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Contaminated Land
and Hydrogeology

Glan Llyn, Llanwern: Soil Quality Validation Report, Units 11-16

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Date: 21/07/2025

Status: Final

Reference: 30984 R2

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Version History

Version	Author	Checked by	Issue date	Comment
30984 R2D1	Joe Gomme	Hannah Fraser	17/07/2025	Draft report issued to client
30984 R2	Joe Gomme	Hannah Fraser	21/07/2025	Final report

NON-TECHNICAL SUMMARY

Rogers Leask Environmental (RL) has appointed H Fraser Consulting Ltd (HFCL) to assist with validating remediation works undertaken at Units 11-16 on the Commercial site at the former Llanwern Steelworks site at Glan Llyn

Remediation has been undertaken on Units 11-16 of the Glan Llyn development site, comprising excavation of Made Ground materials, stockpiling, removal of unsuitable materials, and placement of suitable materials as a compacted engineered fill. The plot is subdivided into 127 backfill zones, which were sequentially backfilled. The backfill zones are defined areas of varying sizes that were backfilled with specific source materials.

Verification samples were taken from stockpiles, and material movements were then tracked so that the soil quality of each backfill zone is known. Surface samples were also taken after the backfill was placed, to enhance the verification sample data set. In total 1,077 samples are available from fill materials, and an additional 48 samples were taken from the near-surface, post-placement.

The dataset was screened against Soil Re-use Values (SRVs) by comparing the 95%ile value for each contaminant against the SRV. For all potential contaminants with the exception of two PAHs (fluoranthene and benzo(b)fluoranthene), the 95%ile concentration was below the SRV. Further assessment was therefore undertaken for fluoranthene and benzo(b)fluoranthene.

- For fluoranthene, 128 of 1,074 analyses exceeded the SRV of 30.1 mg/kg. The maximum, 95%ile and average concentrations were 1,260 mg/kg, 58.1 mg/kg and 14.9 mg/kg.
- For benzo(b)fluoranthene, 135 of 1,077 analyses exceeded the SRV of 15.5 mg/kg. The maximum, 95%ile and average concentrations were 378 mg/kg, 35.72 mg/kg and 7.48 mg/kg.

Box plots and histograms show that the data sets for these two contaminants were affected by a small number of high concentrations. Spatial plots indicated that average concentrations across most of the site area were below SRVs. Exceptions were three backfill zones in the southeast corner of the site for both the assessed PAHs, and a further three in the centre of the site for fluoranthene only. Uncertainty in the data has been assessed by calculating an upper confidence limit in the average value for each backfill zone. For both fluoranthene and benzo(b)fluoranthene, this indicated that the mean concentration across significant parts of the site, taking into account uncertainty in the data set, may exceed the SRV. The nearest such backfill zone to a surface water receptor is at a minimum distance of 40 m.

Modelling of transport processes through the engineered fill was previously undertaken to develop reference tables for maximum allowable soil concentrations at specific distances from surface water receptors. The reference tables show that neither of the assessed substances can be expected to travel even as far as 12.5 m over a 1,000-year period, owing to attenuation processes along the groundwater transport pathway.

Hydraulic conductivity of the fill averaged less than the value assumed by the conceptual model for remediation (10^{-6} m/s).

It can be concluded that the concentrations of potential contaminants within the fill materials meet the remediation requirements for Units 11-16, with respect to protection of controlled waters.

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1. INTRODUCTION

Rogers Leask (RL) has appointed H Fraser Consulting Ltd (HFCL) to assist with validating remediation works undertaken at Units 11-16 on the Commercial site at 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 apply to the site remediation work.

- PC27 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.
- PC28 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.

1.1 Objective

The objective of this report is to demonstrate that the remediation criteria relating to controlled waters have been met.

1.2 Scope of works

The following works have been undertaken:

- Provision of advice to Rogers Leask (RL) regarding processing and presentation of verification data;
- Review of data and analysis presented by RL;
- Validation reporting, based on the process agreed with NRW, Indurent and RL in 2024.

2 BACKGROUND

2.1 Site location

The approximate site boundary and location of Units 11-16 (orange numbers in squares) are shown in Figure 2.1. A surface water drain (Drain 5) snakes through the Commercial site area, and runs along the western side of Units 11-16.

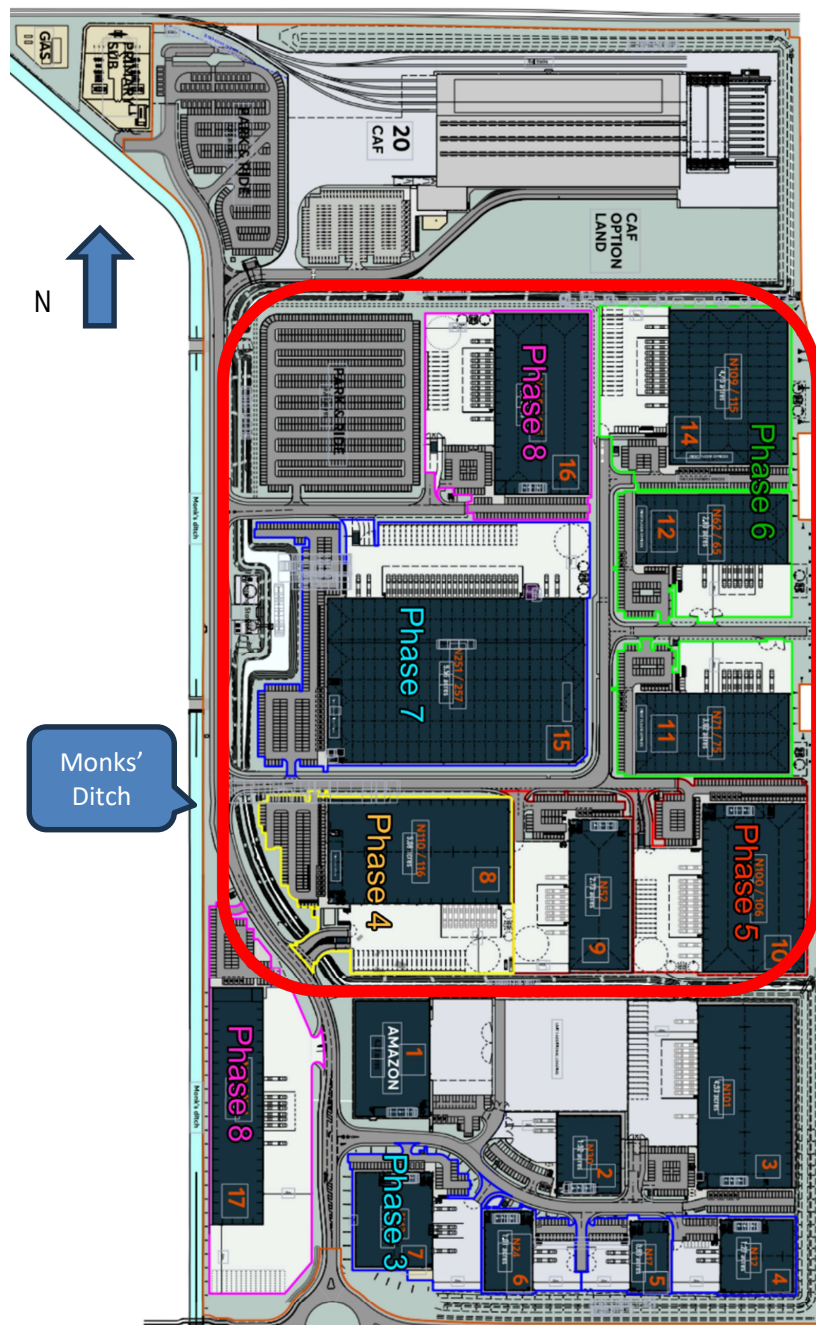


Figure 2.1 Site Location

2.2 Derivation of remediation criteria

Soil re-use values (SRVs) were derived by Atkins and amended by RL, assuming the following conceptual model.

