Port of Mostyn Ltd.

Overview of Maintenance Dredge and Disposal

Report to accompany Progress Note 48; June 2019

July 2019





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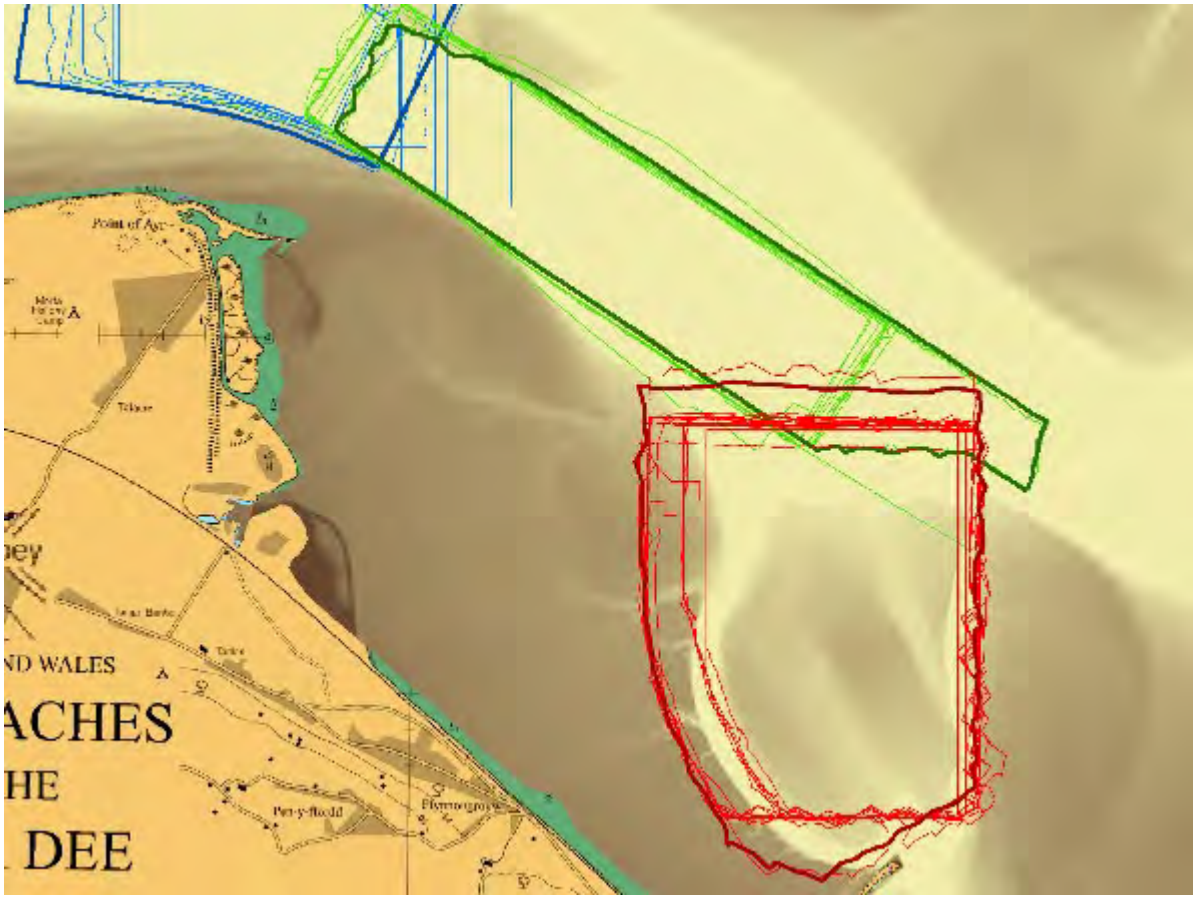

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Notice

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1 ABPmer Progress Overview

1.1 Introduction

This note provides a brief overview of the monitoring work that is being carried out by the Port of Mostyn as part of their ongoing approach channel dredging and disposal work. This monitoring is being undertaken as a condition of marine licences issued by Natural Resources Wales (NRW). The current licence (Ref DML1542v1) was issued on 1 May 2019 and covers the period from 1 May 2019 to 31 March 2025. This replaces the preceding licence (Ref DML1542) that was issued on 1 June 2016 and covered the period from 1 June 2016 to 31 March 2019.

The monitoring programme is being progressed according to an agreed set of protocols that were developed in 2008 (SMP 2008). It is also being progressed according to recommendations for adjustments to this programme that were made in a stand-alone review of 11 years' of survey work (ABPmer 2017).

The 11-year review, which considered data collected between 2005 and 2016, was issued in May 2017 as a condition of the two recent marine licences (as cited above). The findings were then discussed further and were largely agreed with NRW although some topics requiring future ongoing discussion were also identified.

The findings from this monitoring programme have been reviewed in regular and standardised progress notes and annual (or biennial) reports. A summary of the main reports produced to date are as follows:

- Annual reports including the most recent report which was issued in October 2018 (SMP, 2018) and encompassed the two-year period from November 2015 to November 2017; and
- Regular progress notes, including the latest report which covered data from April to July 2017 (Progress Note 47) and was also included in the recent annual review SMP (2018).

This brief overview report has now been prepared to accompany Progress Note 48. It considers the available monitoring data that has been collected up to May 2019. This report has been produced as an additional item to the standard reporting work and to complement the production of the standardised progress reporting proforma. The completed standardised proforma is included as Appendix A.

An overview report of this type is not usually prepared as part of the progress note production work, but it has been commissioned on this occasion by the Port of Mostyn in recognition of the following:

- A comparatively large amount of time has elapsed since the last reporting events with the latest issued reports covering the period up to November 2017 (as noted above). It was considered appropriate, therefore, to carry out extra analysis, mapping and review work to identify and clarify temporal changes that have occurred over this extended period; and
- Following the May 2017 monitoring review (ABPmer 2017) a number of recommended adjustments to the monitoring programme were made and the marine licences recognise the need to undertake the monitoring in accordance with these agreed revisions. These protocol changes will need to be reviewed with NRW on an ongoing basis. This overview, therefore, presents information needed to inform these ongoing discussions about any survey adjustments that are required (see Section 1.6).

It is intended, therefore, that this extra overview will help to facilitate review work by, and discussions with, NRW about this monitoring programme in a way that will both help to maintain continuity in the programme and also allow for continuing discussions about future monitoring adjustments building on from the 11-year monitoring review (ABPmer 2017)[1]. To help achieve these aims, this additional short overview includes some extra analysis over and above that carried out for the normal monitoring progress reports which link back to this review work that was undertaken two years ago.

1.2 Dredging Activity

To outline the most recent dredging activity at the Port of Mostyn, Table 1 summarises the dates, volumes and locations for the five most recent dredging campaigns. These campaigns include two that were carried out in 2016 and 2017 (Campaigns A16 and A17), which were also recorded within the most recent annual monitoring report (SMP 2018). In addition to these, Table 1 provides summary details about three subsequent campaigns in 2018 and 2019 that have not been reported previously (Campaigns A18, A19 and B19). The full dredge record in each case is also included as Appendix B.

Table 1. Approach channel dredge campaigns between 2016 and 2019

Dredge Campaign (Marine Licence	Date	Volume (m^3) Channel	Volume (m^3) Harbour	Channel Dredge Location relative to Buoy Locations
A16 (DML 1542)	June 2016	10,674	12,973	M3, M6
A17 (DML 1542)	Jan to Mar 2017	27,426	1,375	M3, M6
A18 (DML 1542)	Sept to Oct 2018	10,633	0	Dredger: Sospan Dau S1 buoy – 1443m^3 S2 buoy – 4316m^3 S4 buoy – 4874m^3
A19 (DML 1542)	March 2019	12,951	0	Dredger: Sospan Dau S4 buoy – 12951m^3
B19 (DML 1542v1)	May 2019	13,511	0	Dredger: Deo Gloria S2 buoy – 13511m^3

In these three recent campaigns (A18, A19 and B19), relatively small volumes of sediment have been dredged from the approach channels and there has been no equivalent dredging (aside from ploughing work) in the harbour area. To illustrate the comparatively small scale of recent campaigns in comparison with previous years, Figure 1 illustrates the volumes dredged from the channel and harbour over the last decade.

As also indicated in Table 1, during 2018 there was a change to the location of the dredging. In previous years the dredging occurred mainly in the 'Mostyn Channel', which is marked by the 'M' labelled navigation marker buoys and particularly in the outer shoaling section around Buoys M3 and M6. In 2018, and again in 2019, the dredging has taken place in the developing 'Salisbury Channel', which is marked by a series of 'S' labelled navigation buoys. In this new navigation approach, modest levels of dredging have taken place around the S1, S2 and S4 buoys over the last two years. The marker buoy locations are shown in Figure 2, as derived from latest Port of Mostyn Notice to Mariners (dated 25 January 2019).

[1] It is not currently envisaged that any changes will need to be made, or will be suggested, that fall outside of the recommendations made in the ABPmer (2017) review and there is no expectation, for example, that any variations to the extant marine licence (DML1542v1) will need to be sought

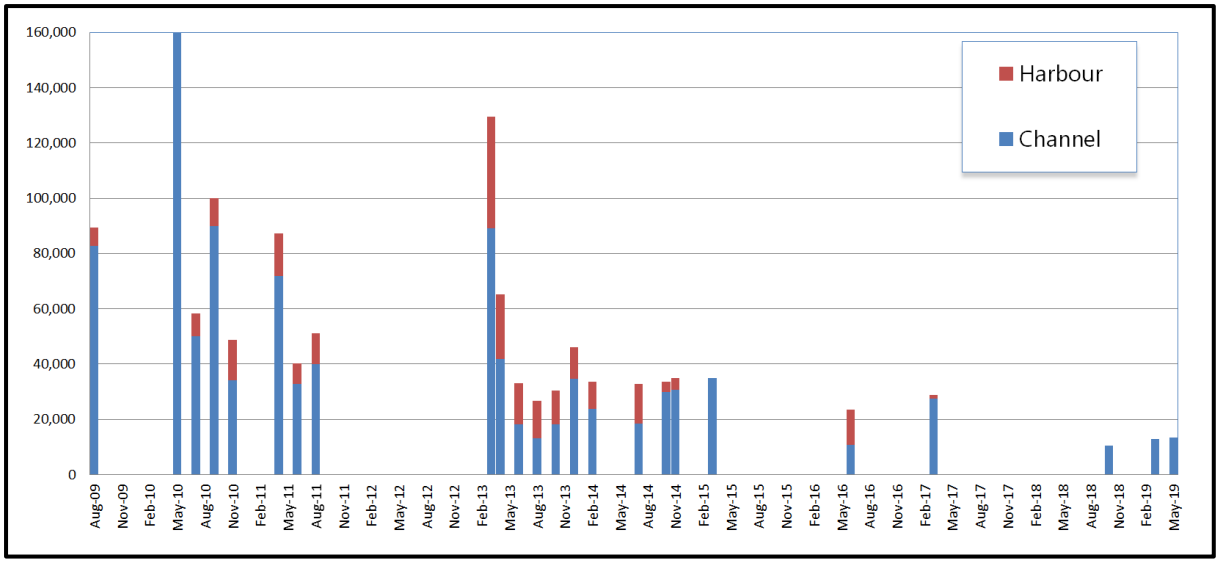


Figure 1. **Volumes (m^3) of sediment dredged from channel and harbour since August 2009**

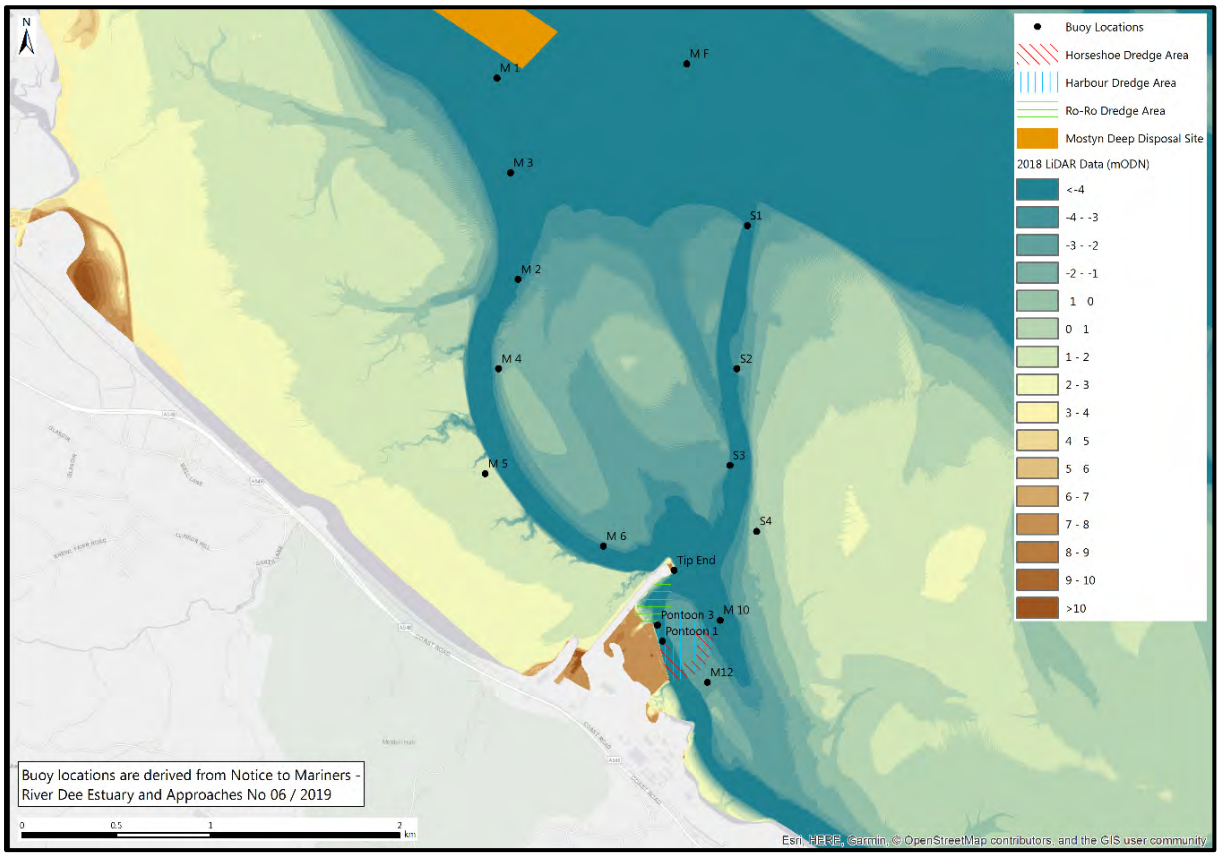


Figure 2. **Location of navigation marker buoys in January 2019**

1.3 Monitoring Overview

This note reviews the results from surveys undertaken since November 2017 when the last phase of reporting was completed. It also seeks to place these results, as appropriate, in the context of the observations and trends that were identified within the 11-year monitoring review (ABPmer, 2017), by employing the same analyses that were used in that study.

The new survey work that has been undertaken, and the new data that has been analysed for this June 2019 progress note, are outlined in Table 2. This table also summarises the survey work that was analysed for the previous progress notes and annual report (SMP, 2018) as well as in the 11-year review. It also includes the relevant threshold criteria for each of the survey components.

To also aid interpretation in this report, the main geomorphological features in the estuary are illustrated in Figure 3. Figure 4 shows the main monitoring sites and survey boundaries and, because these boundaries can be adjusted in response to need, Figure 5 shows the different boundaries for the surveys of Mid-Hoyle (EB3), Mostyn Deep (EB4), and the Approach Channel (LA1).

Table 2. Outline of the survey work completed up to May 2019 as part of the Mostyn Monitoring programme set alongside threshold criteria

Task	Status DML1542 superseded by DML1542v1	Stage I Thresholds	Stage II Threshold Criteria
LA1: Dredged Channel Bathymetry Surveys	**Licence Condition**: every 4 months [3 times per year]. **Surveys completed** as of May 2019: ▪ **11 year Review (2017)**: This review considered 21 surveys undertaken from Feb 2009 to Oct 2016; ▪ **2015 to 2017 Annual Report**: This review included the results from 2 further surveys in Feb and Jun 2017. ▪ **2019 June Progress Note**: A further 4 surveys have been carried out in 2017 (Nov) and then again in 2018 (Feb, July and Oct). *The Port also completed a survey in mid-June 2019 and this data will be reviewed in the next progress report*	▪ Channel Flank – elevation change exceeding 1 m ▪ Direct Impact Corridor-width change exceeding 100 m	Increases in seabed level within the ambient areas defined for dredging and deposition above forecast, not reflected outside these areas in general estuary behaviour or seabed level changes outside the 300 m wide dredged central corridor not reflected in general estuary changes in the area.
LA2: Mostyn Deep Site 'A' Deposition Area Bathymetry Surveys	**Licence Condition**: Before/after each dredge campaign. **No surveys needed yet** as this is only for dredging deeper than 2 m BCD.	No threshold defined.	No threshold defined.
LA3: Mostyn Deep Site 'A' Deposition Area Seabed Sediment Samples	**Licence Condition**: Annual at same time as EB4. **Surveys completed** as of May 2019: ▪ **11 year Review (2017)**: This review considered 6 annual surveys undertaken from 2009 to 2015; ▪ **2015 to 2017 Annual Report**: This review included 2 surveys in 2016 and 2017. ▪ **2019 June Progress Note**: A further survey was undertaken in December 2018.	Particle size distribution change based on the changing balance between D15, D50, and D85 values.	Non-dispersion of deposited sediments from Site 'A' over a six month period;

Task	Status DML1542 superseded by DML1542v1	Stage I Thresholds	Stage II Threshold Criteria
LA4 Cockle Survey – Salisbury/Mostyn Bank	**Licence Condition**: Annual using data supplied by NRW. **Reviews completed** as of May 2019: ▪ **11 year Review (2017)**: For this review no extra analysis outside of reviews in each of annual report; ▪ **2015 to 2017 Annual Report**: Two most recent annual NRW 'cockle stocks status' reports from 2016 and 2017 were included in this reporting; ▪ **2019 June Progress Note**: The latest NRW assessment of cockle biomass stocks was completed in Spring 2018 and the report requested by, and provided to, ABPmer on 30 April 2019 *A further NRW survey was undertaken in early 2019 and this data will be reviewed in the next progress report*	Any significant change over a twelve-month period not reflected outside the forecast area of dredged channel ambient impact.	No specific parameter defined change considered in context of cockling intensity and wider physical change.
LA5 Benthic Survey Salisbury/Mostyn Bank	**Licence Condition**: Biannual [need for the survey in autumn depends on findings from the spring survey so can be annual]. **Surveys completed** as of May 2019: ▪ **11 year Review (2017)**: This review considered 12 surveys undertaken from 2009 to 2015; ▪ **2015 to 2017 Annual Report**: This review included the results from two annual surveys in 2016 and 2017; ▪ **2019 June Progress Note**: Further spring annual surveys were undertaken in April of both 2018 and 2019.	Any significant change over a twelve-month period not reflected outside the forecast area of dredged channel ambient impact.	No specific parameter defined although change assessed in the context of wider estuarine physical change.
LA6: Port Area Survey and Local Cockle Survey.	**Licence Condition**: Before/after each dredge campaign and at 4 monthly intervals coincident with LA1. **No surveys needed yet** as this is only for dredging deeper than 2 m BCD. *It has also been agreed historically that if the other post dredge surveys show no significant change to the seabed along the flank of Salisbury Bank then this cockle survey would not be needed. This may continue to be relevant*	No threshold defined.	No threshold defined.

Task	Status DML1542 superseded by DML1542v1	Stage I Thresholds	Stage II Threshold Criteria
EB1 LiDAR/Swathe Survey of seabed levels	**Licence Condition**: Every 2 years (under previous licences was carried out annually); **Surveys completed** as of May 2019: ▪ **11 year Review (2017)**: This review considered 8 surveys undertaken from 2006 to 2016 ▪ **2015 to 2017 Annual Report**: This review included a further survey undertaken in February 2018; ▪ **2019 June Progress Note**: No new surveys have been undertaken.	Not applicable in progress reports since the model results will be subject to detailed assessment as a normal course within the annual monitoring report and thereby provide a culmination of the year's monitoring. There is no Stage I threshold for Task EB1 but in the event of the model results showing any significant increase in dredge and/or deposition impact then a Stage II condition would immediately apply and be presented in the annual report.	▪ Lateral shifting of the location and relative location of Hilbre and Welsh channels. ▪ Re-opening of the Salisbury Bank cross-channel. ▪ Re-opening of the Welshman's Gut
EB2 Estuary Transects	**Licence Condition**: every 4 months [3 times per year] (under previous licences monthly and bi-monthly). **Surveys completed** as of May 2019: ▪ **11 year Review (2017)**: This review considered 65 surveys undertaken from May 2005 to March 2016; ▪ **2015 to 2017 Annual Report**: This review included the results from 5 further surveys in 2016 (June and Sept) and 2017 (January, April, Sept). ▪ **2019 June Progress Note**: A further 5 surveys have been carried out in 2017 (Nov), 2018 (April and Sept) and 2019 (January and May)	Channel and Bank ▪ Offset change exceeding 150 m ▪ Width change exceeding 150 m ▪ Depth change exceeding 1.5 m	Alteration to the location and alignment of the main low water channel off Greenfield. Lateral shifting of the energy balance in the central estuary manifest by bank and channel Relocations.

Task	Status DML1542 superseded by DML1542v1	Stage I Thresholds	Stage II Threshold Criteria
EB3 Mid-Hoyle/ Welsh channel confluence	**Licence Condition**: Annual coincident with LiDAR survey. **Surveys completed** as of May 2019: ▪ **11 year Review (2017)**: This review considered nine surveys from 2006 to 2016 (excluding 2007 and 2008). ▪ **2015 to 2017 Annual Report**: This review included the results from four further surveys. Two each in 2016 and 2017 (May and Nov both years) ▪ **2019 June Progress Note**: Two further surveys have been carried out in 2018 (May) and 2019 (Jan).	Any movement of Mid-Hoyle channel confluence with Welsh Channel westward.	Reversal of the migration trend for Mid-Hoyle channel.
EB4 Mostyn Deep Bathymetry	**Licence Condition**: Annual. **Surveys completed** as of May 2019: ▪ **11 year Review (2017)**: This review considered 12 surveys from 2009 to 2016 (including an extra survey in 2015); ▪ **2015 to 2017 Annual Report**: This review included the results from four further surveys. Two surveys each in 2016 (May and Nov) and 2017 (March and Nov). ▪ **2019 June Progress Note**: Two further surveys have been carried out in 2018 (Apr and Nov).	Any nett accretion over the twelve month period that was equal to or greater than a mean depth change of 2.0 m over the area of the 5.0 m below CD contour.	Increases in seabed level outside but adjacent to the deposition area not reflected elsewhere in Mostyn Deep.
EB5 Holocene Clay Bank	**Licence Condition**: Annual [coincident with LA5]. **Surveys completed** as of May 2019: ▪ **11 year Review (2017)**: For this review no extra analysis outside of reviews in each of annual report; ▪ **2015 to 2017 Annual Report**: This review included the results from surveys and sites visit in 2016 and 2017, ▪ **2019 June Progress Note**: A new site visit was carried out in May 2019.	Any mean monthly clay erosion of the south-western edge of the bank by more than 5.0 m between successive surveys.	

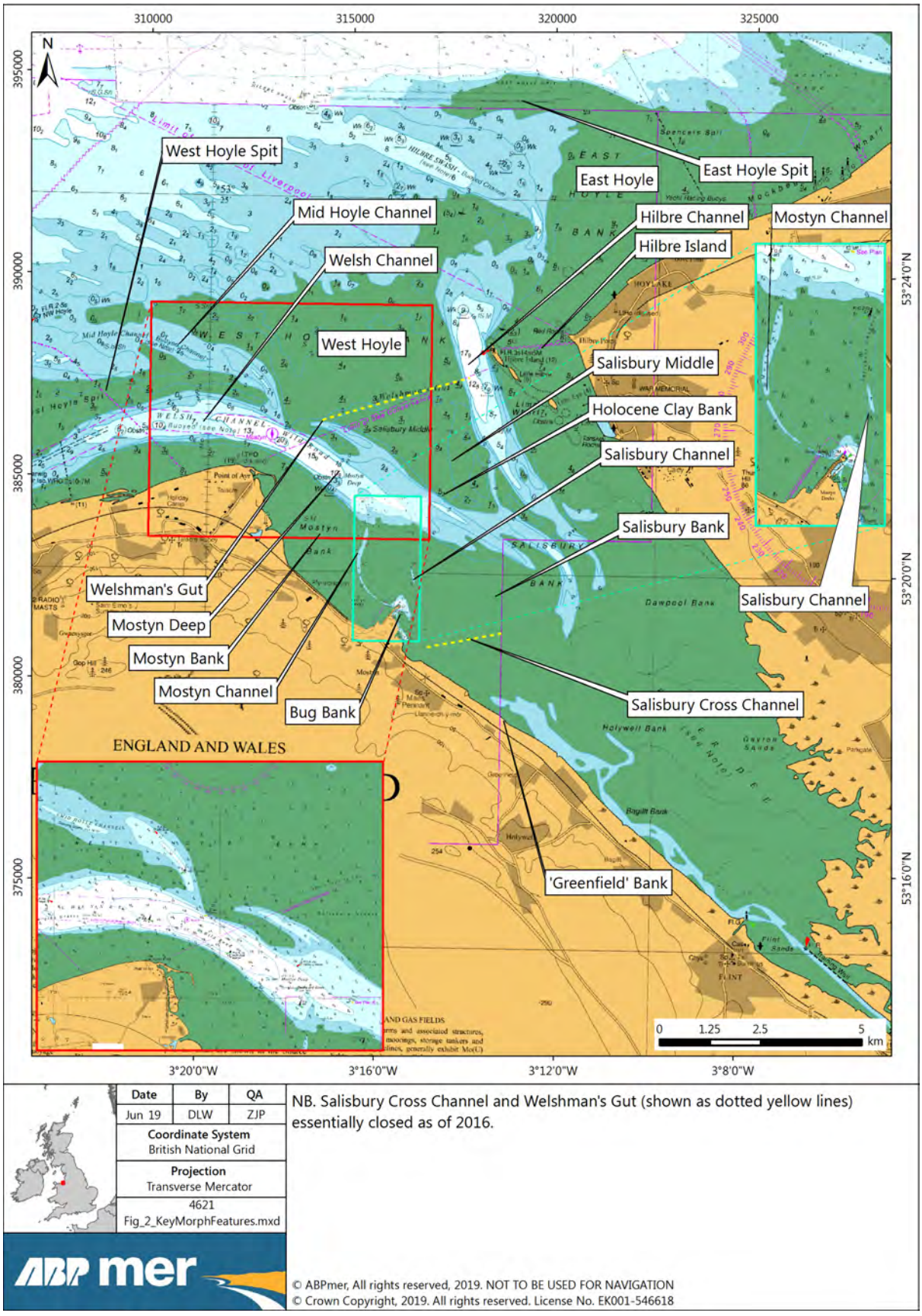


Figure 3. Dee Estuary morphological features of relevance to the monitoring programme

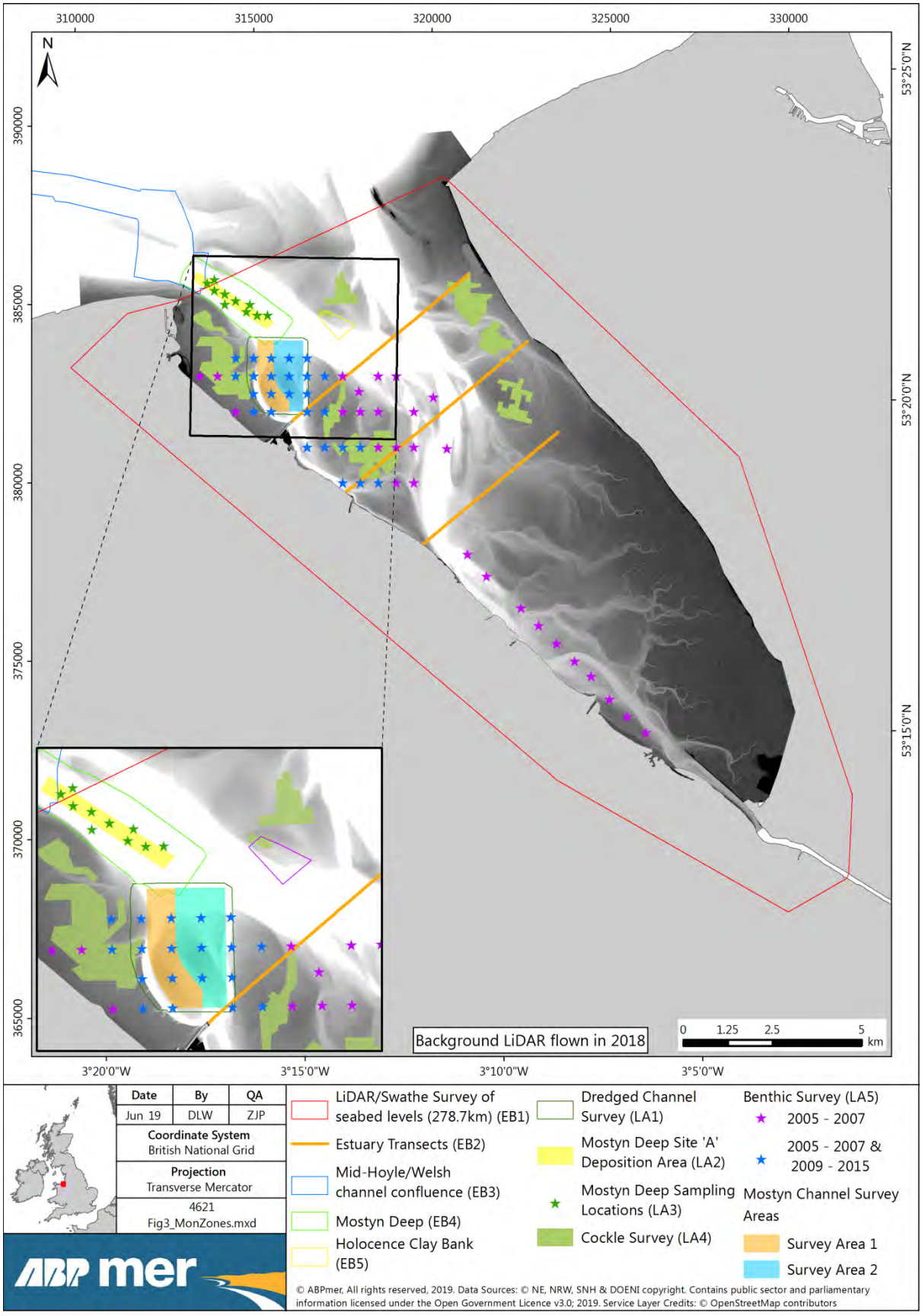


Figure 4. Survey zones and site locations for the Port of Mostyn monitoring programme

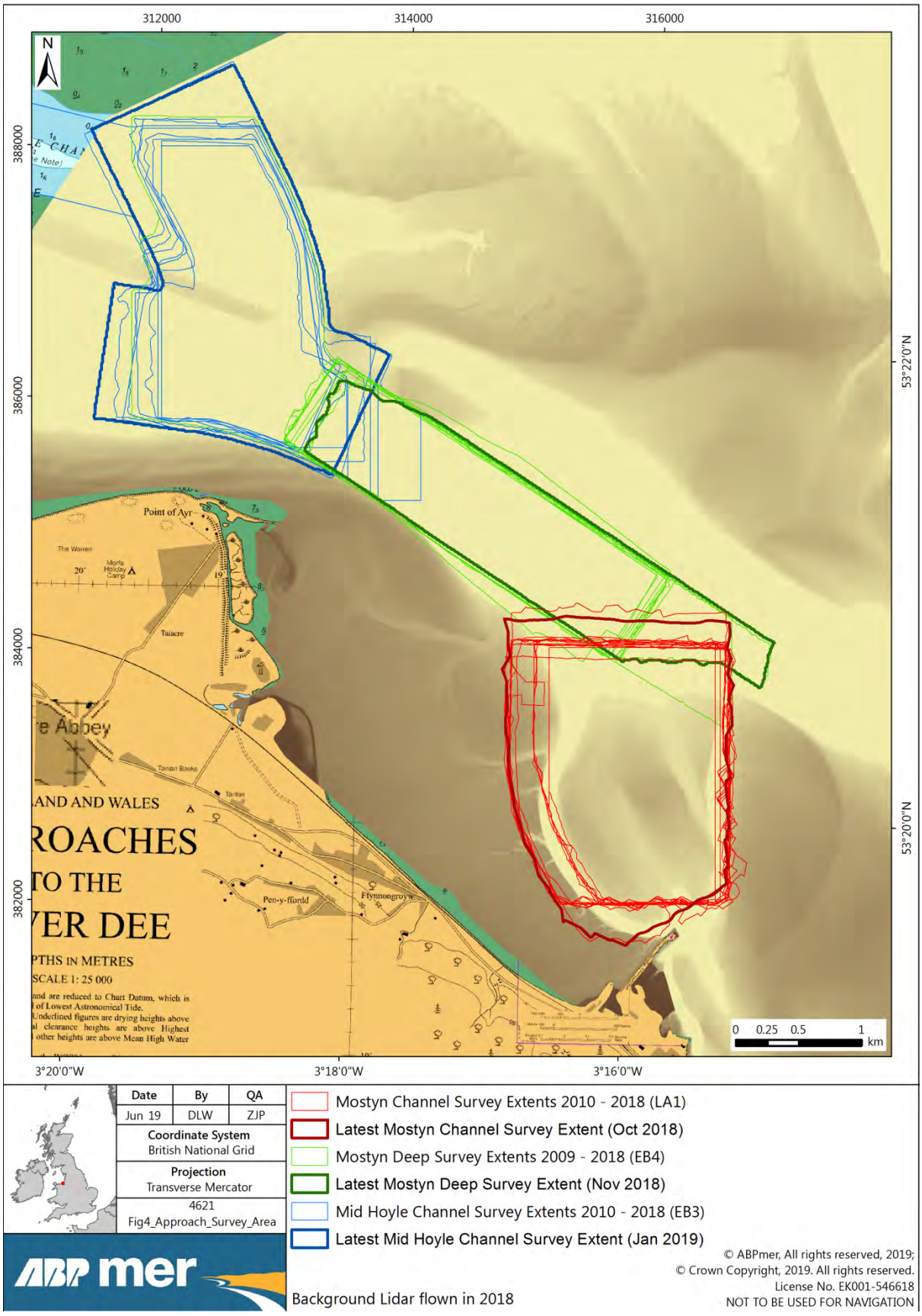


Figure 5. **Boundaries of Mid-Hoyle (EB3), Mostyn Deep (EB4), and Approach Channel (LA1) survey areas**

1.4 Local Area Results

The following sections summarise the survey findings and relevant changes for each of the main components of the monitoring programme.

1.4.1 LA1 Dredged Channel Survey

The aim of the LA1 Dredged Channel Surveys is to monitor the depth changes within the Port's navigation approach channel and its changes over time. The changes over time, up to the October 2018 survey, are illustrated by the transect plots in Figure 6 to Figure 8, and are summarised below. The latest data is also plotted in a sequence of standard survey transect plots, as used in all previous progress notes, that are included as Appendix C.

Since the monitoring programme began, there has been a continuing westerly shift in the alignment, and a shallowing, of the Mostyn Approach Channel. The main area of westerly migration is along the southern end of this channel. The northern end of the channel, on its western side, appears to be relatively stable, when compared to these locations further to the south. Based on these changes, the following terminologies have been used to describe observed changes in the main approach channels:

- **The eastern apex of the Mostyn bank**: This term describes the relatively stable easternmost part of the Mostyn Bank which is located at the extreme northern end of the western flank of the Mostyn Approach Channel;
- **The Mostyn Channel hinge point**. As described further below, there appears to be a switch in the direction of migration along the length of the Mostyn Channel. Towards the northern end, there is evidence of some (limited) eastward migration; to the south, significant westerly migration has been observed from the monitoring campaign. The mid-section of the channel represents a hinge-point, defining the switch in the direction of channel migration; and
- **The eastern channel hinge point**. Similar to the above, the channels identified to the east of the Port of Mostyn (including Salisbury Channel) also show evidence of a variation in the observed migration. The migration to the northern and southern ends of these channels is to the east in both cases, resulting in the channels evolving a curvature around the hinge point.

Maintenance dredging has only been required down to a level of 2 m below CD and the previous surveys have not indicated any direct influence of the dredging on the ongoing processes, although it will have helped to confine flow through the channel. The westward migration of the Mostyn Channel is therefore considered to be primarily a natural evolution, albeit potentially influenced in its current form by the original capital deepening.

The transect plots that are shown in Figure 6 to Figure 8 also illustrate that existing channels to the east of the Mostyn Approach Channel (including the 'Salisbury Channel') have changed with time, but are generally shifting towards the east. The transects shown on these plots are positioned to depict bathymetric change over time (and along the channels) and an overview of the changes occurring along Transects 1 to 3 is included in the sections below.

Transect 1 (Figure 6)

This transect is located toward the north end of the LA1 survey area. Where it crosses the Mostyn Channel it lies close to 'eastern apex' of Mostyn Bank. This eastern apex lies on the western side of the Mostyn Channel that has remained relatively stable, compared to locations further south. This transect shows the following:

- A westward Mostyn Channel migration at all levels on the bank until about 2014;

- After 2014, the western bank of the Mostyn Channel has become shallower in its profile. The bank above +1.5 m CD continued westwards at a slower rate. Below +1.5 mCD migration eastwards has occurred as the channel has continued to reduce in depth, (i.e. a turning point occurs in 2014). This variation in the rates of change with elevation has considerably 'shallowed' the western flank slope to Mostyn Bank during this period;
- There is evidence that the higher elevations have also started to move eastwards, albeit at a slower rate from 2016; and
- Change occurred on the east bank around 2011/12, when the height of the bank began to lower, with accretion occurring at the base, hence shallowing the channel slope. This appears to have halted in 2016 and a slight eastward movement has occurred since.

Transect 2 (Figure 6)

The transect is located just south of the 'hinge point' within the channel and also passes through one of the largest areas of change in the vicinity of the eastern channels (marked A and B on Figure 6). The analysis shows that:

- During 2017 and 2018, migration of the western flank of the Mostyn Channel into Mostyn Bank has continued at a similar rate (average 10 m/year), with the trend for reduced maximum channel depths. Unlike Transect 1, there is no evidence of change in trend up to the latest survey analysed (October 2018); and
- The east side of the Mostyn Channel has generally followed the west side, approximately maintaining the navigation width and bank steepening, particularly during 2016/2017, up until about the end of 2017. The October 2018 survey shows significant erosion towards the top of the slope and outward migration appears to have started.

Transect 3 (Figure 7)

This transect is located approximately through the apex of the bend in the existing Mostyn Channel (October 2018) and passes close to the 'hinge point' in the vicinity of the 'Eastern channels', see below. From this location southwards (towards the Mostyn Breakwater) the highest westward migration rates are observed. Before 2016, the average rate is around 38 m/year, but since 2016, this has increased to *circa* 45 m/year. Channel depths reduced before *circa* 2015 to 1.5 m below CD but have remained at this level up to latest survey analysed (October 2018), with a consistent width.

The channel (remnants) of the original capital dredge have continued to infill over time at a rate of around 0.2 m/year; however, this increased substantially (5 times) to 1 m/year between October 2017 and October 2018, and depths have levelled out at about 3 m above CD.

Eastern Channels (including 'Salisbury Channel' (Figure 6)

Figure 6 identifies two channels (A and B). Channel A has, since 2016, become better defined (at MLWS) over a longer length, albeit there are two pinch points shown at either end. The evolution trend of Channel B has also changed. Before 2016 the orientation of the channel was generally north–south, whilst moving eastwards. Since this period, a 'hinge point' has developed approximately half way along with little further migration observed at this location. However, both the northern and southern ends have continued migration eastwards, hence developing a curved channel. As Channel A has become more defined (with the east bank migrating faster than the west bank and deepening at a faster rate, particularly since 2017), this has potentially caused the increased flow (doubling the rate), assisting the migration of Channel B at the southern end.

As a result of the variance between the channels, a 'triangular shaped' bank has formed between the channels at the northern end which appears to be migrating south, associated with these changes in the channel migration.

