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Contaminated Land
and Hydrogeology

Glan Llyn, Llanwern: Soil Quality Verification Report, Phase 5E1

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Prepared by: H Fraser Consulting Ltd



H FRASER CONSULTING LTD
The Pump House, Coton Hill, SY1 2DP
T: 01743 352797 M: 07527 006625 E: hfraser@hfraserconsulting.co.uk www.hfraserconsulting.co.uk
Registered Company No 07712855



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1. INTRODUCTION

Brighton STM Developments Ltd, on behalf of Revantage, has appointed H Fraser Consulting Ltd (HFCL) to assist with validating remediation works undertaken the former Llanwern Steelworks site at Glan Llyn.

The site has undergone remediation, comprising excavation of Made Ground materials, removal of materials unsuitable for re-use in the development platform, and recompaction of suitable Made Ground materials as an engineered fill. The remediation strategy for the site also requires a drainage layer to be installed above the engineered fill layer, to reduce infiltration to the Made Ground.

Two planning conditions (PC) apply to the site remediation work.

- PC 27 requires that, prior to commencement of each phase of development, a risk assessment, remediation strategy and verification plan are submitted to and approved in writing by the Local Authority.
- PC 28 requires that prior to commencement of each phase of development (excluding works required for the remediation strategy) a verification report is submitted to and approved in writing by the Local Authority, to demonstrate completion of the remediation strategy and the effectiveness of the remediation.

The site is being redeveloped in phases, and the current report relates to Phase 4G.

1.1 Remediation verification

Discussion between Revantage (and its predecessor St Modwen Developments), Natural Resources Wales (NRW), the designers of the remediation strategy Rodgers Leask Ltd (RLL) and HFCL resulted in an agreed process for the verification of phase-by-phase remediation of the site. This process is described in HFCL (2024a).

RLL has collected and processed the data relevant to verification of the remediation process and has provided the data used in this report. HFCL has reviewed and agreed RLL's data processing for Phase 4G.

1.2 Objective

The objective of this report is to demonstrate that the remediation criteria relating to controlled waters have been met. (RLL (2025) has separately reviewed the risks to human health.) This verification report is intended to be submitted alongside the human health assessment, to obtain discharge of Part 1 of PC 28 for Phase 4G.¹

1.3 Scope of works

The following work has been undertaken:

- RLL has reviewed and presented the data relevant to Phase 4G;

¹ Part 2 of PC 28 requires presentation of evidence of the placement of a drainage layer beneath the engineered fill material. This is the responsibility of the plot developers and will be signed off separately.

- HFCL has confirmed its agreement with the presented data and has checked that the data can be adequately mapped onto the agreed verification process.
- HFCL has produced this report to determine whether controlled waters risks related to Phase 5E1 have been adequately addressed.

2 BACKGROUND

2.1 Plot location

The location of Phase 5E1 is shown in the southeast corner of Figure 2.1. Grid squares measure 50 m. Phase 5E1 has water on one side – a reën to the north. It is part of the site surface water drainage reën system (still under development).

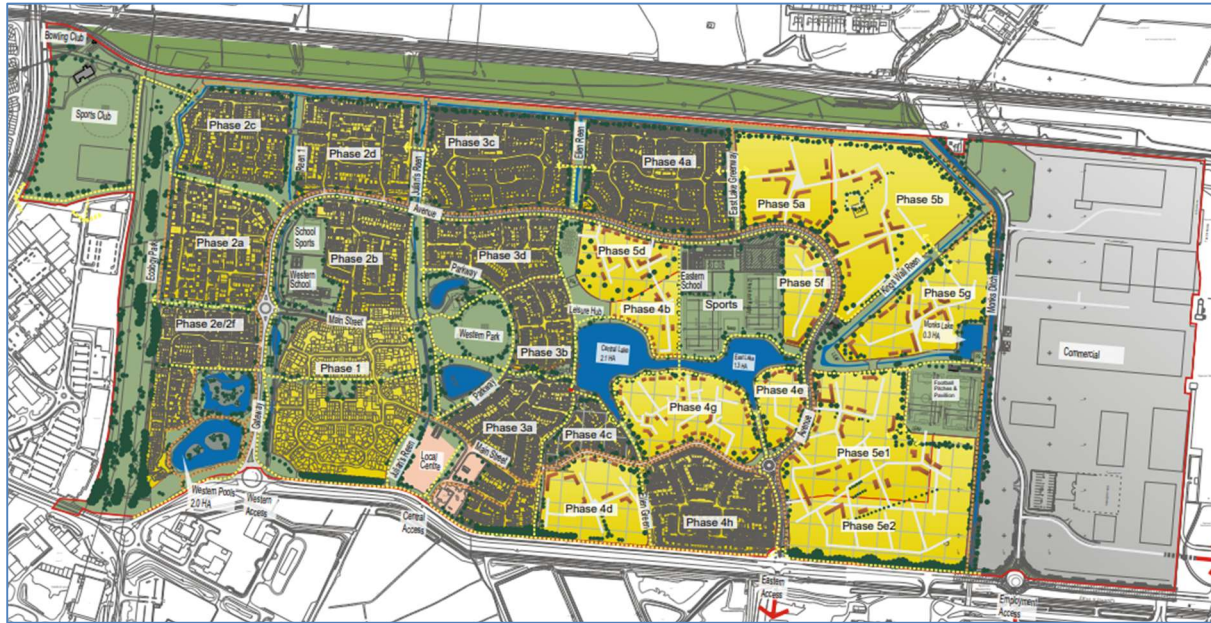


Figure 2.1 Plot Location

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2.2 Derivation of remediation criteria

Soil re-use values (SRVs) were derived by Atkins (2017) and amended by RLL (2019-22). A further minor correction for the residential development areas (including Phase 5E1) was presented by HFCL (2024b). The derivation of SRVs assumes the following conceptual model.

- 60% of the site surface is impermeable, and 100% of incident rainfall on impermeable areas either evaporates or is routed via the drainage system directly to the reens
- 40% of the site has soft landscaping, and in these areas infiltration was calculated as 12.85 mm/a, by subtracting evapotranspiration and runoff from the total rainfall figure. Runoff from these areas also passes to the reens.
- 12.85 mm/a infiltrates the drainage layer overlying the engineered fill.
- In the soft landscaping areas, 60% of infiltration drains laterally through the drainage layer into a reën, and does not enter the engineered fill.
- 40% of infiltration drains into the engineered fill and migrates through the fill to a reën, dissolving potential contaminants from the fill materials.
- The infiltration that travels through the fill is diluted on reaching the reens by runoff and infiltration through the drainage layer. The relative fluxes of water passing through the fill to clean runoff provides the dilution factor.

- SRVs are calculated by multiplying the Environmental Quality Standard (EQS) by the dilution factor, and converting this water concentration into a soil concentration using a partition co-efficient.

This approach was set out originally by Atkins in 2017, modified by Rogers Leask in their Remediation Strategy report and approved by the Local Authority under discharge of Planning Condition 27.

Soil re-use values (SRVs) are set out HFCL (2024b) and values for potential contaminants of concern are reproduced in the "SRVs" tab of Appendix A.

3 REMEDIATION ACTIVITIES AND VERIFICATION DATA

3.1 Remediation process

The remediation and verification work on Phase 5E1 has included the following:

- Complete excavation of Made Ground materials to the underlying Tidal Flat Deposits, screening and stockpiling;
- Sampling of stockpile materials;
- Removal of material unsuitable for use;
- Subdivision of the site into backfill zones;
- Placement of engineered fill in 300 mm layers, zone by zone;
- Sampling of surface materials, post-placement, to provide additional verification data.

3.2 Soil movements

All of the engineered fill used for Phase 5E1 derived from excavated site soils; various stockpiles of these soils were exploited to provide the required materials. No fill materials were brought from off site.

3.3 Soils validation data

In total 404 samples are available from fill materials for Phase 5E1, and an additional 27 samples were taken from the near-surface, post-placement. Figure 3.1 shows the backfill zones for Phase 5E1; each zone was backfilled in 300 mm layers and given a reference code. A materials management database was maintained so that there is a record of which stockpile was used for each layer in each backfill zone. Appendix A presents a full summary of the CoC data. Laboratory certificates are provided as an appendix to Rodgers Leask (2025).



Figure 3.1 Backfill zones

4 ASSESSMENT OF CONTAMINANTS OF CONCERN

4.1 Assessment stages

HFCL (2024a) sets out the verification process that has been agreed. This proceeds through three stages, as follows.

4.1.1 Identification of Contaminants of Concern

The verification data for the phase are screened against the SRVs. Contaminants of Concern (CoCs) are defined as determinands for which the 95thile of the analytical results from the fill materials exceeded the SRV. Some CoCs have such slow travel times that they cannot be expected to travel the minimum 12.5 m assessment distance within a 1,000-year assessment period and therefore present no significant risk. Those that have a 95thile exceeding the SRV and that are mobile enough to travel more than 12.5 m in the assessment period are taken forward for further evaluation.

4.1.2 Statistical assessment

At this stage a thorough statistical and spatial analysis is carried out. This includes presentation of the entire data set for each CoC as a box plot, presentation of the same data sets as histograms; and spatial assessment of the data, with an average concentration and the upper confidence limit of the mean value (UCLmean) concentration calculated for each backfill zone in the phase. If the UCLmean concentration for any CoC in any backfill zone exceeds the SRV this is taken to the next stage.

4.1.3 Screening against Reference Values

The average and UCLmean concentrations for the different backfill zones are then compared against the Reference Values that are relevant, considering the distance of each backfill zone from the nearest surface water (the travel distance required for contaminants to move from the backfill zone to the receptor). These Reference Values were derived using the Remedial Targets Methodology (RTM – Environment Agency, 2006).

Any UCLmean concentration that exceeds the relevant Reference Value requires additional justified mitigation, or fails the validation method.

4.1.4 Review of hydraulic conductivity data for engineered fill

Because the derivation of the SRVs assumes a hydraulic conductivity no higher than 1×10^{-6} m/d for the engineered fill, hydraulic conductivity data need to be presented to show that this has been achieved.

4.2 Stage 1 – Identification of Contaminants of Concern

The verification data for Phase 5E1 have been screened against the SRVs. Results are summarised in Table 4.1 and detailed in Appendix A. This includes the samples taken from stockpiles prior to backfilling and the surface verification samples taken after placement. In both the table and the appendix any value exceeding the SRV is highlighted in red.

The analysis shows that most of the assessed determinands were detected in a significant number of soil samples. Maximum values exceeded the SRV in 16 cases, but 95th percentile values exceeded the SRV for only three determinands.

