m p rogers & associates pl ABN 14 062 681 252
creating better coasts and ports

R1817 Rev 3

January 2025

Department of Transport

Tantabiddi Dredge Plume Modelling Report

marinas
boat harbours
canals
breakwaters
jetties
seawalls
dredging
reclamation
climate change
waves
currents
tides
flood levels
water quality
siltation
erosion
rivers
beaches
estuaries

www.coastsandports.com.au

m p rogers & associates pl
creating better coasts and ports

Suite 1, 128 Main Street, Osborne Park, WA 6017
p: +618 9254 6600
e: admin@coastsandports.com.au
w: www.coastsandports.com.au

K2041, Report R1817 Rev 3
Record of Document Revisions

Rev	Purpose of Document	Prepared	Reviewed	Approved	Date
A	Draft for MRA & DoT review	M Peterson	C Doak	C Doak	16/06/23
0	Issued to Client	M Peterson	C Doak	C Doak	07/08/23
1	Updated with Client comments	M Peterson	C Doak	C Doak	14/08/23
2	Updated for EPA Submission	M Peterson	C Doak	C Doak	31/07/24
3	Updated with revised sedimentation plots	M Peterson	C Doak	C Doak	21/01/25

Form 035 18/06/2013

Limitations of this Document

Table of Contents

Table of Figures

Table of Tables

1. Introduction

The Tantabiddi Boat Ramp precinct is of regional significance and is a key asset as a gateway to the Ningaloo Reef tourism and recreational experiences. The Shire of Exmouth (Shire) and the Department of Biodiversity, Conservation and Attractions (DBCA) jointly manage the Tantabiddi land and marine environment under the governance of the Jurabi and Bundegi Coastal Parks and Muiron Island Management Plan (1999). Both agencies manage civil maintenance, environmental maintenance, and preservation programs, though the Shire generally maintains the boat ramp infrastructure. The location of the boat ramp relative to the North West Cape is shown in in Figure 1.1, below.

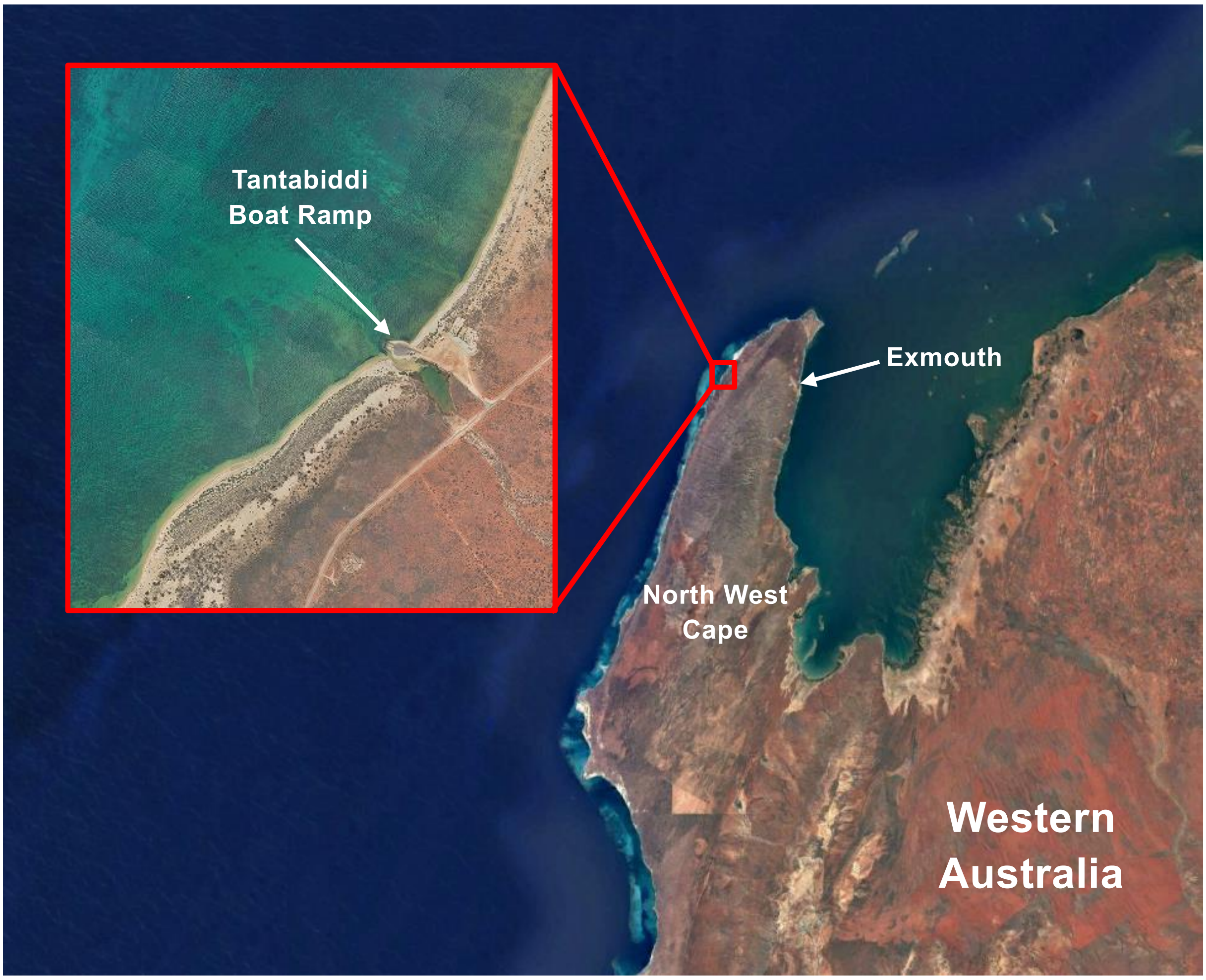


Figure 1.1 Location Plan

To address capacity limitations and maintenance issues associated with the existing Tantabiddi ramp, the Department of Transport (DoT) in collaboration with the Shire, DBCA, Department of Primary Industries and Regional Development (DPIRD), and Tourism WA have resolved to identify the planning, investigations and approvals necessary to develop a new facility at Tantabiddi.

This has involved significant assessment of the coastal processes of the area and the development of a preliminary concept for the Tantabiddi Boating Facility (TBF), which is shown in Figure 1.2.

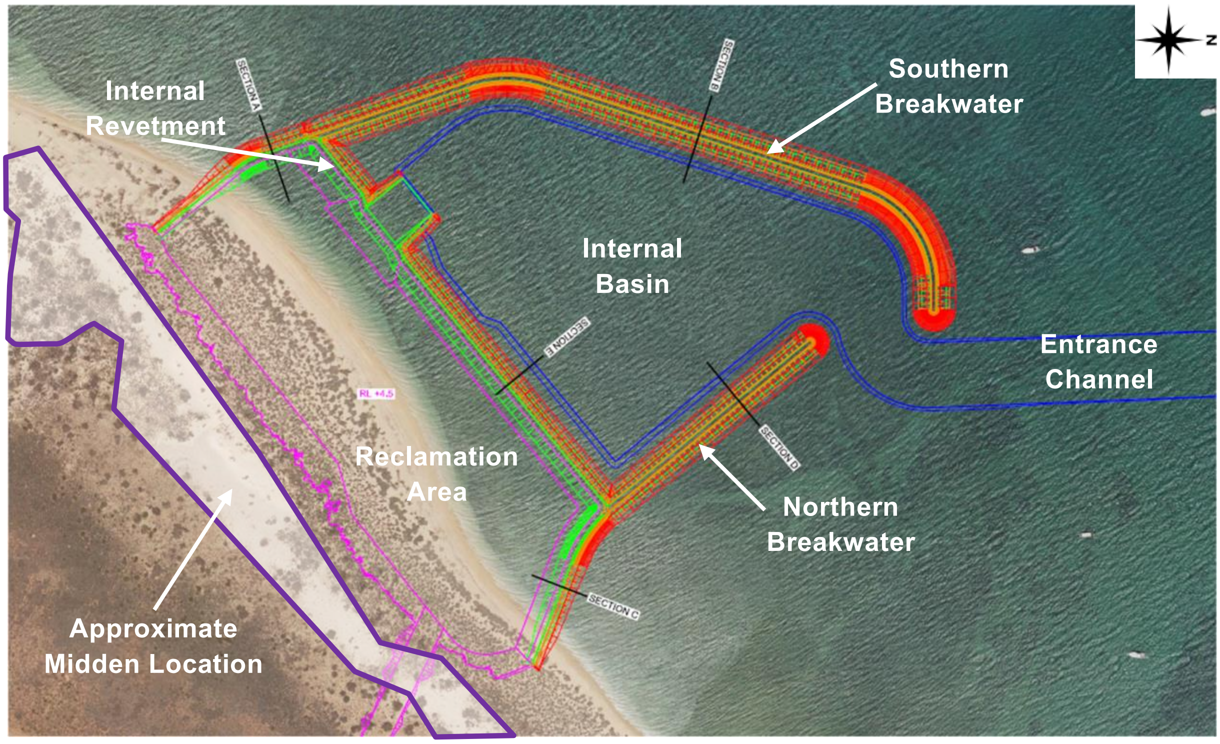


Figure 1.2 Proposed TBF Concept Layout

DoT previously engaged specialist coastal and port engineers M P Rogers & Associates Pty Ltd (MRA) to assess the constructability of the required dredging and coastal structures for the proposed TBF concept. Plume dispersion modelling was included as a provisional scope item as part of these works. One of the outcomes of the constructability assessment was the confirmation of the need to complete detailed plume dispersion modelling for the dredging works associated with the proposed TBF. MRA were subsequently engaged to complete this dredge plume modelling.

1.1 Scope

The scope of this modelling includes the following items.

- Setup, calibrate and validate the Delft3D hydrodynamic model to numerically model the wave and hydrodynamic conditions of the site.
- Use the validated Delft3D model to simulate the wave and hydrodynamic conditions over 16 selected periods corresponding to the proposed dredging activities.
- Set up and calibrate the Delft3D PART model for the simulation of the dredge plume dispersion.
- Simulate 16 selected metocean periods using Delft3D PART, and assess the resulting dredge plumes.
- Provide recommendations on the results of the modelling.

1.2 Proposed Dredging Works

There are two different areas that require dredging as part of the construction works – the internal marina basin and the entrance channel. MRA (2023) provided a detailed review of the constructability of the dredging works and developed recommended construction approaches and methodologies for each.

The internal basin of the proposed TBF will be used as a safe location for the mooring, launching and retrieval of vessels. The current design involves the excavation of this internal basin to - 2.65 mCD. This depth has been chosen to accommodate the draft of a 25 m design vessel (DoT 2022). An over dredge allowance has been included in the design to provide a tolerance for the dredging and to ensure that the design depth is achieved in all locations. Given the nature of the natural environment within which this facility would be constructed, it is expected that best practice environmental management techniques would need to be completed to minimise construction impacts. Based on this, it is expected that the dredging of the internal basin would need to be completed following the construction of the breakwaters since the breakwaters would serve to efficiently and effectively contain the associated plumes generated by the dredging works. This would likely include the installation of a silt curtain across the entrance of the facility to provide a further control against the dispersal of fines outside of the facility.

The entrance channel for the proposed TBF will extend from the entrance of the internal basin approximately 440 m to the north. The channel will be excavated to a depth of -2.65 mCD to match the depth of the internal basin. An over dredge allowance has been included in the design to provide a tolerance for the dredging and to ensure that the design depth is achieved in all locations. The dredging of the entrance channel would not be able to be completed in a protected and contained environment, as is possible for the internal marina basin, and would therefore be prone to more expansive dispersal of dredge plumes. Further details regarding the construction considerations for this channel are outlined in MRA (2023) as well as in latter sections of this report.

2. Previous Modelling

MRA's previously calibrated and validated Delft3D model for the Tantabiddi area was adapted for use in the dredge plume modelling. The setup, calibration and validation of this model, along with the model outputs, are detailed in depth in MRA (2022). A brief summary is provided in the following sections for context.

2.1 Previous Hydrodynamic Modelling

The Delft3D suite of models provides an integrated model approach that can be used to accurately simulate wind fields, wave climates and water levels across a domain. These models have been extensively used around the world and are recognised as high-quality models. The use of high quality, calibrated and validated modelling suites such as Delft3D is recognised as a best practice approach. An integrated modelling methodology has been adopted for this study in order to best represent the physical processes that generate waves and currents at the site.

The physical processes that lead to the generation of these waves and currents operate on a significant spatial scale. Due to computational limitations, it is not efficient to model large areas at high resolutions. As such nested grids have been utilised to reduce computational cost whilst maintaining high resolution at the site.

2.1.1 Grid Layout

Three grid sizes were used for the wave and hydrodynamic modelling and their respective sizes and resolutions are provided in Table 2.1.

Table 2.1 Grid Sizing

Grid	Length (m)	Width (m)	Cell Sizing (m)
B	50,000	130,000	1000
C	~8,000	~21,000	111.11
D	1,444	2,777	10.10

Figure 2.1 shows the model domain and extents of the grids. Figures 2.2 and 2.3 present the domain and bathymetry for each of the grids prepared for the model calibration. Bathymetric and topographic data were sourced from the most recent surveys along the coast as well as the 2011 LiDAR survey data captured by CSIRO (2011). Where survey data was not available, the bathymetry was approximated using the nautical chart WA900.

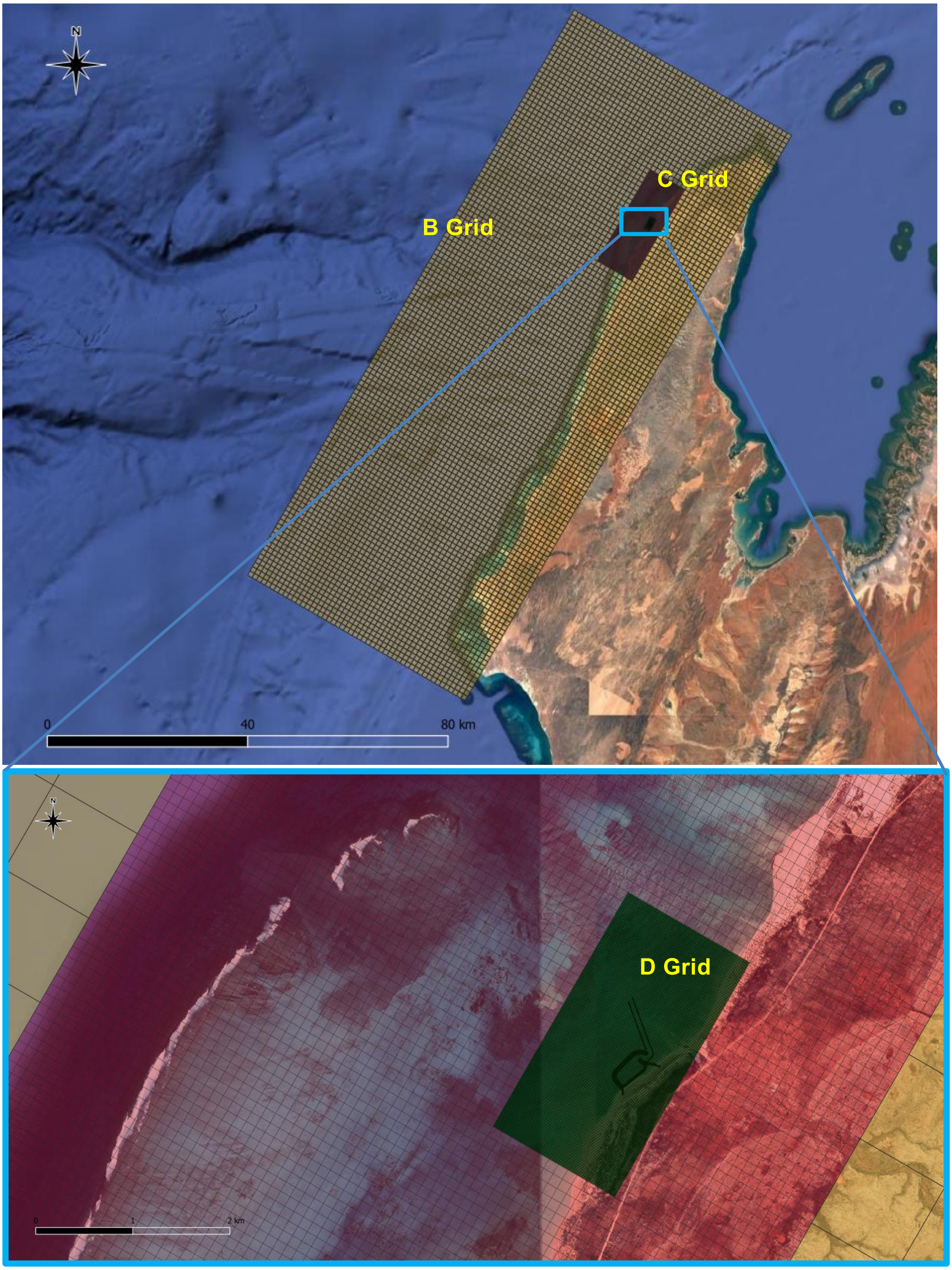


Figure 2.1 Wave Model Domains

2.1.2 Calibration

Calibration of the hydrodynamic model was completed through the simulation of two periods; a summer period (sea breeze dominated) and a winter period (storm and swell dominated). These periods were selected to provide confidence that the wave heights, periods and current velocities were adequately reflected by the model at the site. Simulations of both of these periods were completed and the results compared against measurements taken by an AWAC and Aquadopp deployed by DoT.

The modelled wave and current conditions at the AWAC and Aquadopp adequately matched the recorded conditions and provided confidence in the use of the model for the simulation of wave and hydrodynamic conditions. For further information on the calibration of the model refer to MRA (2022).

2.1.3 Representative Periods

To determine likely hydrodynamic conditions at the proposed TBF, six representative periods of three months were modelled. Four "typical" periods representing each of the seasons were selected resulting in a "typical year" (refer Table 2.2).

Table 2.2 Typical Conditions Representative Periods

Season	Representative Period
Summer (Typical)	01/12/15 – 29/02/16
Autumn (Typical)	01/03/13 – 31/05/13
Winter (Typical)	01/06/11 – 31/08/11
Spring (Typical)	01/09/07 – 31/11/07

In addition, two abnormal seasonal periods were selected for modelling; an unusually stormy winter period and an unusually calm autumn (refer Table 2.3).

Table 2.3 Abnormal Conditions Representative Periods

Season	Representative Period
Autumn (Abnormal)	01/03/98 – 01/05/98
Winter (Abnormal)	01/06/14 – 31/08/14

3. Hydrodynamic Modelling for Plume Dispersion

3.1.1 Revised Grid Layout

The grids and bathymetry used for the previous modelling of the Tantabiddi area were adjusted for the dredge plume modelling. The changes to the grids included the following.

- Increasing the offshore extent of the D Grid (and associated reduction of the C Grid).
- Reduction in the alongshore length of the D Grid (and associated increase in the C Grid).
- Increasing the resolution of the C Grid.
- Change to a 3D model with 5 layers for C and D Grids.

The changes to the extents of the D Grid were completed to allow for the inclusion of the portion of the Tantabiddi Sanctuary Zone closest to the proposed TBF within the high-resolution D Grid (refer Figure 2.2). Previously this area was located in the C grid which would have prevented high resolution plume modelling of this highly ecologically important area. To mitigate the increased computational cost associated with the increase of the D Grid area, the alongshore width of the grid was decreased as high-resolution modelling of these areas was not as important. These changes to the D Grid have also resulted in corresponding changes to the size of the C Grid.

To provide a greater degree of resolution in the modelling of the entire Tantabiddi Lagoon the resolution of the C grid was increased. This resulted in a slight increase to the resolution of the D Grid to maintain appropriate grid ratios, however the new resolution is comparable to that used previously. There was no change to the B Grid.

Table 3.1 Revised Grids

Grid	Length (m)	Width (m)	Cell Sizing (m)
B	50,000	130,000	1000
C	~8,000	~21,000	66.67
D	~1,740	~2,220	9.52

Both the C and D Grids were changed to include five layers to allow for more accurate modelling of the plume dispersion at different levels in the water column. Details of the layers are presented in Table 3.2.

Table 3.2 Layers

Layer	% of Water Column
1 (surface)	15
2	21
3	28
4	21
5 (near bed)	15

As can be seen in Table 3.2, layers 1 and 5 are smaller than the other layers as this allows for more refined modelling of currents and associated plume dispersion near the bed and at the surface of the water column.

3.1.2 Selected Periods

The periods selected for the simulation of the dredge plume for both the entrance channel and internal basin dredging were adapted from the proposed schedule for the dredging and construction included in MRA (2023). The selected periods are outlined in Table 3.3.

Table 3.3 Model Periods

Dredging Event	Model Period	Days
Internal Basin Dredging	1 June – 14 September	105
Entrance Channel Dredging	1 May - 7 June	37

In addition, simulation of both dredge events over the summer period starting from the 1st of November was also completed. The wind, wave and water level conditions for these periods were extracted from the previously completed "typical year" modelling discussed in Section 2.

For the simulation of severe events in winter the abnormal winter modelling completed previously was used as the source of the wind, wave and water level conditions.

Full details of the modelled scenarios are provided in Section 4.6.

4. Dredge Plume Model Setup

The model used to describe the behaviour of the dredge plume associated with the internal basin and entrance channel dredging works was Delft3D D-WAQ PART. PART is a 3D random walk particle tracking model which is coupled to the Delft3D hydrodynamic model (Deltares 2023). Re-suspension of material was included in the model predictions, with all fines released and suspended during the dredging settling through the water column and being available for later re-suspension. This re-suspension was based on a critical shear stress formulation.

4.1 Model Assumptions

4.1.1 Sediment Characteristics

A number of boreholes have been taken at the site to assess the geotechnical conditions of the site (CMW, 2021). The available data included the following.

- Boreholes.
- Point Load Strength.
- Compressive Strength.
- Carbonate Content.
- Particle size distributions (PSD's)

As part of these works, sediment samples were taken at boreholes 8 and 16 respectively, and assessed using PSD's. In addition, a number of PSD's have been completed on sediment from the shoreline and the Tantabiddi Inlet in the last few years. Of these samples only the sediment taken from borehole 16 falls within the dredge areas for the proposed TBF.

As such the sediment data taken from borehole 16 only has been used to inform the dredge plume modelling, though it is noted that there is generally a level of consistency across the boreholes within this area (CMW 2021).

4.1.2 Sediment Classes and Settling Velocity

Sediment plume dispersion studies typically require at least three particle size classes to be defined in order to properly simulate sediment movement and resuspension. These classes are defined based on their distinct settling patterns and potential for resuspension as a result of current and/or wave action. As the dredge plume model is used to simulate the dispersion and settling of material suspended into the water column, typically only the fine particles including silts and clays are included in the model. Coarser materials, including sand and gravels tend to settle out almost immediately and as such are not as critical for assessment of the dredge plume dispersion. As can be seen in the PSD for borehole 16, only approximately 2% of the available sediment falls into the fine fraction (less than 0.075 mm).

Sieve Size (mm)	Percent Passing Sieve (%)
150.0	
100.0	
75.0	
37.5	100
19.0	64
9.5	40
4.75	29
2.36	24
1.18	20
0.600	16
0.425	14
0.300	11
0.150	4
0.075	2

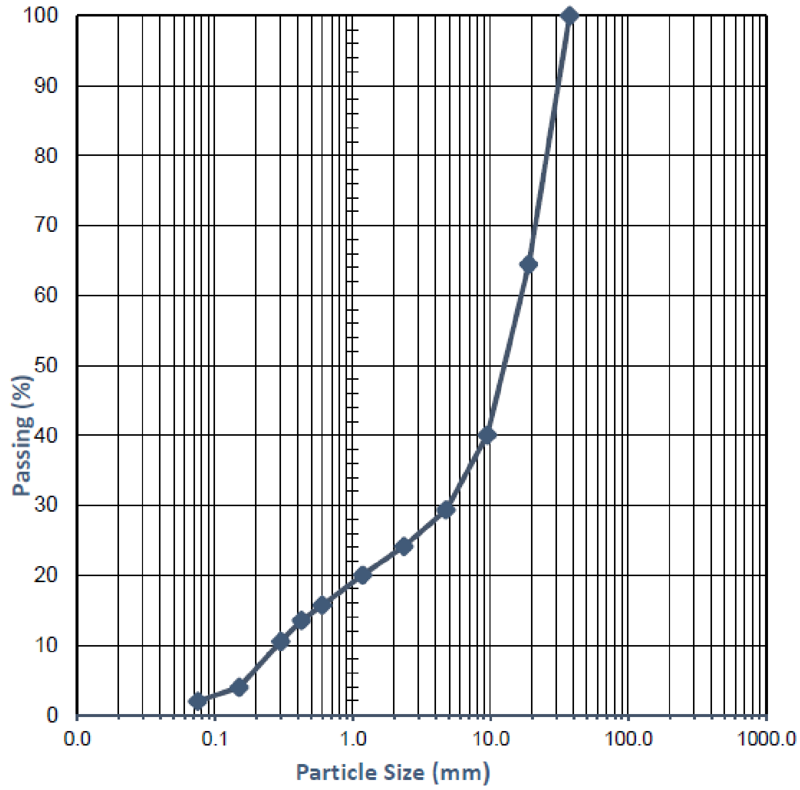


Figure 4.1 Borehole 16 PSD (CMW 2021)

Each sediment size fraction will have different settling velocities. Typical settling velocities for each fraction are presented in Table 4.1 and are based on a review of settling velocities from recent dredge plume modelling studies in Australia.

Table 4.1 Particle Size Classes & Settling Velocities

Particle Size Fraction (micron)	Settling Velocity (m/s)
Clay (2 – 6)	3.5×10^{-6}
Fine Silt (6 – 30)	3.5×10^{-4}
Coarse Silt (30 – 75)	0.003
Fine Sand (75 – 150)	0.012

The sediment settling velocity classifications listed in Table 4.1 are based on an unflocculated sediment sample. In reality, at high sediment concentrations (>300mg/L) the individual particles tend to floc together resulting in larger particles with higher settling velocities, however as this only occurs at quite high concentrations the unflocculated settling velocities will be used within the modelling. The use of unflocculated settling velocities within the model will result in slightly conservative simulation of sediment suspension times. This will result in the modelled plumes remaining for longer and potentially being more widespread.

4.1.3 Deposition

In the model, the deposition rate is formulated as a function of the settling velocity, the near bed concentration of sediment and the actual critical bed shear stress for deposition (Deltares 2023). For the dredge plume modelling for Tantabiddi, a critical bed shear stress for deposition of 0.05 N/m^2 was employed. This is consistent with the recommendations for dredge dispersion studies in areas of similar seabed characteristics (Doorn-Groen & Foster 2007; Van Rijn 1989)

4.1.4 Erosion/Resuspension

The erosion rate depends on the seabed properties which are represented in the model through the inclusion of a threshold shear stress value. In the model the bed is described as one layer where the material is deposited once it has settled out of the water column. This bed layer then provides a source for the resuspension of material. Importantly, this resuspension of material is limited to that which has been deposited as a result of the dredging works at the site. This enables the impact of the proposed dredging works to be determined in isolation from any other sediment transport which may be occurring at the site. In this way the direct impact of the dredging works can be assessed.

Partheniades (1965) and Parchure & Mehta (1985) investigated the critical shear stress for erosion of cohesive sediments as listed in Table 4.2. For the present modelling study the critical shear stress parameter was set to the value of 0.1 N/m^2, corresponding with the upper bound of shear stress required to mobilise mobile fluid muds. Given the relatively low concentrations of fines in the available sediment and the relatively short timeframes associated with the dredging works (refer Section 4.3) it has been assumed that fine sediments which settle to the bottom will be unlikely to begin consolidating before resuspension. Thus the adoption of 0.1 N/m^2 for the critical shear stress is seen as an appropriately conservative assumption.

Table 4.2 Critical Shear Stress for Sedimentation & Erosion (Partheniades 1965, Parchure & Mehta 1985)

Mud Type	Density (kg/m^3)	Typical Critical Shear Stress (N/m^2)
Mobile Fluid Mud	180	0.05 – 0.1
Partly Consolidated Mud	450	0.2 – 0.4
Hard Mud	600+	0.6 – 2.0

4.1.5 Fines Production

During the dredging works a significant portion of the dredging is likely to occur in limestone of variable hardness, as indicated by the available geotechnical information and discussed in MRA (2023). When this material is worked, abrasion of the rock against the machinery and other rocks produces a fine powder commonly referred to as rock flour. This rock flour is generally of variable composition with particle sizes ranging from Clays to Fine Sands. Given that a large portion of the dredging works will likely occur in limestone, the production of rock flour will need to be considered as part of the dredge plume modelling.

Based on MRA experience with dredging operations at Ocean Reef Marina and discussions with the contractor about nearby quarrying works, both of which involved working with comparable limestone to that present at the site, it was determined that a conservative estimate of rock flour and fines production from the limestone dredging works would be 10% (Galetakis et al 2012). This 10% would likely be comprised of the following fractions.

- Approximately 4% coarse sand (not included in the modelling).
- Approximately 2% fine sand.
- Approximately 2% coarse silt.
- Approximately 1% fine silt.
- Approximately 1% clay.

4.2 Parameter Summary

The sediment parameters used in the model set-up, based upon review of other sediment dispersion studies carried out in Western Australia are summarised in Table 4.3. The dispersion coefficients are critical parameters with respect to the spatial spreading of the sediment plume. They model the effects of turbulence that is not included in the hydrodynamic modelling, including small-scale deviations from the mean hydrodynamic velocity field.

Table 4.3 Key Parameters used in the Delft3D D-WAQ PART Model

Model Parameter	Value
Critical Shear Stress for Deposition (N/m^2)	0.05
Critical Shear Stress for Erosion (N/m^2)	0.1
Horizontal Dispersion Coefficient (m^2/s)	1.0
Vertical Dispersion Coefficient (m^2/s)	0.01
Number of Vertical Sigma Layers	5 plus bed layer

4.3 Dredging Campaigns

Based on the proposed preferred dredging methodology outlined in MRA (2023) there will be two separate dredging campaigns to achieve the design depth for the internal basin and entrance channel of -2.65 mCD.

The following dredging campaigns have been used in the model as they were considered to represent the most conservative cases for sediment plume generation based on the proposed dredge methodology outlined in MRA (2023). The proposed dredge volumes used in the modelling are outlined in Table 4.4.

- Dredge Campaign 1 (Internal Basin)
    - Dredging of the internal basin to the design depth of -2.65 mCD plus an overdredge allowance of 0.3 m.

- Completed using land-based plant operating from purpose built bunds over a period of 13 weeks.

- Dredge Campaign 2 (Entrance Channel)
  - Dredging of the entrance channel to the design depth of -2.65 mCD plus an overdredge allowance of 0.3 m.
  - Completed using a BHD with excavated material placed in barges and subsequently transported to the internal basin where it is dumped before being excavated by land-based plant over a duration of 4 weeks

Table 4.4 Dredge Volumes

Item	Dredge Volume (m^3)	Overdredge Allowance (m^3)	Total Dredge Volume (m^3)
Internal Basin	112,700	16,650	129,350
Entrance Channel	15,320	7,250	22,570
Total	**128,020**	**23,900**	**151,920**

Whilst it is possible that a cutter suction dredge could potentially complete the entrance channel dredging, a BHD has been selected as this is assumed to create more of a plume for the following reasons.

- Whilst a cutter suction dredge may produce more fines at the bed, a BHD introduces fines throughout the water column as the bucket is pulled up.
- With a cutter suction dredge, once removed from the seabed, dredge spoil is pumped to shore using a pipeline, reducing the potential for fines to be introduced into the water column. Conversely the BHD would need to firstly fill a barge where overflow back into the water column would likely occur. This would then likely be followed by the dumping of the dredge spoil within the marina before it is excavated and placed on land, by land-based plant. As such during this process there are a number of opportunities where fines could be added back into the water column potentially resulting in larger plumes.

The locations of the proposed dredging works are presented in Figure 4.2.

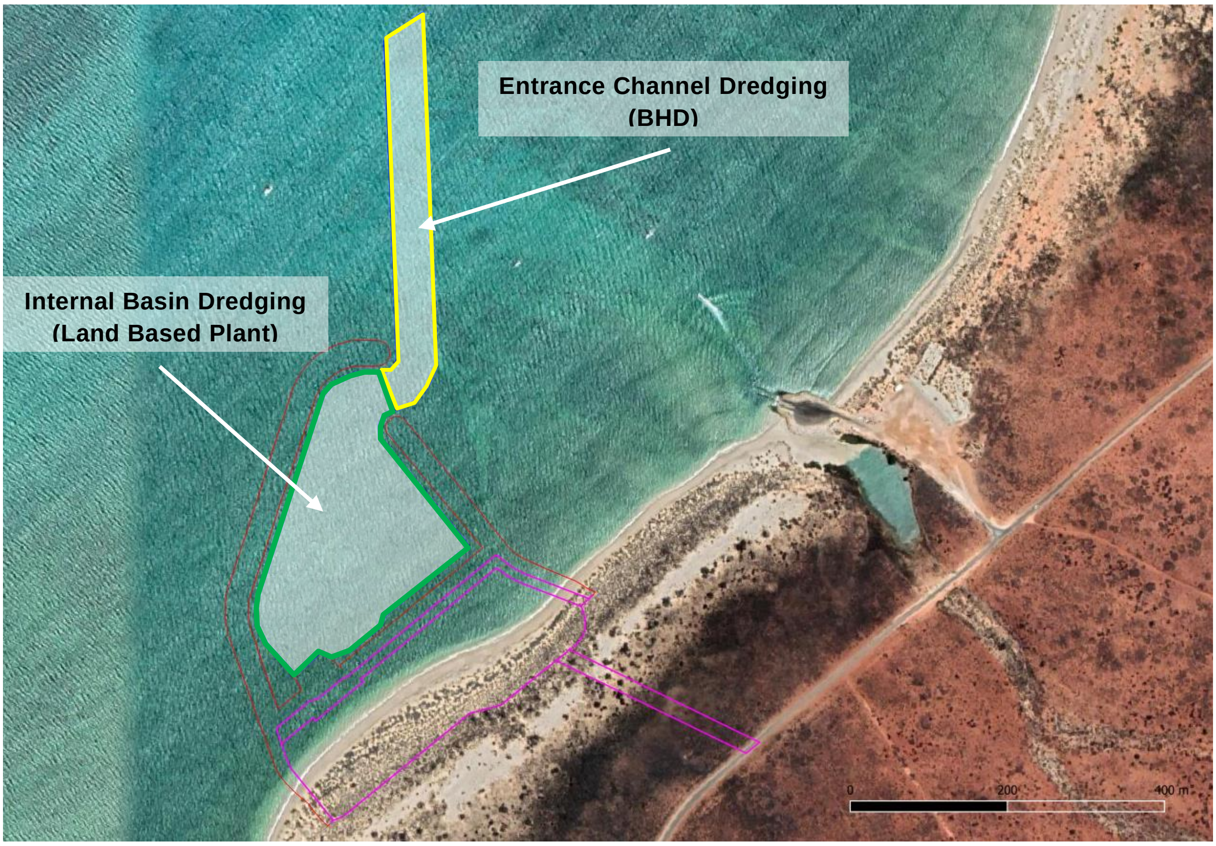


Figure 4.2 Proposed Dredge Areas

4.4 Dredge Plant & Dredge Rates

For the internal basin dredging, land based plant are proposed to be used, whereas for the entrance channel dredging a BHD is proposed to be used.

4.4.1 Land Based Plant Dredging

It is proposed to use land based plant operating from purpose built bunds for the dredging of the internal basin, with the works likely completed by excavators in the 60 to 90 ton range. The material removed from the bed will subsequently be used in the construction of additional bunds if required and/or the reclamation works. Harder material which cannot be removed solely using an excavator bucket, will need to be broken up into smaller pieces prior to removal using a rock hammer or rock wheel. These works will result in the mobilisation of sediment into the entire water column as the excavator bucket is pulled up through the water. However, a greater proportion of the sediment is mobilised in the lower part of the water column adjacent to the excavation.

The dredging of the internal basin using land based plant is estimated to take approximately 13 weeks.

4.4.2 Back Hoe Dredging

A BHD is proposed to be used for dredging the Entrance Channel. The likely BHD to be used for the works is the USL 2B & 2D or similar size due to the limited navigable depth within the Tantabiddi Lagoon. The dredge is comprised of a long reach excavator mounted on a barge. The dredger excavates the seabed using the attached excavator and fills one or more non propelled split hopper barges with a capacity of 250 m^3 respectively (MRA 2023). Once filled the barges are propelled into the marina using a Multicat or similar where they dump the dredge spoil, which is subsequently excavated by land-based plant and used in the reclamation works. TAMS have advised that a production rate of approximately 50 m^3/hr for the BHD can be expected assuming the dredging of hard limestone material.

4.4.3 Dredge Fines Generation Rates

The *Guideline on Dredge Plume Modelling for Environmental Impact Assessment* (Sun et al 2020) recommends the use of the Becker method for the estimation of the far field source term. This is accomplished using the following equation.

$$m_{eq} = \sigma_{eq} * m_t$$

Where:

- m_{eq} (kg/m^3) is the dry solids mass of fines entering the system from a particular piece of equipment.
- σ_{eq} is an empirical source term
- m_t (kg/m^3) is the total mass of fines available in the dredged material from a particular piece of equipment.

Sun et al (2020) provides a recommendations for empirical source term range for a number of plume sources. The following source terms ranges and corresponding adopted values are listed below.

- TSHD overflow discharge (proxy for barge overflow discharge) = 0.5 – 1.0
  - Adopted σ_{eq} = 1.0
- BHD (assumed representative of land based excavators as well) = 0.01 – 0.10
  - Adopted σ_{eq} = 0.10

Thus assuming that the Borehole 16 PSD is applicable across the dredging sites (available fines ~ 2%) and a bulk density of the sediment of 2,100 kg/m^3, the source rates for each of the machines when excavating sandy material can be determined.

- BHD and Land Based Plant (sediment)

$$m_t = 2\% * 1m^3 * 2100\ kg/m^3 = 42\ kg/m^3$$

$$m_{eq} = 0.1 * 42\ kg/m^3 = 4.2\ kg/m^3$$

- Barge overflow: Fines entering water column = fines placed in barge.

However, as a significant portion of the works are likely to occur in limestone, the fines contribution from these works needs to be determined. Adopting the fines generation rates discussed in Section 4.1.5, a limestone density of 2,100 kg/m^3 and assuming that of the generated fines approximately 50% of the fine sand and 25% of the coarse silt is removed from the water column in the excavator bucket, the following fines source rates are estimated.

- Fine Sand = 21 kg/m^3
- Coarse Silt = 31.5 kg/m^3
- Fine Silt = 21 kg/m^3
- Clay= 21 kg/m^3

These source rates for the BHD and land-based plant are significantly higher when excavating limestone then when excavating sediment. Given these increased rates and the likely high percentage of the dredging works which will occur in rock, the limestone fines production rates have been adopted for all dredging works. It has also been assumed that all fines (excluding fine sand) that enter the barge are lost as overflow back into the water column as a worst-case scenario.

For the fine silt and clay fractions of the fines it has been assumed that approximately 10% of the produced fines are transported into the barge for the BHD works. This allows these fines to then re enter the water column in the barge overflow. For the land-based plant work all of the fine silt and clay fraction are assumed to disperse in the water column for conservatism.

4.5 Dredge Plume Dispersion Methodology

The release and settlement of sediments during dredging has been simulated using a particle tracking model. The particle tracking extension to Delft3D incorporates variable settling rates and allows the particles to be deposited and resuspended, to best represent conditions in the natural environment (Deltares 2023).

The model itself relies on the input of the Delft3D 3D hydrodynamic and wave model simulations, including allowing for wetting and drying effects and a number of diffusion models.

For the BHD, sediment releases would occur from the bucket throughout the water column with 40% released in Layer 5 (bottom layer), 20% released in Layers 4, 3 and 2 and an additional 10% released in Layer 1 (composed of Fine Silt and Clay fractions only) to represent the combination of any minor release from the bucket at the surface as well as overflow from the barge. This additional 10% also includes any additional rock flour which is generated during the transport in the excavator bucket and when the material is dumped into the barge. This results in more fines entering the water than are generated from the initial excavation of the bed.

For the land-based plant sediment release would also occur throughout the water column. However, the spread across the layers is a little different with 40% in layer 5, 20% in layers 4 and 3 and 10% in layers 2 and 1. This has been changed to decrease the overall input into the system due to the lack of overflow.

The following assumptions were used in modelling the production rate of fines at the dredging sites.

- For the BHD a production rate of 50 m^3/hr has been assumed based on advice provided by contractors.

- For the land based plant a production rate of 50 m^3/hr has been assumed based on advice provided by contractors and MRA experience with dredging works in similar material at Ocean Reef Marina.

4.6 Modelled Scenarios

In total 17 model scenarios have been simulated and assessed. These scenarios are listed in Table 4.5 and fall under the following main categories.

- Internal basin dredging during the winter months.
- Internal basin dredging during the summer months.
- Resuspension of fines following the completion of the internal basin dredging.
- Entrance channel dredging during the winter months.
- Entrance channel dredging during the summer months.

In addition, for each of the above categories simulations were conducted for “typical” moderate conditions as well as abnormal conditions with winter periods including winter storms and summer periods including a cyclone event.

Table 4.5 Modelled Events

Run	Dredge Event	Period	Conditions	Simulation Start Date	Duration (days)	Dredging Start Date	Duration (days)
1	Internal Basin	Winter	Typical	1st May	105	8th May	91
2			Typical with Silt Curtain	1st May	105	8th May	91
3			Abnormal	1st May	105	8th May	91
4			Abnormal with Silt Curtain	1st May	105	8th May	91
5		Summer	Typical	1st November	105	8th November	91
6			Typical with Silt Curtain	1st November	105	8th November	91
7			Abnormal (cyclone)	1st November	105	8th November	91
8			Abnormal (cyclone) with Silt Curtain	1st November	105	8th November	91
9	Entrance Channel	Winter	Typical	1st May	37	3rd May	28
10			Abnormal	1st May	37	3rd May	28

11		Winter Alternate	Typical	1st June	37	3rd June	28
12			Abnormal	1st June	37	3rd June	28
13		Summer	Typical	1st November	37	3rd November	28
14			Abnormal (cyclone)	1st November	37	3rd November	28
15	Resuspension	NA	Seabreeze & Swell	20th July	12	NA	NA
16			50 year ARI Cyclone	1st November	8	NA	NA
9b	Entrance Channel	Winter	Typical	1st May	37	3rd May	28

Runs 9 through 14 assess the impact of the dredging of the entrance channel but do not include the potential effects of the subsequent dumping of the dredge spoil within the harbour basin. A separate simulation was completed to assess the additional contribution from the dumping and subsequent excavation (in line with the recommended dredging methodology discussed in MRA (2023)) of dredged material within the harbour . This simulation (Run 9b) will be used to assess the potential for the dumping and removal of dredge spoil by land based plant to contribute to dredge plumes outside of the harbour.

5. Model Results

The model presents total suspended sediment concentrations (TSS, in mg/L) above the background levels. This allows the effects of the dredging works to be assessed in isolation from other natural sources of suspended sediments (e.g. stirring, coral spawning, etc). Generally a plume is observable to a casual observer above the water when the suspended sediment concentration is above approximately 5 mg/L. This would include suspended sediments in the water column from natural sources which are often around 2 – 3 mg/L. For this reason concentrations of 1, 2 and 5 mg/L were plotted allowing the extent of the potentially visible plume to be presented. In addition once plume concentration are potentially above 10 mg/L and definitely above 100 mg/L for extended periods there can be deleterious impacts on the local ecosystem. As such, concentrations of 10 and 100 mg/L were also plotted.

Given the relatively shallow nature of the Tantabiddi Lagoon and the significant impact that shading of the bottom due to the dredge plume (regardless of its position in the water column) can have on benthic fauna and flora the maximum concentrations across all five layers of the model were assessed. This provides the maximum concentration at each location at each time step. In turn this provide a greater understanding of the likely impacts of the dredge plume than looking at one or two of the layers in isolation by ensuring that the maximum concentration across the water column in a location is always considered.

5.1 Internal Basin Dredging

The simulation of the internal basin dredging works assessed eight different scenarios, which considered the timing of the works and variation in the severity of metocean conditions. For all eight scenarios the locations and rates of the dredging have been kept consistent. The sediment input locations are presented in Figure 5.1 and the associated times are outlined in Table 5.1. It is noted that the mouth of the harbour (area 5) is dredged before area 6. This is due to the dredging of the mouth with land based plant likely requiring the construction of a bund through area 6 to access the area.

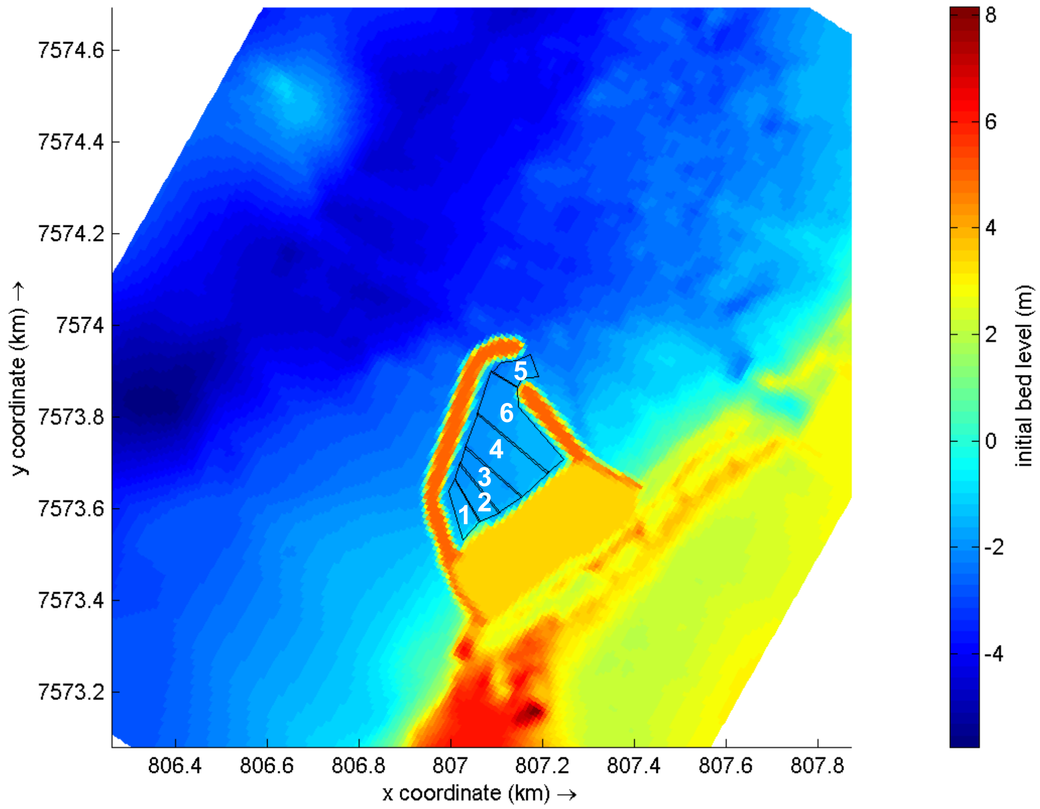


Figure 5.1 Internal Basin Sequential Dredge Areas

Table 5.1 Internal Basin Dredging Sequence

Dredge Area	Input Commencement (days)
1	8
2	15
3	29
4	42
5	55
6	78

The outputs from all 8 of the simulations are included in Appendix A. The main outputs are exceedance plots which show the concentrations that are met or exceeded for a given percentage of the run time. The following exceedance plots have been produced for each of the simulations.

- 50% exceedance plot (eg concentration > 1mg/L for at least 50% of the run).
- 80% exceedance plot (eg concentration > 1mg/L for at least 20% of the run).

- 95% exceedance plot (eg concentration > 1mg/L for at least 5% of the run).

For example if a specific location had the following concentrations over the simulation:

- 0 mg/L for 70% of the simulation period;
- 2.5 mg/L for 23% of the simulation period; and
- 6.4 mg/L for the remaining 7% of the simulation period,

then the 50% exceedance concentration at that location would be 0 mg/L, the 80% exceedance concentration would be around 2.5 mg/L and the 95% exceedance concentration would be around 6.4 mg/L.

Run 1 simulated the dredging of the internal basin over the originally proposed period and subject to “typical” winter conditions without a silt curtain across the entrance to the harbour. The percentile exceedance plots of the TSS concentrations in mg/L for Run 1 are presented in Figures 5.2 and 5.3. From these figures it can be seen that, for the majority of the 105 day simulation, the dredge plume has remained contained within the breakwaters. For the 50 and 80% exceedance plots there was little to no dispersion of the plume outside of the breakwaters (refer Figure 5.1). For the 95% exceedance plot some dispersion outside the breakwaters is observed in the area adjacent to the northern breakwater (refer Figure 5.3). This dispersion outside of the breakwaters only occurs at low concentrations of around 1 – 2 mg/L.

It appears that the majority of the dispersion outside of the breakwaters is associated with the dredging works in and around the mouth of the harbour, as would be expected.

Figure 5.2 Run 1 Exceedance Plots, 50% Exceedance (left) & 80% Exceedance (right)

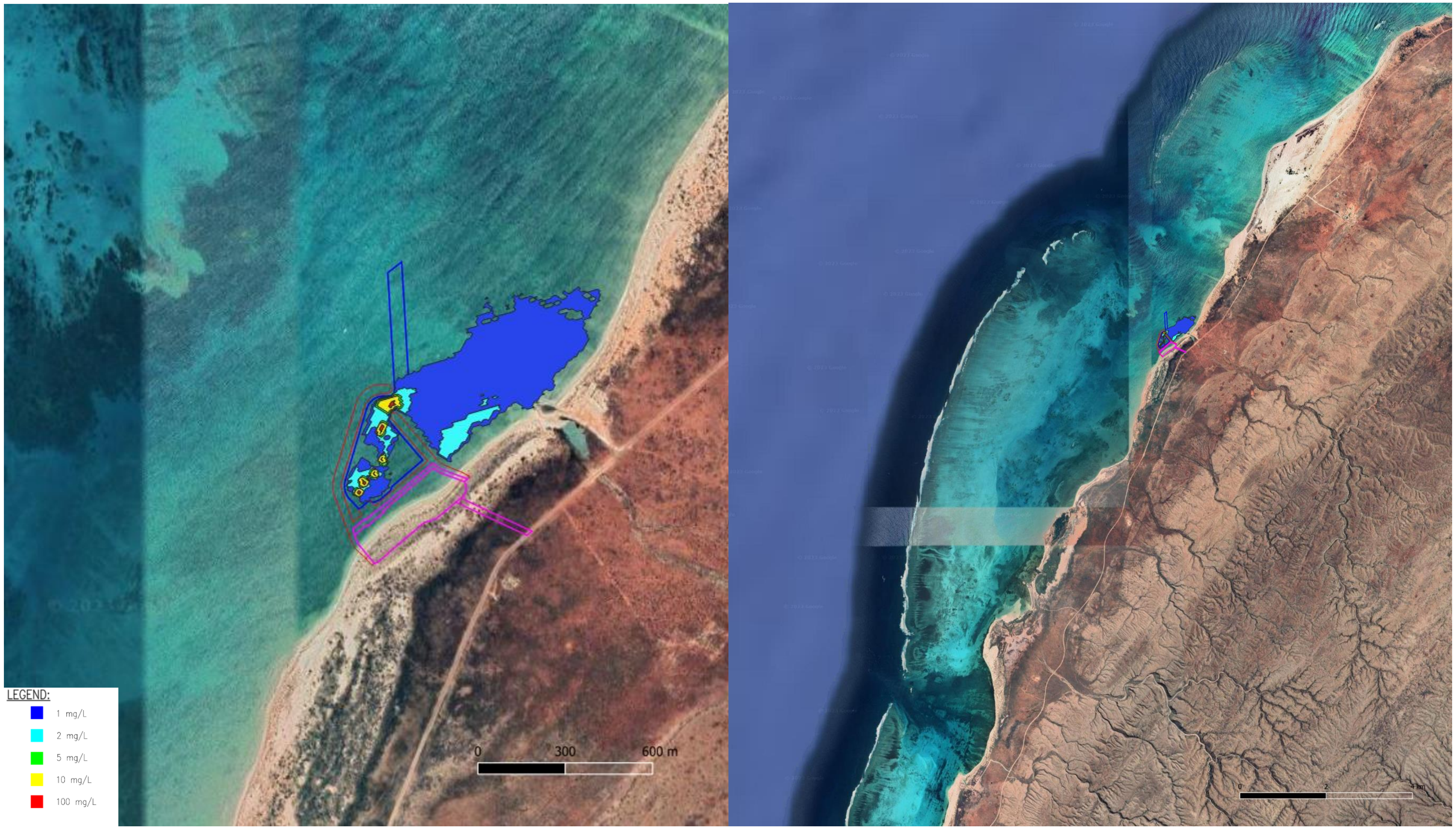


Figure 5.3 Run 1 - 95% Exceedance Plots, Near Field Impact (left) & Far Field Impact (right)

Figure 5.4 presents the 95% exceedance plots for Runs 1, 2 and 3 for comparison. From these plots it can be seen that there appears to be little difference in the concentrations and extents of the 95% exceedance plumes between the base run (Run 1), a run using a silt curtain (Run 2) and a run with more severe winter conditions (Run 3). There are slight differences between the exact locations and extents of the plumes, however all three runs have comparable plumes. This similarity in the dredge plumes is consistent across all of the internal basin dredging simulations and exceedance plots.

Figure 5.5 compares the 95% exceedance plots for the base winter run (Run 1) and an equivalent simulation run in summer (without cyclones) instead of winter (Run 5). Again the 95% exceedance plumes are comparable for both of these runs. There is a reduced concentration of suspended sediment present in Run 5 along the shoreline immediately adjacent to the northern breakwater. This is likely due to the reduced wave energy generally present in the summer months.

It is noted that the silt curtain restricts flow of the upper portion of the water column which results in stronger currents near the bed where the majority of suspended sediment is located. As a result, the dredge plumes for these runs has the potential to extend over a slightly larger area than observed for the runs without the silt curtain.

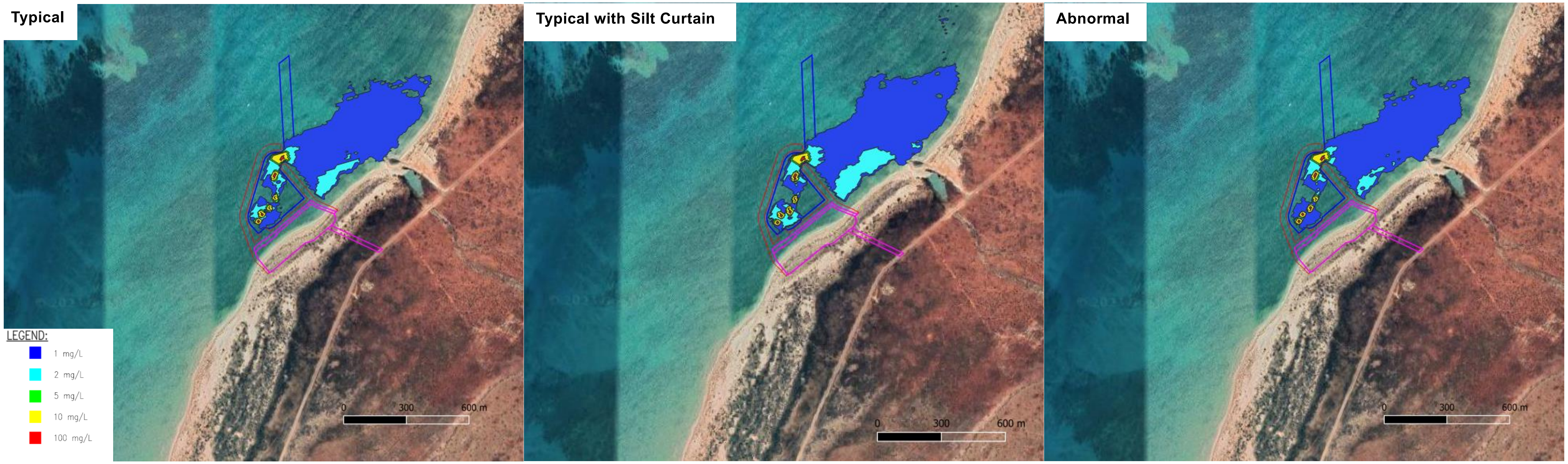


Figure 5.4 95% Exceedance Near Field Plots for Winter, Run 1 (left), Run 2 (middle) & Run3 (right)

Figure 5.5 95% Exceedance Near Field Plots for Winter (Run 1, left), & Summer (Run 5, right) for Comparison

To provide a more in depth assessment of the TSS concentrations at specific locations, time series of the sediment concentrations were extracted at the location displayed in Figure 5.6.

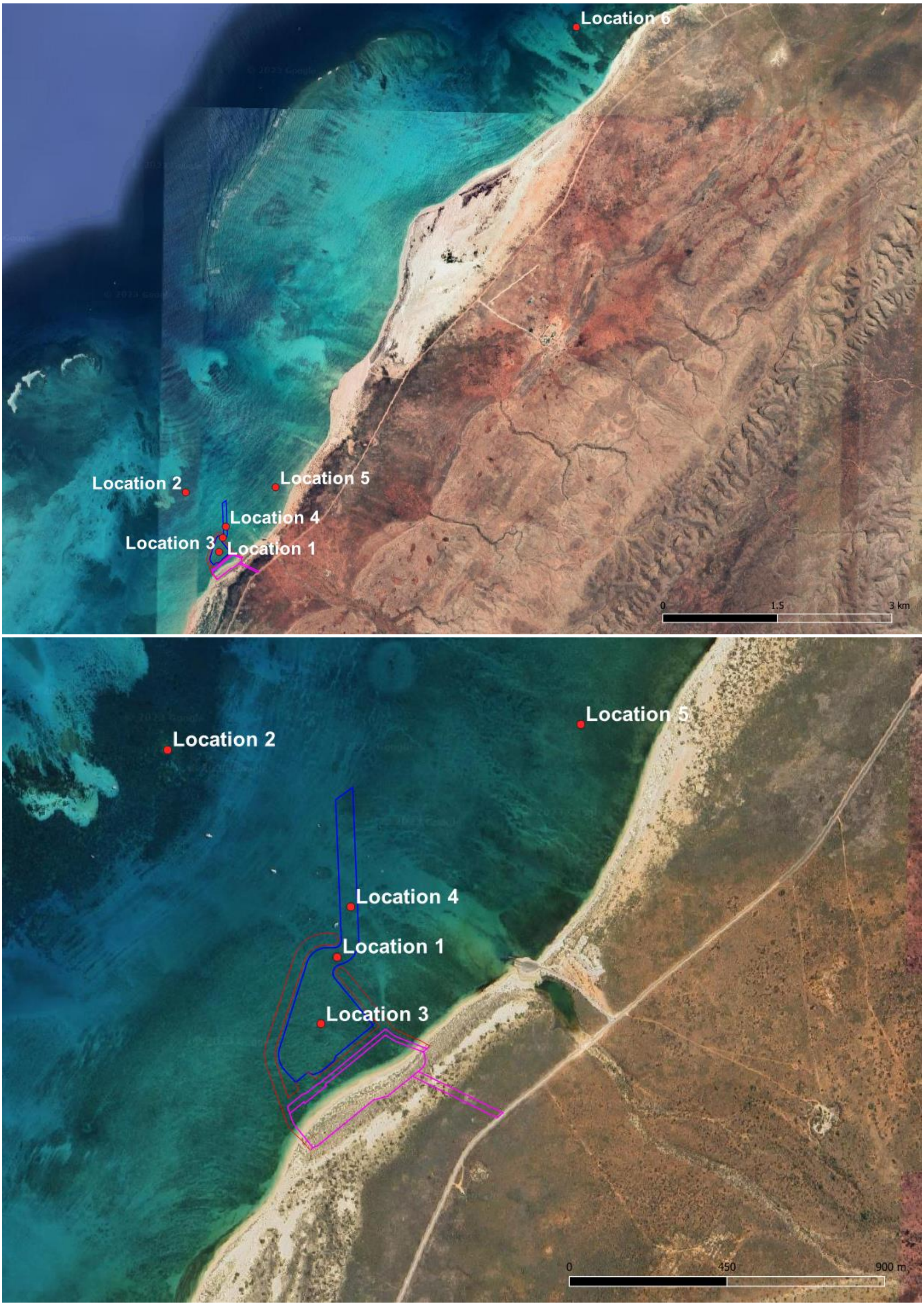


Figure 5.6 Timeseries Output Locations

Figure 5.7 presents the timeseries TSS concentrations for all locations during Run 1. As can be seen in these plots during the majority of the simulation there are relatively low concentrations (less than 1 mg/L) of TSS's at the output locations. However, at locations 1 and 3 there are significant spikes in the TSS concentrations which coincide with the dredging works around the mouth of the harbour as would be expected. Given the location of these outputs in the centre of the internal basin and the mouth of the harbour respectively, the spikes in TSS concentrations are expected. These concentrations peak at around 1,000 mg/L however concentrations above 400 mg/L are infrequent and relatively brief. Slight increases in the TSS concentrations at locations 4 and 5, which coincide with the dredging works around the mouth of the harbour, are also observed. However these concentrations peak at around only 4 mg/L.

Figures 5.8 and 5.9 compare the TSS concentrations at Locations 1 and 2 across Runs 1, 2, 3 and 5 during the dredging works around the mouth of the harbour. Comparable concentrations and peaks are observed at Location 1 for Runs 1, 2 and 3 with Run 5 displaying consistently higher concentrations over this time period. This is likely due to the reduced wave energy present in Run 5 resulting in less dispersion and corresponding higher concentrations in the mouth of the harbour. Output Location 2 is situated on the edge of the Tantabiddi Sanctuary Zone (TSZ) which is an ecologically important site and as such TSS concentrations at this site will need to be actively managed. Figure 5.8 shows that TSS concentrations at this location are negligible over the simulation period for the modelled runs.

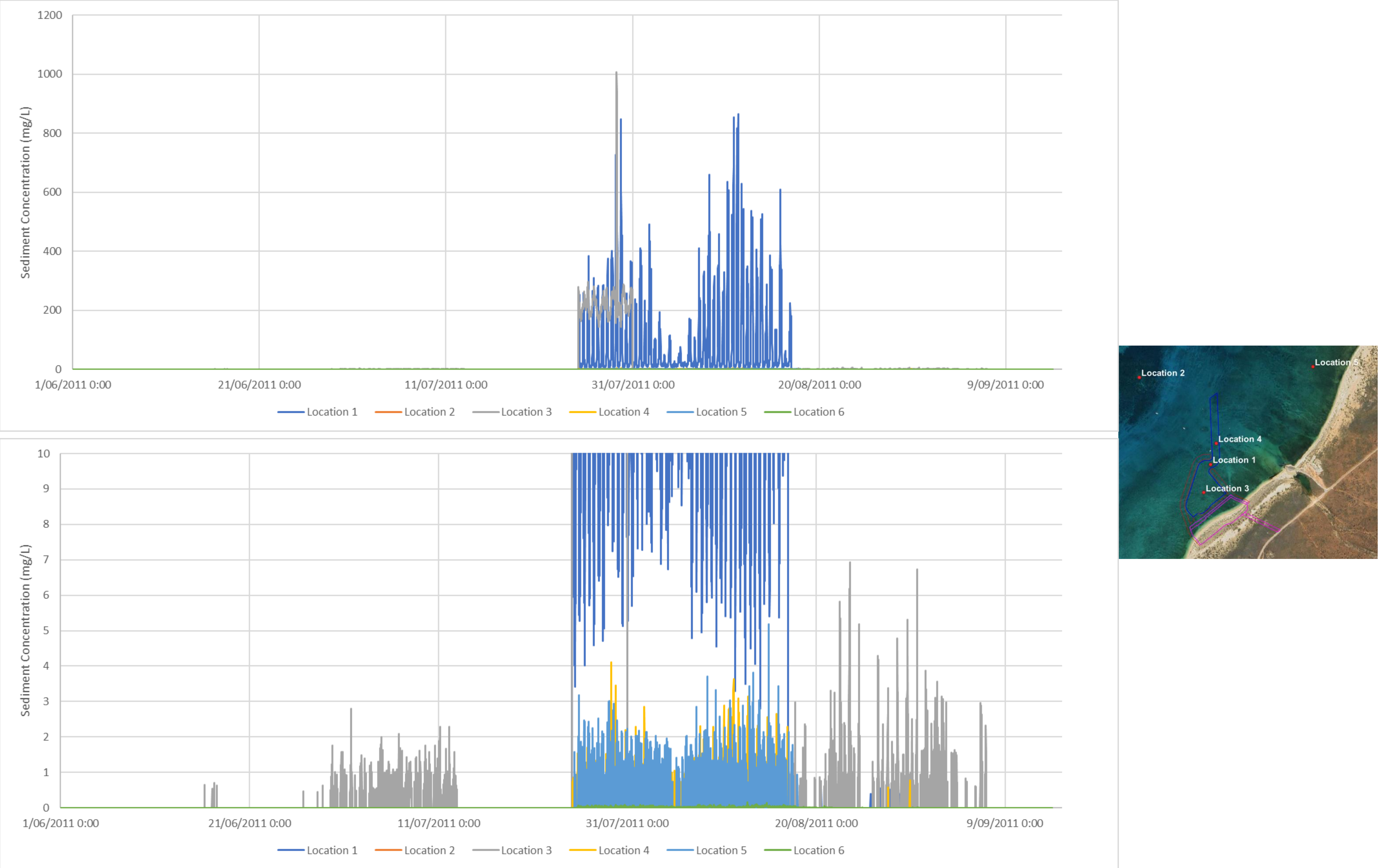
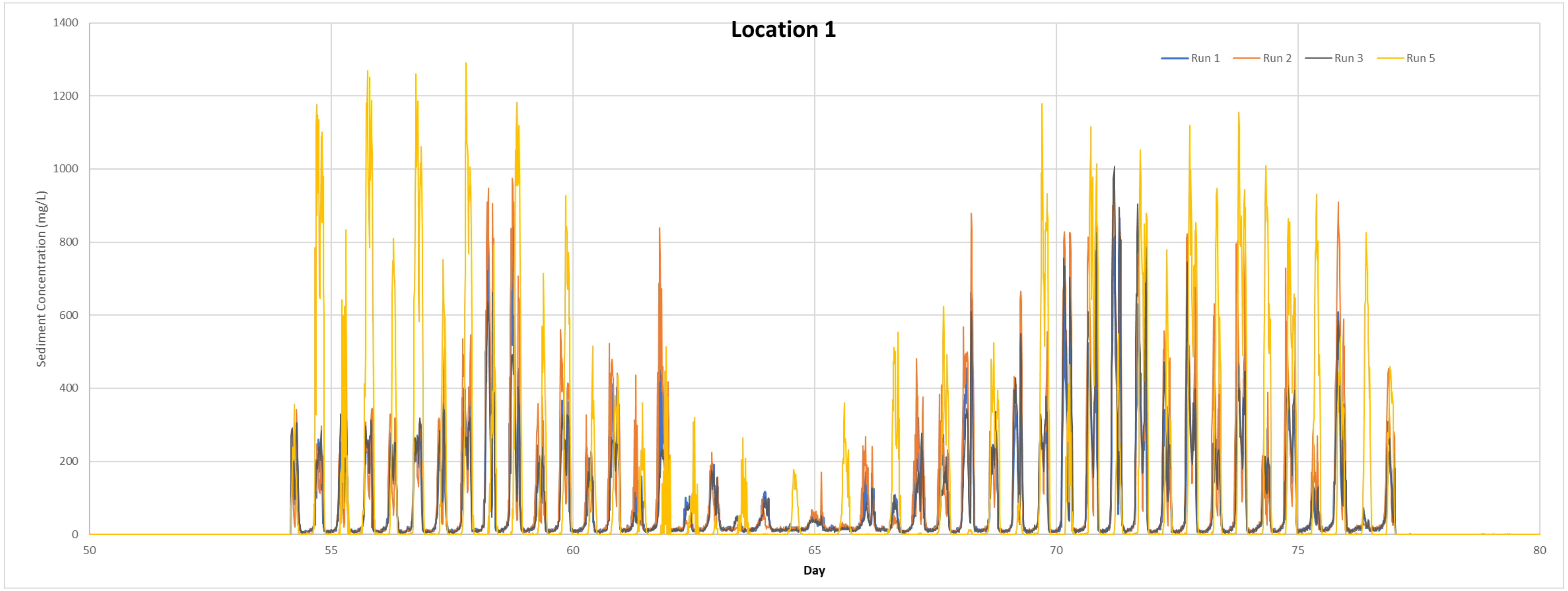


Figure 5.7 Run 1 Times Series at all Locations (top) & Zoomed In (bottom)



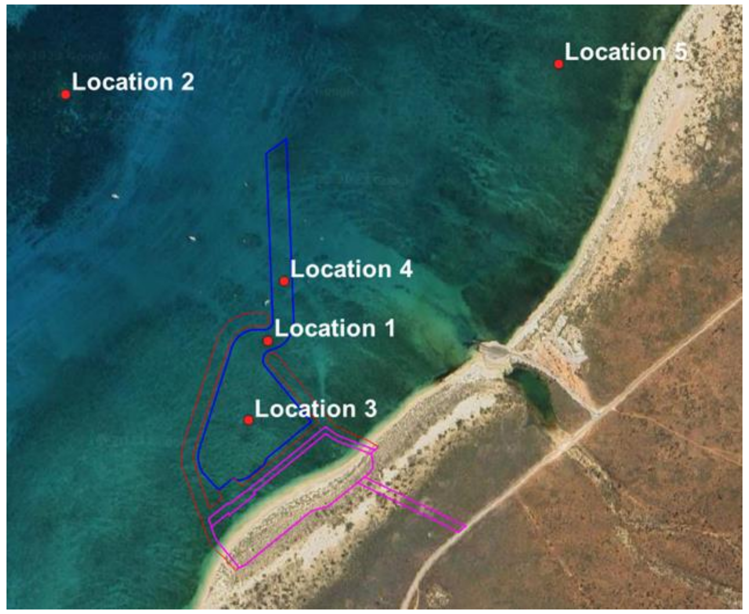


Figure 5.8 Time Series Concentrations at Location 1

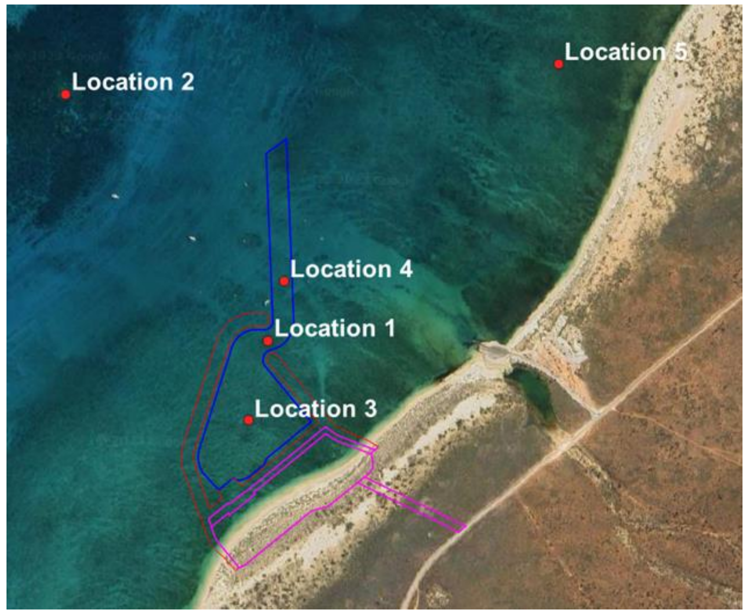


Figure 5.9 Time Series Concentrations at Location 2

5.2 Entrance Channel Dredging

Runs 9 through 14 simulated the dredging of the entrance channel for a number of periods and metocean conditions (refer Table 4.5). For all six scenarios the locations and rates of dredging have been kept consistent. The sediment input locations are presented in Figure 5.10 and the associated times are outlined in Table 5.2.