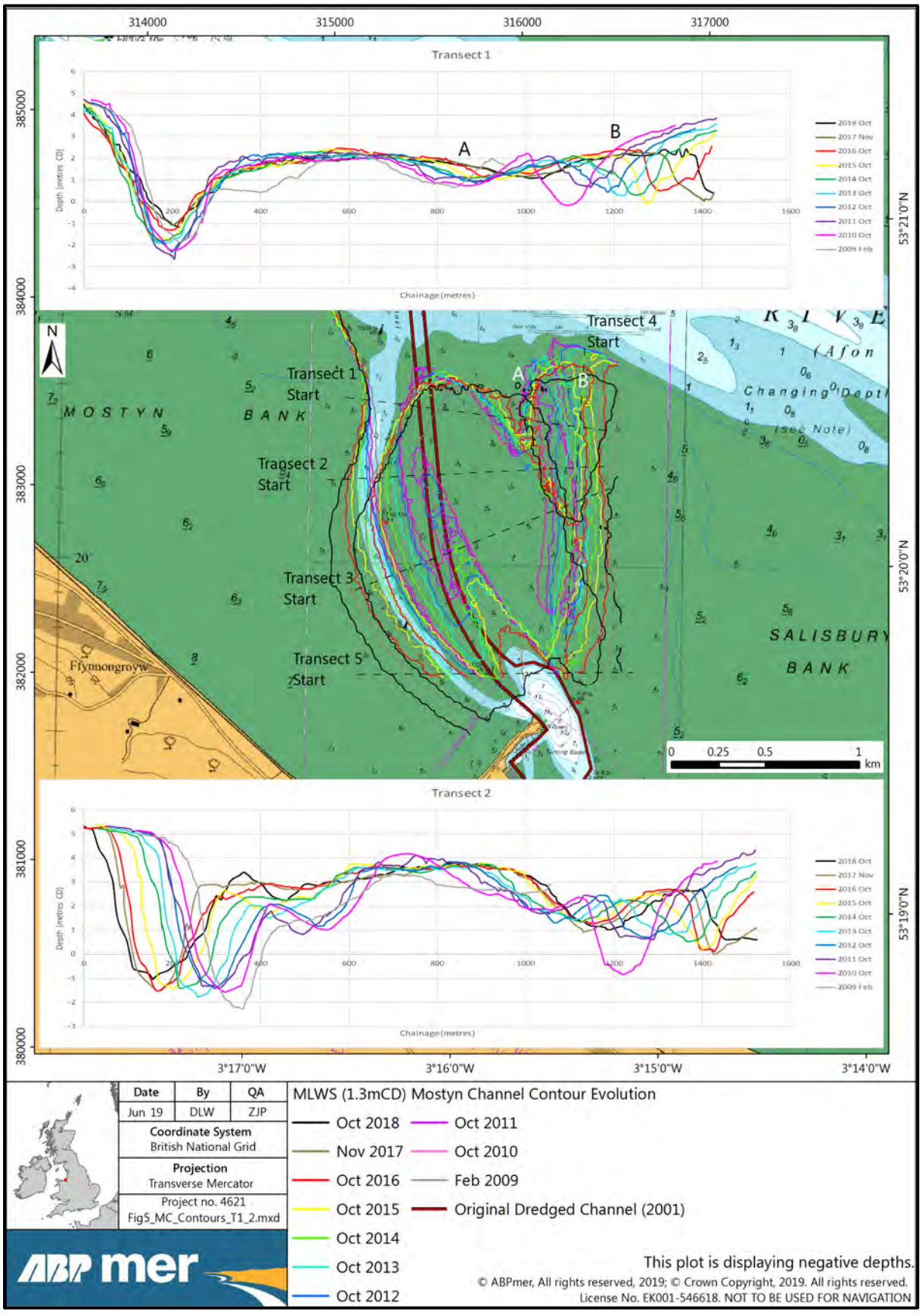


Figure 6. **Mostyn Approach Channel bathymetric change from 2009 to 2018 also showing the MLWS contour and profile details from Transects 1 and 2**

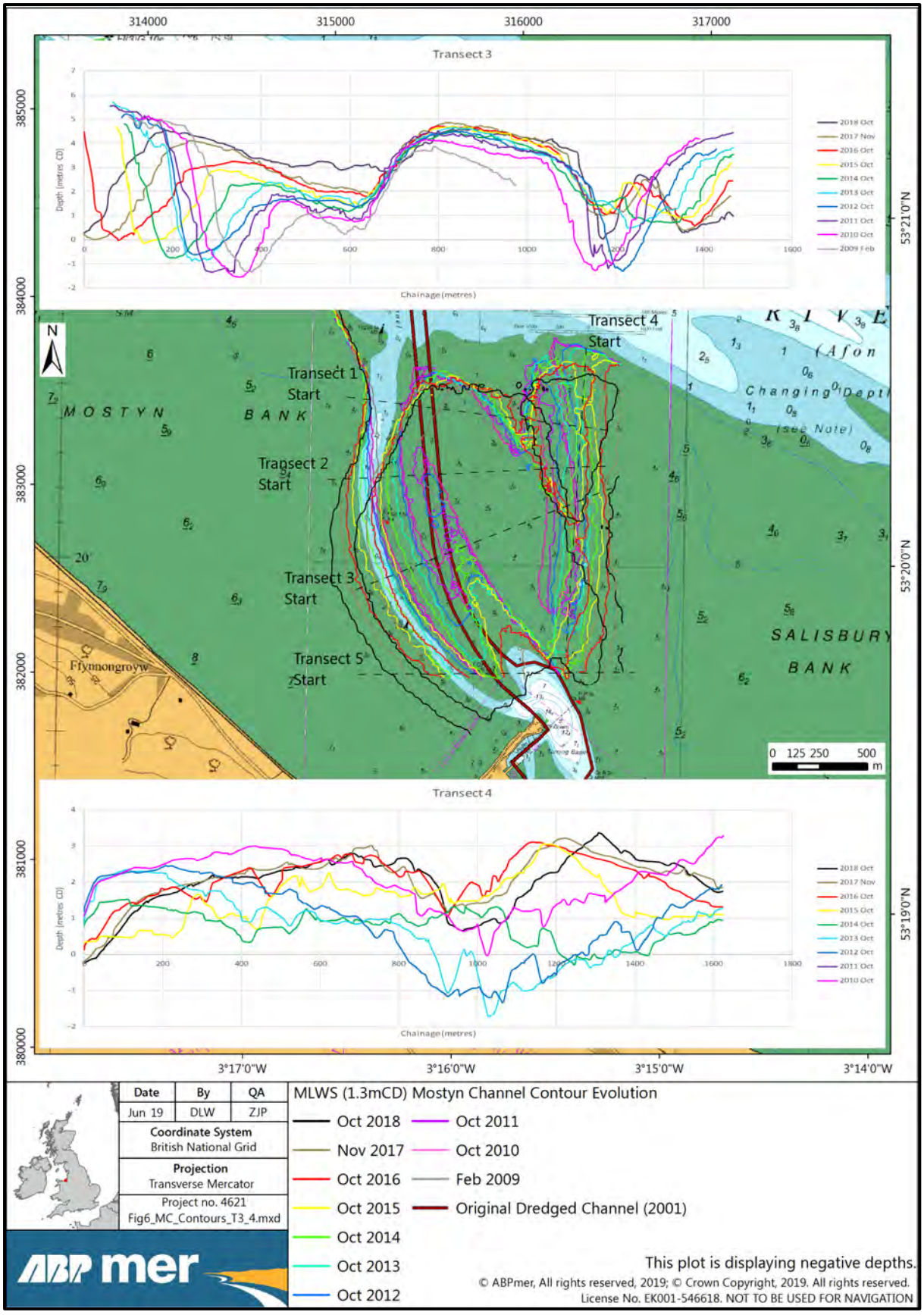


Figure 7. **Mostyn Approach Channel bathymetric change from 2009 to 2018 also showing the MLWS contour and profile details from Transects 3 and 4**

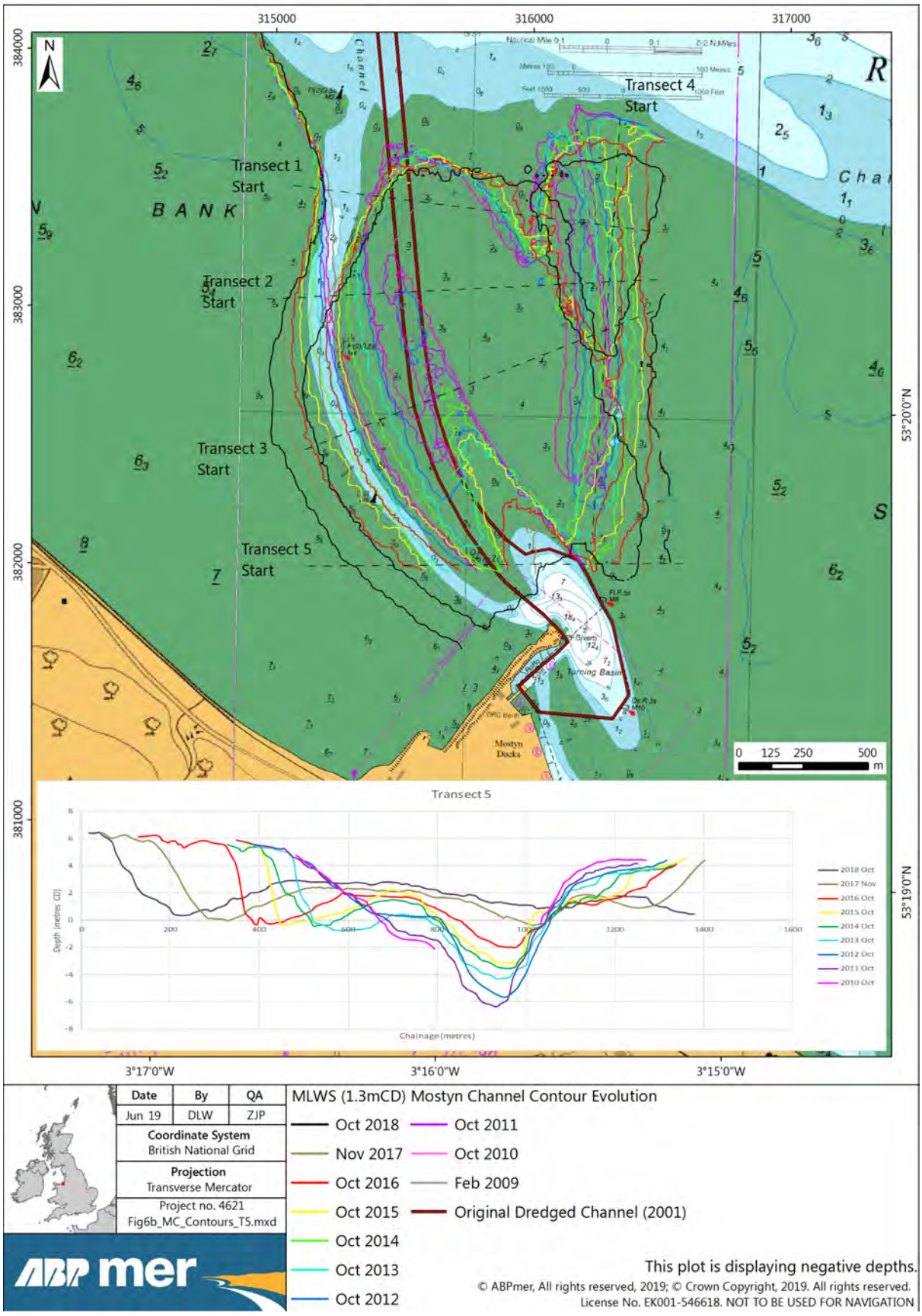


Figure 8. **Mostyn Approach Channel bathymetric change from 2009 to 2018 also showing the MLWS contour and profile details from Transects 3 and 4**

1.4.2 LA3 Mostyn Deep Site 'A' Deposition Area Seabed Samples

The aim of Task LA3 is to monitor the sediment characteristics of the deposition area and the wider Mostyn Deep channel through the collection of sediment samples. This is to understand whether the deposition has any material effect on the physical characteristics of the seabed substratum.

This work involves taking sediment samples from within and around the Mostyn Deep disposal site. Seabed samples are collected from the 10 established sampling locations and subject to Particle Size Analysis (PSA). The site locations are shown in Figure 9.

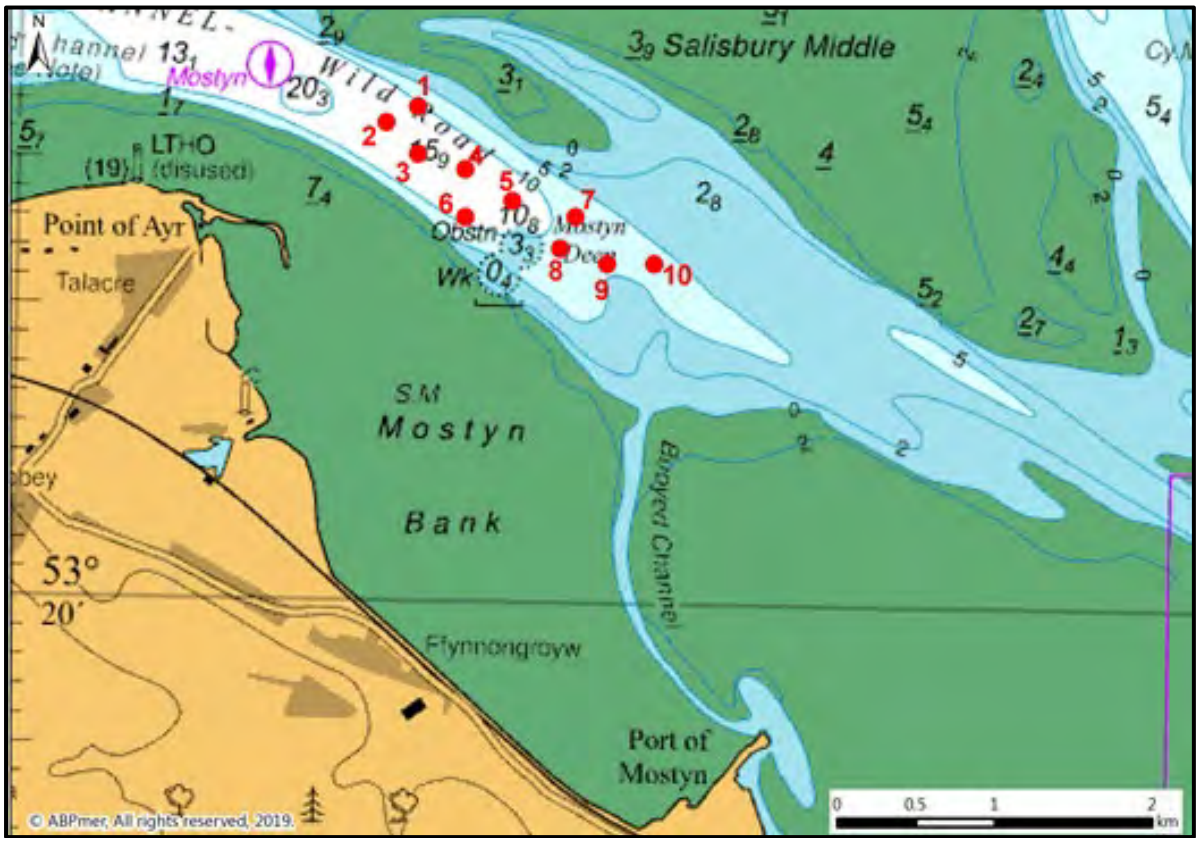


Figure 9. Location of the ten established Mostyn Deep seabed sampling sites (LA3)

The latest samples were collected in December 2018 by the Port of Mostyn and the results were reviewed in a short technical note, which is included as Appendix D of this report. In Appendix D the PSA results from December 2018 were compared against data from 2009 to 2015, reviewed within ABPmer (2017). It was found that there was:

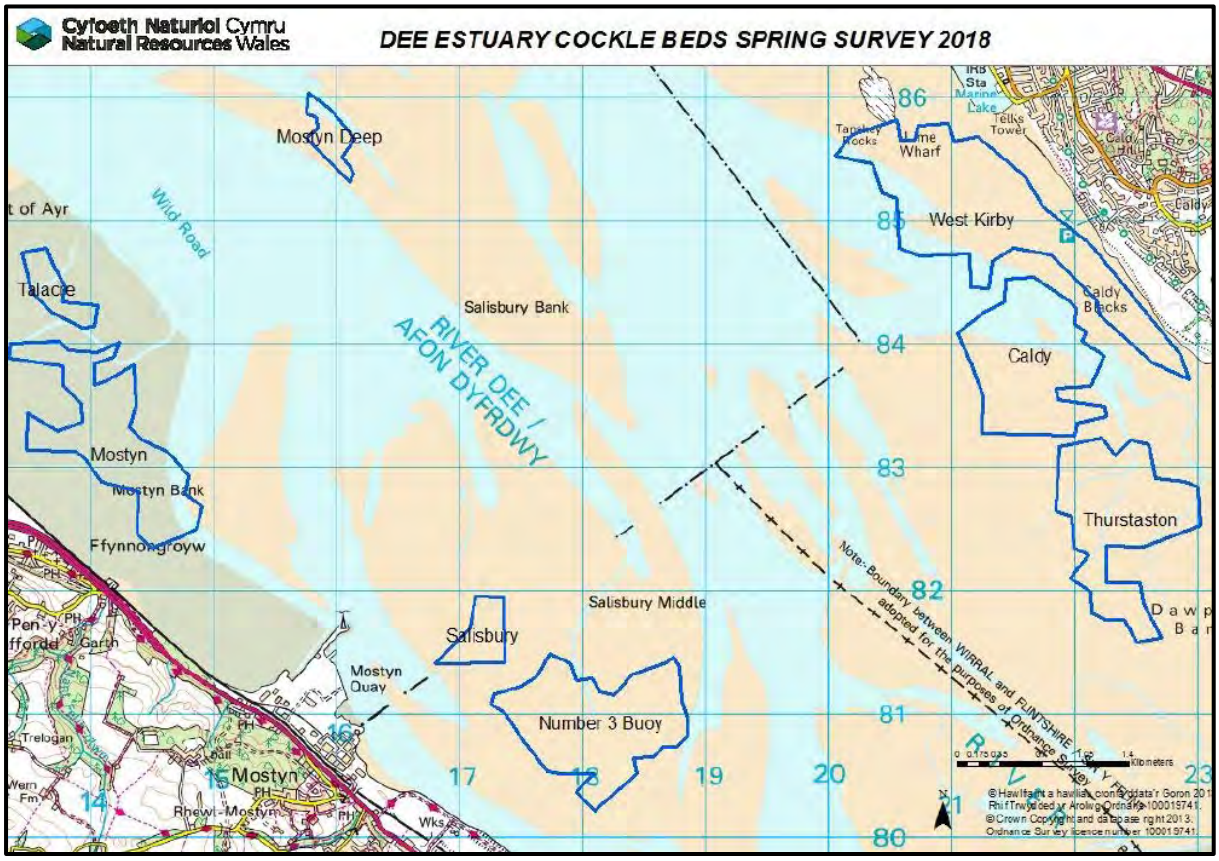
- Little overall change against the D_{15} criteria can be seen between samples located within the deposition area. Outside of the deposition area individual samples have either become slightly finer or coarser, but remain under the threshold criteria. An exception is Site 6 which has seen a coarsening above threshold;
- D_{50} values remain generally under criteria both inside and outside of the deposition area. The exceptions to this are Sites 6 and 8, which have seen short-term positive 'spikes' in D_{50} values (first identified in ABPmer 2018), maintained within the latest samples; and
- The D_{85} parameter remains variable, both inside and outside of the deposition area. Significant increases/decreases occur regularly between successive samples at the same locations, which are likely to be a result of large individual pebbles in the gravel fraction. Both long-term increase of D_{85} at Site 6, and decreasing of D_{85} at Site 7, has continued.

It is notable, however, that only small volumes of dredging have been taking place in recent years and that any sediment which has collected has been removed (under licence), rather than deposited at the disposal site. Therefore, there have been no recent depositions to Mostyn Deep and the results obtained are a reflection of the natural variability in background conditions.

1.4.3 LA4 Cockle Survey – Salisbury/Mostyn Bank

The aim of this work is to check whether there have been any notable changes to the cockle populations in the estuary using data that is collected by NRW.

The latest NRW assessment of cockle biomass stocks was completed in Spring 2018 and the report provided to ABPmer on 30 April 2019. A further NRW survey was undertaken in early 2019 but this has not been reported yet. The location of the surveyed cockle beds is shown in Figure 10 and the NRW report is included as Appendix E of this report.



Source NRW, 2018 (see Appendix E)

Figure 10. Location of Dee Estuary cockle beds surveyed by NRW

1.4.4 LA5 Benthic Survey - Salisbury/Mostyn Bank

The aim of the benthic sampling work is to examine the ecological characteristics of intertidal mudflats and sandflats surrounding the Approach Channel to understand whether they are affected by the dredging work.

Since the latest annual report and progress notes were produced two surveys have been undertaken (in April of both 2018 and 2019). A report of the 2018 survey was produced and was reviewed by NRW last year (ABPmer, 2018). A report of the 2019 survey (ABPmer, in prep) will also be issued to NRW at the same time as the June progress note.

The locations of the surveys sites are shown in Figure 11 and, during the 2018 survey, habitat changes were observed at the following sites:

- Site B3 had been affected by the migrating Mostyn Channel in recent years and is now located on a low lying sandy shoal on the eastern side of the channel;
- Site B2 was sandier than usual and is potentially more ecologically-impoverished than previous years. This could be due to sediment being released following changes around the Mostyn Channel and Salisbury Channel;
- Site B5 has been affected by the 'maturing' Salisbury Channel and is now located at a lower elevation along the channel margin. It lies below the eroding channel edge where the Salisbury Channel is cutting into Salisbury Bank; and
- Site C4 has a coarser substratum and this is considered to be a function of ongoing changes in this area over recent years.

As in past years, it was recognised that these observed changes were a function of the natural morphological shifts taking place in this area, rather than a response to dredging work.

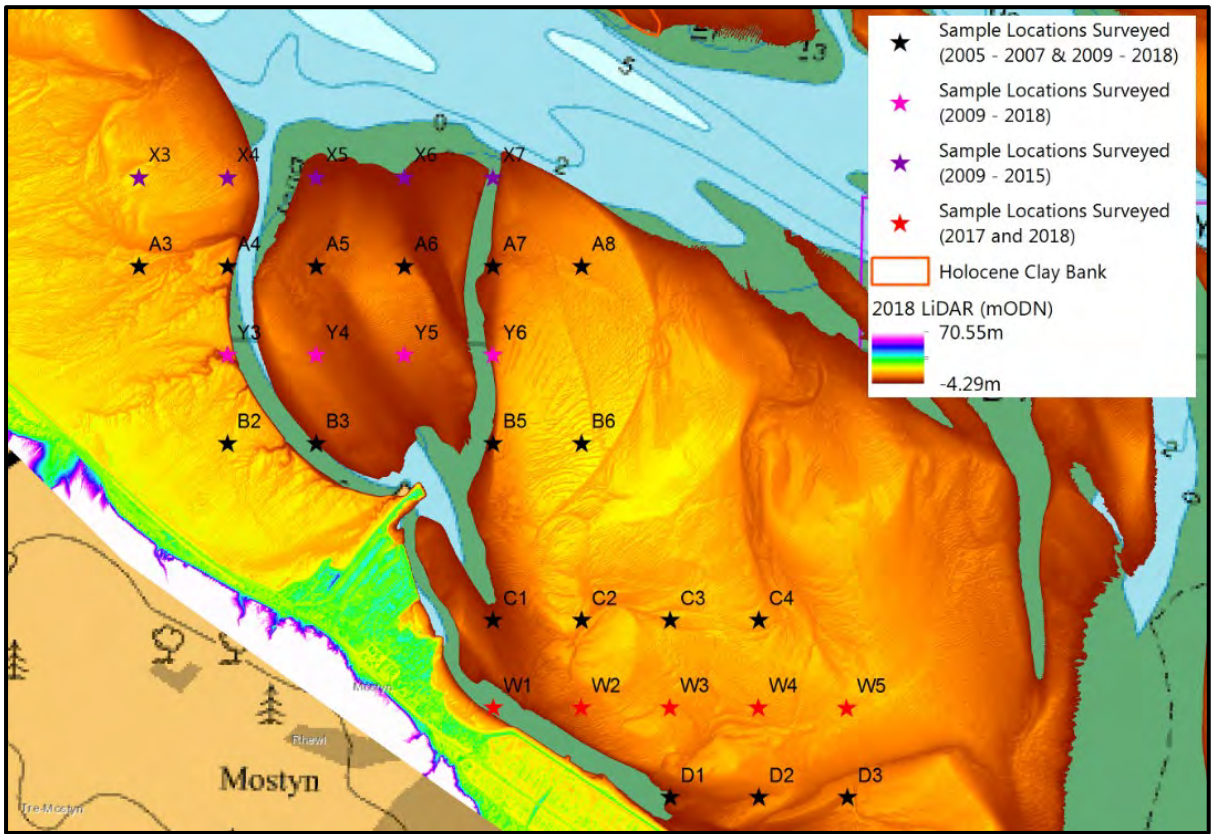


Figure 11. Location of LA5 benthic sediment sampling sites

On the basis of the Spring 2018 findings, it was not recommended that further sampling be carried out during the Autumn that year. However, it was considered valuable to carry out a trial aerial Unmanned Aerial Vehicle (UAV) photography survey during the summer/autumn months to complement the overall monitoring programme by providing a visual description of the area.

This trial UAV photography work was carried out in July 2018 and two stills from the resulting video are shown as Image 1 and Image 2. The tidal and light conditions for this survey were not ideal but this proved to be a useful way of visually describing the environment and this may become a useful alternative/additional tool for monitoring in the future.

For example, it was useful for describing the steepened edge of the migrating Mostyn Channel (Image 1) as well as the distribution of surface sand over the southern Mostyn Bank (Image 2), which may have influenced Site B3 during the surveys.

Image 1. View south towards Port of Mostyn along the western edge of Mostyn Channel

Image 2. View north from Port of Mostyn along the southern part of Mostyn Bank

It should be emphasised though that the UAV work (July 2018) was not undertaken at the same time as the LA5 benthic survey (April 2018) and therefore care needs to be taken when seeking to directly compare the results between them. It is unclear, for example, how persistent the thin sand cover is over Mostyn Bank and this may only be a temporary or intermittent response to particular weather conditions, rather than a longer-term change. This thin veneer of sand overlying the mudflat at B2 was not evident during the recent April 2019 survey for example (ABPmer, in prep).

The full results of the April 2019 benthic surveys will be reviewed and reported separately (ABPmer, in prep.). However, in summary, the habitats across most of the survey site are largely unchanged but, as in previous years, there have been some distinct changes at sites which are influenced by the changing channel morphologies. These changes have, for example, occurred at both Site Y3 and B5 which have becoming subtidal due to movements of the Mostyn and Salisbury Channels respectively as well as at Site B3, which has become ecologically richer between the 2018 and 2019 surveys, as the maturing shoal on this eastern of Mostyn Channel has evidently become more stable.

1.5 Estuary-wide Results

1.5.1 EB1 LiDAR/Swathe Survey of seabed levels;

The aim of the EB1 surveys is to monitor changes in the general morphology of the estuary system to understand the interactions between the local changes around the dredge area and the wider system. The main element of this work involves carrying out full-estuary Light Detection and Ranging (LiDAR) surveys on a regular basis. LiDAR uses pulsed radar from aircraft to measure land elevations (in this case the levels of the visible intertidal areas above the low water level).

This most recent LiDAR survey was undertaken as part of the 2017 monitoring programme but was delayed until February 2018 due to the challenges of carrying out the work (including over the extended area) at times that had both suitable weather and tidal conditions. As suggested during previous survey reports, and in the 2017 monitoring review, the spatial coverage of this survey was increased (when compared with previous years), to additionally include the outer banks.

The results of this latest LiDAR survey were reviewed in the annual report issued at the end of 2018 (covering the two-year period from 2015 to 2017). This data was also used to underpin the usual review of the estuary-wide morphological characteristics (including analysis of estuary bed levels and sediment volume) and the required hydrodynamic modelling simulations of a potential future -4 mCD Approach Channel deepening project (ABPmer, 2018).

As this LiDAR survey data and modelling work has already been reviewed, and no further LiDAR work has been undertaken, no additional analysis is included in this progress note. It is anticipated that the next LiDAR survey will be carried out in spring months (on equinox tides) of 2020 (see Section 1.6).

1.5.2 EB2 Estuary Transects

The aim of the EB2 monitoring is to help understand the estuary-wide morphological changes occurring within the estuary. This is done by carrying out bathymetric monitoring along three cross-estuary transects to describe changes in the bank and channel widths and elevation changes between surveys and over time. The results of this work are summarised below and the standard plots, as used for past progress reviews, are also presented in Appendix F.

Up until March 2016, the three monitored transects (Figure 12) indicated that there was monthly and annual variability, but little evidence for a significant overall trend for an increase or decrease in the channel volume below Mean Sea Level (MSL) over time. The North Transect, which is closest to the Mostyn Approach Channel did not indicate any changes in this area (due to dredging).

Since around 2012, different trends have occurred on all three transects, which have been highlighted further in the monitoring undertaken since 2016. During this period, the overall channel width at the elevation of MSL on the Northern and Middle Transects have reduced by around 1 km and 1.5 km respectively (average 14 and 20 m/month), whilst initially the estuary at this level widened at the

South Transect, albeit narrowing again post 2016 (*circa* 26 m/month). Similar, but generally slower, trends were evident around elevations of MLWS and CD and the trend starting later.

These trends would appear to be sufficiently different to those previously monitored to indicate a change in the morphological process occurred around 2012/2013 and appears to be continuing into 2019. The south transect shows a shift of flows to the west over the two year span and middle transect shows a shift of flows to the east. These changes are likely to be linked to changes in energy balance between Welsh channel and Hilbre channel. These changes, however, are less than the thresholds for further analysis originally set for the monitoring progress reports.

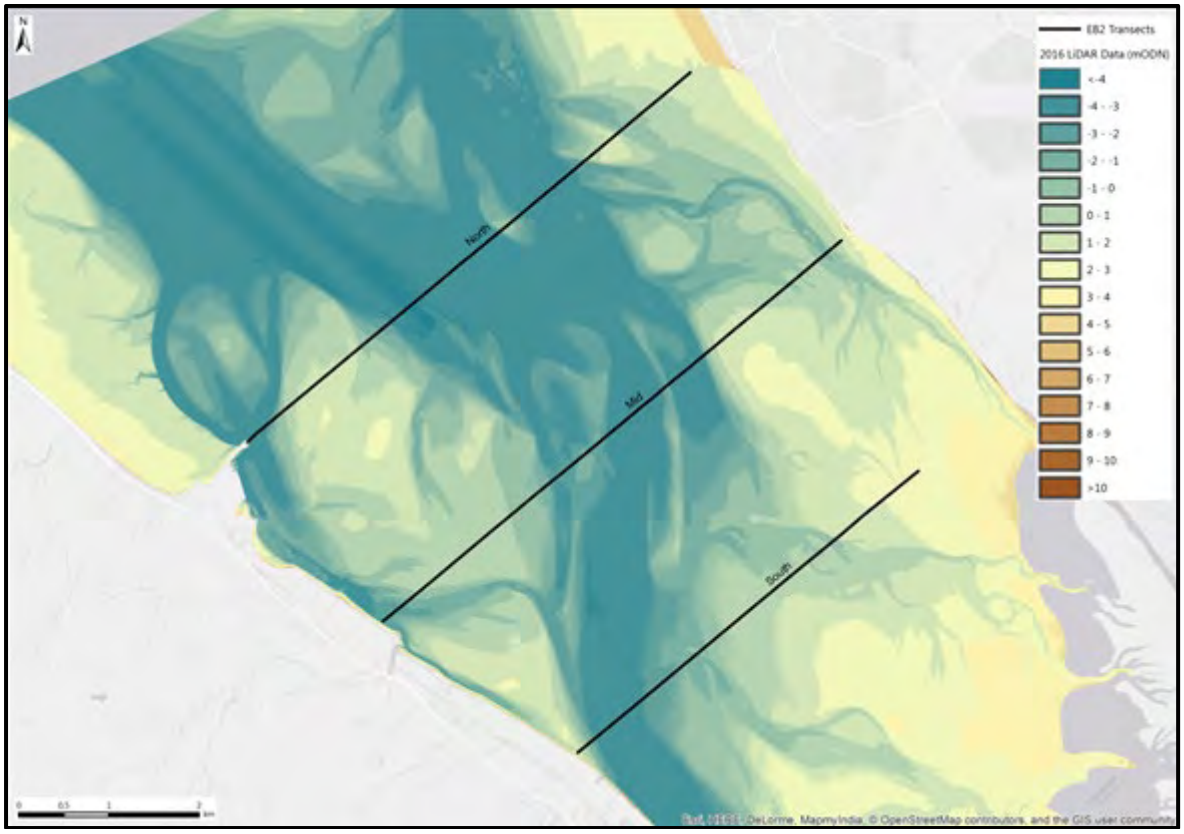


Figure 12. Location of the three cross-estuary transects

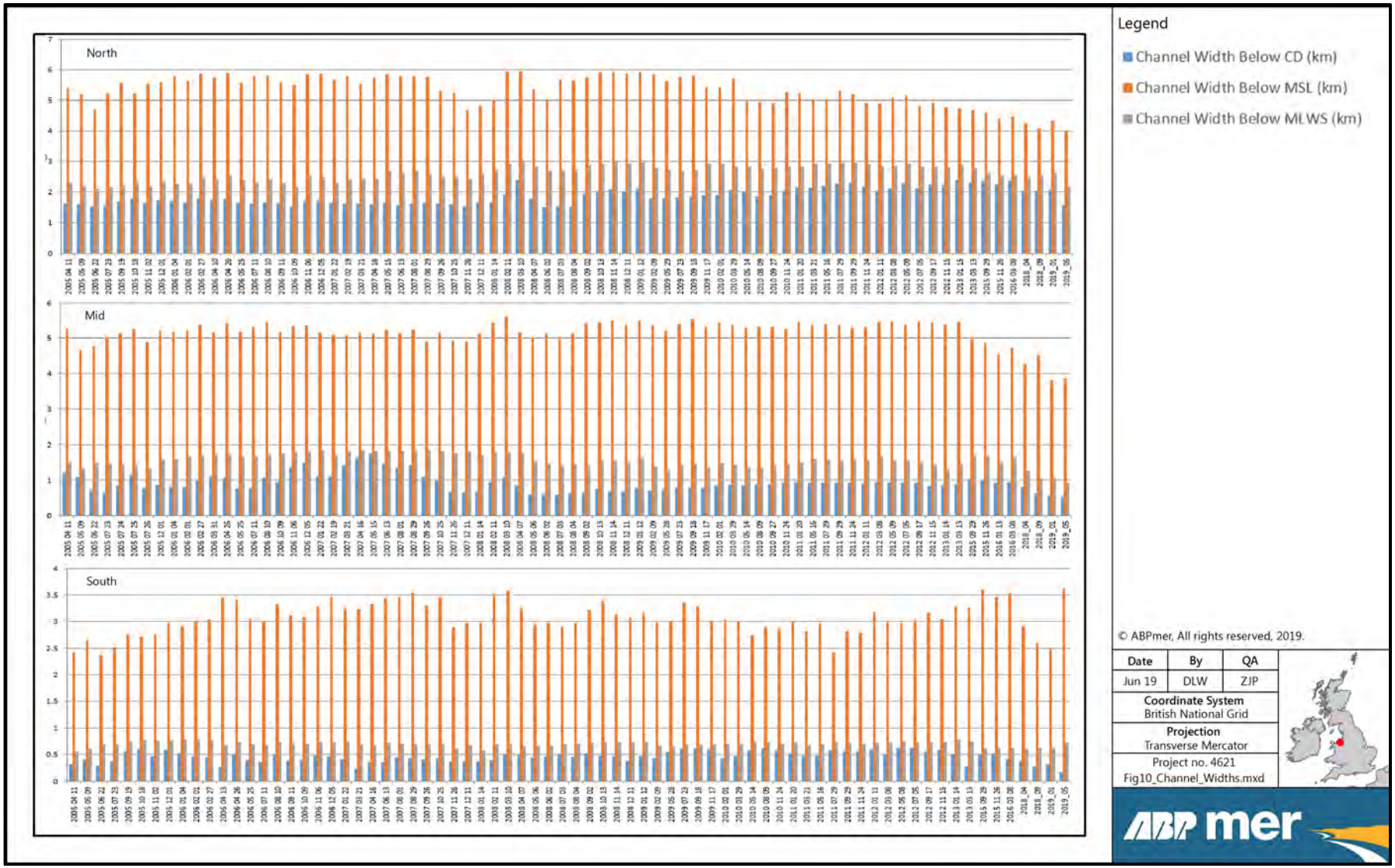


Figure 13. Comparison of cumulative channel widths along each EB2 transect over time

1.5.3 EB3 Mid-Hoyle/Welsh channel confluence;

The aim of the EB3 surveys is to monitor channel movements within the Mid-Hoyle Channel and Welsh Channel confluence. The overall change in bathymetry in this area between November 2010 and January 2019 is shown in Figure 14[2]. This change is seen as a progression with time in Figure 15 which has continued post 2016.

Since May 2016 the Mid-Hoyle Channel has continued to shallow with the deeper water continuing to move south and eastwards within the confines of the channel, albeit at a slowing rate. Little change has occurred at the elevation of the start of the intertidal (i.e. around 0.5 mCD). Across the confluence with the Welsh Channel, the pattern is a continuation of the accretion seen for the Mostyn Deep (EB4), i.e. sedimentation on the side slope, but little change to the main entry depth of the Mid-Hoyle Channel.

To the north of the West Hoyle Bank, in the shallow subtidal, Transect 1 (Figure 15) indicates erosion was prevalent until about 2015 and since that time depths have stabilized at 2 m below CD. The intertidal area immediately west of the Mid-Hoyle Channel has, however, continued to erode at a rate of around 1 m over the last two years.

Overall, there has been no change in the on-going processes occurring in this area and the changes monitored do not meet the monitoring progress report thresholds for further analysis.

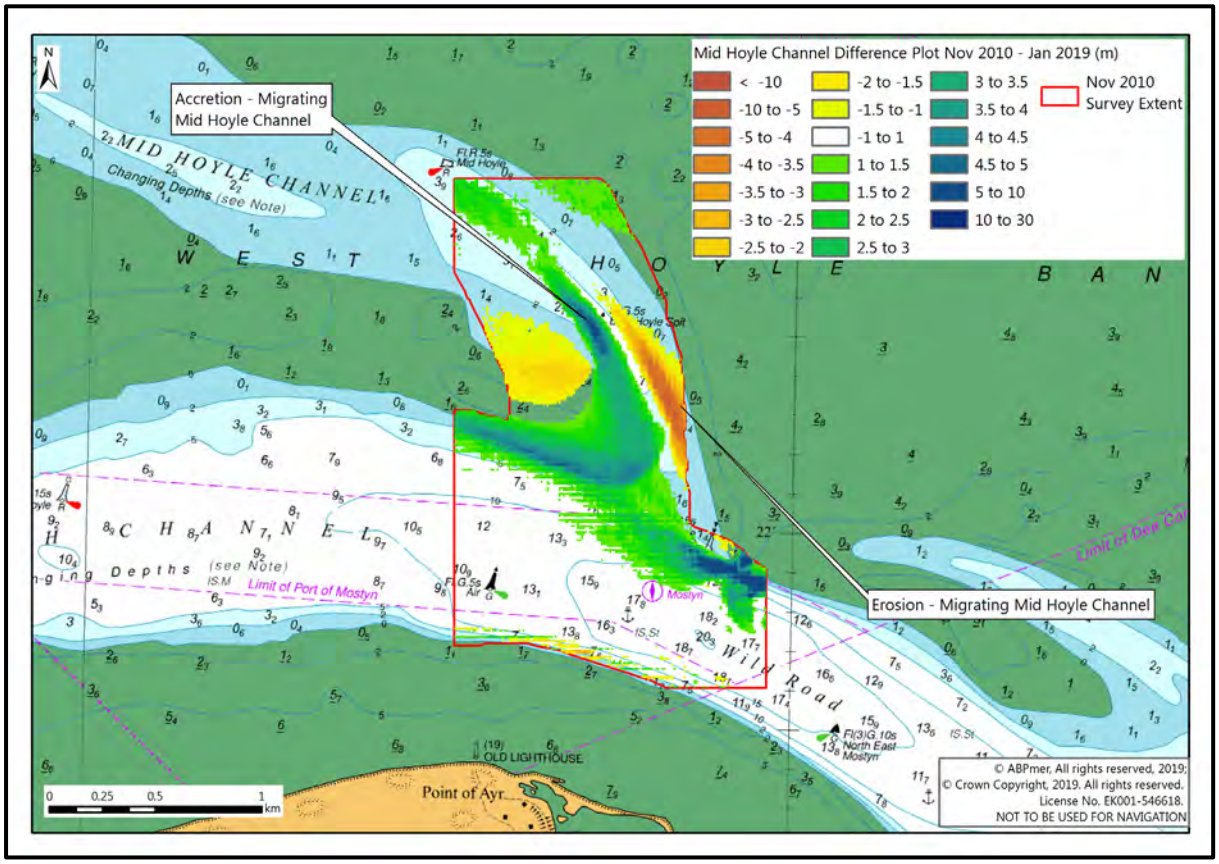


Figure 14. Bathymetry difference plot indicating net change from November 2010 to January 2019

[2] These surveys are to be undertaken at least on an annual basis. It is noted that this work was done twice in 2016 and 2017, and also that an early survey has already been done this year (in January 2019) which was officially in lieu of a second survey in 2018 (see Table 2).

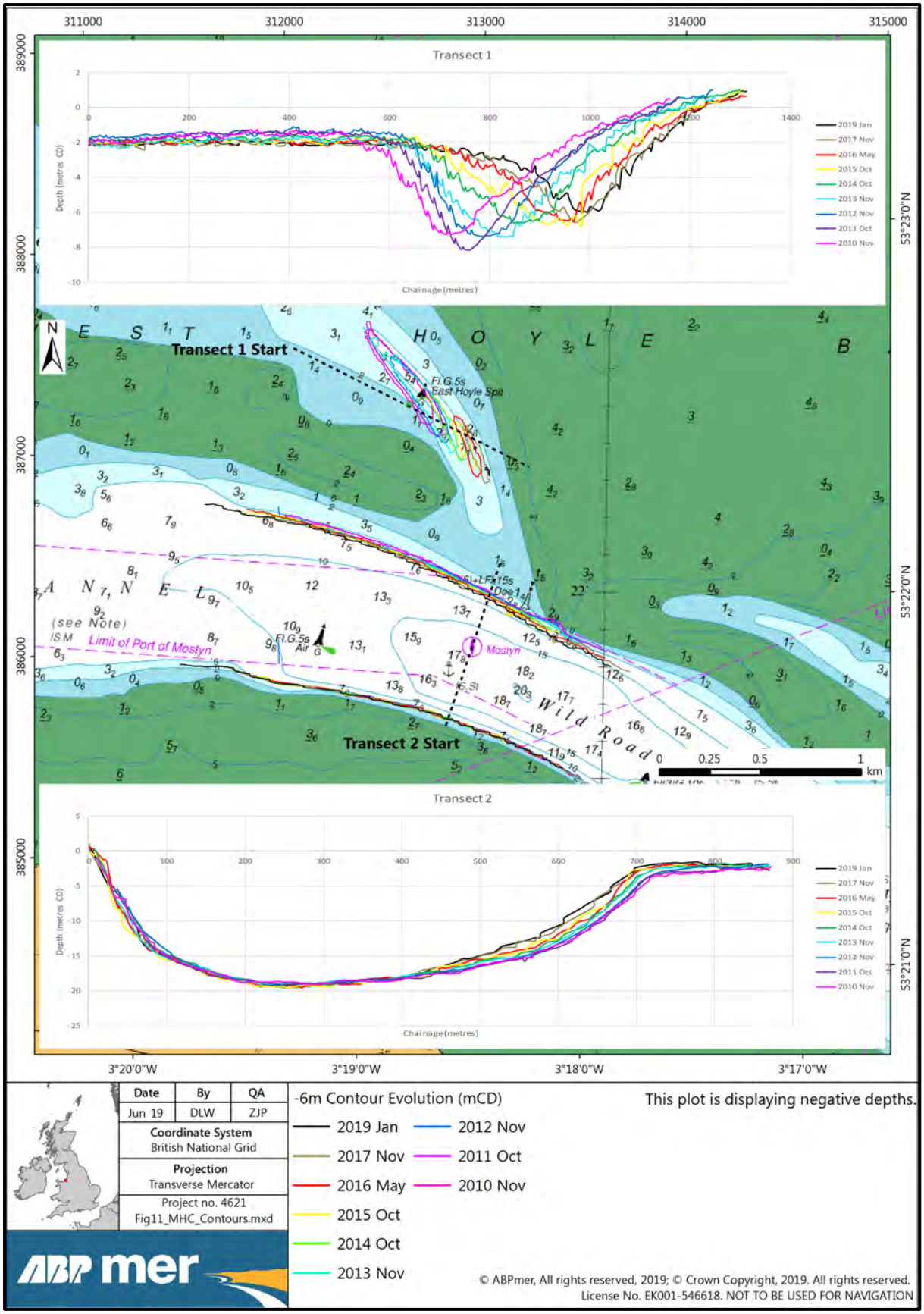


Figure 15. **Bathymetric survey results describing change in the Mid-Hoyle/Welsh Channel confluence 2009 to 2019**

1.5.4 EB4 Mostyn Deep Bathymetry

The aim of the EB4 task is to describe the morphological conditions within Mostyn Deep and including areas within and around where dredge sediment has, historically, been deposited. This is undertaken in order to understand whether there are any effects in this area arising from the dredge campaigns or any change to the morphology of this area.

For this component of the monitoring, bathymetric surveys of the Mostyn Deep area are carried out. The overall change in bathymetry since monitoring analysis began (July 2009) to the April 2018 survey is shown in Figure 16, with the change in strategic profiles at approximate annual intervals shown in Figure 17.

The changes monitored represent the natural on-going change occurring within the area associated with the present changes occurring, particularly those in the Mostyn Approach Channel. Figure 16 and Figure 17 indicate that the pattern of change in Mostyn Deep has remained the same as for the previous assessment undertaken in July 2016.

Slightly greater erosion has occurred towards the entrance to the Mostyn Approach Channel, maintaining the most recent trend. The greatest change during 2017 and 2018 has been an increase in sedimentation along the side slope up to Salisbury Middle, particularly the western end of the survey area. These changes to the erosion and siltation pattern will tend to swing tidal flood flows onto the south-western side of the Welsh Channel upstream of the confluence. This, with the changes seen on the wider estuary transects, suggests a change in the relative balance of flows through the main channels has started to occur. These changes (at present) do not exceed the monitoring progress report thresholds. Otherwise, the main part of the channel is one of general stability in this area over the last two years.