Table 4.1 Summary of soil quality results

Determinand	Units	SRV	N Detects*	Mean	Max	95%ile
Inorganics						
Cyanide (Total)	mg/kg	2.02	216	3.31	273	13.0
Ammoniacal Nitrogen	mg/kg	154	248	12.66	376	20.0
Iron (Total)	mg/kg	305,000	431	79,595	618,000	242,000
Arsenic	mg/kg	2,533	407	12.75	125	30.2
Cadmium	mg/kg	73	335	0.62	12.0	1.84
Chromium	mg/kg	9,431	415	156	1,200	550
Manganese	mg/kg	33,300	429	10,444	120,000	34,750
Copper	mg/kg	451	404	28.36	290	81.2
Mercury	mg/kg	132	230	0.70	8.70	1.40
Nickel	mg/kg	11,500	430	24.84	496	46.0
Lead	mg/kg	15,700	427	93.70	2,280	263
Selenium	mg/kg	702	276	5.12	71.3	15.6
Vanadium	mg/kg	1,606	430	287	2,880	1,145
Zinc	mg/kg	138,000	430	213	5,280	562
Speciated TPH						
Aliphatic TPH >C5-C6	mg/kg	73	19	0.61	0.04	1.00
Aliphatic TPH >C6-C8	mg/kg	359	58	0.61	0.10	1.00
Aliphatic TPH >C8-C10	mg/kg	2,841	67	0.67	11.0	1.00
Aliphatic TPH >C10-C12	mg/kg	22,500	72	2.27	48.0	12.0
Aliphatic TPH >C12-C16	mg/kg	450,000	155	5.85	310	22.2
Aliphatic TPH >C16-C21	mg/kg	56,600,000	203	14.48	1,200	51.1
Aliphatic TPH >C21-C35	mg/kg	56,600,000	253	68.88	3,000	240
Aliphatic TPH >C35-C44	mg/kg	56,600,000	141	14.22	1,330	34.3
Aromatic TPH >C5-C7	mg/kg	8.51	6	0.62	7.20	1.00
Aromatic TPH >C7-C8	mg/kg	177	8	0.64	7.00	1.00
Aromatic TPH >C8-C10	mg/kg	144	64	0.69	16.0	1.00
Aromatic TPH >C10-C12	mg/kg	227	84	2.92	62.0	13.0
Aromatic TPH >C12-C16	mg/kg	451	138	5.43	190	25.0
Aromatic TPH >C16-C21	mg/kg	1424	225	29.73	3,400	116
Aromatic TPH >C21-C35	mg/kg	11,300	281	107	4,500	500
Aromatic TPH >C35-C44	mg/kg	11,300	156	15.83	1,580	33.3
PAH						
Naphthalene	mg/kg	27	309	2.42	39.0	12.0
Acenaphthylene	mg/kg	16.7	280	0.89	51.8	3.95
Acenaphthene	mg/kg	30	266	0.19	3.31	0.70
Fluorene	mg/kg	27	283	0.81	53.0	3.09
Phenanthrene	mg/kg	27	393	5.36	275	20.0
Anthracene	mg/kg	34	357	1.58	86.0	6.20
Fluoranthene	mg/kg	6.64	413	7.95	331	32.8
Pyrene	mg/kg	76	412	5.82	204	23.0
Benzo[a]anthracene	mg/kg	607	393	3.26	109	13.0
Chrysene	mg/kg	621	394	3.26	84.6	12.1
Benzo[b]fluoranthene	mg/kg	3.42	385	4.59	121	16.0

Determinand	Units	SRV	N Detects*	Mean	Max	95%ile
Benzo[k]fluoranthene	mg/kg	5.05	374	1.57	36.5	5.75
Benzo[a]pyrene	mg/kg	34	381	3.42	71.9	13.0
Indeno(1,2,3-c,d)pyrene	mg/kg	25	341	2.58	56.7	9.85
Dibenz(a,h)anthracene	mg/kg	838	304	0.52	12.0	1.95
Benzo[g,h,i]perylene	mg/kg	13	335	2.26	49.0	8.20
Other organics						
Phenol	mg/kg	3.05	22	0.019	0.88	0.020
Benzene	µg/kg	3,800	22	70.13	240	180
Toluene	µg/kg	128,000	24	53.77	22.0	140
Ethylbenzene	µg/kg	80,000	5	30.97	33.0	80.0
m & p-Xylene	µg/kg	74,000	7	76.42	36.0	200
o-Xylene	µg/kg	74,000	5	76.30	9.60	200

* from a total of 431 samples

Of the 18 determinands with an exceedance of the SRV, three (iron, manganese and vanadium) were metals, and 12 were PAH. Cyanide, ammoniacal nitrogen and aromatic TPH (C16-C21) were the others. For two of the metals, ammoniacal nitrogen, the aromatic TPH fraction and most of the PAH, the 95th percentile values were below the SRV. However, cyanide, manganese, fluoranthene, benzo(b)fluoranthene and benzo(k)fluoranthene are shown to be CoCs that require a further stage of assessment.

4.3 Stage 2 – Statistical assessment

4.3.1 Stockpile samples – box plots and histograms

Box plots are used to show the minimum value of the data set, the range of data falling between the 25th and 75th percentile, the mean value and the maximum value. They are useful to visually assess whether the data points are evenly distributed throughout the range. Histograms show the data distributed by the number of data points within specific ranges and are useful for identifying the distribution of data across the range, and also for identifying whether higher values are common or rare in the data set. Box plots and histograms are presented in Figure 4.1 to 4.10.

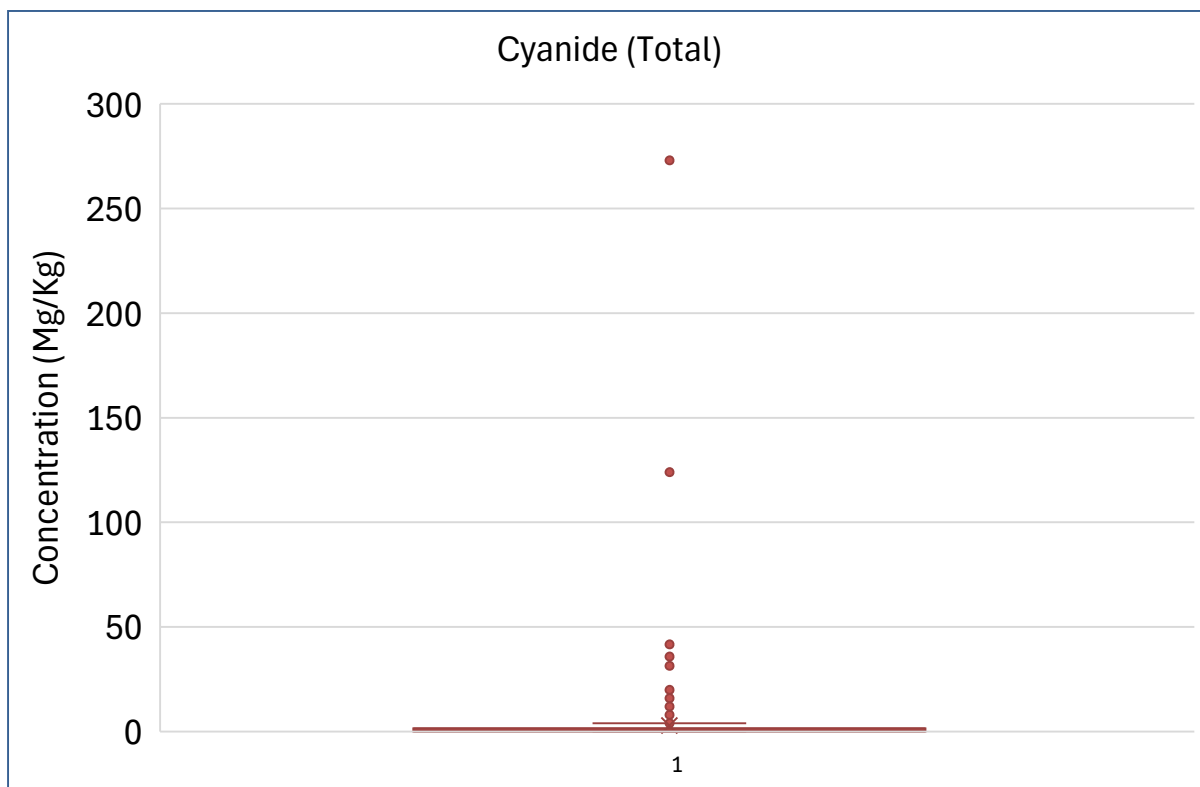


Figure 4.1 Box plot for cyanide (mg/kg)

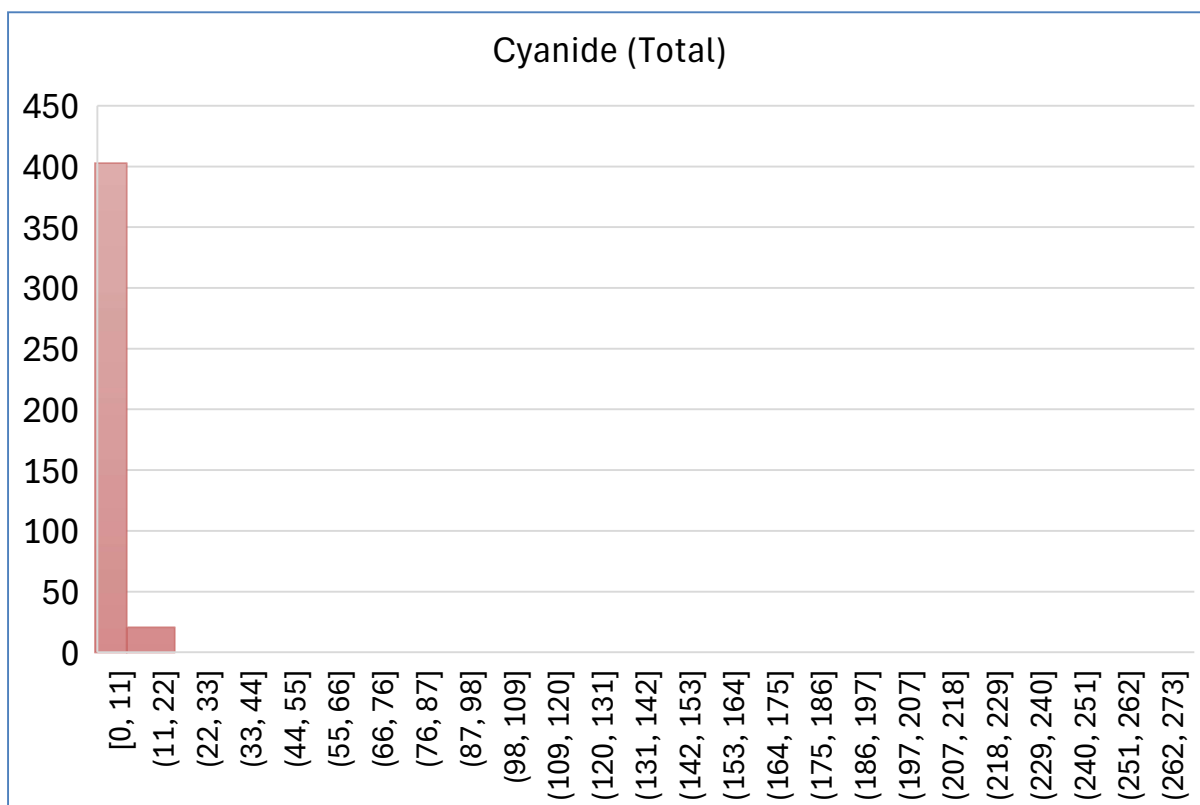


Figure 4.2 Histogram for cyanide (mg/kg)