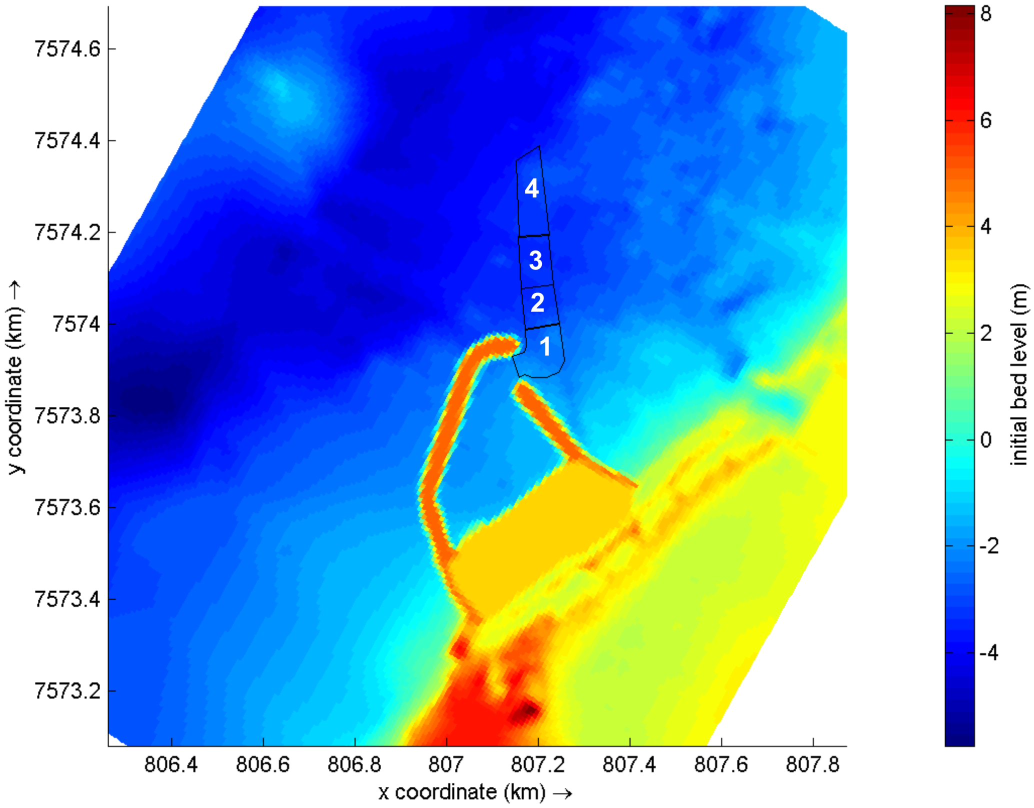


Figure 5.10 Entrance Channel Sequential Dredge Areas

Table 5.2 Entrance Channel Dredging Sequence

Dredge Area	Input Commencement (days)
1	3
2	10
3	17
4	24

The exceedance plots for each of these runs are included in Appendix A. Figure 5.11 and 5.12 present the exceedance plots for Run 9 which simulated the dredging of the entrance channel over the initial proposed period with "typical" late autumn and winter conditions. The dredge plume associated with the entrance channel dredging works is significantly larger in all three exceedance plots than was observed for any of the simulations of the internal basin dredging works, as expected due to the lack of constraints on the plume dispersion. In addition, for the 80 and 95% exceedance plots the dredge plume is observed to extend north from the works, pass outside the northern end of the Tantabiddi lagoon and exits the modelled area. However, by the time the plume exited the model domain the concentration is generally below 5 mg/L.

Figure 5.13 presents the exceedance plots for Run 9b which was simulated to assess the potential plume associated with the dumping of dredge spoil within the internal basin during the entrance channel dredging works. This allows for assessment of the contribution to overall plume dispersion and concentration from the dumping of the dredge spoil within the internal basin prior to its removal using land-based plant. For this run it was assumed that all of the coarse silt, fine silt and clay fractions that enter the barge are contained within the barge and subsequently dumped inside the harbour. This was input as a continuous release into the model as whilst the dumping of the dredge spoil would likely only occur every few hours the dumped material would be worked and excavated by land based plant in between which would release and resuspend previously trapped fines. As can be seen in Figure 5.13 the dumping of the dredge spoil within the harbour is unlikely to significantly contribute to the overall dredge plume as relatively small concentrations of TSS manage to escape the harbour and then generally only at concentrations of 1 or 2 mg/L.

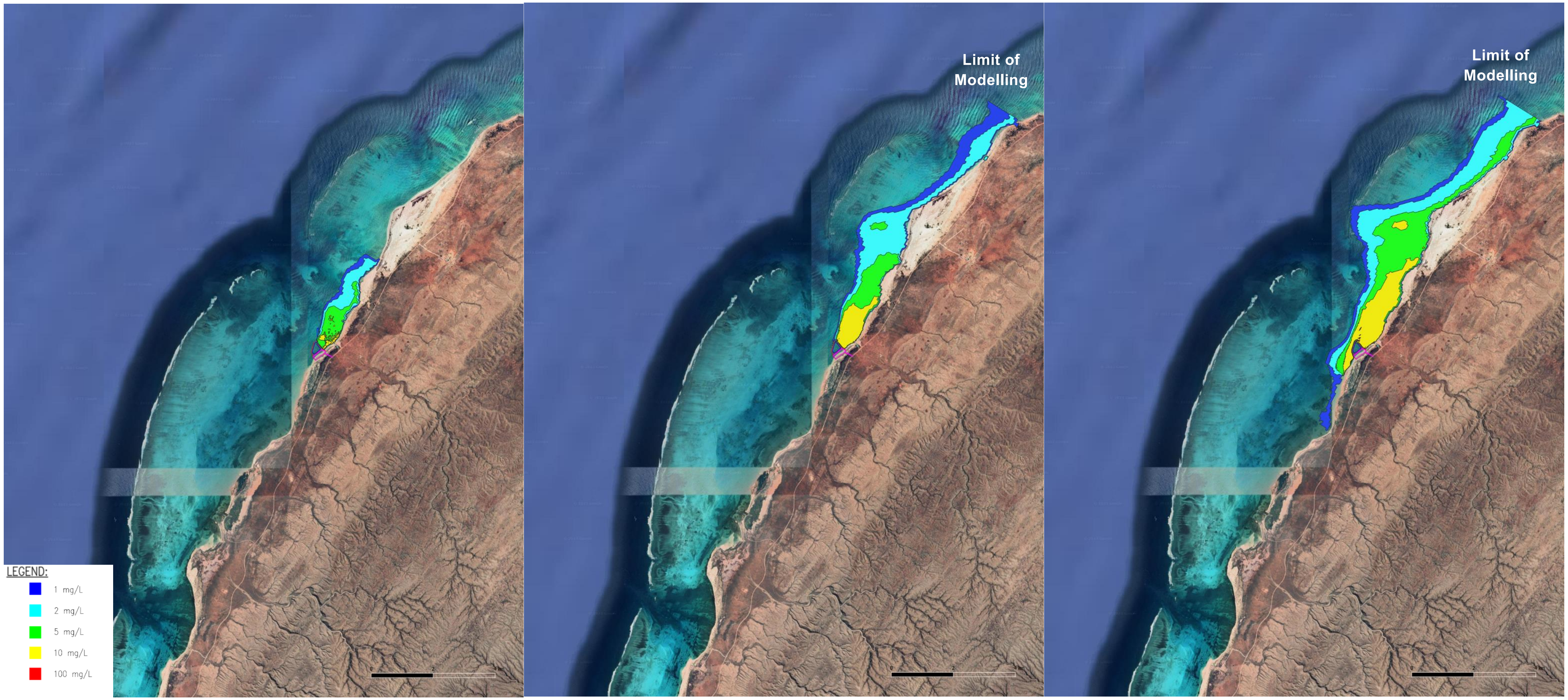


Figure 5.11 Run 9 Far Field Exceedance Plots, 50% Exceedance (left), 80% Exceedance (middle) & 95% exceedance (right)

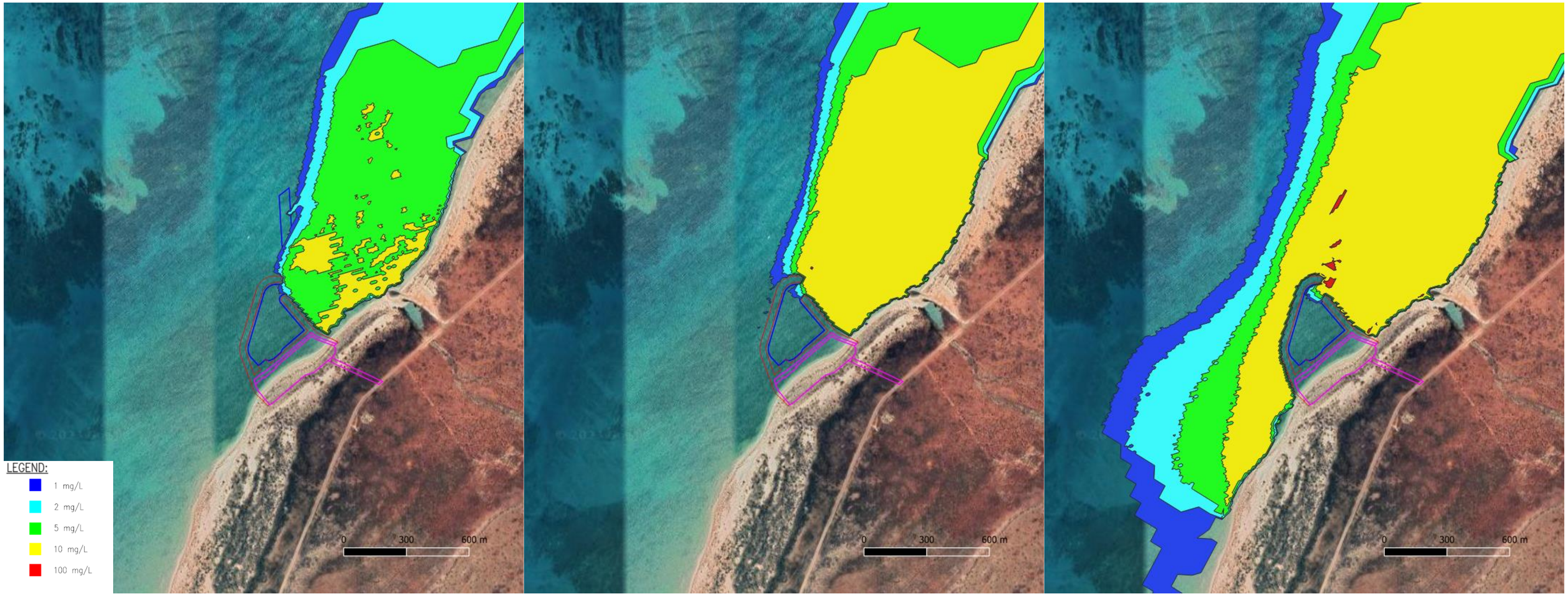


Figure 5.12 Run 9 Near Field Exceedance Plots, 50% Exceedance (left), 80% Exceedance (middle) & 95% Exceedance (right)

Figure 5.13 Run 9b Near Field Exceedance Plots, 50% Exceedance (left), 80% Exceedance (middle) & 95% exceedance (right)

Figure 5.14 presents the 95% exceedance plots for the base run (Run 9); a simulation with more severe conditions, though run over the same period (Run 10); and a run using “typical” winter conditions completed one month later than the base run (Run 11). The 95% exceedances plots for each of these dredge plumes are all comparable. Runs 9 and 10 display very similar plumes and Run 11 displays a bit more northerly transport and a smaller extent of southerly transport than the others.

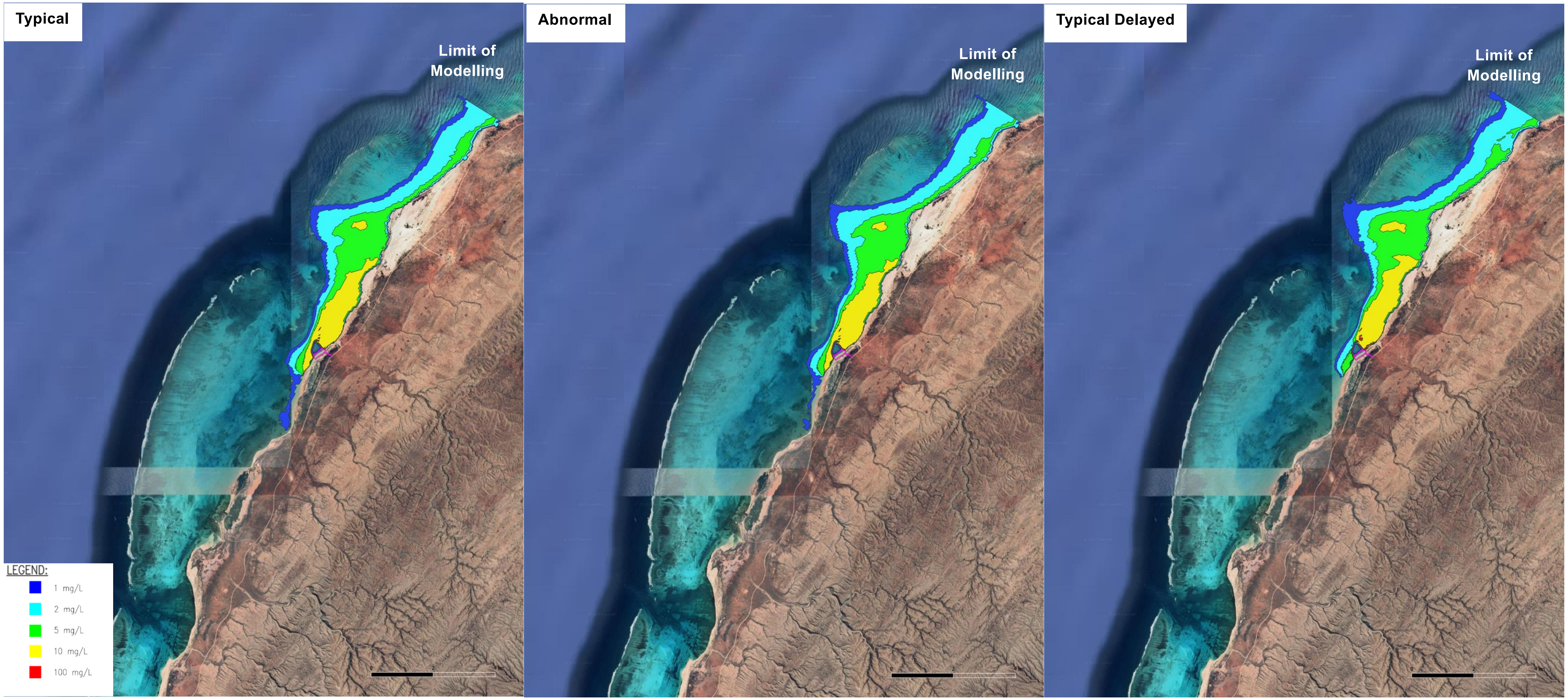


Figure 5.14 95% Exceedance Far Field Plots for Winter, Run 9 (left), Run 10 (middle) & Run 11 (right)

Figure 5.15 presents the 95% exceedance plots for the base late autumn run (Run 9); the winter run with "typical" conditions (Run 11); and a run in early summer with "typical" conditions (Run 13). In these plots it can be seen that Run 11 displays greater northerly transport than Run 9, as previously discussed, and Run 13 shows an even greater tendency towards northerly transport. In addition there is little to no southerly transport observed in the 95% exceedance plot for Run 13. These differences are likely due to the predominance of south westerly sea breezes over the summer months which promote northerly currents.

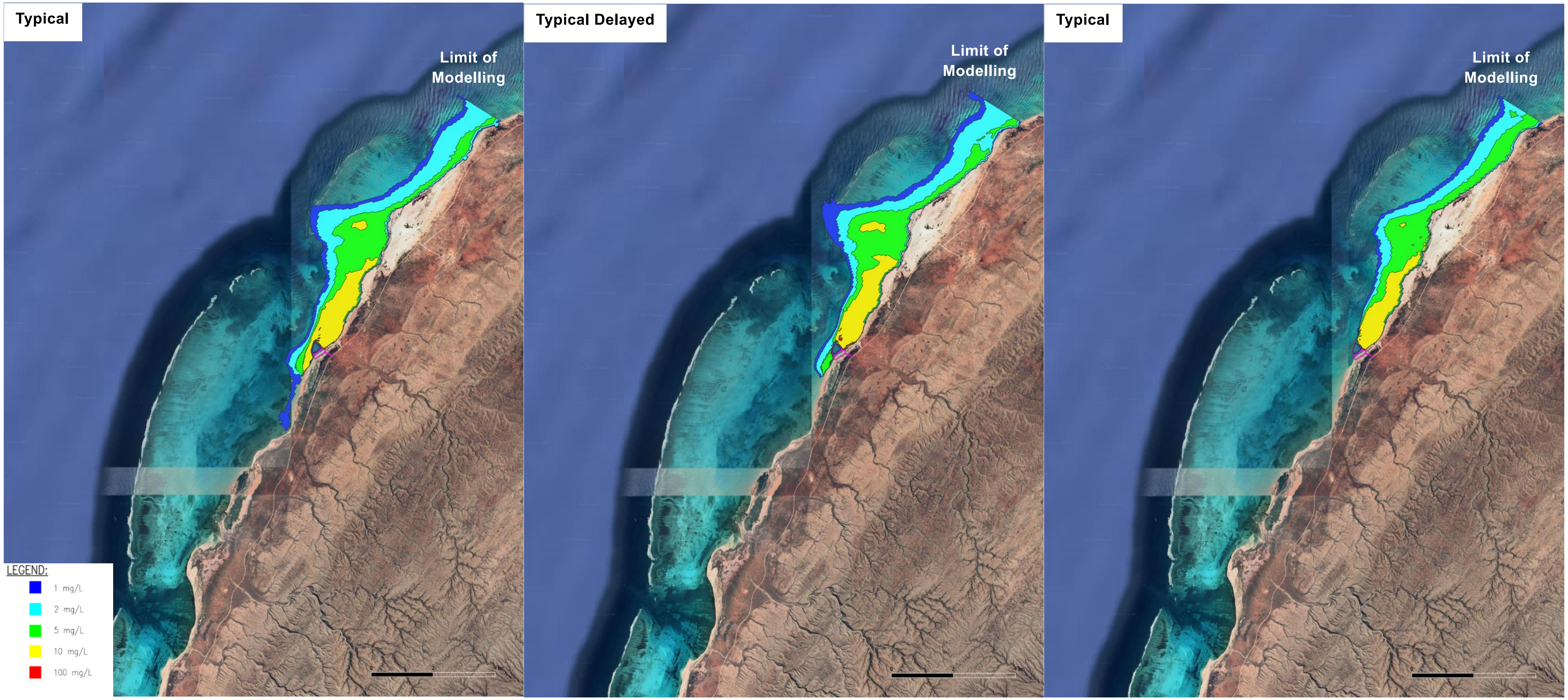
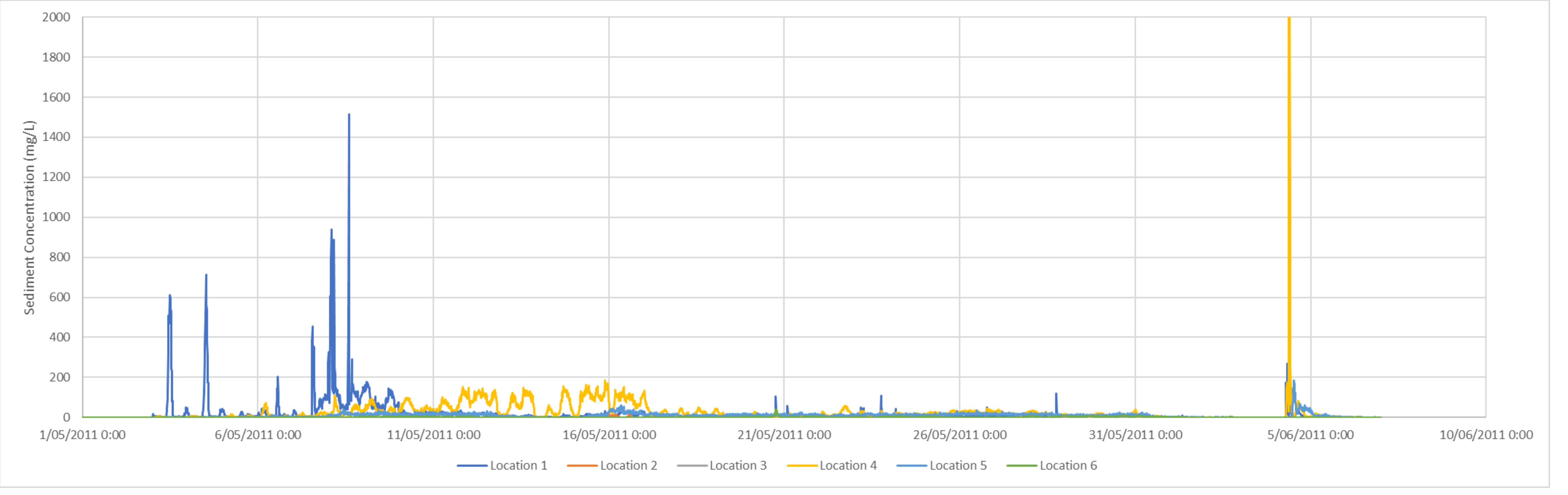


Figure 5.15 95% Exceedance Far Field Plots for Winter (Run 9 left & Run 11 middle) & Summer (Run 13 right)

Figure 5.16 present the timeseries TSS concentrations at all six output locations for Run 9. In comparison to the timeseries for the internal basin dredging simulations there are generally lower TSS concentrations at Locations 1 and 3 for Run 9. Conversely there are higher concentrations at locations 2, 3, 5 and 6 as would be expected due to the change in location of the dredging works.

Figure 5.17 presents timeseries concentrations at Locations 1 and 2 for Runs 9, 10, 11 and 13. This demonstrates that for the entrance channel dredging works the TSS concentrations at Location 1 generally display isolated peaks of high concentration across the entire modelled period compared to the consistent spike observed in internal basin dredging simulations (refer Figure 5.8). This indicates that there is potential for the plume associated from the entrance channel dredging works to extend into the harbour throughout the works, not just when the dredging is conducted adjacent to the mouth.

In addition, at Location 2 higher TSS concentrations are observed for the entrance channel dredging simulations in comparison to the internal basin dredging simulations. However concentrations do not appear to exceed 14 mg/L and concentrations above 5 mg/L are generally infrequent isolated events.



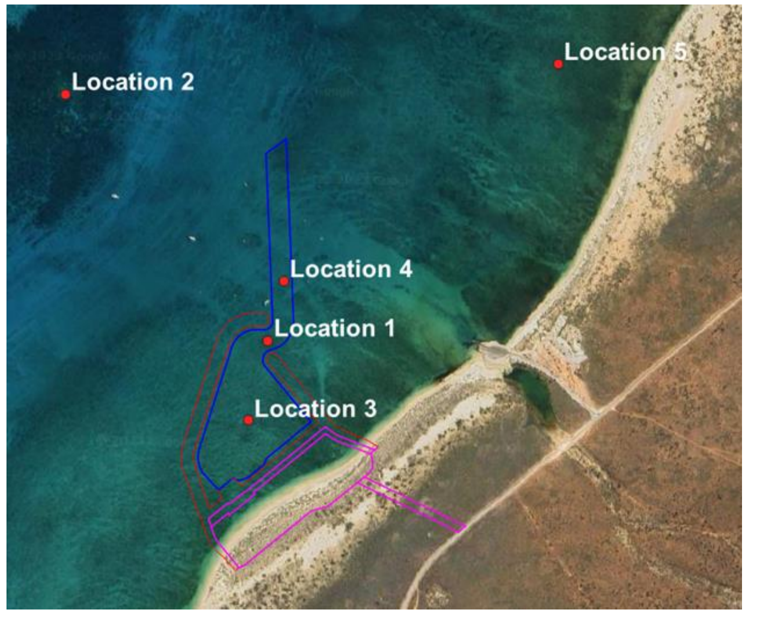


Figure 5.16 Run 9 Time Series Concentrations at all Locations

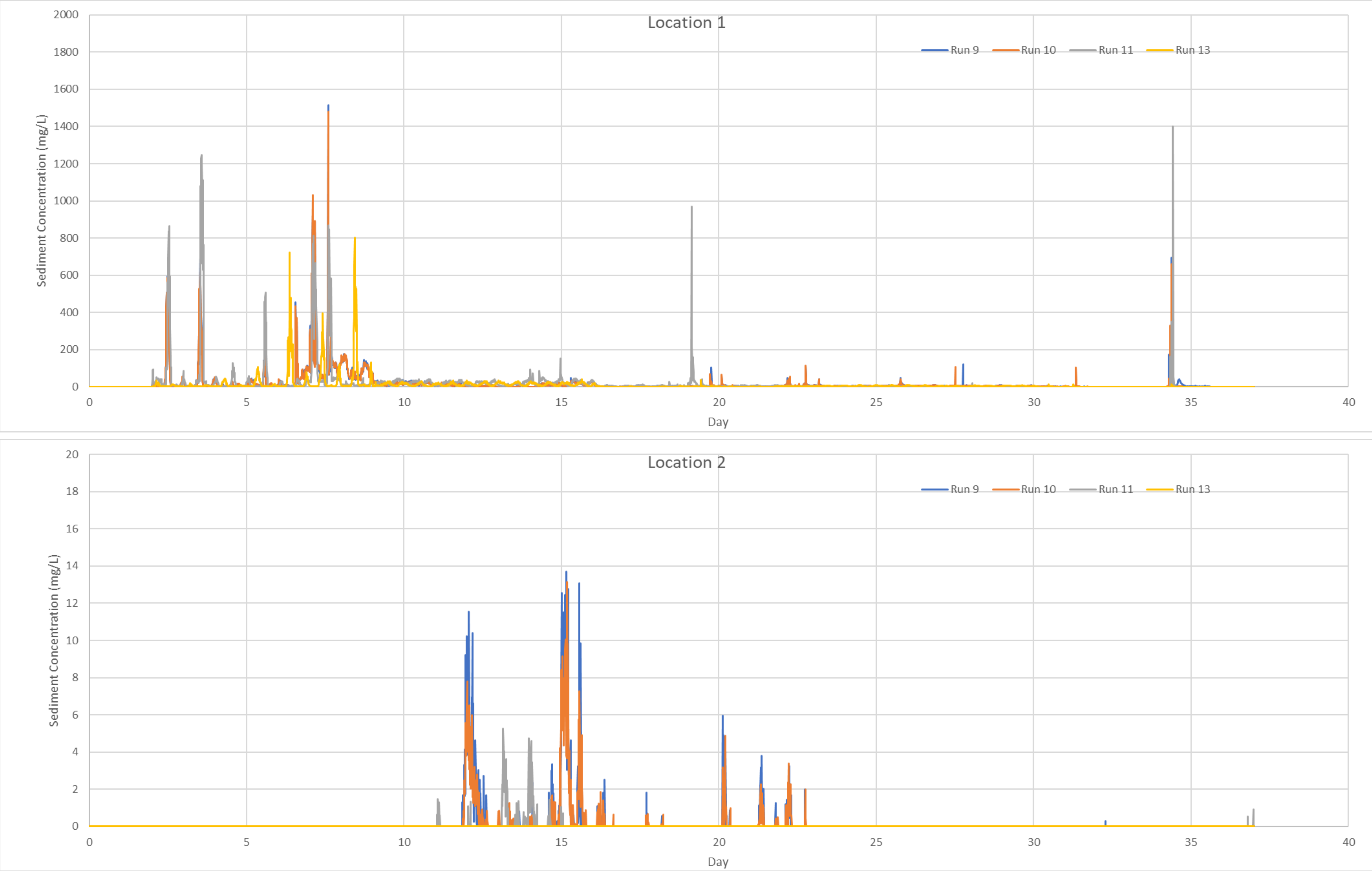


Figure 5.17 Entrance Channel Dredging Time Series Concentrations at Locations 1 (top) & 2 (bottom)

Figure 5.18 provides a comparison of the total dredge plume extent for Runs 1 and 9. The plume extents represent the areas where concentration equal to or greater than 1 mg/L are achieved at any time during the respective simulations. The dredge plume for Run 9 clearly disperses over a much greater area than the plume from Run 1. This again indicates that the breakwaters have significantly reduced the dispersion of the plume from the internal basin dredging works. It is also noted that the internal basin dredging works are removing in the order of 5 times more material than the entrance channel dredging works.

The spatial extent of the dredge plume presented in Figure 5.18 can be considered to be indicative of the potential extent of the visible plume from the dredging activities.

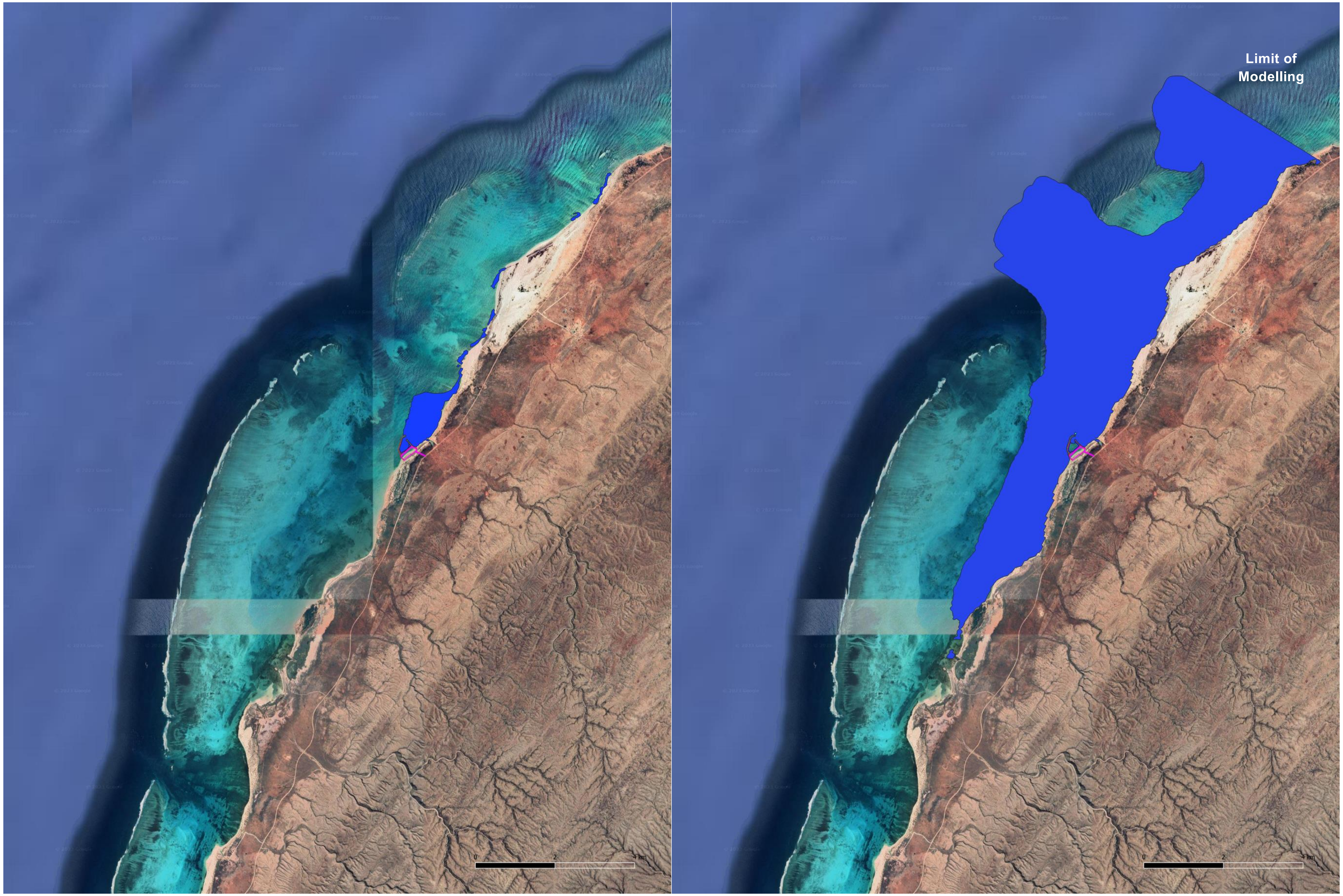


Figure 5.18 Spatial Extent of Dredge Plume at Concentrations above 1 mg/L for Internal Basin (Run 1 left) & Entrance Channel Works (Run 9 right)

5.3 Resuspension of Internal Basin Fines

Further simulations were completed to assess the likelihood of the resuspension of fines which remain within the harbour after the completion of the internal basin dredging works. These simulations were completed as Runs 15 and 16. Run 15 models the impact of southerly swells and sea breezes as are typically encountered at the site. Whereas Run 16 assesses the impact of a 50 year Average Recurrence Interval (ARI) cyclone event. At the beginning of these simulations a large quantity of fines was added into the internal basin and allowed to settle to the bed. Once all the fines had settled out of the water column the two events were modelled.

The 95% exceedance plots and spatial plume extent plots are presented in Figures 5.19 and 5.20 respectively. There is no noticeable resuspension of the fines and dispersion outside of the breakwaters for either of these events. During the cyclone event there is some movement of the fines, however this occurs during the strong north easterly winds as the cyclone passes the site which resulted in the fines being moved further into the harbour. As such there does not appear to be a significant risk of resuspension of fines within the harbour. This is likely due to the significant protection provided by the breakwaters.

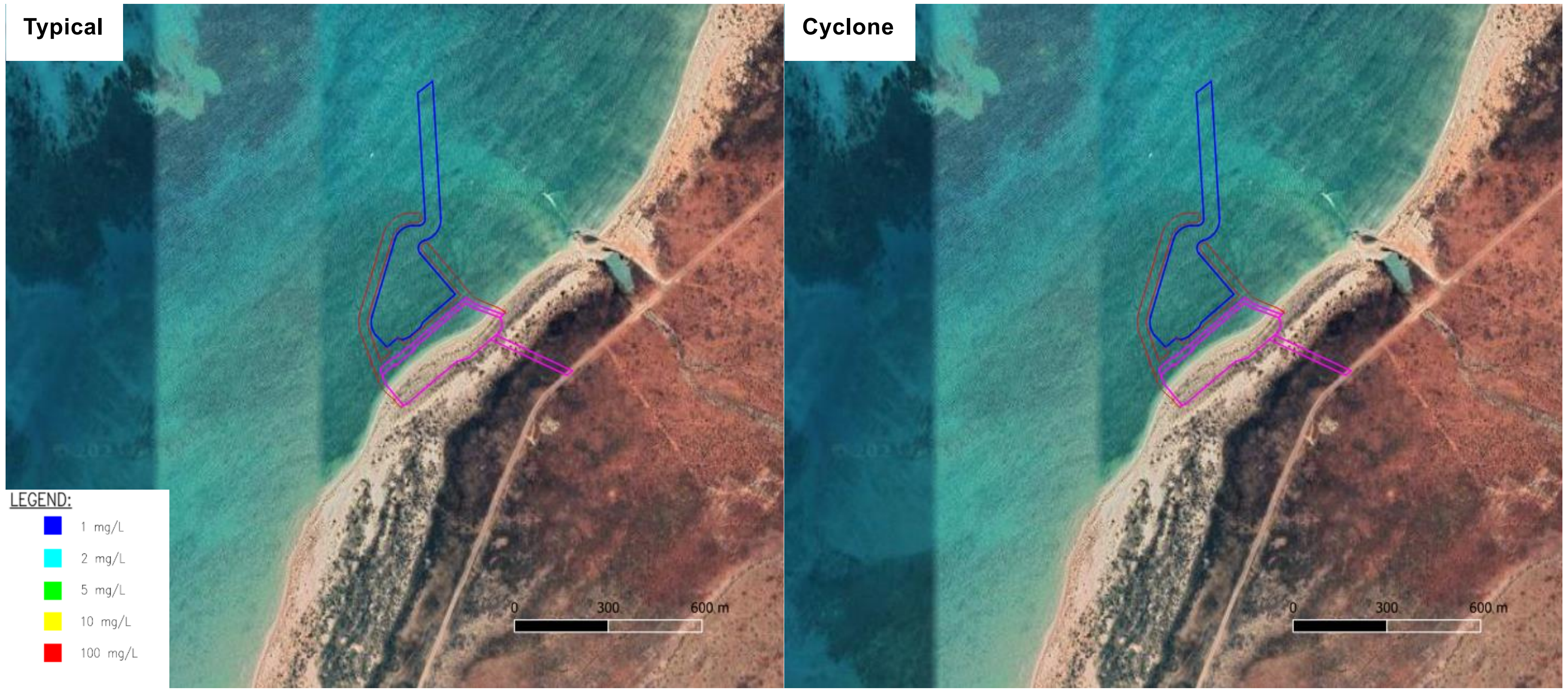


Figure 5.19 95% Exceedance for Run 15 (left) and Run 16 (right)

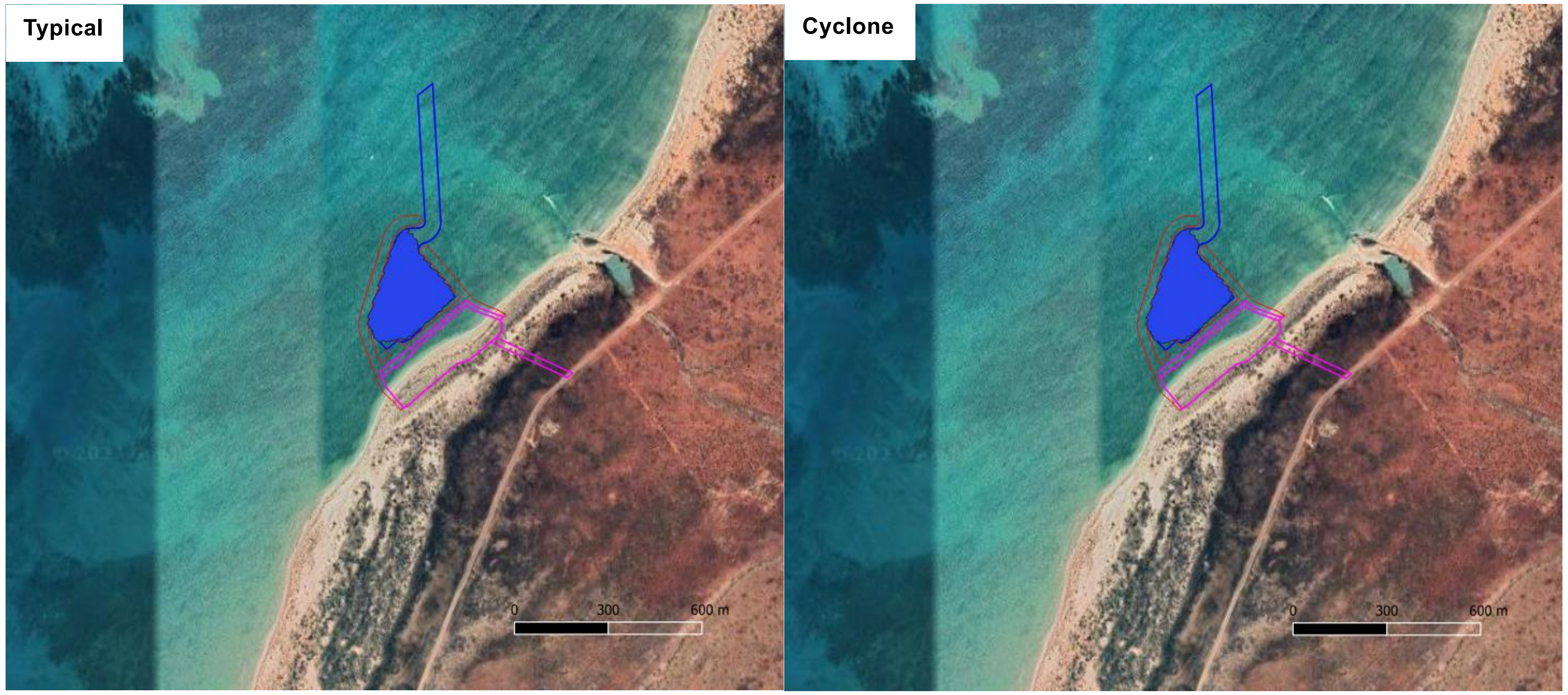


Figure 5.20 Dredge Plume Extent for Run 15 (left) and Run 16 (right)

5.4 Sedimentation

In addition to the dispersion of the plume associated with the dredging works the sedimentation which occurs when sediments settle out of the water column is also of interest. Significant sedimentation can result in the burial/smothering of benthic flora and fauna which will likely not be acceptable within the Ningaloo Marine Park. Spatial plots of the total sedimentation in mm have been produced for each of the simulations and are included in Appendix C. As the total sedimentation at any one location is time dependent, plots have been generated corresponding with 25%, 50%, 75% and 100% of the model run time for each simulation. The temporal location of each of these run times for the internal basin and entrance channel dredging works are presented in Table 5.3.

Table 5.3 Sedimentation Plots Output Times

Percentage of Simulation	Simulation Time (days)	
	Internal Basin Dredging	Entrance Channel Dredging
25	26.25	9.25
50	52.5	18.5
75	78.75	27.75
100	105	37

Figures 5.21 and 5.22 presents the total sedimentation amounts across Run 1 (Internal Basin, Winter, Typical). These plots are representative of the plots for all of the simulations of the Internal Basin dredging works. Whilst there are minor differences between the runs (refer Appendix C) the extents and depths of sedimentation are comparable. Notably the majority of sedimentation occurs within the internal basin, as expected due to the dredge plume for these simulations remaining mostly within the harbour as discussed in Section 5.1. The sedimentation which occurs outside of the harbour generally occurs offshore of the northern portion of the Tantabiddi Lagoon with deposition thicknesses less than 1 mm.

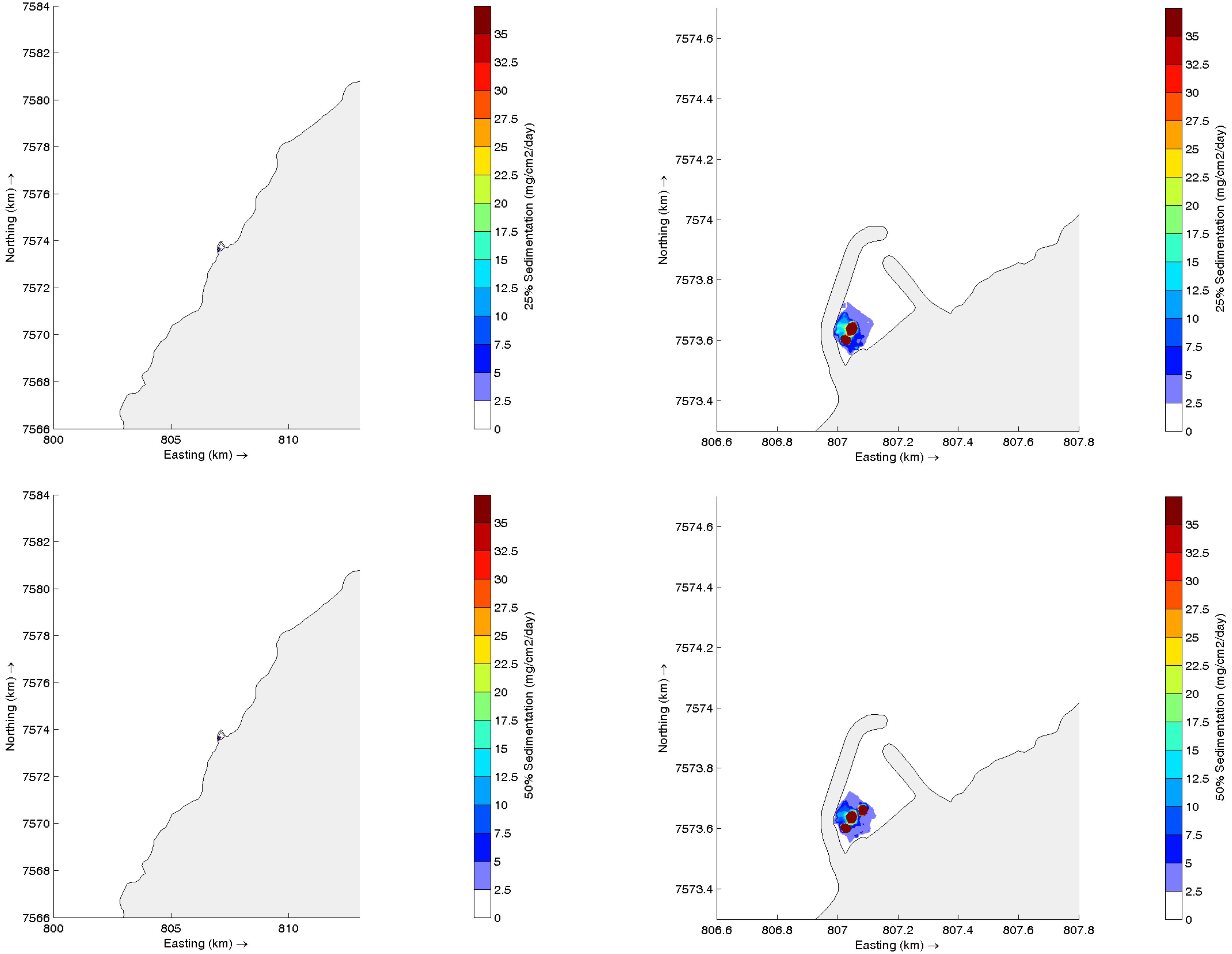


Figure 5.21 Sedimentation Spatial Plots Run 1, Day 26.25 (top) & Day 52.5 (bottom)

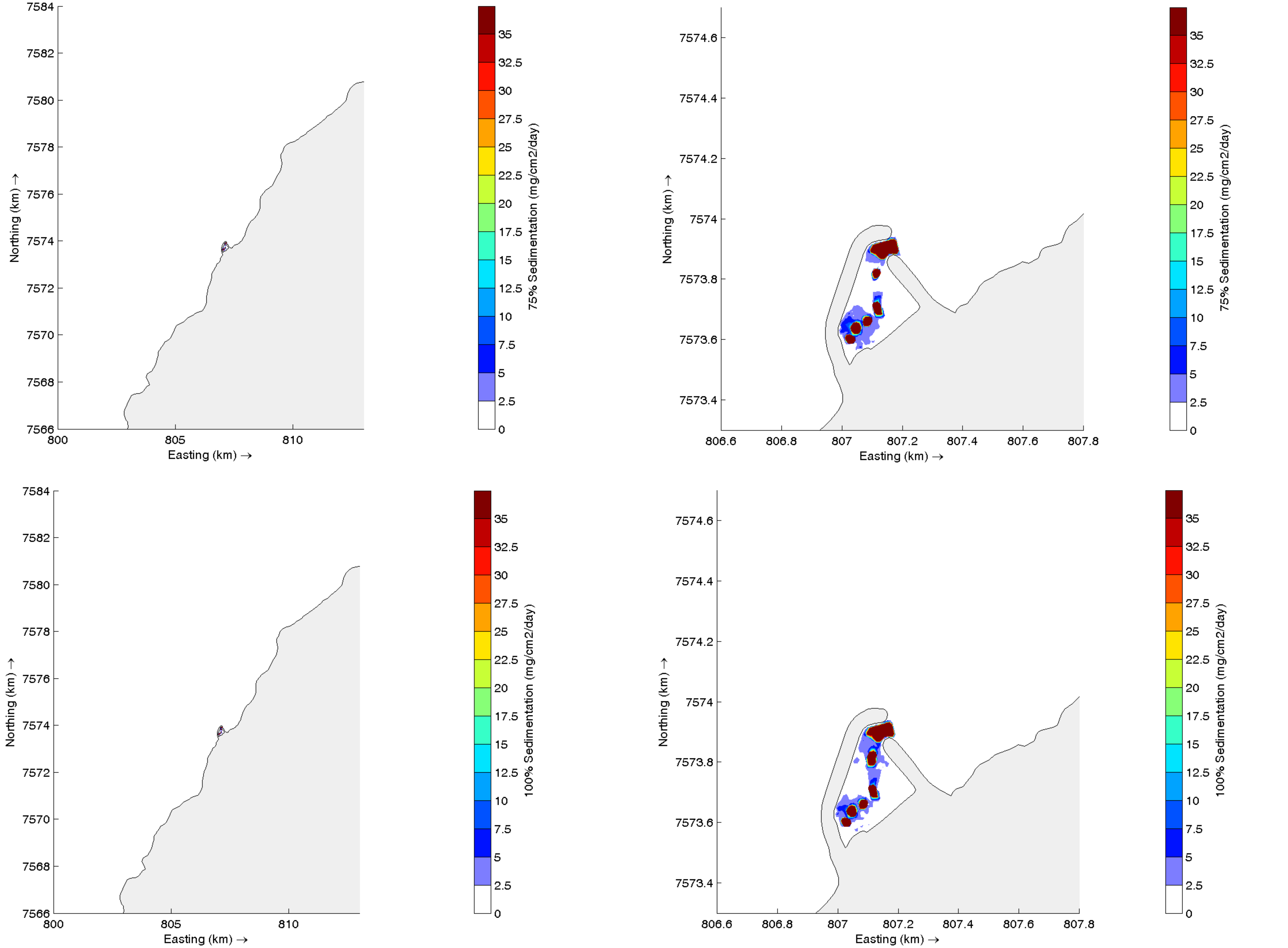


Figure 5.22 Sedimentation Spatial Plots Run 1, Day 78.75 (top) & Day 105 (bottom)

Figures 5.23 and 5.24 presents spatial plots showing the extent and depths of sedimentation from Run 9 (Entrance Channel, Winter, Typical) which is representative of the Entrance Channel dredging simulations (refer Appendix C). As with the internal Basin simulations there are minor differences between, however the spatial extents and sedimentation depths are comparable between runs. There is an initial and continuing sedimentation within the mouth of the harbour, as expected, as once sediment enters this area it is unlikely to exit again due to the protection of the breakwaters. Elsewhere there is minimal sedimentation, generally below 1 mm, with the majority of the sedimentation occurring in the Tantabiddi Channel and offshore of the Tantabiddi Lagoon.

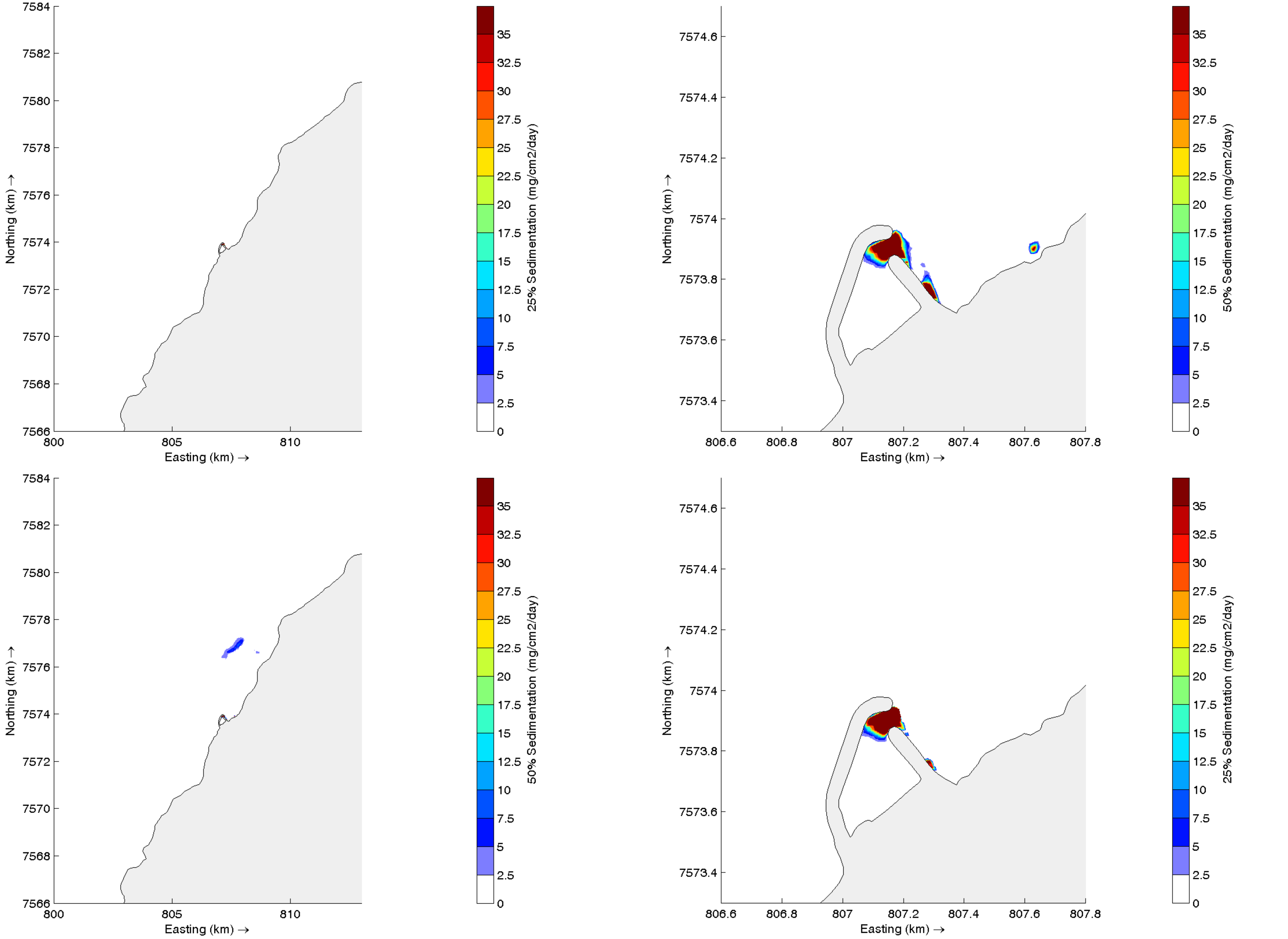


Figure 5.23 Sedimentation Spatial Plots Run 9, Day 9.25 (top) & Day 18.5 (bottom)

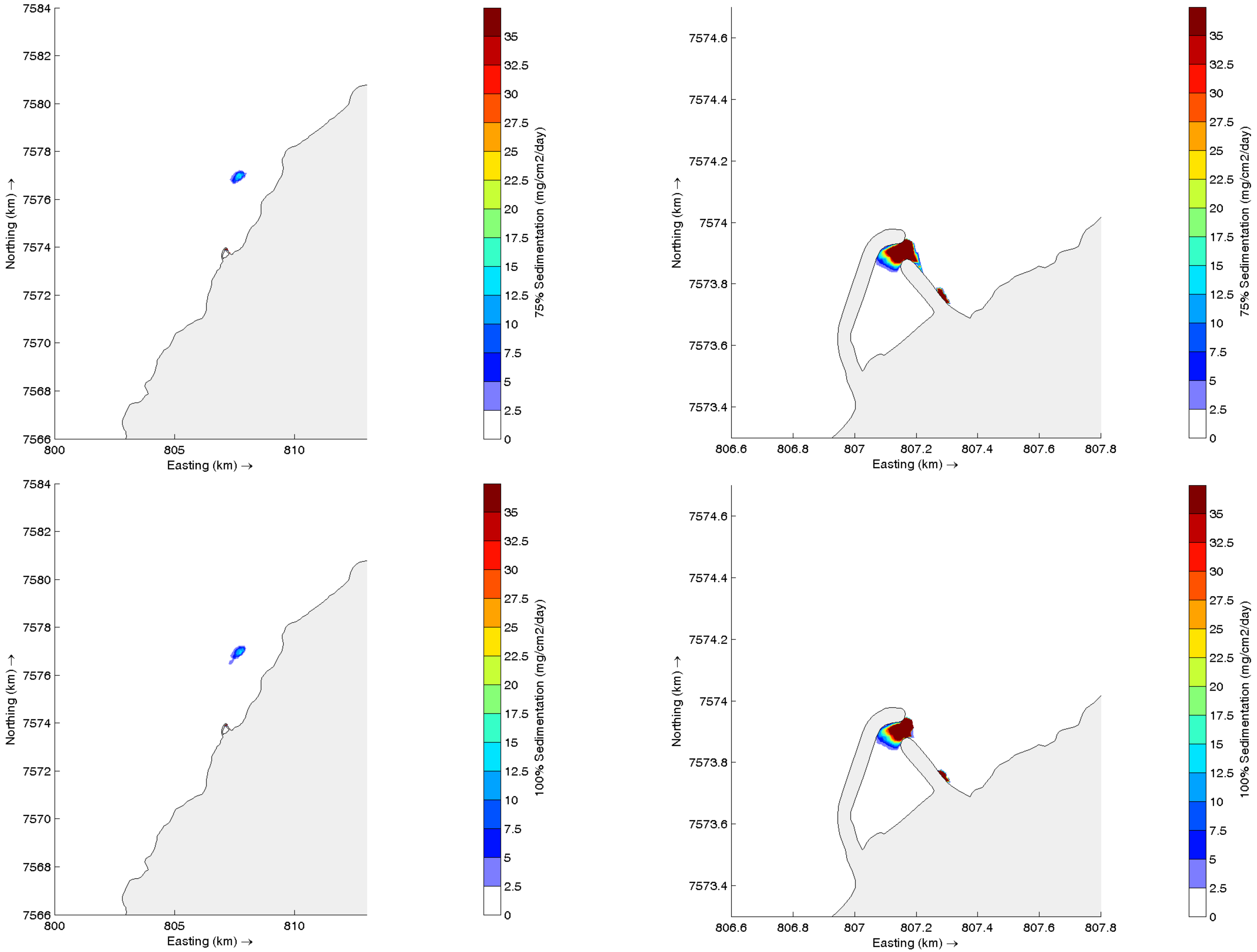


Figure 5.24 Sedimentation Spatial Plots Run 9, Day 27.75 (top) & Day 37 (bottom)

6. Discussion & Recommendations

6.1 Discussion

There is a significant difference in the extent and concentrations of the plumes between the internal basin and the entrance channel dredging works (refer Figures 5.3 and 5.12). As can be seen in Figure 5.16 the dredge plume from the entrance channel dredging works disperses over a far larger area and extends out through the central channel and the northern end of the Tantabiddi Lagoon. The breakwaters are clearly acting to confine the plume associated with the internal basin works. This is accomplished through the sheltering and physical barriers that these breakwaters provide significantly reducing the wave and current energy which can enter the internal basin and reduce the potential for migration of the plume. The relatively low energy environment results in there generally being insufficient energy to keep fines is suspension and carry them outside of the harbour. The portion of the plume which does manage to exit the harbour appears to be associated with the dredging in and around the mouth of the harbour where there is a greater exposure to wave and currents.

Among the various simulations of the internal basin dredging works there does not appear to be significant differences in the dredge plumes. A small degree of difference is observed between runs in winter and summer (refer Figure 5.4) likely due to the seasonal changes in the wave and current conditions. Notably there is very little difference in the plumes between runs with and without a silt curtain across the harbour entrance. This is likely due to the manner in which silt curtains work and have been implemented within the model. Silt curtains are highly effective at preventing fines suspended near the surface from passing from one side of the curtain to the other. However, water and fines can still pass under the curtain allowing fines to exit the harbour. This partial barrier has been implemented within the model through the use of porous plates. Given that generally in the modelling the majority of fines are located in the bottom two layers of the water column, this restricts the effectiveness of the silt curtain at reducing the plume extent. Despite this it is still recommended that a silt curtain be used for these works to reduce dispersion outside of the harbour, particular in the upper portion of the water column.

The simulations of the entrance channel dredging clearly display that these works result in far greater spatial extents of dredging plumes. In general, these plumes extend to the north of the works area regardless of timing, due to the prevailing southerly winds and corresponding northerly currents experienced at the site. South of Jurabi Point, TSS concentrations above 10 mg/L are commonly observed at the 95% exceedance level with the highest concentrations observed immediately adjacent to the dredging works. Concentrations of this strength have the potential to negatively impact the ecosystem and as such may require management. Once north of Jurabi Point the plume tends to migrate closer to the shore and concentrations typically decrease before the plume exits the northern end of the Lagoon. The completed modelling suggests that there will be minimal impact to the Tantabiddi Sanctuary area located to the west of the site.

Little to no resuspension of fines is observed within the internal basin following the completion of the internal basin dredging (refer Figures 5.17 and 5.18). This lack of resuspension is due to the significant sheltering provided by the breakwaters. This sheltering results in the bed shear stresses (critical parameter for resuspension) within the harbour remaining incredibly low even during a 50 year ARI cyclone event. Whilst there was some resuspension associated with the cyclone event this only occurred once the winds had swung to the north / north east and waves and currents were entering the harbour mouth directly. However, this results in any resuspended fines being pushed away from the mouth further into the harbour. As such resuspension of fines following the completion of the internal basin dredging works is considered unlikely to be an issue.

The simulation of the sedimentation shows that there is likely to be minimal sedimentation within the Tantabiddi Lagoon, outside of areas within and immediately adjacent to the dredging works. The simulations of the Internal Basin dredging works indicate that the majority of the sedimentation will occur within the harbour. Comparatively the entrance channel works are likely to result in the majority of sedimentation occurring in the Tantabiddi Channel and offshore of the lagoon.

6.2 Limitations

The modelling works discussed above were completed in line with best engineering practices. However, there are a number of limitations inherent an any numerical modelling study such as that outlined in this report. The following limitations are noted.

- The plume dispersion modelling has been completed for the dredging operations only.
- Limited geotechnical information is available within the dredge area. Due to the changes to the design of the TBF since the initial geotechnical works, very few of the boreholes fell within the dredge area. As such the composition of the bed and likely dredge volumes of sand and rock had to be estimated based on the limited information available.
- Limited information on rock flour production is available. There is relatively little information on the production of rock flour during the dredging of limestones. As such conservative estimates of the contribution of rock flour to the plume were made based on records from limestone quarries and MRA experience with previous dredging works at Ocean Reef Marina.
- The model domain extent limited far-field plume dispersion. To reduce the computational cost of the modelling to a reasonable level, the plume dispersion was modelled over the entirety of the Tantabiddi Lagoon and no further. This resulted in the northern end of the dredge plume being truncated by the edge of the modelled area for some runs.
- The sediments generated from the dredging process were input into the model at a limited number of locations instead of more uniformly spread across the dredge areas which would likely happen with actual dredging works. The input of the sediments at the limited number of locations was designed to be indicative of the dredging works but not necessarily perfectly represent them.
- The modelling has assumed a particular dredging approach as outlined in this report. If the dredging methodology differs from that assumed in the modelling, the resulting dredge plume will likely differ from the results of the modelling.

6.3 Recommendations

The following recommendations are made based on the results of the modelling.

- Completion of the construction of the breakwaters to crossover (potentially at an initially lower height) prior to the commencement of the internal basin dredging works.
- Installation and maintenance of a silt curtain across the mouth of the harbour prior to and for the duration of the internal basin dredging works.

- Complete an assessment of the likely ecological impacts of the simulated dredge plume dispersions and sedimentation depths. Based on the results of this assessment, propose any control measures deemed necessary for the dredging works.

7. References

CMW Geosciences 2021. *Tantabiddi Boating Facility, North West Cape, WA, Factual Geotechnical Investigation Report.* Prepared for the Department of Transport, Perth, Western Australia.

Deltares 2023. *D-Water Quality Particle Tracking User Manual.*

Department of Transport 2022. *Tantabiddi Concept Option 14A (Stage 1).*

Doorn-Groen S. & Foster 2007. *Environmental Monitoring and Management of Reclamations Works Close to Sensitive Habitats*.

Galetakis M., Alevizos G. & Konstantinos L. 2012. *Evaluation of fine limestone quarry by-products, for the production of building elements – An experimental approach.* Construction and Building Materials.

M P Rogers & Associates 2022. *Tantabiddi Creek Coastal Processes Study*. R1518 Rev 0. Prepared for the Department of Transport, Perth, Western Australia

M P Rogers & Associates 2023. *Tantabiddi Dredging and Coastal Structures Constructability Assessment.* R1762 Draft B. Prepared for the Department of Transport, Perth, Western Australia

Partheniades E. 1965. *Erosion and Deposition of Cohesive Soils.* Journal of the Hydraulics Division.

Parchure T. & Mehta A. 1985. *Erosion of Soft Cohesive Sediment Deposits.* Journal of Hydraulic Engineering.

Searle 2021. *Tantabiddi Boating Facility Geotechnical Interpretive Report.* Prepared for the Department of Transport, Perth, Western Australia.

Sun C., Branson P., Mills D. 2020. *Guideline on Dredge Plume Modelling for Environmental Impact Assessment.*

Van Rijn L. 1989. *Handbook Sediment Transport by Currents and Waves.* Delft Hydraulics.