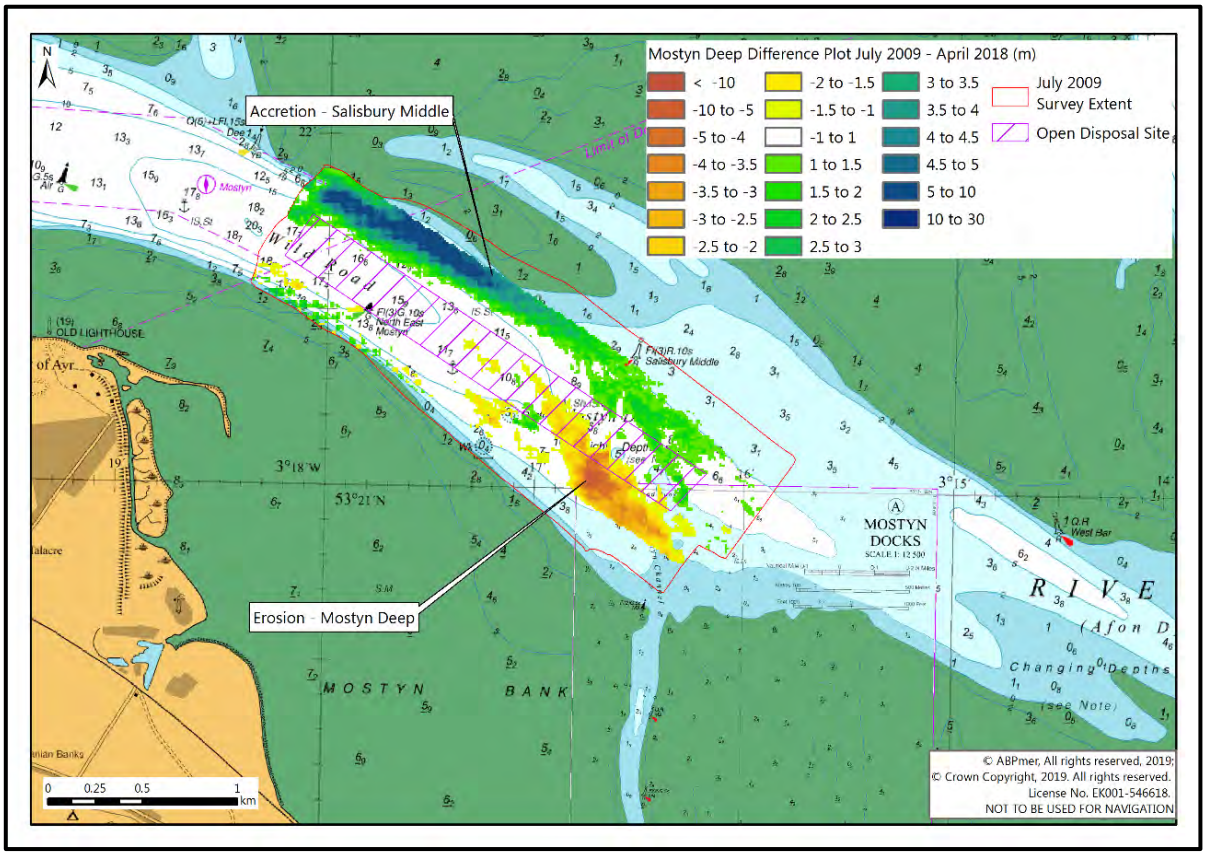


Figure 16. Bathymetry difference plot indicating net change from July 2009 to April 2018

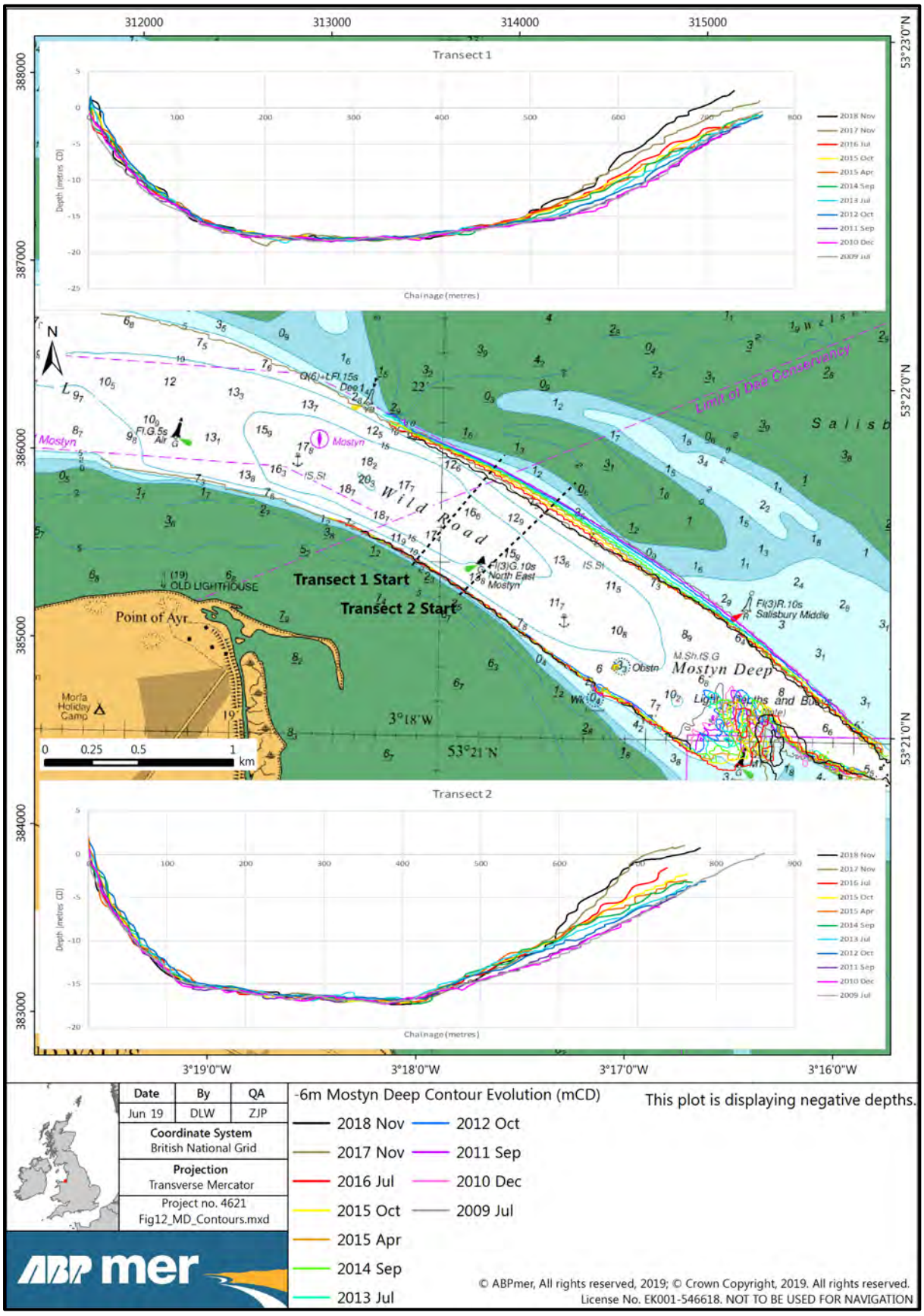


Figure 17. Bathymetric contour plot describing change in Mostyn Deep area 2009 to 2018

1.5.5 EB5 Holocene Clay Bank.

The aim of these surveys is to describe condition on the Holocene Clay Bank which is located on the Salisbury Middle and is a sub-feature of the Dee Estuary European Marine Site. This site is visited to understand the physical and ecological conditions of this exposed clay feature. Originally these surveys were carried out annually or biennially to describe the abundance of piddock species within the clay habitat and also describe the extent of the clay bank and the rate at which the exposed clay edge was eroding.

In recent years, however, the clay has been covered by a thick layer of sand. It has therefore been agreed with NRW that during such periods of sand coverage only *ad hoc* observations, rather than more detailed site visit and sampling work, are appropriate at this location. More detailed surveys and quantitative analyses of the site are only required as and when the bank becomes exposed again.

Observations of the bank that were made in March 2018, and again in May 2019, indicate that the area remains covered in a thick layer of sand. Therefore, no formal site visit was carried out during either the 2018 (ABPmer, 2018) or 2019 (ABPmer, in prep) Spring Equinox survey periods.

1.6 Notes for Ongoing Monitoring

In light of the findings from this review, some of the key considerations for the next phases of the work have been identified and are summarised below. In particular, it will be important to ensure that the recommendations arising from the 2017 monitoring protocols review are adopted (in keeping with requirements in Paragraphs 9.5 to 9.7 of the extant marine licence). The key observations for the next stages of the work are:

- **LA1 Dredged Channel Bathymetry Surveys**. This continues to be the most important element of the monitoring programme. Surveys will need to be undertaken every 4 months as required under the licence. For future surveys the following should be noted:
  - **Extend survey area to west**: The survey area needs to extend in a more westerly direction to capture the evolving Mostyn Channel. As the channel is migrating mainly along its central and southern areas, the survey area needs to extend west in these areas. This applies, especially to transect Section 20.
  - **Reduce survey lines (even-numbered lateral transects only):** In the future the surveys do not need to cover every lateral transect. As recommended by NRW following the 2017 review, only the even-numbered ones need to be undertaken in the future. All longitudinal transects should continue to be surveyed at this time although this could be reviewed further with NRW.
  - **Look upstream briefly each year**: As recommended in the 2017 review, in October each year the surveys should include a broad sweep of the channels just upstream of the Port. This is to check their depths so that we can understand whether these alter in response to the changes that occur downstream of the Port.

- **LA5 Benthic Survey Salisbury/Mostyn Bank**: As required under the licence, these surveys need to continue on an annual basis in the spring months (on equinox tides) with the results of these surveys dictating the need for a second survey during the autumn equinox tides. Going forward it will be helpful to make occasional use of UAV photography work. This can be either alongside, or in lieu (wholly or partially) of, sampling. This would offer an opportunity to have a much greater spatial coverage of the banks. Such a survey could be carried out in Spring 2020 but the scope of any such work and the extent to which it alters the existing ground truthing sampling would need to be carefully reviewed with NRW.

- **EB1 LiDAR/Swathe Survey of seabed levels**: The next LiDAR survey is scheduled to take place during the spring equinox period of 2020. By that time, just over 2 calendar years will have elapsed since the last such survey was carried out (which was delayed 2017 survey components, as described above). Going forward, the LiDAR is formally tabled to be done 'Every 2 years' under the marine licence but also it is noted that the 2017 review recommended the expanded LiDAR be undertaken every 2 and 3 years to fit in with a rolling 5-year modelling cycle. This precise timing of the LiDAR surveys beyond 2020, and the way in which these integrate with a proposed 5-year modelling cycle, does however need further discussion and verification with NRW.

- **EB2 Estuary Transects**. Understanding the tidal energy balance between Hilbre, Welsh and Mid-Hoyle channels at the mouth of the estuary is understood to be an important one for interpreting the functioning of the central sections of the estuary. To address this there is already a commitment to increase the extent of the LiDAR (LA1) survey area to describe the outer estuary intertidal banks. However, it would also be valuable to add an additional cross-estuary transect covering as much of the estuary mouth (Point of Ayr to Hilbre Point) as possible. It is recommended that this transect is added but also that the number of such surveys is reduced to twice per year (in the spring and autumn).

- **EB4 Mostyn Deep Bathymetry**. For this element of monitoring the timings are presently unclear. The licence asks for annual survey synchronous with EB3 (Mid-Hoyle/ Welsh channel confluence) but six months apart from EB1 (while EB3 also needs to be synchronous with EB1). For clarity, we would recommend that the EB3 and EB4 surveys are done once per year in the spring, and that should be at the same time as EB1 (LiDAR) in years when EB1 is conducted. These surveys could be scheduled for the spring, but if there are challenges with the weather and tides, they could then be carried out in the autumn equinox as a back-up.

The next progress note will be issued in October 2019 and the annual report will then be produced that will cover the period from 2017 to 2019. That annual report will build upon the extra analyses presented in this additional overview report, and recommendations arising from ongoing discussions with NRW.

2 References

ABPmer, 2017. Review of dredge and disposal monitoring: Overview of survey work carried out by the Port in the Dee Estuary from 2005 to 2016. ABPmer Report R.2713, March 2017.

ABPmer, (2018). Mostyn Channel Dredge and Disposal -Hydraulic Modelling Studies 2017, Review of annual bathymetric survey and numerical modelling work for Marine Licence DML1542, ABPmer Report No. R.3011. A report produced by ABPmer for Port of Mostyn Ltd, August 2018

NRW, 2016. Marine Licence DML1542. Natural Resources Wales, 10 May 2016.

NRW, 2019. Marine Licence DML1542v1. Natural Resources Wales, 1 May 2019.

SMP (2008) Maintenance of Navigation – Mostyn Channel Monitoring Protocols, Revision 4.0 dated December 2008. Shoreline Management Partnership.

SMP (2018) Maintenance of Navigation Annual Monitoring Report (November 2015 to November 2017). October 2018. Shoreline Management Partnership.

Appendices





Innovative Thinking - Sustainable Solutions

ABP mer

A Standard Proforma June 2019 Progress Note

MONITORING PROGRESS REPORT

Port of Mostyn Ltd.						PROGRESS REPORTING
Project	Maintenance Dredge/Deposition	Period	From	Apr 2017	To	May 2019
Report prepared by:	ABPmer	Date	26 June 2019	Report No.	3189	Pg. 1 of **5**

1. TRAFFIC LIGHT – MOVING SUMMARY

Monitoring Task	Monitoring Regime – 2.0m below CD dredge limit						Threshold Exceedance Report
	-5	-4	-3	-2	-1	Current	
EB2	●	●	●	●	●	●	N/A
LA1	●	●	●	●	●	●	N/A

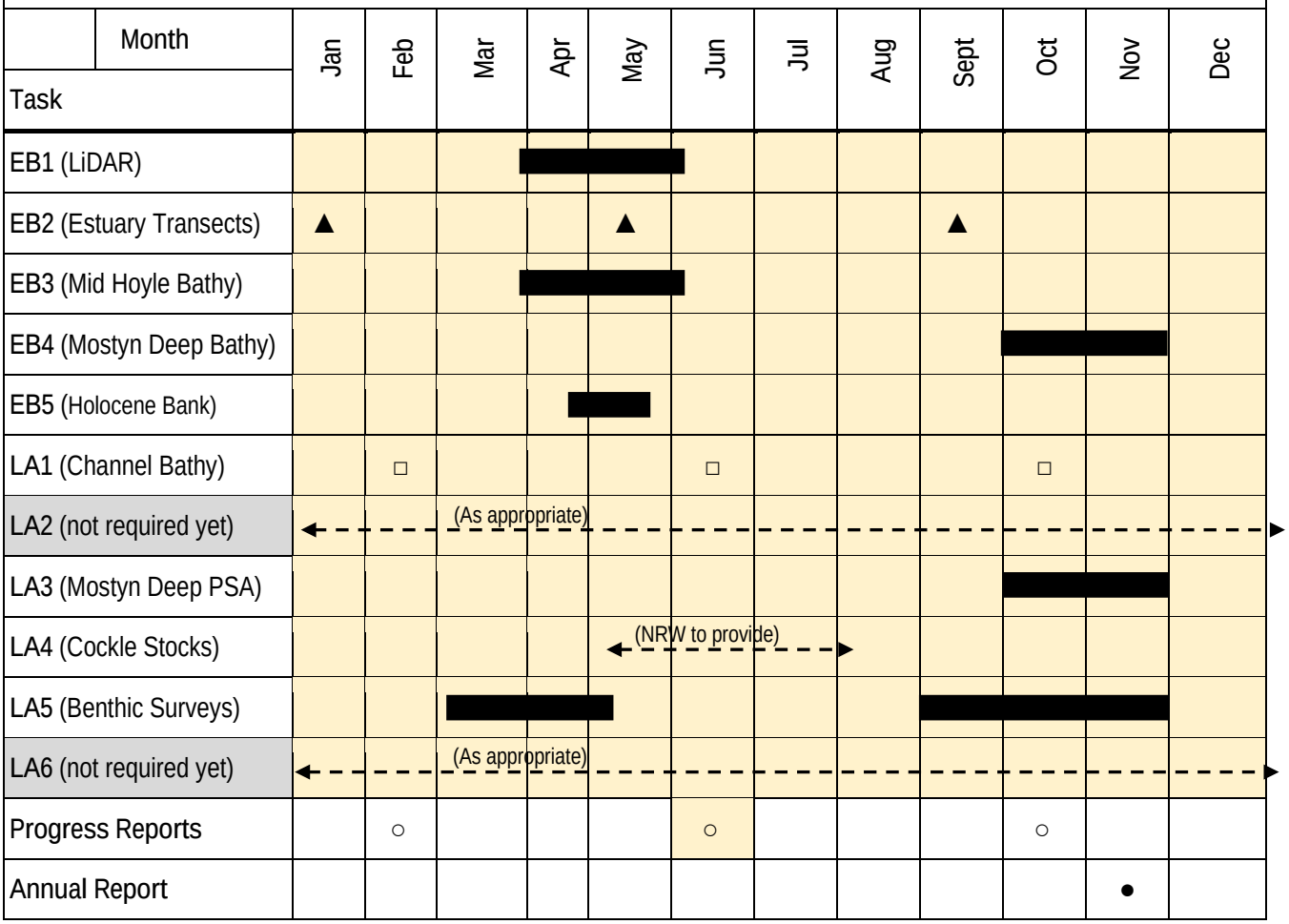
Monitoring Task	Bi-annual			Threshold Exceedance Report
	-2	-1	Current for this report	
EB3	●	●	●	NA
EB5	●	●	●	NA

Monitoring Task	Annual		Threshold Exceedance Report
	Previous	Current for this report	
EB1 (LiDAR)	●	NA	NA
EB4	●	●	NA
LA3	●	●	NA
LA4	●	●	NA
LA5	●	●	NA

Monitoring Task	Dredge Campaign - A18, A19 and B19		Threshold Exceedance Report
	Previous Campaign B19	Current for this report	
LA2	●	NA	NA
LA6	●	NA	NA

Port of Mostyn Ltd.						PROGRESS REPORTING
Project	Maintenance Dredge/Deposition	Period	From	Apr 2017	To	May 2019
Report prepared by:	ABPmer	Date	26 June 2019	Report No.	3189	Pg. 2 of **5**

2) TIMETABLE CONCORDANCE



TASKS	
Current	Next
EB2	LA1 (June and Oct 2019)
EB3	LA3 (Autumn 2019)
EB4	LA4 (NRW Cockle Report)
EB5	EB1 LiDAR (Spring 2020)
LA1	EB2 (Autumn 2019)
LA3	EB4 (Autumn 2019)
LA4	Progress Report (Oct 2019)
LA5	Annual Report (Nov 2019)

Port of Mostyn Ltd.						PROGRESS REPORTING
Project	Maintenance Dredge/Deposition	Period	From	Apr 2017	To	May 2019
Report prepared by:	ABPmer	Date	26 June 2019	Report No.	3189	Pg. 3 of **5**

3. MONITORING PLAN REQUIREMENTS

Task Ref	Description	Reported Here (Y/N)	Status: (Red/Amber/Green)	Threshold Exceedance Report
EB1	Estuary Seabed Level Survey (LiDAR)	N	NA	NA
EB2	Estuary Transects Bathy' Surveys	Y	Green	NA
EB3	Mid Hoyle/Welsh Bathy' Surveys	Y	Green	NA
EB4	Mostyn Deep Bathy' Surveys	Y	Green	NA
EB5	Holocene Clay Bank	Y	Green	NA
LA1	Dredged Channel Bathy' Survey	Y	Green	NA
LA2	Mostyn Deep Site 'A' Bathy' Surveys	N	Survey Not Required	Survey Not Required
LA3	Mostyn Deep Seabed Samples	Y	Green	NA
LA4	Cockle Survey (NRW Surveys)	Y	Green	NA
LA5	Benthic Survey Salisbury/Mostyn Bank	Y	Green	NA
LA6	Berthing Area Survey	N	Survey Not Required	Survey Not Required

4. PROGRESS NARRATIVE

Task Ref	Narrative	Annex
EB2	Estuary transects surveyed 04/17, 09/17, 11/17, 04/18, 09/18, 01/19 and 05/19	
EB3	Mid Hoyle / Welsh Channel bathymetry survey conducted January 2019	
EB4	Mostyn Deep bathymetry survey conducted April 2018	
EB5	Holocene bank observations conducted in March 2018 and May 2019	
LA1	Dredged channel surveyed 10/16, 02/17, 06/17, 11/17, 02/18, 07/18 and 10/18	
LA3	Mostyn Deep samples collected December 2018	
LA4	Cockle survey carried out Spring 2018	
LA5	Salisbury / Mostyn Bank benthic surveys conducted April 2018 and April 2019	

5) MONITORING OVERVIEW

Reconciliation of results in this report with 'early-warning' parameters and estuary basis summary as set out in SMP 'Mostyn Channel Monitoring Protocols' (2008).

Monitoring Protocols report (rev. 4.0) December '08 relevant extracts:

EXTRACT 1

Task	Frequency	Spatial Extent	Analysis	Evolution Issues
EB2 Estuary Transects	Bi-monthly Swathe survey) survey six months apart from EB1)	North, Middle and South transects as presently	Channel/Bank parameters; Datum level LiDAR/Swathe survey. LiDAR/Swathe survey.	A, B, D(part)

Task	Frequency	Spatial Extent	Analysis	Local/Ambient Issues
LA1 Dredged Channel Survey	Bi-monthly	Northern limit = 384000; Southern limit = 382000; Western limit = 250m west of channel centreline; Eastern limit = 316400. Survey lines to be 100m apart except for longitudinal sections A to K to be set 50m apart (see Figure 3). Survey spatial limits shown on Figures 1& 2.	Selected cross-section and longitudinal section profiles overlaid on previous surveys with correlation to dredge campaign locations and volumes.	Local – spatial extent and depth of dredging campaigns; lateral extent of profile changes due to dredging. Ambient – seabed level changes adjacent to channel over the area of impact forecast by the numerical model.

Port of Mostyn Ltd.						PROGRESS REPORTING
Project	Maintenance Dredge/Deposition	Period	From	Apr 2017	To	May 2019
Report prepared by:	ABPmer	Date	26 June 2019	Report No.	3189	Pg. 5 of **5**

5. MONITORING OVERVIEW (...cont.)

EB2 – Estuary Transects		
Transect Ref.	Relevant Features	Stage I Threshold exceedance
North	No significant change from previous survey	N
Middle	No significant change from previous survey	N
South	No significant change from previous survey	N
LA1 – Channel Cross-sections & Longitudinal Sections		
Channel Section Ref.	Relevant Features	Stage I Threshold exceedance
1, 4, 7, 8, 10, 11, 12, 14, 15, 16, 17, 18, 19, 20	No significant change from previous survey	N
A, B, C	No significant change from previous survey	N
I, J, K	No significant change from previous survey	N

Threshold Exceedance Report

NA

6. ACTIONS		
Task Ref	Action Description	To be initiated by
	None identified although commentary on future monitoring included in the overview report	

B Dredge Records for Campaigns A18, A19 and B19

DREDGE CAMPAIGN 'A18' Disposal Licence DML 1542

MOSTYN DEEP

Daily / Weekly Dredge Totals (30th September to 4th October 2018)

	LOAD	Salisbury Channel (m3)	Harbour (m3)		LOAD	Channel (m3)	Harbour (m3)
Sospan Dau							
30/09/2018	1	949					
		949	**0**				
01/10/2018	2	934					
	3	754					
		1688					
02/10/2018	4	487					
	5	949					
	6	791					
		2227					
03/10/2018	7	979					
	8	943					
	9	911					
		2833	**0**				
04/10/2018	10	1011					
	11	958					
	12	967					
		2936					
TOTAL for Dredger		**10633**	**0**				

TOTAL Dredged (Channel) m3	**10633**	**Licence DML 1542**
TOTAL Dredged (Harbour) m3	**0**	**Licence DML 1542**
TOTAL to Shore	**10633**	**Metres Cubed**
TOTAL to Mostyn Deep	**0**	**Metres Cubed**
TOTAL	**10633**	**Metres Cubed**

DREDGE CAMPAIGN 'A19' Disposal Licence DML 1542

MOSTYN DEEP

Daily / Weekly Dredge Totals (11th March 2019 to 17th March 2019)

	LOAD	Salisbury Channel (m3)	Harbour (m3)		LOAD	Channel (m3)	Harbour (m3)
Sospan Dau							
11/03/2019	1	964					
	2	955					
		1919	**0**				
12/03/2019	3	908					
	4	1005					
		1913	**0**				
13/03/2019		0					
		0					
		0	**0**				
14/03/2019	5	917					
	6	934					
		1851	**0**				
15/03/2019	7	990					
	8	964					
		1954	**0**				
16/03/2019	9	946					
	10	940					
	11	934					
	12	923					
		3743	**0**				
17/03/2019	13	926					
	14	645					
		1571	**0**				
TOTAL for Dredger		**12951**	**0**				

TOTAL Dredged (Channel) m3	**12951**	**Licence DML 1542**
TOTAL Dredged (Harbour) m3	**0**	**Licence DML 1542**
TOTAL to Shore	**12951**	**Metres Cubed**
TOTAL to Mostyn Deep	**0**	**Metres Cubed**
TOTAL	**12951**	**Metres Cubed**

DREDGE CAMPAIGN 'B19' Disposal Licence DML 1542v1

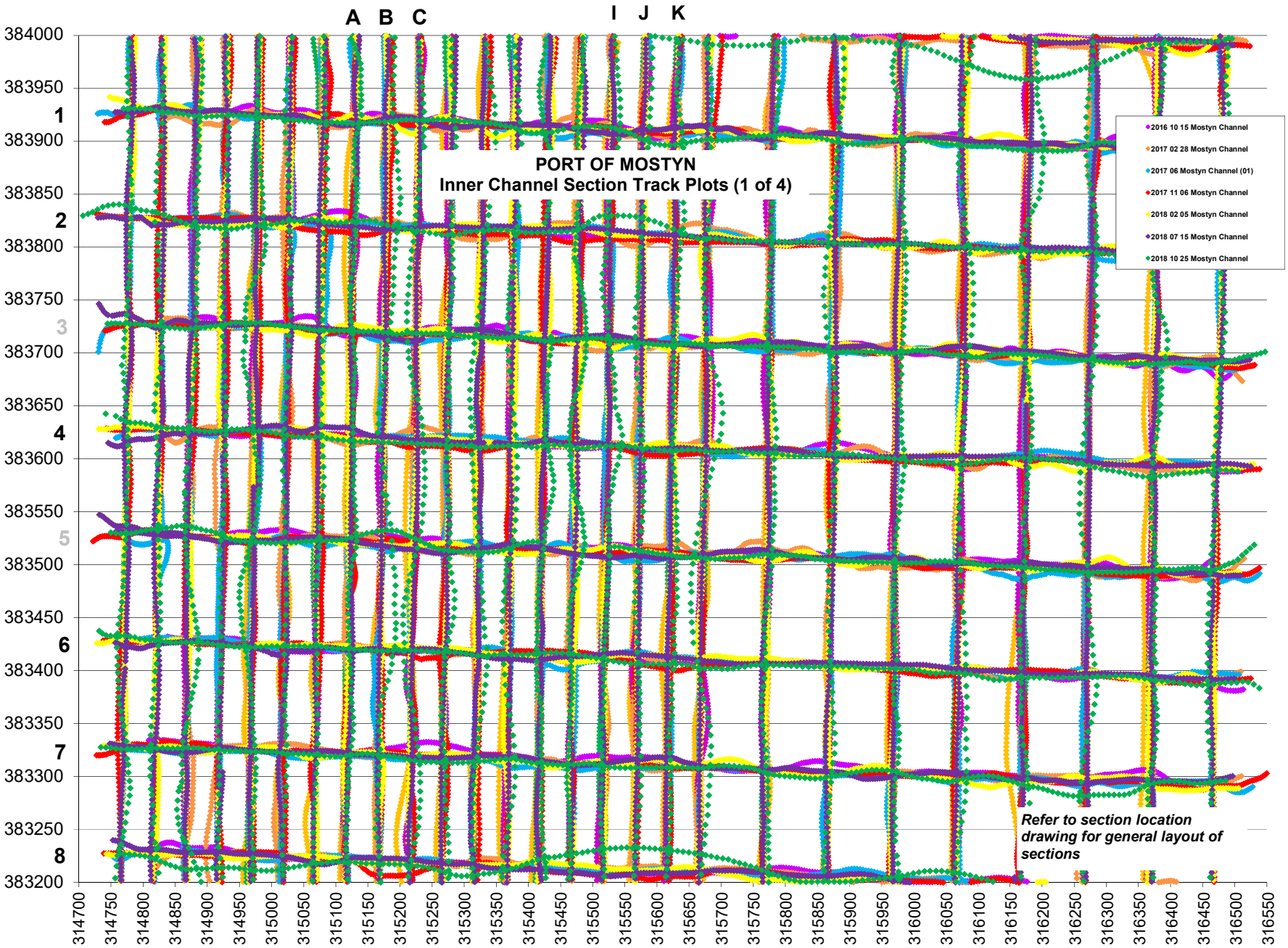
MOSTYN DEEP

Daily / Weekly Dredge Totals (11th May 2019 to 17th May 2019)

	LOAD	Salisbury Channel (m3)	Harbour (m3)		LOAD	Channel (m3)	Harbour (m3)
Deo Gloria							
11/05/2019	1	1063					
	2	776					
		1839	**0**				
12/05/2019	3	1051					
	4	917					
	5	1072					
	6	932					
		3972	**0**				
13/05/2019	7	999					
	8	930					
	9	1022					
	10	897					
		3848	**0**				
14/05/2019	11	1062					
	12	888					
	13	1032					
	14	870					
		3852	**0**				
TOTAL for Dredger		**13511**	**0**				

TOTAL Dredged (Channel) m3	**13511**	**Licence DML 1542v1**
TOTAL Dredged (Harbour) m3	**0**	**Licence DML 1542v1**
TOTAL to Shore	**12951**	**Metres Cubed**
TOTAL to Mostyn Deep	**0**	**Metres Cubed**
TOTAL	**13511**	**Metres Cubed**

C Standardised Survey Transect Plots for LA1 Surveys


A B C I J K
PORT OF MOSTYN
Inner Channel Section Track Plots (1 of 4)
2016 10 15 Mostyn Channel
2017 02 28 Mostyn Channel
2017 06 Mostyn Channel (01)
2017 11 06 Mostyn Channel
2018 02 05 Mostyn Channel
2018 07 15 Mostyn Channel
2018 10 25 Mostyn Channel
Refer to section location drawing for general layout of sections
1
2
3
4
5
6
7
8
384000
383950
383900
383850
383800
383750
383700
383650
383600
383550
383500
383450
383400
383350
383300
383250
383200
314700
314750
314800
314850
314900
314950
315000
315050
315100
315150
315200
315250
315300
315350
315400
315450
315500
315550
315600
315650
315700
315750
315800
315850
315900
315950
316000
316050
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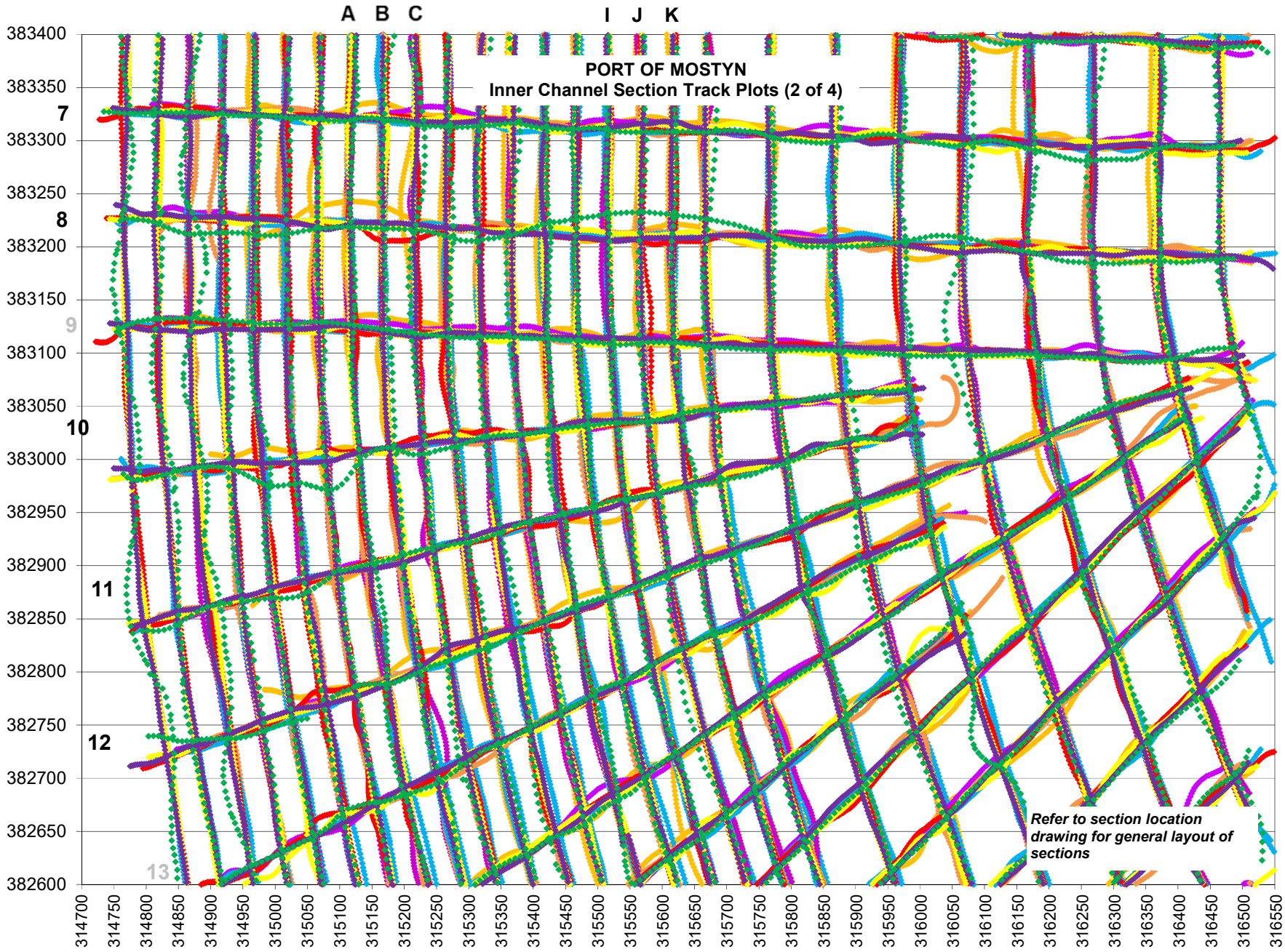
316150
316200
316250
316300
316350
316400
316450
316500
316550

Drawing 'B'


A B C
I J K
PORT OF MOSTYN
Inner Channel Section Track Plots (2 of 4)
7
8
9
10
11
12
13
383400
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383300
383250
383200
383150
383100
383050
383000
382950
382900
382850
382800
382750
382700
382650
382600
314700
314750
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314900
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315350
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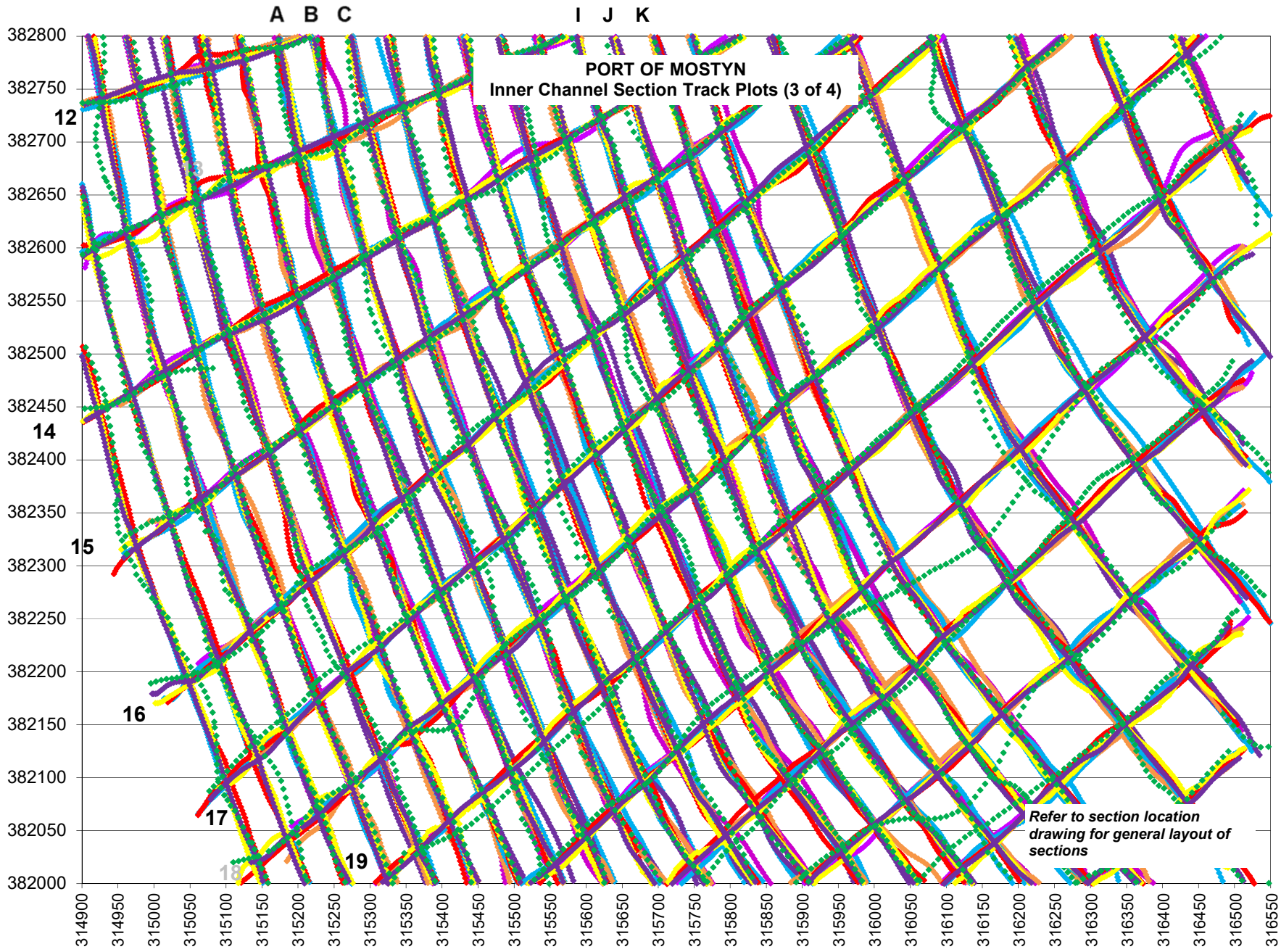
315500
315550
315600
315650
315700
315750
315800
315850
315900
315950
316000
316050
316100
316150
316200
316250
316300
316350
316400
316450
316500
316550
Refer to section location drawing for general layout of sections

Drawing 'B'


A B C
I J K
PORT OF MOSTYN
Inner Channel Section Track Plots (3 of 4)
12
14
15
16
17
18
19
382800
382750
382700
382650
382600
382550
382500
382450
382400
382350
382300
382250
382200
382150
382100
382050
382000
314900
314950
315000
315050
315100
315150
315200
315250
315300
315350
315400
315450
315500
315550
315600
315650
315700
315750
315800
315850
315900
315950
316000
316050
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316300
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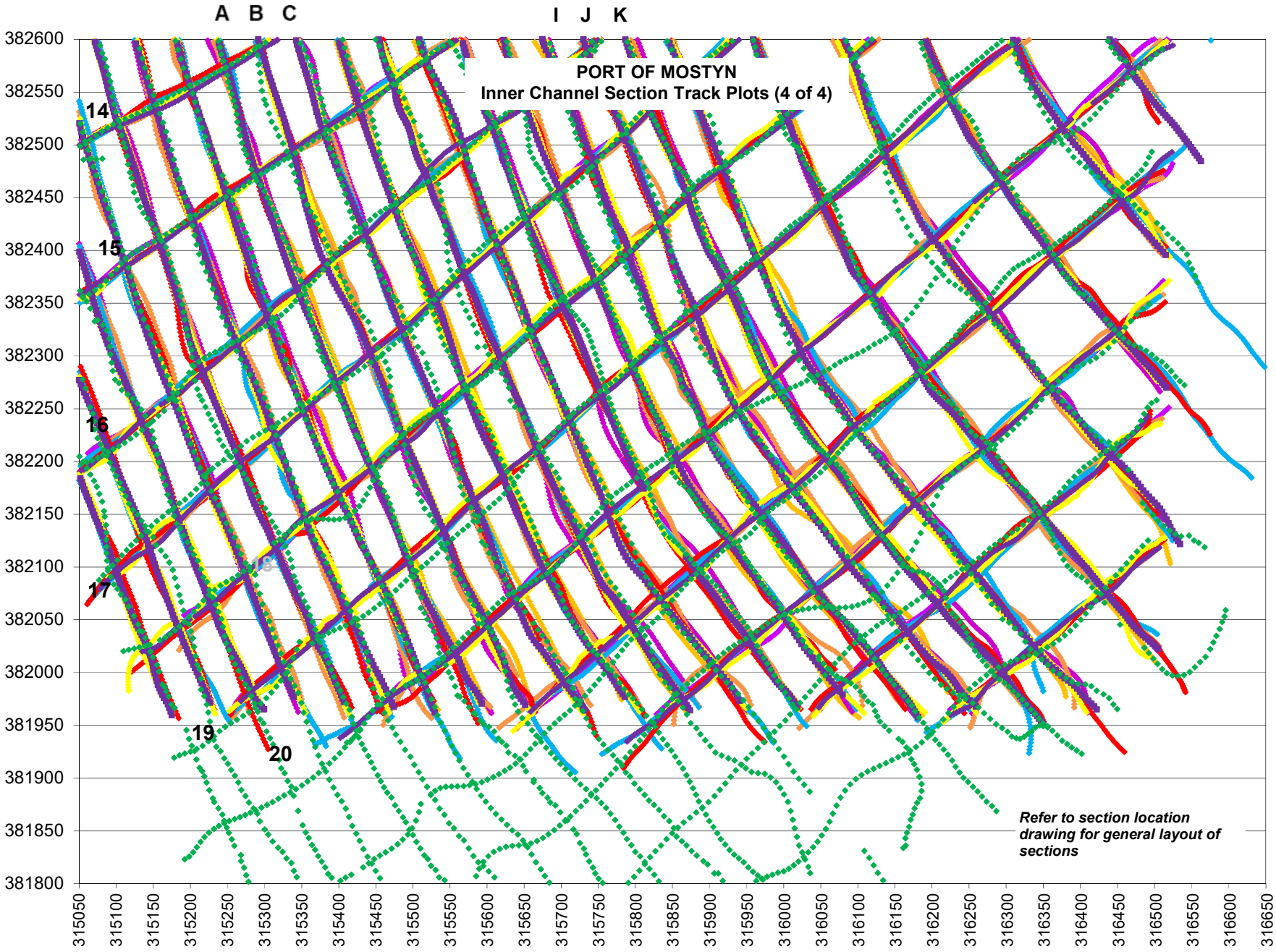
316400
316450
316500
316550
Refer to section location drawing for general layout of sections

Drawing 'B'


