concentrations span a similar range (<20 to ~77 μg/l, in 2022) to those in the groundwaters (<20 to 150μg/l) and undergo large fluctuations. These occur simultaneously in all three locations. There is little difference between the upstream or downstream concentrations, though the discharge zinc concentrations are nearly always at or below the upstream strength. The synchronous occurrence of large fluctuations raises a question as to whether the zinc analyses in surface and groundwaters are affected by some analytical artefact or perhaps by the inclusion of some fine solids.

**Figure 7-1 Water quality trends in Santon Burn samples: inorganic indicators**

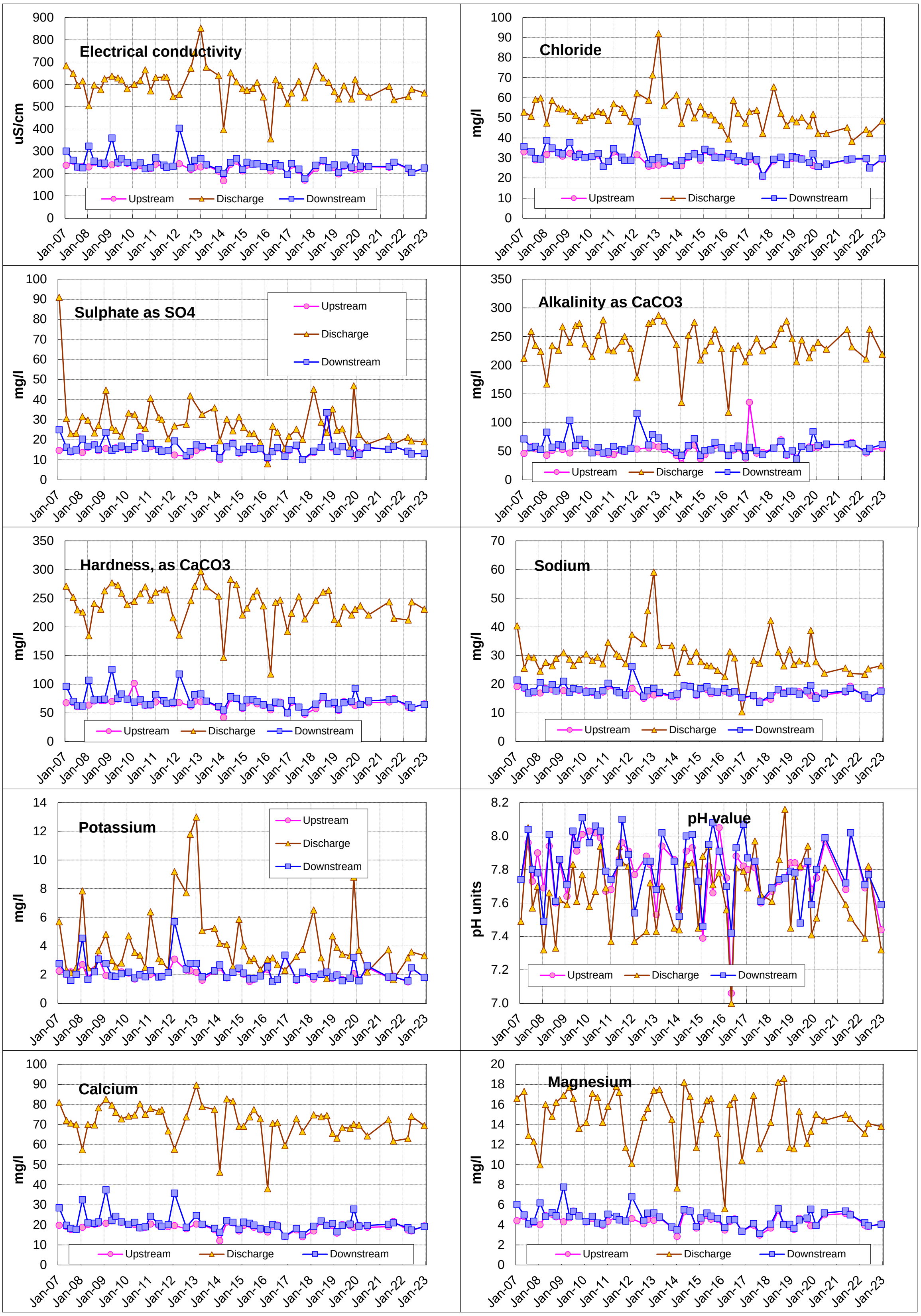
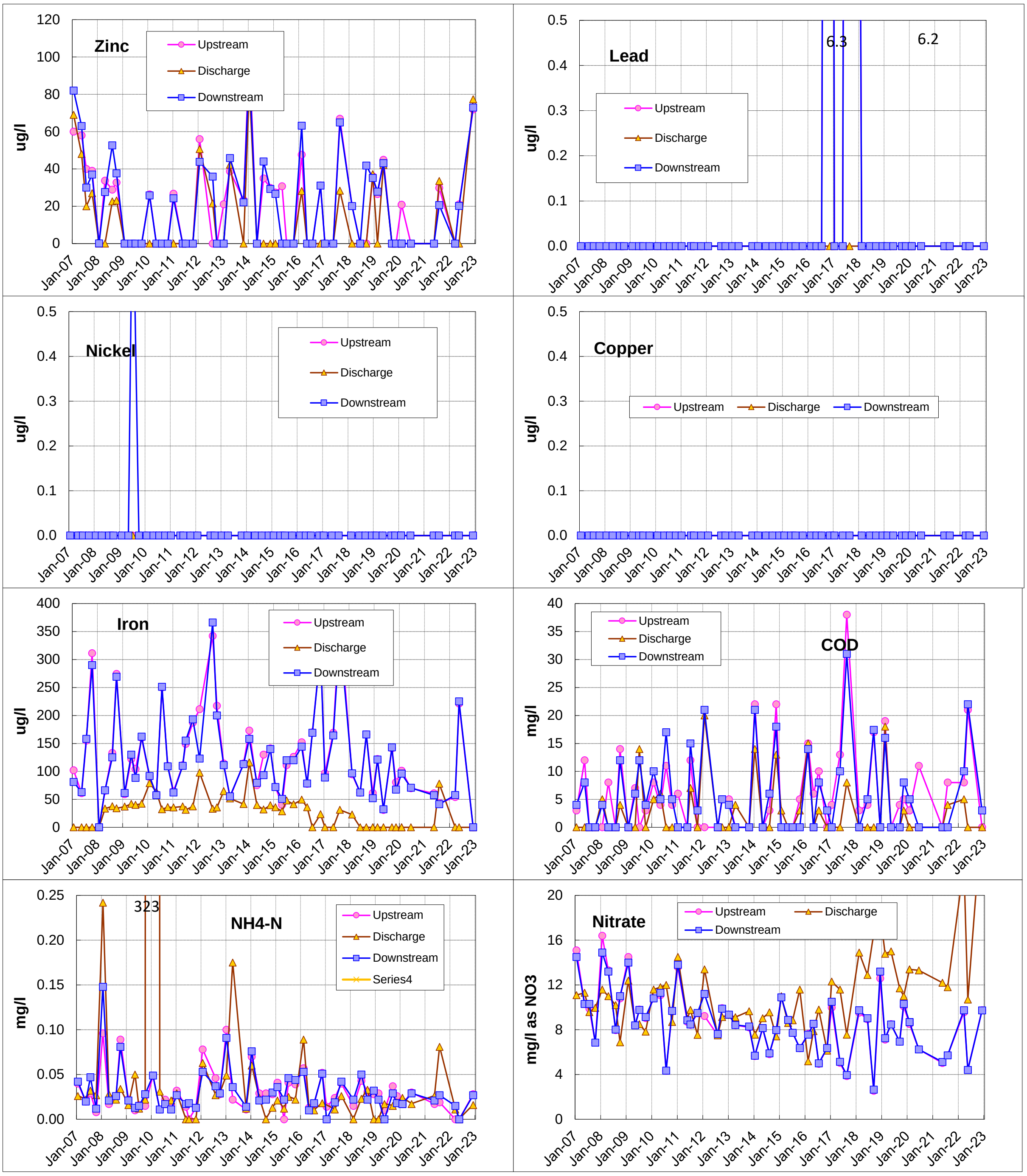


Figure 7-2 Water quality trends in Santon Burn samples: metals and sanitary parameters



Some anomalous lead (Pb) concentrations have occurred in the last few years: most samples are below detection limits but in November 2016 and August 2017, the upstream and downstream samples recorded ~6µg/l, while the discharge remained below the detection limit as usual. Pb has not been detected in any samples since in 2018. There is no evidence of heavy metal contamination in the stream from IBA leachate.

Antimony, Cobalt, Molybdenum and Selenium were analysed for all samples taken during the year. As in previous years antimony was detected in all samples at low concentrations of between 1 and 1.3 µg/l. Mercury was not analysed. It is **recommended** that Hg should be added to the list of parameters that are analysed.

Iron concentrations are generally higher in the stream than in the discharge. In the discharge, they average <50µg/l, similar to OTL groundwaters, but are typically in the range 50 to 350µg/l in the stream (41 to 225µg/l during 2022).

For sanitary indicators $NH_4$-N, nitrate and COD, there is usually no difference between the discharge and the stream quality. All three parameters are generally at similar concentrations to those in the OTL groundwaters, possibly slightly lower overall. Nitrate concentrations in the fissure discharge increased significantly during 2018, and again in 2022 where average concentrations exceeded 20 mg/l.

Neither the fissure discharge nor the Santon Burn samples show evidence of contamination by IBA leachate.

## 7.2. Marine water quality

Results obtained to date for marine samples are shown as time series graphs in Figures 7.3 (major ions), 7.4 (heavy metals) and 7.5 (organic indicators).

For comparison, the approximate composition of seawater around the Isle of Man is estimated, based on a reported salinity in the Irish Sea of 34[18] as follows.

**Table 7.1 Typical chemistry of seawater with a salinity of 34**

| **Cations** | mg/l | **Anions** | Mg/l |
|---|---|---|---|
| Sodium | 10,200 | Chloride | 18,300 |
| Magnesium | 1,220 | Sulphate | 2,560 |
| Calcium | 391 | Bicarbonate | 140 |
| Potassium | 378 | | |
| **Other** | | | |
| Strontium | 7.5 | Bromide | 63.3 |
| | | | |

Anomalies in the laboratory results for major ions affected the cation results in February 2017: these were atypically low, when compared with the anions and with electrical conductivity results (not graphed). Eluate samples from leaching tests submitted on the same date had the same anomaly, confirming that this was a laboratory error. Low cation results in July 2014 appear likely to have been due to the same error. A review of results since November 2019 have indicated a considerable amount of variance in the major ion chemistry compared to results prior to that date. This corresponds to a change in the laboratory undertaking the analyses and these discrepancies have now been raised with the laboratory. However, the laboratory in 2021 still seemed to have problems with the major ion analysis of seawater, probably due to dilution errors in reporting. The one set of samples taken in 2022 match the expected concentrations of seawater. However, it is

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[18] Review of the Irish Sea (Area 6) Oceanography. https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/197307/SEA6_Oceanography.pdf

***recommended*** that as soon as any marine water sampling results are received from the laboratory the major ion chemistry is checked **immediately** against the expected values in Table 7.1. Any discrepancy should then reported back to the laboratory who should still have the physical sample on which further checks can be made.

**Figure 7-3 Time series data for marine water quality near TRWM discharge: major ions**

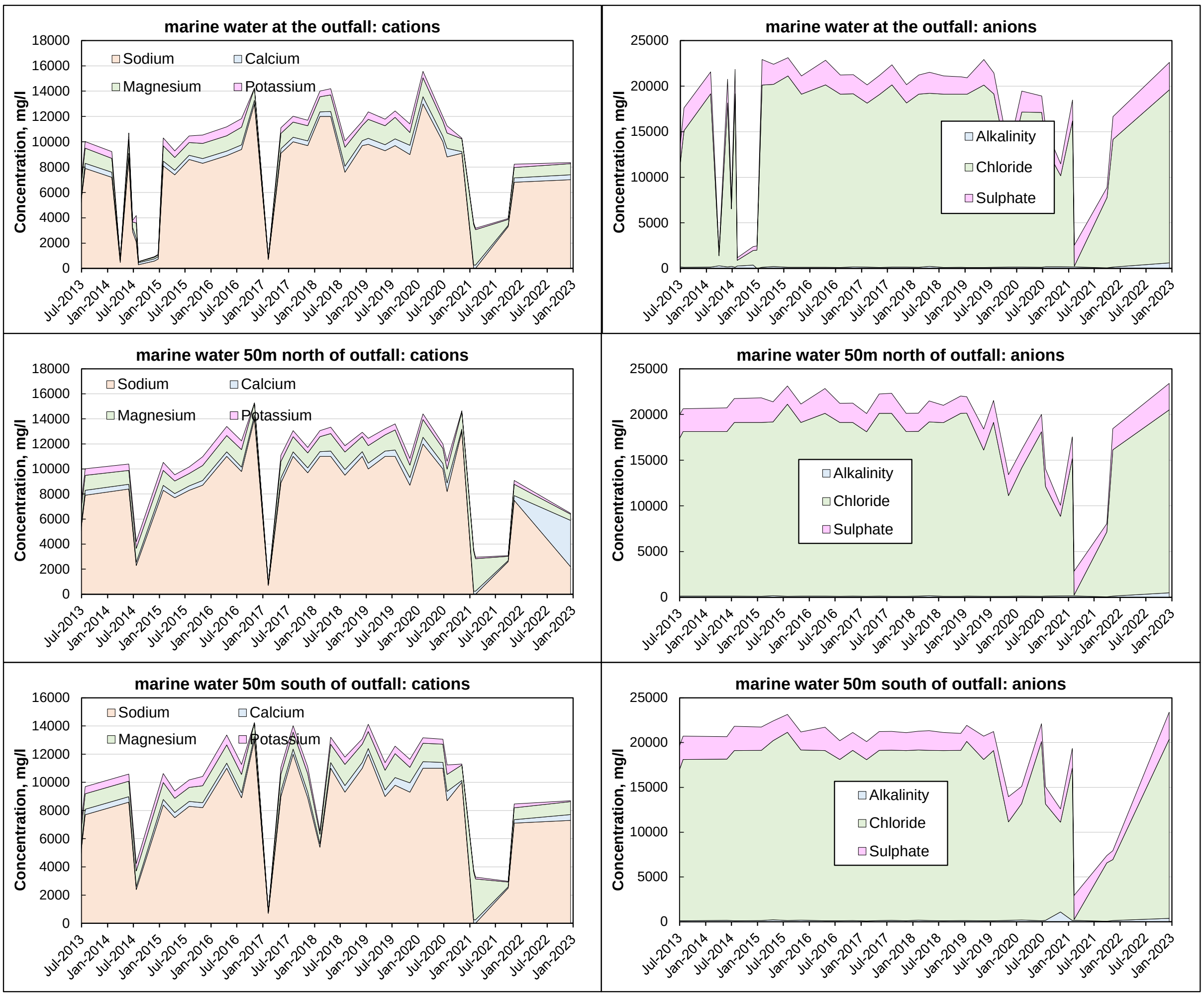
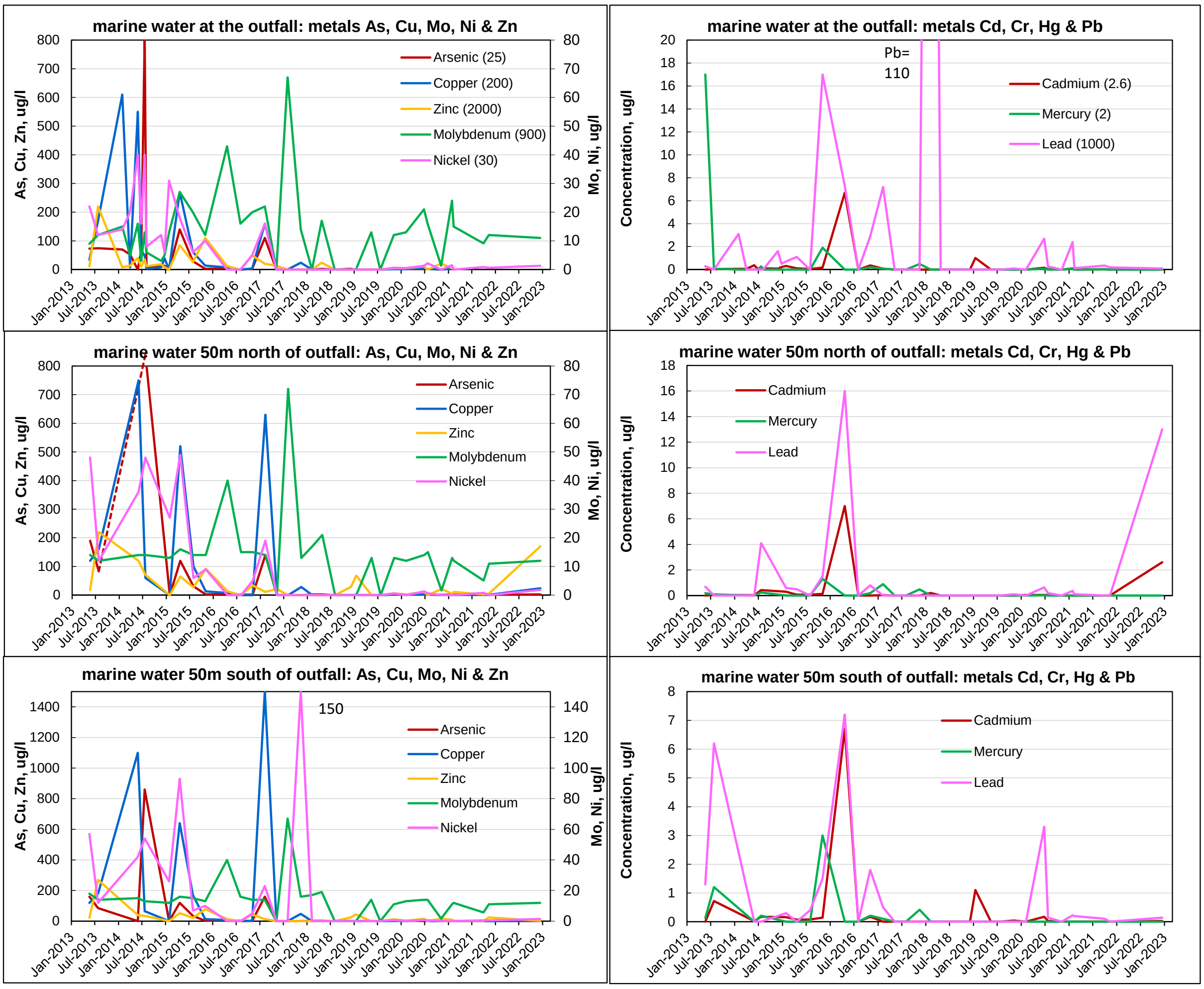


**Figure 7-4 Time series data for marine water quality near TRWM discharge: heavy metals**

(Discharge limits shown in brackets)



Comments on heavy metal concentrations are as follows:

- Results up to mid-2014 were affected by errors at CLS (formerly SAL) laboratory, due to failure to filter the samples and report dissolved metals. This resulted in erroneously high concentrations being reported. (This error was discussed in detail in the 2015 review.)

