Port of Brisbane Dredge Plume Monitoring Program 2020 – Final Report

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Synopsis: **This report describes a monitoring program that examines the behaviour of turbid plumes generated by dredge material loading and disposal by the TSHD Brisbane in the Port of Brisbane in February 2020.**

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Executive Summary

Background

The Port of Brisbane Pty Ltd (PBPL) conducts capital and maintenance dredging campaigns within the Brisbane Port limits. Dredging and disposal activities create plumes of suspended sediment, hereafter referred to as dredge plumes. PBPL has developed the Dredge Plume Monitoring Program (DPMP) to investigate the spatial and temporal patterns and behaviour of dredge plumes. The PMP provides a basis for understanding the potential for dredge plumes to reach nearby sensitive environmental receptors, such as seagrass meadows and reefs.

This report describes the methodology and findings of the PMP for maintenance dredging undertaken by the trailing suction hopper dredge (TSHD) *Brisbane* during February 2020. Monitoring was undertaken at two locations:

- The subject dredge site – located in the Hamilton reach of the lower Brisbane River (North Bank and South Bank)
- The ocean disposal site – located at Mud Island dredge material placement area (DMPA).

Monitoring methods consisted of:

- An acoustic Doppler current profiler (ADCP) was used to measure acoustic backscatter through the water column along transects intersecting the dredge plumes. The strength of the backscatter signal provides an uncalibrated measurement of suspended sediment concentrations in two dimensions
- Measurement of turbidity through the water column on ADCP transects using an optical backscatter turbidity sensor
- Collection of water samples for the analysis of total suspended sediment concentrations (TSS) and particle size distribution (PSD) of suspended sediments.

Regression analysis was undertaken to quantify the relationship between the acoustics backscatter signal, TSS and turbidity. This enabled the backscatter signal measured by the ADCP to be converted to TSS and turbidity, enabling two dimensional measurements of TSS concentrations.

Findings

Dredging created larger plumes (i.e. spatial extent, intensity, duration) than dredged material disposal. Once the dredger began overflowing, dredge plumes were typically <100 metres wide and had TSS concentrations typically between 100–200 mg/L. The maximum recorded TSS concentration in dredge plumes was 375 mg/L. Dredge plumes were detected for approximately one hour and travelled approximately one kilometre from the dredging site before reaching ambient levels. At the Hamilton Reach (North Bank) dredge site, the dredge plume was indistinguishable from background, whereas the Hamilton Reach (South Bank) dredge site had a near-bed sediment plume. However, the near-bed sediment plume at the Hamilton Reach (South Bank) was determined to be likely due to ambient materials and tidal conditions, rather than due to dredging. These characteristics are consistent with previous studies. Based on the observations, dredge plumes from operations in the Hamilton Reach did not extend to sensitive ecological receptor sites in Moreton Bay.

For disposal operations at the Mud Island DMPA, measurements approximately 10 minutes after bottom dumping indicate the initial plume covered an area of approximately 100 m x 100 m with concentrations of 50-200 mg/L. The maximum recorded concentration in the initial plume was 245 mg/L. This is consistent with previous monitoring campaigns. Due to the advection, dispersion and settlement of the plumes, within an hour, plumes typically had low concentrations (10-20 mg/L) and had travelled approximately 0.5-1 km from the placement location. Soon after, the dredge plume was indiscernible from background readings. This is consistent with the 2014 and 2017 campaigns. As such, it is likely the plume was contained entirely within the bounds of the DMPA and did not approach sensitive receptor sites in Moreton Bay.

Glossary and Abbreviations

Abbreviation	Definition
ADCP	Acoustic Doppler Current Profiler
DMPA	Dredge Material Placement Area
FPE	Future Port Expansion
NTU	Nephelometric Turbidity Units
OBS	Optical Backscatter
PBPL	Port of Brisbane Pty Ltd
PSD	Particle Size Distribution
TSHD	Trailing arm suction hopper dredge
TSS	Total Suspended Solids

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1 Introduction

1.1 Background

The Port of Brisbane Pty Ltd (PBPL) is responsible for the maintenance of 90 km of navigational shipping channel stretching from the northern tip of Bribie Island, across Moreton Bay, and into the Brisbane River. Maintenance dredging between Fisherman Islands and the Hamilton Reach of the Brisbane River is also undertaken to enable safe passage of vessels visiting berths upstream. All dredging is conducted within approved navigation channels, berths and swing basins. The resultant dredged material is either placed within the Port of Brisbane Future Port Expansion (FPE) reclamation area or at the Mud Island Dredge Material Placement Area (DMPA), subject to specific approval. Refer to Figure 1-1 for a locality plan.

The creation of turbid plumes of suspended sediment is associated with the processes of dredging of marine sediments. Once disturbed by dredging activities, seabed sediments become entrained in the water column usually creating plumes of turbid water. The nature and extent of the plumes created depends on a range of factors including the type of dredge, the depth of dredging, the nature of the dredged material, the magnitude and direction of tidal currents, the surrounding bathymetry and the prevailing weather.

PBPL has implemented the Dredge Plume Monitoring Program (DPMP) to investigate the spatial and temporal patterns and behaviour of dredge plumes, i.e. sediment plumes created by dredging and offshore disposal. The DPMP builds on earlier plume monitoring studies undertaken for the port's dredging fleet (e.g. WBM Oceanics Australia 1995, 1997, 2002a, 2002b, 2004; BMT WBM 2008, 2011, 2014, 2017). BMT WBM (2017) summarises the findings of previous dredge plume monitoring studies in the lower Brisbane River and Mud Island DMPA.

The 2020 DPMP specifically focuses on dredge plumes created by the trailing suction hopper dredger (TSHD) *Brisbane* while undertaking dredging and offshore disposal activities in February 2020. The results of the DPMP will be used by PBPL to understand and manage potential risks associated with plumes of suspended sediment generated by dredging operations.

1.2 Study Aim and Objectives

The aim of the DPMP is to characterise the turbid plumes of suspended sediment generated by typical operations of the *Brisbane*. The specific objectives of this study are to:

- Quantify the behaviour, extent and intensities of plumes of suspended dredged sediments at and adjacent to the dredging (loading) sites in Hamilton Reach of the Lower Brisbane River and Mud Island DMPA
- Based on the measurements assess the potential exposure of existing sensitive receptors to sediment plumes.

1.3 Description of the Activity

1.3.1 The Brisbane

The *Brisbane* is the largest vessel in PBPL's dredging fleet and is an 85 m long ocean-going trailing arm suction hopper dredge (TSHD). The *Brisbane* performs maintenance and capital dredging works within the Port of Brisbane for around three months of the year and contract maintenance dredging services for Central and North Queensland ports for the remainder.

The *Brisbane* is equipped with two trailing arm suction heads, on the port and starboard sides of the vessel, which are typically lowered and dragged along the seafloor, simultaneously dredging the bed sediments either side of the vessel as it progresses forward. The drag heads are lifted clear of the seabed when moving astern. To efficiently fill the hopper (volume 2,900 m^3) with dredged material, the vessel is usually operated in an overflowing mode whereby the dredged sediments are concentrated within the hopper over time. A telescoping weir within the centre of the hopper can be elevated to maximise the retention of dredged material before discharge from the hopper occurs. Excess water and suspended sediments are ultimately discharged from the hopper via the weir to the underside of the keel, approximately five metres below the water line.

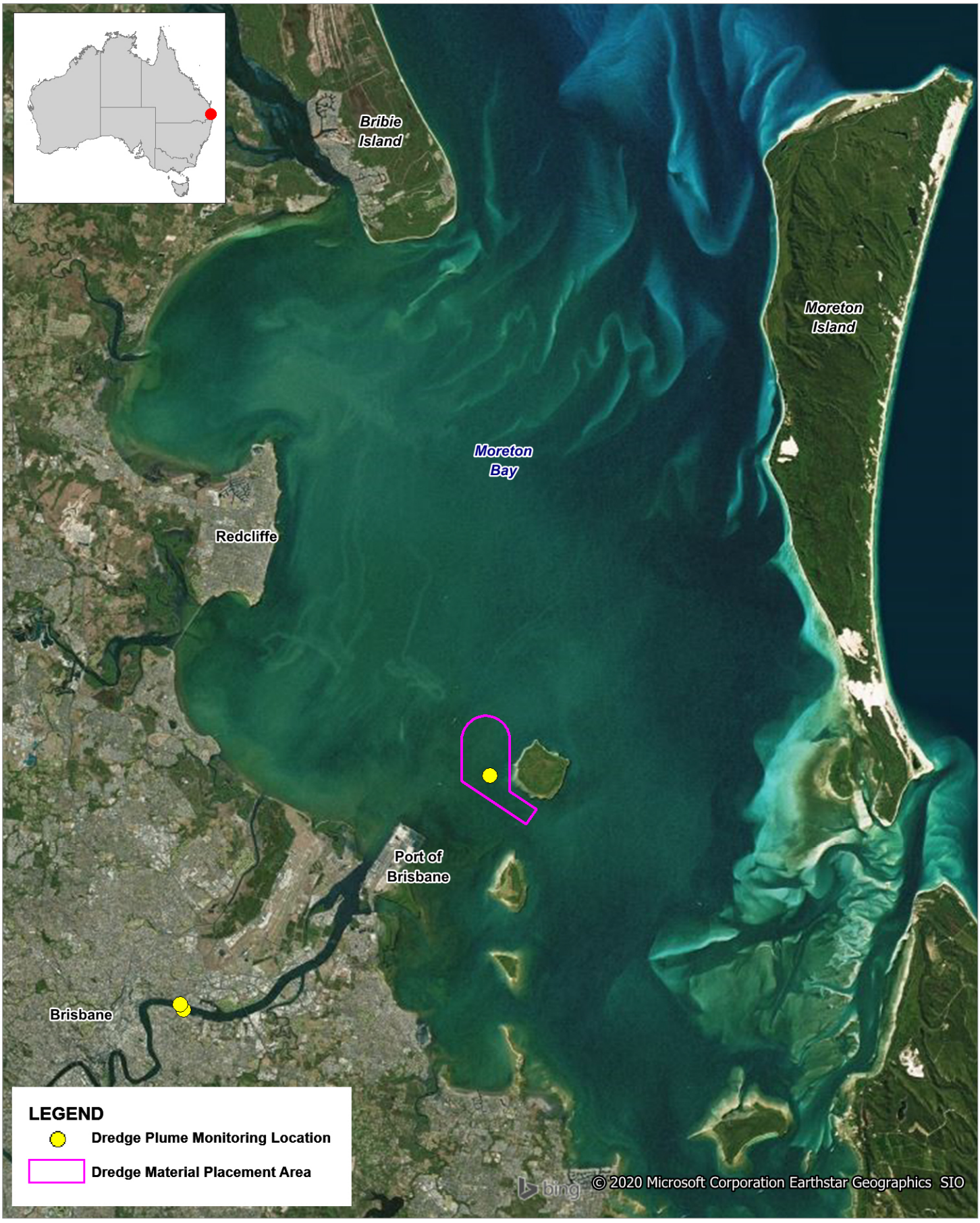
Depending upon the nature of sediments to be dredged, dredging to effectively fill the dredge hopper generally lasts around one hour, typically without any overflow from the hopper occurring in the first 15 – 20 minutes. Subsequently, a dredging overflow plume of turbid water is usually obvious as the overflow water and suspended sediments discharged from the underside of the keel are entrained to the water surface by the action of the vessel's propellers operating near the stern of the vessel as it moves ahead. This results in an obvious surface plume of dredged sediment astern of the *Brisbane* for the remainder of the dredging cycle.

Following cessation of dredging, the *Brisbane* typically delivers its load of material to a designated disposal area, either the Mud Island DMPA or onshore at the FPE. For offshore disposal, the dredger typically slows to a speed of a few knots on arrival at the DMPA and the dredged sediment loaded within the hopper is deposited over the required placement area by opening a series of five valves set within the bottom of the hopper, allowing for gravitational settlement of dredged material from the vessel through the water column to the seafloor. Alternatively, the dredged material can be pumped ashore from the hopper for settlement within bunded reclamation areas, for example at the Port of Brisbane FPE area.

1.3.2 February 2020 Maintenance Dredge Campaign

Monitoring of the turbid plumes around the *Brisbane* took place daily between 25th and 27th (inclusive) of February 2020 whilst the vessel was performing the following duties:

- Maintenance dredging at Hamilton Reach, North Bank on 25th February from 11:50 to 12:35 during ebb tide
- Maintenance dredging at Hamilton Reach, South Bank on 26th February from 08:00 to 08:50 during flood tide
- Material placement at the Mud Island DMPA on 27th February at 10:45 during flooding tide and at 15:50 during ebbing tide.



Title:
Locality Plan

Figure: 1-1

Rev: A

BMT WBM endeavours to ensure that the information provided in this map is correct at the time of publication. BMT WBM does not warrant, guarantee or make representations regarding the currency and accuracy of information contained in this map.

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Approx. Scale

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Figure 1-2 TSHD *Brisbane* Operating at Hamilton Reach (North Bank)

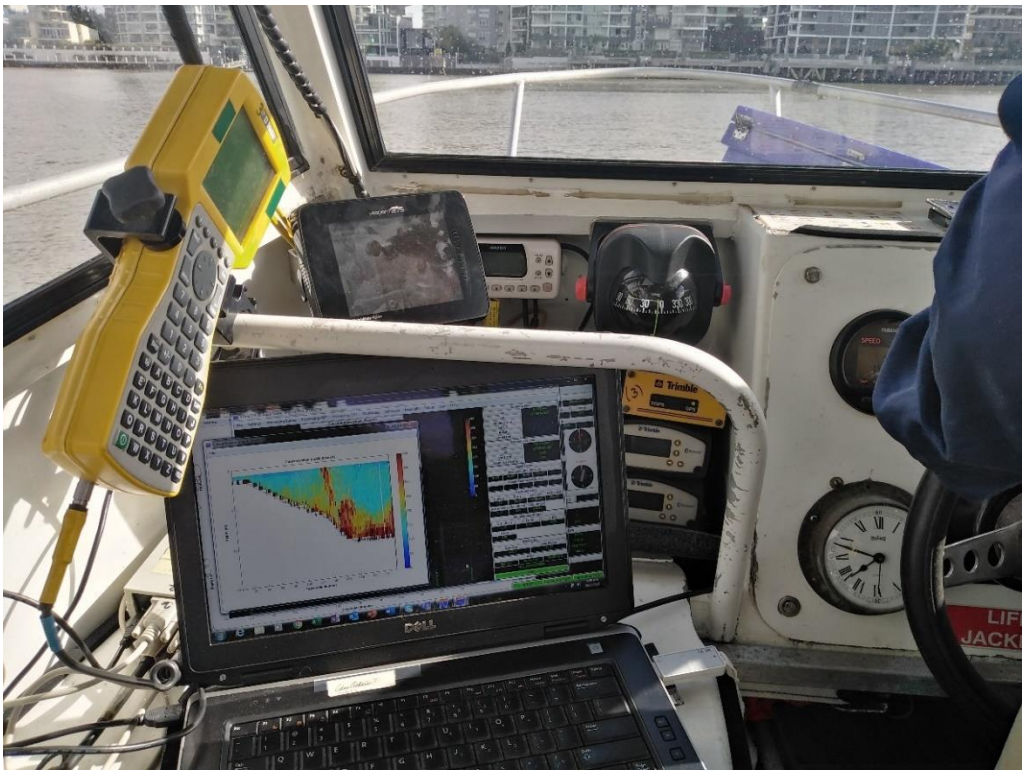

Figure 1-3 Monitoring Equipment and Plume Detection on Board *Resolution II*

2 Methodology

2.1 Data Acquisition

All field measurements were conducted from BMT's six metre research vessel *Resolution II* operating in the vicinity of the dredging operations. During the dredge plume monitoring, BMT communicated and co-ordinated measurement and sampling activities with the dredging plant *via* mobile telephone or VHF marine radio.

The following field measuring instrumentation and techniques were employed during the dredge plume monitoring:

- Water sampling for laboratory analysis of total suspended solids (TSS) concentrations to be used in the calibration of the turbidity probe and in assessments of the dredge plumes. Selected samples were also analysed for particle size distribution (PSD). Water samples were sent to the laboratories of ALS for analysis of the TSS and PSD. In total, 52 TSS samples and six PSD samples were taken. See Appendix A and Appendix B for raw TSS and PSD results, respectively.
- Turbidity profiling, using a Campbell Scientific OBS (Optical Backscatter)-3A turbidity probe, within and beyond the extents of the dredge plumes for use in the calibration of the Acoustic Doppler Current Profiler (ADCP) and in assessments of the dredge plumes.
- Conducting transects of the dredge plumes with a vessel mounted downward facing 1200kHz Teledyne RDI ADCP to record the acoustic backscatter intensity, providing an insight into the otherwise hidden plume characteristics across the various transects.
- Deployment of a drogue into the plume to assist with the ADCP transects and turbidity profiling, thus ensuring that measurements were collected from where the concentrations of suspended sediments were highest.

2.2 Post Processing

Processed ADCP measurements were used to remotely measure the suspended sediment in the water column with sufficient resolution to provide pictorial views of the suspended sediment associated with dredging.

ADCP measurements can be used to estimate suspended sediment concentrations throughout the water column, however an ADCP instrument does not directly measure TSS. The principle of ADCP operation is that a pulse of sound is propagated through the water column and is reflected/backscattered off suspended particles such as suspended sediments. The Doppler shift of the backscattered acoustic signal is used to directly determine the water currents throughout the water column. The intensity of the backscattered echo can be translated into TSS values through a series of steps as detailed below.

Laboratory analysis of the TSS in water samples spanning a wide range of sediment concentrations provides the means to calibrate the measurements from the OBS turbidity profiling instrument. By pairing the TSS values with the Nephelometric Turbidity Units (NTU), recorded in the field by the OBS, the site and date specific NTU-TSS relationship can be determined.

The turbidity profiles measured with the OBS, once converted to TSS, are then used to derive a relationship between the ADCP acoustic signal backscatter intensity and TSS. The software package VISEA includes a built-in calibration module for this purpose which is based on acoustic theory. The calibration process requires information on water temperature and salinity at the site and various scaling factors and offsets for each of the four transducers.

2.3 Presentation of Results

To characterize the turbid plume behaviour in terms of extent, intensity and longevity, spatial plots of the estimated suspended sediment concentration are presented for the respective monitoring locations and times in Section 3. An example of these plots is provided as Figure 2-1. Due to the complexity of such plots, the layout and interpretation is described in detail below.

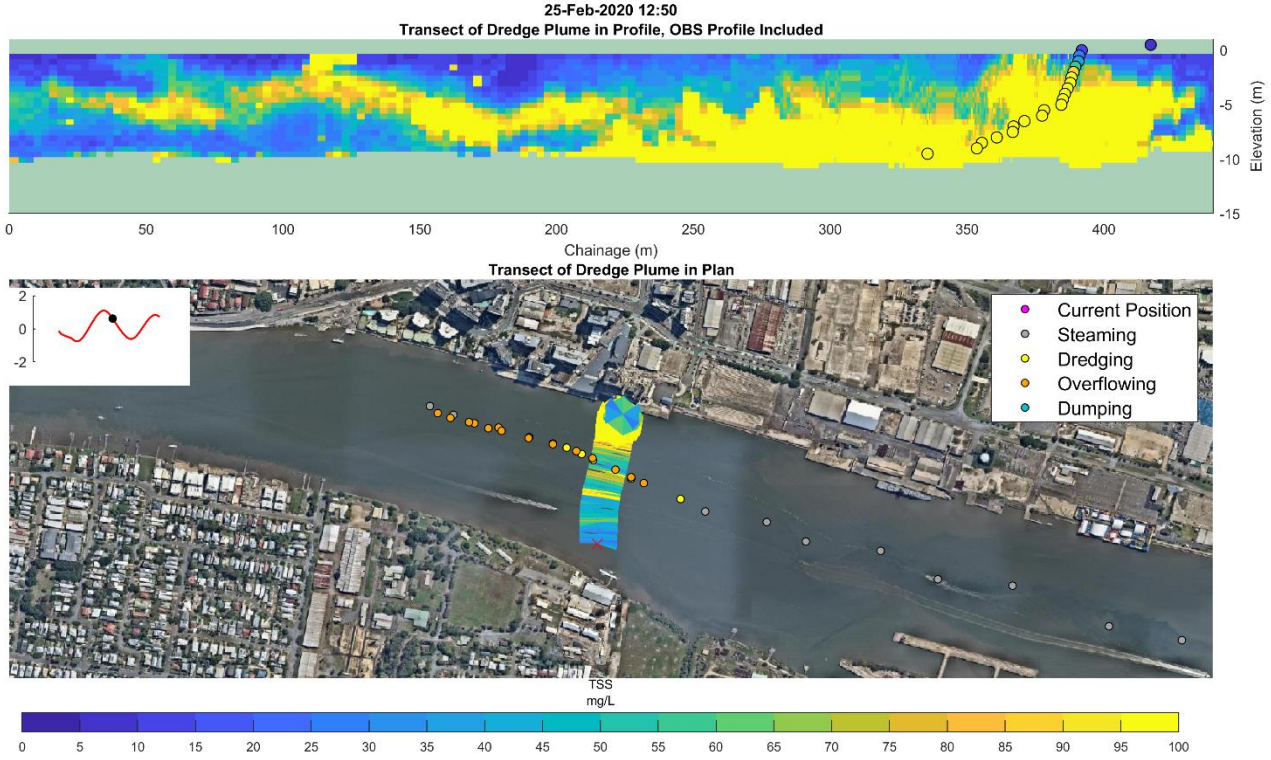

Figure 2-1 Example Turbid Plume Transect Plot

The plots are comprised of two components, an upper and a lower component. The upper component is a profile-view of the ADCP transect which depicts the TSS concentrations along the transect and through the water column. The lower component depicts the depth averaged plume concentrations in plan-view along the transect.

The coloured circles in the upper component depict the OBS TSS (based on turbidity) profile measured on the transect. The colour of the circles represents the TSS concentration returned by the OBS which align with those returned by the ADCP. The OBS profiles are plotted directly onto the elevation-chainage axes. As the OBS instrument is lowered down through the water column, a process which can take over a minute, the monitoring vessel often drifts with the wind/currents and

hence the chainage along the transect increases with depth. Hence the OBS profiles do not appear vertical. Transects which were performed in an east to west direction have been reversed so the lower plan view plot links more intuitively with the upper profile view plot.

The red 'x' plotted in the lower component identifies the start of the ADCP transect which extends from left to right in the upper profile-view component of the plot. All ADCP transects have been presented with the red 'x' on the most westerly end point and have been reversed if necessary. The timing of the measurement within the tidal cycle is depicted in the upper right-hand corner of the plot (date shown on x-axis).

The operations of the TSHD *Brisbane* are represented by small coloured circles in the lower pane. They depict the *Brisbane's* position at the time the transect was conducted and where and how the dredge had been operating for the past 120 minutes.

TSS estimates are capped at a maximum value due to the uncertainty surrounding the backscatter–TSS relationship above that value. It should also be noted that due to its mounting and a measurement 'blanking-distance', the ADCP was only able to resolve TSS concentrations below a depth of approximately 1.5 m. The ADCP was also unable to estimate the TSS within approximately 1 m from the seabed.

Background concentrations have not been removed from the data. Several of the data sets include a transect conducted before the dredge commenced operations and hence depict the background concentrations at that time. Where possible, the transects extend beyond the extents of the dredge plume and hence can be used to quantify the background concentrations at the time of the transect.

3 Results

3.1 TSS and Turbidity Relationship

Figure 3-1 shows the relationship between turbidity and TSS from background and plume samples generated by TSHD *Brisbane* collected at the loading site and Mud Island DMPA. There was a significant (p<0.05) positive linear relationship between turbidity and TSS, with 79% of variation in TSS explained by the linear prediction model.

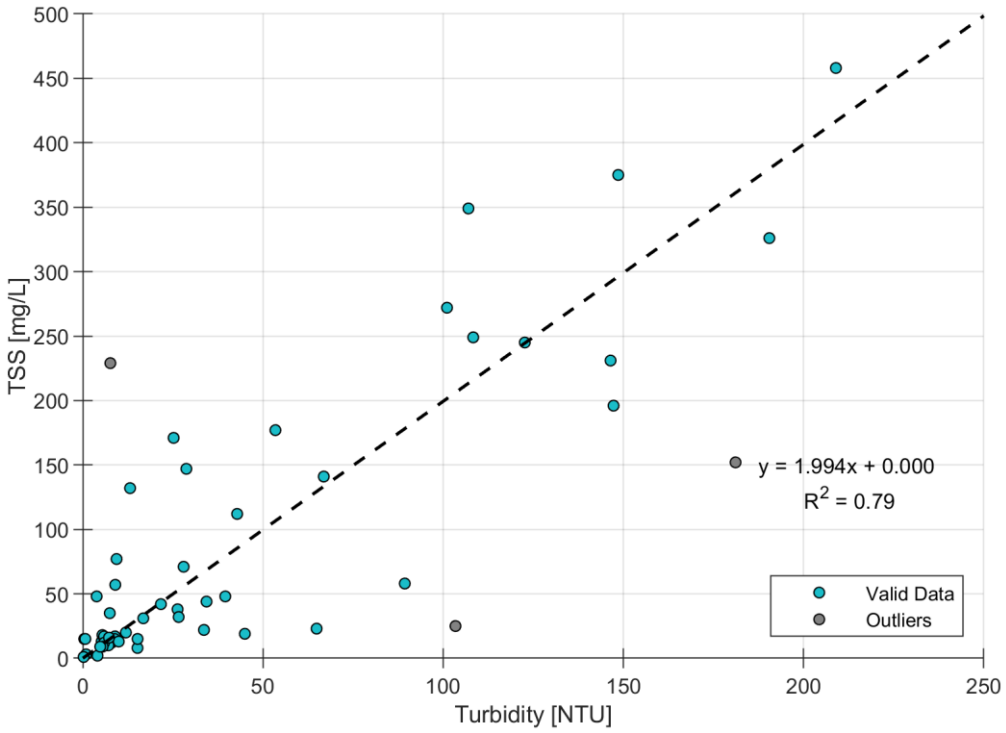

Figure 3-1 TSS and Turbidity Correlation Plot

The conversion factor from turbidity to TSS differed between the 2014, 2017 and 2020 studies – based on a *y* intercept at 0, the lines of best fit for the respective years are:

- TSS (2014) = 1.3 × turbidity. This relationship was based on measurements undertaken at the Swing Basin and Outer Bar Cutting.
- TSS (2017) = 2.9 × turbidity. This relationship was based on measurements undertaken at the Pelican Banks Swing Basin and Inner Bar.
- TSS (2020) = 1.9 x turbidity (Hamilton Reach).

The differences between the years reflects both the broader range (i.e. higher concentrations) of TSS measured and differences in dredged material properties between years (and related to this, different areas dredged).

3.2 Turbid Plume Transects

3.2.1 Hamilton Reach (North Bank) Ebb Tide

The *Brisbane* was monitored whilst dredging the North Bank of the Hamilton Reach from 11:50 to 12:35 on 25th February 2020 during an ebbing tide. According to the dredge logs, the *Brisbane* operated for approximately 45 minutes whist removing approximately 2,379 tonnes (dry mass) of sediment.

Weather at the time of monitoring was fine, with light winds and calm seas. Prior to the commencement of dredging works, ambient suspended sediment concentrations were recorded on a transect across the river (Figure 3-2). Ambient suspended sediment concentrations ranged from 0-10 mg/L near the surface and 50-60 mg/L near the bed, with higher concentrations in shallow areas near the banks.

After dredging commenced at 11:50, the *Brisbane* operated without overflow along the North Bank heading upstream, before turning around and conducting a second pass whilst overflowing, heading downstream. Immediately after operations concluded, a cross section showed a distinct plume approximately 100 m wide with TSS concentrations greater than 100 mg/L throughout the water column (Figure 3-3). The highest recorded TSS concentration was 349 mg/L. Transecting then continued until the plume was no longer detectable. See Appendix C for the full set of transect plots.

The plume remained detectable for approximately one hour. A longitudinal transect at this time showed surface particulates had settled and dispersed such that only an attenuated near-bed plume that stretched approximately one kilometre downstream remained (Figure 3-4). Thereafter, the plume was indistinguishable from the background.

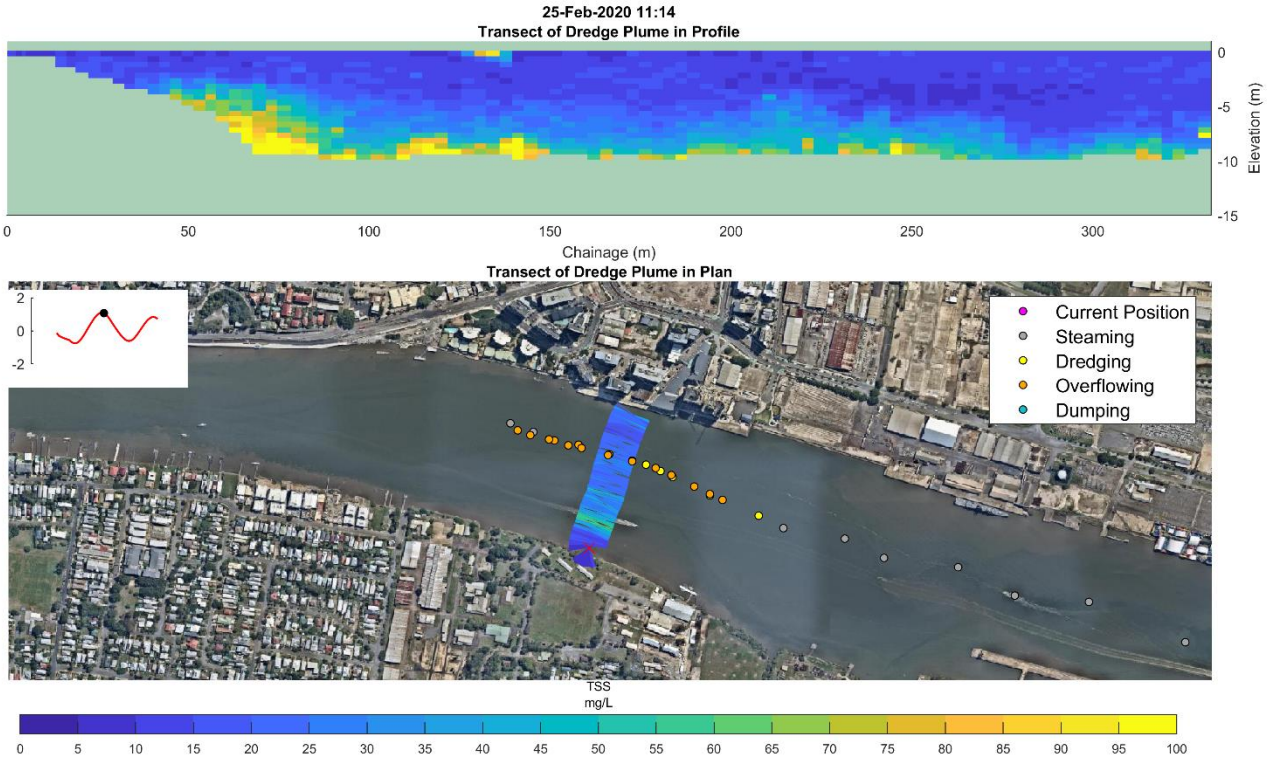

Figure 3-2 Ambient Transect at Hamilton Reach Prior to Dredging of North Bank

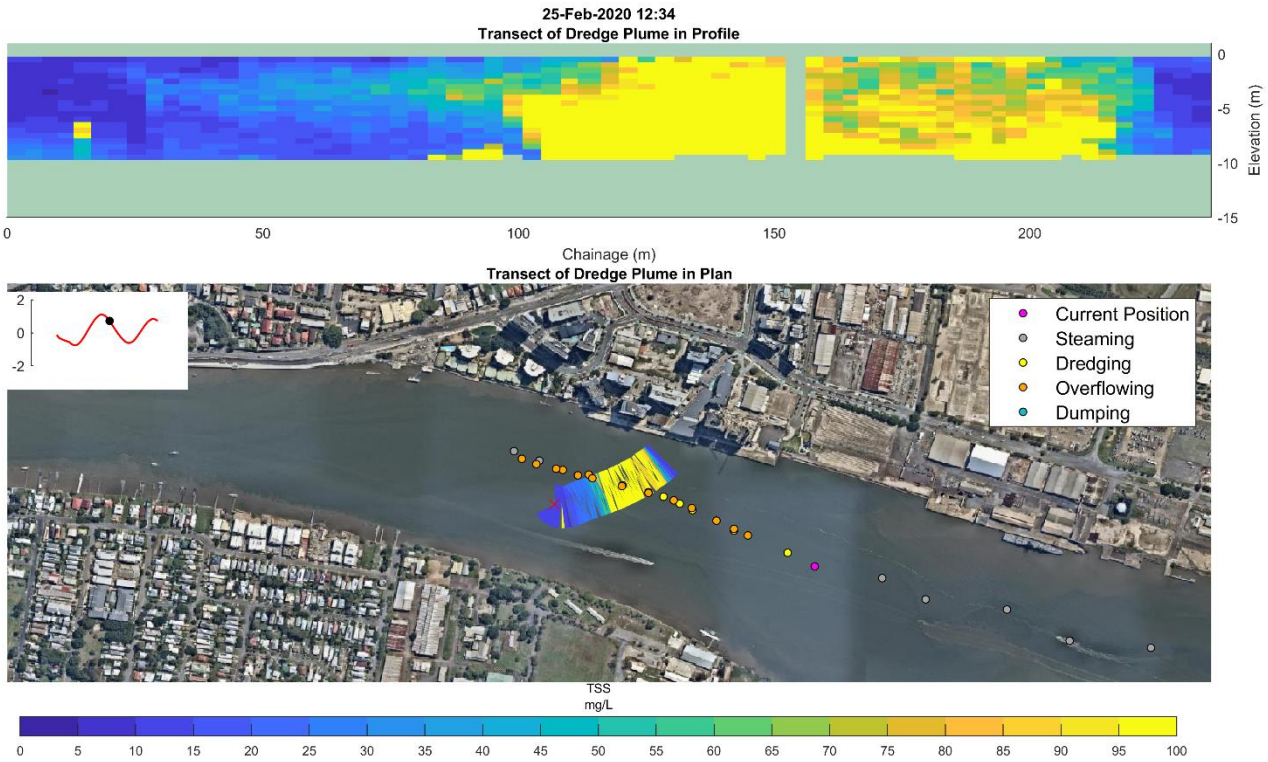

Figure 3-3 Dredge Plume Transect at Hamilton Reach During Dredging of North Bank

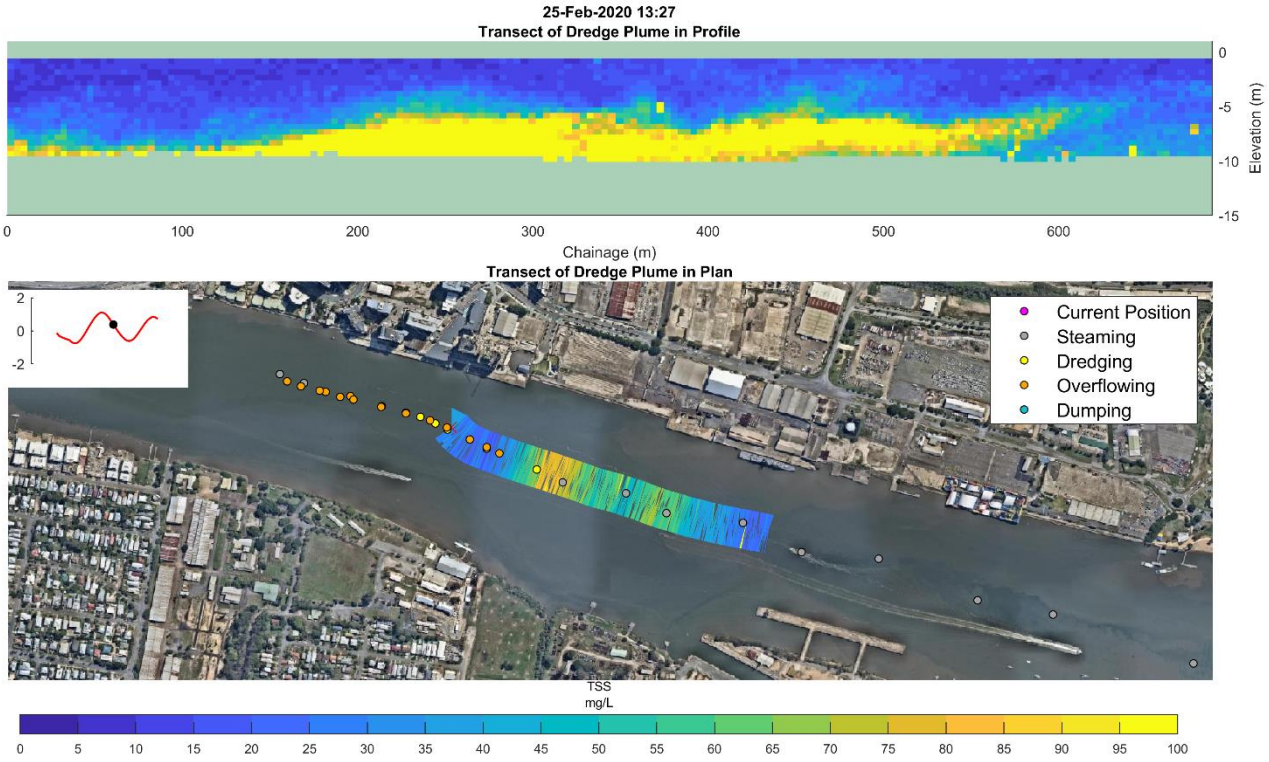

Figure 3-4 Attenuated Dredge Plume Approximately 1 Hour After Dredging North Bank

3.2.2 Hamilton Reach (South Bank) Flooding Tide

The *Brisbane* was monitored whilst dredging the South Bank of the Hamilton Reach from 08:00 to 08:50 on 26th February 2020 during a flooding tide. According to the dredge logs, the *Brisbane* operated for approximately 50 minutes whist removing approximately 2,251 tonnes (dry mass) of sediment.

Weather at the time of monitoring was fine, with light winds and calm seas. Prior to commencement of dredge works, baseline measurements were undertaken on a transect across the river (Figure 3-5). Ambient suspended sediment concentrations were 0-10 mg/L near the surface and 60-100 mg/L near the bed.