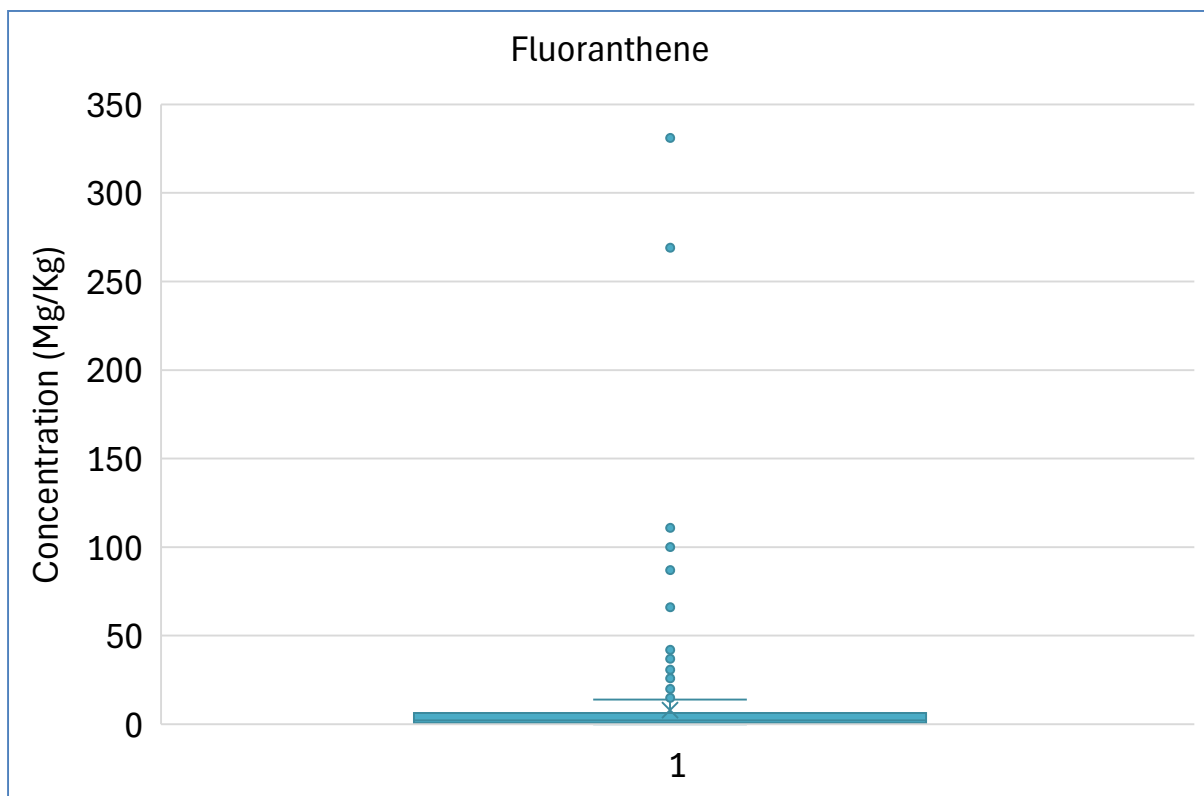


Figure 4.3 Box plot for fluoranthene (mg/kg)

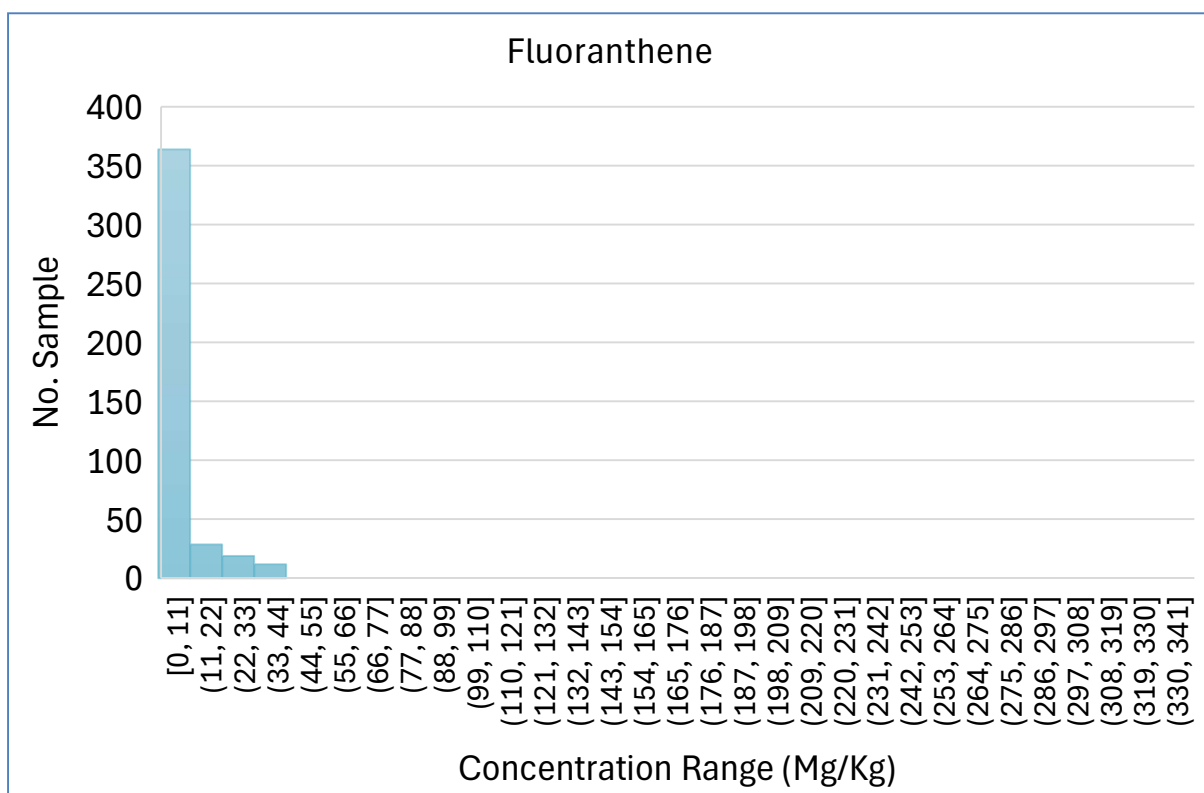


Figure 4.4 Histogram for fluoranthene (mg/kg)

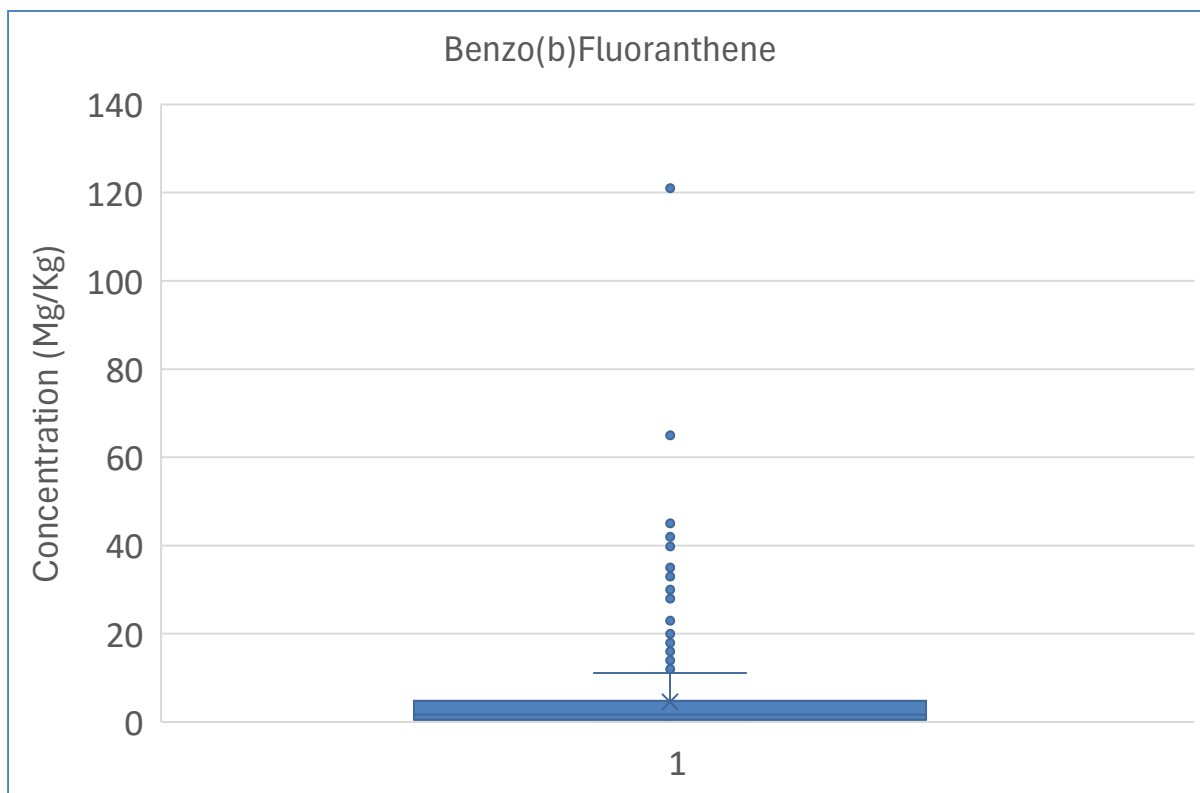


Figure 4.5 Box plot for benzo(b)fluoranthene (mg/kg)

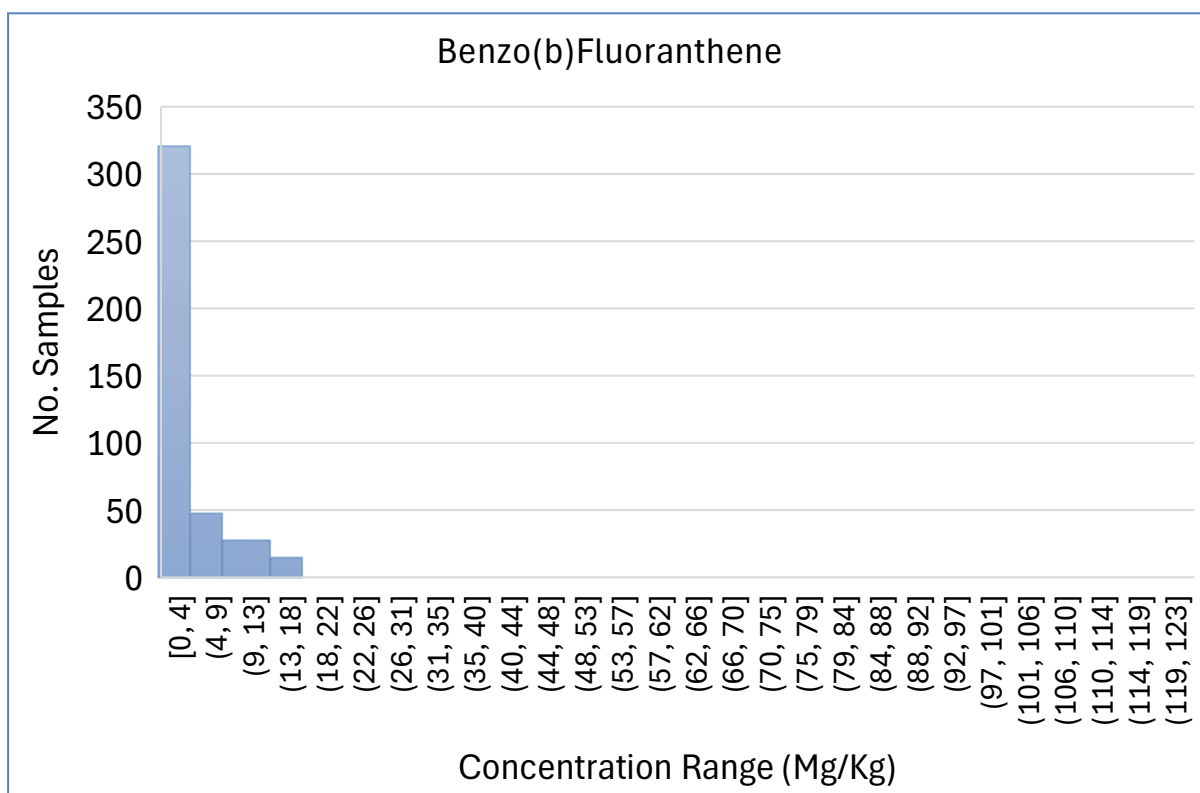


Figure 4.6 Histogram for benzo(b)fluoranthene (mg/kg)