- Results from 2015 onwards show no elevation at the outfall samples compared with the other two locations, and therefore no evidence of contamination by IBA leachate.

- Since 2015, concentrations of many metals have remained at low concentrations in most samples, often being below detection limits. In 2020 the laboratory have started reporting lower detection limits, meaning that there have been more positive readings.

- Some metals are now consistently below their marine Environmental Quality Standards (EQS), at all three stations, namely: As (25µg/l), Mo (70µg/l) & Ni (8.6 µg/l). [See summary statistics on the marine water quality data for 2022 given below in Table 7.2]

**Table 7.2 Summary statistics on marine water quality at Turkeyland in 2022**

| Metal | EQS µg/l | Colas Discharge limit µg/l | IOM Coastal Water Quality Standards[19] Mean value µg/l | IOM Coastal Water Quality Standards Max value µg/l | Average concentration in marine samples µg/l |
|---|---|---|---|---|---|
| As | 25 | 25 | 25 | | 1.8 |
| Cd | | 2.6 | 0.2 | | 1.32 |
| Cr | 0.6 | 6 | 0.6 | 32 | 3.98 |
| Cu | 3.76 | 200 | 3.76 | | 9.33[1] |
| Hg | | 2 | | 0.07 | <0.01 |
| Mo | 70* | 900 | | | 11.7 |
| Ni | 8.6 | 30 | 8.6 | 34 | 1.5 |
| Pb | 1.3 | 1000 | 1.3 | 14 | 4.41 |
| Se | 10* | | | | 0.25 |
| Zn | 6.8 | 2000 | 6.8 | | 58.5[1] |

[1] *Values highlighted in red exceed IOM maximum (or mean where no max' value exists) water quality standard values for coastal waters. The average value are skewed by concentrations in the north sample on 13 December 2022 of 24* µg/l *and 170* µg/l *for copper and zinc respectively. Copper and zinc in the two other samples taken at the same time were below the IOM Water Quality Standard mean value.*

*No marine EQS set, so value shown is WHO drinking water standard.

- Spikes have sometimes occurred for Pb, Cd, Cu, Ni and occasionally Hg, at all three marine stations. There is no pattern to these spikes and no correlation with possible contamination by IBA leachate. Copper spikes in February 2017 were very high in the North and South samples, reaching 630 and 1500µg/l respectively, but much lower, at 160µg/l in the Outfall sample. Ni spiked at 150µg/l in the November 2017 sample at the South location but was below detection (<1µg/l) at the other two locations. A large Pb spike (110µg/l) occurred in the November 2018 sample for the outfall sample. However, Pb in the NTL discharge samples was always below detection limits so it is unlikely that the NTL discharge was the cause of the spike.

- Four metals, Cr, Cu, Zn and Pb, regularly exceed their EQS values of 0.6, 3.76, 6.8 and 1.3 µg/l respectively, at all three locations. There was only one set of marine samples taken in 2022 which included a spike of 170 µg/l for dissolved zinc and 24 µg/l for copper from the northern sample.

- There is no obvious correlation between heavy metals concentrations in the marine samples and those in the Turkeyland discharges.

- Localised elevations of some heavy metals have been recorded elsewhere in some inshore marine waters. To determine whether this is the case for Turkeyland, two

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[19] WATER POLLUTION (STANDARDS AND OBJECTIVES) SCHEME 2020. SD No. 2020/0537

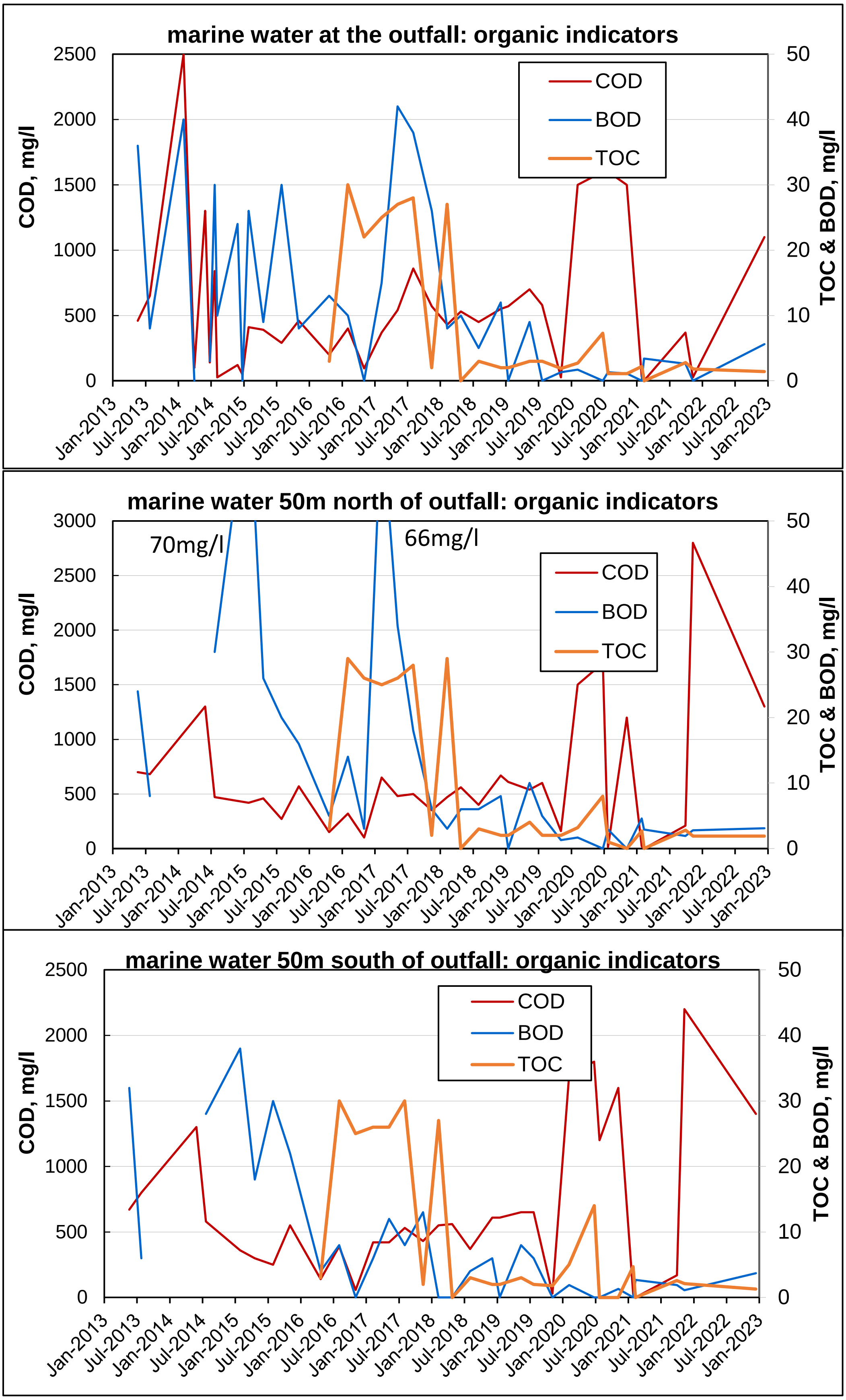
***recommendations*** from earlier reviews are re-iterated here: (i) Comparison with other Isle of Man inshore marine waters that may have been analysed by Government or by others; (ii) a cross-check of the laboratory's (DETS from October 2019) results by submitting parallel samples to another laboratory e.g. the Government laboratory.

Figure 7.5 shows unexpectedly high concentrations of organic indicators COD. They remain higher than would be expected for unpolluted marine waters:

- The high CODs, in the range ~300 to >1500 mg/l, could be due to positive interference by the high chloride concentrations. This is a common issue that can be addressed by the laboratory adding extra amounts of complexing agents to inhibit the oxidation of chloride by dichromate during the test. DETS have been asked to investigate, but considering the difficulty of this analysis consideration could be given to removing COD from the list of analyses undertaken on marine samples.

- This explanation is supported by results for Total Organic Carbon. TOC results at all three stations have typically been in the range 20-30mg/l. These would be equivalent to COD concentrations of 30-90mg/l. Therefore, the reported CODs remain anomalous and perhaps erroneous. Average TOC results for 2021 were 2.6 mg/l, with a maximum reading of 4.7 mg/l. The average TOC in 2022 was 1.5 mg/l.

**Figure 7-5 Time series data for organic indicators in marine waters near TRWM discharge**



# 8. Conclusions

8.1 Compliance with the sampling and monitoring programme during 2022 was adversely affected by the unexpected death of a key member of staff responsible for the monitoring of TRWM. Colas have been unable to access all of the monitoring records that are locked into the individual's computer and this is reflected in the low compliance rates, especially for measurements of dip readings. (Table 2.1, p15).

8.2 The solid phase composition of IBA delivered to the TRWM facility has fluctuated and changed in some respects since the evaluation trials carried out during 2007-08:

- In the Primary ash, concentrations of metals continue to vary considerably between samples; during 2022 concentrations of all metals were within the historical range monitored since 2005.
- The Secondary ash has exhibited sustained increases in Cu, Ni, Pb, Cr and Co. Concentrations of Cu, Zn, Cr and Ni in the Secondary ash are generally higher than in the Primary ash These are presumed to be due to changes in waste inputs to the secondary line.
- In late 2022 changes to the secondary incinerator operation resulted in "yellow bag" clinical wastes being processed via the primary incinerator. Sharp wastes are stockpiled and processed via the secondary line approximately every 6 months. There was no discernible influence on the composition of the bottom ash from the combination of the two waste streams.

8.3 Leaching of most heavy metals in LS10 tests on processed IBA has remained similar to historic evaluation study levels. The formal CEN leaching test BS EN12457-4 was replaced in 2021 with a standard WAC 2-stage leaching test BS EN12457-3. The initial leaching stage at LS2 in EN12457-3 provides additional useful information of potential higher leachate concentrations that could arise from IBA ash, and consequently has benefits over EN12457-4. Persistent differences between leaching test results for chromium between the on-site leaching test and the laboratory CEN or WAC tests continue into 2022 and is an area of ongoing concern.

8.4 All inert wastes accepted at the site must continue to exclude materials (e.g. fines) with a significant organic content, This mainly relates to C&D wastes arriving in skips that have not been subjected to WACS testing or any waste pre-treatment stage. All biodegradable organic waste **MUST** be excluded from the site.

8.5 The remaining airspace in NTL at the end of 2022 is estimated at ~330,000 m$^3$. The average airspace consumption between September 2020 (previous survey) and June 2022 was 38,650 m$^3$/year. Based on this value the **operational life of the site** is estimated at approximately **8.5 years from the start of 2023**.

8.6 OTL Cell leachate analyses up to 2016 indicated it was initially similar to expectations used in modelling but was significantly diluted since then, by rainfall ingress. Data prior to 2021 from reinstated monitoring in a temporary surface water collection sump in the base of Cell A reflect an ongoing decline in major ionic strength with a superimposed seasonal effect. No samples from this point were possible since 2021.

8.7 Leachate level fluctuations of 0.5m to 1m per year in OTL up to 2016, together with water balance considerations, suggest that on the order of ~6,300m$^3$/a of leachate may have been generated and then been escaping from OTL Cells A-C, largely into the surface drainage system. The situation changed in 2017 due to removal of a high proportion of the ash from OTL to NTL: the monitoring points were destroyed and no level data were obtained in 2017 or 2018. Estimated effective rainfall of 391 mm in 2022 and a surface area of ~1.2 ha of the three OTL cells indicate that ~4,700 m$^3$ of potentially contaminated surface water may be generated from OTL, equivalent to an average flow of ~13 m$^3$/day.

8.8 The major ion strength of the **Pad run-off** has been between ~10% and 100% of the predicted IBA leachate strength, compared with a range of 25% to 100% used in the impact modelling. In 2022 it was typically <10% to 25% of predicted IBA strength. Average concentrations of antimony (Sb) exceeded predicted IBA leachate strength by a factor of ~3. The majority of heavy metals are consistently at lower concentrations than predicted and consistently below their discharge limits. The exceptions are Cr, which often exceeds its discharge limit by a factor of ~2 to ~7, and Sb, which exceeds predictions but for which there is no limit on discharge

8.9 The ambiguity over the volumes of Pad run-off discharged during 2021 has been resolved. The volumes of Pad run-off discharged during 2021 averaged ~14.3 m$^3$/d and ~10.3 m$^3$/d during 2022, which (as in previous years) is slightly larger than an estimate based on effective rainfall. During 2022 there was an average of 54 days when pumping exceeded the licensed maximum discharge rate of 25m$^3$ day, and 5 days when over 50 m$^3$/day was discharged.

8.10 There was no reported discharge of NTL leachate to marine water during 2022.

8.11 Leachate levels in NTL are stabilising at around 5.5 m AOD and is in accordance with the long term hydrogeological conceptual flow model for the site.

8.12 Groundwater levels around NTL have risen in all wells other than Bh A2 (which screens different horizons than original Bh A) since 2007. The rises range from ~5.5m (Bh D) to 9m (Bh B). Water levels now range from ~10 to 12 m OD at the more inland locations (Bhs A2, B and C) to ~4 to 5 m OD at the boreholes nearest the shoreline (Bh D and E). All groundwater levels are currently above mean sea level, and water levels in Bh E and Bh D are lower than leachate levels in the site. This is in accordance with the hydrogeological conceptual flow model for the long term operation of the site. There is a seasonal variation in levels, but further monitoring is required to establish the magnitude of this. Water levels do not appear to be directly affected by the state of the tide in any borehole.

Groundwater quality around NTL shows no impact from IBA leachate. Since dewatering in NTL stopped there has been a noticeable decrease in evidence of seawater ingress into Bh E. The reasons for this are not yet understood. It may be a real effect related to the cessation in dewatering in the quarry, but may also relate to a change in monitoring protocols (e.g. the borehole may not have been properly purged prior to sampling) associated with a change in staff undertaking the monitoring. Procedural changes to the monitoring procedures enacted in September 2023 should result in monitoring after this date clarifying the position.

8.13 Some uncertainty remains regarding the accuracy of heavy metals concentrations reported for some of the marine water samples, that needs further investigation by interlab comparison and by comparison with data for other inshore marine water samples. Some metals are above their respective EQS values, but this is not linked to the landfills. There are also concerns over interference of chloride in the COD tests, in the marine water samples, and the reliability of the laboratory on reporting major ion analyses of seawater.

8.15 The monitoring data provide no evidence of an impact from IBA leachate on groundwater quality around OTL landfill, NTL landfill, or on Santon Burn. Spikes of copper and zinc in one marine sample within the context of the historical record also cannot be attributed to contamination from the landfills. A reducing trend in TOC in all marine samples starting in 2018 and extending through to 2022 is perhaps indicative of a general improvement in seawater quality.

# 9. Recommendations

## Sampling and monitoring infrastructure

9.1 In addition to the new sumps installed in the inert waste area of NTL during 2019 it is recommended [s2.5, s4.3] that at least one, preferably two at least 30 m apart, further dedicated monitoring well/sumps be installed further to the north west in the IBA area of NTL. This is to allow separate monitoring of the respective leachate quality and water levels in the inert and IBA parts of the landfill. All sumps should be provided with monitoring point identification names and monthly leachate level dipping started. The elevation (to ordnance datum) and location (for plotting on plans) of each point needs to be obtained through regular (at least once per year) surveying, and a record maintained of how these reference elevations change through time as the chambers are raised [s2.5, s5.2].

9.2 With the cessation of the pumped discharge from NTL to the sea outfall, monthly monitoring of leachate quality is no longer necessary. However, **monthly** leachate level dips should be taken in all points and bi-monthly sampling (**6 per year**) should occur in all monitoring points until a baseline record is generated **and** leachate levels in the site have stabilised to their natural "equilibrium" levels [s4.3]. All leachate samples should be obtained by pumping after 2 to 3 bore volumes of the monitoring points have been removed [s4.3]. In the case of the existing NTL leachate sumps they will require removal of many $m^3$ of water, and an appropriately sized leachate monitoring borehole pump(s) needs to be procured.