8. Appendices

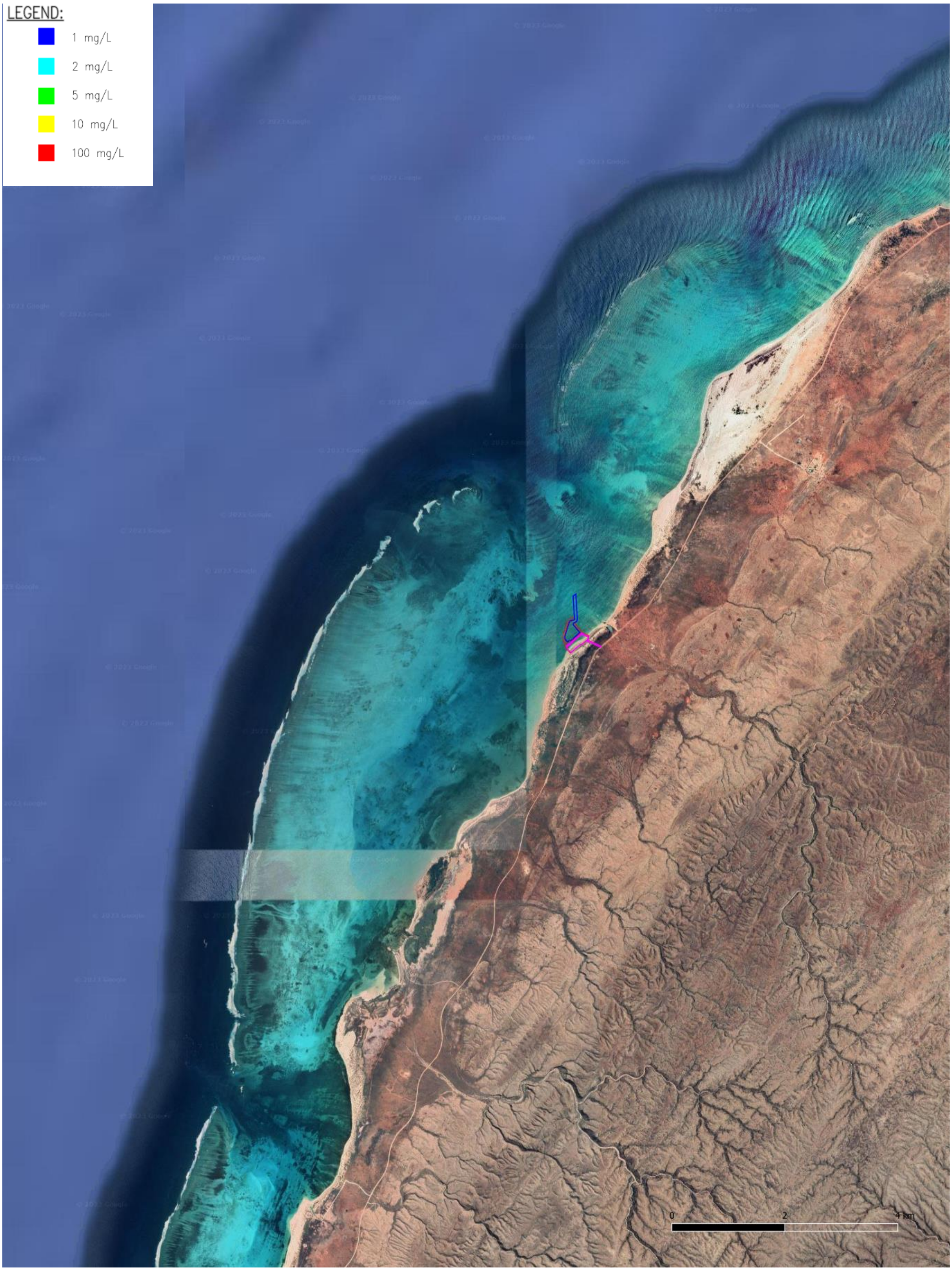
Appendix A **Exceedance Spatial Plots**

Appendix B **Times Series Plots**

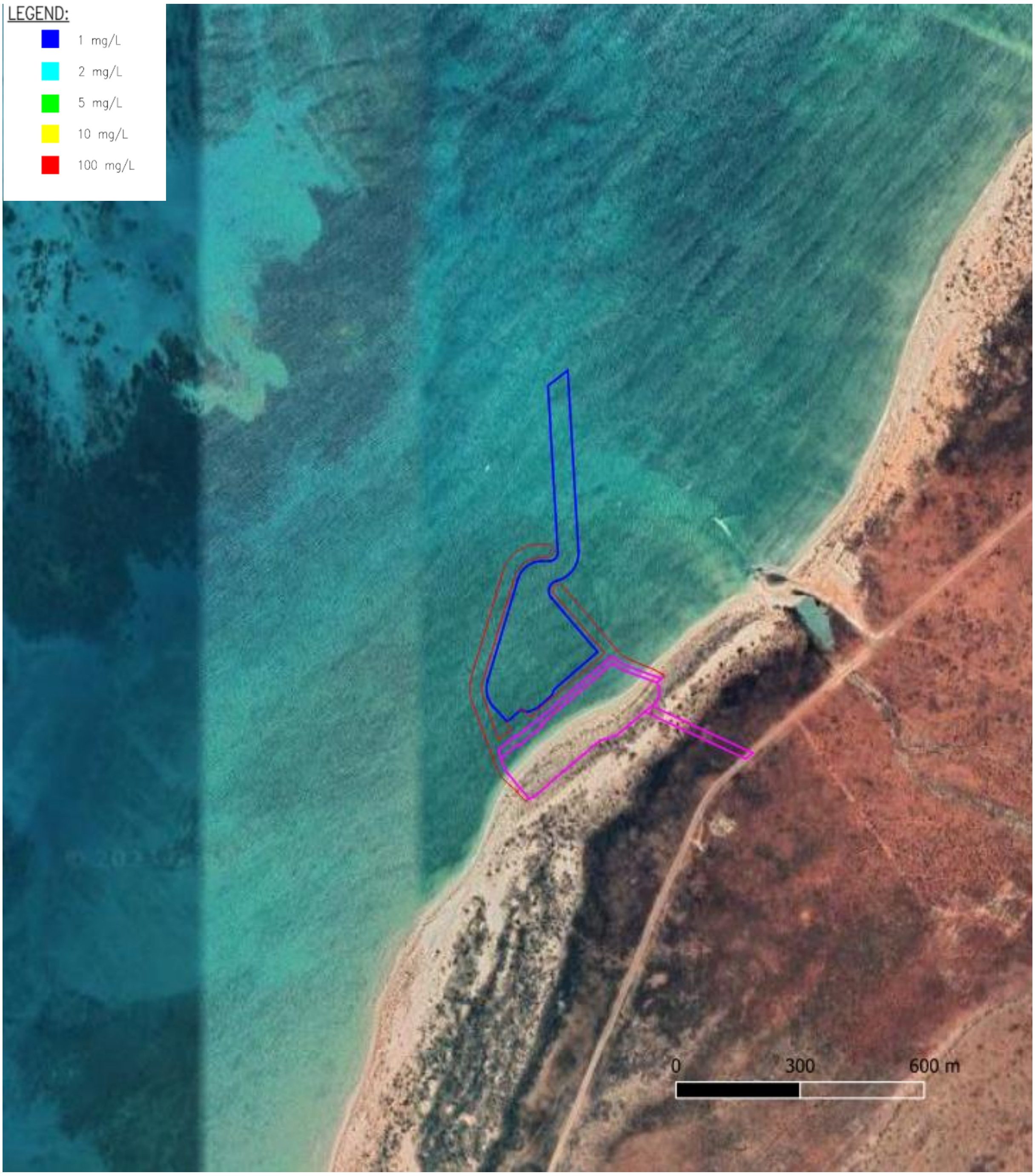
Appendix C **Sedimentation Spatial Plots**