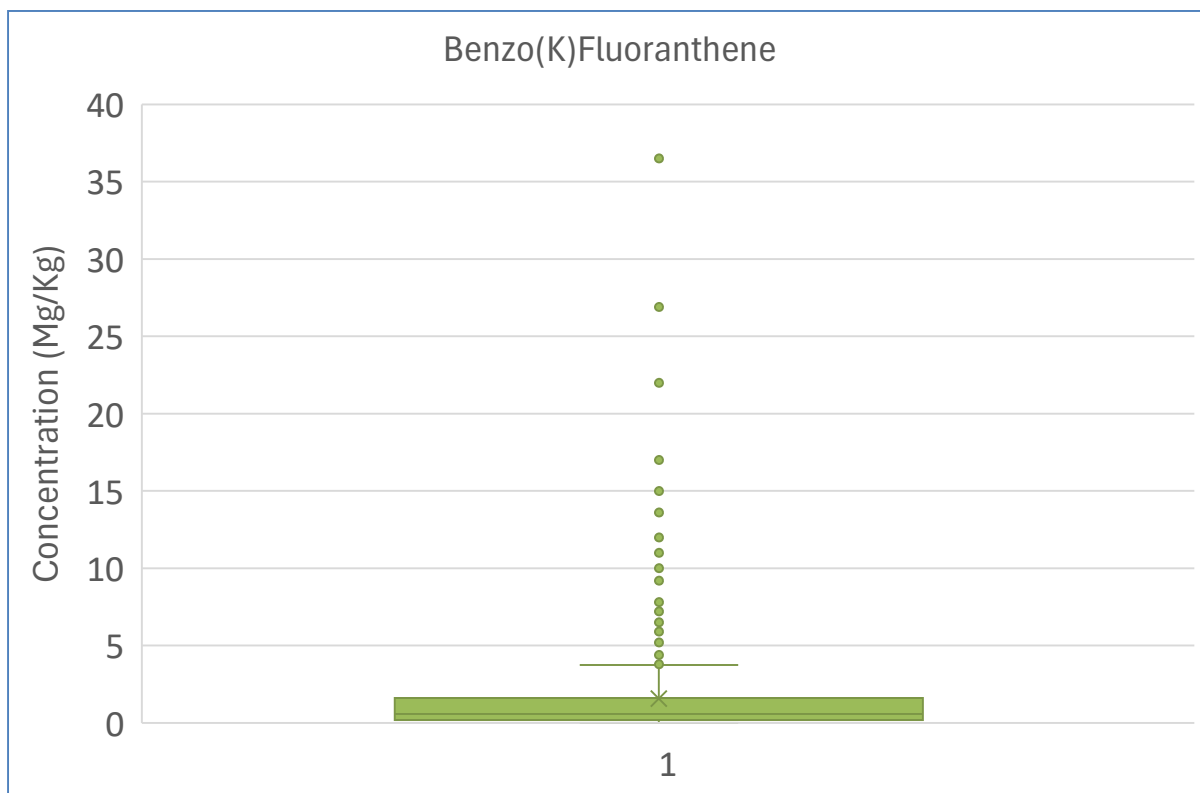


Figure 4.7 Box Plot for benzo(k)fluoranthene (mg/kg)

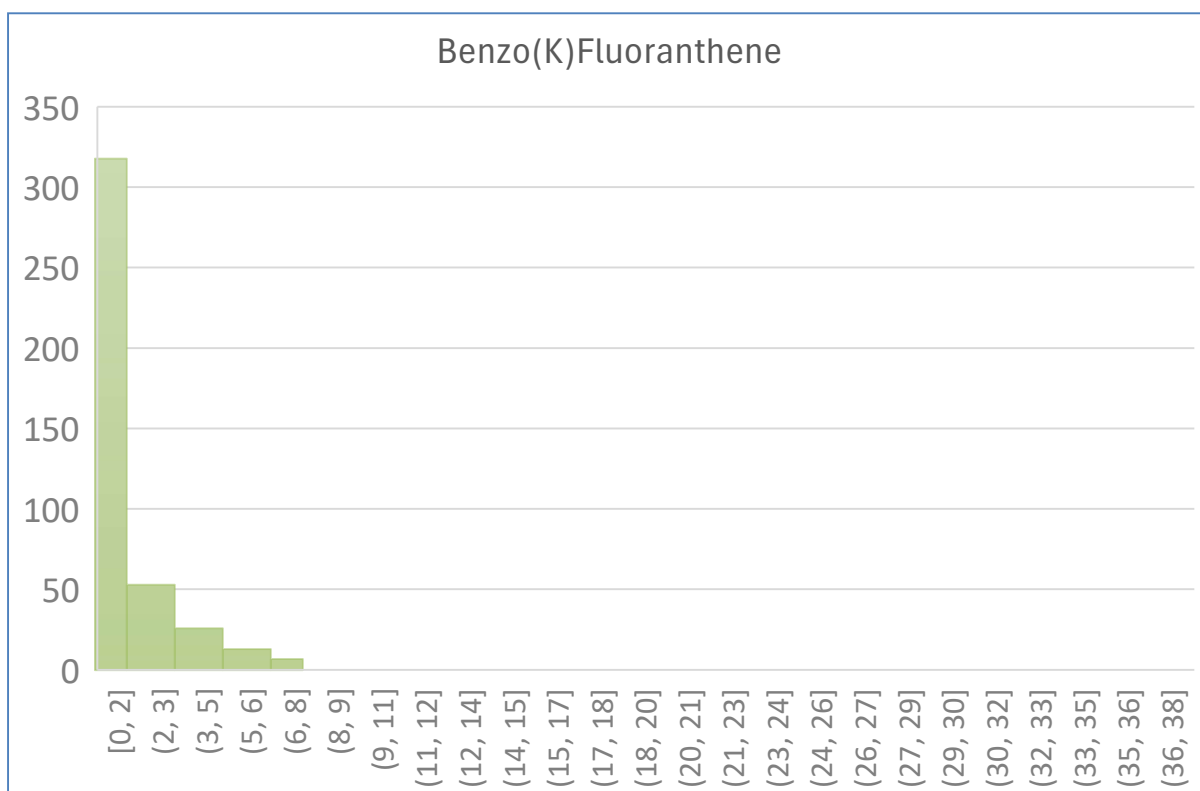


Figure 4.8 Histogram for benzo(k)fluoranthene (mg/kg)

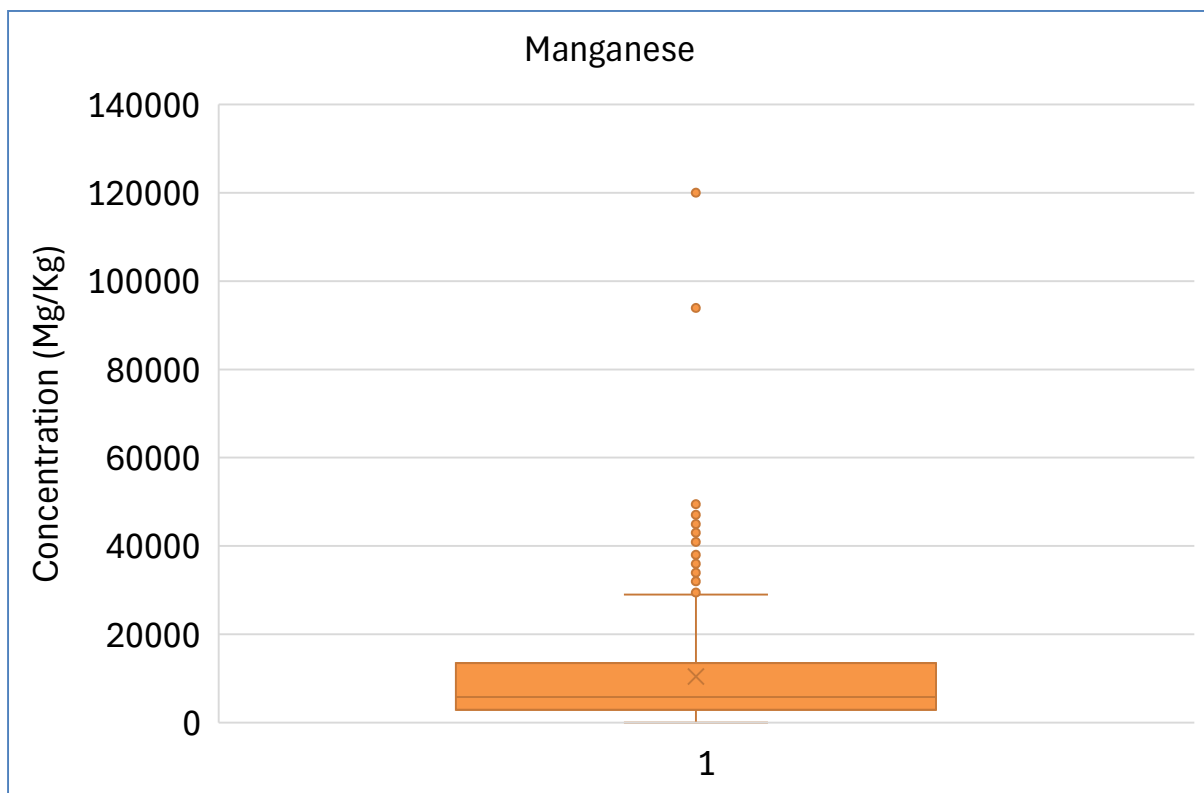


Figure 4.9 Box Plot for manganese (mg/kg)