9.3 In OTL landfill, if the remaining IBA is to be there for some time, consideration should be given to installing a more formal leachate collection and pumping sump [s1.2] and measures taken to regularise the discharge of contaminated runoff to surrounding water courses. The regular monthly sampling from the temporary sump needs to be reviewed to establish why no samples were obtained during 2021 and 2022.

9.4 The groundwater monitoring infrastructure around OTL should be upgraded to provide better spatial monitoring around the site and so that it is in line with UK guidance that aims to fulfil the requirement of the landfill directive. [s2.3]. This is especially important for when OTL is redeveloped as a stable non-reactive hazardous waste landfill. It is also recommended that a more extensive suite of mainly organic pollutants are added to the routine monitoring suite of OTL ground water borehole samples. The monitoring should be kept under review and altered according to the quality of the new source term when this is better characterised following landfilling in the new facility.

9.5 At NTL the majority of the groundwater monitoring wells are screened (i.e. monitor) horizons that are not ideally located for picking up potential migration of any leachate [s2.3]. Three new groundwater monitoring wells should be installed down-gradient of NTL site with a monitoring response zone between approximately -5 m and +5 m OD [s2.3].

9.6 The volume of liquid removed (purged) from all ground water boreholes prior to a sample being taken should be recorded [s6.1.2, s6.2.2].

9.7 The frequency of groundwater level monitoring at NTL should continue on a monthly basis [s6.2.1].

9.8 On-site sampling methodology from the windrows for the IBA leaching tests should continue to ensure that (i) the oldest windrow on the pad is the one being analysed, and (ii) that on at least 4 sampling occasions the composite includes sub-samples from both interior and exterior zones of the windrow [s3.2].

9.9 The previously used single stage solid waste leaching test BS EN12457-4 should formally be replaced with WAC testing according to EN12457-3 (as occurred since 2021) [s2.1]. The difference is that EN12457-3 is a two stage leaching test that produces eluate data at LS2 and then on a second leaching stage at LS8. The initial leaching stage at LS2 in EN12457-3 provides additional useful information of potential higher leachate concentrations that could arise from IBA ash, and consequently has benefits over EN12457-4.

9.10 It is recommended that the whole of the IBA pad's discharge to outfall arrangements are reviewed. This should include whether any areas outside the pad are contributing to its catchment area, and logging of the flow meter output should be considered, to confirm that discharge is occurring at high tide according to the operating requirements of the system [s5.3.2].

9.11 Environmental monitoring of the Turkeyland landfill sites will need to continue for many decades after the site(s) are restored. It is recommended that Government considers the adoption of its own in-house data management and reporting system for environmental data for all landfills it is responsible for [s2].

## Scope and accuracy of testing

9.12 Government should press the incinerator operator Suez to resolve the inconsistency between TOC and LoI results on the solid ash analyses received from Suez [s3.1.

9.13 It is noted that the Government laboratory is now generating results for Co, Mo, Sb and Se in all groundwater and Santon Burn samples. Analysis for Hg should also be re-instated [s6.1.2, s7.1] (no results have been reported for Hg since 2010).

9.14 One or more sets of marine samples should be subjected to an inter-laboratory check for the accuracy of the heavy metal results [s7.2.

9.15 The monitoring procedure for taking marine samples should be reassessed to address H&S concerns [s2.4].

9.16 The laboratory DETS often make errors on their reporting of major ions in seawater samples. As soon as any marine water sampling results are received from the laboratory the major ion chemistry should be checked immediately against the expected values in Table 7.1. Any discrepancy should then reported back to the laboratory who should still have the physical sample on which further checks can be made. DETS continue to have difficulty with the analysis of COD in marine samples due to the interference of chloride. Consideration could be given to removing COD from the list of analyses undertaken on marine samples. [s7.2]

9.16 Colas should review the training of new monitoring personnel to ensure the requirements of the monitoring schedule are being interpreted correctly, that laboratory data is looked at in a timely fashion and that records are maintained in a secure and accessible manner [s3.2, s7.2].

## Impact assessment and impact reduction

9.17 Other examples should be sought, with the help of Government, of heavy metals concentrations in inshore marine waters around the Isle of Man [s7.2].

9.18 Now that dewatering of NTL has stopped and leachate levels in NTL are being allowed to rise, source term concentrations of leachate arising from IBA and inert wastes should be characterised by monitoring as soon as possible – see s9.1 and s9.2 above.

9.19 If IBA is to remain in place in OTL landfill for any length of time, a more formal leachate collection sump should be installed, to reduce the potential for uncontrolled seepage [s4.1,p30].

# Appendix 1

## Environmental monitoring programme for OTL IBA process facility, OTL secure landfill cells, and NTL landfill

## [as amended 11.04.17]

## 1. Old Turkeyland IBA processing facility

Waste Disposal Licence WDL/04/2010/V1
NTL Discharge Licence WPA/07/2008

**Table 1. Waste acceptance testing at OTL IBA processing facility**

| Waste type | Parameters | Limits | Frequency |
|---|---|---|---|
| Matured IBA from processing facility | Suite A on 10:1 aqueous eluate | none set | monthly |
| Matured IBA from processing facility | Suite A on BS EN12457-4 aqueous eluate | none set | 6-monthly |

Suite A: Comprehensive IBA characterization suite, comprising:
Alkalinity, as $CaCO_3$; Aluminium; Ammoniacal nitrogen; Antimony; Arsenic; Barium; Biochemical Oxygen Demand; Cadmium; Calcium; Chemical Oxygen Demand; Chloride; Chromium; Copper; Cyanide (Total); Electrical Conductivity; Fluoride; Iron; Lead; Magnesium; Manganese; Mercury; Molybdenum; Nickel; Nitrate; Nitrite; Nitrogen(Kjeldahl); pH; Potassium; Selenium; Sodium; Sulphate (Total); Thallium; Tin; Total Organic Carbon; Vanadium; Zinc.

**Table 2. Discharge via sea outfall, from IBA processing facility at OTL**

| Location | Parameters | Limits | Frequency |
|---|---|---|---|
| Run-off sump, maturation pad | Suite A | As - 25 µg/l<br>Cd – 2.6µg/l<br>Cr – 6µg/l<br>Cu – 200µg/l<br>Pb – 1,000µg/l<br>Hg – 2µg/l<br>Mo – 900µg/l<br>Ni - 30µg/l<br>Zn (total) – 2,000µg/l<br>TSS – 100mg/l<br>pH 5 – 11.4 | Monthly |
| Discharge from maturation pad to sea outfall WPA/07/2008 | Flow totaliser; pump hours run | 0.56 litres/second; $9m^3$/d continuous; $25m^3$/d limited to two days per week, and only when NTL not discharging IBA affected leachate.* | Daily |

* Reference document: ‘Impact assessment for marine disposal of run-off from pad’ prepared 17/09/10, Knox Associates (UK) Ltd.

Suite B: Discharge consent parameters: Arsenic, cadmium, chromium, copper, lead, mercury, molybdenum, nickel, zinc, pH

## 2. Old Turkeyland Landfill (OTL)

Waste Disposal Licence WDL/05/2003/V3

**Table 3. Leachate level monitoring at OTL landfill**

| Monitoring point description, as identified on Drg SLP1 Sample Locations Plan, 30.03.16 | Parameters | Limits | Frequency |
|---|---|---|---|
| OTL, Cell A, Monitoring points A1, B1, C1 | Leachate elevation | none set | monthly |

**Table 4. Leachate quality monitoring and emission monitoring at OTL landfill**

| Monitoring point description, as identified on Drg 8TS001A-03, WGS Ltd, September 2013 | Parameters | Limits | Frequency |
|---|---|---|---|
| OTL, Cell A, Monitoring points A1, B1, C1 | Suite A | none set | 6-monthly |
| OTL, Cell A, discharge via pad pipeline | Suite A | As - 25 µg/l<br>Cd – 2.6µg/l<br>Cr – 6µg/l<br>Cu – 200µg/l<br>Pb – 1,000µg/l<br>Hg – 2µg/l<br>Mo – 900µg/l<br>Ni - 30µg/l<br>Zn (total) – 2,000µg/l<br>TSS – 100mg/l<br>pH 5 – 11.4 | monthly when implemented |
| Combined discharge from OTL landfill cells to sea outfall WPA/07/2008 | Flow totaliser | none set yet | All discharges |

Suite A: Comprehensive IBA characterization suite comprising:

Alkalinity, as $CaCO_3$; Aluminium; Ammoniacal nitrogen; Antimony; Arsenic; Barium; Biochemical Oxygen Demand; Cadmium; Calcium; Chemical Oxygen Demand; Chloride; Chromium; Copper; Cyanide (Total); Electrical Conductivity; Fluoride; Iron; Lead; Magnesium; Manganese; Mercury; Molybdenum; Nickel; Nitrate; Nitrite; Nitrogen(Kjeldahl); pH; Potassium; Selenium; Sodium; Sulphate (Total); Thallium; Tin; Total Organic Carbon; Vanadium; Zinc.

**Table 5. Groundwater quality monitoring at OTL**

| Monitoring point description, as identified on Drg SLP1 Sample Locations Plan, 30.03.16 | Parameters | Reference levels | Frequency |
|---|---|---|---|
| OTL boreholes 1 to 5 | Suite C plus Mo, Sb and Se* | none set | quarterly |

Suite C: Historic groundwater suite, comprising:

COD; Cadmium; Copper; Iron; Lead; Manganese; Mercury; Molybdenum; Nickel; Zinc; $NH_4$-N; chloride; Na; K; Ca; Mg; Hardness; $SO_4$; Nitrate; Nitrite; Alkalinity; pH; electrical conductivity; temperature; dissolved oxygen;

*[2013 Review recommended addition of Mo, Sb and Se, to match marine impact assessment scope]

## 3. New Turkeyland (NTL) Landfill

Waste Disposal Licence WDL/04/2005/V2, Condition 4.10
NTL Discharge Licence WPA/07/2008

| Table 6. Leachate level monitoring at NTL | | | |
|---|---|---|---|
| **Monitoring point description, as identified on Drg SLP1 Sample Locations Plan, 30.03.16** | **Parameters** | **Limits** | **Frequency** |
| NTL, leachate sump | Leachate elevation | none set | monthly* |

* Level monitoring to start when pumping rate is reduced to allow controlled recovery of groundwater levels in NTL quarry.

| Table 7. Leachate quality and emission monitoring at NTL | | | |
|---|---|---|---|
| **Monitoring point description, as identified on Drg SLP1 Sample Locations Plan, 30.03.16** | **Parameters** | **Limits** | **Frequency** |
| NTL, leachate sump | Suite A | none set | 6-monthly |
| NTL, discharge from sump to marine outfall | Suite A | As - 25 µg/l<br>Cd – 2.6µg/l<br>Cr – 6µg/l<br>Cu – 200µg/l<br>Pb – 1,000µg/l<br>Hg – 2µg/l<br>Mo – 900µg/l<br>Ni - 30µg/l<br>Zn (total) – 2,000µg/l<br>TSS – 100mg/l<br>pH 5 – 11.4 | monthly |
| Discharge from NTL sump to sea outfall WPA/07/2008 | Flow totaliser; pump hours run | 16m$^3$/d for two days per week* | All discharges |

* Monitoring of discharge volumes begins once processed IBA has been deposited in NTL landfill

Suite A: Comprehensive IBA characterization suite, comprising:
Alkalinity, as $CaCO_3$; Aluminium; Ammoniacal nitrogen; Antimony; Arsenic; Barium; Biochemical Oxygen Demand; Cadmium; Calcium; Chemical Oxygen Demand; Chloride; Chromium; Copper; Cyanide (Total); Electrical Conductivity; Fluoride; Iron; Lead; Magnesium; Manganese; Mercury; Molybdenum; Nickel; Nitrate; Nitrite; Nitrogen(Kjeldahl); pH; Potassium; Selenium; Sodium; Sulphate (Total); Thallium; Tin; Total Organic Carbon; Vanadium; Zinc.

**Table 8. Surface water quality monitoring at NTL**

| Monitoring point description, as identified on Drg SLP1 Sample Locations Plan, 30.03.16 | Parameters | Reference levels | Frequency |
|---|---|---|---|
| Three inshore marine sampling locations ('pipe', 'north' and 'south') as identified on Drg SLP1 Sample Locations Plan, 30.03.16 | Suite A | none set | quarterly |

Suite A: Comprehensive IBA characterization suite, as above:

**Table 9. Groundwater quality monitoring at NTL**

| Monitoring point description, from Drg SLP1 Sample Locations Plan, 30.03.16 | Parameters | Reference levels | Frequency |
|---|---|---|---|
| NTL upgradient boreholes BH A and B | Suite A. | As – tbd*<br>Bisphenol-A tbd<br>BOD – 30mg/l<br>Cd - 5µg/l<br>Cu - 20µg/l<br>Hg - 5µg/l<br>Mo - 5µg/l<br>Naphthalene – tbd<br>Ni - 20µg/l<br>$NH_4$-N – 0.25mg/l<br>Pb - 6µg/l<br>Sb – tbd<br>Se – tbd<br>Zn - 150µg/l | quarterly |
| NTL downgradient boreholes BH C, D and E | Suite A. | As – tbd<br>Bisphenol-A tbd<br>BOD – tbd<br>Cd - 5µg/l<br>Cu - 20µg/l<br>Hg - 5µg/l<br>Mo - 400µg/l<br>Naphthalene – tbd<br>Ni - 20µg/l<br>$NH_4$-N – 0.6mg/l<br>Pb - 5µg/l<br>Sb – tbd<br>Se – tbd<br>Zn - 100µg/l | quarterly |

*tbd = to be determined following baseline sampling and analysis for these parameters

Suite A: Comprehensive IBA characterization suite, comprising:

Alkalinity, as $CaCO_3$; Aluminium; Ammoniacal nitrogen; Antimony; Arsenic; Barium; Biochemical Oxygen Demand; Cadmium; Calcium; Chemical Oxygen Demand; Chloride; Chromium; Copper; Cyanide (Total); Electrical Conductivity; Fluoride; Iron; Lead; Magnesium; Manganese; Mercury; Molybdenum; Nickel; Nitrate; Nitrite; Nitrogen(Kjeldahl); pH; Potassium; Selenium; Sodium; Sulphate (Total); Thallium; Tin; Total Organic Carbon; Vanadium; Zinc.

## 4. Santon Burn (not part of waste licensing controls)

**Table 10. Surface water quality monitoring of Santon Burn**

| Monitoring point description, as identified on Drg SLP1 Sample Locations Plan, 30.03.16 | Parameters | Reference levels | Frequency |
|---|---|---|---|
| Three locations:<br>Upstream of fissure discharge<br>Fissure discharge<br>Downstream of fissure discharge | Suite C | none set | quarterly |

Suite C: Historic groundwater monitoring suite, comprising:
COD; Cadmium; Copper; Iron; Lead; Manganese; Mercury; Molybdenum; Nickel; Zinc; $NH_4$-N; chloride; Na; K; Ca; Mg; Hardness; $SO_4$; Nitrate; Nitrite; Alkalinity; pH; electrical conductivity; temperature; dissolved oxygen;

# Appendix 2

## Completed monitoring schedule for 2022

Schedule not received – see Table 2.1, page 15

# Appendix 3

## Waste acceptance protocol for IBA processing facility

## Turkeyland Recycling and Waste Management Ltd
## Licence number WDL/04/2010/V1: Bottom ash waste transfer station with treatment.

# Protocol for waste acceptance testing

### Responsibilities of others

1. It shall be the responsibility of the Client (DLGE, subsequently the Department of Infrastructure) to ensure that the composition of the IBA delivered to the OTL processing facility is consistent with previously tested IBA.

2. The Client shall provide Turkeyland Recycling and Waste Management Ltd (TRWM) with copies of routine test results and analyses carried out on the IBA. It is understood that these analyses are carried out quarterly. These results shall be submitted to Colas within 3 months of the date of production of the IBA.

3. The Client shall inform TRWM of any material change in either the incineration process, the waste inputs, or the incinerator licence, that may affect the properties of the IBA during processing at Old Turkeyland and subsequent landfilling in New Turkeyland.

### Responsibilities of TRWM

4. On arrival of the IBA at OTL, a designated TRWM employee shall carry out a visual inspection of each load prior to its being deposited in a quarantine area. This will include checking for the presence of non-IBA materials and for unacceptable amounts of unburnt organic materials in the IBA. If the load is noted to be of sub-standard quality at this stage, it will be rejected and not be allowed to proceed further for processing.

5. TRWM shall notify the Client and the regulator in writing within 3 working days of rejecting any load, giving details of the vehicle, its load and the reasons for rejection. TRWM shall maintain a log of rejected loads and include this in its quarterly returns of waste tonnages to the regulatory department of DEFA.

6. TRWM shall carry out a monthly leaching test on matured ash from the Old Turkeyland processing facility. Sampling and mixing of a composite sub-sample shall be carried out according to the Sampling Plan set out in Annex 1 to this document The leaching test shall be carried out on site according to a protocol set out as an Annex 2 to this document. The results of each leaching test shall be submitted to DEFA within 3 months of each sample being taken. At intervals of not more than 12 months, the results shall be collated and compared with historic leaching test results on this material.

7. Every six months, TRWM shall submit a replicate sample of the composite sub-sample of matured ash from the OTL processing facility to an external laboratory for a leaching test according to BS EN12457-4. The results shall be compared with those from the in-house leaching test and used to determine whether the in-house test remains adequate for routine quality control.

8. TRWM shall take a sample of ~2kg of matured IBA from the Old Turkeyland processing facility at intervals of not more than 2 weeks and retain the sample for a period of 26 weeks. Each sample shall be large enough to allow a leaching test and chemical analysis to be carried out.