- 90% 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 drain.
- 10% 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 drain.
- 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 the drain, and does not enter the engineered fill.
- 40% of infiltration drains into the engineered fill and migrates through the fill to the drain, dissolving potential contaminants from the fill materials.
- The infiltration that travels through the fill is diluted on reaching the drain 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 2017¹, modified by Rogers Leask² in their Controlled Waters DQRA report and approved by the Local Authority under discharge of PC27³.

Soil re-use values (SRVs) are set out in Appendix J to RL's Remediation Strategy and are included in Appendix A (column M).

2.3 Groundwater or perched water data

Groundwater monitoring boreholes are being installed for long-term water quality checks. In assessing whether these data should form part of the validation process HFCL's Method Report for validation of the remediation⁴ considered the following points.

- The agreed remediation strategy relies only on the analysis of soil concentrations and does not include analysis of waters. If reliable soils data are available, therefore, they should be sufficient to make a judgement on the validity of the remediation achieved.
- The density of soil samples is sufficient to provide confidence that the analyses are representative of the mass of fill that has been placed.
- The analyses have been carried out by reputable laboratories using accredited analytical techniques.

On this basis we consider that additional assessment of groundwater or perched water is not needed and robust conclusions can be drawn on the basis of the soils assessment.

¹ Atkins, 2017, Glan Llyn, Llanwern: Llanwern Controlled Waters Detailed Quantitative Risk Assessment

² Rodgers Leask, 2019-2022: Glan Llyn Llanwern Sitewide: Controlled Waters DQRA 2019 Update

³ PC27 discharge notice

⁴ HFCL, 2024, Glan Llyn: Soils validation strategy for protection of controlled waters, report no. 30937 R2

3 REMEDIATION ACTIVITIES AND VERIFICATION DATA

The remediation and verification work on Units 11-16 has included the following:

- Excavation of Made Ground materials to a minimum elevation of 5.1 m aOD, 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, to a minimum of 2 m thickness;
- Sampling of surface materials, post-placement, to provide additional verification data.

In total 1,077 samples are available from fill materials, and an additional 48 samples were taken from the near-surface, post-placement. Figure 3.1 shows the backfill zones for Units 11-16; each zone was backfilled in 300 mm layers, managed using the zone boundaries shown. A materials management database was maintained so that there is a record of which stockpile was used for each layer in each backfill zone.

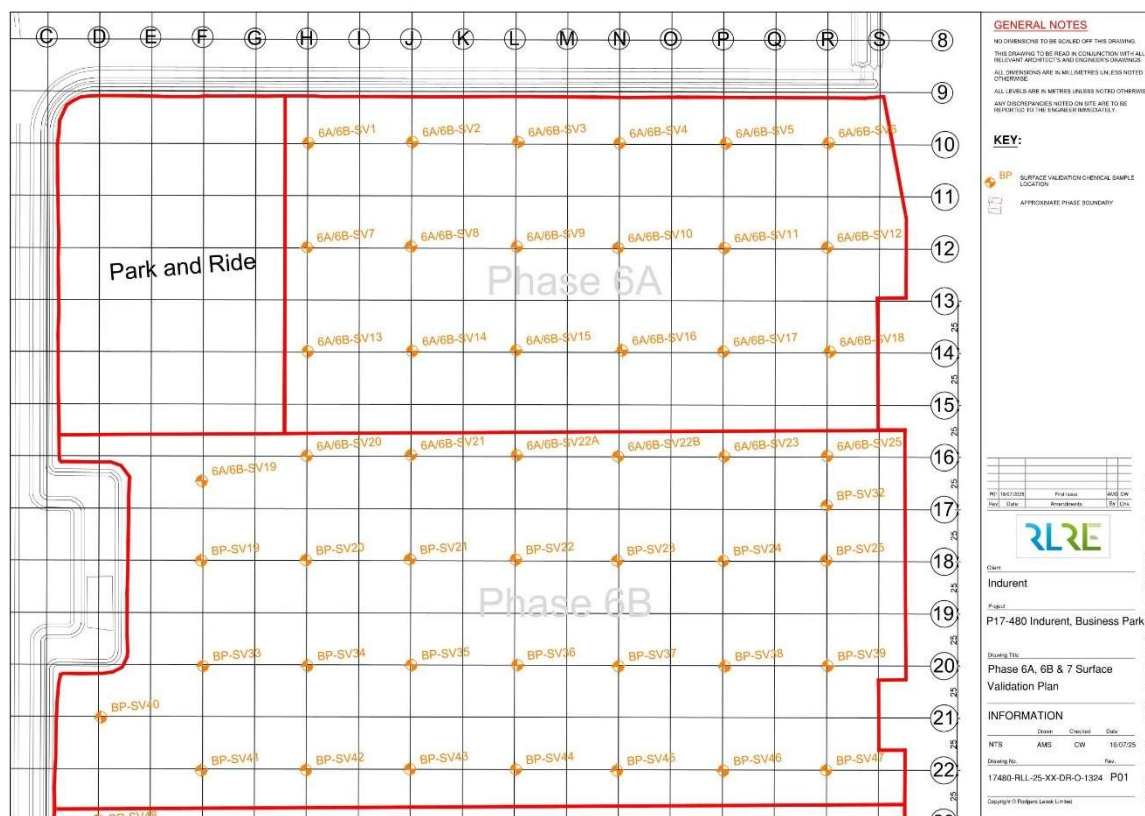


Figure 3.1 Backfill zones

Appendix A presents a full summary of the CoC data.

4 ASSESSMENT OF CONTAMINANTS OF CONCERN

4.1 Assessment stages

HFCL's Method Report sets out the verification process that has been agreed.⁵ 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 95%ile of the analytical results from the fill materials exceeded the SRV. Those that have a 95%ile exceeding the SRV 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 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).

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.

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 have been screened against the SRVs; a shortlist of substances where the maximum value exceeded the SRV was drawn up, as shown in Table 4.1. Exceedances of the SRV are shown in bold. Appendix A provides the data, summary statistics and screening process.

⁵ HFCL, 2024, Glan Llyn: Soils validation strategy for protection of controlled waters, report no. 30937 R2.

Table 4.1 Substances where maximum value exceeds SRV (mg/kg)

Determinands where max exceeds SRV	Units	SRV	No. Analyses	No. Exceed SRV	Mean	Max	95%ile
Cyanide (Total)	mg/kg	9.14	1,072	44	3.66	449	7.01
Ammoniacal Nitrogen		699	957	6	47.59	919	267
Iron (Total)		1,380,000	1,064	2	95,786	*2,390,000	238,000
Manganese		151,000	1,071	1	11,215	408,000	31,790
Aromatic VPH >C5-C7		38.5	1,072	3	0.25	50.0	1.00
Naphthalene	ug/kg	124	1,077	8	8.96	1550	20.0
Acenaphthylene		75.7	1,077	1	1.71	204	5.93
Fluorene		123	1,075	2	2.02	166	7.50
Phenanthrene		123	1,074	15	9.79	831	34.8
Anthracene		155	1,077	2	3.10	204	11.0
Fluoranthene		30.1	1,077	128	14.85	1,260	58.1
Pyrene		346	1,074	1	10.70	953	41.1
Benzo[b]fluoranthene		15.5	1,077	135	7.48	378	35.7
Benzo[k]fluoranthene		22.9	1,077	19	2.69	159	12.5
Benzo[a]pyrene		150	1,077	1	5.19	303	24.0
Indeno(1,2,3-c,d)Pyrene		115	1,077	1	3.94	194	19.2
Benzo[g,h,i]perylene		60.2	1,074	9	3.61	223	16.6

*Note that this maximum value, being greater than 1 kg/kg, is implausible; it was retained in the data set for conservativity.