Dredging commenced at 08:00, and the *Brisbane* operated without overflow along the South Bank heading downstream. It soon started overflowing and continued downstream, before turning around and conducting a second pass whilst overflowing, heading upstream. During the first pass, a dense plume was measured approximately 60 m wide on the South Bank with concentrations greater than 100 mg/L throughout the water column (Figure 3-6). The highest sampled concentration was 375 mg/L. See Appendix D for the full set of transect plots.

Transecting continued for over an hour after dredge operations concluded. Suspended sediment concentrations greater than 100 mg/L below approximately 5 m depth persisted for over an hour after dredge operations ceased. A cross section during this time showed a near-bed plume 1.5 km upstream from the cutting location (Figure 3-7). See Section 4 for a discussion of the likely sources of this near bed plume.

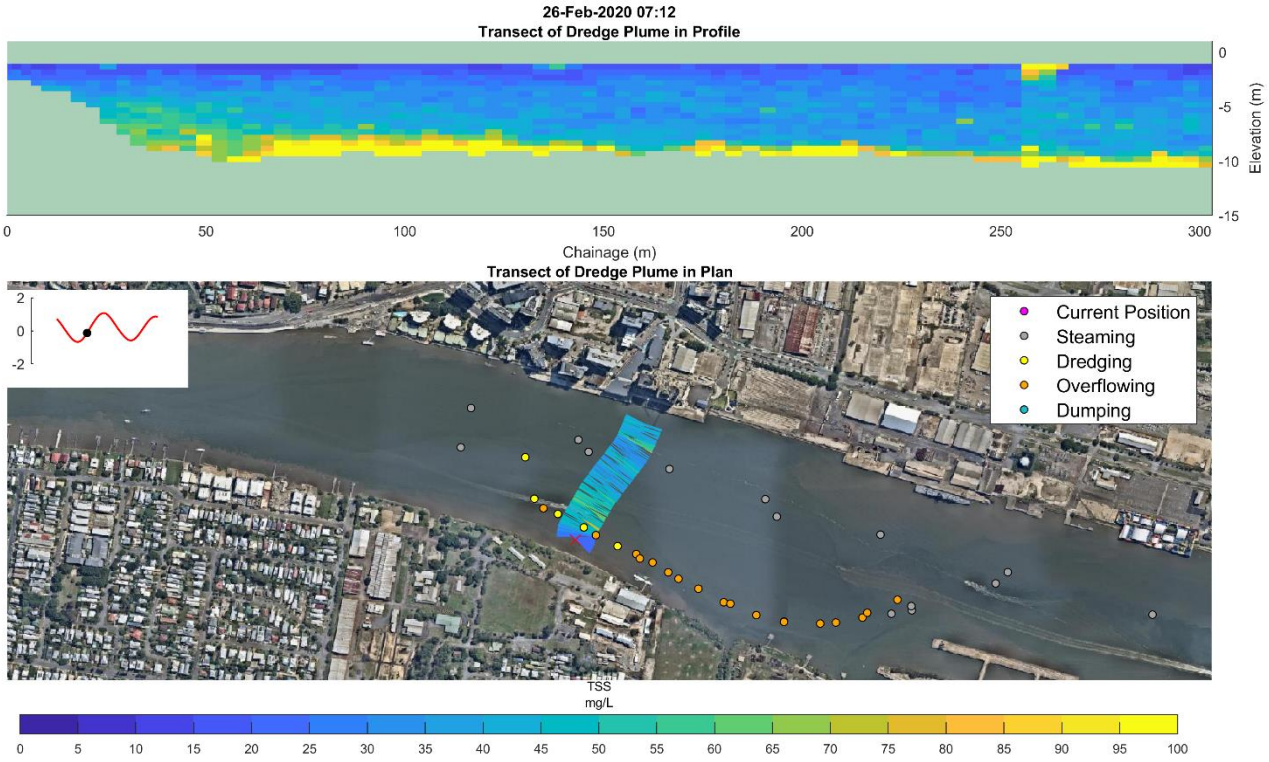

Figure 3-5 Ambient Transect at Hamilton Reach Prior to Dredging of South Bank

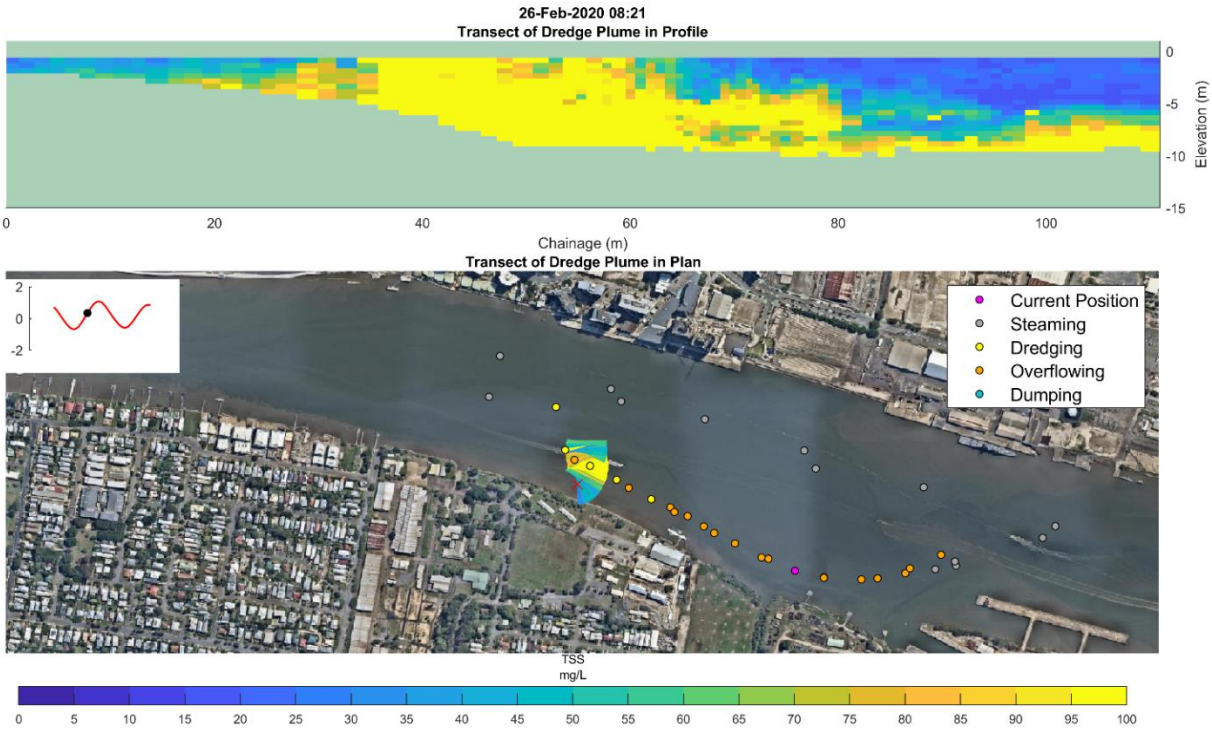

Figure 3-6 Dredge Plume Transect at Hamilton Reach During Dredging of South Bank

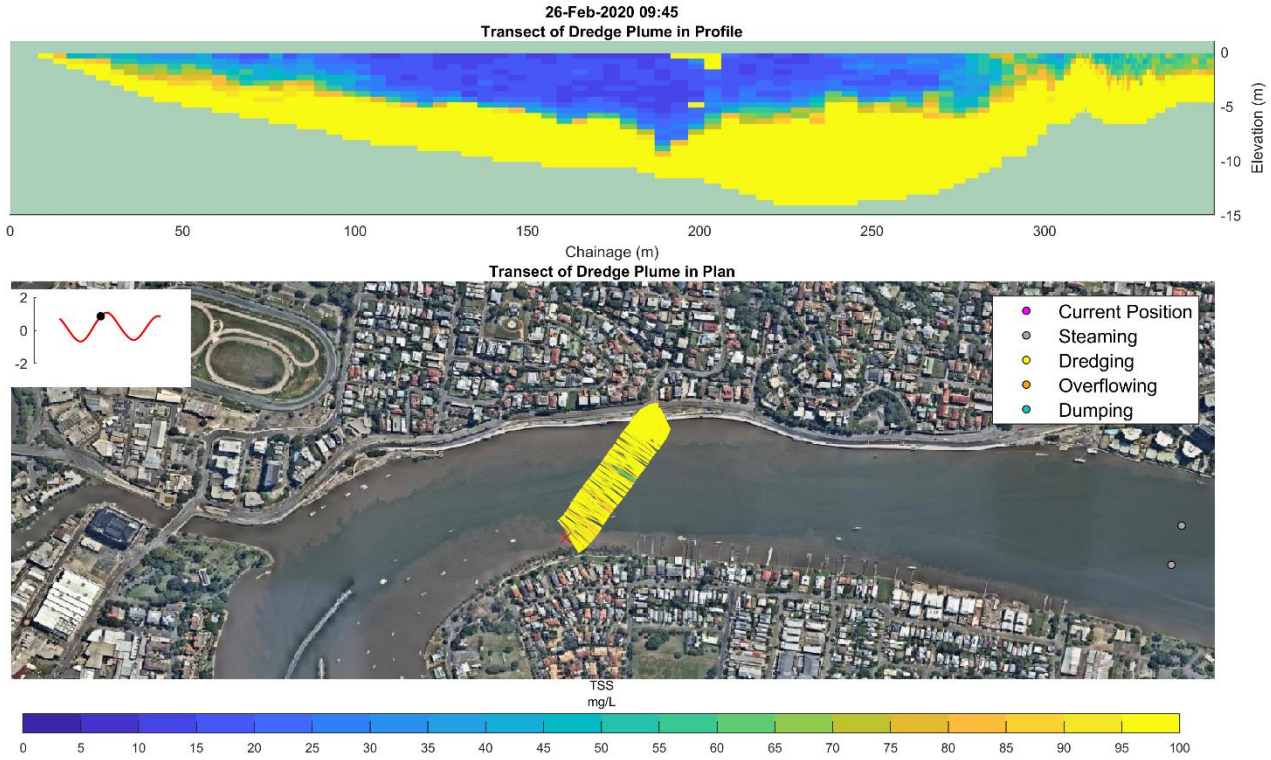

Figure 3-7 Suspended Sediments Approximately 1 Hour After Dredging South Bank

Two PSD samples of dredge related suspended sediment at Hamilton Reach (South Bank) were collected (see Table 3-1). The distributions indicate the suspended sediment was primarily silt. Refer to Appendix B for detailed results.

Table 3-1 Hamilton Reach (South Bank) PSD Results

Time	Depth	D_{10} (um)	D_{50} (um)	D_{90} (um)
08:18	4.63	2.61	11.5	192
08:30	7.46	2.3	8.93	61.3

3.2.3 Mud Island DMPA Flooding and Ebb Tide

The *Brisbane* was monitored twice on the 27th February 2020 whilst disposing of dredged material at the Mud Island DMPA. First, at 10:45 with a load of approximately 2,367 tonnes (dry mass) during a flooding tide and again at 15:50 with a load of approximately 2,343 tonnes (dry mass) during an ebbing tide. Weather during monitoring was fine, with light winds and calm seas.

Baseline transects were undertaken at the DMPA prior to commencement of disposal works. Ambient suspended sediment concentrations varied little across the day ranging from 0-5 mg/L throughout the water column.

For the first load, the *Brisbane* approached from the north, before turning west, dumping and then sailing north west towards the entrance channel. Entrained air bubbles from the initial release made immediate measurement difficult. Good quality measurements were obtained approximately 10

minutes after release. A transect of the plume at this time shows high concentrations of 50-200 mg/L in an area 100 m in diameter, and most sediment had already settled to the near-bed area (Figure 3-8). Approximately 50 minutes after the release the plume had advected south with residual concentrations of 10-20 mg/L distributed throughout the water column, thus were no longer distinguishable (Figure 3-9). Refer to Appendix E for the full set of transects at Mud Island DMPA during flooding tide.

Similar plume behaviour was observed for the second load. However, the release was somewhat staggered such that a transect 10 minutes after release shows two distinct plumes (Figure 3-10). Approximately 40 minutes after release, the plume had advected north with near-bed concentrations of 100 mg/L and diffuse concentrations of 20–50 mg/L throughout the water column (Figure 3-11). Soon after it became indistinguishable from background. Refer to Appendix F for the full set of transects at Mud Island DMPA during ebb tide.

Additional to the acoustic readings, four PSD samples of dredge related suspended sediment at Mud Island DMPA were collected. Key PSD results are shown in Table 3-2. Two different distributions are shown across the four measurements, one comprised mostly of silt and the other of fine sand. Interestingly, the distributions with greater sand content were recorded nearer to the surface. Refer to Appendix B for detailed results.

Table 3-2 DMPA PSD Measurements

Time	Depth	D_{10} (um)	D_{50} (um)	D_{90} (um)
11:44	8.92	3.08	10.1	141
12:30	2.64	5.71	84.6	187
15:15	7.03	2.18	8.59	54.4
16:17	5.92	15.6	87.1	157

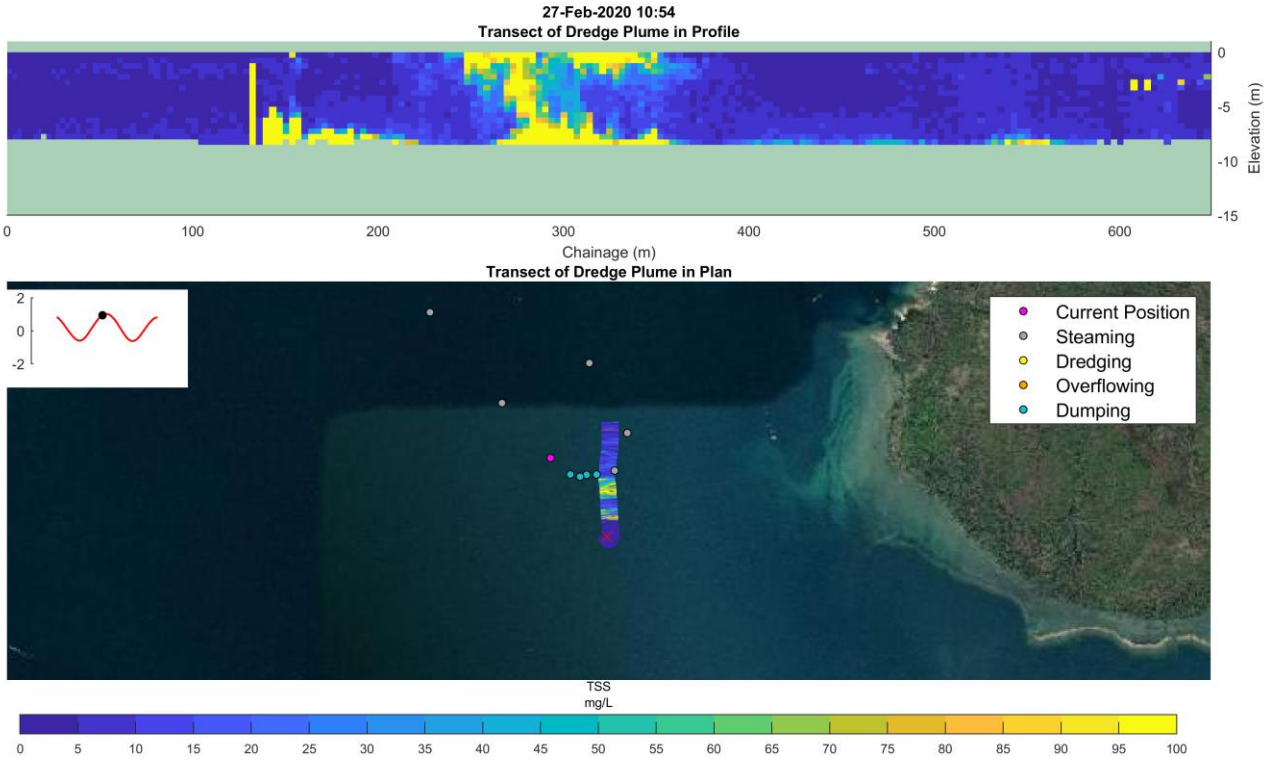

Figure 3-8 Flooding Tide Dump Plume Transect Approximately 10 Minutes After Release

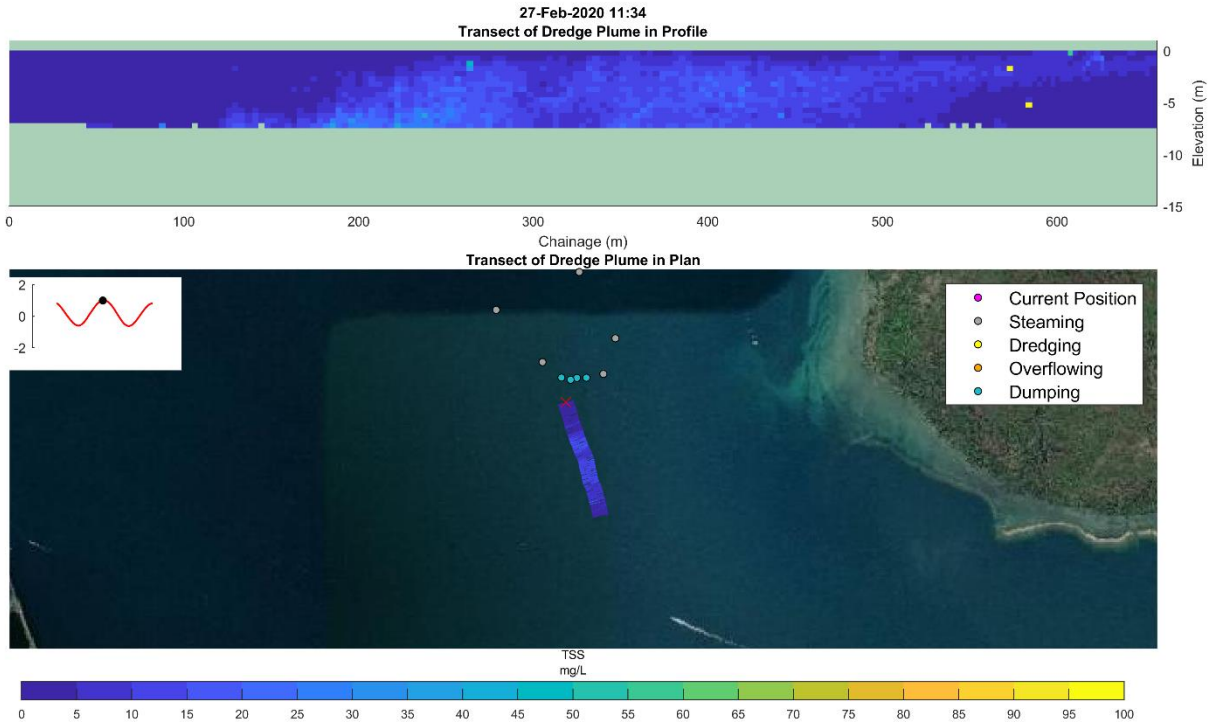

Figure 3-9 Flooding Tide Dump Plume Transect Approximately 50 Minutes After Release

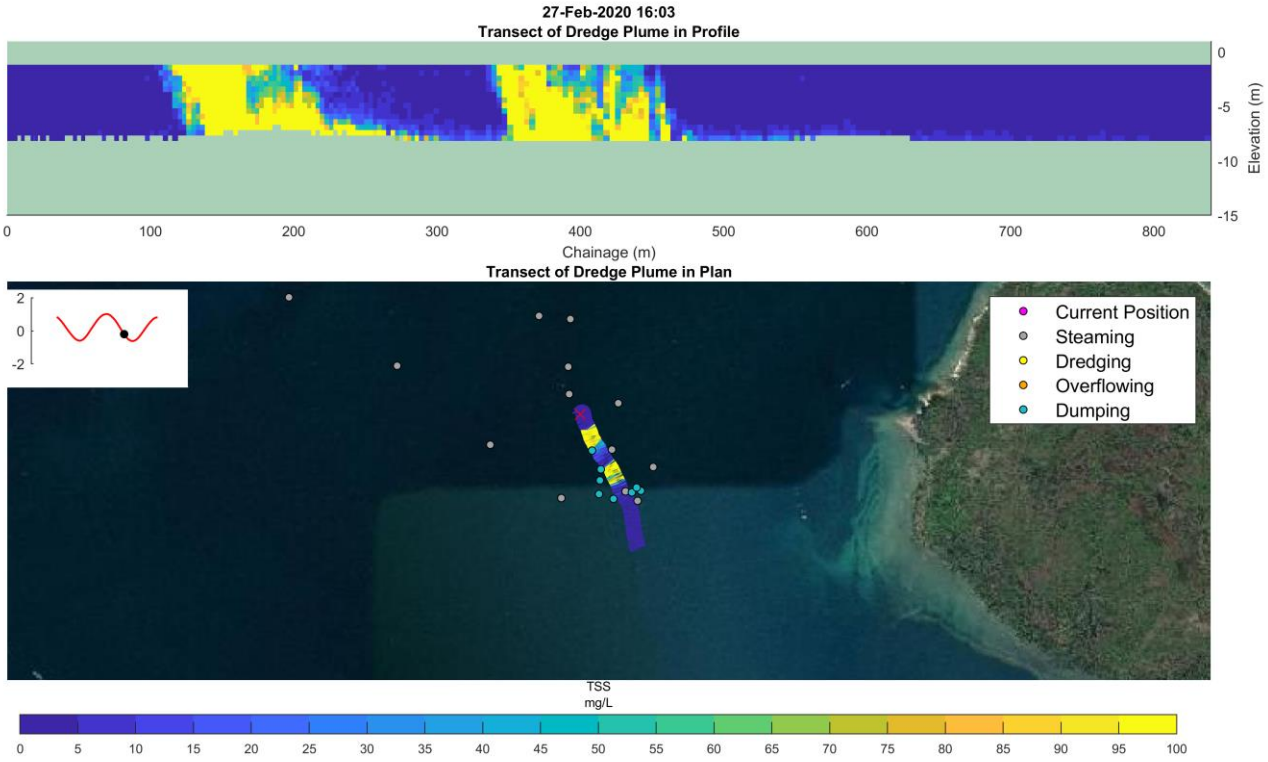

Figure 3-10 Ebbing Tide Dump Plume Transect Approximately 10 Minutes After Release

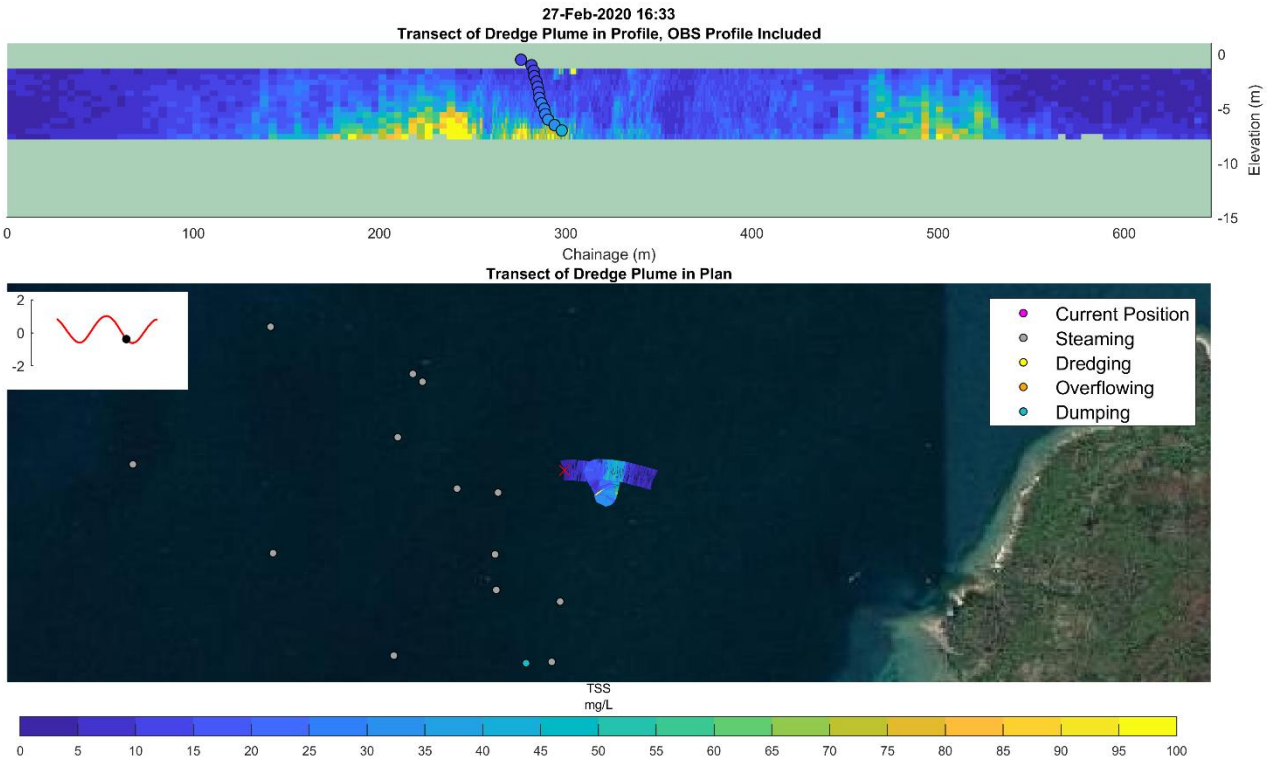

Figure 3-11 Ebbing Tide Dump Plume Transect Approximately 40 Minutes After Release

4 Discussion

4.1 Dredge Sites

For dredging operations in the channel, the plume characteristics were consistent with previous studies. The disturbance of the seabed by the drag heads resulted in the generation of an initial plume near the seabed. The hopper gradually filled up and within seconds of the commencement of overflow from the hopper, a plume of sediment was visible at the water surface. This was the result of turbulence generated by the *Brisbane's* propellers mixing the sediments released at keel level from the hopper throughout the water column.

The combination of the additional sediment released into the water column from the hopper and the inhibited settling due to the turbulence generated by the propellers resulted in a plume of sediment evenly distributed throughout the water column. The immediate plumes generated were typically <100 metres in width with suspended sediment concentrations typically between 100–200 mg/L, with a maximum of 375 mg/L.

Immediately after dredging operations concluded, the distributed plumes simultaneously settled and advected, resulting in attenuated near-bed plumes. These plumes were discernible for approximately 1 hour and travelled approximately 1 km from the cutting location at both monitoring sites. Thereafter, the sediment plume behaviour differed between dredge sites. At the Hamilton Reach (North Bank) dredge site, the dredge plume was indistinguishable from background, whereas the Hamilton Reach (South Bank) dredge site had a near-bed sediment plume.

There are several lines of evidence suggesting that this near-bed sediment plume dredging at the Hamilton Reach (South Bank) dredge site was mostly ambient material:

- Natural (ambient) patterns - background measurements undertaken prior to dredging indicate that there was a distinct near-bed layer of suspended sediments, with TSS measurements up to 100 mg/L in the lower 1-2 metres of the water column. The post dredging near-bed layer of suspended sediments had similar concentrations to the ambient near-bed layer, but now extended approximately 5 m above the bed.
- Tidal state of measurements - the pre-dredge ambient measurements were taken just after slack water when current velocities and sediment resuspension are lowest. By contrast, the post-dredge measurements were taken under more energetic conditions (larger currents) resulting in larger quantities of suspended sediment mixed higher into the water column (i.e. higher ambient concentrations).
- Spatial patterns in near-bed plume intensity – the near bed plume one hour after was larger in extent than during dredging, covering the entire channel. This is not consistent with expected patterns if the post-dredge near-bed material was mostly dredging derived.

4.2 Disposal

For bottom dumping operations at the Mud Island DMPA, the released sediment was observed to rapidly settled to the bed with a relatively small amount remaining in suspension as the measured plume. Due to the entrainment of air bubbles in the water column during the disposal event,

immediate measurement could not be made of the newly formed plumes. Measurements undertaken approximately 10 minutes after bottom dumping indicate the initial plume covered an area of approximately 100 m by 100m with concentrations of 50-200 mg/L. This is consistent with previous monitoring campaigns.

Due to the advection, dispersion and settlement of the plumes, within an hour they were typically reduced to low concentrations of 10-20 mg/L and had travelled approximately 0.5-1 km from the placement location. Soon after, they became indiscernible from background readings. This is consistent with the 2014 and 2017 campaigns. As such, it is likely the plume was contained entirely within the bounds of the DMPA and did not approach any sensitive receptor sites in Moreton Bay.

5 References

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Appendix A TSS Results

Sample No.	Location	Time [AEST]	Depth [m]	TSS [mg/l]
1	Hamilton Reach (North Bank)	25/02/2020 11:25:45	10.12	42
2	Hamilton Reach (North Bank)	25/02/2020 11:27:16	5.19	35
3	Hamilton Reach (North Bank)	25/02/2020 12:05:53	8.59	8
4	Hamilton Reach (North Bank)	25/02/2020 12:19:48	6.95	25
5	Hamilton Reach (North Bank)	25/02/2020 12:29:49	0.25	112
6	Hamilton Reach (North Bank)	25/02/2020 12:31:48	9.8	31
7	Hamilton Reach (North Bank)	25/02/2020 12:38:28	3.39	58
8	Hamilton Reach (North Bank)	25/02/2020 12:48:00	6.44	196
9	Hamilton Reach (North Bank)	25/02/2020 12:49:36	9.16	349
10	Hamilton Reach (North Bank)	25/02/2020 13:03:23	9.12	177
11	Hamilton Reach (North Bank)	25/02/2020 13:04:40	2.11	132
12	Hamilton Reach (North Bank)	25/02/2020 13:16:42	4.51	15
13	Hamilton Reach (North Bank)	25/02/2020 13:18:12	10.85	22
14	Hamilton Reach (North Bank)	25/02/2020 13:35:37	1.83	13
15	Hamilton Reach (North Bank)	25/02/2020 13:37:32	9	48
16	Hamilton Reach (South Bank)	26/02/2020 07:19:54	8.28	38
17	Hamilton Reach (South Bank)	26/02/2020 07:21:19	0.68	57
18	Hamilton Reach (South Bank)	26/02/2020 08:17:10	4.62	326
19	Hamilton Reach (South Bank)	26/02/2020 08:30:05	7.32	375
20	Hamilton Reach (South Bank)	26/02/2020 08:44:15	9.27	152
21	Hamilton Reach (South Bank)	26/02/2020 08:45:47	1.57	229
22	Hamilton Reach (South Bank)	26/02/2020 08:57:06	10.4	23
23	Hamilton Reach (South Bank)	26/02/2020 08:57:42	10.51	249
24	Hamilton Reach (South Bank)	26/02/2020 09:12:16	7.99	272
25	Hamilton Reach (South Bank)	26/02/2020 09:13:52	3.62	77

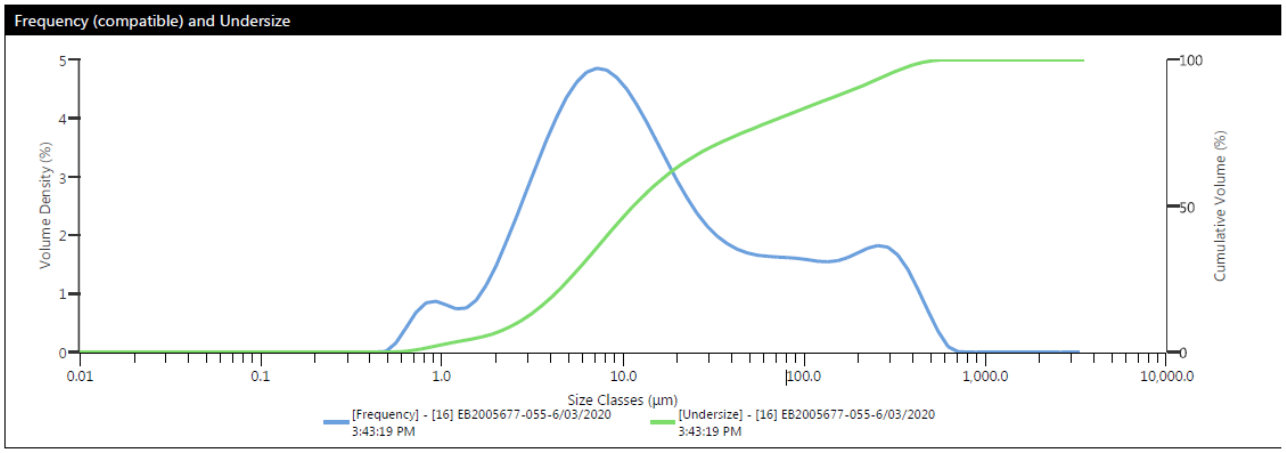
TSS Results

Sample No.	Location	Time [AEST]	Depth [m]	TSS [mg/l]
26	Hamilton Reach (South Bank)	26/02/2020 09:24:58	8.28	231
27	Hamilton Reach (South Bank)	26/02/2020 09:26:19	1.58	18
28	Hamilton Reach (South Bank)	26/02/2020 09:40:04	11.35	458
29	Hamilton Reach (South Bank)	26/02/2020 09:41:23	7.77	147
30	Mud Island DMPA	27/02/2020 10:18:16	8.05	17
31	Mud Island DMPA	27/02/2020 10:19:31	1.91	15
32	Mud Island DMPA	27/02/2020 10:48:31	9.22	19
33	Mud Island DMPA	27/02/2020 11:03:47	7.94	71
34	Mud Island DMPA	27/02/2020 11:05:19	3.34	20
35	Mud Island DMPA	27/02/2020 11:25:06	8.89	44
36	Mud Island DMPA	27/02/2020 11:26:48	3.52	48
37	Mud Island DMPA	27/02/2020 11:44:36	8.92	9
38	Mud Island DMPA	27/02/2020 12:02:40	8.29	12
39	Mud Island DMPA	27/02/2020 12:04:17	1.72	15
40	Mud Island DMPA	27/02/2020 12:29:31	2.62	3
41	Mud Island DMPA	27/02/2020 15:32:38	7.2	2
42	Mud Island DMPA	27/02/2020 15:34:47	2.06	1
43	Mud Island DMPA	27/02/2020 15:55:47	6.58	245
44	Mud Island DMPA	27/02/2020 15:57:20	2.81	141
45	Mud Island DMPA	27/02/2020 16:12:28	7.55	171
46	Mud Island DMPA	27/02/2020 16:13:52	2.46	17
47	Mud Island DMPA	27/02/2020 16:33:06	6.6	32
48	Mud Island DMPA	27/02/2020 16:34:33	2.77	15
49	Mud Island DMPA	27/02/2020 16:56:49	5.69	10
50	Mud Island DMPA	27/02/2020 17:19:20	5.98	13
51	Mud Island DMPA	27/02/2020 17:20:40	1.7	12

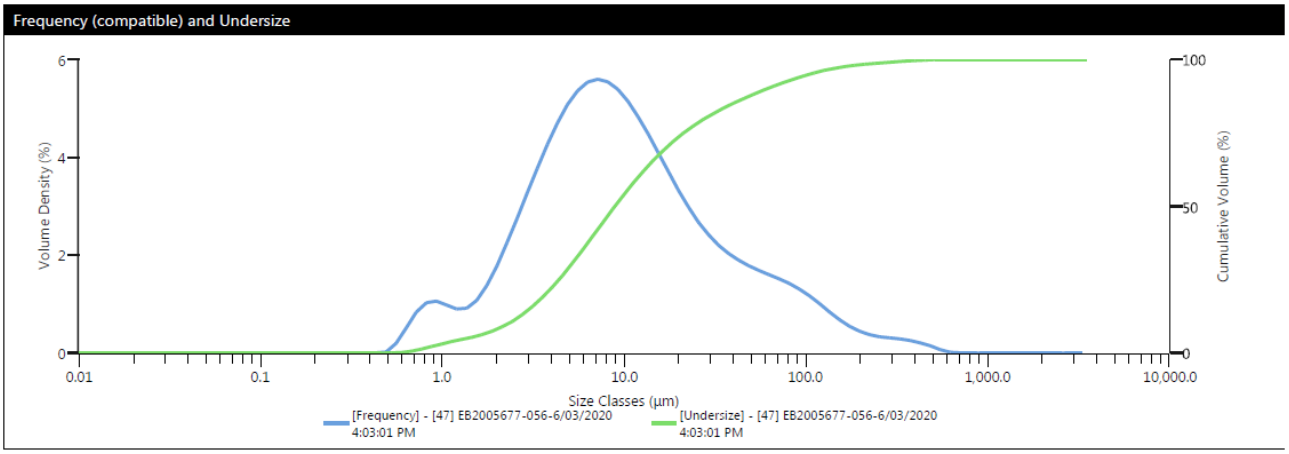
TSS Results

Sample No.	Location	Time [AEST]	Depth [m]	TSS [mg/l]
52	Mud Island DMPA	27/02/2020 17:37:34	4.63	16