## Annex 1: Sampling Plan to prepare a composite sub-sample from a stockpile of matured IBA

### Objective

The purpose of testing samples is to ensure that the processed IBA has undergone a degree of maturation, and has leaching characteristics, comparable with those established at the stage of carrying out the impact assessments for New Turkeyland landfill and for the disposal of run-off from the maturation pad.

### Monthly

1. The ***composite*** sub-sample shall be prepared from ***increments***, taken from a single stockpile of IBA that has been in place on the maturation pad for ~3 months following processing to remove metals.
2. Select the stockpile to be sampled. The selected stockpile should contain ~10-20 tonnes of material. This is roughly equivalent to 20% to 50% of a normal working day's intake of IBA.
3. Record the date on which the IBA in the selected stockpile first entered the facility and/or was processed to remove metals. Ideally, the stockpile should be from IBA that entered the facility on a date on which a sample was taken at the EfW plant for analysis of solids.
4. The stockpile should be mixed in preparation for the taking of increments, by repeatedly flattening it and mixing it with the bucket of a mechanical digger/excavator. This is necessary to ensure that increments are taken equally from all parts of the stockpile. Mixing should be achieved by lifting bucketful's from the edges of the flattened pile into to the centre, re-forming a pile, re-flattening and repeating the process [twenty]* times.
5. At the end of mixing, the stockpile should be flattened, ready for taking of increments.
6. Increments should be taken from the flattened pile using a stainless steel hand trowel. They should be taken from at least [9]** locations forming a 'W' pattern across the whole of the pile.
7. The increments should be placed in a plastic container and should create a composite of at least 5kg. This should be mixed in the container, ready for sub-sampling to use in the leaching test. Material not used in the leaching test either on site or by an external laboratory should be retained in a container with an air-tight clip on lid.

### Six monthly

8. The ~5kg of mixed composite should be passed through a 10mm sieve. The weights of both the sieved materials and the materials retained on the sieve should be recorded.
9. The sieved material should be re-mixed in the container.
10. The 6-monthly on site leaching test and the 6-monthly sample for external leach testing to BS EN12457-4 should be carried out on sub-samples of the sieved IBA.

* Twenty times is suggested in the 2011 EA guidance document on ash sampling. The number for Turkeyland should be reviewed after some initial trials and this Protocol then updated if necessary.

** The 2011 EA guidance suggests at least 7 increments into each composite sample. In this sampling design, the extremities of each point of the 'W' plus one from half way along each leg of the 'W' would give 9 increments.

## Annex 2. Protocol for in-house leaching test as alternative to BS EN12457-4

## Status: Draft 3, 15.11.13, unapproved

### Equipment

Mini cement mixer (single phase 250v);

Scales for weighing IBA samples

### Procedure

1. Use IBA from a pre-mixed composite, prepared by taking increments from a stockpile as set out in Annex 1 to this protocol.
2. Use 2kg of IBA plus 20 litres of tap water in the leaching test; IBA to be weighed out on scales for every test, exact weight to be recorded for audit trail. Water volume to be measured out for every test; exact volume to be recorded for audit trail.
3. Mix the water and IBA in the cement mixer for 5 x 30 minutes with 30 minute intervals between each mixing, controlled by simple timer switch.
4. After the final rest period, decant the leachate, through a coarse filter if necessary to remove gross solids, into a plastic sample container with screw-on lid.
5. Filter at least 2 litres of leachate from this container through a fine filter [0.45μm]* into at least two 1 litre containers suitable for submission to an external laboratory for analysis.
6. N.B. The sample will be alkaline, with a pH value up to 13. Therefore you must ensure that suitable gloves and eye protection are used when carrying out these tests to avoid irritation from splashes.
7. Retain at least one 1 litre container of the remaining filtered leachate until confirmation that satisfactory analysis has been received. Dispose of used ash and remaining leachate on the ash pad.
8. The stockpile sampling details together with the eluate weights and water volumes, date of leaching test and date of dispatch to the external laboratory shall be collated in a single pro forma, set up in Excel spreadsheet format suitable for electronic archiving.

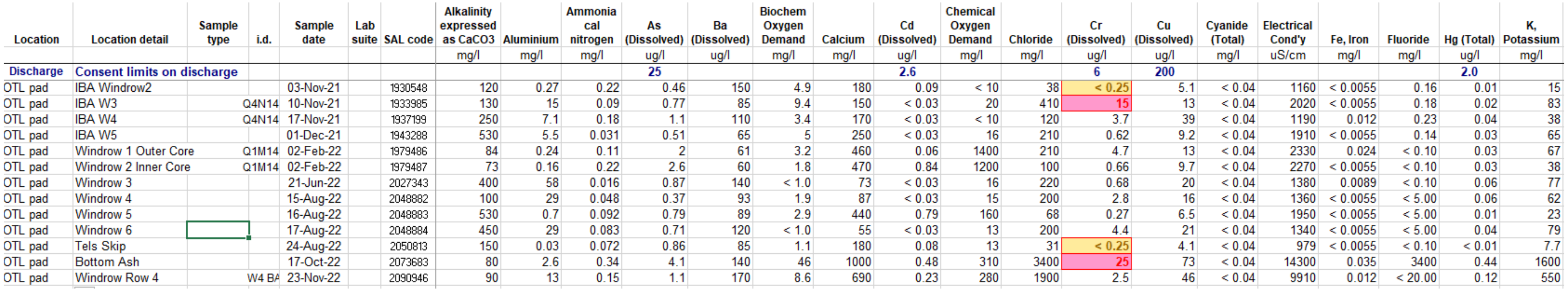
* Filter pore size subject to practicality trials and evaluation of impact on results.

# Appendix 4

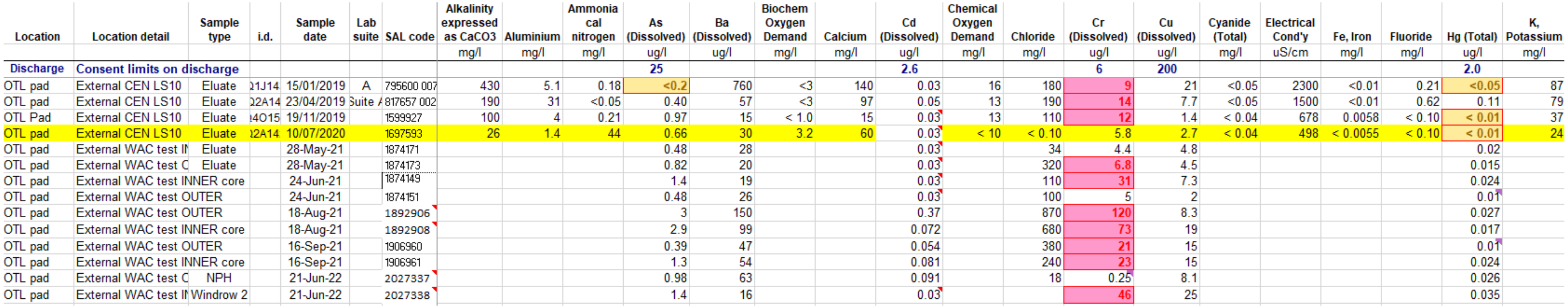
## Tabulated results for leaching tests, leachates, sumps, discharges and inshore marine water samples

# Results of leaching tests on IBA residuals from OTL processing facility, and OTL Cell leachates

Table shows concentrations in aqueous LS 10:1 eluates [Pink shading denotes results exceeding discharge limits]



| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | Alkalinity expressed as CaCO3 | Aluminium | Ammonia cal nitrogen | As (Dissolved) | Ba (Dissolved) | Biochem Oxygen Demand | Calcium | Cd (Dissolved) | Chemical Oxygen Demand | Chloride | Cr (Dissolved) | Cu (Dissolved) | Cyanide (Total) | Electrical Cond'y | Fe, Iron | Fluoride | Hg (Total) | K, Potassium |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | mg/l | mg/l | mg/l | ug/l | ug/l | mg/l | mg/l | ug/l | mg/l | mg/l | ug/l | ug/l | mg/l | uS/cm | mg/l | mg/l | ug/l | mg/l |
| Discharge | Consent limits on discharge |  |  |  |  |  |  |  |  | 25 |  |  |  | 2.6 |  |  | 6 | 200 |  |  |  |  | 2.0 |  |
| OTL pad | IBA Windrow2 |  |  | 03-Nov-21 |  | 1930548 | 120 | 0.27 | 0.22 | 0.46 | 150 | 4.9 | 180 | 0.09 | < 10 | 38 | < 0.25 | 5.1 | < 0.04 | 1160 | < 0.0055 | 0.16 | 0.01 | 15 |
| OTL pad | IBA W3 |  | Q4N14 | 10-Nov-21 |  | 1933985 | 130 | 15 | 0.09 | 0.77 | 85 | 9.4 | 150 | < 0.03 | 20 | 410 | 15 | 13 | < 0.04 | 2020 | < 0.0055 | 0.18 | 0.02 | 83 |
| OTL pad | IBA W4 |  | Q4N14 | 17-Nov-21 |  | 1937199 | 250 | 7.1 | 0.18 | 1.1 | 110 | 3.4 | 170 | < 0.03 | < 10 | 120 | 3.7 | 39 | < 0.04 | 1190 | 0.012 | 0.23 | 0.04 | 38 |
| OTL pad | IBA W5 |  |  | 01-Dec-21 |  | 1943288 | 530 | 5.5 | 0.031 | 0.51 | 65 | 5 | 250 | < 0.03 | 16 | 210 | 0.62 | 9.2 | < 0.04 | 1910 | < 0.0055 | 0.14 | 0.03 | 65 |
| OTL pad | Windrow 1 Outer Core |  | Q1M14 | 02-Feb-22 |  | 1979486 | 84 | 0.24 | 0.11 | 2 | 61 | 3.2 | 460 | 0.06 | 1400 | 210 | 4.7 | 13 | < 0.04 | 2330 | 0.024 | < 0.10 | 0.03 | 67 |
| OTL pad | Windrow 2 Inner Core |  | Q1M14 | 02-Feb-22 |  | 1979487 | 73 | 0.16 | 0.22 | 2.6 | 60 | 1.8 | 470 | 0.84 | 1200 | 100 | 0.66 | 9.7 | < 0.04 | 2270 | < 0.0055 | < 0.10 | 0.03 | 38 |
| OTL pad | Windrow 3 |  |  | 21-Jun-22 |  | 2027343 | 400 | 58 | 0.016 | 0.87 | 140 | < 1.0 | 73 | < 0.03 | 16 | 220 | 0.68 | 20 | < 0.04 | 1380 | 0.0089 | < 0.10 | 0.06 | 77 |
| OTL pad | Windrow 4 |  |  | 15-Aug-22 |  | 2048882 | 100 | 29 | 0.048 | 0.37 | 93 | 1.9 | 87 | < 0.03 | 15 | 200 | 2.8 | 16 | < 0.04 | 1360 | < 0.0055 | < 5.00 | 0.06 | 62 |
| OTL pad | Windrow 5 |  |  | 16-Aug-22 |  | 2048883 | 530 | 0.7 | 0.092 | 0.79 | 89 | 2.9 | 440 | 0.79 | 160 | 68 | 0.27 | 6.5 | < 0.04 | 1950 | < 0.0055 | < 5.00 | 0.01 | 23 |
| OTL pad | Windrow 6 |  |  | 17-Aug-22 |  | 2048884 | 450 | 29 | 0.083 | 0.71 | 120 | < 1.0 | 55 | < 0.03 | 13 | 200 | 4.4 | 21 | < 0.04 | 1340 | < 0.0055 | < 5.00 | 0.04 | 79 |
| OTL pad | Tels Skip |  |  | 24-Aug-22 |  | 2050813 | 150 | 0.03 | 0.072 | 0.86 | 85 | 1.1 | 180 | 0.08 | 13 | 31 | < 0.25 | 4.1 | < 0.04 | 979 | < 0.0055 | < 0.10 | < 0.01 | 7.7 |
| OTL pad | Bottom Ash |  |  | 17-Oct-22 |  | 2073683 | 80 | 2.6 | 0.34 | 4.1 | 140 | 46 | 1000 | 0.48 | 310 | 3400 | 25 | 73 | < 0.04 | 14300 | 0.035 | 3400 | 0.44 | 1600 |
| OTL pad | Windrow Row 4 |  | W4 B | 23-Nov-22 |  | 2090946 | 90 | 13 | 0.15 | 1.1 | 170 | 8.6 | 690 | 0.23 | 280 | 1900 | 2.5 | 46 | < 0.04 | 9910 | 0.012 | < 20.00 | 0.12 | 550 |

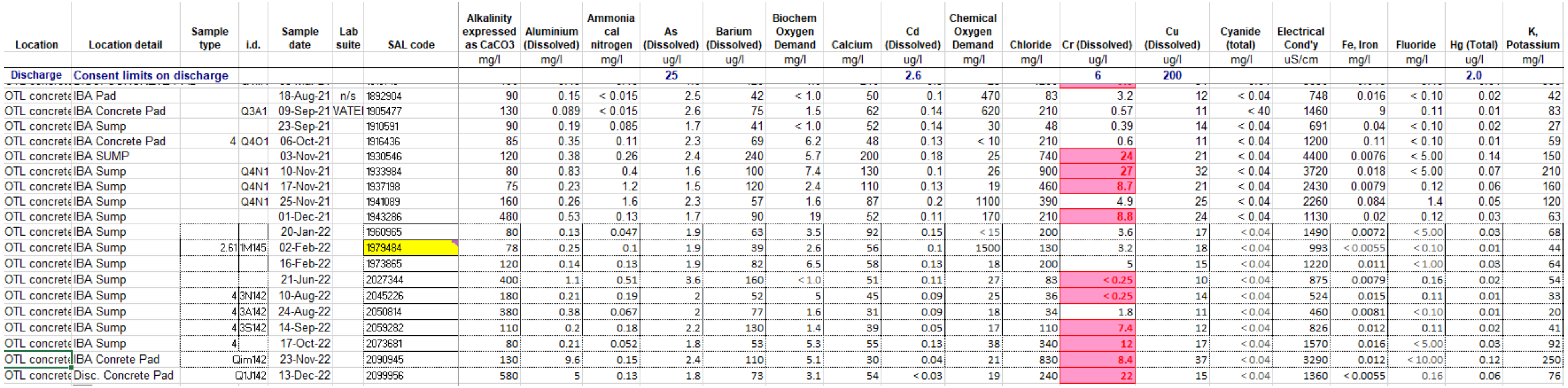


| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | Alkalinity expressed as CaCO3 | Aluminium | Ammonia cal nitrogen | As (Dissolved) | Ba (Dissolved) | Biochem Oxygen Demand | Calcium | Cd (Dissolved) | Chemical Oxygen Demand | Chloride | Cr (Dissolved) | Cu (Dissolved) | Cyanide (Total) | Electrical Cond'y | Fe, Iron | Fluoride | Hg (Total) | K, Potassium |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  | mg/l | mg/l | mg/l | ug/l | ug/l | mg/l | mg/l | ug/l | mg/l | mg/l | ug/l | ug/l | mg/l | uS/cm | mg/l | mg/l | ug/l | mg/l |
| Discharge | Consent limits on discharge |  |  |  |  |  |  |  |  | 25 |  |  |  | 2.6 |  |  | 6 | 200 |  |  |  |  | 2.0 |  |
| OTL pad | External CEN LS10 | Eluate | 1J14 | 15/01/2019 | A | 795600 007 | 430 | 5.1 | 0.18 | <0.2 | 760 | <3 | 140 | 0.03 | 16 | 180 | 9 | 21 | <0.05 | 2300 | <0.01 | 0.21 | <0.05 | 87 |
| OTL pad | External CEN LS10 | Eluate | 2A14 | 23/04/2019 | Suite | 817657 002 | 190 | 31 | <0.05 | 0.40 | 57 | <3 | 97 | 0.05 | 13 | 190 | 14 | 7.7 | <0.05 | 1500 | <0.01 | 0.62 | 0.11 | 79 |
| OTL Pad | External CEN LS10 | Eluate | 4O15 | 19/11/2019 |  | 1599927 | 100 | 4 | 0.21 | 0.97 | 15 | < 1.0 | 15 | 0.03 | 13 | 110 | 12 | 1.4 | < 0.04 | 678 | 0.0058 | < 0.10 | < 0.01 | 37 |
| OTL pad | External CEN LS10 | Eluate | 2A14 | 10/07/2020 |  | 1697593 | 26 | 1.4 | 44 | 0.66 | 30 | 3.2 | 60 | 0.03 | < 10 | < 0.10 | 5.8 | 2.7 | < 0.04 | 498 | < 0.0055 | < 0.10 | < 0.01 | 24 |
| OTL pad | External WAC test I | Eluate |  | 28-May-21 |  | 1874171 |  |  |  | 0.48 | 28 |  |  | 0.03 |  | 34 | 4.4 | 4.8 |  |  |  |  | 0.02 |  |
| OTL pad | External WAC test C | Eluate |  | 28-May-21 |  | 1874173 |  |  |  | 0.82 | 20 |  |  | 0.03 |  | 320 | 6.8 | 4.5 |  |  |  |  | 0.015 |  |
| OTL pad | External WAC test INNER core |  |  | 24-Jun-21 |  | 1874149 |  |  |  | 1.4 | 19 |  |  | 0.03 |  | 110 | 31 | 7.3 |  |  |  |  | 0.024 |  |
| OTL pad | External WAC test OUTER |  |  | 24-Jun-21 |  | 1874151 |  |  |  | 0.48 | 26 |  |  | 0.03 |  | 100 | 5 | 2 |  |  |  |  | 0.01 |  |
| OTL pad | External WAC test OUTER |  |  | 18-Aug-21 |  | 1892906 |  |  |  | 3 | 150 |  |  | 0.37 |  | 870 | 120 | 8.3 |  |  |  |  | 0.027 |  |
| OTL pad | External WAC test INNER core |  |  | 18-Aug-21 |  | 1892908 |  |  |  | 2.9 | 99 |  |  | 0.072 |  | 680 | 73 | 19 |  |  |  |  | 0.017 |  |
| OTL pad | External WAC test OUTER |  |  | 16-Sep-21 |  | 1906960 |  |  |  | 0.39 | 47 |  |  | 0.054 |  | 380 | 21 | 15 |  |  |  |  | 0.01 |  |
| OTL pad | External WAC test INNER core |  |  | 16-Sep-21 |  | 1906961 |  |  |  | 1.3 | 54 |  |  | 0.081 |  | 240 | 23 | 15 |  |  |  |  | 0.024 |  |
| OTL pad | External WAC test C | NPH |  | 21-Jun-22 |  | 2027337 |  |  |  | 0.98 | 63 |  |  | 0.091 |  | 18 | 0.25 | 8.1 |  |  |  |  | 0.026 |  |
| OTL pad | External WAC test I | Windrow 2 |  | 21-Jun-22 |  | 2027338 |  |  |  | 1.4 | 16 |  |  | 0.03 |  |  | 46 | 25 |  |  |  |  | 0.035 |  |