Appendix D **Technical Note**

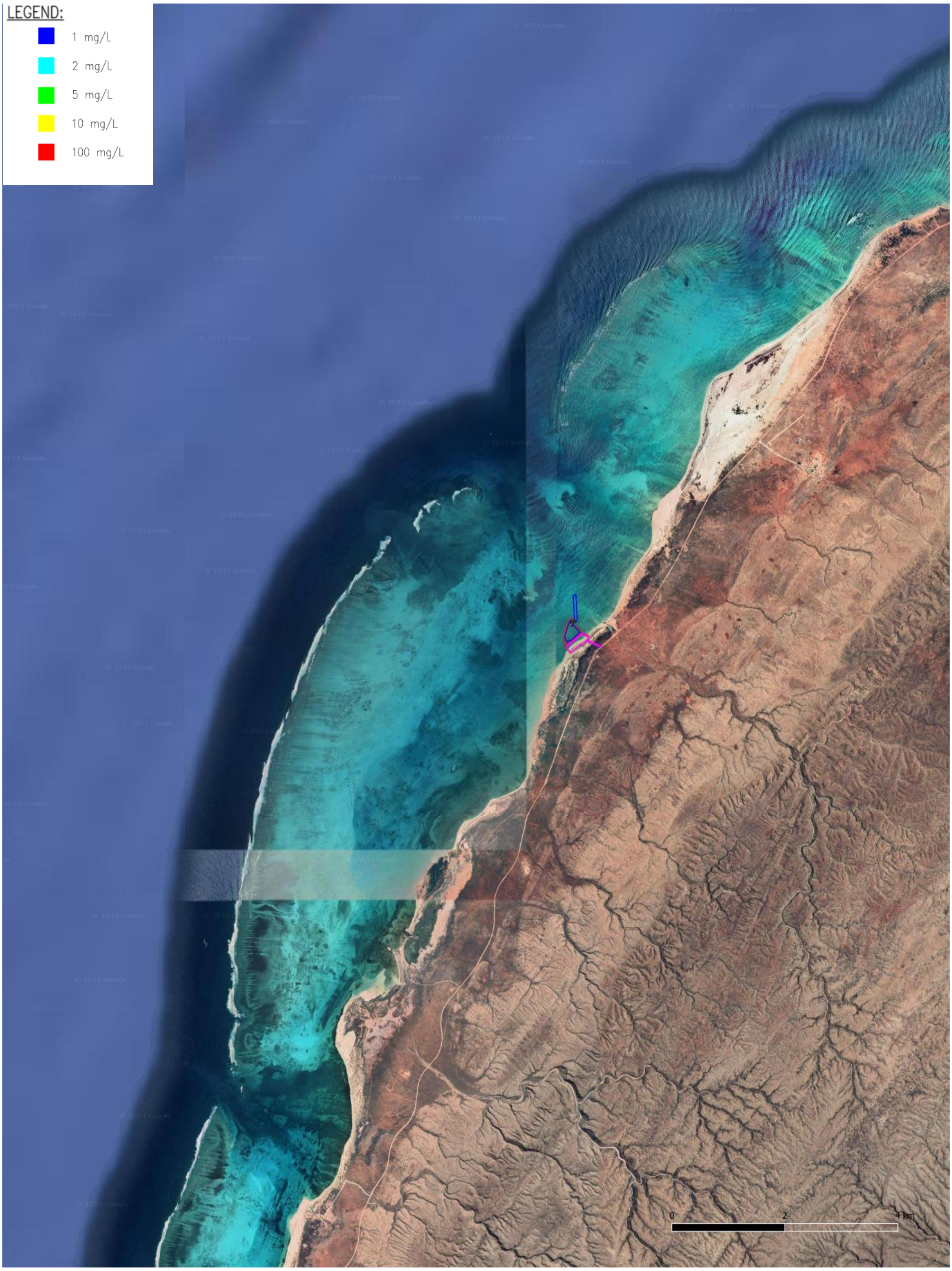
Appendix A Exceedance Spatial Plots



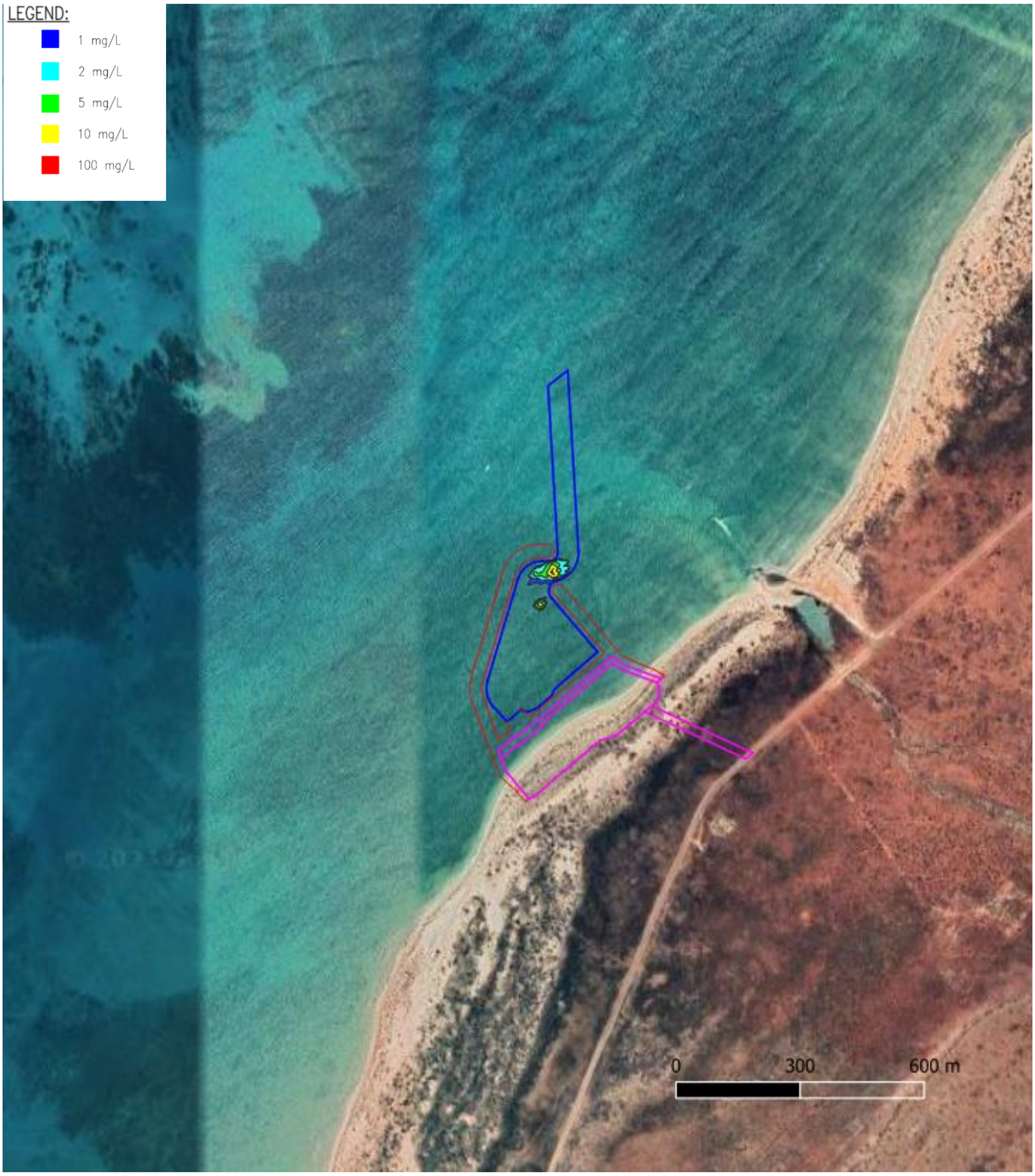
Run 1 -50% Exceedance



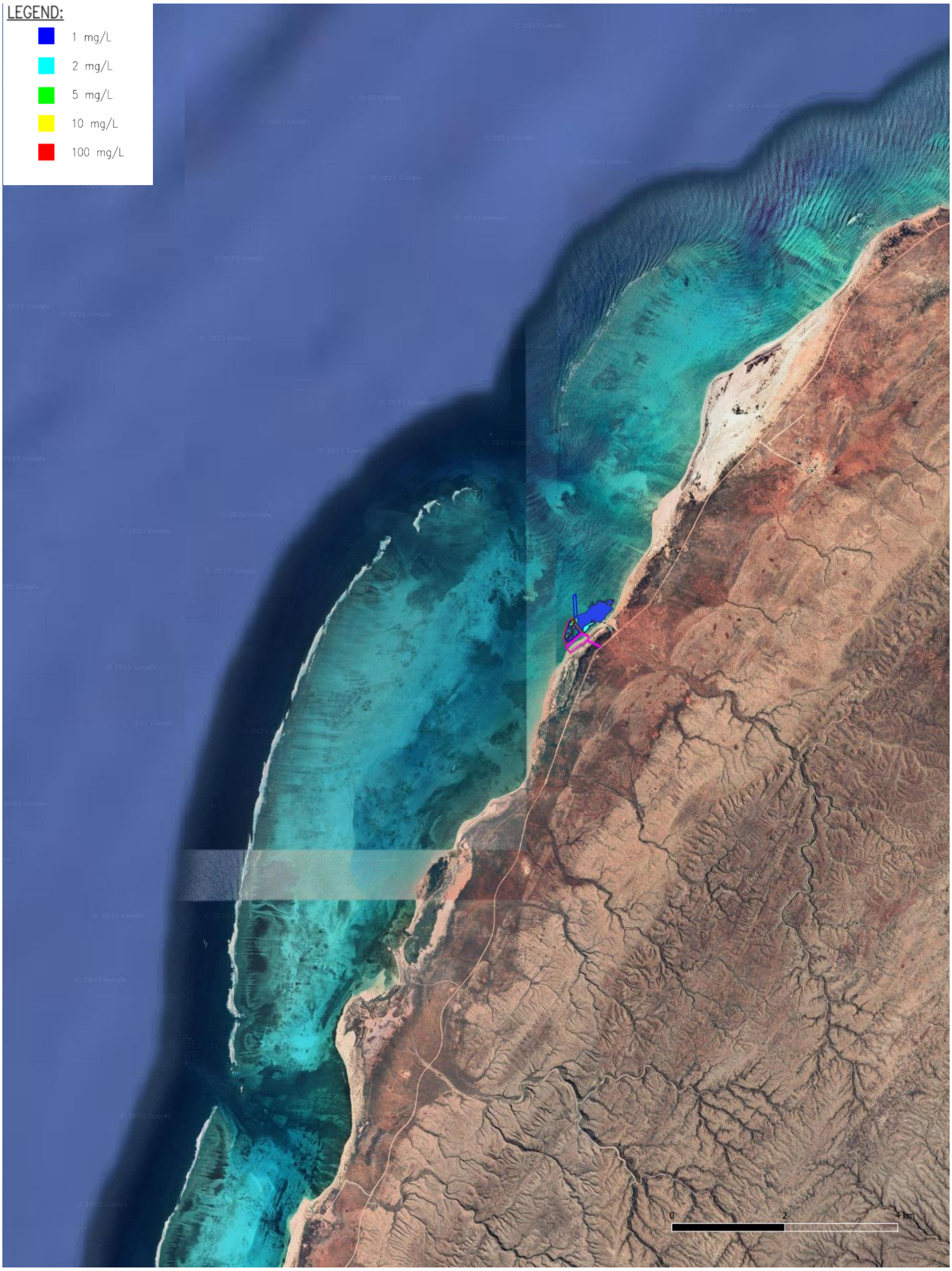
Run 1 -50% Exceedance Zoomed In



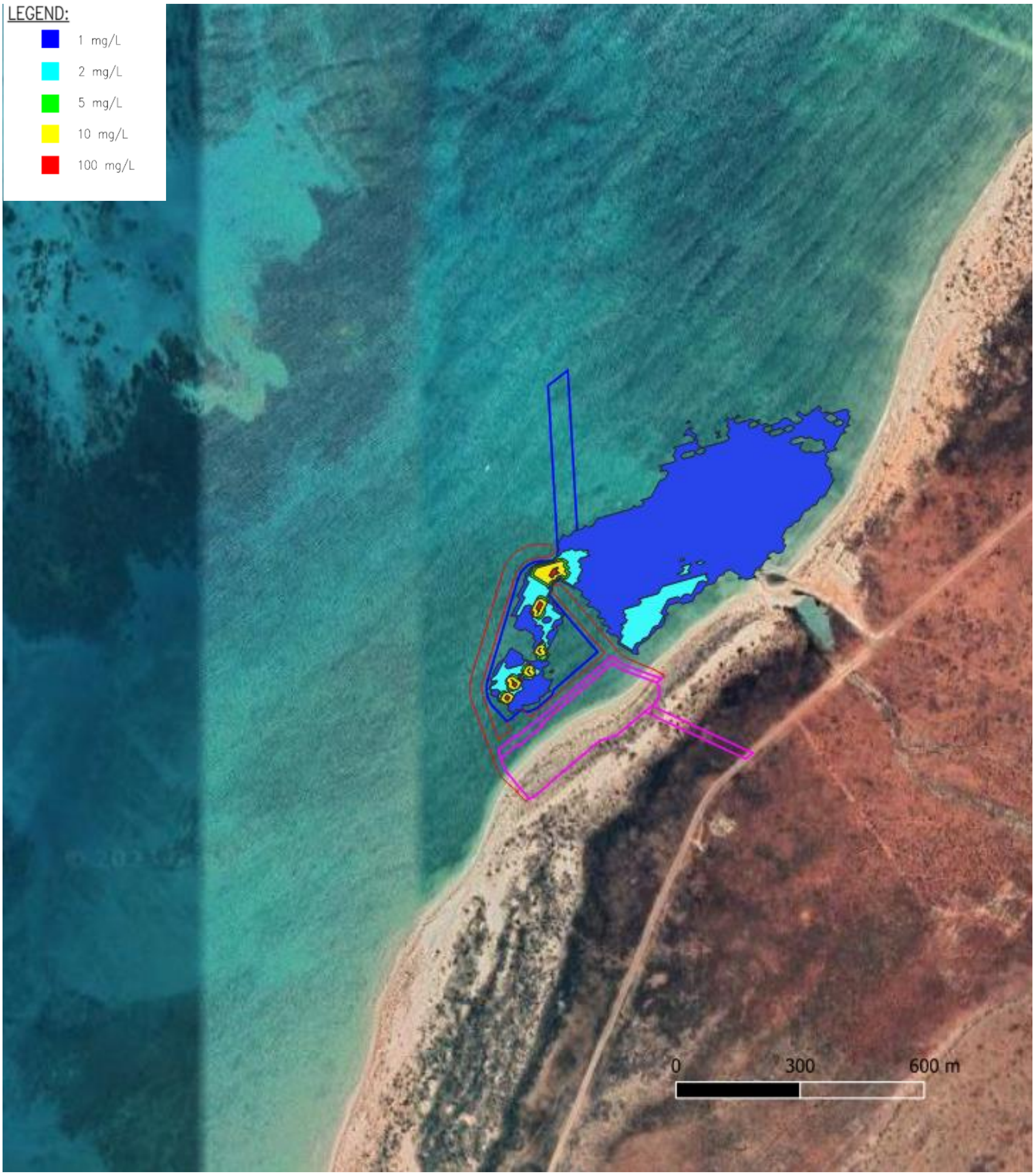
Run 1 - 80% Exceedance



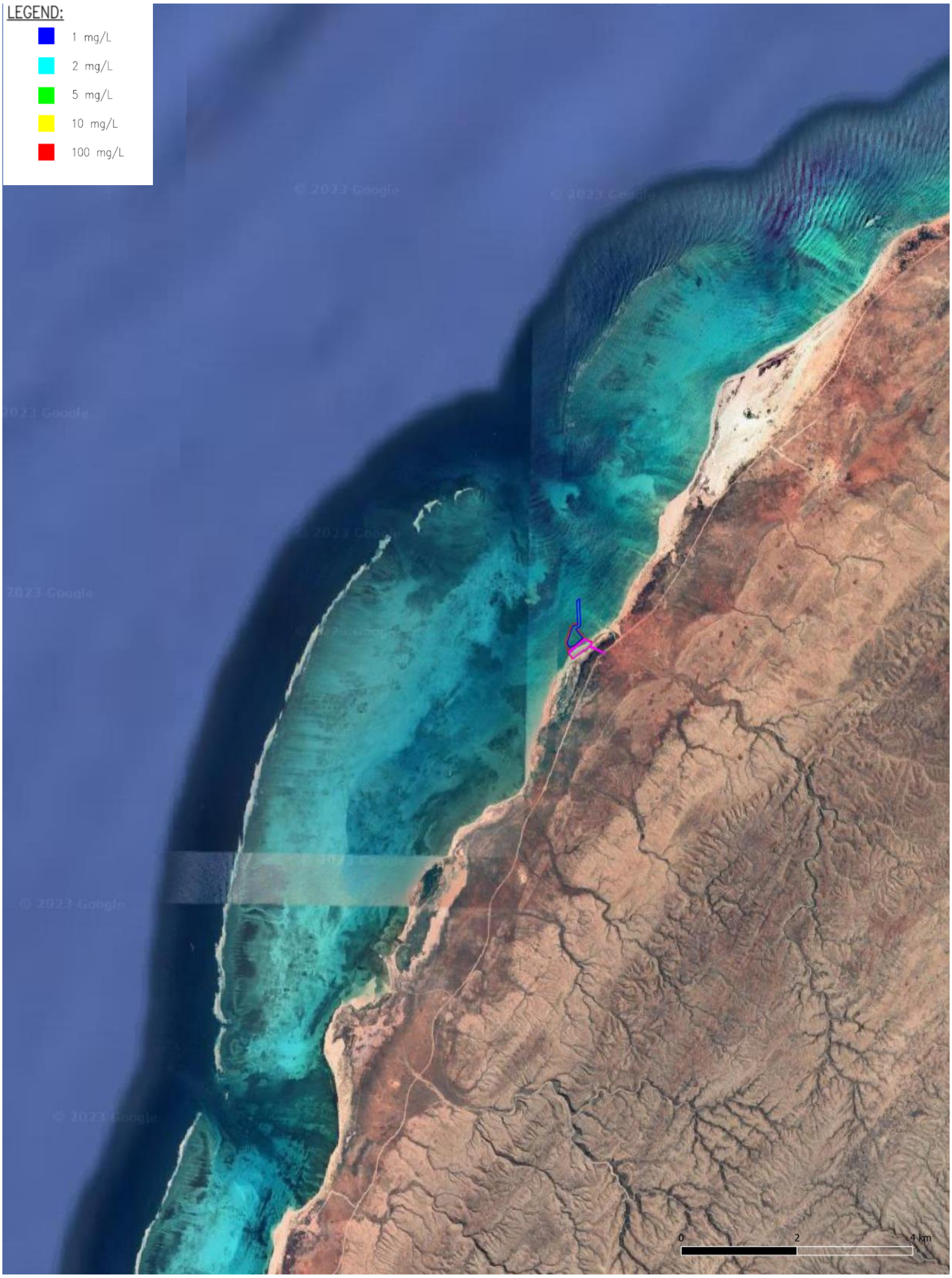
Run 1 - 80% Exceedance Zoomed In



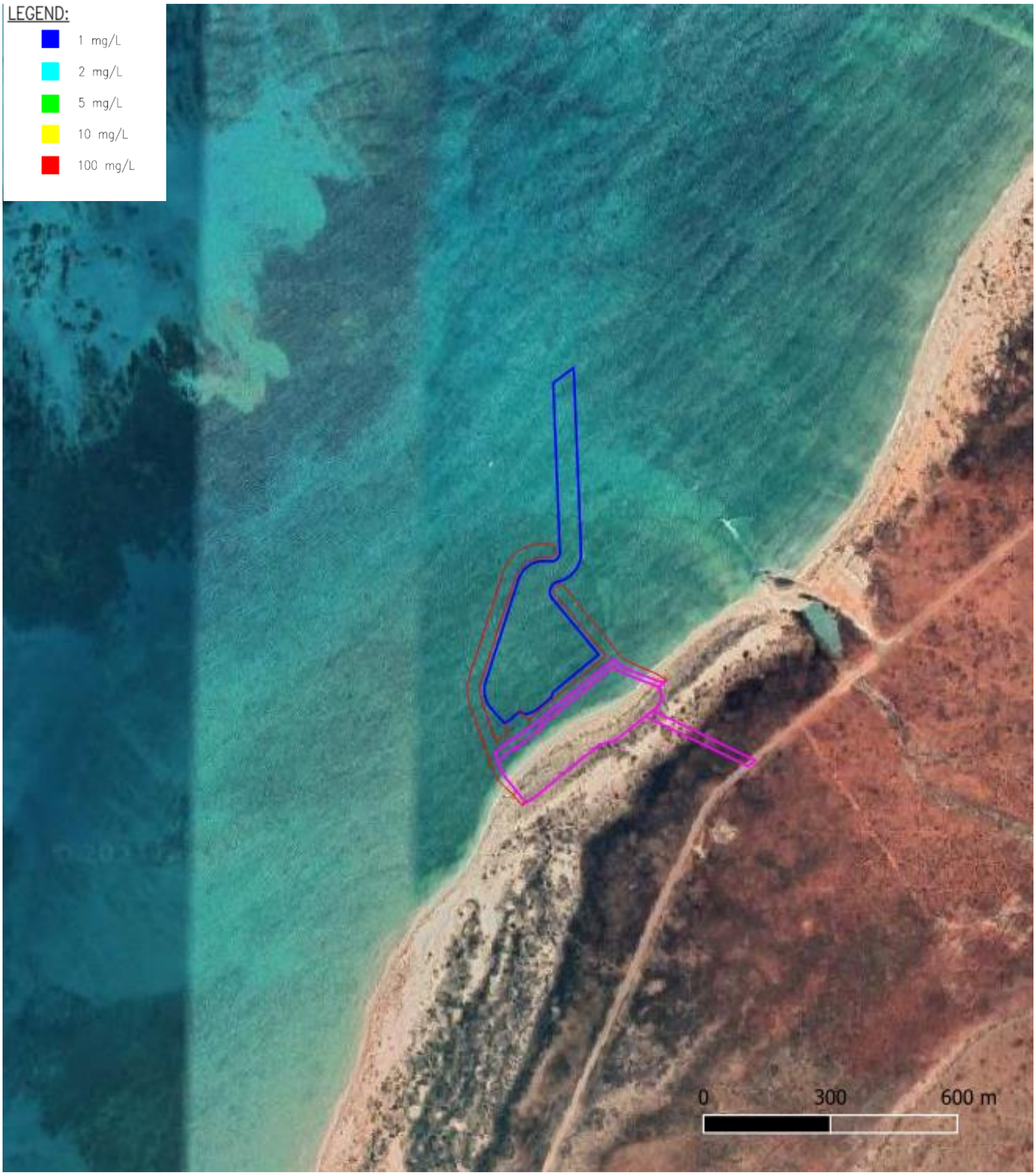
Run 1 - 95% Exceedance



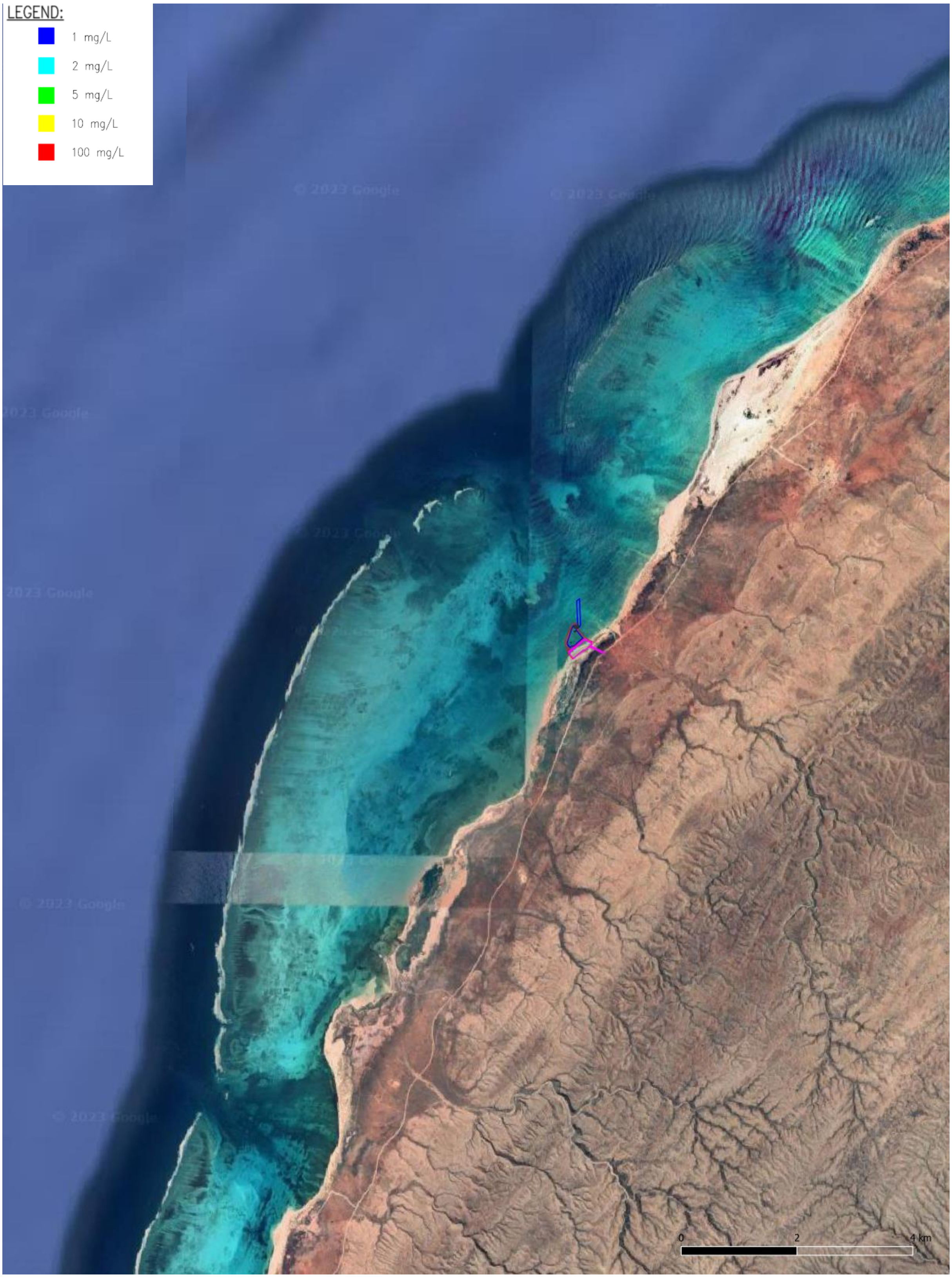
Run 1 - 95% Exceedance Zoomed In



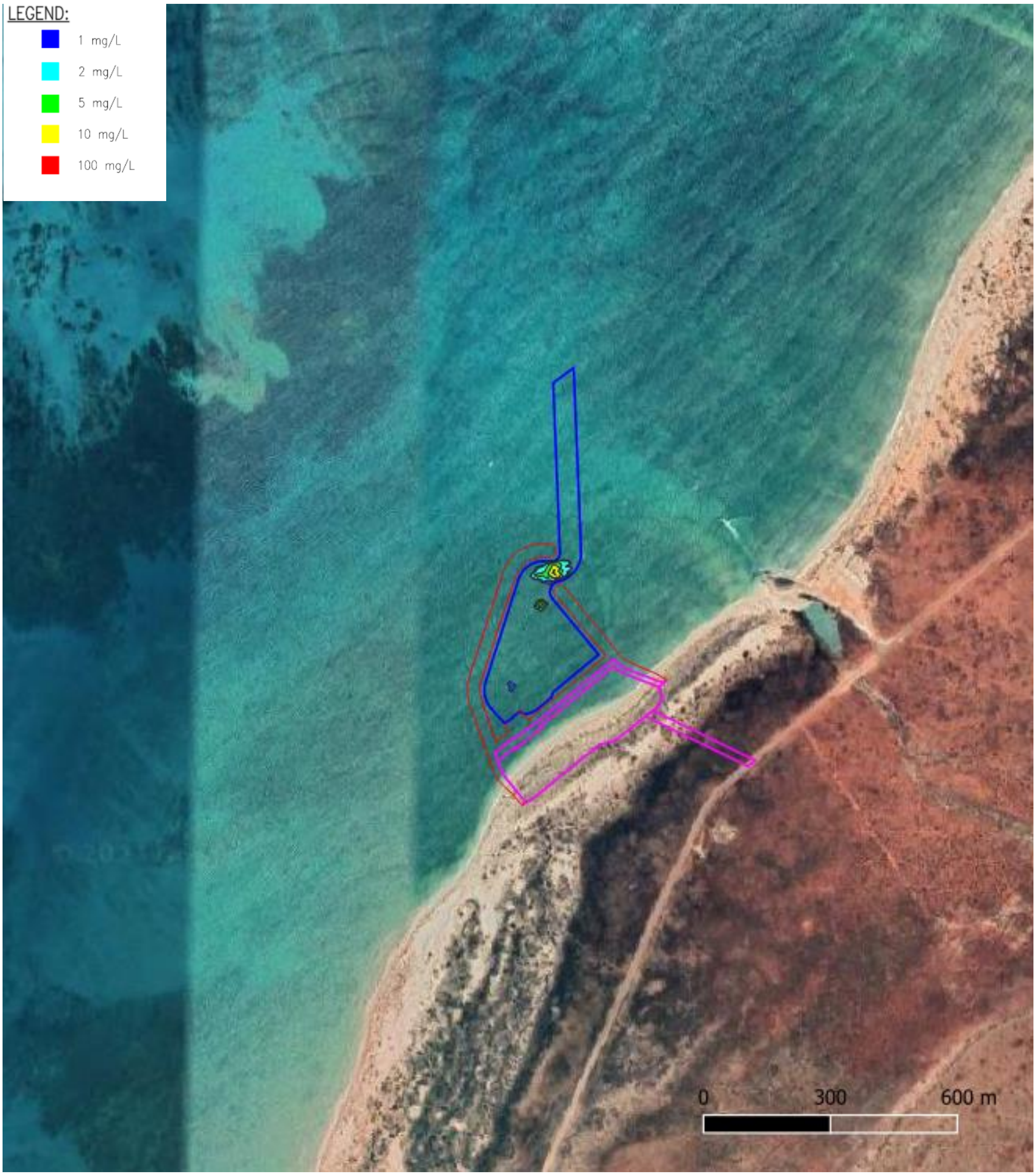
Run 2 - 50% Exceedance



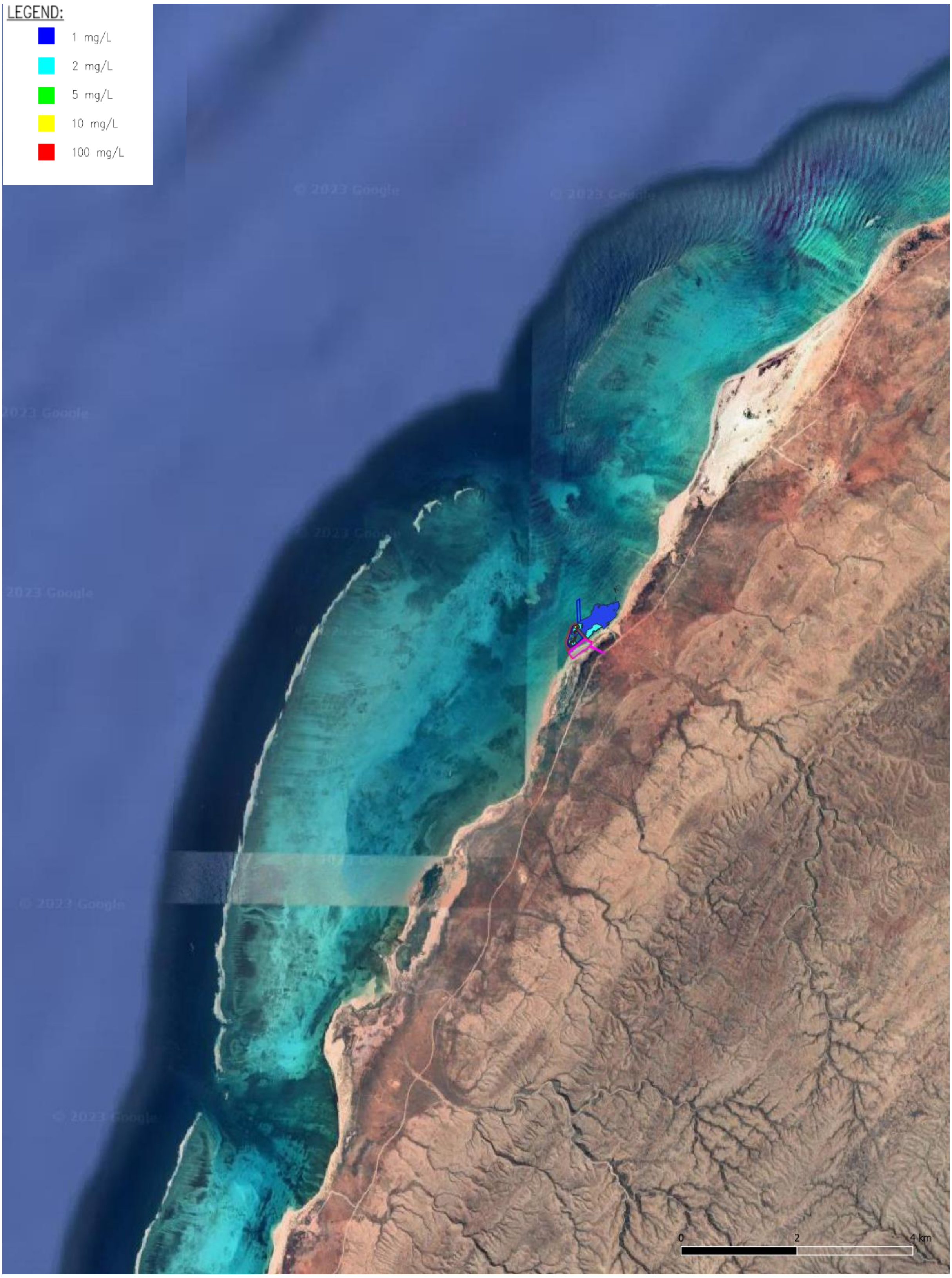
Run 2 - 50% Exceedance Zoomed In



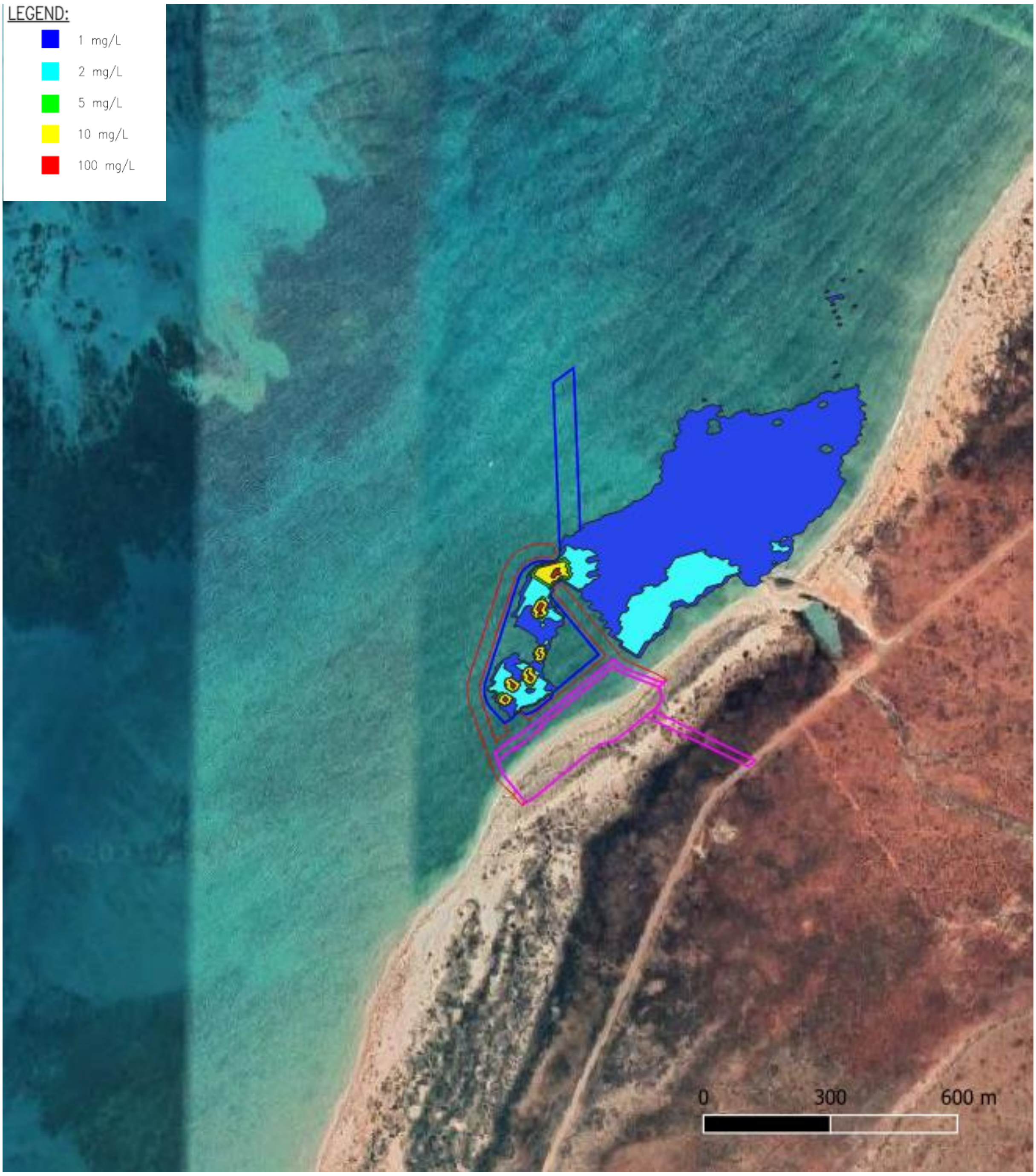
Run 2 - 80% Exceedance



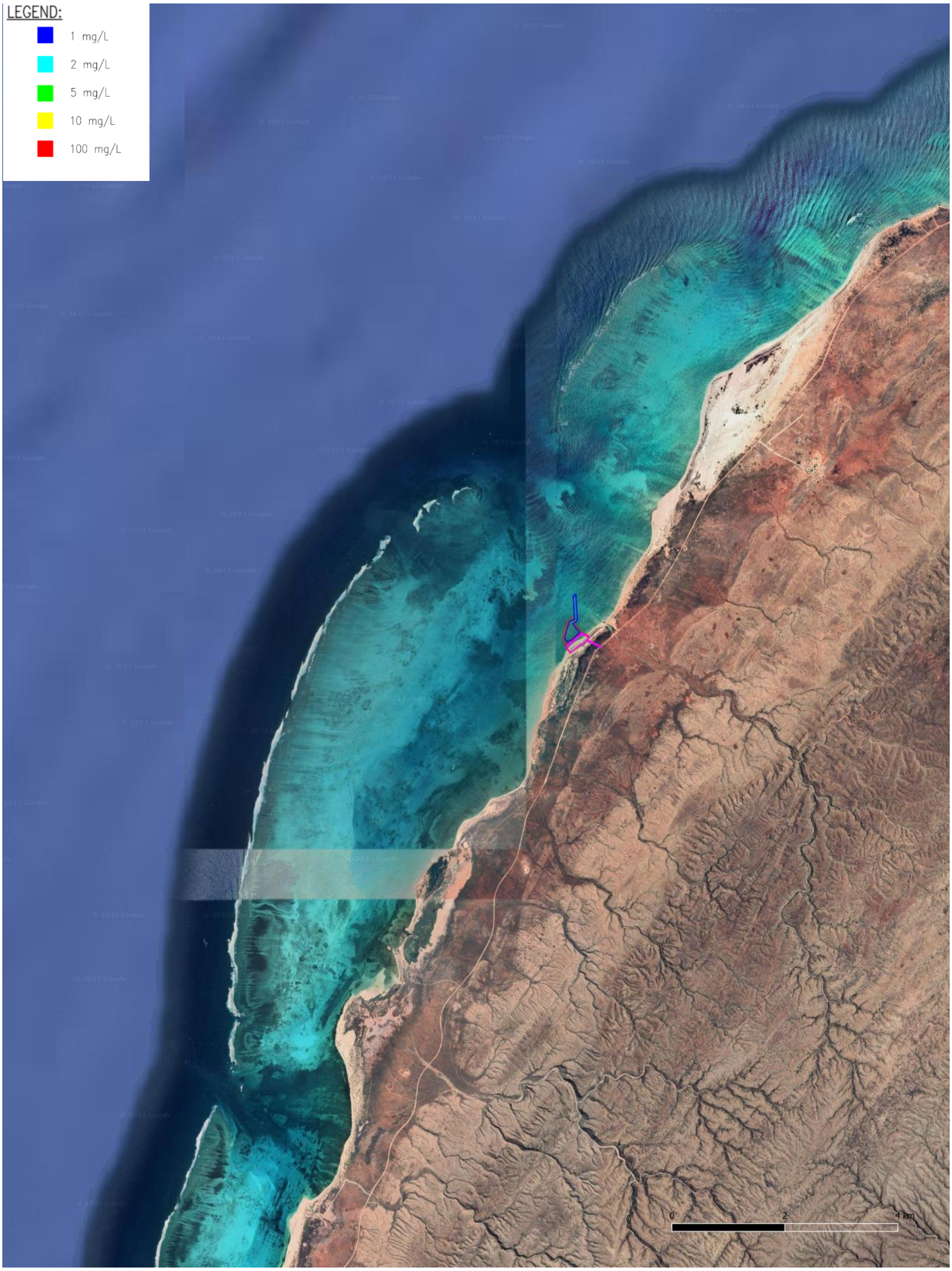
Run 2 - 80% Exceedance Zoomed In



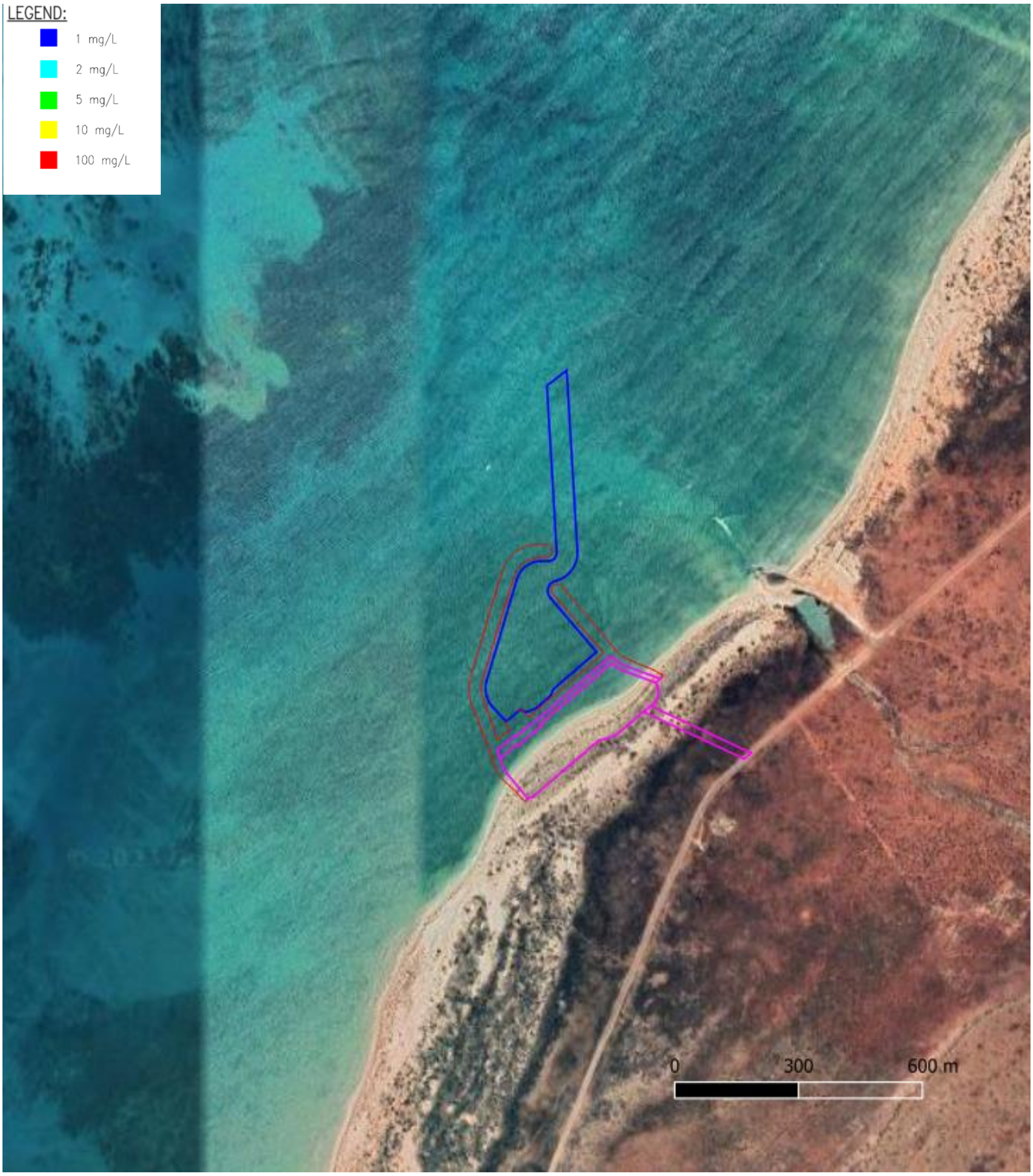
Run 2 - 95% Exceedance



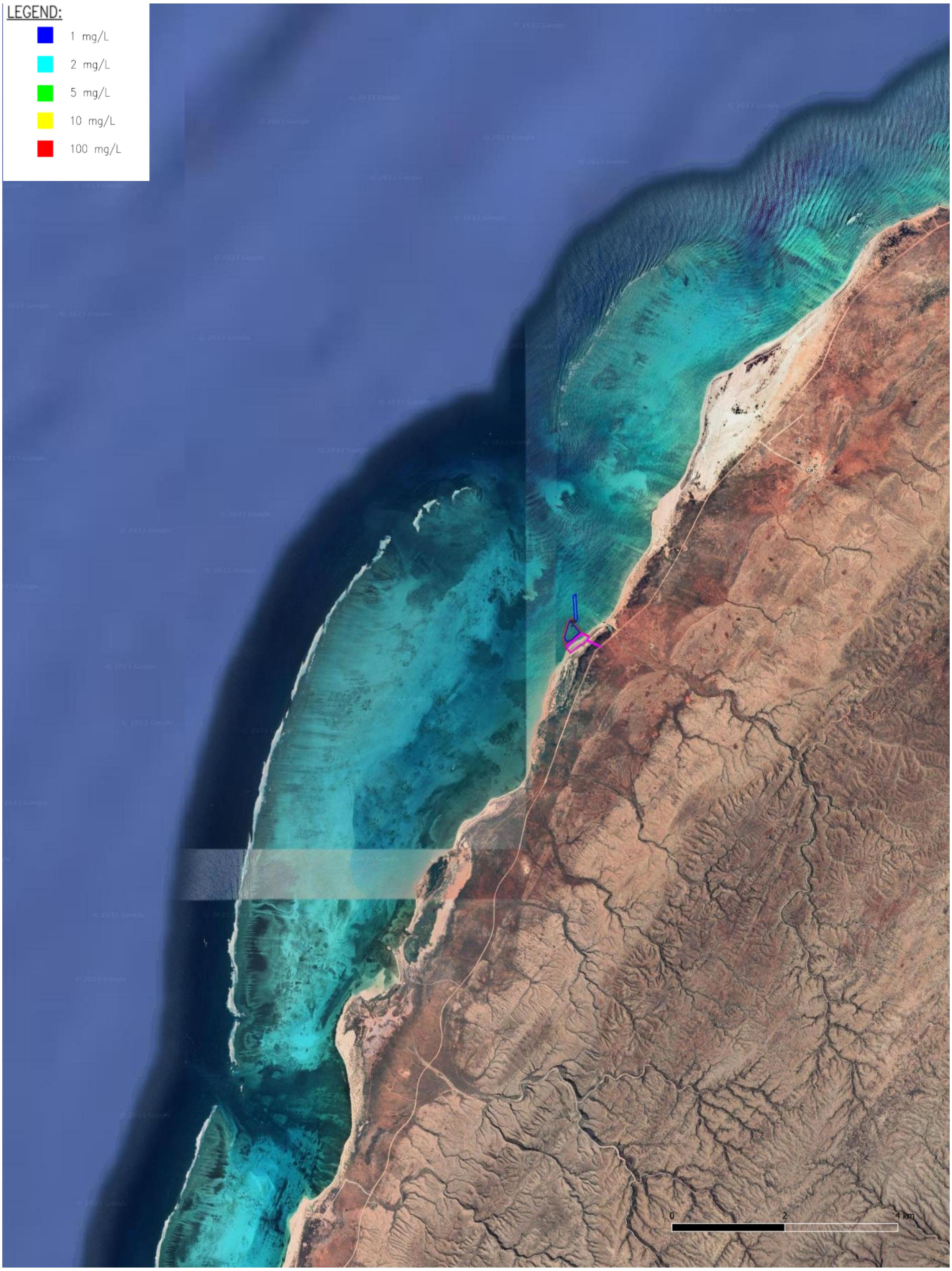
Run 2 - 95% Exceedance Zoomed In



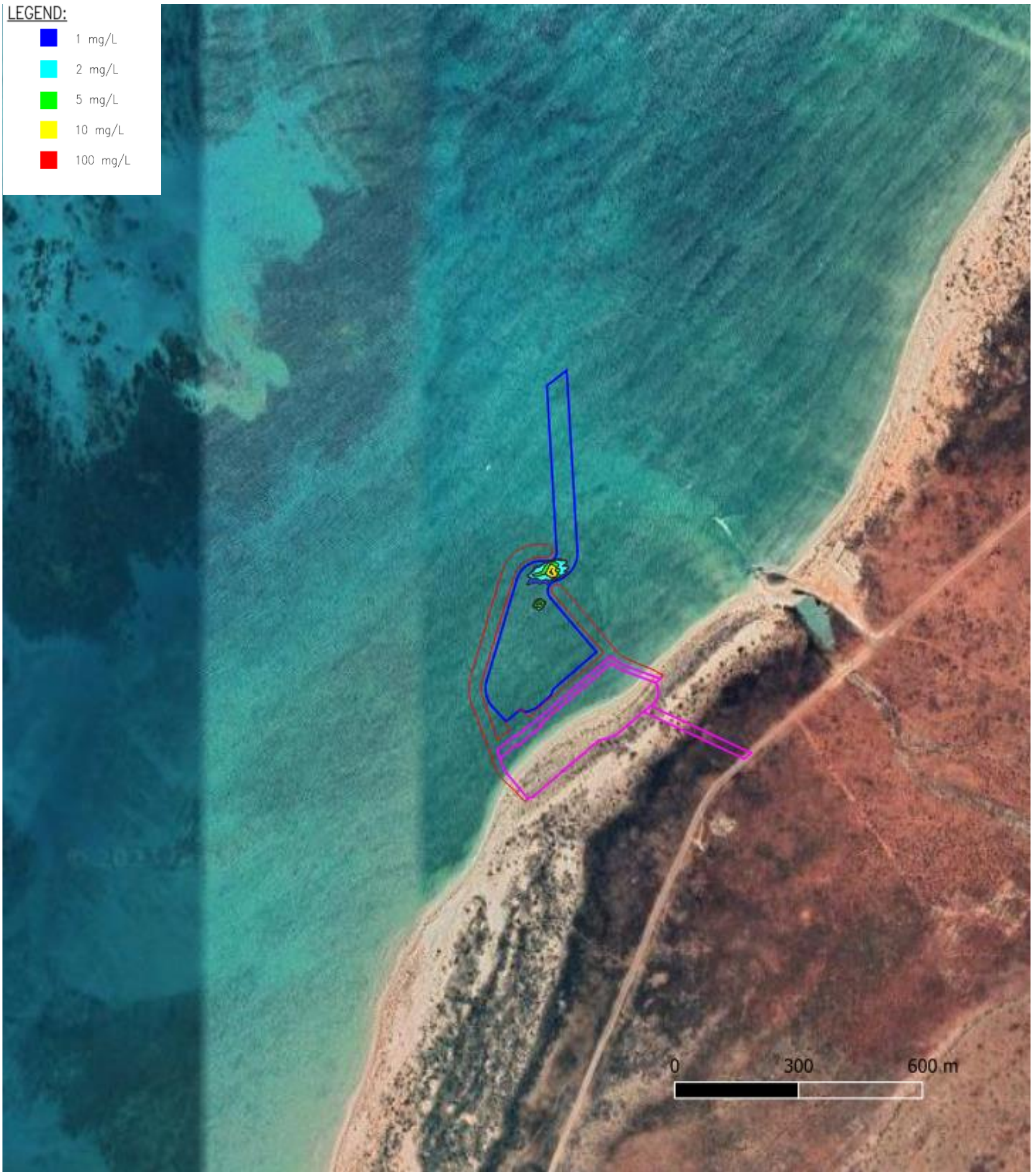
Run 3 - 50% Exceedance



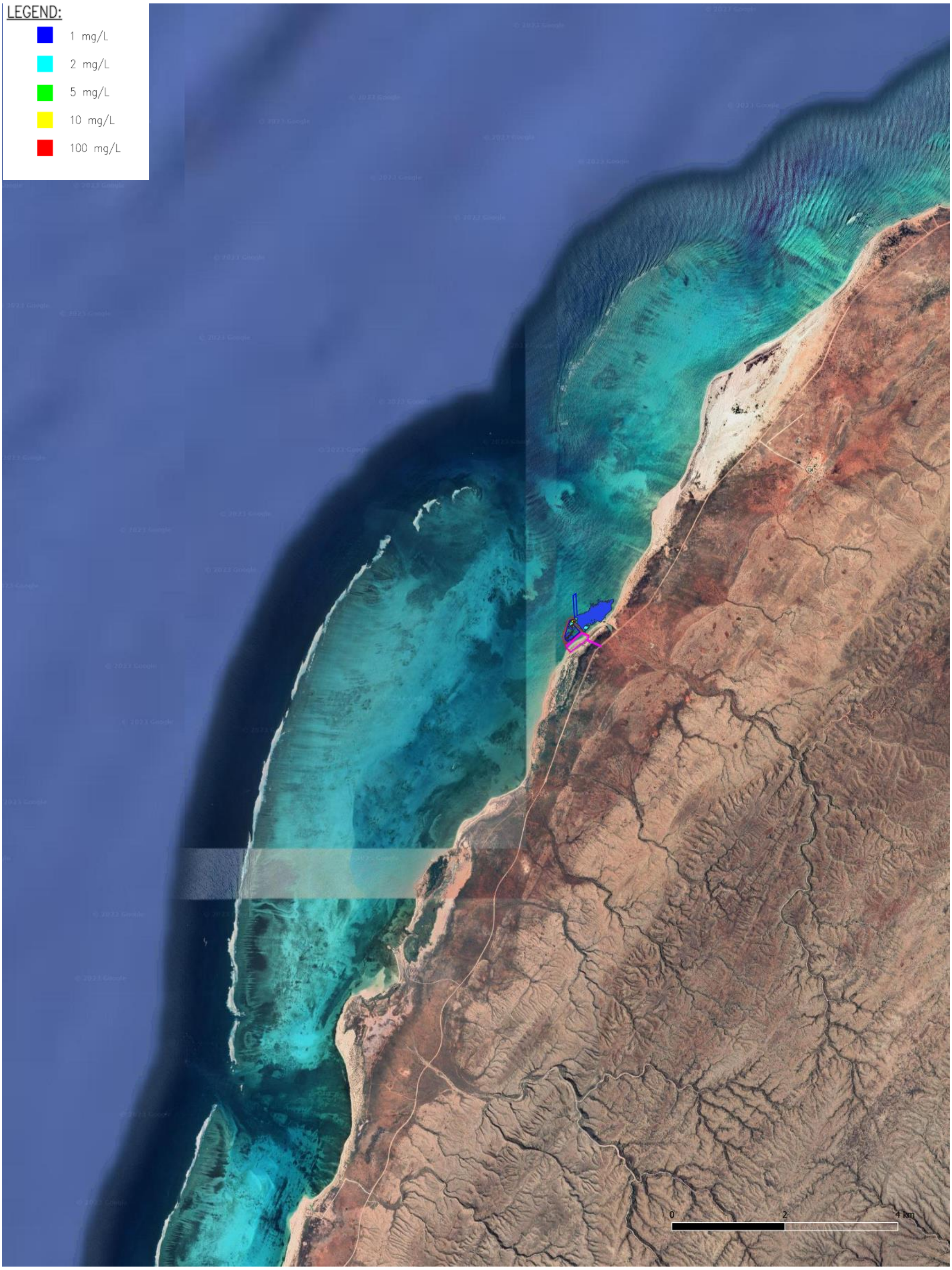
Run 3 - 50% Exceedance Zoomed In



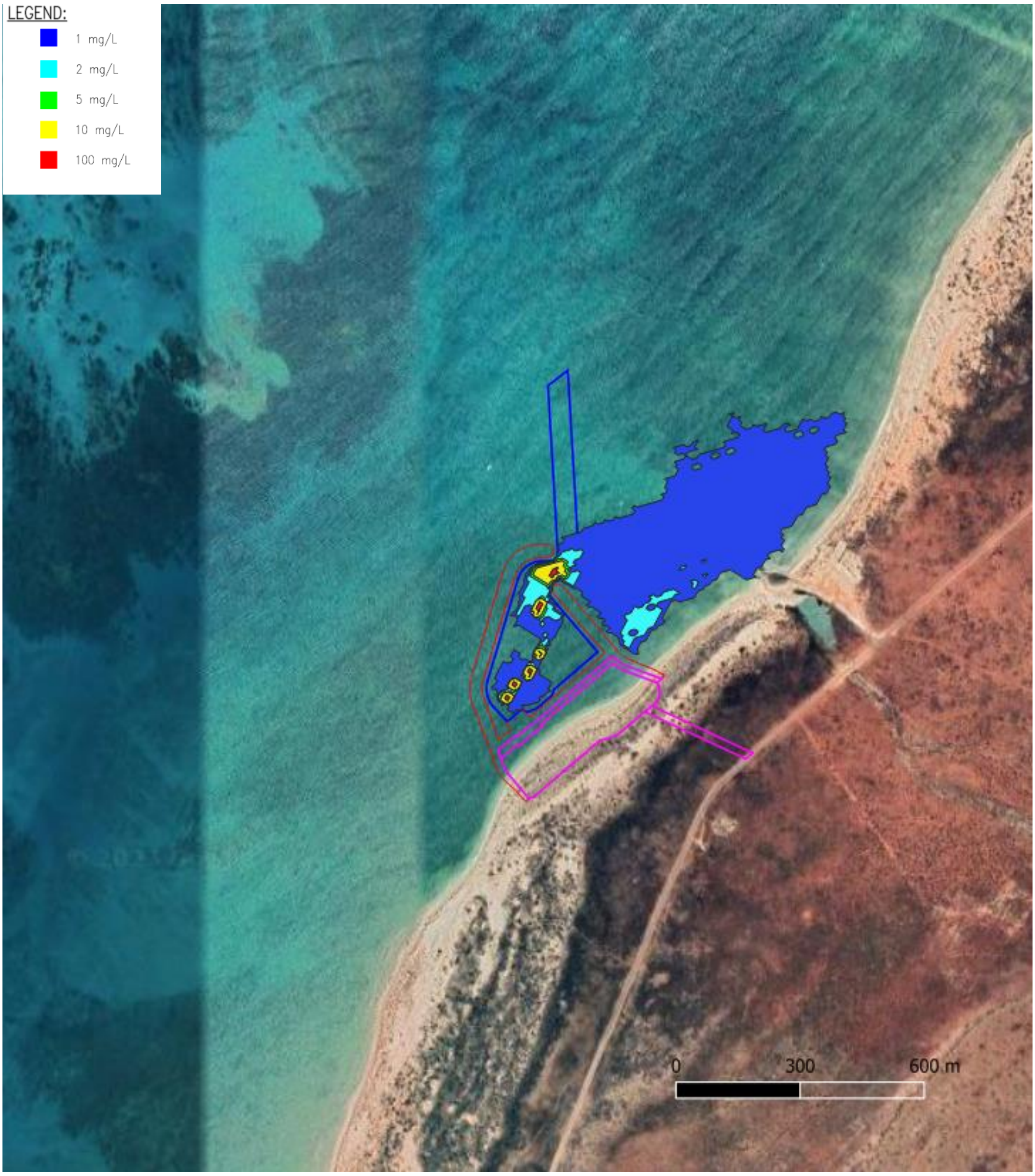
Run 3 - 80% Exceedance



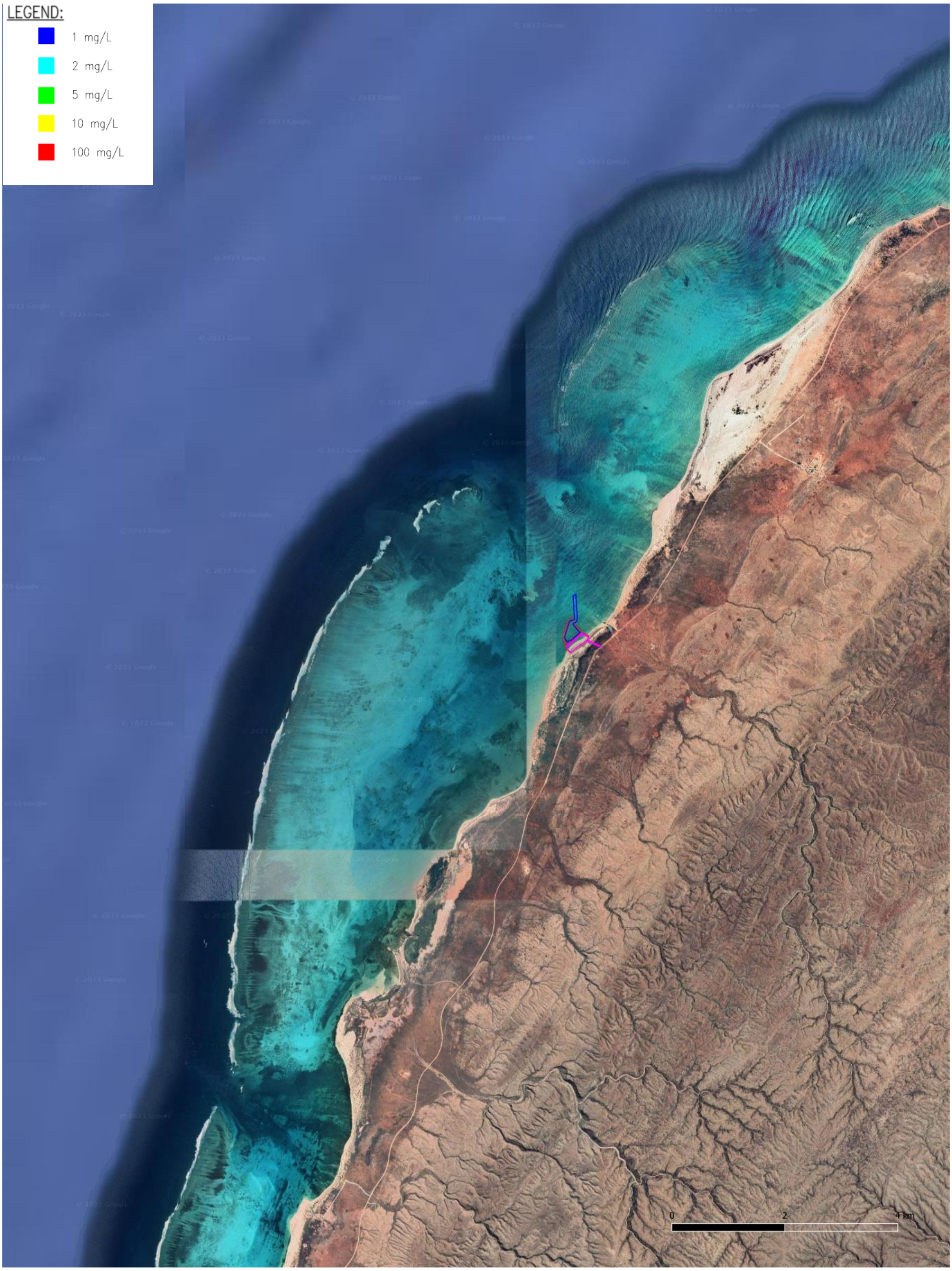
Run 3 - 80% Exceedance Zoomed In



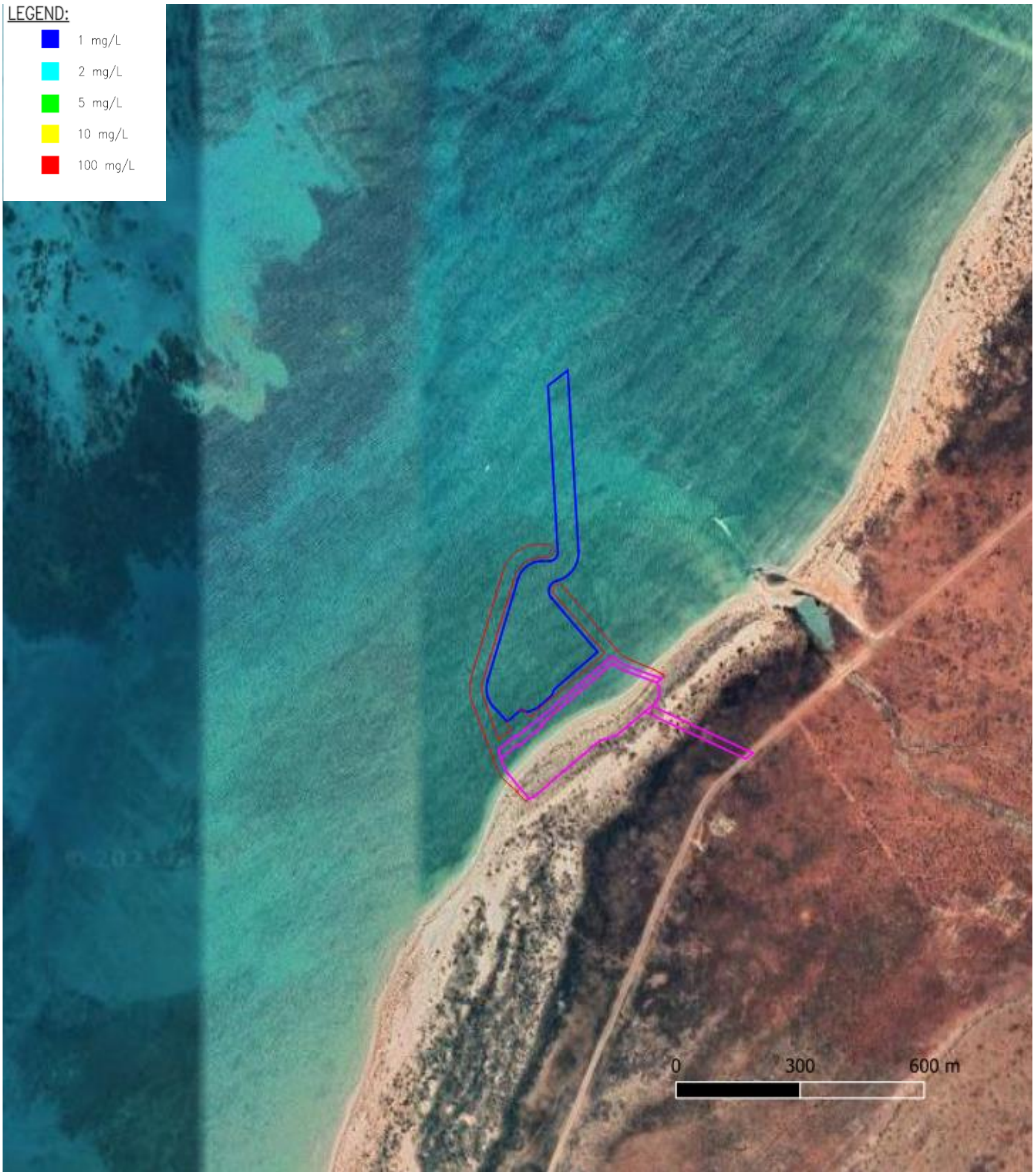
Run 3 - 95% Exceedance



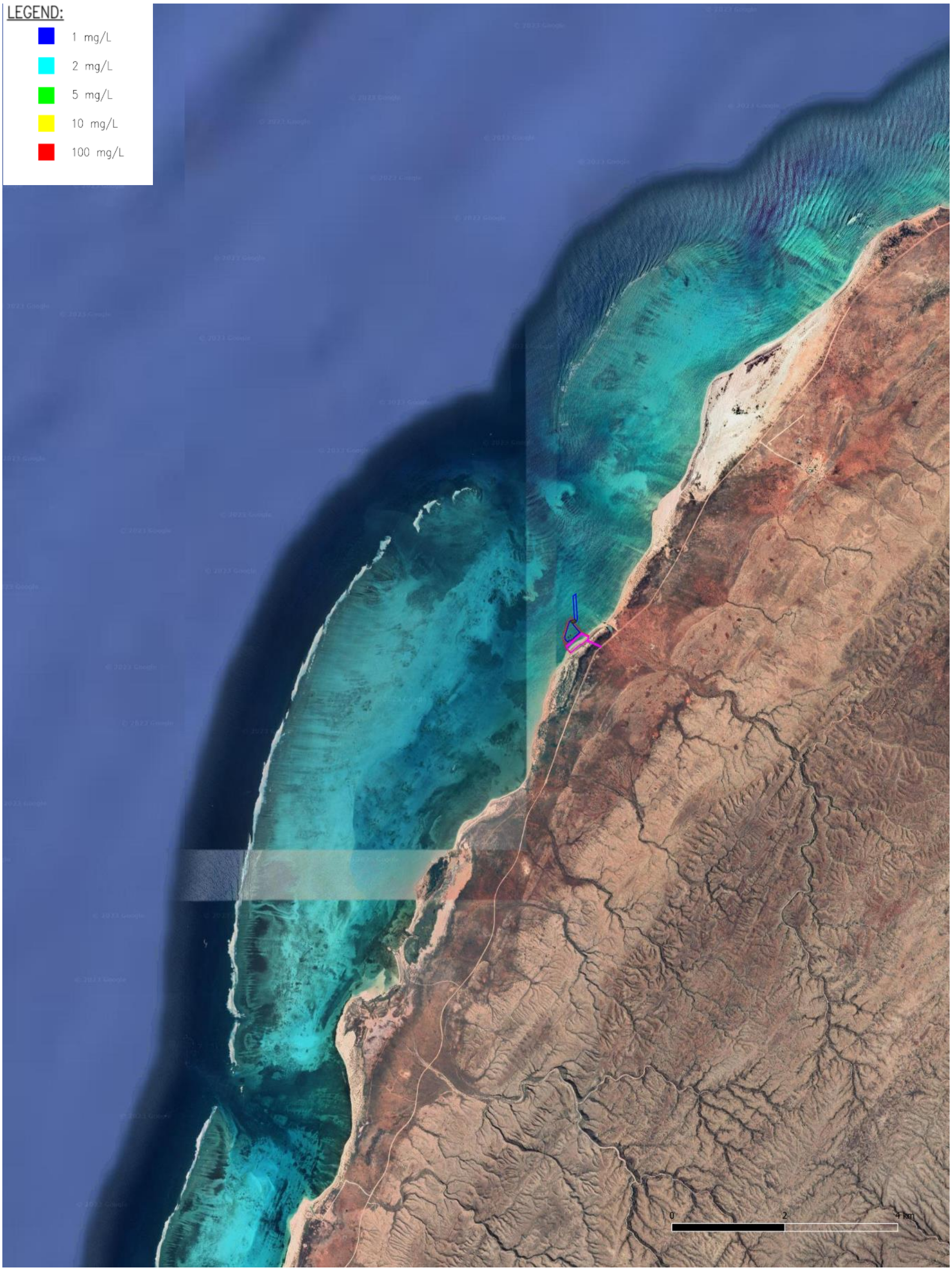
Run 3 - 95% Exceedance Zoomed In



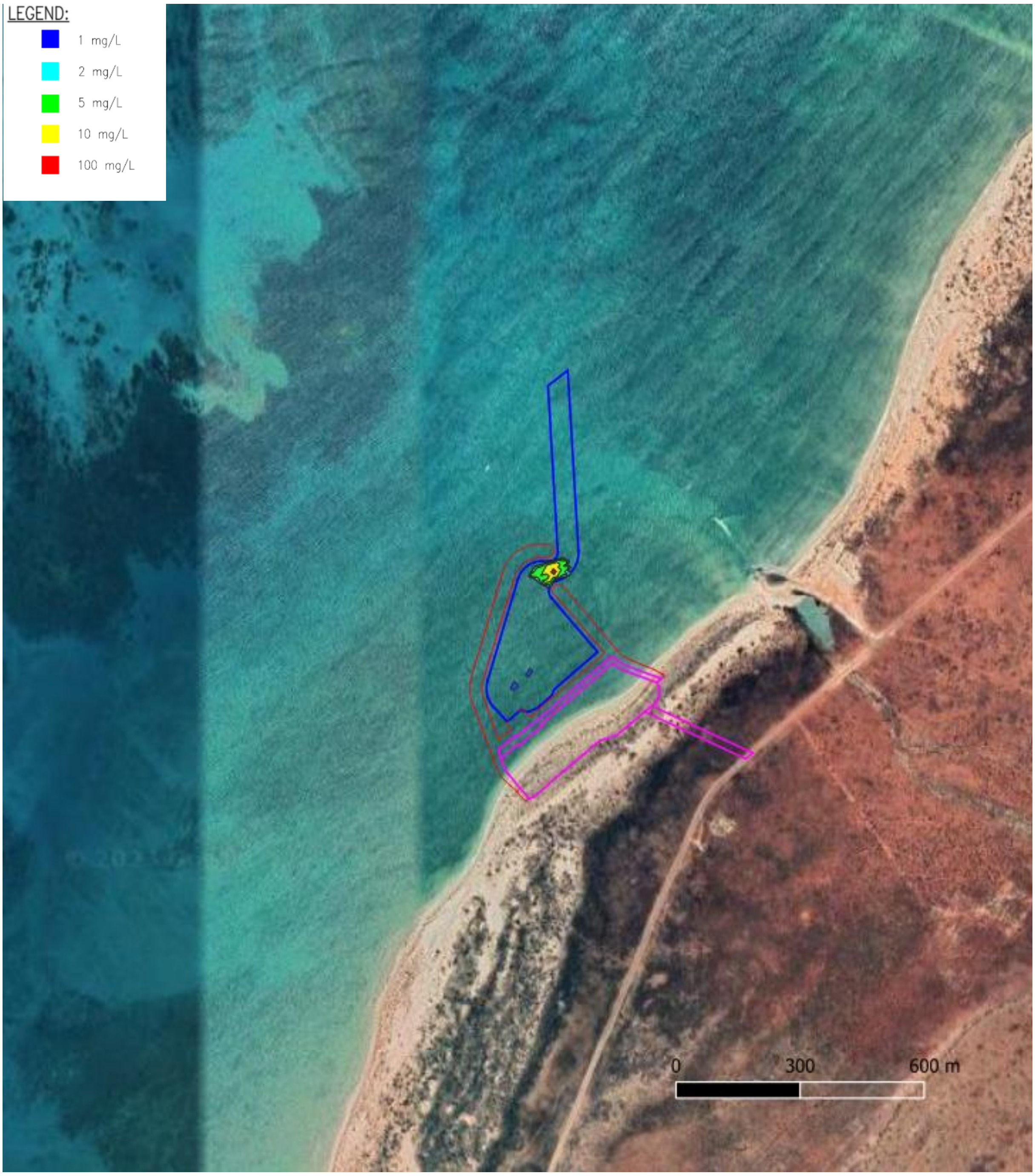
Run 4 - 50% Exceedance



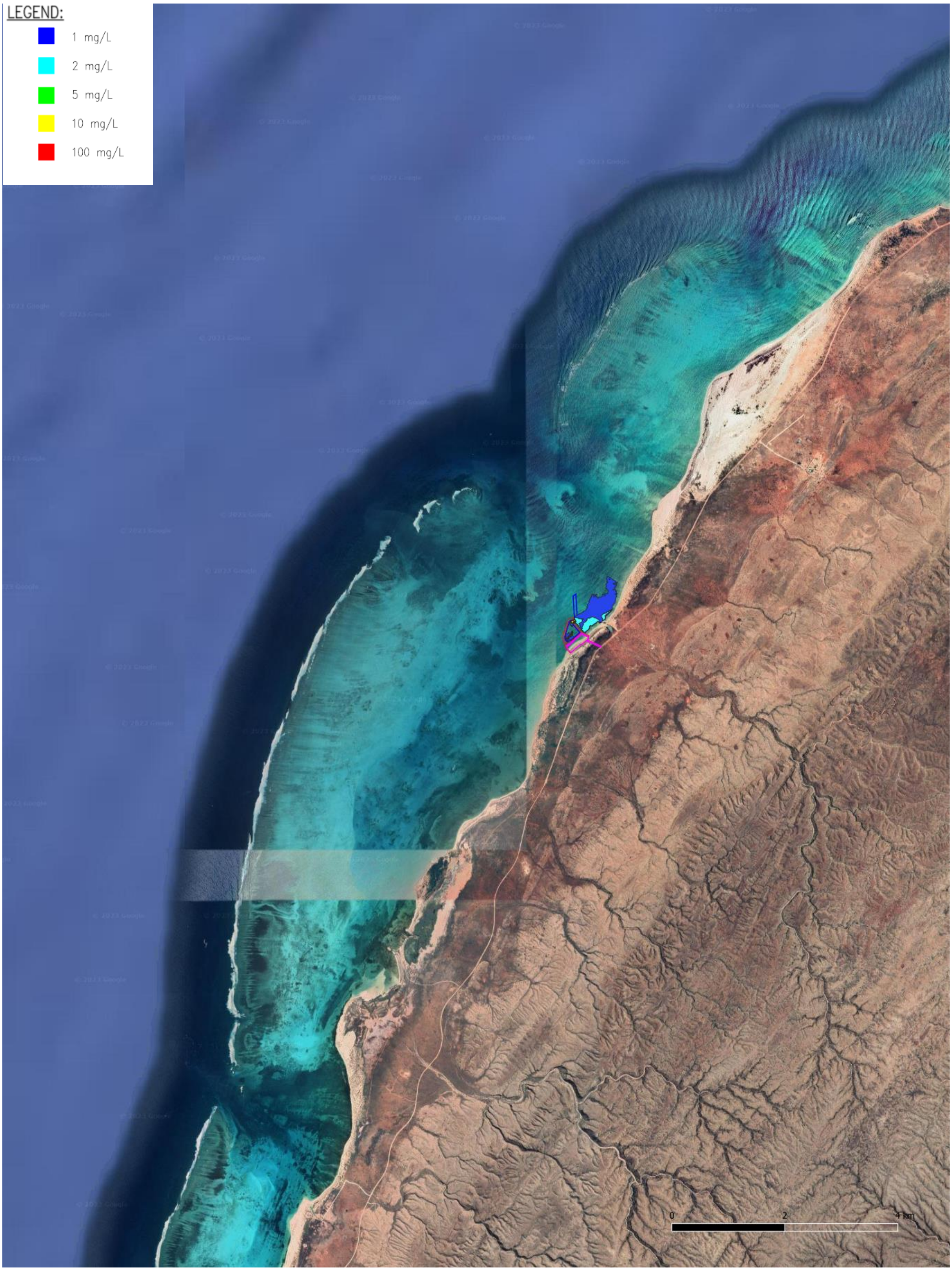
Run 4 - 50% Exceedance Zoomed In



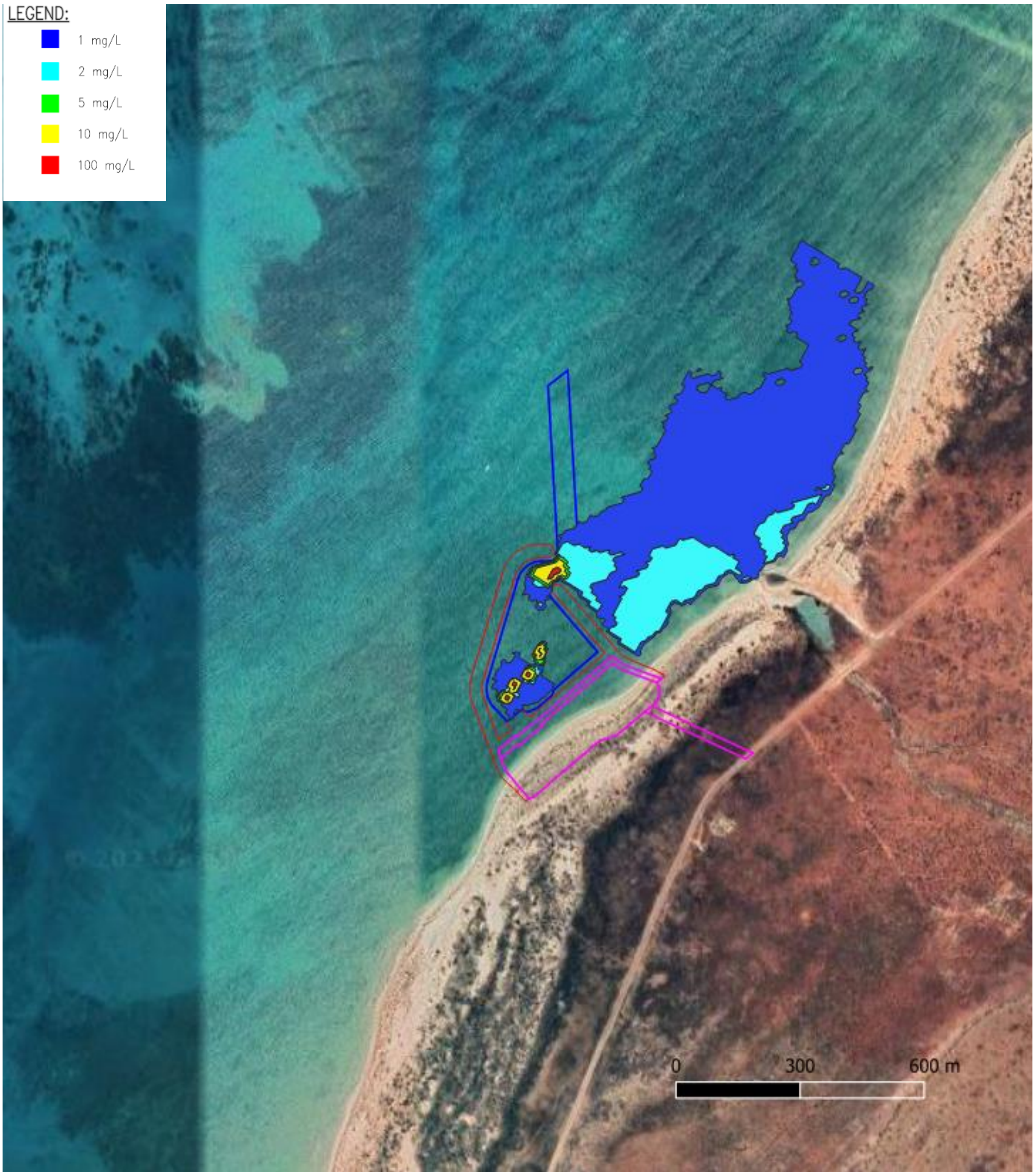
Run 4 - 80% Exceedance



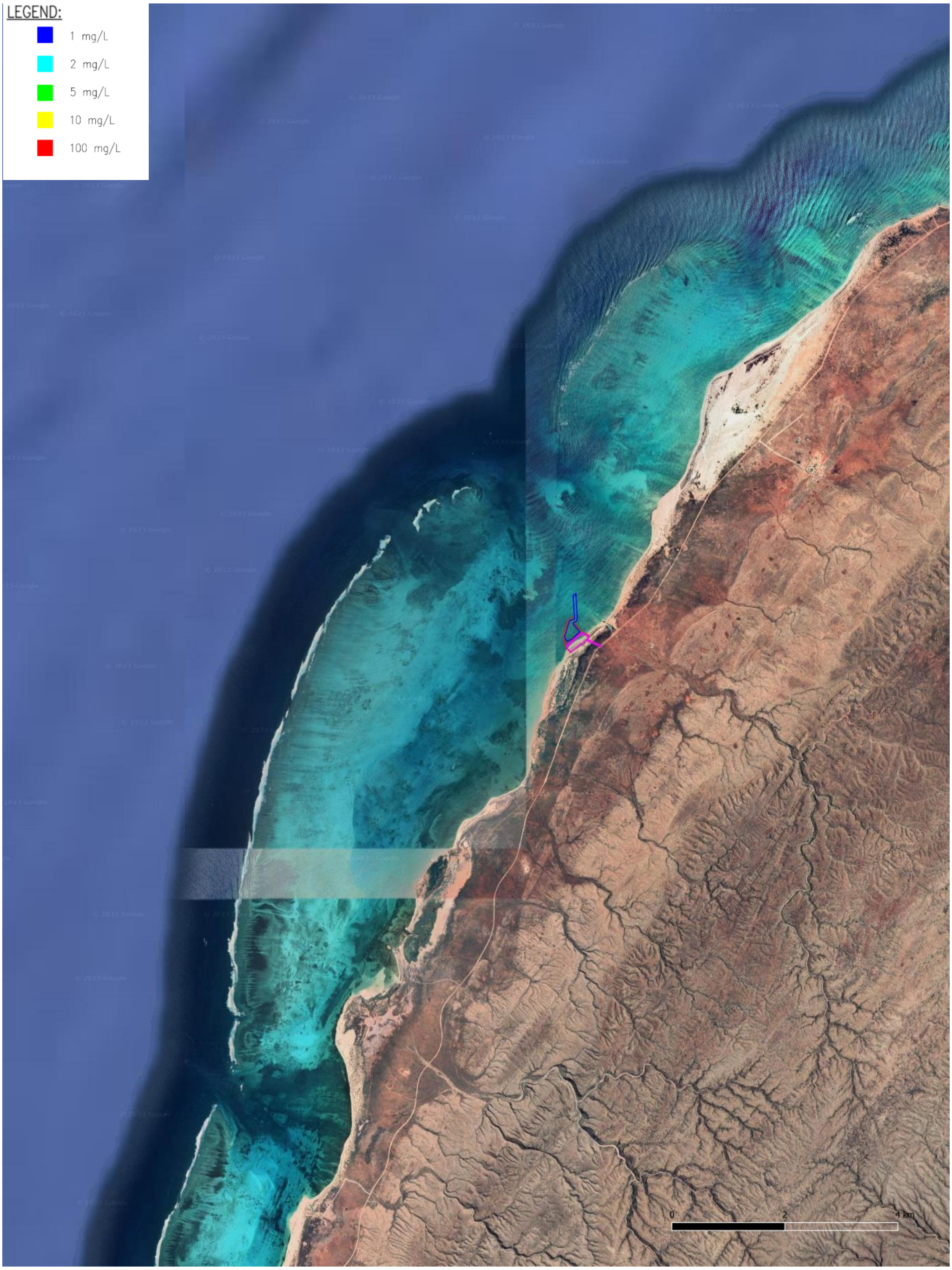
Run 4 - 80% Exceedance Zoomed In



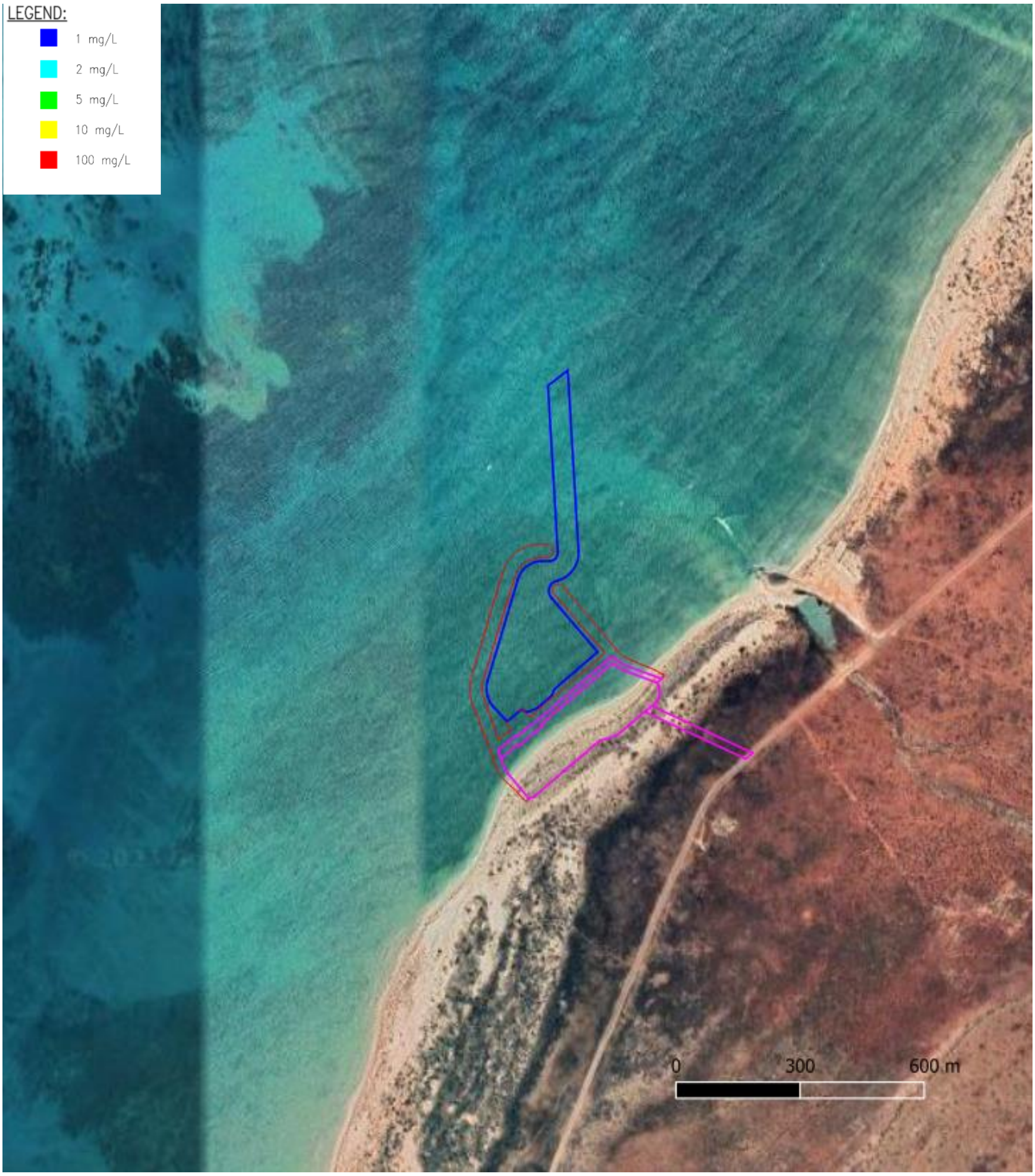
Run 4 - 95% Exceedance



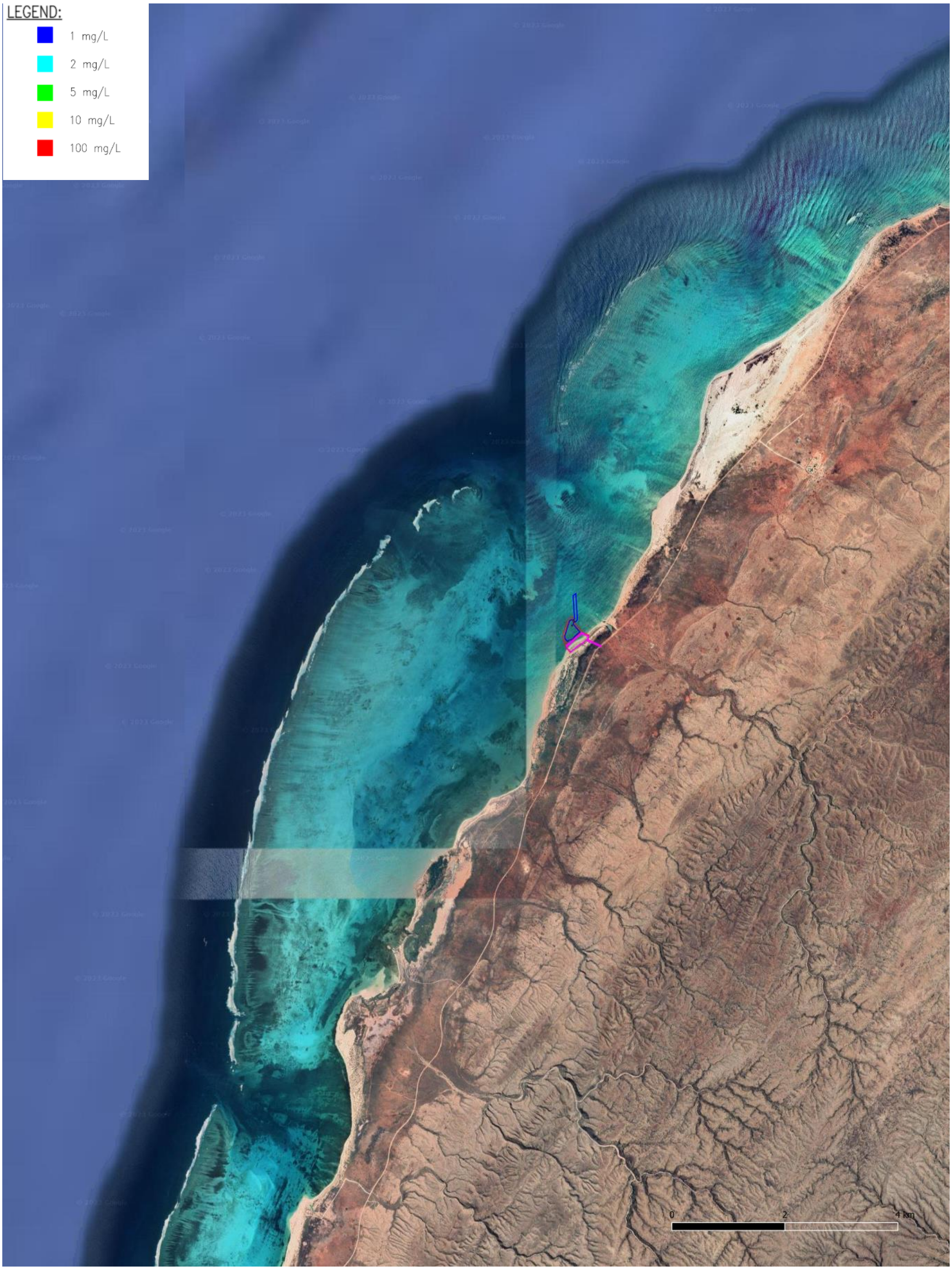
Run 4 -95% Exceedance Zoomed In



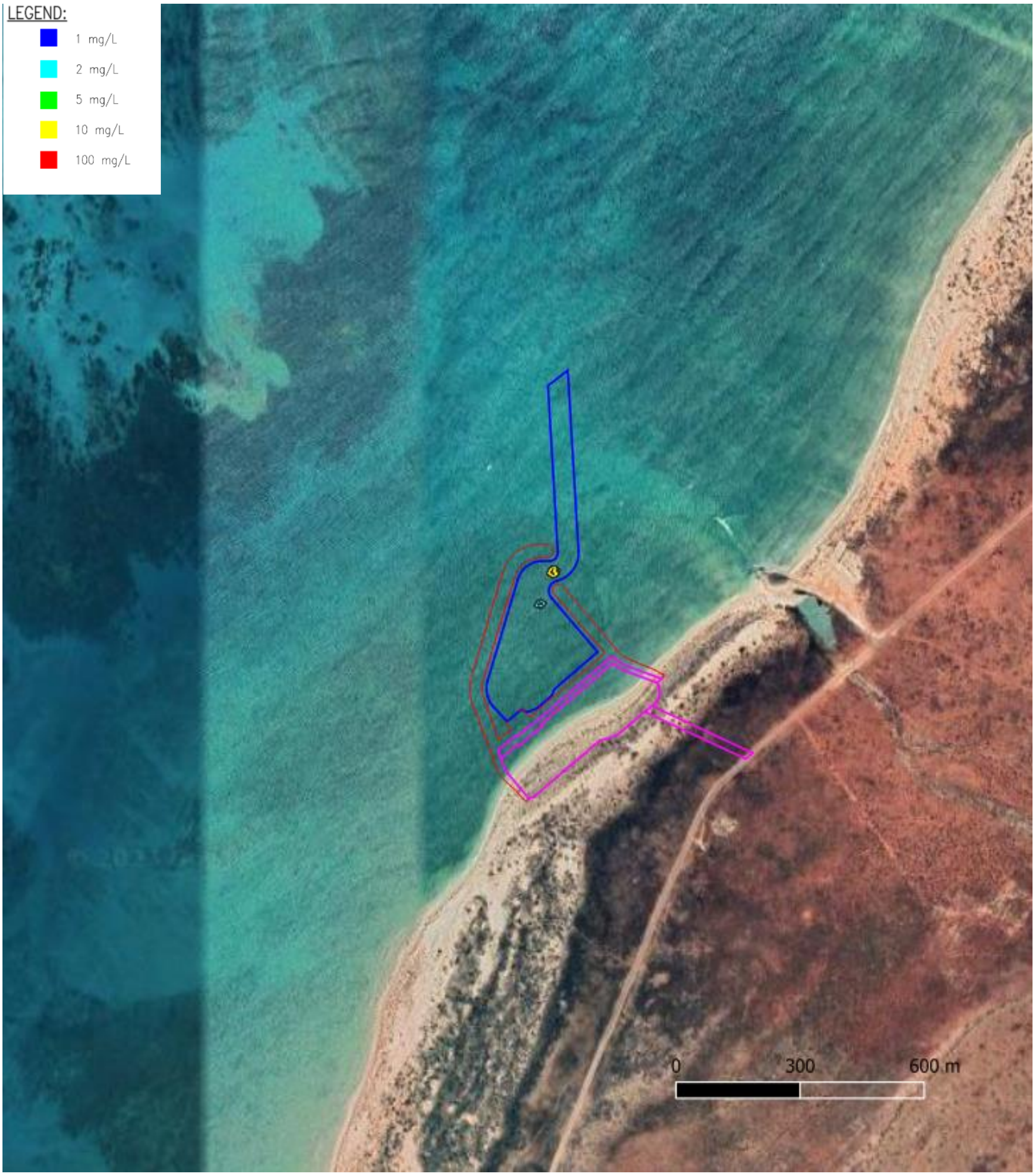
Run 5 - 50% Exceedance



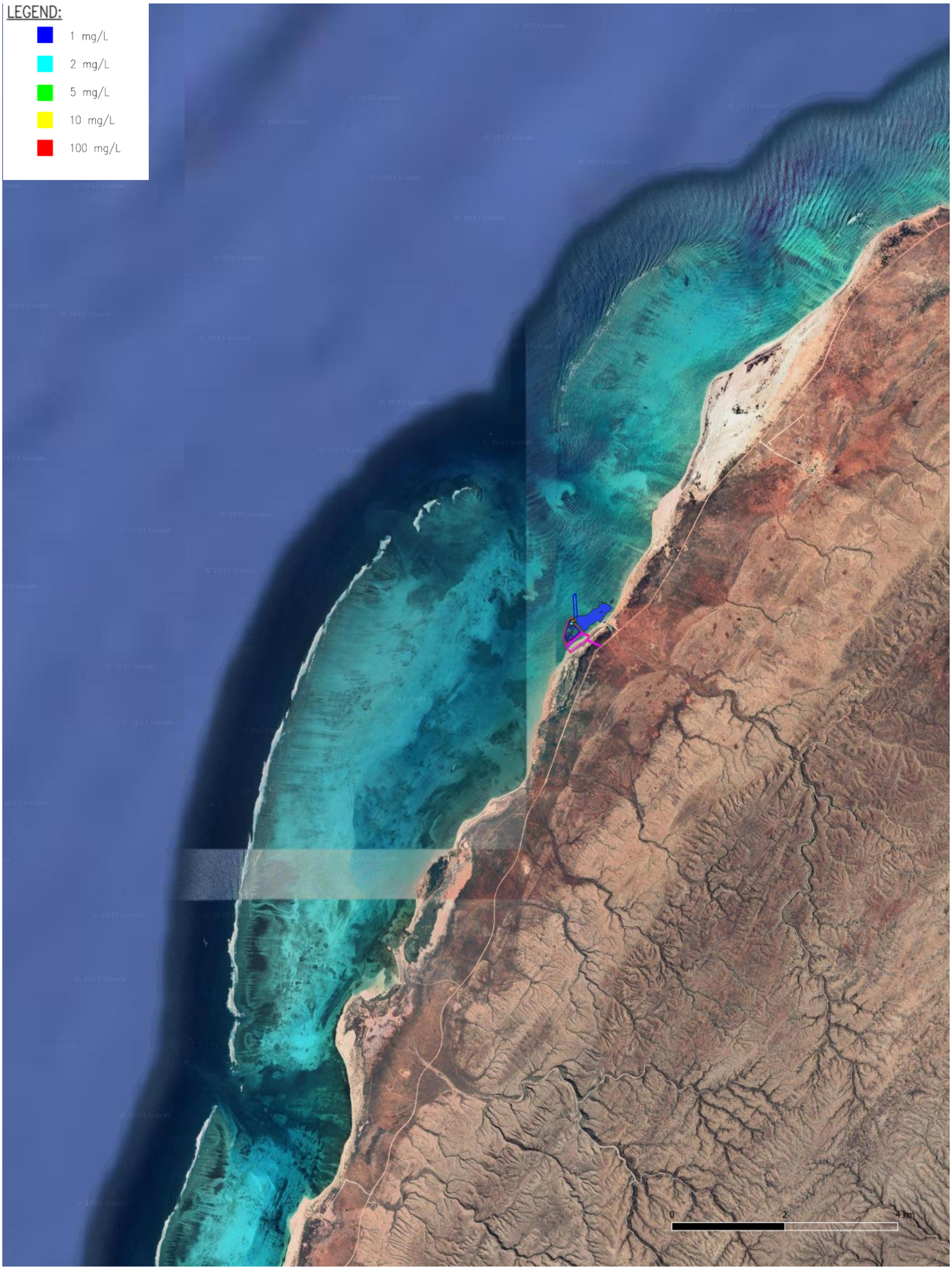
Run 5 - 50% Exceedance Zoomed In



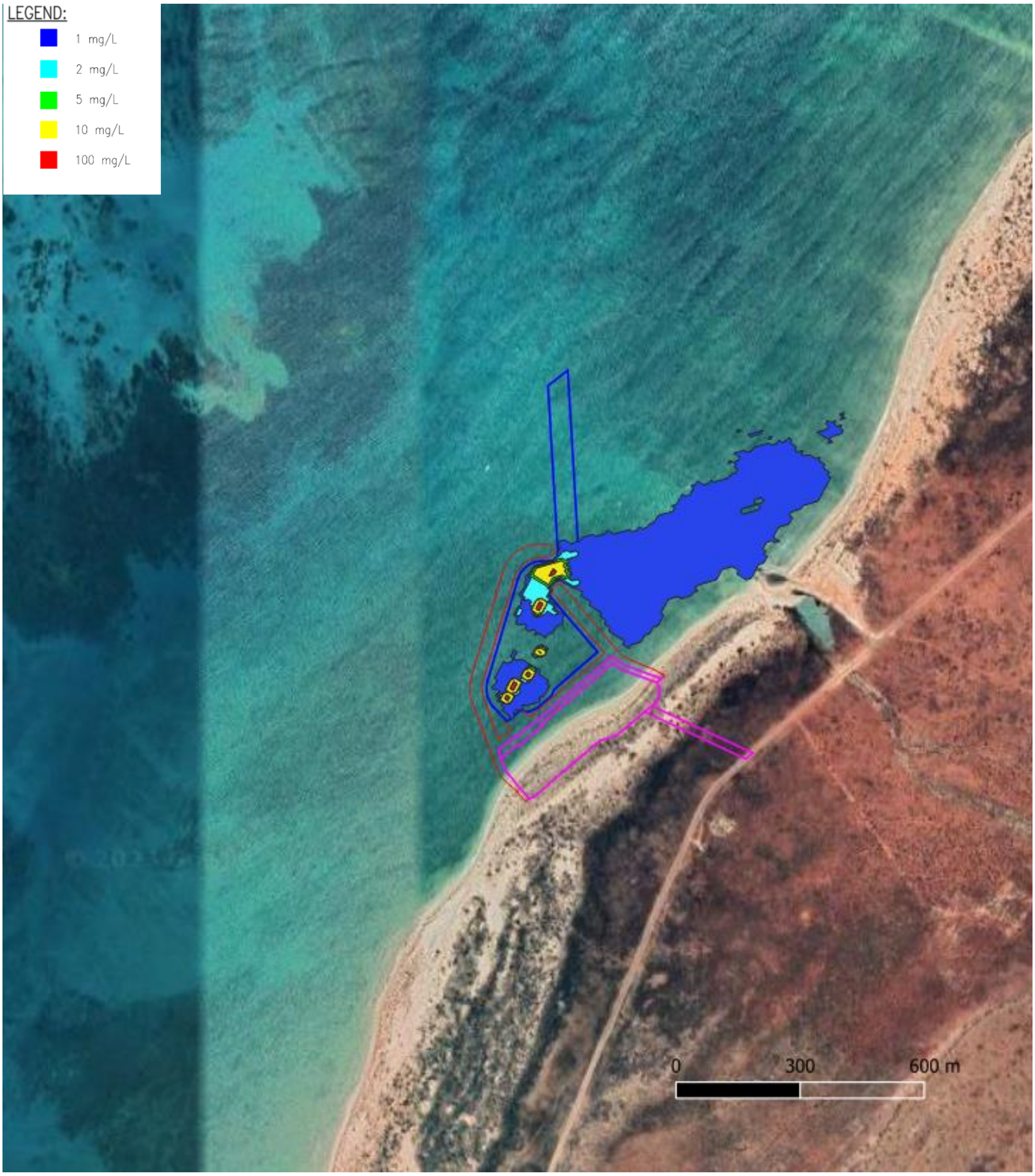
Run 5 - 80% Exceedance



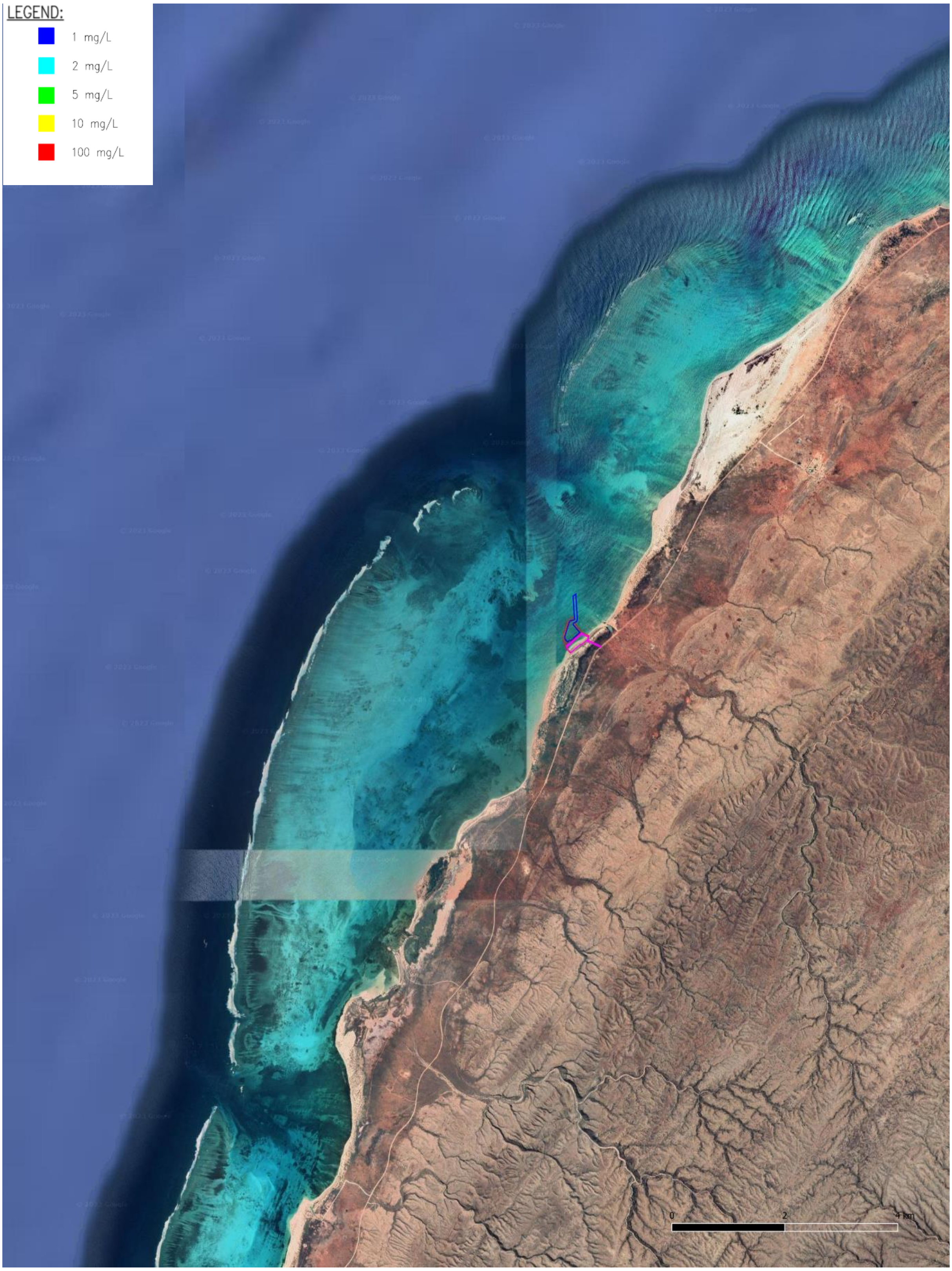
Run 5 - 80% Exceedance Zoomed In



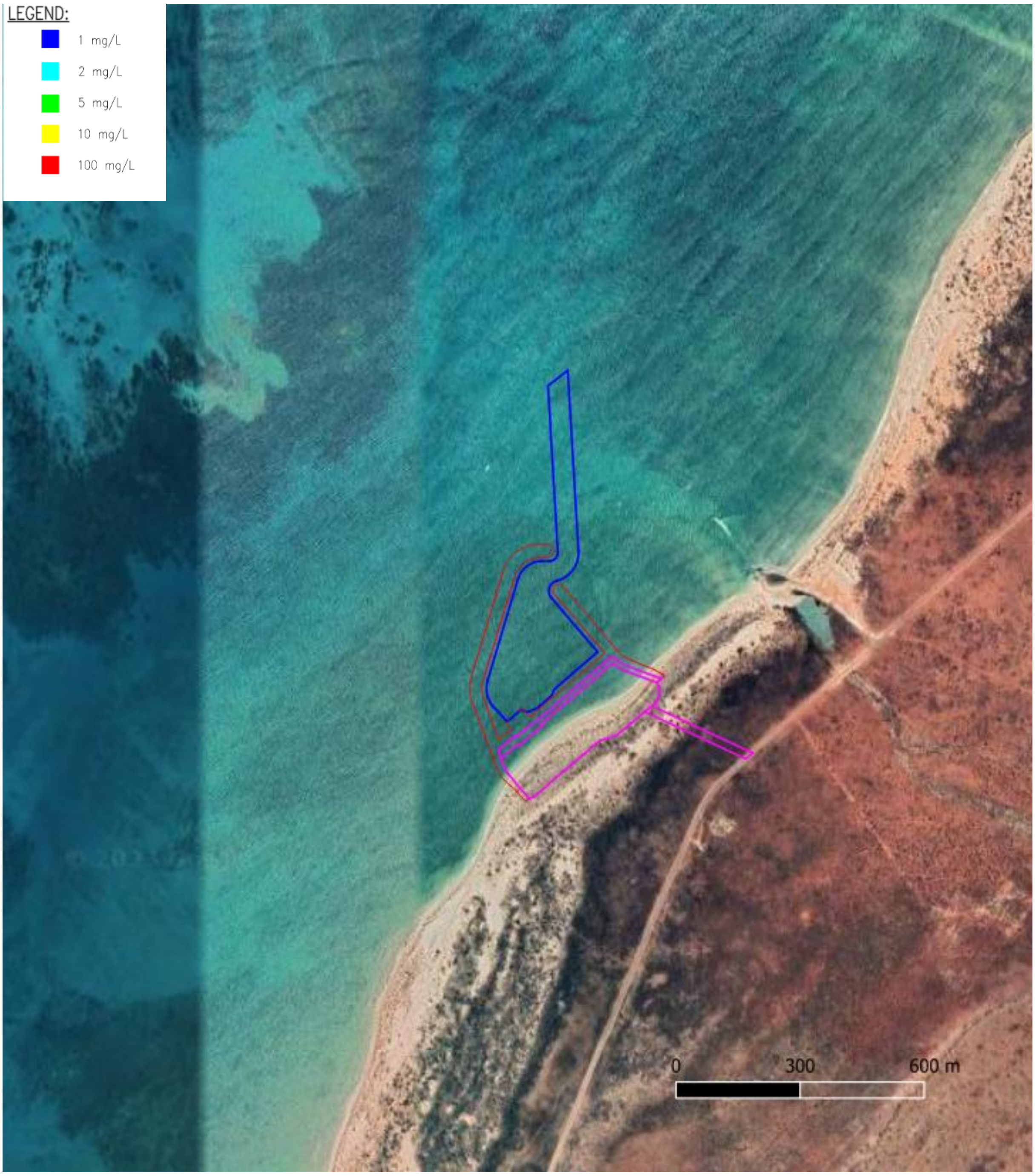
Run 5 - 95% Exceedance