Appendix B PSD Results



PSD 1: Hamilton Reach, South Bank 8:18 26/02/2020



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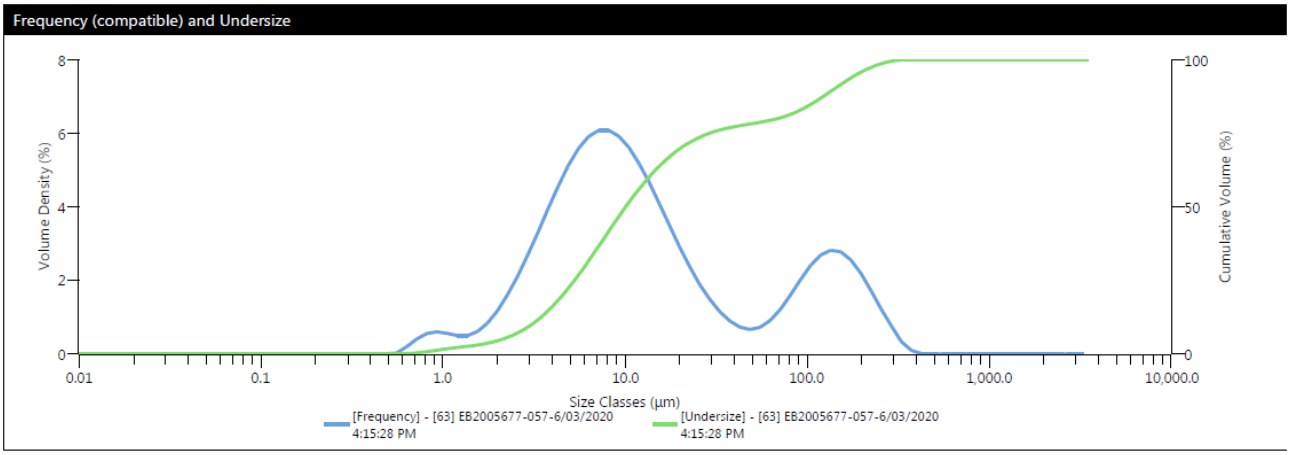
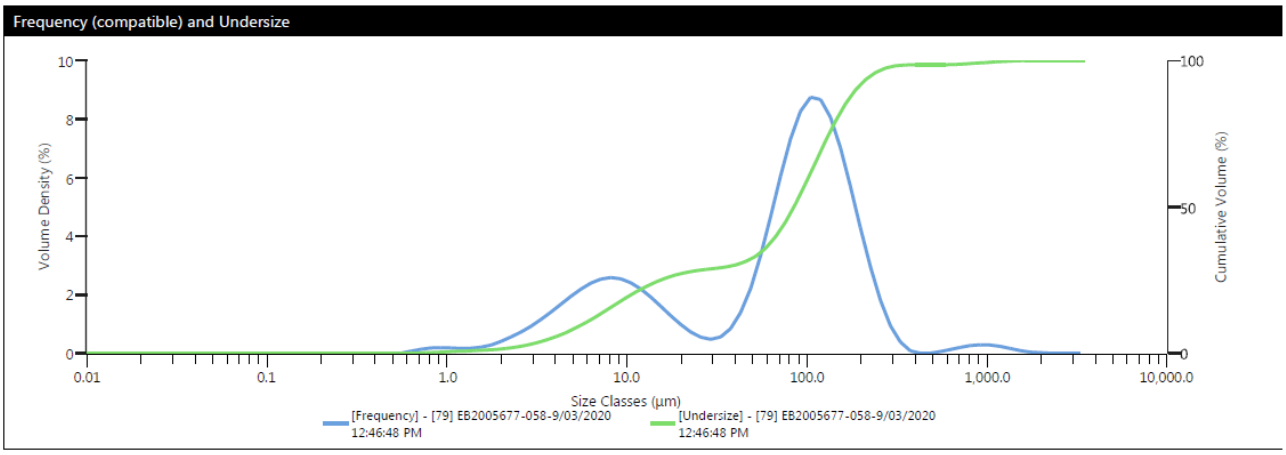


PSD 3: Mud Island DMPA, 11:44 27/02/2020

PSD Results



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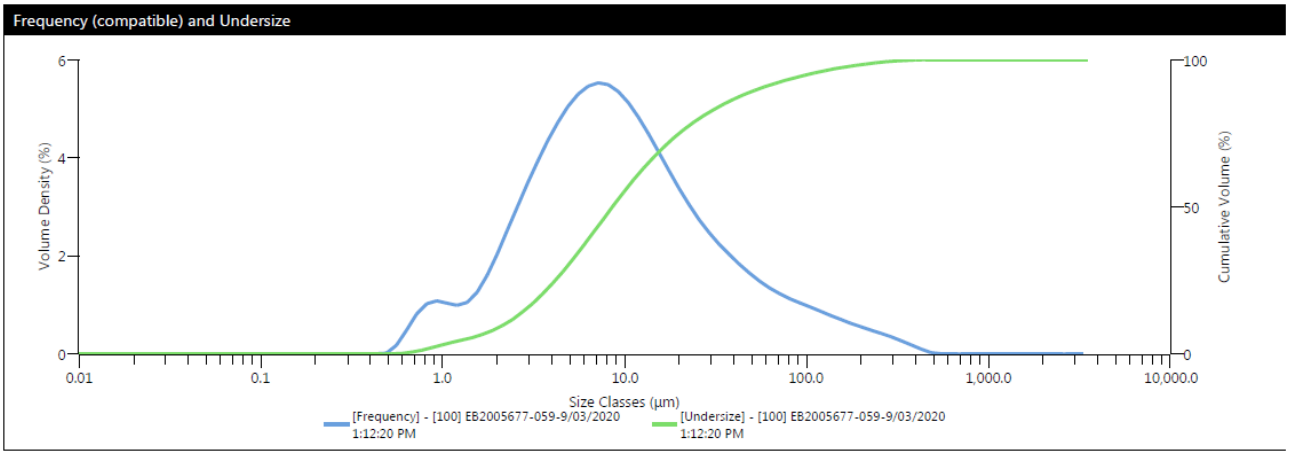

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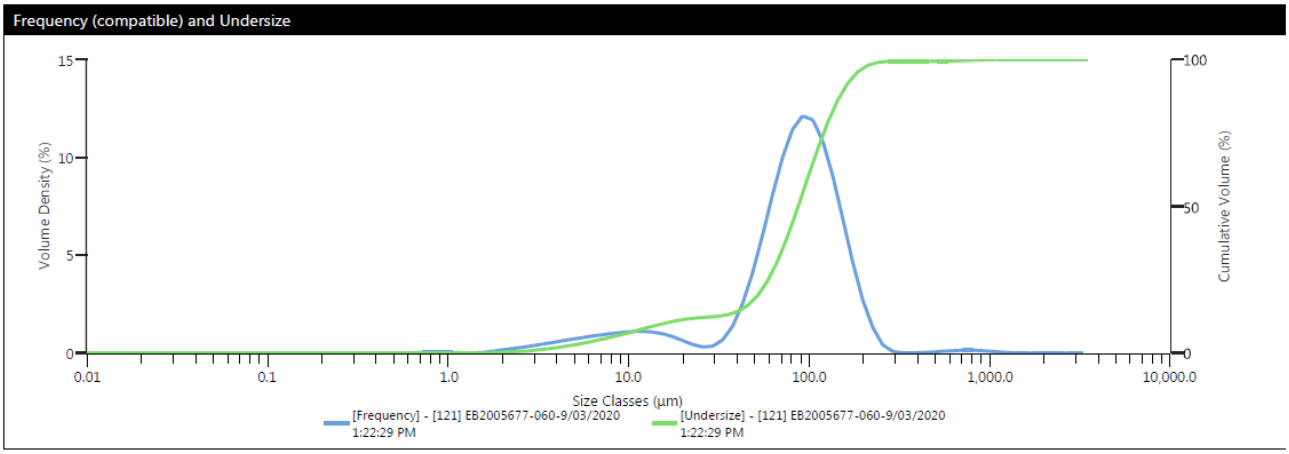
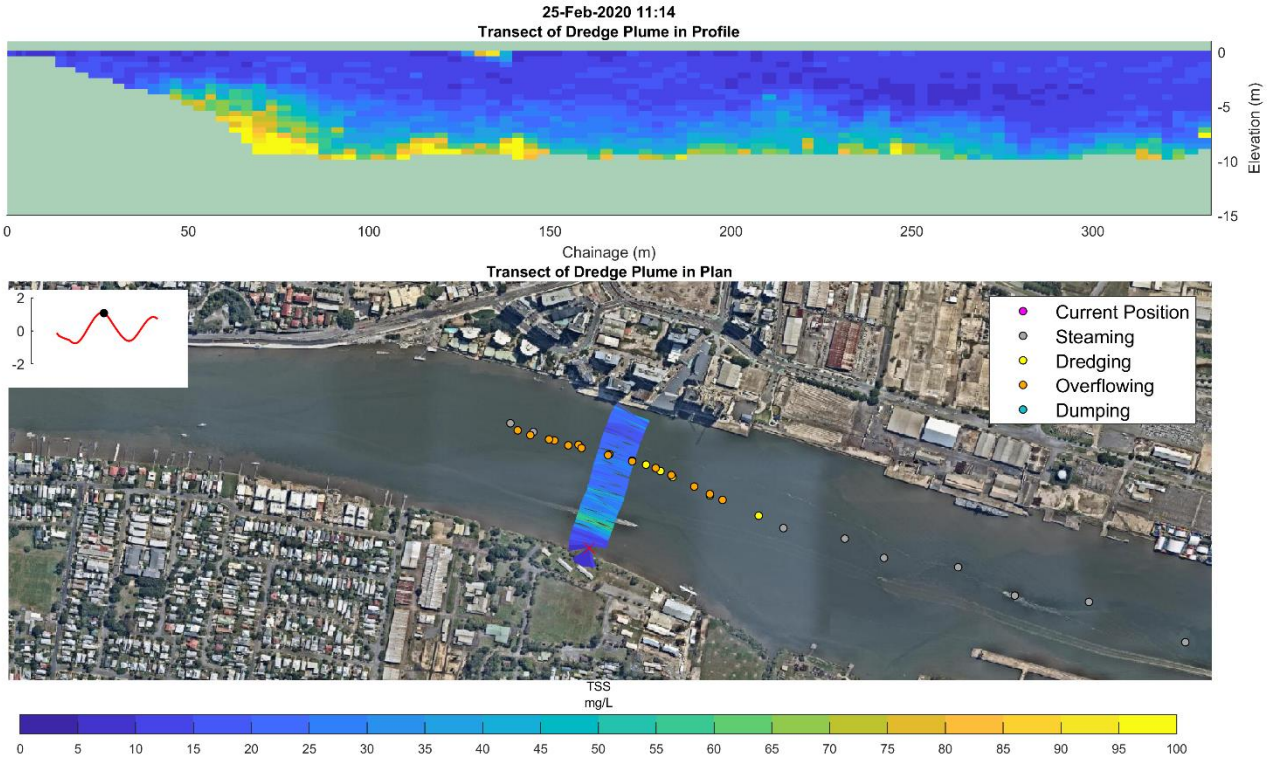
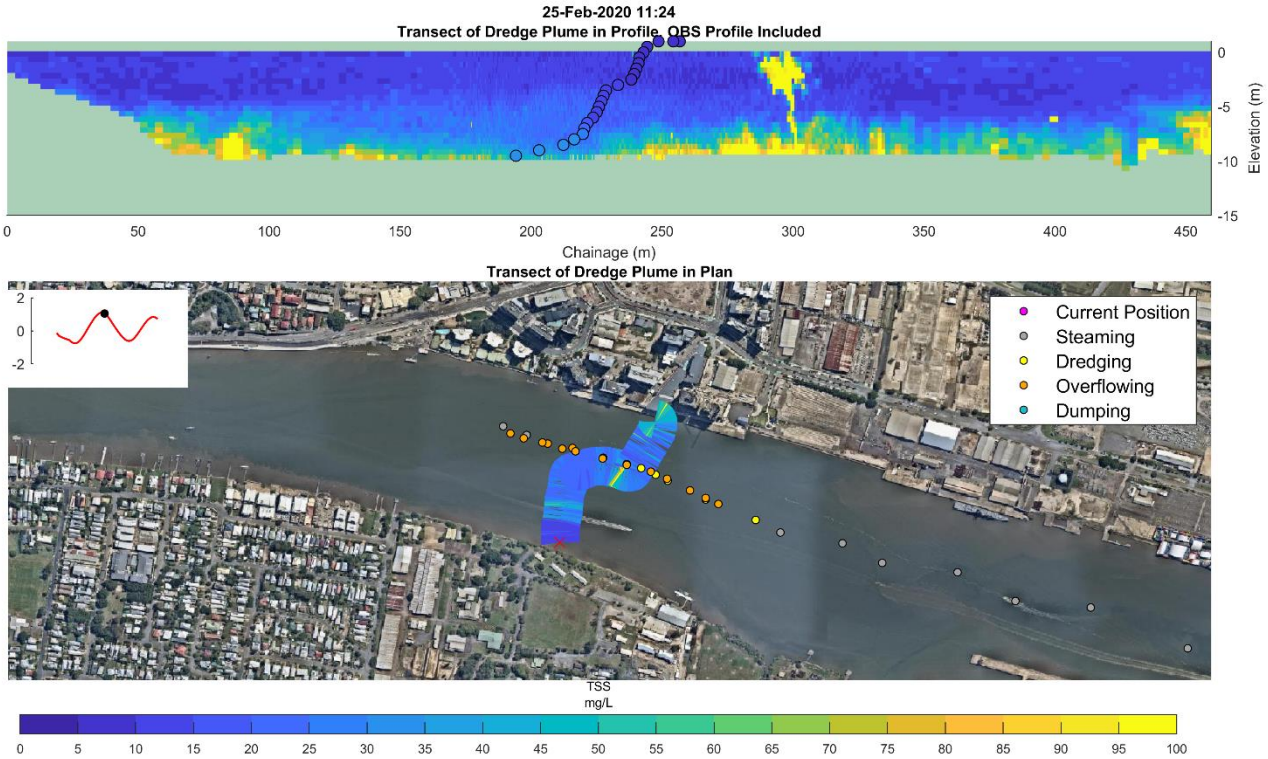


PSD 6: Mud Island DMPA, 16:57 27/02/2020

Appendix C Hamilton Reach (North Bank) Transect Plots





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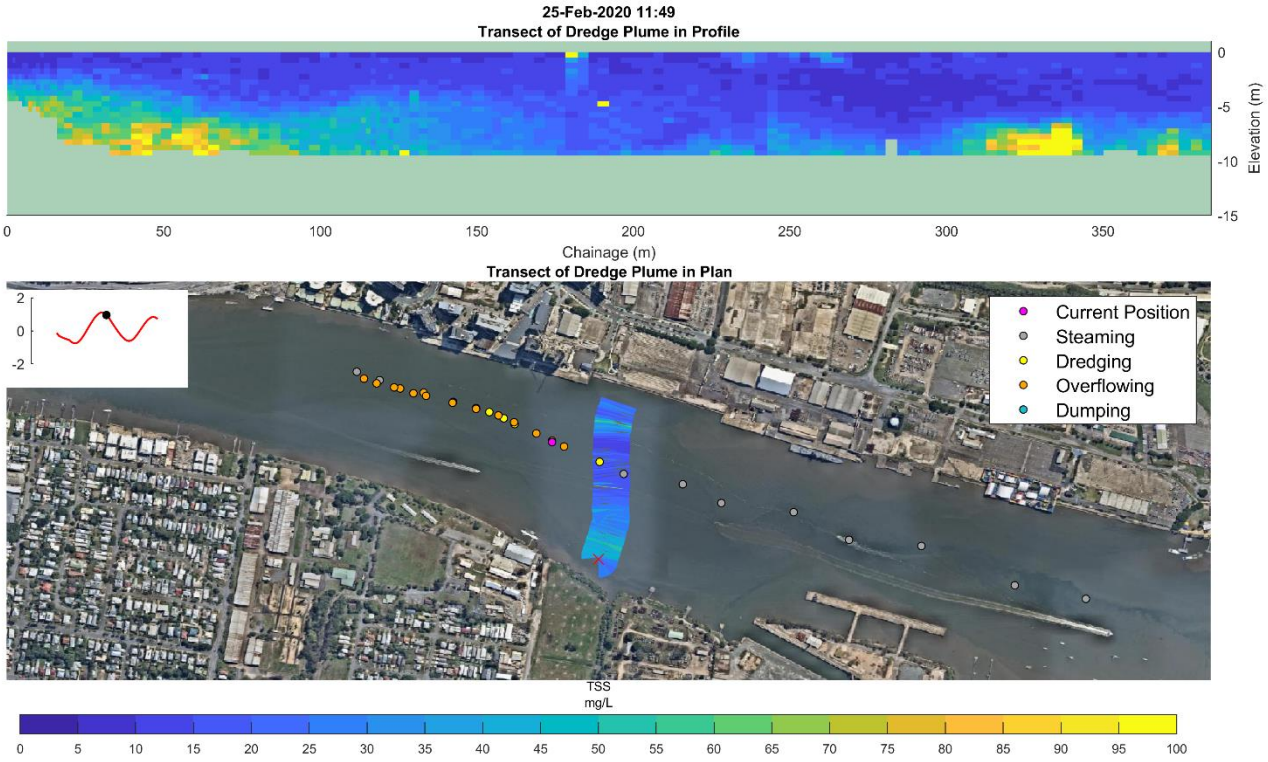

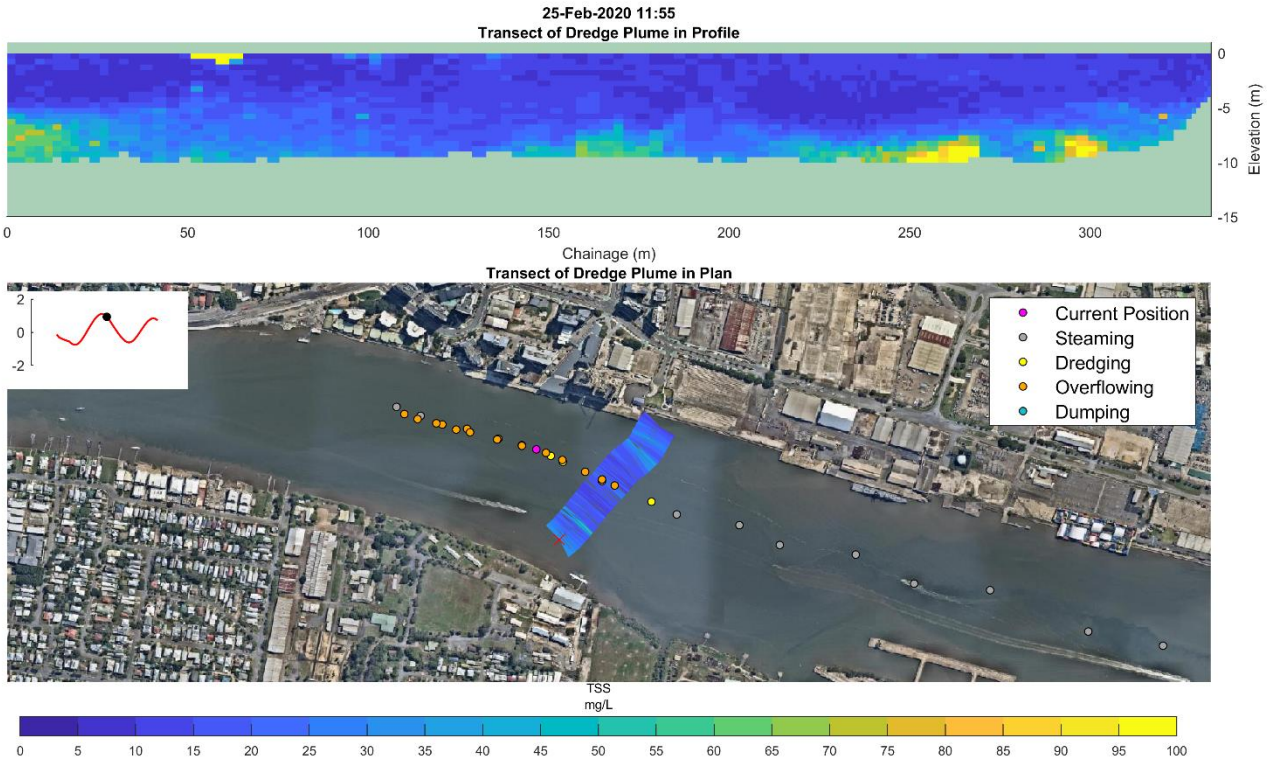

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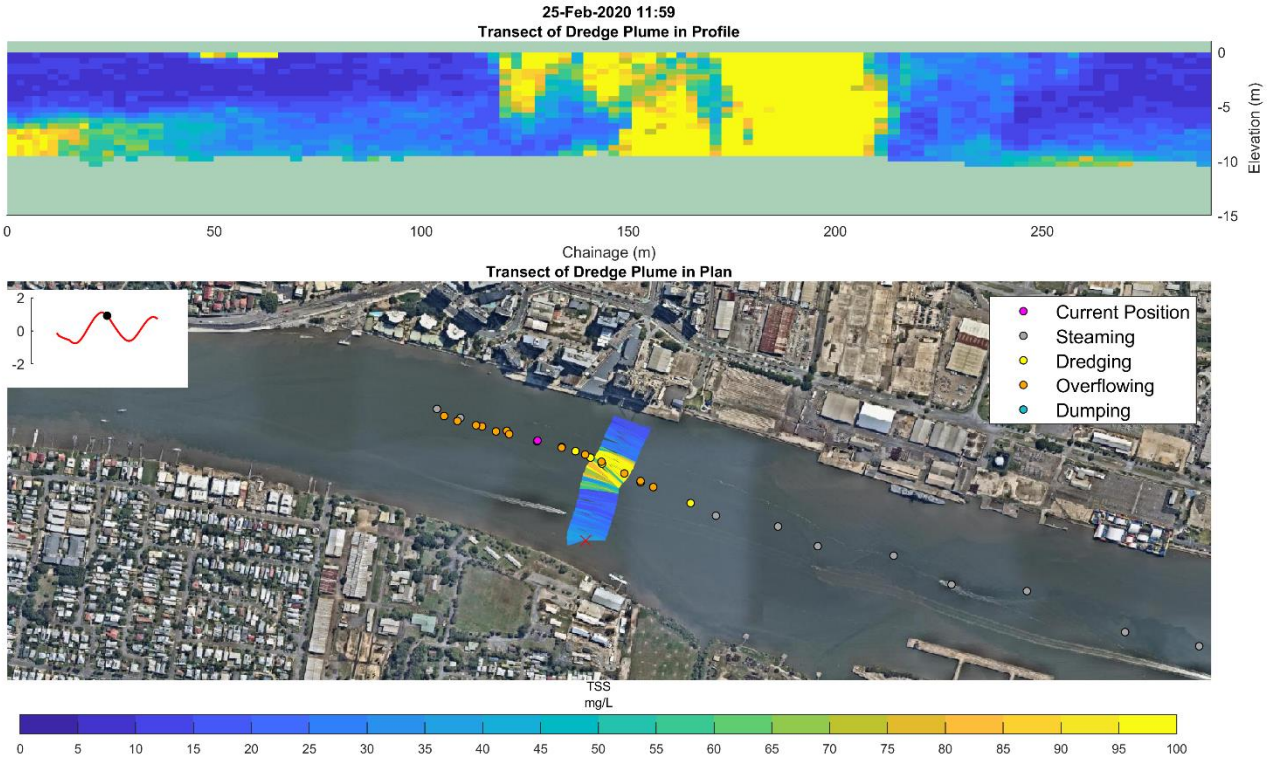

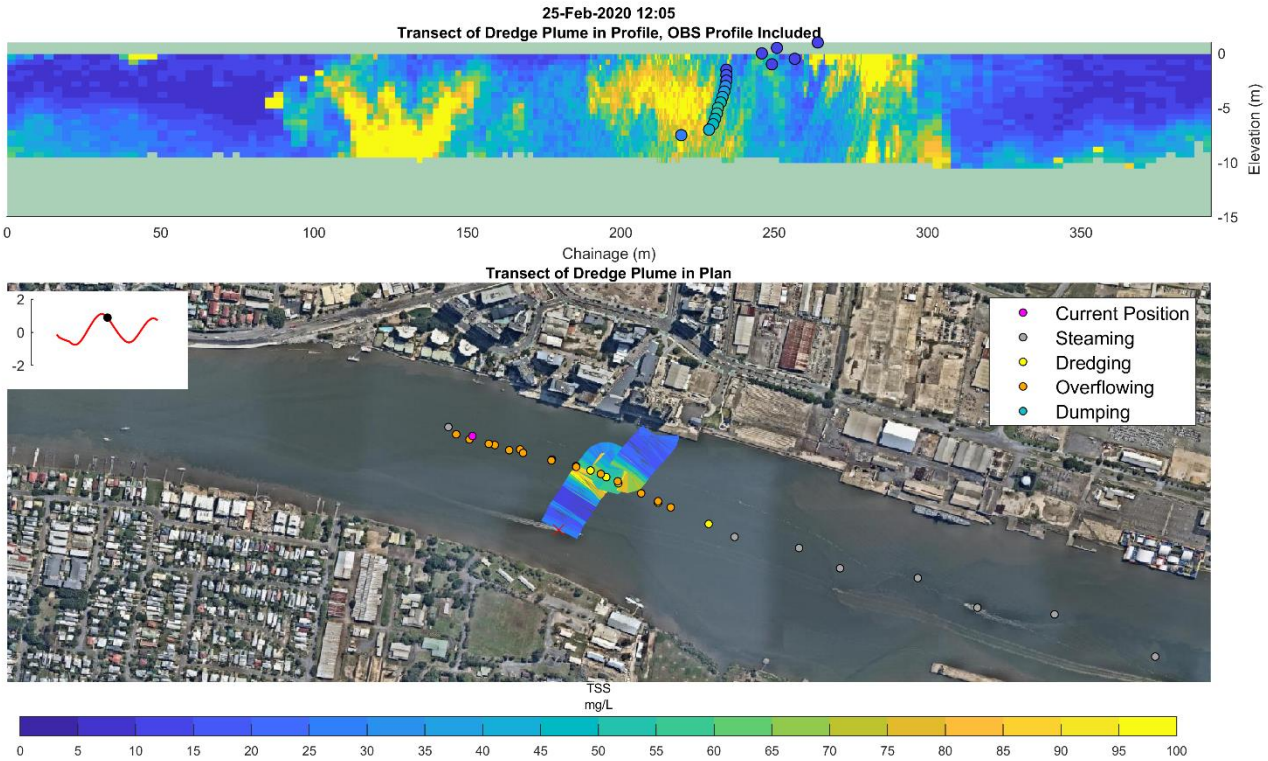

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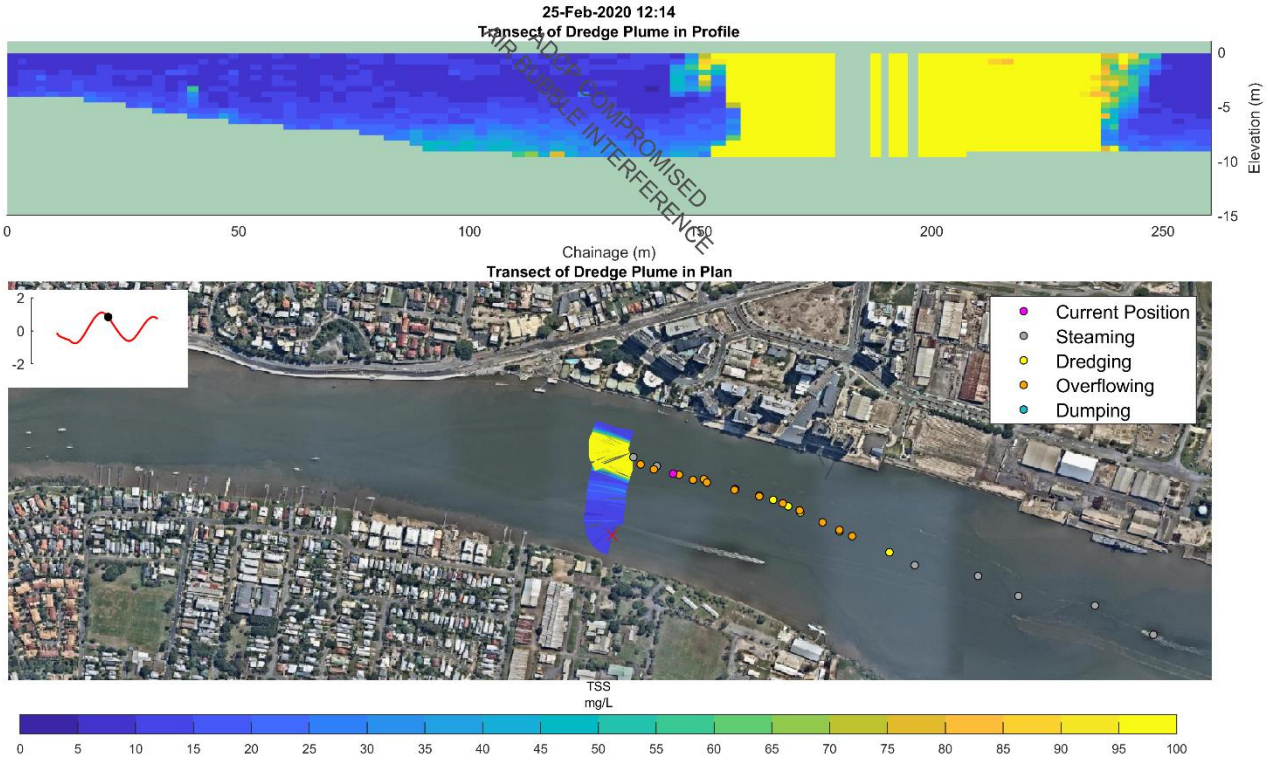

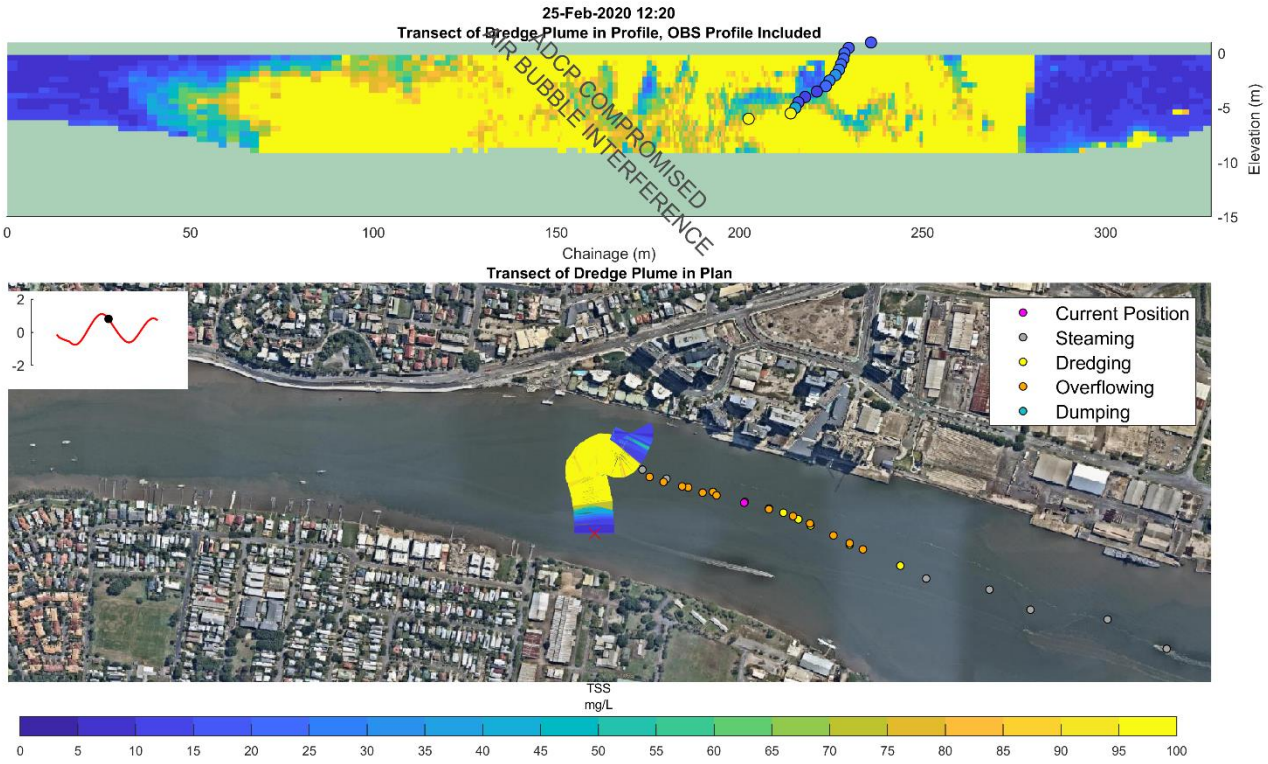

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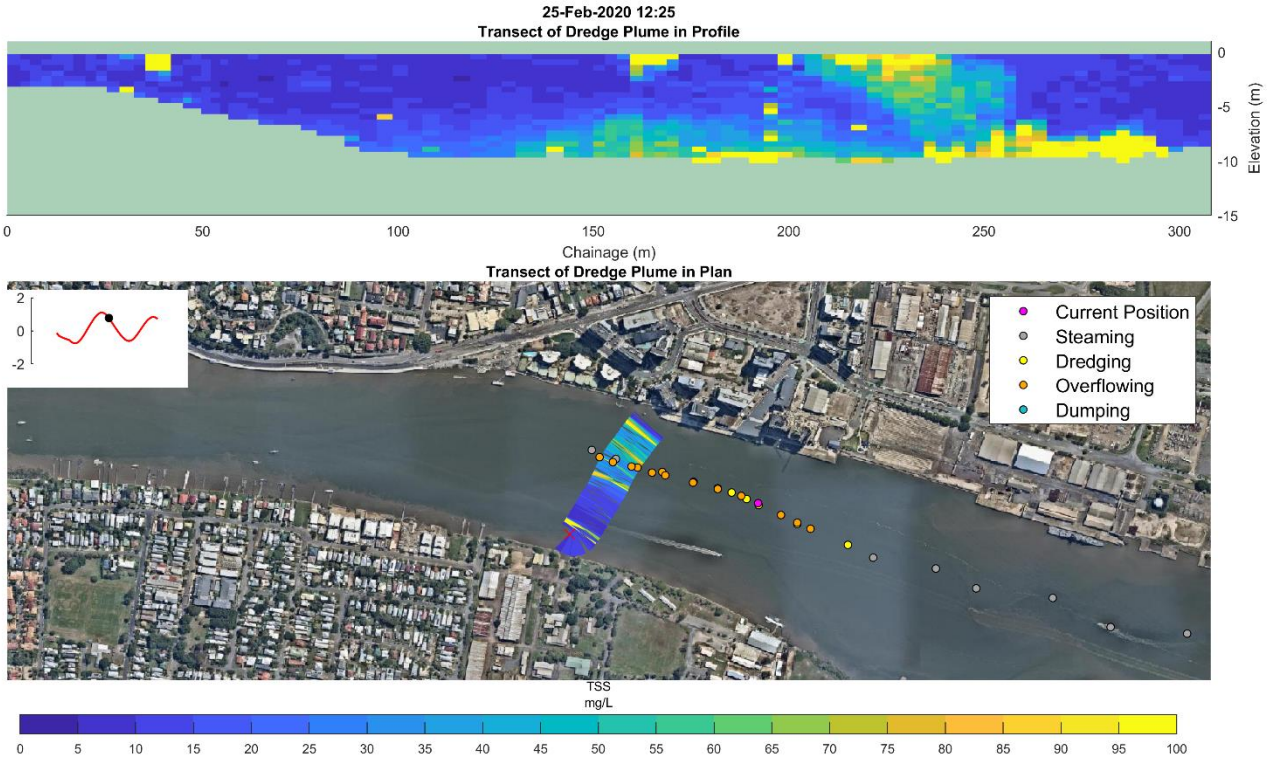

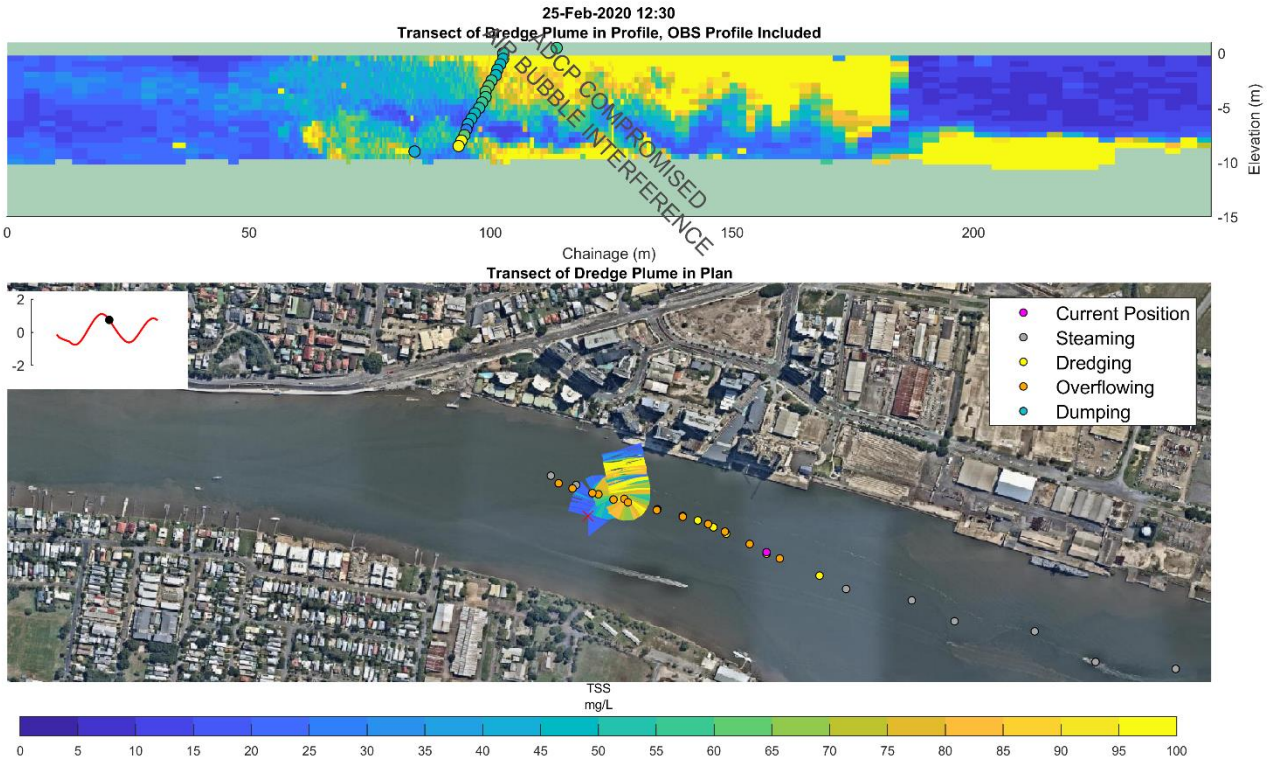

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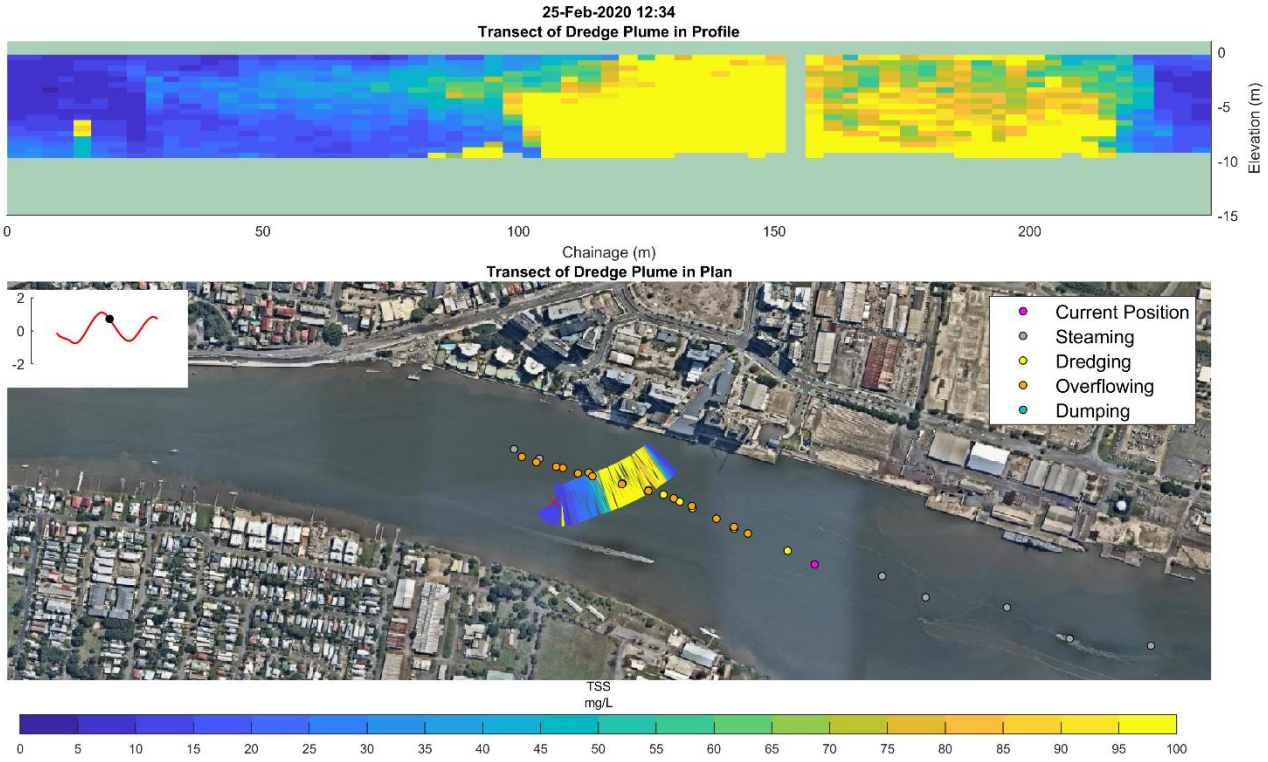