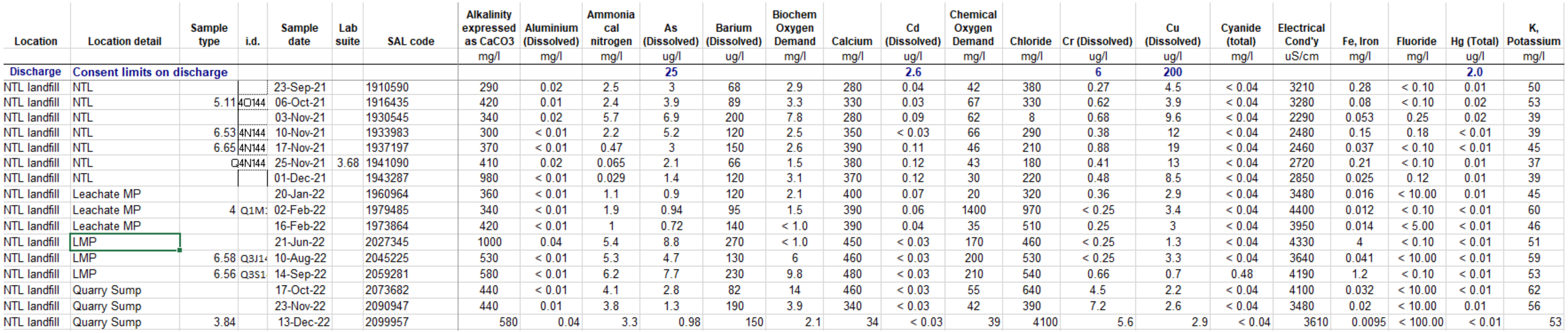
| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | Mg | Mn (Dissolved) | Mo (Total) | Na, Sodium | Ni (Dissolved) | Nitrate | Nitrite | Nitrogen (Kjeldahl) | Pb (Dissolved) | pH | Sb (Dissolved) | Se (Dissolved) | Sn, Tin | SO4 (Total) | Suspended solids | Thallium | Total Organic Carbon | V (Dissolved) | Zn (Dissolved) | Zn (Total) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | mg/l | ug/l | ug/l | mg/l | ug/l | mg/l | mg/l | mg/l | ug/l | 5 - 11.4 | ug/l | ug/l | mg/l | mg/l | mg/l | mg/l | mg/l | ug/l | ug/l | ug/l |
| **Discharge** | **Consent limits on discharge** | | | | | | | | **900** | | **30** | | | | **1000** | **11.4** | | | | | | | | | **2000** | |
| OTL pad | IBA Windrow2 | | | 03-Nov-21 | | 1930548 | 4.1 | 47 | 9.3 | 22 | 1.2 | | 0.59 | 0.5 | 0.12 | 7.9 | 26 | 0.92 | 0.0026 | 51 | 76 | < 0.08 | < 1.0 | < 0.6 | 36 | 530 |
| OTL pad | IBA W3 | | Q4N14 | 10-Nov-21 | | 1933985 | 0.29 | 0.52 | 27 | 180 | < 0.5 | 0.44 | 3.8 | 2.1 | < 0.09 | 10.1 | 8.2 | 1.8 | < 0.0004 | 660 | 42 | < 0.08 | 9.3 | 3.5 | 23 | 670 |
| OTL pad | IBA W4 | | Q4N14 | 17-Nov-21 | | 1937199 | 0.83 | 0.89 | 22 | 61 | 0.5 | 0.4 | 0.89 | 0.8 | 0.16 | 9.5 | 13 | 1.2 | < 0.0004 | 370 | 46 | < 0.08 | 3.3 | 2.6 | 62 | 390 |
| OTL pad | IBA W5 | | | 01-Dec-21 | | 1943288 | 3.3 | 26 | 30 | 110 | 0.5 | 1.4 | 2.9 | 0.4 | < 0.09 | 8.5 | 40 | 2.1 | < 0.0004 | 710 | 110 | < 0.08 | 1.5 | < 0.6 | 14 | 840 |
| OTL pad | Windrow 1 Outer Core | | Q1M14 | 02-Feb-22 | | 1979486 | 2 | 18 | 22 | 55 | < 0.5 | < 0.10 | < 0.035 | 0.5 | 0.38 | 10 | 7.8 | 4 | < 0.0004 | 1600 | 74 | 0.55 | 2.2 | 5.5 | 5.1 | 6000 |
| OTL pad | Windrow 2 Inner Core | | Q1M14 | 02-Feb-22 | | 1979487 | 6.8 | 24 | 16 | 43 | 1.6 | < 0.10 | < 0.035 | 0.7 | 3.4 | 8.7 | 29 | 3.5 | < 0.0004 | 1500 | 100 | 0.55 | 1.2 | 1.3 | 12 | 1900 |
| OTL pad | Windrow 3 | | | 21-Jun-22 | | 2027343 | 0.59 | 6.4 | 63 | 150 | < 0.5 | 0.23 | < 0.035 | 0.6 | < 0.09 | 10.4 | 27 | 0.9 | 0.0005 | 140 | 70 | < 0.08 | 2.4 | 6 | 15 | 530 |
| OTL pad | Windrow 4 | | | 15-Aug-22 | | 2048882 | 0.66 | 6.5 | 39 | 140 | < 0.5 | < 0.10 | < 0.035 | 1 | < 0.09 | 9.3 | 18 | 1.4 | < 0.0004 | 250 | 51 | < 0.08 | 1.7 | < 0.6 | 3.8 | 33 |
| OTL pad | Windrow 5 | | | 16-Aug-22 | | 2048883 | 4.9 | 76 | 12 | 39 | 1.4 | 4.1 | < 0.035 | < 0.2 | 0.59 | 7.9 | 20 | 1.6 | < 0.0004 | 1000 | 53 | < 0.08 | < 1.0 | < 0.6 | 46 | 840 |
| OTL pad | Windrow 6 | | | 17-Aug-22 | | 2048884 | 0.06 | 0.39 | 38 | 120 | < 0.5 | < 0.10 | < 0.035 | 0.8 | 0.12 | 11 | 24 | 0.93 | 0.0005 | 150 | 46 | < 0.08 | < 1.0 | 5 | 21 | 270 |
| OTL pad | Tels Skip | | | 24-Aug-22 | | 2050813 | 6.1 | 20 | 5 | 19 | 0.7 | 3.6 | < 0.035 | 0.3 | 0.15 | 7 | 2.6 | 1.1 | < 0.0004 | 360 | 110 | < 0.08 | 8.2 | < 0.6 | 26 | 120 |
| OTL pad | Bottom Ash | | | 17-Oct-22 | | 2073683 | 5.3 | 35 | 320 | 1300 | 4.4 | < 0.10 | 0.054 | 1.7 | 1.3 | 10.3 | 2.1 | 37 | < 0.0004 | 2000 | 5300 | 0.32 | 11 | 6.6 | 7.3 | 6300 |
| OTL pad | Windrow Row 4 | | W4 BA | 23-Nov-22 | | 2090946 | 9.6 | 8 | 310 | 1100 | 1.1 | < 0.10 | 0.064 | 1 | < 0.09 | 8 | 6.1 | 25 | 0.0017 | 1800 | 13000 | < 0.08 | 9.3 | 1.4 | 13 | 38000 |

| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | Mg | Mn (Dissolved) | Mo (Total) | Na, Sodium | Ni (Dissolved) | Nitrate | Nitrite | Nitrogen (Kjeldahl) | Pb (Dissolved) | pH | Sb (Dissolved) | Se (Dissolved) | Sn, Tin | SO4 (Total) | Suspended solids | Thallium | Total Organic Carbon | V (Dissolved) | Zn (Dissolved) | Zn (Total) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | mg/l | ug/l | ug/l | mg/l | ug/l | mg/l | mg/l | mg/l | ug/l | 5 - 11.4 | ug/l | ug/l | mg/l | mg/l | mg/l | mg/l | mg/l | ug/l | ug/l | ug/l |
| **Discharge** | **Consent limits on discharge** | | | | | | | | **900** | | **30** | | | | **1000** | **11.4** | | | | | | | | | **2000** | |
| OTL pad | External CEN LS10 | Eluate | 1J14 | 15/01/2019 | A | 795600 007 | <1 | <1 | 49 | 120 | 1 | <0.5 | <0.1 | <10 | 67 | 11.9 | 3 | <0.5 | <0.01 | 11 | <10 | <0.04 | 5 | <2 | 210 | |
| OTL pad | External CEN LS10 | Eluate | 2A14 | 23/04/2019 | Suite | 817657 002 | <1 | <1 | 45 | 150 | 1 | <0.5 | <0.1 | <10 | 3.6 | 11.2 | 20 | 0.7 | <0.01 | 140 | 34 | <0.04 | 2 | 7 | 15 | |
| OTL Pad | External CEN LS10 | Eluate | 4O15 | 19/11/2019 | | 1599927 | 0.26 | 0.33 | 33 | 58 | 0.05 | < 0.10 | 0.47 | 12 | 0.22 | 10.3 | 8.2 | 1.1 | < 0.0004 | 48 | | | 2.7 | 1.4 | 1.3 | |
| OTL pad | External CEN LS10 | Eluate | 2A14 | 10/07/2020 | | 1697593 | 1.1 | 4.3 | 4.2 | 17 | 0.5 | 0.2 | < 0.2 | 180 | 0.09 | 8.2 | 11 | 0.6 | < 0.0004 | 1.3 | 3.3 | | | 2.1 | 1.3 | < 1.3 |
| OTL pad | External WAC test IN | Eluate | | 28-May-21 | | 1874171 | | | 5.8 | | 0.5 | | | | 0.38 | 7.8 | 10 | 0.87 | | 130 | | | 2 | | 1.7 | |
| OTL pad | External WAC test O | Eluate | | 28-May-21 | | 1874173 | | | 9.1 | | 0.5 | | | | 0.56 | 9.8 | 11 | 0.69 | | 54 | | | 2.1 | | 5.3 | |
| OTL pad | External WAC test INNER core | | | 24-Jun-21 | | 1874149 | | | 32 | | 0.5 | | | | 0.5 | 9.7 | 7.1 | 0.92 | | 71 | | | 2.6 | | 2.8 | |
| OTL pad | External WAC test OUTER | | | 24-Jun-21 | | 1874151 | | | 10 | | 0.5 | | | | 0.09 | 8.2 | 5.4 | 1.2 | | 200 | | | 2 | | 1.3 | |
| OTL pad | External WAC test OUTER | | | 18-Aug-21 | | 1892906 | | | 85 | | 0.5 | | | | 3.9 | 9.3 | 10 | 23 | | 0.1 | | | 2.1 | | 1.8 | |
| OTL pad | External WAC test INNER core | | | 18-Aug-21 | | 1892908 | | | 73 | | 0.5 | | | | 2.1 | 9.8 | 3.6 | 8.5 | | 0.1 | | | 7.1 | | 2.4 | |
| OTL pad | External WAC test OUTER | | | 16-Sep-21 | | 1906960 | | | 10 | | 0.84 | | | | 0.09 | 6.9 | 14 | 1 | | 140 | | | 2.2 | | 6.4 | |
| OTL pad | External WAC test INNER core | | | 16-Sep-21 | | 1906961 | | | 14 | | 1 | | | | 1.9 | 8.4 | 14 | 1.7 | | 200 | | | 2 | | 7.8 | |
| OTL pad | External WAC test O | NPH | | 21-Jun-22 | | 2027337 | | | 2.4 | | 1 | | | | 0.09 | 9.8 | 2.2 | 0.62 | | 770 | | | 4.5 | | 20 | |
| OTL pad | External WAC test IN | Windrow 2 | | 21-Jun-22 | | 2027338 | | | 33 | | 0.5 | | | | 0.09 | 11.2 | 8.2 | 0.72 | | 53 | | | 3.9 | | 1.3 | |

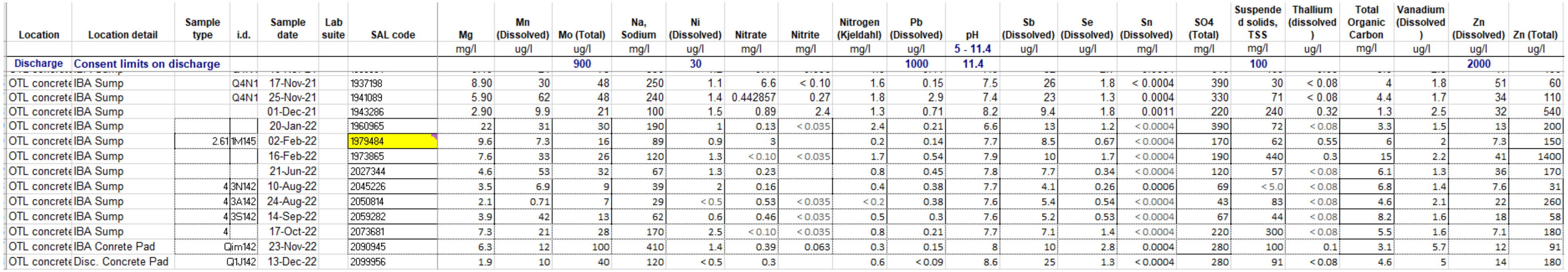
## **Results for Pad run-off and NTL landfill sump leachate** [Pink shading denotes results exceeding discharge limits]