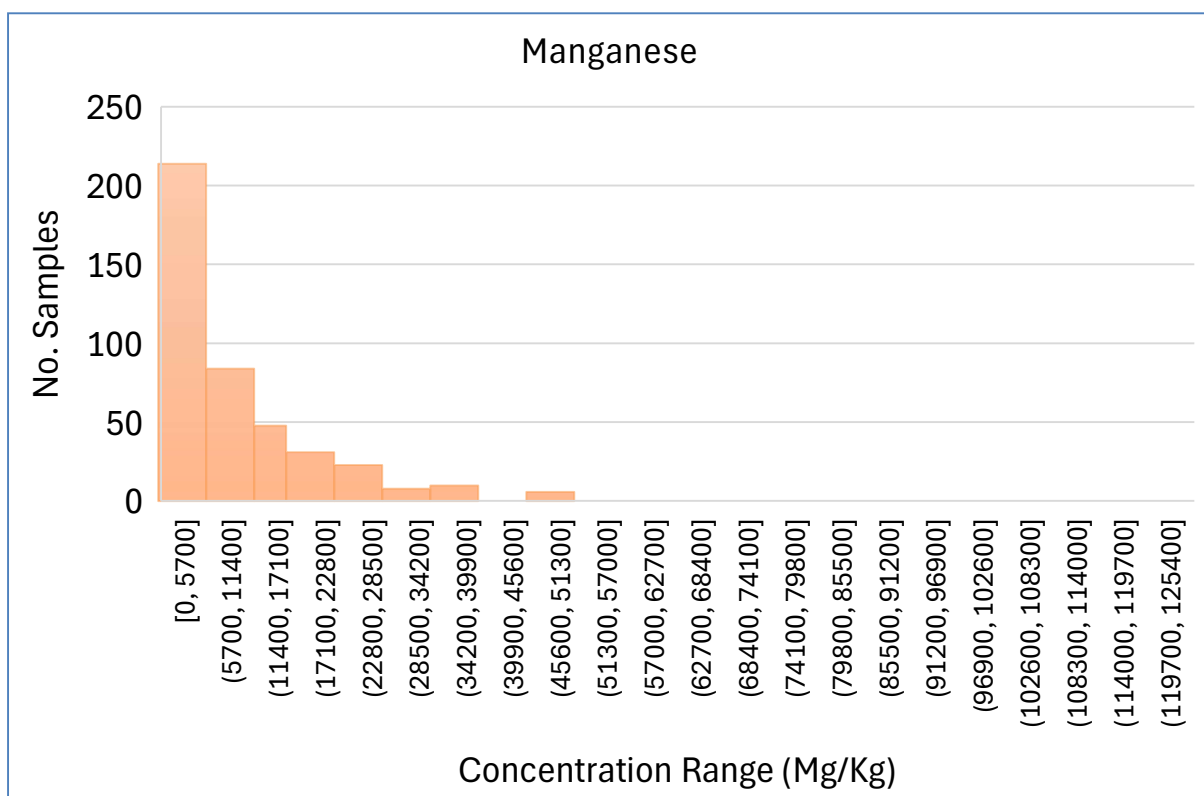


Figure 4.10 Histogram for manganese (mg/kg)

The following points can be seen from the plots.

- For cyanide, the data range from <0.50 mg/kg to 273 mg/kg, the average value being 3.31 mg/kg. Figure 4.1 shows this data set to have a 95th percentile of 13 mg/kg which exceeds the SRV for cyanide (2.02 mg/kg) on this site. The histogram confirms that the data have a long-tailed distribution, with lower values being relatively common.
- For fluoranthene the data range from <0.02 mg/kg to 331 mg/kg, the average value being 7.95 mg/kg. The 95th percentile (32.8 mg/kg) exceeds the SRV (6.64 mg/kg), indicating that it is an element of concern. The histogram confirms that the data have a long-tailed distribution, with lower values being relatively common.
- For benzo(b)fluoranthene the data range from <0.02 mg/kg to c. 121 mg/kg, the average value being 4.59 mg/kg. The 95th percentile (16.0 mg/kg) again exceeds the SRV (3.42 mg/kg). The histogram confirms that the data have a long-tailed distribution, with lower values being relatively common.
- For the benzo(k)fluoranthene the data range from <0.01 mg/kg to 36.5 mg/kg, the average concentration being 1.57 mg/kg. The 95th percentile (5.75 mg/kg) exceeds the SRV (5.05 mg/kg). The histogram confirms that the data have a long-tailed distribution, with lower values being relatively common.
- For manganese the data range from <1 mg/kg to 120,000 mg/kg, with the average concentration being 10,444 mg/kg. The 95th percentile (34,750 mg/kg) again exceeds the SRV. The histogram confirms that the data have a long-tailed distribution, with lower values being relatively common.

4.3.2 Stockpile samples – spatial plots

The verification data have been plotted spatially as follows.

An average concentration has been derived from each stockpile location. Each 300 mm layer of backfill was sourced from a specific stockpile and the average stockpile concentration was therefore, ascribed to the layer. Each backfill zone was typically backfilled with seven layers, and an average concentration derived for each zone. The plots, drawn up by Rodgers Leask, are presented in Figure 4.11, Figure 4.12, Figure 4.13, Figure 4.14 and Figure 4.15. In each plot, the highest colour category represents values exceeding the SRV.

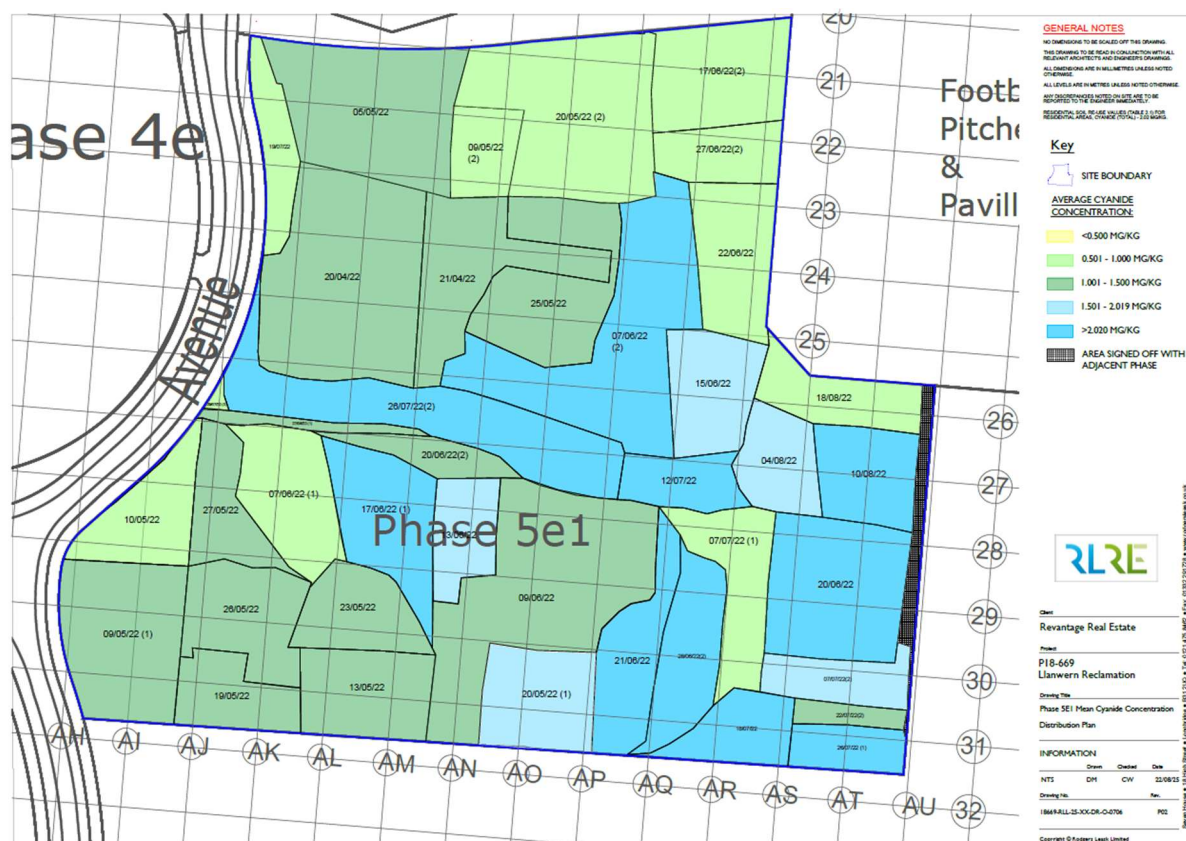


Figure 4.11 Cyanide distribution (mean values)

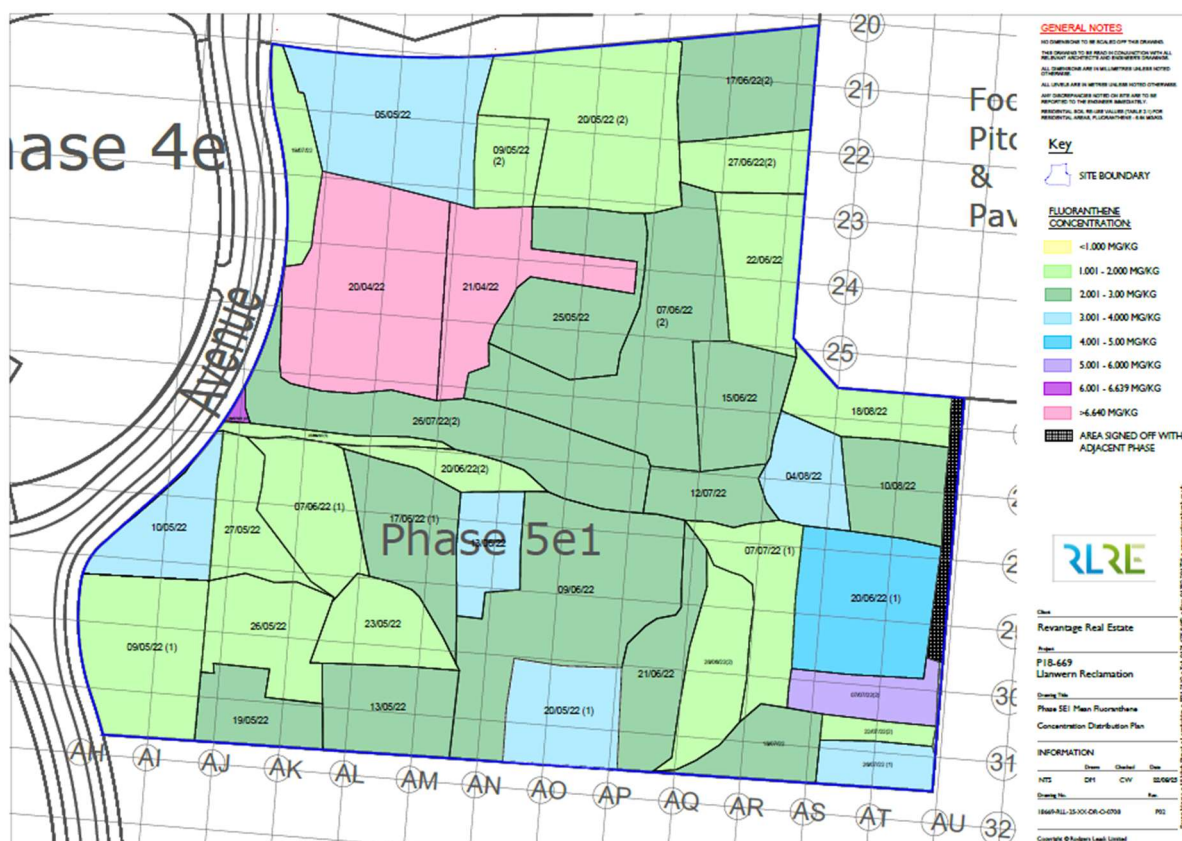
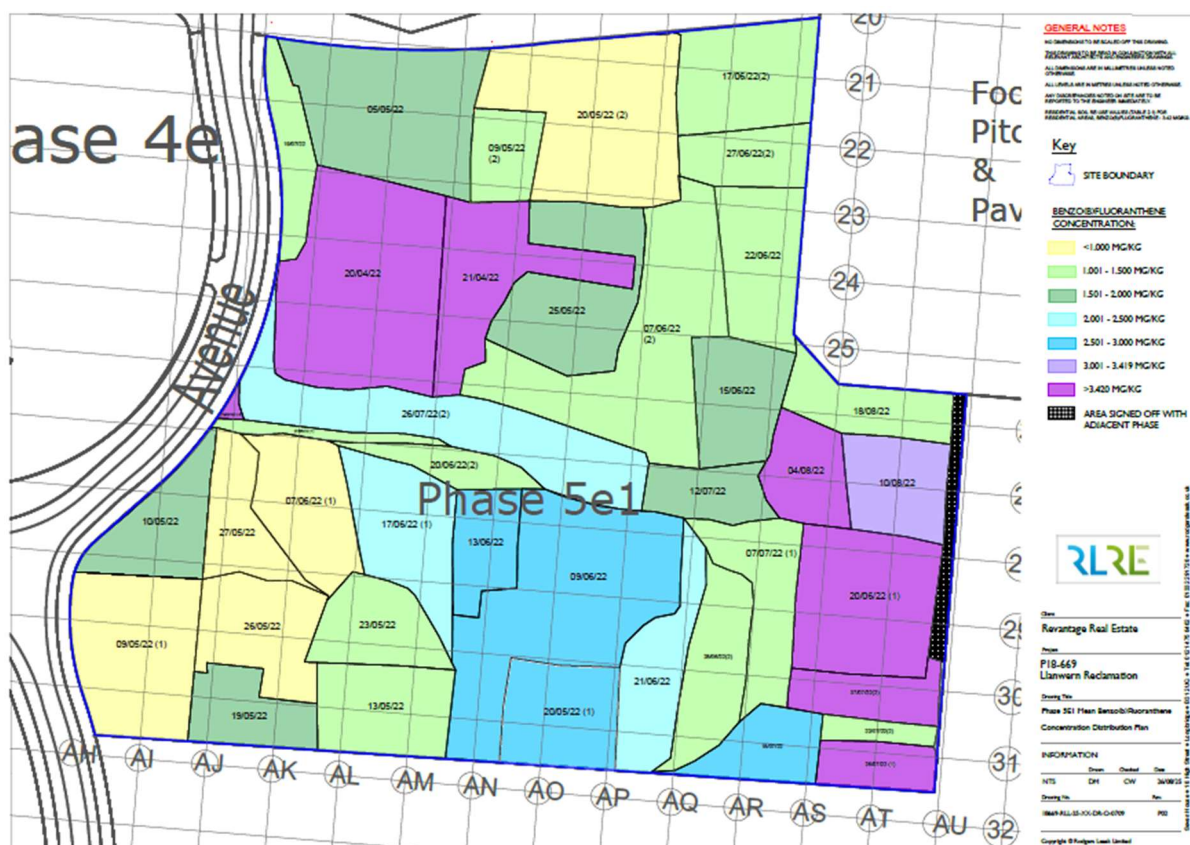