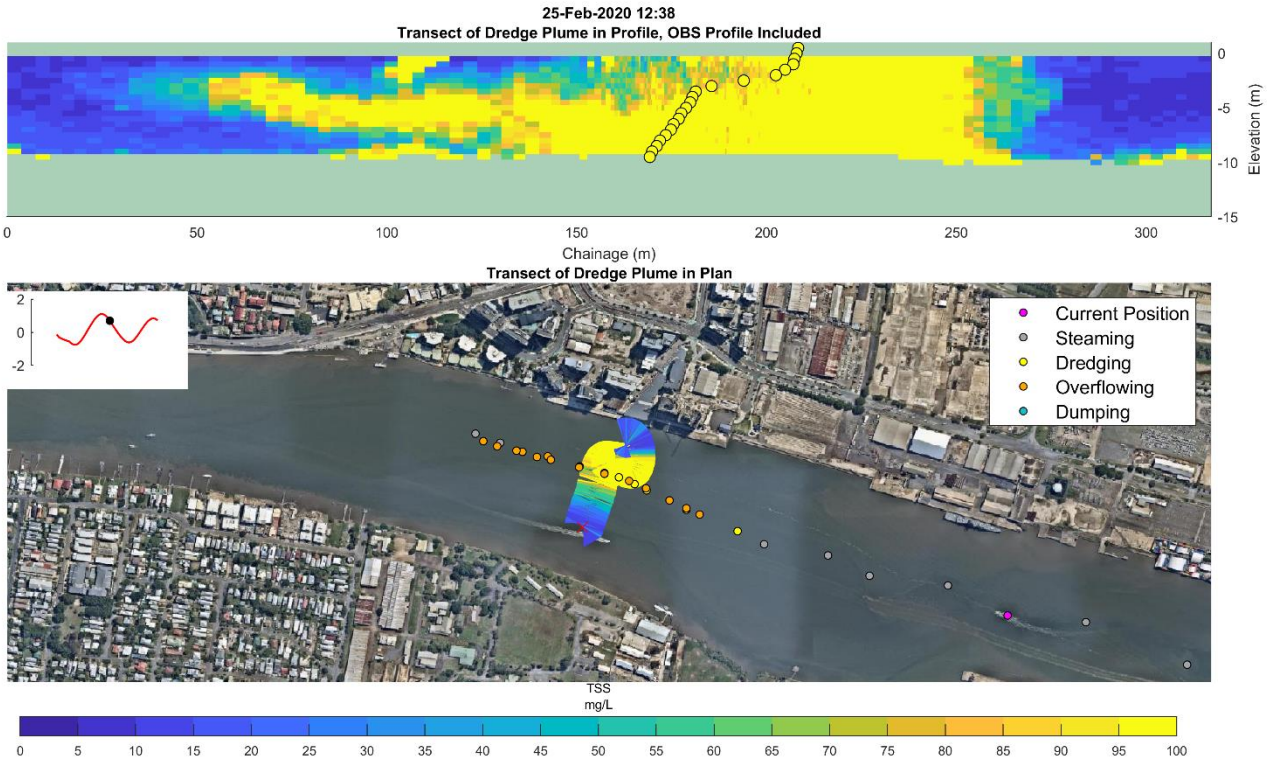

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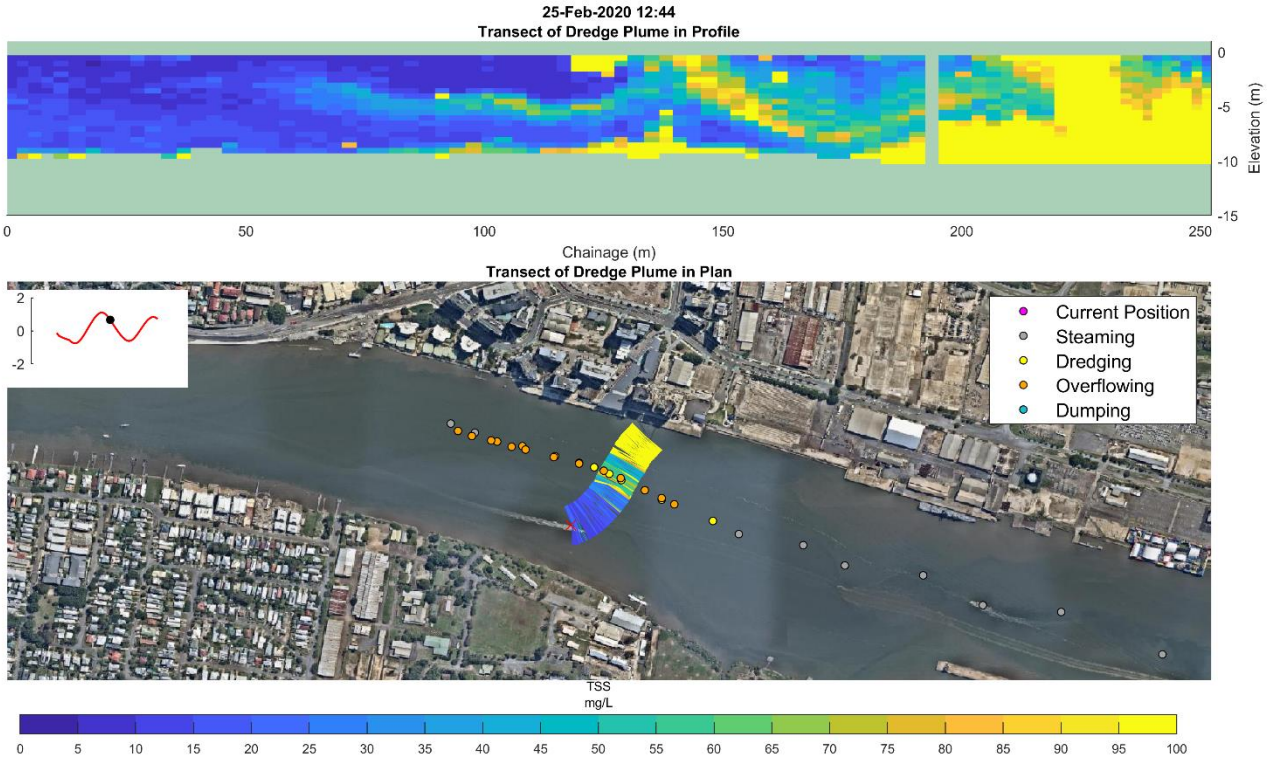

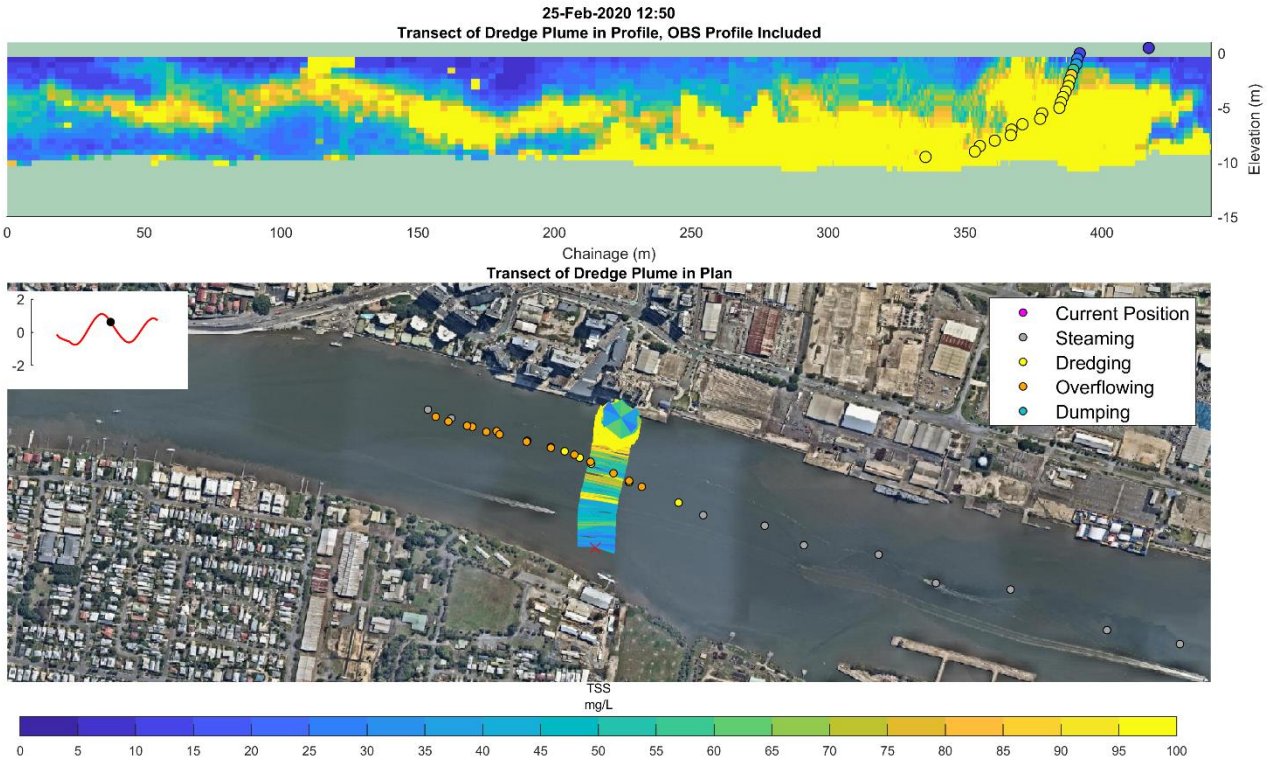

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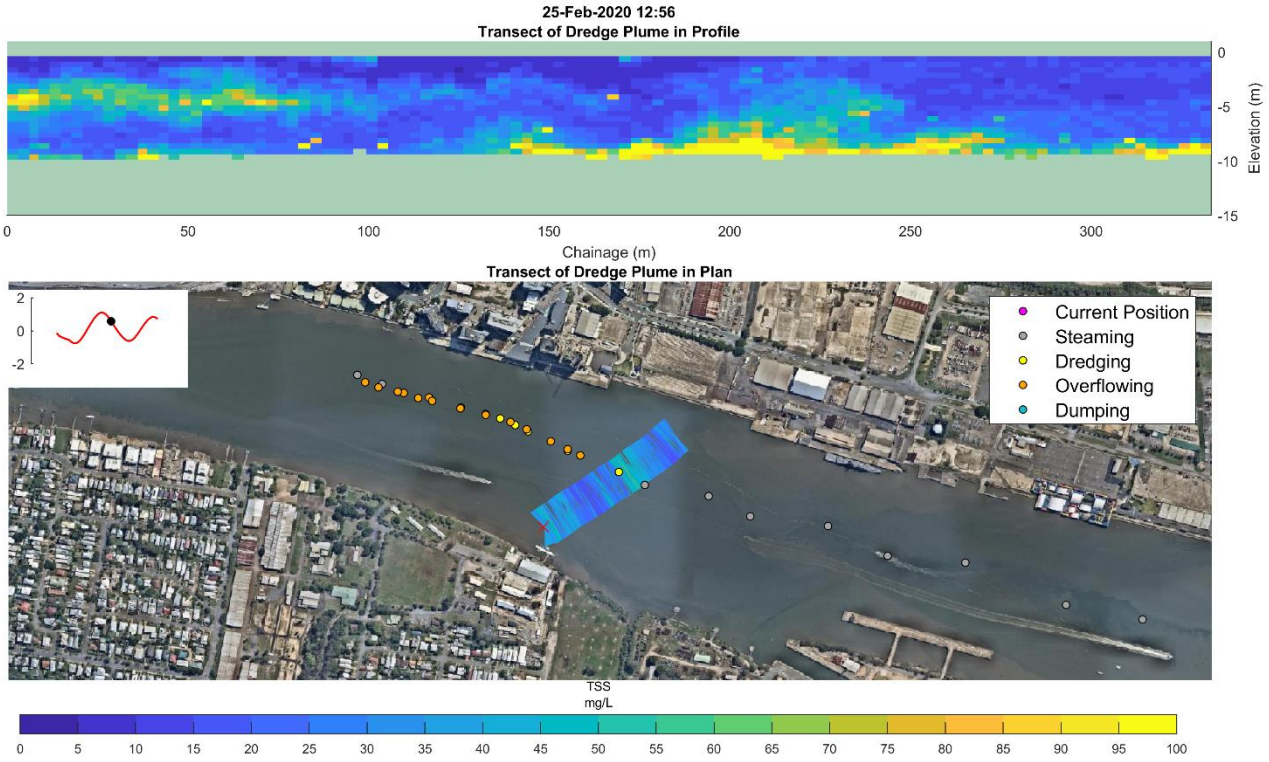

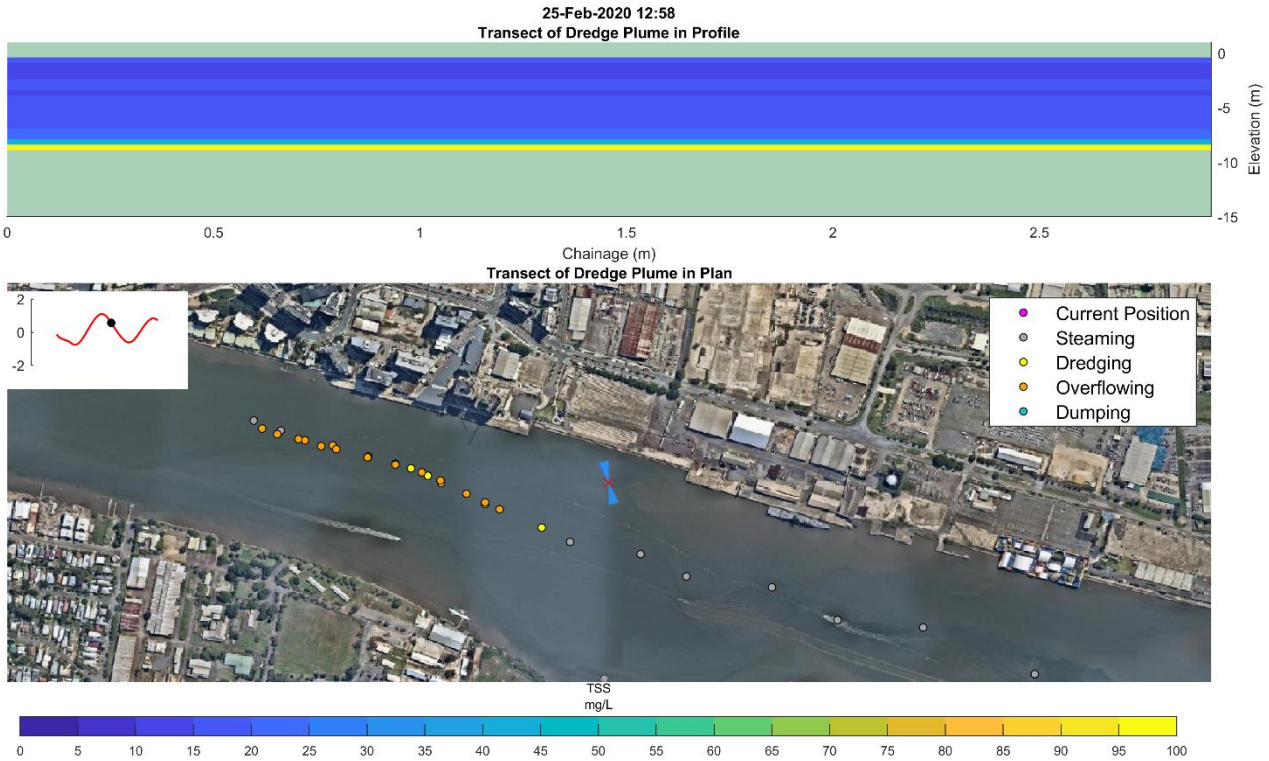

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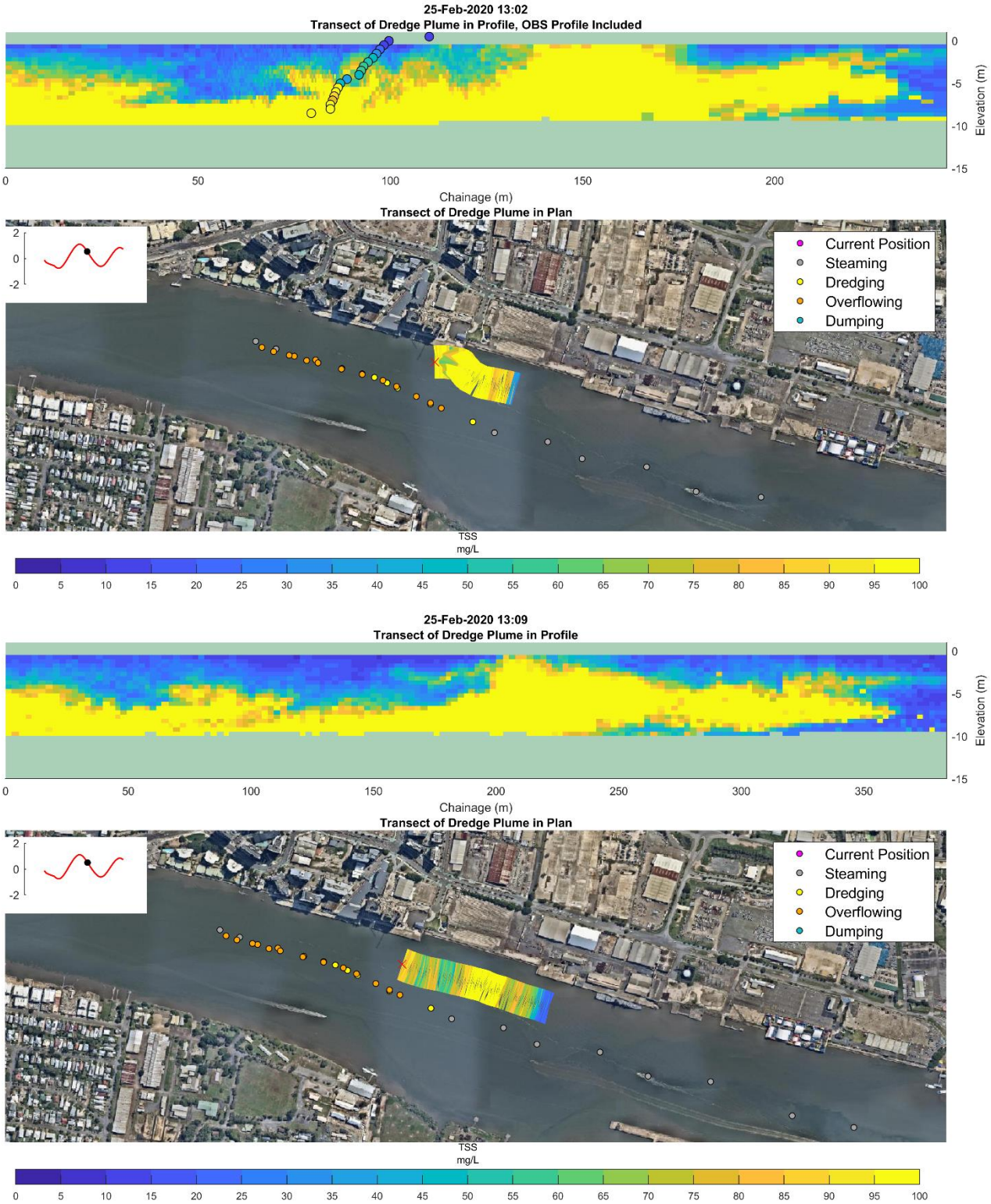

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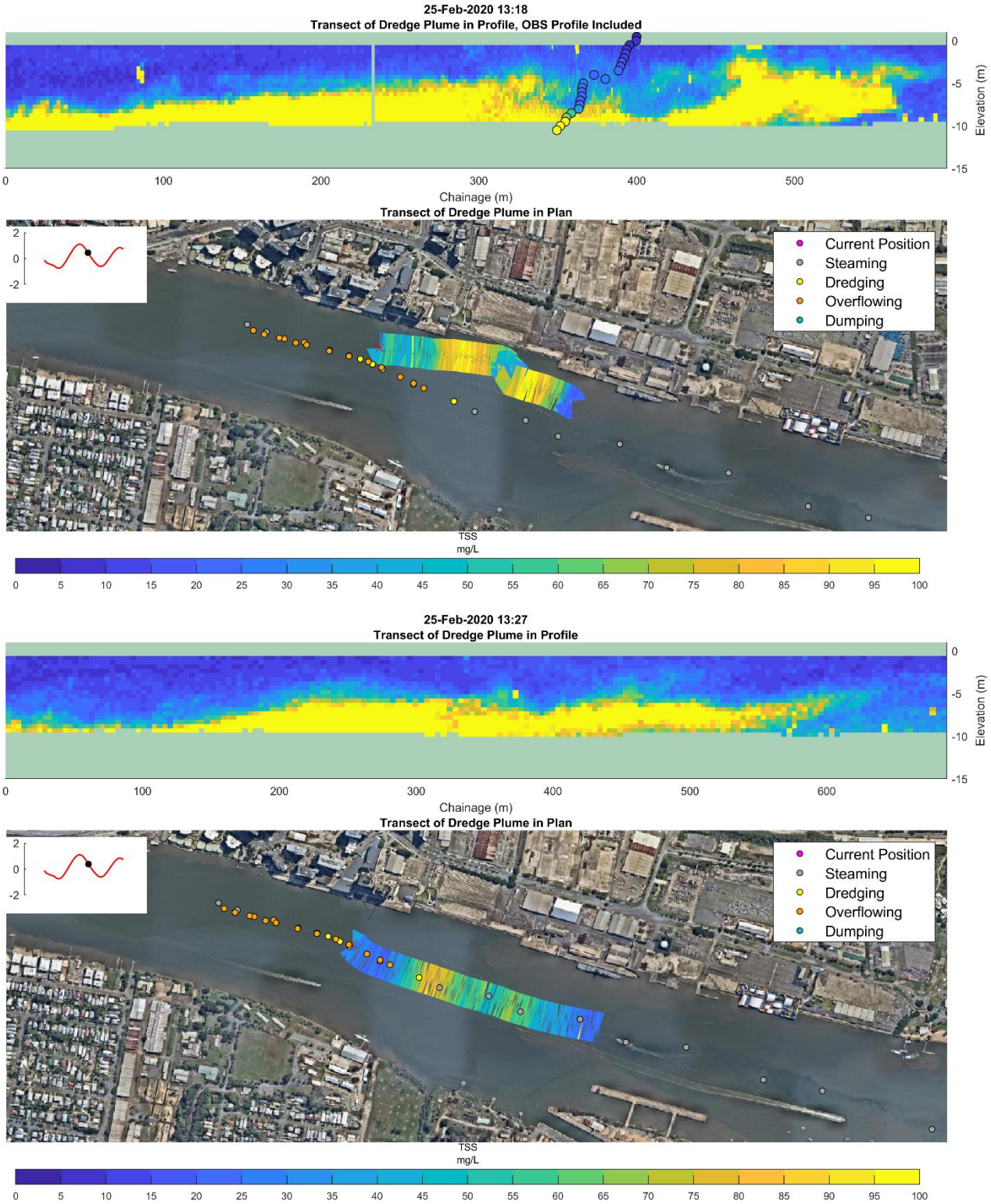

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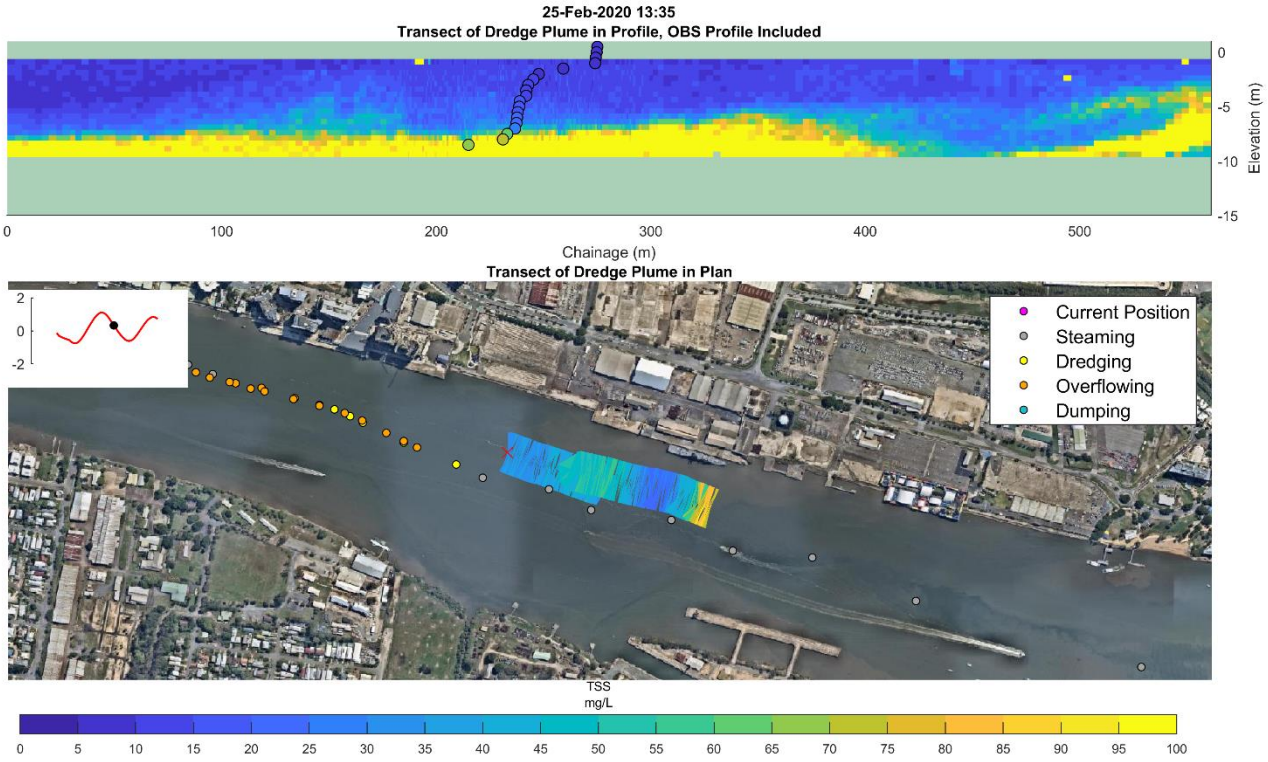

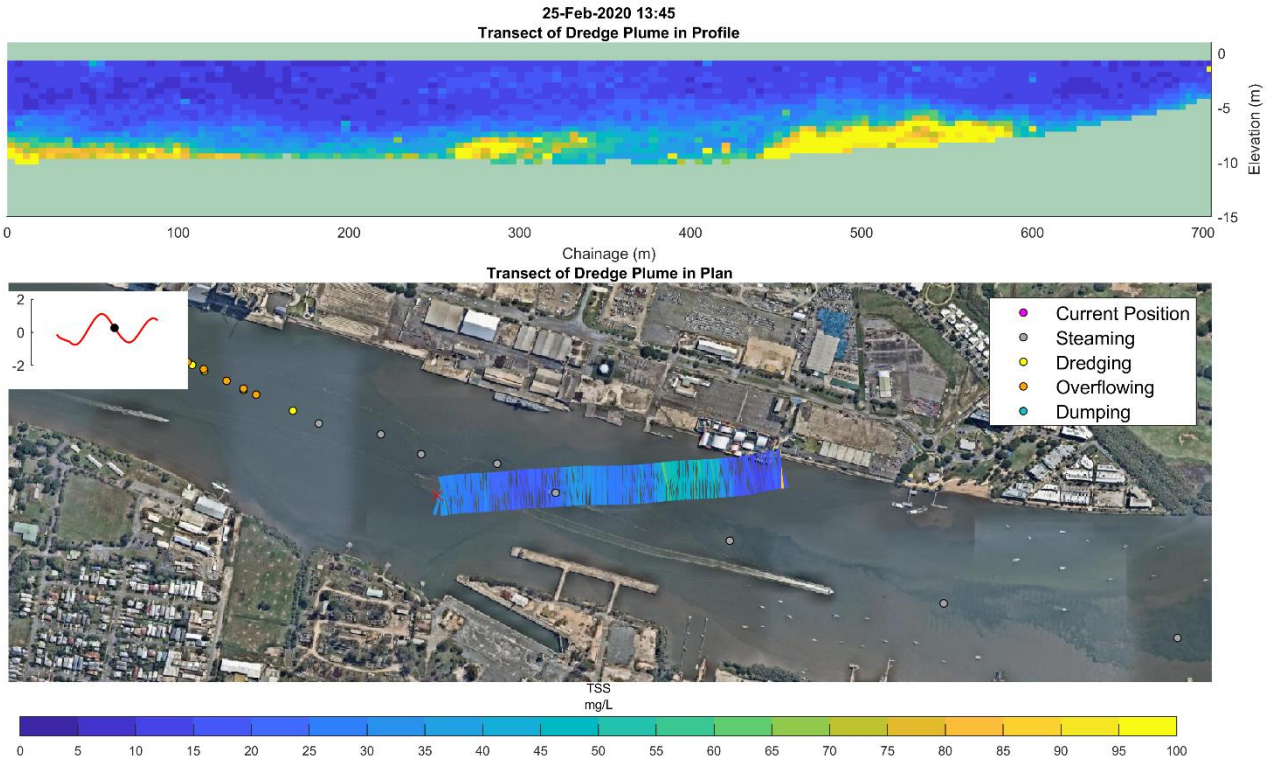

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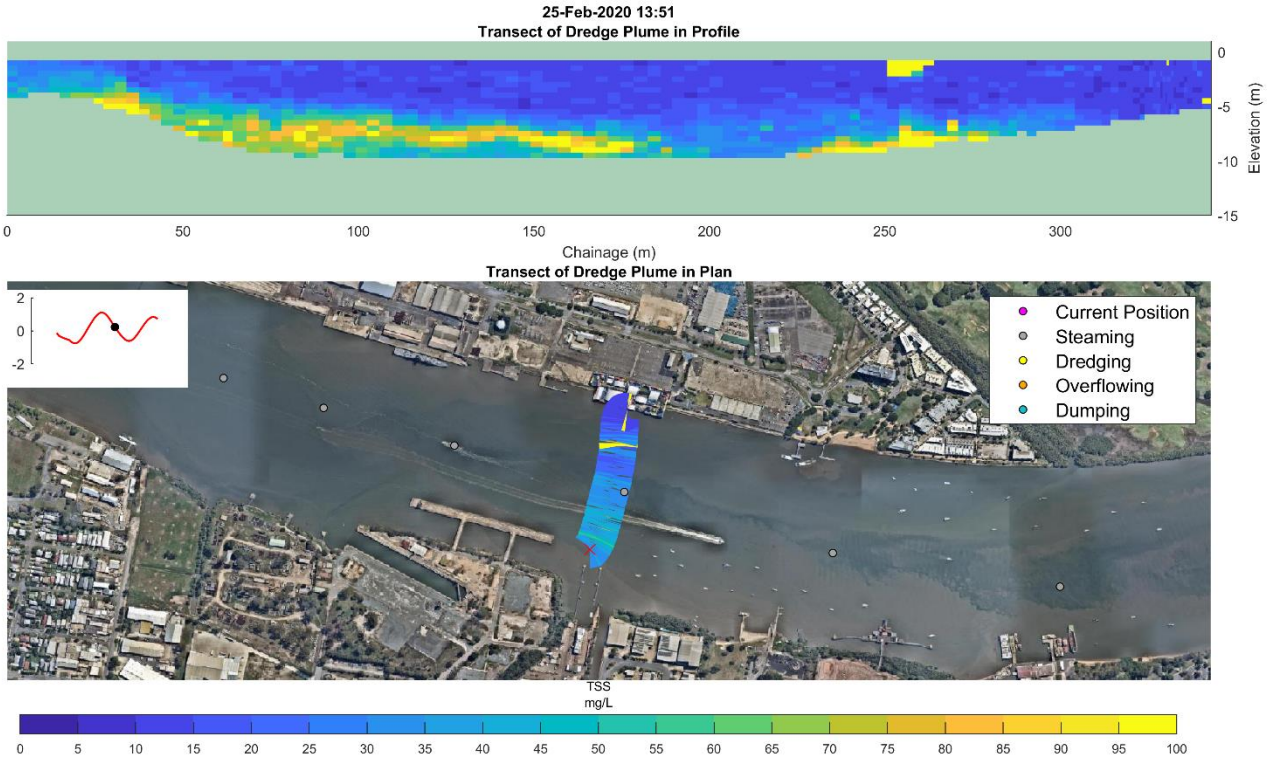
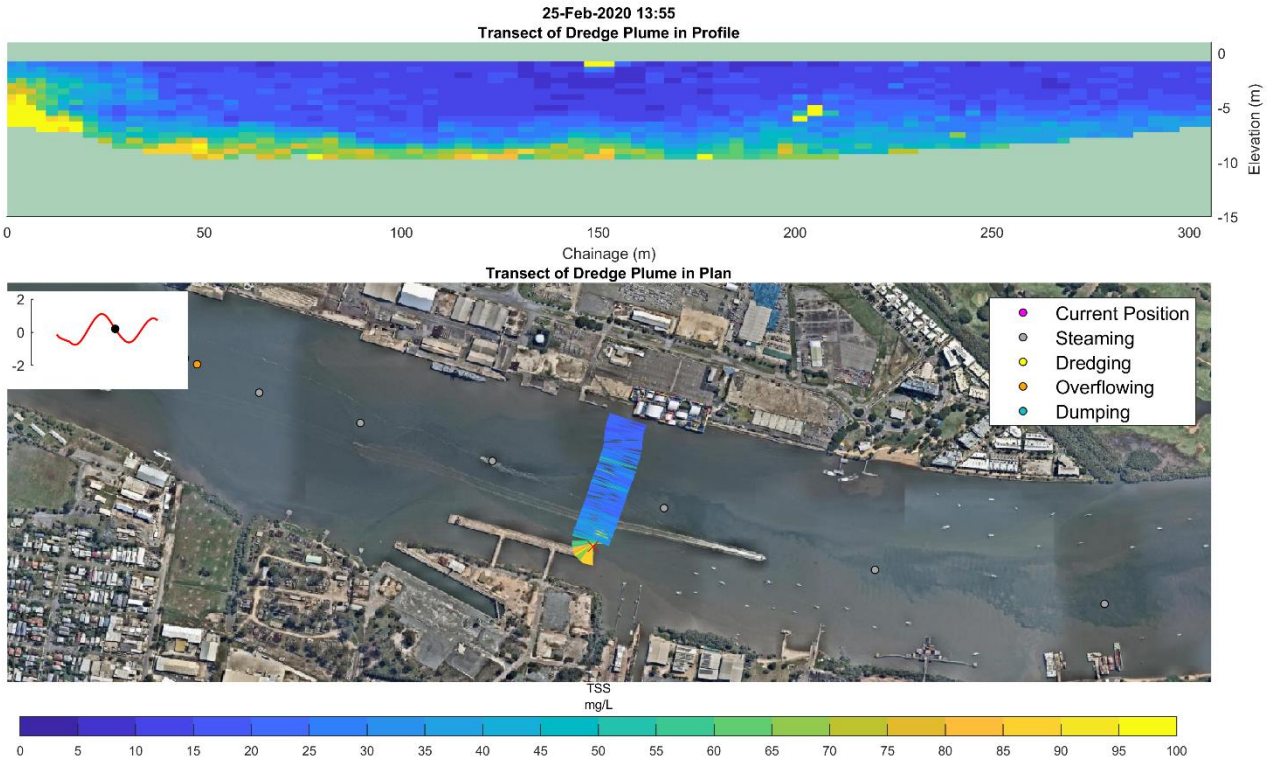
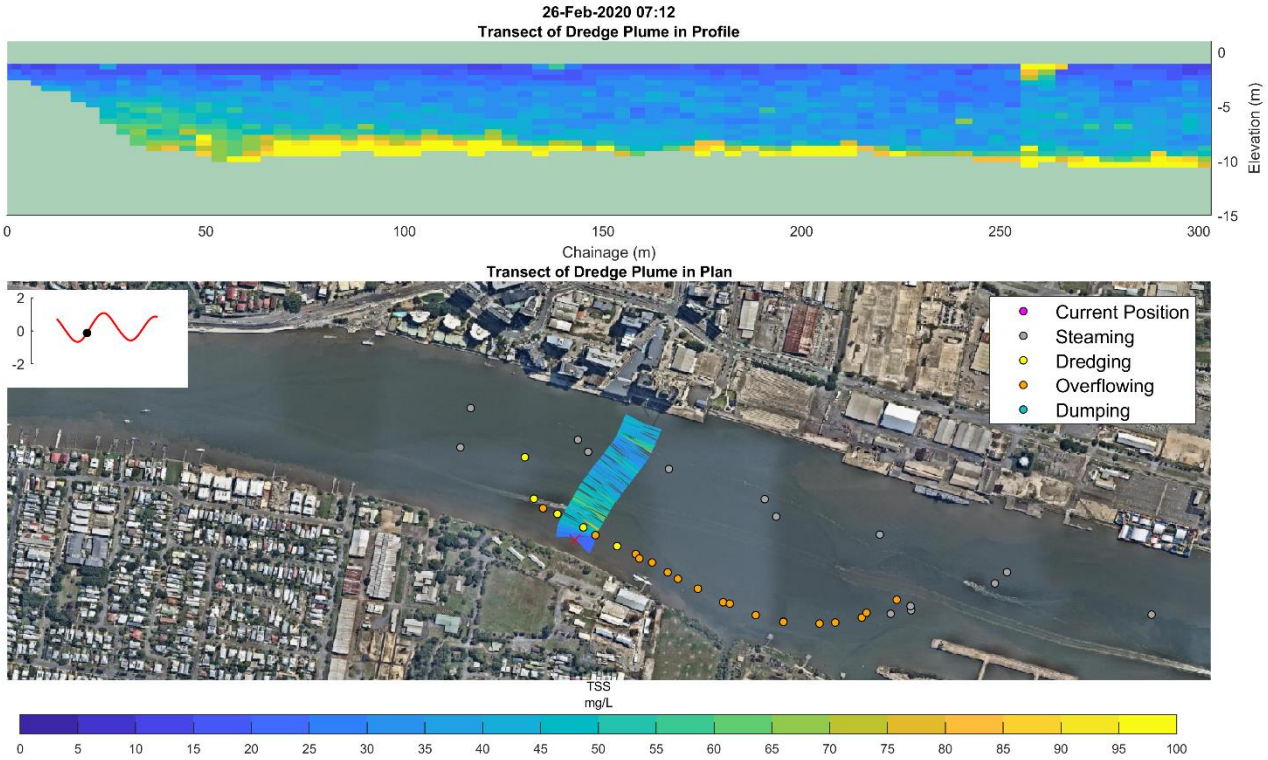
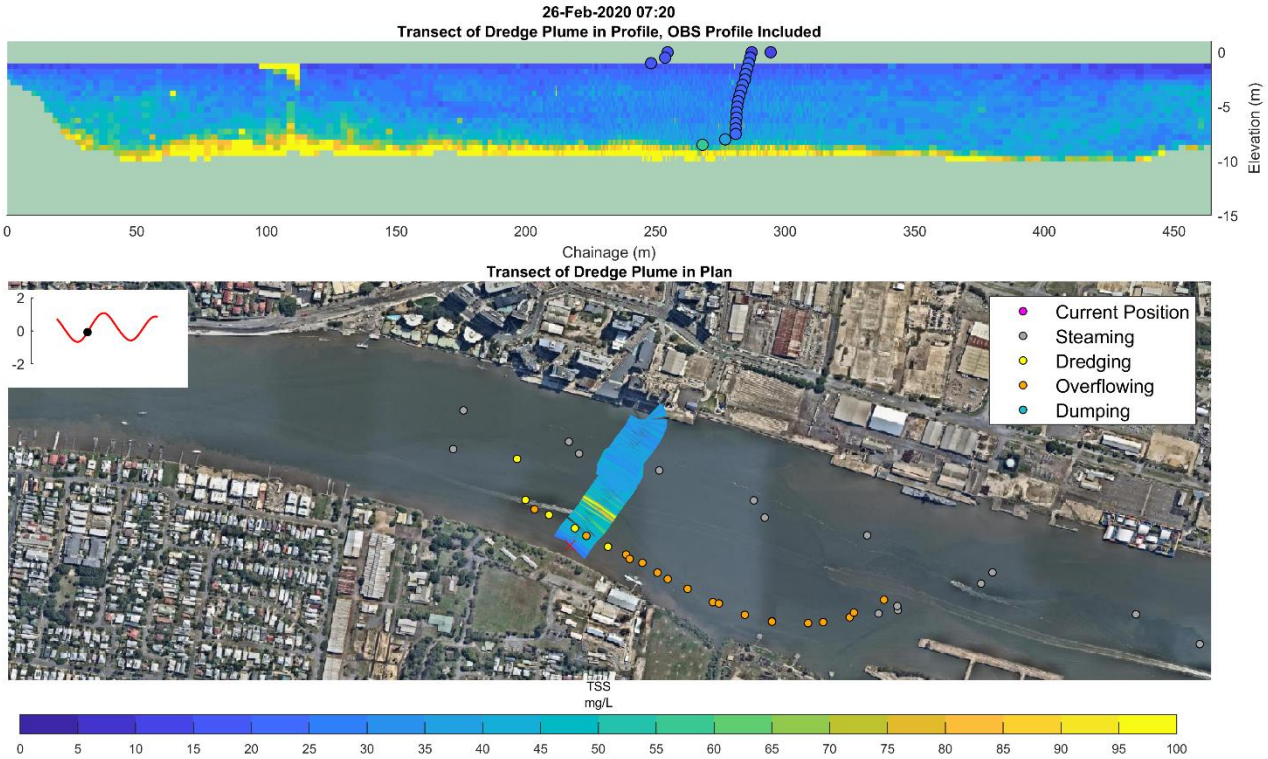