Contaminants of Concern (CoCs) were defined as determinands for which the 95%ile of the analytical results from the fill materials exceeded the SRV. The only determinands for which this is true are fluoranthene and benzo(b)fluoranthene. The CoCs taken forward for further assessment on Units 11-16, are:

- Fluoranthene
- Benzo(b)fluoranthene

Soil re-use values (SRVs) are set out here in Table 4.2.

Table 4.2 Soil re-use values (commercial)

Determinand	Units	SRV
Fluoranthene	mg/kg	30.1
Benzo(b)fluoranthene	mg/kg	15.5

4.3 Stage 2 – Statistical assessment

As noted above, the identified contaminants of concern are fluoranthene, benzo(b)fluoranthene and ammoniacal nitrogen. These CoCs were taken forward for further assessment.

The stockpile verification samples have been analysed as follows:

- Statistical assessment of the data, including conservative assessment of the mean values;

- Presentation of the entire data set for each CoC as a box plot;
- Presentation of the entire data set for each CoC as a histogram; and
- Spatial assessment of the data.

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 Figure 4.4.

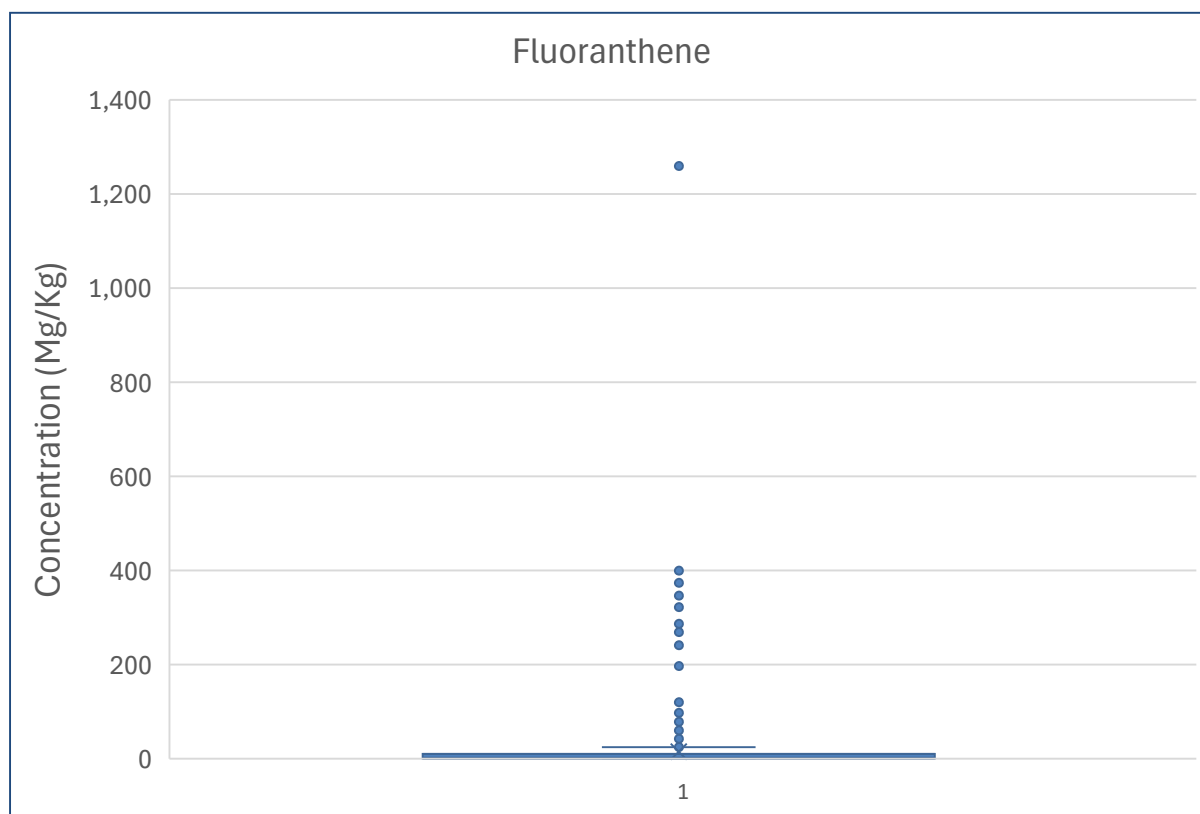


Figure 4.1 Box plot for fluoranthene (mg/kg)

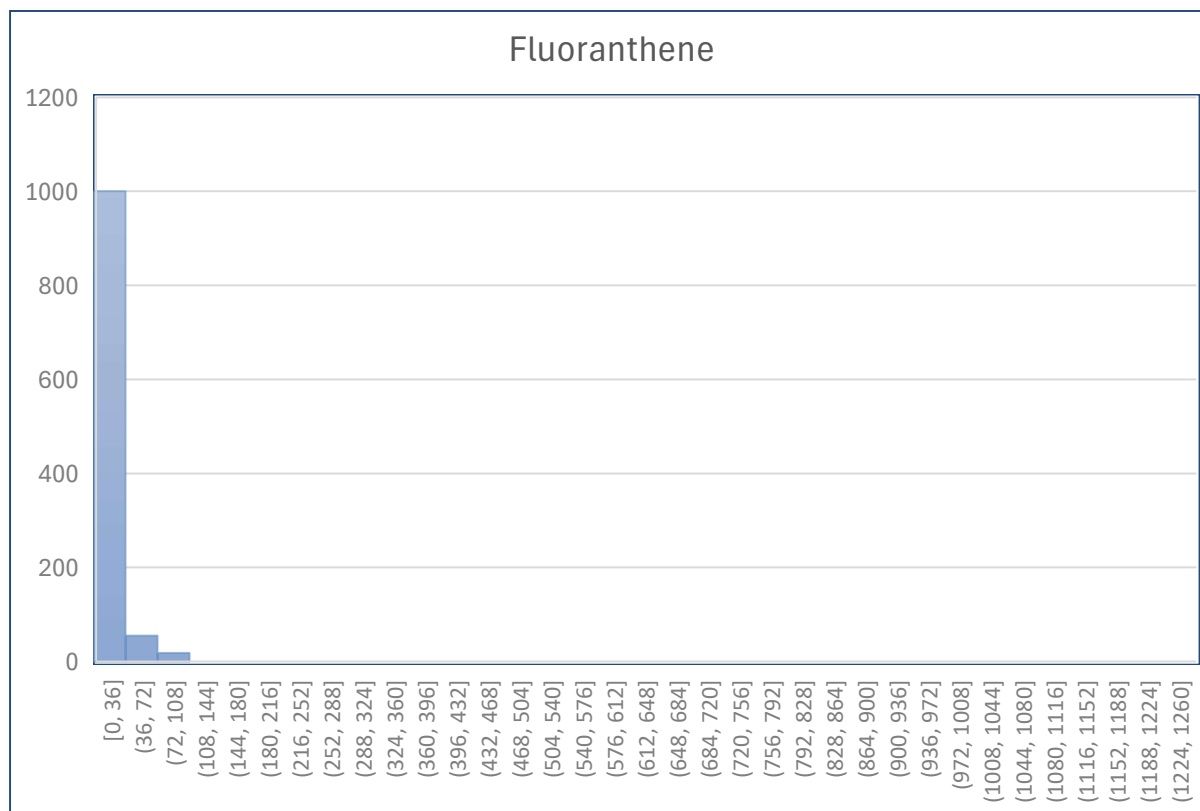


Figure 4.2 Histogram for fluoranthene (mg/kg)