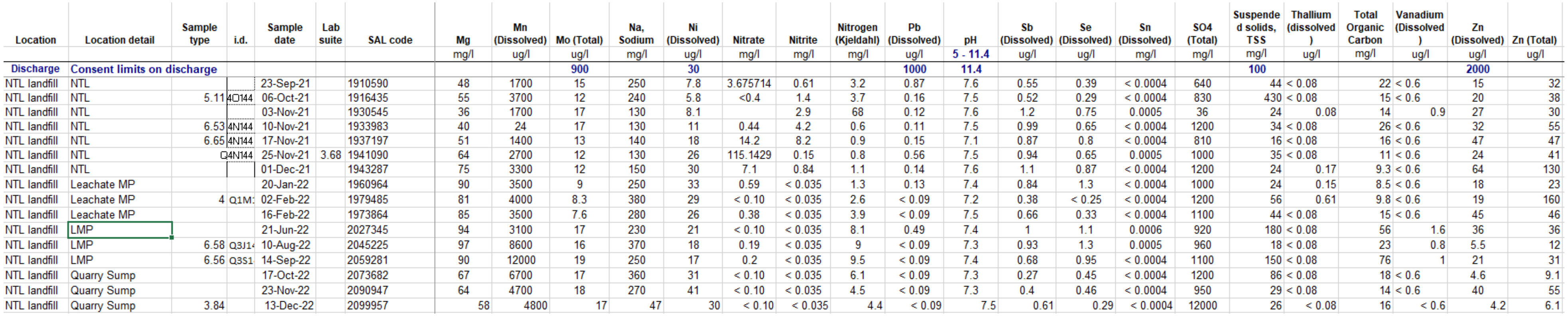
| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | Alkalinity expressed as CaCO3 | Aluminium (Dissolved) | Ammonia cal nitrogen | As (Dissolved) | Barium (Dissolved) | Biochem Oxygen Demand | Calcium | Cd (Dissolved) | Chemical Oxygen Demand | Chloride | Cr (Dissolved) | Cu (Dissolved) | Cyanide (total) | Electrical Cond'y | Fe, Iron | Fluoride | Hg (Total) | K, Potassium |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | mg/l | mg/l | mg/l | ug/l | ug/l | mg/l | mg/l | ug/l | mg/l | mg/l | ug/l | ug/l | mg/l | uS/cm | mg/l | mg/l | ug/l | mg/l |
| **Discharge** | **Consent limits on discharge** | | | | | | | | | **25** | | | | **2.6** | | | **6** | **200** | | | | | **2.0** | |
| OTL concrete | IBA Pad | | | 18-Aug-21 | n/s | 1892904 | 90 | 0.15 | < 0.015 | 2.5 | 42 | < 1.0 | 50 | 0.1 | 470 | 83 | 3.2 | 12 | < 0.04 | 748 | 0.016 | < 0.10 | 0.02 | 42 |
| OTL concrete | IBA Concrete Pad | | Q3A1 | 09-Sep-21 | VATEI | 1905477 | 130 | 0.089 | < 0.015 | 2.6 | 75 | 1.5 | 62 | 0.14 | 620 | 210 | 0.57 | 11 | < 40 | 1460 | 9 | 0.11 | 0.01 | 83 |
| OTL concrete | IBA Sump | | | 23-Sep-21 | | 1910591 | 90 | 0.19 | 0.085 | 1.7 | 41 | < 1.0 | 52 | 0.14 | 30 | 48 | 0.39 | 14 | < 0.04 | 691 | 0.04 | < 0.10 | 0.02 | 27 |
| OTL concrete | IBA Concrete Pad | 4 | Q4O1 | 06-Oct-21 | | 1916436 | 85 | 0.35 | 0.11 | 2.3 | 69 | 6.2 | 48 | 0.13 | < 10 | 210 | 0.6 | 11 | < 0.04 | 1200 | 0.11 | < 0.10 | 0.01 | 59 |
| OTL concrete | IBA SUMP | | | 03-Nov-21 | | 1930546 | 120 | 0.38 | 0.26 | 2.4 | 240 | 5.7 | 200 | 0.18 | 25 | 740 | 24 | 21 | < 0.04 | 4400 | 0.0076 | < 5.00 | 0.14 | 150 |
| OTL concrete | IBA Sump | | Q4N1 | 10-Nov-21 | | 1933984 | 80 | 0.83 | 0.4 | 1.6 | 100 | 7.4 | 130 | 0.1 | 26 | 900 | 27 | 32 | < 0.04 | 3720 | 0.018 | < 5.00 | 0.07 | 210 |
| OTL concrete | IBA Sump | | Q4N1 | 17-Nov-21 | | 1937198 | 75 | 0.23 | 1.2 | 1.5 | 120 | 2.4 | 110 | 0.13 | 19 | 460 | 8.7 | 21 | < 0.04 | 2430 | 0.0079 | 0.12 | 0.06 | 160 |
| OTL concrete | IBA Sump | | Q4N1 | 25-Nov-21 | | 1941089 | 160 | 0.26 | 1.6 | 2.3 | 57 | 1.6 | 87 | 0.2 | 1100 | 390 | 4.9 | 25 | < 0.04 | 2260 | 0.084 | 1.4 | 0.05 | 120 |
| OTL concrete | IBA Sump | | | 01-Dec-21 | | 1943286 | 480 | 0.53 | 0.13 | 1.7 | 90 | 19 | 52 | 0.11 | 170 | 210 | 8.8 | 24 | < 0.04 | 1130 | 0.02 | 0.12 | 0.03 | 63 |
| OTL concrete | IBA Sump | | | 20-Jan-22 | | 1960965 | 80 | 0.13 | 0.047 | 1.9 | 63 | 3.5 | 92 | 0.15 | < 15 | 200 | 3.6 | 17 | < 0.04 | 1490 | 0.0072 | < 5.00 | 0.03 | 68 |
| OTL concrete | IBA Sump | 2.61 | 1M145 | 02-Feb-22 | | 1979484 | 78 | 0.25 | 0.1 | 1.9 | 39 | 2.6 | 56 | 0.1 | 1500 | 130 | 3.2 | 18 | < 0.04 | 993 | < 0.0055 | < 0.10 | 0.01 | 44 |
| OTL concrete | IBA Sump | | | 16-Feb-22 | | 1973865 | 120 | 0.14 | 0.13 | 1.9 | 82 | 6.5 | 58 | 0.13 | 18 | 200 | 5 | 15 | < 0.04 | 1220 | 0.011 | < 1.00 | 0.03 | 64 |
| OTL concrete | IBA Sump | | | 21-Jun-22 | | 2027344 | 400 | 1.1 | 0.51 | 3.6 | 160 | < 1.0 | 51 | 0.11 | 27 | 83 | < 0.25 | 10 | < 0.04 | 875 | 0.0079 | 0.16 | 0.02 | 54 |
| OTL concrete | IBA Sump | 4 | 3N142 | 10-Aug-22 | | 2045226 | 180 | 0.21 | 0.19 | 2 | 52 | 5 | 45 | 0.09 | 25 | 36 | < 0.25 | 14 | < 0.04 | 524 | 0.015 | 0.11 | 0.01 | 33 |
| OTL concrete | IBA Sump | 4 | 3A142 | 24-Aug-22 | | 2050814 | 380 | 0.38 | 0.067 | 2 | 77 | 1.6 | 31 | 0.09 | 18 | 34 | 1.8 | 11 | < 0.04 | 460 | 0.0081 | < 0.10 | 0.01 | 20 |
| OTL concrete | IBA Sump | 4 | 3S142 | 14-Sep-22 | | 2059282 | 110 | 0.2 | 0.18 | 2.2 | 130 | 1.4 | 39 | 0.05 | 17 | 110 | 7.4 | 12 | < 0.04 | 826 | 0.012 | 0.11 | 0.02 | 41 |
| OTL concrete | IBA Sump | 4 | | 17-Oct-22 | | 2073681 | 80 | 0.21 | 0.052 | 1.8 | 53 | 5.3 | 55 | 0.13 | 38 | 340 | 12 | 17 | < 0.04 | 1570 | 0.016 | < 5.00 | 0.03 | 92 |
| OTL concrete | IBA Conrete Pad | | Qim142 | 23-Nov-22 | | 2090945 | 130 | 9.6 | 0.15 | 2.4 | 110 | 5.1 | 30 | 0.04 | 21 | 830 | 8.4 | 37 | < 0.04 | 3290 | 0.012 | < 10.00 | 0.12 | 250 |
| OTL concrete | Disc. Concrete Pad | | Q1J142 | 13-Dec-22 | | 2099956 | 580 | 5 | 0.13 | 1.8 | 73 | 3.1 | 54 | < 0.03 | 19 | 240 | 22 | 15 | < 0.04 | 1360 | < 0.0055 | 0.16 | 0.06 | 76 |



| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | Alkalinity expressed as CaCO3 | Aluminium (Dissolved) | Ammonia cal nitrogen | As (Dissolved) | Barium (Dissolved) | Biochem Oxygen Demand | Calcium | Cd (Dissolved) | Chemical Oxygen Demand | Chloride | Cr (Dissolved) | Cu (Dissolved) | Cyanide (total) | Electrical Cond'y | Fe, Iron | Fluoride | Hg (Total) | K, Potassium |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | mg/l | mg/l | mg/l | ug/l | ug/l | mg/l | mg/l | ug/l | mg/l | mg/l | ug/l | ug/l | mg/l | uS/cm | mg/l | mg/l | ug/l | mg/l |
| **Discharge** | **Consent limits on discharge** | | | | | | | | | **25** | | | | **2.6** | | | **6** | **200** | | | | | **2.0** | |
| NTL landfill | NTL | | | 23-Sep-21 | | 1910590 | 290 | 0.02 | 2.5 | 3 | 68 | 2.9 | 280 | 0.04 | 42 | 380 | 0.27 | 4.5 | < 0.04 | 3210 | 0.28 | < 0.10 | 0.01 | 50 |
| NTL landfill | NTL | 5.11 | 4O144 | 06-Oct-21 | | 1916435 | 420 | 0.01 | 2.4 | 3.9 | 89 | 3.3 | 330 | 0.03 | 67 | 330 | 0.62 | 3.9 | < 0.04 | 3280 | 0.08 | < 0.10 | 0.02 | 53 |
| NTL landfill | NTL | | | 03-Nov-21 | | 1930545 | 340 | 0.02 | 5.7 | 6.9 | 200 | 7.8 | 280 | 0.09 | 62 | 8 | 0.68 | 9.6 | < 0.04 | 2290 | 0.053 | 0.25 | 0.02 | 39 |
| NTL landfill | NTL | 6.53 | 4N144 | 10-Nov-21 | | 1933983 | 300 | < 0.01 | 2.2 | 5.2 | 120 | 2.5 | 350 | < 0.03 | 66 | 290 | 0.38 | 12 | < 0.04 | 2480 | 0.15 | 0.18 | < 0.01 | 39 |
| NTL landfill | NTL | 6.65 | 4N144 | 17-Nov-21 | | 1937197 | 370 | < 0.01 | 0.47 | 3 | 150 | 2.6 | 390 | 0.11 | 46 | 210 | 0.88 | 19 | < 0.04 | 2460 | 0.037 | < 0.10 | < 0.01 | 45 |
| NTL landfill | NTL | | Q4N144 | 25-Nov-21 | 3.68 | 1941090 | 410 | 0.02 | 0.065 | 2.1 | 66 | 1.5 | 380 | 0.12 | 43 | 180 | 0.41 | 13 | < 0.04 | 2720 | 0.21 | < 0.10 | 0.01 | 37 |
| NTL landfill | NTL | | | 01-Dec-21 | | 1943287 | 980 | < 0.01 | 0.029 | 1.4 | 120 | 3.1 | 370 | 0.12 | 30 | 220 | 0.48 | 8.5 | < 0.04 | 2850 | 0.025 | 0.12 | 0.01 | 39 |
| NTL landfill | Leachate MP | | | 20-Jan-22 | | 1960964 | 360 | < 0.01 | 1.1 | 0.9 | 120 | 2.1 | 400 | 0.07 | 20 | 320 | 0.36 | 2.9 | < 0.04 | 3480 | 0.016 | < 10.00 | 0.01 | 45 |
| NTL landfill | Leachate MP | 4 | Q1M: | 02-Feb-22 | | 1979485 | 340 | < 0.01 | 1.9 | 0.94 | 95 | 1.5 | 390 | 0.06 | 1400 | 970 | < 0.25 | 3.4 | < 0.04 | 4400 | 0.012 | < 0.10 | < 0.01 | 60 |
| NTL landfill | Leachate MP | | | 16-Feb-22 | | 1973864 | 420 | < 0.01 | 1 | 0.72 | 140 | < 1.0 | 390 | 0.04 | 35 | 510 | 0.25 | 3 | < 0.04 | 3950 | 0.014 | < 5.00 | < 0.01 | 46 |
| NTL landfill | LMP | | | 21-Jun-22 | | 2027345 | 1000 | 0.04 | 5.4 | 8.8 | 270 | < 1.0 | 450 | < 0.03 | 170 | 460 | < 0.25 | 1.3 | < 0.04 | 4330 | 4 | < 0.10 | < 0.01 | 51 |
| NTL landfill | LMP | 6.58 | Q3J1 | 10-Aug-22 | | 2045225 | 530 | < 0.01 | 5.3 | 4.7 | 130 | 6 | 460 | < 0.03 | 200 | 530 | < 0.25 | 3.3 | < 0.04 | 3640 | 0.041 | < 10.00 | < 0.01 | 59 |
| NTL landfill | LMP | 6.56 | Q3S1 | 14-Sep-22 | | 2059281 | 580 | < 0.01 | 6.2 | 7.7 | 230 | 9.8 | 480 | < 0.03 | 210 | 540 | 0.66 | 0.7 | 0.48 | 4190 | 1.2 | < 0.10 | < 0.01 | 53 |
| NTL landfill | Quarry Sump | | | 17-Oct-22 | | 2073682 | 440 | < 0.01 | 4.1 | 2.8 | 82 | 14 | 460 | < 0.03 | 55 | 640 | 4.5 | 2.2 | < 0.04 | 4100 | 0.032 | < 10.00 | < 0.01 | 62 |
| NTL landfill | Quarry Sump | | | 23-Nov-22 | | 2090947 | 440 | 0.01 | 3.8 | 1.3 | 190 | 3.9 | 340 | < 0.03 | 42 | 390 | 7.2 | 2.6 | < 0.04 | 3480 | 0.02 | < 10.00 | 0.01 | 56 |
| NTL landfill | Quarry Sump | 3.84 | | 13-Dec-22 | | 2099957 | 580 | 0.04 | 3.3 | 0.98 | 150 | 2.1 | 34 | < 0.03 | 39 | 4100 | 5.6 | 2.9 | < 0.04 | 3610 | 0.0095 | < 100.00 | < 0.01 | 53 |

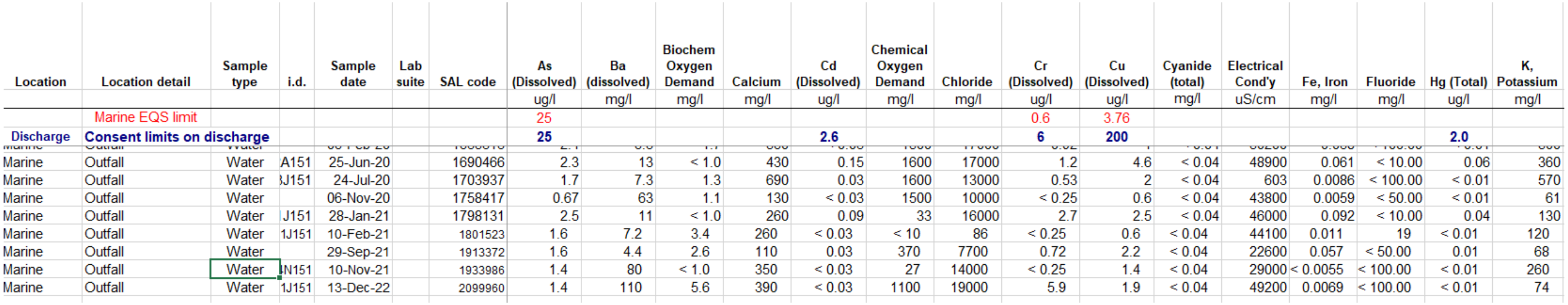


| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | Mg | Mn (Dissolved) | Mo (Total) | Na, Sodium | Ni (Dissolved) | Nitrate | Nitrite | Nitrogen (Kjeldahl) | Pb (Dissolved) | pH | Sb (Dissolved) | Se (Dissolved) | Sn (Dissolved) | SO4 (Total) | Suspended solids, TSS | Thallium (dissolved) | Total Organic Carbon | Vanadium (Dissolved) | Zn (Dissolved) | Zn (Total) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | mg/l | ug/l | ug/l | mg/l | ug/l | mg/l | mg/l | mg/l | ug/l | 5 - 11.4 | ug/l | ug/l | mg/l | mg/l | mg/l | ug/l | mg/l | ug/l | ug/l | ug/l |
| **Discharge** | **Consent limits on discharge** | | | | | | | | **900** | | **30** | | | | **1000** | **11.4** | | | | | **100** | | | | **2000** | |
| OTL concrete | IBA Sump | | Q4N1 | 17-Nov-21 | | 1937198 | 8.90 | 30 | 48 | 250 | 1.1 | 6.6 | < 0.10 | 1.6 | 0.15 | 7.5 | 26 | 1.8 | < 0.0004 | 390 | 30 | < 0.08 | 4 | 1.8 | 51 | 60 |
| OTL concrete | IBA Sump | | Q4N1 | 25-Nov-21 | | 1941089 | 5.90 | 62 | 48 | 240 | 1.4 | 0.442857 | 0.27 | 1.8 | 2.9 | 7.4 | 23 | 1.3 | 0.0004 | 330 | 71 | < 0.08 | 4.4 | 1.7 | 34 | 110 |
| OTL concrete | IBA Sump | | | 01-Dec-21 | | 1943286 | 2.90 | 9.9 | 21 | 100 | 1.5 | 0.89 | 2.4 | 1.3 | 0.71 | 8.2 | 9.4 | 1.8 | 0.0011 | 220 | 240 | 0.32 | 1.3 | 2.5 | 32 | 540 |
| OTL concrete | IBA Sump | | | 20-Jan-22 | | 1960965 | 22 | 31 | 30 | 190 | 1 | 0.13 | < 0.035 | 2.4 | 0.21 | 6.6 | 13 | 1.2 | < 0.0004 | 390 | 72 | < 0.08 | 3.3 | 1.5 | 13 | 200 |
| OTL concrete | IBA Sump | 2.61 | 1M145 | 02-Feb-22 | | 1979484 | 9.6 | 7.3 | 16 | 89 | 0.9 | 3 | | 0.2 | 0.14 | 7.7 | 8.5 | 0.67 | < 0.0004 | 170 | 62 | 0.55 | 6 | 2 | 7.3 | 150 |
| OTL concrete | IBA Sump | | | 16-Feb-22 | | 1973865 | 7.6 | 33 | 26 | 120 | 1.3 | < 0.10 | < 0.035 | 1.7 | 0.54 | 7.9 | 10 | 1.7 | < 0.0004 | 190 | 440 | 0.3 | 15 | 2.2 | 41 | 1400 |
| OTL concrete | IBA Sump | | | 21-Jun-22 | | 2027344 | 4.6 | 53 | 32 | 67 | 1.3 | 0.23 | | 0.8 | 0.45 | 7.8 | 7.7 | 0.34 | < 0.0004 | 120 | 57 | < 0.08 | 6.1 | 1.3 | 36 | 170 |
| OTL concrete | IBA Sump | 4 | 3N142 | 10-Aug-22 | | 2045226 | 3.5 | 6.9 | 9 | 39 | 2 | 0.16 | | 0.4 | 0.38 | 7.7 | 4.1 | 0.26 | 0.0006 | 69 | < 5.0 | < 0.08 | 6.8 | 1.4 | 7.6 | 31 |
| OTL concrete | IBA Sump | 4 | 3A142 | 24-Aug-22 | | 2050814 | 2.1 | 0.71 | 7 | 29 | < 0.5 | 0.53 | < 0.035 | < 0.2 | 0.38 | 7.6 | 5.4 | 0.54 | < 0.0004 | 43 | 83 | < 0.08 | 4.6 | 2.1 | 22 | 260 |
| OTL concrete | IBA Sump | 4 | 3S142 | 14-Sep-22 | | 2059282 | 3.9 | 42 | 13 | 62 | 0.6 | 0.46 | < 0.035 | 0.5 | 0.3 | 7.6 | 5.2 | 0.53 | < 0.0004 | 67 | 44 | < 0.08 | 8.2 | 1.6 | 18 | 58 |
| OTL concrete | IBA Sump | 4 | | 17-Oct-22 | | 2073681 | 7.3 | 21 | 28 | 170 | 2.5 | < 0.10 | < 0.035 | 0.8 | 0.21 | 7.7 | 7.1 | 1.4 | < 0.0004 | 220 | 300 | < 0.08 | 5.5 | 1.6 | 7.1 | 180 |
| OTL concrete | IBA Conrete Pad | | Qim142 | 23-Nov-22 | | 2090945 | 6.3 | 12 | 100 | 410 | 1.4 | 0.39 | 0.063 | 0.3 | 0.15 | 8 | 10 | 2.8 | 0.0004 | 280 | 100 | 0.1 | 3.1 | 5.7 | 12 | 91 |
| OTL concrete | Disc. Concrete Pad | | Q1J142 | 13-Dec-22 | | 2099956 | 1.9 | 10 | 40 | 120 | < 0.5 | 0.3 | | 0.6 | < 0.09 | 8.6 | 25 | 1.3 | < 0.0004 | 280 | 91 | < 0.08 | 4.6 | 5 | 14 | 180 |