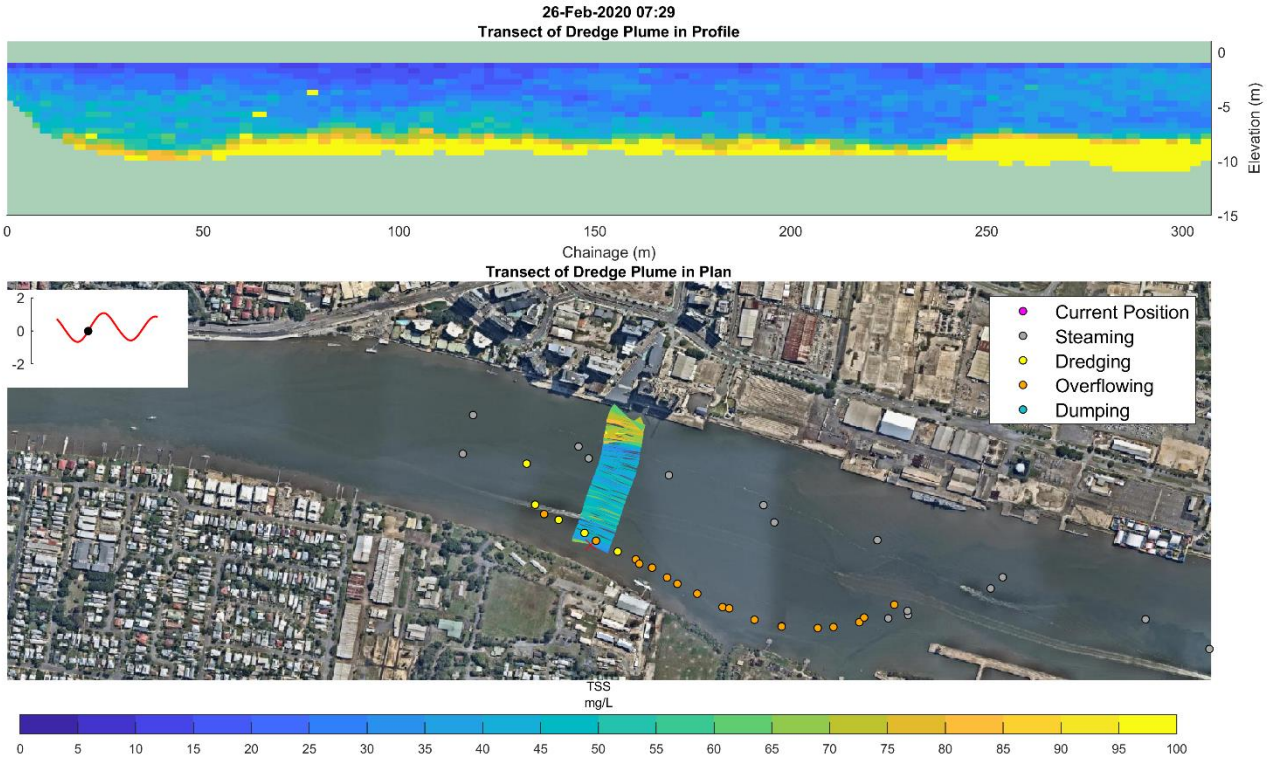


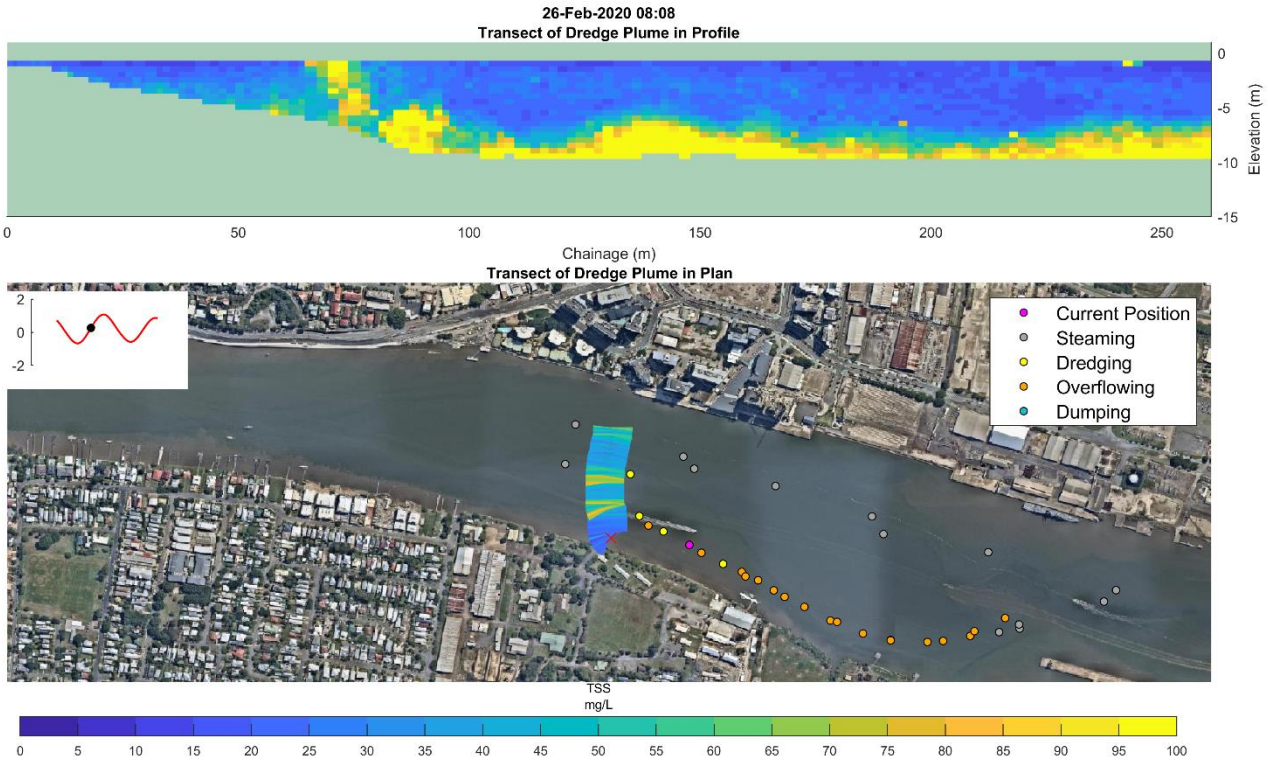
Appendix D Hamilton Reach (South Bank) Transect Plots





Hamilton Reach (South Bank) Transect Plots





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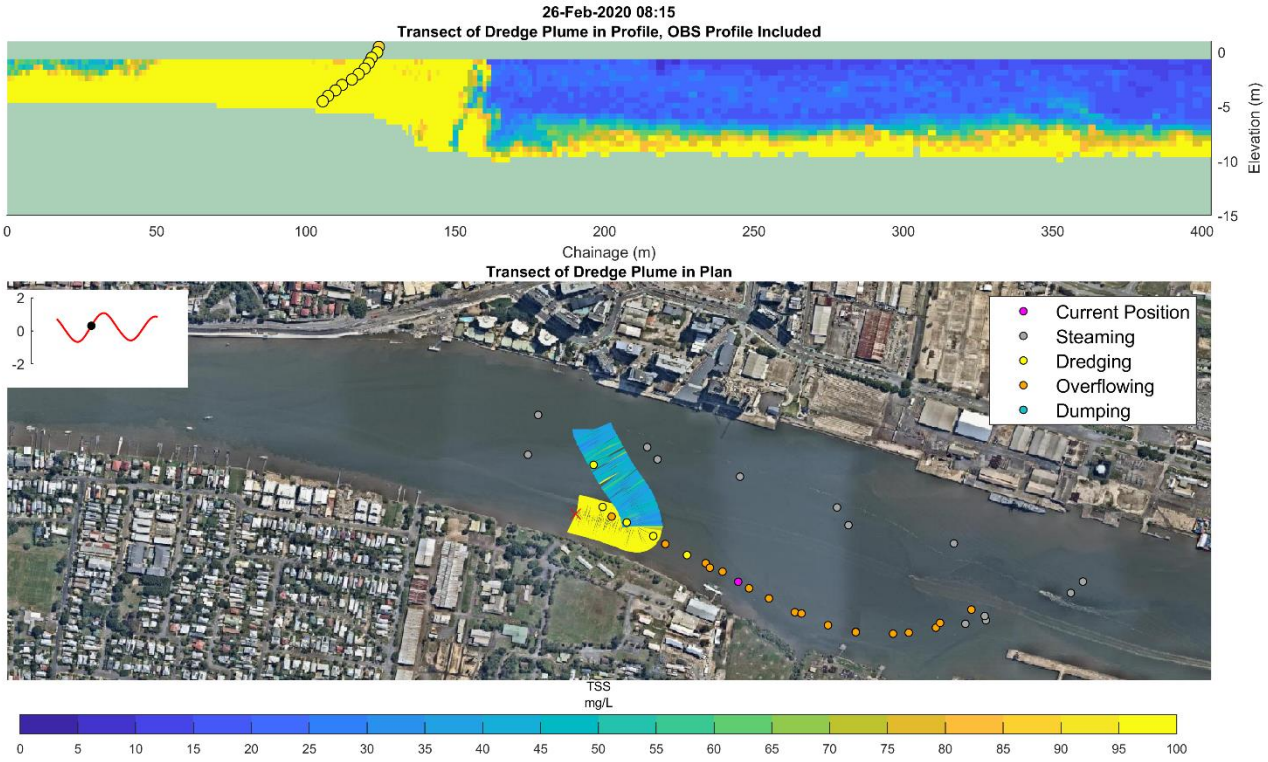

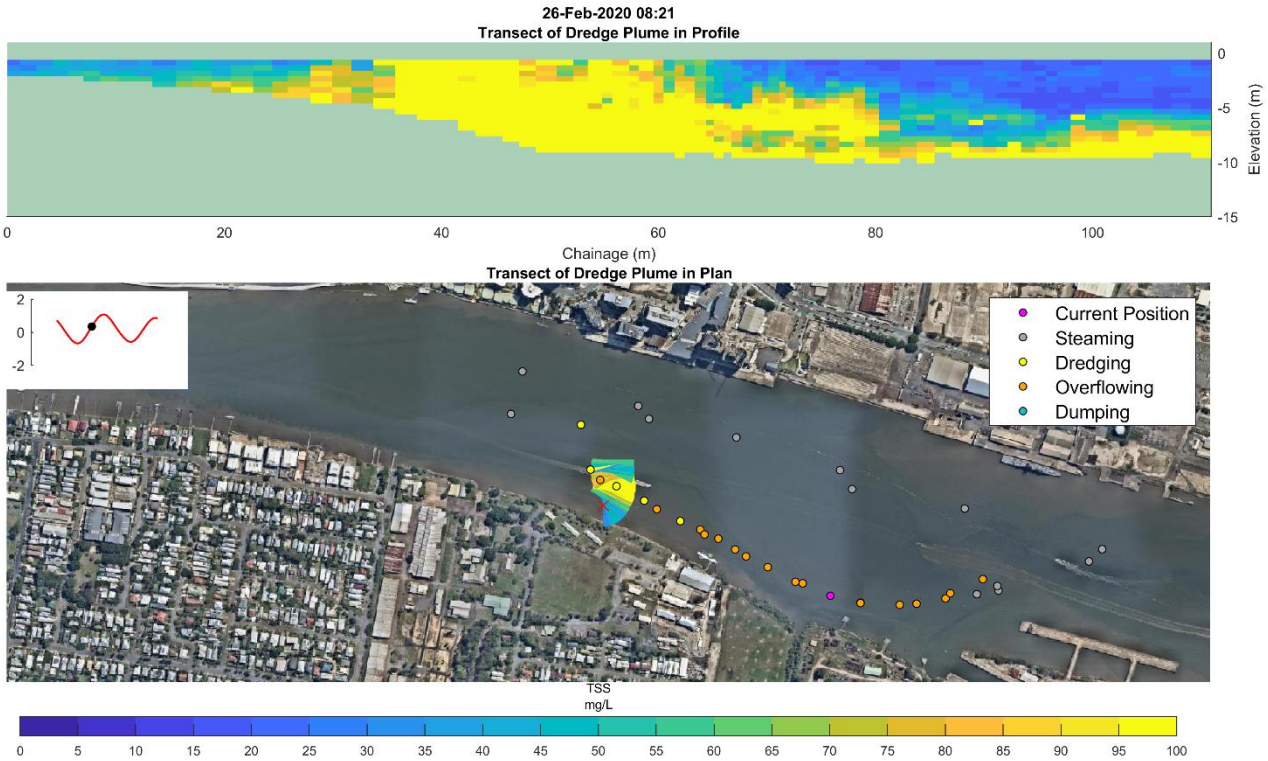

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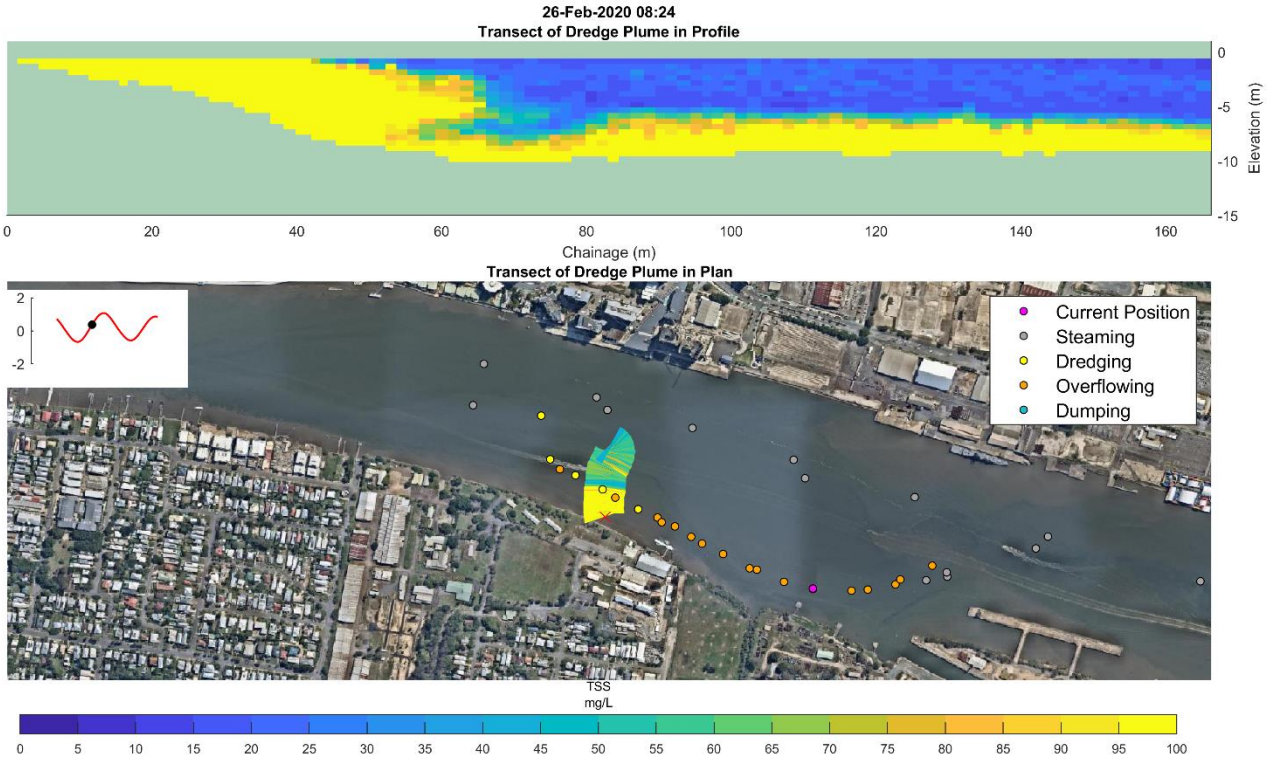

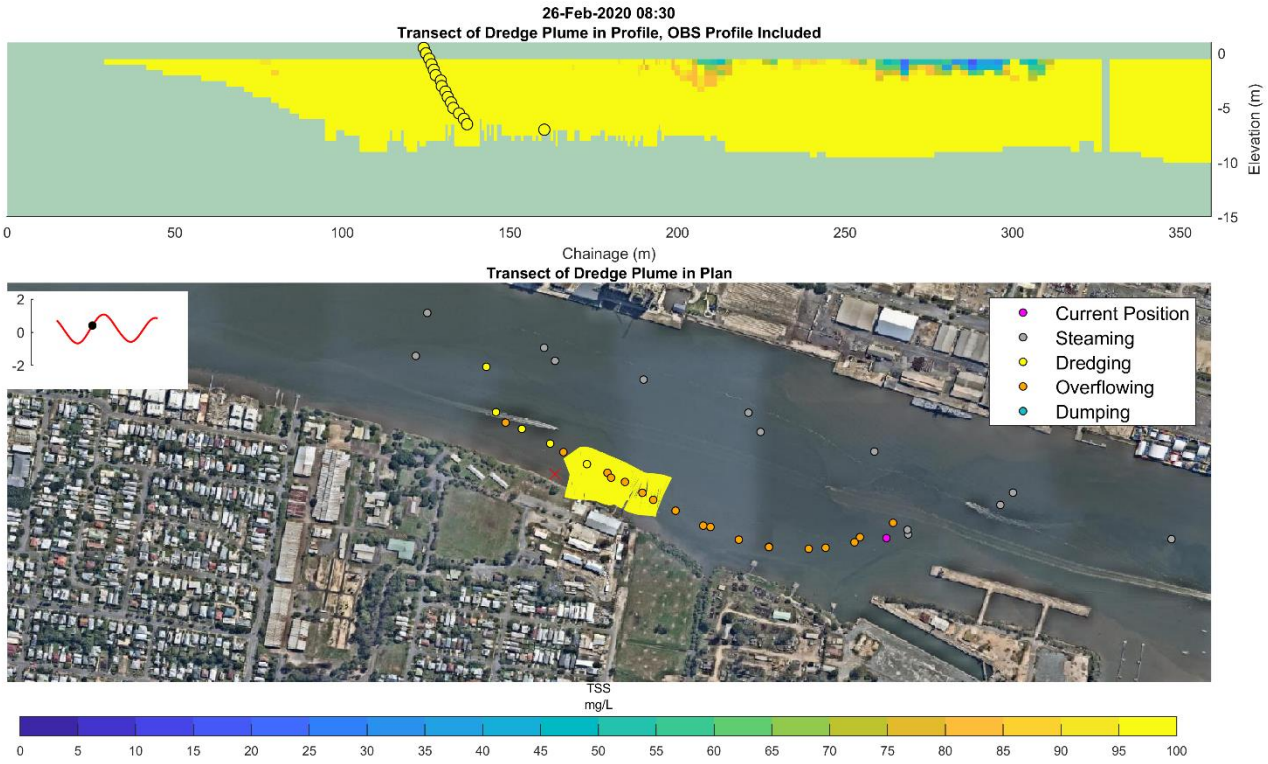

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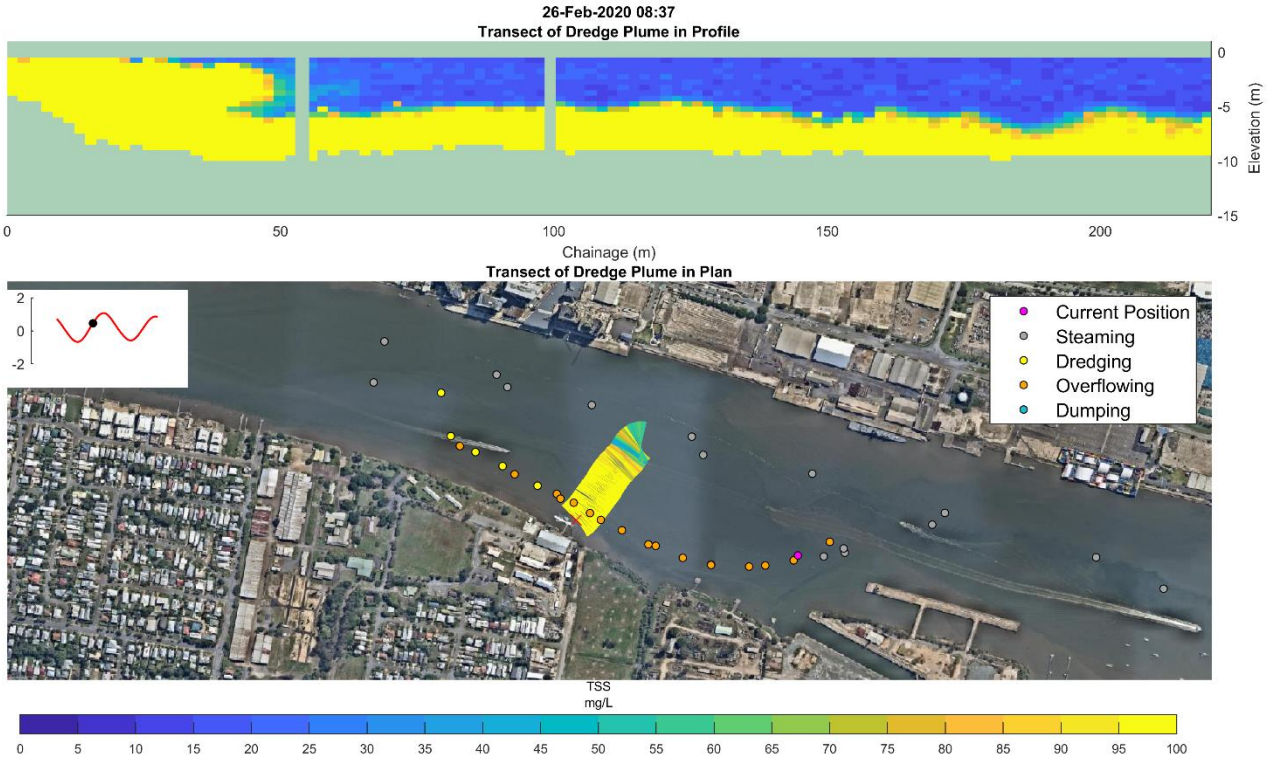
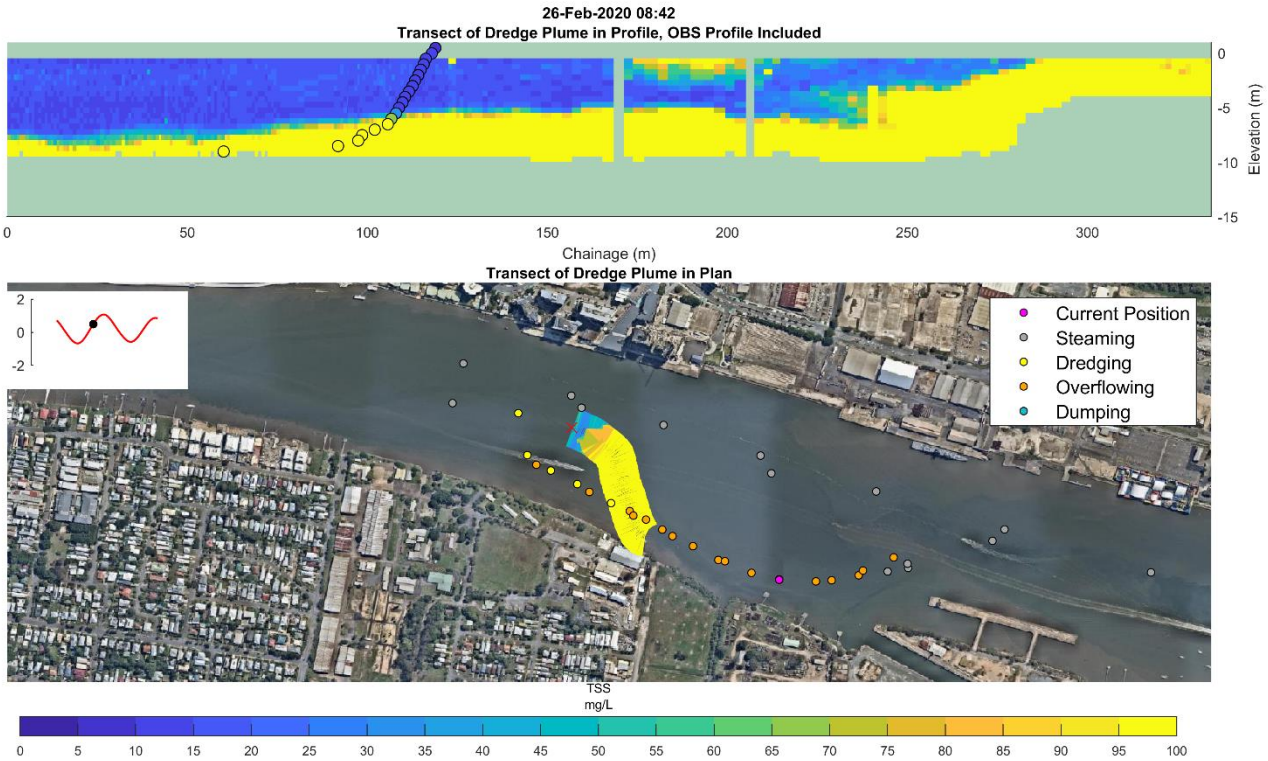
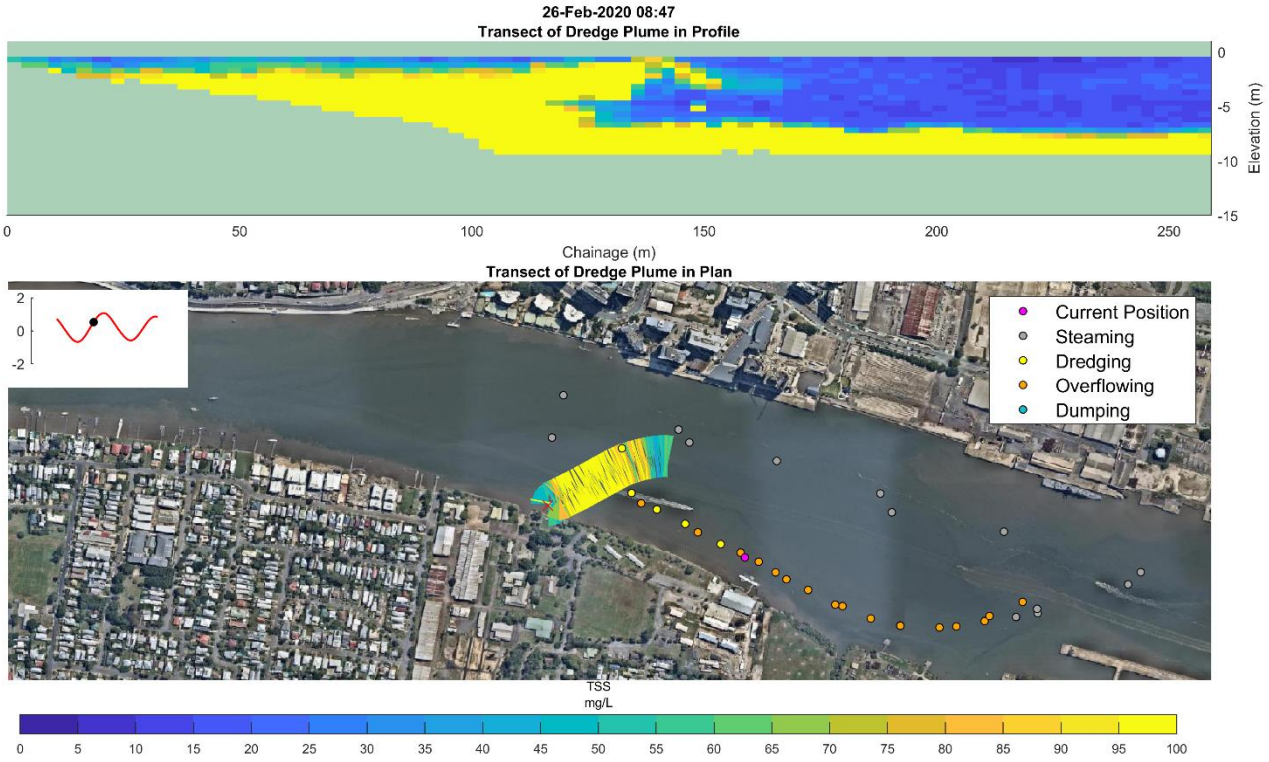
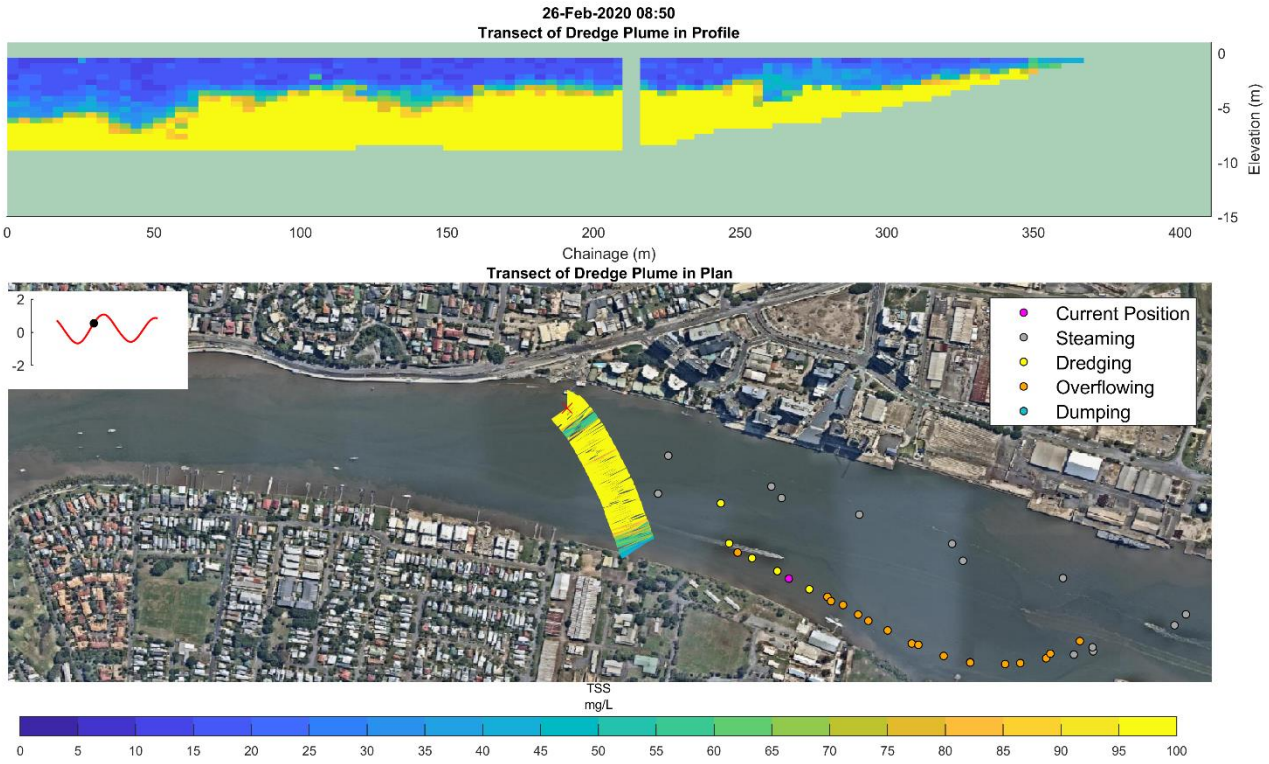




