Port of Mostyn

Mostyn and Warwick Compensation Works

Pre-works survey report

October 2025





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		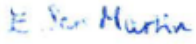

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1 Introduction

This report has been prepared by ABPmer on behalf of the Port of Mostyn to present the results of a monitoring survey that was undertaken to assess the condition of the compensation sites at Mostyn and Warwick (Marsh Row) prior to the compensation works taking place. The basis of this survey is the Compensation Monitoring Plan (ABPmer, 2025a). Further details of the compensation sites are provided in the Compensation Plan (ABPmer, 2025b).

The pre-works monitoring survey was conducted by ABPmer in April 2025, and was conducted in line with the Compensation Monitoring Plan (ABPmer, 2025a). The plan stipulated that a survey would be undertaken within 3 months prior to the start of works and will be followed by a post-works survey within 3 months of completion of the works. There will be further post-works surveys at Year 1 (2026) and Year 3 (2028). A review of survey data collected at Year 3 will be undertaken in consultation with NRW Advisory to determine if any further monitoring is required.

As outlined within the Compensation Monitoring Plan (ABPmer, 2025a), the following surveys were undertaken:

- A minimum of 5 Elevation (Topographic) transects;
- Benthic sampling;
    - 15 samples per site for particle size analysis[1];
    - 3 samples per site for contamination analysis;
    - 5 samples for macrofauna and total organic carbon analysis (at the Warwick site only); and
- A Phase 1 intertidal habitat survey of both sites.

The survey methodologies are detailed in Section 2 and the survey results are presented in Section 3. Overall summary conclusions are then provided in Section 4.

[1] Fewer than 15 samples were collected at both sites. This was due to the pre-works condition of the site which was dominated by hard substrate (including debris) particularly in the upper shore which prevented viable samples from being collected.

2 Methods

2.1 Elevation transects

Topographic surveys were conducted alongside sampling operations at each compensation site. All sample locations and transects across the Mostyn and Warwick sites were surveyed using GNSS (Global Navigation Satellite System). Points were established using a Geomax Zenith16 GNSS system with RTK (Real Time Kinematic) corrections. This provided vertical and horizontal positional accuracies of ±0.03 m. Observations at each survey point were logged at 1 Hz rate for 5-seconds, with an average position and elevation calculated.

RTK points were collected in ETRS89 geographic coordinates before being converted to OSGB36 using the OSTN15 transformation model. In the vertical, data was acquired relative to the ETRS89 ellipsoid and offset to ODN using the OSGM15 transformation model.

RTK positions were taken along transects across the width of each survey area (seven transects[2] at Mostyn and five transects at Warwick). Distance between survey points varied between 1-11 m. Attention was given to areas where topography altered significantly by decreasing distance between survey point, this included areas such as at the top of the foreshore and where large material was present. Elevation data was then processed to create vertical profiles of each transect.

RTK positions were also logged for future fixed-point photographic surveys at the Mostyn and Warwick sites to ensure consistency when subsequent surveys are completed.

2.2 Benthic sampling and processing

To help inform the pre-works condition assessment of the Mostyn and Warwick foreshores, numerous samples were taken across both sites. Across both Mostyn and Warwick, samples were collected for particle size analysis (PSA) and for contamination analysis. Additionally, at Warwick, samples were also collected to determine the macrofauna present and total organic carbon content (TOC).

2.2.1 Particle size analysis

At Mostyn twelve samples were collected, with the first six (MO1-MO6) collected from the Southern extent of the foreshore (Figure 1), and the second six (MO7-MO12) collected from the Northern extent of the foreshore (Figure 2). At Warwick, fourteen samples were collected from representative locations across the foreshore (Figure 3).

It should be noted that at both locations, fewer than 15 samples were collected. This was due to dense areas of hard substrata in the upper shore which prevented viable samples from being collected.

Due to the presence of rocks and boulders across much of the survey extent, the majority of samples were collected using a 'surface scraping' approach. This was a semi-quantitative approach which saw the removal of the finer material that was present in pockets across the foreshore and were representative of the material that currently settles in the area of the proposed scrape back works. The material was collected to a depth of approximately 5 cm (taking a volume of sediment approximately

[2] Two additional transects were undertaken at Mostyn to capture the area influenced by the former sand quarry (TRO3) and the area most greatly influenced by slag deposits (TR06)

equivalent to that collected with a hand core)[3]. Where sediment was suitable, a core sample was taken to a depth of ~15 cm using a 0.1 m hand core. This was typically achievable in the low shore at the foot of the transect where intertidal mud/sand flats were present. The PSA samples that were taken using the corer were typically outside of the proposed scrape back areas. However, these were included to provide a representation of the potential material that may accumulate within the compensation sites following the completion of the works. A breakdown of which approach was taken for each sample is presented in Table 1.

Table 1. A breakdown of the sampling method (core versus surface scraping) used for each of the PSA samples collected from Mostyn and Warwick.

Mostyn		Warwick	
ID	Collection Method	ID	Collection Method
MO1	Surface scraping	WA1	Surface scraping
MO2	Core	WA2	Surface scraping
MO3	Core	WA3	Core
MO4	Surface scraping	WA4	Surface scraping
MO5	Core	WA5	Surface scraping
MO6	Core	WA6	Core
MO7	Surface scraping	WA7	Surface scraping
MO8	Surface scraping	WA8	Core
MO9	Core	WA9	Surface scraping
MO10	Surface scraping	WA10	Surface scraping
MO11	Core	WA11	Core
MO12	Core	WA12	Surface scraping
-	-	WA13	Core
-	-	WA14	Core

The PSA sample analysis was undertaken using the NMBAQC standardised methodology. The analysis was carried out using a Mastersizer laser diffractor which produces detailed sedimentary profiles for fine sediments (clay, sand and silts).

[3] Hard ground prevented collecting sediment below 5 cm.

Figure 1. **The location of sediment samples collected for PSA within the southern extent of Mostyn site.**

Figure 2. **The location of sediment samples collected for PSA within the northern extent of Mostyn site.**

Figure 3. The location of sediment samples collected for PSA across the Warwick site.

2.2.2 Contamination

Three contamination sampling locations were chosen at both the Mostyn (Figure 4) and Warwick (Figure 5) sites.

Where possible, samples were taken from within the proposed scrape back areas focusing on the fine material (<5 mm) that had accumulated within the rock/boulders. It should however be noted that where there was an absence or insufficient quantity of fine material within the rock/boulders, samples were taken at the transition point between the hard/mixed layer and the adjacent mud/sand flats. This was the case in the southern extent of the Mostyn foreshore (MO1_Con1) and at two locations at Warwick (WA_Con1 and WA_Con2).

Upon collection, the samples were dispatched to an ISO/IEC 17025 accredited lab within 24 hours of collection and were subsequently tested for:

- Trace metals;
- Organotins;
- Polycyclic Aromatic Hydrocarbons (PAHs);
- Polychlorinated Biphenyls (PCBs);
- Organochlorines; and
- Brominated diphenyl ethers (BDEs).

The results of the analysis were then compared to Cefas Action Level 1 (AL1) and Action Level 2 (AL2)[4] to determine the quality of sediment at the compensation sites prior to the works.

[4] https://www.gov.uk/guidance/marine-licensing-sediment-analysis-and-sample-plans

Figure 4. The location of sediment samples collected for contamination analysis at the Mostyn site.

Figure 5. **The location of sediment samples collected for contamination analysis at the Warwick site.**

2.2.3 Macrofauna and total organic carbon

At Warwick, macrofaunal core samples (using 0.01 m^2 core) were taken from five locations within the compensation site. These locations were located at either the foot of the elevation transect, or at the first point a suitable core could be taken along the respective transect Figure 6. The results of the macrofaunal analysis, coupled with onsite observations, helped to inform the phase 1 mapping of both locations.

Upon completion of the sampling, the benthic macrofaunal analysis was undertaken by Hull Marine Laboratory. The laboratory is National Marine Biological Analytical Quality Control Scheme (NMBAQC) accredited. The faunal samples were first sieved through a 0.5 mm mesh and preserved in a formalin solution. The sieved residue was then sorted, identified and enumerated using low power binocular microscopes. Where practicable macroinfaunal specimens were identified to species level. Upon completion of the identification and enumeration, the biomass was determined for each species based on wet weight. This work was undertaken in adherence with ISO 16665 standards and the NMBAQC scheme guidelines.

To supplement the macrofaunal analysis, additional samples for TOC analysis were collected adjacent to each sampling location. The TOC samples were first dried in an oven for 24 hr at 105ºC to determine an initial dry weight. This was followed by 12 hours in a muffle furnace at 475°C which incinerated the organic content within the samples. The weight of the remaining material was taken, and a Loss-on-ignition (LOI) percentage was recorded.

Figure 6. The macrofauna and TOC sampling locations at Warwick site.

2.3 Phase 1 Intertidal habitat survey

Phase 1 intertidal habitat surveys were undertaken at both the Mostyn and Warwick sites. The seaward boundary was the lowest part of the shore that could be accessed safely at low water and/or limited to the area of the compensation site and proposed works.

The habitat surveys were undertaken on foot, aided by aerial photography and satellite images which were taken into the field to create sketch maps. The habitat survey observations were refined by incorporating the data acquired from the elevation transects, PSA, and macrofauna analysis. This approach was based on the standardised Phase 1 mapping methodology as detailed in the Marine Monitoring Handbook, Procedural Guidance No. 3-1 (Wyn and Brazier, 2001) and Countryside Council for Wales (CCW) Handbook for Marine Intertidal Phase 1 Survey and Mapping (Wyn *et al*. 2000). Using the Marine Habitat Classification for Britain and Ireland (MHCBI) 04.05 (Connor *et al*. 2004), the survey areas were classified to biotope class levels 4 or 5 (where possible). Biotopes, or other notable features, covering less than 5 m^2 were recorded using referenced target notes. Any characterising, INNS, or rare/scarce species were also noted as well as any evidence of anthropogenic disturbance.

3 Results

3.1 Elevation transects

A total of seven transects (TR01 to TR07) were surveyed across the Mostyn site, two transects within the Southern extent of the site and five covering the northern extent. At Warwick a total of five transects (TR01 to TR05) were undertaken at representative locations across the foreshore. Transect lengths varied depending on a combination of factors including elevation, topography, substrate type, and/or safety of access. The results are discussed below and the individual elevation transects are presented in Appendix A.

3.1.1 Mostyn

The intertidal mud/sand flats across the southern extent (TR01 and TR02) were more compacted than in the northern extent of the site. This enabled the survey team to collect additional data beyond the boundaries of the compensation site (Figure 7). The presence of a large drainage channel close to the survey area restricted safe access to the low shore mud/sand flats in the northern extent of the site. Where access was not possible, data was collected up to the transition point between the rock/mixed substrate and intertidal mud/sand flats (Figure 8).

The overall trend showed that the existing bank/revetments started with elevations of between 3.8 mODN and 7.2 mODN, with the highest starting elevations occurring in the southern extent and gradually decreasing as the transects moved northward. In the majority of cases, the elevations along the transects dropped significantly to between 2 to 4 mODN, and these generally declined seawards. The elevations at the southern extent of the site decreased to between 2.4 and 2.6 mODN whilst the elevations at the northern extent decreased to 1.2 mODN.

A summary of each transect is presented below:

- TR01: Maximum elevation was observed at the shoreward side of the transect at 7.1 mODN. Elevation decreased to 2.7 mODN towards the edge of the intertidal over a distance of 22 m. Elevation points were also taken along 35 m of the intertidal mud/sand flats where elevation remained relatively constant between 2.5 to 2.8 mODN. The average slope angle was 11.12°.
- TR02: Maximum elevation was observed at 6.5 mODN, which sloped down toward the intertidal mud at 2.6 mODN at a distance of 10 m from the top of the transect. Elevations from the intertidal mud/sand flats showed the levelling off of the slope at approximately 2.4 mODN. The average slope angle was 11.15°.
- TR03: Maximum elevation was observed at 5.6 mODN which sloped down toward the intertidal mud/sand flats at 2.4 mODN at the edge of the intertidal which was at a distance of 30 m from the top of the transect. The average slope angle was 6.04°.
- TR04: Maximum elevation observed was 5 mODN with a relatively shallower slope to the edge of the intertidal which was at 2.5 mODN at a distance of 21 m from the top of the transect. The average slope angle was 7.49°.
- TR05: Elevation range observed was between 5.4 mODN and 1.6 mODN over a distance of 25 m. The average slope angle was 8.62°.
- TR06: Elevation range observed was between 5.9 mODN and 1.2 mODN over the 14.5 m transect. Relatively steep steps between some topographic points were recorded due to large slag deposits present. The average slope angle was 10.40°.
- TR07: Elevation range observed was between 3.8 mODN and 1.2 mODN over the 25 m distance from the top of the transect. The average slope angle was 5.30°.

Figure 7. Elevation transects from the southern extent of the Mostyn site.

Figure 8. Elevation transects from the northern extent of the Mostyn site.

3.1.2 Warwick

In contrast to the Mostyn foreshore, there was less variability in elevations across the Warwick site with peak elevations varying from 5.7 mODN to 6.9 mODN at the start of the transects decreasing to between 2 mODN and 2.9 mODN at the end of the transects. Transects typically ranged from 23-36 m in length and due to the presence of soft sediments at TR01 to TR03 and TR05, these transects were stopped at the transition point between rock/hard substrate and intertidal mud/sand flats. The intertidal mud/sand flats in the vicinity of TR04 were relatively compact allowing safe access to the lower shore and for an additional 22 m of data to be collected (Figure 9).

A summary of each transect is presented below:

- TR01: Elevations observed ranged from 6.1 mODN at the shoreward start of the transect to 2.5 mODN on the seaward end over a distance of 29 m. The average slope angle was 7.34°.
- TR02: Elevations observed ranged from 6.9 mODN at the start to 2.0 mODN at the end of the transect over a distance of 36 m. The average slope angle was 9.11°.
- TR03: Elevations observed ranged from 6.5 mODN to 2.4 mODN over 27 m. The average slope angle was 8.70°.
- TR04: Elevations observed ranged from 5.7 mODN to 2.9 mODN over 46 m. The elevation decreased in the initial 24 m part of the transect and remained consistent for the final 22 m which overlapped with the intertidal mud/sand flats. The average slope angle was 6.69°.
- TR05: Elevations observed ranged from 6.4 mODN to 2.6 mODN over 23 m. The average slope angle was 9.38°.

