NEWPORT EFFLUENT PIPE REPLACEMENT

Marine Licence Consultation

Introduction

A pipeline, approximately 1,360 m long, is currently in place to safely discharge effluent from Eastman Chemicals in Newport, South Wales, into the Severn Estuary and it has reached the end of its operational lifecycle. The pipeline crosses the intertidal zone and discharges below mean low water spring (MLWS). To continue to safely discharge effluent into the Severn Estuary, the current pipeline needs to be replaced to reduce risks associated with the structure's integrity and to reduce the likelihood of any future leaks. The proposed pipeline and sea outfall replacement works will involve the placement of the new effluent pipe adjacent to the existing pipe.

Following the withdrawal of application CML2222, a meeting has been arranged for Kaymac to receive advice from NRW Advisory on the potential new methods proposed and their possible requirements prior to the submission of a new application.

Having first-hand experience of working in this area undertaking the emergency slip lining repair to the outfall in September, we believe that the existing design offers the most pragmatic and least environmentally disruptive option to undertake the replacement of the existing outfall. Before discussing alternative options, we would like to briefly discuss the initial comments received from the Marine Area Management and Advice Team dated 6th May 2022, which are summarised in bullet point form below (in black). As aforementioned, now having actually undertaken works in the vicinity, we have formed responses beneath each bullet point comment (in blue).

In addition, following the meeting which took place on the 24th November 2022, further information regarding the as-built data that is available on the outfall, recent ground investigation data and an analysis on the Natural Variation of the sea bed is further discussed in Appendix A.

- **Coastal Physical Processes**

Key Issues

We are concerned that the concrete mattresses could potentially become exposed following installation, particularly across the intertidal, due to the dynamic nature of the estuarine hydrodynamics and the mobility of the cohesive sediments (mud and clay). Please see detailed comments below.

Detailed comments

KM-Eastman-RAMS-Version 3

Intertidal Zone

We note that in Section 3.3 and section 3,6 you state the following:

- "During the works, Kaymac will (as far as reasonably practical) ensure that no activities will be completed in a manner that could damage or permanently alter the existing seabed profile."
- "prior to demobilising from site, Kaymac will ensure that the seabed profile is restored it its original state (or as specified in the construction drawings)."

We welcome the proposal to access the site by sea using landing craft. The ground conditions are likely to consist of very soft mud, with a subsurface layer of more consolidated clay. Are the tracked excavator and Terrier Rig able to operate in such environments without causing significant compaction and rutting of the mudflat, which could damage or permanently alter the existing seabed profile across the intertidal? Are there any additional measures that can be used to prevent these issues or is there sufficient confidence (experience from elsewhere for example?) to support the conclusion that effects will be minimal and temporary as stated in the HRA?

The ground conditions are as described- a top layer consisting of very soft mud with a sub-surface layer consisting of a more consolidated clay. Although we were able to undertake the emergency slip-ling works using a traditional excavator on the beach, we feel that the use of such plant and equipment would impose difficulties and restrictions whilst undertaking the outfall replacement works (above low tide) if they were to be undertaken in the same manner.

During the ground investigation works completed by Kaymac in May/ June 2022, we instructed Quantum that the tidal flat deposits were to be analysed to ascertain the likely allowable bearing capacity at surface level. It was advised that the 'Tidal Flat deposits at the surface are expected to provide an allowable bearing capacity in excess of 15kN/m^2'.

The traditional excavating plant that we had originally proposed to use would have imposed a bearing pressure of approximately 40kN/m^2, essentially 2.7 times the allowable bearing capacity of the deposits, which would undoubtedly lead to significant compaction and rutting of the mudflat. As an alternative, we propose to use an Amphibious excavator (Please see image below) which would impose a bearing pressure of approximately 12kN/m^2, essentially 0.8 times the allowable bearing capacity of the deposits.

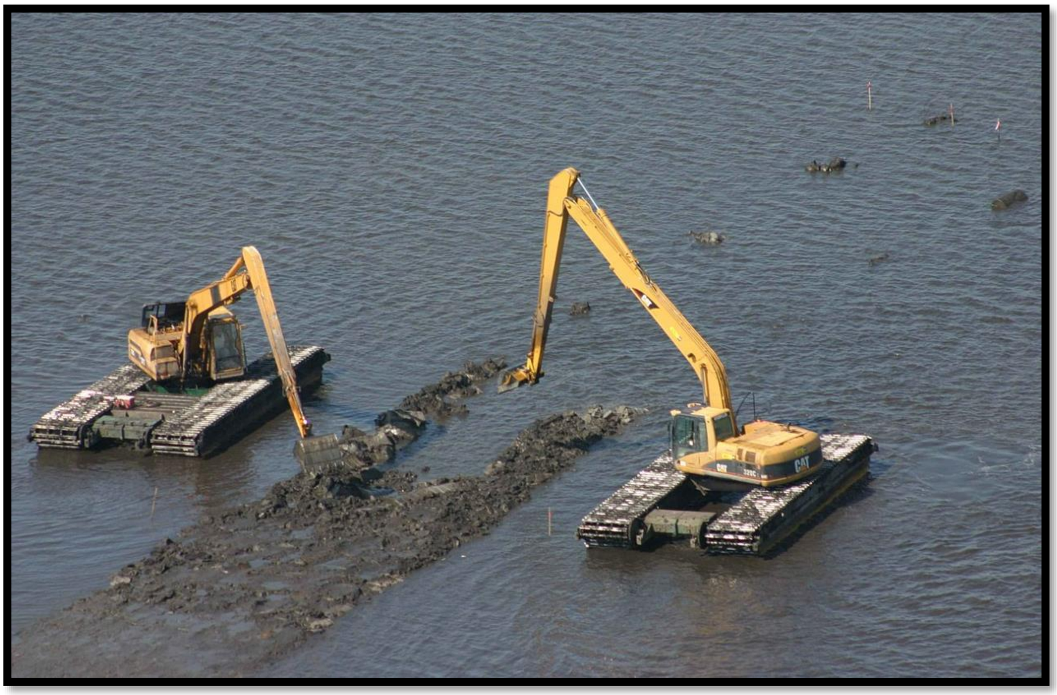


Image 1: Amphibious Excavator

We feel that the use of an Amphibious excavator will greatly reduce the potential 'significant compaction and rutting of the mudflats' which could in turn have resulted in an increased risk of damage to or permanently altering the existing seabed profile across the inter-tidal zone.

In response to the comment 'is there sufficient confidence (experience from elsewhere for example?) to support the conclusion that effects will be minimal and temporary as stated in the HRA?', please see the 4 photographs below. The photographs were taken 1) Ahead of commencement 2) during the emergency slip-lining works, 3) Upon initial reinstatement and 4) Approximately 6 weeks after demobilisation from site.

1) Ahead of commencement

2) During the emergency slip-lining works (please note that the 9t excavator shown imposed a ground bearing pressure of approx. 39.8kN/m^2).

3) Upon initial reinstatement

4) Approximately 6 weeks after demobilisation from site

- We ask for clarification of the methods will be employed to ensure that the seabed profile is restored to its original state both in the intertidal and subtidal where the pipe has been layed. We anticipate that this will be very difficult to carry out, given the existing ground conditions i.e. a dynamic and changing nature of the intertidal mud overlaying consolidated Holocene clay. Will the reprofiling be conducted after all the pipe laying works across the intertidal have been carried out or during the works? Will a beach profile survey be carried out to confirm that the beach profile has been restored to its original state on completion of works?

  It would be beneficial to understand the impact from the ground investigation works if photographs or other supporting information is available, to help understand the potential impact from the proposed pipe replacement.

We acknowledge that the precise reinstatement of the seabed profile will be difficult to undertake given the dynamic nature of the intertidal surface mud. However, this issue will present itself with most construction methods that could be undertaken to replace the outfall and not solely attributed to this proposed method.

A comparison of the previous topographic & bathymetric surveys undertaken between 1973 and 2022 show the interchangeable nature of the surface deposits in this area. An analysis of these results is further discussed in Appendix A. The Ground Investigation works undertaken in May & June of 2022 found that the tidal flat deposits at the surface ranged between 300-400mm thick, which correlate with the variations identified in the topographic and bathymetric survey comparisons, suggesting that this surface layer, being dynamic in nature, is susceptible to movement and change.

This is reinforced with the comparison between the Photographs below. Photograph 5 was taken in February 2022 and Photograph 6 taken in November 2022. There is a clear difference between the surface of the tidal deposits outside of our working areas.

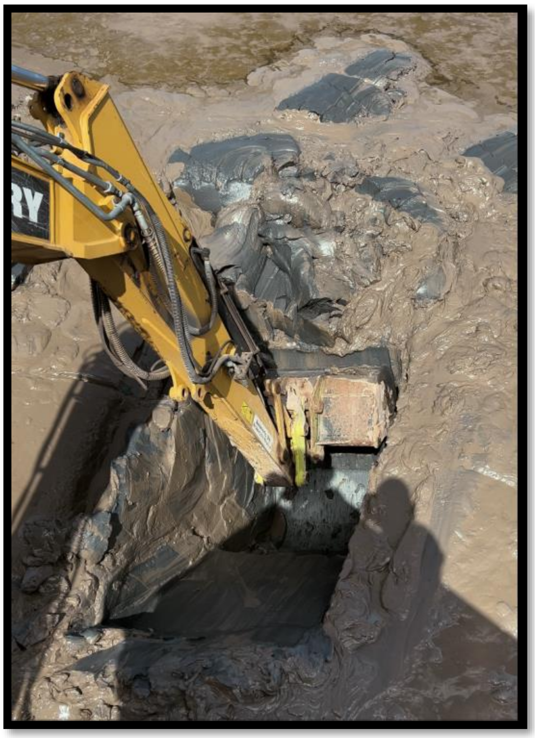
Photograph 5- Taken February 2022

Photograph 6- Taken November 2022

We are unable to guarantee that the seabed profile will be reinstated to the exact pre-commencement profile but believe that a pragmatic and sensible approach should be adopted. We do propose to undertake a pre-commencement bathymetric survey to determine a baseline for the current seabed profile. This survey can also be used to compare with the results of the bathymetric survey that we undertook in January 2022 to establish any movement or changes of the profile within this time. We would like to discuss with NRW a suitable and achievable reinstatement tolerance that would be acceptable. We would then suggest that a completion bathymetric survey is undertaken at a later date beyond completion at a duration to be agreed with all parties.

In response to the request for photographs illustrating the impact from the ground investigation works please see images below;

Photograph 7 – Taken during the Ground Investigation works



Photograph 8 – Taken during the Ground Investigation works

Photograph 9 – Taken during the Ground Investigation works- note the consistency of the underlying clay.

Photograph 10 – Taken approximately 6 weeks after completion of the Ground Investigation Works.

- Section 6.0 Method Statement
  Trenching across intertidal and subtidal

  Have geotechnical investigations been carried out along the pipeline route to determine what type of sediments will be excavated down to depths of 2.0m? No information has been presented which describes the seabed substrate. However, given its location in the Severn Estuary, we anticipate that the seabed substrate will be composed of a layer of soft mud, and then more consolidated Holocence clay beneath. Cohesive sediments (silt, clay) generally exhibit four states: a mobile suspended sediment layer, a higher concentration near bed layer "fluid mud", a newly deposited or partially consolidated bed and a settled or consolidated bed layer. All four states can be experienced depending on the tidal state. There is therefore a high possibility that the thickness of the mobile mud surface layer overlaying the consolidated clay layer will not maintain a consistent depth along the pipeline route and will vary over the course of the pipe laying works.

Ground Investigation works have been undertaken by Quantum Geotech (under instruction from Kaymac Marine & Civil Engineering Ltd) in 2 areas above MLWS. These works were carried out towards the end of May 2022. The findings can be found in Report No. Q0756/FR.02 with key findings summarised in a further Technical Note Ref Q0756-TN1.

A summary of the works undertaken at site are given below:
•5 No. Windowless Sample Boreholes (Ref: WS01 – 05)
•2 No. Machine Dug Trial Pits
•4 No. TRL-DCP Tests
•In-situ SPT tests in the boreholes.

•Geo-environmental Laboratory Testing.
• Geotechnical Laboratory Testing.