Hamilton Reach (South Bank) Transect Plots





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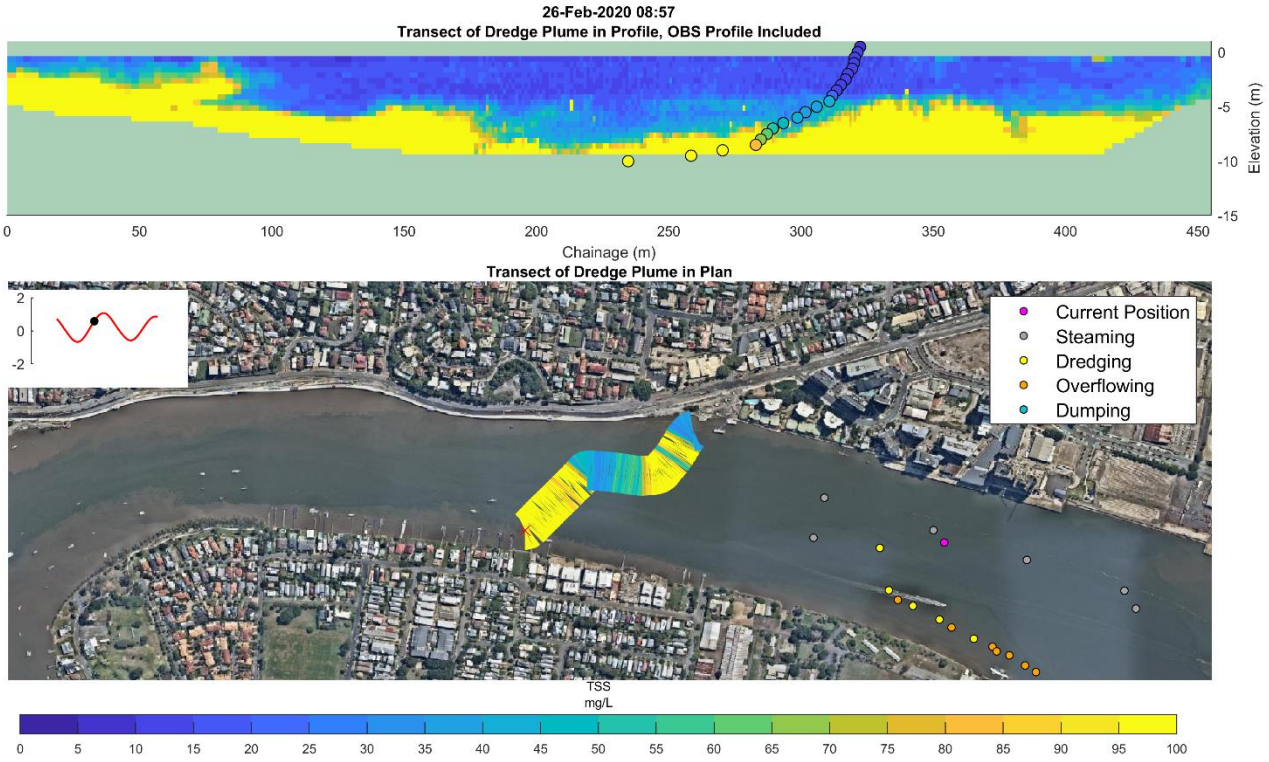

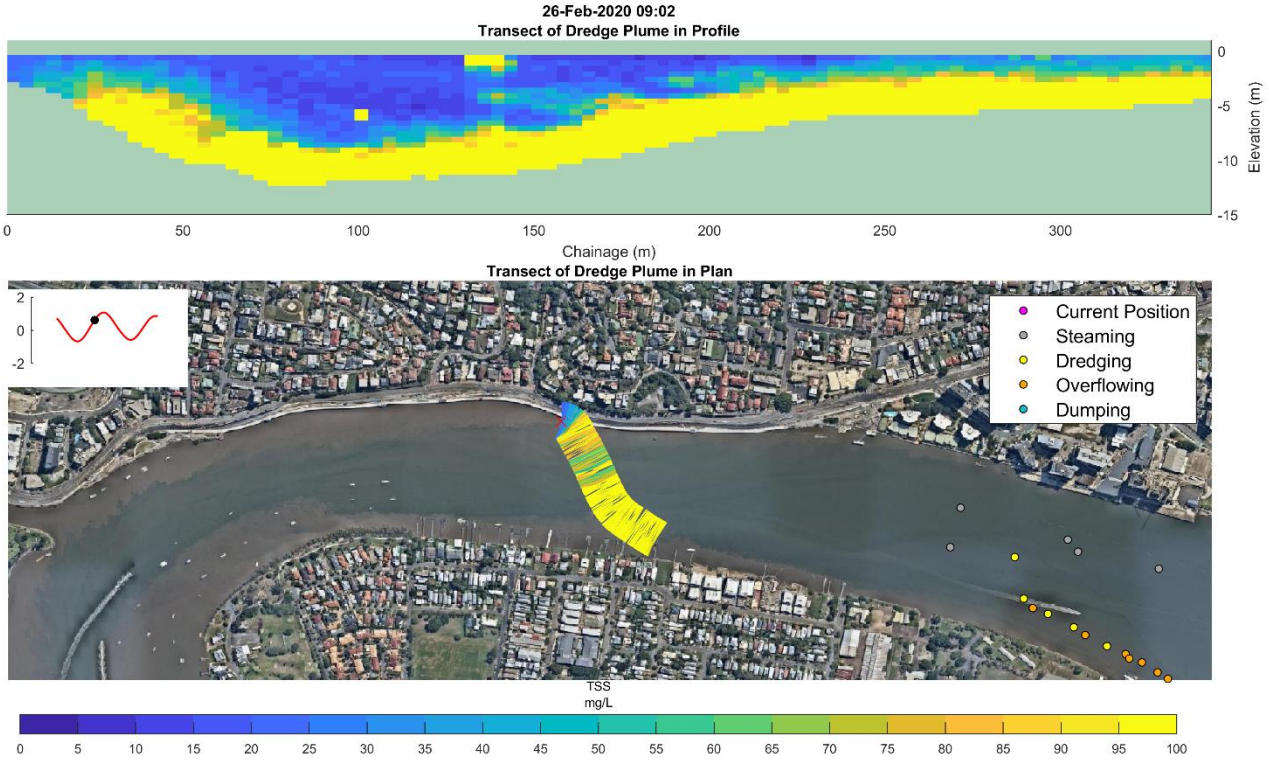

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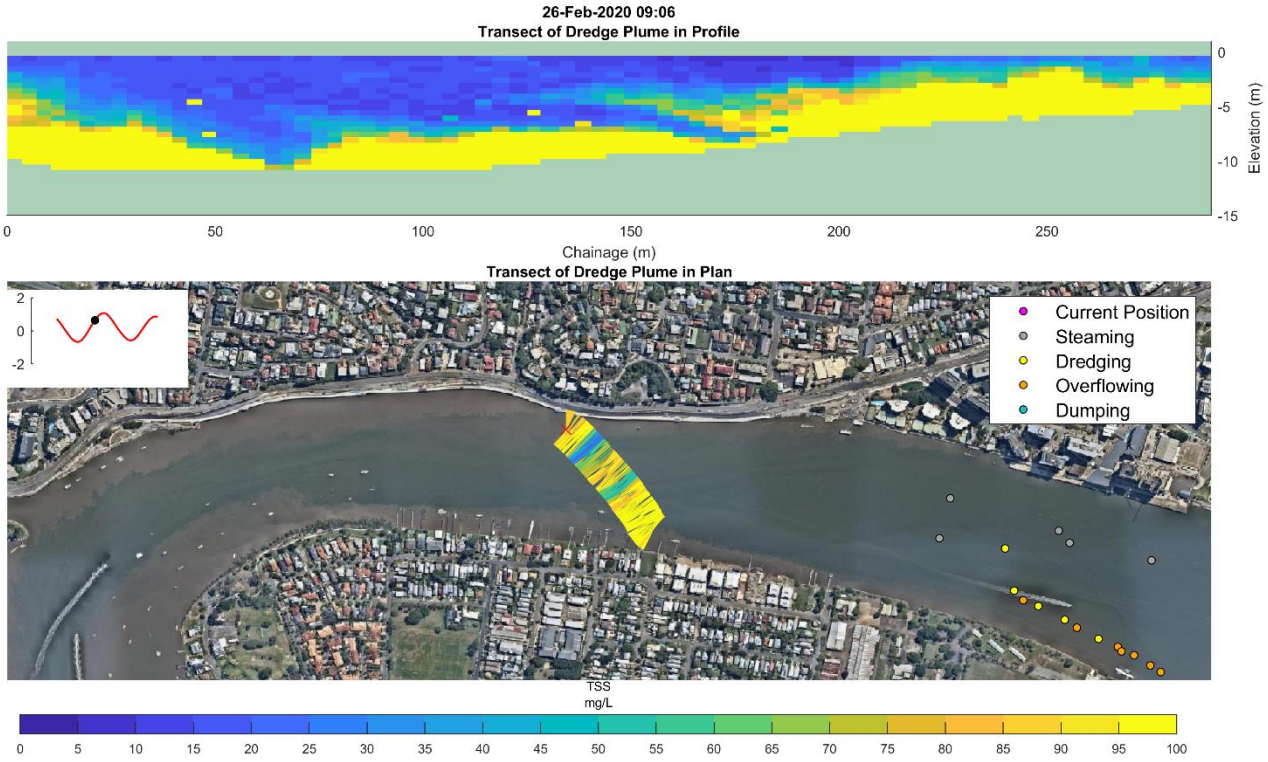

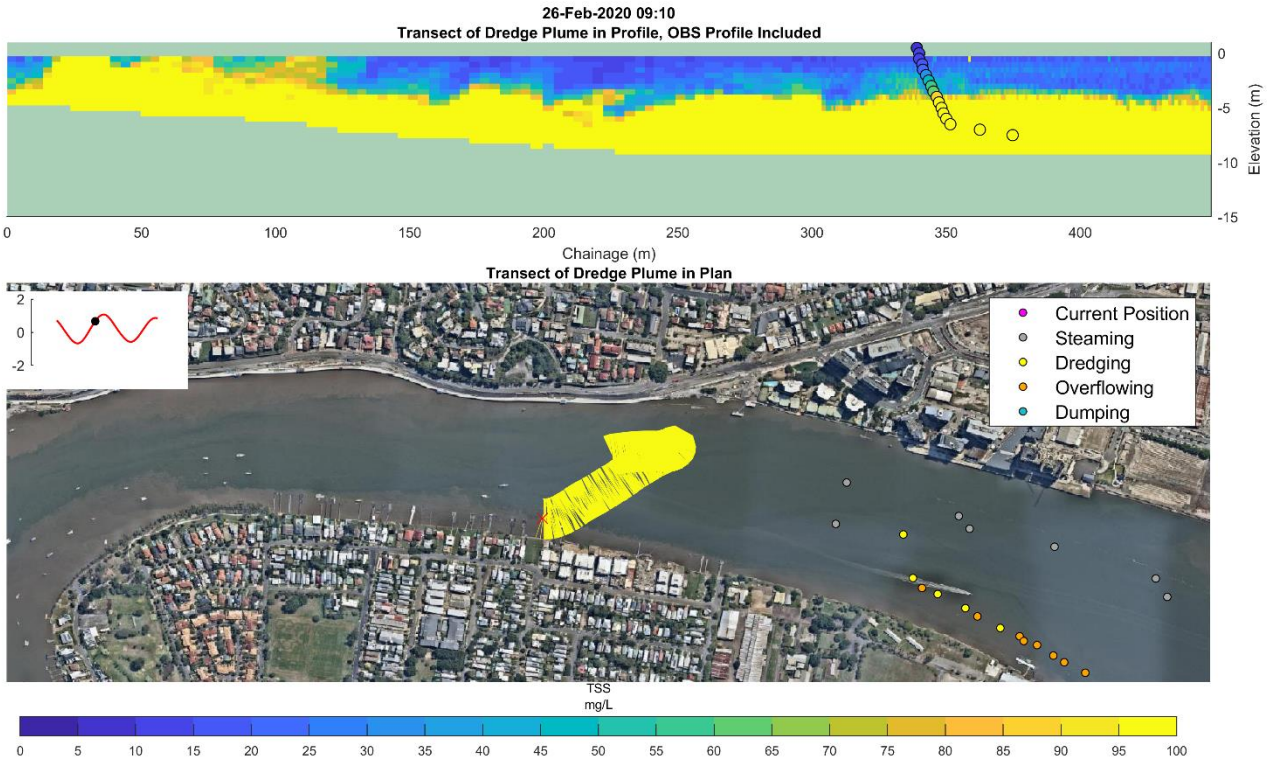

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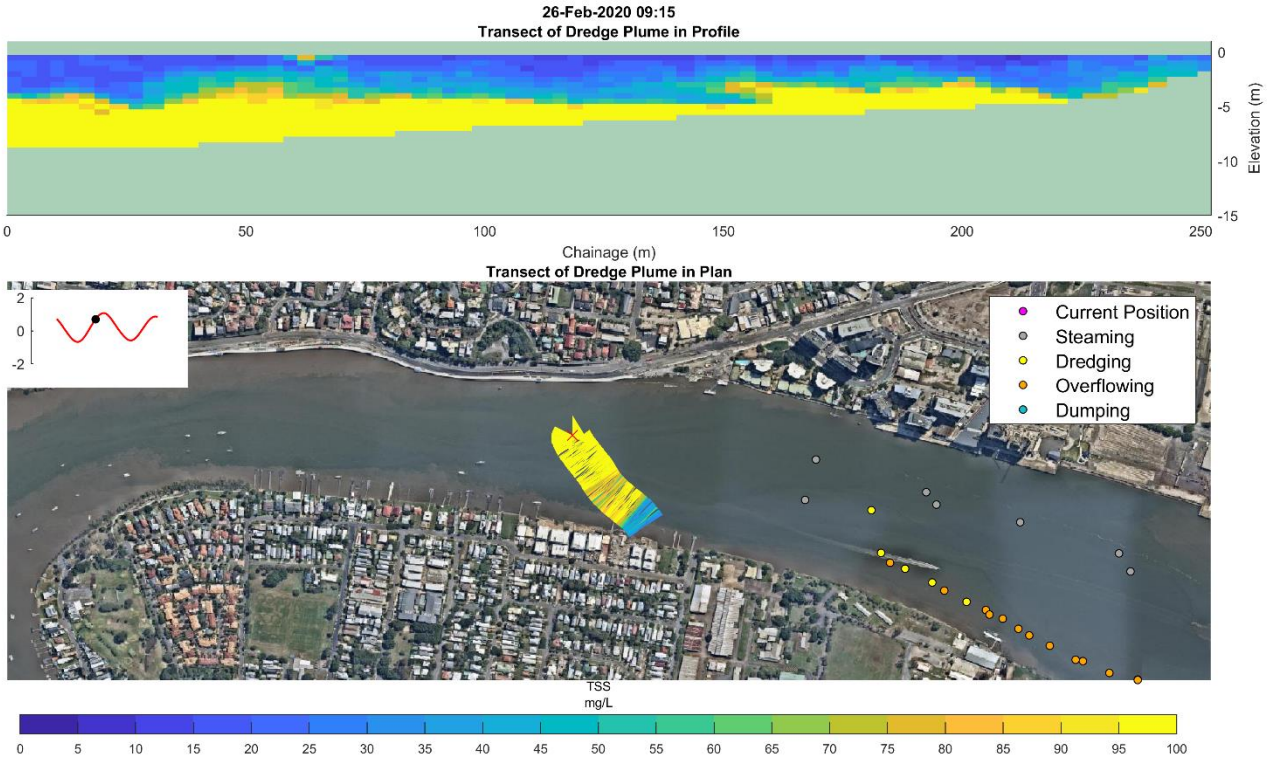

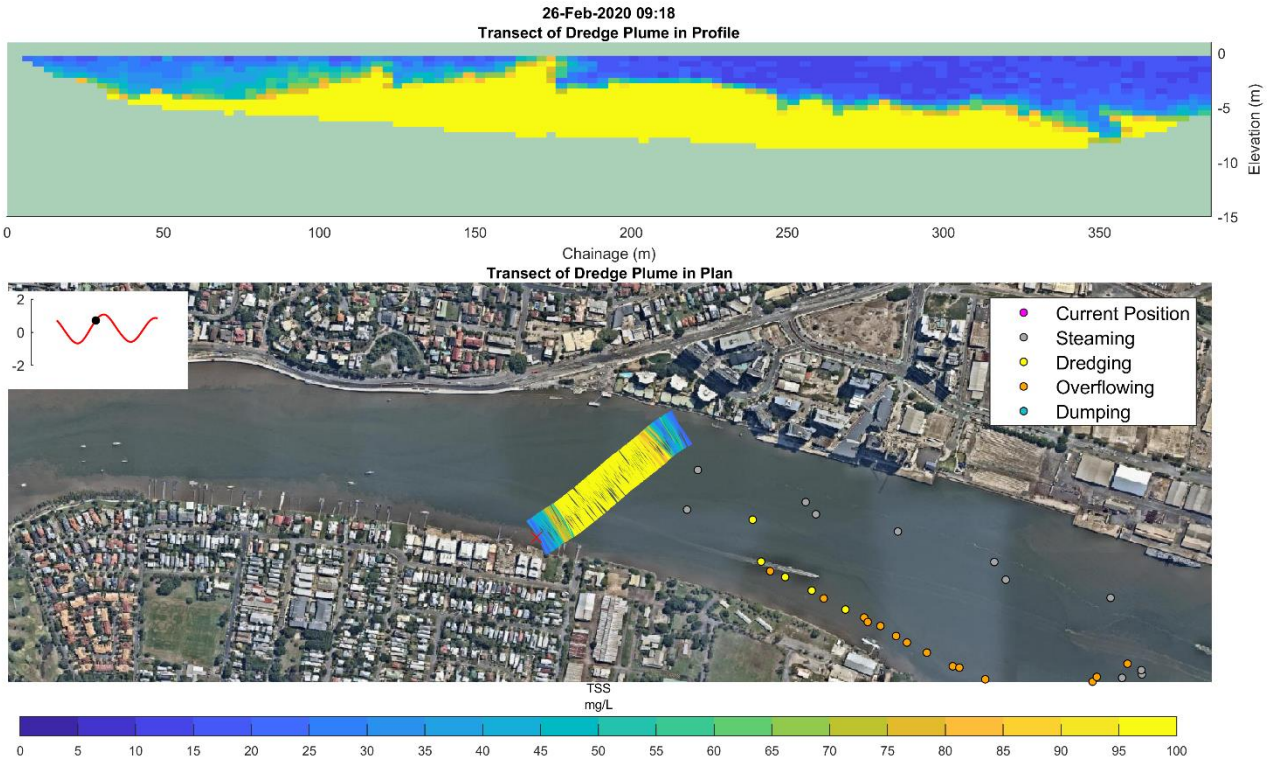

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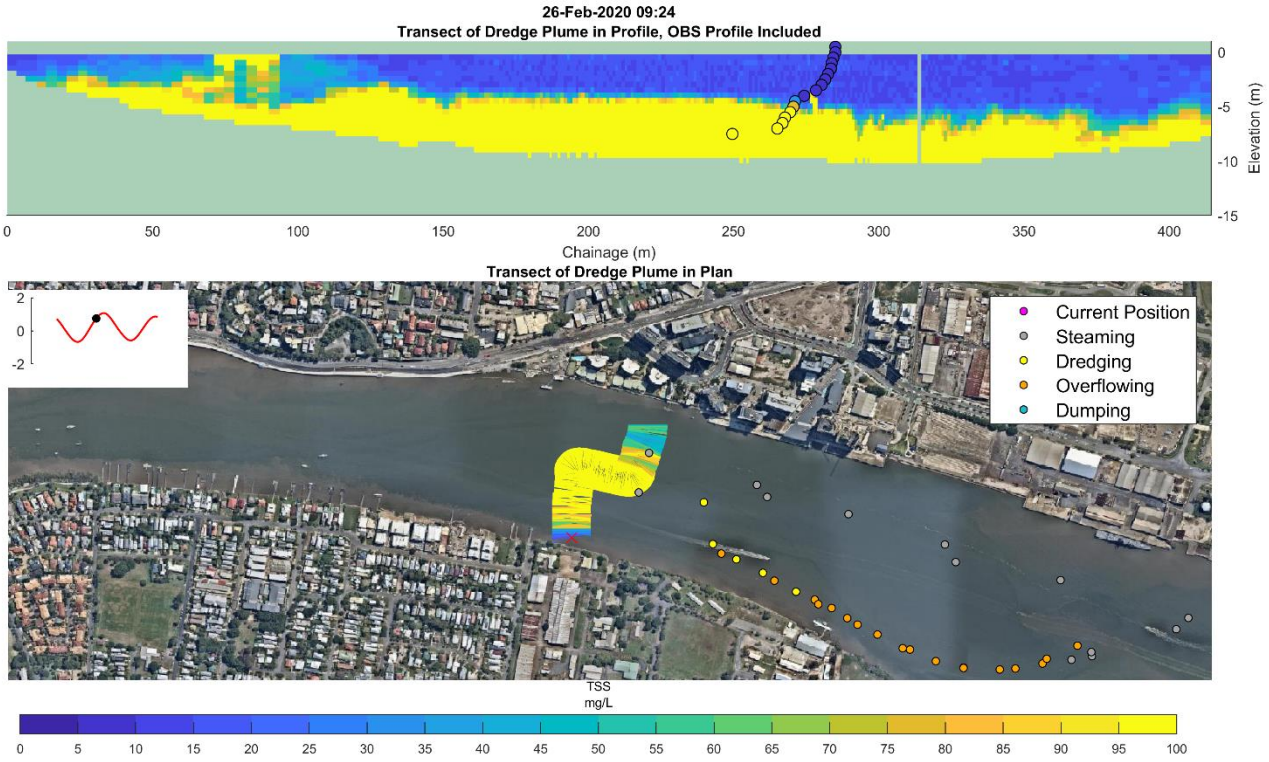

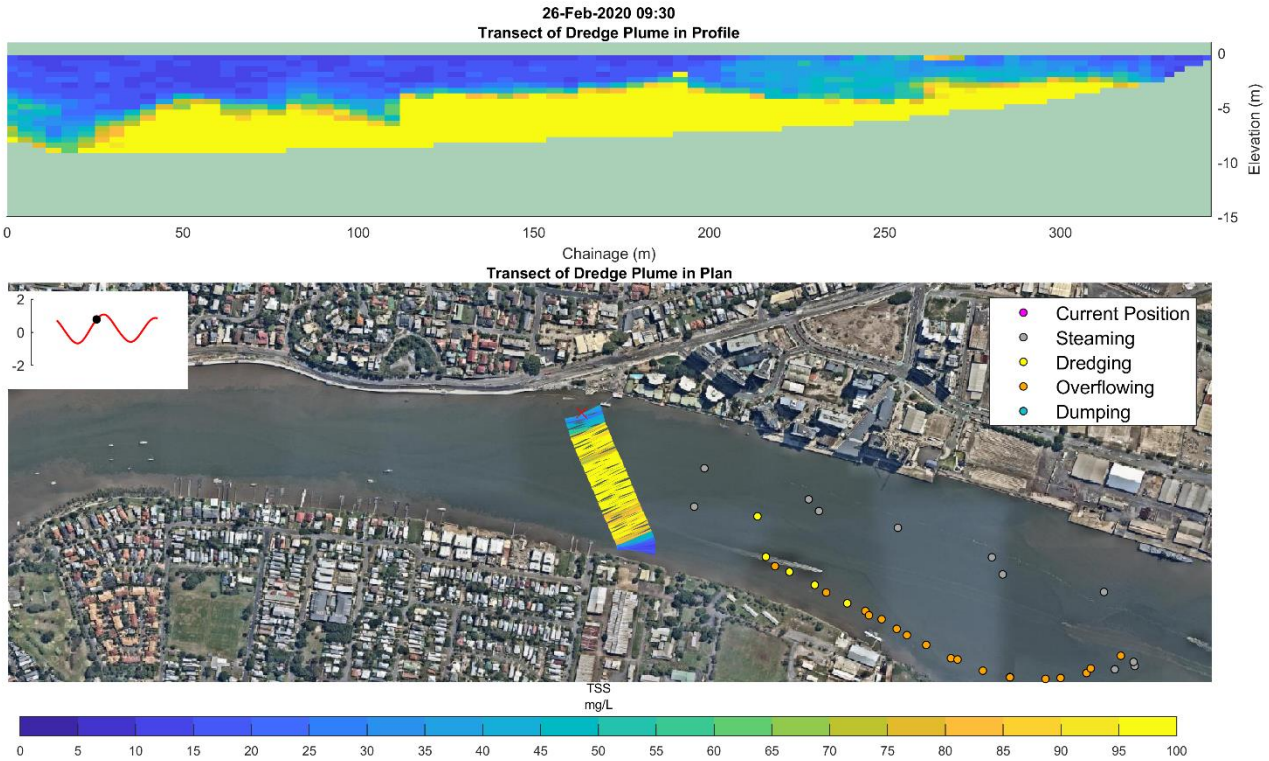

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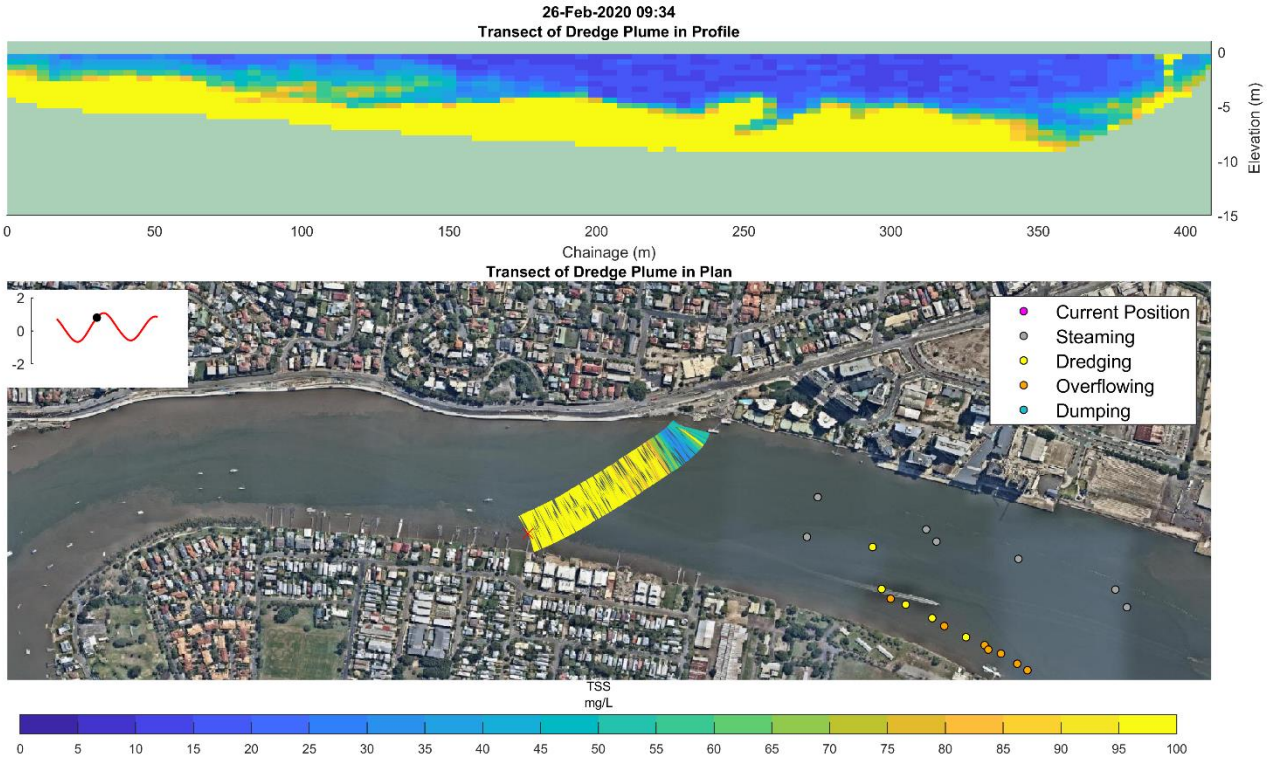

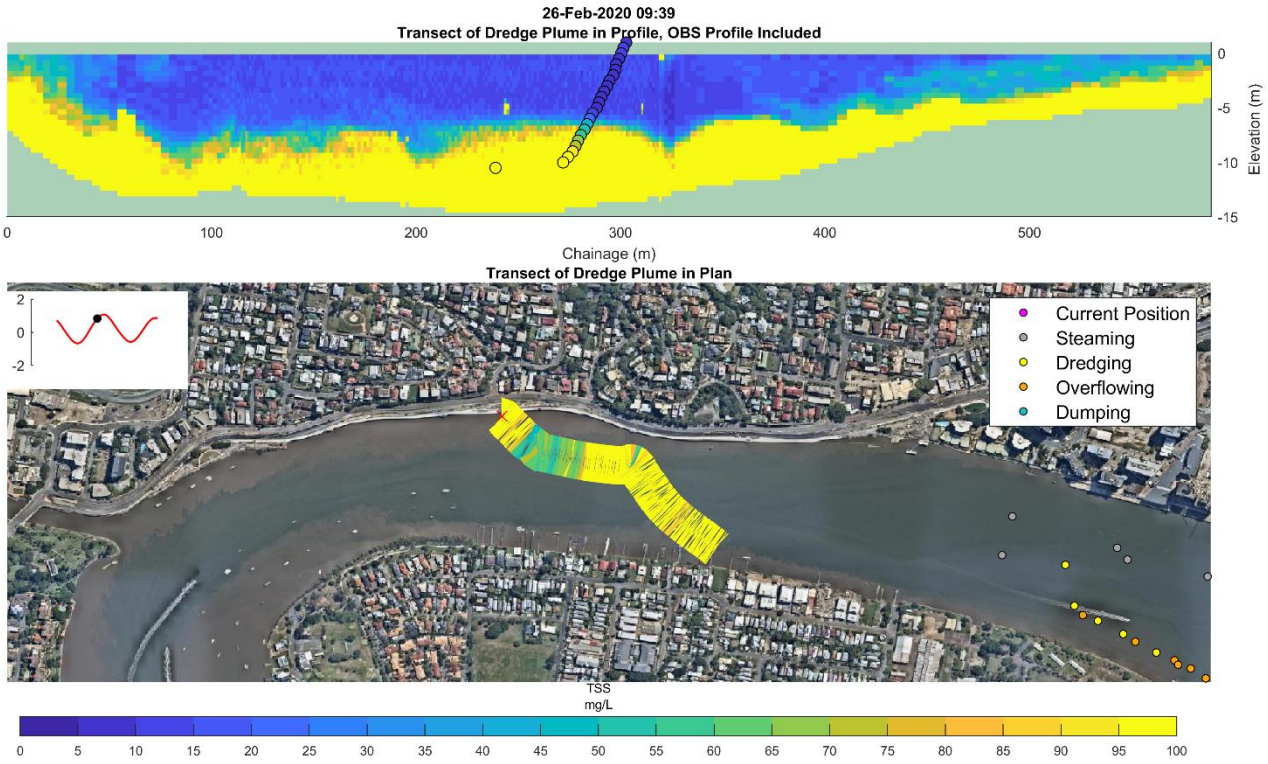

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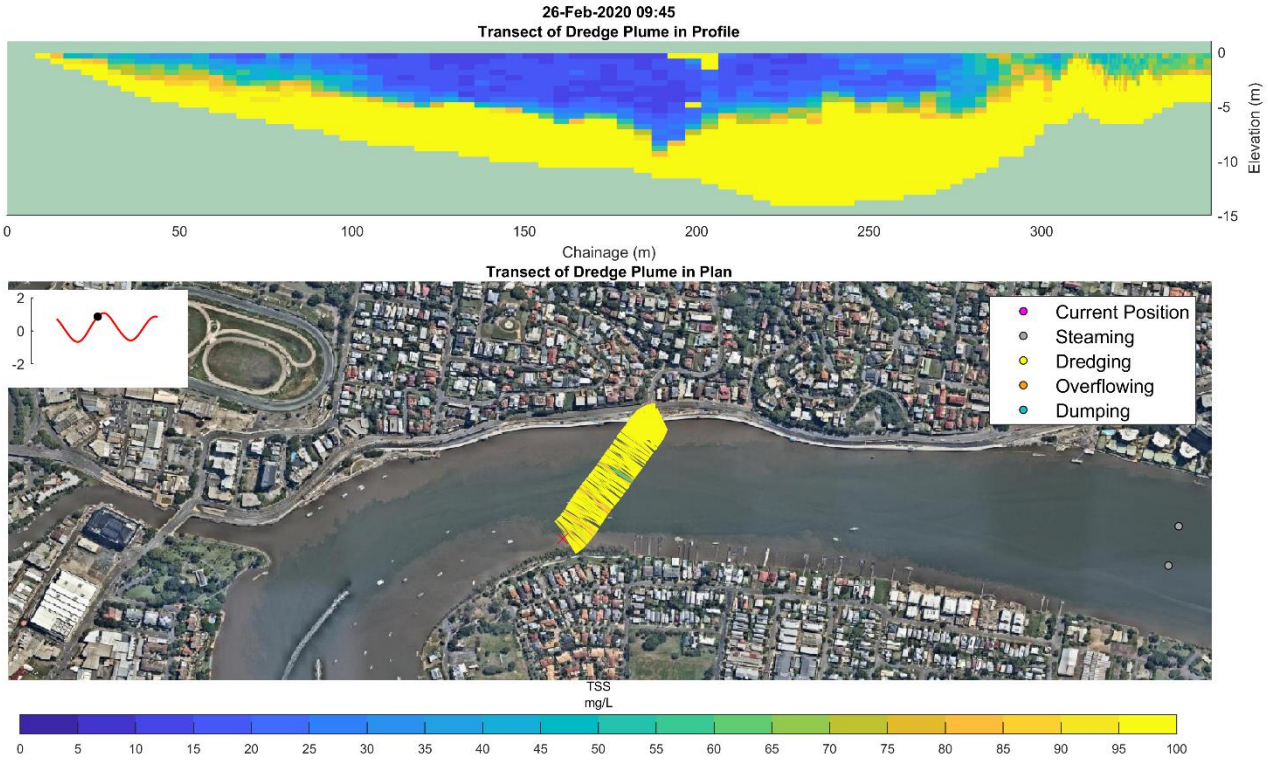
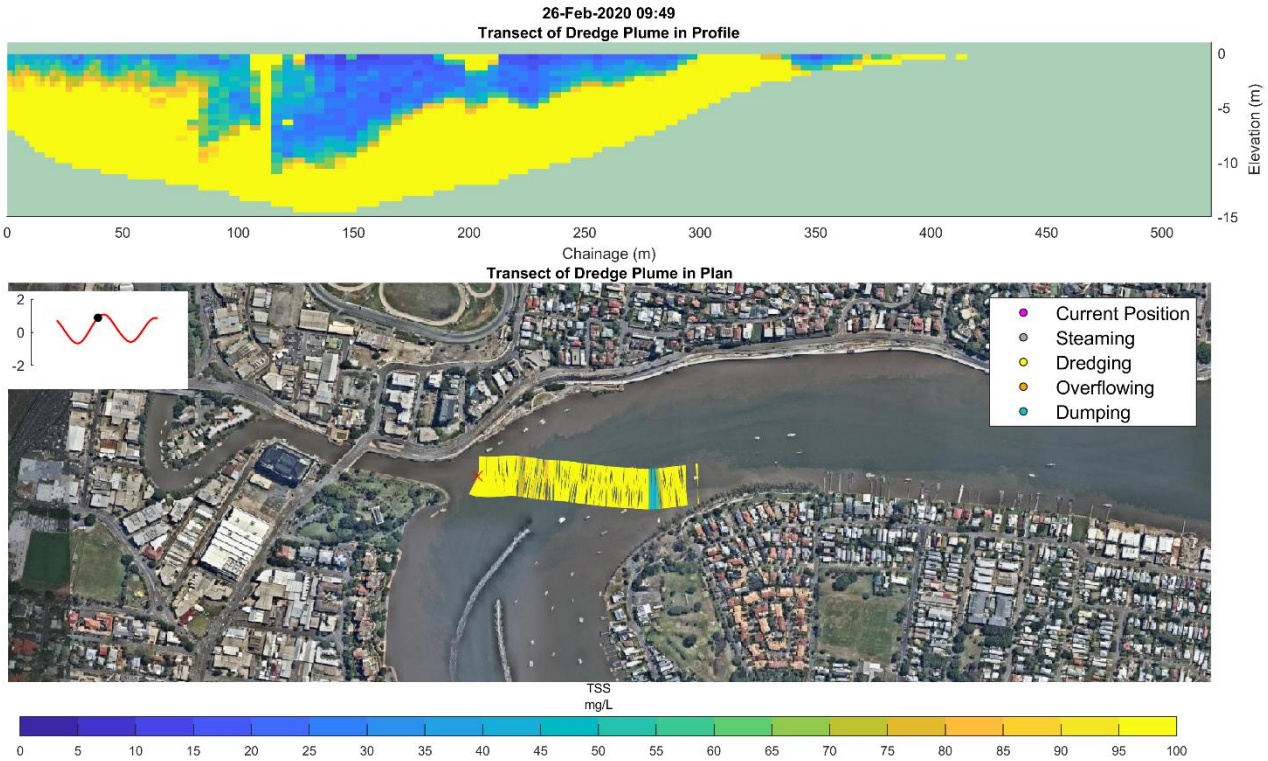
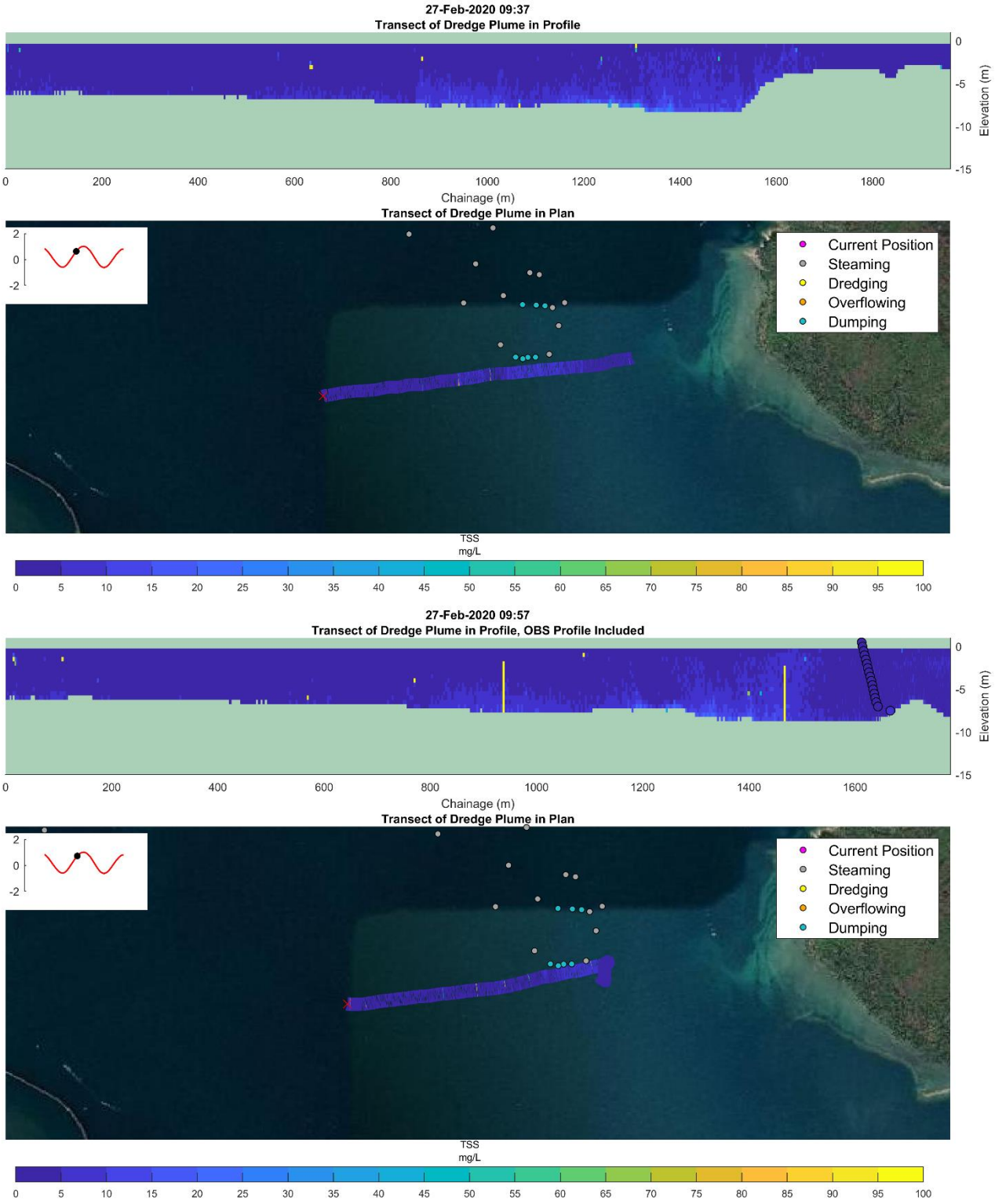
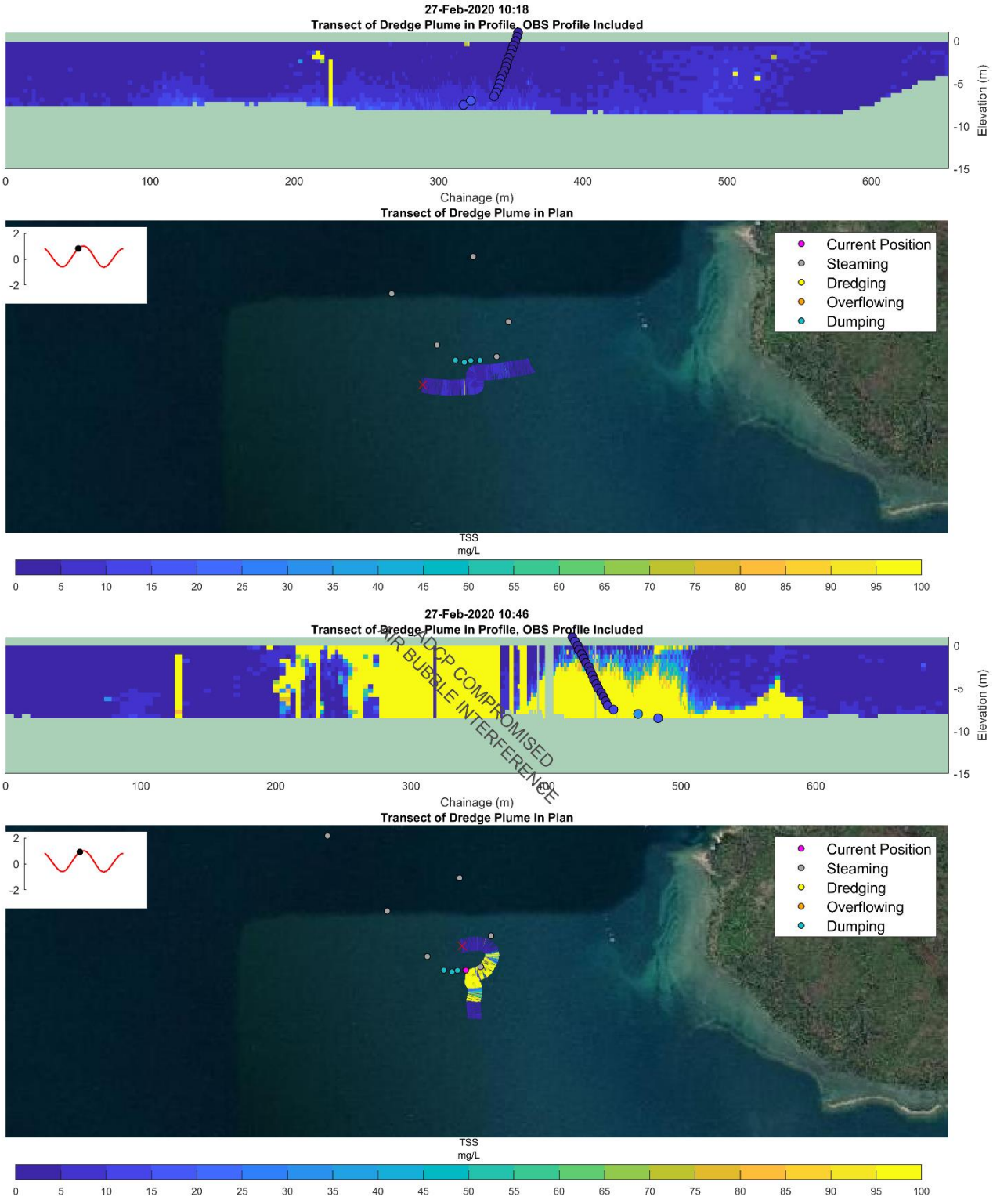