A B C
I J K
PORT OF MOSTYN
Inner Channel Section Track Plots (4 of 4)
14
15
16
17
19
20
Refer to section location drawing for general layout of sections
382600
382550
382500
382450
382400
382350
382300
382250
382200
382150
382100
382050
382000
381950
381900
381850
381800
315050
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315150
315200
315250
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315350
315400
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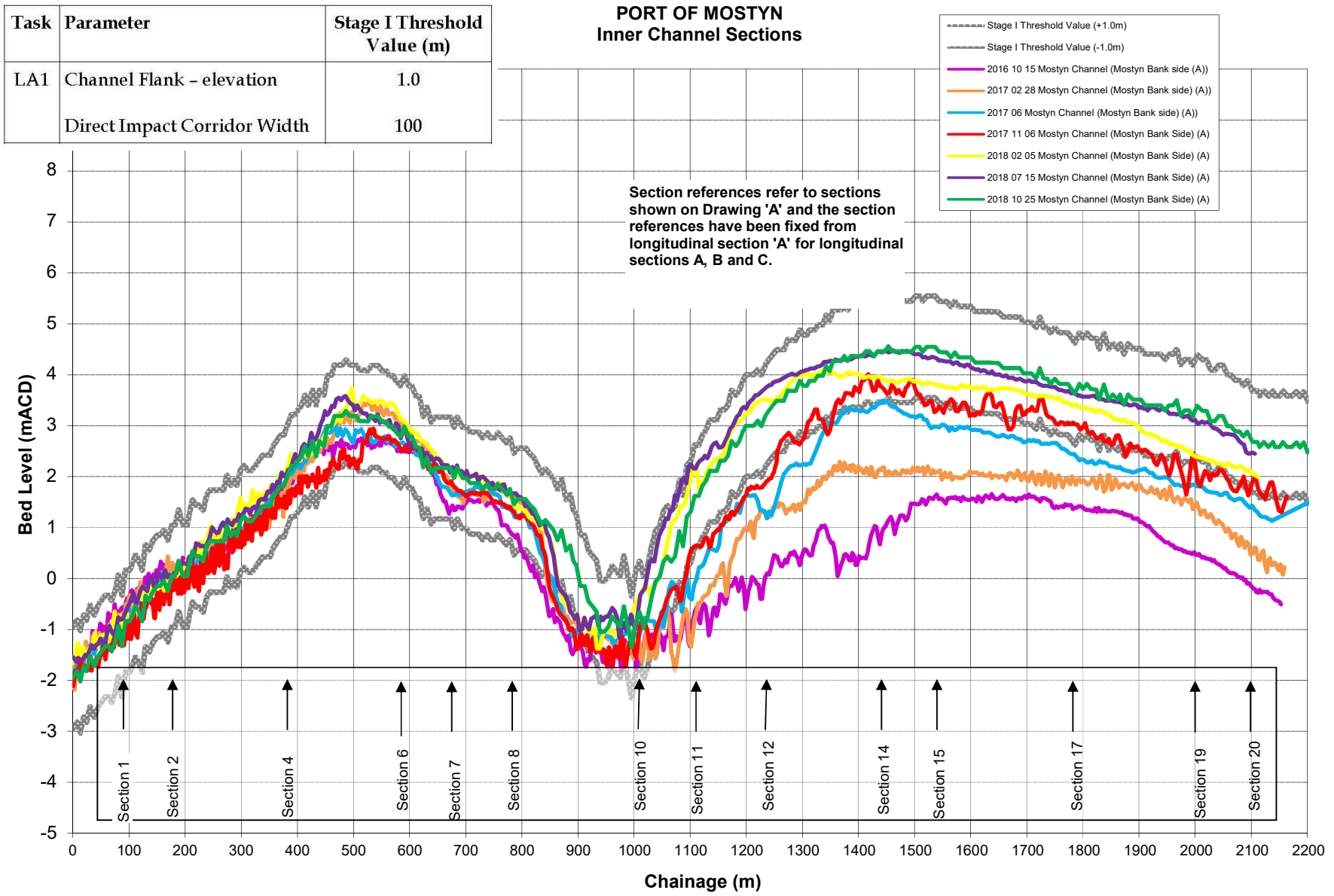
315500
315550
315600
315650
315700
315750
315800
315850
315900
315950
316000
316050
316100
316150
316200
316250
316300
316350
316400
316450
316500
316550
316600
316650

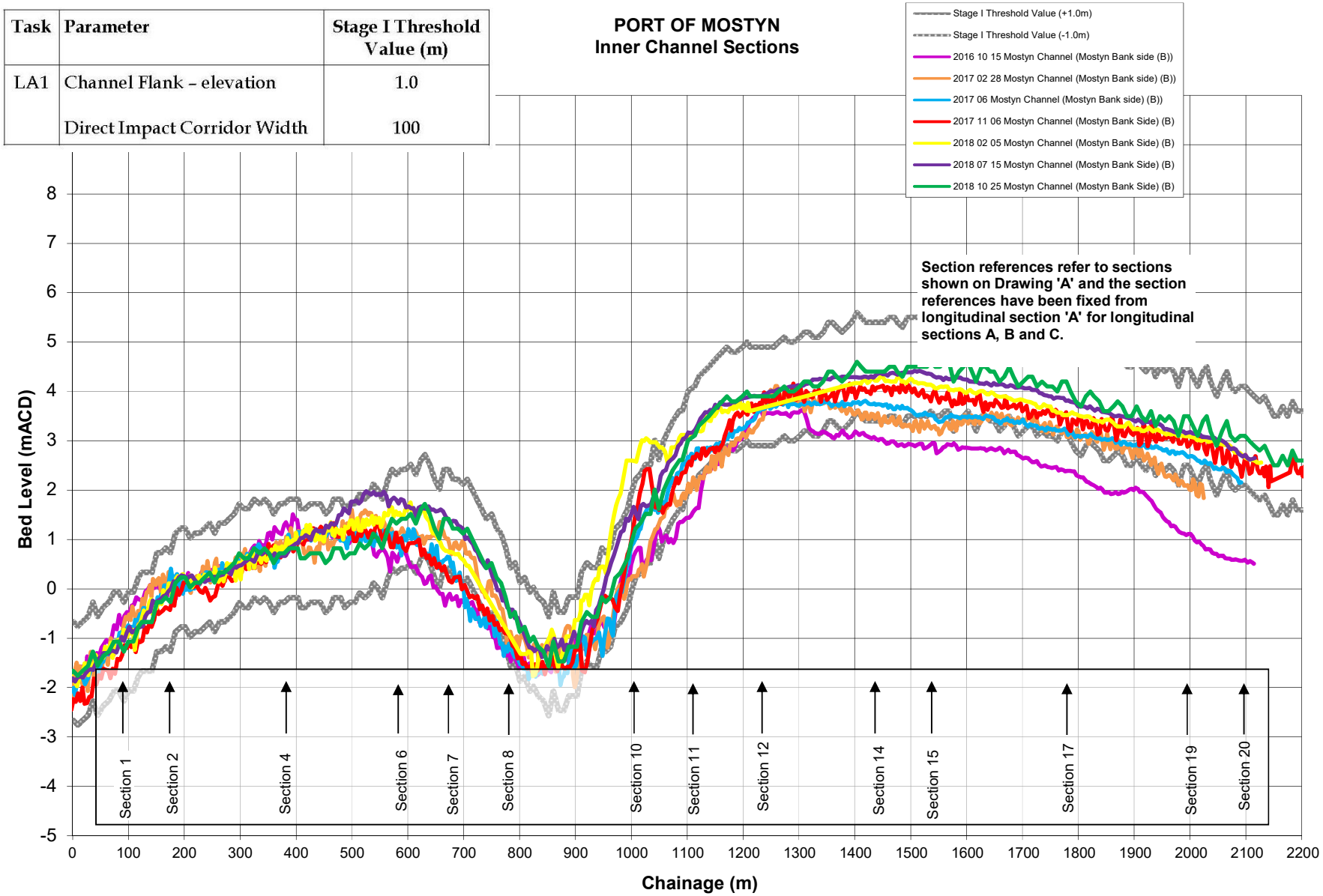
Drawing 'B'

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



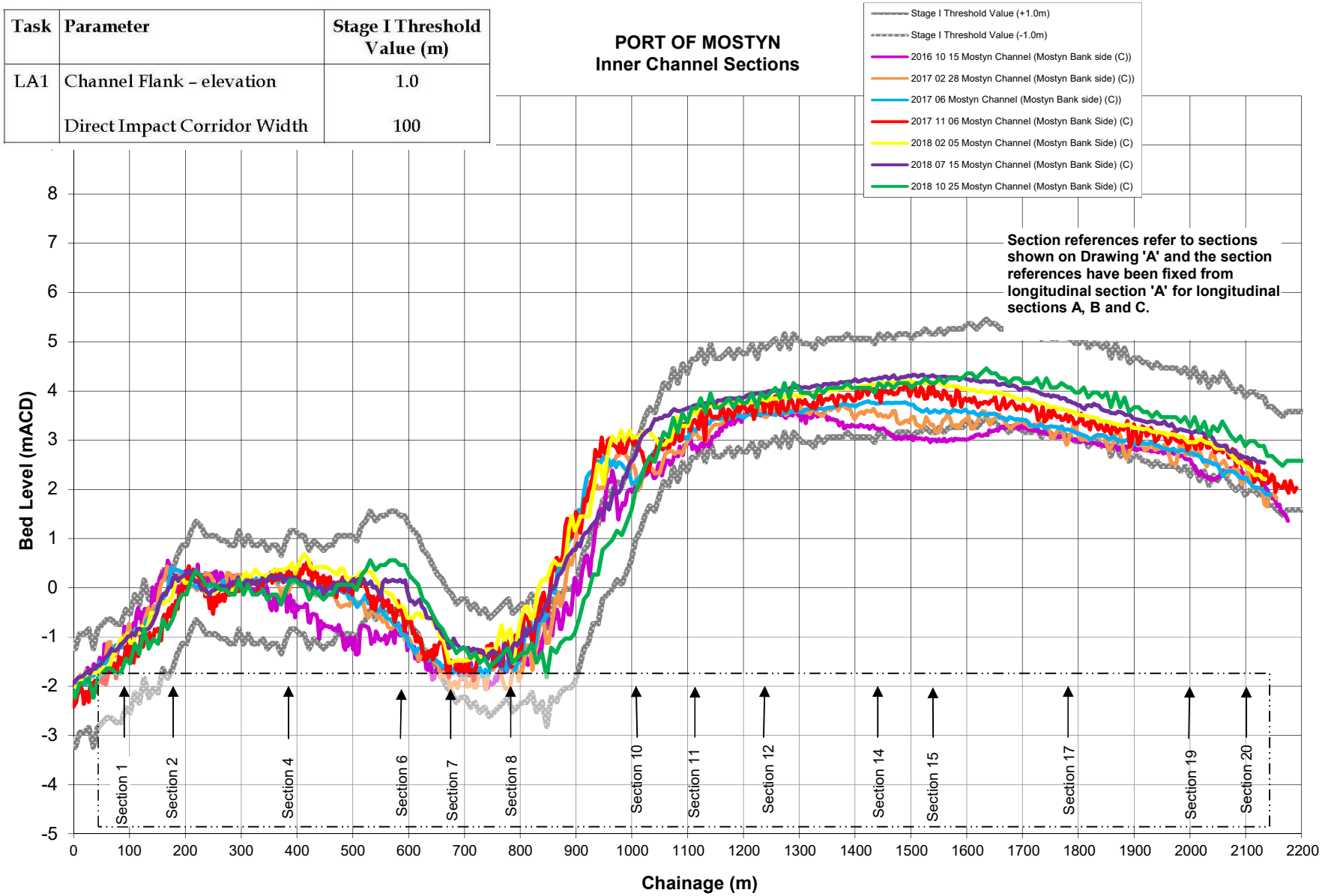
Drawing D (1of6) (Section A(6)

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



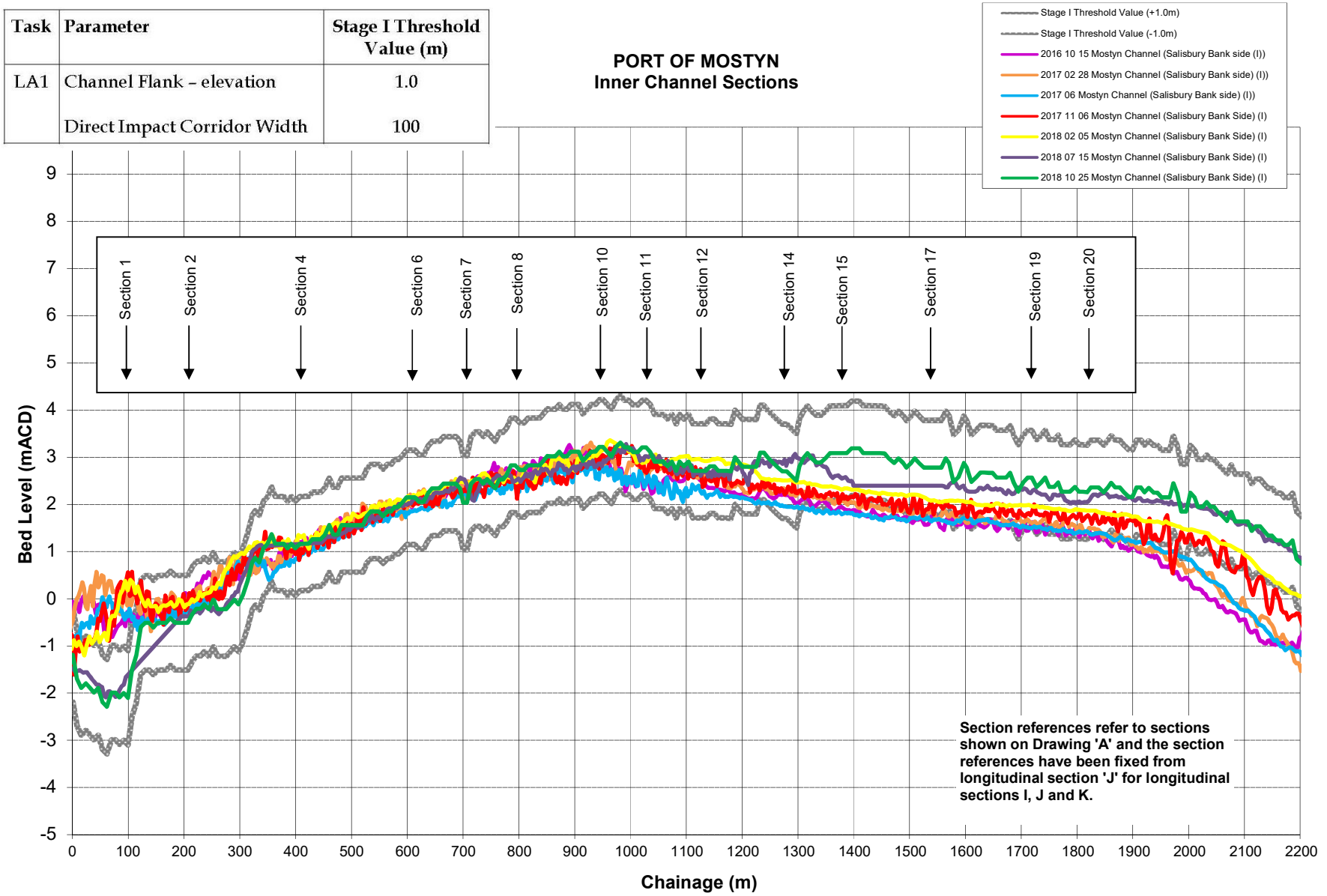
Drawing D (2of6) (Section B(6)

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



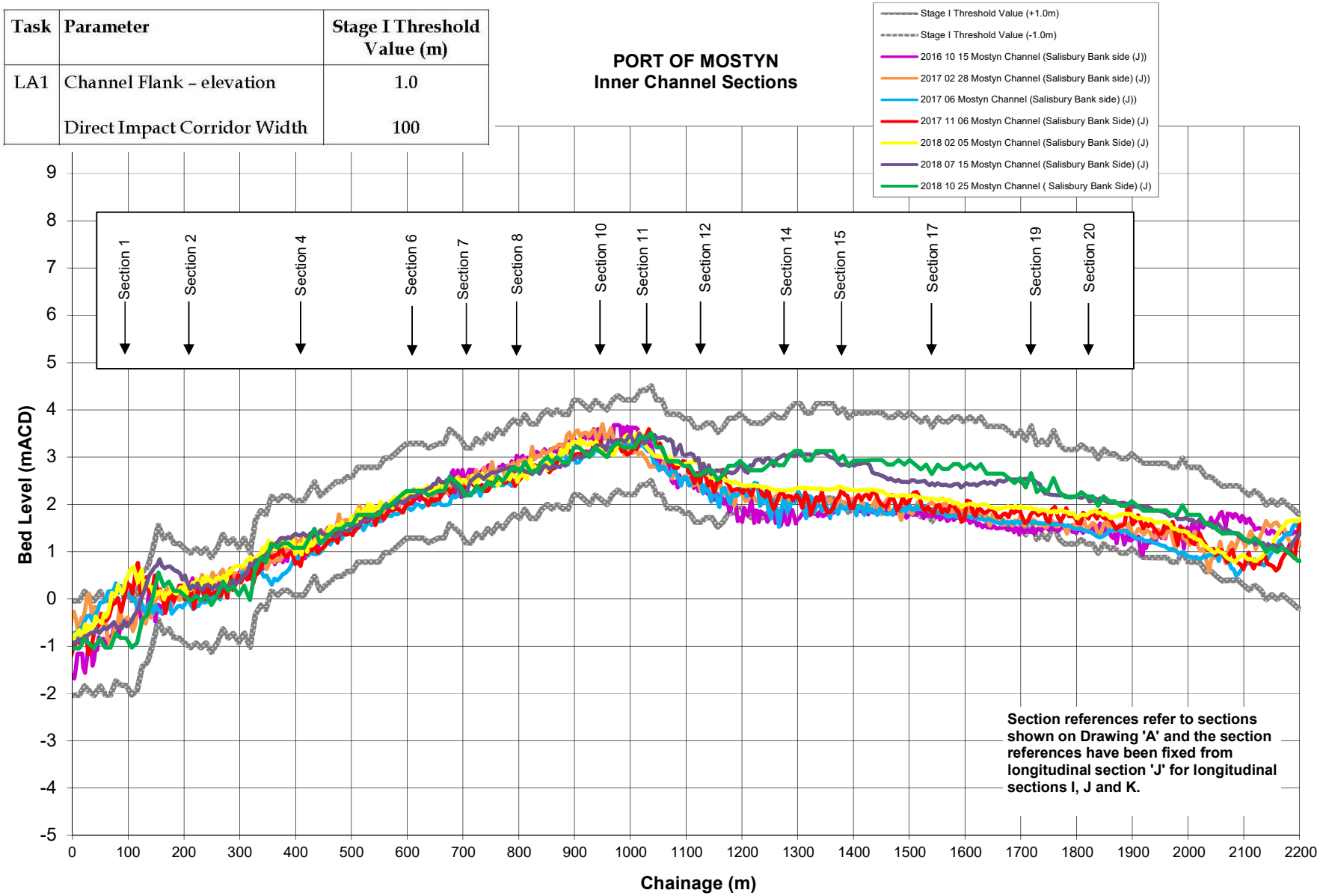
Drawing D (3of6) (Section C(6)

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



Drawing D (4of6) (Section I(6)

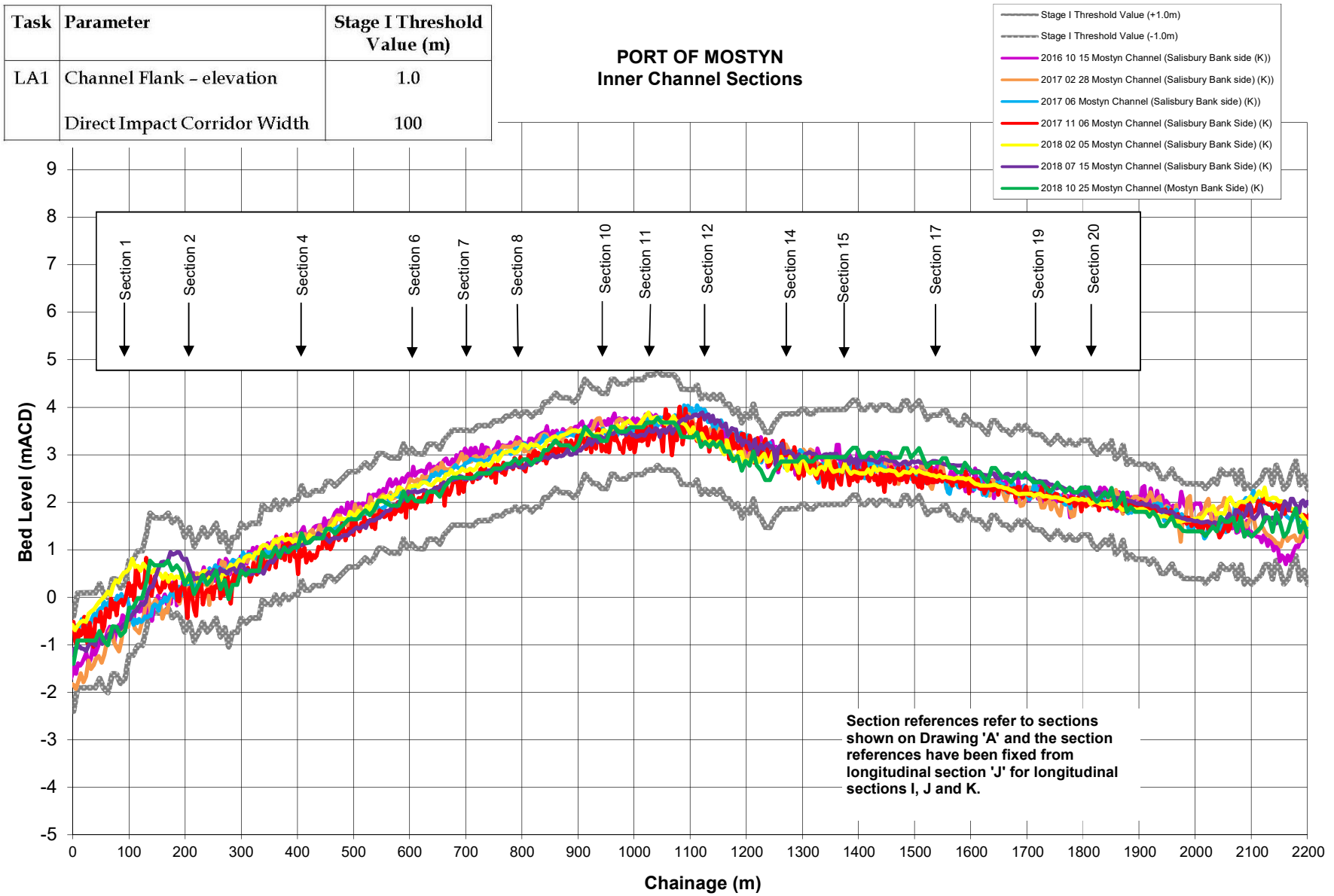
Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



Drawing D (5of6) (Section J(6)

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100

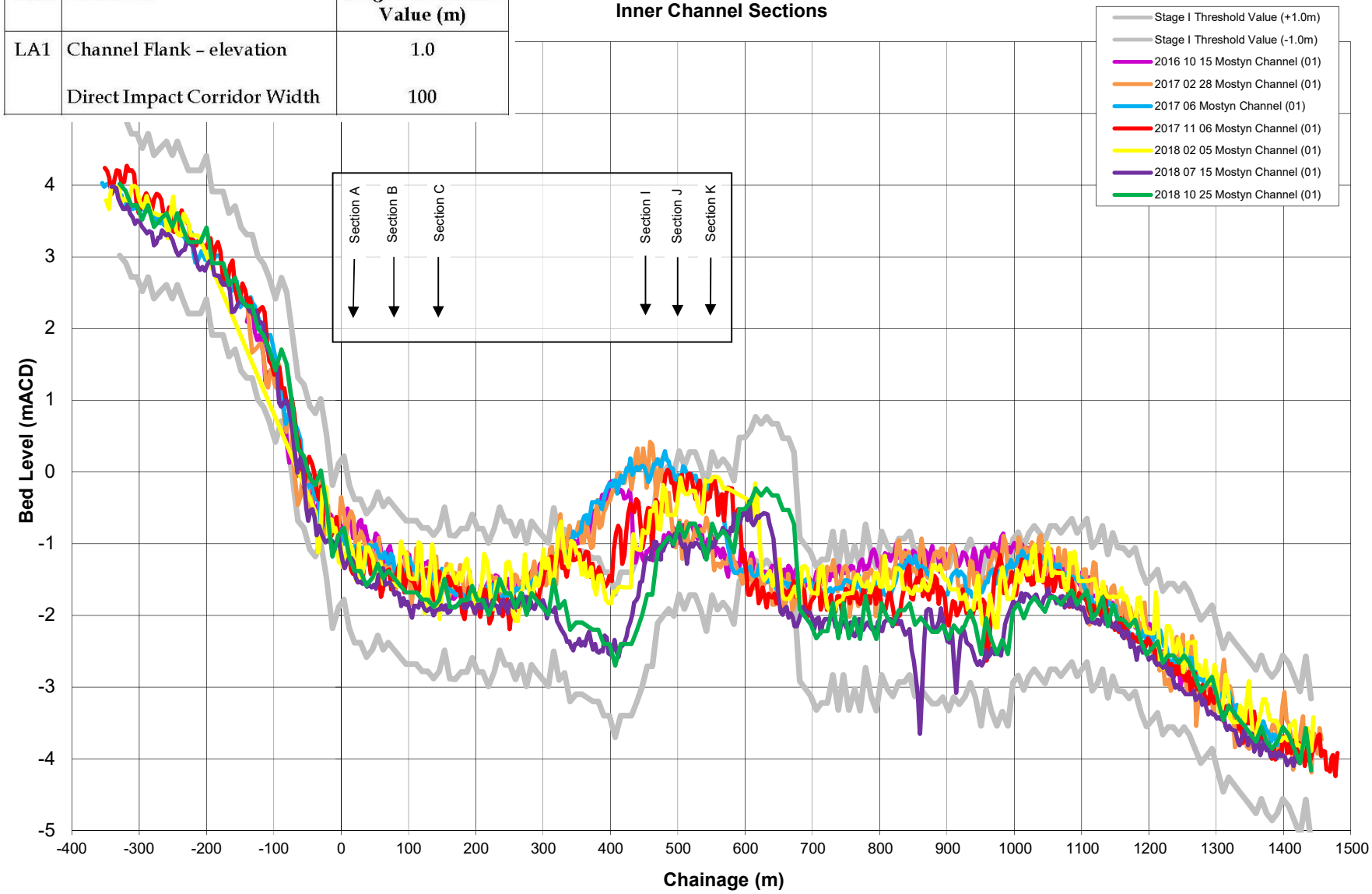
PORT OF MOSTYN
Inner Channel Sections



Drawing D (6of6) (Section K(6)

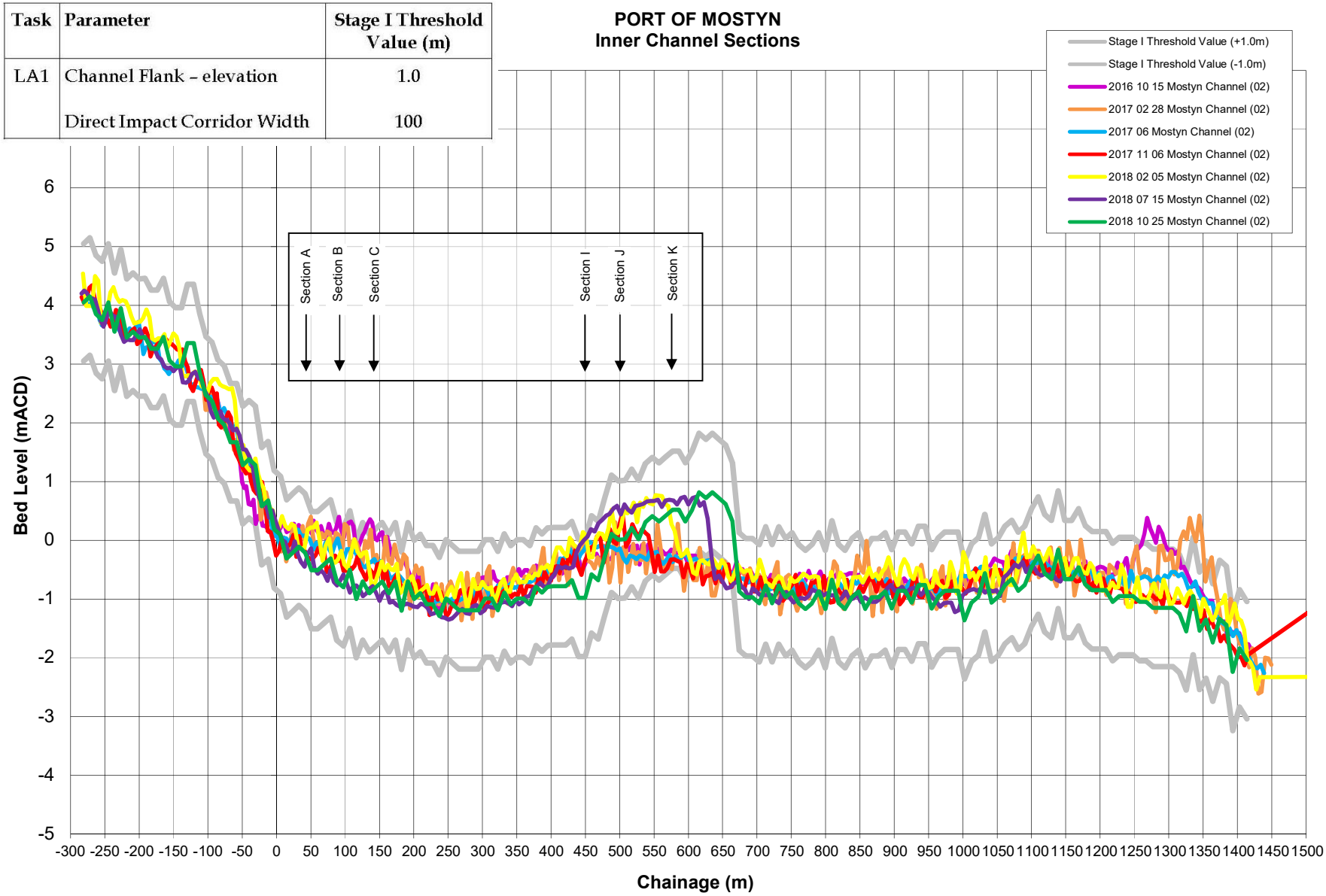
Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100