The tables below details the positions and ground levels of the intrusive testing locations, together with the borehole termination details;

Exploratory Hole ID	Easting	Northing	Height (mAOD)
WS01	334467.984	181868.816	-3.801
WS02	334467.557	181870.710	-3.810
WS03	334414.844	182146.614	-0.160
WS04	334414.681	182147.529	-0.097
WS05	334414.589	182148.041	-0.099
TP01	334466.912	181873.674	-3.729
TP02	334413.787	182151.124	0.108

Exploratory Hole ID	Window [WS]	Termination Depth (mbgl)	Terminating Strata	Notes/Reason for Termination
WS01	[WS]	3.00	Tidal Flat Deposits	Kaymac Instruction
WS02	[WS]	5.00	Tidal Flat Deposits	Specification Depth
WS03	[WS]	6.00	Tidal Flat Deposits	Specification Depth
WS04	[WS]	6.00	Tidal Flat Deposits	Specification Depth
WS05	[WS]	5.85	Tidal Flat Deposits	Specification Depth

The investigation works found that the tidal flat deposits at the surface ranged between 300-400mm thick which coincides with the comment 'There is therefore a high possibility that the thickness of the mobile mud surface layer overlaying the consolidated clay layer will not maintain a consistent depth along the pipeline route'. The photograph below shows the consistency of the clay that was recovered during the excavation of the most Southerly Trial Pit.

Photograph 11 – Taken during the Ground Investigation works- again, note the consistency of the underlying clay.

These results are further discussed in Appendix A.

- Has consideration been given to the potential for the excavated clay/mud mix to be resuspended by the tidal currents which could reduce the amount of sediment available for backfilling once the pipe has been layed? If this was the case, where would the sediment be sourced to backfill the trench?

From what we have experienced through undertaking the Ground Investigation works, we are confident that through our planned project programme, enough excavated clay/mud will be readily available for backfilling purposes. The quantity that could potentially be re-suspended by the tidal currents is incredibly difficult to quantify. As a means to reduce the time that the excavated material could be subject to the tidal movements, we have developed our project programme specifically to limit the durations between the excavation and backfilling activities.

As an exercise, we have also taken into consideration how the design of the permanent works allows for some loss of backfill material by comparing the cross-sectional area of the planned open excavation with the cross-sectional area of the required backfill around the pipeline, collars and mattresses.

The CSA of the open excavation is in the order of $5.42m^2$. The CSA of the pipeline, collars and mattresses is approximately $1.45m^2$ resulting in an approximate 27% reduction in the required volume of backfill per linear metre run of pipe.

If during construction we find that there is not enough backfill material available to reinstate to the surrounding bed levels, this will undoubtedly result in a depression in the surface layer. The design will not be compromised in any way and the concern will purely be aesthetic. We believe that over time (as shown by the further discussion of the bathymetric comparison data in Appendix A), any depressions will be reinstated with the settlement of the suspended sediment within the tide- a further reason why we propose to undertake the completion bathymetric survey at an agreed date beyond the completion of the scheme.

- Backfill and Placement of Concrete Mattresses
  To what extent does the proposed layout design of the pipe and mattress protection (see diagram Typical Trench Profile – seabed Front Elevation) rely on the integrity of the backfilled sediment being retained in the trench? The backfilled mud/silt mix previously excavated, will only be partially consolidated and will take time to consolidate under its own weight. If the concrete mattresses are designed to sit flat across the trench as shown in the diagram, what will happen in the event that the underlying sediment either side of the pipe and level with the top of the concrete collar cannot take the weight of the mattresses if the sediment is only partially consolidated? Are the concrete mattresses designed to bend around the pipe as shown in the Concrete mattress example – Image courtesy of Subsea Protection Systems - if the mattresses sink into the sediment?

The design does not rely on the integrity of the backfill material within the trench. The required ballast to maintain stability is applied through the pre-cast concrete collars fitted to the pipeline and the concrete mattresses. Testing was carried out during the backfilling of the trial pits undertaken during the Ground Investigation works. As suggested, given the soft nature of the Tidal Flat Deposits, some long-term settlement should be expected. However, at such loadings in this instance, any settlement would be expected to be less than 25mm.

During the Ground Investigation works, testing was undertaken to the backfilled trial pit material. TRL DCP tests were undertaken within TP02 during the backfilling process at 0.5mbgl intervals, to provide an indication of the bearing capacity of the disturbed backfilled material. With TRL DCP tests, an indicative Safe Bearing Capacity is provided rather than Allowable Bearing Capacity. The indicative value is always conservative and in this instance, the values ranged between 19 to 44kN/m^2, with an average value of 21kN/m^2.

The proposed mattresses are shown below.

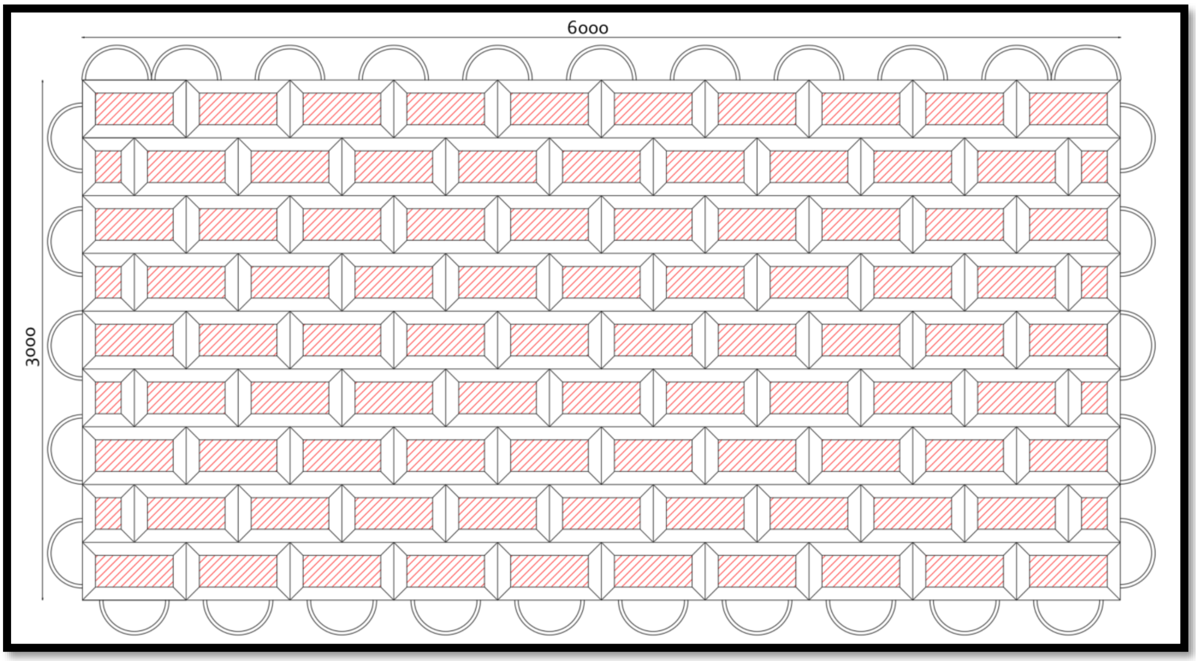


Image 1: plan View of the Proposed Mattresses

The red hatch indicates the contact area that the mattresses will have with the seabed and equate to 7.15m^2.

The weight of the mattresses in air and when submerged are 8.330T and 4.775T respectively.

For these 2 scenarios, the anticipated ground bearing pressure exerted by these mattresses is;

In Air	Submerged
8.330T /7.15m^2 = 1.16T/m^2 = 11.38kN/m^2	4.775T/7.15m^2 = 0.66T/m^2 = 6.47kN/m^2

Now even taking into account the most conservative Indicative Ground Bearing Capacity value of 19kN/m^2, at the un-submerged weight of 8.330T, the applied ground bearing pressure of 11.38kN/m^2 is approximately 60% of the indicative capacity. This suggests that although movement is likely given the tidal nature of the works, the pressure that is likely to be exerted by the mattress is less than the indicative capacity of the material.

The mattresses are designed to conform to profile changes in the seabed and do not require further pinning or restraints. They are a recognised engineering solution for the seabed and soil protection/stabilisation challenges faced in subsea pipeline construction. They are an articulated unit consisting of individual concrete blocks connected using polypropylene rope. They have been used successfully for several decades to protect oil and gas pipelines and since the early 1990s have been increasingly used to protect ocean outfalls.

In this particular application, the mattresses are to be used to provide;

- Protection from dropped objects
- Added weight and stabilisation
- Protection from Trawl Boards
- Scour prevention

There is little uplift induced by waves and unconsolidated seabed material will accumulate within the spaces between the individual concrete blocks thereby further increasing the stability. The concrete blocks provide a good substrate for growth of marine organisms which must be seen as a positive environmental factor. Finally, these mattresses can be recovered to enable any future pipeline repairs that could be required, before being reinstalled.

- It is stated that "once the concrete mattresses are securely in position, a final layer of backfill will be placed over the pipe to achieve the specified finish level". What exactly defines the secure position of the concrete mattresses? If it is the case that the mattresses are designed to bend around the pipe, then what is the expected time required for this to occur before the final layer of backfill is placed over the mattress to achieve the specified finish level. If the final layer is placed over the mattresses before they have settled in position, there is a potential for the surface sediment to slump and create a depression in the seabed.

  There is also a strong possibility that the sediment backfill over the top of the concrete mattressing if loosely packed in the short term, will be remobilised by currents and wave action particularly across the shallow intertidal, which could potentially expose the concrete mattresses above the seabed. Exposure of the mattresses could also occur over time in response to changing sea levels and increase in storminess

The mattresses are designed to conform to profile changes in the seabed meaning that if any unplanned or forecasted scour or movement was to occur in the future, the pipe remains protected as the mattresses are able to articulate. If a solid mattress was to be used, then in the event of any scour, the mattress would become undermined and likely break, reducing the protection to the pipe and also removing an element of the ballast needed to maintain overall stability.

There is no 'expected time' for this movement to occur before the final layer of backfill is placed. As expressed in the sections above, the comparison of the previous topographic and bathymetric surveys suggest that movement of the surface layer does occur and the introduction of these mattresses are a requirement from a design perspective to maintain future longevity of the outfall.

Appendix A

Following the meeting which took place on the 24th November 2022 between NRW & Kaymac, additional questions were asked and requests made for further information. The following has been provided:

1. A summary of the As-Built Information for the existing pipeline
2. A summary of the recent geotechnical investigation works that have been undertaken
3. An assessment on the Natural Variance of the Seabed profile
4. Further information relating to the offshore element of the works

1.0 A summary of the As Built Information (Please note that the measurements were given in feet and inches).

A thorough and well documented compilation of as-built information has been provided by our client (Document Reference; Black Book- Monsanto Chemicals Ltd, Project 712 Design & Construction Report dated March 1965), which is summarised below;

The installed marine pipeline is described as a mild steel all welded pipe, flanged to the land-based cast pipe approximately 50’ North of the seawall. The outlet end was not fitted with a flap valve as it was deemed to always be underwater and there were concerns at the time with the maintenance costs. At the time of installation, the end of the pipe was anchored to the seabed by means of 4 no. chains, each 100’ long, fitted to 4 x 3t concrete blocks on the seabed.

The marine pipeline is 18” N.B x ½” wall thickness. At the time of the design, the end of the outlet was designed to be;

- 6’9” below MLWS
- 15’ below MLWN
- 35’7” below MHWN
- 45’10” below MHWS

To protect the pipe exterior and provide additional weight, the following coatings were applied;

1. Bituminous solution
2. Glass reinforced sheathing
3. Galvanized weldmesh fabric (No 213), placed ½” from the surface
4. 1 ½” thick concrete surround applied by pneumatic concreter.

The marine pipeline was constructed by butt welding 35’ long pipe sections to form 2 complete pipes each 2410’ long, which were constructed over the fields to the North of the seawall. The pipes were prepared and one fitted with a pulling head. The first section was mounted on a tyre conveyor and prepared for pulling into the sea on the 1st June 1960, through a gap in the seawall across the seabed in a previously prepared trench, by means of a cable fixed to the pulling head and pulled by a capstan mounted on an anchored barge 1 mile out in the Bristol Channel. After the first section was pulled out, the second was welded to the end using a 18/8 stainless steel pipe section 3’ long. Once the pipe was installed, the seawall was made good and divers were used to recover the pulling head using oxy-acetylene cutting equipment.

2.0 A summary of the recent geotechnical investigation works that have been undertaken

The following is a detailed summary of the findings following ground investigation works undertaken on site in May 2022. The findings can be found in Report No. Q0756/FR.02 with key findings summarised in a further Technical Note Ref Q0756-TN1.