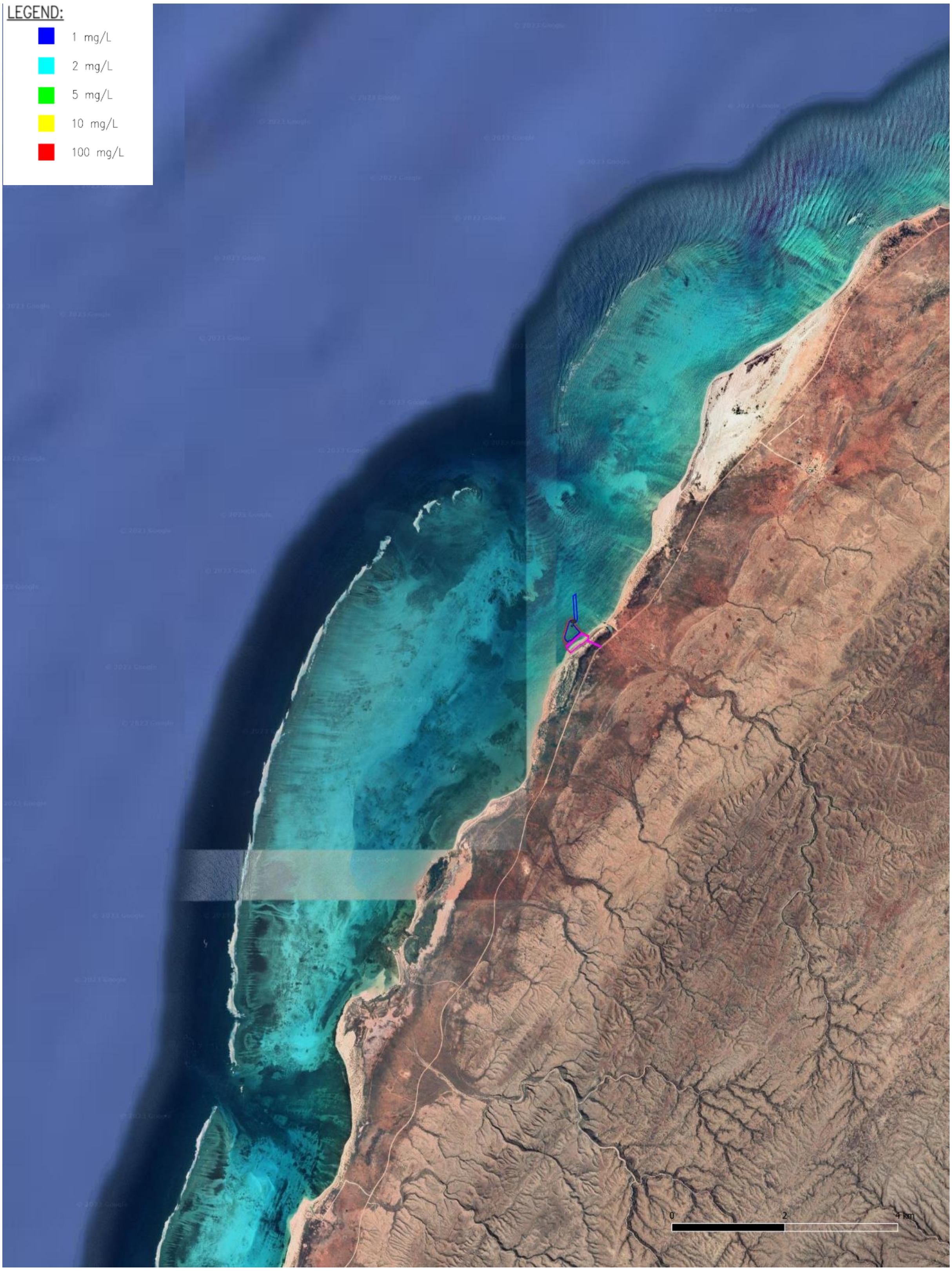
Run 5 - 95% Exceedance Zoomed In



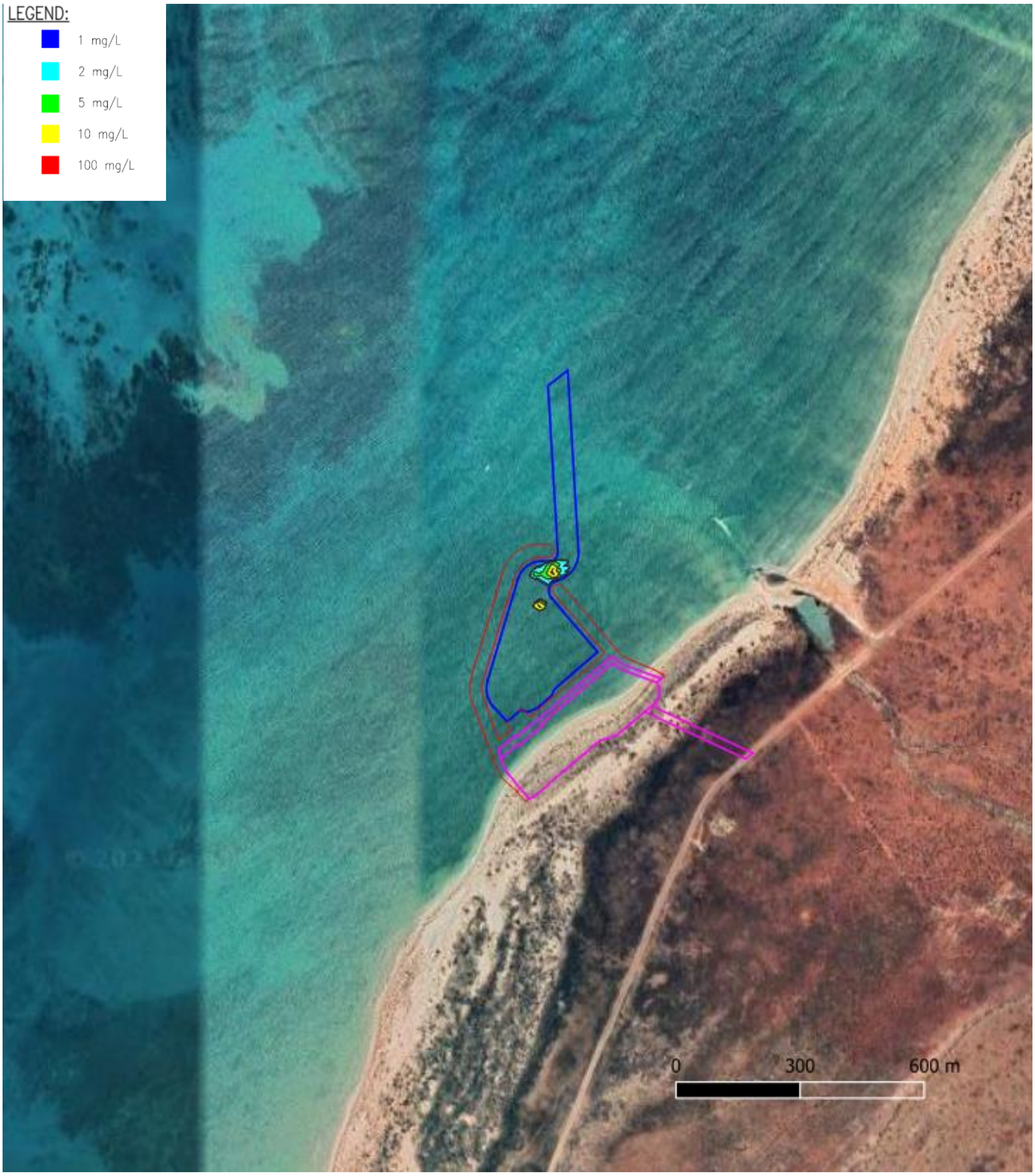
Run 6 - 50% Exceedance



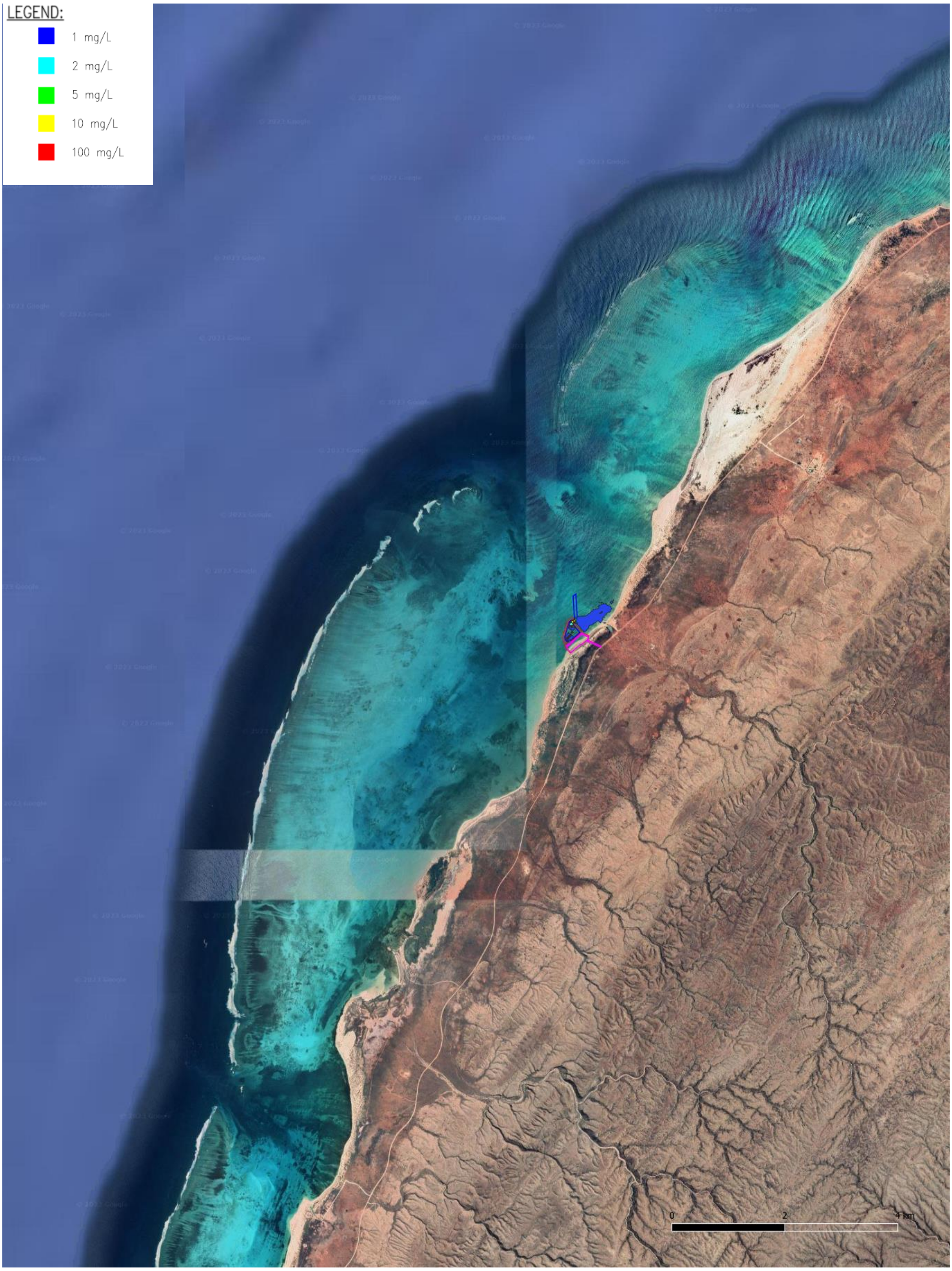
Run 6 - 50% Exceedance Zoomed In



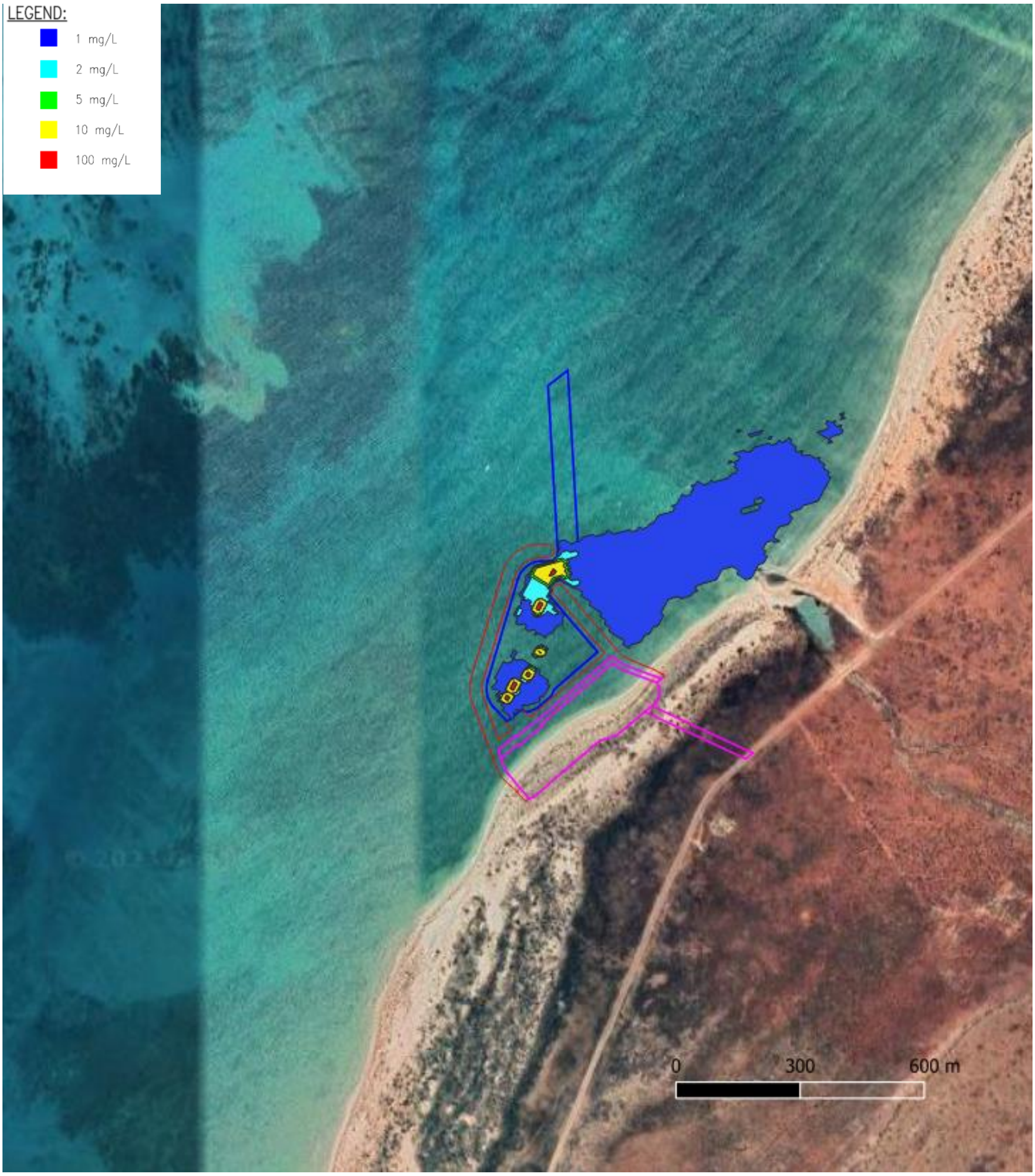
Run 6 -80% Exceedance



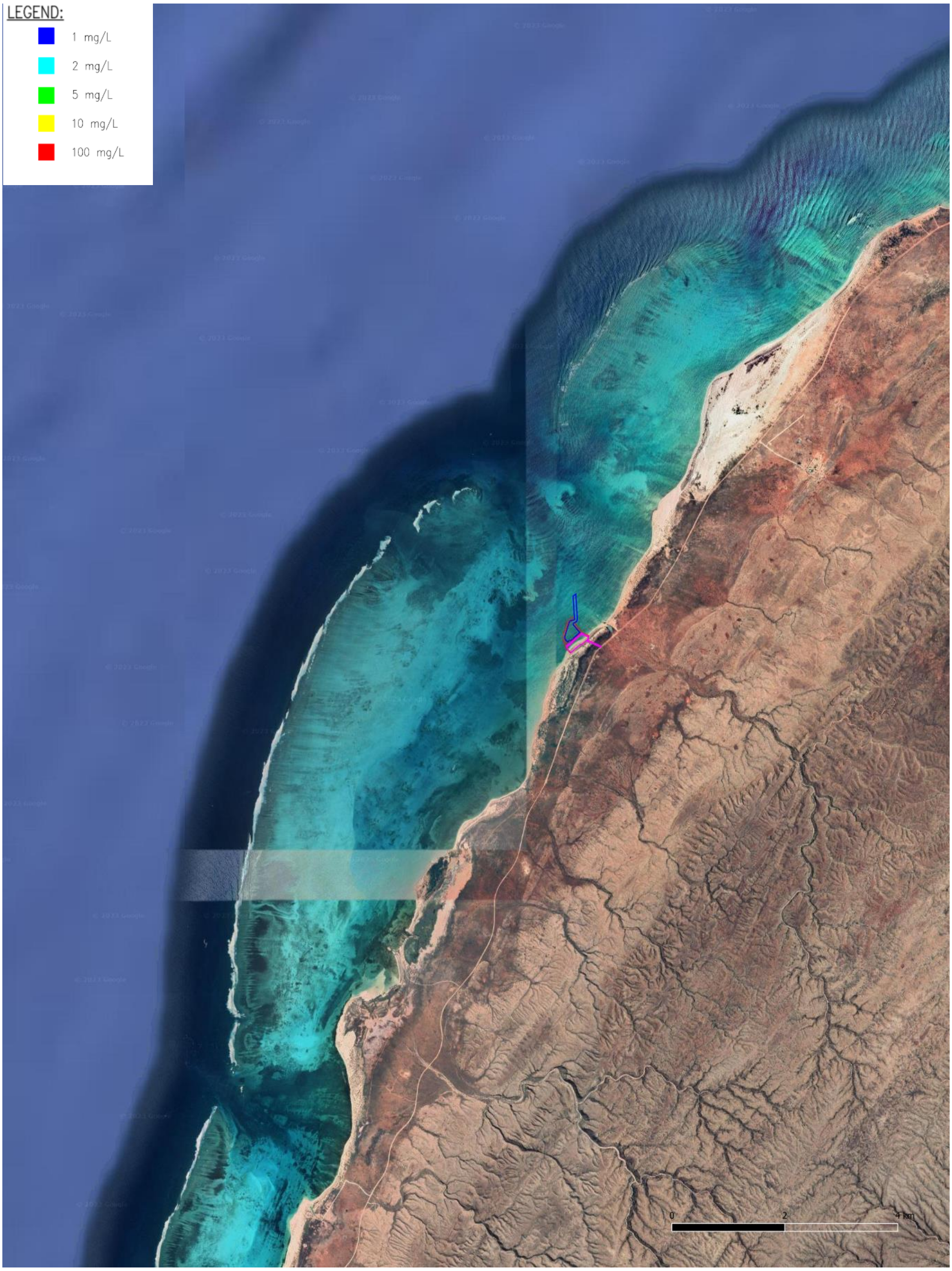
Run 6 - 80% Exceedance Zoomed In



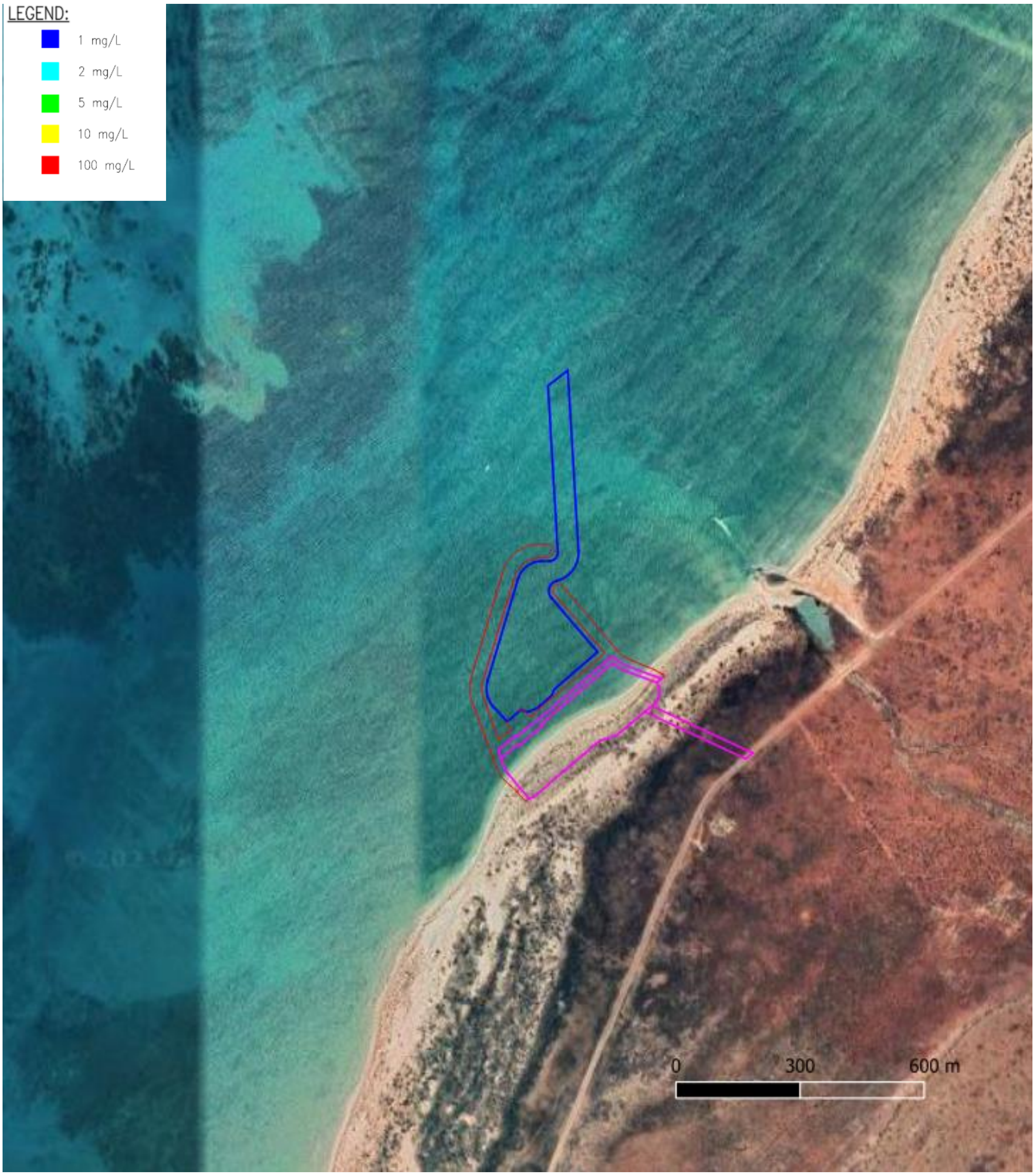
Run 6 - 95% Exceedance



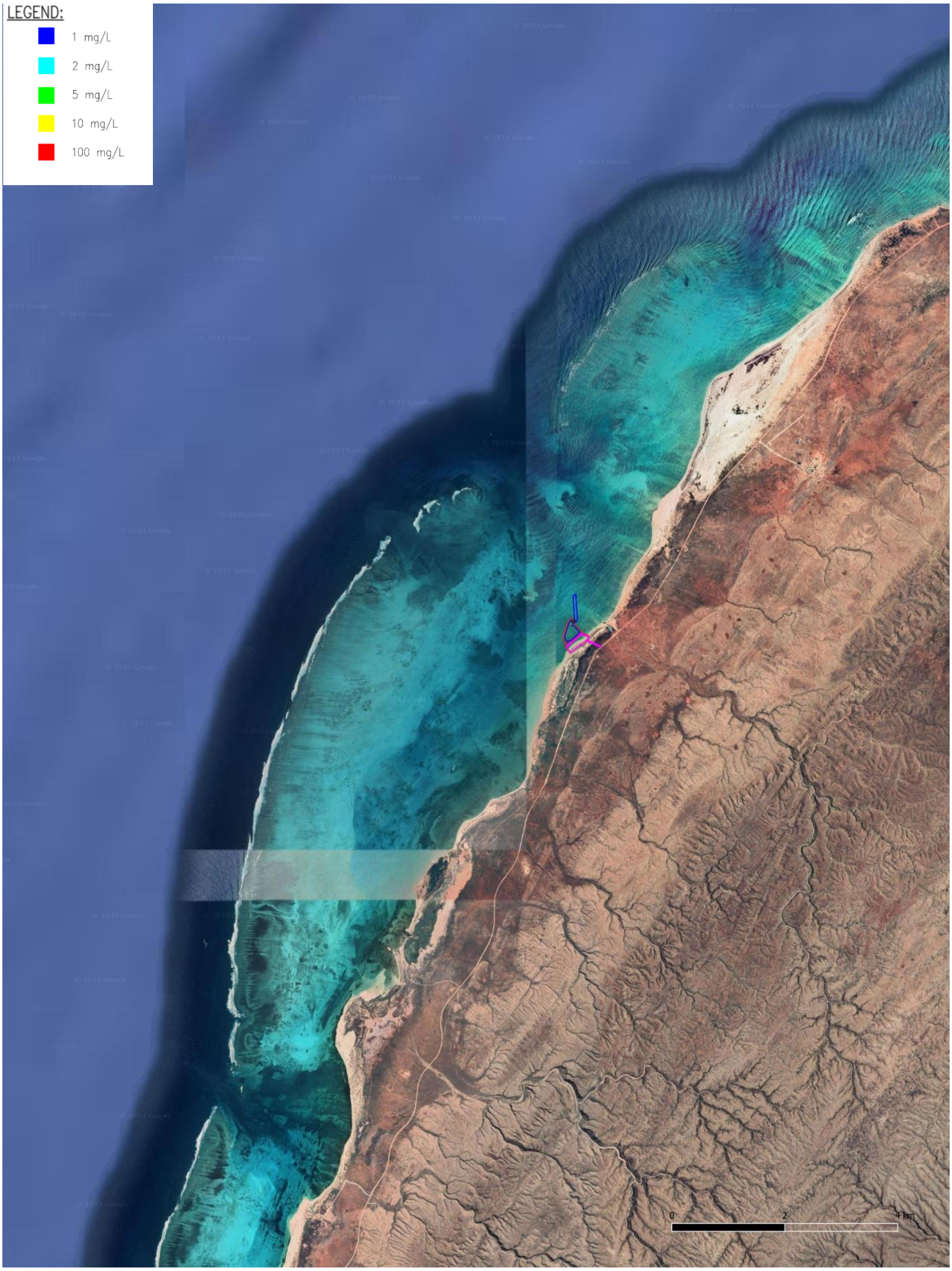
Run 6 - 95% Exceedance Zoomed In



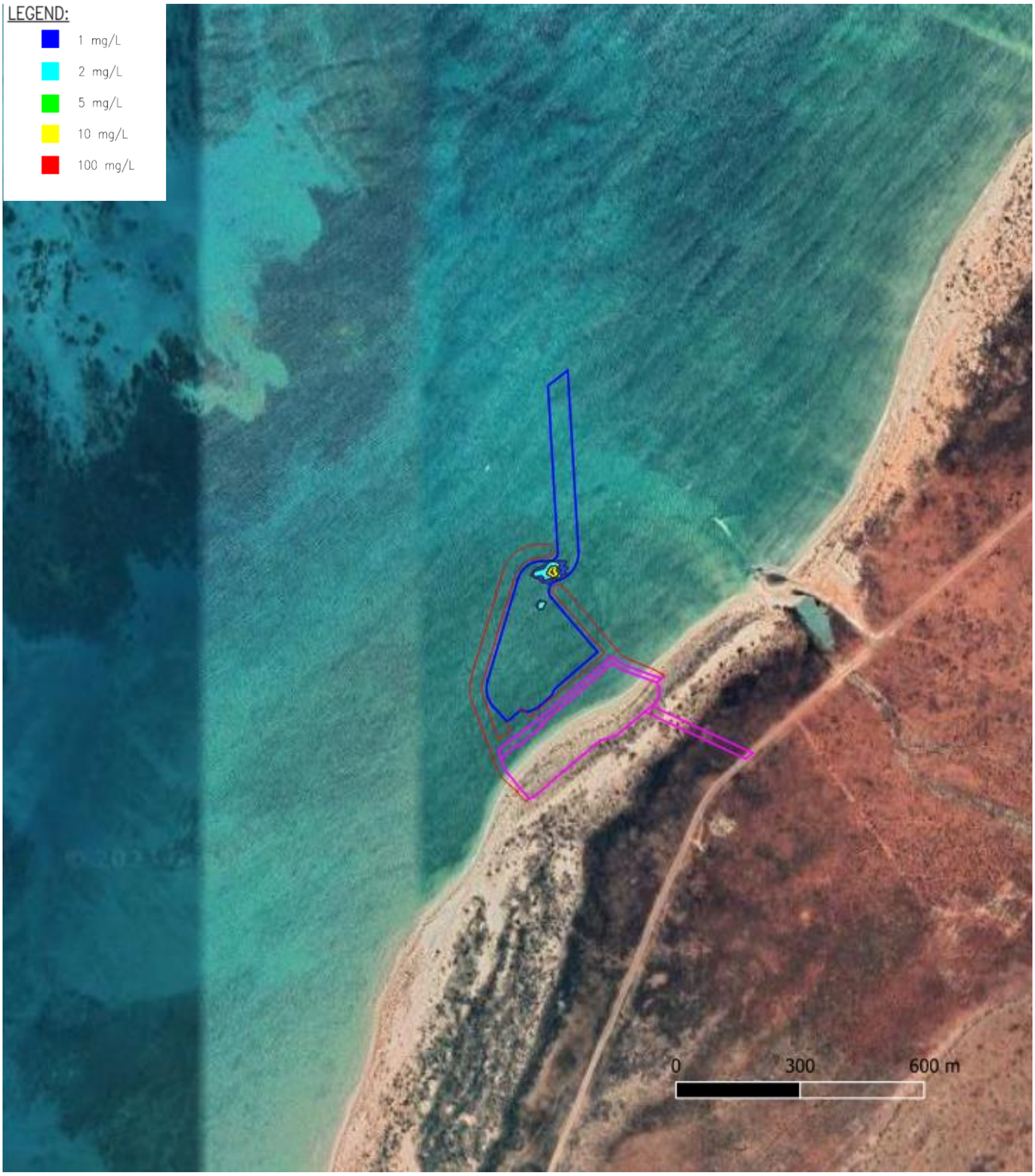
Run 7 - 50% Exceedance



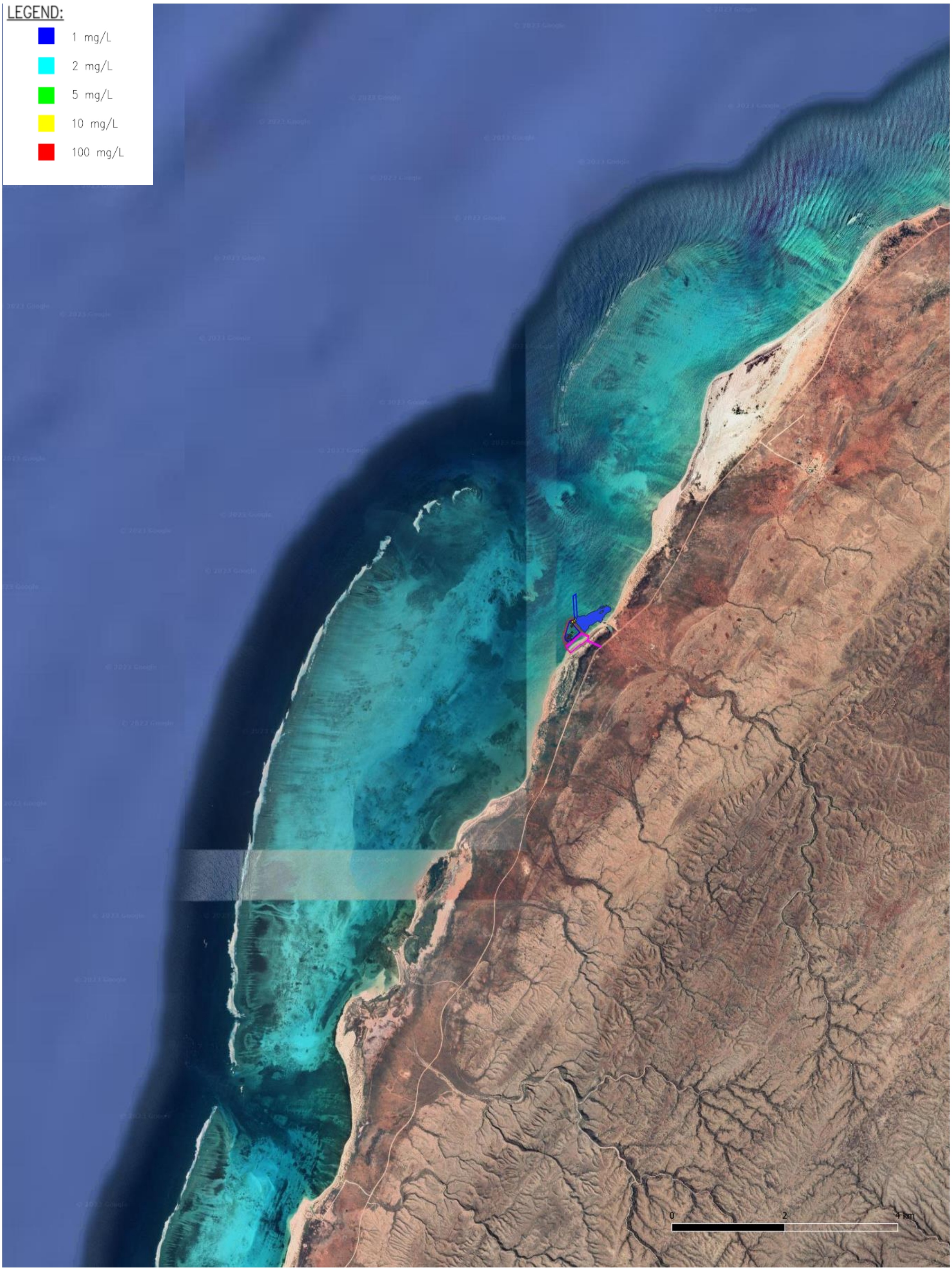
Run 7 - 50% Exceedance Zoomed In



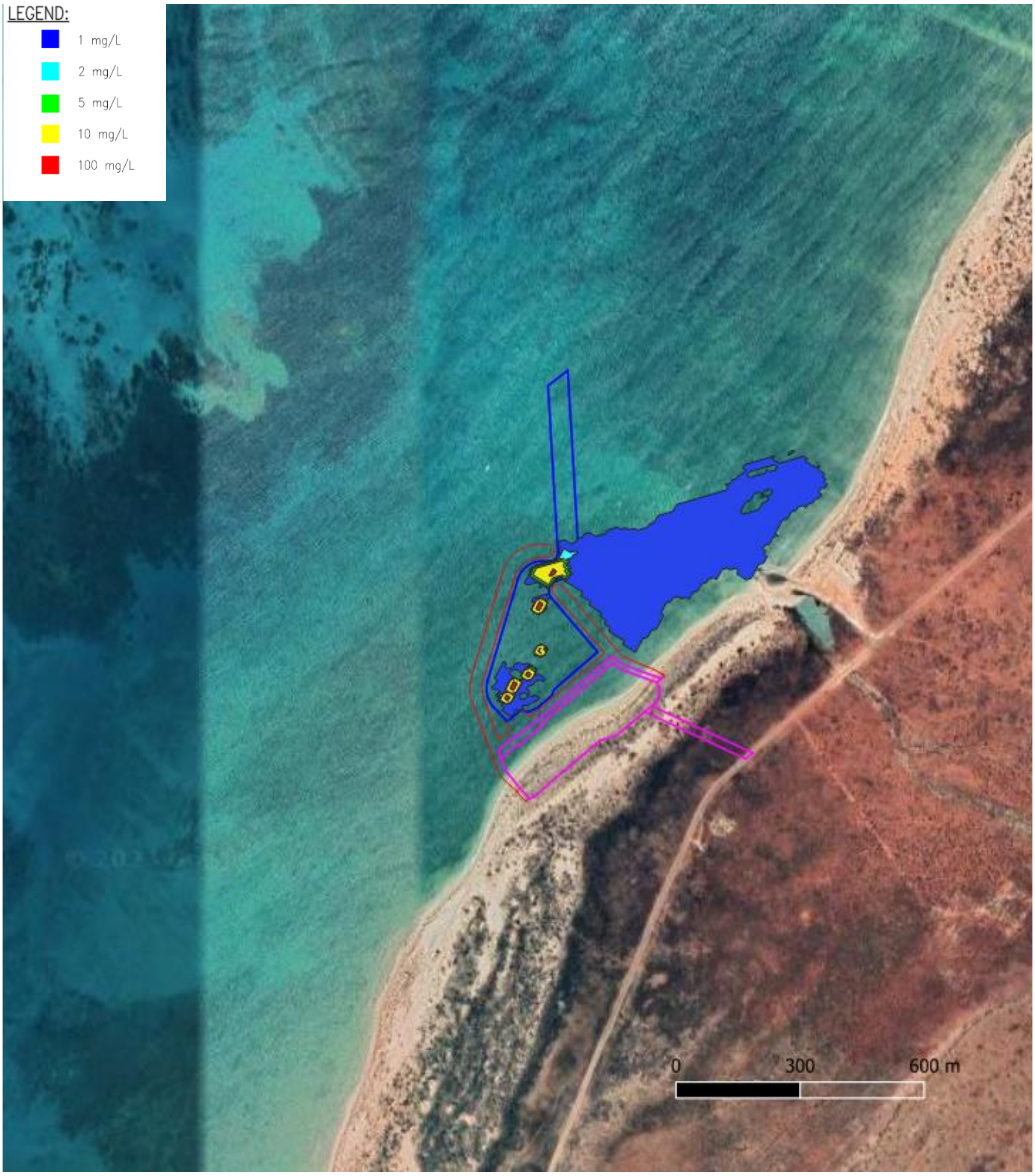
Run 7 - 80% Exceedance



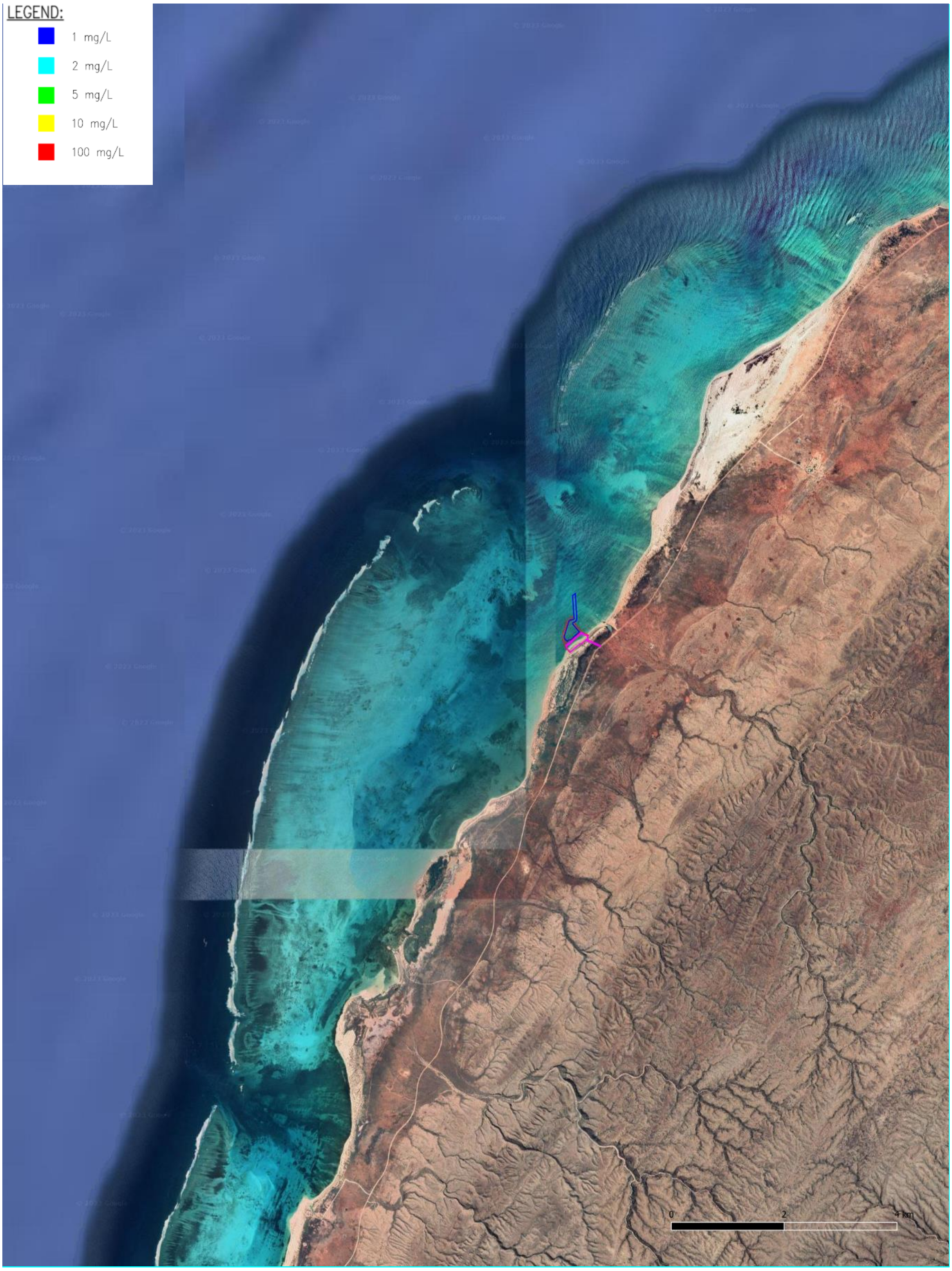
Run 7 - 80% Exceedance Zoomed In



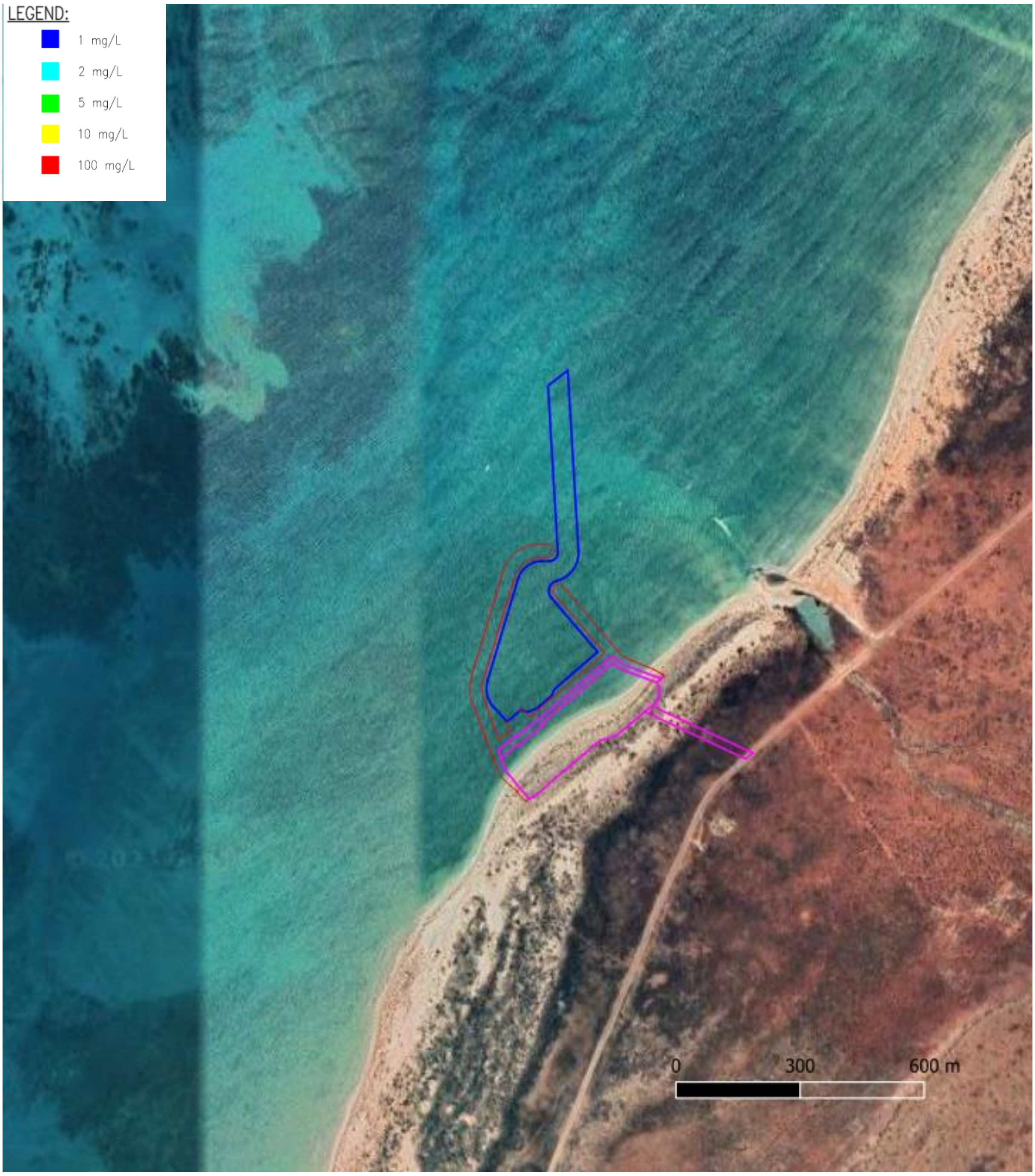
Run 7 - 95% Exceedance



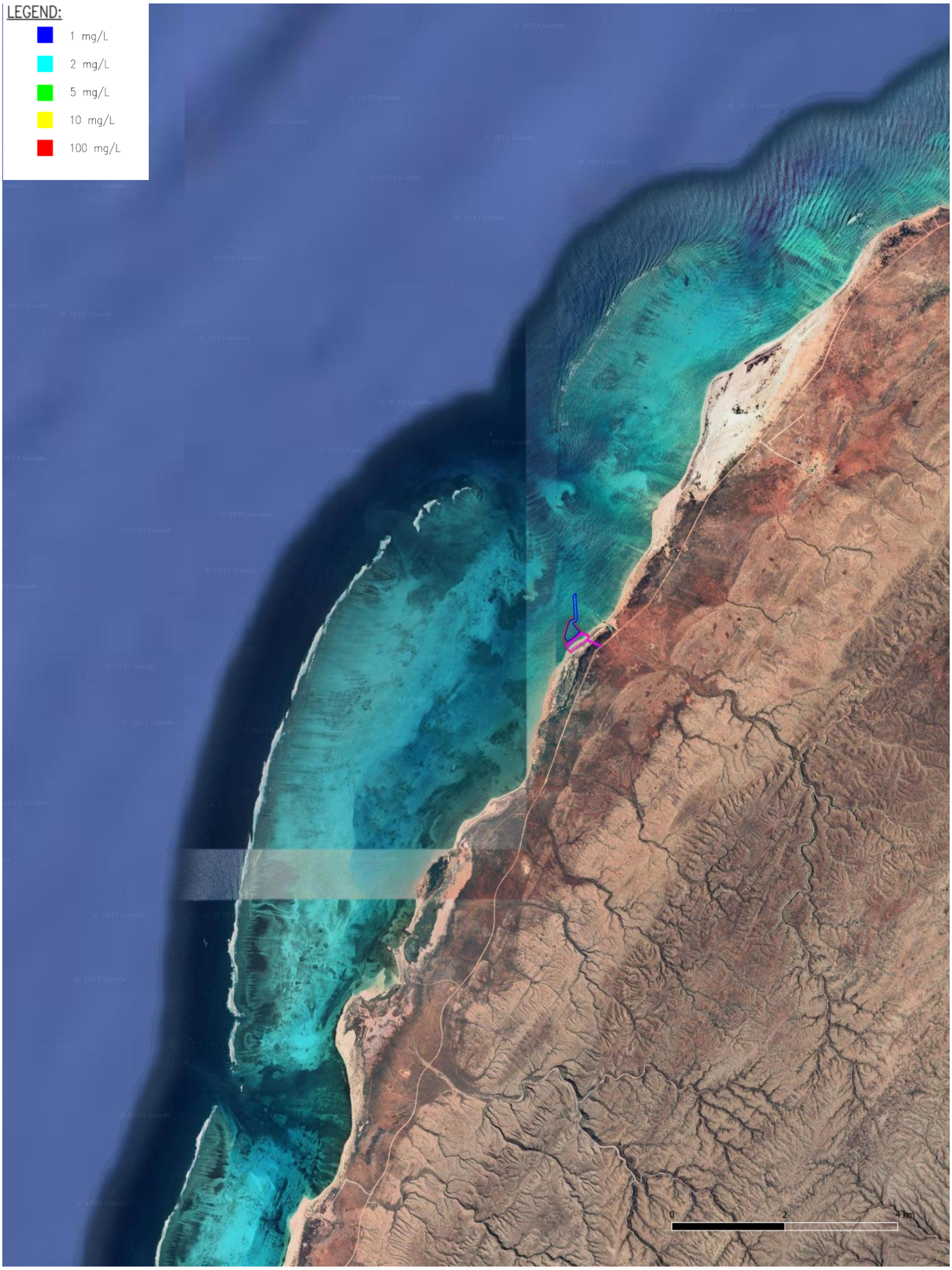
Run 7 - 95% Exceedance Zoomed In



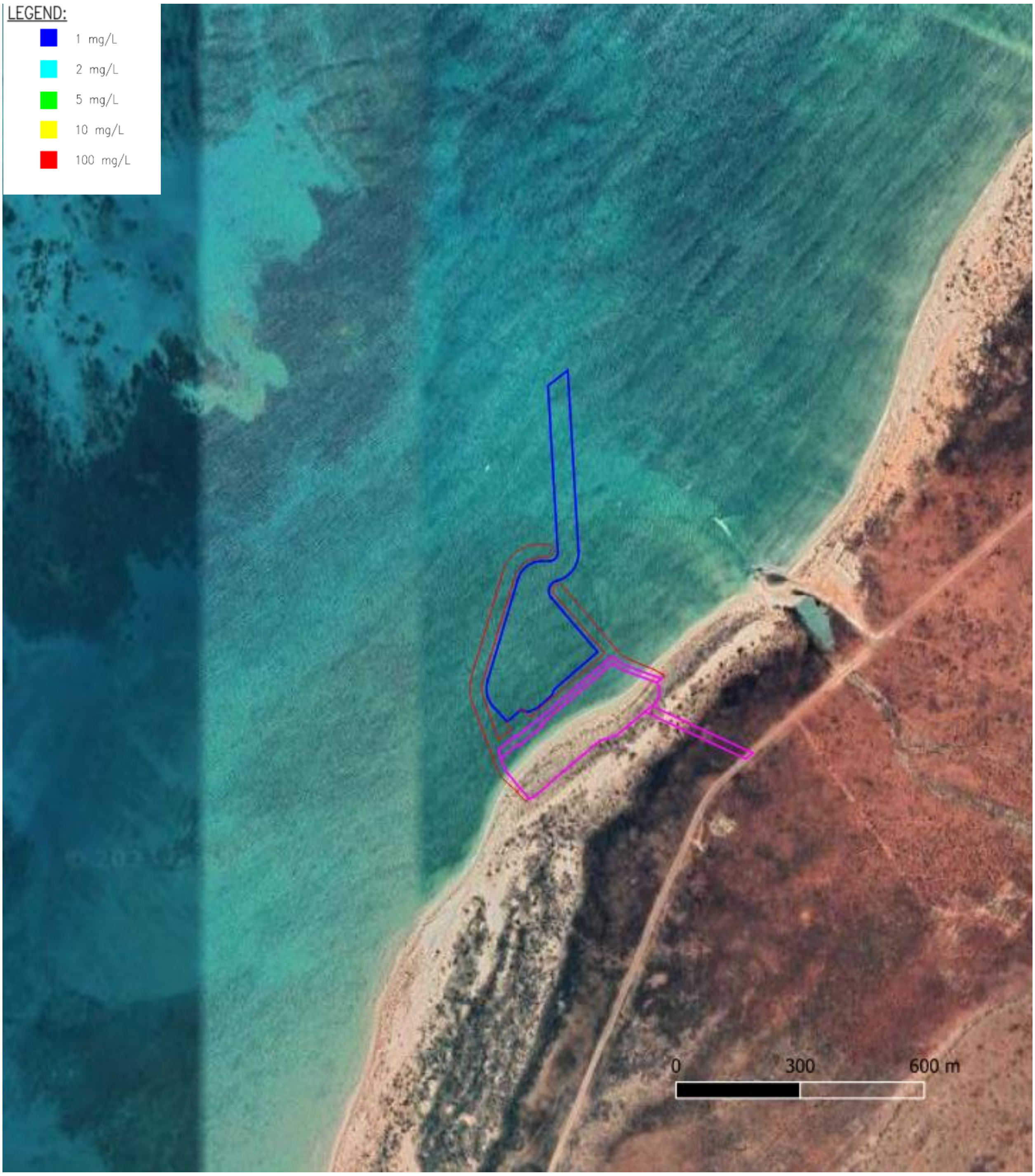
Run 8 - 50% Exceedance



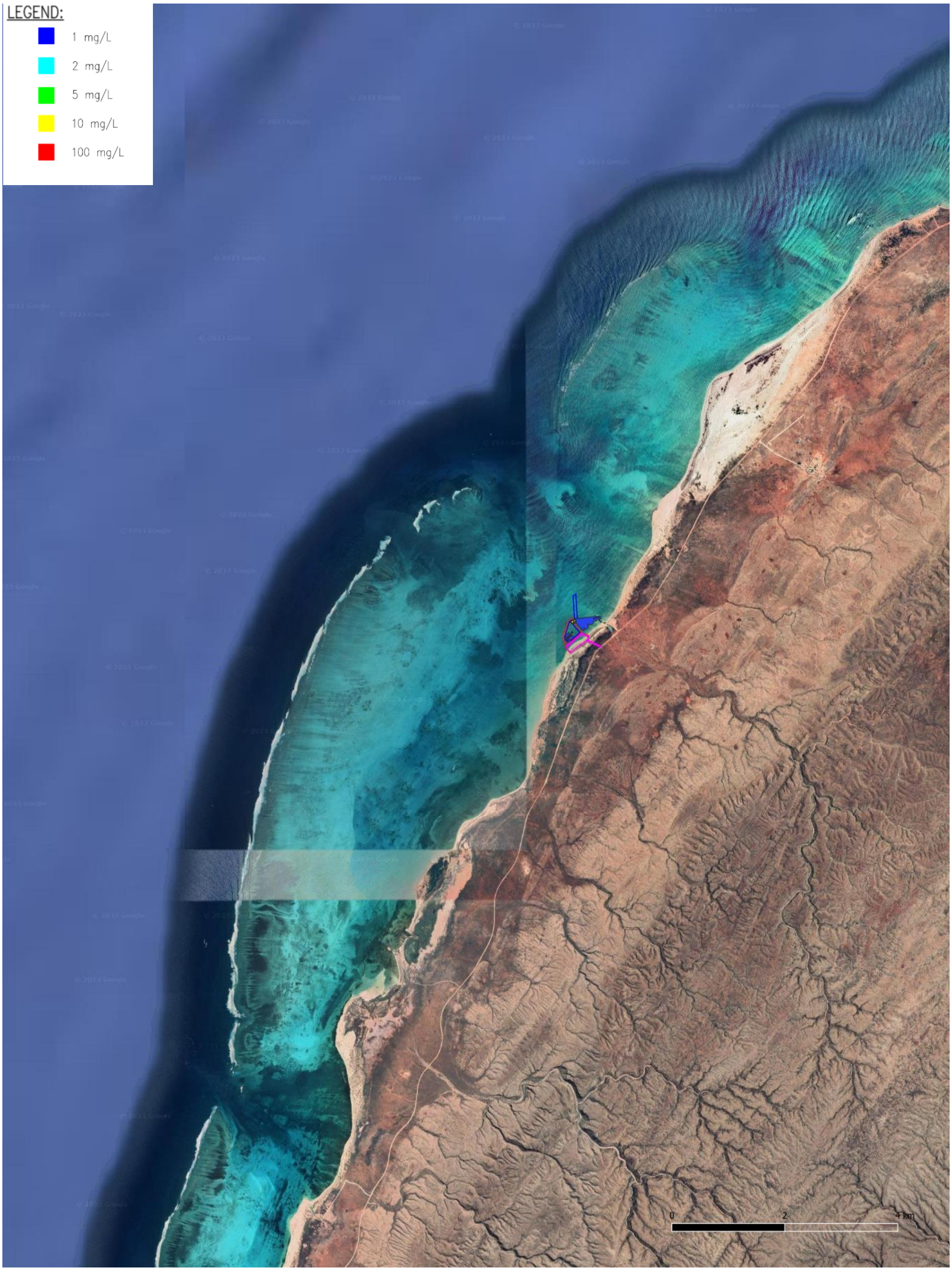
Run 8 - 50% Exceedance Zoomed In



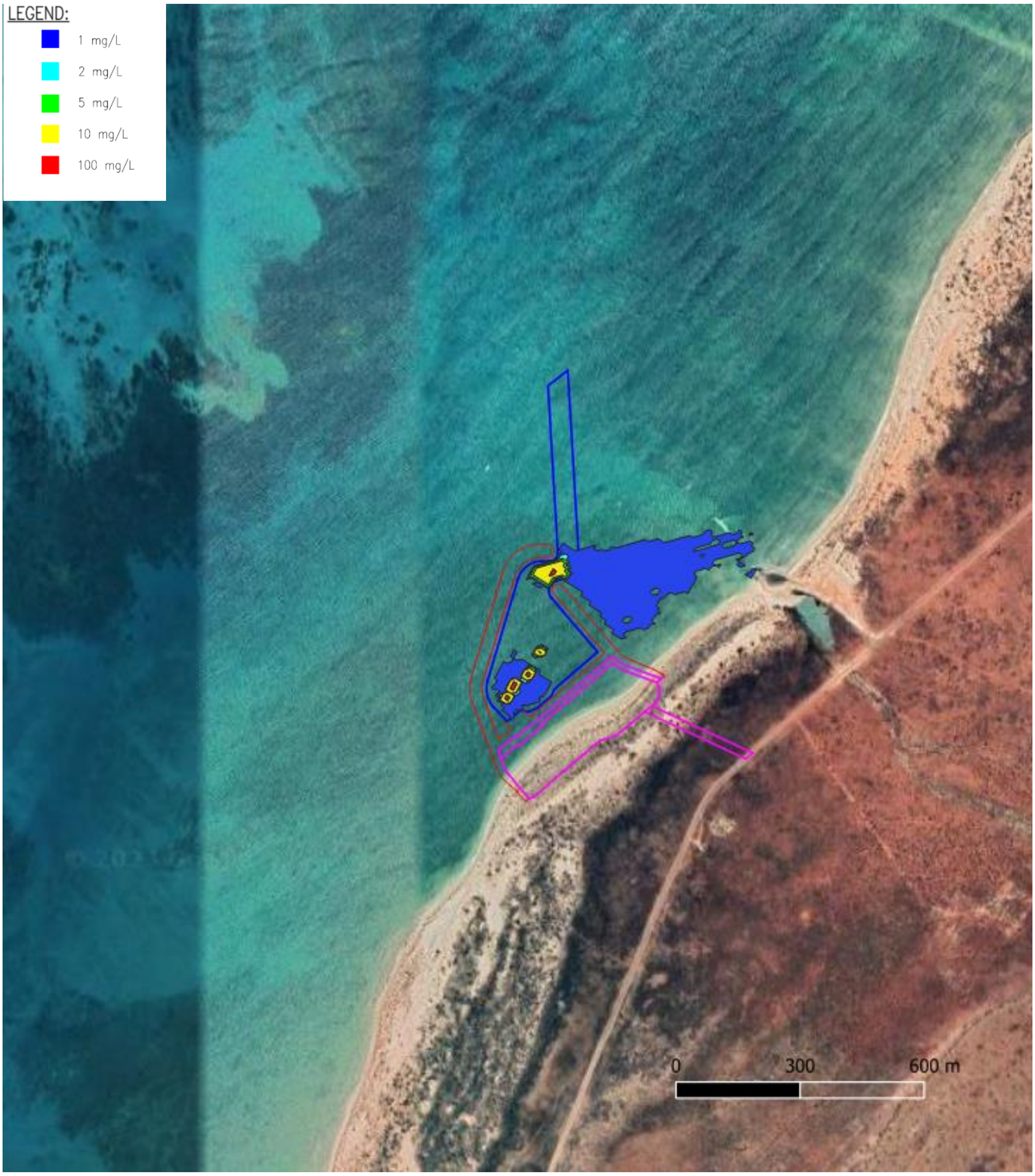
Run 8 - 80% Exceedance



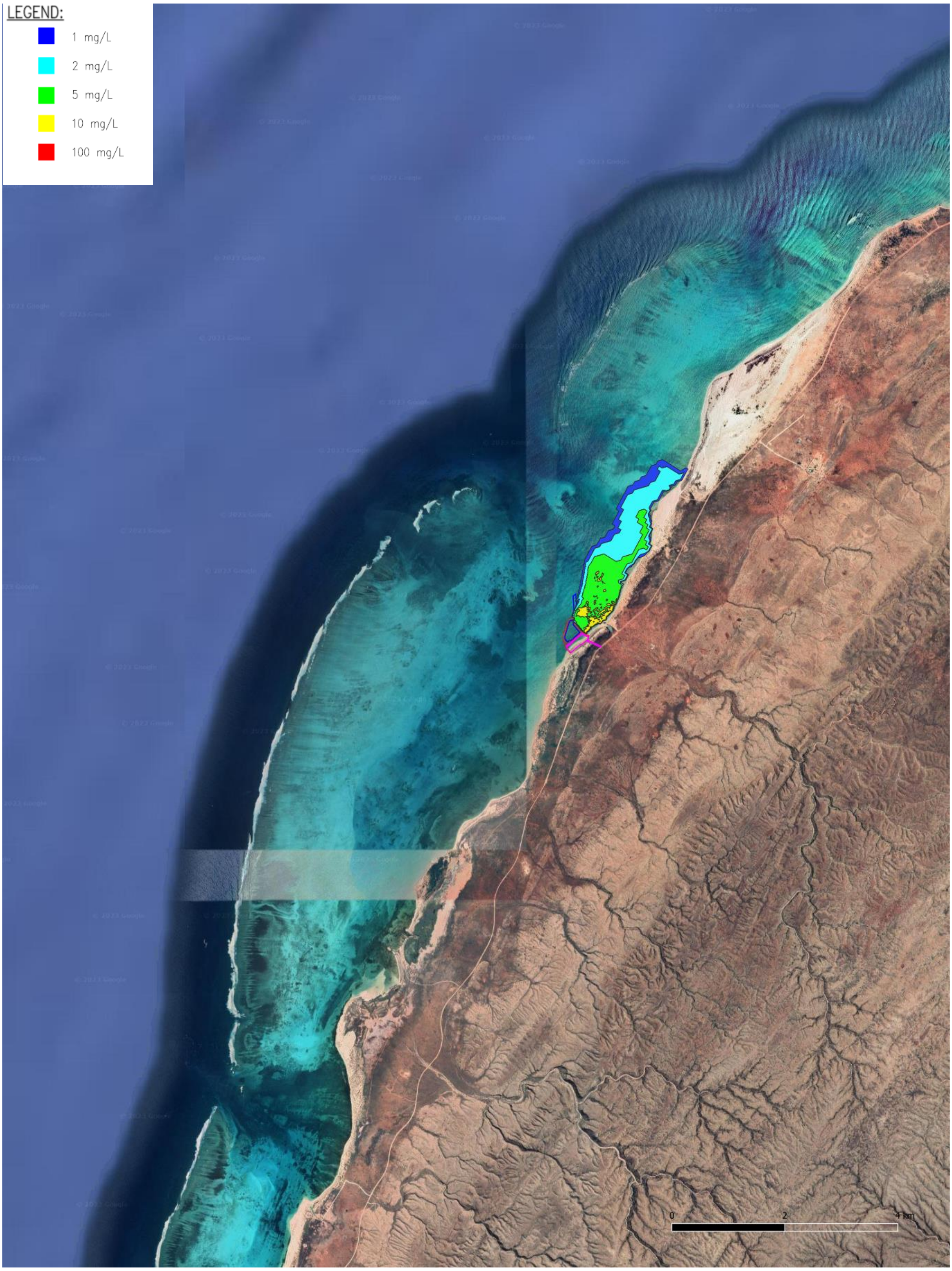
Run 8 - 80% Exceedance Zoomed In



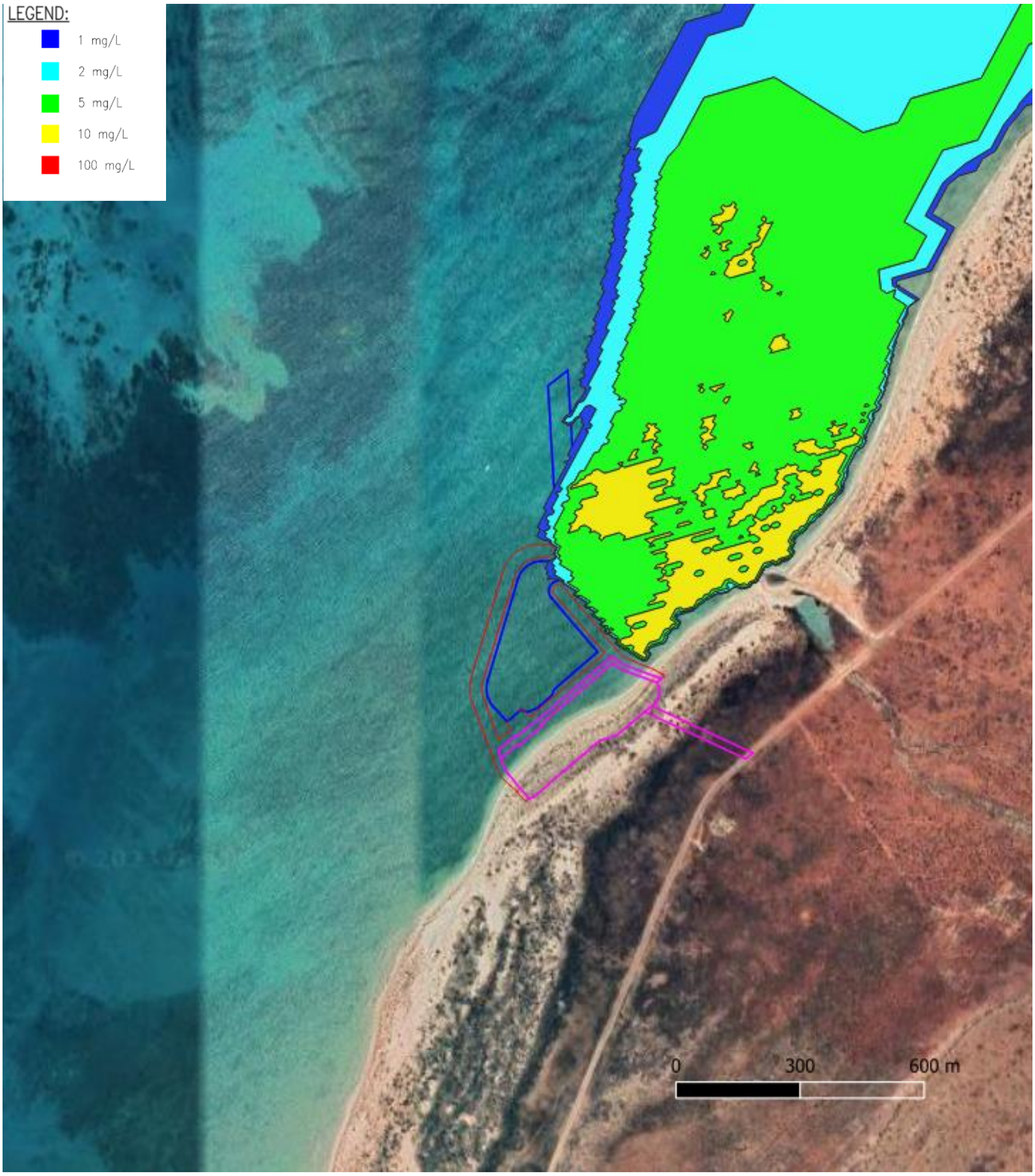
Run 8 - 95% Exceedance



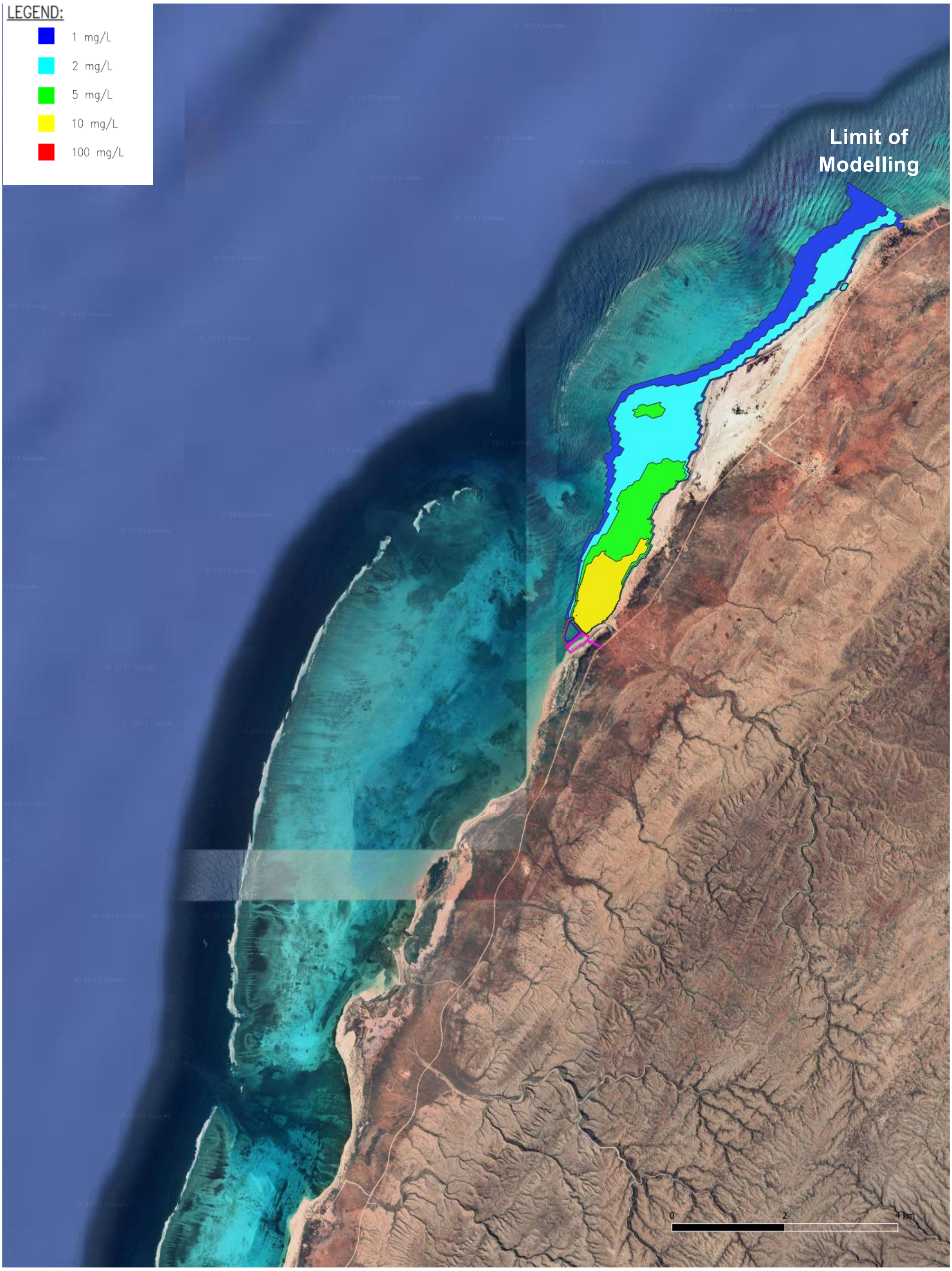
Run 8 - 95% Exceedance Zoomed In



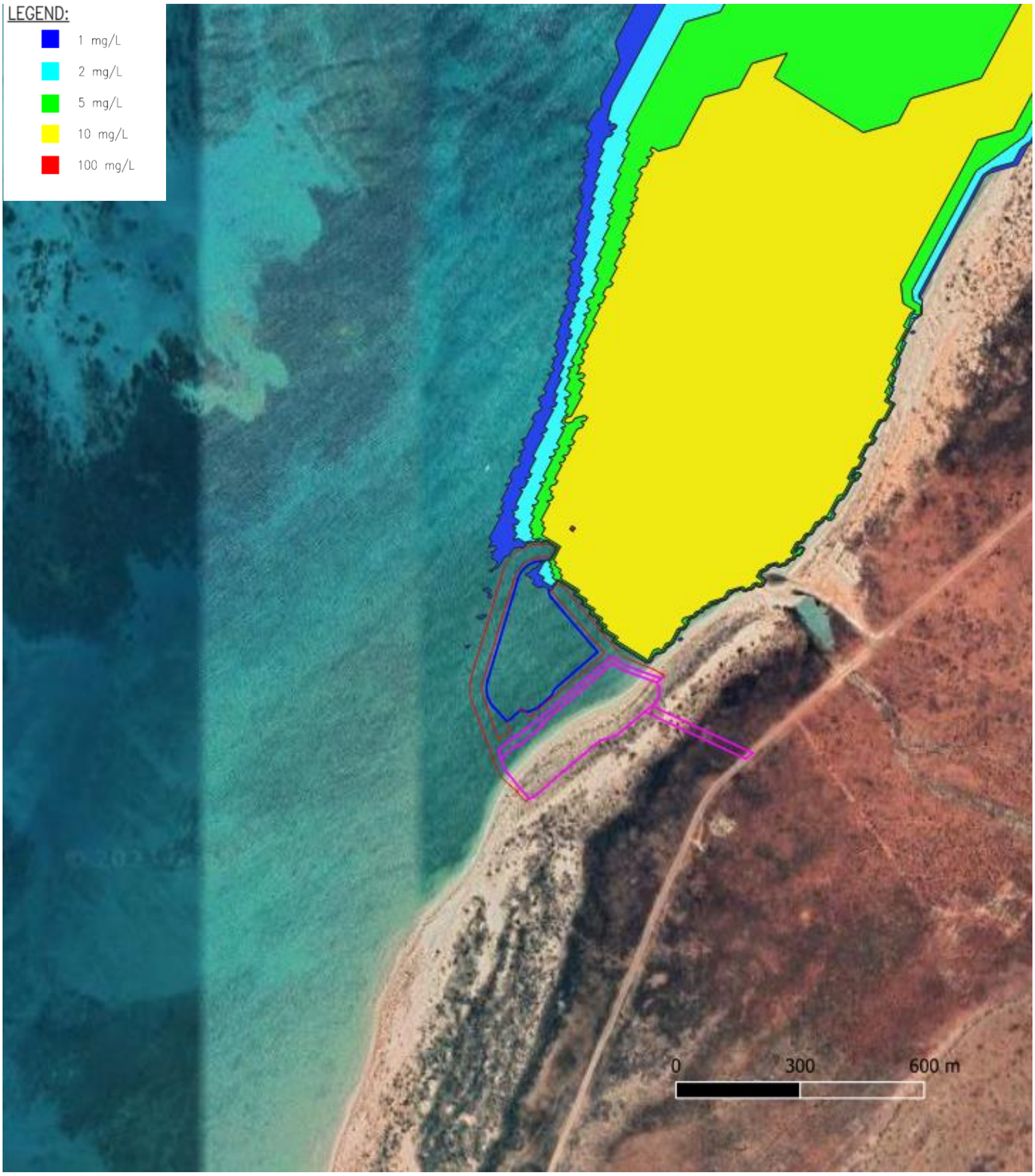
Run 9 - 50% Exceedance



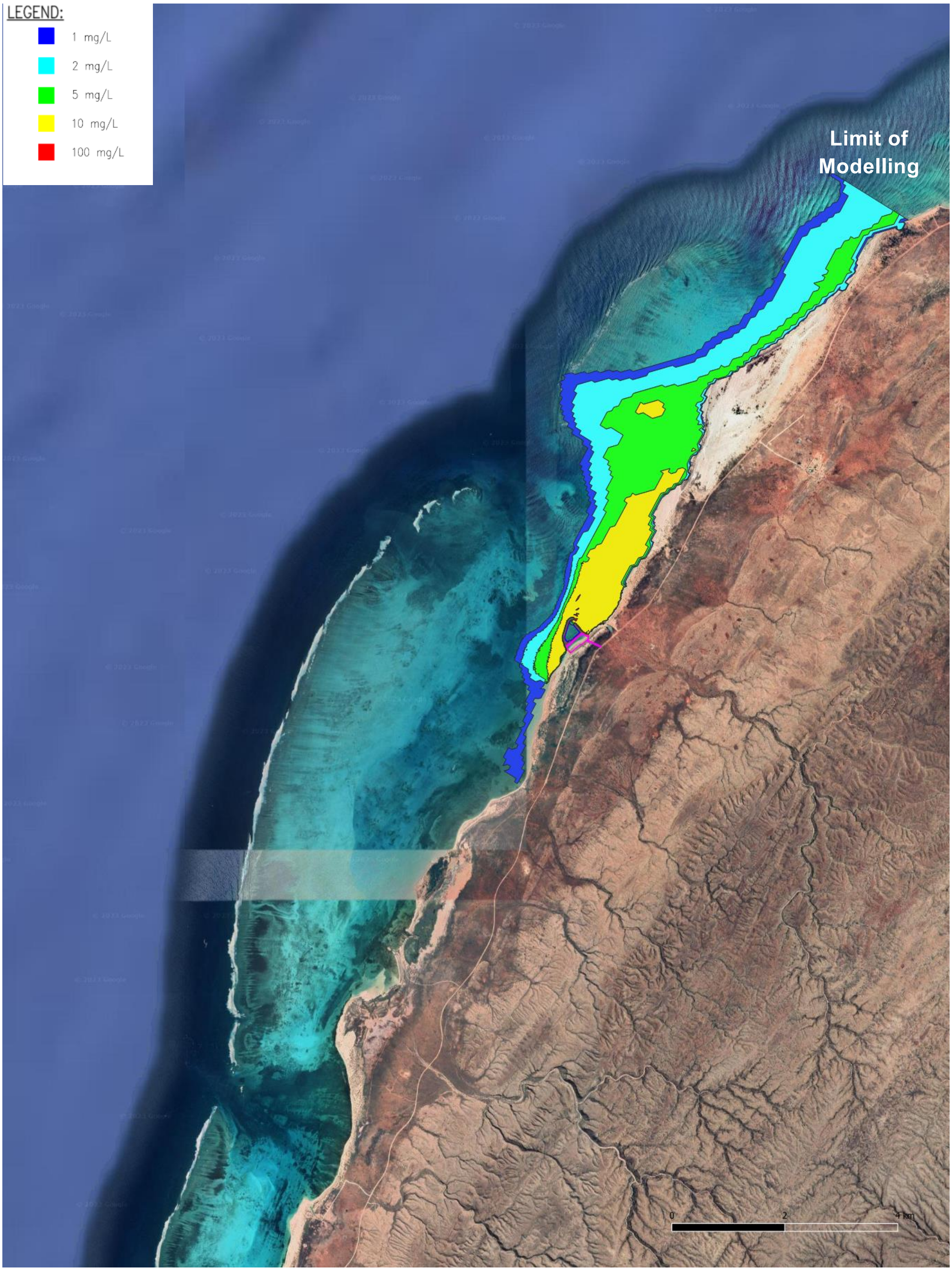
Run 9 - 50% Exceedance Zoomed In



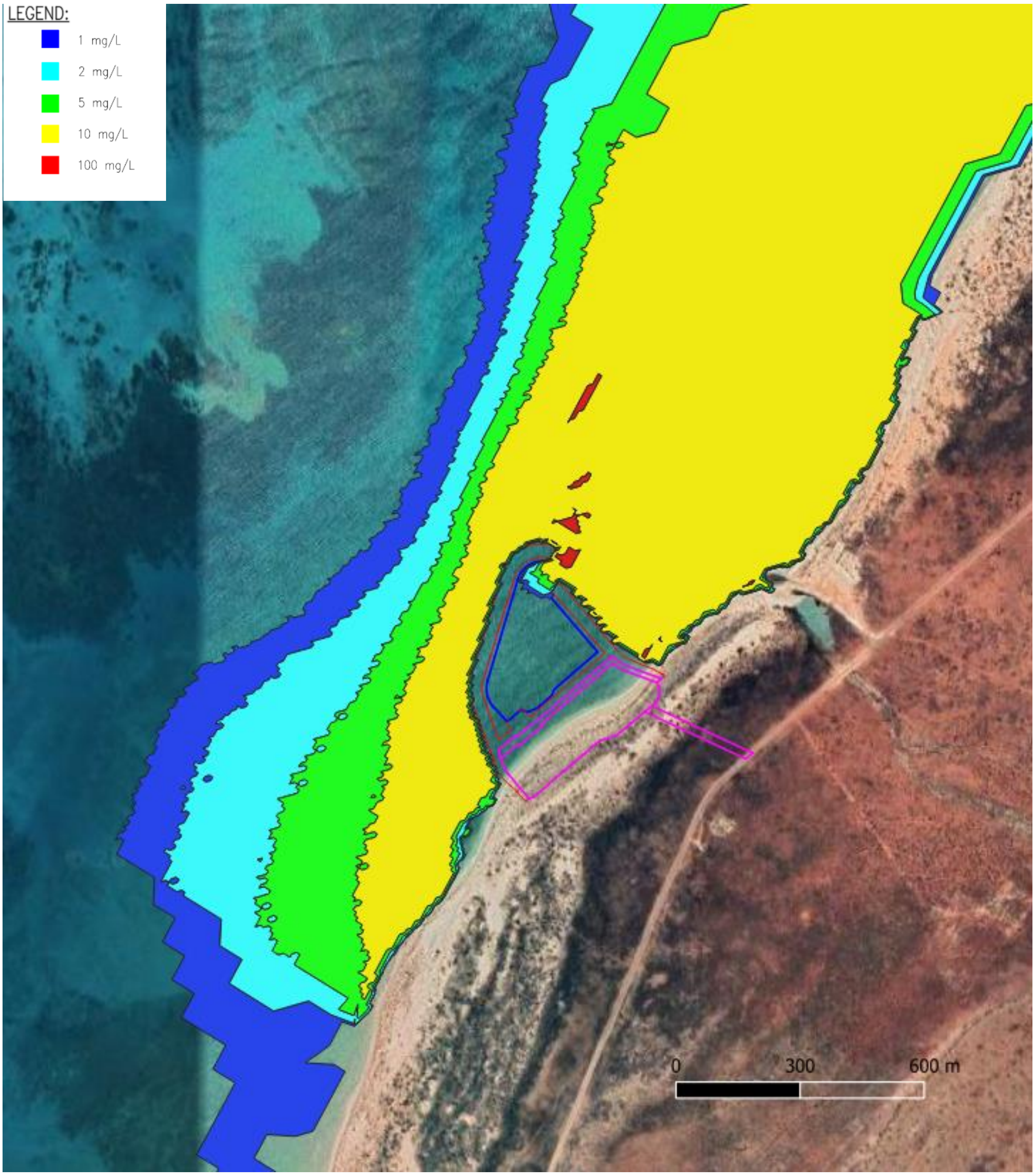
Run 9 - 80% Exceedance



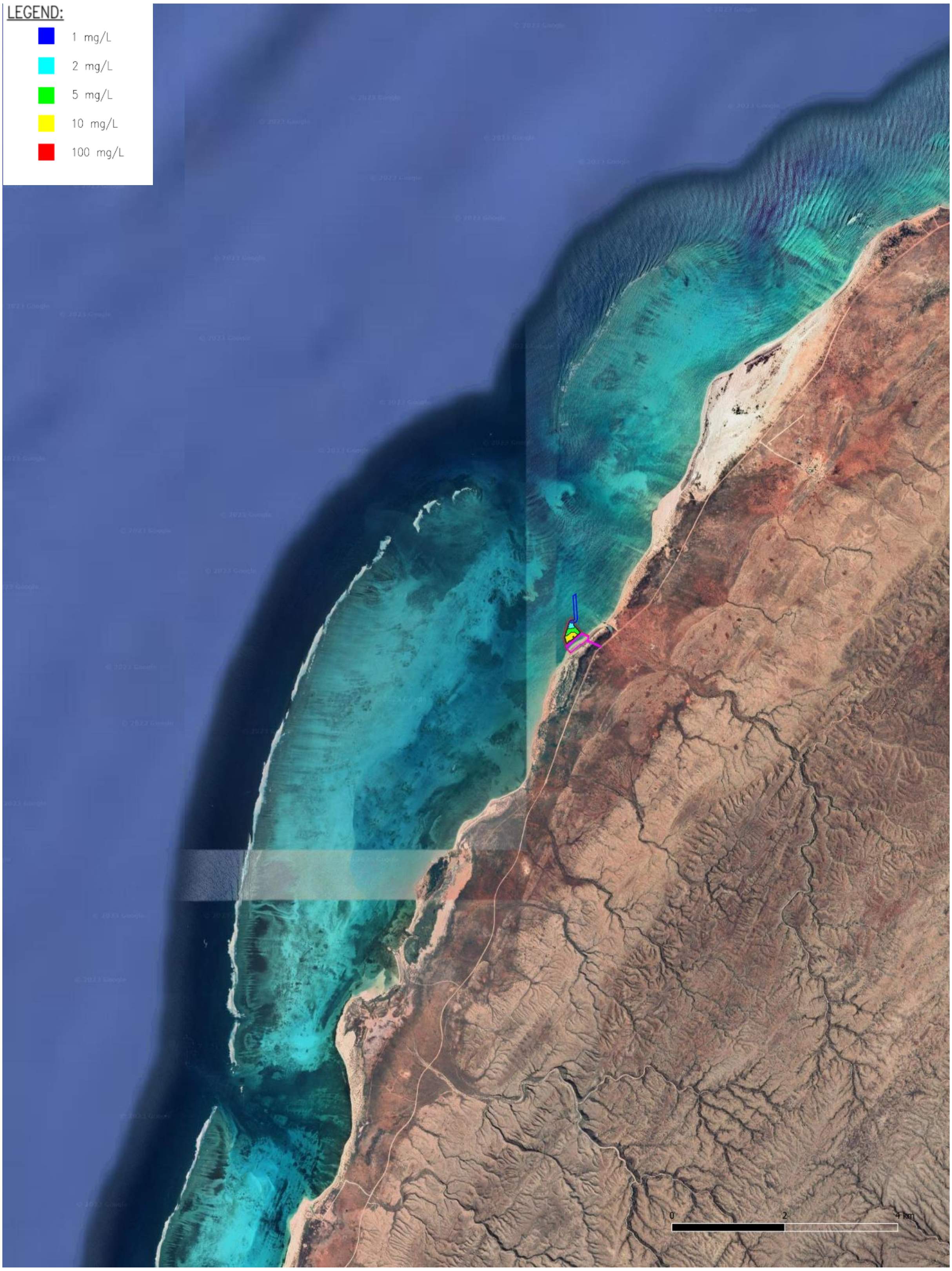
Run 9 - 80% Exceedance Zoomed In



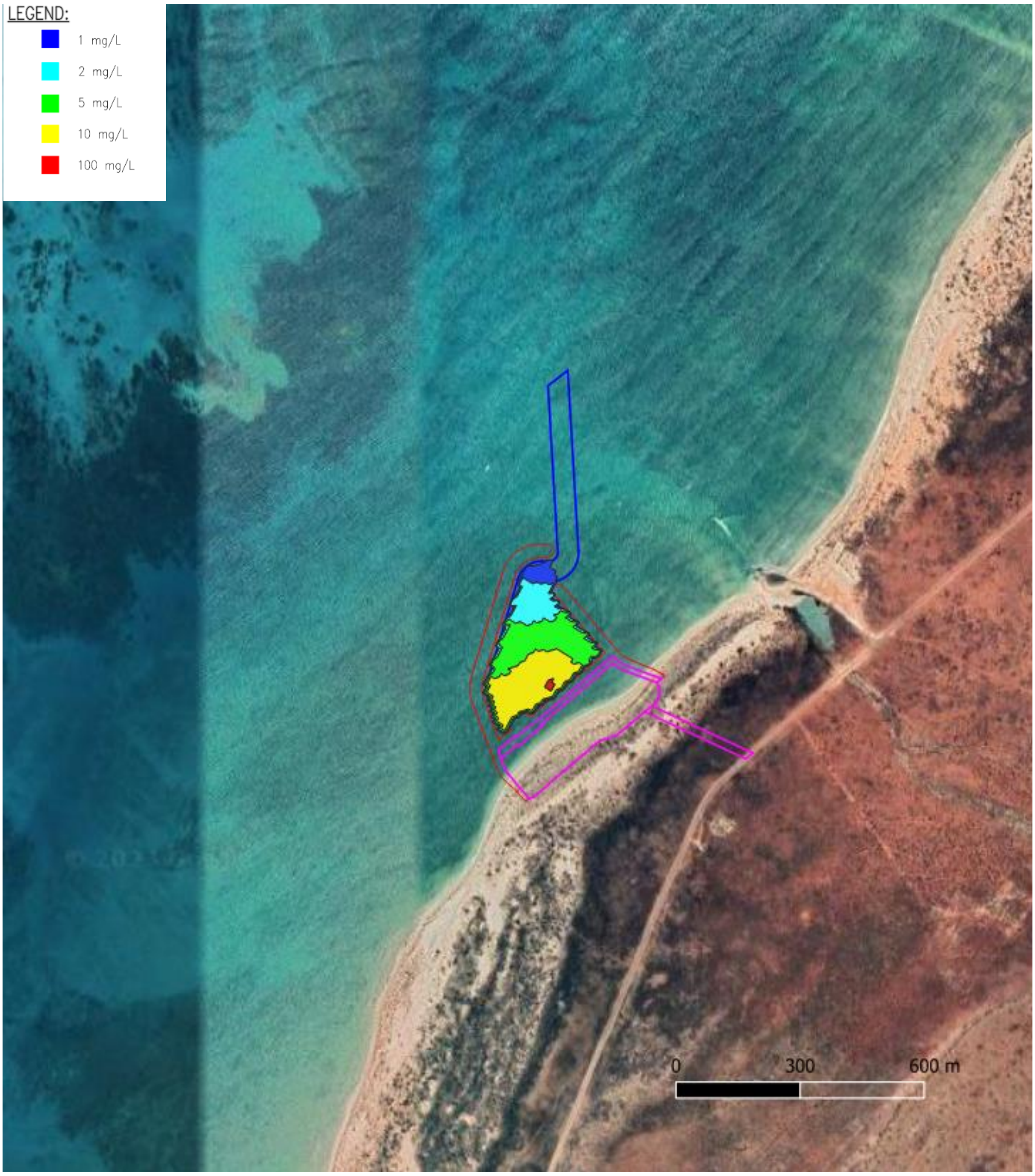
Run 9 - 95% Exceedance



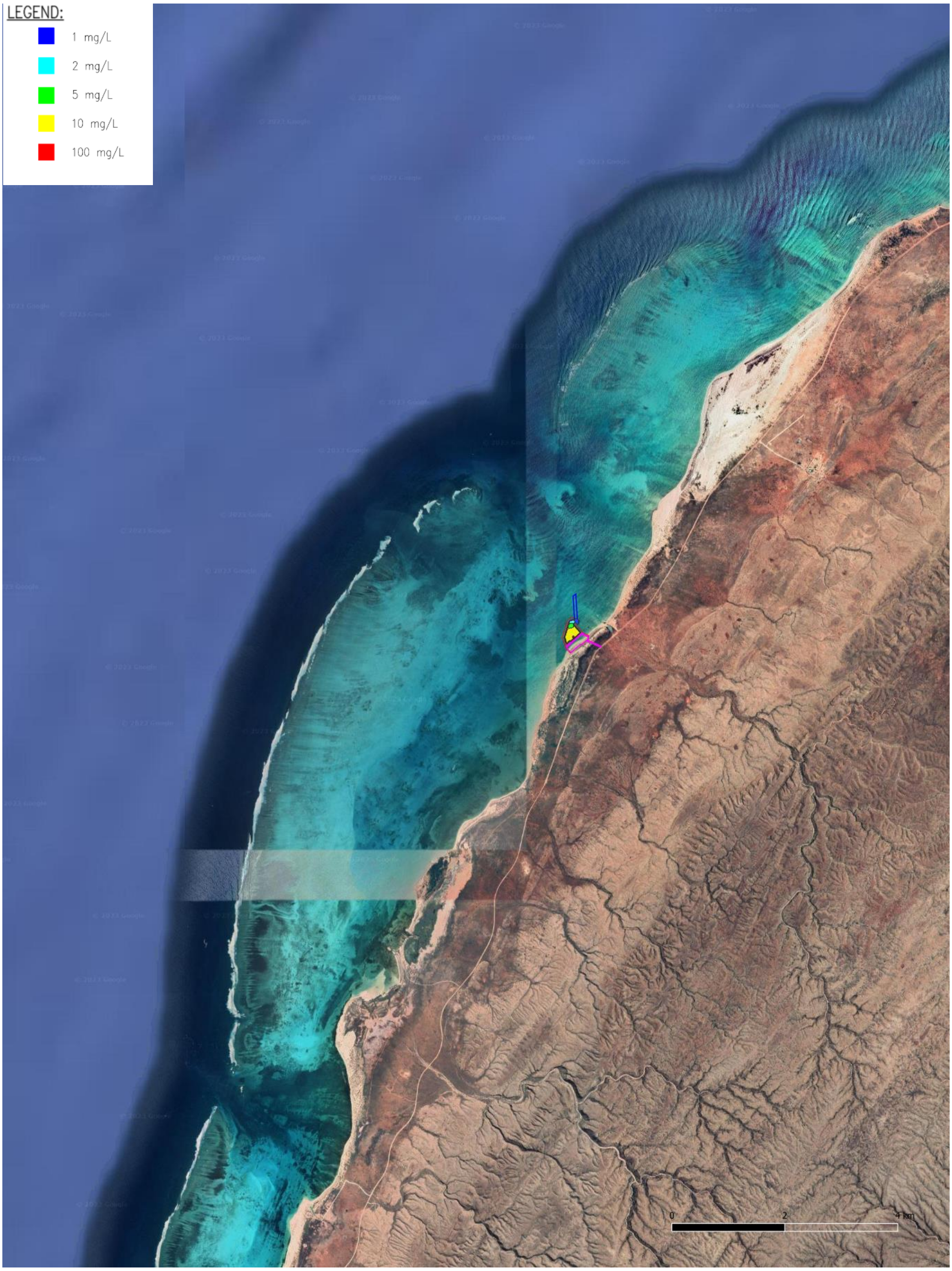
Run 9 -95% Exceedance Zoomed In



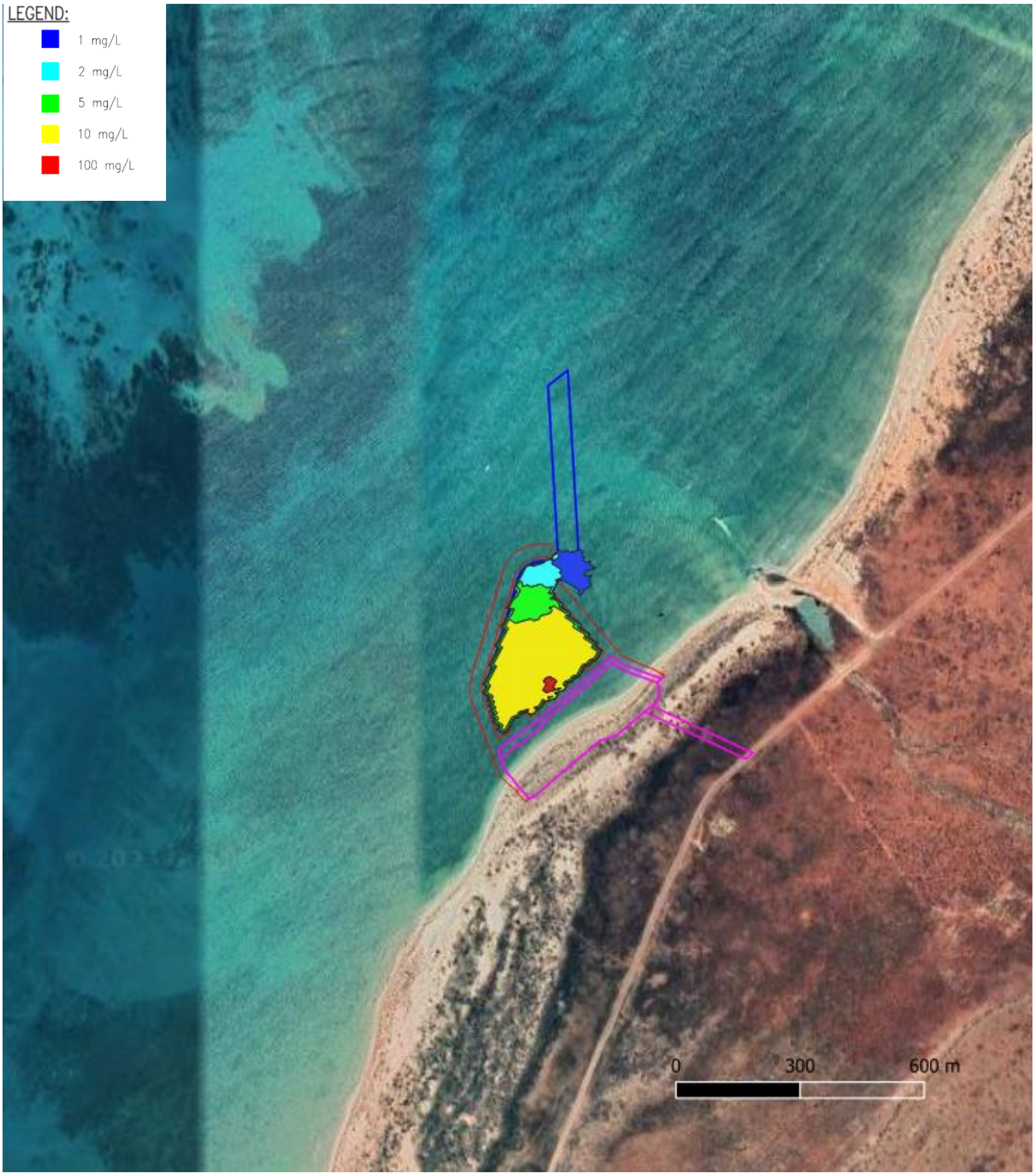
Run 9b - 50% Exceedance



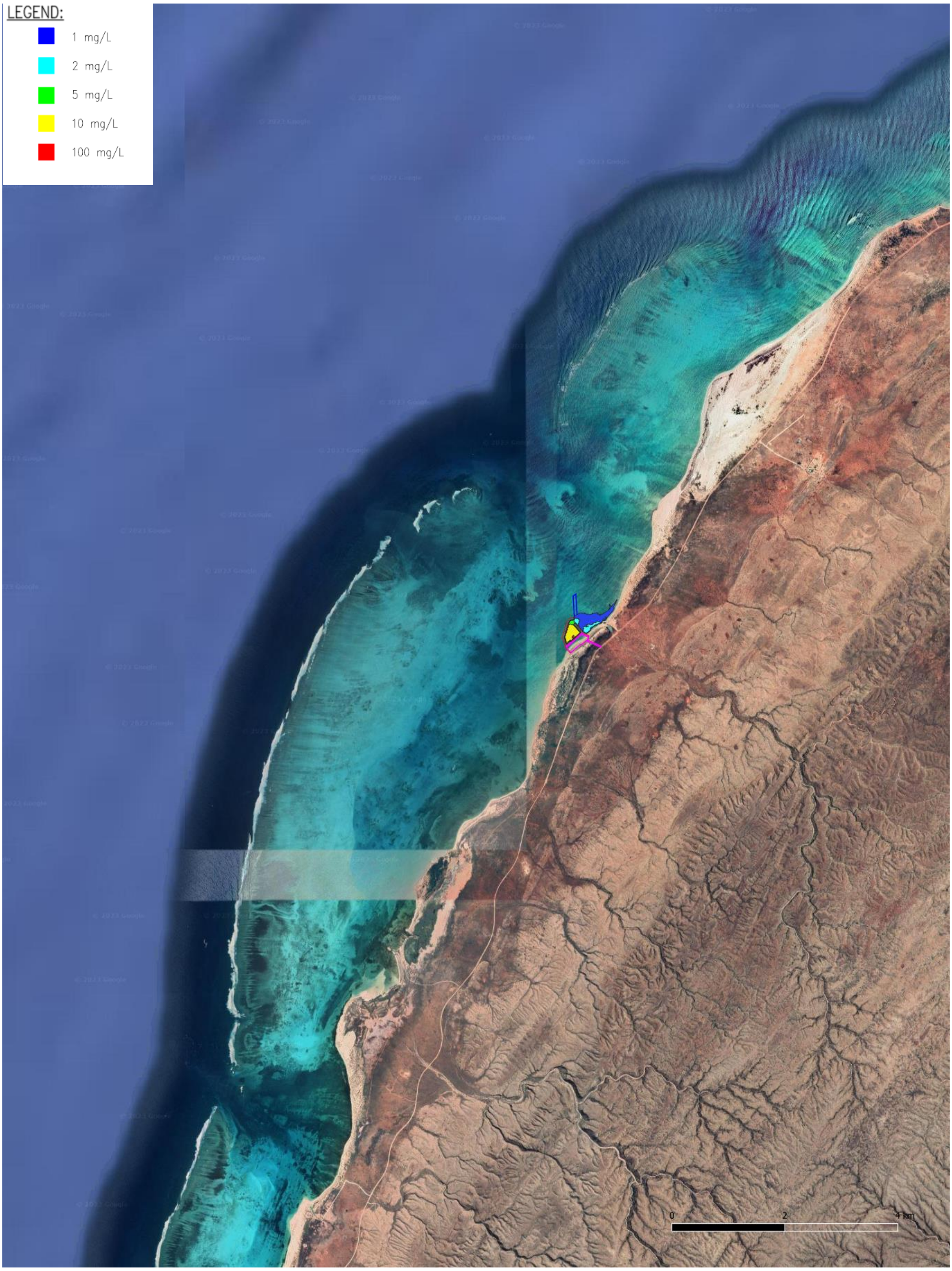
Run 9b - 50% Exceedance Zoomed In



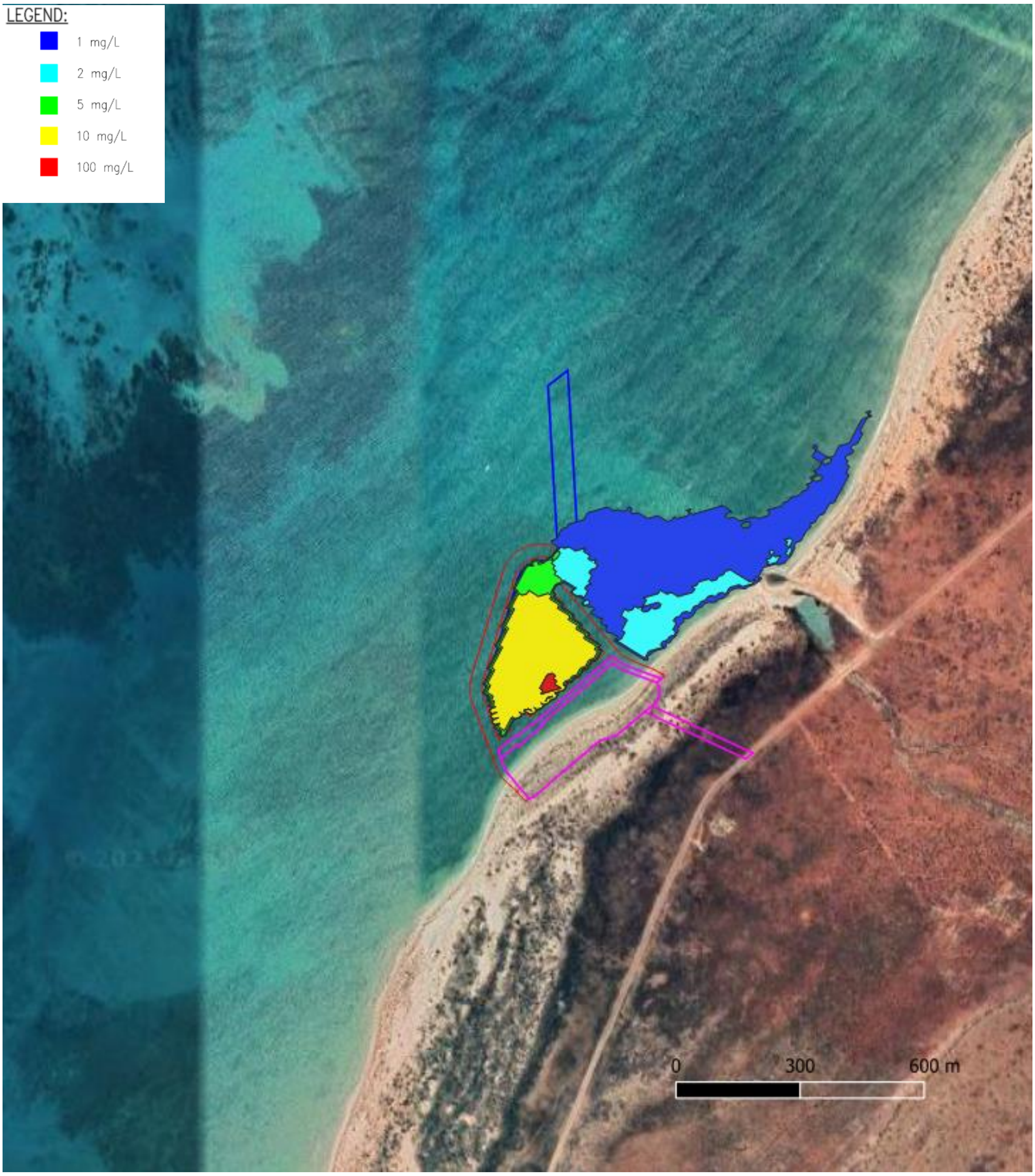
Run 9b - 80% Exceedance



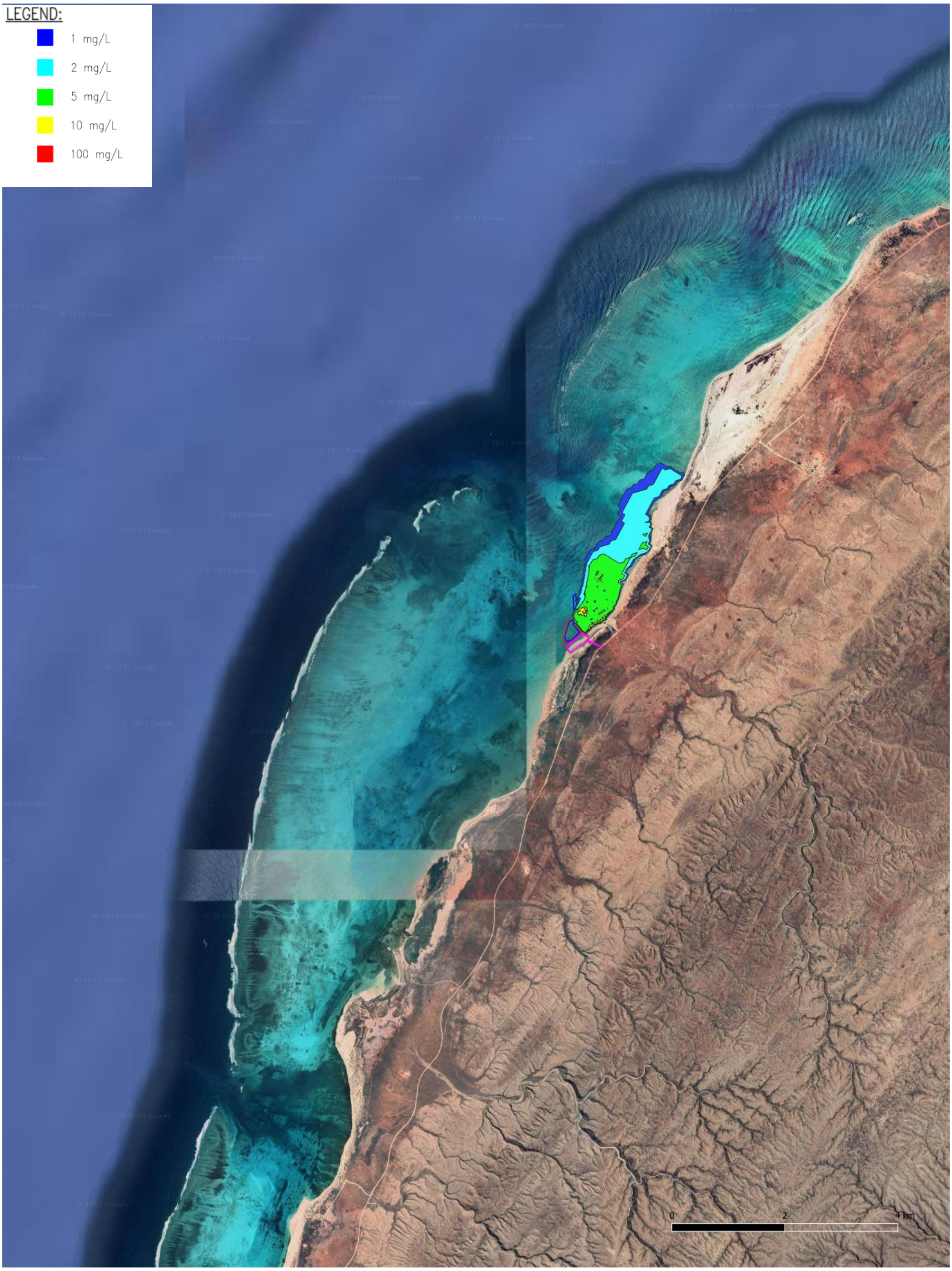
Run 9b - 80% Exceedance Zoomed In



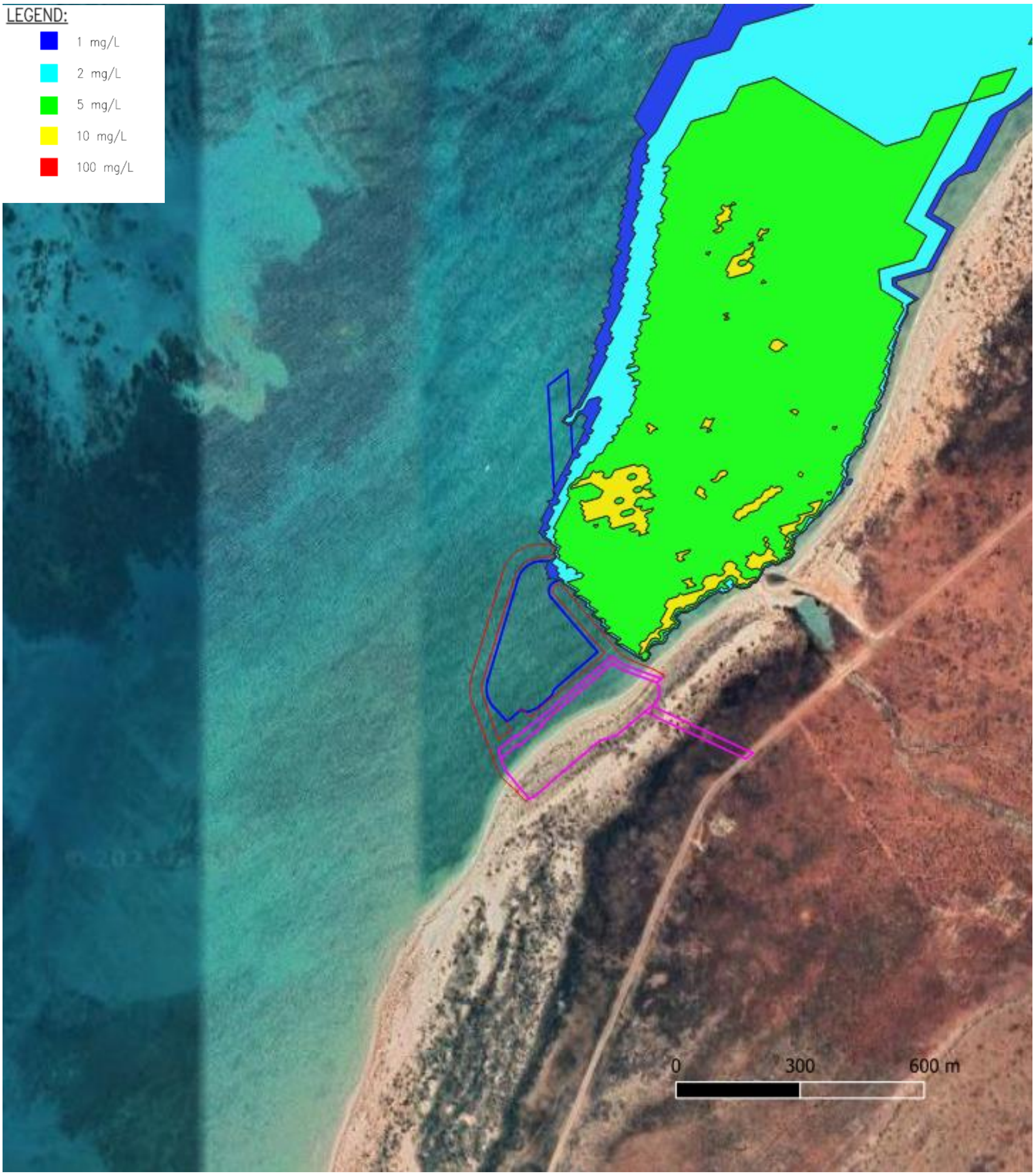
Run 9b - 95% Exceedance