PORT OF MOSTYN
Inner Channel Sections



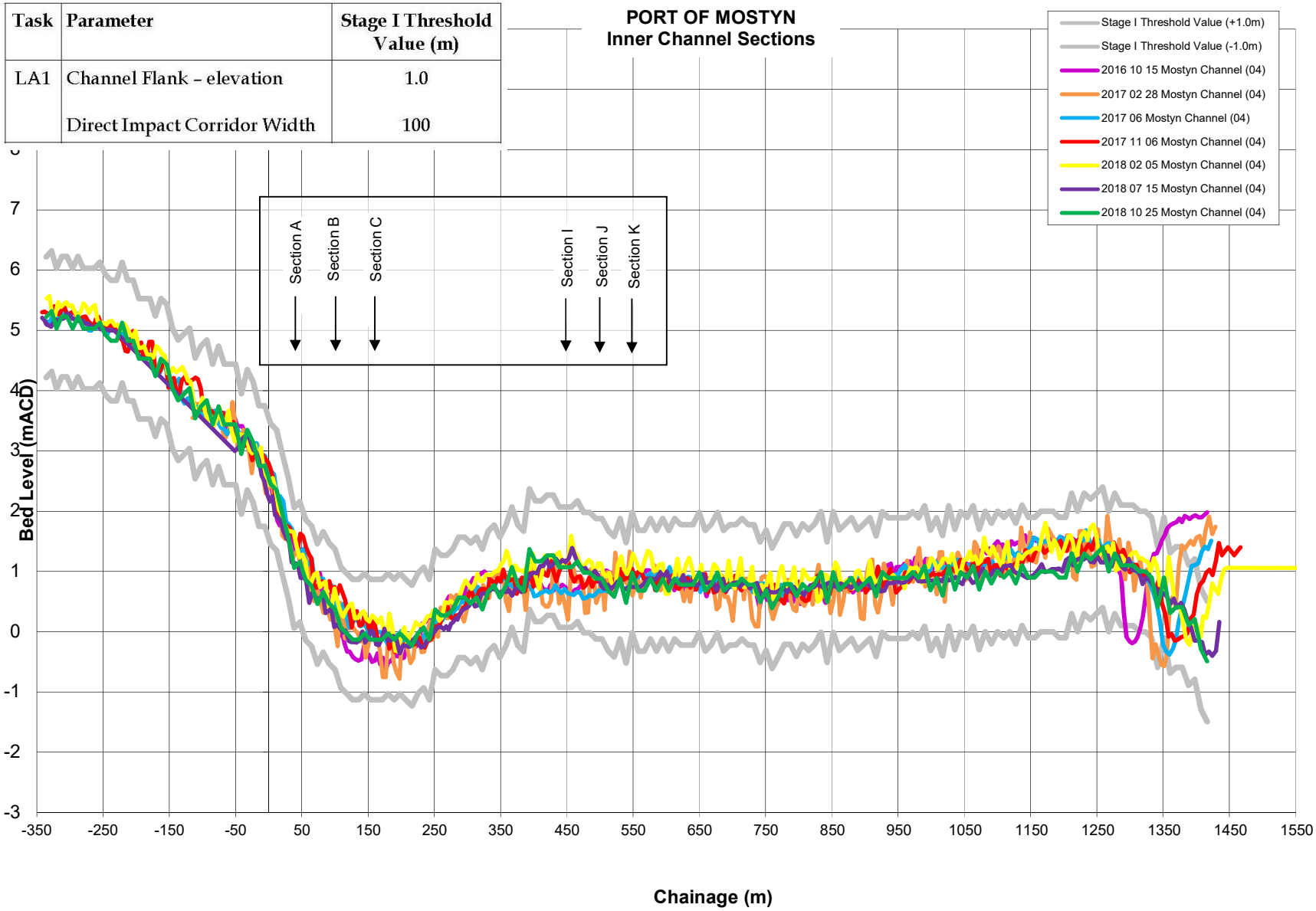
Drawing C (1 of 15) Section 1

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



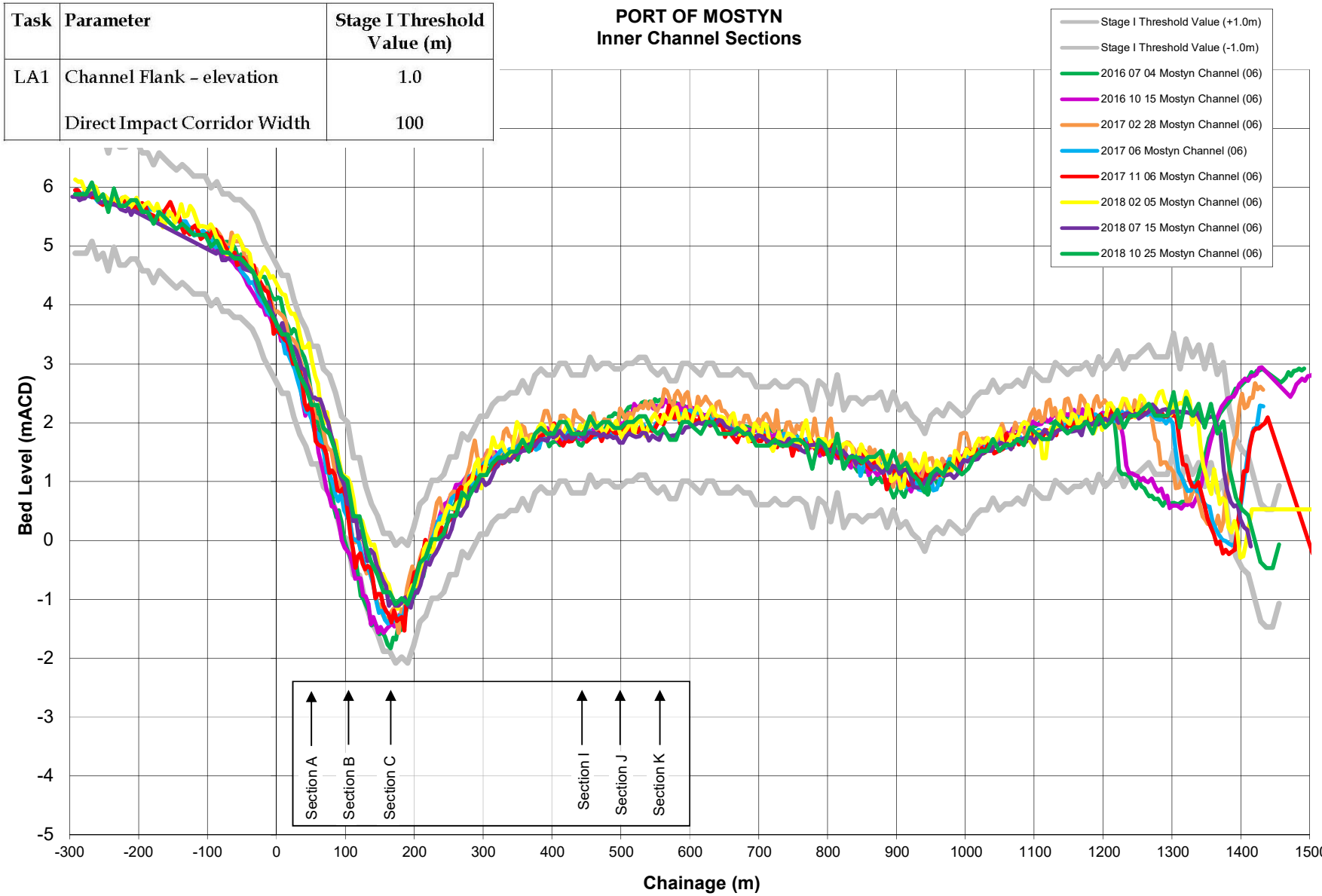
Drawing C (2 of 15) Section 2

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



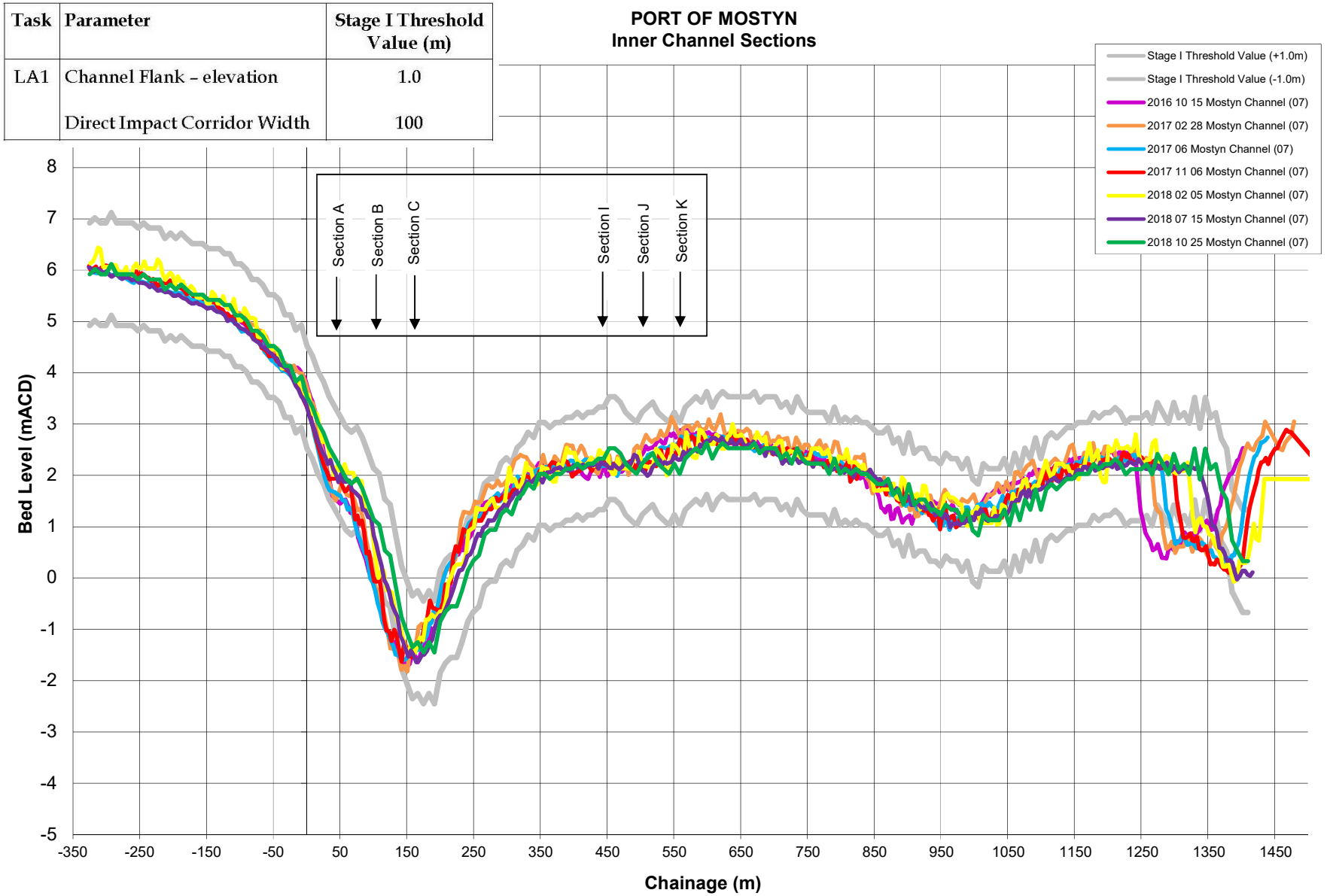
Drawing C (3 of 15) Section 4

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



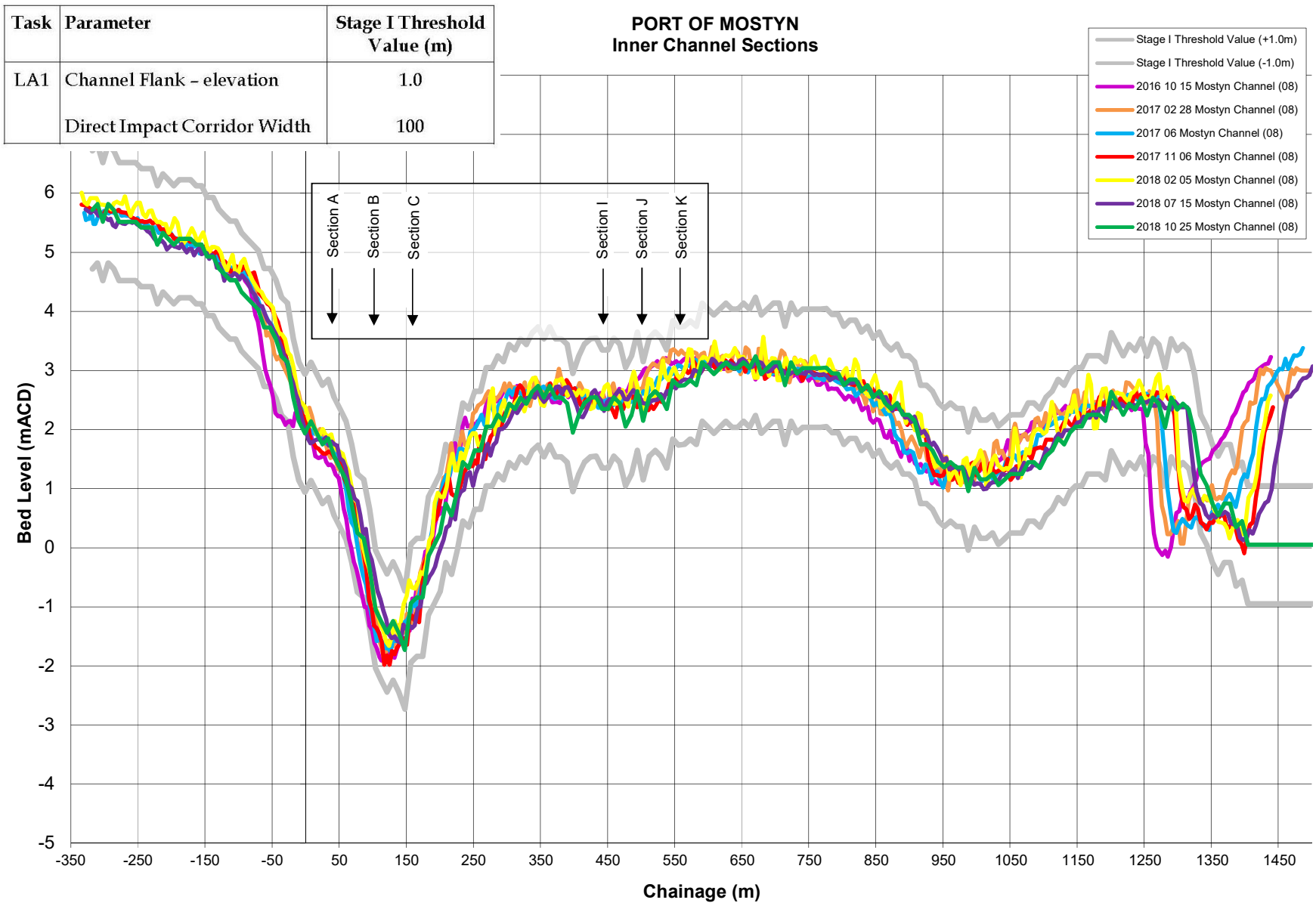
Drawing C (4 of 15) Section 6

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



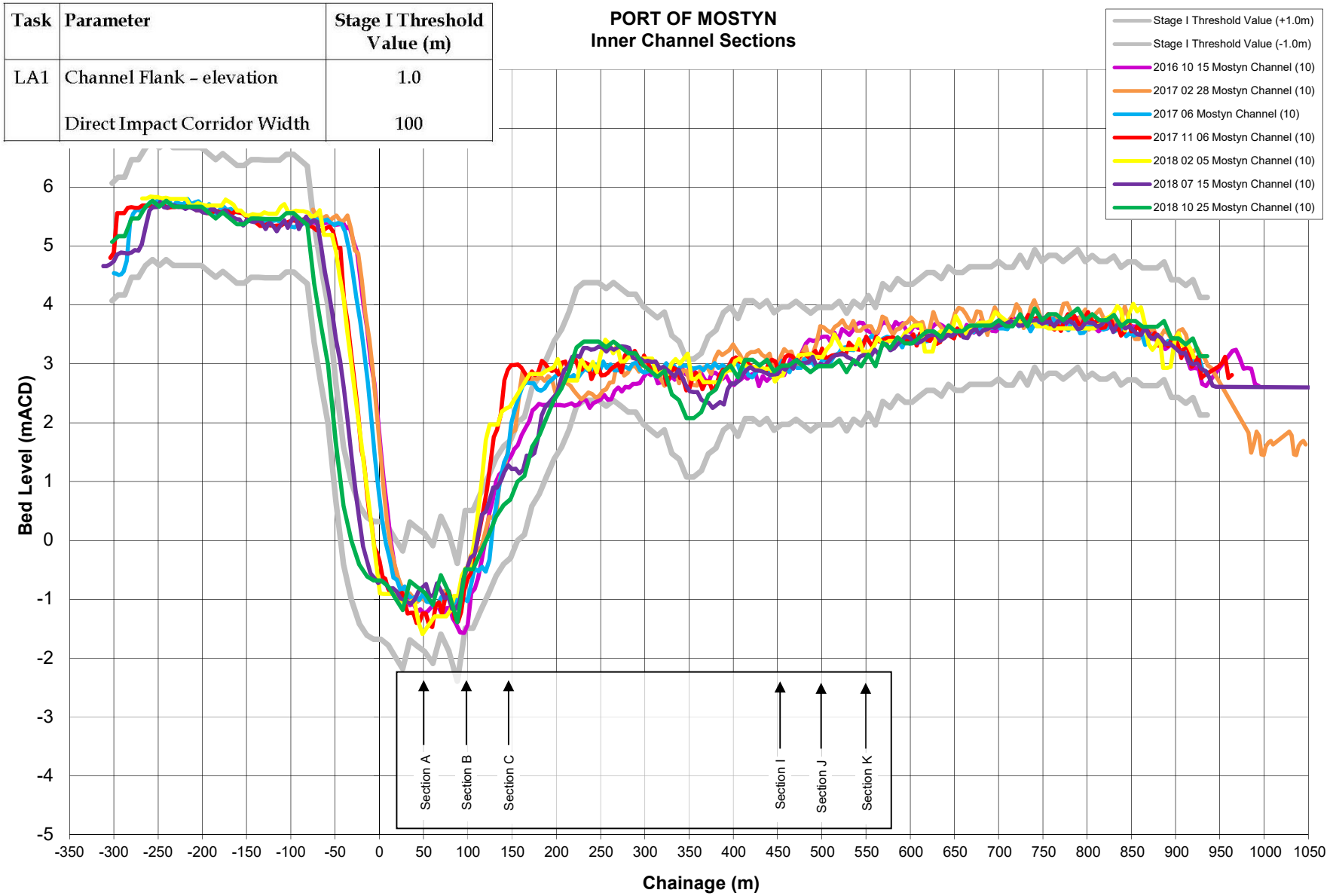
Drawing C (5 of 15) Section 7

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



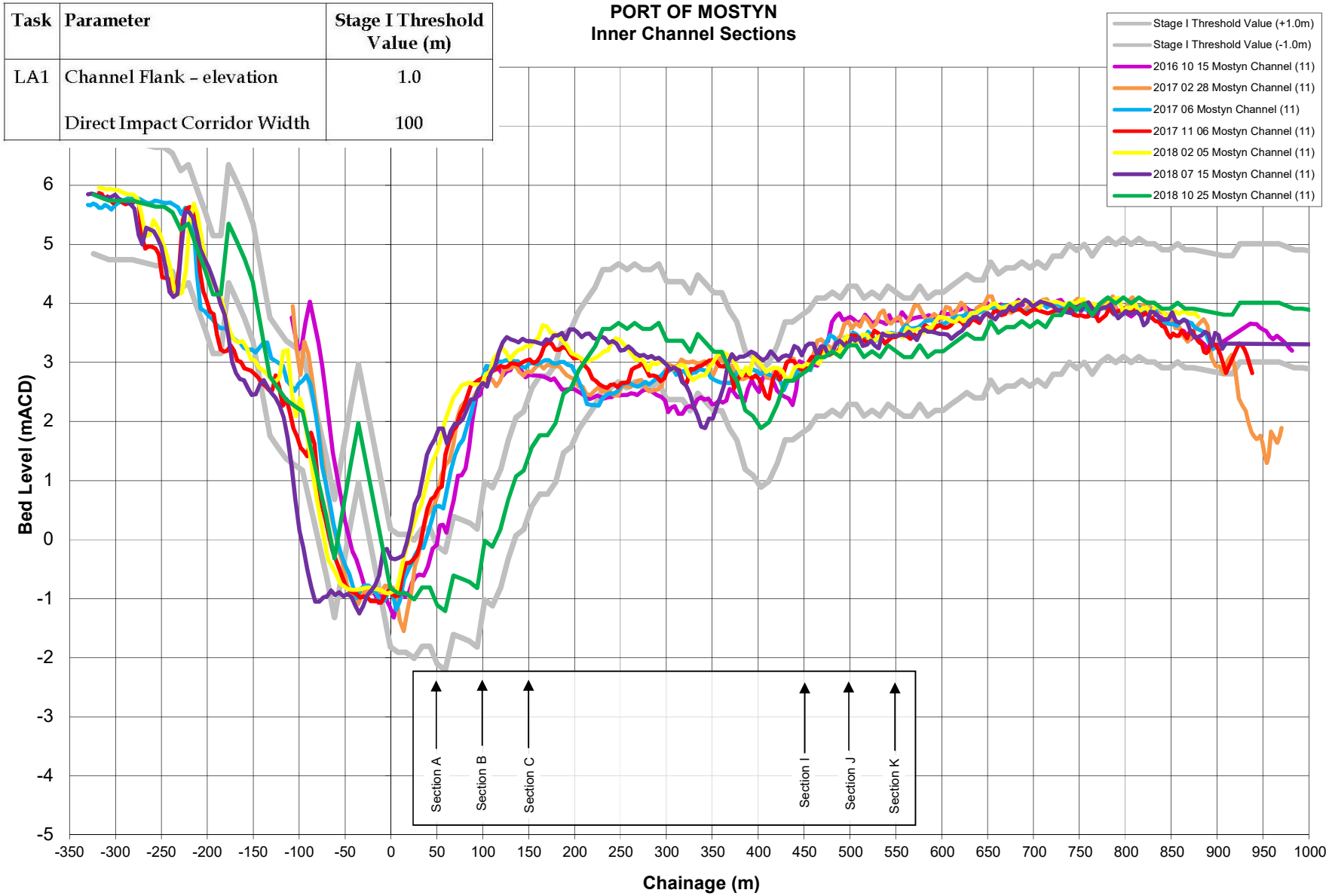
Drawing C (6 of 15) Section 8

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



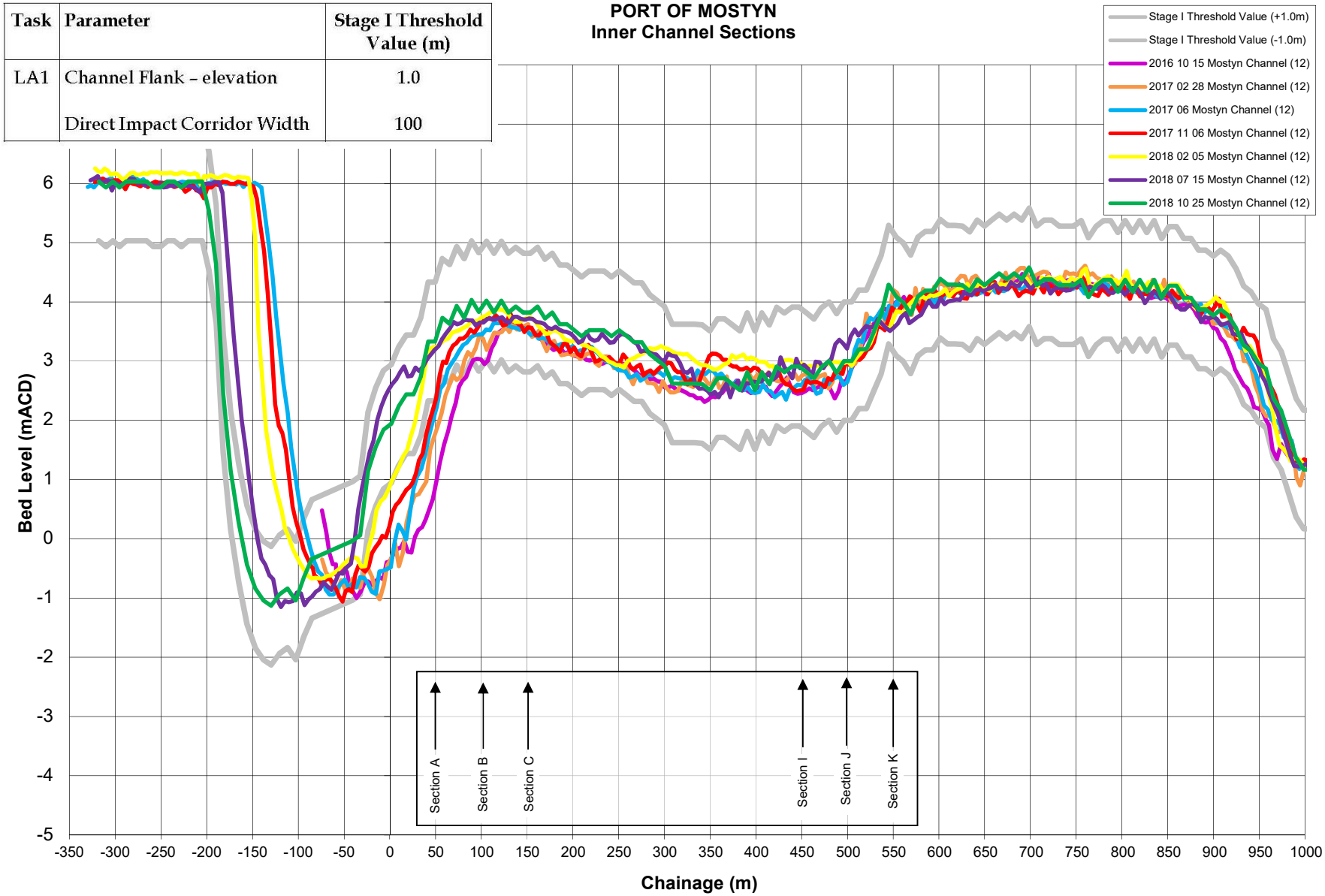
Drawing C (7 of 15) Section 10

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



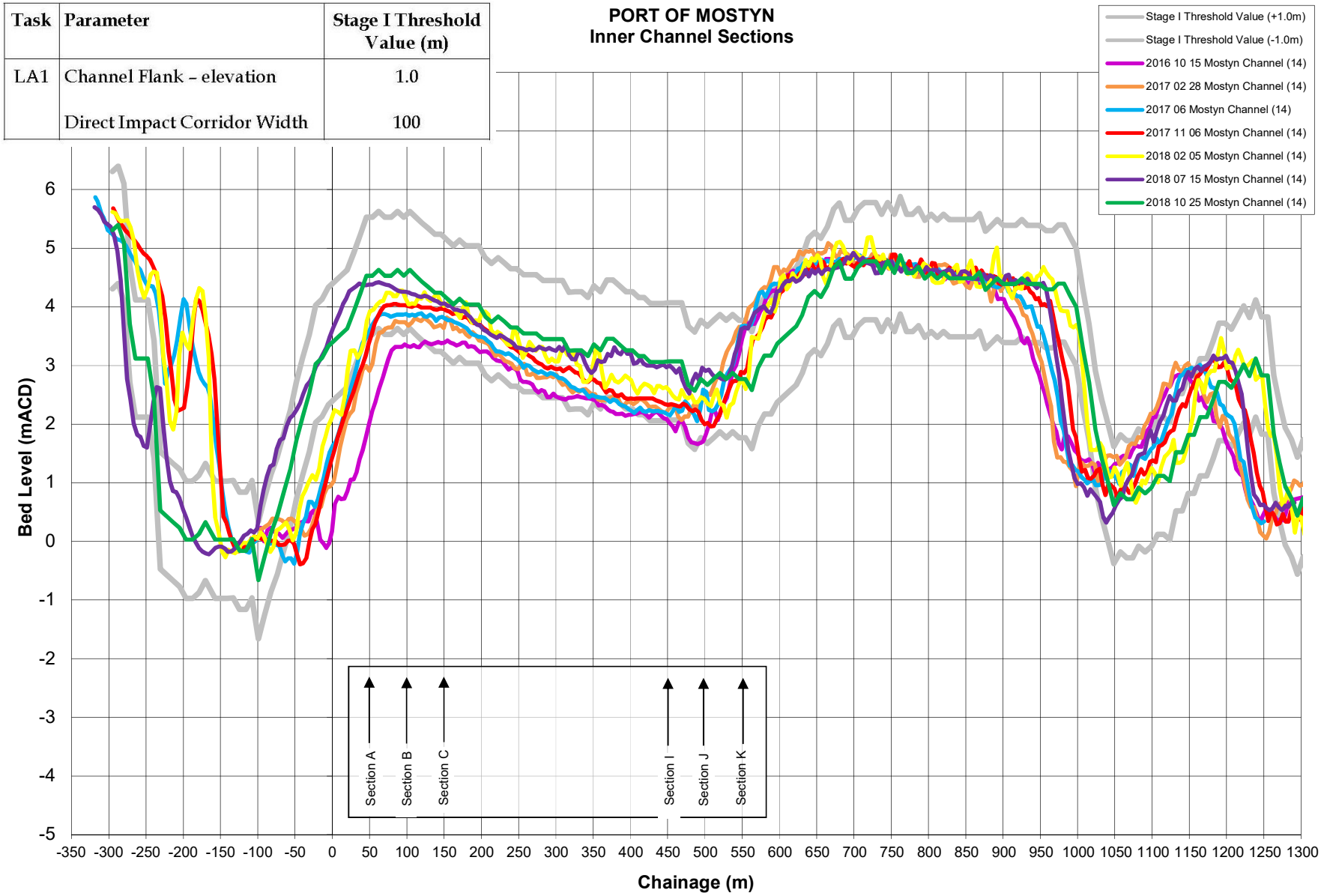
Drawing C (8 of 15) Section 11

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



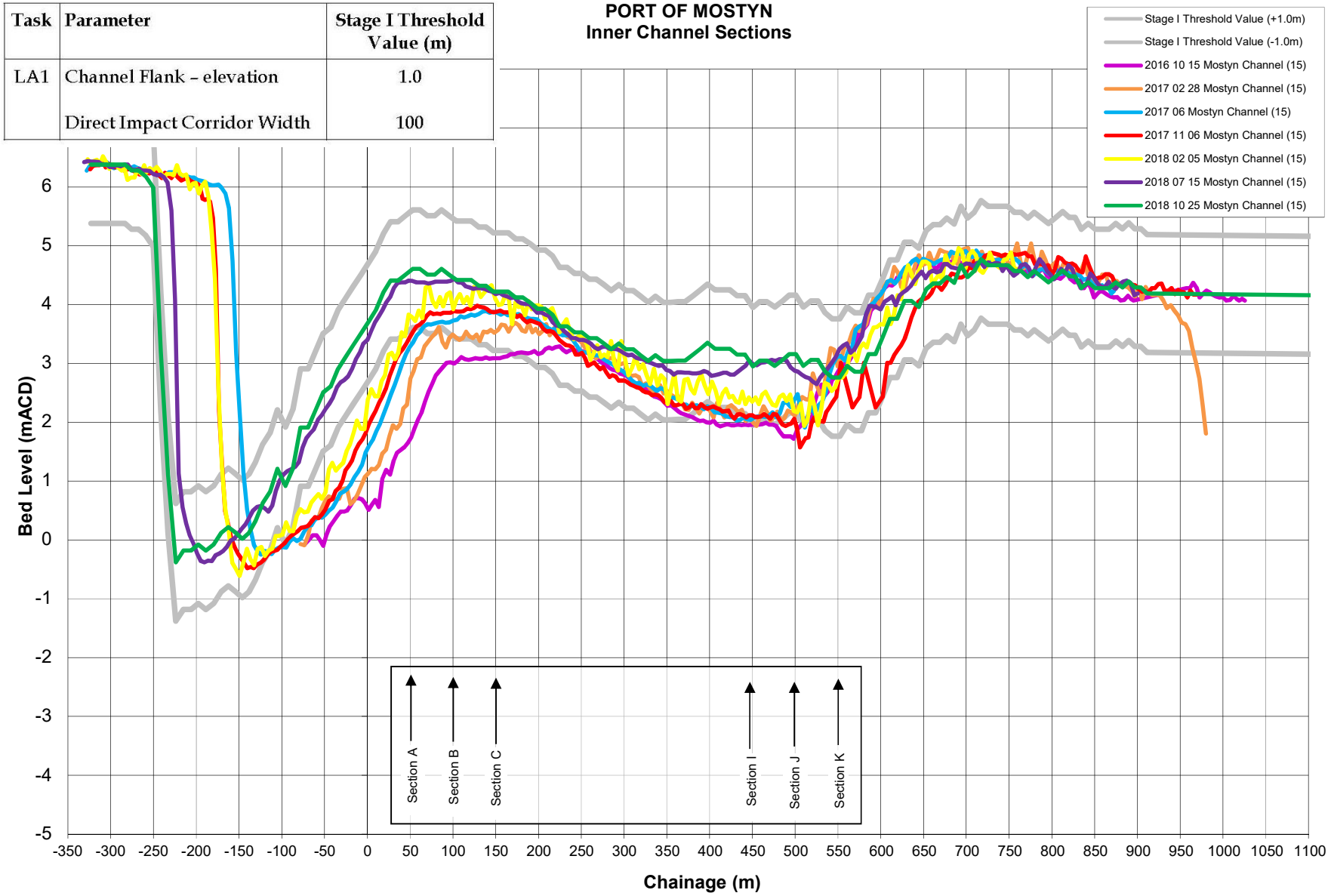
Drawing C (9 of 15) Section 12

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100

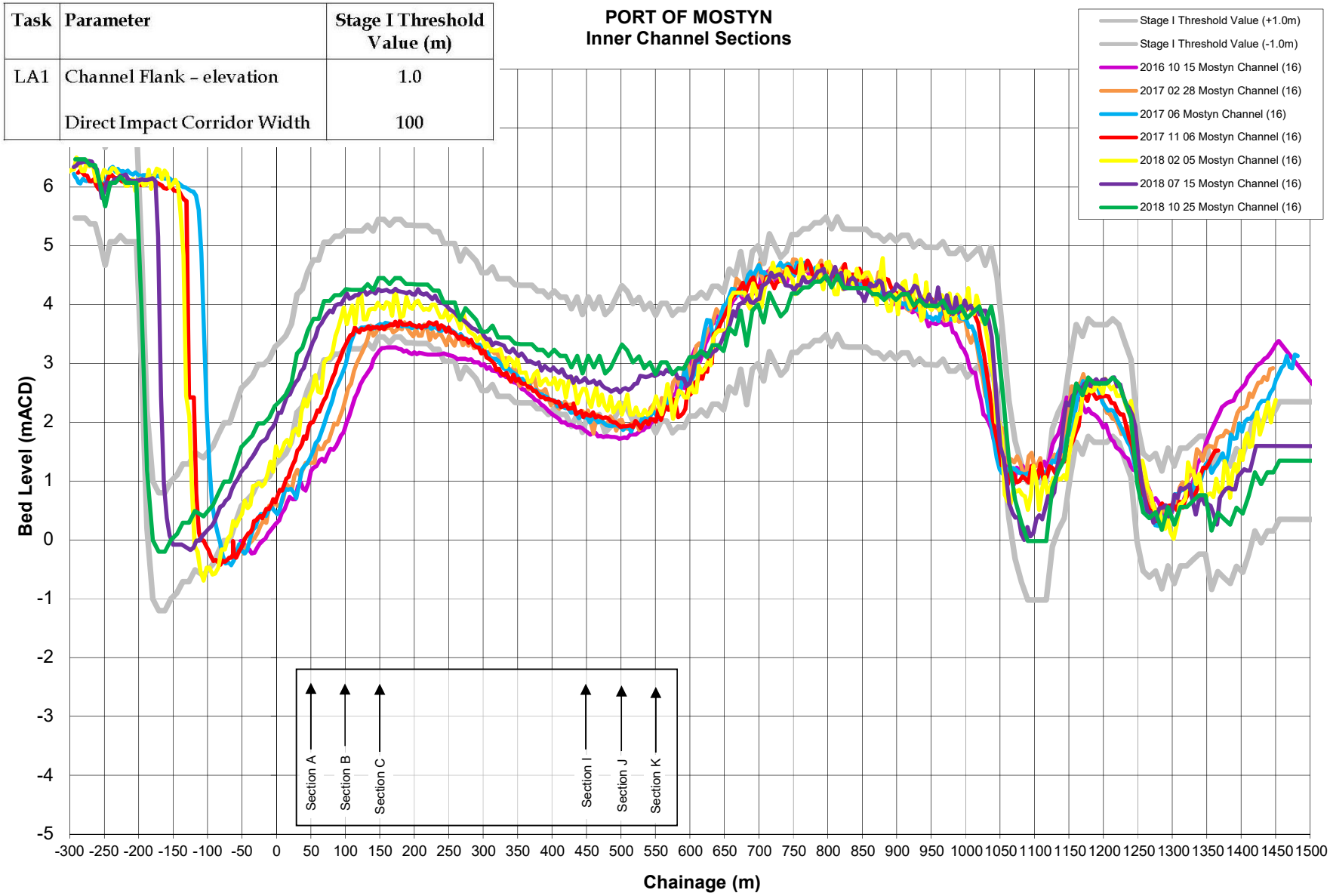


Drawing C (10 of 15) Section 14

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100

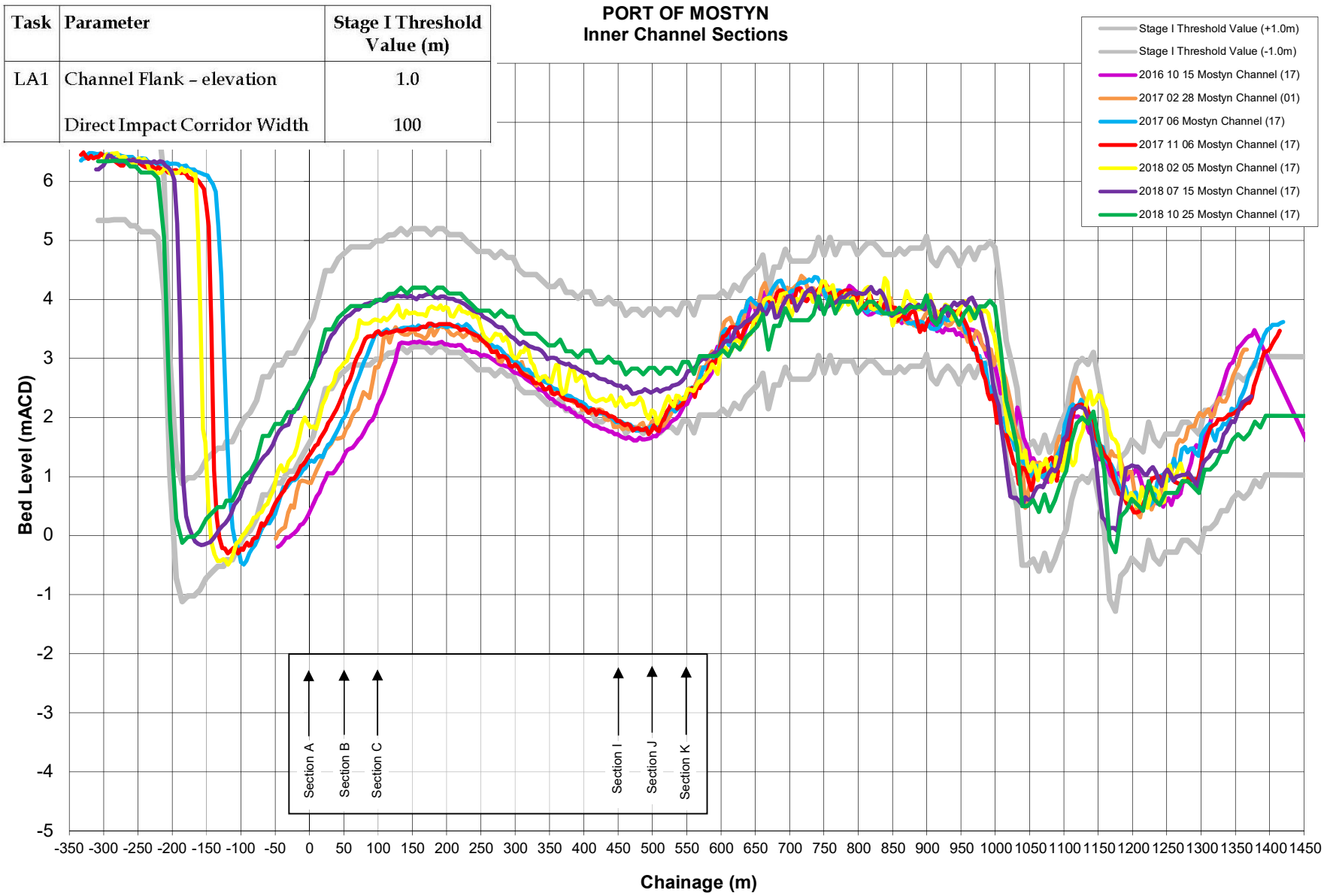


Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100

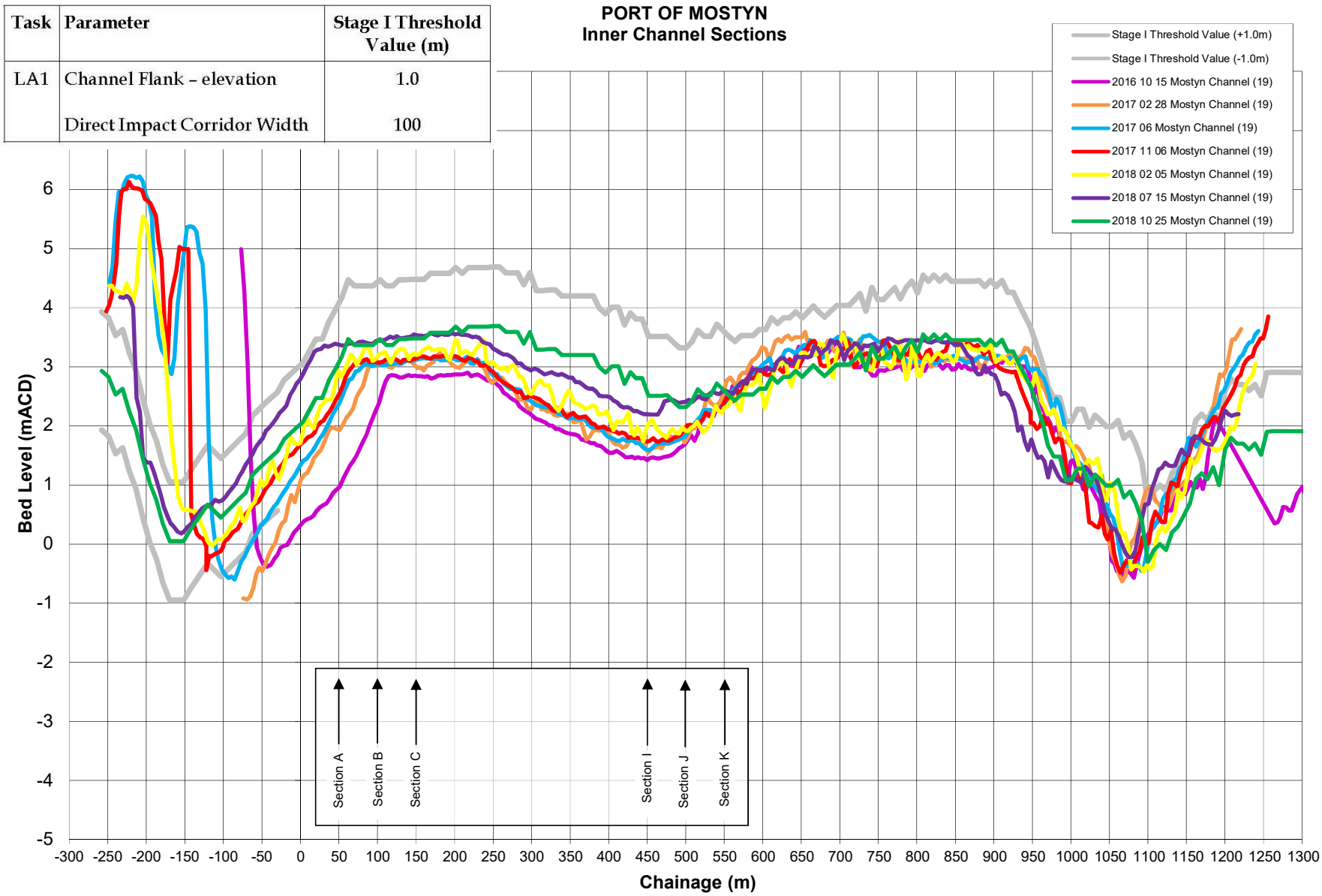


Drawing C (12 of 15) Section 16

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100

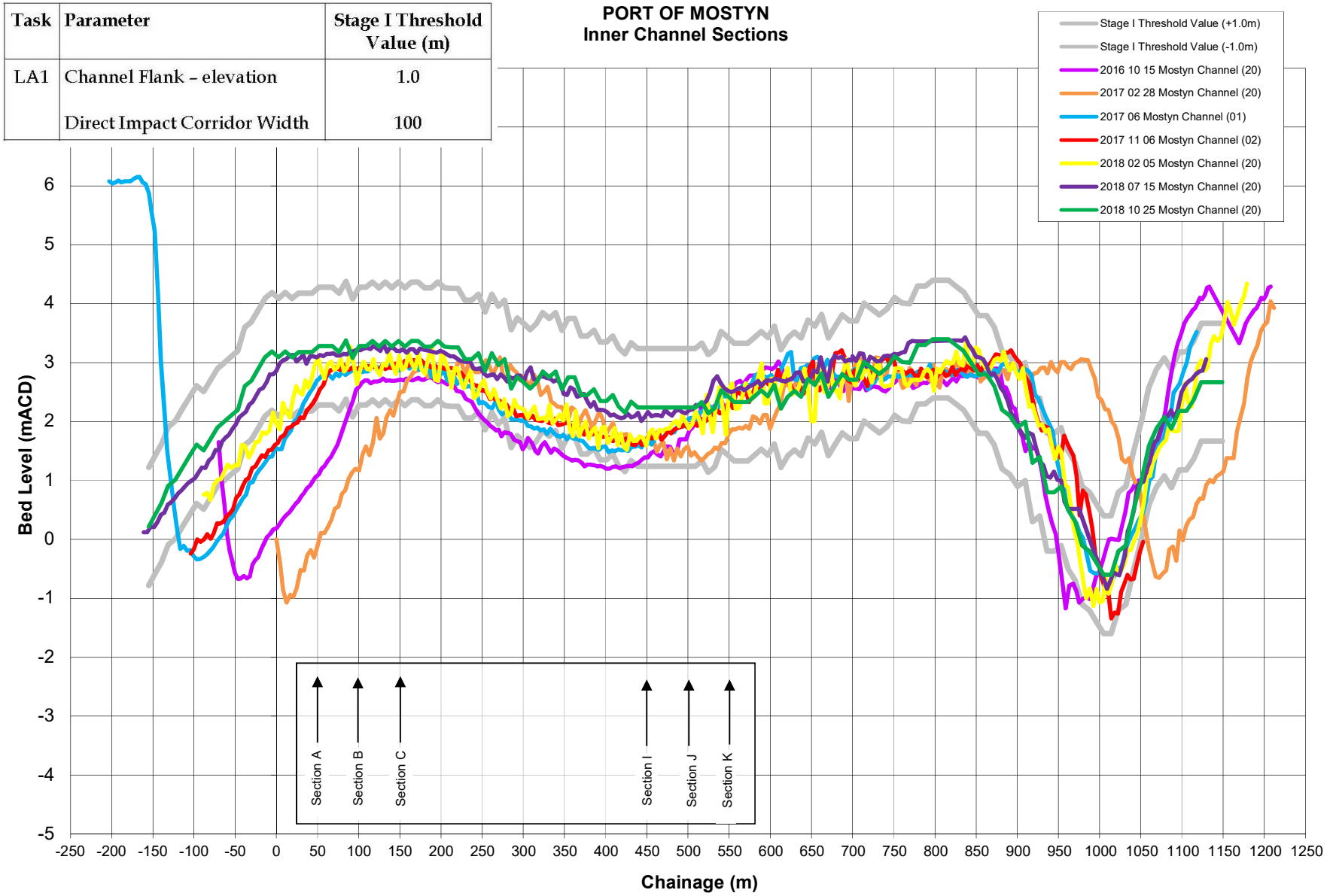


Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



Drawing C (14 of 15) Section 19

Task	Parameter	Stage I Threshold Value (m)
LA1	Channel Flank – elevation	1.0
	Direct Impact Corridor Width	100



Drawing C (15 of 15) Section 20

D PSA Results from December 2018 Mostyn Deep LA3 Survey

Memorandum

To: Rob Jackson

Ref: 4621/02: Mostyn Sediment Analysis

From: Ian Davidson (tel. 02380 711855)

cc: Colin Scott (tel. 02380 711860)

Date: 18 January 2019

Subject: Mostyn Deep bed sample PSA

The Port of Mostyn has commissioned ABPmer to undertake Particle Size Analysis (PSA) of 10 bed sediment samples obtained during Q4 2018 from pre-determined locations throughout Mostyn Deep as part of the required Approach Channel monitoring (i.e. under marine licence reference DML1542, 10 May 2016, Task Ref "LA3 Mostyn Deep Site 'A' Deposition Area Seabed"). The locations of the samples are as below in Table 1 and Figure 1:

Table 1. Sample Coordinates (OSGB36 and WGS84 projections)

Sample No.	Easting	Northing	Latitude (N)	Longitude (W)
1	313900	385700	53°21.653	3°17.636
2	313700	385600	53°21.597	3°17.815
3	313900	385400	53°21.492	3°17.631
4	314200	385300	53°21.440	3°17.359
5	314500	385100	53°21.336	3°17.085
6	314200	385000	53°21.279	3°17.354
7	314900	385000	53°21.286	3°16.723
8	314800	384800	53°21.177	3°16.810
9	315100	384700	53°21.126	3°16.538
10	315400	384700	53°21.129	3°16.268

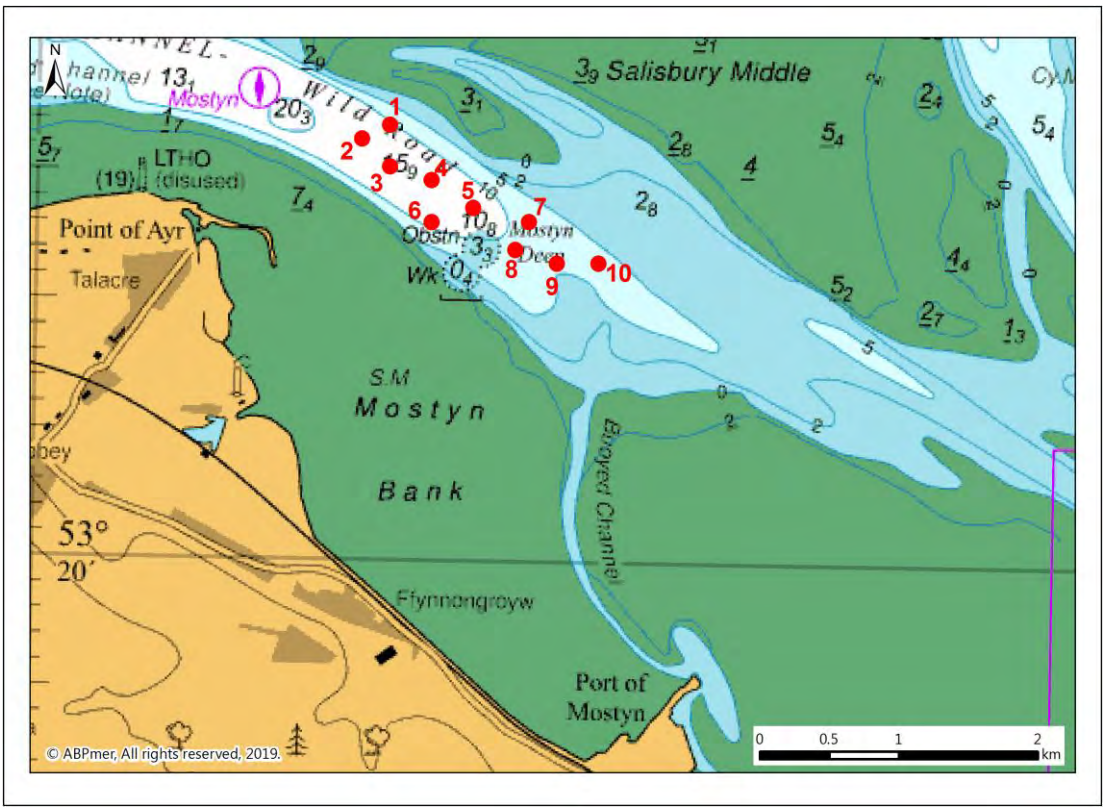


Figure 1. Location map of samples collected within Mostyn Deep

The results of the PSA carried out between 10 January and 16 January 2019 can be viewed in Appendix A. Digital copies of the PSA is also provided. The standard output of grain size parameters from ABPmer's PSA is D_{10}, D_{50}, and D_{90}. However, it is noted that a requirement of the ongoing monitoring programme is to also obtain the D_{15} and D_{85} parameters of respective samples. These additional parameters are tabulated in Appendix B.

As laid out within the Port of Mostyn's Monitoring Protocol document (Port of Mostyn Ltd. 2008), any change in the parameters whereby any one of the following relationships between successive sample PSA triggers an exceedance(s) of Stage 1 Thresholds. These are:

- $D_{15} \geq D_{50}$;
- $D_{50} \geq D_{85}$;
- $D_{50} \leq D_{15}$; or
- $D_{85} \leq D_{50}$.

Comparison against PSA results from 2009 to 2015 (ABPmer, 2017) and that within the 2018 Q1 technical note (ABPmer, 2018) indicates that:

- Little overall change against the D_{15} criteria can be seen between samples located within the deposition area. Outside of the deposition area individual samples have either become slightly finer or coarser, but remain under the threshold criteria. An exception is Site 6 which has seen a coarsening above threshold;
- D_{50} values remain generally under criteria both inside and outside of the deposition area. The exceptions to this are Sites 6 and 8, which have seen short-term positive 'spikes' in D_{50} values (first identified in ABPmer 2018) maintained within the latest samples; and
- The D_{85} parameter remains variable both inside and outside of the deposition area. Significant increases/decreases occur regularly between successive samples at the same locations, which are likely to be a result of large individual pebbles in the gravel fraction. Both Long-term increase of D_{85} at Site 6, and decreasing of D_{85} at Site 7, has continued.

References

ABPmer (2017). Review of Dredge and Disposal Monitoring: Overview of survey work carried out by the Port in the Dee Estuary from 2005 to 2016. Report No. R.2713. A report produced by ABPmer for the Port of Mostyn.

ABPmer (2018). Mostyn Deep bed sample PSA. A technical note produced by ABPmer for the Port of Mostyn. February 2018.

Port of Mostyn Ltd. (2008). Maintenance of Navigation: Mostyn Channel Monitoring Protocols.