The scope of the GI works undertaken at site are given below:
•5 No. Windowless Sample Boreholes (Ref: WS01 – 05)
•2 No. Machine Dug Trial Pits
•4 No. TRL-DCP Tests
•In-situ SPT tests in the boreholes.
•Geo-environmental Laboratory Testing.
• Geotechnical Laboratory Testing.

Details of the published and inferred geology of the site are summarised as follows;

Made Ground: No mapped made ground is associated with the site study area.

Superficial Deposits: The superficial geology of the area is associated with 'Tidal Flat Deposits' comprising mud flat and sand deposits, deposited on extensive nearly horizontal marshy land in the intertidal zone that is alternately covered by the rise and fall of the tide.

Bedrock Geology: the bedrock geology of the area is associated with the 'Mercia Mudstone Formation'. Lithologically, the formation comprises dominantly red, less commonly green-grey, mudstone and subordinate siltstone with thick halite bearing units in some basinal areas. These beds of gypsum/anhydrite are widespread with less common sandstone.

Table 1 below summarises the Exploratory hole locations and windowless sample boreholes, together with the commencing ground levels at each location. The locations and levels were surveyed to ordnance datum (with readings accurate to within 0.005m horizontal and 0.01m vertical).

Exploratory Hole ID	Easting	Northing	Height (mAOD)
WS01	*334467.984*	*181868.816*	*-3.801*
WS02	*334467.557*	*181870.71*	*-3.81*
WS03	*334414.844*	*182146.614*	*-0.16*
WS04	*334414.681*	*182147.529*	*-0.097*
WS05	*334414.589*	*182148.041*	*-0.099*
TP01	*334466.912*	*181873.674*	*-3.729*
TP02	*334413.787*	*182151.124*	*0.108*

Table 1: Exploratory Hole Co-Ordinates & Levels

2 Nr. Exploratory holes were excavated (labelled TP01 & TP02) and are shown below;

Contract : Sea Wall, Saltmarsh Lane

Client : Kaymac

Trial Pit No. TP01

Dates: 27/5/22 - 27/5/22	Job Number : Q0756	Ground Level :
Location : Lower end of Beach	Engineer : Quantum Geotechnic Ltd	Coordinates:

Samples		Tests		Strata				
Depth	Type No.	Depth	Test Results	Depth (Thick-ness)	Description	Legend	Depth (Thick-ness)	WATER
				0.40	Very soft brown slightly sandy SILT		(0.40)	
0.50 -	B1			0.40	Very soft dark blue grey slightly clayey slightly sandy SILT.		0.40	
				0.85			(0.85)	
1.50 -	B2			1.25	Soft blue grey slightly silty sandy CLAY with small lenses of peat. Sand is fine to medium.		1.25	
				1.75	becoming more sandy from 2.0mbgl		(1.75)	
2.50 - 3.00	B3							
				3.00	Hole terminated on clients instruction at 3.0mbgl		3.00	

Image 2: Trial Pit 01 Log

Contract : Sea Wall, Saltmarsh Lane			**Trial Pit No.**
Client : Kaymac			**TP02**
Dates : 28/5/22 - 28/5/22	Job Number : Q0756	Ground Level :	
Location : Rear end of beach	Engineer : Quantum Geotechnic Ltd	Coordinates:	

m B.G.L.	Samples		Tests		Strata				WATER
	Depth	Type No.	Depth	Test Results	Depth (Thickness)	Description	Legend	Depth (Thickness)	
					0.30	Very soft brown slightly sandy SILT		(0.30)	
					0.30	Soft blue grey slightly silty sandy CLAY with small lenses of peat. Sand is fine to medium.		0.30	
	0.50 -	B1							
1									
	1.50 -	B2							
					2.70			(2.70)	
2									
	2.50 - 3.00	B3							
3					3.00	Hole terminated on clients instruction at 3.0mbgl		3.00	

Image 3: Trial Pit 02 Log

The findings of both exploratory holes are indicative of the strata that would be expected in this location- a surface layer of 'very soft brown, slightly sandy silt (approximately 300-400mm thick), covering a layer of underlying clay.

The trial pits were excavated using an 8t tracked excavator. This method of investigation allows direct sampling of the near surface deposits for identification purposes, as well as assessment of any salient features and made or disturbed ground. The trial pits were logged in accordance with the relevant Brisitsh Standards and supervised at all times by an engineering geologist. Details of the trial pits including final depths in Metres Below Ground Level (mBGL) are shown below in Table 2;

Exploratory Hole ID	Trial Pit (TP)	Termination Depth (mBGL)	Terminating Strata
TP01	TP	3.00	Tidal Flat Deposits
TP02	TP	3.00	Tidal Flat Deposits

Table 2: Windowless Sample Borehole Termination Details

5 No. windowless sample boreholes were undertaken on site. Windowless sampling techniques involve a sampler dynamically driven down to depth using sampling tubes, nominally 116mm ⌀ and reducing as the depth increases. Further details on the windowless sample boreholes are shown below in Table 3:

Exploratory Hole ID	Window (WS)	Termination Depth (mBGL)	Terminating Strata
WS01	*WS*	*3.00*	*Tidal Flat Deposits*
WS02	*WS*	*5.00*	*Tidal Flat Deposits*
WS03	*WS*	*6.00*	*Tidal Flat Deposits*
WS04	*WS*	*6.00*	*Tidal Flat Deposits*
WS05	*WS*	*5.85*	*Tidal Flat Deposits*

Table 3: Windowless Sample Borehole Termination Details

A technical note was compiled by Quantum Geotech to summarise the ground conditions that were encountered, the results of the laboratory testing undertaken and also to provide relevant soil design parameters based on the ground investigations.

The tidal flat deposits were described as 'very soft to soft silty sandy clay', 'slightly clayey slightly sandy silt' and 'slightly silty clayey sand'. The laboratory testing indicates these deposits to be predominantly clay; although localised thin layers of peat were identified. Mercia Mudstone was proven in the boreholes that were drilled on land, North of the seawall. It was identified at 18.0mBGL (approx. -12.0mAOD).

A range of geotechnical in-situ and laboratory tests were carried out as part of the ground investigation to gain an understanding of their engineering properties. A summary of the test results is presented below in Table 4;

Tidal Flat Deposits		**Range**	**Average**	**No. Tests**
Moisture Content	(%)	42-84	58	9
Atterberg Limits/Plasticity Indices	Liquid Limit (%) Plastic Limit (%) Plasticity Index (%)	59-90 29-36 29-54	72 32 40	9
Particle Size Distribution	Cobbles (%) Gravel (%) Sand (%) Silt (%) Clay (%)	0 0-2 2-12 8-34 62-88	0 0 6 16 78	6

Bulk Unit Weight	Mg/m^3	1.81-1.84	1.825	2
Angle of Friction	°	24.0-28.0	25.25	4
Undrained Shear Strength	kN/m^2	16.0-35.0	25.5	2
Hand Shear Vane	Peak Shear Strength kN/m^2 Residual Shear Strength kN/m^2	3-5 1	4.4 1	15
Standard Penetration Test 'N' Value	Test Depth (mBGL) 1.0 1.65 2.0 2.7 3.0 4.0 5.2 5.7 7.2 8.7 10.2	 0 0 0 1-3 2 3-4 1 1 1 1 1	 0 0 0 2 2 3.5 1 1 1 1 1	
Backfilled Trial Pits				
TRL DCP	CBR(%)	0.61-1.92	0.93	4

Table 4: Laboratory / In situ test result Summary

The undrained shear strength of the tidal flat deposits measured within the Quick Undrained Triaxial tests ranged between 16 & 35kN/m², whilst the in-situ testing measured undrained shear strengths between 3 & 5kN/m². Based on the aforementioned information, it is recommended that an undrained shear strength of 10kN/m2 is used for design purposes for the tidal flat deposits.

Based on the analysis of the identified ground conditions, in-situ testing and laboratory testing, an allowable bearing capacity of 25kN/m² at a depth of 1.0mBGL for a linear foundation up to 1.0m wide is considered suitable. An allowable bearing capacity of 30kN/m² at a depth of 1.0mBGL for a square foundation up to 1.0m wide is considered to be suitable.

The tidal flat deposits at the surface are expected to provide an allowable bearing capacity in excess of 15kN/m². Some long-term settlement should be expected due to the low shear strength/soft nature of the tidal flat deposits however, at such loadings, settlements would be expected to be less than 25mm.

A key requirement of the ground investigation works was to determine the safe bearing capacity of the backfilled trial pit material. Transport Research Laboratory Dynamic Core Penetrometer (TRL DCP) tests were undertaken within TP02 during the backfilling operations, at 0.5mBGL intervals during the second phase of investigation, to provide an indication of the bearing capacity of the backfilled material.

Due to site constraints, it was not possible to undertake plate bearing tests and therefore, TRL DCP tests were considered to be the most suitable test method based on the site conditions. It should be noted that Bearing Capacities derived from TRL DCP's and the calculated CBR values are treated as indicative only and as a result, an indicative safe bearing capacity is provided rather than an allowable bearing capacity.

Based on the results of the TRL DCP testing, the backfilled material reported indicative safe bearing capacities of 19 to 44kN/m2, with an average indicative value of 21kN/m^2.

3.0 An assessment on the Natural Variance of the Seabed profile

An assessment of the Natural Variance of the bed levels along the proposed outfall length has been undertaken by Kaymac. This has been undertaken to better understand the dynamic nature and potential for movement of the seabed surface layer and sediment profile.

Through information provided by our client in both DWG & PDF Format, Kaymac have been able to overlay a number of previous bathymetric and topographical surveys in order to assess the variances in measurements at determined intervals. For this exercise, chainage 0.00m has been taken as the south face of the existing seawall, with the provided measurements being compared at 100.00m intervals along the length of the proposed new outfall.

The dates of the analysed survey data are as follows;

- October 1973 (measurements provided to mAOD)
- June 1984 (measurements provided to mAOD)
- August 1994 (measurements provided to mAOD)
- April 2006 (measurements provided to mAOD)
- January 2022 (measurements provided to mAOD)

Table 5 below illustrates the findings of this exercise. To assist with visualizing the comparison, additional information was incorporated, including the proposed 'Top of Mattress Level' and the proposed 'Crown of pipe level' at those same specific chainages.