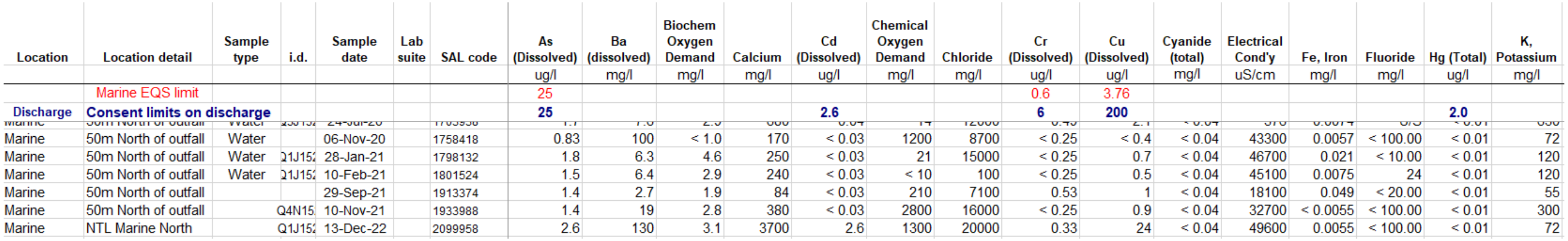


| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | Mg | Mn (Dissolved) | Mo (Total) | Na, Sodium | Ni (Dissolved) | Nitrate | Nitrite | Nitrogen (Kjeldahl) | Pb (Dissolved) | pH | Sb (Dissolved) | Se (Dissolved) | Sn (Dissolved) | SO4 (Total) | Suspended solids, TSS | Thallium (dissolved) | Total Organic Carbon | Vanadium (Dissolved) | Zn (Dissolved) | Zn (Total) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | mg/l | ug/l | ug/l | mg/l | ug/l | mg/l | mg/l | mg/l | ug/l | 5 - 11.4 | ug/l | ug/l | mg/l | mg/l | mg/l | ug/l | mg/l | ug/l | ug/l | ug/l |
| **Discharge** | **Consent limits on discharge** | | | | | | | | **900** | | **30** | | | | **1000** | **11.4** | | | | | **100** | | | | **2000** | |
| NTL landfill | NTL | | | 23-Sep-21 | | 1910590 | 48 | 1700 | 15 | 250 | 7.8 | 3.675714 | 0.61 | 3.2 | 0.87 | 7.6 | 0.55 | 0.39 | < 0.0004 | 640 | 44 | < 0.08 | 22 | < 0.6 | 15 | 32 |
| NTL landfill | NTL | 5.11 | 4O144 | 06-Oct-21 | | 1916435 | 55 | 3700 | 12 | 240 | 5.8 | <0.4 | 1.4 | 3.7 | 0.16 | 7.5 | 0.52 | 0.29 | < 0.0004 | 830 | 430 | < 0.08 | 15 | < 0.6 | 20 | 38 |
| NTL landfill | NTL | | | 03-Nov-21 | | 1930545 | 36 | 1700 | 17 | 130 | 8.1 | | 2.9 | 68 | 0.12 | 7.6 | 1.2 | 0.75 | 0.0005 | 36 | 24 | 0.08 | 14 | 0.9 | 27 | 30 |
| NTL landfill | NTL | 6.53 | 4N144 | 10-Nov-21 | | 1933983 | 40 | 24 | 17 | 130 | 11 | 0.44 | 4.2 | 0.6 | 0.11 | 7.5 | 0.99 | 0.65 | < 0.0004 | 1200 | 34 | < 0.08 | 26 | < 0.6 | 32 | 55 |
| NTL landfill | NTL | 6.65 | 4N144 | 17-Nov-21 | | 1937197 | 51 | 1400 | 13 | 140 | 18 | 14.2 | 8.2 | 0.9 | 0.15 | 7.1 | 0.87 | 0.8 | < 0.0004 | 810 | 16 | < 0.08 | 16 | < 0.6 | 47 | 47 |
| NTL landfill | NTL | | Q4N144 | 25-Nov-21 | 3.68 | 1941090 | 64 | 2700 | 12 | 130 | 26 | 115.1429 | 0.15 | 0.8 | 0.56 | 7.5 | 0.94 | 0.65 | 0.0005 | 1000 | 35 | < 0.08 | 11 | < 0.6 | 24 | 41 |
| NTL landfill | NTL | | | 01-Dec-21 | | 1943287 | 75 | 3300 | 12 | 150 | 30 | 7.1 | 0.84 | 1.1 | 0.14 | 7.6 | 1.1 | 0.87 | < 0.0004 | 1200 | 24 | 0.17 | 9.3 | < 0.6 | 64 | 130 |
| NTL landfill | Leachate MP | | | 20-Jan-22 | | 1960964 | 90 | 3500 | 9 | 250 | 33 | 0.59 | < 0.035 | 1.3 | 0.13 | 7.4 | 0.84 | 1.3 | < 0.0004 | 1000 | 24 | 0.15 | 8.5 | < 0.6 | 18 | 23 |
| NTL landfill | Leachate MP | 4 | Q1M: | 02-Feb-22 | | 1979485 | 81 | 4000 | 8.3 | 380 | 29 | < 0.10 | < 0.035 | 2.6 | < 0.09 | 7.2 | 0.38 | < 0.25 | < 0.0004 | 1200 | 56 | 0.61 | 9.8 | < 0.6 | 19 | 160 |
| NTL landfill | Leachate MP | | | 16-Feb-22 | | 1973864 | 85 | 3500 | 7.6 | 280 | 26 | 0.38 | < 0.035 | 3.9 | < 0.09 | 7.5 | 0.66 | 0.33 | < 0.0004 | 1100 | 44 | < 0.08 | 15 | < 0.6 | 45 | 46 |
| NTL landfill | LMP | | | 21-Jun-22 | | 2027345 | 94 | 3100 | 17 | 230 | 21 | < 0.10 | < 0.035 | 8.1 | 0.49 | 7.4 | 1 | 1.1 | 0.0006 | 920 | 180 | < 0.08 | 56 | 1.6 | 36 | 36 |
| NTL landfill | LMP | 6.58 | Q3J1 | 10-Aug-22 | | 2045225 | 97 | 8600 | 16 | 370 | 18 | 0.19 | < 0.035 | 9 | < 0.09 | 7.3 | 0.93 | 1.3 | 0.0005 | 960 | 18 | < 0.08 | 23 | 0.8 | 5.5 | 12 |
| NTL landfill | LMP | 6.56 | Q3S1 | 14-Sep-22 | | 2059281 | 90 | 12000 | 19 | 250 | 17 | 0.2 | < 0.035 | 9.5 | < 0.09 | 7.4 | 0.68 | 0.95 | < 0.0004 | 1100 | 150 | < 0.08 | 76 | 1 | 21 | 31 |
| NTL landfill | Quarry Sump | | | 17-Oct-22 | | 2073682 | 67 | 6700 | 17 | 360 | 31 | < 0.10 | < 0.035 | 6.1 | < 0.09 | 7.3 | 0.27 | 0.45 | < 0.0004 | 1200 | 86 | < 0.08 | 18 | < 0.6 | 4.6 | 9.1 |
| NTL landfill | Quarry Sump | | | 23-Nov-22 | | 2090947 | 64 | 4700 | 18 | 270 | 41 | < 0.10 | < 0.035 | 4.5 | < 0.09 | 7.3 | 0.4 | 0.46 | < 0.0004 | 950 | 29 | < 0.08 | 14 | < 0.6 | 40 | 55 |
| NTL landfill | Quarry Sump | 3.84 | | 13-Dec-22 | | 2099957 | 58 | 4800 | 17 | 47 | 30 | < 0.10 | < 0.035 | 4.4 | < 0.09 | 7.5 | 0.61 | 0.29 | < 0.0004 | 12000 | 26 | < 0.08 | 16 | < 0.6 | 4.2 | 6.1 |

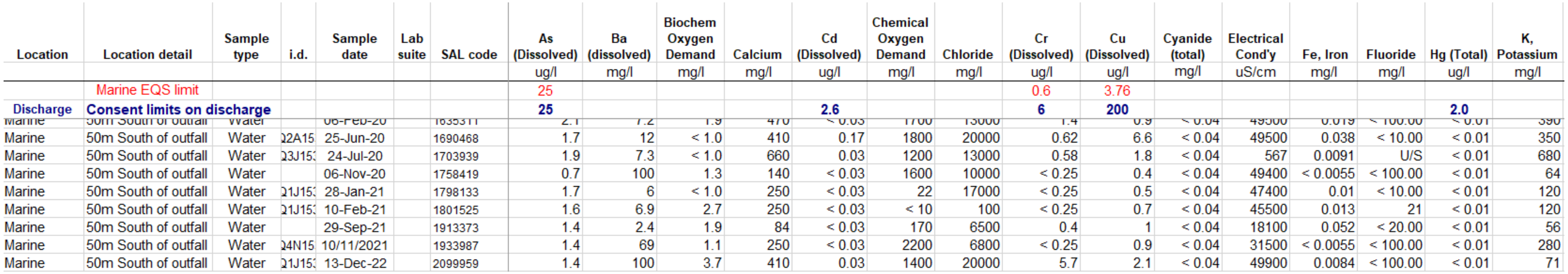
## Results for inshore marine water samples [Pink shading denotes results exceeding discharge limits]



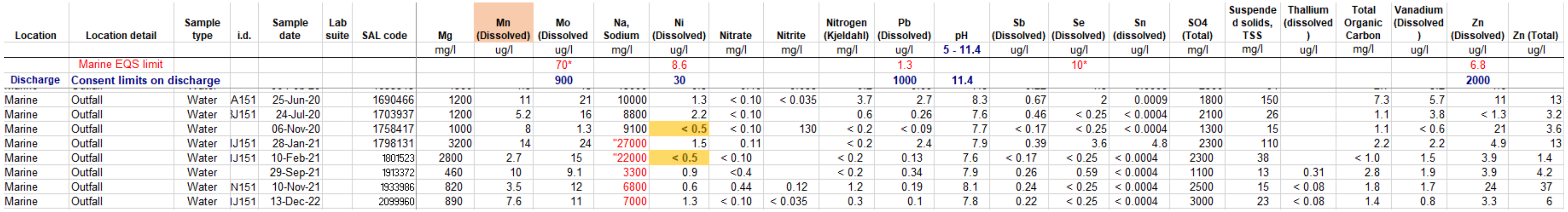
| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | As (Dissolved) ug/l | Ba (dissolved) mg/l | Biochem Oxygen Demand mg/l | Calcium mg/l | Cd (Dissolved) ug/l | Chemical Oxygen Demand mg/l | Chloride mg/l | Cr (Dissolved) ug/l | Cu (Dissolved) ug/l | Cyanide (total) mg/l | Electrical Cond'y uS/cm | Fe, Iron mg/l | Fluoride mg/l | Hg (Total) ug/l | K, Potassium mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Marine EQS limit | | | | | | 25 | | | | | | | 0.6 | 3.76 | | | | | | |
| Discharge | Consent limits on discharge | | | | | | 25 | | | | 2.6 | | | 6 | 200 | | | | | 2.0 | |
| Marine | Outfall | Water | A151 | 25-Jun-20 | | 1690466 | 2.3 | 13 | < 1.0 | 430 | 0.15 | 1600 | 17000 | 1.2 | 4.6 | < 0.04 | 48900 | 0.061 | < 10.00 | 0.06 | 360 |
| Marine | Outfall | Water | J151 | 24-Jul-20 | | 1703937 | 1.7 | 7.3 | 1.3 | 690 | 0.03 | 1600 | 13000 | 0.53 | 2 | < 0.04 | 603 | 0.0086 | < 100.00 | < 0.01 | 570 |
| Marine | Outfall | Water | | 06-Nov-20 | | 1758417 | 0.67 | 63 | 1.1 | 130 | < 0.03 | 1500 | 10000 | < 0.25 | 0.6 | < 0.04 | 43800 | 0.0059 | < 50.00 | < 0.01 | 61 |
| Marine | Outfall | Water | J151 | 28-Jan-21 | | 1798131 | 2.5 | 11 | < 1.0 | 260 | 0.09 | 33 | 16000 | 2.7 | 2.5 | < 0.04 | 46000 | 0.092 | < 10.00 | 0.04 | 130 |
| Marine | Outfall | Water | 1J151 | 10-Feb-21 | | 1801523 | 1.6 | 7.2 | 3.4 | 260 | < 0.03 | < 10 | 86 | < 0.25 | 0.6 | < 0.04 | 44100 | 0.011 | 19 | < 0.01 | 120 |
| Marine | Outfall | Water | | 29-Sep-21 | | 1913372 | 1.6 | 4.4 | 2.6 | 110 | 0.03 | 370 | 7700 | 0.72 | 2.2 | < 0.04 | 22600 | 0.057 | < 50.00 | 0.01 | 68 |
| Marine | Outfall | Water | N151 | 10-Nov-21 | | 1933986 | 1.4 | 80 | < 1.0 | 350 | < 0.03 | 27 | 14000 | < 0.25 | 1.4 | < 0.04 | 29000 | < 0.0055 | < 100.00 | < 0.01 | 260 |
| Marine | Outfall | Water | 1J151 | 13-Dec-22 | | 2099960 | 1.4 | 110 | 5.6 | 390 | < 0.03 | 1100 | 19000 | 5.9 | 1.9 | < 0.04 | 49200 | 0.0069 | < 100.00 | < 0.01 | 74 |



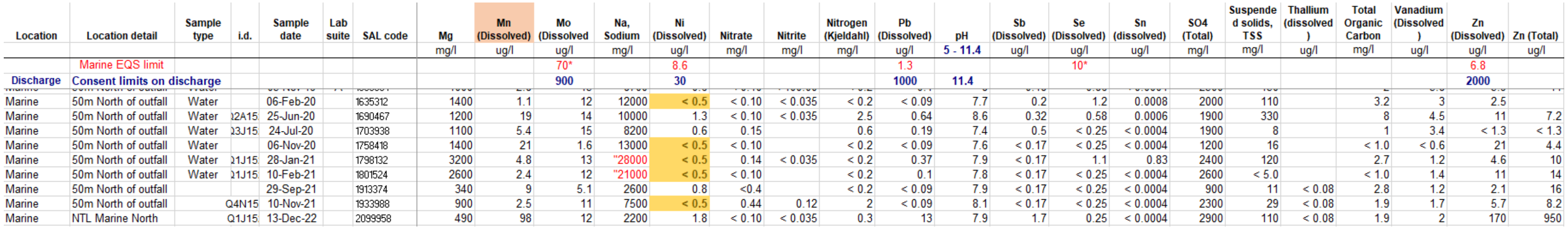
| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | As (Dissolved) ug/l | Ba (dissolved) mg/l | Biochem Oxygen Demand mg/l | Calcium mg/l | Cd (Dissolved) ug/l | Chemical Oxygen Demand mg/l | Chloride mg/l | Cr (Dissolved) ug/l | Cu (Dissolved) ug/l | Cyanide (total) mg/l | Electrical Cond'y uS/cm | Fe, Iron mg/l | Fluoride mg/l | Hg (Total) ug/l | K, Potassium mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Marine EQS limit | | | | | | 25 | | | | | | | 0.6 | 3.76 | | | | | | |
| Discharge | Consent limits on discharge | | | | | | 25 | | | | 2.6 | | | 6 | 200 | | | | | 2.0 | |
| Marine | 50m North of outfall | Water | | 06-Nov-20 | | 1758418 | 0.83 | 100 | < 1.0 | 170 | < 0.03 | 1200 | 8700 | < 0.25 | < 0.4 | < 0.04 | 43300 | 0.0057 | < 100.00 | < 0.01 | 72 |
| Marine | 50m North of outfall | Water | 1J15 | 28-Jan-21 | | 1798132 | 1.8 | 6.3 | 4.6 | 250 | < 0.03 | 21 | 15000 | < 0.25 | 0.7 | < 0.04 | 46700 | 0.021 | < 10.00 | < 0.01 | 120 |
| Marine | 50m North of outfall | Water | 1J15 | 10-Feb-21 | | 1801524 | 1.5 | 6.4 | 2.9 | 240 | < 0.03 | < 10 | 100 | < 0.25 | 0.5 | < 0.04 | 45100 | 0.0075 | 24 | < 0.01 | 120 |
| Marine | 50m North of outfall | | | 29-Sep-21 | | 1913374 | 1.4 | 2.7 | 1.9 | 84 | < 0.03 | 210 | 7100 | 0.53 | 1 | < 0.04 | 18100 | 0.049 | < 20.00 | < 0.01 | 55 |
| Marine | 50m North of outfall | | Q4N15 | 10-Nov-21 | | 1933988 | 1.4 | 19 | 2.8 | 380 | < 0.03 | 2800 | 16000 | < 0.25 | 0.9 | < 0.04 | 32700 | < 0.0055 | < 100.00 | < 0.01 | 300 |
| Marine | NTL Marine North | | Q1J15 | 13-Dec-22 | | 2099958 | 2.6 | 130 | 3.1 | 3700 | 2.6 | 1300 | 20000 | 0.33 | 24 | < 0.04 | 49600 | 0.0055 | < 100.00 | < 0.01 | 72 |