Appendix A- PSA results

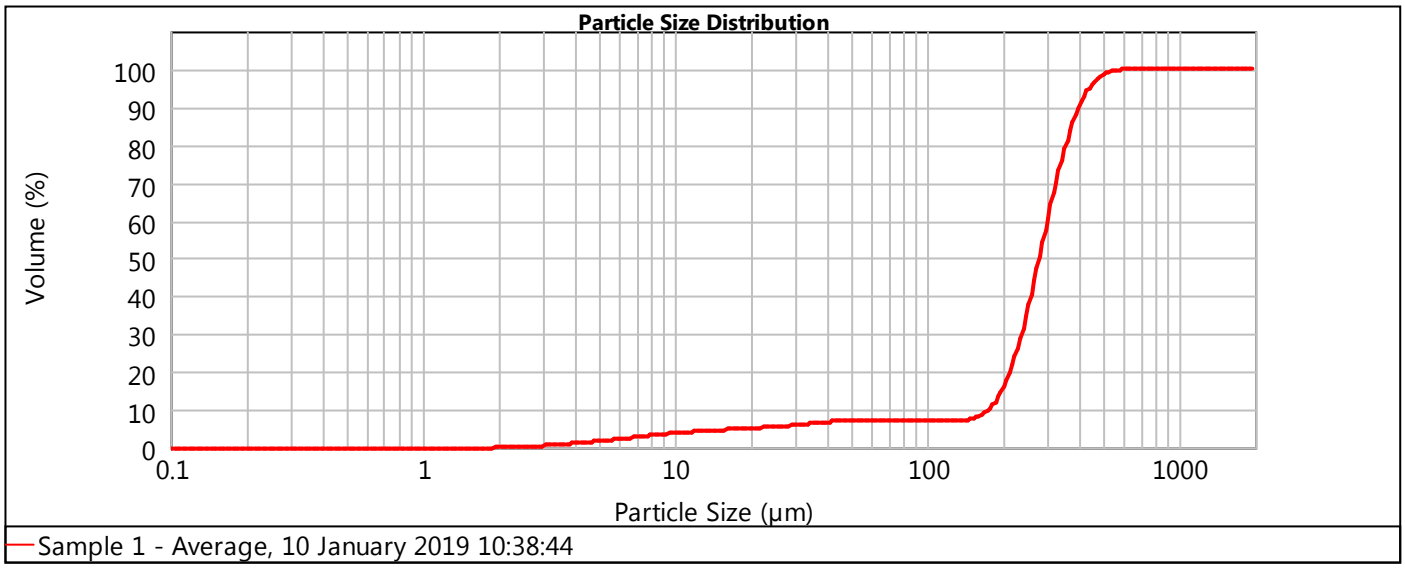
ABPmer
Quayside Suite, Medina Chambers
Town Quay, Southampton, SO14 2AQ
www.abpmer.co.uk

Particle Size Analysis Report

Sample Name:	Sample 1 - Average	**Measured by:**	IDavidson on 10 January 2019
Sample Source:	Mostyn	**Obscuration:**	12.04 %
Sample Collected:		**Weighted Residual:**	0.867 %

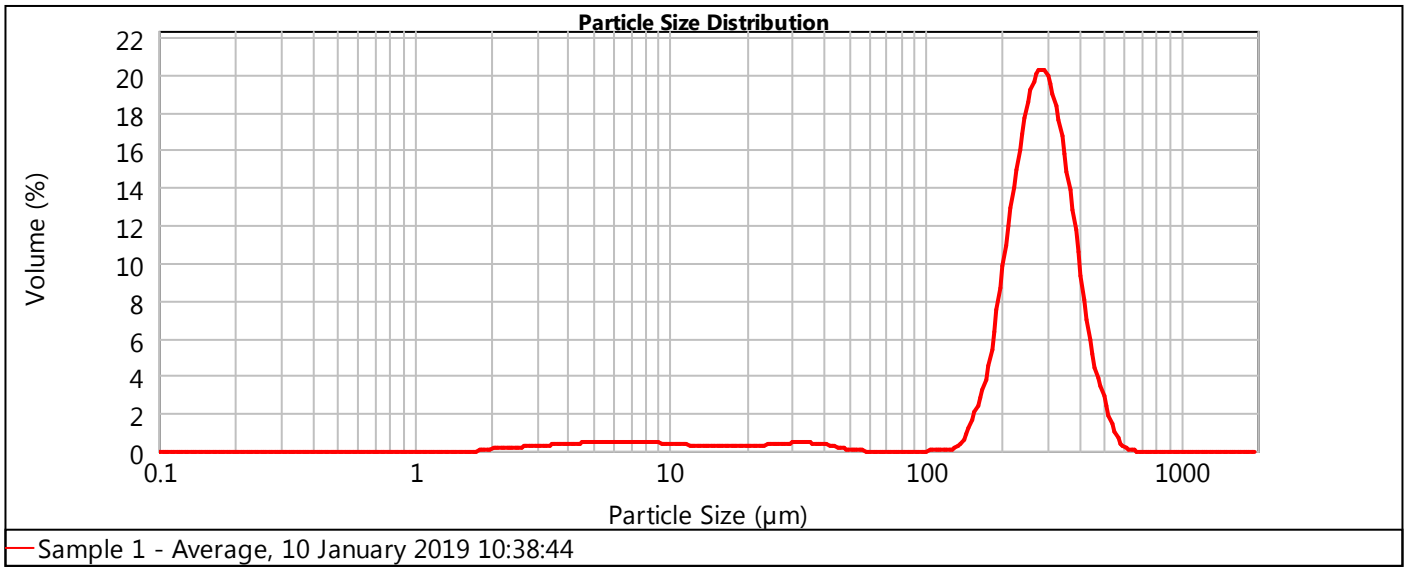
d(0.1): 173.916 µm	**d(0.5): 278.217 µm**	d(0.9): 398.821 µm

Cumulative Frequency Plot



Clay	Silt			Sand		
	Fine	Medium	Coarse	Fine	Medium	Coarse
0 %	2 %	3 %	2 %	9 %	84 %	0 %

Frequency Curve



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Town Quay, Southampton, SO14 2AQ
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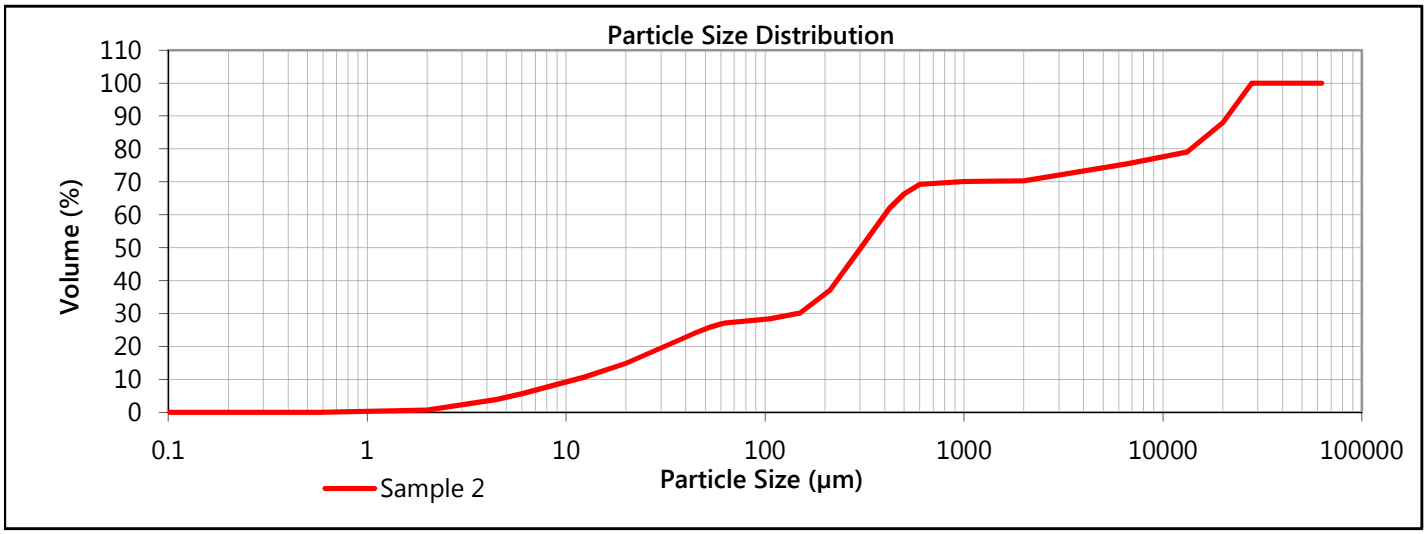
Particle Size Analysis Report

Sample Name:	Sample 2	**Measured by:**	IDavidson
Sample Source:	Mostyn Deep		
Sample Collected:	Jan 2019		

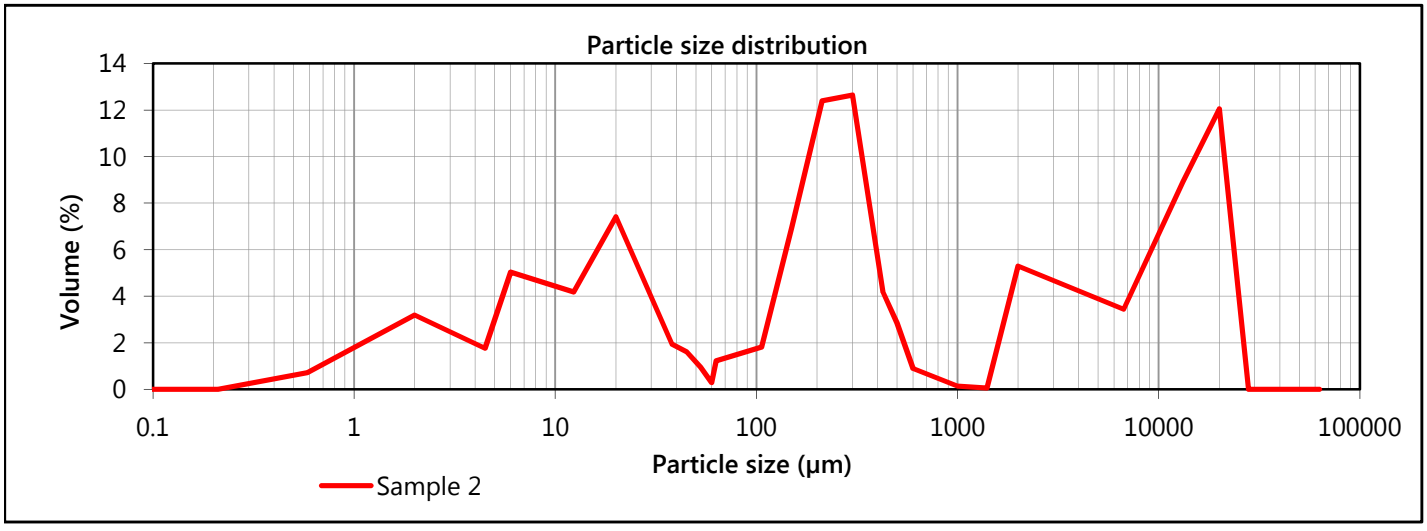
d(0.1):	11.4	µm	**d(0.5):**	**304.6**	**µm**	d(0.9):	21356.4	µm

Cumulative Frequency Plot



Clay (%)	Silt (%)			Sand (%)			Gravel (%)			Cobble (%)
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
0.7	5.0	9.2	11.9	10.3	32.1	1.1	5.3	12.4	12.0	0.0

Frequency Curve



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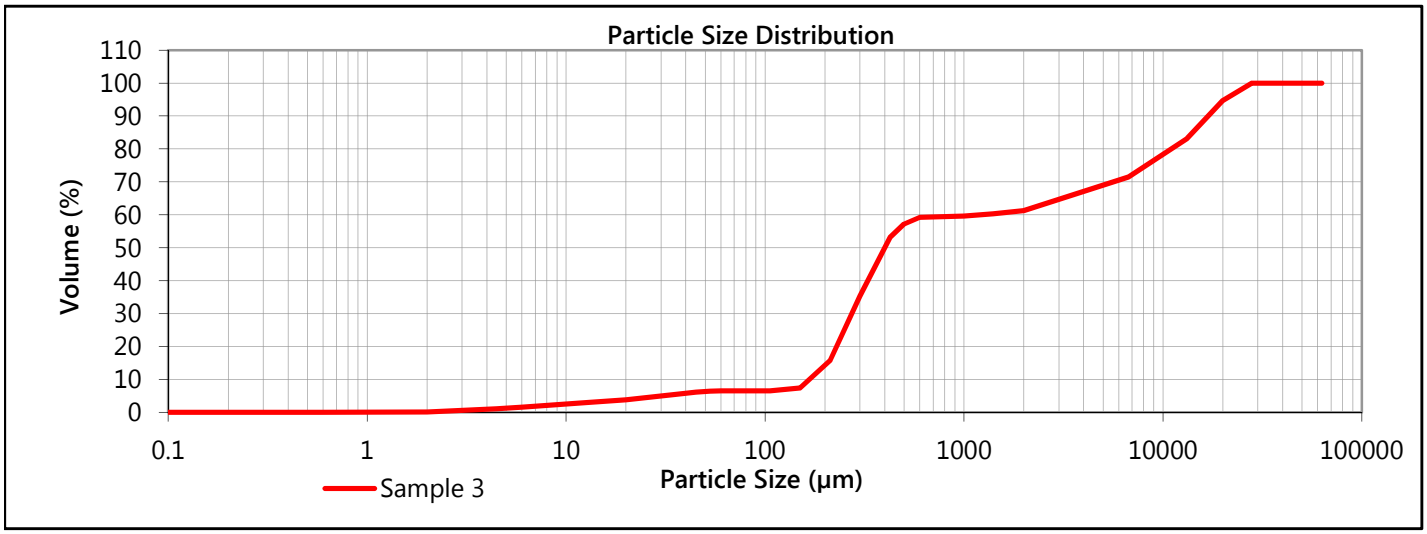
Particle Size Analysis Report

Sample Name:	Sample 3	**Measured by:**	IDavidson
Sample Source:	Mostyn Deep		
Sample Collected:	Jan 2019		

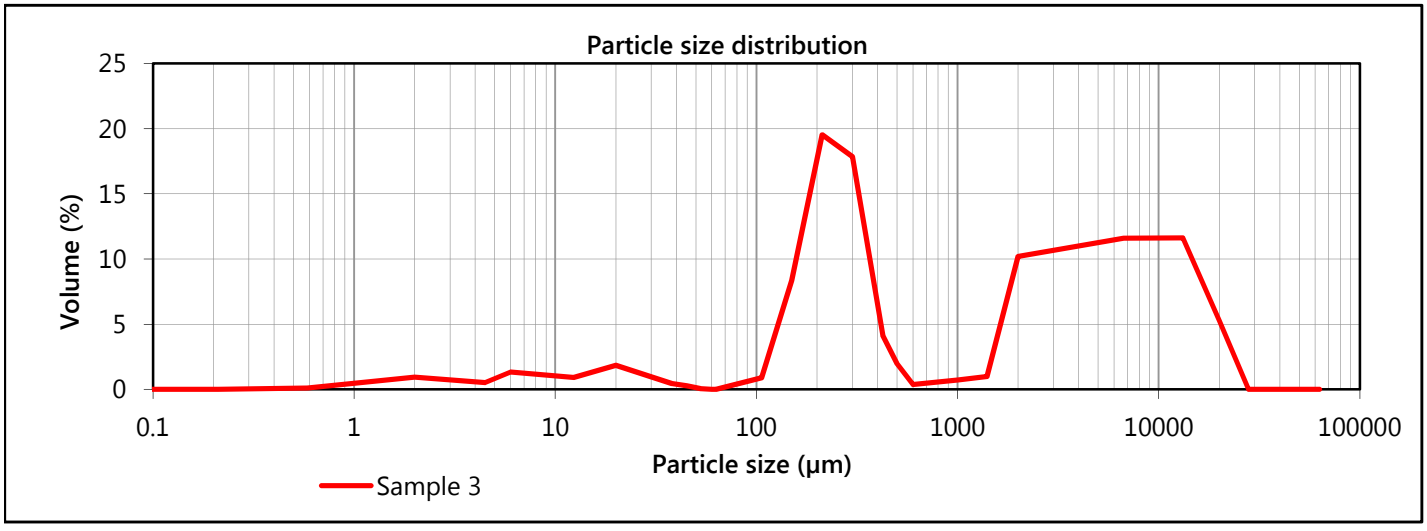
d(0.1):	169.2	µm	**d(0.5):**	**403.1**	**µm**	d(0.9):	17234.6	µm

Cumulative Frequency Plot



Clay (%)	Silt (%)			Sand (%)			Gravel (%)			Cobble (%)
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
0.1	1.5	2.3	2.7	9.2	43.4	2.1	10.2	23.2	5.3	0.0

Frequency Curve



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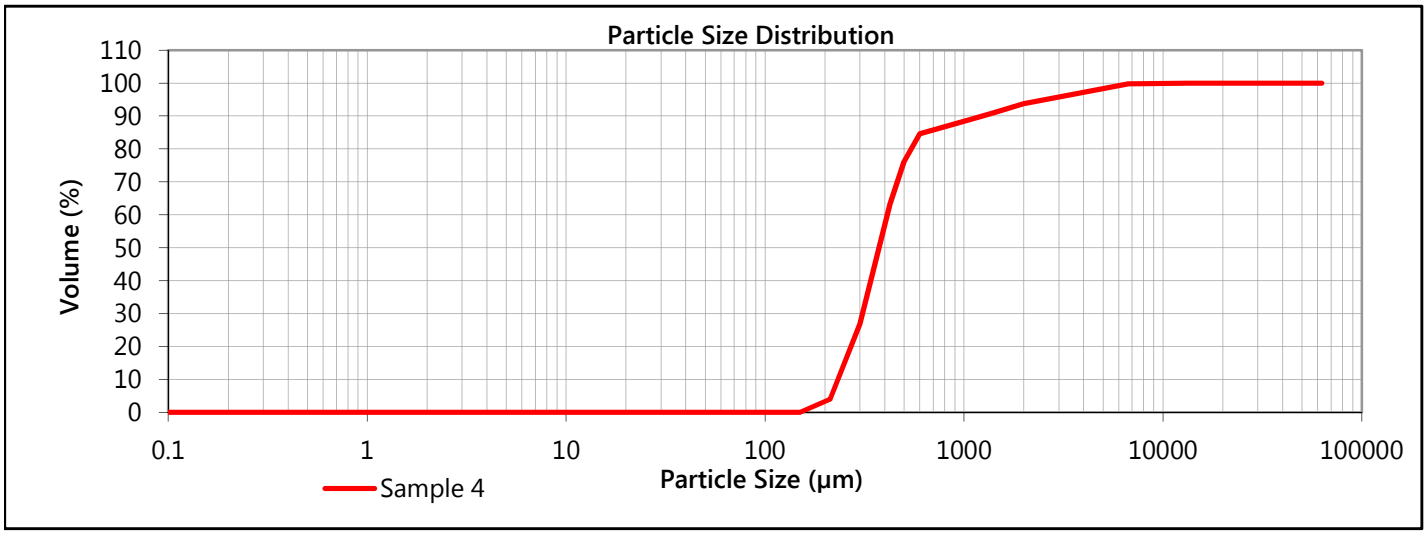
Particle Size Analysis Report

Sample Name:	Sample 4	**Measured by:**	IDavidson
Sample Source:	Mostyn Deep		
Sample Collected:	Jan 2019		

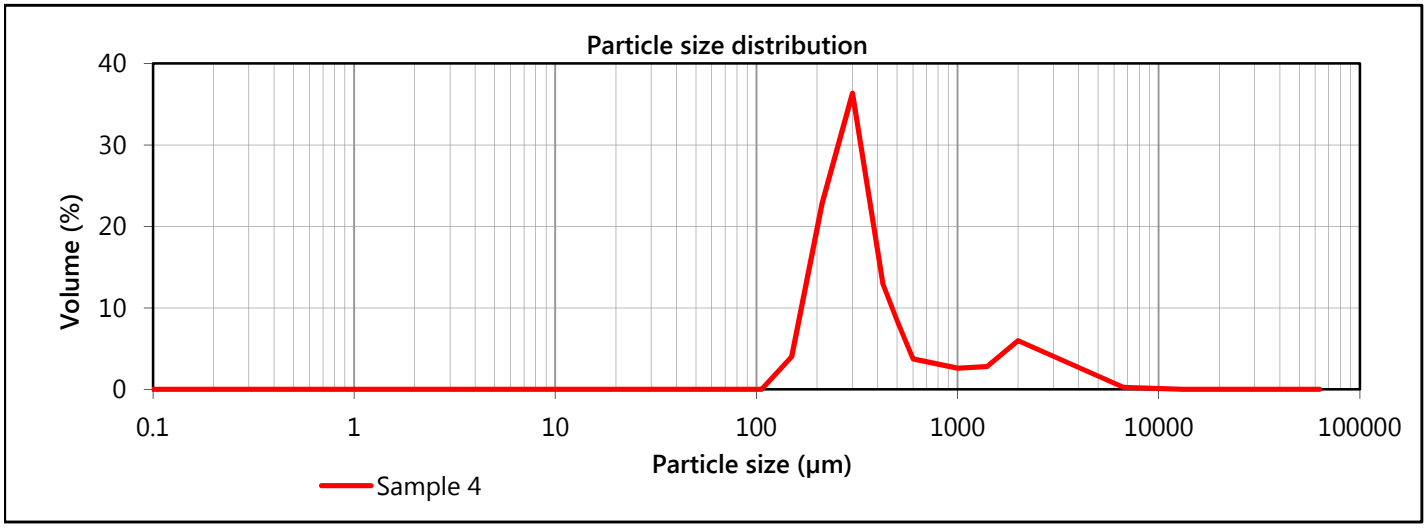
d(0.1):	235.0	µm	**d(0.5):**	**379.5**	**µm**	d(0.9):	1253.3	µm

Cumulative Frequency Plot



Clay (%)	Silt (%)			Sand (%)			Gravel (%)			Cobble (%)
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
0.0	0.0	0.0	0.0	4.0	80.6	9.2	6.0	0.3	0.0	0.0

Frequency Curve



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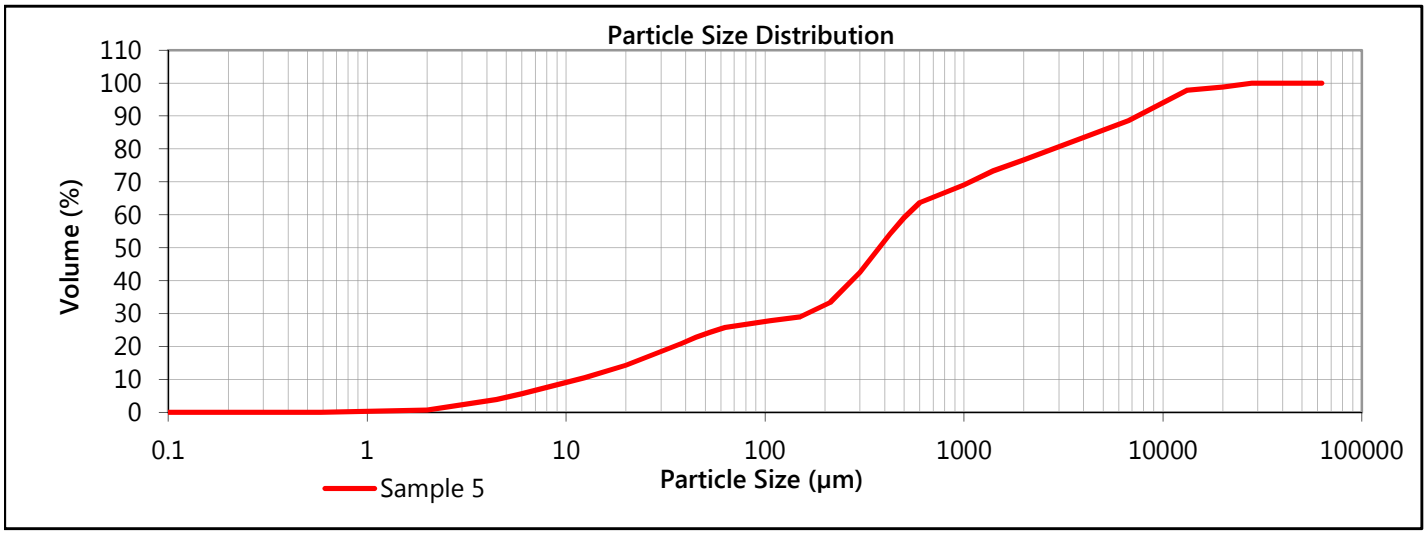
Particle Size Analysis Report

Sample Name:	Sample 5	**Measured by:**	IDavidson
Sample Source:	Mostyn Deep		
Sample Collected:	Jan 2019		

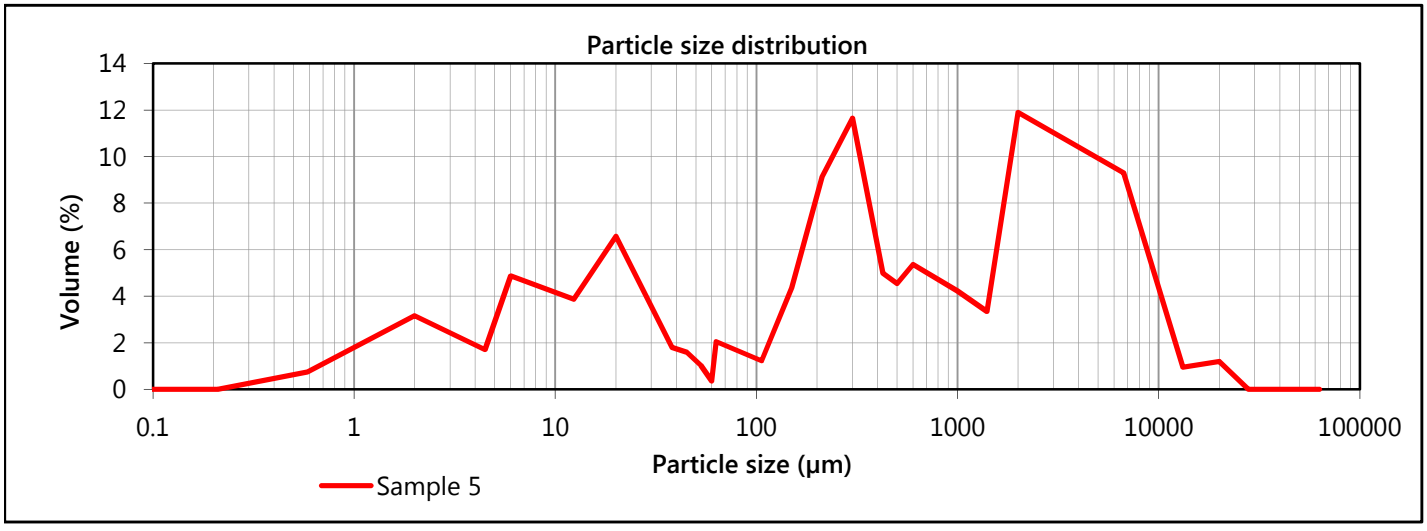
d(0.1):	11.7	µm	**d(0.5):**	**380.3**	**µm**	d(0.9):	7718.4	µm

Cumulative Frequency Plot



Clay (%)	Silt (%)			Sand (%)			Gravel (%)			Cobble (%)
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
0.8	4.9	8.7	11.0	8.0	30.3	12.9	11.9	10.3	1.2	0.0

Frequency Curve



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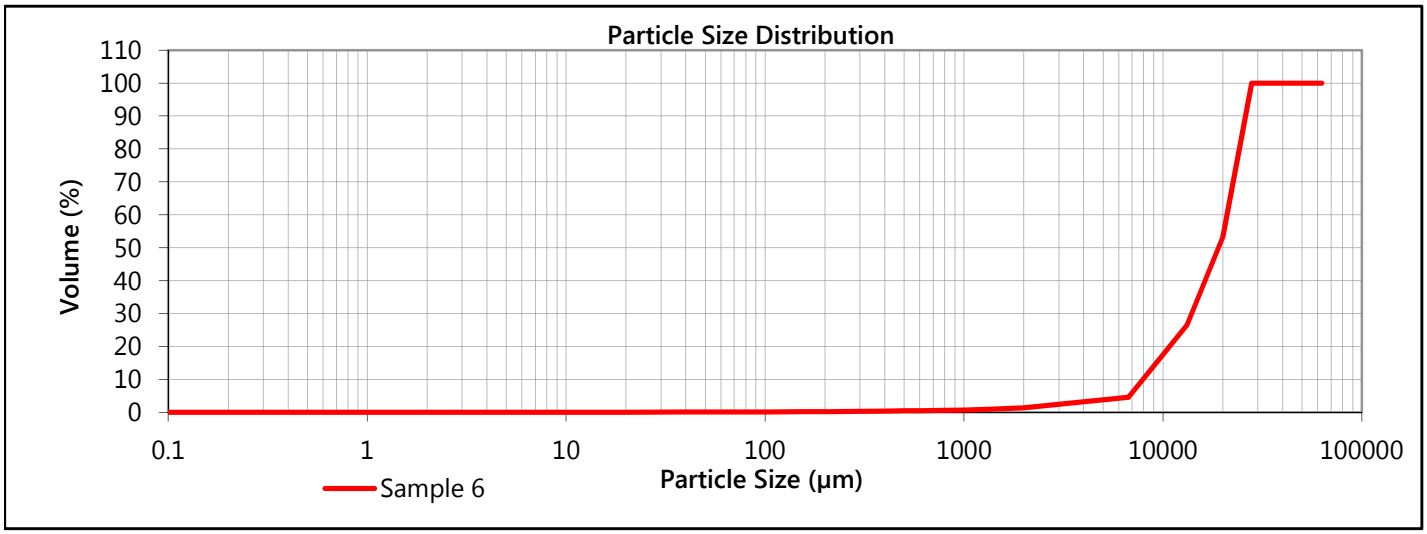
Particle Size Analysis Report

Sample Name:	Sample 6	**Measured by:**	IDavidson
Sample Source:	Mostyn Deep		
Sample Collected:	Jan 2019		

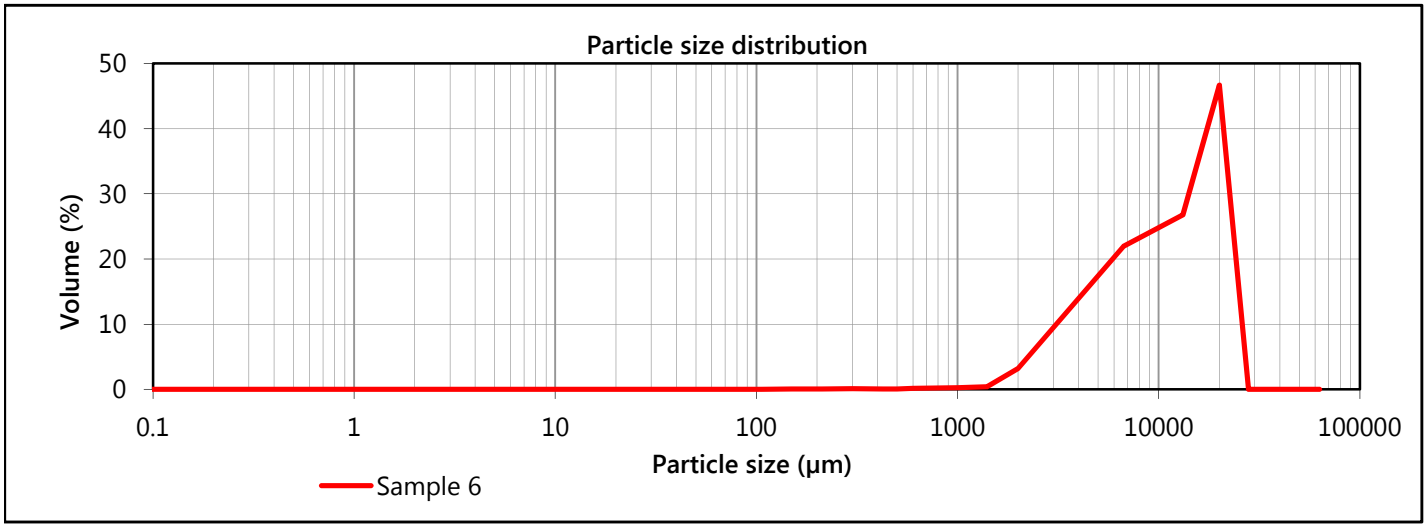
d(0.1):	8296.7	µm	**d(0.5):**	**19153.2**	**µm**	d(0.9):	26285.7	µm

Cumulative Frequency Plot



Clay (%)	Silt (%)			Sand (%)			Gravel (%)			Cobble (%)
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
0.0	0.0	0.0	0.1	0.1	0.3	0.8	3.2	48.7	46.7	0.0

Frequency Curve



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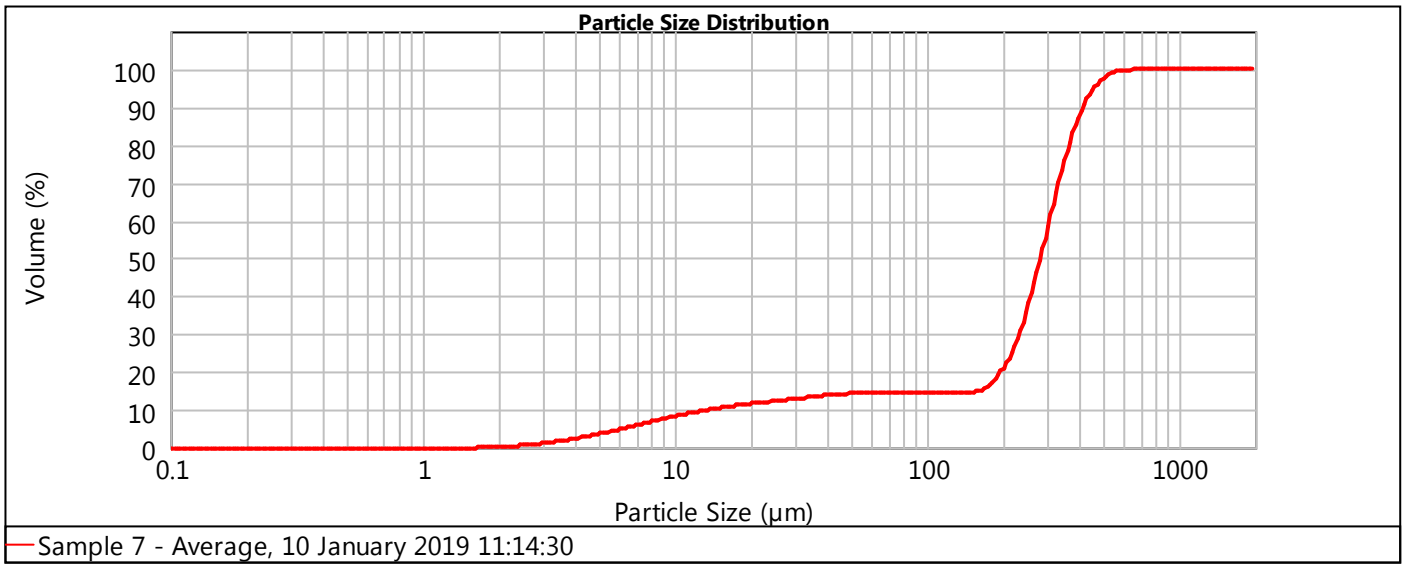
Particle Size Analysis Report

Sample Name:	Sample 7 - Average	**Measured by:**	IDavidson on 10 January 2019
Sample Source:	Mostyn	**Obscuration:**	12.46 %
Sample Collected:		**Weighted Residual:**	1.162 %

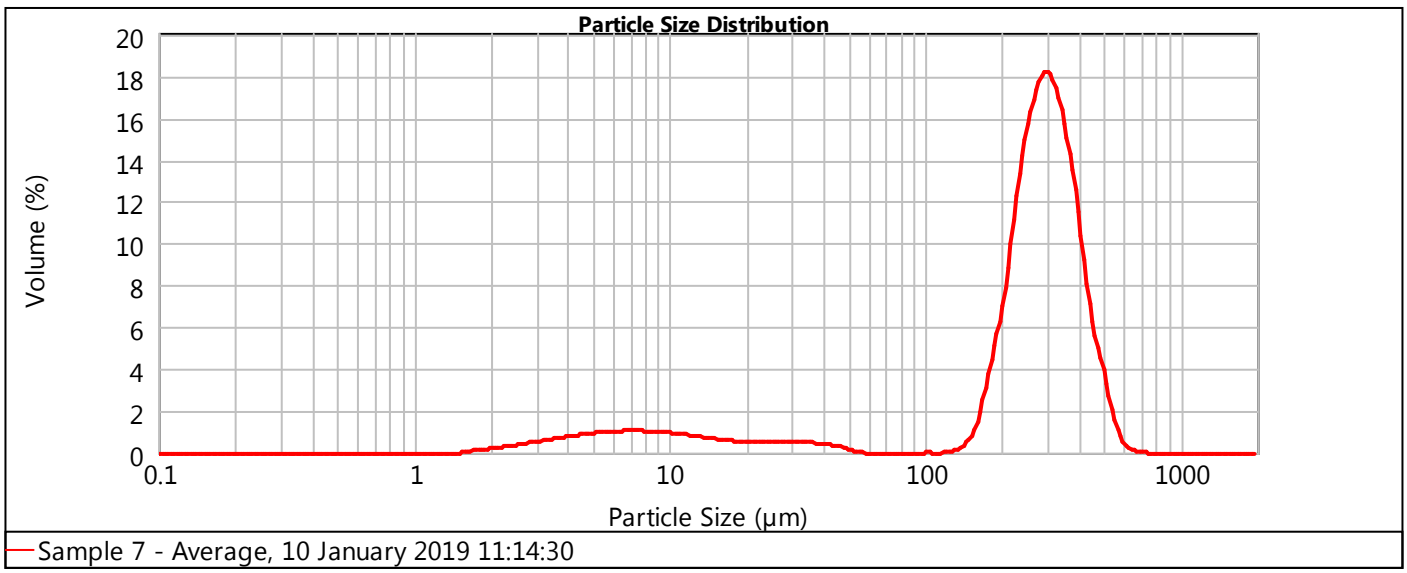
d(0.1): 13.478 µm	**d(0.5): 280.885 µm**	d(0.9): 413.840 µm

Cumulative Frequency Plot



Clay	Silt			Sand		
	Fine	Medium	Coarse	Fine	Medium	Coarse
0 %	5 %	7 %	3 %	6 %	79 %	0 %

Frequency Curve



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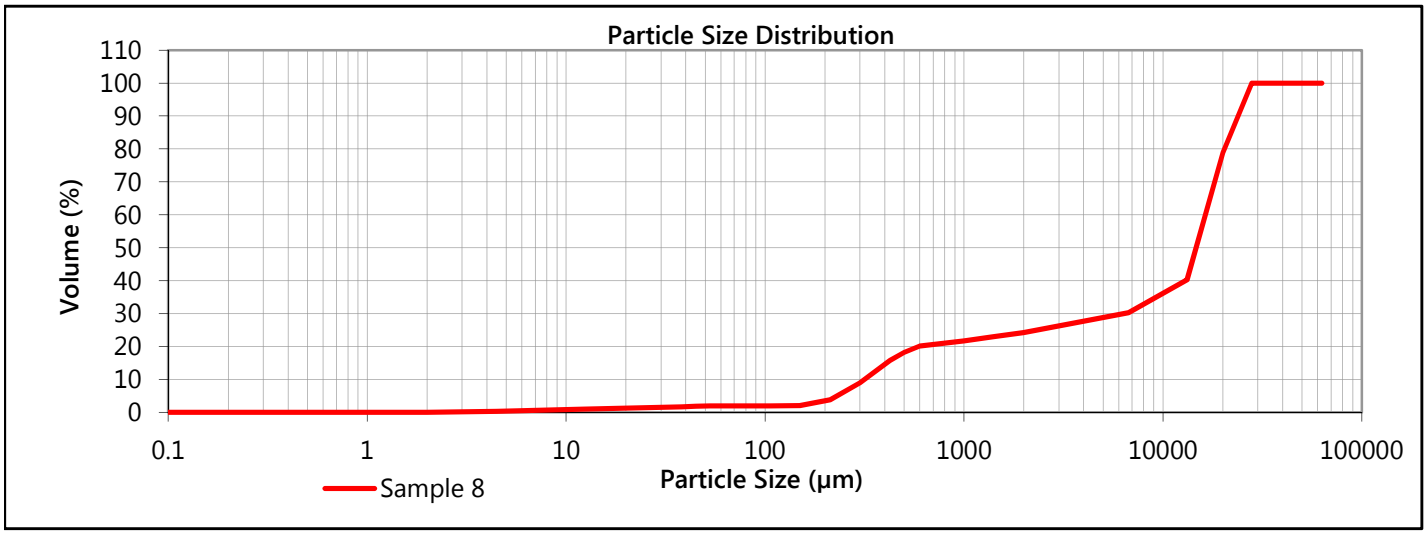
Particle Size Analysis Report

Sample Name:	Sample 8	**Measured by:**	IDavidson
Sample Source:	Mostyn Deep		
Sample Collected:	Jan 2019		

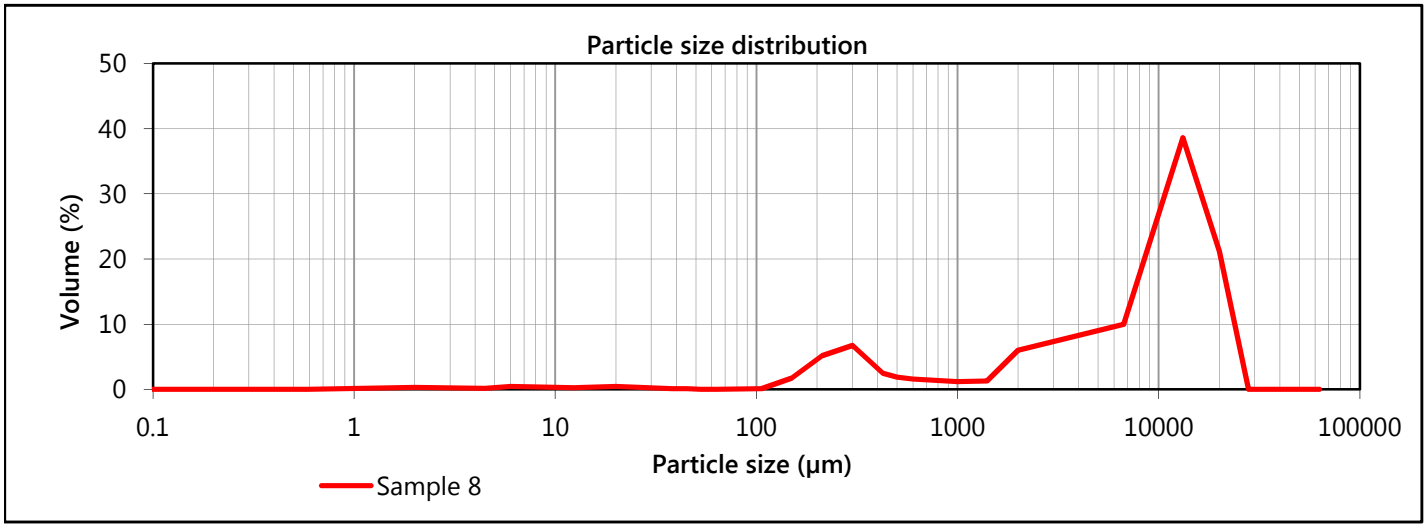
d(0.1):	318.9	µm	**d(0.5):**	**14920.9**	**µm**	d(0.9):	24221.0	µm

Cumulative Frequency Plot



Clay (%)	Silt (%)			Sand (%)			Gravel (%)			Cobble (%)
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
0.0	0.5	0.7	0.8	1.8	16.3	4.1	6.0	48.6	21.2	0.0

Frequency Curve



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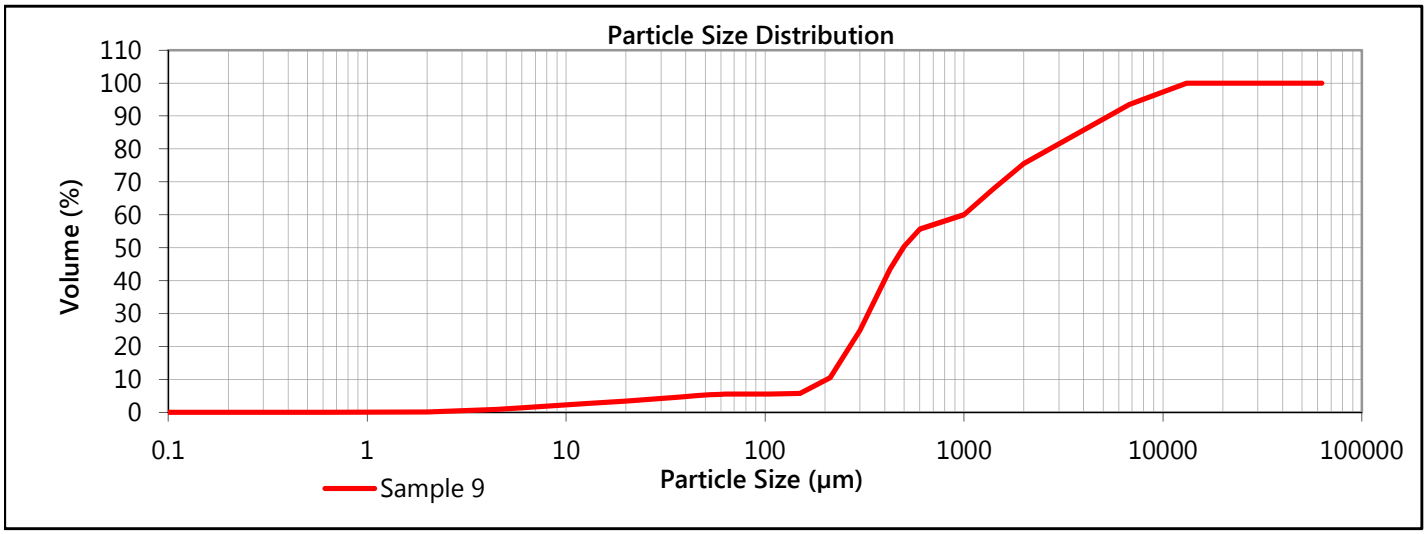
Particle Size Analysis Report