	1	2	3	4	5	6	7	8	9
A	A Comparison of Historic Bathymetric Data at Set Chainages to Determine the Natural Variance of the Seabed Surface								
B	Taking South Face of the Sea Wall as Zero Chainage	October 1973 (mAOD)	June 1984 (mAOD)	August 1994 (mAOD)	April 2006 (mAOD)	January 2022 (mAOD)	Dynamic Range (m)	Proposed Top of Mattress (mAOD)	Comments
C		1973	1984	1994	2006	2022			
D	Chainage 0-100.00m- not analyzed- Salt Marsh								
E	Level at 0.00m								-
F	Level at 100.00m								-
G	Chainage 100*-200.00m- Measurements taken from cut line (Ch 155.65m)								
H	Level at Cut Line (Ch 155.65m)		1.282	0.919		1.069	0.363		Direct comparison at the same chainage
I	Level at 200.00m		0.013	0.058		-0.203	0.261	-0.149	Direct comparison at the same chainage
J	Top of Mattress Level (mAOD)	-0.149	-0.149	-0.149	-0.149	-0.149			
K	Crown of pipe level (mAOD)	-0.609	-0.609	-0.609	-0.609	-0.609			Taken at Ch 200m
L	Chainage 200-300.00m								
M	Level at 200.00m		0.013	0.058		-0.203	0.261	-0.149	Direct comparison at the same chainage
N	Level at 300.00m		-1.745	-1.953		-1.990	0.245	-2.342	Direct comparison at the same chainage
O	Top of Mattress Level (mAOD)	-2.342	-2.342	-2.342	-2.342	-2.342			
P	Crown of pipe level (mAOD)	-2.802	-2.802	-2.802	-2.802	-2.802			Taken at Ch 300m
Q	Chainage 300-400.00m								
R	Level at 300.00m		-1.745	-1.953		-1.990	0.245	-2.342	Direct comparison at the same chainage
S	Level at 400.00m		-2.200	-2.784	-3.030	-3.158	0.958	-3.414	Direct comparison at the same chainage
T	Top of Mattress Level (mAOD)	-3.414	-3.414	-3.414	-3.414	-3.414			
U	Crown of pipe level (mAOD)	-3.875	-3.875	-3.875	-3.875	-3.875			Taken at Ch 400m
V	Chainage 400-500.00m								
W	Level at 400.00m		-2.200	-2.784	-3.030	-3.158	0.958	-3.414	Direct comparison at the same chainage
X	Level at 500.00m		-3.341	-3.650	-3.950	-3.918	0.609	-4.412	Direct comparison at the same chainage
Y	Top of Mattress Level (mAOD)	-4.412	-4.412	-4.412	-4.412	-4.412			
Z	Crown of pipe level (mAOD)	-4.872	-4.872	-4.872	-4.872	-4.872			Taken at Ch 500m
AA	Chainage 500-600.00m								
AB	Level at 500.00m*	-3.800	-3.341	-3.650	-3.950	-3.918	0.609	-4.412	*Starts @ Ch 541.0m
AC	Level at 600.00m	-5.422	-5.283	-5.088	-5.530	-5.234	0.442	-5.409	Direct comparison at the same chainage
AD	Top of Mattress Level (mAOD)	-5.409	-5.409	-5.409	-5.409	-5.409			
AE	Crown of pipe level (mAOD)	-5.869	-5.869	-5.869	-5.869	-5.869			Taken at Ch 600m
AF	Chainage 600-700.00m								
AG	Level at 600.00m	-5.422	-5.283	-5.088	-5.530	-5.234	0.442	-5.409	Direct comparison at the same chainage
AH	Level at 700.00m	-6.198	-5.505	-5.650	-5.370	-5.203	0.995	-5.827	Direct comparison at the same chainage
AI	Top of Mattress Level (mAOD)	-5.827	-5.827	-5.827	-5.827	-5.827			
AJ	Crown of pipe level (mAOD)	-6.287	-6.287	-6.287	-6.287	-6.287			Taken at Ch 700m
AK	Chainage 700-800.00m								
AL	Level at 700.00m	-6.198	-5.505	-5.650	-5.370	-5.203	0.995	-5.827	Direct comparison at the same chainage
AM	Level at 800.00m	-5.921	-5.640	-5.650	-5.250	-5.073	0.848	-5.903	Direct comparison at the same chainage
AN	Top of Mattress Level (mAOD)	-5.903	-5.903	-5.903	-5.903	-5.903			
AO	Crown of pipe level (mAOD)	-6.363	-6.363	-6.363	-6.363	-6.363			Taken at Ch 800m
AP	Chainage 800-900.00m								
AQ	Level at 800.00m	-5.921	-5.640	-5.650	-5.250	-5.073	0.848	-5.903	Direct comparison at the same chainage
AR	Level at 900.00m	-5.966	-5.732	-5.750	-5.260	-5.099	0.867	-5.980	Direct comparison at the same chainage
AS	Top of Mattress Level (mAOD)	-5.980	-5.980	-5.980	-5.980	-5.980			
AT	Crown of pipe level (mAOD)	-6.440	-6.440	-6.440	-6.440	-6.440			Taken at Ch 900m
AU	Chainage 900-1000.00m								
AV	Level at 900.00m	-5.966	-5.732	-5.750	-5.260	-5.099	0.867	-5.980	Direct comparison at the same chainage
AW	Level at 1000.00m	-5.700	-5.616	-5.650	-5.240	-5.032	0.668	-6.056	Direct comparison at the same chainage
AX	Top of Mattress Level (mAOD)	-6.056	-6.056	-6.056	-6.056	-6.056			
AY	Crown of pipe level (mAOD)	-6.516	-6.516	-6.516	-6.516	-6.516			Taken at Ch 1000m
AZ	Chainage 1000-1100.00m								
BA	Level at 1000.00m	-5.700	-5.616	-5.650	-5.240	-5.032	0.668	-6.056	Direct comparison at the same chainage
BB	Level at 1100.00m	-5.604	-5.617	-5.550	-5.290	-5.015	0.602	-6.133	Direct comparison at the same chainage
BC	Top of Mattress Level (mAOD)	-6.133	-6.133	-6.133	-6.133	-6.133			
BD	Crown of pipe level (mAOD)	-6.593	-6.593	-6.593	-6.593	-6.593			Taken at Ch 1100m
BE	Chainage 1100-1200.00m								
BF	Level at 1100.00m	-5.604	-5.617	-5.550	-5.290	-5.015	0.602	-6.133	Direct comparison at the same chainage
BG	Level at 1200.00m	-5.500	-5.636	-5.592	-5.330	-5.306	0.330	-6.209	Direct comparison at the same chainage
BH	Top of Mattress Level (mAOD)	-6.209	-6.209	-6.209	-6.209	-6.209			
BI	Crown of pipe level (mAOD)	-6.669	-6.669	-6.669	-6.669	-6.669			Taken at Ch 1200m
BJ	Chainage 1200-1300.00m								
BK	Level at 1200.00m	-5.500	-5.636	-5.592	-5.330	-5.306	0.330	-6.209	Direct comparison at the same chainage
BL	Level at 1300.00m	-5.000	-5.502	-5.599	-5.530	-5.928	0.928	-6.286	Direct comparison at the same chainage
BM	Top of Mattress Level (mAOD)	-6.286	-6.286	-6.286	-6.286	-6.286			
BN	Crown of pipe level (mAOD)	-6.746	-6.746	-6.746	-6.746	-6.746			Taken at Ch 1300m
BO	Chainage 1300-1400.00m								
BP	Level at 1300.00m	-5.000	-5.502	-5.599	-5.530	-5.928	0.928	-6.286	Direct comparison at the same chainage
BQ	Level at 1400.00m	-4.747	-5.687	-5.650	-5.630	-6.110	1.363	-6.362	Direct comparison at the same chainage
BR	Top of Mattress Level (mAOD)	-6.362	-6.362	-6.362	-6.362	-6.362			
BS	Crown of pipe level (mAOD)	-6.822	-6.822	-6.822	-6.822	-6.822			Taken at Ch 1400m
BT	Chainage 1400-Existing Outlet 1460.00m								
BU	Level at 1400.00m	-4.747	-5.687	-5.650	-5.630	-6.110	1.363	-6.362	Direct comparison at the same chainage
BV	Level at 1460.00m	-4.924	-6.085	-5.918	-6.010	-6.022	1.161	-6.408	Direct comparison at the same chainage
BX	Top of Mattress Level (mAOD)	-6.408	-6.408	-6.408	-6.408	-6.408			
BY	Crown of pipe level (mAOD)	-5.233	-5.233	-5.233	-5.233	-5.233			Taken at Ch 1460m- top of riser

Table 5: Natural Variance – Bathymetric & Topographical Measurement Comparison

The data has been analysed to determine the difference in measured levels at those set distances shown. Column 7 labelled 'Dynamic Range (m)' has been calculated to be the difference between the highest and lowest recorded data points across the 5 separate surveys. For example, at Chainage 1300.00m, the highest recorded level is -5.000mAOD (Taken in 1973) and the lowest is -5.928mAOD (Taken in 2022). The results show that at this particular location, the seabed level has fluctuated by at least 0.928m between this time period.

At the specific chainages above, the average natural variance along the whole length of the outfall is in the order of 0.709m, with a maximum measurement of 1.363m and a minimum measurement of 0.245m.

To assist with visualizing the above data, the following charts have been compiled. Each chart conveys the variance between each survey data set, together with the proposed top of mattress level and proposed crown of pipe level, at each particular chainage, commencing at Chainage 200.00m (please note, that in the rare occurrence where a data point is missing, that is because the measurement was missing from the survey data)