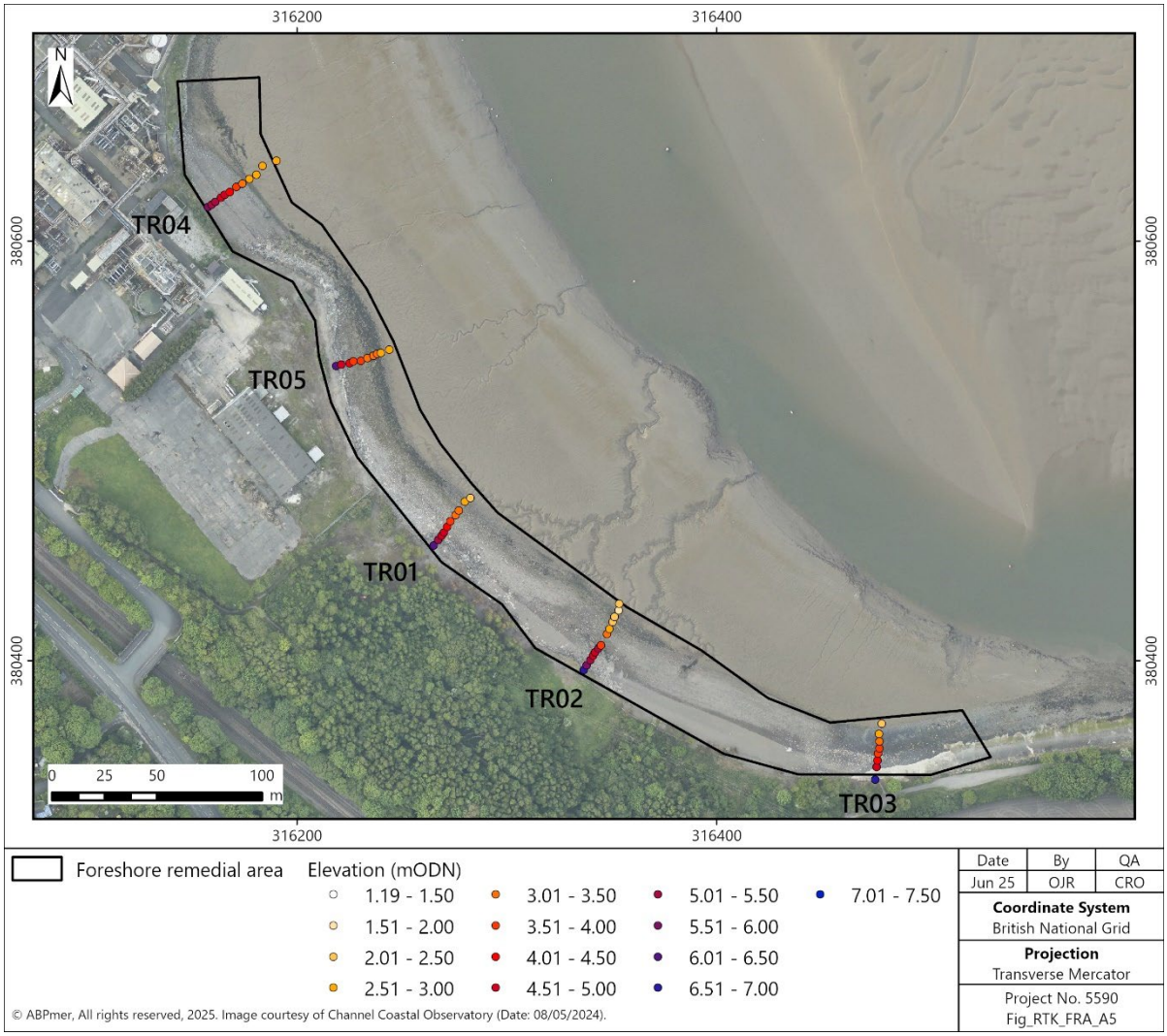

Figure 9. Elevation transects from Warwick site.

3.2 Benthic sampling

3.2.1 Particle size analysis

Mostyn

The PSA results from the Mostyn site showed that the majority of the samples consisted of sandy mud (Table 2). MO1 – MO6 were collected from the southern extent of the foreshore whilst MO7- MO12 were collected from the northern extent.

The mud fraction was often greatest in areas where the surface scraping approach was used. However, it is important to note that surface scraping was undertaken in areas of rock/hard ground and samples were taken from pockets of deposited fine sediment. It is likely that due to the relatively sheltered nature of these locations, the suspended muddy material was able to settle out of the water column, resulting in the muddy deposits encountered within these samples.

The core samples, which were collected from the adjacent mud/sand flats showed some variation dependant on whether they were collected from the southern extent or the northern extent of the site. In the southern extent of the site, sand was typically more prevalent with it being the most dominant fraction at MO2 and MO5 accounting for > 90% of the material at both stations. At MO3 and MO6, the sand fraction accounted for >40 % of the material, with mud accounting for < 60%. The northern extent typically had a greater mud fraction ranging from 55 – 86% from the core locations. MO12 was taken within the vicinity of the sand quarry area, which may have attributed to the relatively high sand fraction (44%) observed at this location. A full break down of the results is presented in Appendix B.

Warwick

The PSA results from the Warwick site showed that the majority of the samples consisted of sandy mud (Table 3). Mud fractions ranged from 57% - 86% in areas where sample scraping was undertaken and between 62 - 87% in areas where core samples were collected. The sand fraction ranged 14% - 38% within the surface scrape areas and between 13% - 35% within the core sample areas. Gravel was recorded at four locations where surface scraping was undertaken ranging from 2%-9% and on one occasion from a core sample (WA13) where it accounted for 3% of the sample. The presence of gravel within the samples that were collected using the surface scraping approach was expected. This is due to the nature of the surface scraping approach and sample locations[5]. Where the fine material which has settled is often mixed with gravel and small shingle.
The areas where gravel was most prevalent occurred relatively high up the shore with WA1 and WA4 present in areas where discarded breeze blocks were present. These breeze blocks were in varying stages of degradation and fragmentation and may have modified the sedimentary characteristics in these areas. Additionally, the hollow nature of the blocks may have allowed for fine material to settle and minimise resuspension.

WA9 consisted of a shallow layer of coarse sand and gravel (<2 cm). This gave way to an area of fine sand and mud. WA7 which was situated at the other end of the of the foreshore was collected from a sediment deposit within an area of coarse shingle and rock. The mixed nature of this location resulted in a small gravel fraction (2%) and relatively mixed sand and mud fractions, with sand accounting for 38% and the mud accounting for 60%.

A full breakdown of the PSA results for Warwick are presented in Appendix B.

[5] The surface scrape approach was utilised in areas where the ground condition did not allow for a successful core sample to be taken. This was typically deployed in areas of hard substrate (rock, shingle and/or gravel), where fine material (clay, mud and/or sand) was also present.

Table 2. A summary of the PSA results collected from the Mostyn site.

Sample ID	MO1	MO2	MO3	MO4	MO5	MO6	MO7	MO8	MO9	MO10	MO11	MO12
Collection method:	Surface scraping	Core	Core	Surface scraping	Core	Core	Surface scraping	Surface scraping	Core	Surface scraping	Core	Core
Sample type:	Trimodal, Extremely Poorly Sorted	Unimodal, Moderately Sorted	Bimodal, Very Poorly Sorted	Trimodal, Extremely Poorly Sorted	Unimodal, Poorly Sorted	Bimodal, Very Poorly Sorted	Unimodal, Poorly Sorted	Bimodal, Poorly Sorted	Bimodal, Poorly Sorted	Unimodal, Poorly Sorted	Bimodal, Very Poorly Sorted	Bimodal, Very Poorly Sorted
Textural group:	Slightly Gravelly Sandy Mud	Sand	Sandy Mud	Gravelly Mud	Sand	Sandy Mud	Sandy Mud	Sandy Mud	Sandy Mud	Sandy Mud	Sandy Mud	Sandy Mud
Sediment name:	Slightly Very Fine Gravelly Medium Sandy Mud	Moderately Sorted Fine Sand	Fine Sandy Medium Silt	Medium Gravelly Mud	Poorly Sorted Medium Sand	Very Fine Sandy Very Coarse Silt	Very Fine Sandy Medium Silt	Very Fine Sandy Medium Silt	Very Fine Sandy Medium Silt	Very Fine Sandy Fine Silt	Very Fine Sandy Medium Silt	Fine Sandy Medium Silt
Gravel:	2.2%	0.0%	0.0%	5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
Sand:	34.9%	93.1%	40.7%	36.7%	90.8%	43.5%	13.6%	16.7%	16.9%	13.0%	23.7%	44.4%
Mud:	62.9%	6.9%	59.3%	58.3%	9.2%	56.5%	86.4%	83.3%	83.1%	87.0%	76.3%	55.6%

Table 3. A summary of the particle size analysis (PSA) results collected from the Warick foreshore.

Sample ID	WA1	WA2	WA3	WA4	WA5	WA6	WA7	WA8	WA9	WA10	WA11	WA12	WA13	WA14
Collection method	Surface scraping	Surface scraping	Core	Surface scraping	Surface scraping	Core	Surface scraping	Core	Surface scraping	Surface scraping	Core	Surface scraping	Core	Core
Sample type:	Trimodal, Extremely Poorly Sorted	Bimodal, Very Poorly Sorted	Bimodal, Poorly Sorted	Trimodal, Extremely Poorly Sorted	Bimodal, Poorly Sorted	Unimodal, Poorly Sorted	Trimodal, Extremely Poorly Sorted	Unimodal, Poorly Sorted	Trimodal, Extremely Poorly Sorted	Trimodal, Very Poorly Sorted	Bimodal, Poorly Sorted	Trimodal, Very Poorly Sorted	Trimodal, Extremely Poorly Sorted	Bimodal, Poorly Sorted
Textural group:	Gravelly Mud	Sandy Mud	Sandy Mud	Gravelly Mud	Sandy Mud	Sandy Mud	Slightly Gravelly Sandy Mud	Sandy Mud	Gravelly Mud	Sandy Mud	Sandy Mud	Sandy Mud	Slightly Gravelly Sandy Mud	Sandy Mud
Sediment name:	Medium Gravelly Mud	Very Fine Sandy Medium Silt	Very Fine Sandy Very Coarse Silt	Coarse Gravelly Mud	Very Fine Sandy Medium Silt	Very Fine Sandy Medium Silt	Slightly Very Fine Gravelly Medium Sandy Mud	Very Fine Sandy Medium Silt	Coarse Gravelly Mud	Very Fine Sandy Medium Silt	Very Fine Sandy Very Coarse Silt	Very Fine Sandy Medium Silt	Slightly Very Fine Gravelly Medium Sandy Mud	Very Fine Sandy Medium Silt
Gravel:	5.0%	0.0%	0.0%	6.1%	0.0%	0.0%	2.3%	0.0%	8.6%	0.0%	0.0%	0.0%	3.3%	0.0%
Sand:	36.7%	19.2%	26.4%	37.4%	13.7%	15.9%	37.8%	12.8%	32.5%	27.7%	21.4%	23.5%	35.0%	16.5%
Mud:	58.3%	80.8%	73.6%	56.5%	86.3%	84.1%	59.9%	87.2%	58.8%	72.3%	78.6%	76.5%	61.7%	83.5%

3.2.2 Contamination

A summary of the contaminant analysis from both the Mostyn and Warwick sites is presented in Table 4. Concentrations above Cefas Guideline Action Levels (ALs) are highlighted to provide an indication of sediment quality. Contaminant concentrations were relatively low, with most values below the respective AL1. There were several occurrences where the concentrations of samples were above the respective AL1, and no instances where the concentration exceeded the respective AL2.

In the case of trace metals, nickel and zinc exceeded AL1 across all locations. Additionally, lead exceeded AL1 at all sites excluding MO_Con3 and WA_Con1. Cadmium levels exceeded AL1 at MO_Con1 and WA_Con3 with mercury levels also exceeding AL1 at MO_Con1. PAHs frequently exceeded AL1 at MO_Con2 and across all three locations at Warwick. Organotins and PCBs were below AL1 across all locations. It should be noted that there are no Cefas guideline ALs for organochlorines and BDEs. However, BDE209 (Decabromodiphenyl ether) was relatively high when compared to the limit of detection (LoD) and other BDEs within the testing suite.

Table 4. The results of contaminant analysis conducted from across both the Mostyn and Warwick foreshores.

Contaminant	Unit	LoD	Mostyn (MO)			Warwick (WA)		
			Con1	Con2	Con3	Con1	Con2	Con3
Trace metals								
Arsenic (As)	mg/kg	0.5	6.7	13.2	12.3	12.7	13.3	15.4
Cadmium (Cd)	mg/kg	0.04	0.45	0.25	0.2	0.23	0.23	0.6
Chromium (Cr)	mg/kg	0.5	7.8	35.9	35.8	36.2	37.9	38.4
Copper (Cu)	mg/kg	0.5	8.4	20.3	19.8	21.1	24.4	37.2
Mercury (Hg)	mg/kg	0.01	0.58	0.08	0.24	0.24	0.2	0.23
Nickel (Ni)	mg/kg	0.5	7.8	28.9	29.2	29.5	30.6	32.7
Lead (Pb)	mg/kg	0.5	71.9	62.1	48.4	47.8	52.3	132
Zinc (zn)	mg/kg	2	191	186	135	150	174	286
Organotins								
Dibutyltin (DBT)	mg/kg	0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
Tributyltin (TBT)	mg/kg	0.001	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005
PAHs								
Acenaphthene	µg/Kg	1	5.41	9.92	6.81	10.4	9.53	9
Acenaphthylene	µg/Kg	1	1.71	11.1	8.03	9.35	9.42	16
Anthracene	µg/Kg	1	12.2	19.6	12.9	18.7	15.5	40.3
Benzo(a)anthracene	µg/Kg	1	38.9	62.5	43	59.9	56.3	200
Benzo(a)pyrene	µg/Kg	1	46.5	106	75	95.4	88.9	220
Benzo(b)fluoranthene	µg/Kg	1	41	133	95.2	126	122	235
Benzo(ghi)perylene	µg/Kg	1	35.4	128	91.5	117	115	200
Benzo(e)pyrene	µg/Kg	1	33.7	111	81.2	101	95.1	192
Benzo(K)fluoranthene	µg/Kg	1	39.4	103	75.8	95.4	91.1	214
C1-naphthalenes	µg/Kg	1	15.3	104	90.4	110	102	137
C1-phenanthrene	µg/Kg	1	38.9	116	83.7	103	97.1	196
C2-naphthalenes	µg/Kg	1	14.7	103	82.5	107	96.8	134
C3-naphthalenes	µg/Kg	1	16	98.4	68.1	91	85.1	162
Chrysene	µg/Kg	1	45.2	95.5	66.4	90.8	84.5	245
Dibenzo(ah)anthracene	µg/Kg	1	6.69	25	18.1	23.3	23.4	43.4
Fluoranthene	µg/Kg	1	104	122	86.7	121	108	349
Fluorene	µg/Kg	1	3.17	22.2	16.7	22.1	20.2	17.1
Indeno(1,2,3-cd)pyrene	µg/Kg	1	35.6	128	86.8	119	116	208
Naphthalene	µg/Kg	1	3.92	37.4	27.6	43.4	33.8	43.3