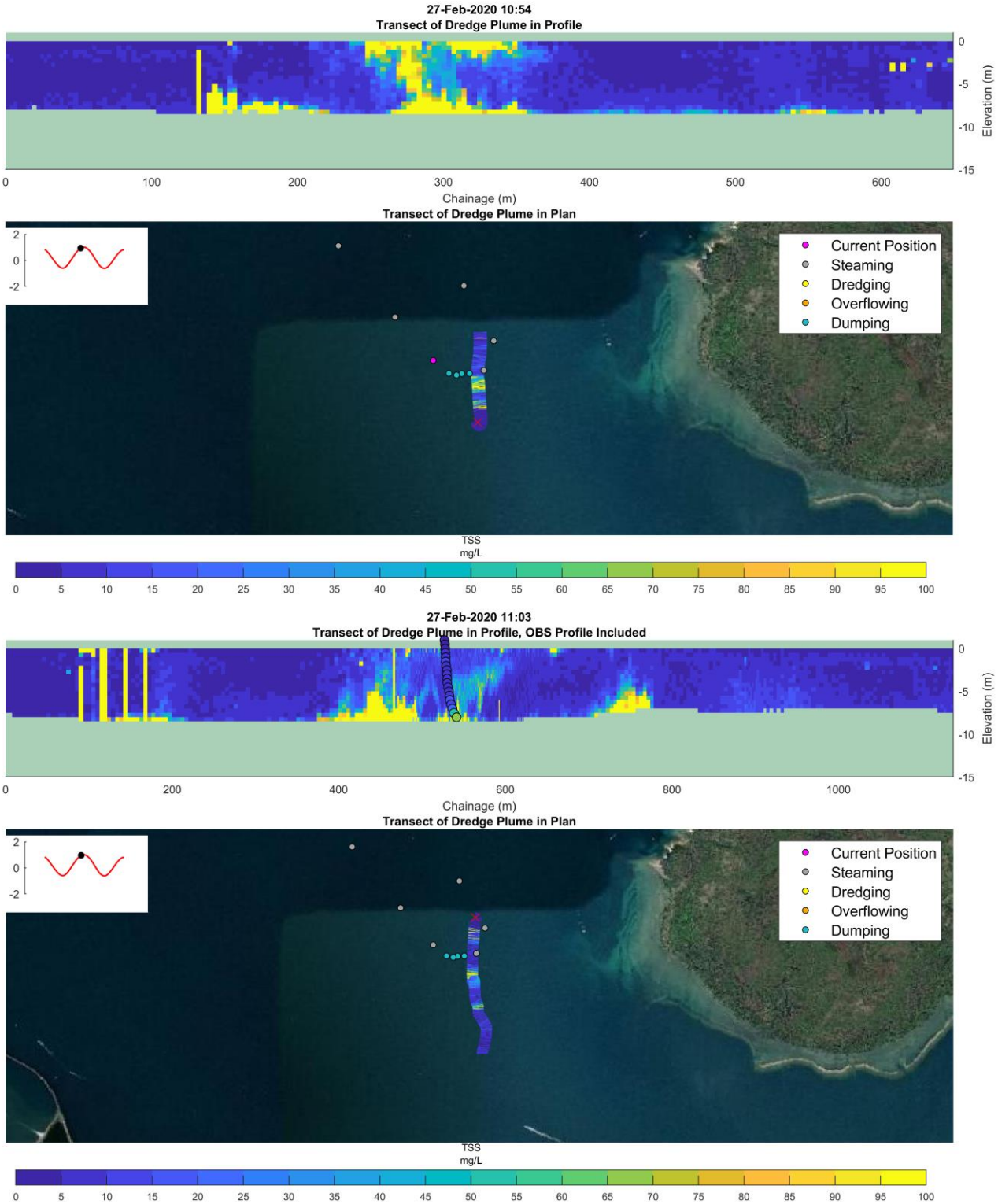
Appendix E Mud Island DMPA Transect Plots – Flooding Tide



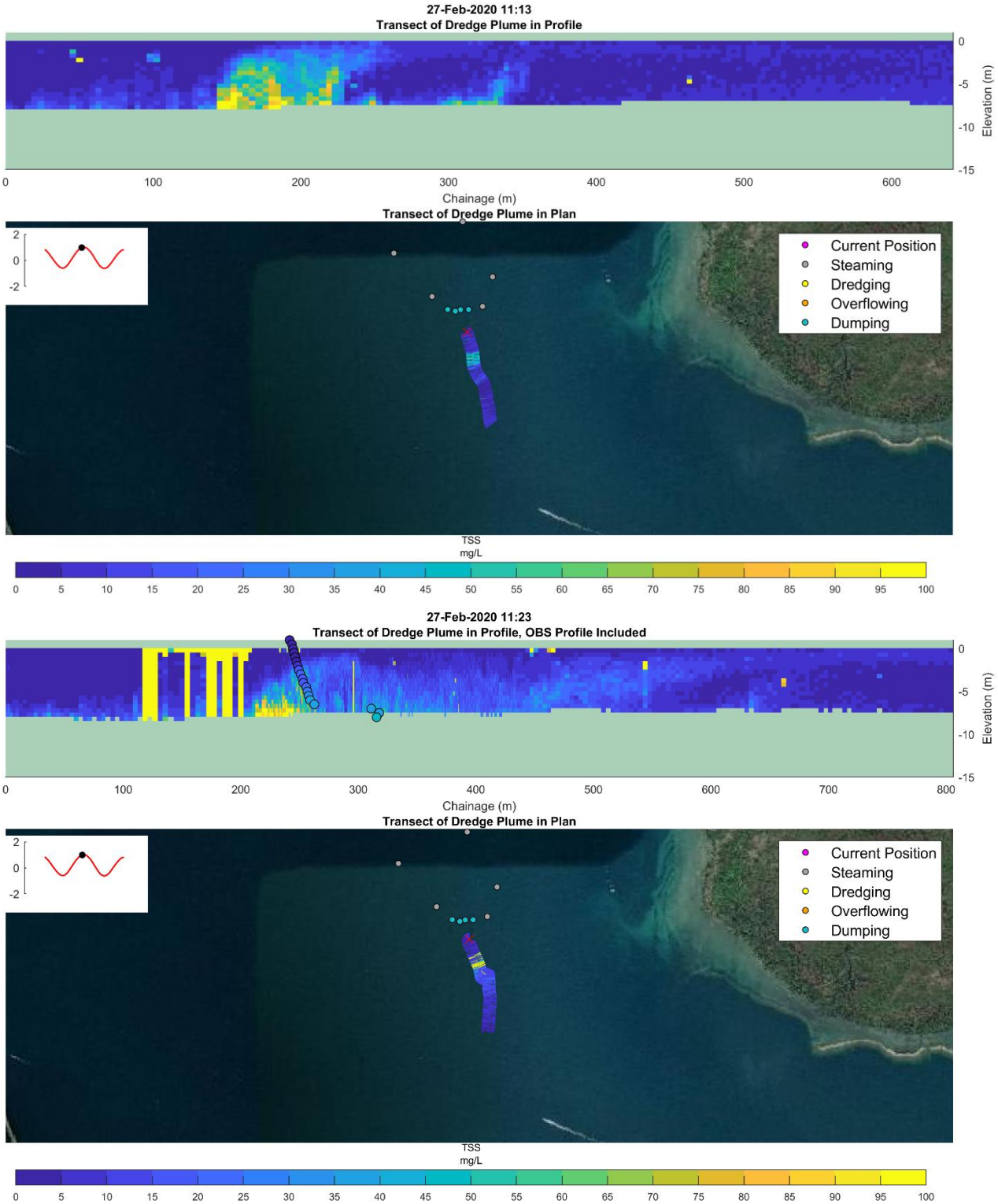
Mud Island DMPA Transect Plots – Flooding Tide



Mud Island DMPA Transect Plots – Flooding Tide



Mud Island DMPA Transect Plots – Flooding Tide



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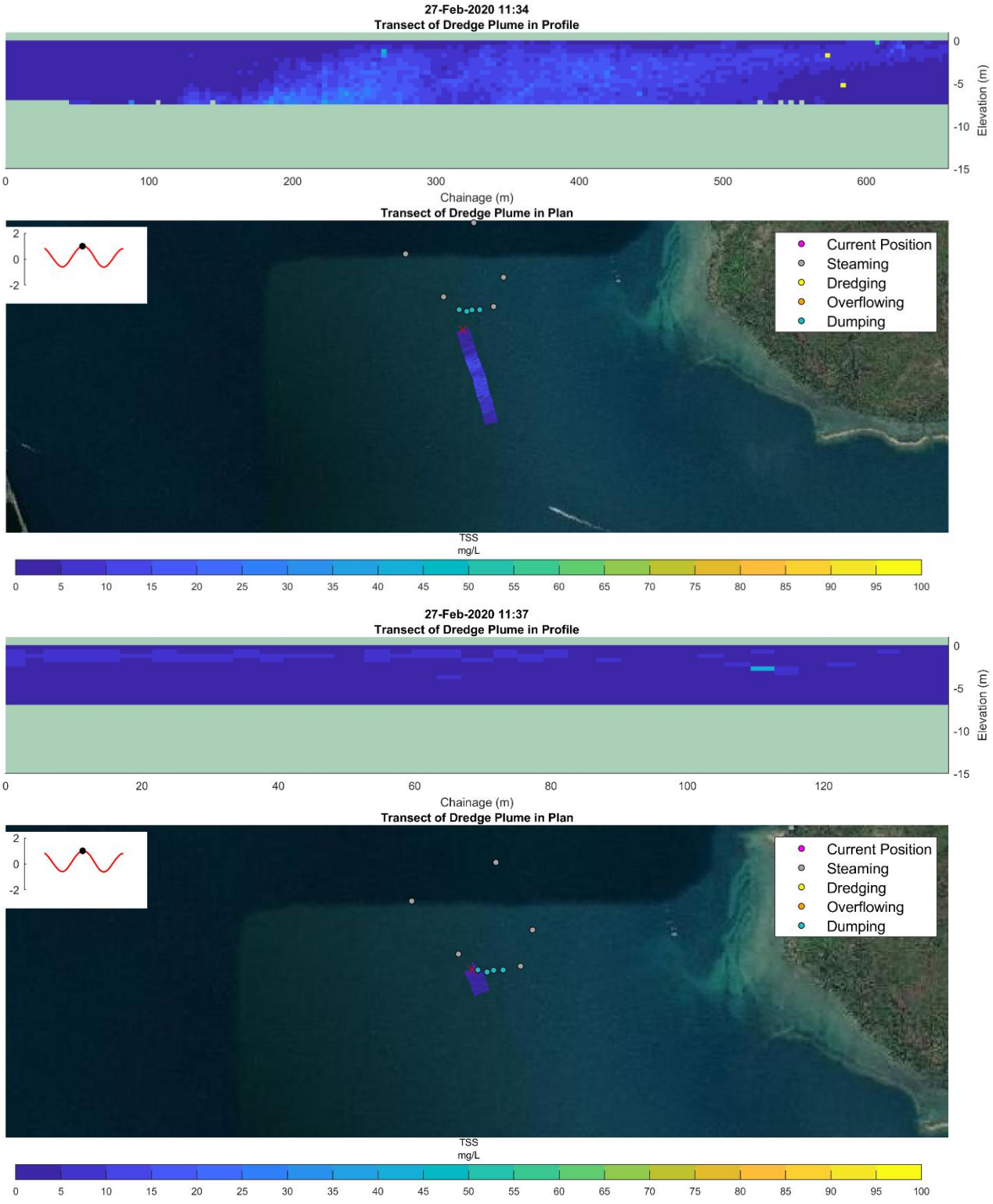
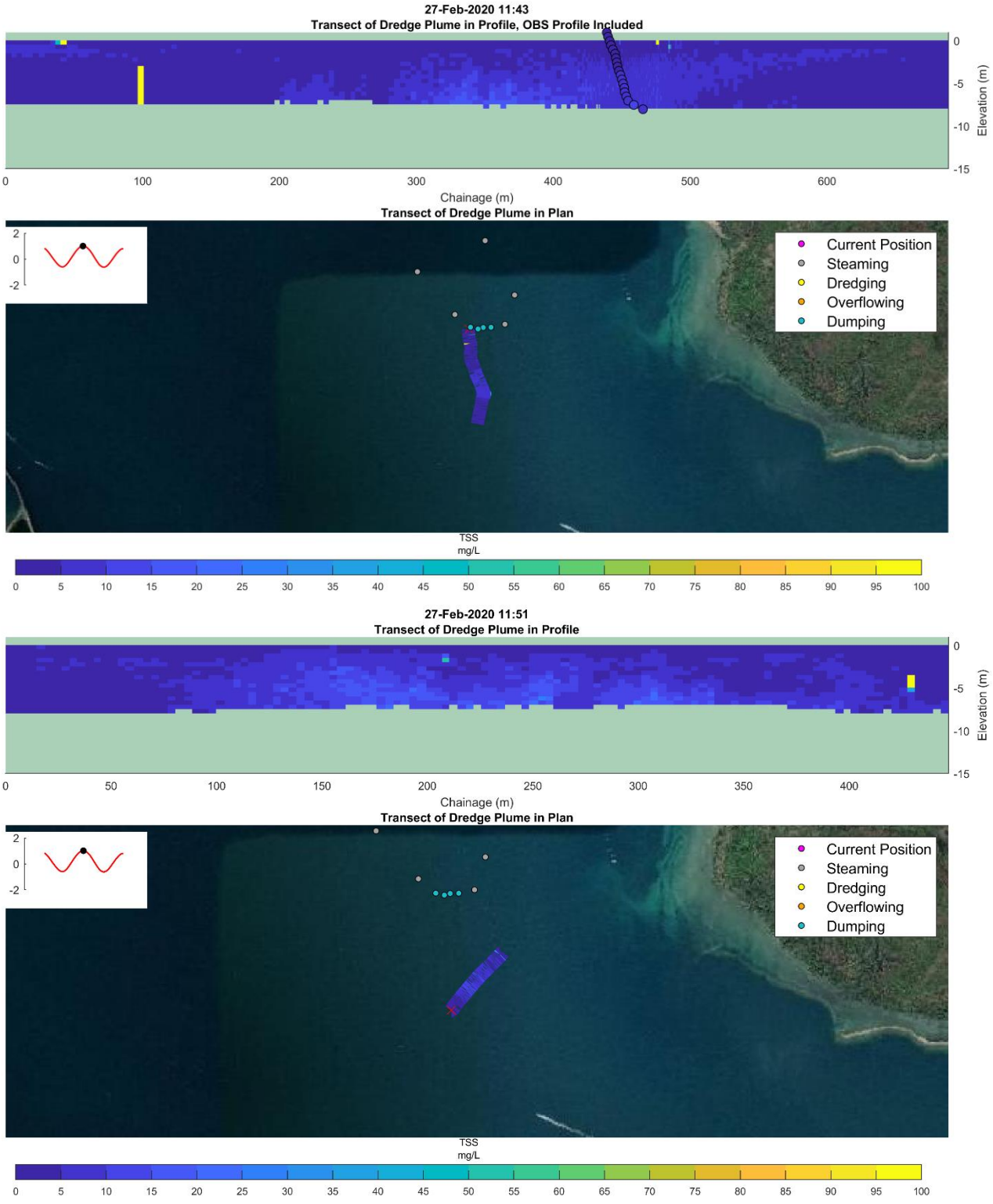
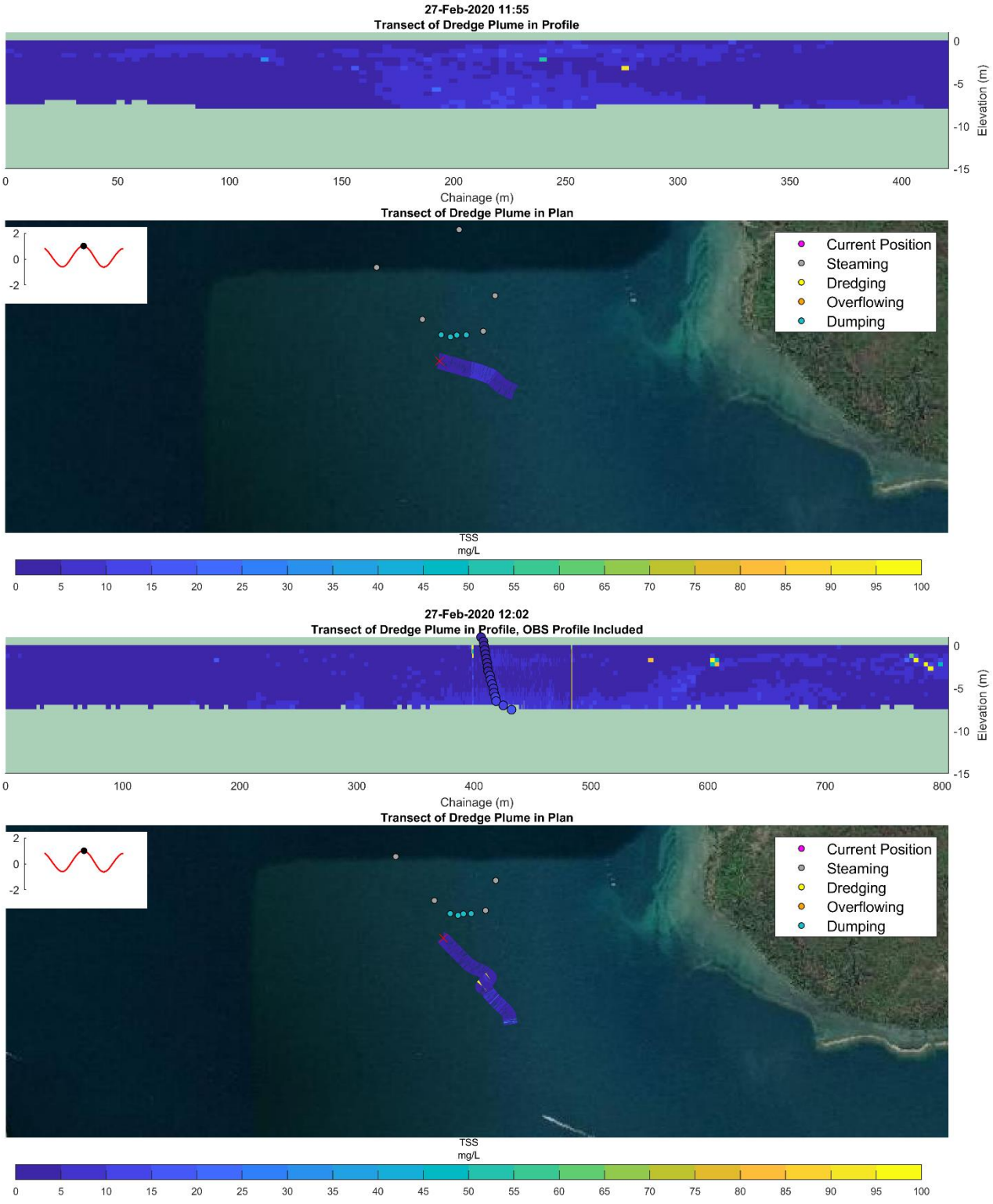


Mud Island DMPA Transect Plots – Flooding Tide



Mud Island DMPA Transect Plots – Flooding Tide



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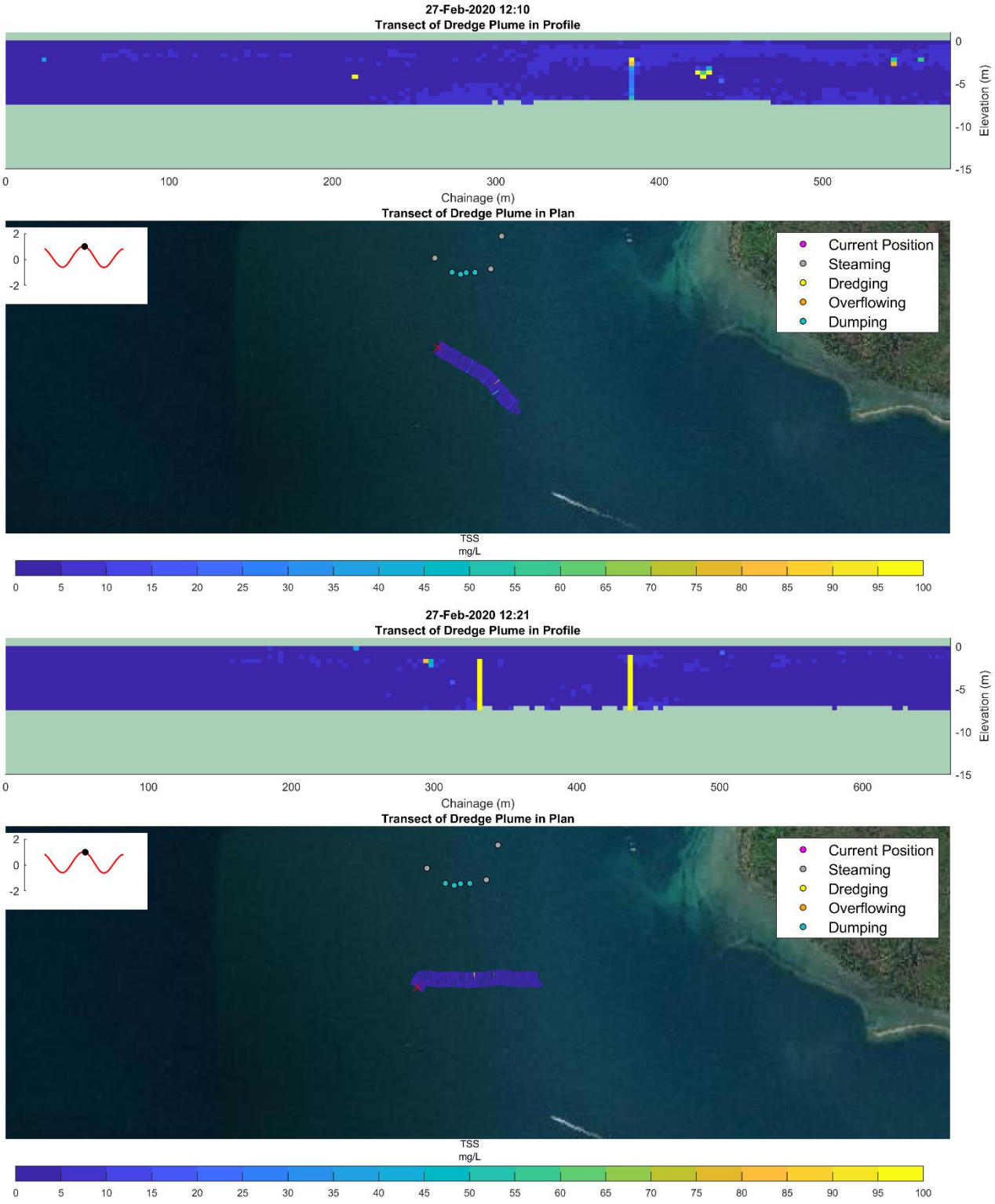

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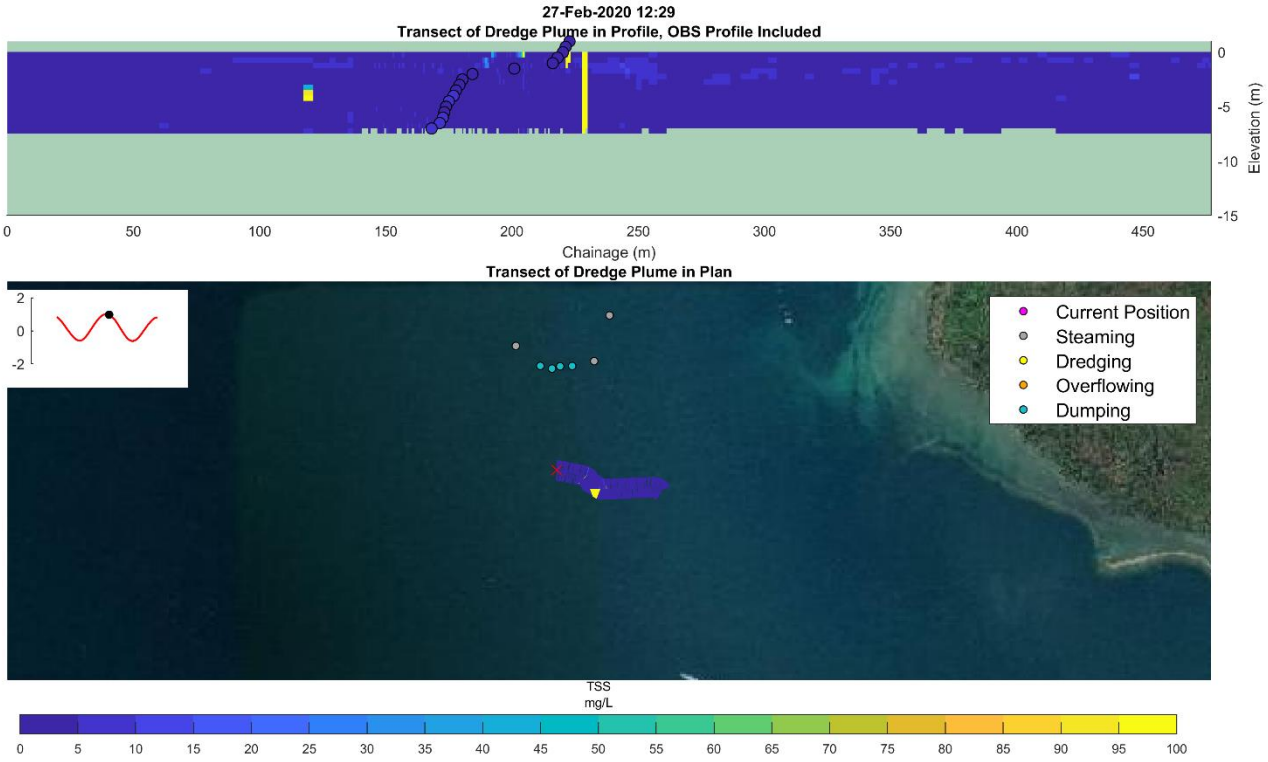
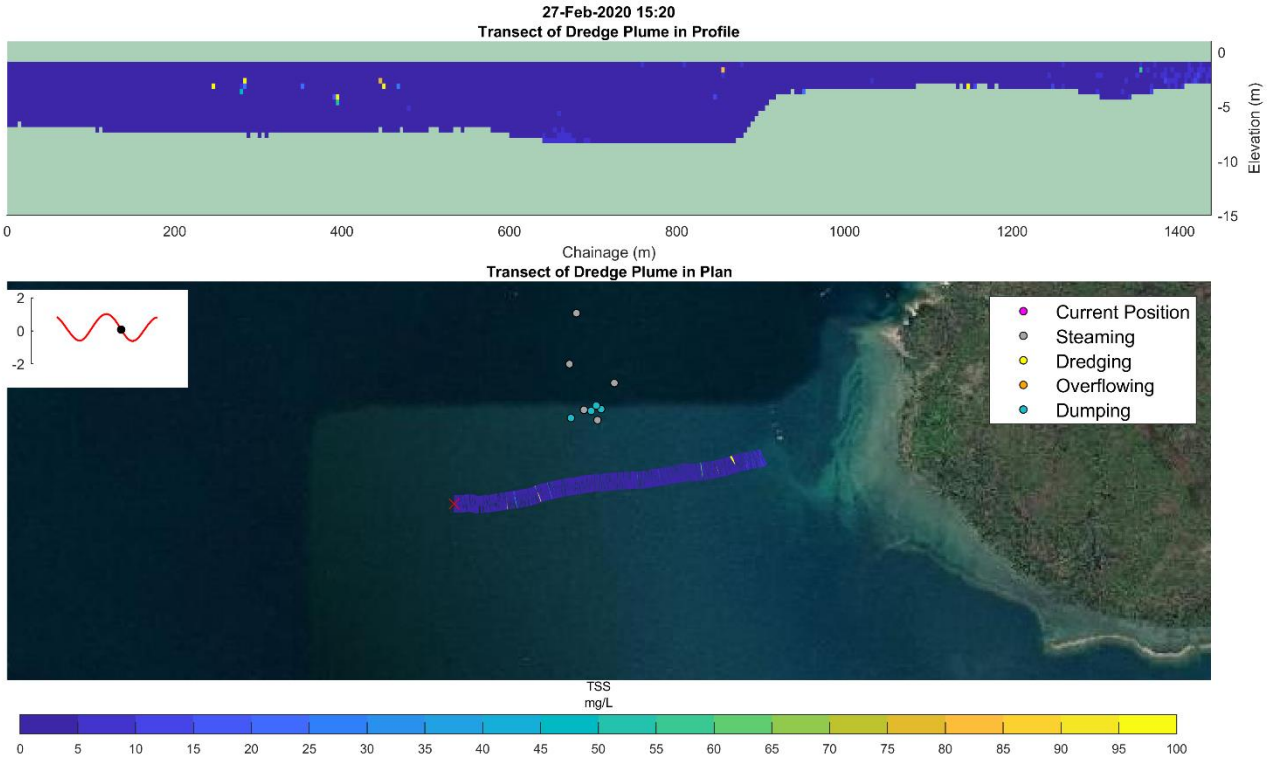
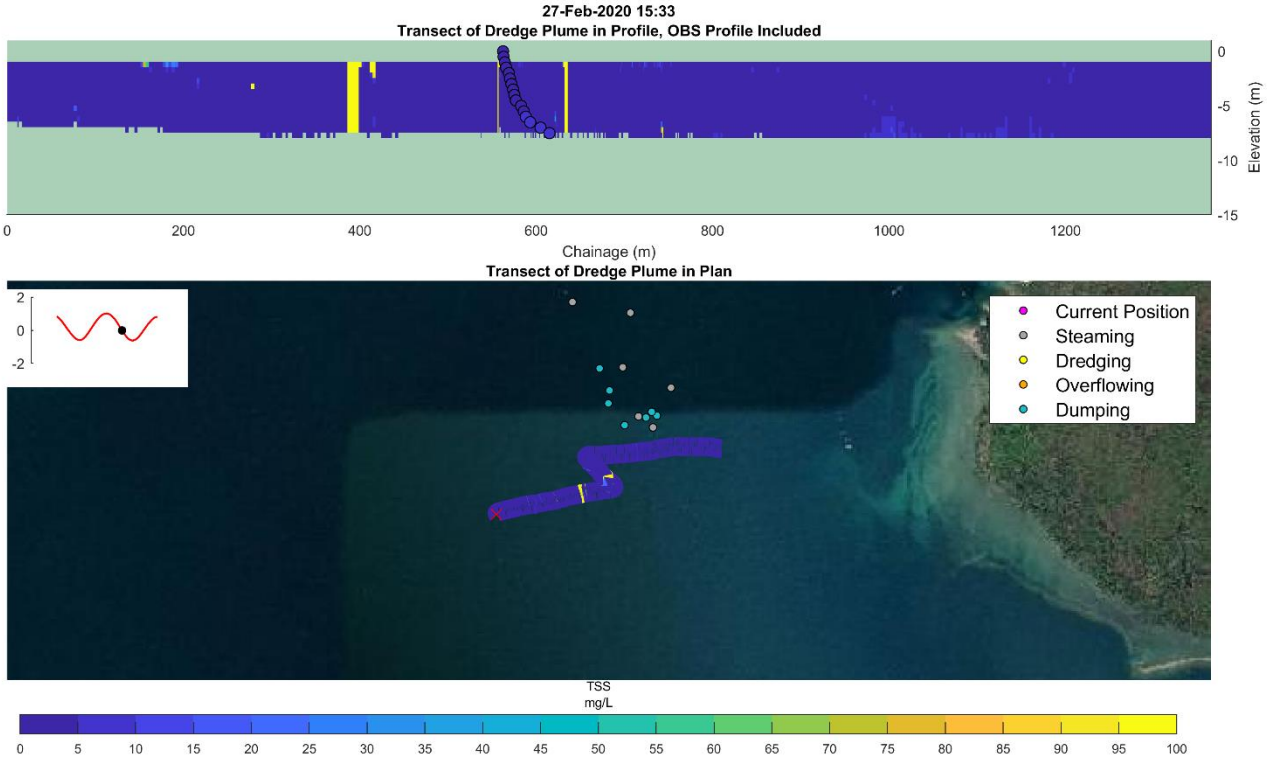