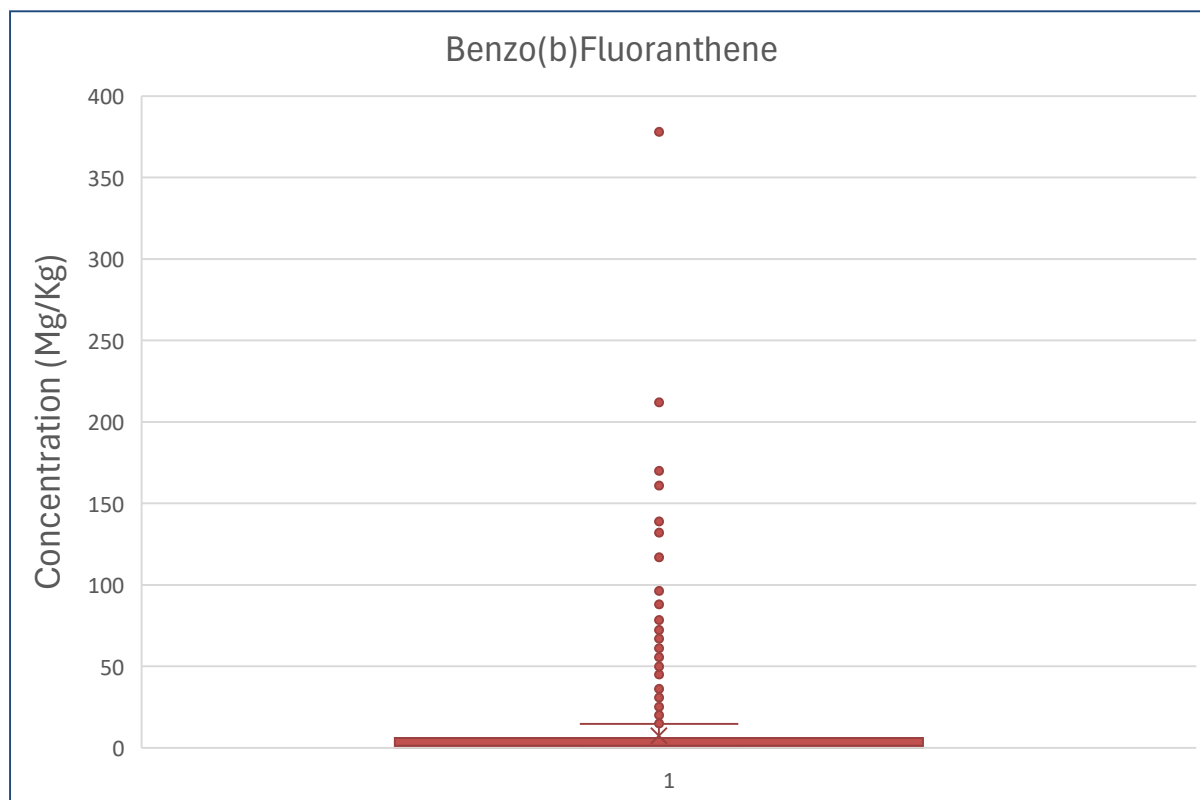


Figure 4.3 Box plot for benzo(b)fluoranthene (mg/kg)

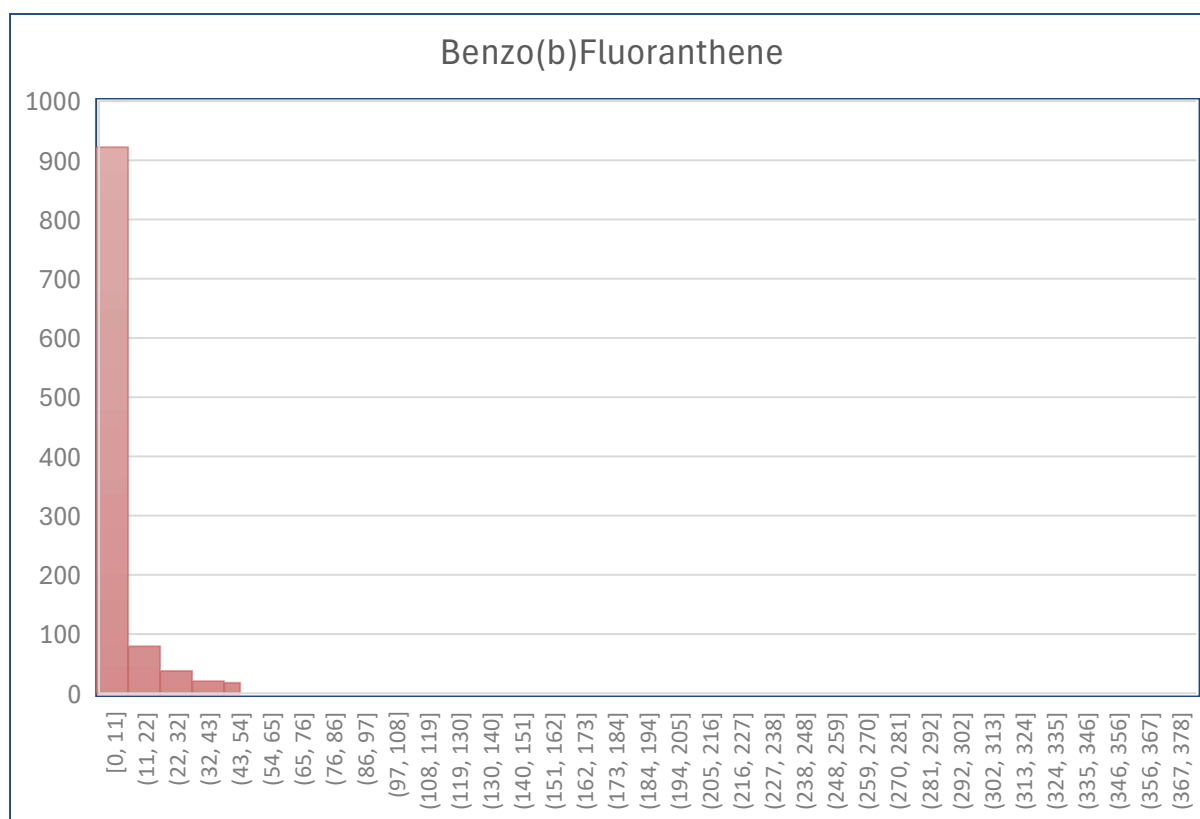


Figure 4.4 Histogram for benzo(b)fluoranthene (mg/kg)

The following points can be seen from the plots.

- For fluoranthene the data range from <0.02 mg/kg to 1,260 mg/kg. The average value is 14.8 mg/kg and 75% of the data points are below 9.56 mg/kg. There are 128 data points that exceed the screening criterion of 30.1 mg/kg.
- For benzo(b)fluoranthene the data range from <0.02 mg/kg to 378 mg/kg. The average value is 7.48 mg/kg and 75% of the data points are below 5.42 mg/kg. There are 135 data points that exceed the screening criterion of 15.5 mg/kg.

The histograms show that the data have a long-tailed distribution. Higher values are relatively uncommon and the averages exceed the 75th percentiles because of the weight carried by the high values.