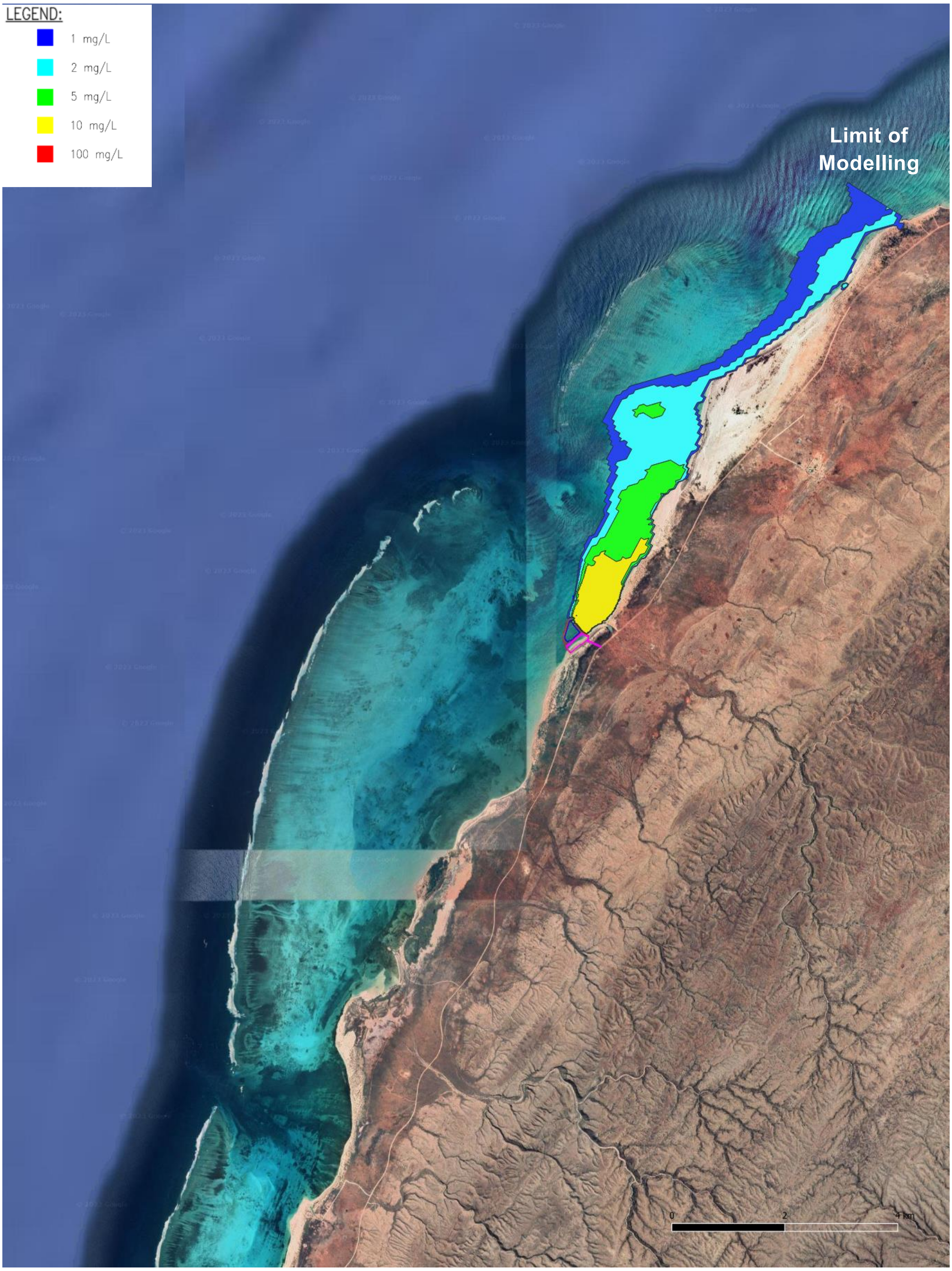
Run 9b - 95% Exceedance Zoomed In



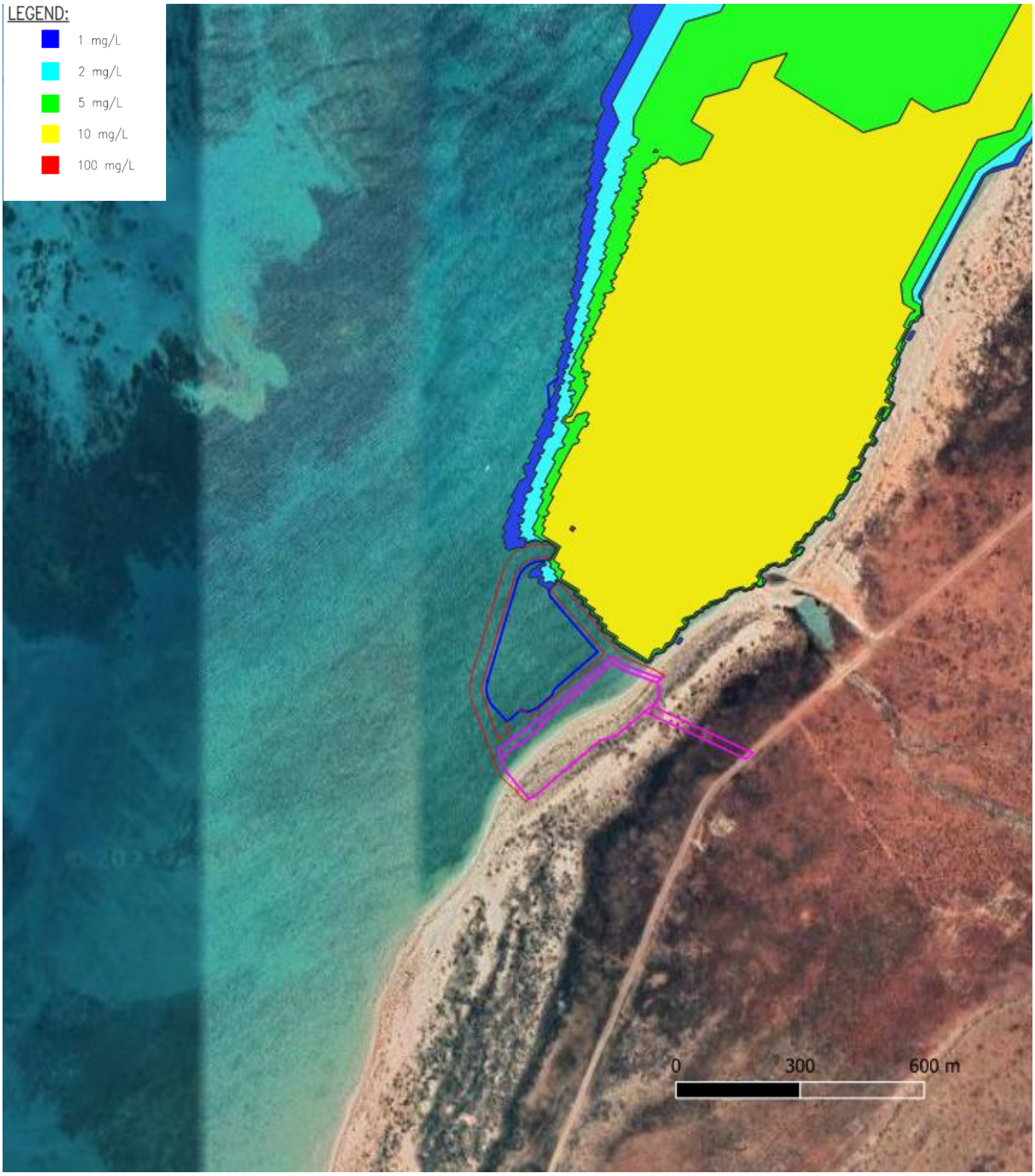
Run 10 - 50% Exceedance



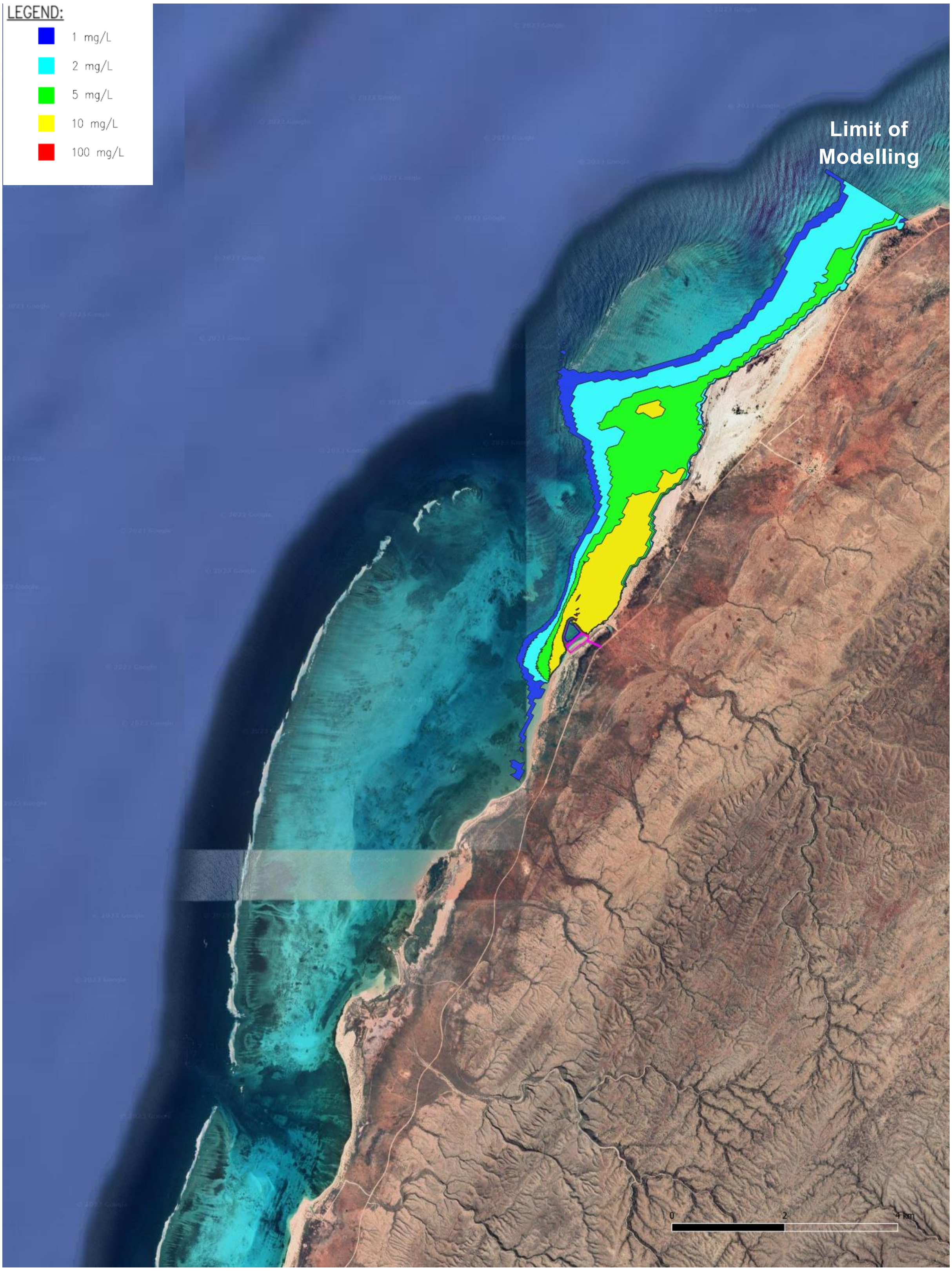
Run 10 - 50% Exceedance Zoomed In



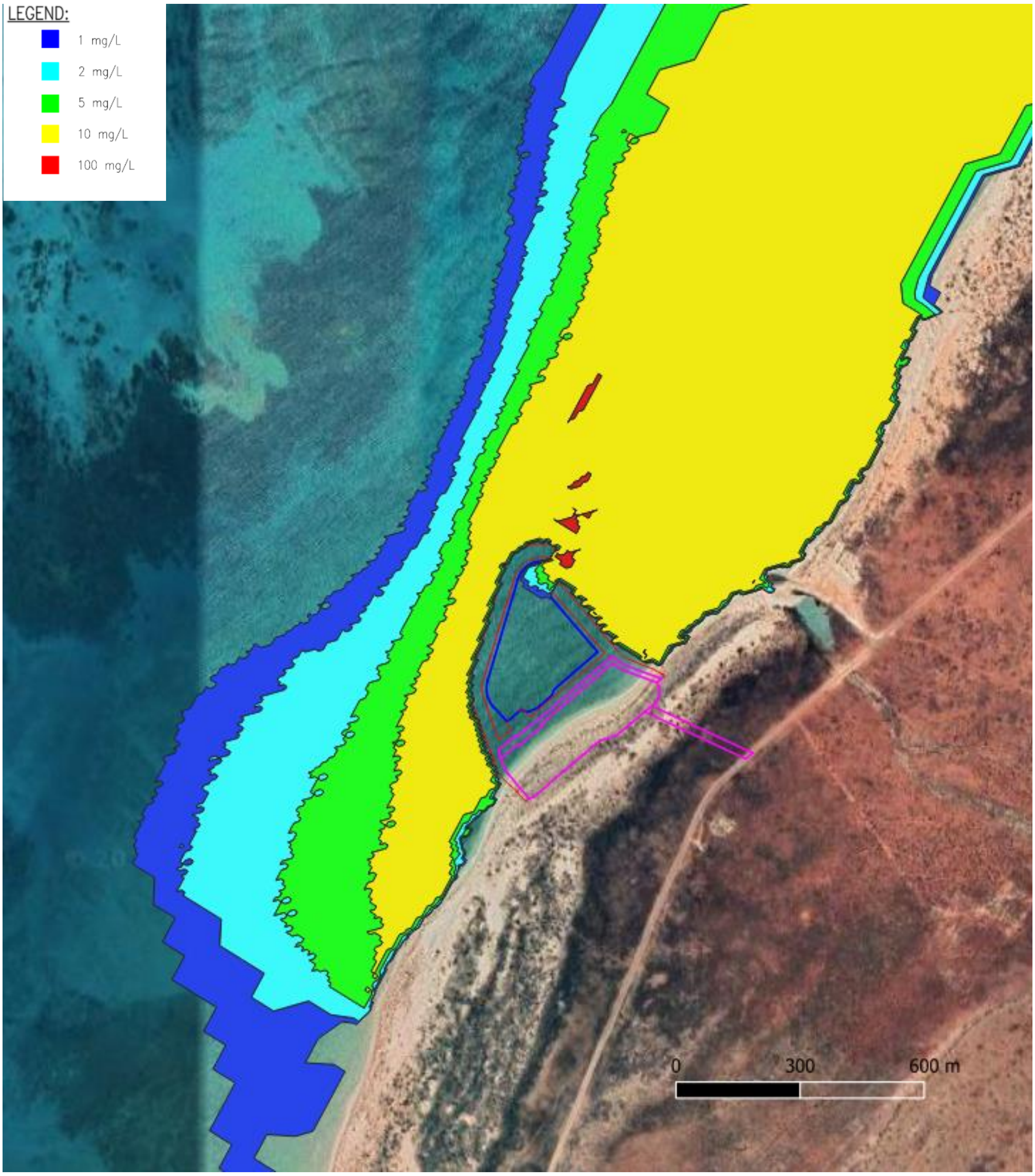
Run 10 - 80% Exceedance



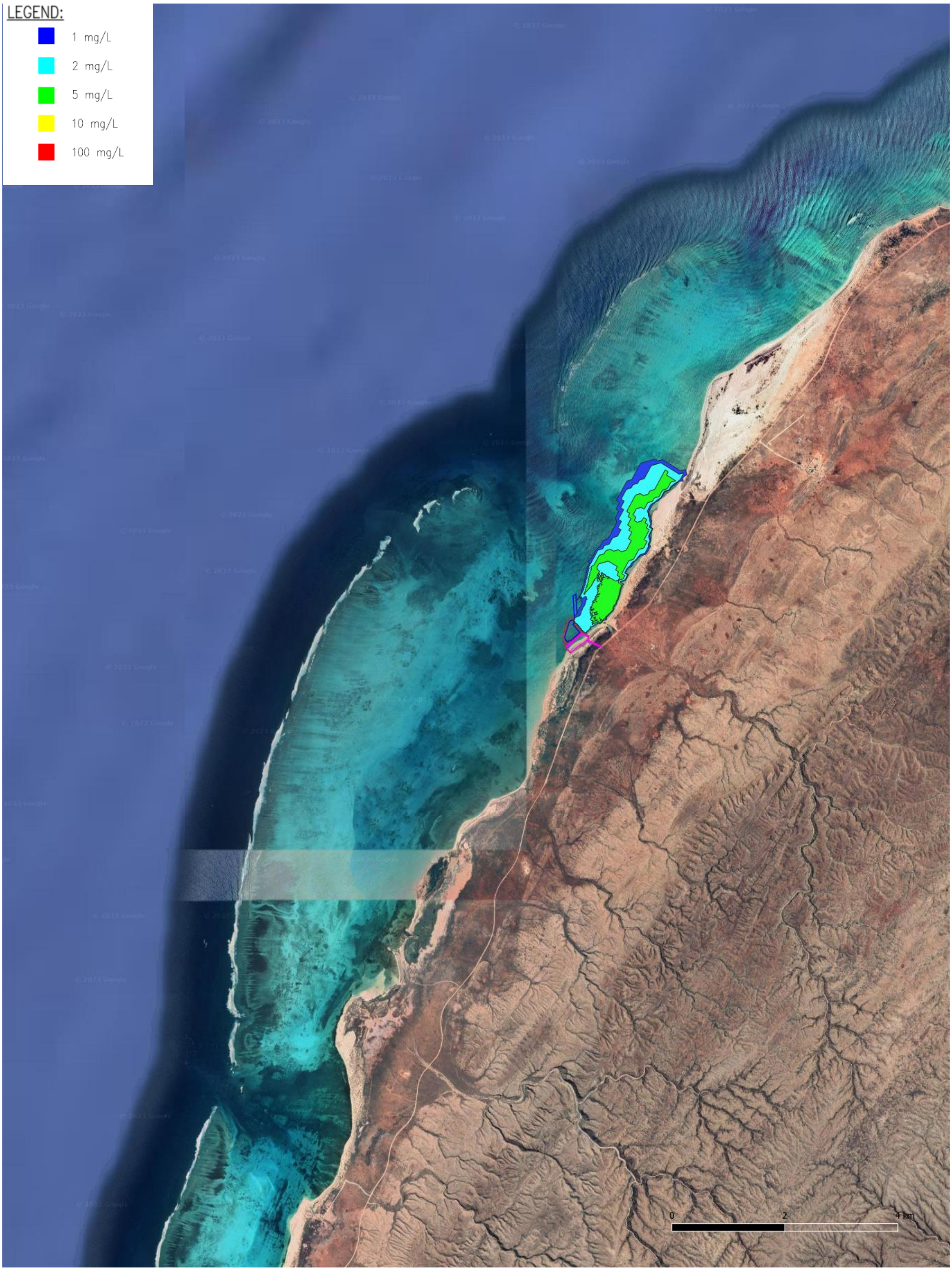
Run 10 - 80% Exceedance Zoomed In



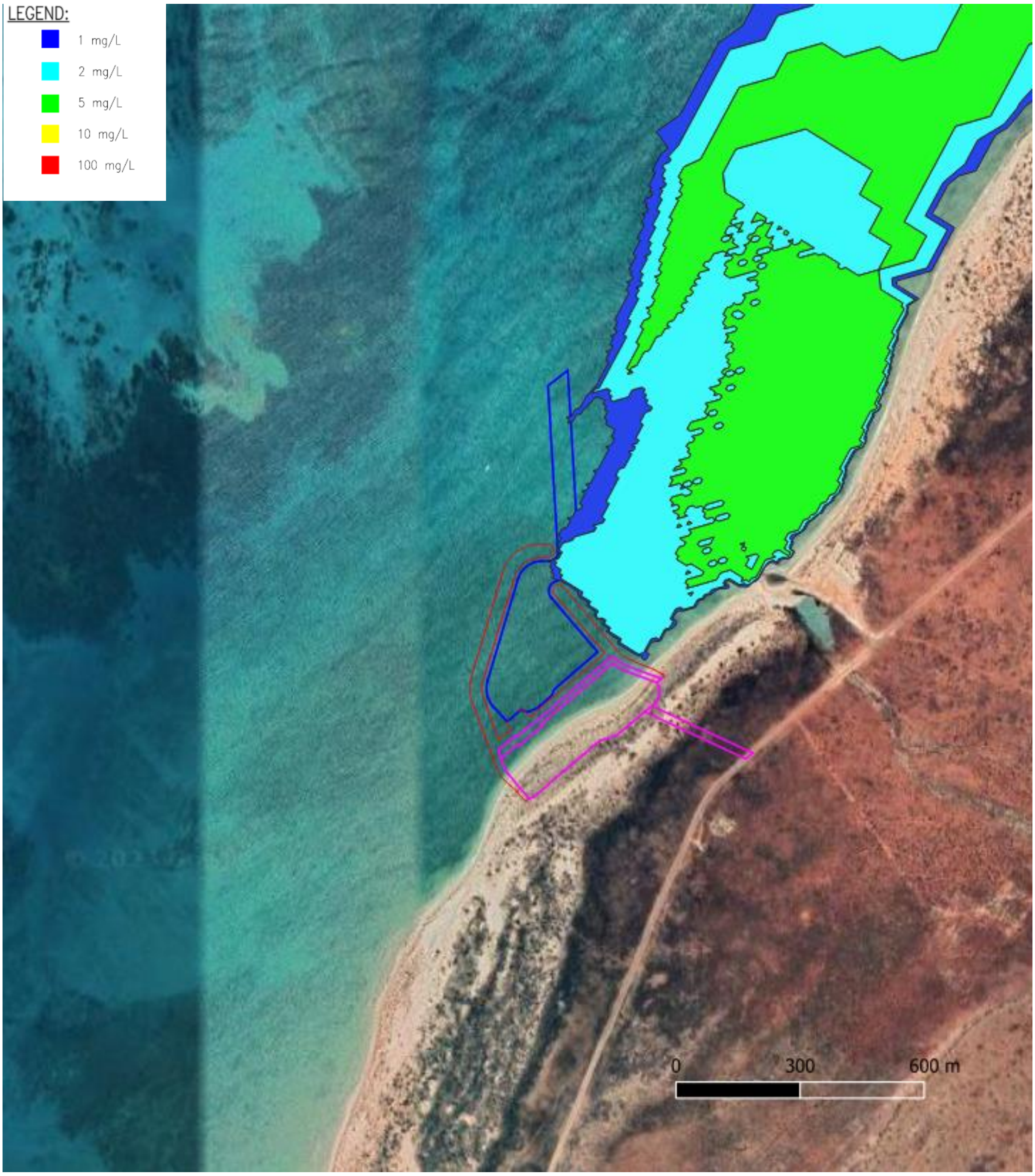
Run 10 - 95% Exceedance



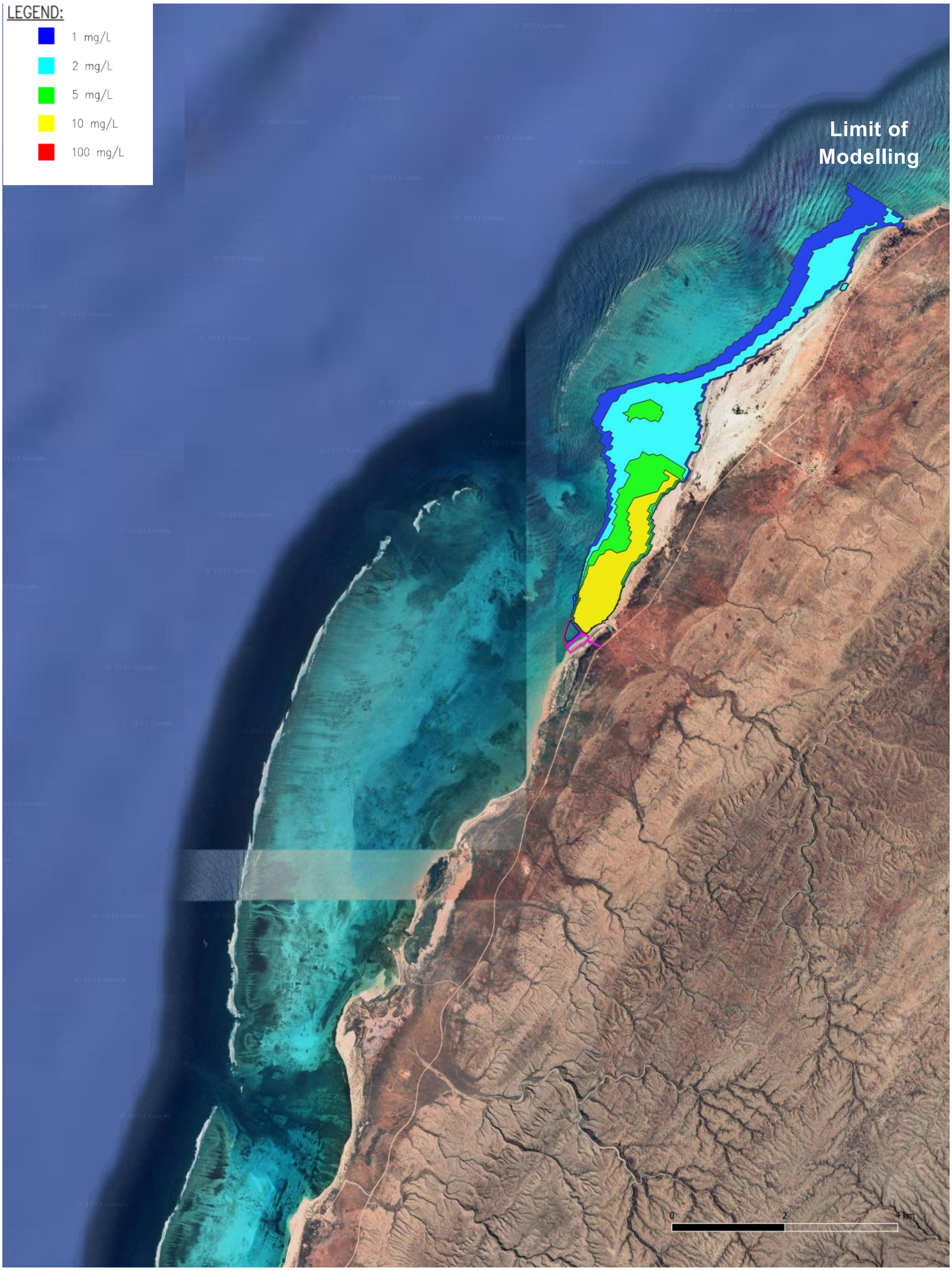
Run 10 - 95% Exceedance Zoomed In



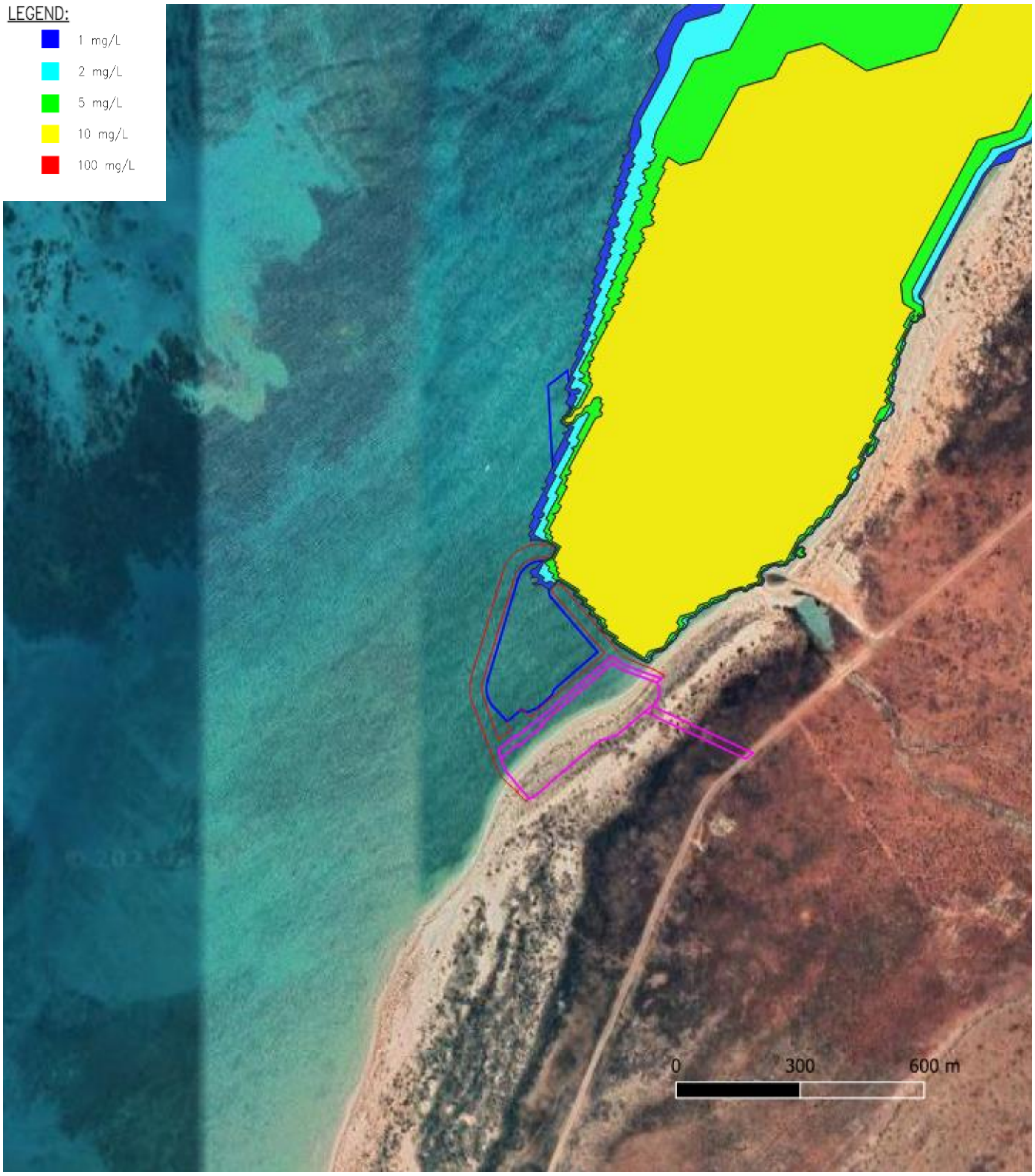
Run 11 - 50% Exceedance



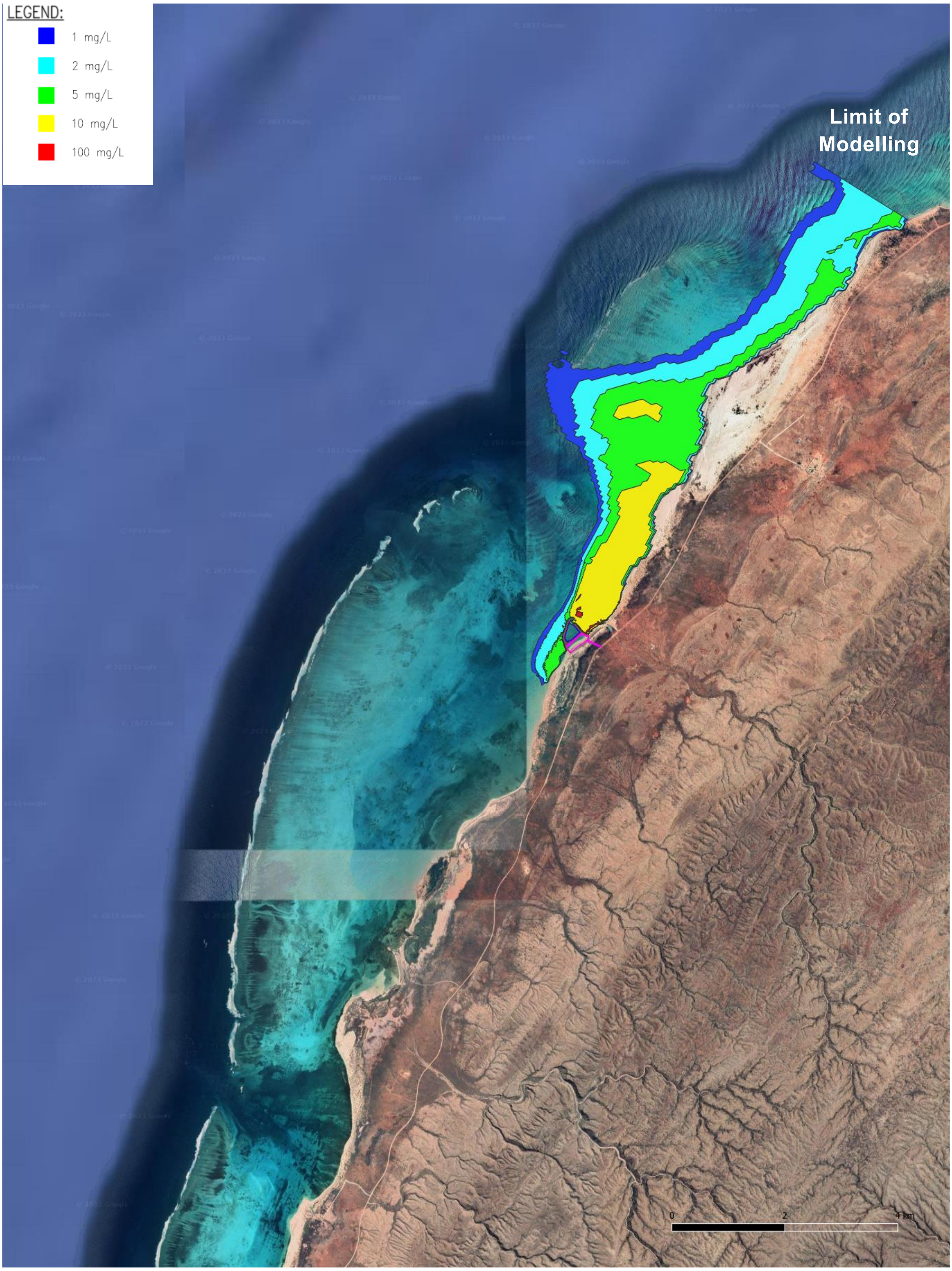
Run 11 - 50% Exceedance Zoomed In



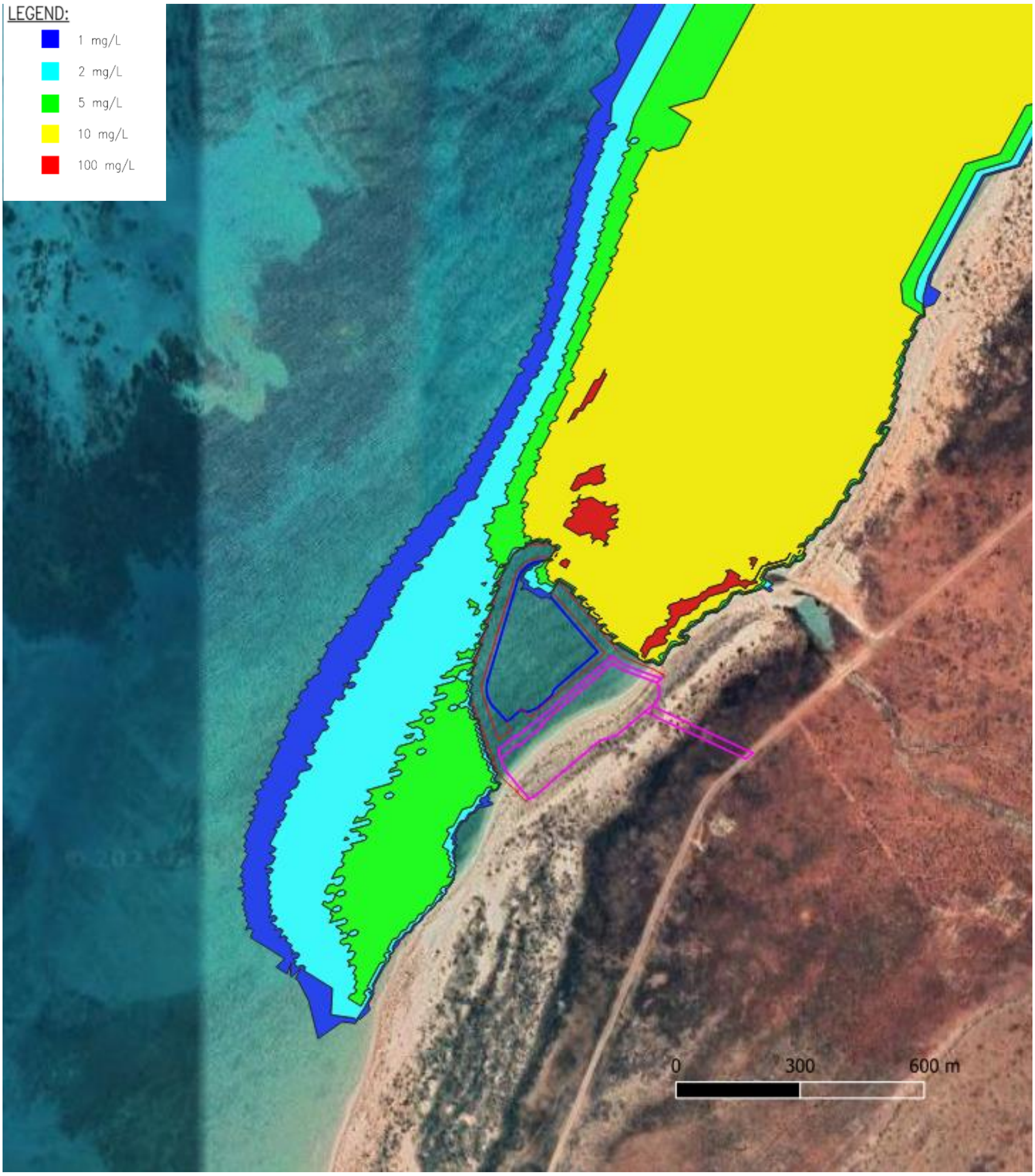
Run 11 - 80% Exceedance



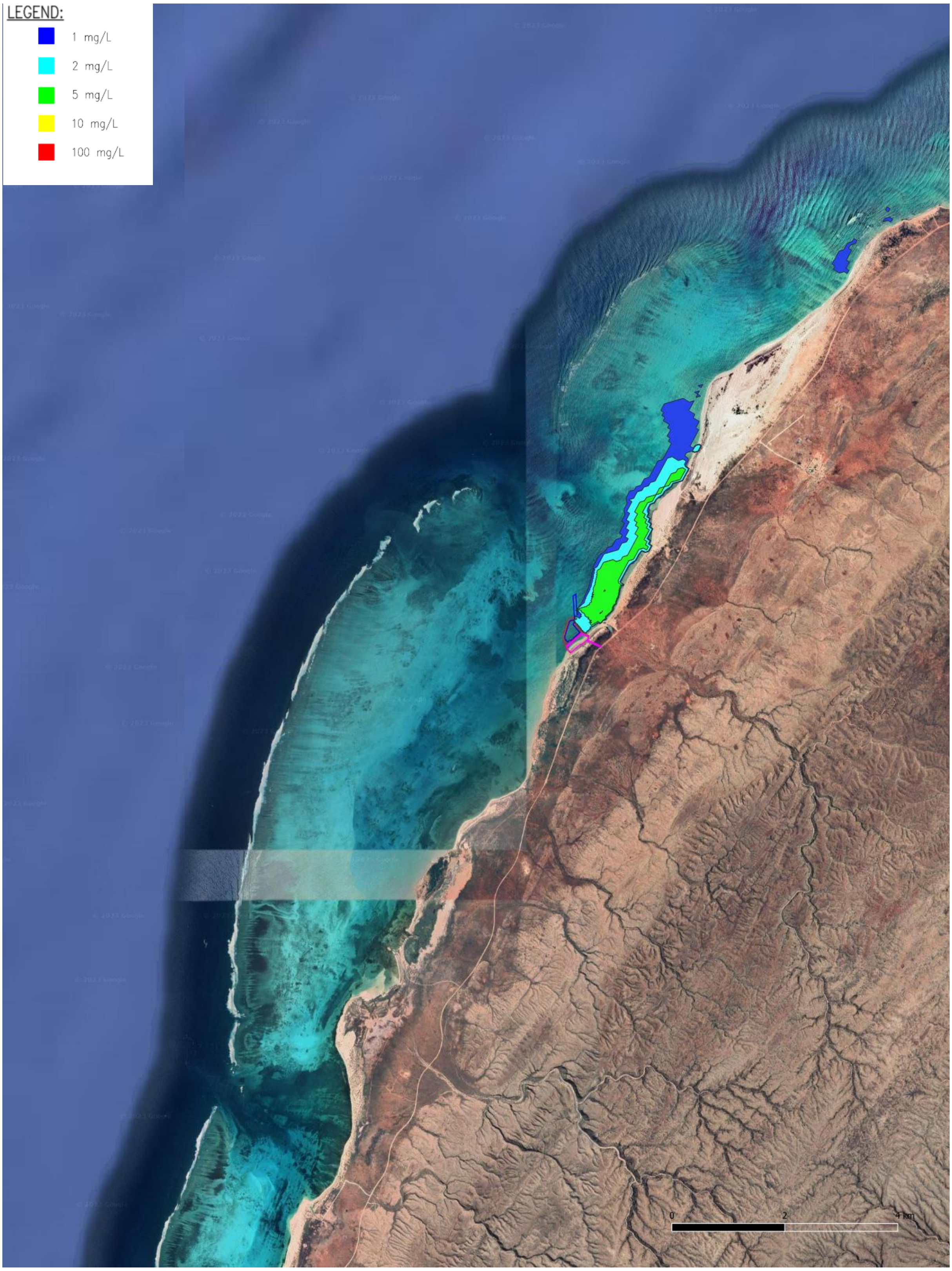
Run 11 - 80% Exceedance Zoomed In



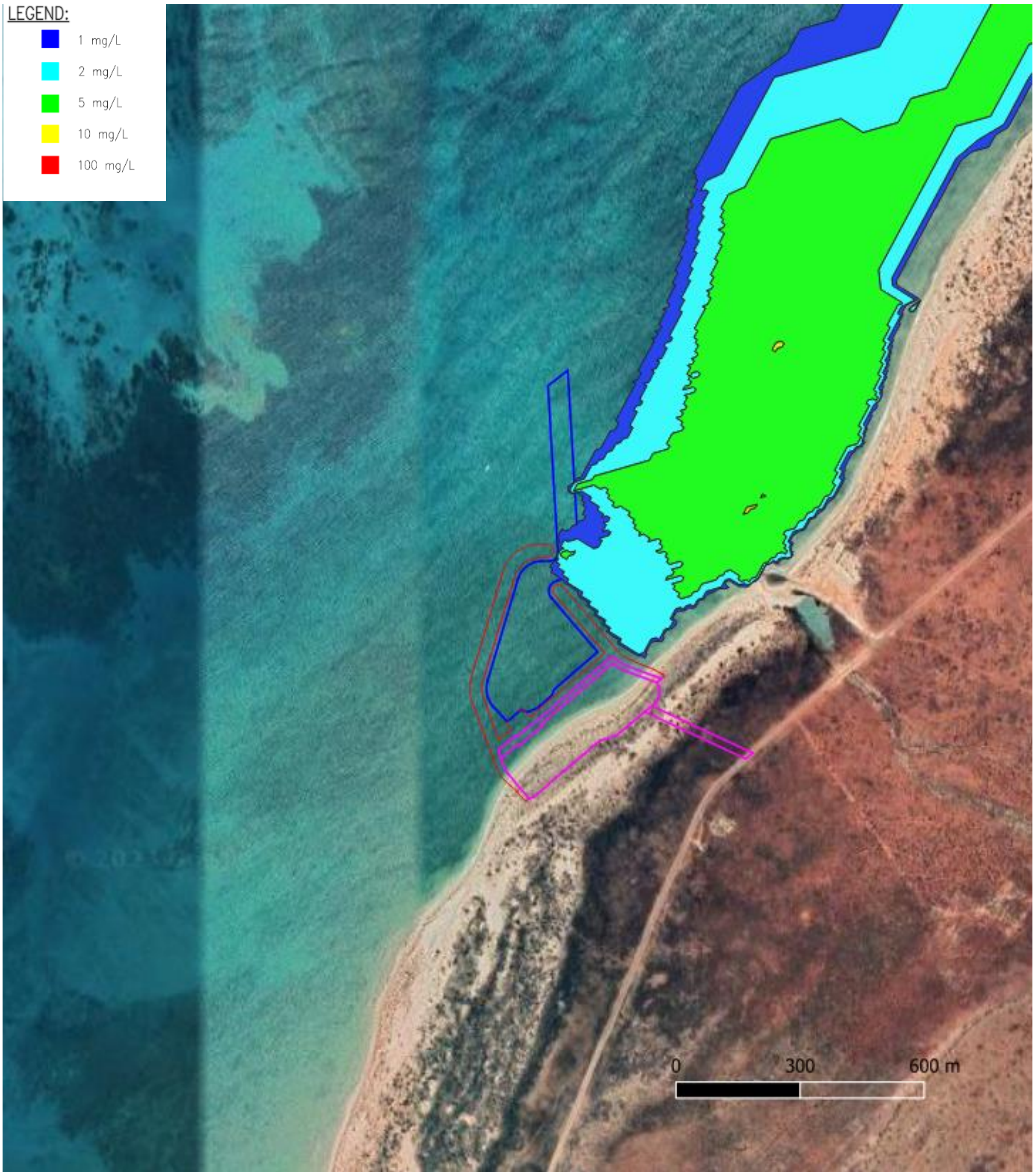
Run 11 - 95% Exceedance



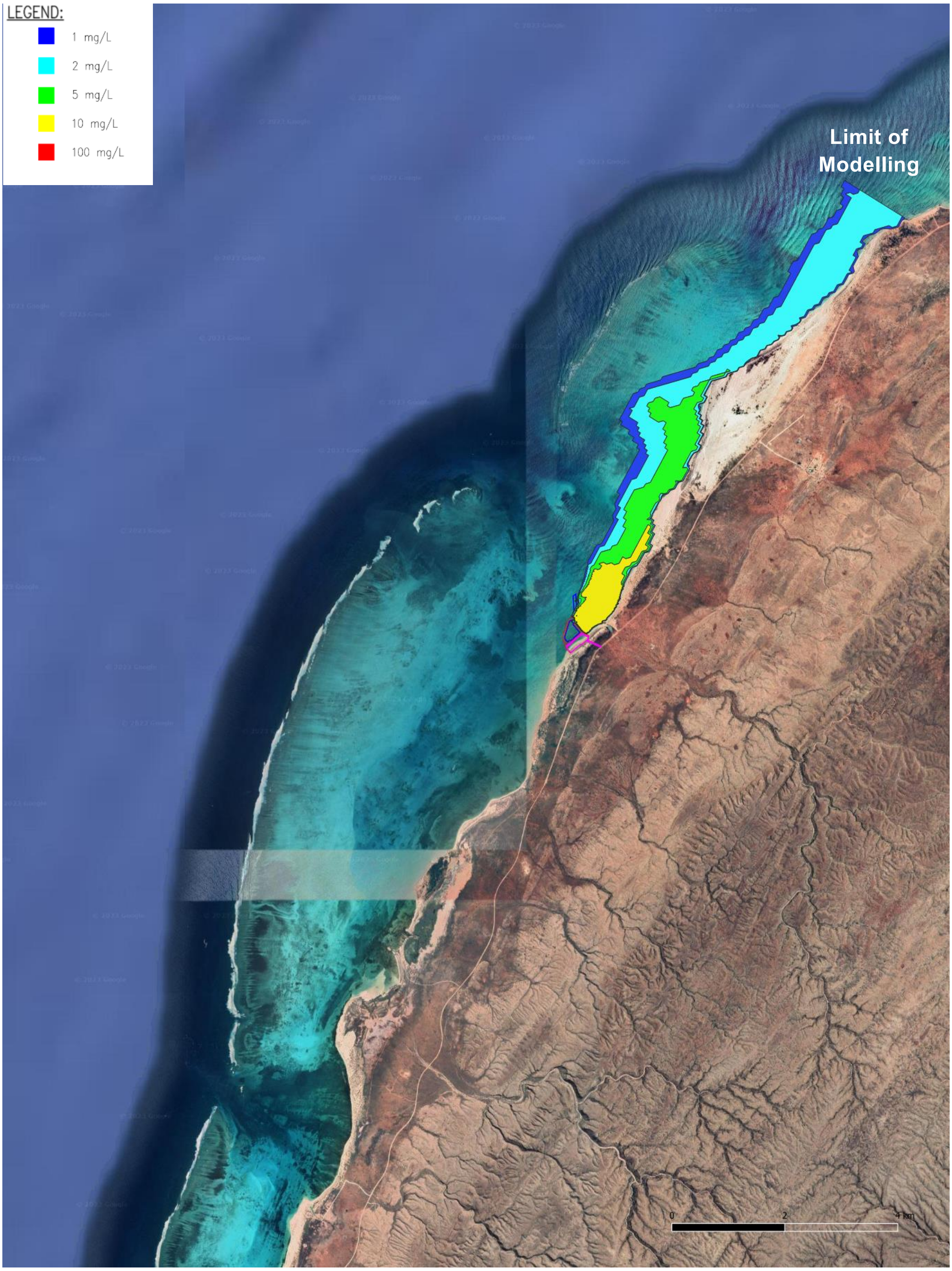
Run 11 - 95% Exceedance Zoomed In



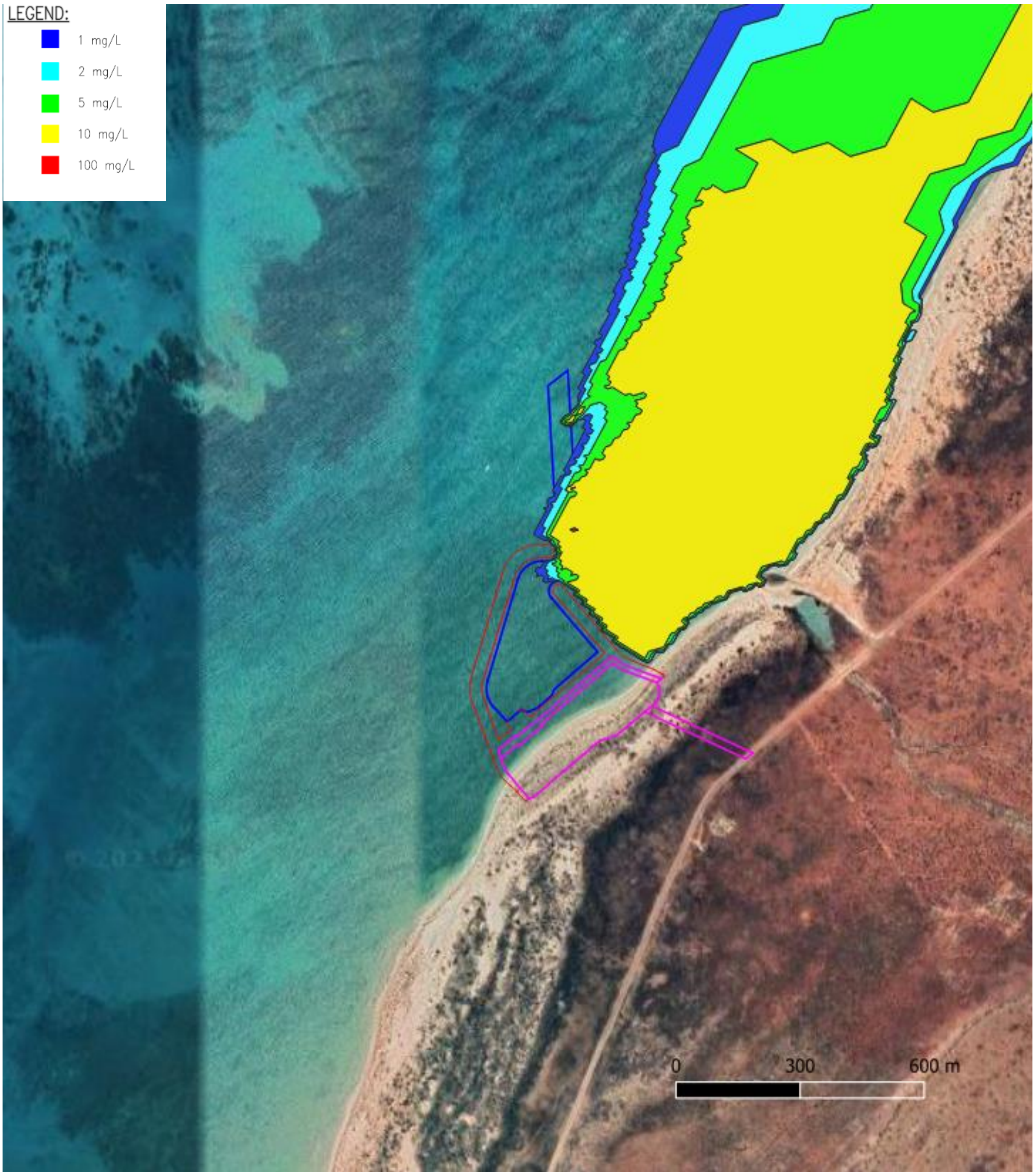
Run 13 - 50% Exceedance



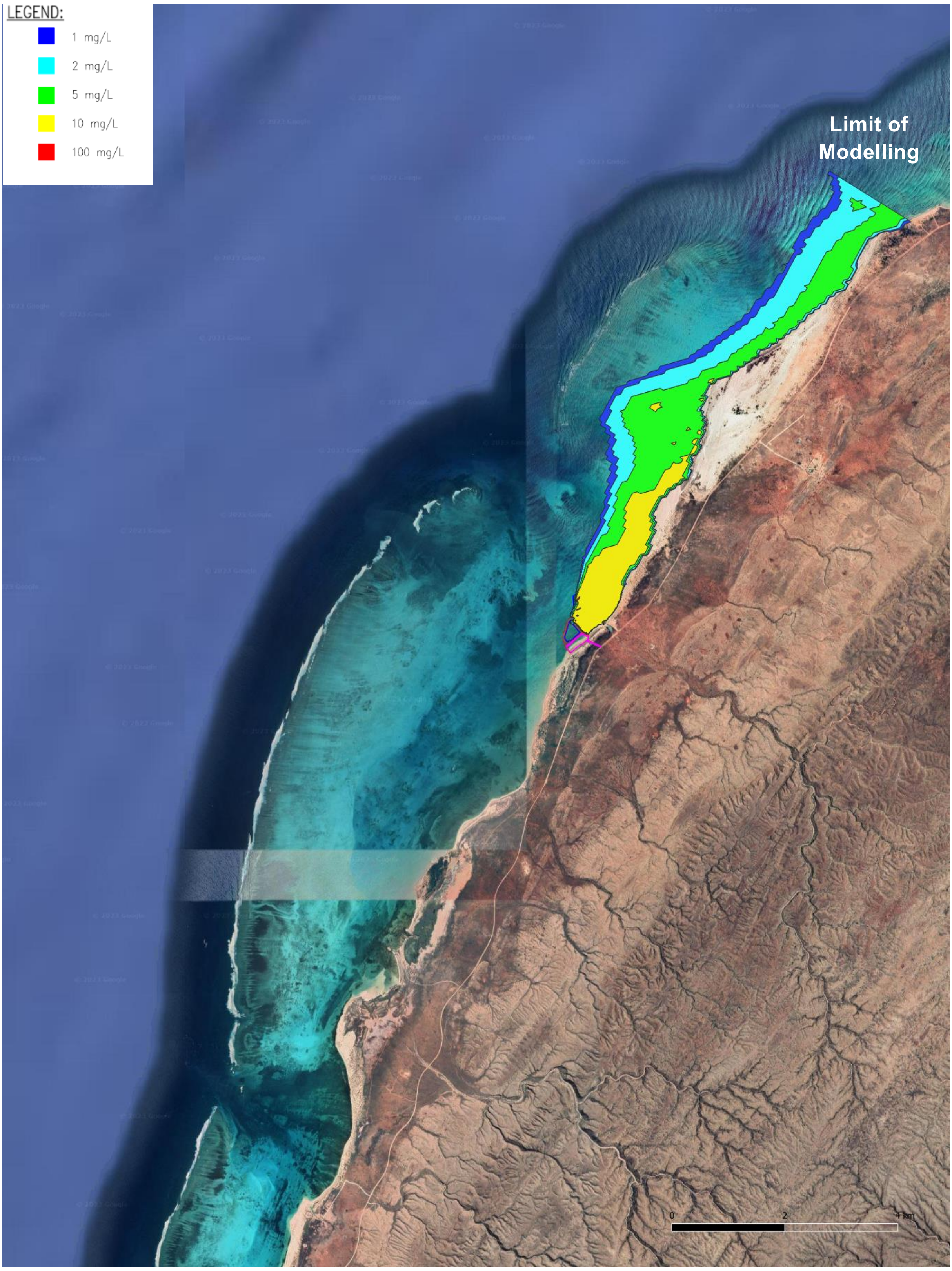
Run 13 - 50% Exceedance Zoomed In



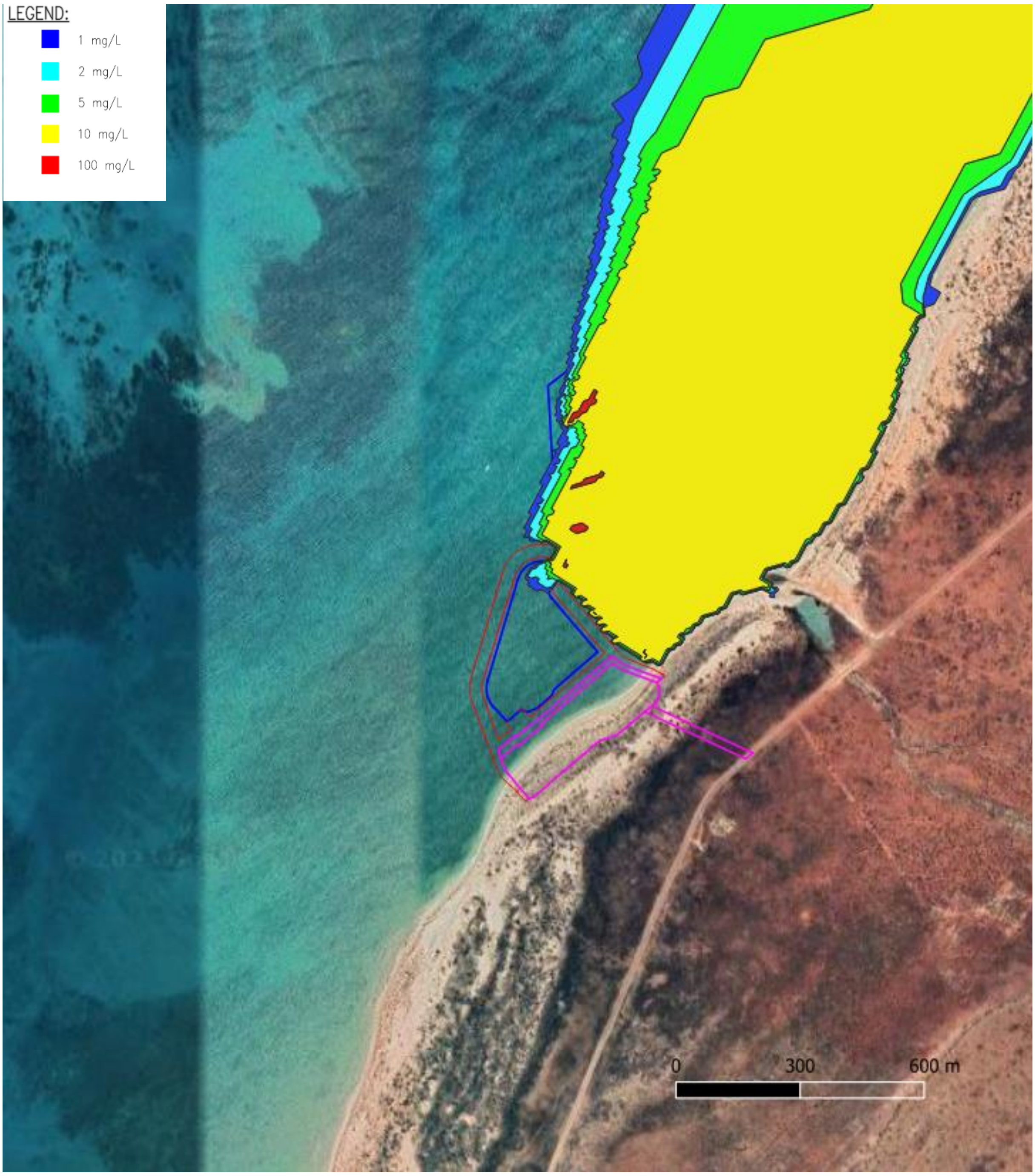
Run 13 - 80% Exceedance



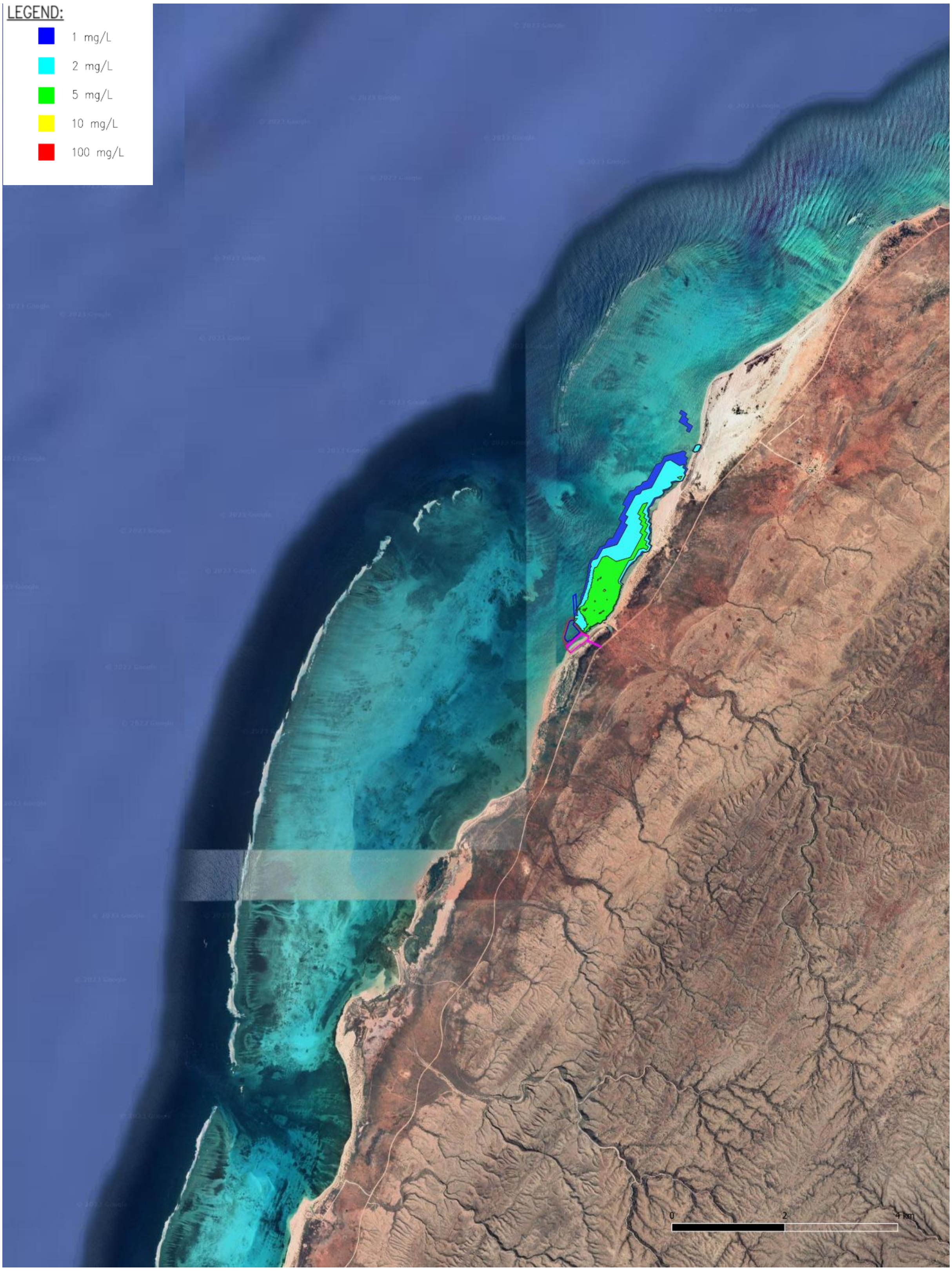
Run 13 - 80% Exceedance Zoomed In



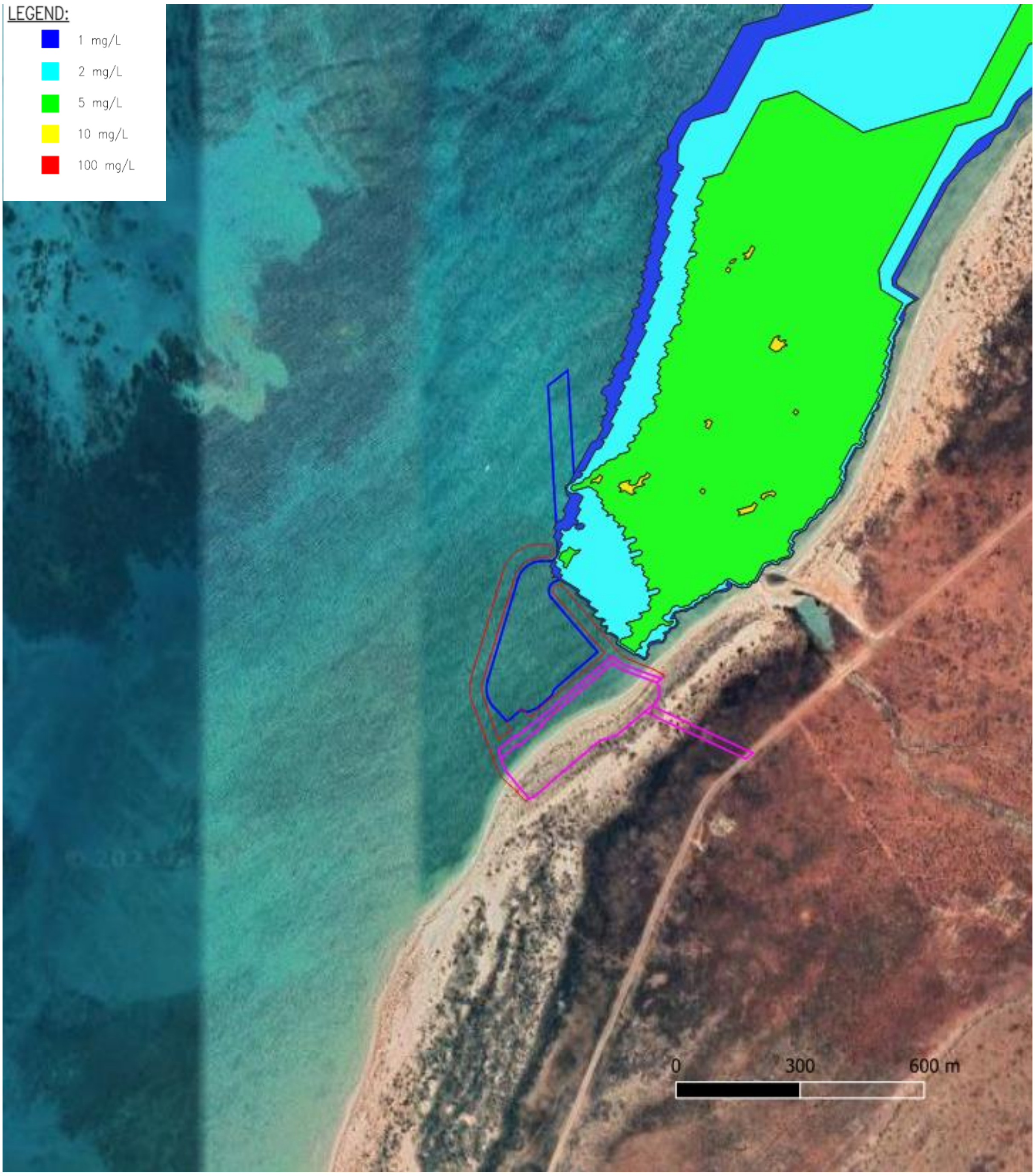
Run 13 - 95% Exceedance



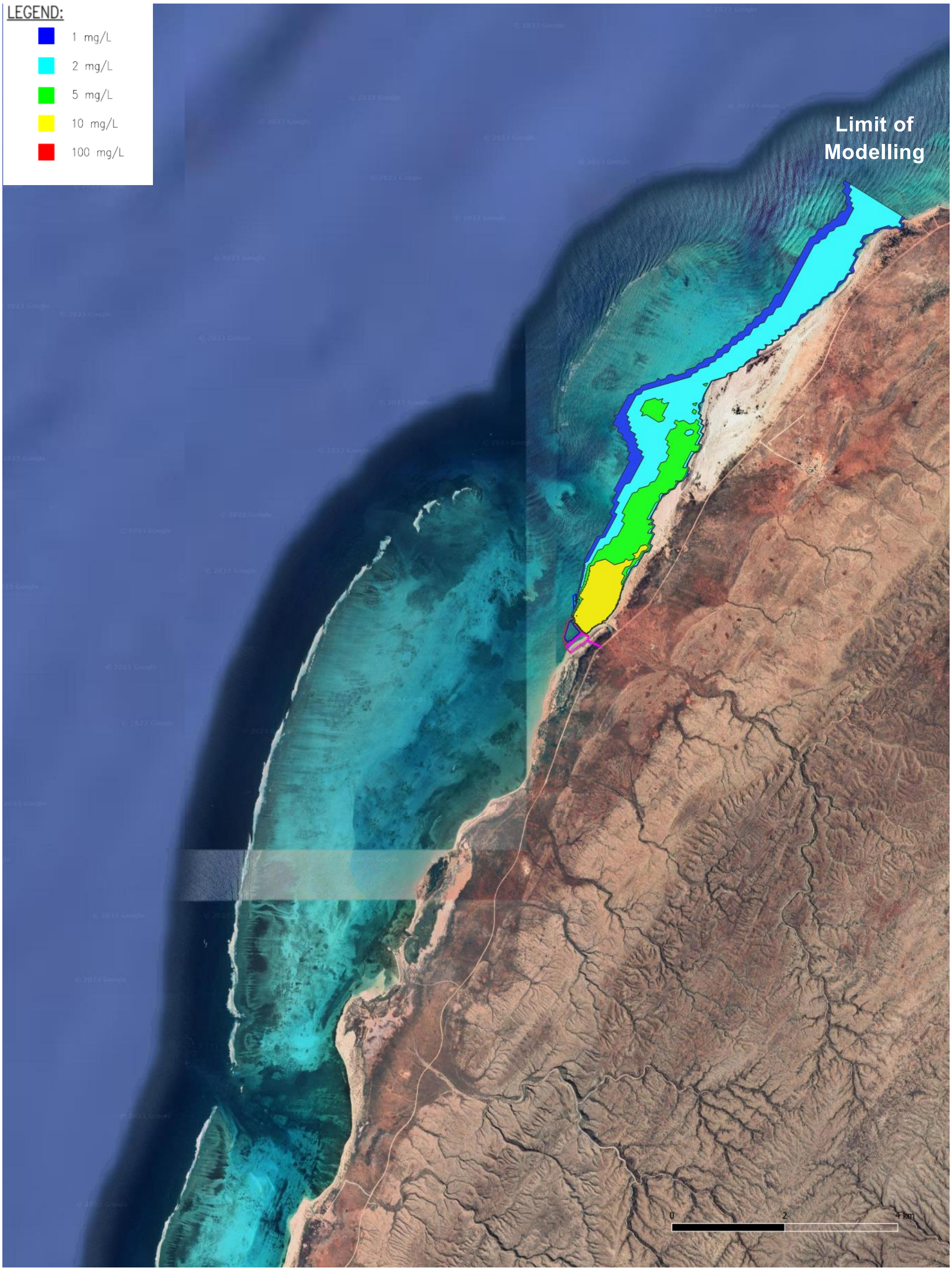
Run 13 - 95% Exceedance Zoomed In



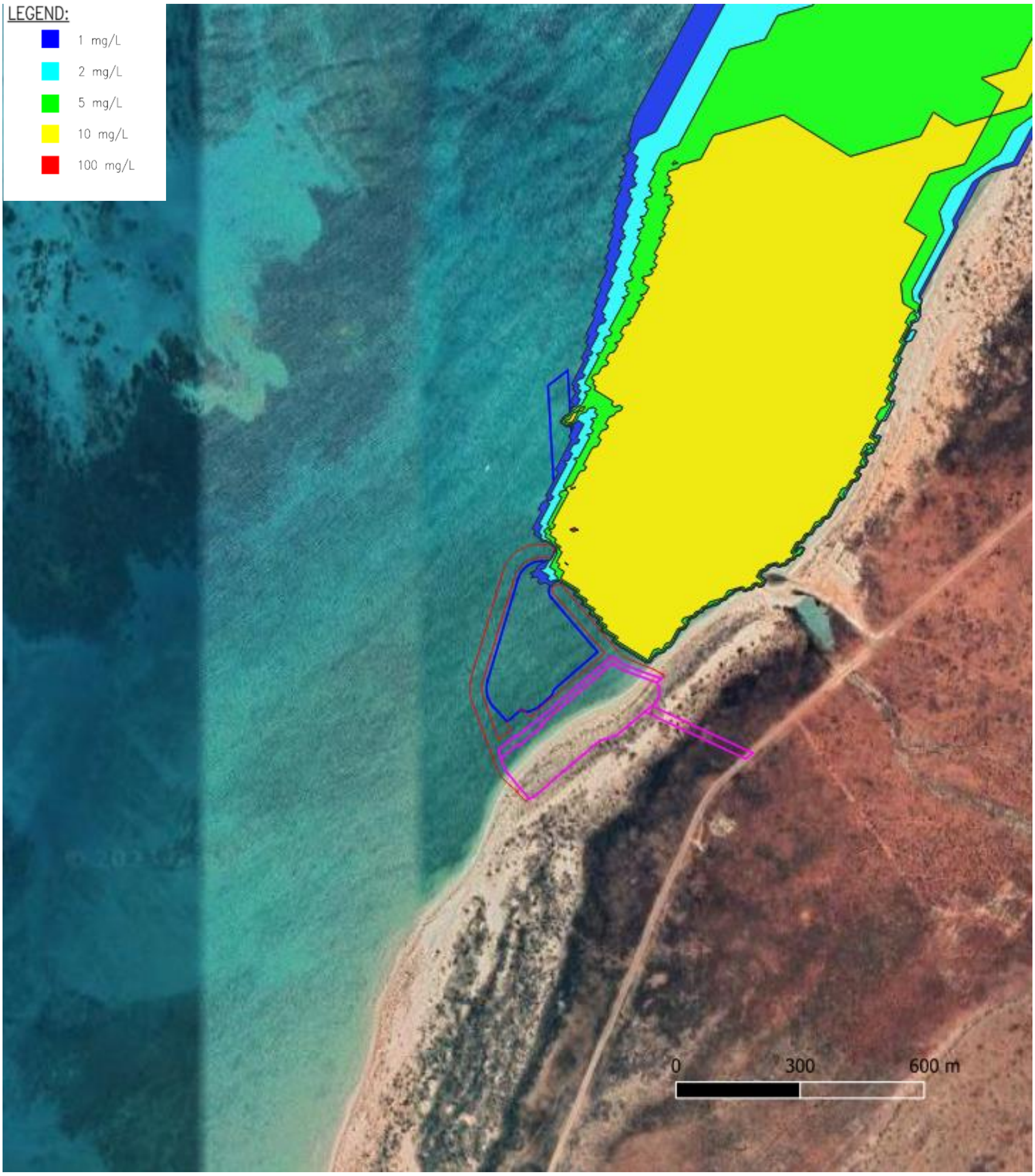
Run 14 - 50% Exceedance



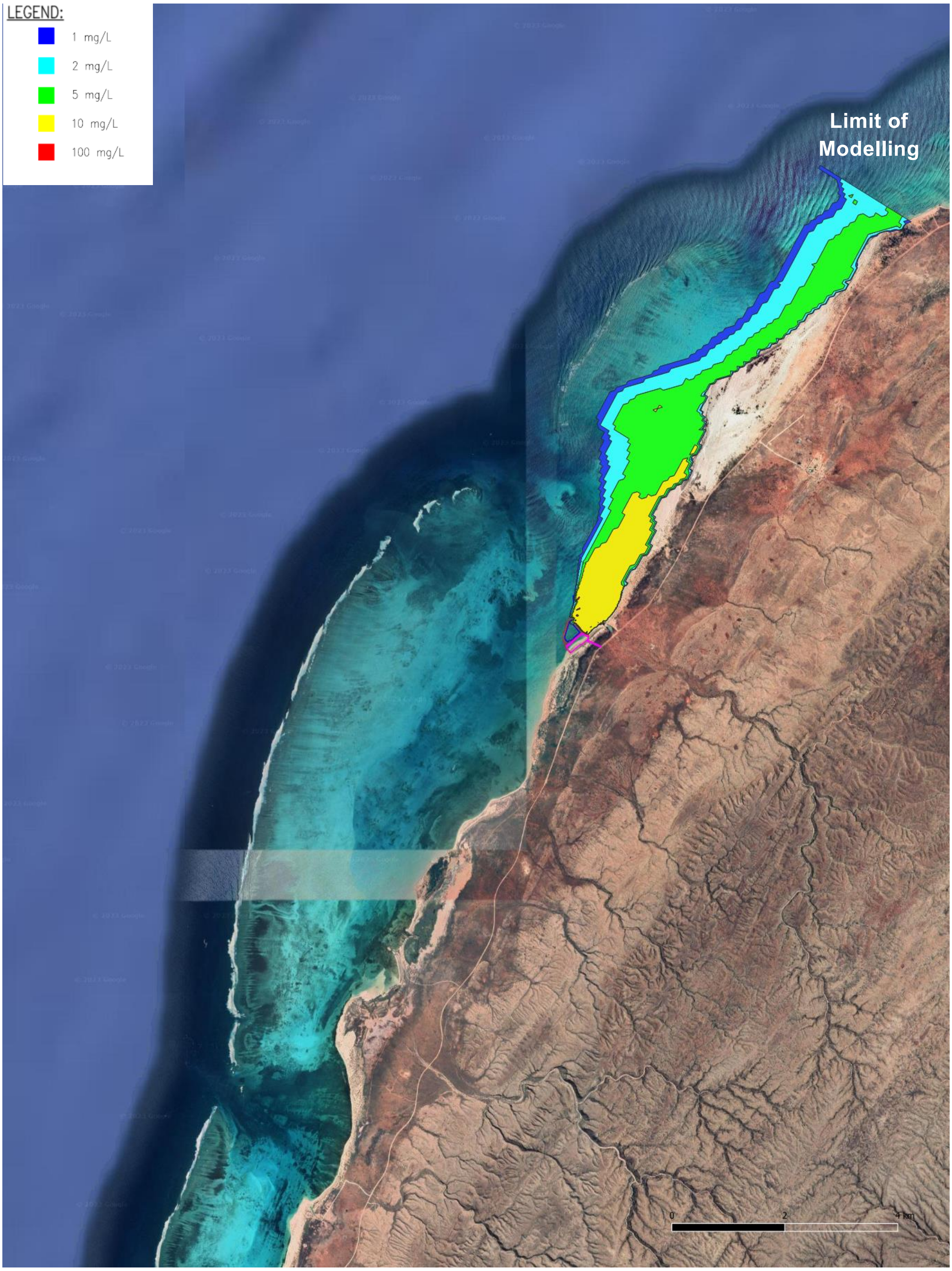
Run 14 - 50% Exceedance Zoomed In



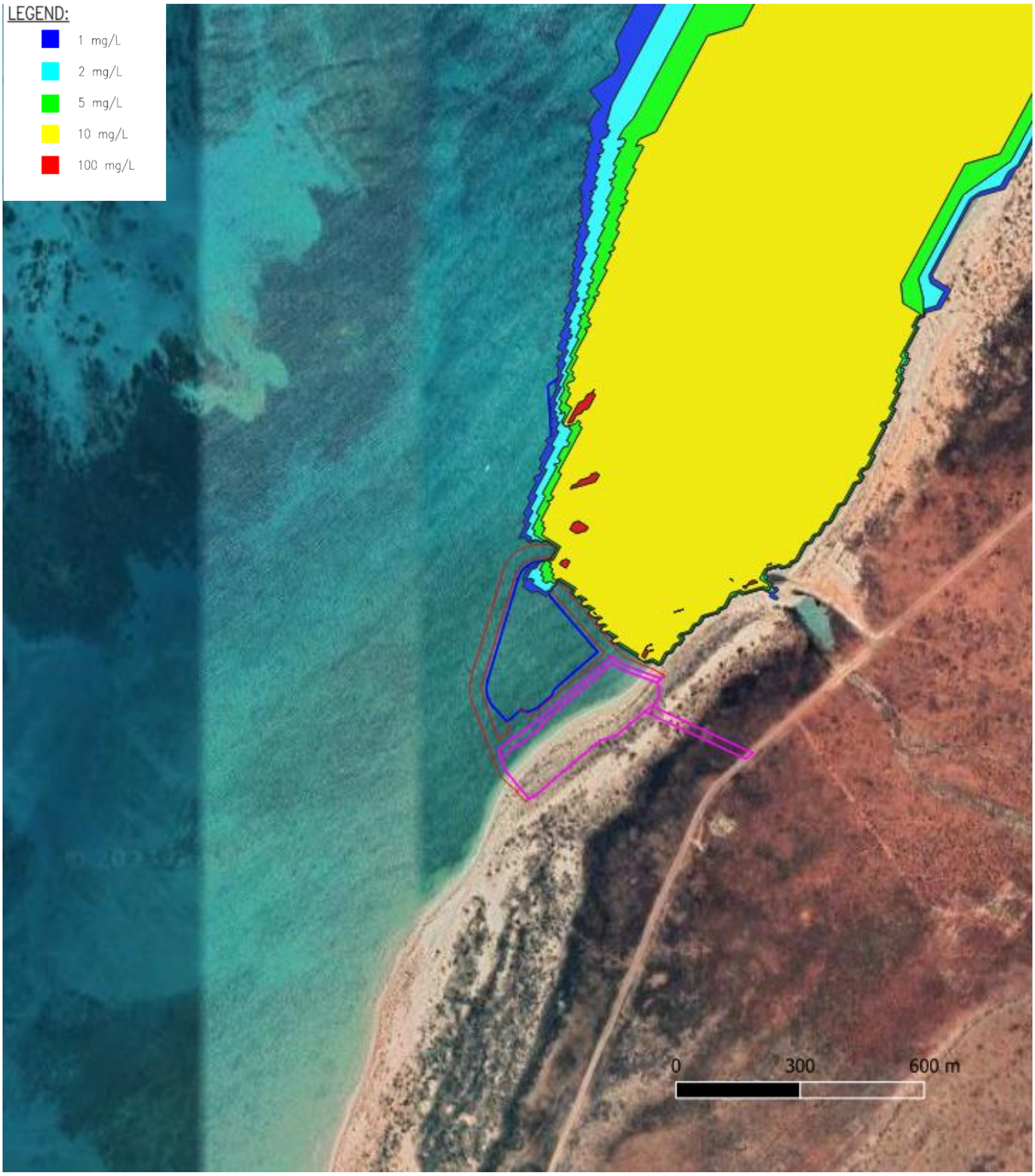
Run 14 - 80% Exceedance



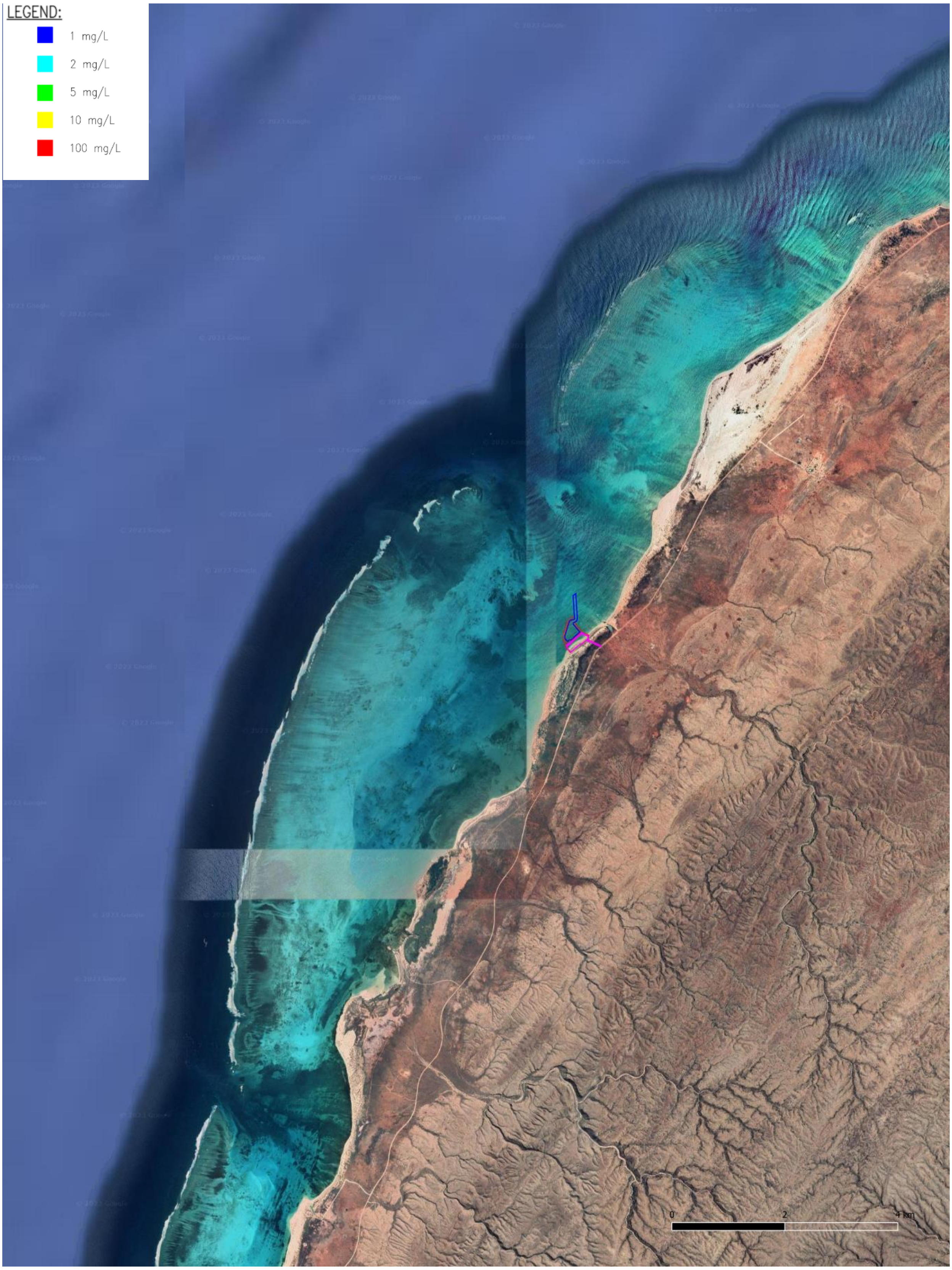
Run 14 - 80% Exceedance Zoomed In



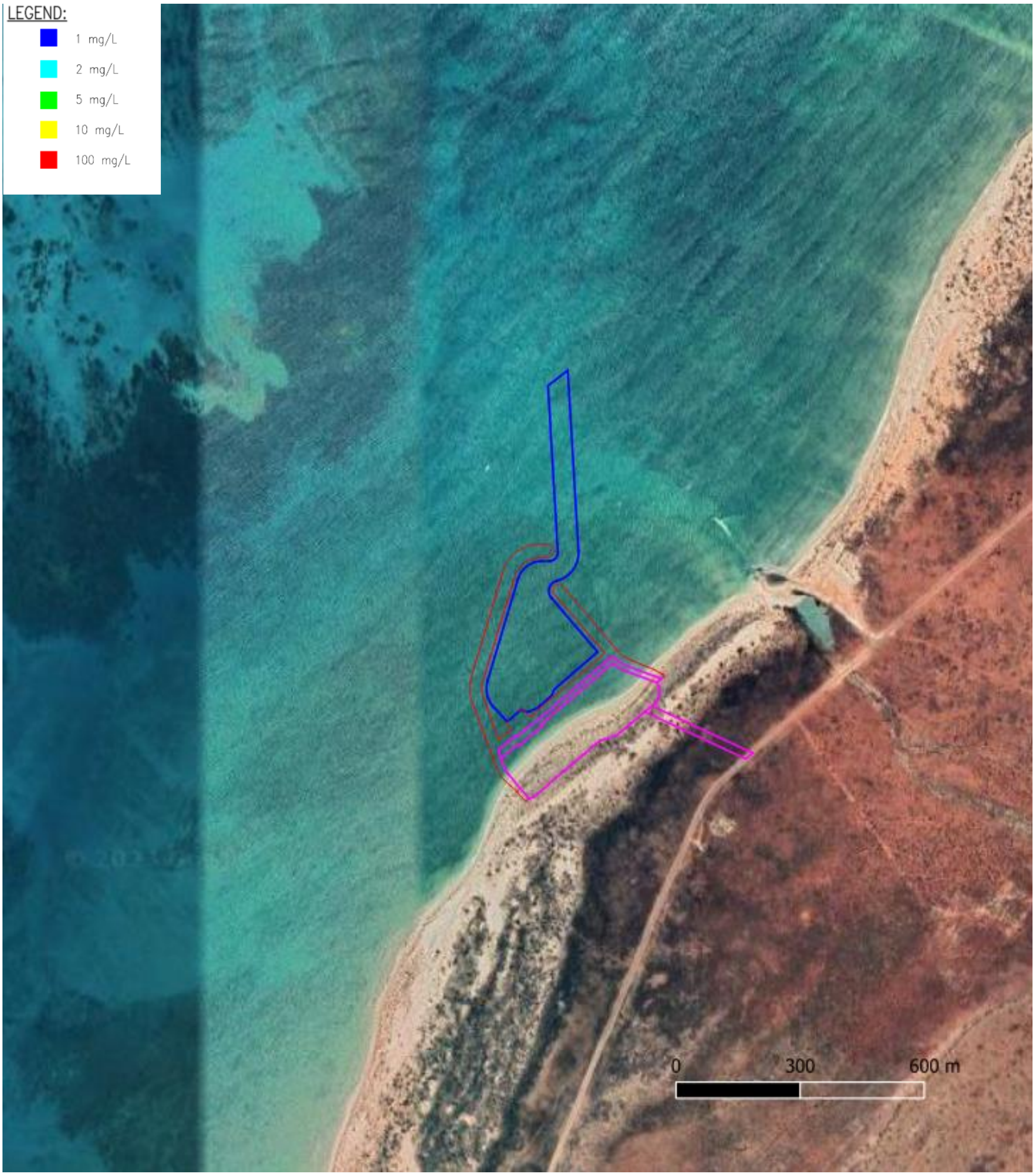
Run 14 - 95% Exceedance



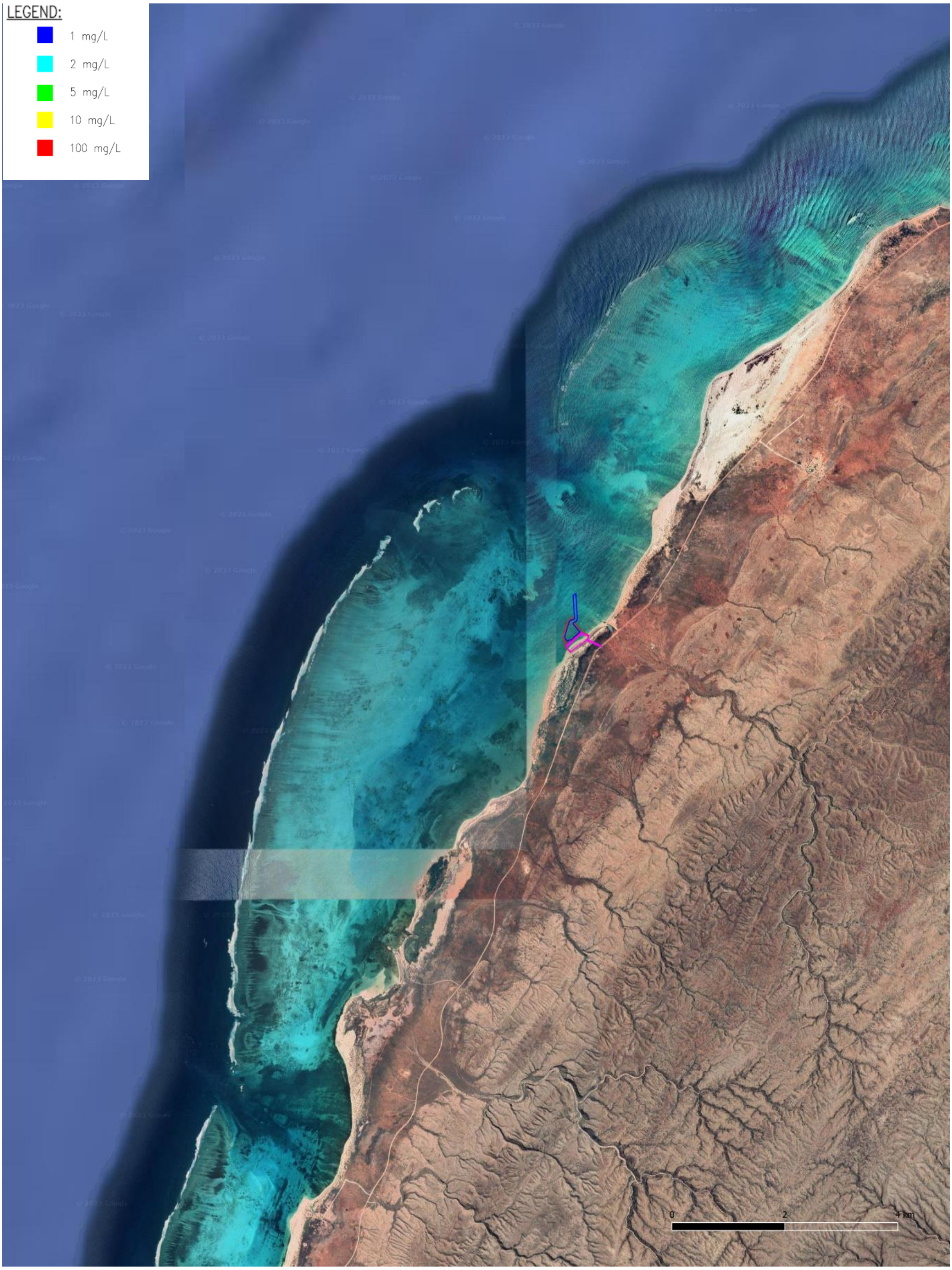
Run 14 - 95% Exceedance Zoomed In



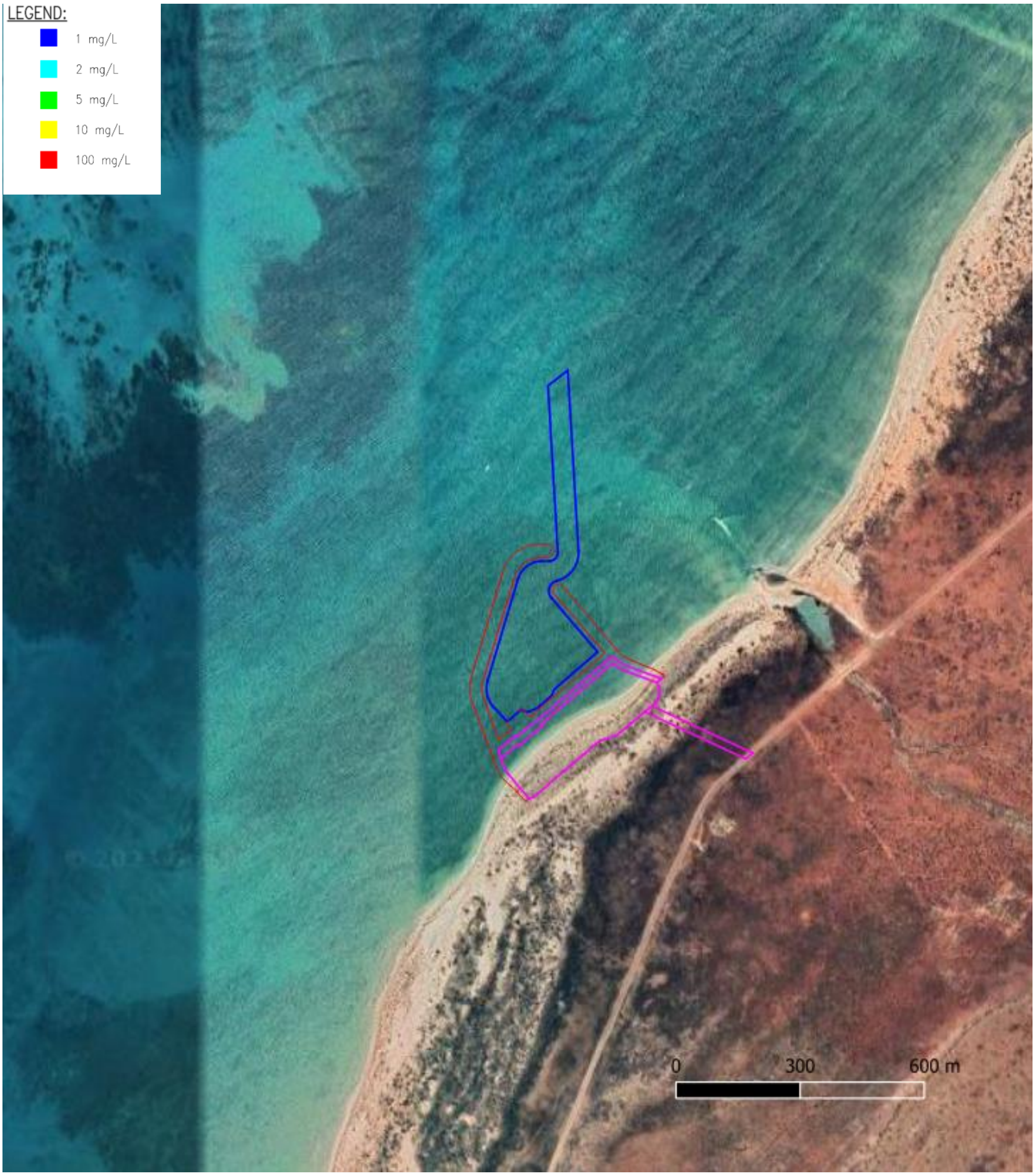
Run 15 - 50% Exceedance



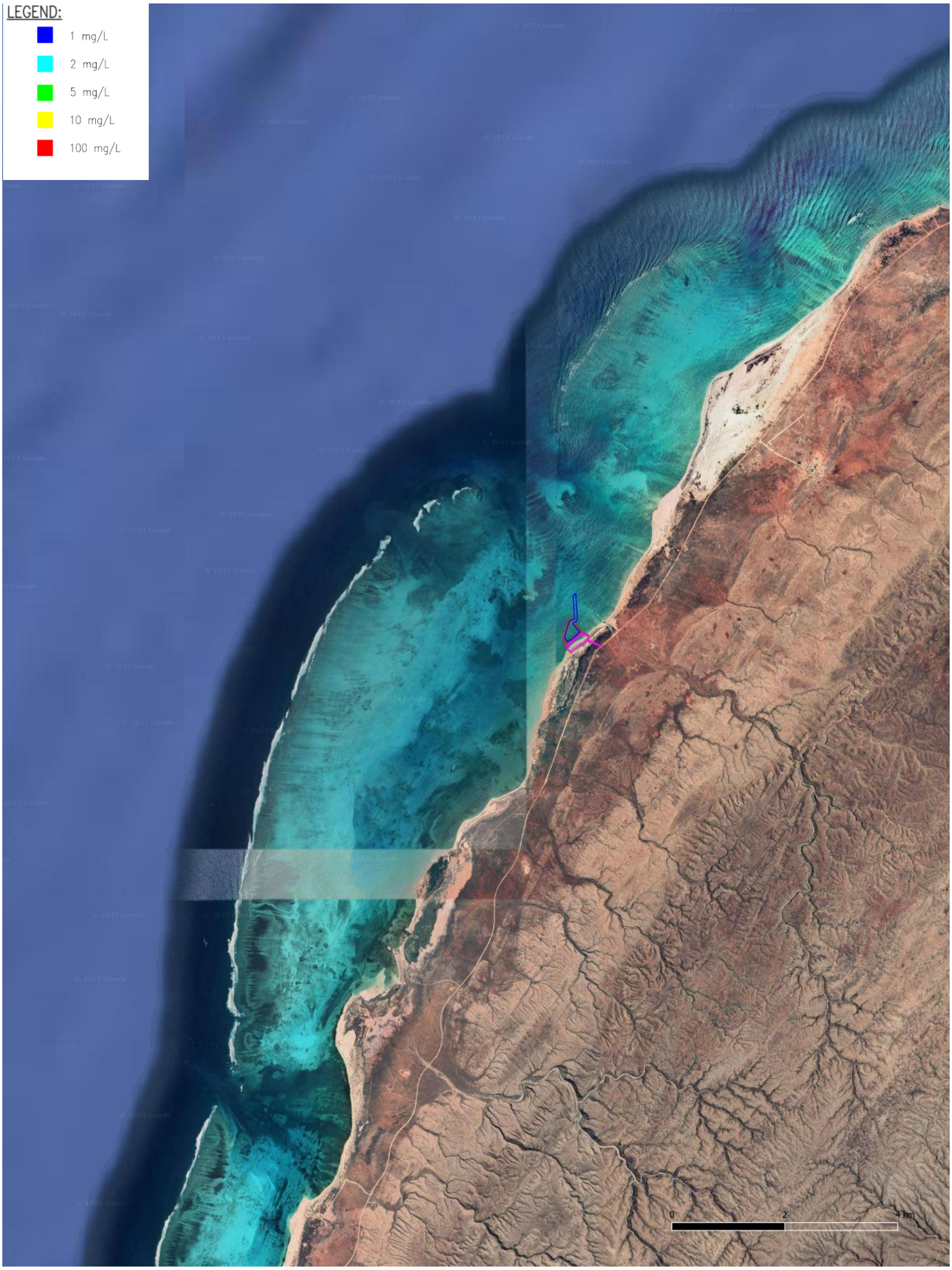
Run 15 - 50% Exceedance Zoomed In



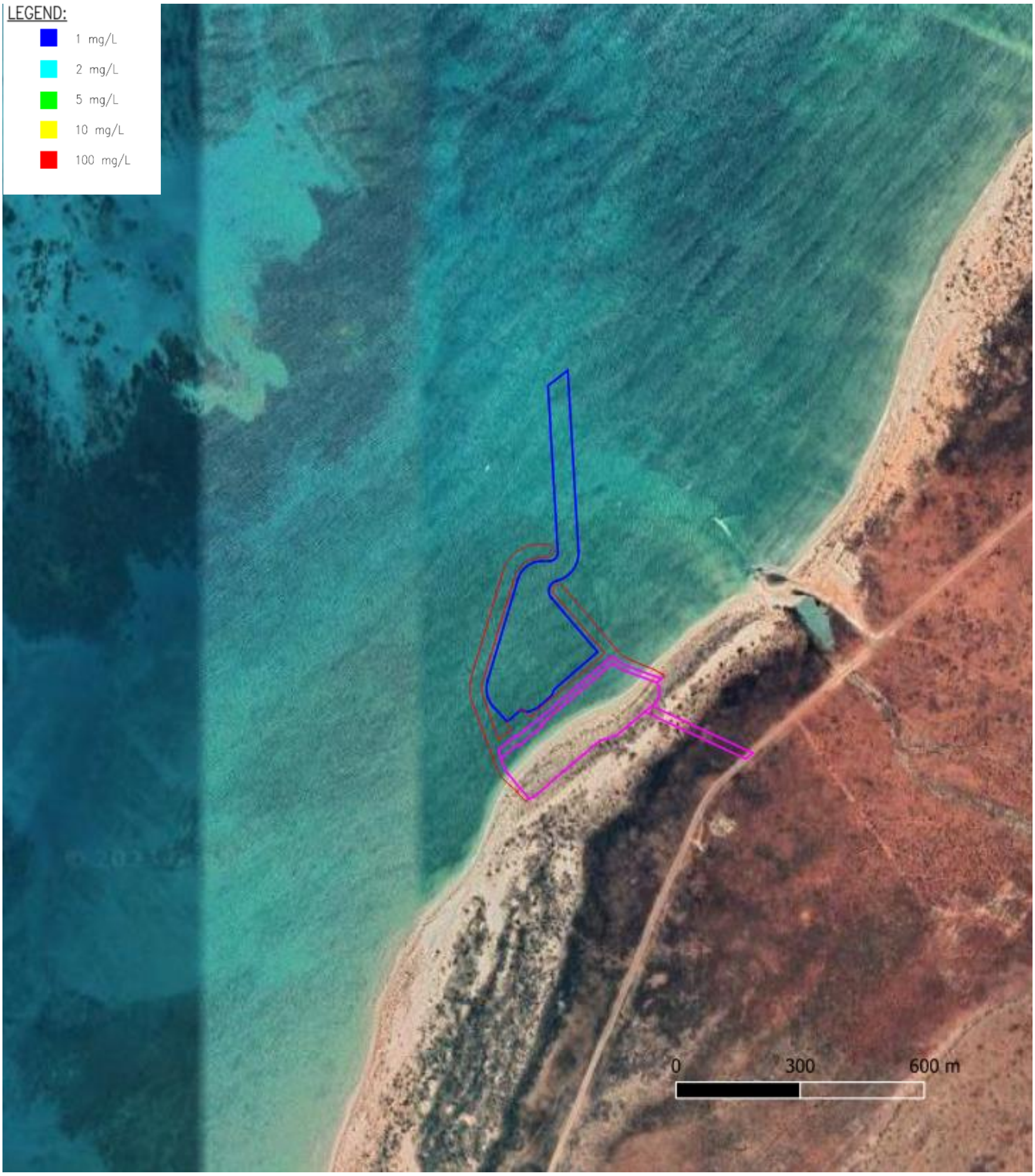
Run 15 - 80% Exceedance



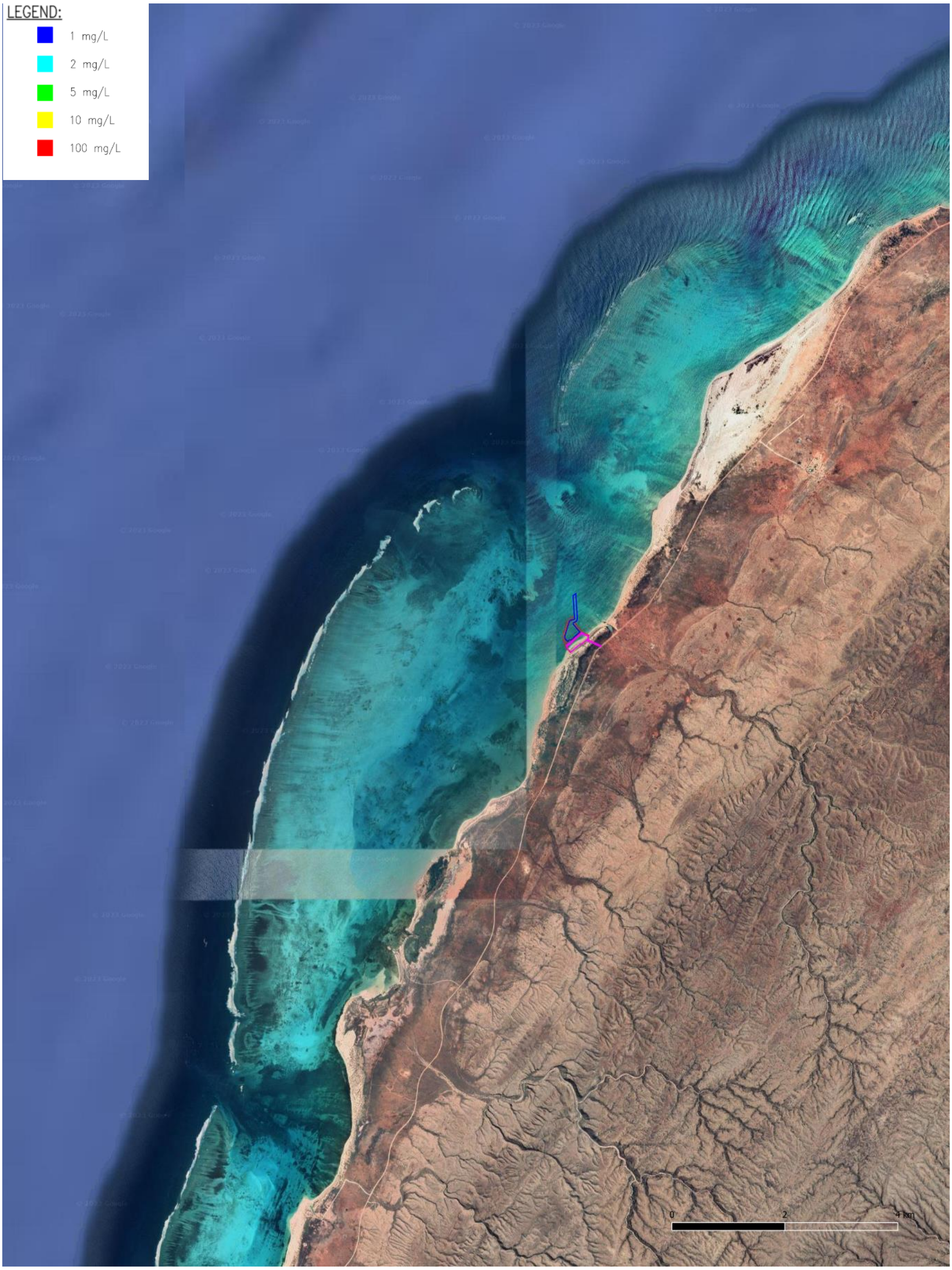
Run 15 - 80% Exceedance Zoomed In



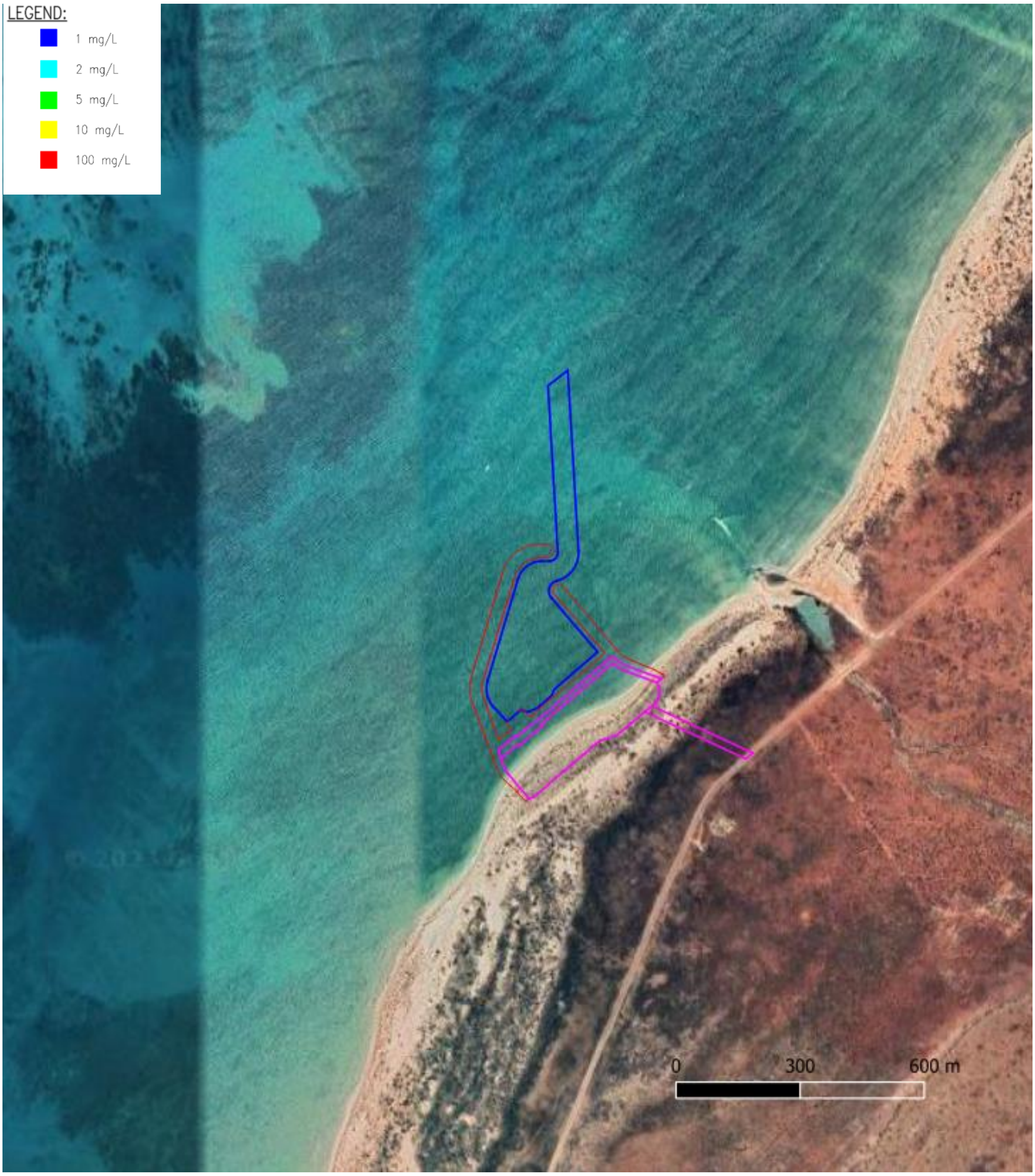
Run 15 - 95% Exceedance