Contaminant	Unit	LoD	Mostyn (MO)			Warwick (WA)		
			Con1	Con2	Con3	Con1	Con2	Con3
Perylene	µg/Kg	1	14.2	37	28	33.4	32.8	68
Phenanthrene	µg/Kg	1	54.5	94.9	69.1	97.6	85.4	178
Pyrene	µg/Kg	1	84.1	119	82.7	116	103	316
Total Hydrocarbon Content	mg/kg	1	38	4.96	8.56	8.39	5.61	285
PCBs								
PCB 18	mg/kg	0.00008	<0.00008	<0.00008	0.00011	<0.00008	<0.00008	<0.00008
PCB 28	mg/kg	0.00008	<0.00008	0.0003	0.00038	0.0003	0.00031	0.00018
PCB 31	mg/kg	0.00008	<0.00008	0.00019	0.00026	0.0002	0.00021	0.00012
PCB 44	mg/kg	0.00008	<0.00008	0.0001	0.00014	0.0001	0.00012	<0.00008
PCB 47	mg/kg	0.00008	<0.00008	<0.00008	0.00008	<0.00008	0.0001	<0.00008
PCB 49	mg/kg	0.00008	<0.00008	0.00012	0.00015	0.00012	0.00014	<0.00008
PCB 52	mg/kg	0.00008	<0.00008	0.00015	0.00016	0.00016	0.00019	0.0001
PCB 66	mg/kg	0.00008	<0.00008	0.00033	0.0004	0.0003	0.00042	0.00014
PCB 101	mg/kg	0.00008	0.0002	0.00024	0.00027	0.00021	0.00028	0.00008
PCB 105	mg/kg	0.00008	<0.00008	0.00009	0.00015	0.0001	0.00033	<0.00008
PCB 110	mg/kg	0.00008	0.00025	0.00028	0.00035	0.00026	0.00032	0.00011
PCB 118	mg/kg	0.00008	0.00016	0.0003	0.00038	0.0004	0.0005	0.00012
PCB 128	mg/kg	0.00008	<0.00008	0.00013	0.0001	<0.00008	0.00021	<0.00008
PCB 138	mg/kg	0.00008	0.00021	0.00047	0.00041	0.00038	0.00048	0.0001
PCB 141	mg/kg	0.00008	<0.00008	<0.00008	<0.00008	<0.00008	0.00019	<0.00008
PCB 149	mg/kg	0.00008	0.0002	0.0002	0.00025	0.00028	0.00035	<0.00008
PCB 151	mg/kg	0.00008	<0.00008	0.00009	<0.00008	<0.00008	0.00021	<0.00008
PCB 153	mg/kg	0.00008	0.00024	0.00042	0.00054	0.00034	0.00052	0.00011
PCB 156	mg/kg	0.00008	<0.00008	<0.00008	<0.00008	<0.00008	0.00033	<0.00008
PCB 158	mg/kg	0.00008	<0.00008	<0.00008	<0.00008	<0.00008	0.00029	<0.00008
PCB 170	mg/kg	0.00008	<0.00008	<0.00008	0.0001	<0.00008	0.00034	<0.00008
PCB 180	mg/kg	0.00008	0.0001	0.00022	<0.00008	0.00017	0.00038	0.00012
PCB 183	mg/kg	0.00008	<0.00008	<0.00008	<0.00008	<0.00008	0.00023	<0.00008
PCB 187	mg/kg	0.00008	<0.00008	0.00017	0.00015	0.00011	0.00029	0.00008
PCB 194	mg/kg	0.00008	<0.00008	<0.00008	<0.00008	<0.00008	0.00025	<0.00008
Organochlorines								
AHCH	mg/kg	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
BHCH	mg/kg	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
GHCH	mg/kg	0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001

Contaminant	Unit	LoD	Mostyn (MO)			Warwick (WA)		
			Con1	Con2	Con3	Con1	Con2	Con3
DIELDRIN	mg/kg	0.0001	<0.0001	0.0004	<0.0001	<0.0001	0.0004	0.0003
HCB	mg/kg	0.0001	<0.0001	0.0002	0.0002	0.0002	0.0002	0.0007
PPTDE	mg/kg	0.0001	<0.0001	0.0008	0.0011	0.0007	0.0013	0.0003
PPDDE	mg/kg	0.0001	<0.0001	0.0004	0.0004	0.0003	0.0004	0.0001
PPDDT	mg/kg	0.0001	<0.0001	0.0001	0.0022	0.0001	0.0007	<0.0001
BDEs								
BDE17	mg/kg	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
BDE28	mg/kg	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	0.00006
BDE47	mg/kg	0.00005	<0.00005	0.00008	0.00009	0.00011	0.00009	0.0001
BDE66	mg/kg	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
BDE85	mg/kg	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
BDE99	mg/kg	0.00005	<0.00005	0.00006	0.00007	0.0001	0.00009	0.00006
BDE100	mg/kg	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
BDE138	mg/kg	0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005	<0.00005
BDE153	mg/kg	0.00005	<0.00005	<0.00005	<0.00005	0.00005	<0.00005	<0.00005
BDE154	mg/kg	0.00005	<0.00005	0.00008	0.0001	0.00011	0.0001	<0.00005
BDE183	mg/kg	0.00005	<0.00005	0.00011	0.00015	0.00015	0.00012	0.00005
BDE209	mg/kg	0.0001	0.0046	0.1928	0.2159	0.3225	0.1982	0.0525
	Cells highlighted yellow exceeded the AL1 threshold.							
	Cells highlighted red exceeded the AL2 threshold.							

3.2.3 Macrofauna and total organic carbon

Five samples were successfully collected from across the site. Each sample was taken from the same approximate elevation and were all taken from sandy mud within 5 m of the transition point between the hard (rock/shingle) and soft substrate (mud/sand).

A total of nineteen species were identified across the macrofaunal samples collected from the Warwick site, with an additional twelve identified to a lower taxonomic resolution (family – kingdom). The majority of individuals present were identified as oligochaetes, nematodes and polychaetes. The oligochaete *Tubificoides benedii* accounted for the highest individual abundance, with 797 individuals observed from Macro5.

Although significantly lower in abundance, the ragworm (*Hediste diversicolor)* and furrow shell *(Scrobicularia plana)* accounted for the highest biomass from an individual species, with the latter having a peak biomass of 5.6 g at Macro4 from 3 individuals, whilst the former had a peak biomass of 4.1 g from 59 individuals at Macro2.

Overall, Macro5 had the highest species richness and abundance, with 1,693 individuals distributed between 18 different organisms; fifteen of which were identified to species level. Biomass was greatest at Macro4 where the total biomass was 5.89 g. However, this was largely attributed to the presence of *S. plana* which accounted for 5.65 g of the total biomass.

In addition to the species above, other species of note included the sea slug *Limapontia depressa* and the parasitic flatworm *Fecampia erythrocephala*. The latter was found to be present within 3 samples and is known to be present within the wider Dee estuary[6]. Eggs of the former were found to be present at Marcro3 and Macro4. There are no known records of *F. erythrocephala* in the Dee Estuary with the closest recorded observation occurring west of Llandudno[7] , approximately 30 miles west of the survey area. However, due to the size and life cycle of the species, its presence is likely to be under recorded.

A full breakdown of the species observed, and their respective abundance and biomass is presented in Table 5.

The TOC content ranged from 3.68 – 6.16% with the lowest loss on ignition (LOI) percentage occurring from the Macro5 sample and the highest LOI percentage occurring from Macro3. The relatively low value observed from Macro5 despite the high number of species observed during the macrofaunal analysis is likely attributed to the presence of shelled species which would have retained some of their weight following the drying process. Meanwhile the comparatively high LOI observed from Macro3, which had comparatively low abundance and biomass recorded from the macrofauna analysis, is likely to attributed to the presence of soft bodied organisms and other organic content such as leaf litter, the latter of which was encountered within the same representative area in the PSA sampling.

A full breakdown of the LOI is presented in Table 6.

6 https://species.nbnatlas.org/species/NBNSYS0000176144
7 https://species.nbnatlas.org/species/NHMSYS0020461060

Table 5. The species identified within the core samples taken across Warwick foreshore.

ID	Macro1		Macro2		Macro3		Macro4		Macro5	
	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass	Abundance	Biomass
Animalia	P	-			P	-	P	-	P	-
Fecampia erythrocephala					P	-	P	-		
Nemertea	1	0.0016								
Nematoda	77	0.0001	36	0.0005	127	0.0002	123	0.0033	126	0.0001
Eteone longa	1	0.0001							11	0.0016
Hediste diversicolor	14	0.8376	59	4.1355	17	0.7799	7	0.1813	30	0.9261
Pygospio elegans	54	0.0105					1	0.0051	37	0.0072
Streblospio shrubsolii	3	0.0002	12	0.0084	2	0.0001			25	0.0167
Manayunkia aestuarina	4	0.0001	32	0.0003			24	0.0004	60	0.0023
Paranais litoralis	4	0.0001							2	0.0001
Baltidrilus costatus	6	0.0013	3	0.0005	2	0.0001			137	0.0772
Tubificoides benedii	119	0.0858	117	0.0569	12	0.0159	1	0.0016	797	0.4366
Tubificoides pseudogaster			18	0.0039					338	0.0815
Enchytraeidae	74	0.0067	1	0.0001	11	0.0007	259	0.0249	12	0.0002
Acari							1	0.0001		
Balanomorpha (cyprid)			19	-	8	-				
Balanomorpha (juvenile)					4	-				
Copepoda					6	0.0001				
Peringia ulvae	7	0.0009	1	0.0001	1	0.0001	28	0.0238	101	0.0195
Limapontia depressa	1	0.0001			1	0.0001			2	0.0001
Mytilus edulis					6	0.0011				
Kurtiella bidentata									1	0.0001
Tellinoidea	1	0.0001			9	0.0006				
Macoma balthica					1	0.0272			2	0.0792
Scrobicularia plana							3	5.6502	3	2.5656
Scrobicularia plana <10mm			1	0.0143	9	0.0029			9	0.0062
Ulva intestinalis	P	-	P	-			P	-	P	-
Ulva lactuca	P	-	P	-						
Collembola	1	0.0001					22	0.0014		
Dolichopodidae	3	0.0282			1	0.0112				
Lemna	P	-	P	-						

Table 6. The TOC analysis results presented using the loss on ignition percentage.

ID	Loss on Ignition (LOI) %
Macro1	5.24
Macro2	5.33
Macro3	6.16
Macro4	5.70
Macro5	3.68

3.3 Phase 1 Intertidal habitat Survey

3.3.1 Mostyn

The Mostyn site consisted of eight distinct biotopes, five of which were present within the southern extent (Figure 10). In addition to the five biotopes shared with the southern extent, three additional biotopes were present in the northern extent (Figure 11).

The eight biotopes are listed below with biotopes exclusively present within the northern extent marked with '†':

- LR.FLR.Eph.EphX: Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata;
- LR.FLR.Lic: Lichens or small green algae on supralittoral and littoral fringe rock†;
- LR.LLR: Low energy littoral rock;
- LR.LLR.FVS.Fcer: *Fucus ceranoides* of reduced salinity eulittoral rock;
- LR.LLR.FVS.FspiVS: *Fucus spiralis* on sheltered variable salinity upper eulittoral rock†;
- LS.LCS.Sh.BarSh: Barren littoral shingle;
- LS.LSa.MoSa: Barren or amphipod-dominated mobile sand shores†; and
- LS.LSa.MuSa: Polychaete/bivalve dominated muddy sand shores.

The distribution and rationale for defining the commonly occurring biotopes is discussed below.

The majority of the upper littoral zone of the foreshore was determined to be *barren littoral shingle (LS.LCS.Sh.BarSh*) with much of this area consisting of loose rock material between 4-256 mm. This material consisted of shingle (small stone, cobbles and gravel), with pockets of degraded debris (concrete, brickwork and metal). Moving seaward this was then followed by a narrow but consistent band of *Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata (LR.FLR.Eph.EphX)*. Within this band, shore crab (*Carcinus maenas*) and common periwinkle (*Littorina littoria*) were occasionally observed. The mid-lower shore primarily consisted of the biotope *Fucus ceranoides of reduced salinity eulittoral rock (LR.LLR.FVS.Fcer).* Other brown algae such as spiral wrack (*Fucus spiralis*) and channelled wrack (*Pelvetia canaliculata*) was also infrequently observed in the vicinity of the Bull Nose (the former sandstone breakwater head). The lower shore consisted largely of intertidal mud/sand flats, and most closely matched to the biotope *Polychaete/bivalve dominated muddy sand shores (*LS.LSa.MuSa).

Similarly to the southern extent, the high and middle shore was predominantly dominated by hard substrate. The upper most limit consisted of low energy littoral rock. However, much of this band was above the mean high-water level. This was followed by a band of *Barren littoral shingle (LS.LCS.Sh.BarSh)* and *Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata (LR.FLR.Eph.EphX)*.

Towards the mid to lower shore both *Fucus ceranoides* and *Fucus spiralis* were present. *Fucus ceranoides* was most abundant on the lower shore attached to large shingle and loose rock, with these areas being classified as *Fucus ceranoides of reduced salinity eulittoral rock (LR.LLR.FVS.Fcer).*

The areas of slag deposit, which are present along the outer (down river) breakwater supported an abundance of *fucus spiralis* and was therefore classified as *Fucus spiralis on sheltered variable salinity upper eulittoral rock (LR.LLR.FVS.FspiVS)*. Both *Fucus* biotopes were present in the vicinity of the Bull Nose where clear vertical zonation was observed. On the mud/sand flats within the survey extent there was evidence of polychaete casts and burrows, and the common cockle (*Cerastoderma edule)* was frequently recorded. This, coupled with the PSA results for this area, resulted in the habitat being most appropriately classified as *Polychaete/bivalve-dominated muddy sand shores* (*LS.LSa.MuSa*).

The biotope *Barren or amphipod-dominated mobile sand shores (LS.LSa.MoSa*) was encountered in the area adjacent to the old sand quarry. It is likely that the presence of this sand material is the result of spillover/discharge from the quarry as it was localised to this area and was not observed anywhere else within the survey extent or further afield.