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 backfilled with between six and nine (typically seven) layers, depending on the total thickness needed, and an average concentration derived for each zone. The plots, drawn up by Rodgers Leask, are presented in Figure 4.5 and Figure 4.6. The last colour category represents values exceeding the SRV. The plots show that average concentrations exceed the SRV for both assessed PAH in three backfill zones in the southeast corner of the site, and for three additional backfill zones in the west-centre of the site for fluoranthene.

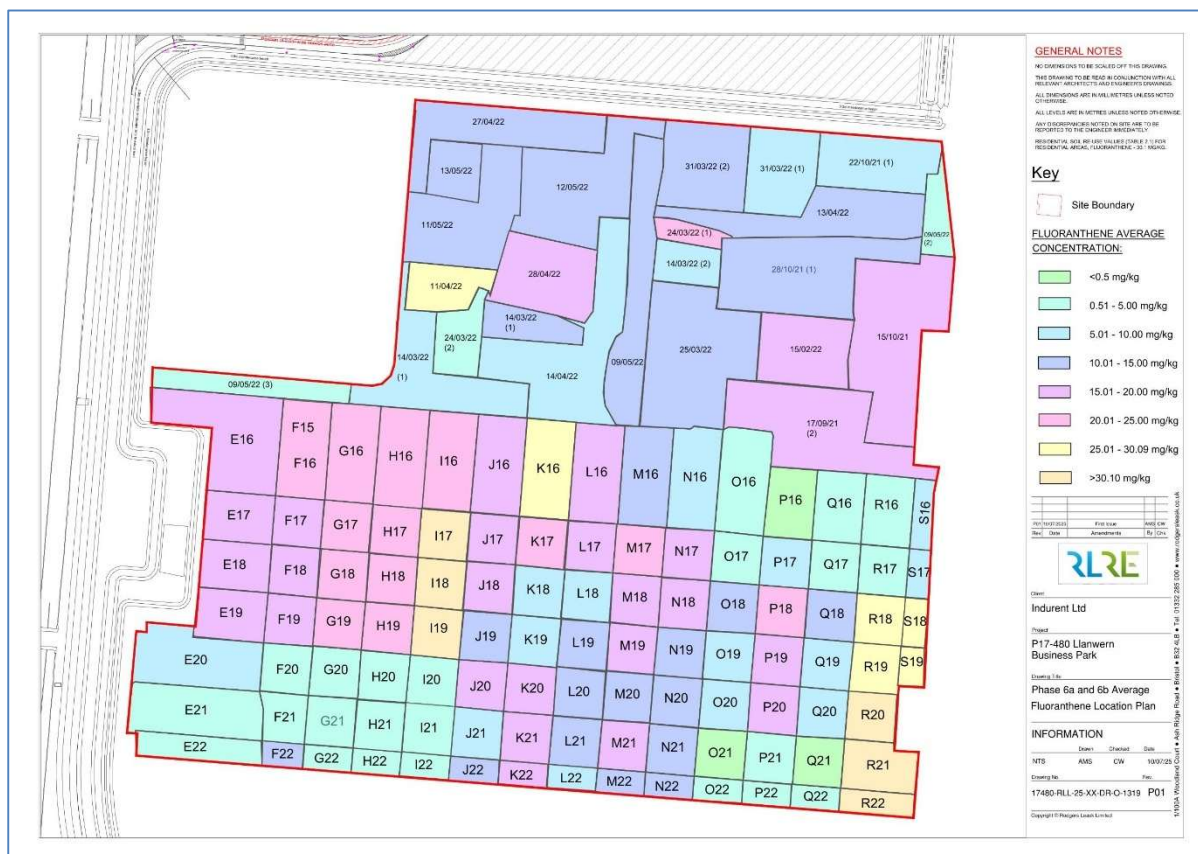


Figure 4.5 Fluoranthene distribution (mean values)

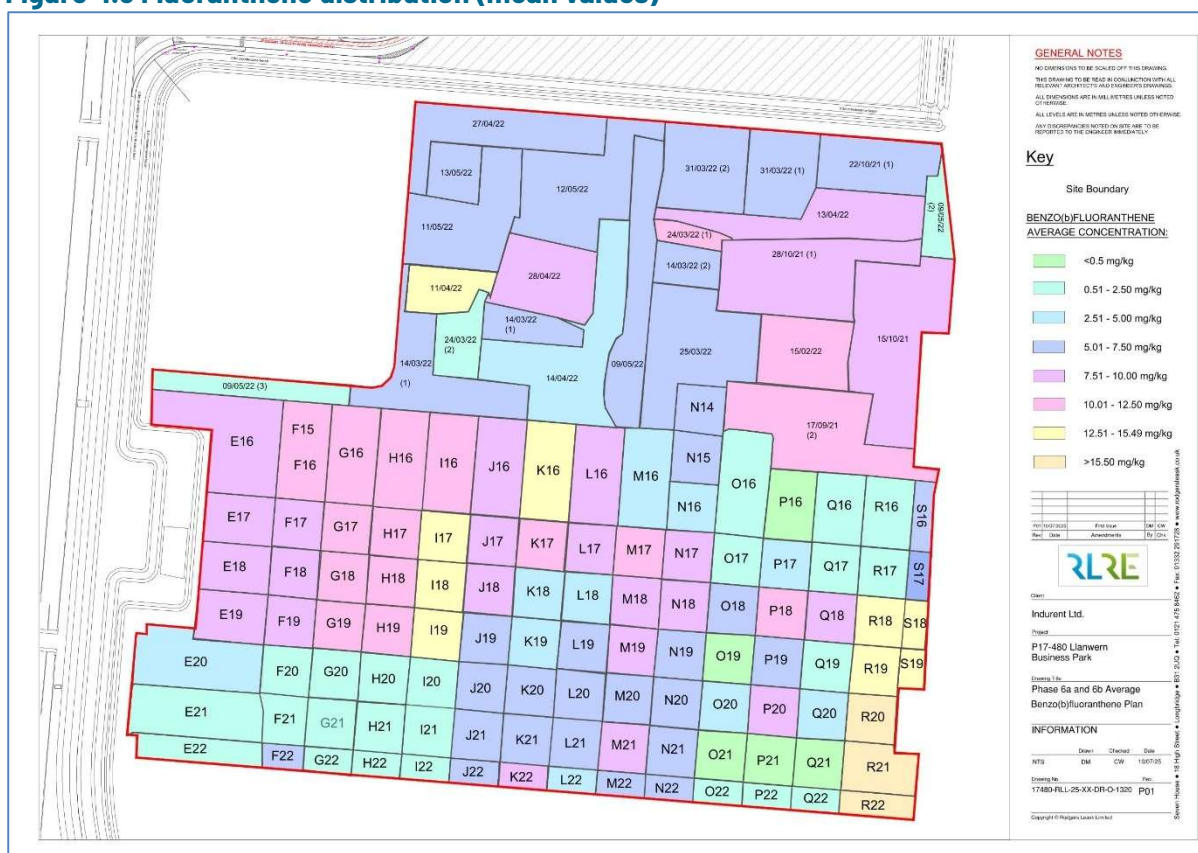


Figure 4.6 Benzo(b)fluoranthene distribution (mean values)

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 4.3.1), resulting in a slightly higher estimate of the average concentration for each backfill zone. This report refers to the 95th percentile upper confidence limit in the mean value as "UCLMean". UCLMean values have been plotted spatially and are presented in Figure 4.7 and Figure 4.8.

Both plots show that there are large parts of the southern section of the site where the UCLMean values exceed the SRV.

This area accepted material exported from the residential site at Glan Llyn, where acceptable soil concentrations are lower because conditions there mean that receptors are at greater risk than on the commercial site. The exceedances shown in these figures mean that further review of the two PAH on Units 11-16 is warranted.