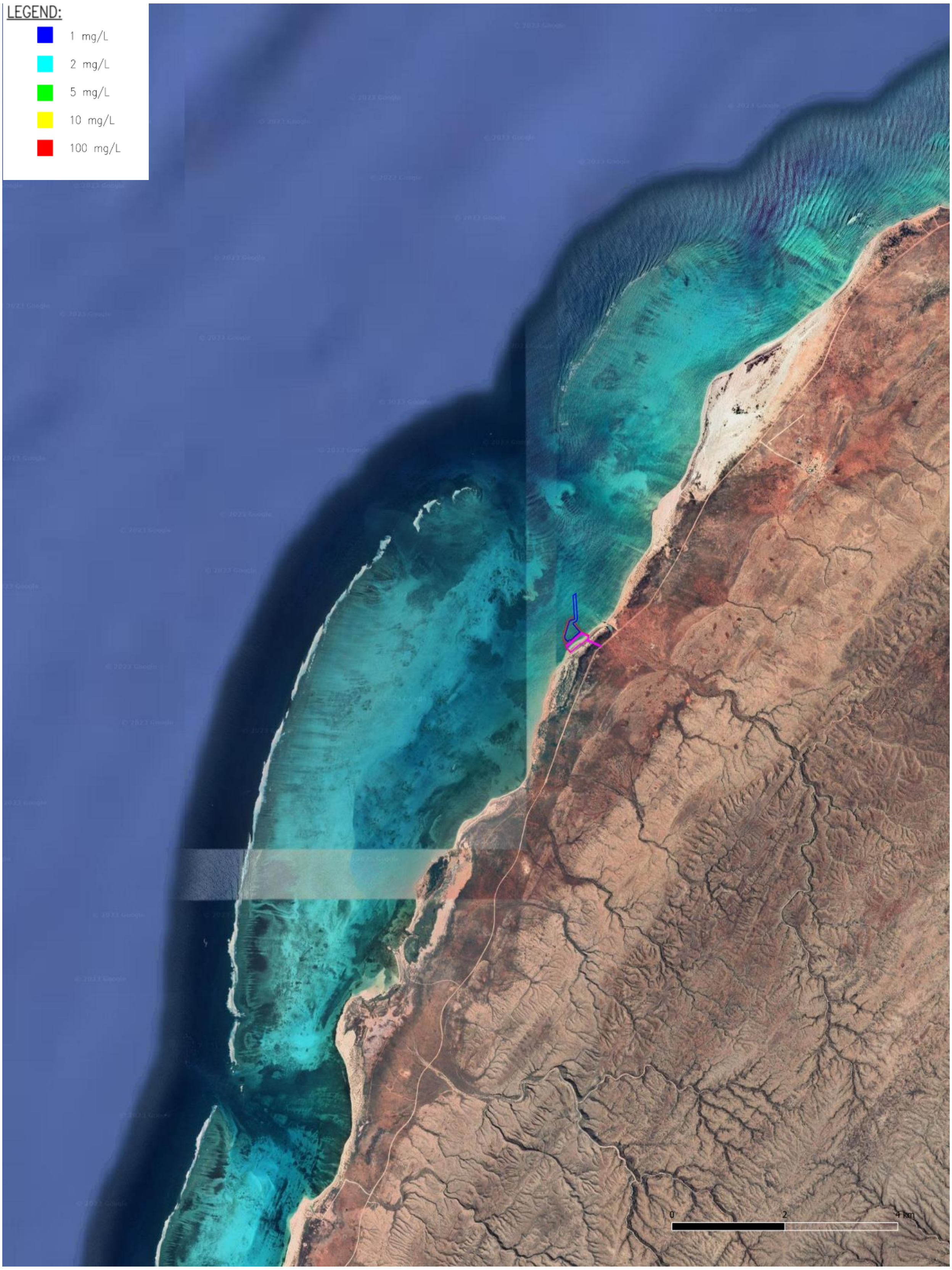
Run 15 - 95% Exceedance Zoomed In



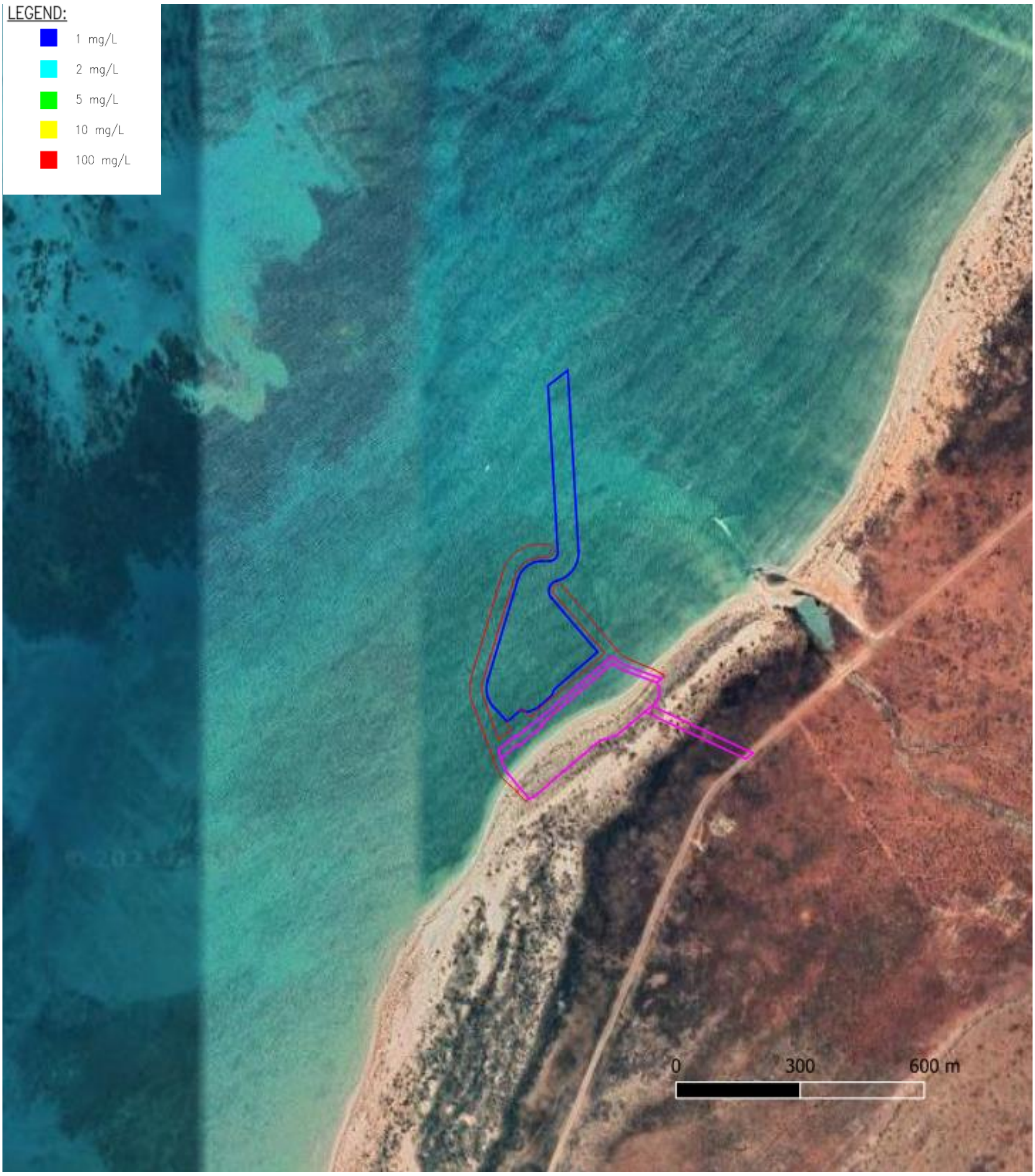
Run 16 - 50% Exceedance



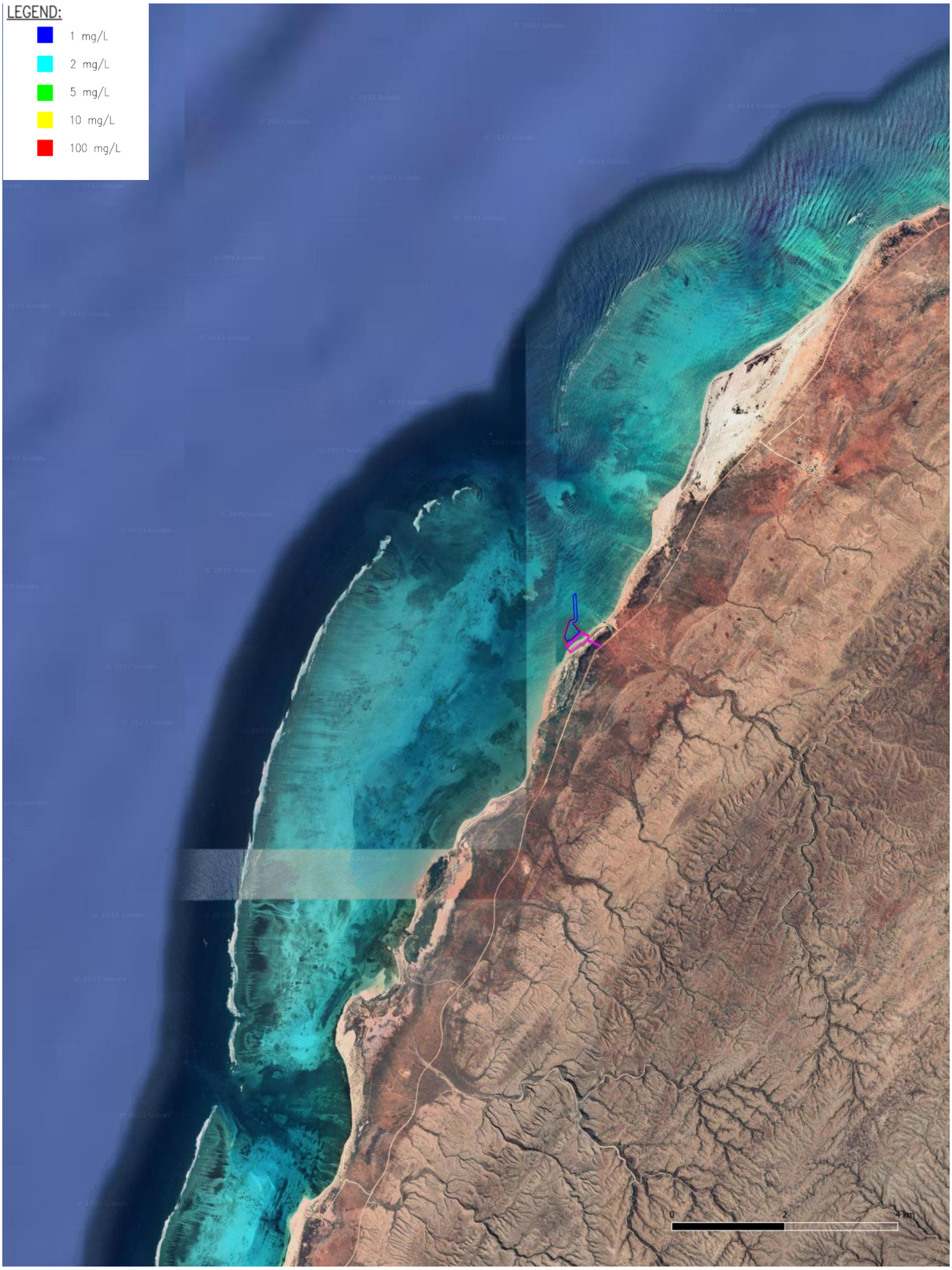
Run 16 - 50% Exceedance Zoomed In



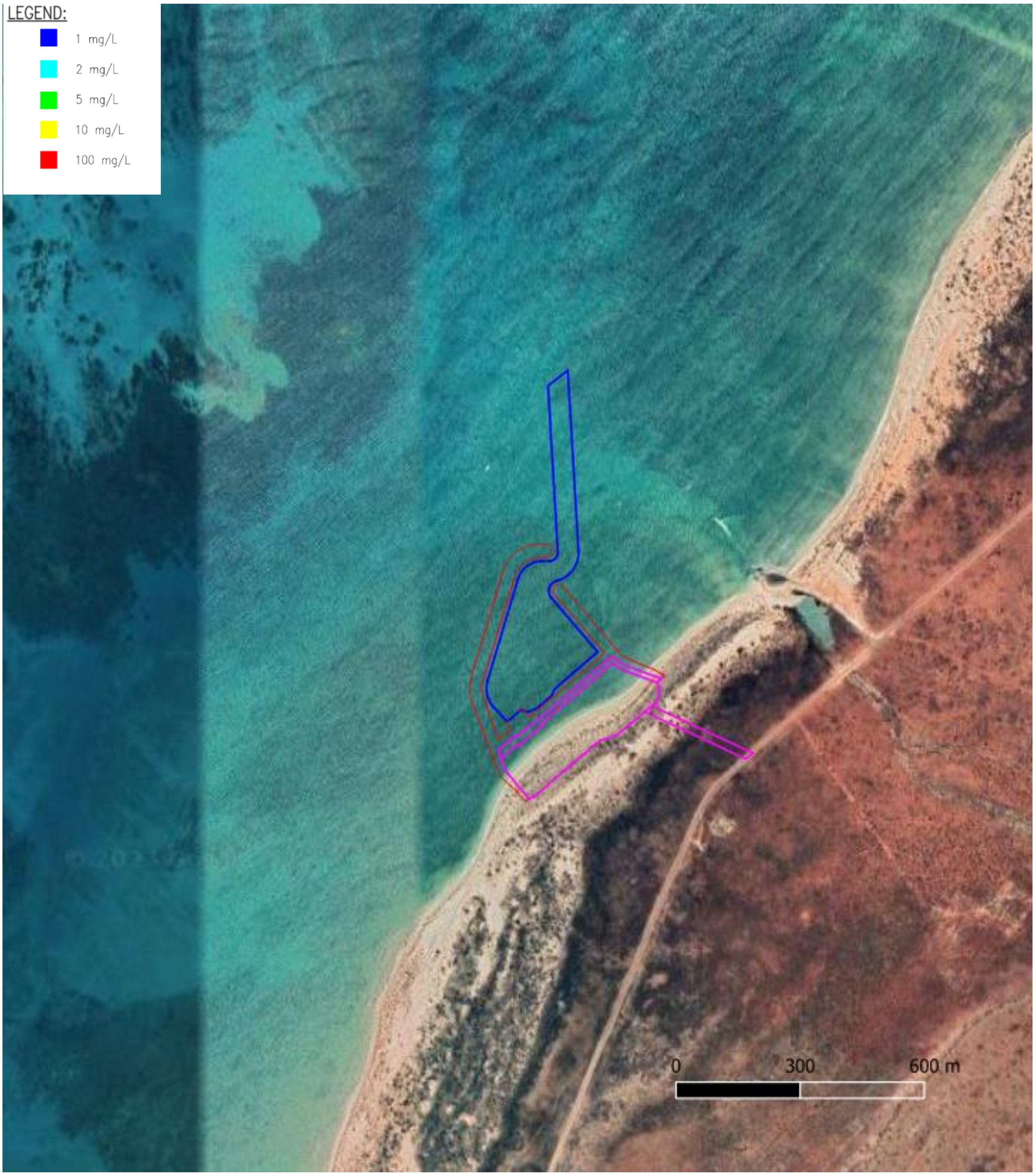
Run 16 - 80% Exceedance



Run 16 - 80% Exceedance Zoomed In

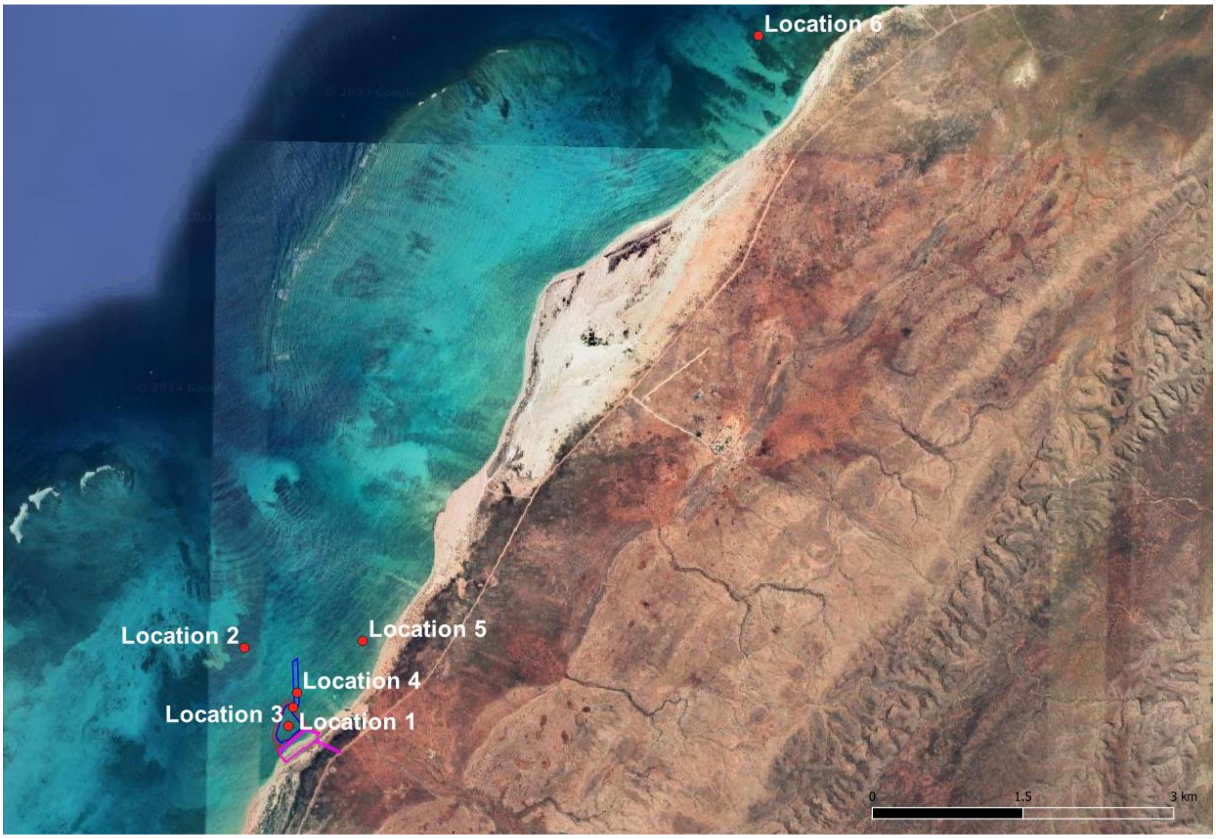


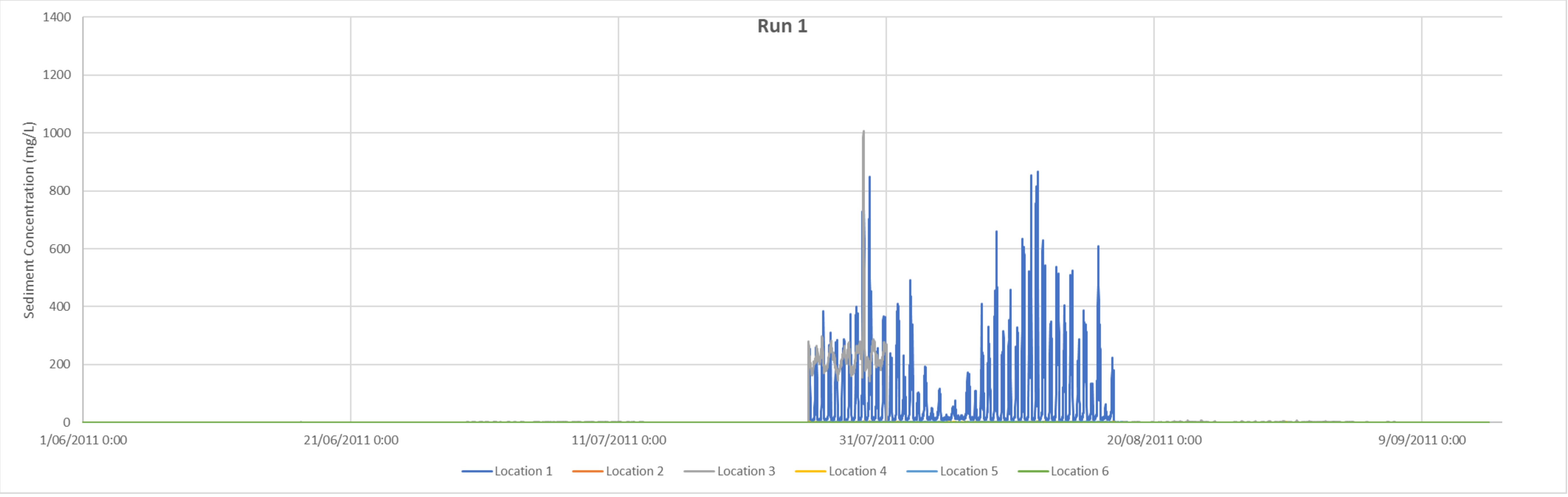
Run 16 - 95% Exceedance



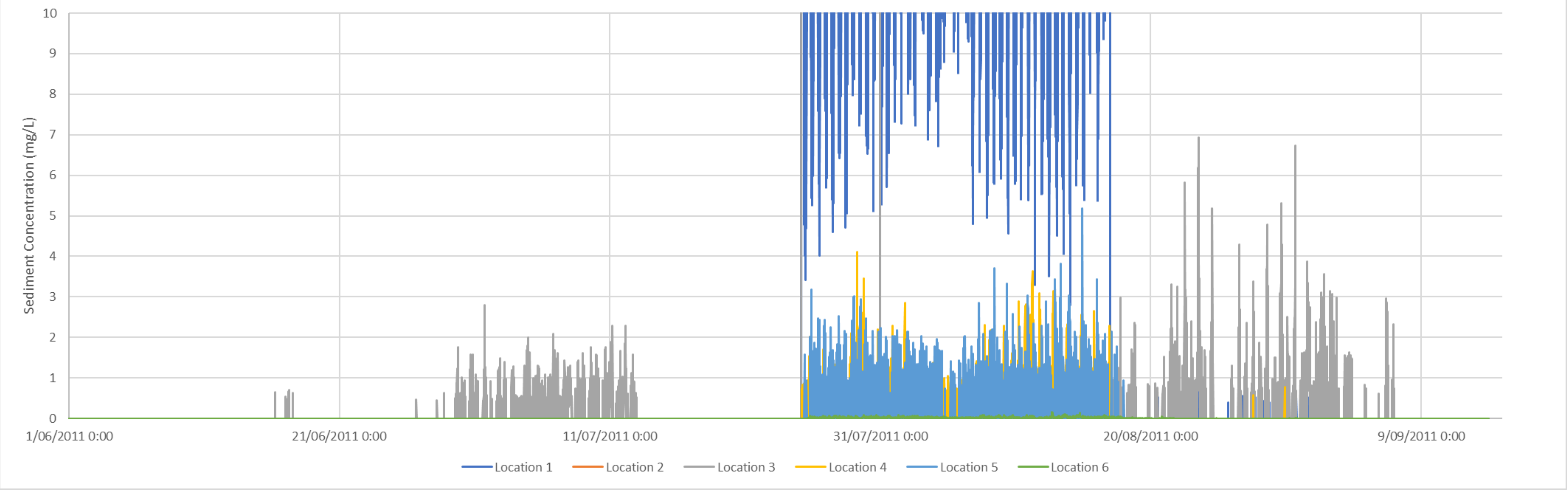
Run 16 - 95% Exceedance Zoomed In

Appendix B Times Series Plots

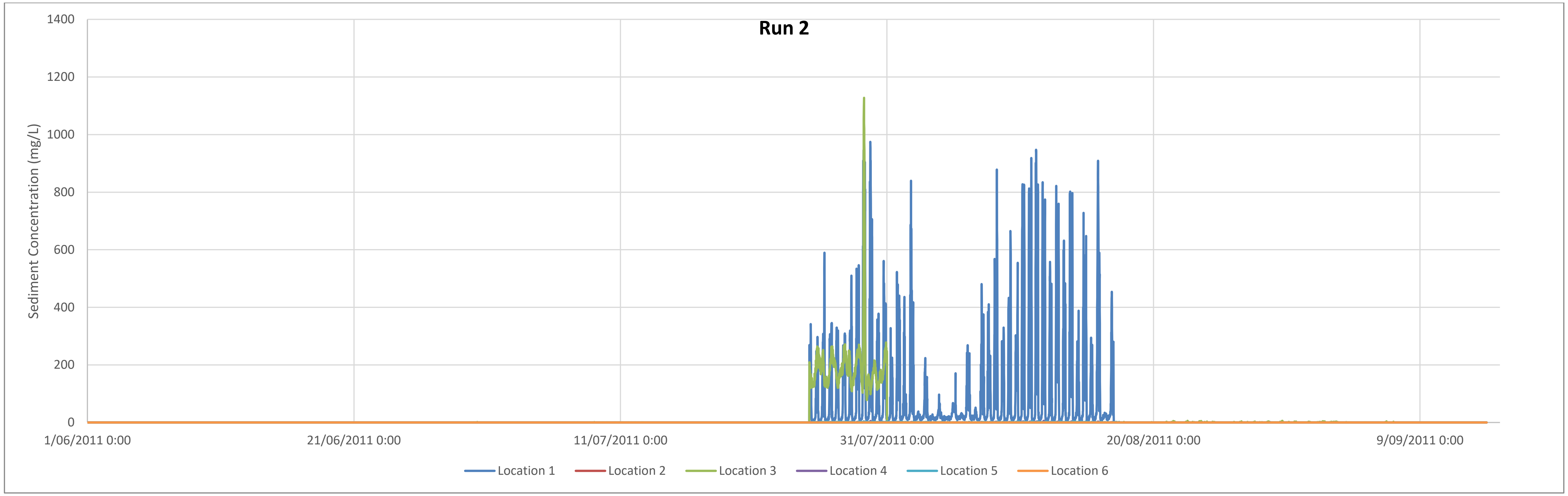


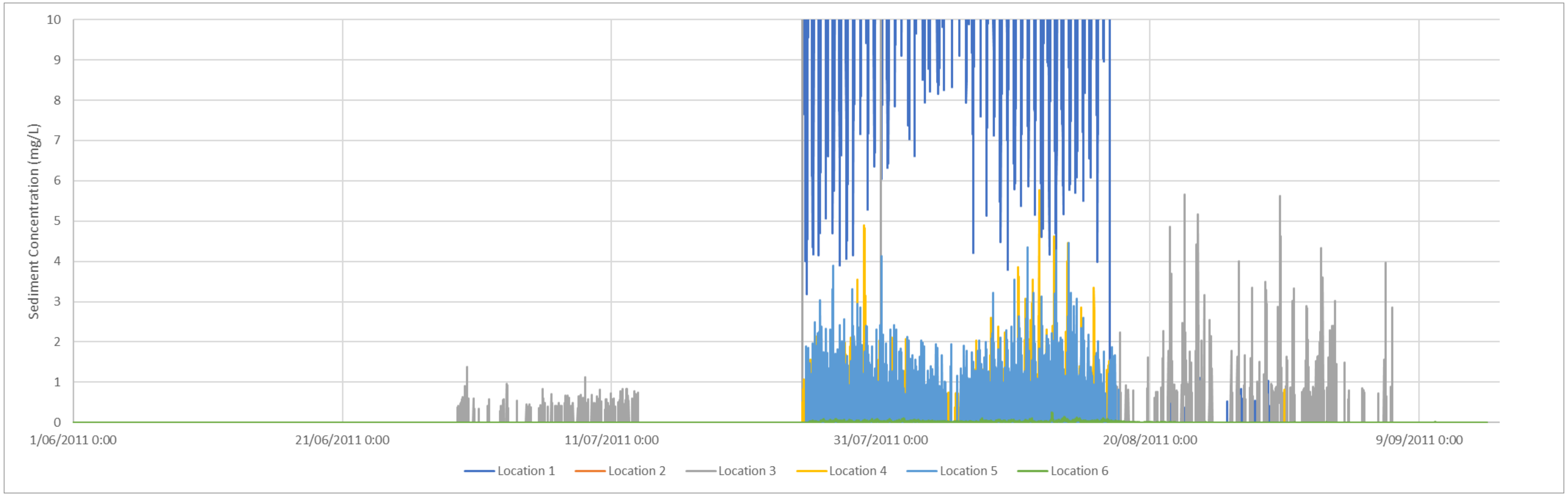


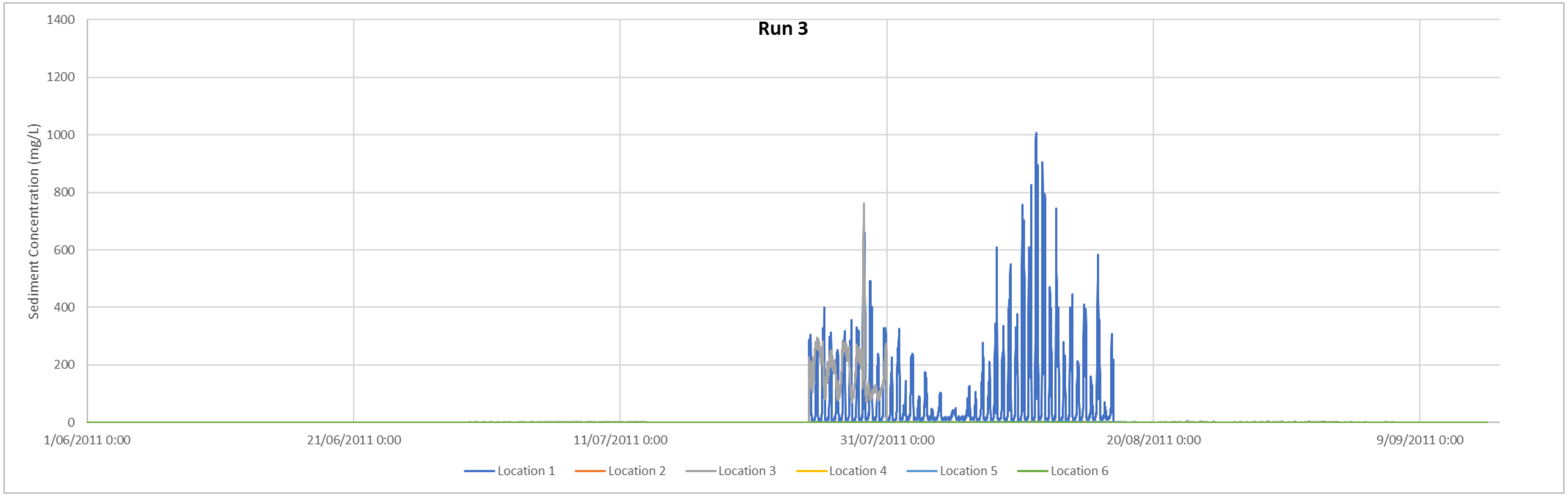
Run 1
Sediment Concentration (mg/L)
1400
1200
1000
800
600
400
200
0
1/06/2011 0:00
21/06/2011 0:00
11/07/2011 0:00
31/07/2011 0:00
20/08/2011 0:00
9/09/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

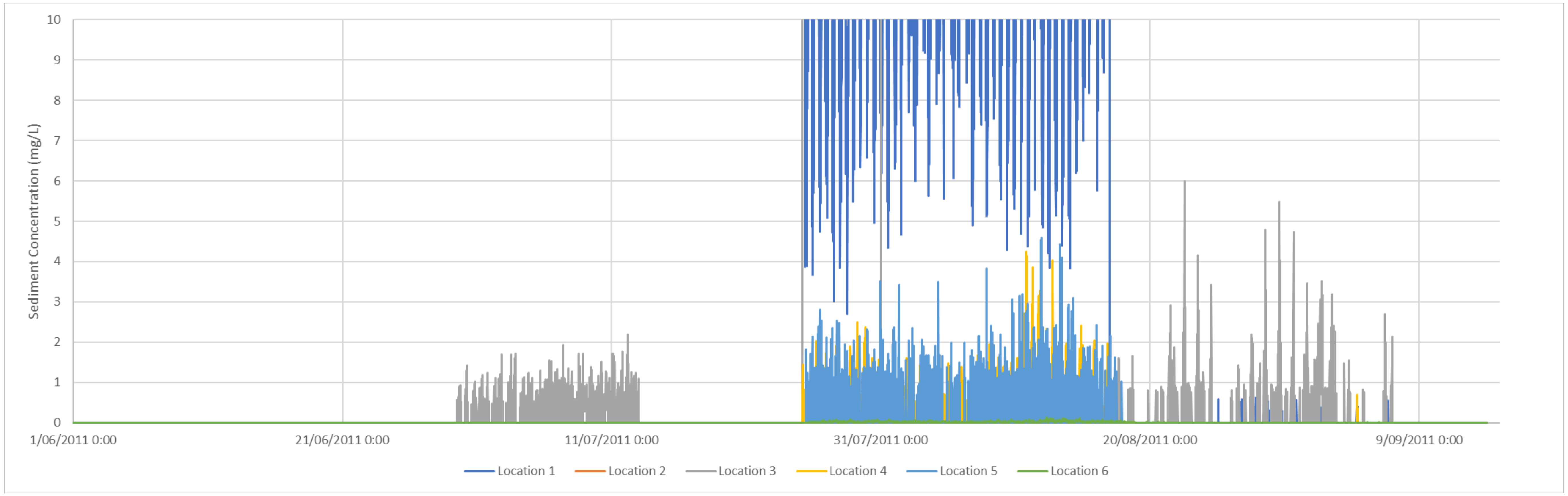


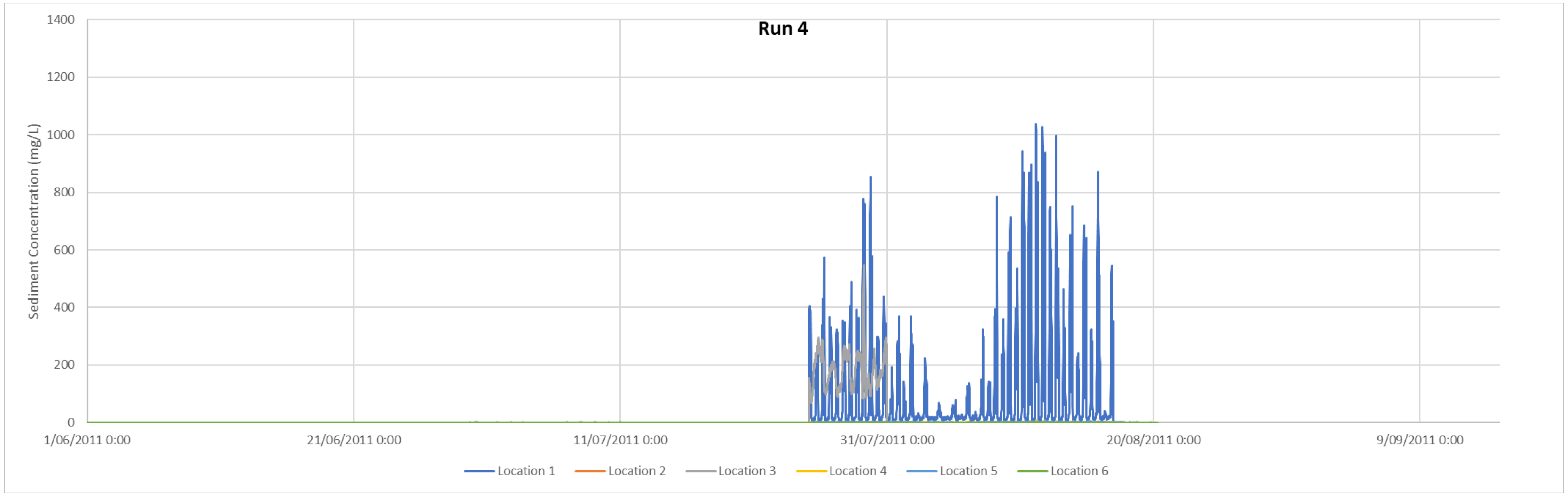
Sediment Concentration (mg/L)
10
9
8
7
6
5
4
3
2
1
0
1/06/2011 0:00
21/06/2011 0:00
11/07/2011 0:00
31/07/2011 0:00
20/08/2011 0:00
9/09/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

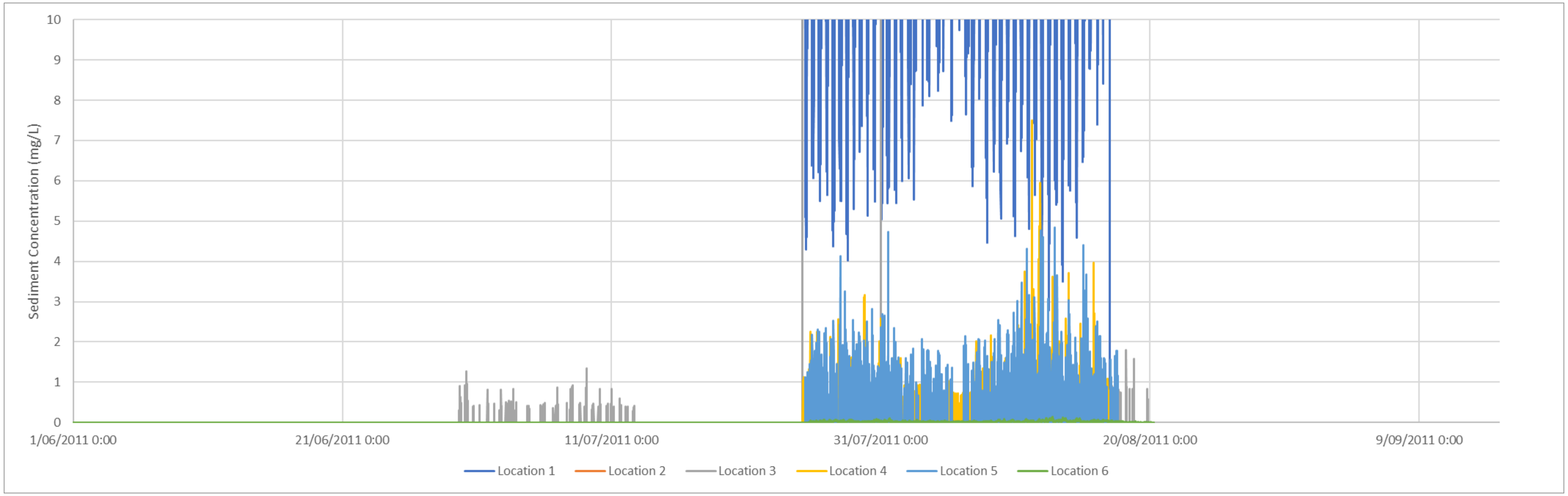

Run 2
Sediment Concentration (mg/L)
1400
1200
1000
800
600
400
200
0
1/06/2011 0:00
21/06/2011 0:00
11/07/2011 0:00
31/07/2011 0:00
20/08/2011 0:00
9/09/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

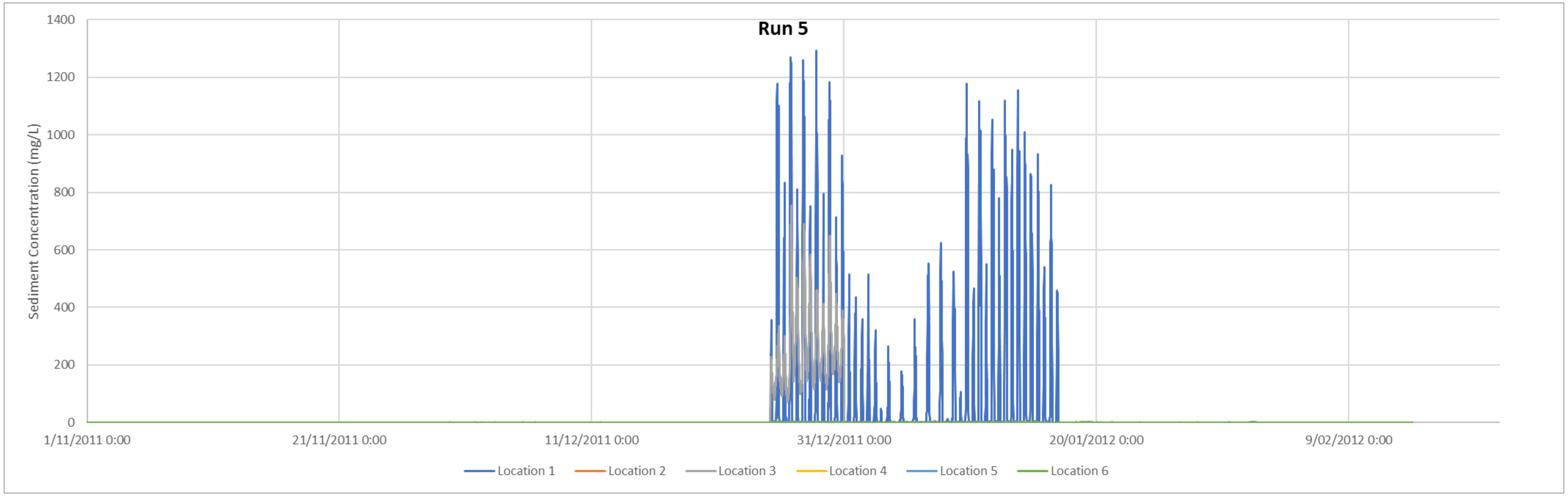

Sediment Concentration (mg/L)
10
9
8
7
6
5
4
3
2
1
0
1/06/2011 0:00
21/06/2011 0:00
11/07/2011 0:00
31/07/2011 0:00
20/08/2011 0:00
9/09/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

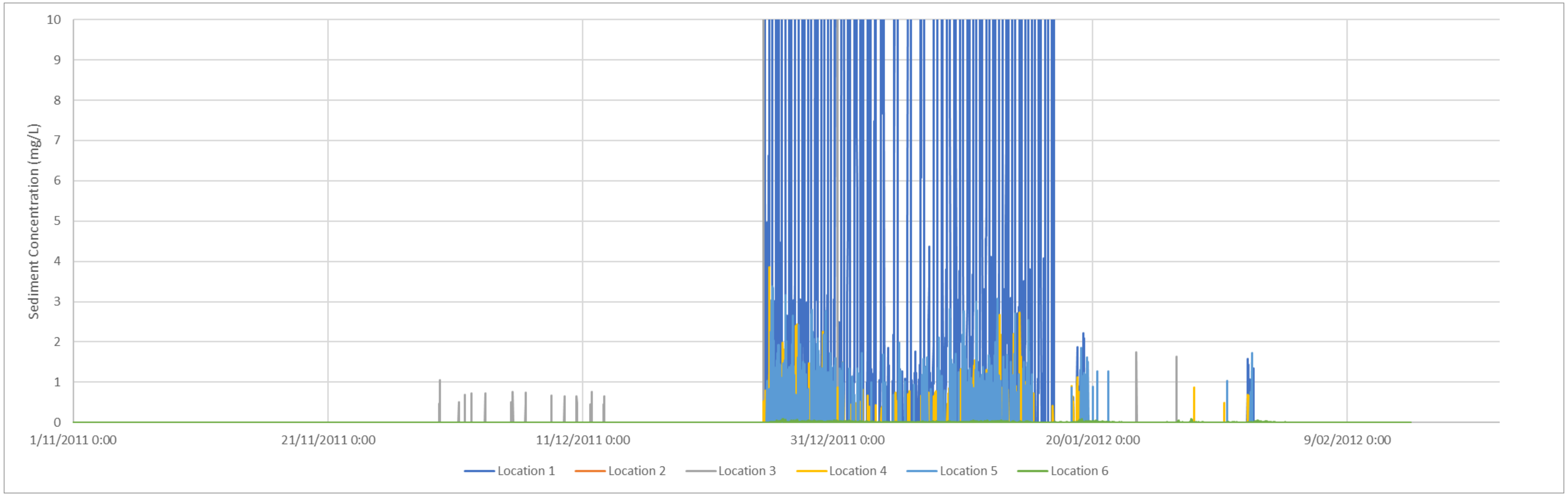

Run 3
Sediment Concentration (mg/L)
1400
1200
1000
800
600
400
200
0
1/06/2011 0:00
21/06/2011 0:00
11/07/2011 0:00
31/07/2011 0:00
20/08/2011 0:00
9/09/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

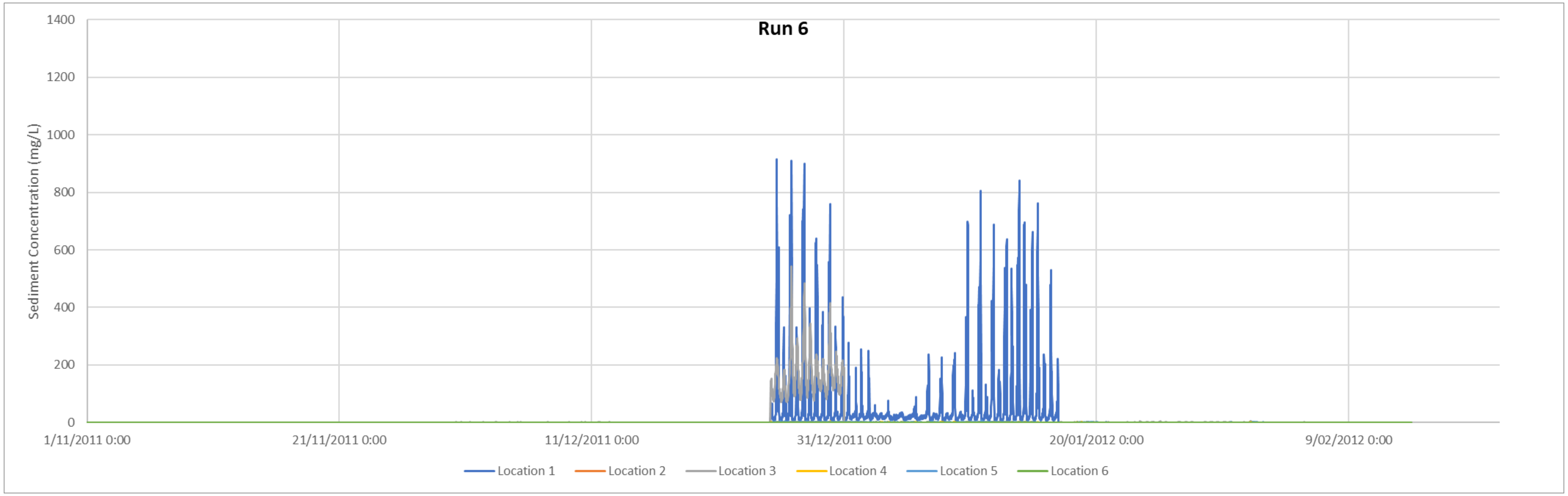

Sediment Concentration (mg/L)
10
9
8
7
6
5
4
3
2
1
0
1/06/2011 0:00
21/06/2011 0:00
11/07/2011 0:00
31/07/2011 0:00
20/08/2011 0:00
9/09/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

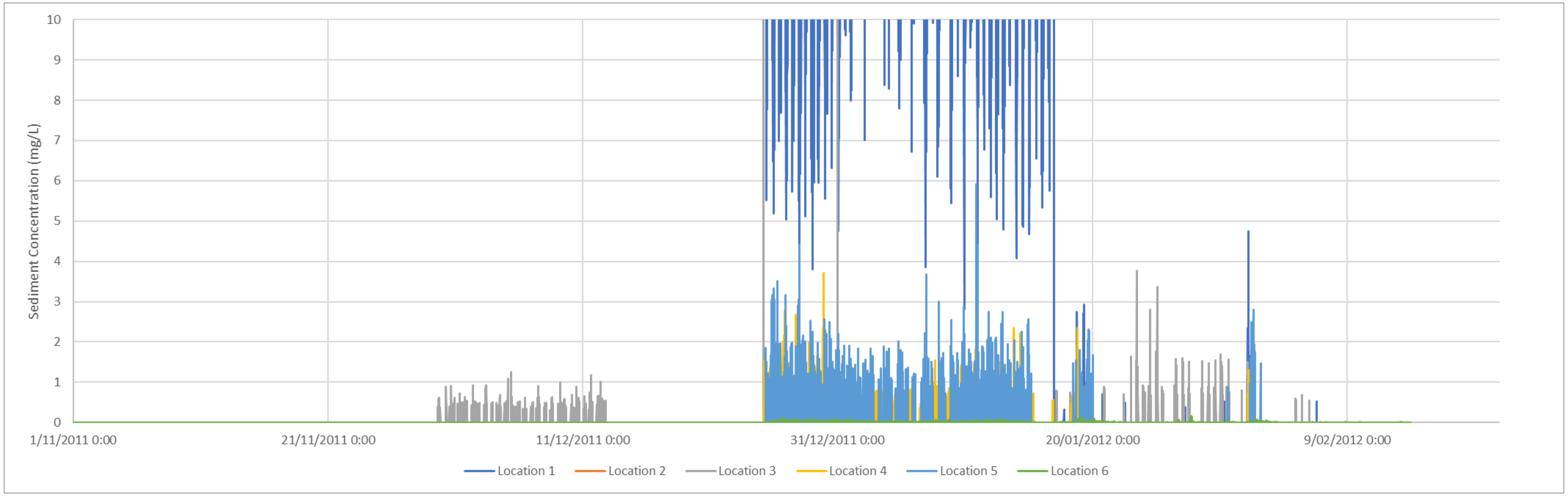

Run 4