Figure 10. The southern most section of the Mostyn site and the associated biotopes identified during the Phase 1 survey

Figure 11. The northern most section of the Mostyn site and the associated biotopes identified during the Phase 1 survey.

3.3.2 Warwick

The foreshore at the Warwick site was heavily modified by industrial activity, with breeze blocks and other building materials discarded across large areas of the foreshore (Image 1). To maintain consistency within the biotope classifications, the discarded material was first classified as either littoral rock or shingle, this was dependent on the condition and size class of the material with rock and debris between 4-256 mm classified as shingle[8] and larger material classified as rock. In the event that biological indicators were present, these were then used to further refine the classification. This is in line with the approach that was used for natural habitats.

Image 1. Evidence of industrial activity and discarded material on the Warwick foreshore.

Overall, seven biotopes were identified across the Warwick foreshore:

- LR.LLR: Low energy littoral rock;
- LR.FLR.Eph.EphX: Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata;
- LS.LSa.MoSa.BarSa: Barren littoral coarse sand;
- LS.LSa.St.Tal: Talitrids on the upper shore and strand-line;
- LS.LCS.Sh.BarSh: Barren littoral shingle;
- LR.LLR.FVS: Fucoids in variable salinity
- LS. LMu.UEst: Polychaete/oligochaete-dominated upper estuarine mud shores

The upper shore consisted of *Low energy littoral rock (LR.LLR)*, with much of this being artificial. Additionally, the upper shore had areas to the northwest and to the southeast where rock gave way to *Barren littoral coarse sand (LS.LSa.MoSa.BarSa)*. Within the northwestern section, there was a pocket of coarse sand which supported the biotope *Talitrids on the upper shore and strand-line (LS.LSa.St.Tal)*. The mid shore consisted of large areas of *Barren littoral shingle (LS.LCS.Sh.BarSh*) and *Ephemeral green and red seaweeds on variable salinity and/or disturbed eulittoral mixed substrata (*LR.FLR.Eph.EphX). The latter area supported communities of common periwinkle (*Littorina littorea*) and rough periwinkle (*Littorina saxatilis*). Juvenile green shore crabs (*Carcinus maenas*) were also frequently encountered. The mixed substrate occasionally supported a small number of barnacles, of which the majority were *Semibalanus balanoides*. The non-native barnacle *Austrominius modestus* was also occasionally encountered within this zone (Image 2).

[8] Size class for shingle is based on guidance provided within the JNCC habitat classification for biotope Barren littoral shingle - JNCC Marine Habitat Classification

The *barren littoral shingle* (*LS.LCS.Sh.BarSh*) zone continued in to the mid-lower shore, however there were large areas where the biotope *Fucoids in variable salinity* (*LR.LLR.FVS*) was prevalent. This was not refined as the distribution and abundance of fucoids was relatively consistent between three key species: horned wrack (*Fucus ceranoides),* spiral wrack (*Fucus spiralis)* and channelled wrack *(Pelvetia canaliculata)*. This was likely in part due to the topography of the site with a number of areas being raised due to the artificial material deposited on the foreshore. The lower shore and adjacent mud flats were best represented by the biotope *Polychaete/oligochaete-dominated upper estuarine mud shores (LS.LMu.UEst)*. This classification was reinforced by the macrofaunal analysis and PSA results, which identified that the majority of organisms were oligochaetes and that the mudflat consisted largely of sandy mud sediment.

Image 2. **Semibalanus balanoides and a singular Austrominius modestus barnacle (bottom left) on barren littoral shingle.**

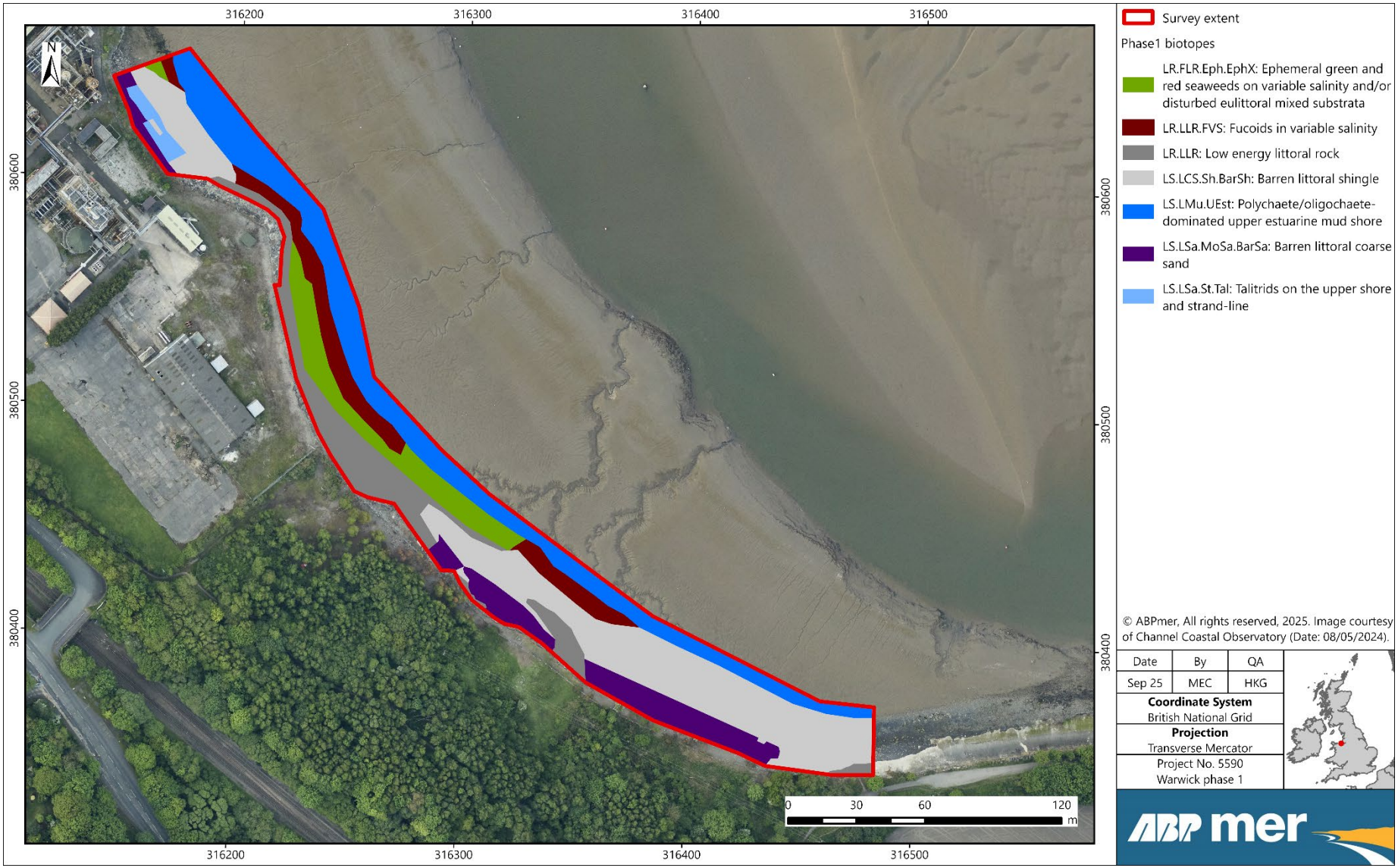

Figure 12. Warwick site and the associated biotopes identified during the Phase 1 survey.

4 Conclusion

Both the Mostyn and Warwick sites were predominantly characterised as being heavily modified rock and shingle shores with varying levels of flora and fauna present. The species composition was largely dictated by the estuarine nature of the site, with many of the species observed known to be tolerant to low salinity conditions. The absence of many important species associated with the Dee Estuary can be attributed to the artificial introduction of hard substrate coupled with associated changes to the elevation and gradient of the foreshore.

The lower shore was characterised predominantly by intertidal mud/sandflats, typical of the wider estuary, and dominated by polychaete and bivalves at Mostyn and polychaetes and oligochaetes at Warwick.

The level of contamination across both locations did not exceed AL2 but did show some exceedances of AL1 reflecting the past industrial nature of the sites. The risk of disturbance/resuspension during the works is low and unlikely to have significant effects on the wider area given the scrape back works will take place when the foreshore is exposed (i.e., in the dry).

There was no evidence of biotopes or species of ecological importance or value within the areas that will be scraped back. Beyond the scrape back areas, within the adjacent intertidal mud/sand flats, there appears to be a healthy polychaete and bivalve population which has been shown to actively support the estuary's bird population.

This survey is in line with the site descriptions presented within the Compensation Plan and Construction Environmental Management Plan (CEMP) (ABPmer, 2025b; ABPmer 2025c). In summary, the habitat within the scrape back areas is of low ecological value.

5 References

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6 Abbreviations/Acronyms

AHCH	Alpha-Hexachlorocyclohexane
AL	Action Level
As	Arsenic
BDEs	Brominated diphenyl ether
BHCH	Benzene Hexachloride
CCW	Countryside Council for Wales
Cd	Cadmium
Cefas	Centre for Environment, Fisheries and Aquaculture Science
CEMP	Construction Environmental Management Plan
Con	Contamination Site
Cr	Chromium
Cu	Copper
°C	Degrees Celsius
DBT	Dibutyltin
GHCH	Gamma-Hexachlorocyclohexane
GNSS	Global Navigation Satellite System
HCB	Hexachloroethane
Hg	Mercury
ID	Identity(ies)
IEC	International Electrotechnical Commission
INNS	Invasive non-native species
ISO	International Organization for Standardization
JNCC	Joint Nature Conservation Committee
LoD	Limit of detection
LOI	Loss-on-ignition
Macro #	Macrofaunal Sample Site
MEC	M E Cooper
MHCBI	Marine Habitat Classification for Britain & Ireland
MMO	Marine Management Organisation
MO	Mostyn
MODE	The phi value of the most abundant size class
NBN	National Biodiversity Network Trust:
Ni	Nickel
NMBAQC	National Marine Biological Analytical Quality Control
NRW	Natural Resources Wales
ODN	Ordnance Datum Newlyn
OSGB36	Ordnance Survey Great Britain 1936
OSGM15	Ordnance Survey geoid models
OSTN15	Ordnance Survey Transformation Grid
PAHs	Polycyclic Aromatic Hydrocarbons
Pb	Lead
PCBs	Polychlorinated Biphenyls
PPDDE	pp'-Dichlorodiphenyl-dichloroethylene
PPDDT	pp'-Dichlorodiphenyl-trichloroethane
PPTDE	pp'-Dichloroethylidene
PSA	Particle Size Analysis
RTK	Real Time Kinematic
TBT	Tributyltin

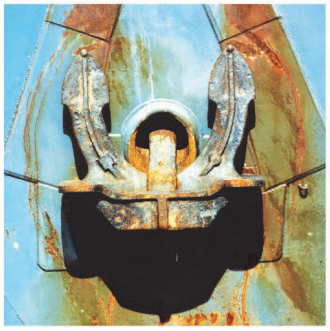
TOC	Total Organic Carbon
TR	Transect
UK	United Kingdom
WA	Warwick
zn	Zinc

Cardinal points/directions are used unless otherwise stated.

SI units are used unless otherwise stated.