Figure 4.12 Fluoranthene distribution (mean values)



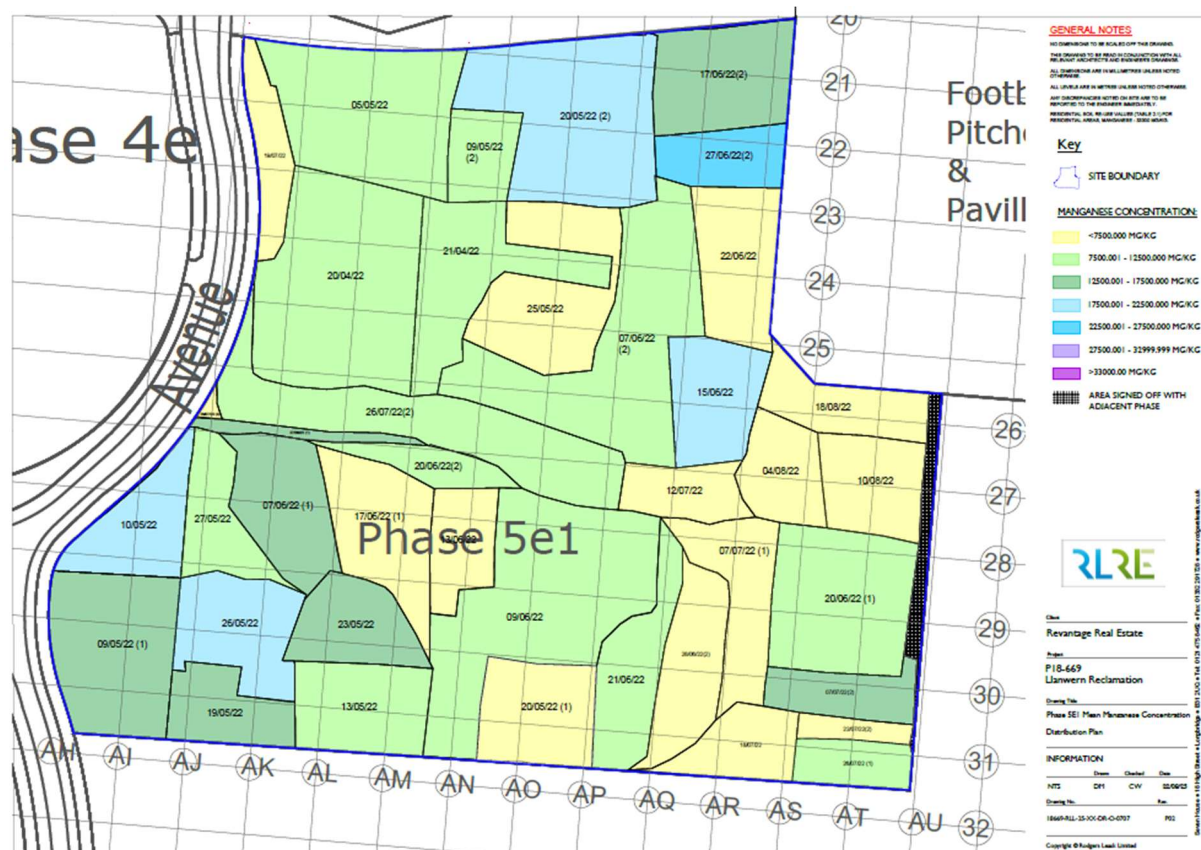


Figure 4.15 Manganese (mean values)

For any data set, there is uncertainty associated with the estimate of the mean value, a conservative assessment of the mean value can be made by calculating an Upper Confidence Limit (UCL) in the mean. This has been done using Student's t-distribution method (likely to be more appropriate for the distribution of analytical results seen in Section 4.1), resulting in a slightly higher estimate of the average concentration for each backfill zone. This report refers to the 95th percentile UCLmean, which have been plotted spatially and are presented in Figure 4.17, Figure 4.17, Figure 4.19, Figure 4.19 and Figure 4.20.

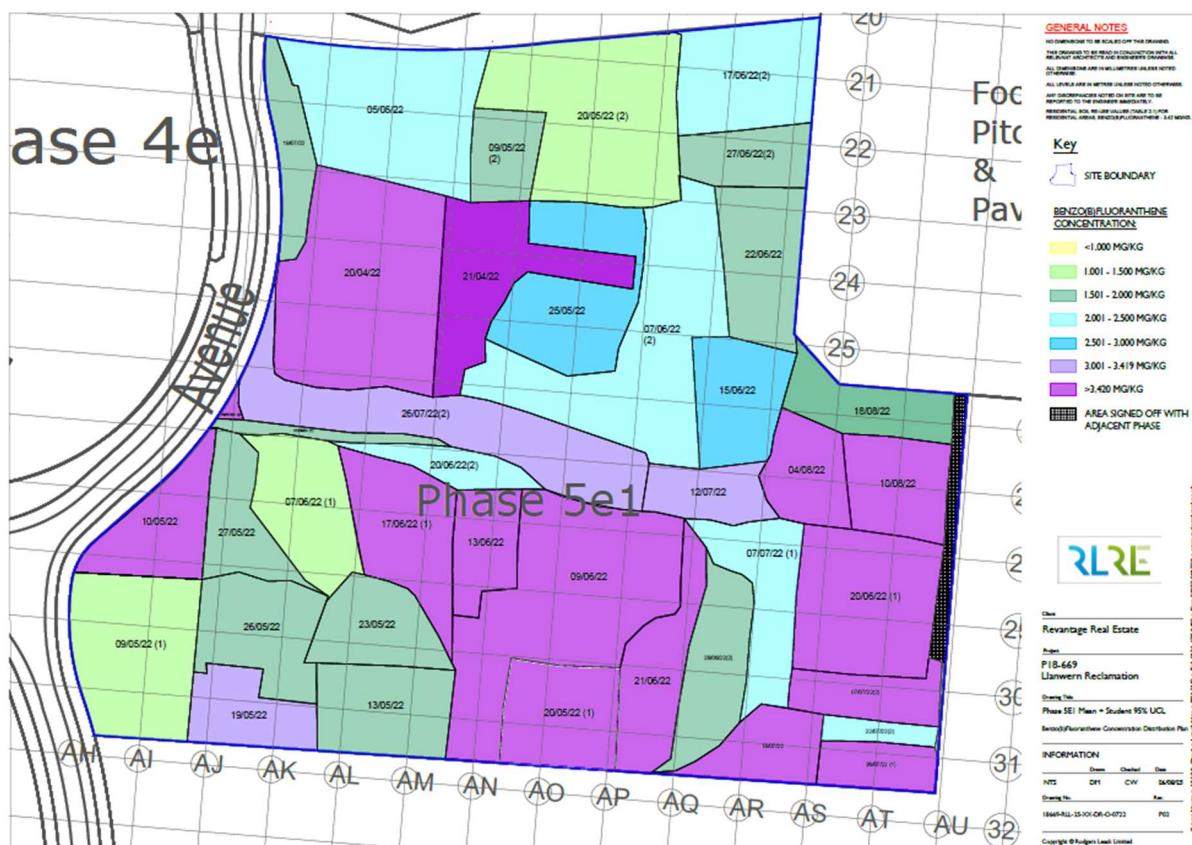


Figure 4.18 Benzo(b)fluoranthene distribution (UCL Mean values)