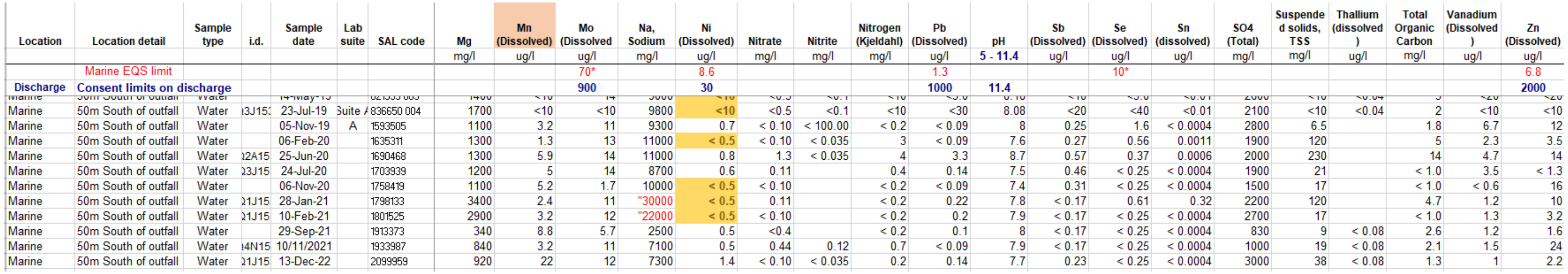
| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | As (Dissolved) ug/l | Ba (dissolved) mg/l | Biochem Oxygen Demand mg/l | Calcium mg/l | Cd (Dissolved) ug/l | Chemical Oxygen Demand mg/l | Chloride mg/l | Cr (Dissolved) ug/l | Cu (Dissolved) ug/l | Cyanide (total) mg/l | Electrical Cond'y uS/cm | Fe, Iron mg/l | Fluoride mg/l | Hg (Total) ug/l | K, Potassium mg/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Marine EQS limit | | | | | | 25 | | | | | | | 0.6 | 3.76 | | | | | | |
| Discharge | Consent limits on discharge | | | | | | 25 | | | | 2.6 | | | 6 | 200 | | | | | 2.0 | |
| Marine | 50m South of outfall | Water | 2A15 | 25-Jun-20 | | 1690468 | 1.7 | 12 | < 1.0 | 410 | 0.17 | 1800 | 20000 | 0.62 | 6.6 | < 0.04 | 49500 | 0.038 | < 10.00 | < 0.01 | 350 |
| Marine | 50m South of outfall | Water | 3J15 | 24-Jul-20 | | 1703939 | 1.9 | 7.3 | < 1.0 | 660 | 0.03 | 1200 | 13000 | 0.58 | 1.8 | < 0.04 | 567 | 0.0091 | U/S | < 0.01 | 680 |
| Marine | 50m South of outfall | Water | | 06-Nov-20 | | 1758419 | 0.7 | 100 | 1.3 | 140 | < 0.03 | 1600 | 10000 | < 0.25 | 0.4 | < 0.04 | 49400 | < 0.0055 | < 100.00 | < 0.01 | 64 |
| Marine | 50m South of outfall | Water | 1J15 | 28-Jan-21 | | 1798133 | 1.7 | 6 | < 1.0 | 250 | < 0.03 | 22 | 17000 | < 0.25 | 0.5 | < 0.04 | 47400 | 0.01 | < 10.00 | < 0.01 | 120 |
| Marine | 50m South of outfall | Water | 1J15 | 10-Feb-21 | | 1801525 | 1.6 | 6.9 | 2.7 | 250 | < 0.03 | < 10 | 100 | < 0.25 | 0.7 | < 0.04 | 45500 | 0.013 | 21 | < 0.01 | 120 |
| Marine | 50m South of outfall | Water | | 29-Sep-21 | | 1913373 | 1.4 | 2.4 | 1.9 | 84 | < 0.03 | 170 | 6500 | 0.4 | 1 | < 0.04 | 18100 | 0.052 | < 20.00 | < 0.01 | 56 |
| Marine | 50m South of outfall | Water | 4N15 | 10/11/2021 | | 1933987 | 1.4 | 69 | 1.1 | 250 | < 0.03 | 2200 | 6800 | < 0.25 | 0.9 | < 0.04 | 31500 | < 0.0055 | < 100.00 | < 0.01 | 280 |
| Marine | 50m South of outfall | Water | 1J15 | 13-Dec-22 | | 2099959 | 1.4 | 100 | 3.7 | 410 | 0.03 | 1400 | 20000 | 5.7 | 2.1 | < 0.04 | 49900 | 0.0084 | < 100.00 | < 0.01 | 71 |



| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | Mg mg/l | Mn (Dissolved) ug/l | Mo (Dissolved ug/l | Na, Sodium mg/l | Ni (Dissolved) ug/l | Nitrate mg/l | Nitrite mg/l | Nitrogen (Kjeldahl) mg/l | Pb (Dissolved) ug/l | pH 5 - 11.4 | Sb (Dissolved) ug/l | Se (Dissolved) ug/l | Sn (dissolved) ug/l | SO4 (Total) mg/l | Suspended solids, TSS mg/l | Thallium (dissolved) ug/l | Total Organic Carbon mg/l | Vanadium (Dissolved) ug/l | Zn (Dissolved) ug/l | Zn (Total) ug/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Marine EQS limit | | | | | | | | 70* | | 8.6 | | | | 1.3 | | | 10* | | | | | | | 6.8 | |
| Discharge | Consent limits on discharge | | | | | | | | 900 | | 30 | | | | 1000 | 11.4 | | | | | | | | | 2000 | |
| Marine | Outfall | Water | A151 | 25-Jun-20 | | 1690466 | 1200 | 11 | 21 | 10000 | 1.3 | < 0.10 | < 0.035 | 3.7 | 2.7 | 8.3 | 0.67 | 2 | 0.0009 | 1800 | 150 | | 7.3 | 5.7 | 11 | 13 |
| Marine | Outfall | Water | J151 | 24-Jul-20 | | 1703937 | 1200 | 5.2 | 16 | 8800 | 2.2 | < 0.10 | | 0.6 | 0.26 | 7.6 | 0.46 | < 0.25 | < 0.0004 | 2100 | 26 | | 1.1 | 3.8 | < 1.3 | 3.2 |
| Marine | Outfall | Water | | 06-Nov-20 | | 1758417 | 1000 | 8 | 1.3 | 9100 | < 0.5 | < 0.10 | 130 | < 0.2 | < 0.09 | 7.7 | < 0.17 | < 0.25 | < 0.0004 | 1300 | 15 | | 1.1 | < 0.6 | 21 | 3.6 |
| Marine | Outfall | Water | J151 | 28-Jan-21 | | 1798131 | 3200 | 14 | 24 | "27000 | 1.5 | 0.11 | | < 0.2 | 2.4 | 7.9 | 0.39 | 3.6 | 4.8 | 2300 | 110 | | 2.2 | 2.2 | 4.9 | 13 |
| Marine | Outfall | Water | J151 | 10-Feb-21 | | 1801523 | 2800 | 2.7 | 15 | "22000 | < 0.5 | < 0.10 | | < 0.2 | 0.13 | 7.6 | < 0.17 | < 0.25 | < 0.0004 | 2300 | 38 | | < 1.0 | 1.5 | 3.9 | 1.4 |
| Marine | Outfall | Water | | 29-Sep-21 | | 1913372 | 460 | 10 | 9.1 | 3300 | 0.9 | <0.4 | | < 0.2 | 0.34 | 7.9 | 0.26 | 0.59 | < 0.0004 | 1100 | 13 | 0.31 | 2.8 | 1.9 | 3.9 | 4.2 |
| Marine | Outfall | Water | N151 | 10-Nov-21 | | 1933986 | 820 | 3.5 | 12 | 6800 | 0.6 | 0.44 | 0.12 | 1.2 | 0.19 | 8.1 | 0.24 | < 0.25 | < 0.0004 | 2500 | 15 | < 0.08 | 1.8 | 1.7 | 24 | 37 |
| Marine | Outfall | Water | J151 | 13-Dec-22 | | 2099960 | 890 | 7.6 | 11 | 7000 | 1.3 | < 0.10 | < 0.035 | 0.3 | 0.1 | 7.8 | 0.22 | < 0.25 | < 0.0004 | 3000 | 23 | < 0.08 | 1.4 | 0.8 | 3.3 | 6 |



| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | Mg mg/l | Mn (Dissolved) ug/l | Mo (Dissolved ug/l | Na, Sodium mg/l | Ni (Dissolved) ug/l | Nitrate mg/l | Nitrite mg/l | Nitrogen (Kjeldahl) mg/l | Pb (Dissolved) ug/l | pH 5 - 11.4 | Sb (Dissolved) ug/l | Se (Dissolved) ug/l | Sn (dissolved) ug/l | SO4 (Total) mg/l | Suspended solids, TSS mg/l | Thallium (dissolved) ug/l | Total Organic Carbon mg/l | Vanadium (Dissolved) ug/l | Zn (Dissolved) ug/l | Zn (Total) ug/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Marine EQS limit | | | | | | | | 70* | | 8.6 | | | | 1.3 | | | 10* | | | | | | | 6.8 | |
| Discharge | Consent limits on discharge | | | | | | | | 900 | | 30 | | | | 1000 | 11.4 | | | | | | | | | 2000 | |
| Marine | 50m North of outfall | Water | | 06-Feb-20 | | 1635312 | 1400 | 1.1 | 12 | 12000 | < 0.5 | < 0.10 | < 0.035 | < 0.2 | < 0.09 | 7.7 | 0.2 | 1.2 | 0.0008 | 2000 | 110 | | 3.2 | 3 | 2.5 | |
| Marine | 50m North of outfall | Water | 2A15 | 25-Jun-20 | | 1690467 | 1200 | 19 | 14 | 10000 | 1.3 | < 0.10 | < 0.035 | 2.5 | 0.64 | 8.6 | 0.32 | 0.58 | 0.0006 | 1900 | 330 | | 8 | 4.5 | 11 | 7.2 |
| Marine | 50m North of outfall | Water | 3J15 | 24-Jul-20 | | 1703938 | 1100 | 5.4 | 15 | 8200 | 0.6 | 0.15 | | 0.6 | 0.19 | 7.4 | 0.5 | < 0.25 | < 0.0004 | 1900 | 8 | | 1 | 3.4 | < 1.3 | < 1.3 |
| Marine | 50m North of outfall | Water | | 06-Nov-20 | | 1758418 | 1400 | 21 | 1.6 | 13000 | < 0.5 | < 0.10 | | < 0.2 | < 0.09 | 7.6 | < 0.17 | < 0.25 | < 0.0004 | 1200 | 16 | | < 1.0 | < 0.6 | 21 | 4.4 |
| Marine | 50m North of outfall | Water | 1J15 | 28-Jan-21 | | 1798132 | 3200 | 4.8 | 13 | "28000 | < 0.5 | 0.14 | < 0.035 | < 0.2 | 0.37 | 7.9 | < 0.17 | 1.1 | 0.83 | 2400 | 120 | | 2.7 | 1.2 | 4.6 | 10 |
| Marine | 50m North of outfall | Water | 1J15 | 10-Feb-21 | | 1801524 | 2600 | 2.4 | 12 | "21000 | < 0.5 | < 0.10 | | < 0.2 | 0.1 | 7.8 | < 0.17 | < 0.25 | < 0.0004 | 2600 | < 5.0 | | < 1.0 | 1.4 | 11 | 14 |
| Marine | 50m North of outfall | | | 29-Sep-21 | | 1913374 | 340 | 9 | 5.1 | 2600 | 0.8 | <0.4 | | < 0.2 | < 0.09 | 7.9 | < 0.17 | < 0.25 | < 0.0004 | 900 | 11 | < 0.08 | 2.8 | 1.2 | 2.1 | 16 |
| Marine | 50m North of outfall | | Q4N15 | 10-Nov-21 | | 1933988 | 900 | 2.5 | 11 | 7500 | < 0.5 | 0.44 | 0.12 | 2 | < 0.09 | 8.1 | < 0.17 | < 0.25 | < 0.0004 | 2300 | 29 | < 0.08 | 1.9 | 1.7 | 5.7 | 8.2 |
| Marine | NTL Marine North | | Q1J15 | 13-Dec-22 | | 2099958 | 490 | 98 | 12 | 2200 | 1.8 | < 0.10 | < 0.035 | 0.3 | 13 | 7.9 | 1.7 | 0.25 | < 0.0004 | 2900 | 110 | < 0.08 | 1.9 | 2 | 170 | 950 |



| Location | Location detail | Sample type | i.d. | Sample date | Lab suite | SAL code | Mg mg/l | Mn (Dissolved) ug/l | Mo (Dissolved ug/l | Na, Sodium mg/l | Ni (Dissolved) ug/l | Nitrate mg/l | Nitrite mg/l | Nitrogen (Kjeldahl) mg/l | Pb (Dissolved) ug/l | pH 5 - 11.4 | Sb (Dissolved) ug/l | Se (Dissolved) ug/l | Sn (dissolved) ug/l | SO4 (Total) mg/l | Suspended solids, TSS mg/l | Thallium (dissolved) ug/l | Total Organic Carbon mg/l | Vanadium (Dissolved) ug/l | Zn (Dissolved) ug/l |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Marine EQS limit | | | | | | | | 70* | | 8.6 | | | | 1.3 | | | 10* | | | | | | | 6.8 |
| Discharge | Consent limits on discharge | | | | | | | | 900 | | 30 | | | | 1000 | 11.4 | | | | | | | | | 2000 |
| Marine | 50m South of outfall | Water | 3J15 | 23-Jul-19 | Suite | 836650 004 | 1700 | <10 | <10 | 9800 | <10 | <0.5 | <0.1 | <10 | <30 | 8.08 | <20 | <40 | <0.01 | 2100 | <10 | <0.04 | 2 | <10 | <10 |
| Marine | 50m South of outfall | Water | | 05-Nov-19 | A | 1593505 | 1100 | 3.2 | 11 | 9300 | 0.7 | < 0.10 | < 100.00 | < 0.2 | < 0.09 | 8 | 0.25 | 1.6 | < 0.0004 | 2800 | 6.5 | | 1.8 | 6.7 | 12 |
| Marine | 50m South of outfall | Water | | 06-Feb-20 | | 1635311 | 1300 | 1.3 | 13 | 11000 | < 0.5 | < 0.10 | < 0.035 | 3 | < 0.09 | 7.6 | 0.27 | 0.56 | 0.0011 | 1900 | 120 | | 5 | 2.3 | 3.5 |
| Marine | 50m South of outfall | Water | 2A15 | 25-Jun-20 | | 1690468 | 1300 | 5.9 | 14 | 11000 | 0.8 | 1.3 | < 0.035 | 4 | 3.3 | 8.7 | 0.57 | 0.37 | 0.0006 | 2000 | 230 | | 14 | 4.7 | 14 |
| Marine | 50m South of outfall | Water | 3J15 | 24-Jul-20 | | 1703939 | 1200 | 5 | 14 | 8700 | 0.6 | 0.11 | | 0.4 | 0.14 | 7.5 | 0.46 | < 0.25 | < 0.0004 | 1900 | 21 | | < 1.0 | 3.5 | < 1.3 |
| Marine | 50m South of outfall | Water | | 06-Nov-20 | | 1758419 | 1100 | 5.2 | 1.7 | 10000 | < 0.5 | < 0.10 | | < 0.2 | < 0.09 | 7.4 | 0.31 | < 0.25 | < 0.0004 | 1500 | 17 | | < 1.0 | < 0.6 | 16 |
| Marine | 50m South of outfall | Water | 1J15 | 28-Jan-21 | | 1798133 | 3400 | 2.4 | 11 | "30000 | < 0.5 | 0.11 | | < 0.2 | 0.22 | 7.8 | < 0.17 | 0.61 | 0.32 | 2200 | 120 | | 4.7 | 1.2 | 10 |
| Marine | 50m South of outfall | Water | 1J15 | 10-Feb-21 | | 1801525 | 2900 | 3.2 | 12 | "22000 | < 0.5 | < 0.10 | | < 0.2 | 0.2 | 7.9 | < 0.17 | < 0.25 | < 0.0004 | 2700 | 17 | | < 1.0 | 1.3 | 3.2 |
| Marine | 50m South of outfall | Water | | 29-Sep-21 | | 1913373 | 340 | 8.8 | 5.7 | 2500 | 0.5 | <0.4 | | < 0.2 | 0.1 | 8 | < 0.17 | < 0.25 | < 0.0004 | 830 | 9 | < 0.08 | 2.6 | 1.2 | 1.6 |
| Marine | 50m South of outfall | Water | 4N15 | 10/11/2021 | | 1933987 | 840 | 3.2 | 11 | 7100 | 0.5 | 0.44 | 0.12 | 0.7 | < 0.09 | 7.9 | < 0.17 | < 0.25 | < 0.0004 | 1000 | 19 | < 0.08 | 2.1 | 1.5 | 24 |
| Marine | 50m South of outfall | Water | 1J15 | 13-Dec-22 | | 2099959 | 920 | 22 | 12 | 7300 | 1.4 | < 0.10 | < 0.035 | 0.2 | 0.14 | 7.7 | 0.23 | < 0.25 | < 0.0004 | 3000 | 38 | < 0.08 | 1.3 | 1 | 2.2 |