Appendices

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A Elevation Transects

A.1 Mostyn

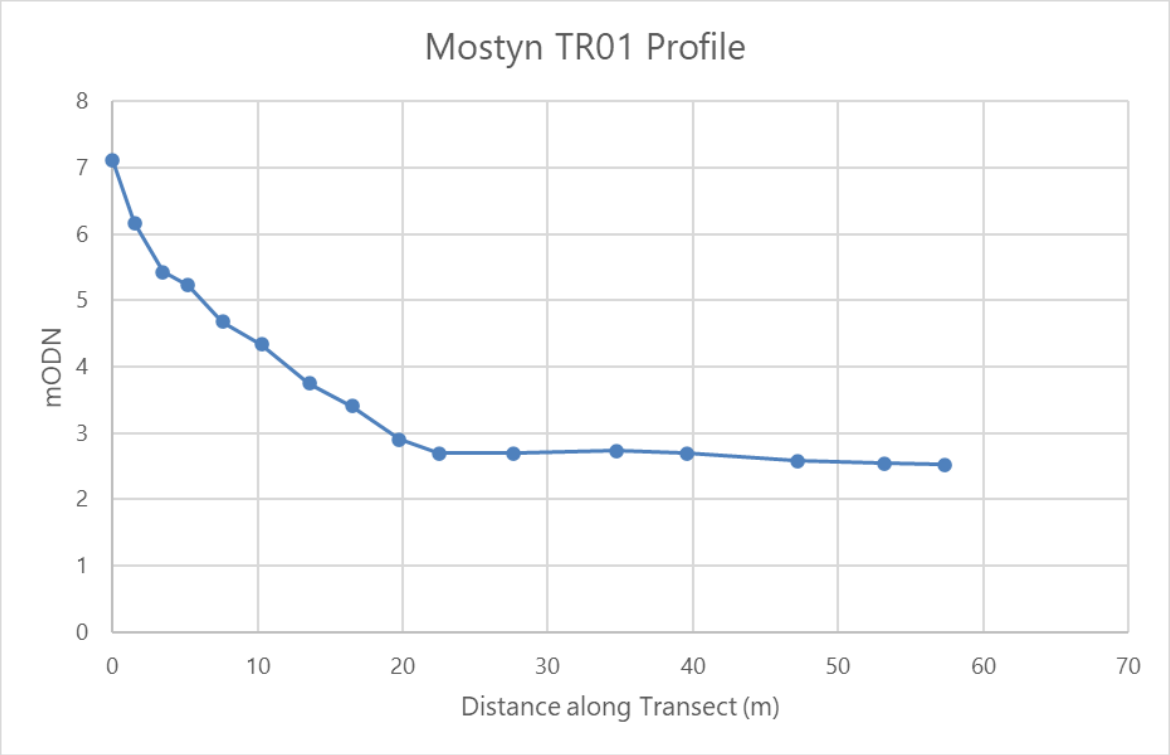

Figure A1. Mostyn TR01 Profile

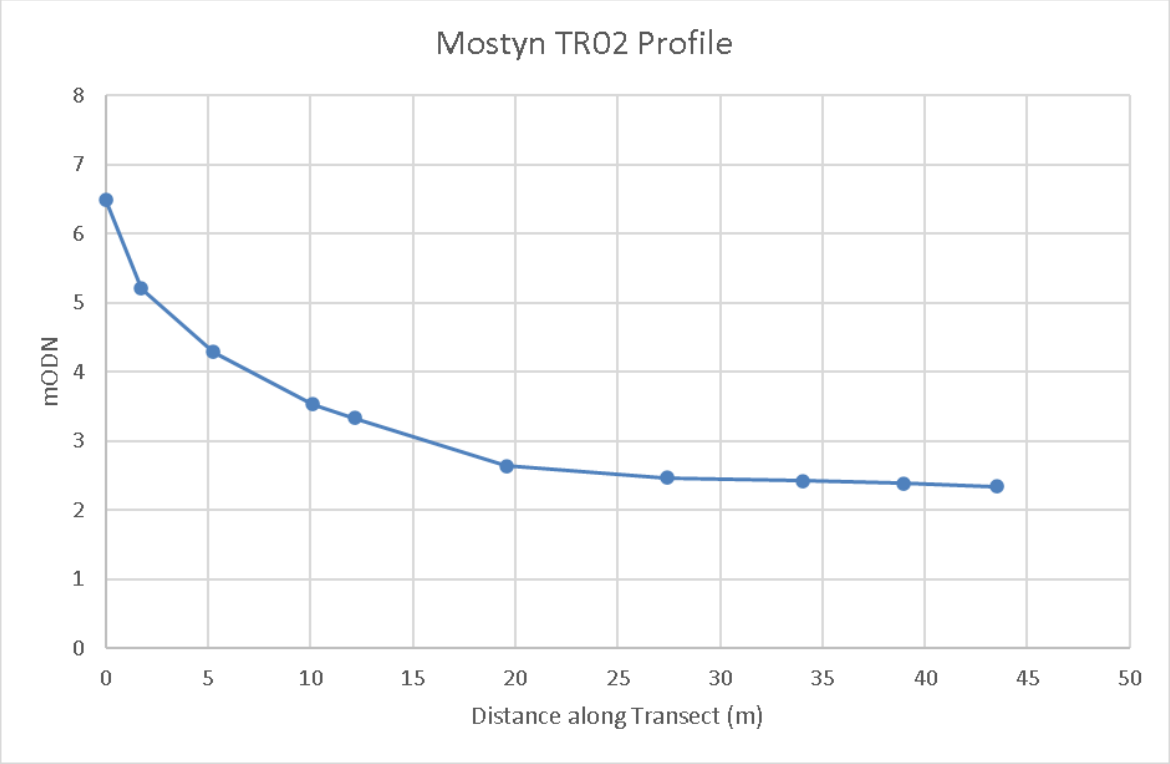

Figure A2. Mostyn TR02 Profile

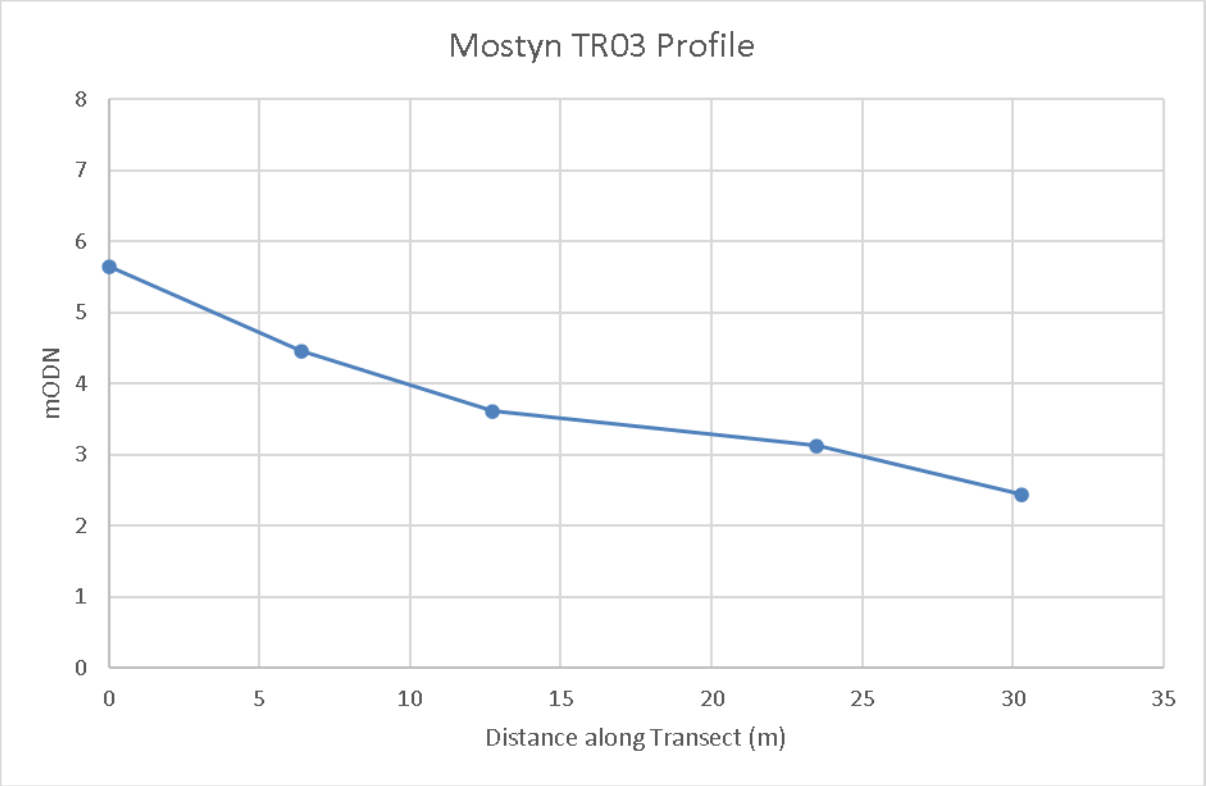

Figure A3. Mostyn TR03 Profile

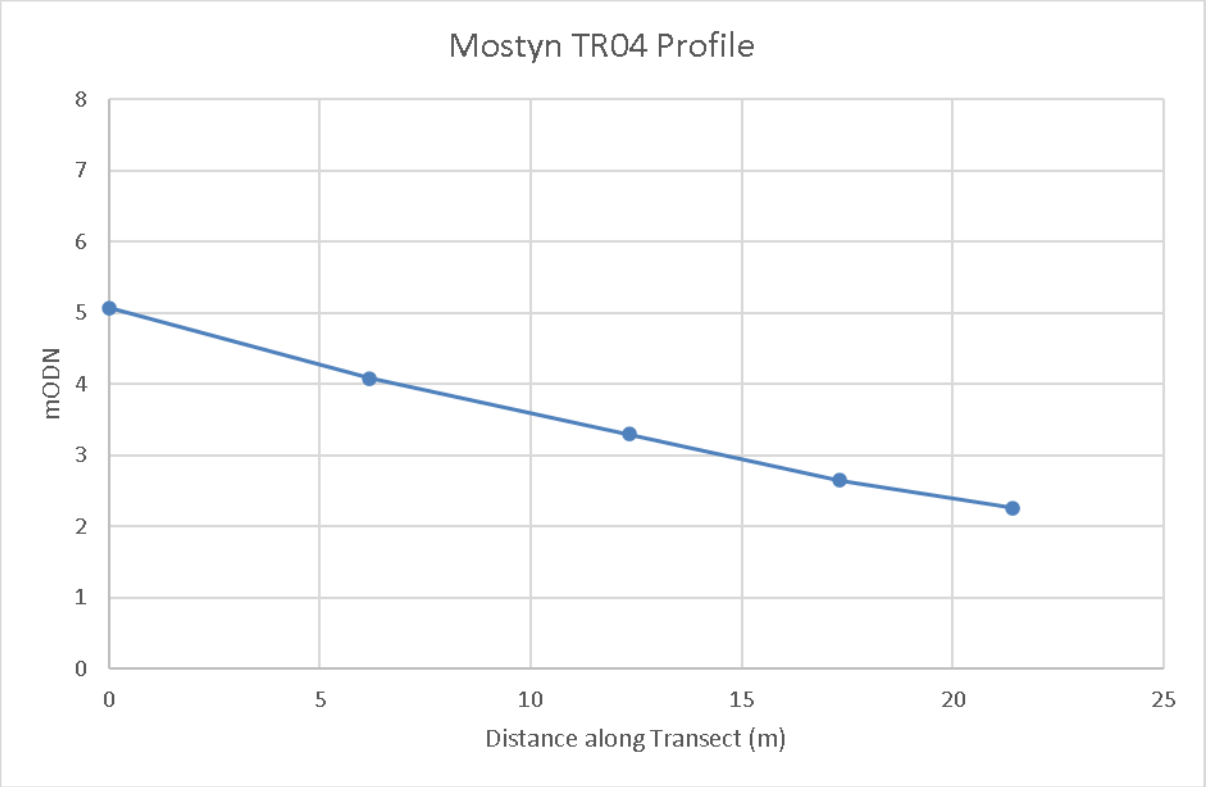

Figure A4. Mostyn TR04 Profile

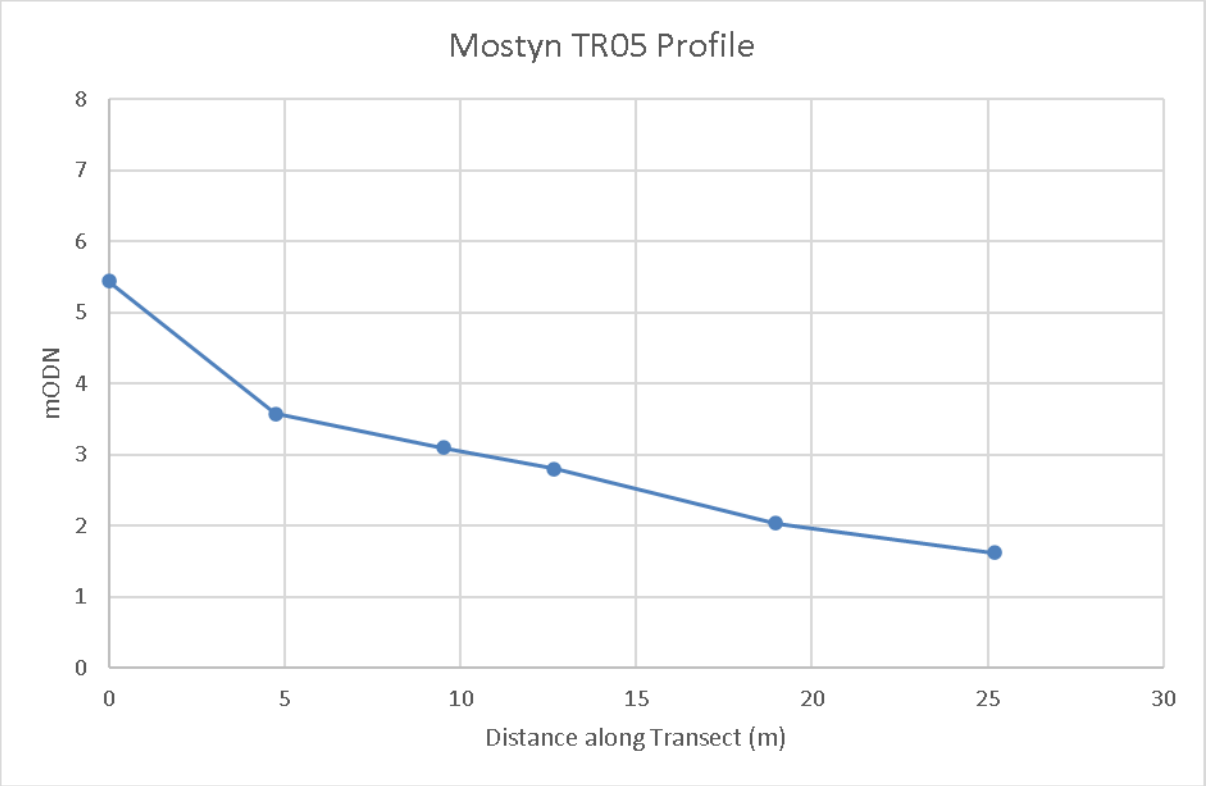

Figure A5. Mostyn TR05 Profile

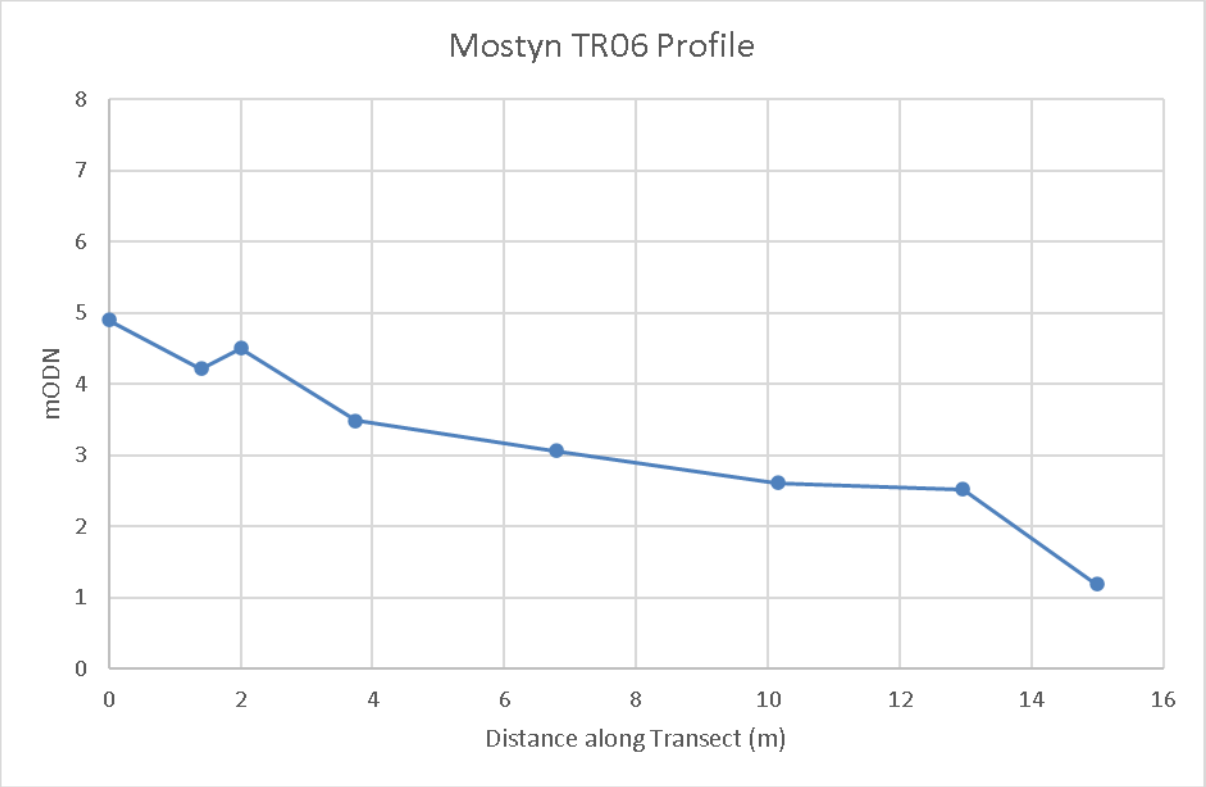

Figure A6. Mostyn TR06 Profile

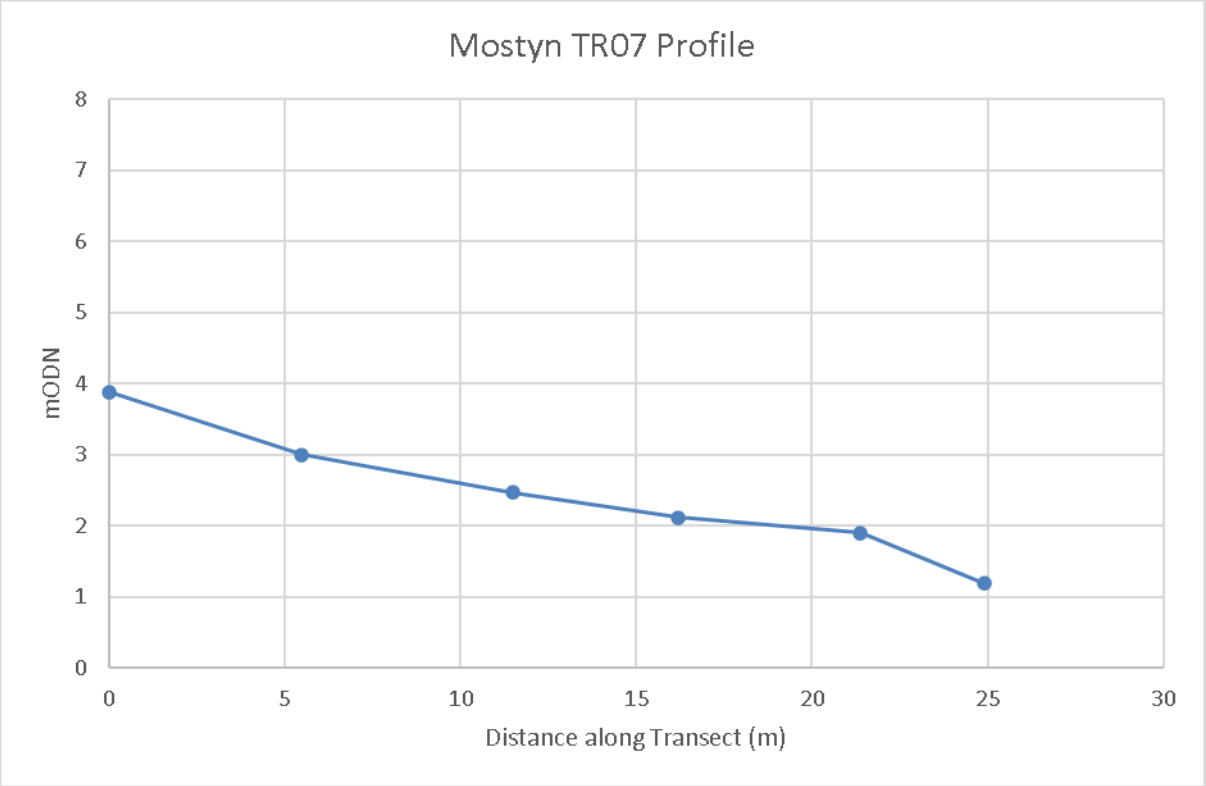

Figure A7. Mostyn TR07 Profile

A.2 Warwick

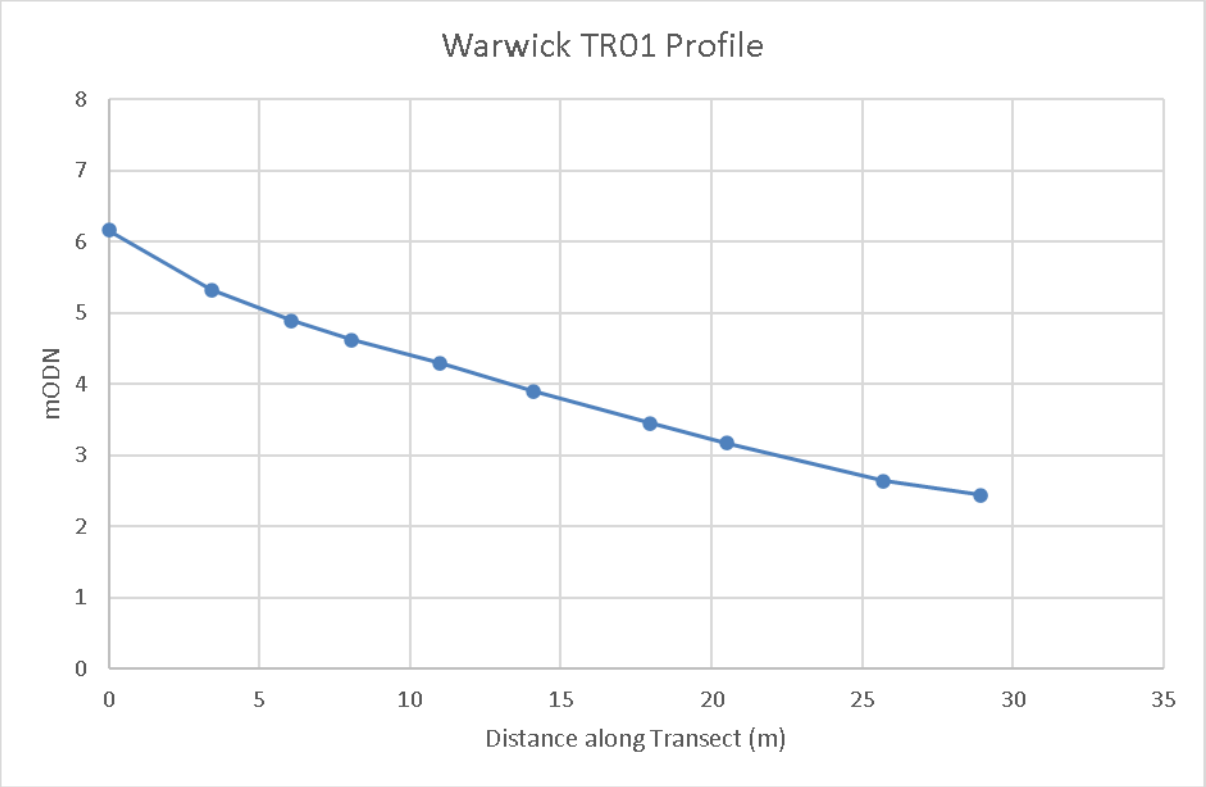

Figure A8. Warwick TR01 Profile

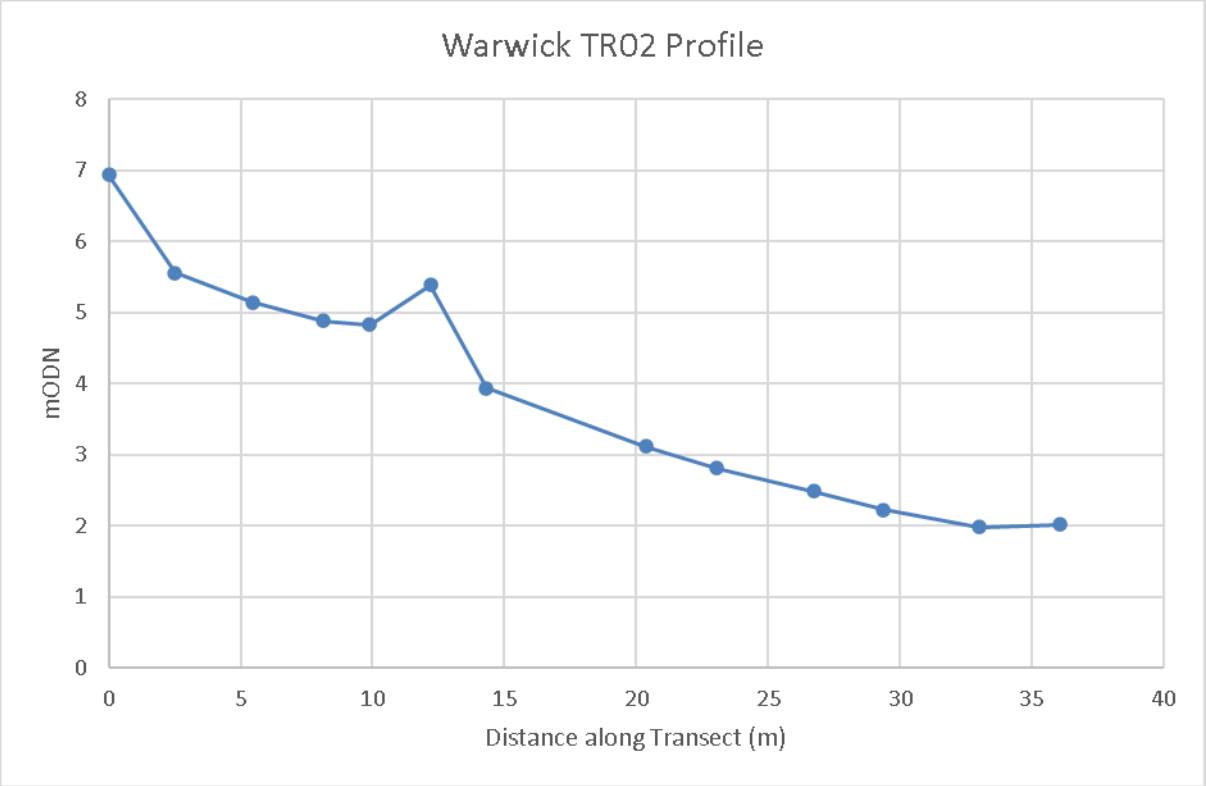

Figure A9. Warwick TR02 Profile

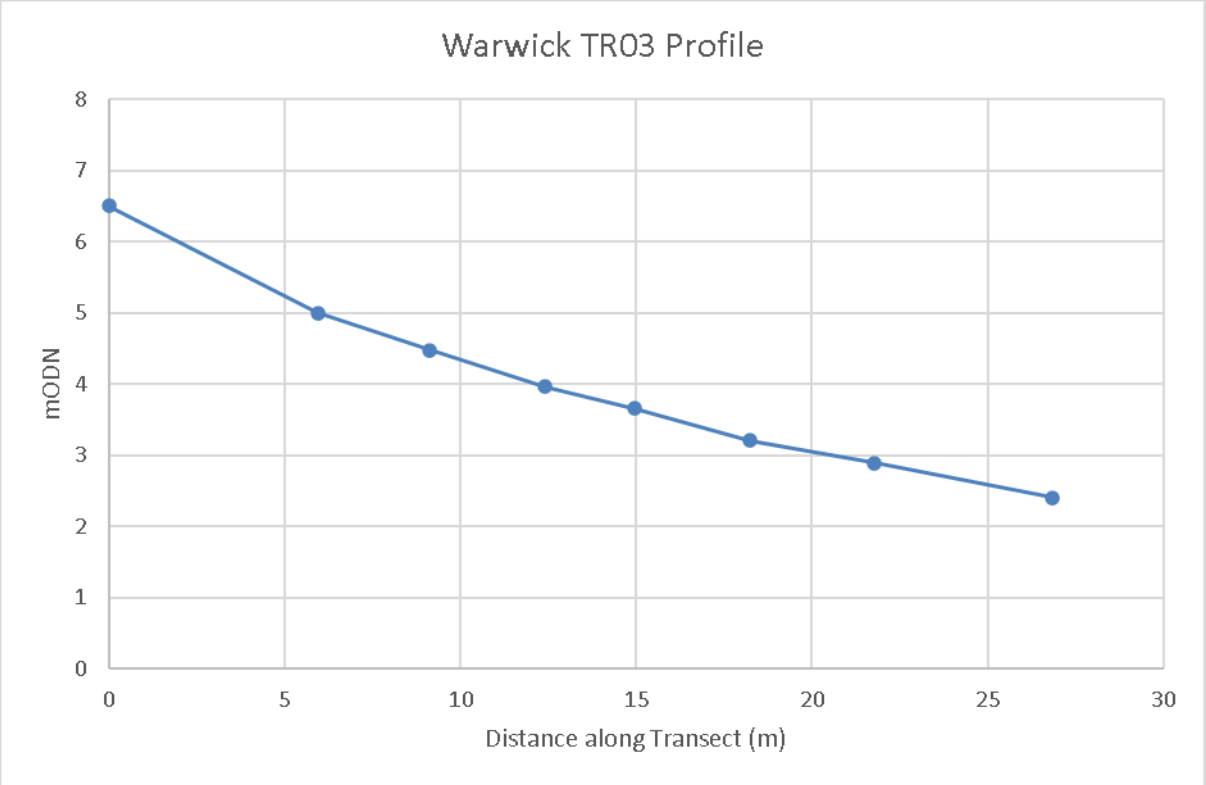

Figure A10. Warwick TR031 Profile

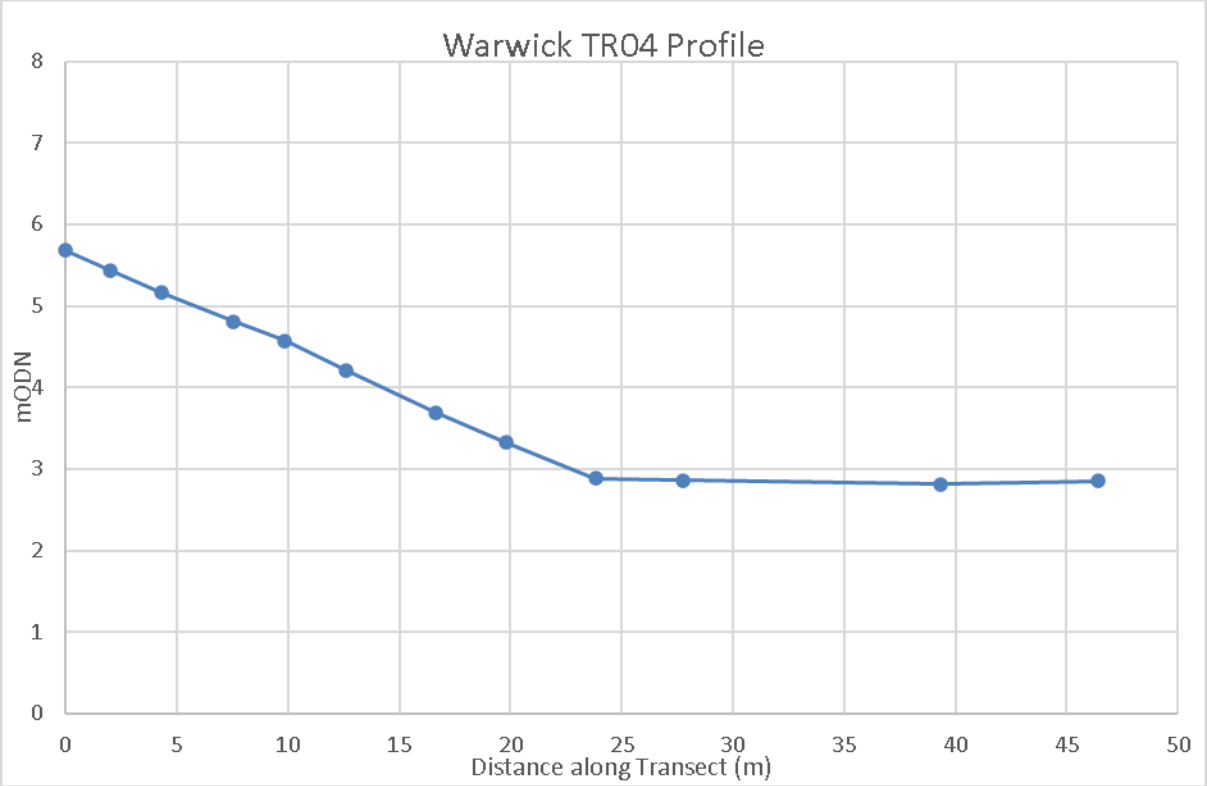

Figure A11. Warwick TR04 Profile

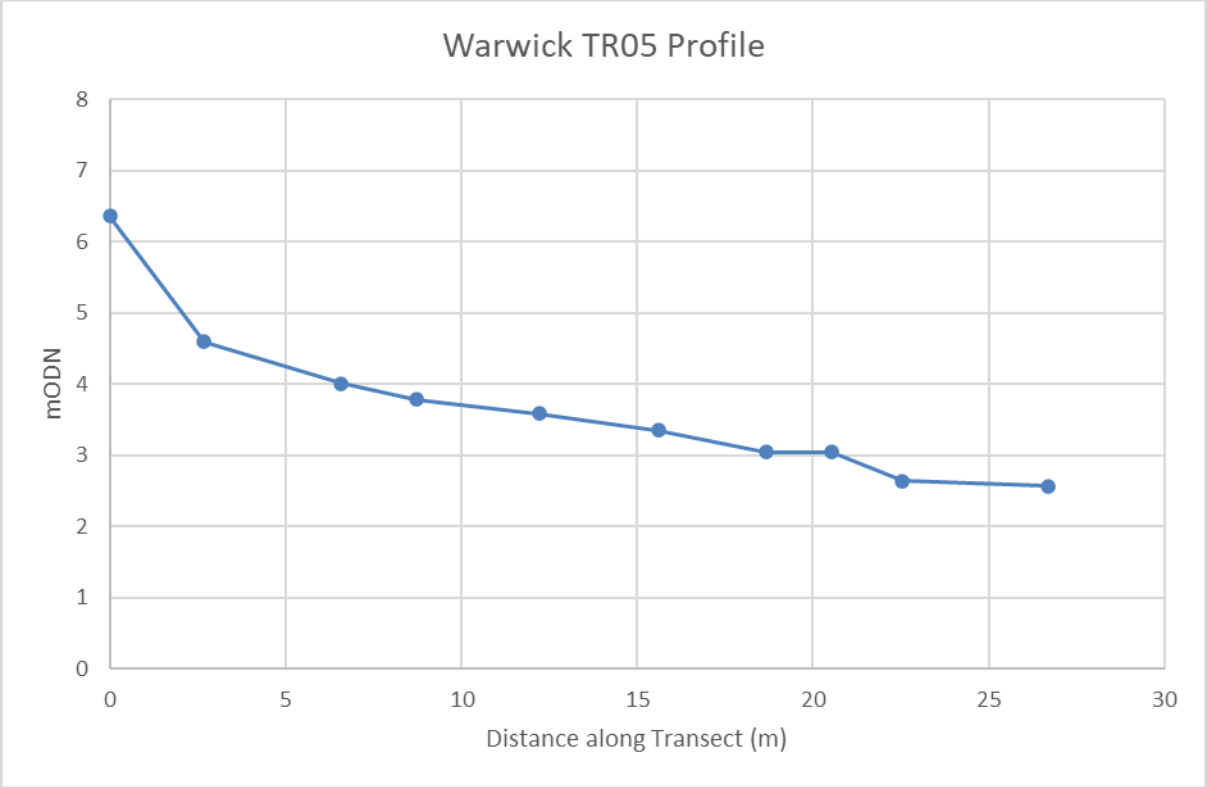

Figure A12. Warwick TR05 Profile

B PSA Results

B.1 Mostyn PSA results

Table B1. Mostyn PSA results

Sample ID		MO1	MO2	MO3	MO4	MO5	MO6	MO7	MO8	MO9	MO10	MO11	MO12
Analyst and Date:		MEC, 23 April 2025											
Sample type:		Trimodal, Extremely Poorly Sorted	Unimodal, Moderately Sorted	Bimodal, Very Poorly Sorted	Trimodal, Extremely Poorly Sorted	Unimodal, Poorly Sorted	Bimodal, Very Poorly Sorted	Unimodal, Poorly Sorted	Bimodal, Poorly Sorted	Bimodal, Poorly Sorted	Unimodal, Poorly Sorted	Bimodal, Very Poorly Sorted	Bimodal, Very Poorly Sorted
Textural group:		Slightly Gravelly Sandy Mud	Sand	Sandy Mud	Gravelly Mud	Sand	Sandy Mud	Sandy Mud	Sandy Mud	Sandy Mud	Sandy Mud	Sandy Mud	Sandy Mud
Sediment name:		Slightly Very Fine Gravelly Medium Sandy Mud	Moderately Sorted Fine Sand	Fine Sandy Medium Silt	Medium Gravelly Mud	Poorly Sorted Medium Sand	Very Fine Sandy Very Coarse Silt	Very Fine Sandy Medium Silt	Very Fine Sandy Medium Silt	Very Fine Sandy Medium Silt	Very Fine Sandy Fine Silt	Very Fine Sandy Medium Silt	Fine Sandy Medium Silt
Method of moments Arithmetic (mm)	Mean	336.3	217.2	78.31	704.4	249.5	72.69	36.46	45.11	35.75	30.58	52.26	99.10
	Sorting	1344.1	93.98	89.79	2580.2	109.7	75.89	67.54	100.7	52.11	48.05	90.25	112.8
	Skewness	8.838	-0.041	1.436	6.163	-0.324	1.496	4.907	5.852	4.164	3.985	4.032	1.136
	Kurtosis	93.91	3.200	4.499	45.51	3.303	5.316	33.17	48.65	28.70	25.01	24.43	3.349
Method of moments Geometric (mm)	Mean	17.75	174.3	32.82	25.14	189.6	34.29	15.70	16.00	16.94	13.70	19.63	35.73
	Sorting	24.57	2.416	4.338	29.03	2.810	4.043	3.408	3.809	3.374	3.416	4.040	5.157