Sample Name:	Sample 9	**Measured by:**	IDavidson
Sample Source:	Mostyn Deep		
Sample Collected:	Jan 2019		

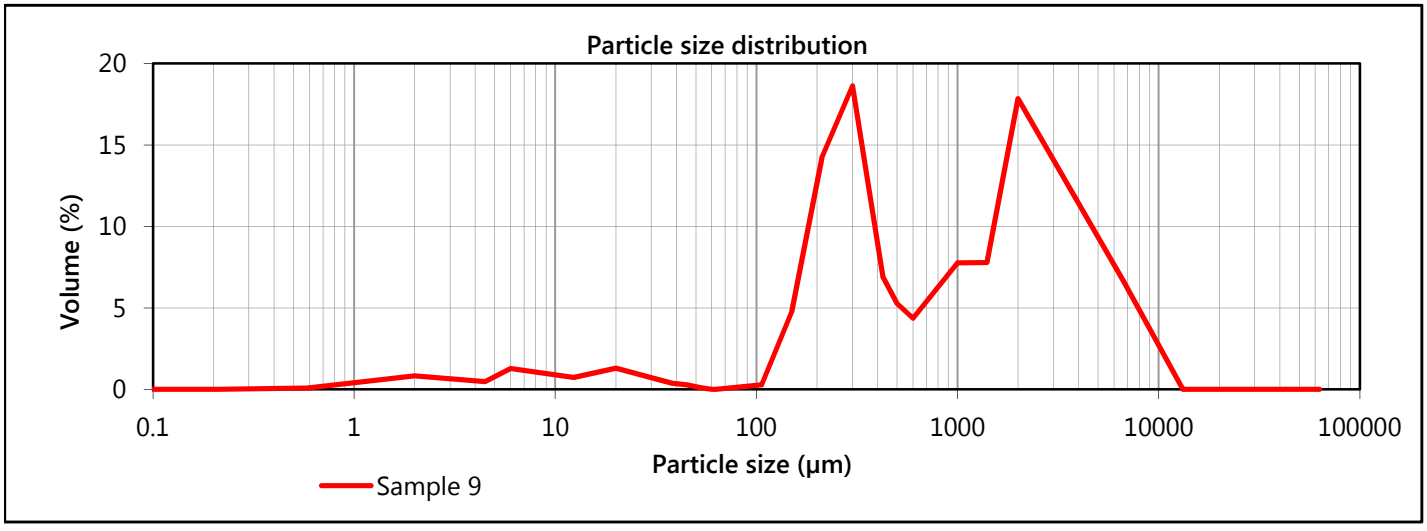
d(0.1):	204.8	µm	**d(0.5):**	**496.2**	**µm**	d(0.9):	5810.9	µm

Cumulative Frequency Plot



Clay (%)	Silt (%)			Sand (%)			Gravel (%)			Cobble (%)
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
0.1	1.3	2.0	2.1	5.0	45.1	19.9	17.8	6.6	0.0	0.0

Frequency Curve



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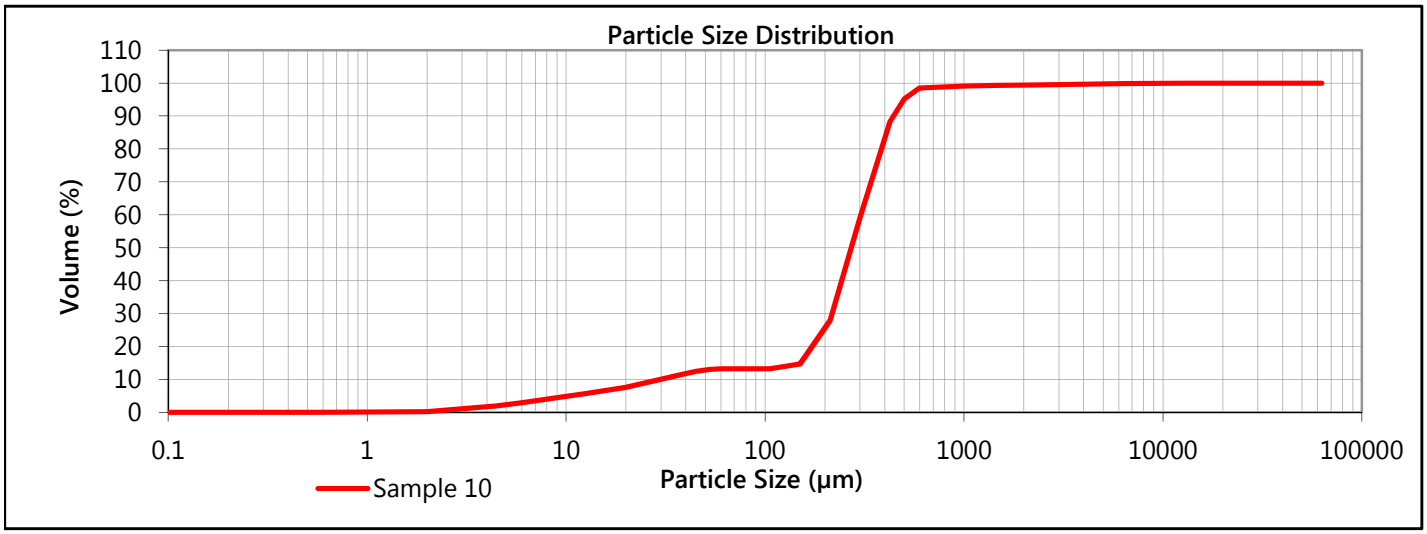
Particle Size Analysis Report

Sample Name:	Sample 10	**Measured by:**	IDavidson
Sample Source:	Mostyn Deep		
Sample Collected:	Jan 2019		

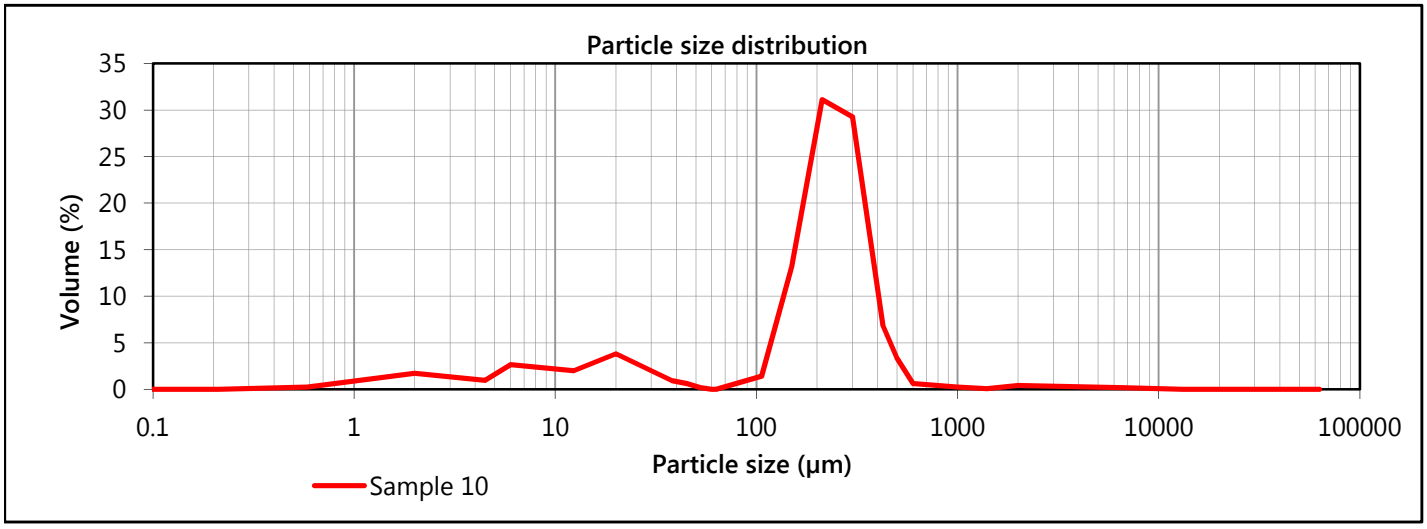
d(0.1):	31.0	µm	**d(0.5):**	**274.6**	**µm**	d(0.9):	444.1	µm

Cumulative Frequency Plot



Clay (%)	Silt (%)			Sand (%)			Gravel (%)			Cobble (%)
	Fine	Medium	Coarse	Fine	Medium	Coarse	Fine	Medium	Coarse	
0.3	2.7	4.7	5.6	14.6	70.6	1.0	0.4	0.2	0.0	0.0

Frequency Curve



Appendix B- Additional grain size parameters

Site Number	D_{15} (µm)	D_{85} (µm)
1	188	393
2	20	17743
3	206	14308
4	254	644
5	22	5300
6	9777	25429
7	152	401
8	412	22332
9	239	4493
10	151	411

E NRW Cockle Stocks Completed in Spring 2018 (LA4)

An Assessment of the Current Status of the Dee Estuary Cockle Stocks Spring 2018

Methodology

The methodology of the cockle survey is explained in detail by West & McGrorty (2003).

In brief, using GIS, the probable extent of the cockle beds were mapped out using last year's survey results and a walkover survey carried out in March/ April 2018. The perimeter of Caldy, West Kirby, Talacre, Mostyn, Thurstaston, Number 3 Buoy, Salisbury, Salisbury middle and Mostyn Deep (also known as the secret garden) were mapped out. A grid of sample stations was then placed over each bed using GIS, and each survey point was given a unique code and the associated NGR readings were uploaded into handheld GPS's.

Between 200 and 400, 0.1m^2 samples were decided upon, as this seemed reasonable in terms of the resources available, but would also give a fairly high degree of confidence in the mean densities obtained (West & McGrorthy,2003). In 2018, a total of 296 points were plotted to be surveyed and the distance between the points were150m apart. Any points on the edge of the bed without cockle or spat present were deleted and the bed area re-calculated.

Two or three teams surveyed the beds between March 12th and April 24th 2018. The teams worked on an ebbing tide and used a Hovercraft or boat to reach the beds, which then stayed near the teams as a safety precaution. The walkover surveys that were planned at the end of February/ beginning of March had to be postponed due to heavy snowfall across much of the country. As a result of this, walkovers and surveys had to be carried out on the same day for some of the smaller beds of Salisbury and Mostyn Deep. No survey was carried out on Salisbury Middle this year due to a lack of cockle being found during the walkover.

The GPS's were used to navigate to the sample stations, where a 0.1m^2 quadrant was dug out to approximately 5cm deep and sieved through a 20 mm riddle. A GPS reading was taken at each station to plot the actual position in the field. A quantitative assessment of the abundance of cockles that were retained (>20mm) or passed through(<20mm) the 20 mm riddle was then made and recorded.

A sub sample of cockles at each station were collected and then measured and weighed in the laboratory to calculate the mean weight of each size class and to produce histograms of the cockles from each bed.

DEE ESTUARY COCKLE STOCK – BIOMASS CALCULATIONS FROM SPRING 2018 COCKLE SURVEY RESULTS

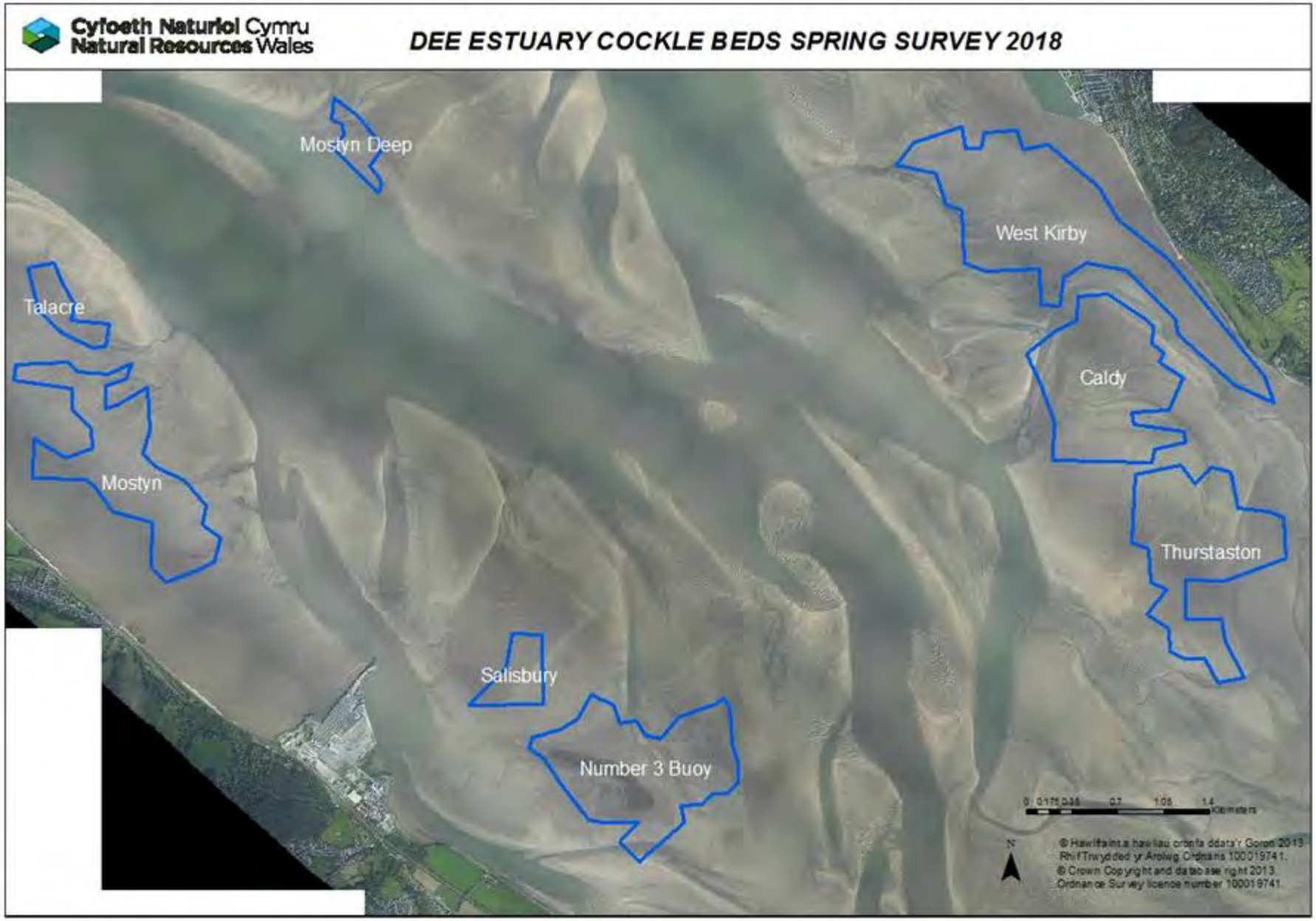
Table 1: Estimated mean cockle densities and biomass from each survey area.

For display purposes figures have been rounded up, but calculations have been carried out with the full decimal number.

2018 Size Group	Parameter	No3 Buoy &South Salisbury	Caldy	Thurstaston	West Kirby	Mostyn	Talacre	Salisbury	Mostyn Deep (aka Secret Garden)
	Area m^2	1089866	1029184	1005282	1625324	942521	160990	185223	127345
	Date Surveyed	10/04/18	27/03/2018	11/04/18	28/03/18	24/04/18	24/04/18	12/03/18	16/04/18
Cockles >20mm	Average Weight (g)	10.3	9.8	5.5	8.7	4.6	6.4	6.4	15.7
	Mean Cockle/ m^2	40.2	90.6	18.7	83.2	10	11.7	6.4	52.9
	Upper CI Mean Cockle/ m2	54.2	120.3	24.5	105.5	15.1	24.5	10.3	92.2
	Lower CI Mean Cockle/ m2	26.2	61	12.9	60.9	4.9	0	2.4	13.5
	Biomass of Cockles >20mm(tonnes)	449.3	912.3	103.6	1176	43.1	12.1	7.5	105.5
	Total Biomass of Cockles >20mm (tonnes)	**2809.4 tonnes**							
Cockles <20mm	Average Weight (g)	2.7	2.2	1.9	2.7	2.6	2.7	1.7	none
	Mean Cockle/ m^2	114.8	138.9	66.7	106.2	79.5	68.3	11.8	
	Upper CI Mean Cockle/ m2	173.6	215.9	102.8	139.3	157.2	124.8	17.6	
	Lower CI Mean Cockle/ m2	56	62	30.7	73.1	1.8	11.9	6	
	Biomass of Cockles <20mm(tonnes)	332.8	307.4	127.5	458.9	193.4	29.6	3.7	
	Total Biomass of Cockles <20mm (tonnes)	**1453.3 tonnes**							

Cockles > 20mm – Cockles retained by a 20mm riddle and large enough to be fished

Cockle <20mm- Cockles that pass through a 20mm riddle and are too small to be take-able


Cyfoeth Naturiol Cymru
Natural Resources Wales
DEE ESTUARY COCKLE BEDS SPRING SURVEY 2018
Mostyn Deep
West Kirby
Talacre
Caldy
Mostyn
Thurstaston
Salisbury
Number 3 Buoy
N
Kilometers
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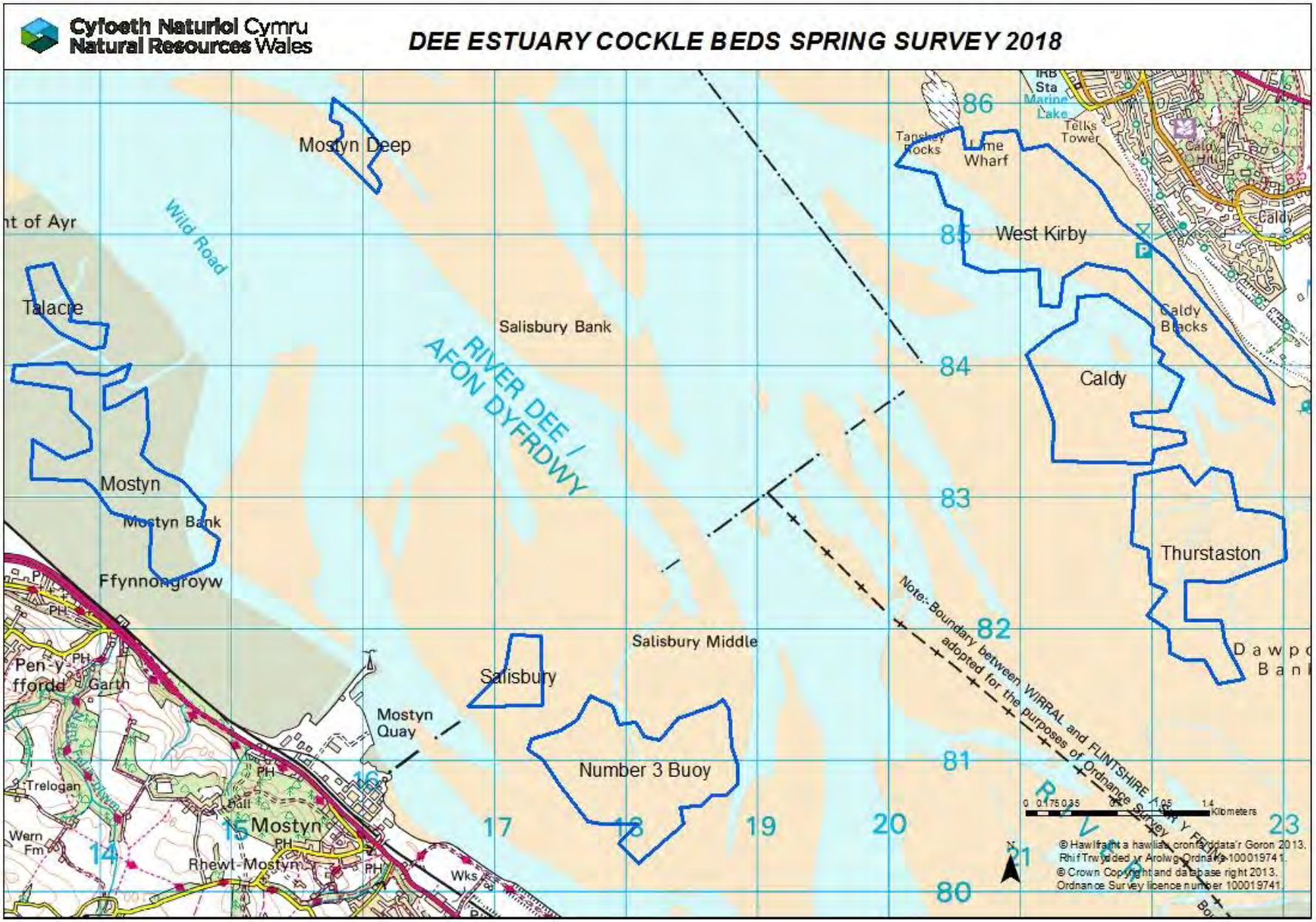
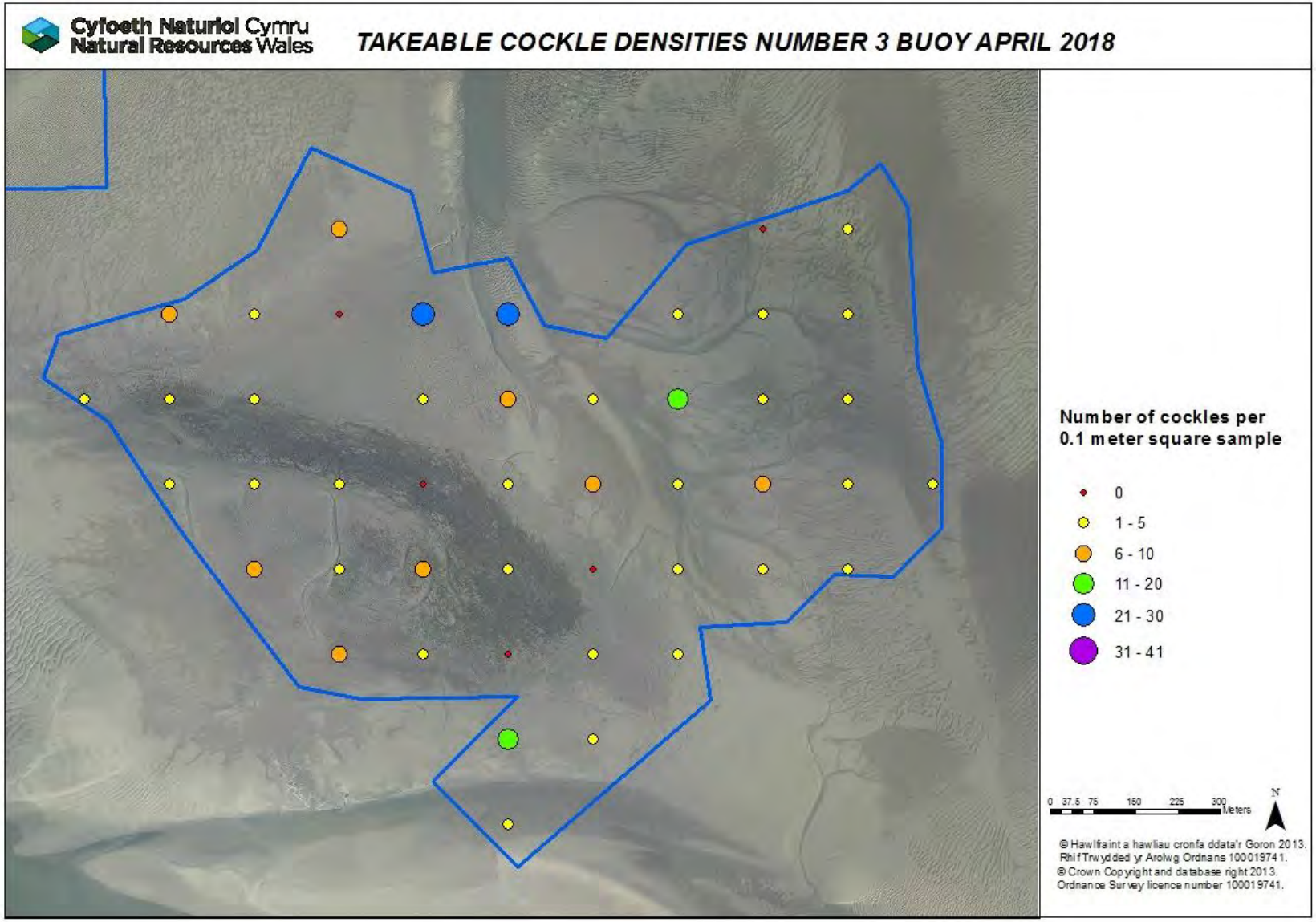
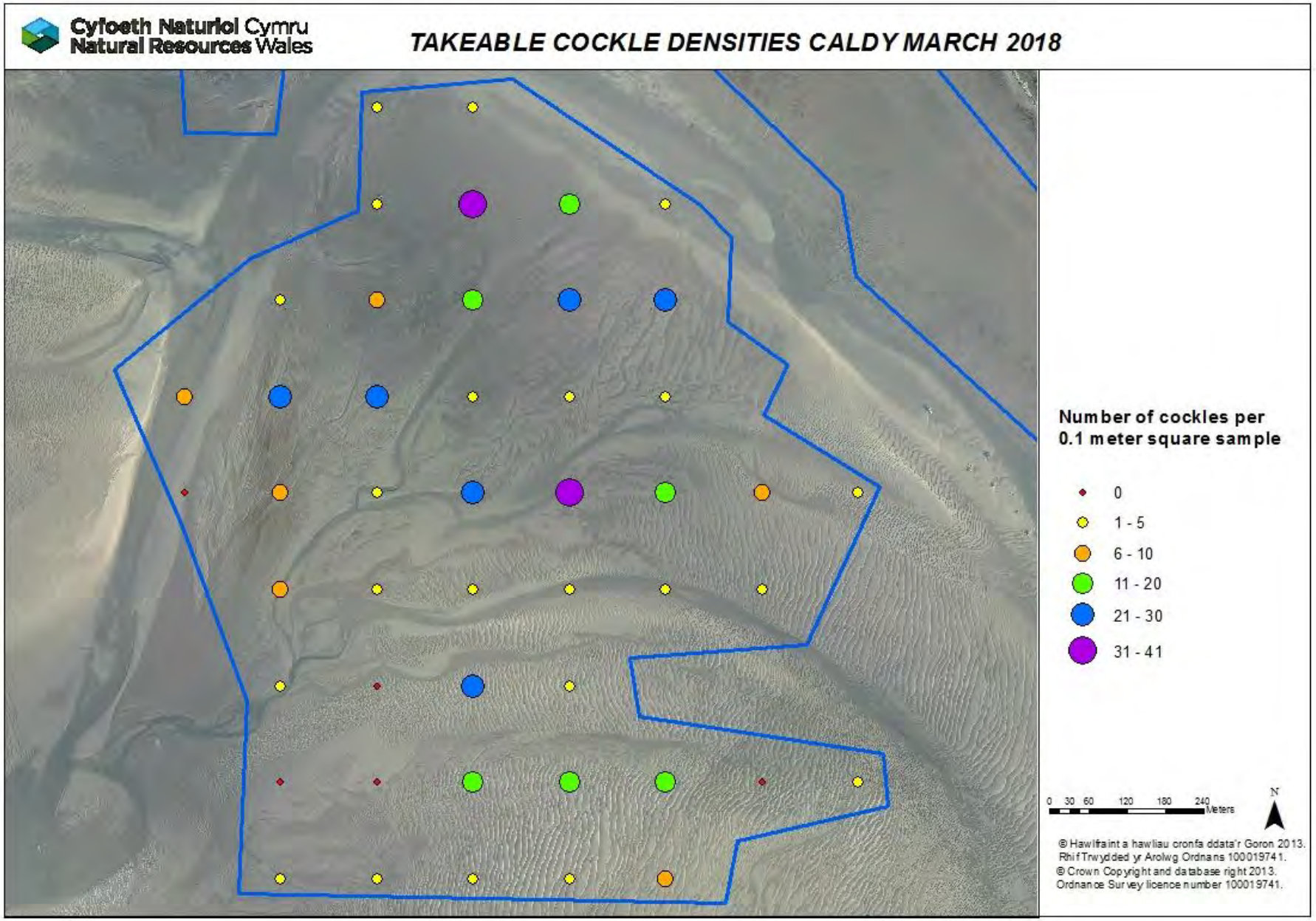


timothy_ellis_cyfoethnaturiolcymru_gov_uk/Documents/2. Cockles/2.7 biomass surveys/cocklememoapril2018.docx

Takeable (retained by 20mm riddle) Cockle densities from each bed surveyed in Spring 2018.



timothy_ellis_cyfoethnaturiolcymru_gov_uk/Documents/2. Cockles/2.7 biomass surveys/cocklememoapril2018.docx



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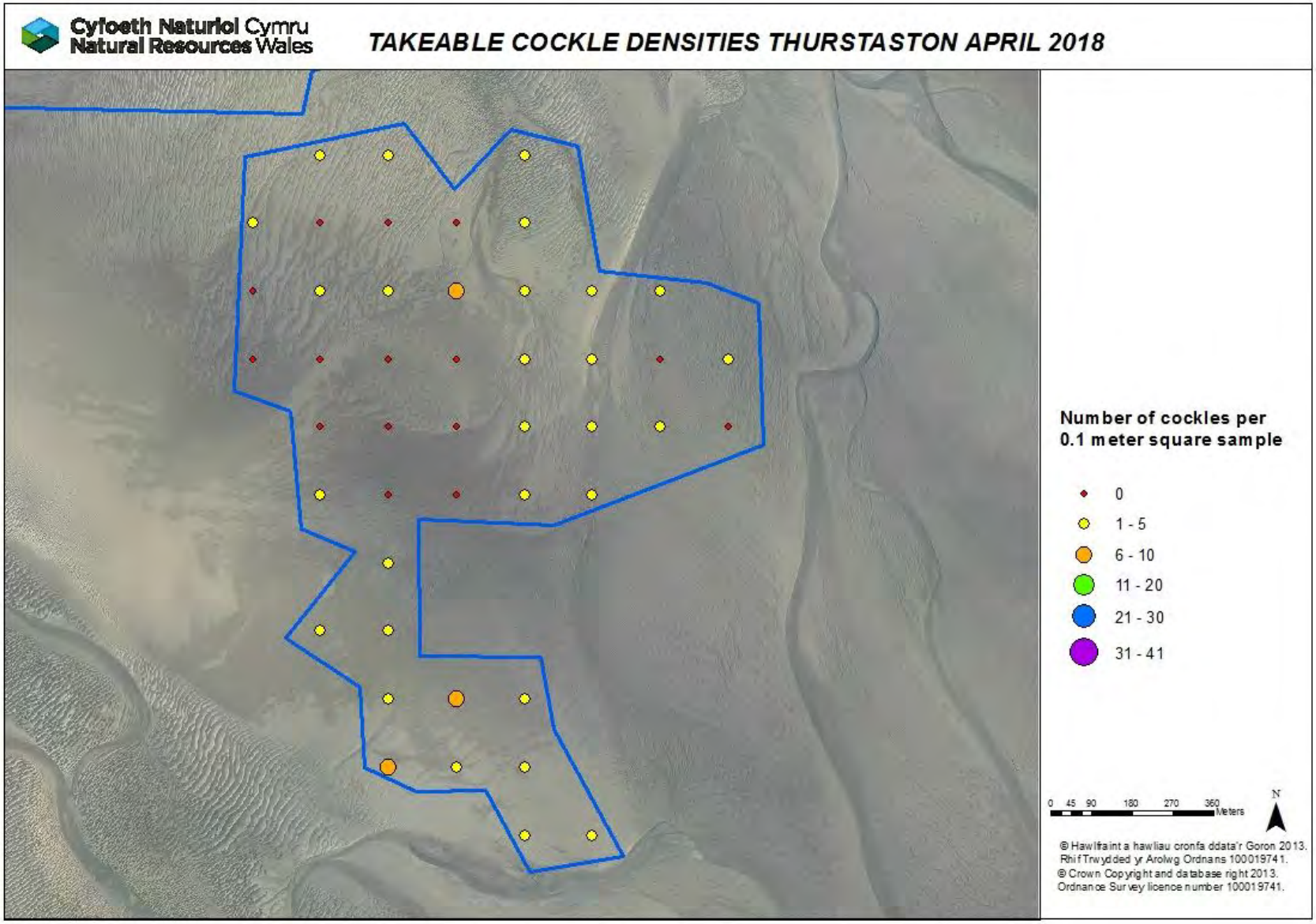

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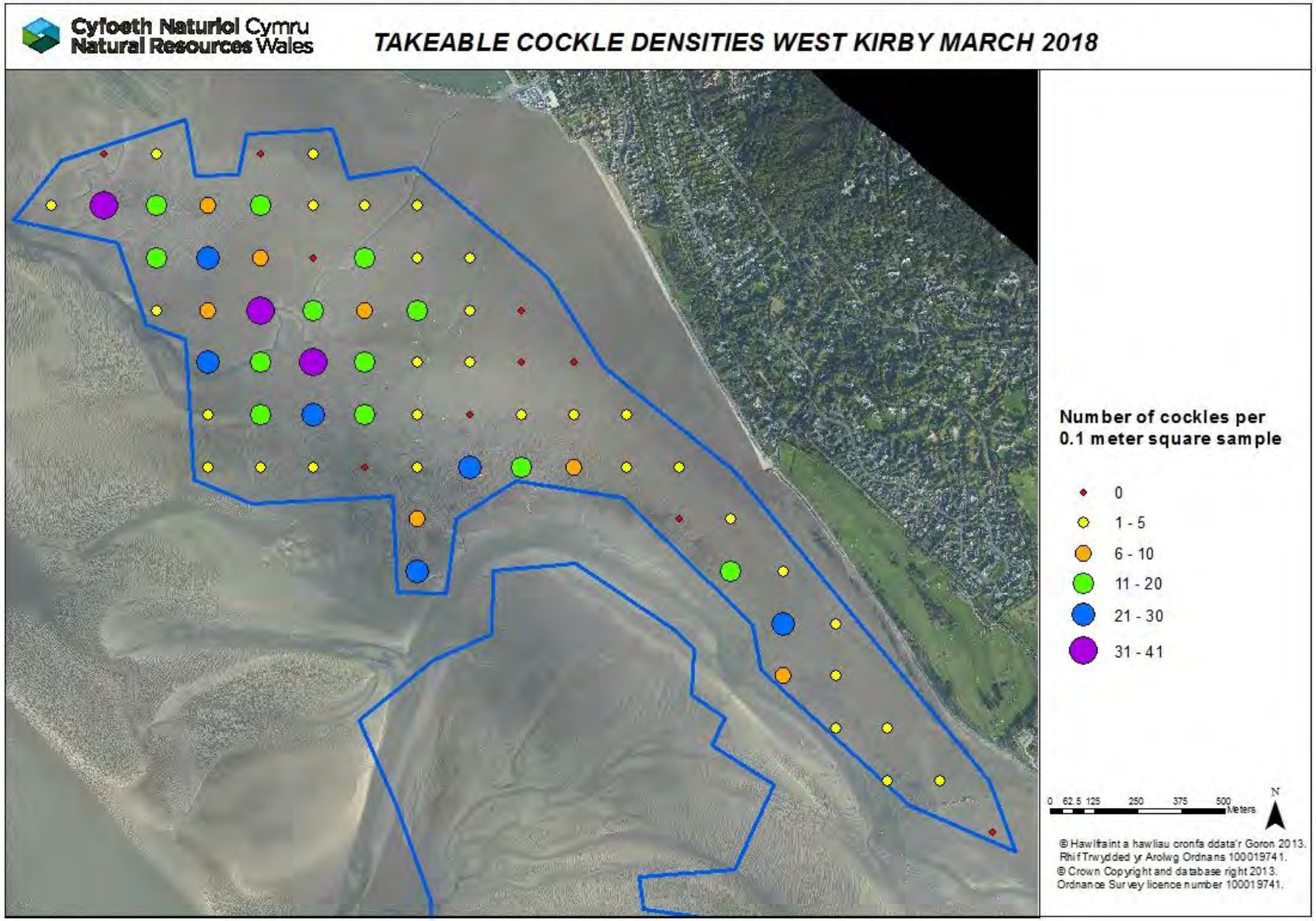

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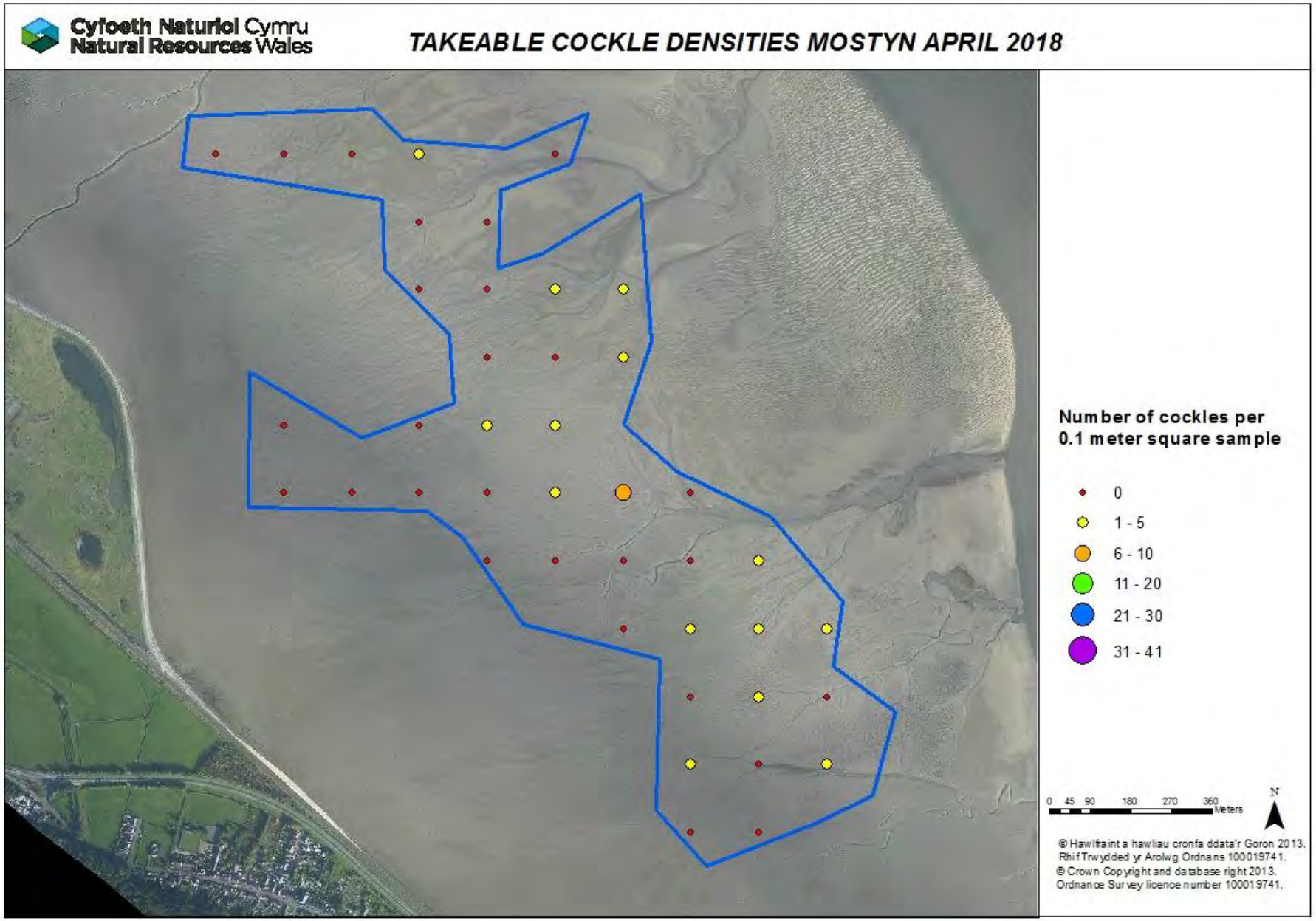