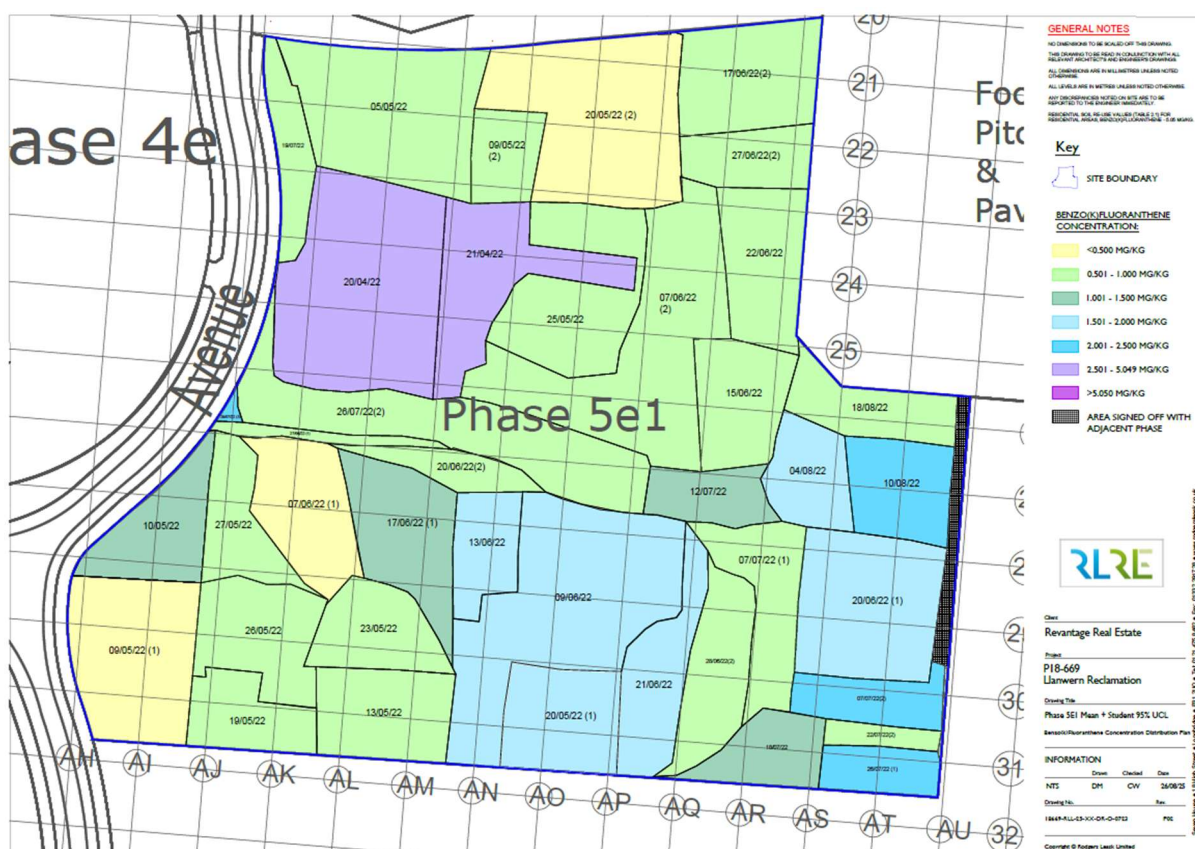


Figure 4.19 Benzo(k)fluoranthene distribution (UCL Mean Values)

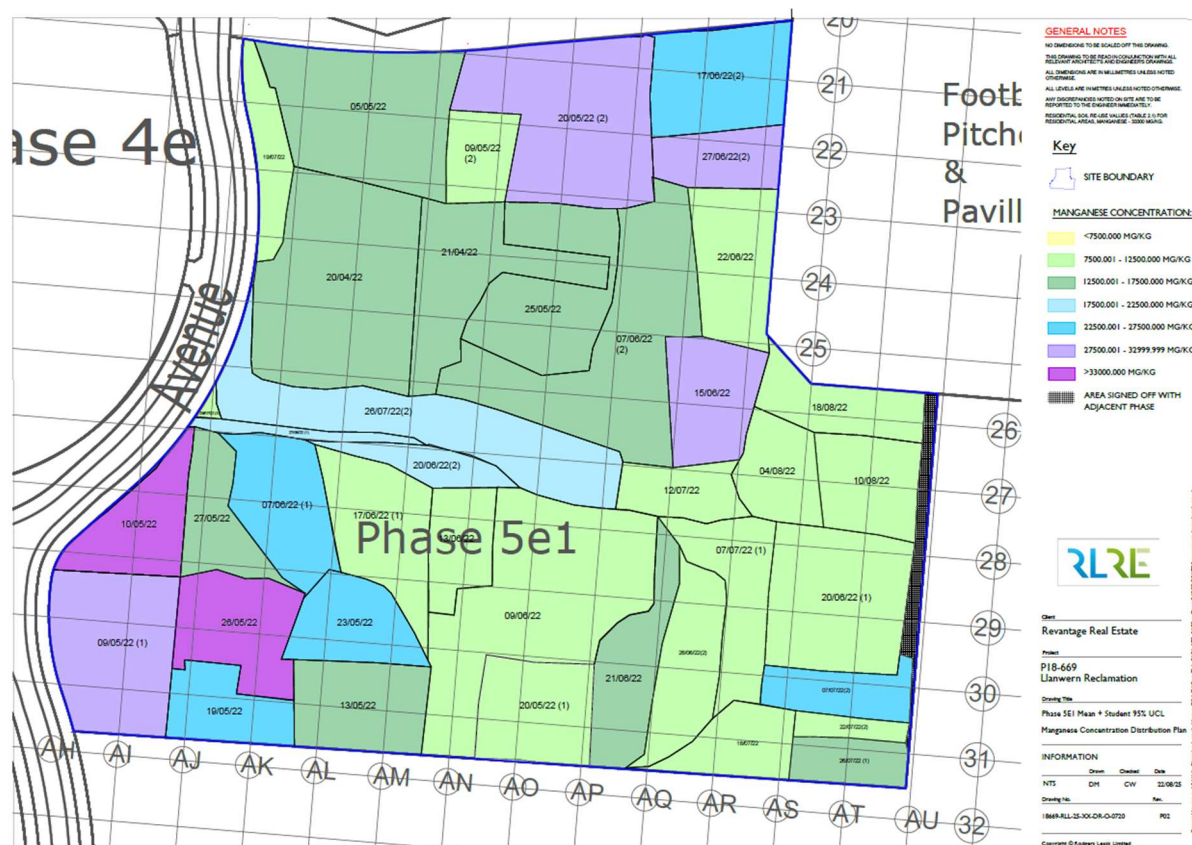


Figure 4.20 Manganese distribution (UCL Mean Values)

4.3.3 Surface verification samples

The surface verification samples are included in the statistical presentation (Table 4.1 and subsequent graphs). For completeness we have summarised them separately in Table 4.2 for the identified CoC.

Table 4.2 Summary of surface verification samples

Determinand	No	No exceeding	Min (mg/kg)	Max (mg/kg)	Mean (mg/kg)	UCLMean (mg/kg)	SRV (mg/kg)
Cyanide	25	4	<0.50	5.10	1.47	1.82	2.02
Fluoranthene	26	8	1.40	13.0	5.45	6.68	6.64
Benzo(b) fluoranthene	26	14	1.20	8.40	4.10	4.93	3.42
Benzo(k) fluoranthene	26	0	0.40	2.60	1.36	1.63	5.05
Manganese	26	0	9.70	12,000	4,231	5,259	33,300

Table 4.2 shows that the UCLmean values for cyanide, benzo(k)fluoranthene and manganese are below the corresponding SRVs; however, this is not the case for fluoranthene and benzo(b)fluoranthene, and there are SRV exceedances for cyanide that also require further review.

Data and calculations related to these exceedances are included in the "SV checks" tabs of Appendix A.

Closer examination of the individual sample results shows that 14 surface verification samples showed exceedances of the SRV for benzo(b)fluoranthene, eight for fluoranthene and four for cyanide. The locations of these samples are shown in Figure 4.21.

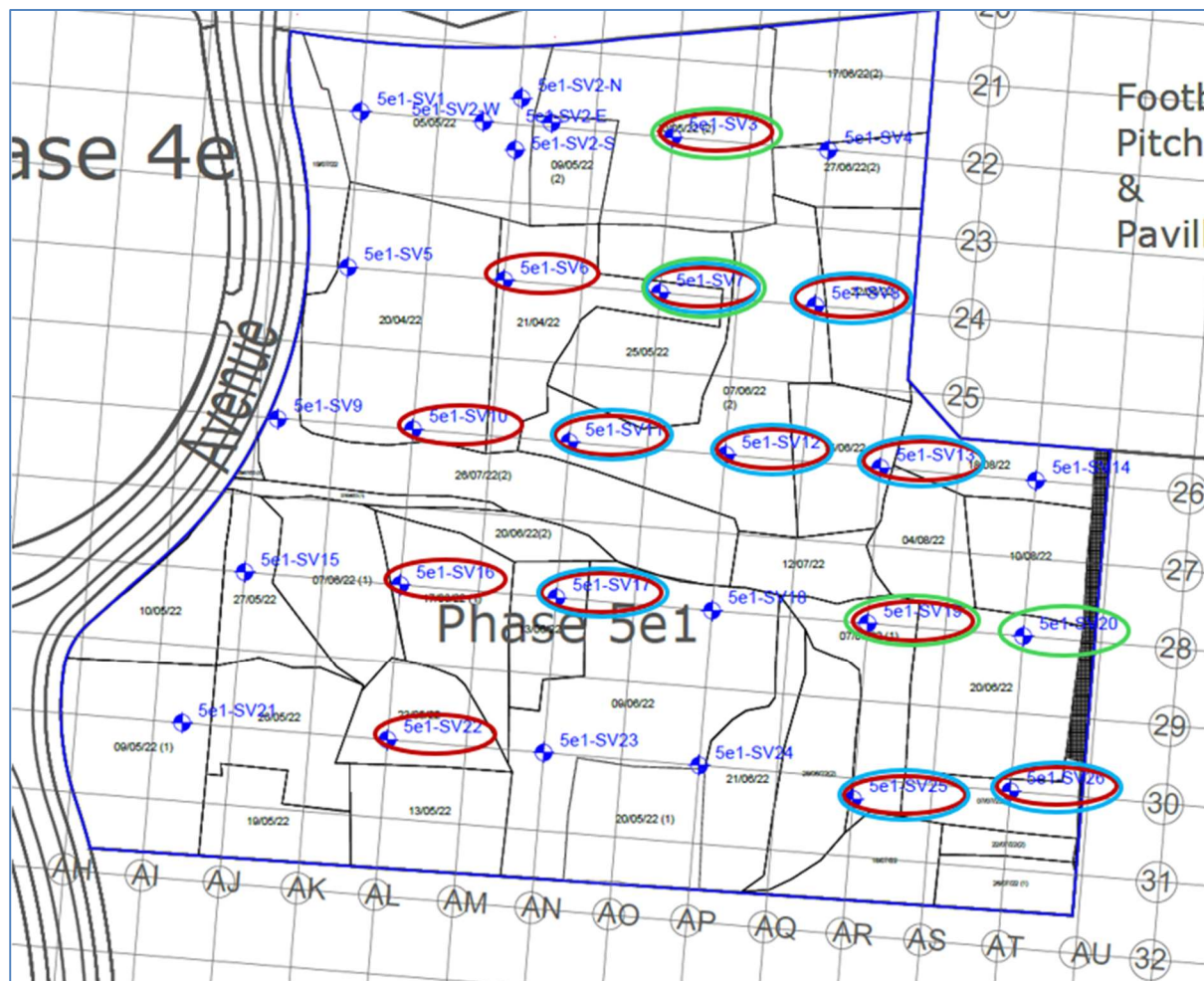


Figure 4.21 SRV exceedances in surface validation samples

Benzo(b)fluoranthene exceedances indicated in red, fluoranthene in blue and cyanide in green

Cyanide

Table 4.3 shows the locations where the SRV was exceeded for cyanide. A conservative estimate of the average value for the relevant fill areas, incorporating the surface sample as well as the fill samples, is calculated by weighting the UCLmean of the stockpile samples by the thickness of fill, and the surface sample value by a thickness of 0.1 m.² The values in the table that exceed the SRV are shown in bold.

² Surface verification samples are taken by hand with a trowel from the top 100 mm of the backfill. This is a different sample set to the stockpile samples. Additionally, due to the grain size bias resulting from the sample method, it is

Table 4.3 Combining surface sample and fill concentrations for cyanide

Determinand	Cyanide (mg/kg)			
SRV	2.02			
Validation sample point	5E1-SV3	5E1-SV7	5E1-SV19	5E1-SV20
Backfill zone	20/05/22(2)	21/04/22	07/07/22(1)	20/06/22
Validation sample value	2.10	2.10	2.10	5.10
Backfill mean value	0.98	1.48	0.91	5.85
Backfill UCLmean	1.18	2.22	1.14	15.5
Backfill and validation mean*	1.02	1.49	0.96	5.82
Weighted UCLmean*	1.30	2.12	1.19	14.5

* Backfill and surface sample combined, with weighting

Examination of Table 4.3 tells us that in two of the backfill zones examined (shaded blue) the backfill UCLmean exceeded the SRV; but in both cases the weighted UCLmean taking account of the surface validation sample was reduced. This is because the surface validation samples had lower concentrations than the calculated backfill UCLmean. Consideration of the surface validation samples therefore slightly reduces the perceived risk from cyanide in these backfill zones.