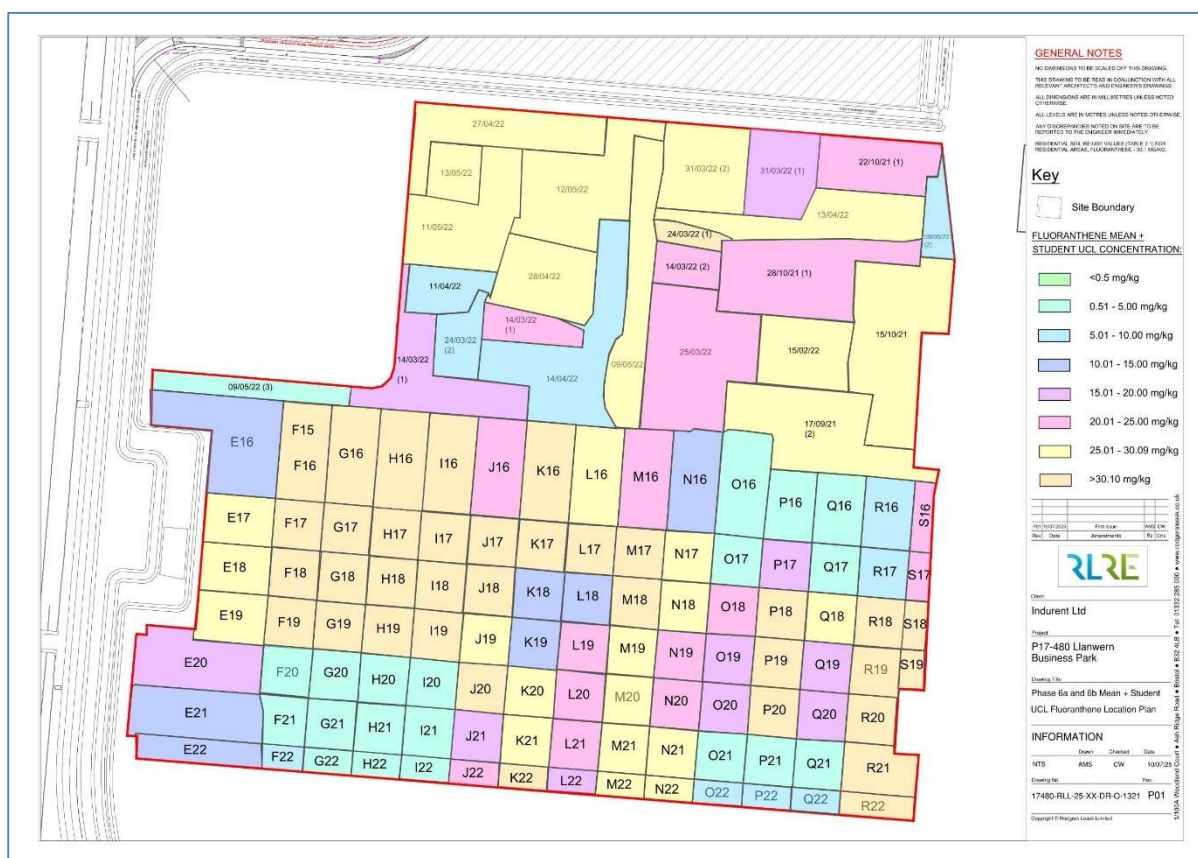


Figure 4.7 Fluoranthene distribution (UCLMean values)

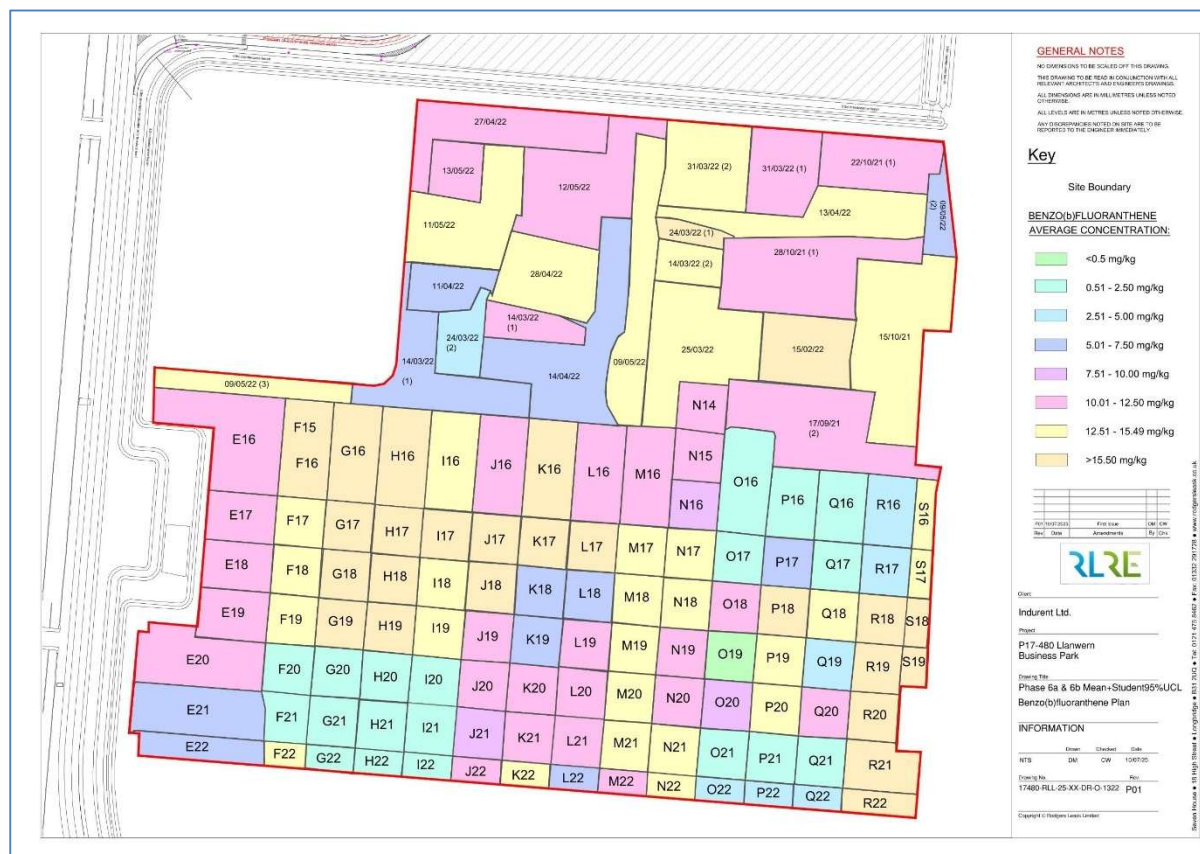


Figure 4.8 Benzo(b)fluoranthene distribution (UCL Mean values)

4.3.3 Surface verification samples

For fluoranthene and benzo(b)fluoranthene, a summary comparison of the 48 surface validation sampling results (SVS in the table) and the main data set (MDS) is presented in Table 4.3. The emboldened text indicates the higher values in pair of columns. Whilst the SVS shows a higher percentage of benzo(b)fluoranthene samples exceeding the SRV and higher average concentrations, the maximum and 95th percentile values are higher for both determinands in the main data set. This shows that the SVS in general have similar values to the main data set.

The locations of the verification samples are shown in Figure 4.9.