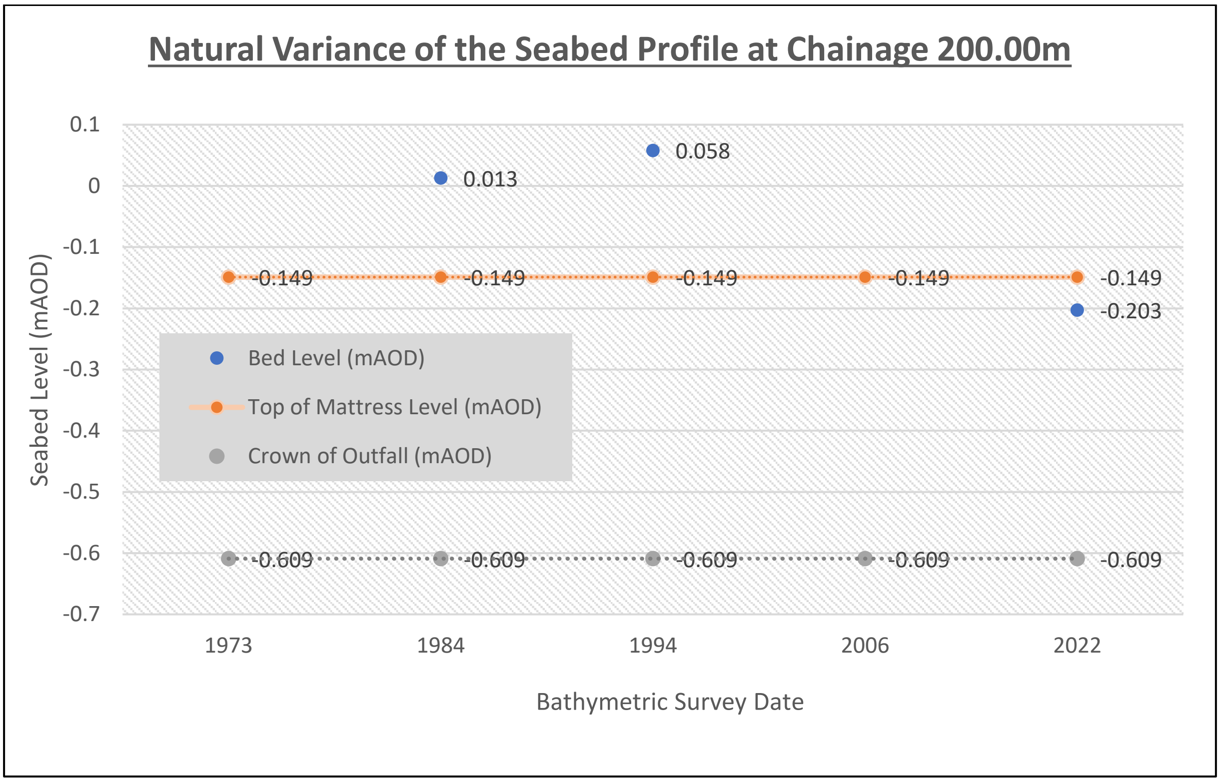


Chart 1: Natural Variance of the Seabed Profile at Chainage 200.00m

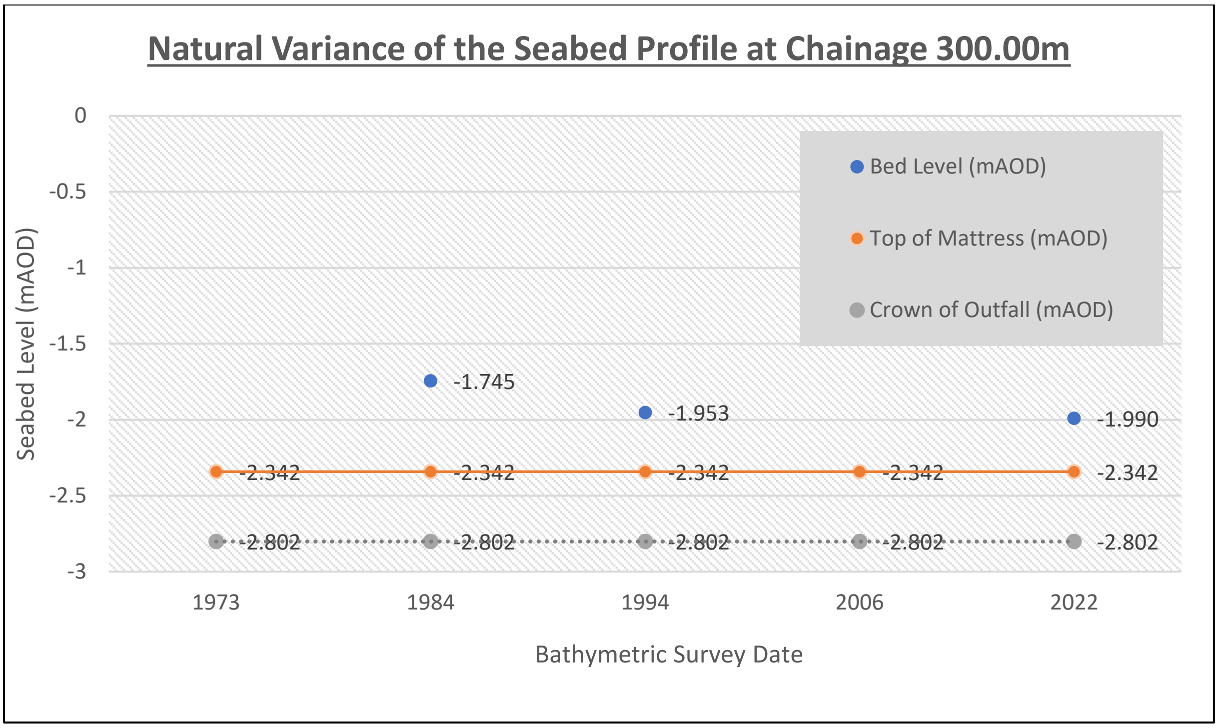


Chart 2: Natural Variance of the Seabed Profile at Chainage 300.00m

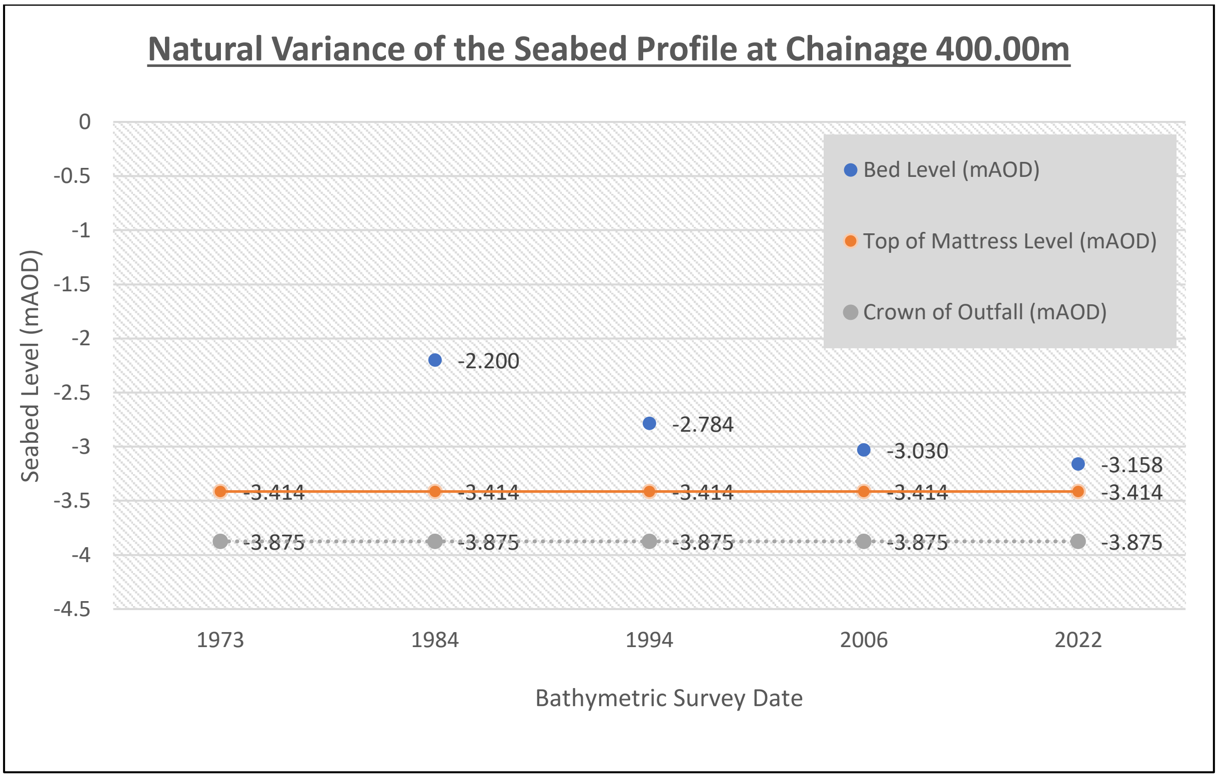


Chart 3: Natural Variance of the Seabed Profile at Chainage 400.00m

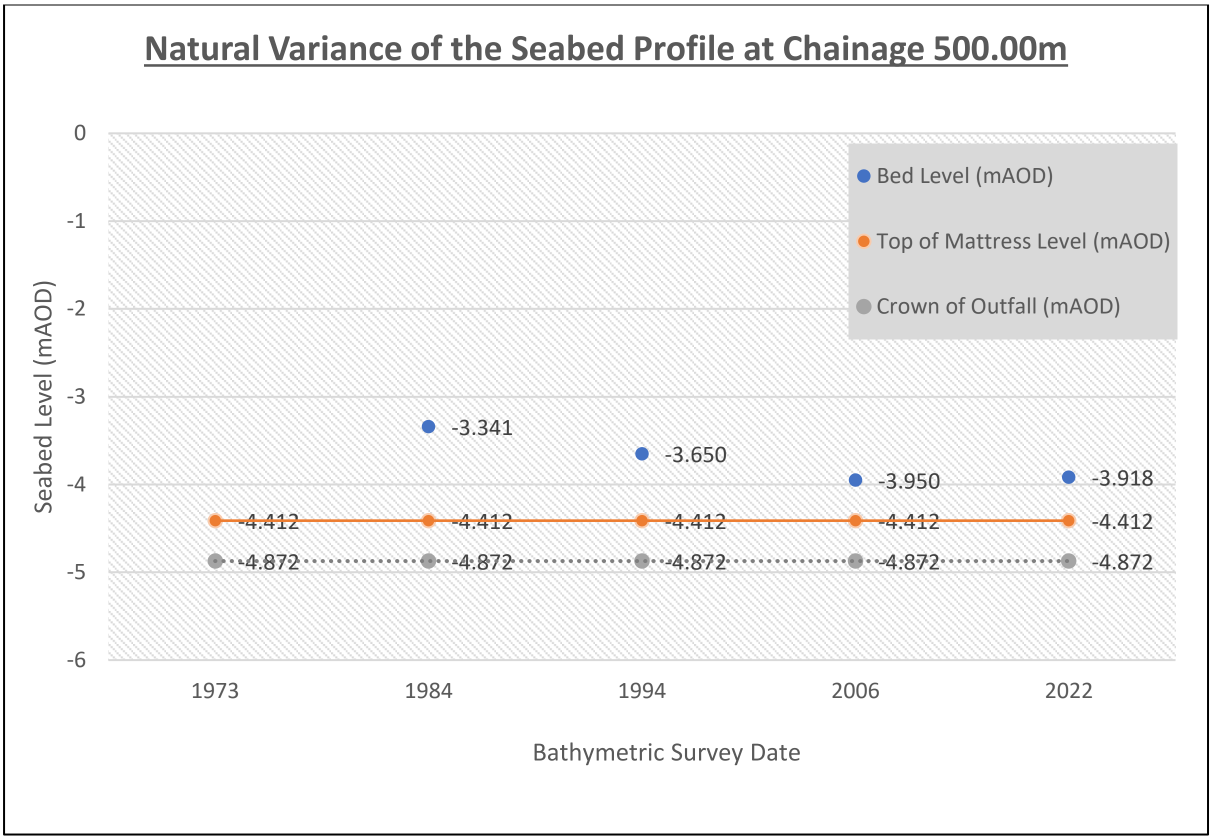


Chart 4: Natural Variance of the Seabed Profile at Chainage 500.00m

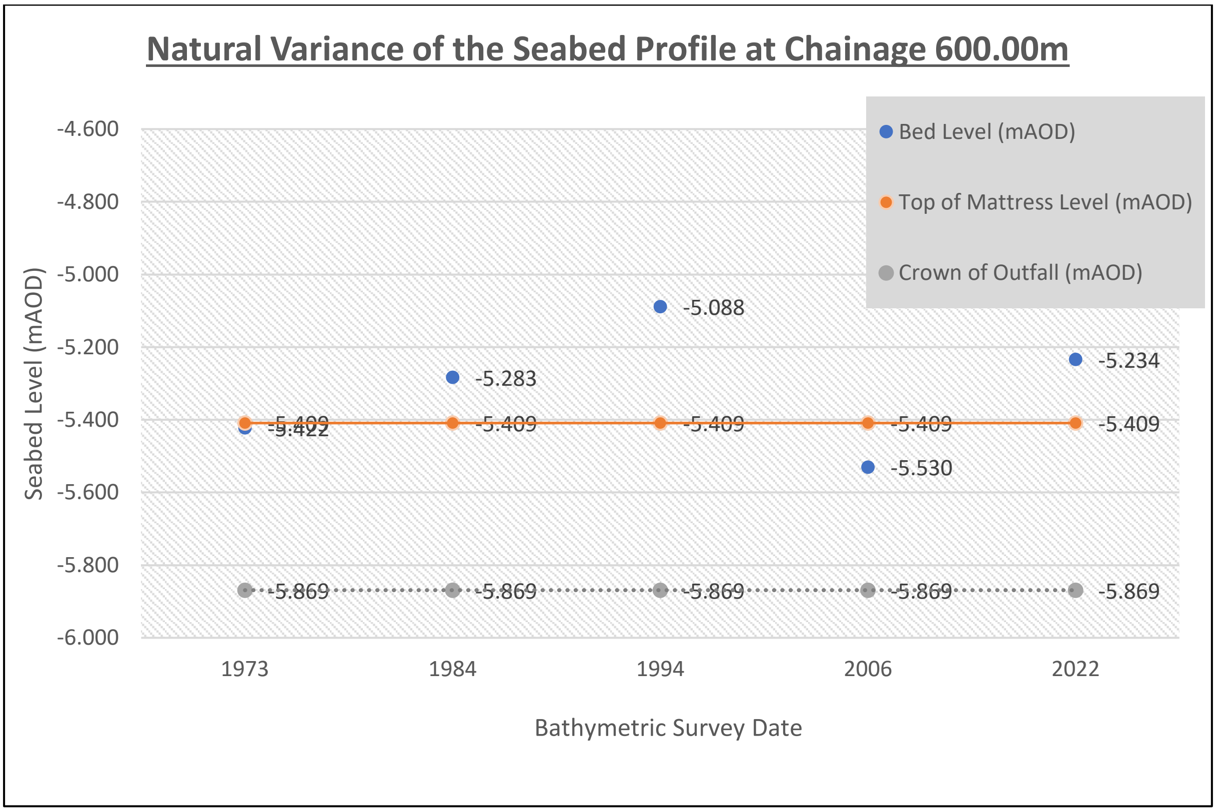


Chart 5: Natural Variance of the Seabed Profile at Chainage 600.00m

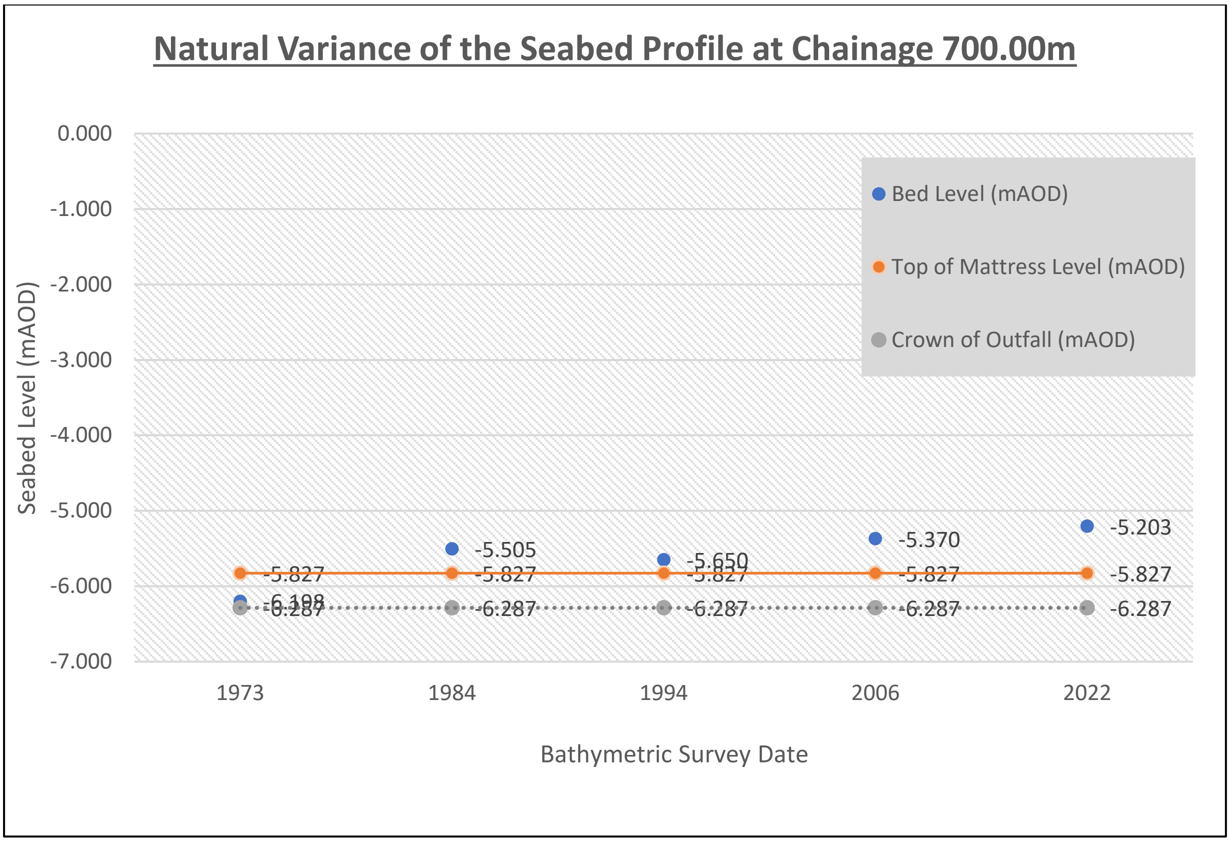


Chart 6: Natural Variance of the Seabed Profile at Chainage 700.00m

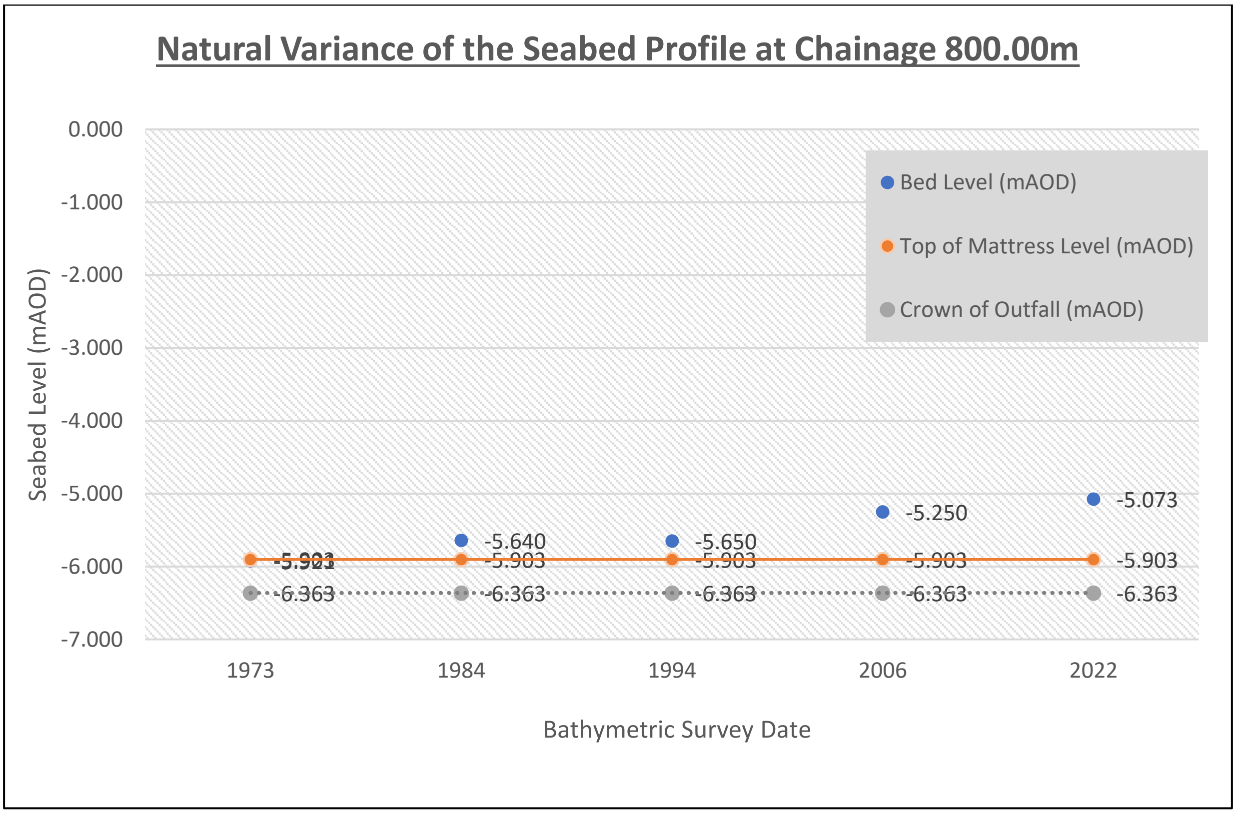


Chart 7: Natural Variance of the Seabed Profile at Chainage 800.00m

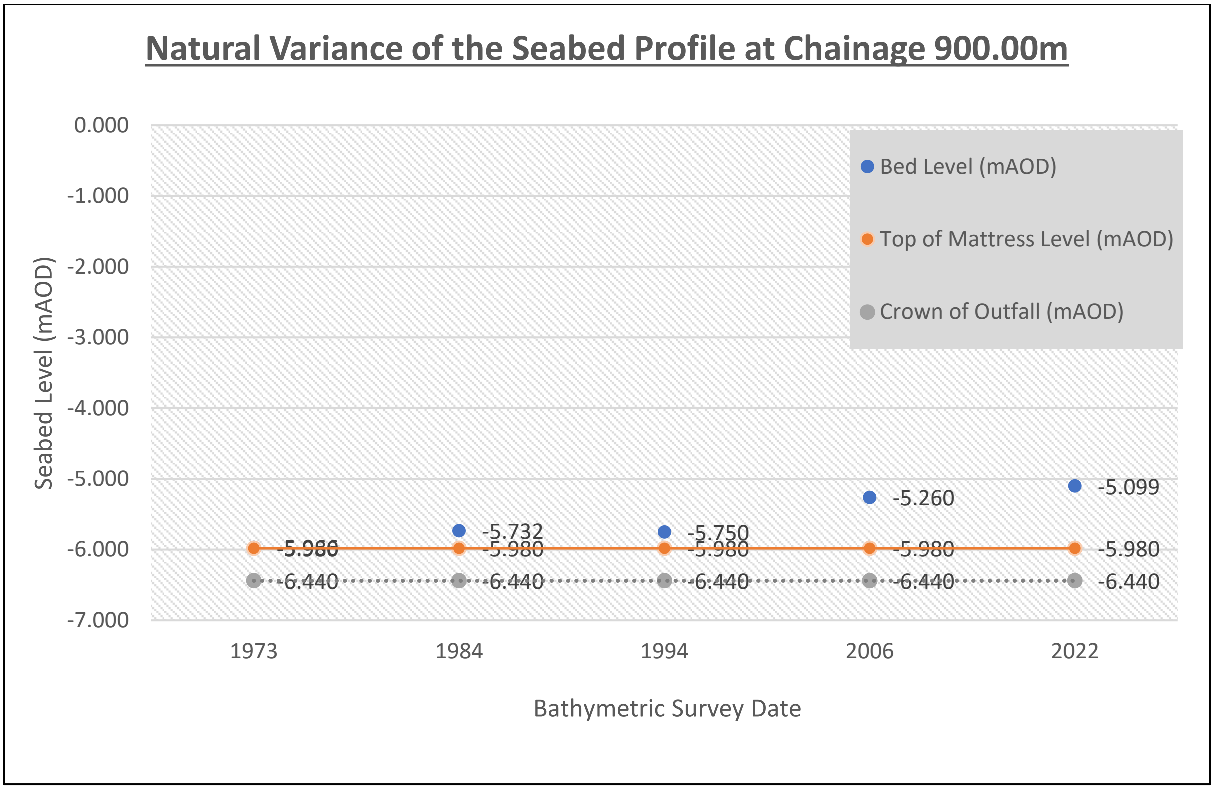


Chart 8: Natural Variance of the Seabed Profile at Chainage 900.00m

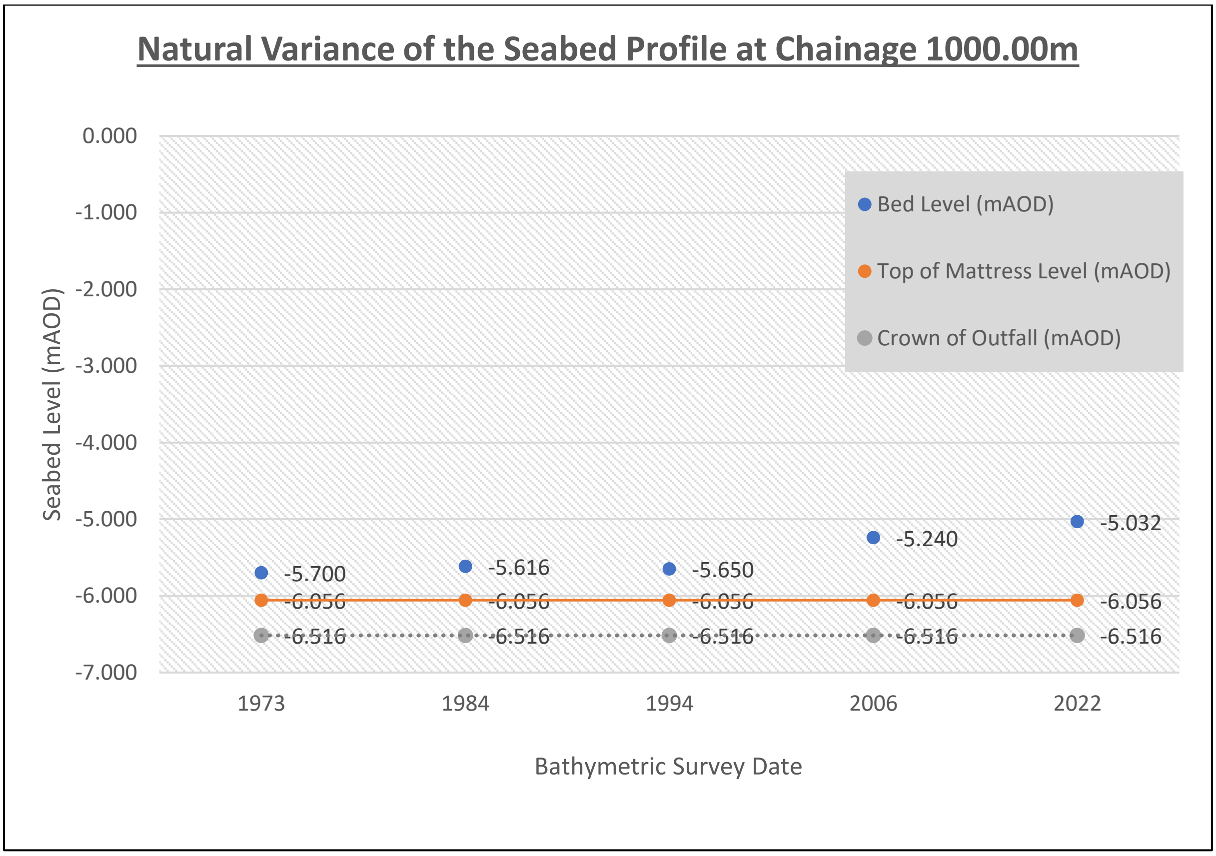


Chart 9: Natural Variance of the Seabed Profile at Chainage 1000.00m

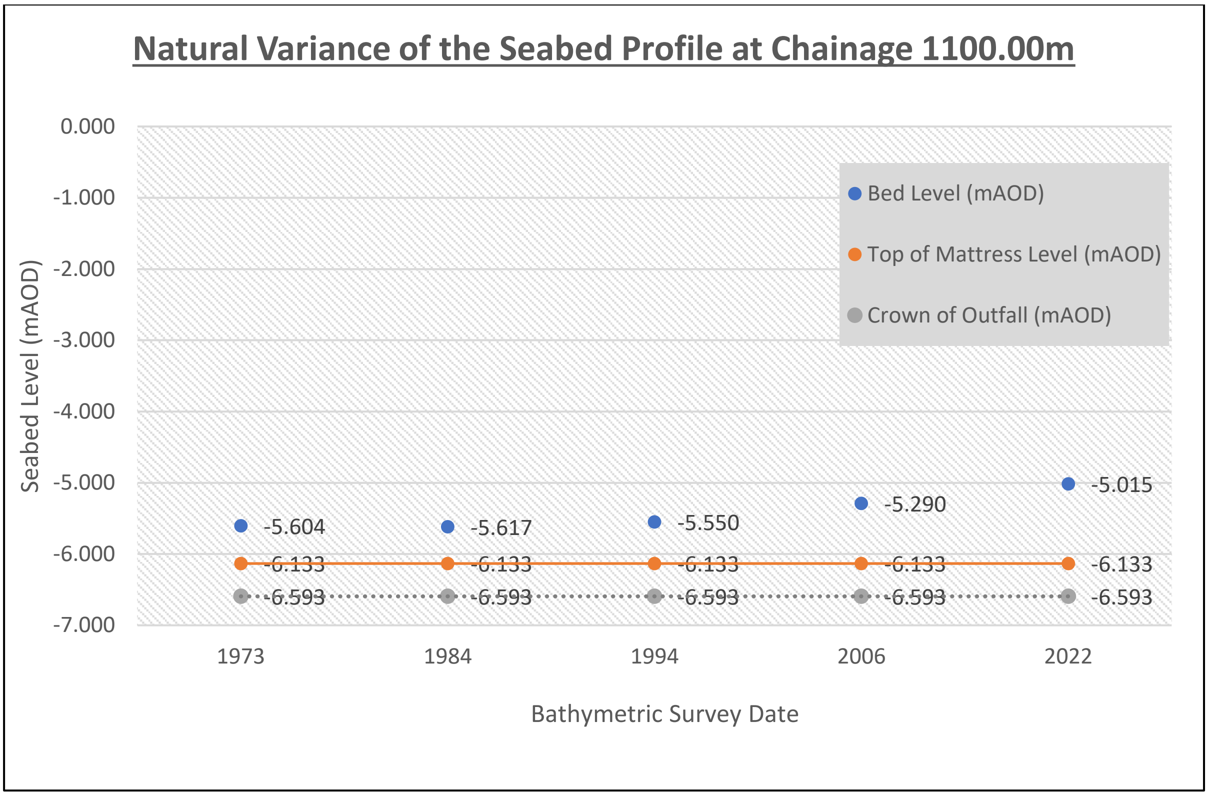


Chart 10: Natural Variance of the Seabed Profile at Chainage 1100.00m

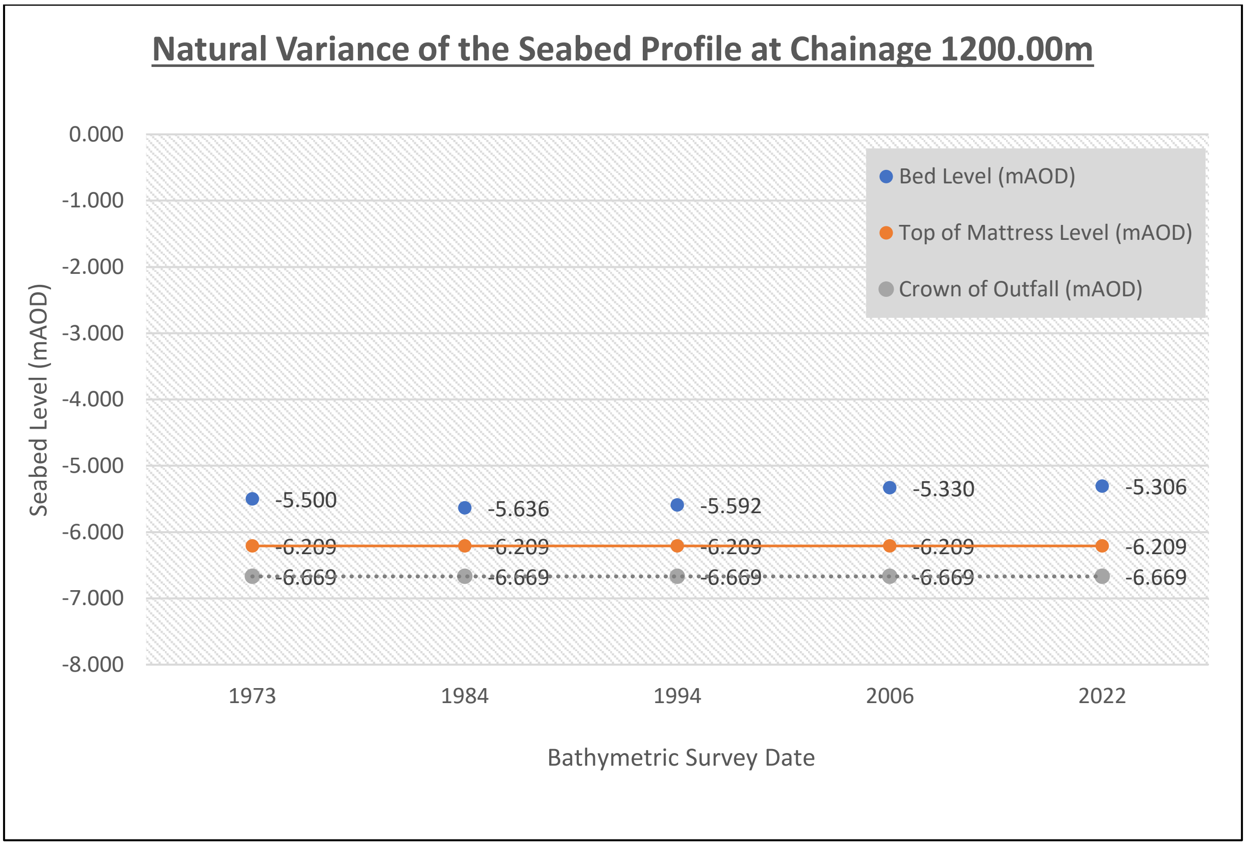


Chart 11: Natural Variance of the Seabed Profile at Chainage 1200.00m

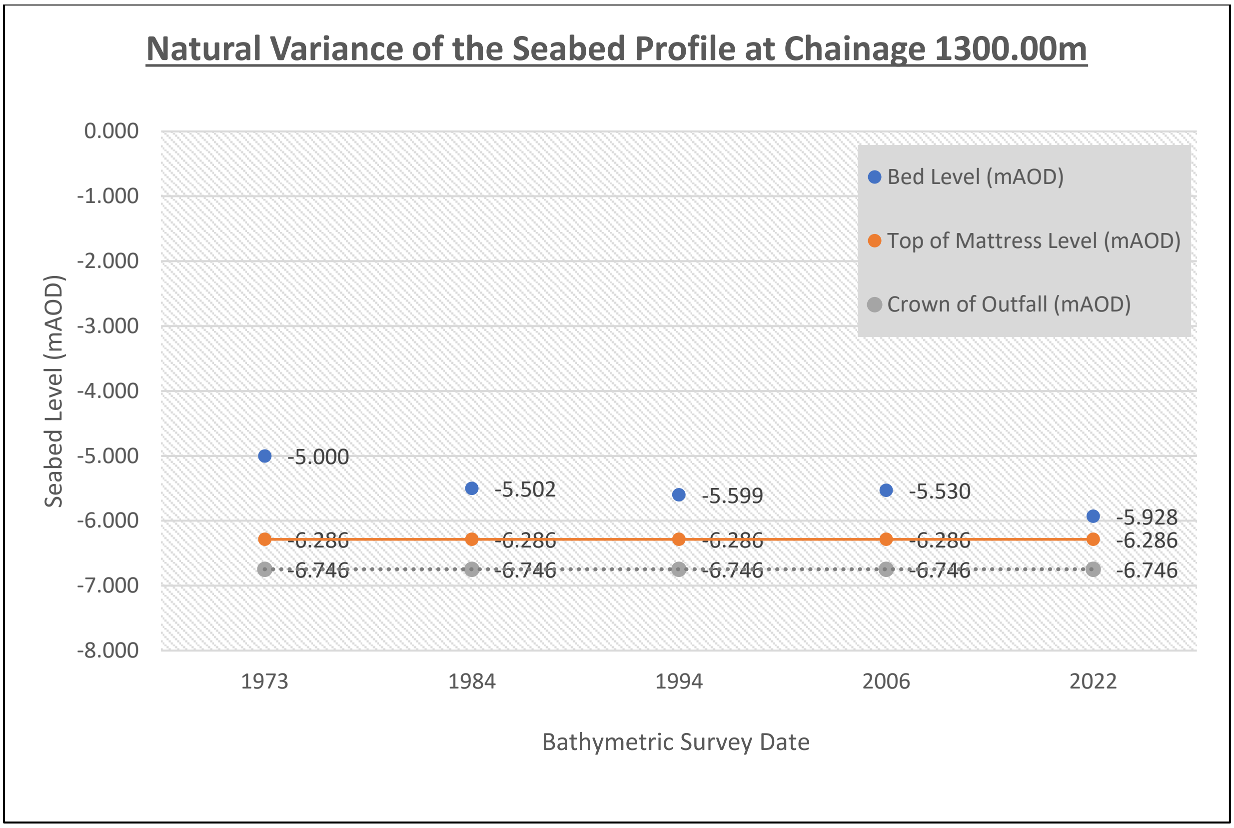


Chart 12: Natural Variance of the Seabed Profile at Chainage 1300.00m

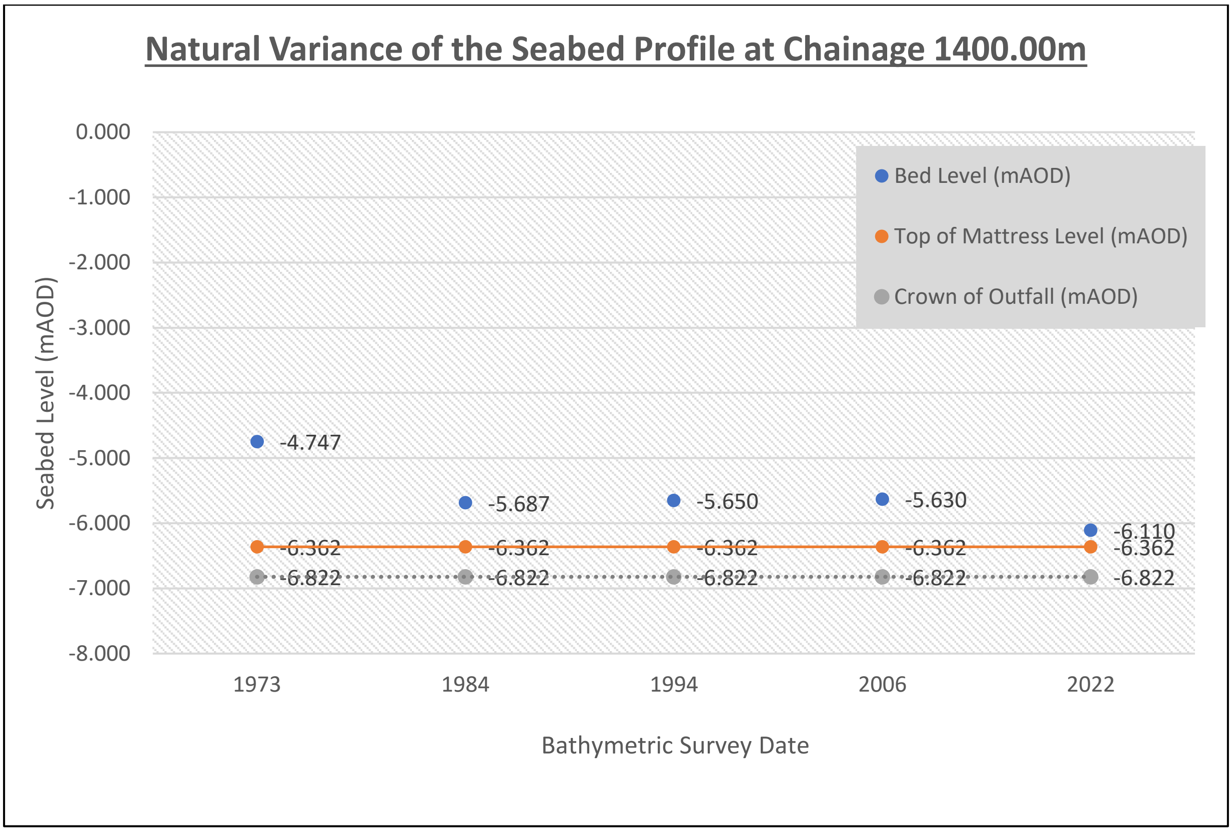


Chart 13: Natural Variance of the Seabed Profile at Chainage 1400.00m

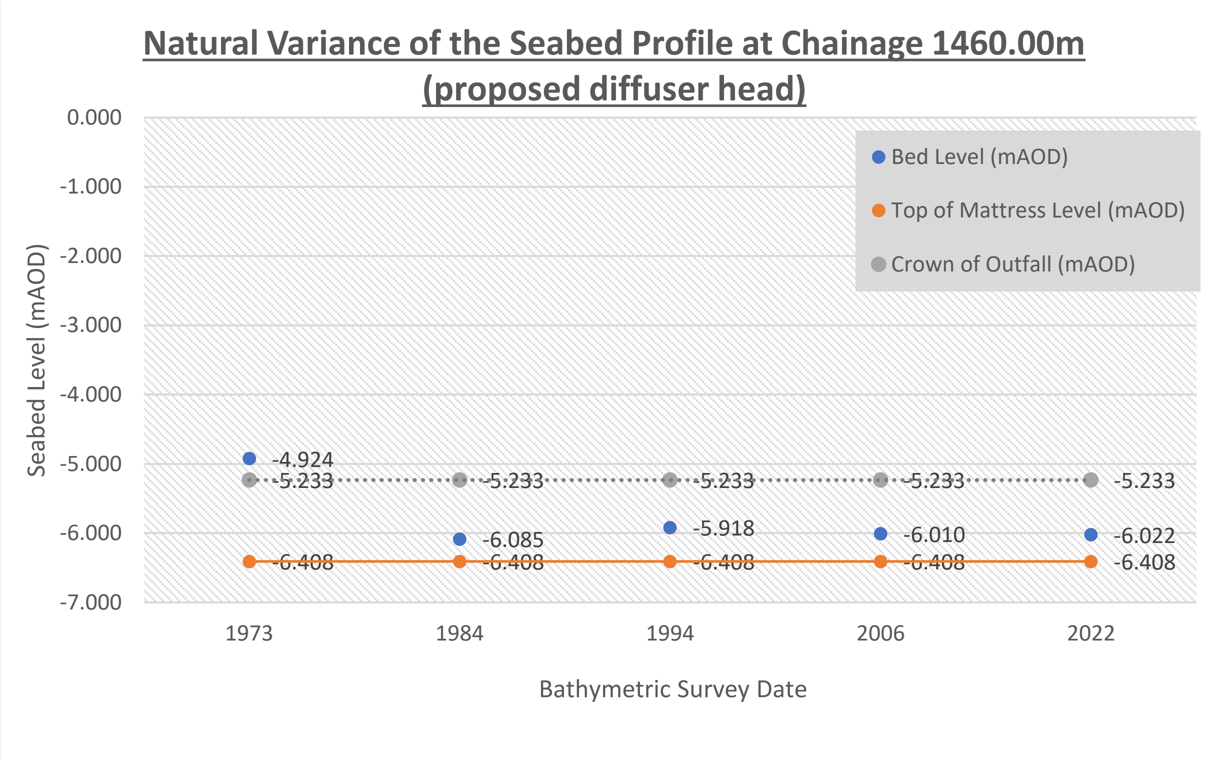


Chart 14: Natural Variance of the Seabed Profile at Chainage 1460.00m

The above data illustrates that generally, at these locations, the top of the mattress level remains below the measured bathymetric and topographic survey data for each data set. There are 3 data points (Chainage 200.00m- 2022 data point, Chainage 600.00m- 2006 data point & Chainage 700.00m-1973 data point) where the proposed mattress level would be slightly higher than the recorded bed level for that particular year, which equates to 3 data points from an analysed total of 64 points which is approximately 4.6% of the entire data set. This provides further confidence in our proposed method and design.