Fluoranthene

Table 4.4 shows the locations where the SRV was exceeded for fluoranthene. The weighted UCLmean, including the surface validation samples, has been calculated as discussed above. The values in the table that exceed the SRV are shown in bold. Note that some backfill zones have more than one surface validation sample (Figure 4.21). In such a case (e.g. zone 07/06/22(2) for fluoranthene) it is appropriate to consider all relevant surface validation samples together with the backfill zone concentrations.

Table 4.4 Combining surface sample and fill concentrations for fluoranthene

Determinand	Fluoranthene (mg/kg)							
SRV	6.64							
Validation sample point	5E1-SV7	5E1-SV8	5E1-SV11	5E1-SV12	5E1-SV13	5E1-SV17	5E1-SV25	5E1-SV26
Backfill zone	21/04/22	07/06/22(2)			15/06/22	13/06/22	07/07/22(1)	20/06/22
Validation sample value	6.7	8.7	11.0	13.0	10.0	10.0	8.1	8.5
Backfill mean value	11.9	2.56			2.93	3.31	1.65	5.91
Backfill UCLmean	20.1	4.07			5.02	6.60	3.26	12.3

likely that the average of the surface samples is not representative of the whole top 300 mm layer, but rather selected fine-grained material from the top 100 mm.

Backfill and validation mean*	11.6	3.16	3.09	3.49	1.92	5.99
Weighted UCLmean*	18.4	5.30	5.26	6.69	3.54	11.7

* Backfill and surface sample combined, with weighting

Examination of Table 4.4 tells us that the weighted UCLmean is lower than the backfill UCLmean for two of the three of the backfill zones in question (shaded blue). Consideration of the surface validation samples therefore slightly reduces the perceived risk from fluoranthene in these backfill zones. For three others (shaded brown) the weighted UCLmean concentration is higher, but still below the SRV.

For area 13/06/22, the weighted UCLmean is higher than the backfill UCLmean, and is also slightly above the SRV. This backfill zone therefore needs to be given further consideration.

Benzo(b)fluoranthene

Table 4.5 shows the locations where the SRV was exceeded for benzo(b)fluoranthene. The weighted UCLmean, including the surface validation samples, has been calculated as discussed above. The values in the table that exceed the SRV are shown in bold.

Table 4.5 Combining surface sample and fill concentrations

Determinand	Benzo(b)fluoranthene (mg/kg)													
SRV	3.42													
Validation sample point	5E1-SV3	5E1-SV6	5E1-SV7	5E1-SV8	5E1-SV11	5E1-SV12	5E1-SV10	5E1-SV13	5E1-SV16	5E1-SV17	5E1-SV19	5E1-SV25	5E1-SV22	5E1-SV26
Backfill zone	20/05/22(2)	21/04/22	07/06/22(2)				20/04/22	15/06/22	17/06/22(1)	13/06/22	07/07/22(1)	23/05/22	07/07/22(2)	
Validation sample value	5.2	4.0	7.6	4.9	5.7	8.4	4.0	8.0	4.4	7.3	5.0	5.6	4.3	5.0
Backfill mean value	0.88	5.25	1.43				6.42	1.55	2.18	2.55	1.15	1.06	3.61	
Backfill UCLmean	1.18	8.30	2.14				10.47	2.63	3.54	4.67	2.31	1.62	6.94	
Backfill and validation mean*	1.01	5.28	1.78				6.35	1.70	2.25	2.68	1.37	1.18	3.65	

Weighted UCLmean*	1.89	7.84	3.00	10.04	2.99	3.54	4.76	2.53	2.03	6.65
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* Backfill and surface sample combined, with weighting

Examination of Table 4.5 tells us that the weighted UCLmean is lower than the backfill UCLmean for three of the backfill zones in question (shaded blue). Consideration of the surface validation samples therefore slightly reduces the perceived risk from fluoranthene in these backfill zones. For five others (shaded brown) the weighted UCLmean concentration is higher, but still below the SRV.

For the remaining two zones, the weighted UCLmean is higher than the backfill UCLmean, and is also above the SRV. These backfill zones therefore need to be given further consideration.

4.3.4 Summary of sample results

For cyanide, it can be seen from Figure 4.11 and Figure 4.16 that the average and UCLmean concentrations exceed the SRV in ten and 20 backfill zones respectively. The surface validation samples provided four exceedances of the SRV for cyanide; however, these did not raise the UCLmean concentration above the SRV for any additional backfill zones. We conclude therefore that further assessment is needed in relation to the 20 backfill zones with UCLmean exceedance of the SRV.

For fluoranthene, it can be seen from Figure 4.12 and Figure 4.17 that the average and UCLmean concentrations exceed the SRV in two and seven backfill zones respectively. Surface validation samples from six backfill zones showed exceedances of the SRV, but, as shown in Table 4.4, incorporating these results did not increase the perceived risk in relation to fluoranthene. Nevertheless, further assessment is needed for seven backfill zones.

For benzo(b)fluoranthene the average concentrations exceed the SRV in seven backfill zones (see Figure 4.13). If the UCL estimate of the mean is used, the concentration of 15 backfill zones exceeds the SRV (Figure 4.18). Surface verification samples from ten backfill zones also exceeded the SRV. When weighted UCLmean values were calculated for the relevant zones (including the surface samples), the values for two zones increased. These zones already had UCLmean values above the SRV. Benzo(b)fluoranthene is therefore taken forward for further assessment of 15 backfill zones.

For benzo(k)fluoranthene it can be seen from Figure 4.14 that the average concentrations did not exceed the SRV for any backfill zone. This remains the case even when the UCL estimate of the mean is used (Figure 4.19). No surface verification samples exceeded the SRV for fluoranthene. No further assessment is therefore needed for this contaminant.

For manganese, again, the average concentration did not exceed the SRV in any backfill zone (see Figure 4.15). If the UCL estimate of the mean is used, the concentration of two backfill zones exceeds the SRV (Figure 4.20). No surface verification samples exceeded the manganese SRV. Manganese is therefore taken forward for further assessment of two backfill zones.

4.4 Stage 3 – Screening against Reference Values

The results of the RTM assessment are presented in Table 4.6. It can be seen that over a 1,000-year period, none of the modelled contaminants is predicted to reach a distance of 12.5 m. We examined the effect of modelling for even longer periods, and neither of the organic contaminants is shown to break through even after 10,000 years. Cyanide and manganese are predicted to break through within that time, but at very low concentrations (several orders of magnitude below the SRV).

Relevant RTM spreadsheet calculations were provided electronically in Appendix C to HFCL (2024a). Print-outs of the relevant spreadsheet tabs for 10,000-year runs are in Appendix B to the current report.

Table 4.6 Model results (mg/l)

Contaminant	Remedial Target (Residential) mg/kg		
	12.5 m	37.5 m	62.5 m
Cyanide	>1E+06	>1E+06	>1E+06
Fluoranthene	No impact	No impact	No impact
Benzo(b)fluoranthene	No impact	No impact	No impact
Manganese	No impact	No impact	No impact

We therefore conclude that concentrations of these four CoC in the fill for Phase 5E1 do not pose a significant risk to controlled waters at Glan Llyn.

4.5 Hydraulic conductivity data

RLL (2025) reports hydraulic conductivity data for Phase 5E1 and includes detailed appendices showing the derivation of the hydraulic conductivity results. They are summarised here for ease of reference.

Table 4.7 Hydraulic conductivity testing at Phase 5E1

Method	N tests	Hydraulic conductivity (m/s)		
		Min	Max	Mean
Infiltration test	9	4.77E-07	9.93E-07	8.65E-07
Falling head test	3	7.22E-08	9.80E-07	4.78E-07
Rising head test	5	1.45E-07	9.48E-07	6.82E-07
Aggregate	17	7.22E-08	9.93E-07	7.43E-07

As the table demonstrates, all measured hydraulic conductivity values were smaller than the assumed value of 10^{-6} m/s and the mean value of all tests was 7.4×10^{-7} m/s. The assumption used in the derivation of the SRVs is therefore valid.

5 CONCLUSIONS

Remediation has been undertaken on Phase 5E1 of the Glan Llyn development site, comprising excavation of Made Ground materials, stockpiling, and placement of suitable materials as a compacted engineered fill. The plot is subdivided into backfill zones, which were sequentially backfilled in layers.

The data set was screened against Soil Re-use Values (SRVs) by comparing the 95thile value for each contaminant against the SRV. For Phase 5E1, the 95thile concentration of cyanide, fluoranthene, benzo(b)fluoranthene and benzo(k)fluoranthene and manganese was above the SRV for assessed contaminants. Further statistical presentation of data and comparison to Reference Values was therefore required for these three contaminants of concern (CoC).

Box plots and histograms show that the data sets for the CoC were affected by a number of high concentrations. Spatial plots indicated that average concentrations across the majority of the site area were below SRVs, although a significant number of backfill zones had UCLmean values above the SRV.

Verification samples comprise stockpile sampling, with materials tracking such that average concentrations of potential contaminants can be calculated for each backfill zone. Surface samples were also taken after the backfill was placed, which enhance the verification sample data set. Review of the verification samples for the five CoC for Phase 5E1 indicated that they did not alter the conclusions of the statistical assessment.

Screening against Reference Values from the modelling of transport processes through the engineered fill has been undertaken to understand the significance of the higher concentrations of the three CoC.

Reference Value screening shows that over a 1,000-year period, fluoranthene and benzo(b)fluoranthene would not travel 12.5 m from the source area, owing to attenuation processes along the groundwater transport pathway. Cyanide and manganese would reach this distance, but at concentrations so low as to be non-detectable.

It can be concluded that the concentrations of potential contaminants within the fill materials meet the remediation requirements for Phase 5E1. We conclude that the data presented are sufficient to allow the sign-off of PC28 Part 1 for Phase 5E1.

REFERENCES

Atkins, 2017, Glan Llyn, Llanwern: Llanwern Controlled Waters Detailed Quantitative Risk Assessment, report no. 5111373-LLA-OUT-0257.

Environment Agency, 2006, Remedial Targets Methodology: hydrogeological risk assessment for land contamination.

HFCL, 2024a, Glan Llyn: Soils validation strategy for protection of controlled waters, report no. 30937 R2.

HFCL, 2024b, Glan Llyn, Llanwern: Soil quality verification – Correction to calculated re-use criteria for soils at Glan Llyn (residential), technical note no. 30937 TN1.

Rodgers Leask, 2019-2022: Glan Llyn Llanwern Sitewide: Controlled Waters DQRA 2019 Update, report no. 18669-RLE-19-RP-O-0006.

Rodgers Leask, 2025: Phase 5E1 Chemical Validation Report - 18669-RLL-22-XX-RP-O-0348-P03.

APPENDIX A

Summary data for Contaminants of Concern (spreadsheet file)

APPENDIX B

Selected Remedial Targets Methodology spreadsheets