Table 4.3 Comparison of surface verification samples and main data set (mg/kg)

Determinand	% exceeding SRV		Max		Average		95 th ile	
	SVS	MDS	SVS	MDS	SVS	MDS	SVS	MDS
Fluoranthene	8%	12%	110	1260	19.5	14.9	34.9	58.1
Benzo(b)fluoranthene	21%	13%	44	378	12.1	7.48	25.8	35.7

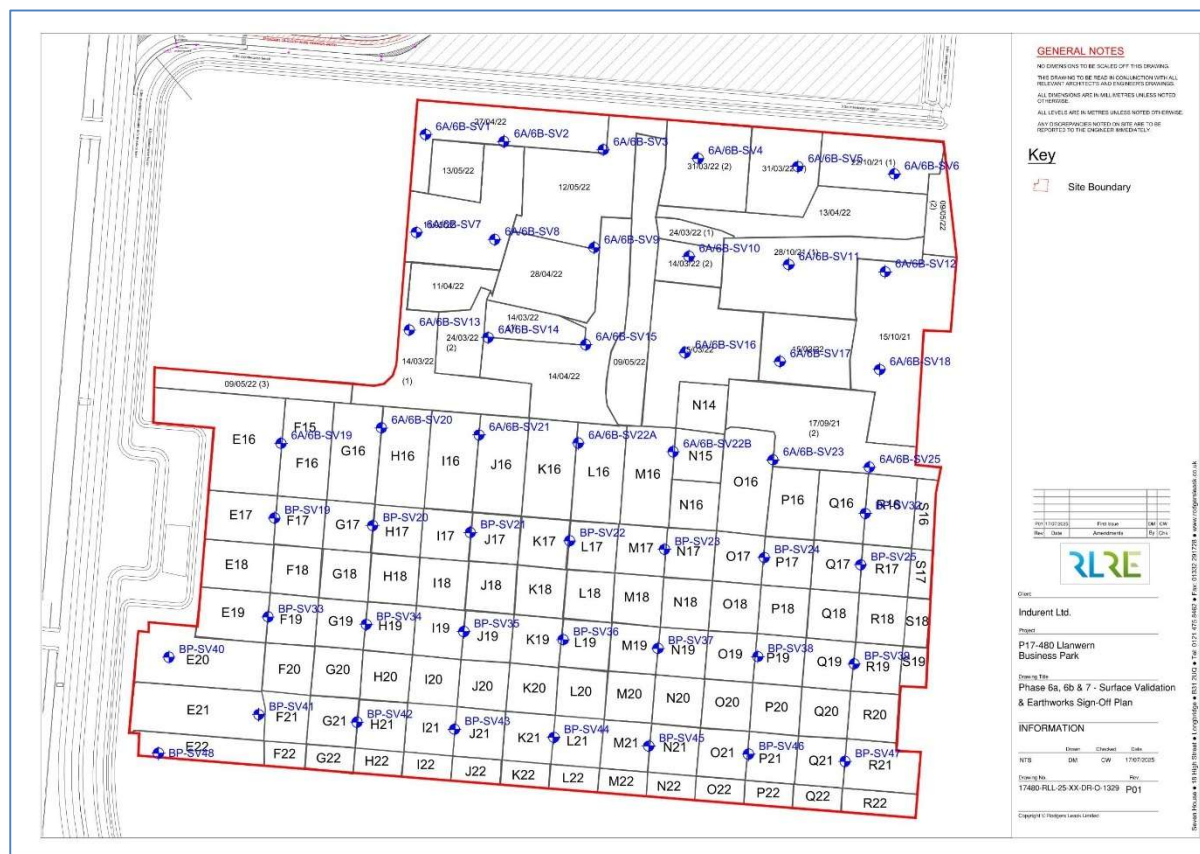


Figure 4.9 Surface verification sample locations

Table 4.4 and Table 4.5 show the locations within Units 11-16 where the SRV was exceeded for fluoranthene and benzo(b)fluoranthene respectively. 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 mean of the stockpile samples by their combined thickness (generally 2.1 to 2.4 m), and the surface sample value by a thickness of 0.1 m.⁶ The values that exceed the SRV are shown in bold, as are backfill zones labels for zones now showing a weighted UCLMean that exceeds the SRV.

Table 4.4 Combining surface sample and fill concentrations, fluoranthene (mg/kg)

Variable	Sample locations			
Validation sample point	6a6b-SV19	6a6b-SV23	BP-SV37	BP-SV43
Backfill zone	F15/F16	17/09/21(2)	N19	J21
Validation sample value	31	52	37	110
Backfill mean value	20.32	17.83	11.95	9.59
Backfill and validation mean*	20.75	19.54	13.09	13.60
Weighted UCLmean*	30.20	31.19	25.80	39.43

⁶ 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 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 surface sample combined, with weighting

Table 4.5 Combining surface sample and fill concentrations, benzo(b)fluoranthene (mg/kg)

Variable	Sample locations									
Validation sample point	6a6b-SV15	6a6b-SV19	6a6b-SV23	BP-SV23	BP-SV34	BP-SV36	BP-SV37	BP-SV43	BP-SV45	BP-SV47
Backfill zone	25/03/22	F15/F16	17/09/21(2)	N17	H19	L19	N19	J21	N21	R21
Validation sample value	18	16	34	17	16	17	30	44	17	16
Backfill mean value	7.00	10.56	8.06	9.98	10.69	5.39	5.37	5.12	7.29	18.00
Backfill and validation mean*	7.55	10.78	9.35	10.30	10.93	5.92	6.49	6.68	7.73	17.91
Weighted UCLmean*	15.19	19.92	16.82	14.35	15.50	11.57	14.72	16.87	13.04	18.47

*Backfill and surface sample combined, with weighting

4.3.4 Summary of sample results

For fluoranthene, it can be seen from Figure 4.5 that the mean concentrations in most of the backfill zones are lower than the SRVs. However, if the UCL estimate of the mean is used (Figure 4.7), the value for 35 of the 127 backfill zones exceeds the SRV. Four surface verification samples within the Units 11-16 boundary also exceed the SRV. As Table 4.4 shows, inclusion of these verification samples results in a weighted UCLmean value exceeding the SRV in three additional backfill zones. Fluoranthene is therefore taken forward for further assessment.

For benzo(b)fluoranthene the mean concentration exceeds the SRV in three backfill zones and the UCL estimate of the mean are above the SRV of 15.5 mg/kg for 23 backfill zones (Figure 4.6, Figure 4.8). Ten surface verification samples within the Units 11-16 boundary exceeded the SRV. As Table 4.5 shows, inclusion of these verification samples results in a weighted UCLmean value exceeding the SRV in three additional backfill zones. Benzo(b)fluoranthene is therefore taken forward for further assessment.

4.4 Stage 3 – Screening against Reference Values

The SRVs are calculated assuming that water infiltrating the engineered fill and travelling to a reën is then diluted in the volume of run-off across the site. The conceptualisation does not include for transport processes such as advection, dispersion, retardation and decay that act to reduce contaminant concentrations along a transport pathway.

HFCL's Method Report (2024) applied the Environment Agency's remedial targets methodology in deriving reference values for potential Contaminants of Concern at specific distances from the surface water receptors that may be vulnerable. These are the reens. Reference Values are reproduced for convenience in Appendix B.

A single reën drains the commercial site and passes the western edge of Units 11-16. In relation to the reën, the nearest of the backfill zones with concentrations above the SRV is F15/F16, in the west-central part of the site. This is true for both the assessed PAH (Figure 4.7, Figure 4.8). The nearest edge of F15/F16 is at a distance of approximately 40 m from the reën.

Examination of the reference value tables in the Method Report (and reproduced here in Appendix B) shows that modelling predicts no impact from either fluoranthene or benzo(b)fluoranthene, even for a contaminant source as close as 12.5 m from the receptor. This is due to the very high sorption characteristics inherent to these substances.