	Skewness	-0.616	-2.944	-0.204	-0.537	-2.710	-0.429	0.325	0.449	0.141	0.279	0.212	-0.185
	Kurtosis	2.569	12.30	1.931	2.587	9.920	2.108	2.798	2.823	2.301	2.466	2.306	1.709
Method of moments Logarithmic (f)	Mean	5.816	2.520	4.929	5.314	2.399	4.866	5.993	5.965	5.884	6.190	5.671	4.807
	Sorting	4.619	1.273	2.117	4.860	1.491	2.015	1.769	1.929	1.755	1.772	2.014	2.366
	Skewness	0.616	2.944	0.204	0.537	2.710	0.429	-0.325	-0.449	-0.141	-0.279	-0.212	0.185
	Kurtosis	2.569	12.30	1.931	2.587	9.920	2.108	2.798	2.823	2.301	2.466	2.306	1.709
Folk and Ward method (mm)	Mean	18.35	203.2	33.32	23.26	241.8	35.45	15.43	15.45	16.94	13.49	19.35	35.44
	Sorting	28.96	1.936	4.542	31.82	2.144	4.188	3.368	3.740	3.449	3.483	4.116	5.281
	Skewness	-0.378	-0.355	-0.082	-0.332	-0.394	-0.306	0.083	0.149	0.069	0.142	0.101	-0.069
	Kurtosis	1.041	2.286	0.736	1.028	2.825	0.773	0.885	0.859	0.812	0.853	0.821	0.661
Folk and Ward method (f)	Mean	5.768	2.299	4.907	5.426	2.048	4.818	6.018	6.017	5.883	6.212	5.692	4.818
	Sorting	4.856	0.953	2.183	4.992	1.100	2.066	1.752	1.903	1.786	1.800	2.041	2.401
	Skewness	0.378	0.355	0.082	0.332	0.394	0.306	-0.083	-0.149	-0.069	-0.142	-0.101	0.069
	Kurtosis	1.041	2.286	0.736	1.028	2.825	0.773	0.885	0.859	0.812	0.853	0.821	0.661
Folk and Ward method (Description)	Mean	Coarse Silt	Fine Sand	Very Coarse Silt	Coarse Silt	Fine Sand	Very Coarse Silt	Medium Silt	Medium Silt	Coarse Silt	Medium Silt	Coarse Silt	Very Coarse Silt
	Sorting	Extremely Poorly Sorted	Moderately Sorted	Very Poorly Sorted	Extremely Poorly Sorted	Poorly Sorted	Very Poorly Sorted	Poorly Sorted	Poorly Sorted	Poorly Sorted	Poorly Sorted	Very Poorly Sorted	Very Poorly Sorted
	Skewness	Very Fine Skewed	Very Fine Skewed	Symmetrical	Very Fine Skewed	Very Fine Skewed	Very Fine Skewed	Symmetrical	Coarse Skewed	Symmetrical	Coarse Skewed	Coarse Skewed	Symmetrical
	Kurtosis	Mesokurtic	Very Leptokurtic	Platykurtic	Mesokurtic	Very Leptokurtic	Platykurtic	Platykurtic	Platykurtic	Platykurtic	Platykurtic	Platykurtic	Very Platykurtic
	MODE 1 (mm):	61.50	256.0	128.0	61.50	256.0	84.50	9.184	9.184	9.184	5.236	9.184	181.0
	MODE 2 (mm):	462.5		9.184	462.5		9.184		49.00	49.00		61.50	9.184
	MODE 3 (mm):	5.236			5.236								
	MODE 1 (f):	4.024	1.987	2.987	4.024	1.987	3.613	6.859	6.859	6.859	7.593	6.859	2.487
	MODE 2 (f):	1.117		6.859	1.117		6.859		4.356	4.356		4.024	6.859
	MODE 3 (f):	7.593			7.593								
	D10 (mm):	0.091	112.2	4.472	0.106	115.3	4.564	3.250	3.036	3.429	2.875	3.248	3.788
	D50 (mm):	44.59	209.8	35.37	51.16	246.9	48.95	14.38	13.55	15.69	11.93	17.53	37.29

Sample ID		MO1	MO2	MO3	MO4	MO5	MO6	MO7	MO8	MO9	MO10	MO11	MO12
Analyst and Date:		MEC, 23 April 2025											