A comparison of the data sets at each chainage shows that there is no direct pattern of deposition and transportation of material, in that for each location, the curves do not correlate or show a reciprocal and measurable rise and fall over time. This further satisfies the understanding that the bed level is very dynamic in nature.

4.0 Further Information relating to the offshore element of the works- Geophysical Surveys

As part of the initial bathymetric survey undertaken by Kaymac in January 2022, we also commissioned Shoreline Surveys Ltd to undertake a geophysical survey of the area, including the proposed position of the replacement outfall. This was undertaken in order to better understand the offshore ground conditions and further to ensure that our proposed working and design method were feasible.

Kaymac Marine and Civil Engineering Ltd Contracted Shoreline Surveys Limited to execute multibeam, side scan sonar and geophysical surveys of an existing outfall pipeline corridor 2 kilometres east of Newport Harbour entrance, Gwent. The survey extents for the multibeam and side scan sonar surveys was 1500 x 100 metres and the survey extents for the geophysical survey was 1500x50metres.

The purpose of the survey was to:
1. Map the top of silt seabed levels using multibeam echo sounding.
2. Map the location and size of any seabed mounted contacts using multibeam echo sounding and side scan sonar.
3. Determine the thickness of the primary isopach (top of silt to first hard return) using a shallow geophysical survey system.
4. Determine the top of pipeline position above and below the seabed level (buried and exposed) using a shallow geophysical survey system and multibeam echo sounding.