Appendix F Mud Island DMPA Transect Plots – Ebb Tide





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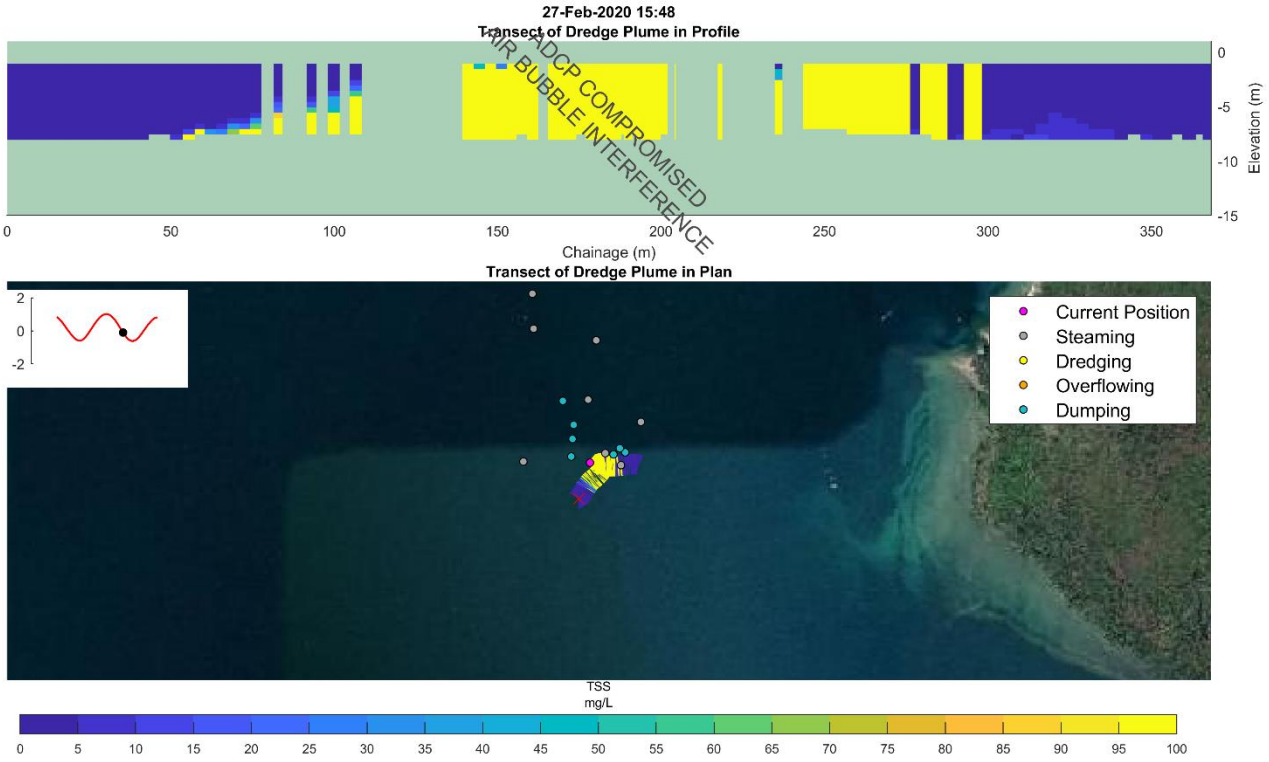

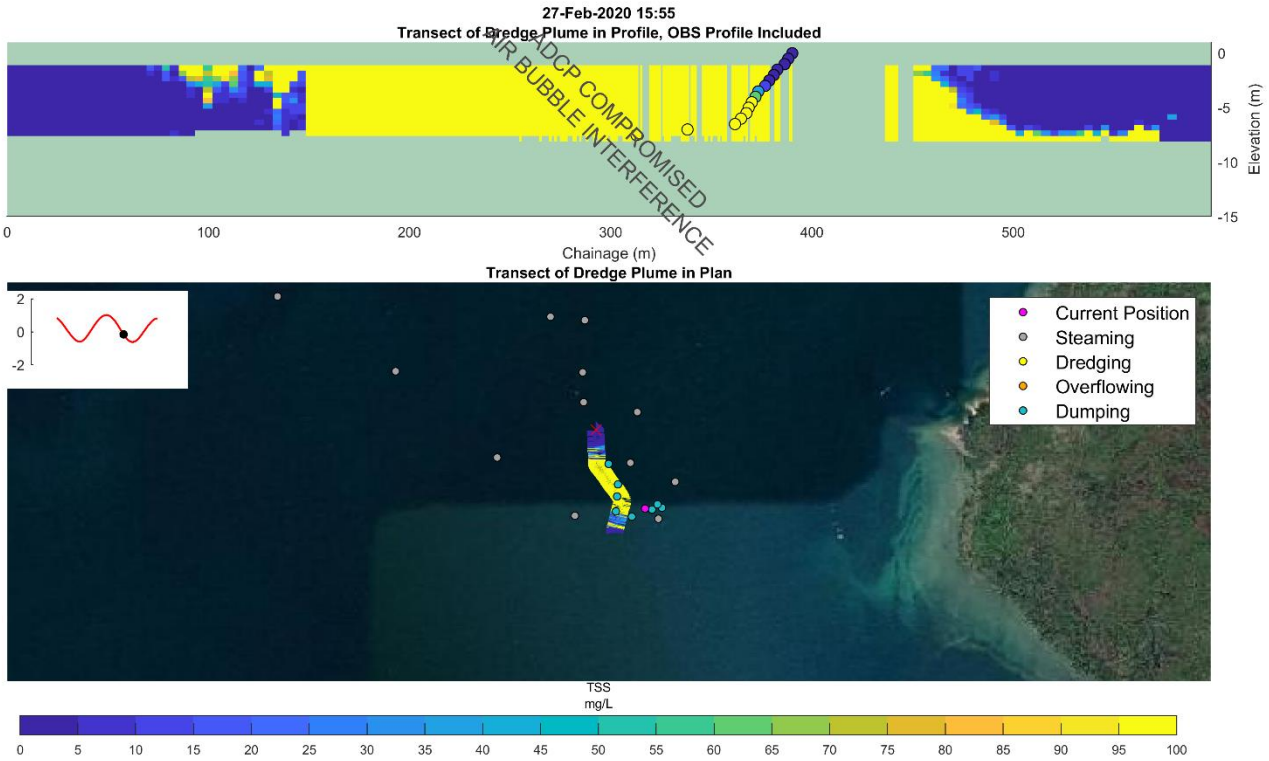

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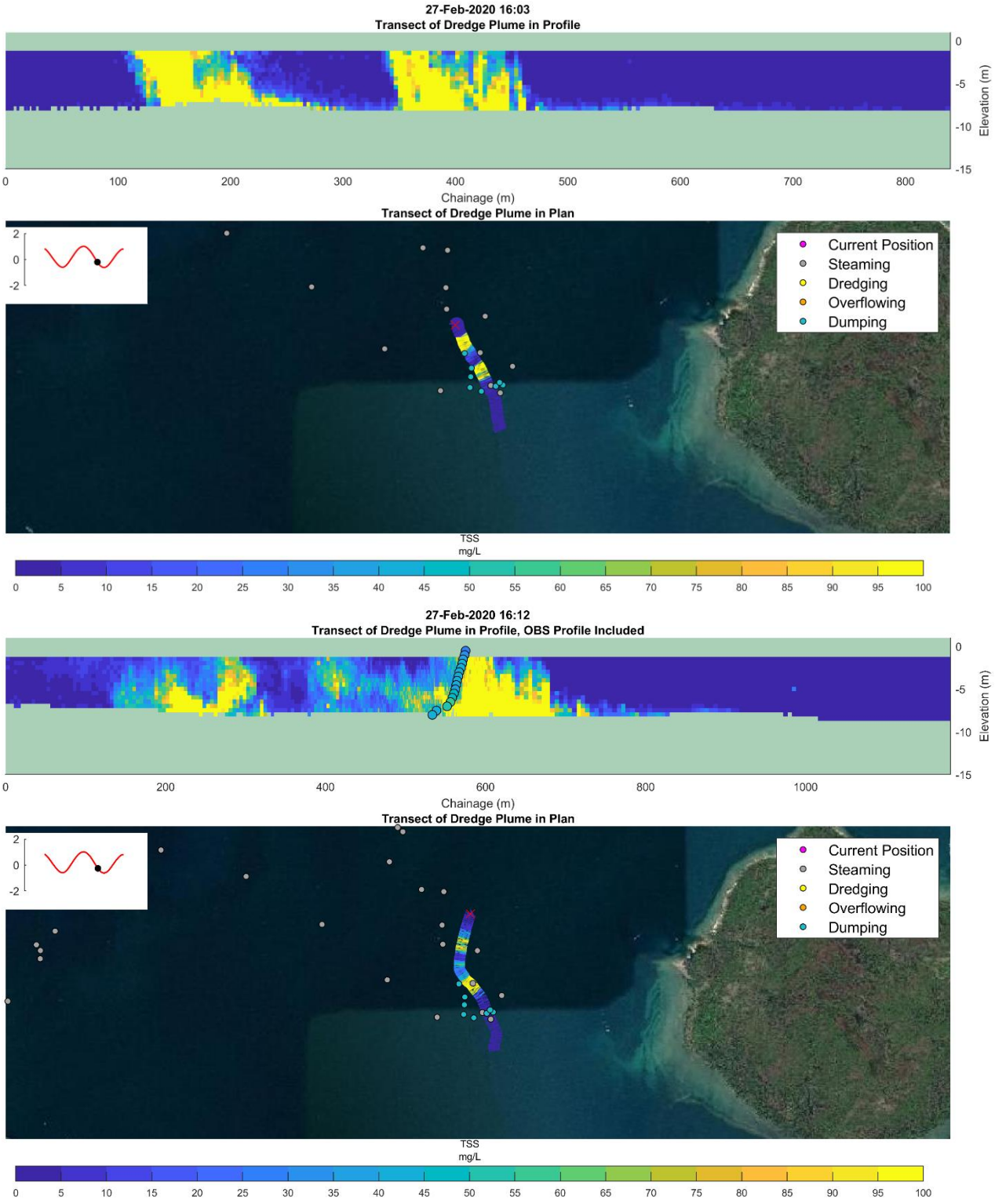

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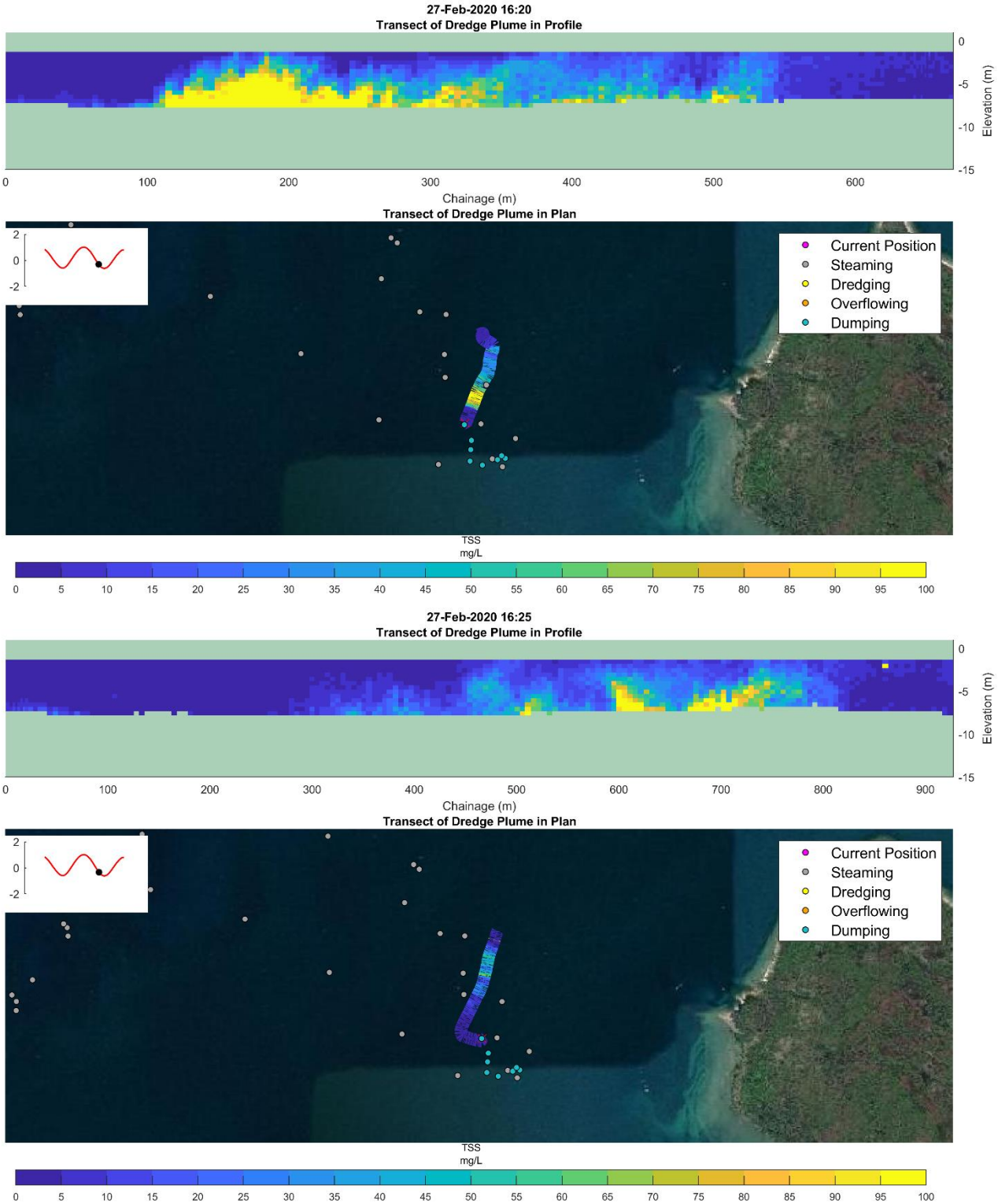

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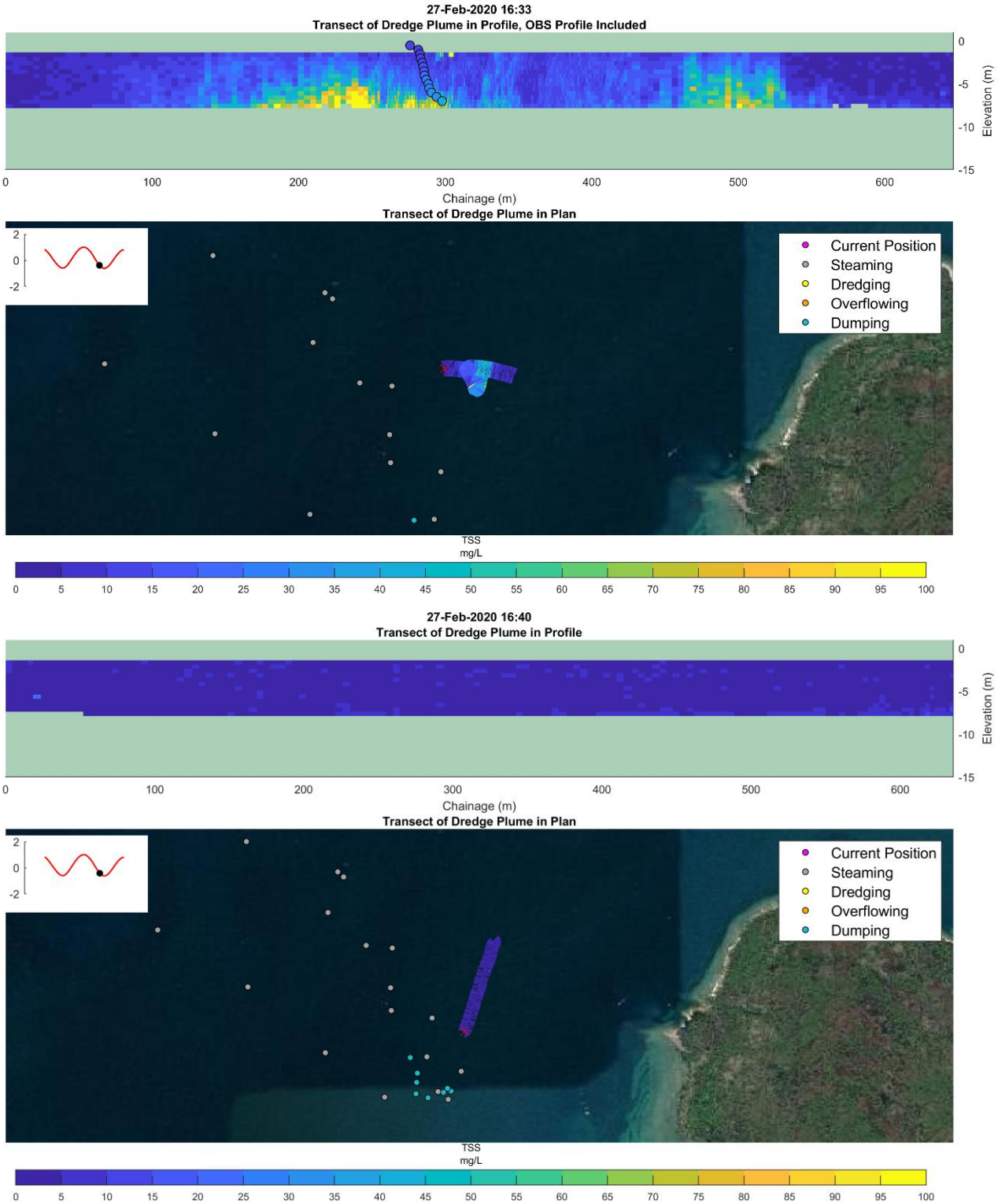

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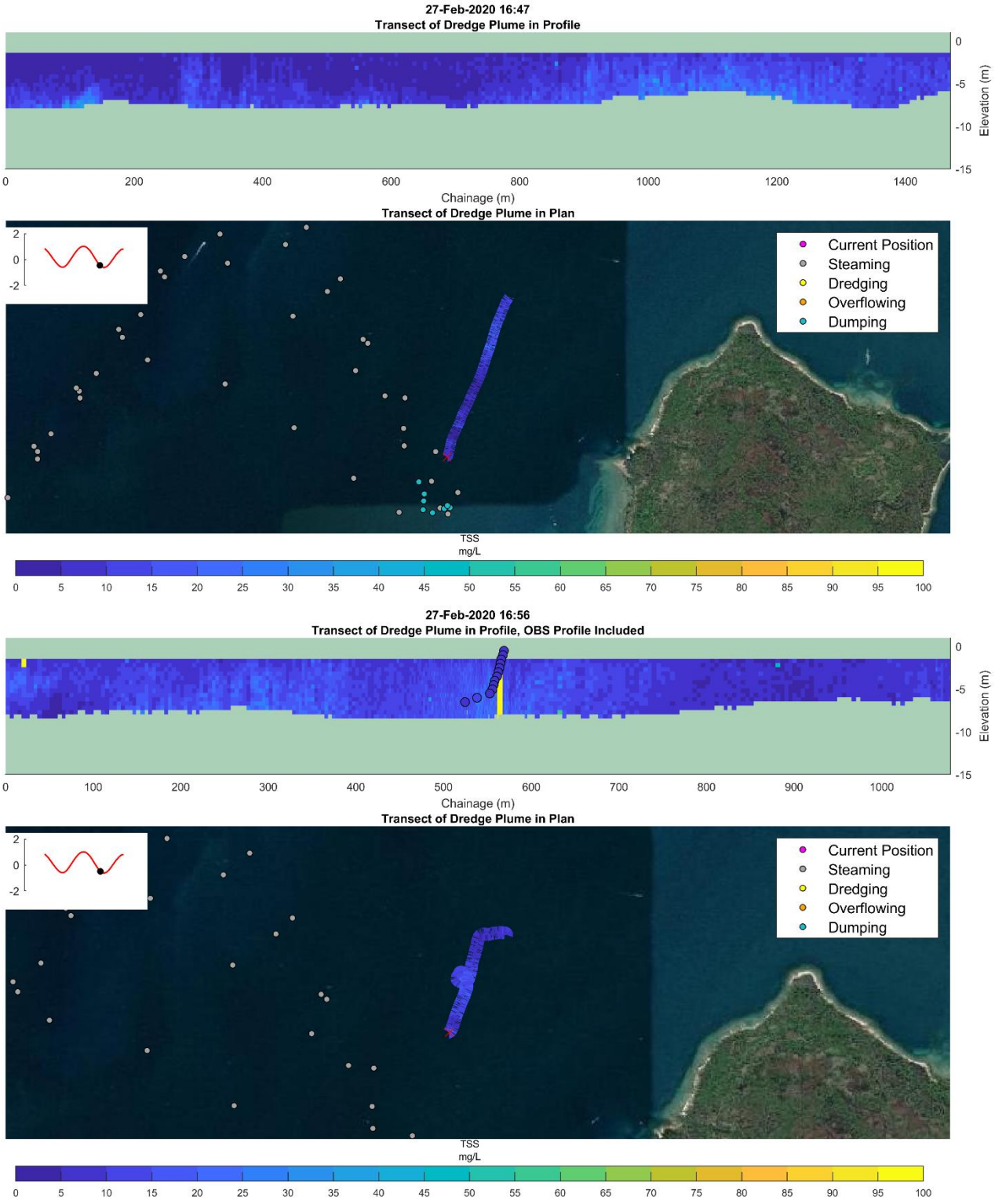

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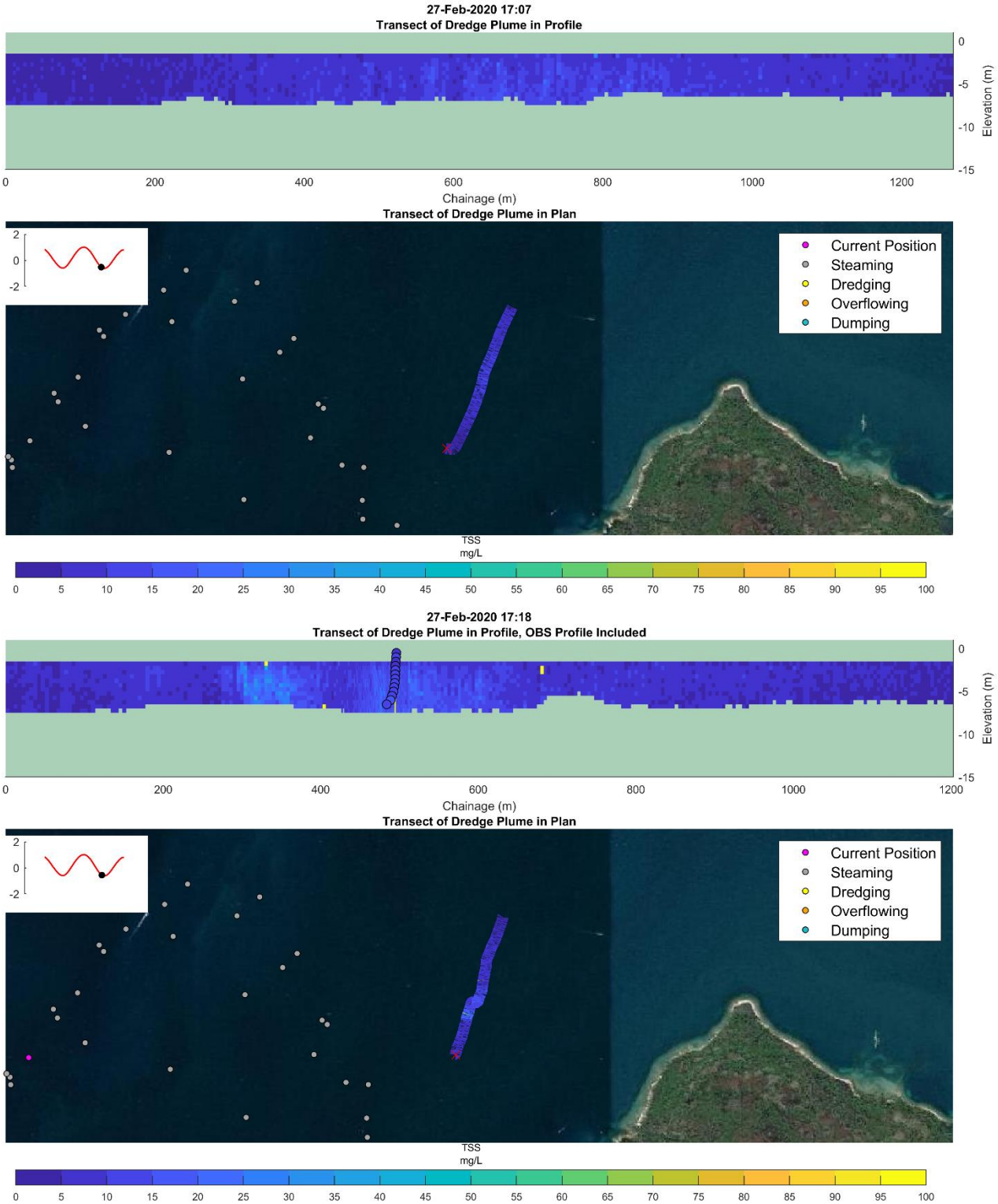

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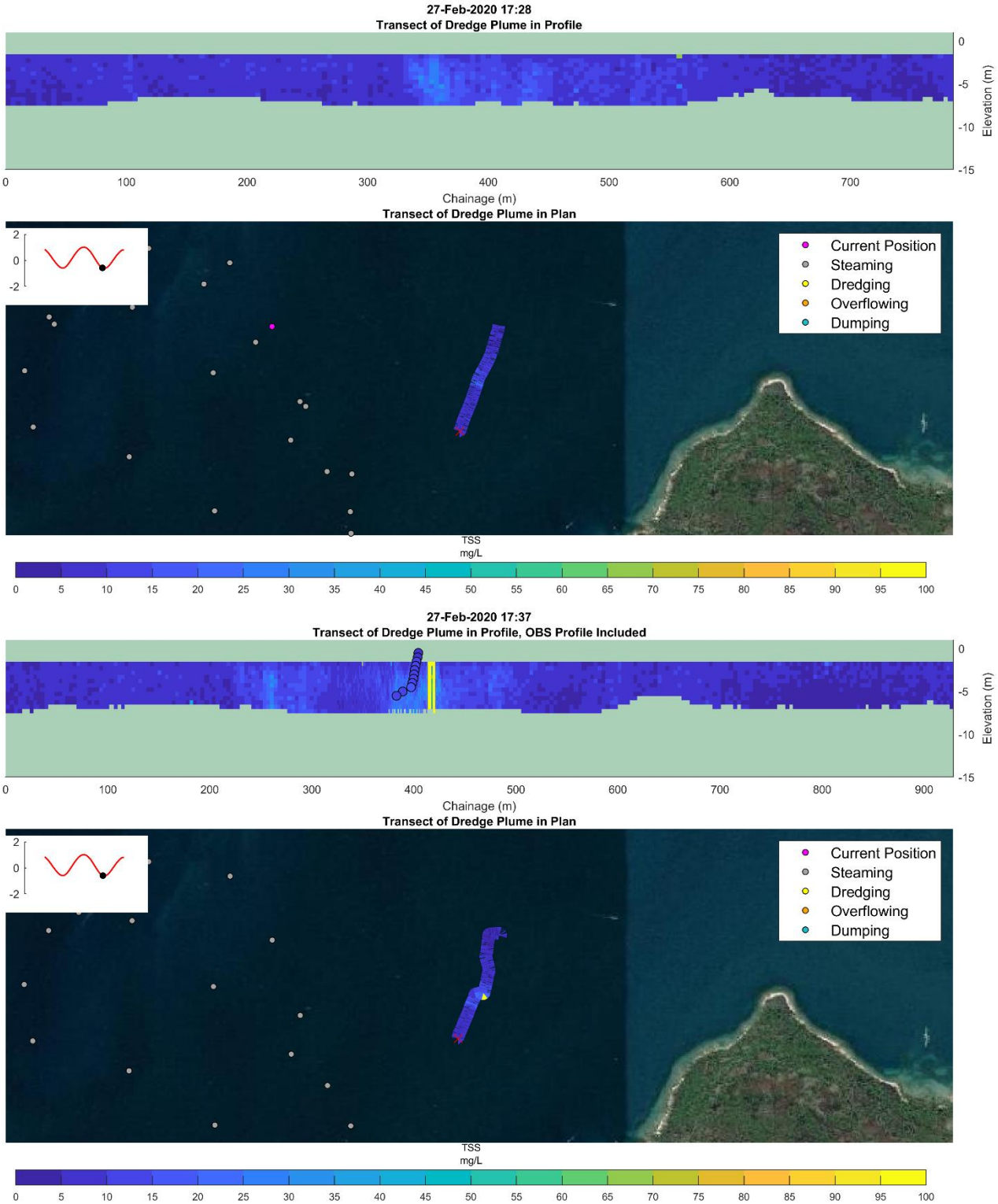

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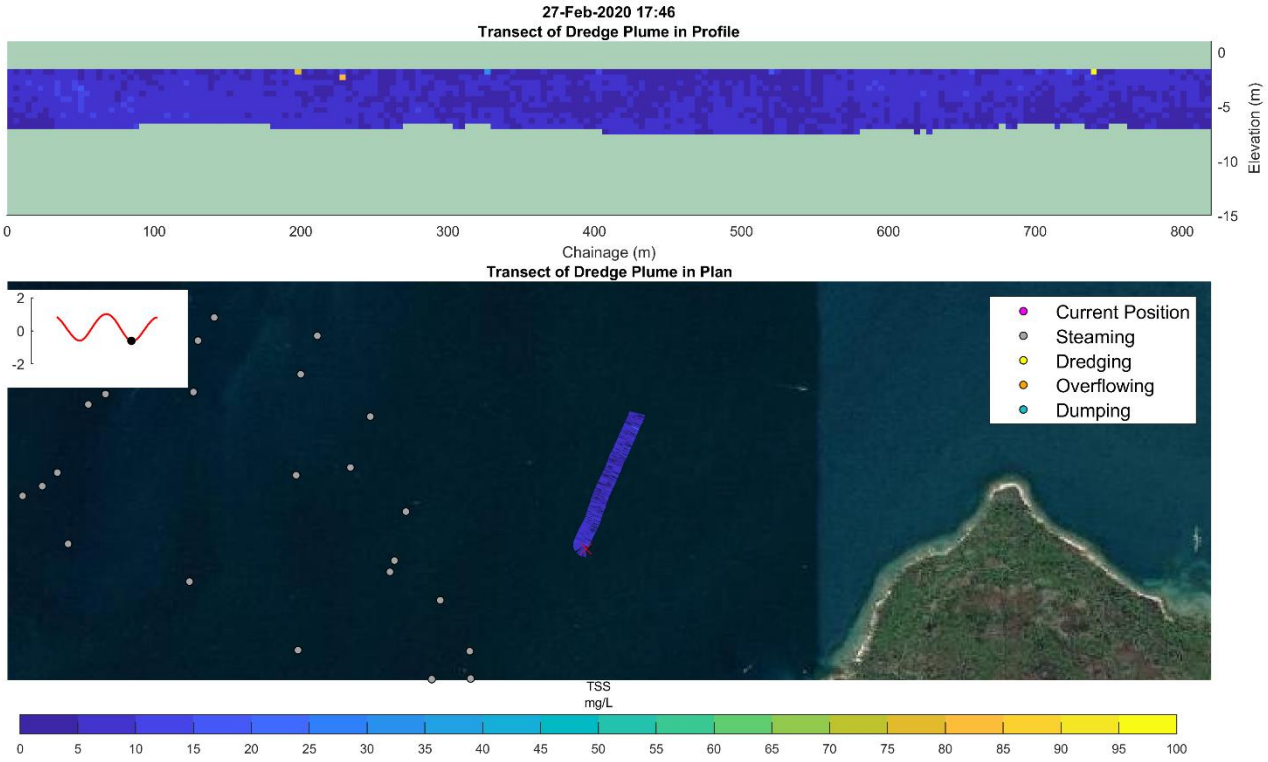
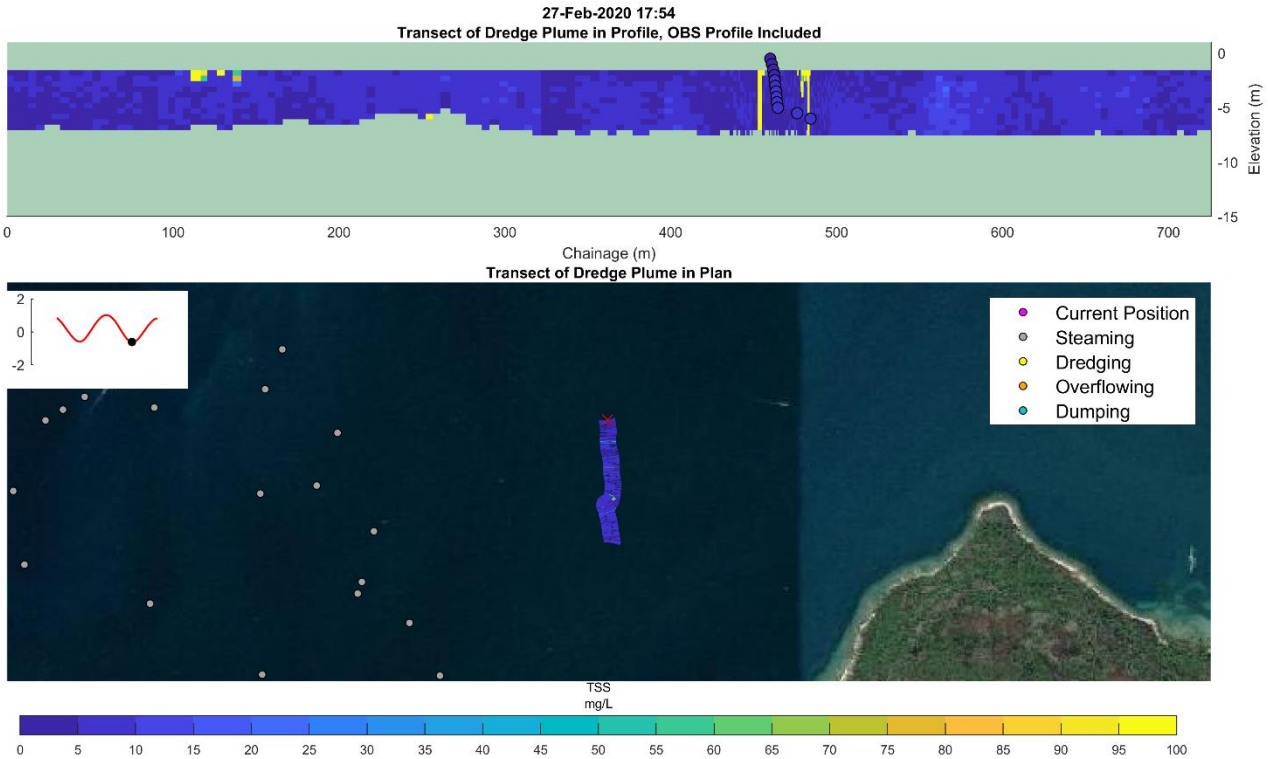
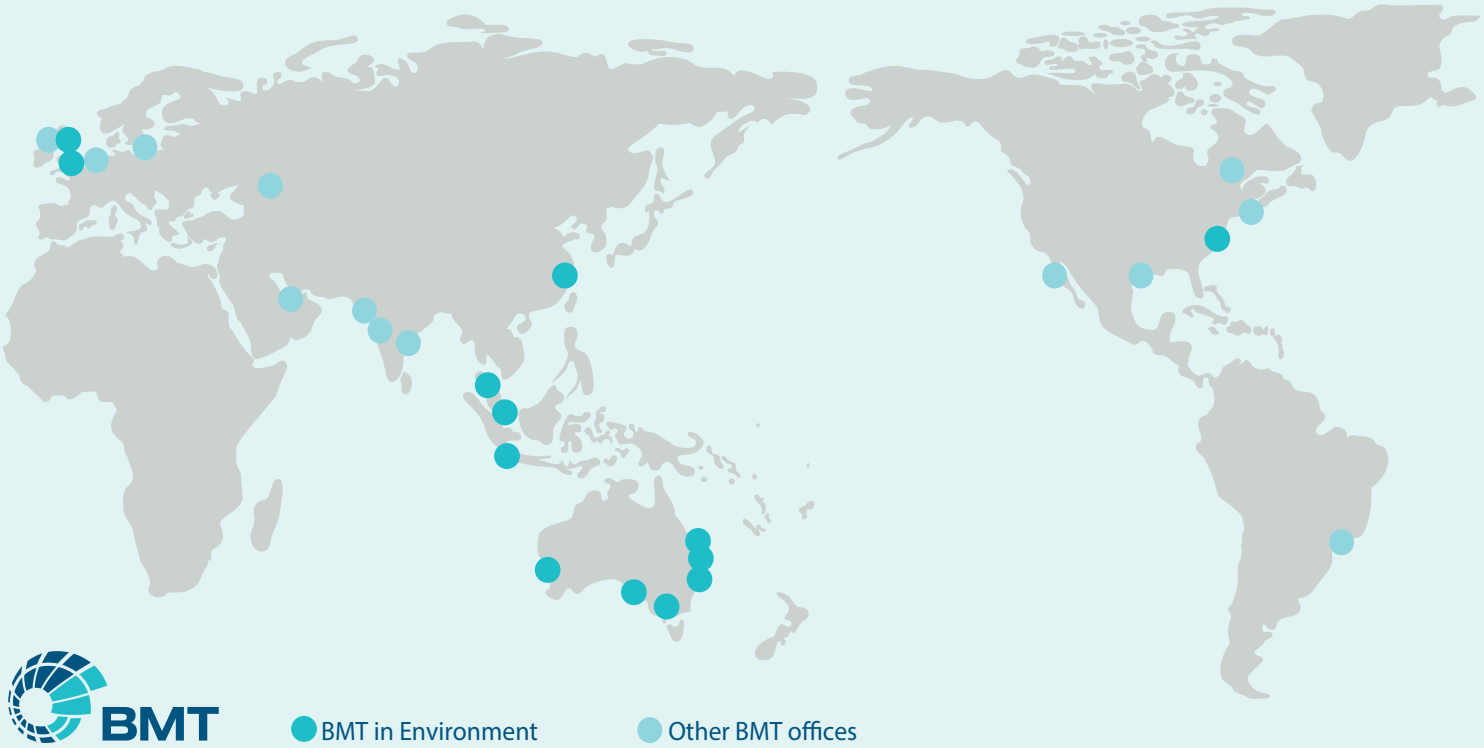




BMT has a proven record in addressing today's engineering and environmental issues.

Our dedication to developing innovative approaches and solutions enhances our ability to meet our client's most challenging needs.



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