	D90 (mm):	566.3	345.6	208.6	1151.5	391.9	177.5	79.30	93.73	87.53	76.72	125.9	269.6
	(D90 / D10) (mm):	6215.1	3.081	46.63	10899.6	3.398	38.89	24.40	30.87	25.53	26.69	38.78	71.16
	(D90 - D10) (mm):	566.2	233.5	204.1	1151.4	276.6	172.9	76.05	90.69	84.10	73.84	122.7	265.8
	(D75 / D25) (mm):	64.30	1.720	12.64	81.05	1.708	10.16	6.038	7.300	6.980	6.472	9.122	20.20
	(D75 - D25) (mm):	181.0	114.2	112.5	306.6	131.0	96.54	31.66	36.52	38.99	29.45	52.65	161.0
	D10 (f):	0.820	1.533	2.261	-0.204	1.352	2.494	3.656	3.415	3.514	3.704	2.989	1.891
	D50 (f):	4.487	2.253	4.821	4.289	2.018	4.353	6.120	6.206	5.994	6.389	5.834	4.745
	D90 (f):	13.42	3.156	7.805	13.21	3.116	7.776	8.265	8.363	8.188	8.442	8.266	8.044
	(D90 / D10) (f):	16.36	2.059	3.451	-64.900	2.306	3.117	2.260	2.449	2.330	2.279	2.765	4.253
	(D90 - D10) (f):	12.60	1.623	5.543	13.41	1.765	5.281	4.609	4.948	4.674	4.738	5.277	6.153
	(D75 / D25) (f):	3.458	1.417	2.206	4.757	1.465	2.038	1.550	1.629	1.629	1.556	1.782	2.693
	(D75 - D25) (f):	6.007	0.782	3.659	6.341	0.772	3.345	2.594	2.868	2.803	2.694	3.189	4.336
	% Gravel:	2.2%	0.0%	0.0%	5.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	% Sand:	34.9%	93.1%	40.7%	36.7%	90.8%	43.5%	13.6%	16.7%	16.9%	13.0%	23.7%	44.4%
	% Mud:	62.9%	6.9%	59.3%	58.3%	9.2%	56.5%	86.4%	83.3%	83.1%	87.0%	76.3%	55.6%
	% Very Coarse gravel:	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	% Coarse gravel:	0.2%	0.0%	0.0%	0.9%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	% Medium gravel:	0.6%	0.0%	0.0%	1.5%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	% Fine gravel:	0.7%	0.0%	0.0%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	% V Fine gravel:	0.8%	0.0%	0.0%	1.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	% V Coarse sand:	4.0%	0.0%	0.0%	6.4%	0.0%	0.0%	0.0%	0.1%	0.0%	0.0%	0.0%	0.0%
	% Coarse sand:	5.9%	0.0%	0.0%	6.8%	0.8%	0.0%	0.4%	1.1%	0.1%	0.0%	0.8%	0.0%
	% Medium sand:	9.2%	33.3%	6.4%	9.1%	47.8%	3.8%	2.0%	2.2%	1.0%	1.0%	3.0%	12.3%
	% Fine sand:	8.6%	52.9%	17.9%	7.8%	40.6%	16.1%	2.2%	3.2%	3.3%	3.0%	6.3%	21.4%
	% V Fine sand:	7.3%	6.9%	16.3%	6.6%	1.5%	23.6%	9.0%	10.2%	12.5%	9.0%	13.6%	10.7%
	% V Coarse silt:	18.5%	0.5%	11.5%	16.8%	0.9%	14.5%	16.2%	14.6%	17.0%	14.3%	14.6%	8.2%
	% Coarse silt:	5.5%	1.8%	13.0%	5.1%	2.1%	10.3%	17.9%	15.2%	16.2%	15.7%	14.2%	10.6%
	% Medium silt:	5.1%	1.6%	14.2%	4.7%	2.3%	12.1%	20.6%	19.5%	19.5%	20.3%	17.5%	13.3%
	% Fine silt:	7.0%	1.6%	12.1%	6.5%	2.3%	11.2%	18.6%	19.2%	18.3%	20.4%	16.9%	13.2%
	% V Fine silt:	3.9%	1.2%	7.3%	3.7%	1.5%	7.1%	11.4%	12.7%	10.8%	13.9%	11.2%	8.9%
	% Clay:	22.9%	0.0%	1.2%	21.4%	0.1%	1.2%	1.7%	2.1%	1.3%	2.4%	1.9%	1.5%