A geophysical survey using a Stratabox geophysical profiler was used to determine the isopach thickness between the top of silt and first hard return (primary sub-bottom reflector) and also the top of pipeline position and depth where it was below the seabed. The Stratabox sensor was mounted on the bow of *Shoreline vessel,* positioned by a Trimble RTK GNSS system. Survey lines were orientated NNE-SSW (perpendicular to the pipeline).

All navigation data was recorded in WGS84 and converted to OSGB36 using the OSTN15 datum transformation within the Hypack Survey software. All depth data was recorded relative to Ordnance Datum Newlyn (ODN) with positive signs presenting levels above ODN.

The Stratabox system performed without fault. Strict quality control procedures were adhered to during data acquisition and processing. The Geophysical data was processed in Hypack Survey software. The primary hard reflector and top of pipeline (where buried) were interpreted and manually picked. To determine the level of the interpreted primary hard reflector the interpreted primary isopach (sediment thickness) was exported from the software and then modelled against the multibeam top of silt levels. An extract of the multibeam top of silt levels illustrating the exposed pipeline approaching the shore is shown below;

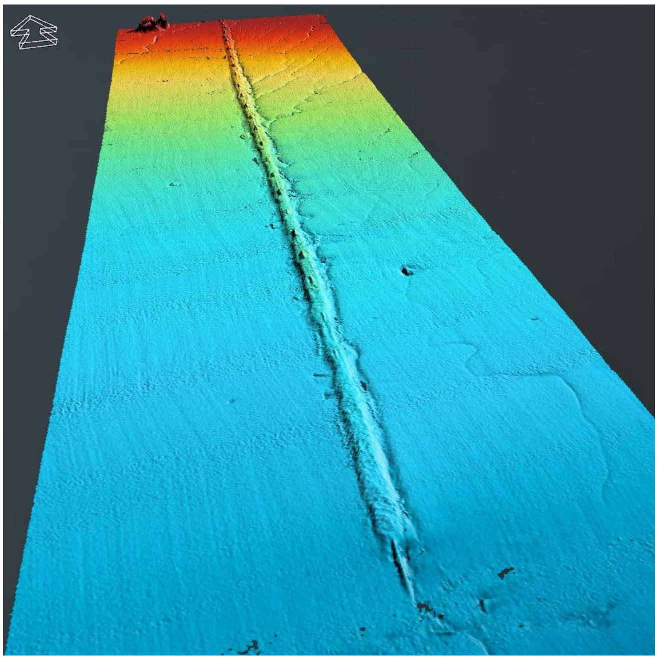


Image 4: Multibeam of exposed pipeline approaching the shore

The geophysical data was deemed to be of good quality. The Stratabox sensor performed well with the primary reflector observed within most of the data. Sea conditions for the first half were marginal (short wave period with a height of 0.2-0.4 metres) due to a stronger than forecasted wind opposing a strong tide. Survey vessel speed through water was varied according to the direction of the survey line (with or against tide) to attempt to maintain a steady speed over ground. However, the fast current flow did mean that there was some data compression in certain lines. However, with survey lines ran at 10 metre intervals and interlaced at 20 metre intervals this effect was minimised.