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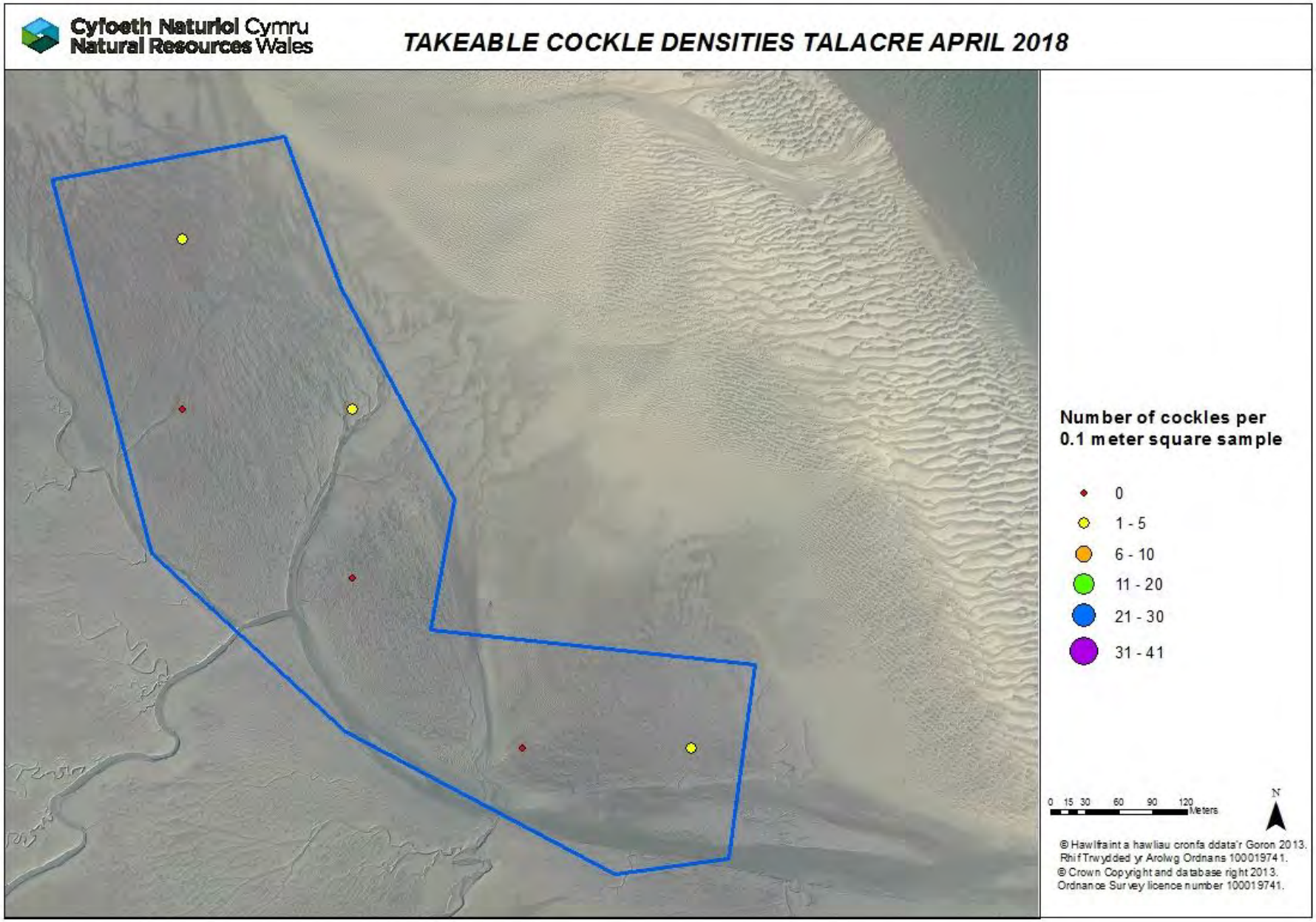
Cyfoeth Naturiol Cymru
Natural Resources Wales
TAKEABLE COCKLE DENSITIES TALACRE APRIL 2018
Number of cockles per
0.1 meter square sample
0
1 - 5
6 - 10
11 - 20
21 - 30
31 - 41
0 15 30 60 90 120
Meters
N
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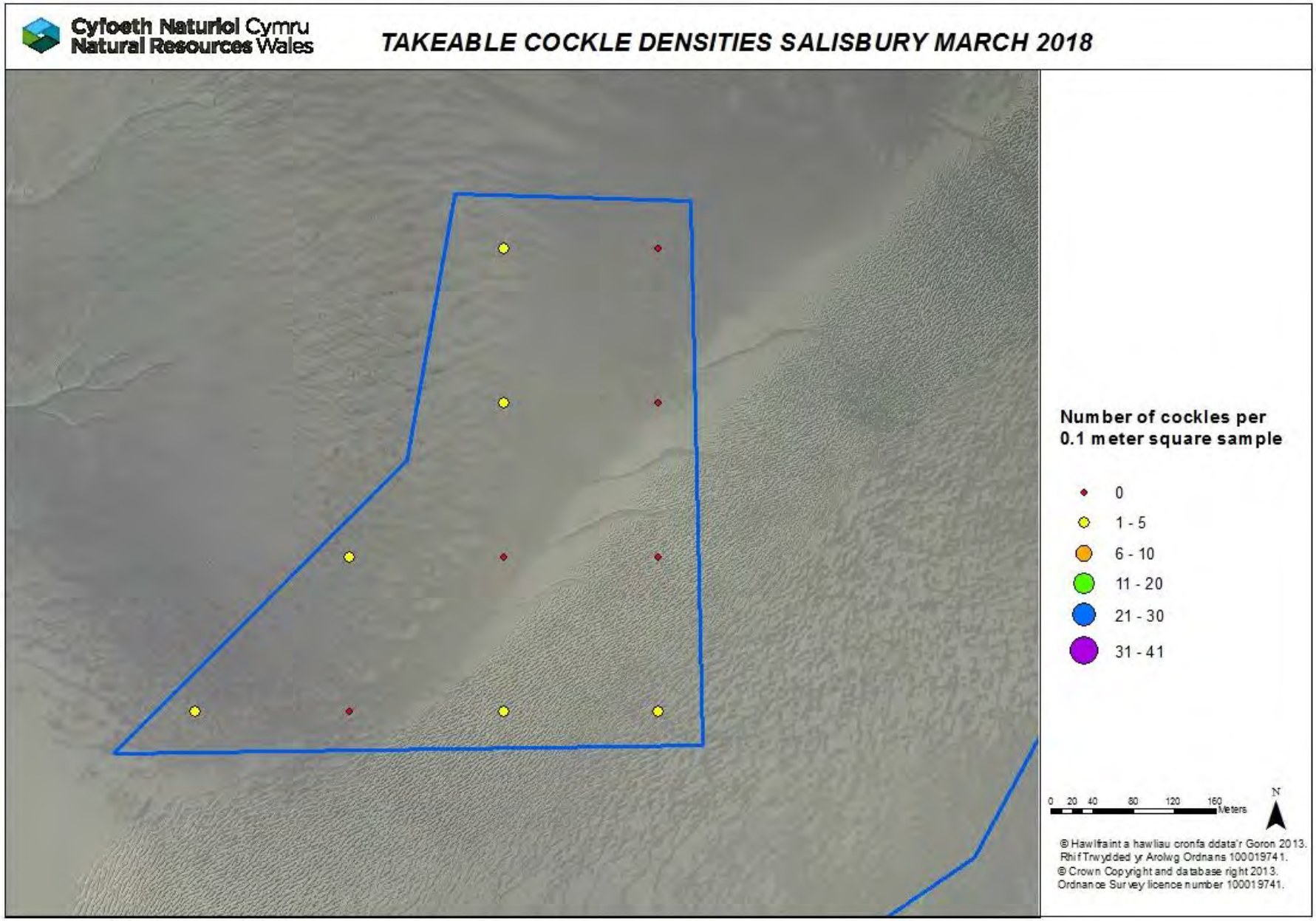
Cyfoeth Naturiol Cymru
Natural Resources Wales
TAKEABLE COCKLE DENSITIES SALISBURY MARCH 2018
Number of cockles per
0.1 meter square sample
0
1 - 5
6 - 10
11 - 20
21 - 30
31 - 41
0 20 40 80 120 160
Meters
N
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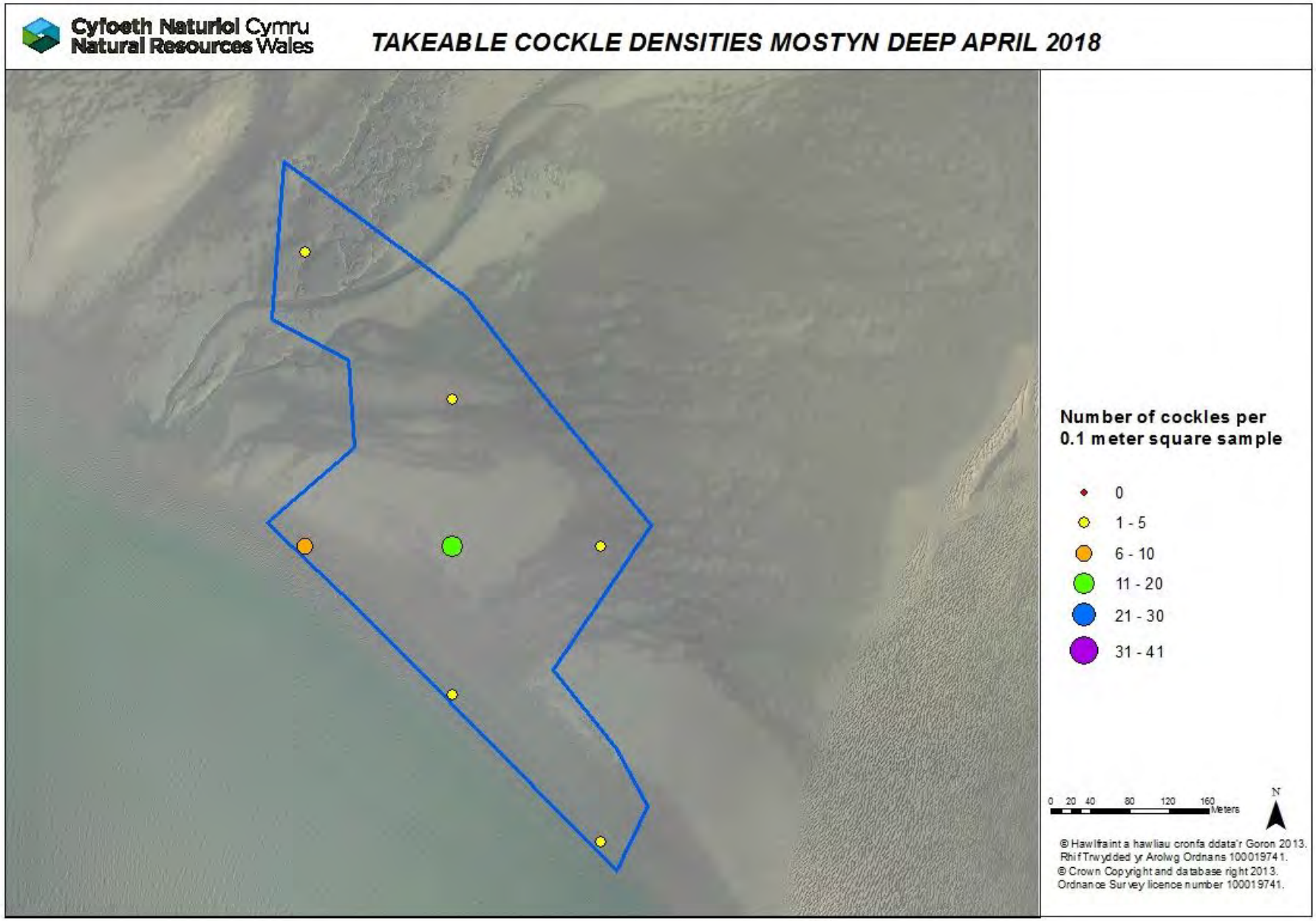
Cyfoeth Naturiol Cymru
Natural Resources Wales
TAKEABLE COCKLE DENSITIES MOSTYN DEEP APRIL 2018
Number of cockles per
0.1 meter square sample
0
1 - 5
6 - 10
11 - 20
21 - 30
31 - 41
0 20 40 80 120 160
Meters
N
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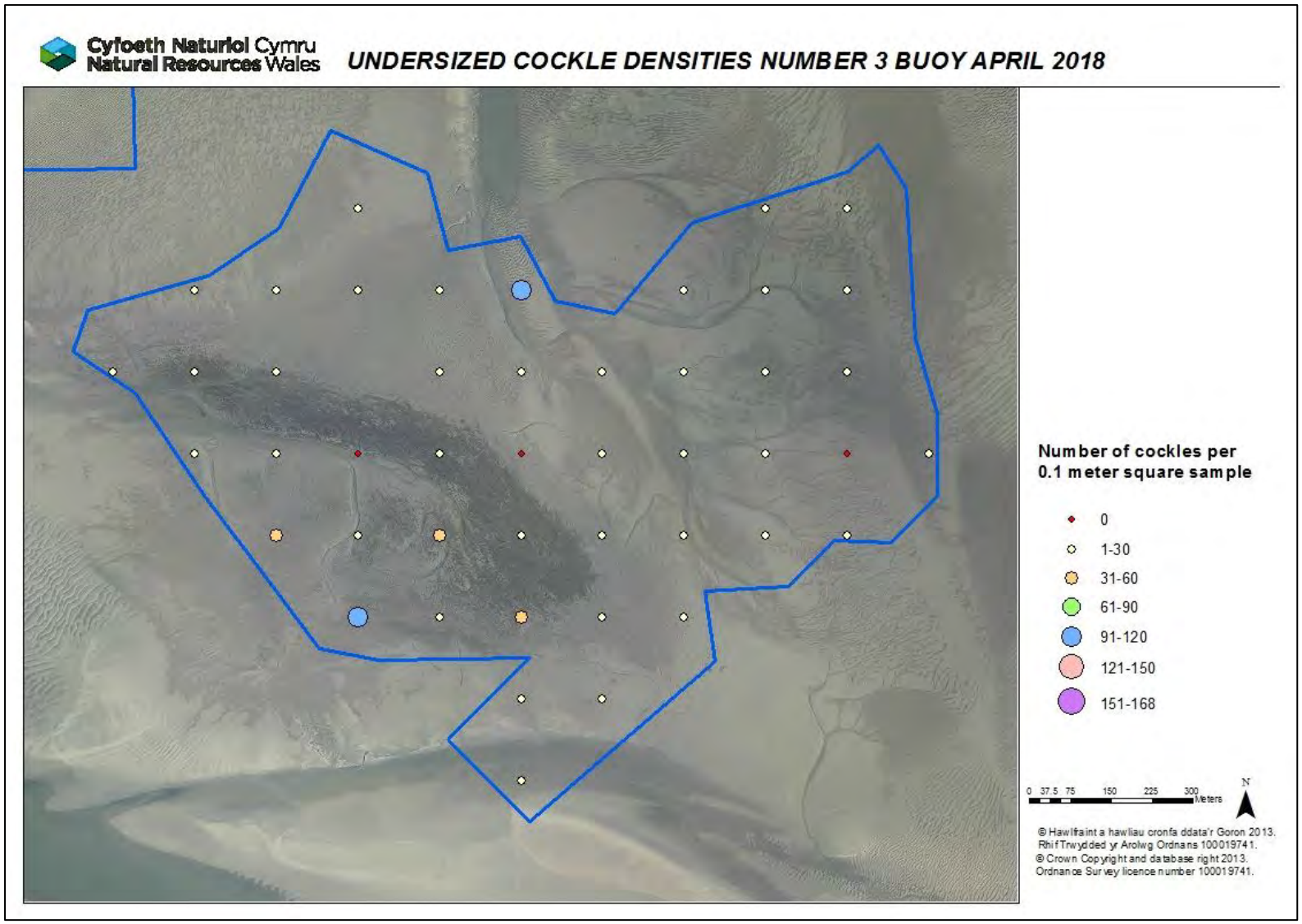
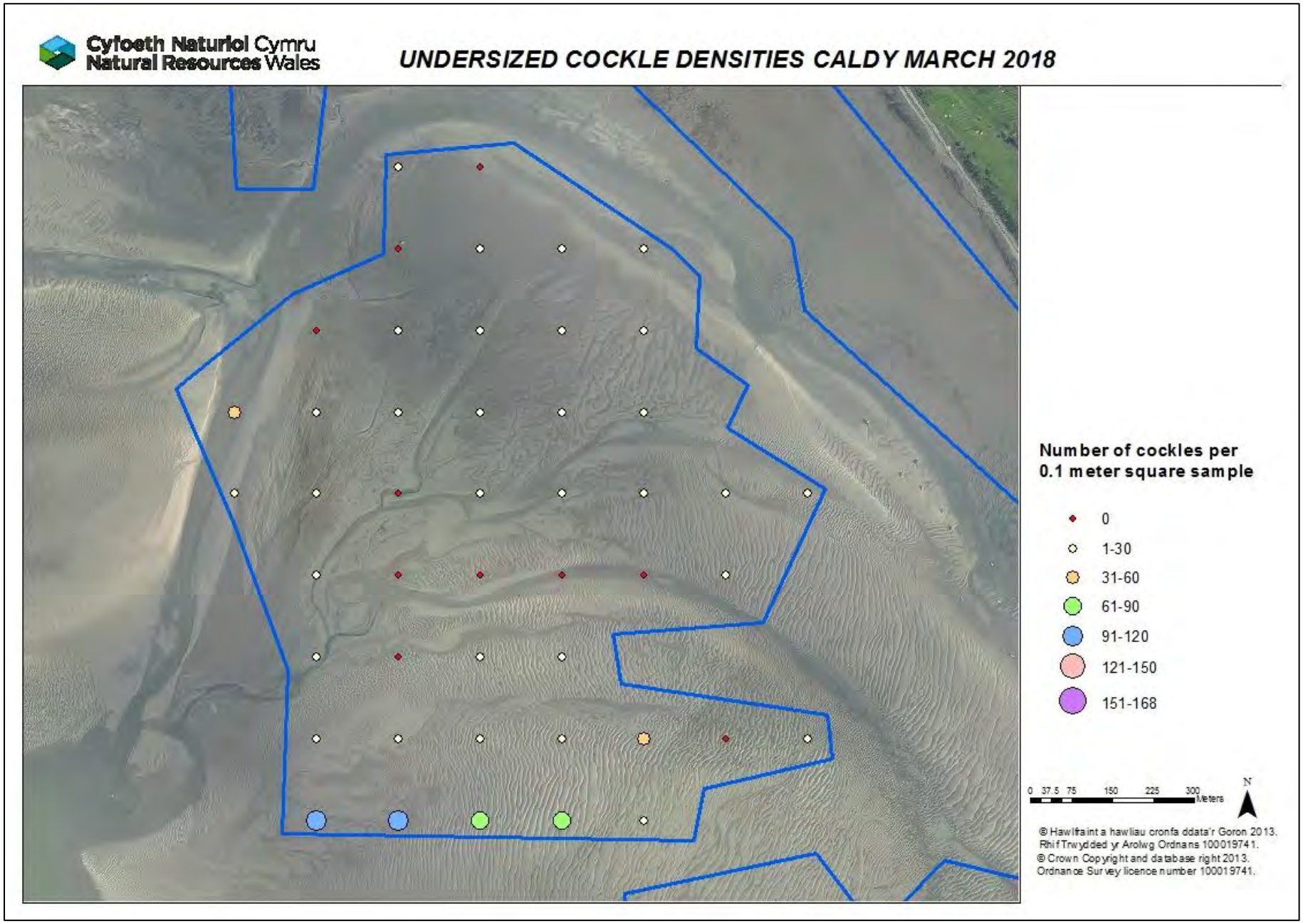
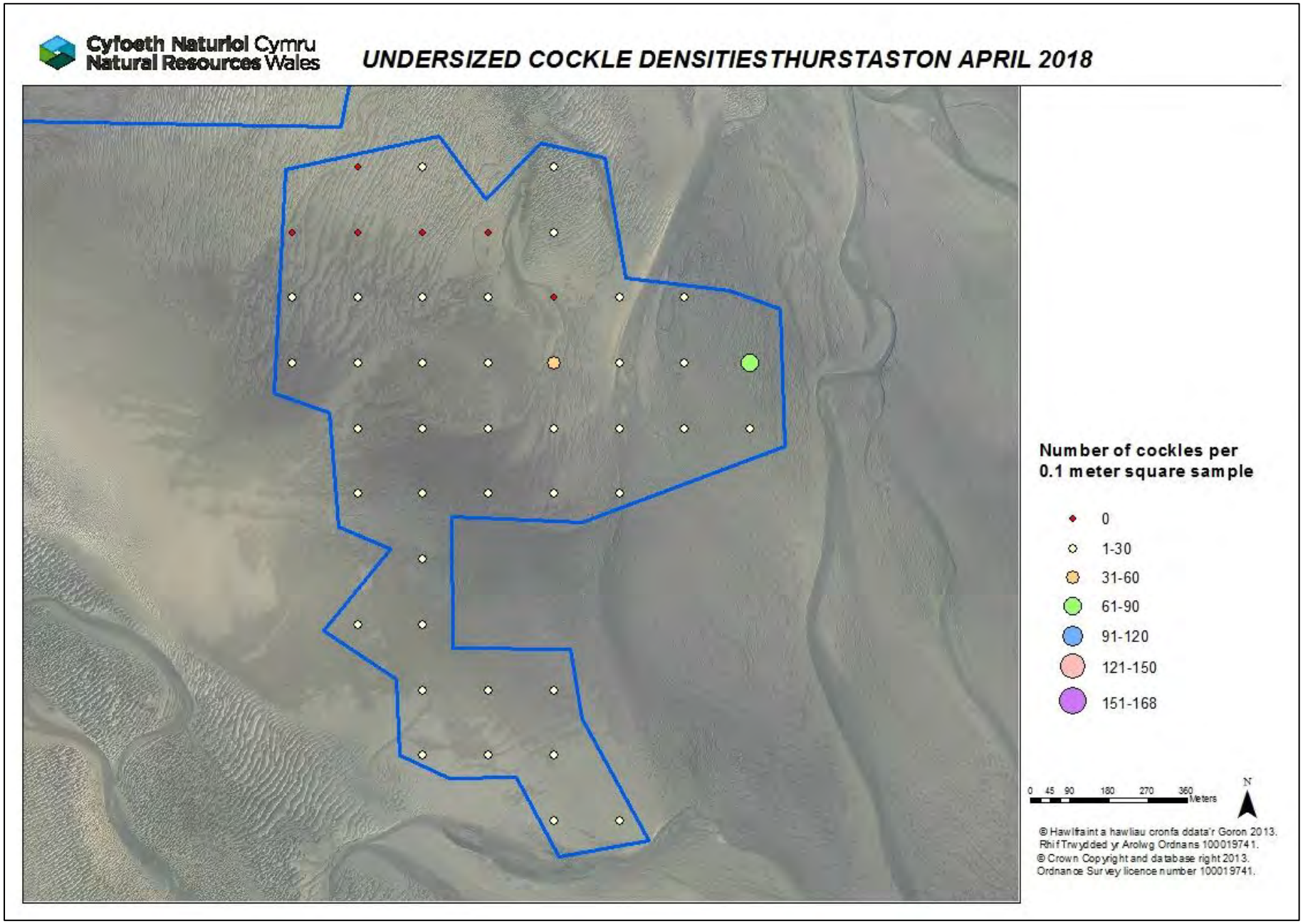
Undersize (pass through a 20mm riddle) Cockle densities from each bed surveyed in Spring 2018





timothy_ellis_cyfoethnaturiolcymru_gov_uk/Documents/2. Cockles/2.7 biomass surveys/cocklememoapril2018.docx


Cyfoeth Naturiol Cymru
Natural Resources Wales
UNDERSIZED COCKLE DENSITIES THURSTASTON APRIL 2018
Number of cockles per
0.1 meter square sample
0
1-30
31-60
61-90
91-120
121-150
151-168
0 45 90 180 270 360
Meters
N
© Hawlfraint a hawliau cronfa ddata'r Goron 2013.
Rhif Trwydded yr Arolwg Ordnans 100019741.
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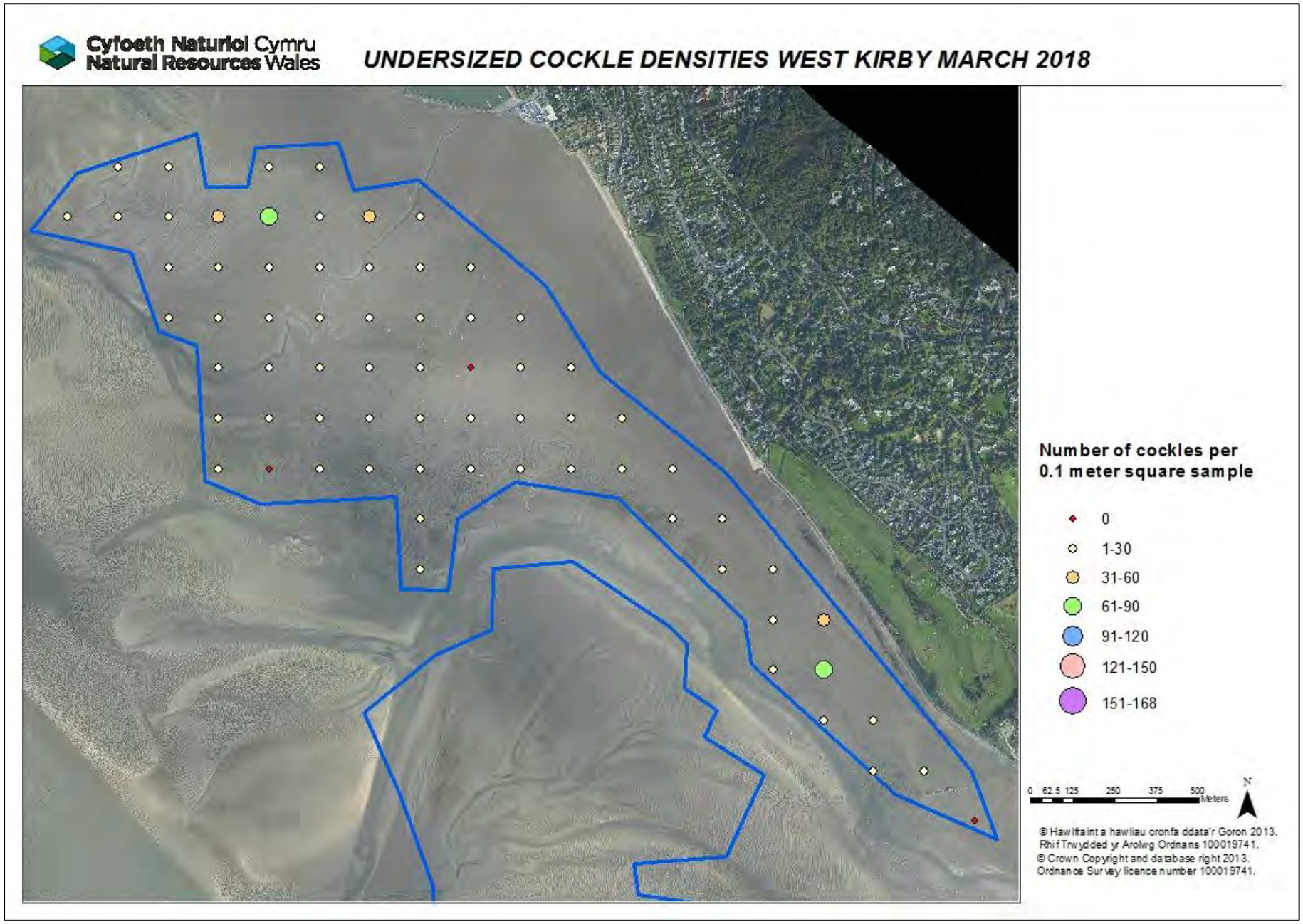

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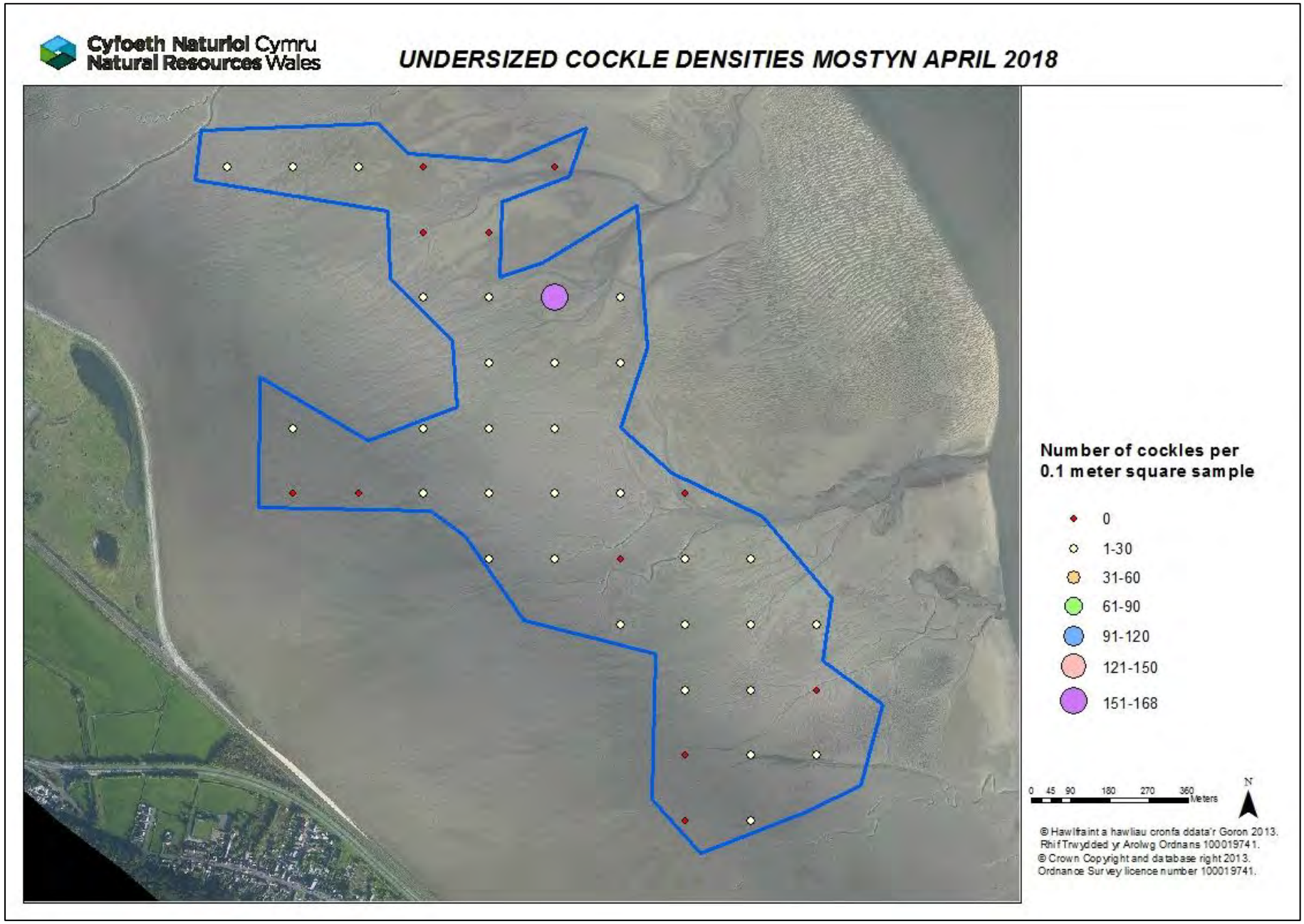


timothy_ellis_cyfoethnaturiolcymru_gov_uk/Documents/2. Cockles/2.7 biomass surveys/cocklememoapril2018.docx

Cyfoeth Naturiol Cymru
Natural Resources Wales

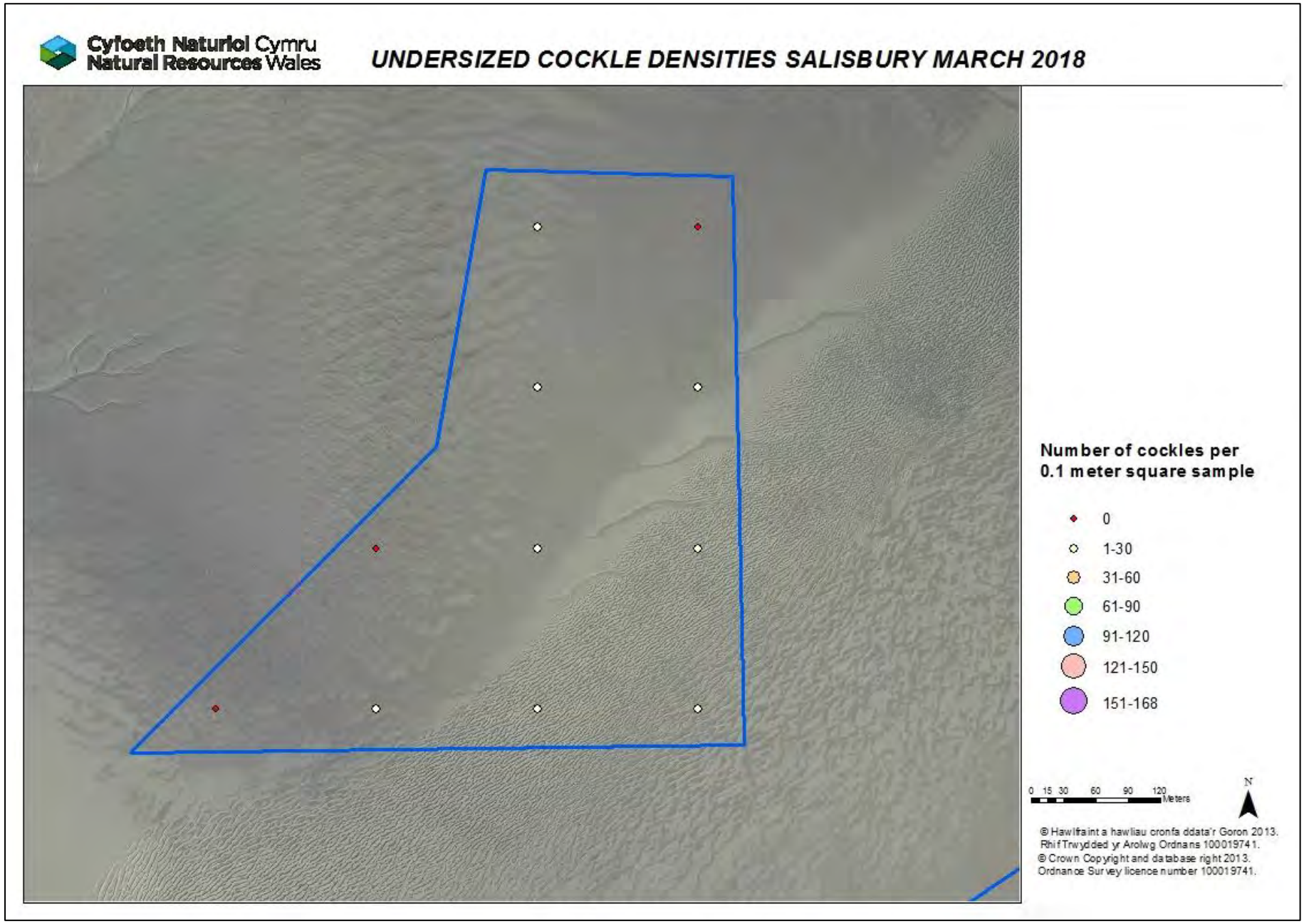
UNDERSIZED COCKLE DENSITIES TALACRE APRIL 2018

Number of cockles per 0.1 meter square sample

- 0
- 1-30
- 31-60
- 61-90
- 91-120
- 121-150
- 151-168

0 20 40 80 120 160 Meters

N



timothy_ellis_cyfoethnaturiolcymru_gov_uk/Documents/2. Cockles/2.7 biomass surveys/cocklememoapril2018.docx

Cyfoeth Naturiol Cymru
Natural Resources Wales

UNDERSIZED COCKLE DENSITIES MOSTYN DEEP APRIL 2018

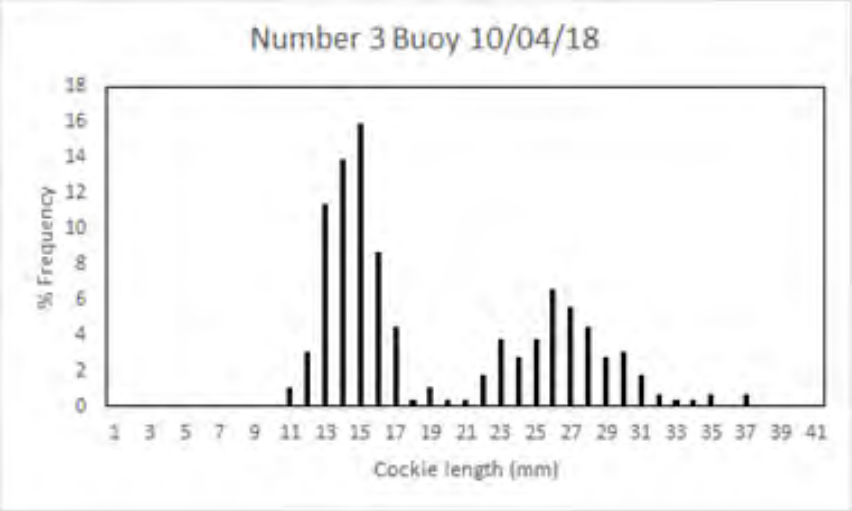
Number of cockles per 0.1 meter square sample

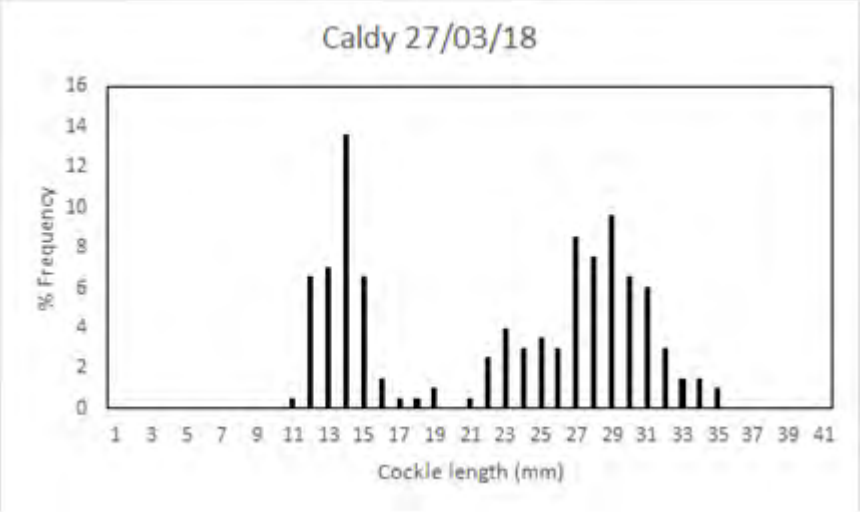
- 0
- 1-30
- 31-60
- 61-90
- 91-120
- 121-150
- 151-168

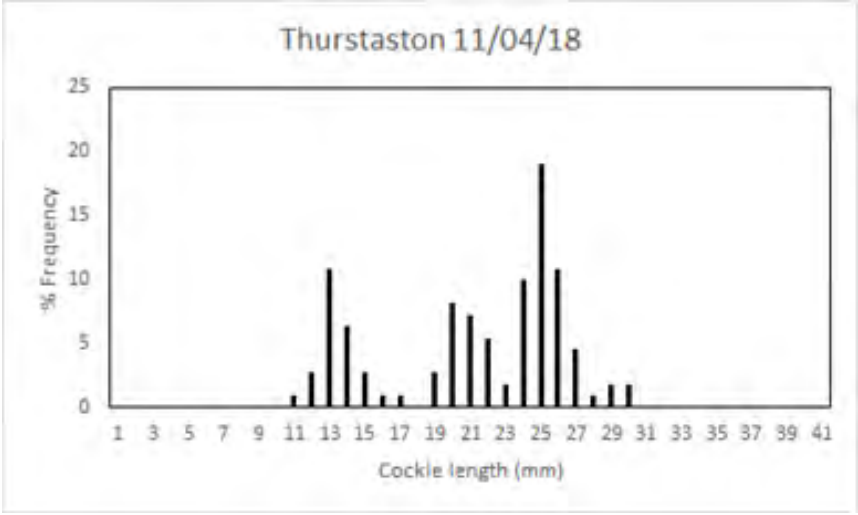
0 20 40 80 120 160 Meters

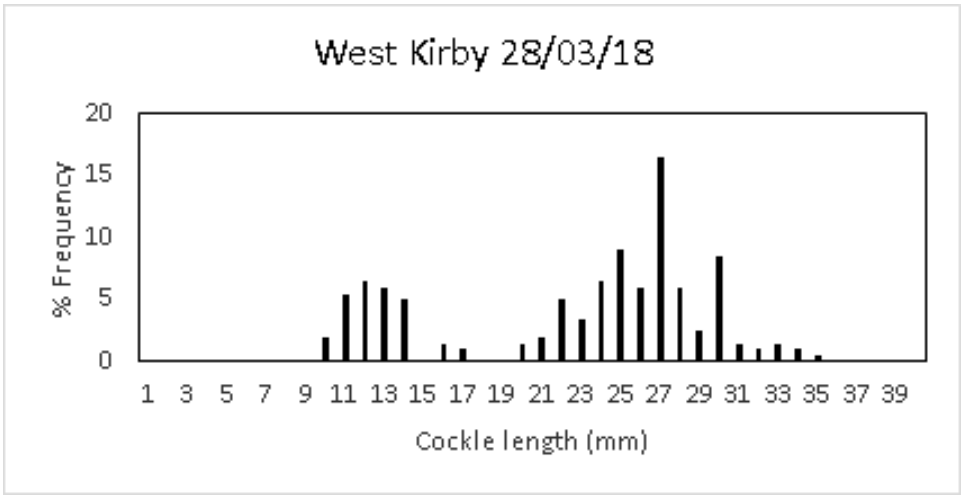
N

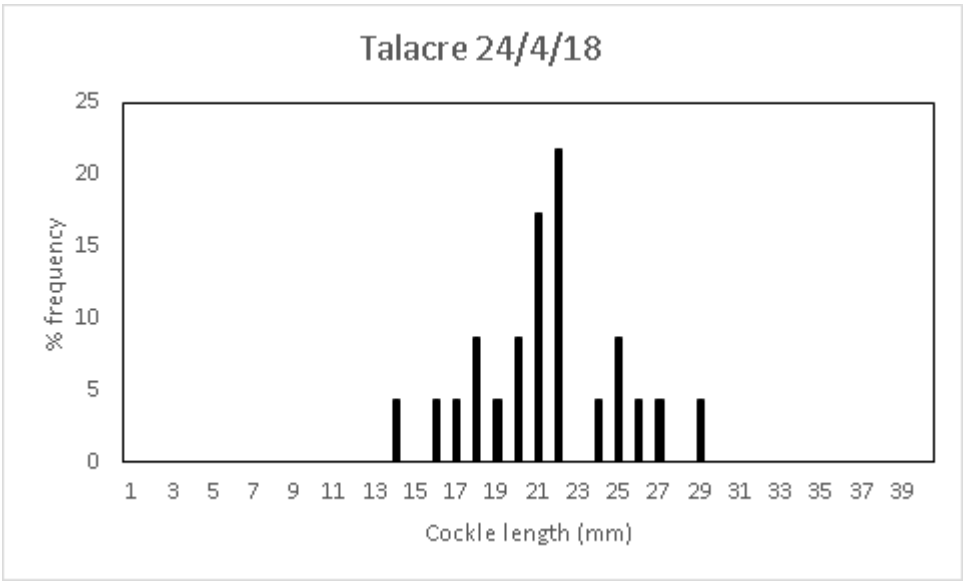
Histograms of each bed showing the size distribution of cockle in subsample

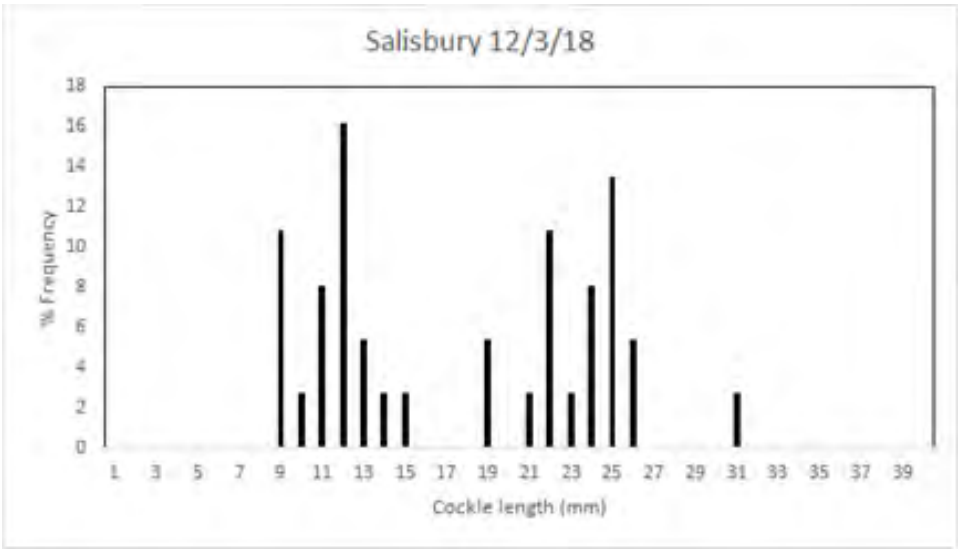


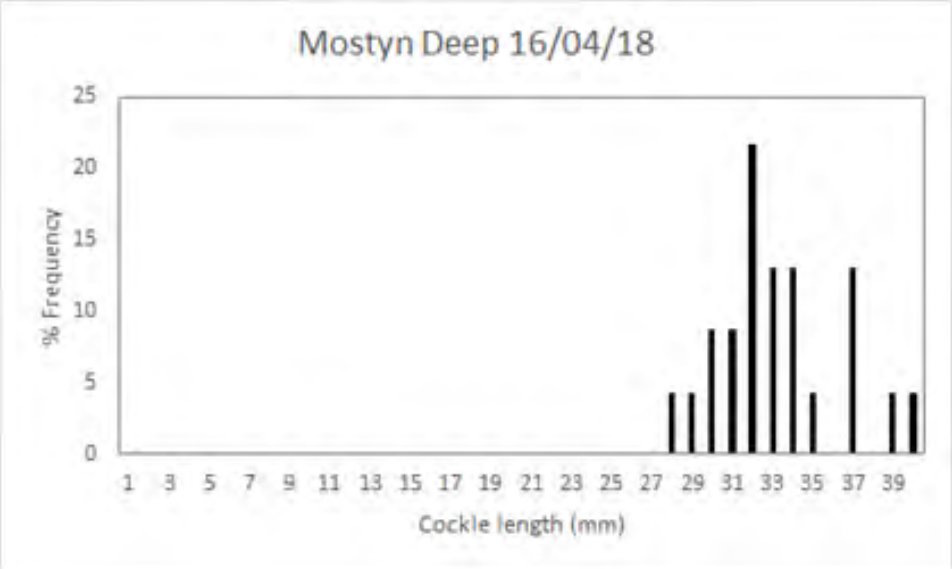





West Kirby 28/03/18
% Frequency
0
5
10
15
20
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
Cockle length (mm)


Talacre 24/4/18
% frequency
0
5
10
15
20
25
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
Cockle length (mm)


Salisbury 12/3/18
% Frequency
0
2
4
6
8
10
12
14
16
18
1 3 5 7 9 11 13 15 17 19 21 23 25 27 29 31 33 35 37 39
Cockle length (mm)



References

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