On this basis we conclude that neither fluoranthene nor benzo(b)fluoranthene represents a significant risk to surface water quality following the remediation works at Units 11-16.

4.5 Hydraulic conductivity data

Rodgers Leask (2025) reports hydraulic conductivity data for Units 11-16, and includes detailed appendices showing the derivation of the hydraulic conductivity results. They are summarised here in Table 4.6 for ease of reference.

Table 4.6 Hydraulic conductivity testing at Units 11-16

Method	N tests	Hydraulic conductivity (m/s)		
		Min	Max	Mean
Falling head test	6	9.23×10^{-7}	9.96×10^{-7}	9.75×10^{-7}
Falling head test	3	8.40×10^{-7}	9.94×10^{-7}	9.42×10^{-7}
Rising head test	Not possible due to lack of water in test wells			
Aggregate	9	8.40×10^{-7}	9.96×10^{-7}	9.64×10^{-7}

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 9.64×10^{-7} m/s. The assumption used in the derivation of the SRVs is therefore valid.

5 DRAINAGE LAYER

The remediation strategy requires that a drainage layer is placed over the engineered fill, to enable 60% of infiltration to drain away above the engineered fill and only 40% of infiltration to enter the engineered fill.

Evidence for the drainage layer will be provided subsequently, and is required for the discharge of Planning Condition 28, Part 2.

6 CONCLUSIONS

Rogers Leask Environmental (RL) has appointed H Fraser Consulting Ltd (HFCL) to assist with validating remediation works undertaken at Units 11-16 on the Commercial site at the former Llanwern Steelworks site at Glan Llyn.

Remediation has been undertaken on Units 11-16 of the Glan Llyn development site, comprising excavation of Made Ground materials, stockpiling, removal of unsuitable materials, and placement of suitable materials as a compacted engineered fill. The plot is subdivided into 127 backfill zones, which were sequentially backfilled in layers from stockpiled remediation material.

Verification samples were taken from stockpiles, and material movements were then tracked so that the soil quality of each backfill zone is known. Surface samples were also taken after the backfill was placed, to enhance the verification sample data set. In total 1,077 samples are available from fill materials, and an additional 48 samples were taken from the near-surface, post-placement

The dataset was screened against Soil Re-use Values (SRVs) by comparing the 95%ile value for each contaminant against the SRV. For all potential contaminants, the 95%ile concentration was below the SRV, with the exception of fluoranthene and benzo(b)fluoranthene. Further assessment was therefore undertaken for these two parameters.

- For fluoranthene, 128 of 1,077 available analyses exceeded the SRV of 30.1 mg/kg. The maximum, 95%ile and average concentrations were 1,260 mg/kg, 58.1 mg/kg and 14.9 mg/kg respectively.
- For benzo(b)fluoranthene, 135 of 1,074 available analyses exceeded the SRV of 15.5 mg/kg. The maximum, 95%ile and average concentrations were 378 mg/kg, 35.7 mg/kg and 7.48 mg/kg.

Box plots and histograms show that the data sets for these two contaminants were affected by a small number of high concentrations. Spatial plots indicated that average concentrations across most but not all of the site area were below SRVs.

Uncertainty in the data has been assessed by calculating an upper confidence limit in the mean value for each backfill zone. This value is labelled the UCLMean. For fluoranthene, this indicated that the UCLMean concentration in 38 backfill zones may exceed the SRV, taking into account additional validation samples and uncertainty inherent in the data set. For benzo(b)fluoranthene the comparable figure potentially exceeding the SRV is 26 backfill zones. The nearest backfill zone with a UCLMean exceeding the SRV is at a distance of 40 m from the nearest reën.

Review of the reference tables developed using the Remedial Targets Methodology shows that neither fluoranthene nor benzo(b)fluoranthene can be expected to travel even as far as 12.5 m over a period of at least 1,000 years.

It can be concluded that the concentrations of potential contaminants within the fill materials meet the remediation requirements for Units 11-16, with respect to protection of controlled waters.

APPENDIX A

Chemical screening (electronic)

APPENDIX B

Remedial Targets reference tables (commercial)

The following reference values were derived using the Environment Agency's Remedial Targets methodology, as reported by H Fraser Consulting Ltd (2024)⁷.

Contaminant Distance from Reen	Reference values (Commercial) mg/kg		
	12.5 m	37.5 m	62.5 m
Metals and metalloids			
Arsenic	>1E+06	No impact	No impact
Cadmium	No impact	No impact	No impact
Chromium	No impact	No impact	No impact
Copper	No impact	No impact	No impact
Iron	No impact	No impact	No impact
Lead	No impact	No impact	No impact
Manganese	No impact	No impact	No impact
Mercury	No impact	No impact	No impact
Nickel	No impact	No impact	No impact
Selenium	>1E+06	No impact	No impact
Vanadium	No impact	No impact	No impact
Zinc	No impact	No impact	No impact
Other inorganics			
Ammoniacal Nitrogen	1,181	3,961	15,084
Cyanide	>1E+06	>1E+06	>1E+06
Organics			
Benzene	37.48	184.3	941.3
Toluene	>1E+06	>1E+06	>1E+06
Ethylbenzene	3,197	95,209	>1E+06
Xylene	1,423	17,137	174,505
Phenol	504,959	>1E+06	>1E+06
Petroleum hydrocarbons			
TPH Aliphatic C5-C6	>1E+06	>1E+06	>1E+06
TPH Aliphatic C6-C8	>1E+06	>1E+06	>1E+06
TPH Aliphatic C8-C10	No impact	No impact	No impact
TPH Aliphatic C10-C12	No impact	No impact	No impact
TPH Aliphatic C12-C16	No impact	No impact	No impact
TPH Aliphatic C16-C21	No impact	No impact	No impact
TPH Aliphatic C21-C35	No impact	No impact	No impact
TPH Aliphatic C35-C44	No impact	No impact	No impact
TPH Aromatic C5-C7	83.04	402.5	2,034
TPH Aromatic C7-C8	>1E+06	>1E+06	>1E+06
TPH Aromatic C8-C10	7,035	>1E+06	>1E+06
TPH Aromatic C10-C12	80,215	>1E+06	No impact
TPH Aromatic C12-C16	>1E+06	No impact	No impact
TPH Aromatic C16-C21	No impact	No impact	No impact
TPH Aromatic C21-C35	No impact	No impact	No impact
TPH Aromatic C35-C44	No impact	No impact	No impact

⁷ H Fraser Consulting Ltd (2024) . Glan Llyn: Soils validation strategy for protection of controlled waters, ref 30937R2, 17/12/2024.

Contaminant Distance from Reen	Reference values (Commercial) mg/kg		
	12.5 m	37.5 m	62.5 m
TPH Aromatic C40-C44	No impact	No impact	No impact
Polyaromatic hydrocarbons			
Acenaphthene	No impact	No impact	No impact
Acenaphthylene	No impact	No impact	No impact
Anthracene	No impact	No impact	No impact
Benzo(a)anthracene	No impact	No impact	No impact
Benzo(a)pyrene	No impact	No impact	No impact
Benzo(b)fluoranthene	No impact	No impact	No impact
Benzo(k)fluoranthene	No impact	No impact	No impact
Benzo(g,h,i)perylene	No impact	No impact	No impact
Chrysene	No impact	No impact	No impact
Di-benz(a,h)anthracene	No impact	No impact	No impact
Fluoranthene	No impact	No impact	No impact
Fluorene	No impact	No impact	No impact
Indeno(1,2,3-cd)pyrene	No impact	No impact	No impact
Naphthalene	1,687	>1E+06	>1E+06
Phenanthrene	No impact	No impact	No impact
Pyrene	No impact	No impact	No impact