B.2 Warwick PSA results

Table B2. Warwick PSA results

Sample ID		WA1	WA2	WA3	WA4	WA5	WA6	WA7	WA8	WA9	WA10	WA11	WA12	WA13	WA14
Analyst and Date:		MEC, 23 April 2025													
Sample type:		Trimodal, Extremely Poorly Sorted	Bimodal, Very Poorly Sorted	Bimodal, Poorly Sorted	Trimodal, Extremely Poorly Sorted	Bimodal, Poorly Sorted	Unimodal, Poorly Sorted	Trimodal, Extremely Poorly Sorted	Unimodal, Poorly Sorted	Trimodal, Extremely Poorly Sorted	Trimodal, Very Poorly Sorted	Bimodal, Poorly Sorted	Trimodal, Very Poorly Sorted	Trimodal, Extremely Poorly Sorted	Bimodal, Poorly Sorted
Textural group:		Gravelly Mud	Sandy Mud	Sandy Mud	Gravelly Mud	Sandy Mud	Sandy Mud	Slightly Gravelly Sandy Mud	Sandy Mud	Gravelly Mud	Sandy Mud	Sandy Mud	Sandy Mud	Slightly Gravelly Sandy Mud	Sandy Mud
Sediment name:		Medium Gravelly Mud	Very Fine Sandy Medium Silt	Very Fine Sandy Very Coarse Silt	Coarse Gravelly Mud	Very Fine Sandy Medium Silt	Very Fine Sandy Medium Silt	Slightly Very Fine Gravelly Medium Sandy Mud	Very Fine Sandy Medium Silt	Coarse Gravelly Mud	Very Fine Sandy Medium Silt	Very Fine Sandy Very Coarse Silt	Very Fine Sandy Medium Silt	Slightly Very Fine Gravelly Medium Sandy Mud	Very Fine Sandy Medium Silt
Method of Moments Arithmetic (mm)	Mean	704.4	50.95	52.97	894.0	31.35	39.27	384.9	36.53	1247.8	79.07	43.03	75.68	400.8	38.36
	Sorting	2580.2	92.27	77.60	3216.9	43.48	74.73	1587.6	77.16	4025.6	133.3	63.85	162.9	1330.9	65.62
	Skewness	6.163	3.290	3.286	5.483	3.899	4.962	10.16	5.418	4.262	2.683	4.345	4.398	7.656	5.336
	Kurtosis	45.51	14.74	17.42	34.86	27.08	35.35	126.8	39.72	21.36	10.87	30.62	27.92	77.84	42.80
Method of Moments Geometric (mm)	Mean	25.14	18.26	22.44	29.06	15.23	15.54	21.24	14.32	25.07	24.45	19.55	22.46	18.96	17.17
	Sorting	29.03	3.936	3.862	29.85	3.336	3.655	25.02	3.488	37.11	4.748	3.622	4.442	27.63	3.454
	Skewness	-0.537	0.421	0.036	-0.534	0.075	0.355	-0.660	0.501	-0.333	0.251	0.004	0.379	-0.547	0.179
	Kurtosis	2.587	2.591	2.173	2.646	2.328	2.641	2.622	3.039	2.399	2.214	2.222	2.716	2.433	2.498
Method of Moments Logarithmic (f)	Mean	5.314	5.775	5.478	5.105	6.036	6.008	5.557	6.125	5.318	5.354	5.677	5.477	5.721	5.864
	Sorting	4.860	1.977	1.949	4.900	1.738	1.870	4.645	1.802	5.214	2.247	1.857	2.151	4.788	1.788
	Skewness	0.537	-0.421	-0.036	0.534	-0.075	-0.355	0.660	-0.501	0.333	-0.251	-0.004	-0.379	0.547	-0.179
	Kurtosis	2.587	2.591	2.173	2.646	2.328	2.641	2.622	3.039	2.399	2.214	2.222	2.716	2.433	2.498
Folk and Ward method (mm)	Mean	23.26	17.67	22.19	25.68	15.22	15.18	21.29	13.85	22.62	24.67	19.61	21.22	19.13	16.99
	Sorting	31.82	4.095	3.971	33.32	3.394	3.661	28.77	3.452	46.83	5.046	3.671	4.550	32.80	3.460
	Skewness	-0.332	0.179	-0.015	-0.300	0.040	0.134	-0.370	0.153	-0.229	0.122	-0.050	0.100	-0.342	0.039
	Kurtosis	1.028	0.964	0.811	1.074	0.821	0.865	1.031	0.941	1.039	0.886	0.779	1.004	0.987	0.822
Folk and Ward method (f)	Mean	5.426	5.822	5.494	5.283	6.038	6.042	5.554	6.174	5.466	5.341	5.672	5.559	5.708	5.879
	Sorting	4.992	2.034	1.990	5.058	1.763	1.872	4.846	1.787	5.549	2.335	1.876	2.186	5.035	1.791
	Skewness	0.332	-0.179	0.015	0.300	-0.040	-0.134	0.370	-0.153	0.229	-0.122	0.050	-0.100	0.342	-0.039
	Kurtosis	1.028	0.964	0.811	1.074	0.821	0.865	1.031	0.941	1.039	0.886	0.779	1.004	0.987	0.822
Folk and Ward method (Description)	Mean:	Coarse Silt	Coarse Silt	Coarse Silt	Coarse Silt	Medium Silt	Medium Silt	Coarse Silt	Medium Silt	Coarse Silt	Coarse Silt	Coarse Silt	Coarse Silt	Coarse Silt	Coarse Silt
	Sorting:	Extremely Poorly Sorted	Very Poorly Sorted	Poorly Sorted	Extremely Poorly Sorted	Poorly Sorted	Poorly Sorted	Extremely Poorly Sorted	Poorly Sorted	Extremely Poorly Sorted	Very Poorly Sorted	Poorly Sorted	Very Poorly Sorted	Extremely Poorly Sorted	Poorly Sorted
	Skewness:	Very Fine Skewed	Coarse Skewed	Symmetrical	Fine Skewed	Symmetrical	Coarse Skewed	Very Fine Skewed	Coarse Skewed	Fine Skewed	Coarse Skewed	Symmetrical	Symmetrical	Very Fine Skewed	Symmetrical
	Kurtosis:	Mesokurtic	Mesokurtic	Platykurtic	Mesokurtic	Platykurtic	Platykurtic	Mesokurtic	Mesokurtic	Mesokurtic	Platykurtic	Platykurtic	Mesokurtic	Mesokurtic	Platykurtic
	MODE 1 (mm):	61.50	9.184	61.50	61.50	9.184	9.184	61.50	9.184	61.50	9.184	56.50	41.50	61.50	9.184
	MODE 2 (mm):	462.5	362.5	9.184	462.5	41.50		462.5		462.5	49.00	5.236	9.184	462.5	49.00
	MODE 3 (mm):	5.236			5.236			5.236		5.236	362.5		462.5	5.236	
	MODE 1 (f):	4.024	6.859	4.024	4.024	6.859	6.859	4.024	6.859	4.024	6.859	4.148	4.596	4.024	6.859
	MODE 2 (f):	1.117	1.486	6.859	1.117	4.596		1.117		1.117	4.356	7.593	6.859	1.117	4.356
	MODE 3 (f):	7.593			7.593			7.593		7.593	1.486		1.117	7.593	
	D_{10} (mm):	0.106	3.332	3.704	0.117	3.065	3.024	0.103	3.037	0.087	3.373	3.408	3.421	0.086	3.365
	D_{50} (mm):	51.16	15.48	22.77	54.43	14.60	13.51	49.06	12.36	47.40	21.84	20.44	20.53	44.42	16.30
	D_{90} (mm):	1151.5	119.9	126.0	1276.7	77.27	90.26	662.1	78.34	1673.9	262.5	97.92	172.2	893.9	86.88
	(D_{90} / D_{10}) (mm):	10899.6	35.98	34.01	10884.1	25.21	29.85	6440.2	25.79	19191.6	77.82	28.73	50.32	10335.3	25.82
	(D_{90} - D_{10}) (mm):	1151.4	116.6	122.3	1276.5	74.20	87.24	662.0	75.30	1673.8	259.1	94.51	168.7	893.8	83.52

Sample ID		WA1	WA2	WA3	WA4	WA5	WA6	WA7	WA8	WA9	WA10	WA11	WA12	WA13	WA14
Analyst and Date:		MEC, 23 April 2025													
	(D_{75} / D_{25}) (mm):	81.05	7.335	8.865	80.25	6.640	6.968	67.36	5.758	143.1	10.47	8.158	8.057	92.67	6.929
	(D_{75} - D_{25}) (mm):	306.6	40.76	58.42	361.0	33.82	34.59	240.7	27.31	373.3	66.59	48.80	51.14	236.8	38.74
	D_{10} (f):	-0.204	3.060	2.989	-0.352	3.694	3.470	0.595	3.674	-0.743	1.930	3.352	2.538	0.162	3.525
	D_{50} (f):	4.289	6.013	5.457	4.199	6.098	6.210	4.349	6.338	4.399	5.517	5.612	5.606	4.493	5.939
	D_{90} (f):	13.21	8.229	8.077	13.06	8.350	8.369	13.25	8.363	13.48	8.212	8.197	8.191	13.50	8.215
	(D_{90} / D_{10}) (f):	-64.900	2.689	2.702	-37.056	2.260	2.412	22.27	2.276	-18.143	4.255	2.445	3.227	83.44	2.331
	(D_{90} - D_{10}) (f):	13.41	5.169	5.088	13.41	4.656	4.900	12.65	4.689	14.23	6.282	4.844	5.653	13.34	4.690
	(D_{75} / D_{25}) (f):	4.757	1.653	1.802	5.358	1.587	1.605	3.988	1.513	6.074	1.900	1.726	1.734	4.167	1.625
	(D_{75} - D_{25}) (f):	6.341	2.875	3.148	6.326	2.731	2.801	6.074	2.526	7.160	3.388	3.028	3.010	6.534	2.793
	% Gravel:	5.0%	0.0%	0.0%	6.1%	0.0%	0.0%	2.3%	0.0%	8.6%	0.0%	0.0%	0.0%	3.3%	0.0%
	% Sand:	36.7%	19.2%	26.4%	37.4%	13.7%	15.9%	37.8%	12.8%	32.5%	27.7%	21.4%	23.5%	35.0%	16.5%
	% Mud:	58.3%	80.8%	73.6%	56.5%	86.3%	84.1%	59.9%	87.2%	58.8%	72.3%	78.6%	76.5%	61.7%	83.5%
	% V Coarse gravel:	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%
	% Coarse gravel:	0.9%	0.0%	0.0%	1.6%	0.0%	0.0%	0.3%	0.0%	2.7%	0.0%	0.0%	0.0%	0.2%	0.0%
	% Medium gravel:	1.5%	0.0%	0.0%	1.6%	0.0%	0.0%	0.5%	0.0%	2.6%	0.0%	0.0%	0.0%	0.5%	0.0%
	% Fine gravel:	1.3%	0.0%	0.0%	1.4%	0.0%	0.0%	0.7%	0.0%	1.8%	0.0%	0.0%	0.0%	1.2%	0.0%
	% V Fine gravel:	1.3%	0.0%	0.0%	1.5%	0.0%	0.0%	0.8%	0.0%	1.6%	0.0%	0.0%	0.0%	1.5%	0.0%
	% V Coarse sand:	6.4%	0.0%	0.0%	6.3%	0.0%	0.0%	4.8%	0.0%	5.7%	0.0%	0.0%	0.5%	6.0%	0.0%
	% Coarse sand:	6.8%	0.6%	0.3%	7.2%	0.0%	0.5%	7.3%	0.7%	6.3%	2.2%	0.3%	2.9%	6.5%	0.4%
	% Medium sand:	9.1%	4.8%	3.1%	9.5%	0.7%	2.0%	10.3%	1.9%	8.3%	8.4%	1.5%	4.7%	8.7%	1.5%
	% Fine sand:	7.8%	4.2%	6.7%	7.8%	2.7%	3.4%	8.4%	2.7%	6.7%	6.8%	4.1%	4.3%	7.4%	2.8%
	% V Fine sand:	6.6%	9.5%	16.3%	6.5%	10.3%	10.0%	7.0%	7.5%	5.6%	10.4%	15.5%	11.0%	6.4%	11.8%
	% V Coarse silt:	16.8%	14.7%	17.3%	16.6%	17.4%	14.6%	17.7%	13.5%	14.9%	14.9%	19.1%	16.5%	16.8%	17.7%
	% Coarse silt:	5.1%	15.9%	13.9%	4.9%	17.2%	15.8%	5.2%	17.1%	4.9%	14.2%	14.9%	16.6%	5.3%	16.8%
	% Medium silt:	4.7%	19.5%	16.2%	4.6%	19.1%	19.7%	4.9%	21.6%	4.9%	15.7%	16.1%	16.7%	5.1%	18.9%
	% Fine silt:	6.5%	18.1%	15.5%	6.3%	18.2%	19.1%	6.7%	20.2%	6.9%	15.2%	16.2%	14.9%	7.1%	17.7%
	% V Fine silt:	3.7%	11.1%	9.5%	3.5%	12.2%	12.7%	3.7%	12.8%	4.0%	10.4%	10.7%	9.9%	4.0%	11.0%
	% Clay:	21.4%	1.5%	1.2%	20.5%	2.2%	2.1%	21.7%	2.0%	23.3%	1.9%	1.5%	2.1%	23.4%	1.5%

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