Image 5 presents a further extract of the Stratabox data where the pipeline was interpreted (two lines recorded in one file - hence pipeline seen twice). The deeper response is characteristic of a solid buried feature presenting a clear hyperbola rather than a single clear reflection. Due to the resolution of data the accuracy of interpreting the top of pipeline will be subject to error and as such should be treated on a tentative basis. However, the consistency in the interpreted buried top of pipeline response was good and presented a deepening nature as it extended offshore. A key observation relating to the level of the interpreted primary hard reflector was that it coincided well with the interpreted bottom of existing pipeline level. That is, the existing pipeline level appeared to be resting upon the primary hard reflector.

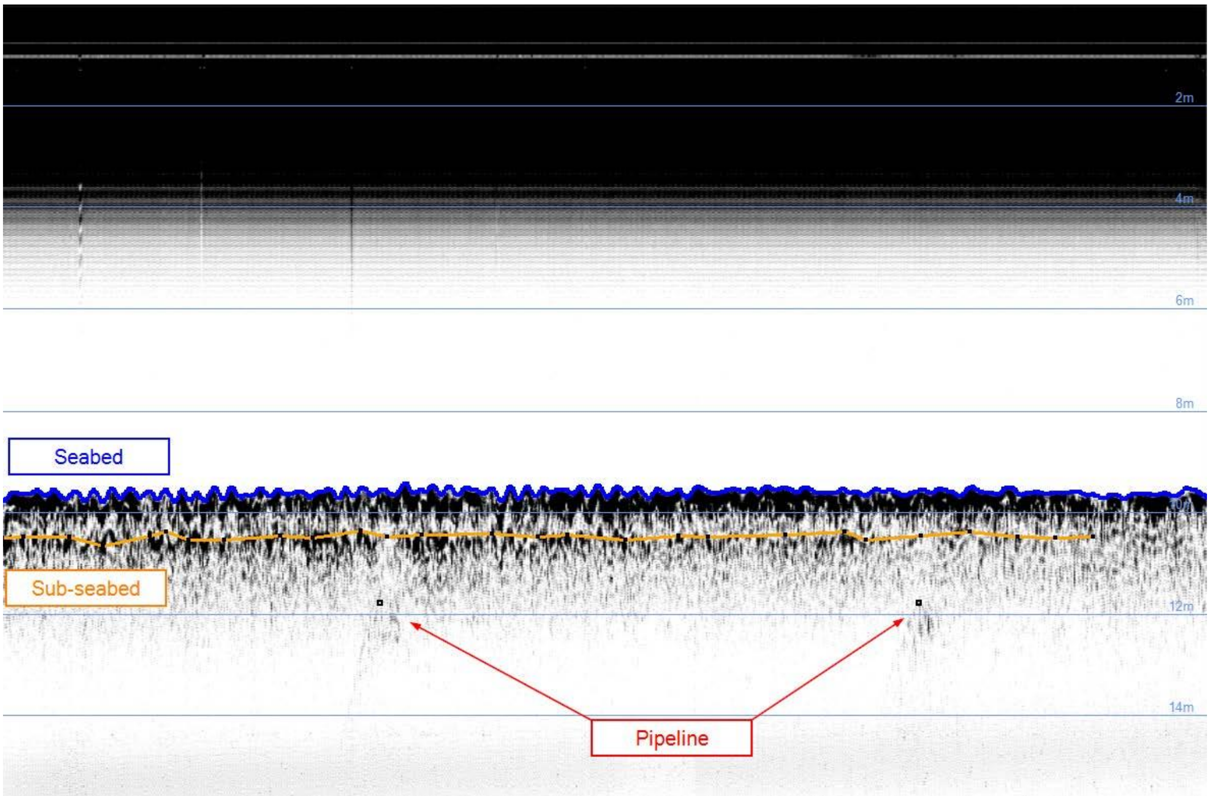


Image 5: Example of seabed, primary hard reflector and pipeline

Further, no bedrock response was observed within the Stratabox data providing further confidence that our offshore trench can be excavated in the proposed manner.

The stratabox data can also be further verified by the findings of the ground investigation works. Image 6 below shows the interpreted primary sub-bottom isopach in the location of Trial Pit 01 (TP01), where the numbers shown are the identified sediment thicknesses.

Image 6: Geophysical Sediment Thickness Readings in the location of TP01

At TP01, the geophysical survey identified that the sediment thickness was in the region of 1.2m deep as shown in Image 6. The Trial Pit Log at this location (Please see Image 2 above) shows that 'Soft blue grey slightly silty sandy clay' was identified at a depth of 1.25m, which is considerably close to the Stratabox data. The recorded data out to the proposed outfall discharge point is highly consistent, providing further confidence in the validity of the recorded Stratabox geophysical measurements. It provides Kaymac further assurance with regard to the suitability and practicality of the proposed outfall design