Sediment Concentration (mg/L)
1400
1200
1000
800
600
400
200
0
1/06/2011 0:00
21/06/2011 0:00
11/07/2011 0:00
31/07/2011 0:00
20/08/2011 0:00
9/09/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

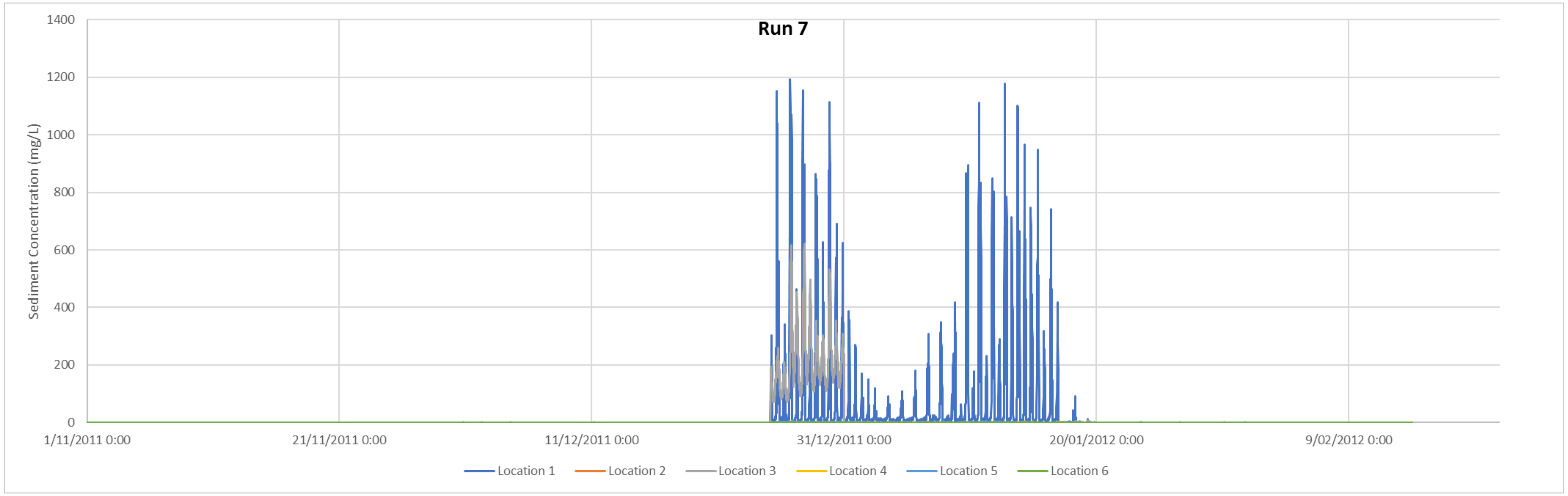

Sediment Concentration (mg/L)
10
9
8
7
6
5
4
3
2
1
0
1/06/2011 0:00
21/06/2011 0:00
11/07/2011 0:00
31/07/2011 0:00
20/08/2011 0:00
9/09/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

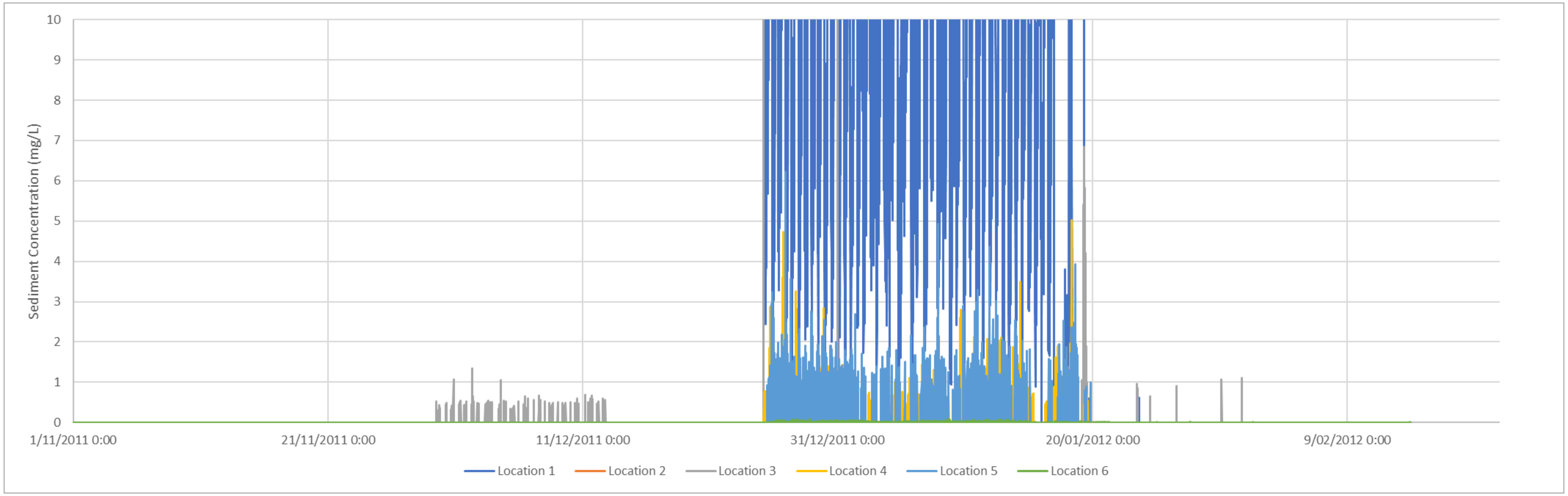

Run 5
Sediment Concentration (mg/L)
1400
1200
1000
800
600
400
200
0
1/11/2011 0:00
21/11/2011 0:00
11/12/2011 0:00
31/12/2011 0:00
20/01/2012 0:00
9/02/2012 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

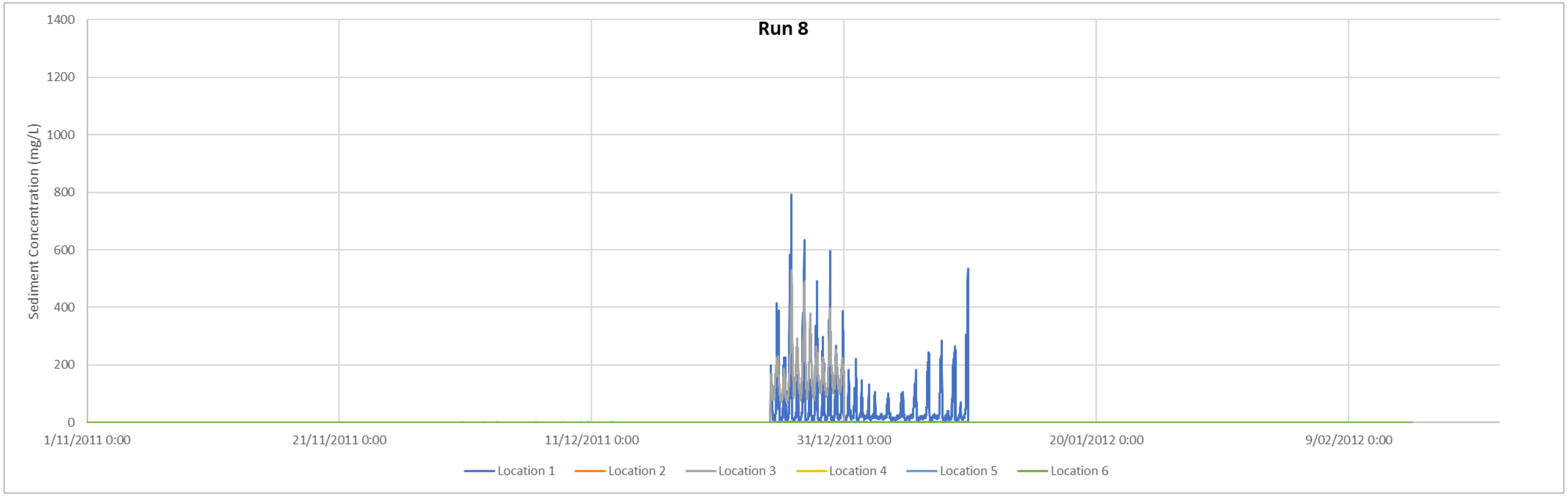

Sediment Concentration (mg/L)
10
9
8
7
6
5
4
3
2
1
0
1/11/2011 0:00
21/11/2011 0:00
11/12/2011 0:00
31/12/2011 0:00
20/01/2012 0:00
9/02/2012 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6


Run 6
Sediment Concentration (mg/L)
1400
1200
1000
800
600
400
200
0
1/11/2011 0:00
21/11/2011 0:00
11/12/2011 0:00
31/12/2011 0:00
20/01/2012 0:00
9/02/2012 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

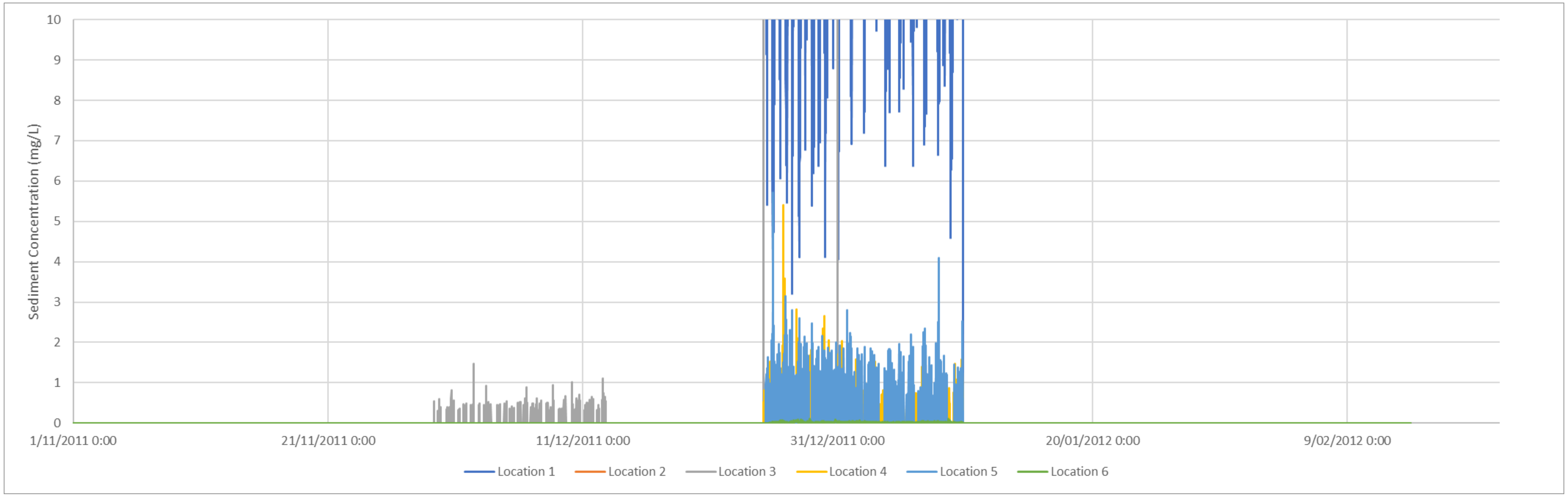

Sediment Concentration (mg/L)
10
9
8
7
6
5
4
3
2
1
0
1/11/2011 0:00
21/11/2011 0:00
11/12/2011 0:00
31/12/2011 0:00
20/01/2012 0:00
9/02/2012 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6


Run 7
Sediment Concentration (mg/L)
1400
1200
1000
800
600
400
200
0
1/11/2011 0:00
21/11/2011 0:00
11/12/2011 0:00
31/12/2011 0:00
20/01/2012 0:00
9/02/2012 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

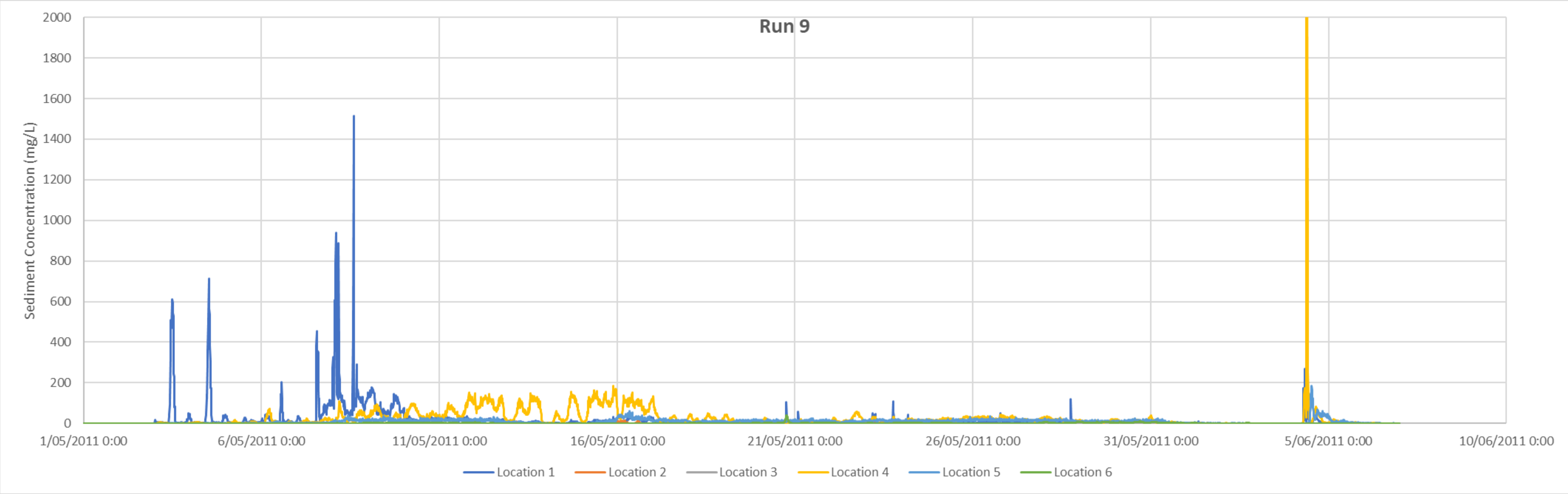

Sediment Concentration (mg/L)
10
9
8
7
6
5
4
3
2
1
0
1/11/2011 0:00
21/11/2011 0:00
11/12/2011 0:00
31/12/2011 0:00
20/01/2012 0:00
9/02/2012 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

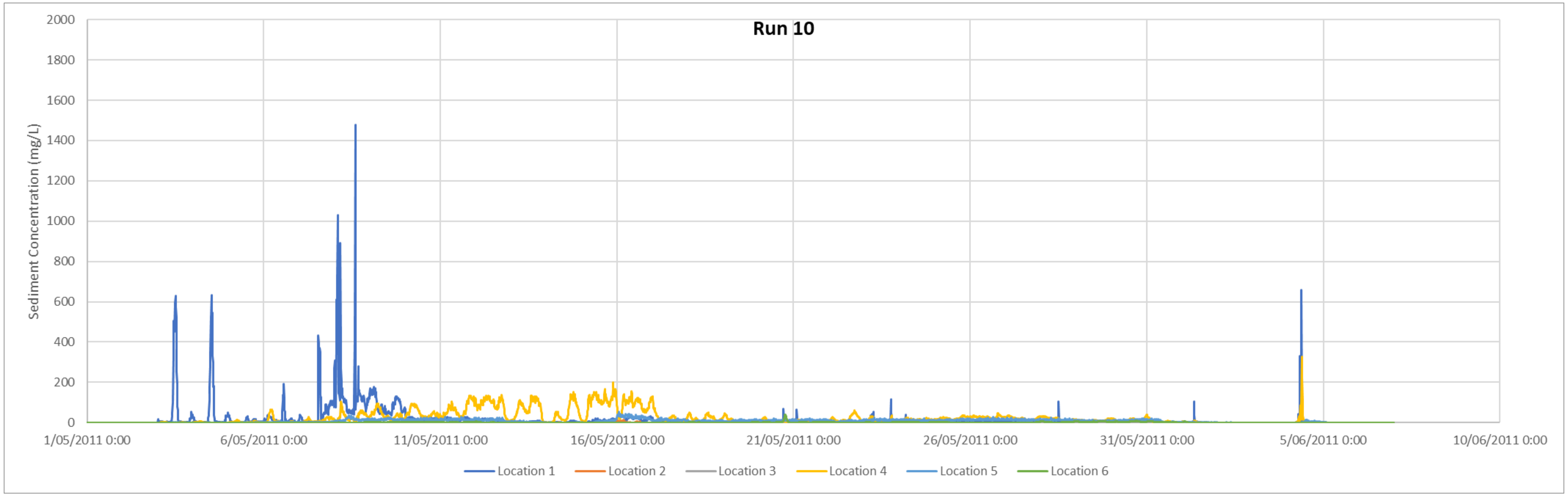


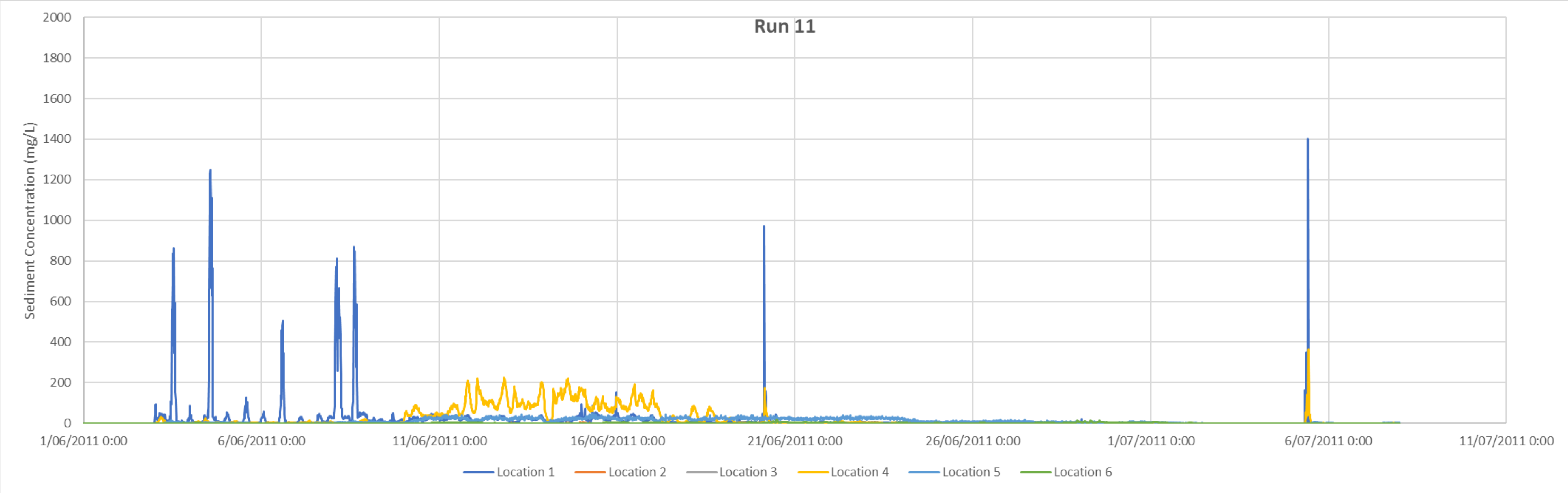
Run 8
Sediment Concentration (mg/L)
1400
1200
1000
800
600
400
200
0
1/11/2011 0:00
21/11/2011 0:00
11/12/2011 0:00
31/12/2011 0:00
20/01/2012 0:00
9/02/2012 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

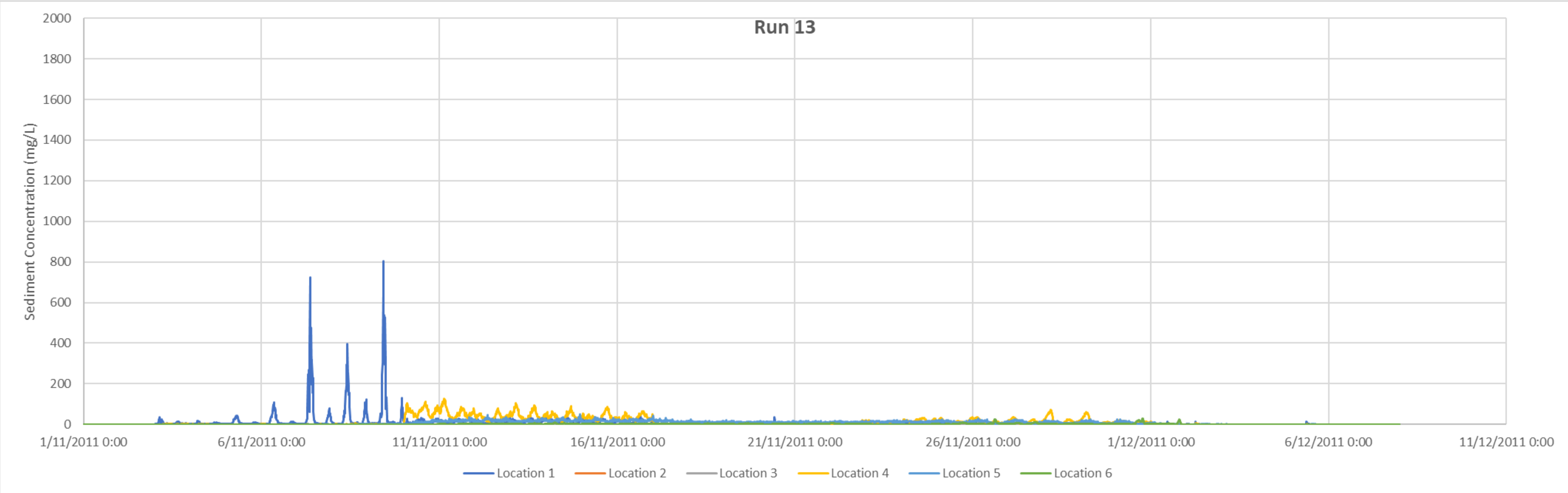


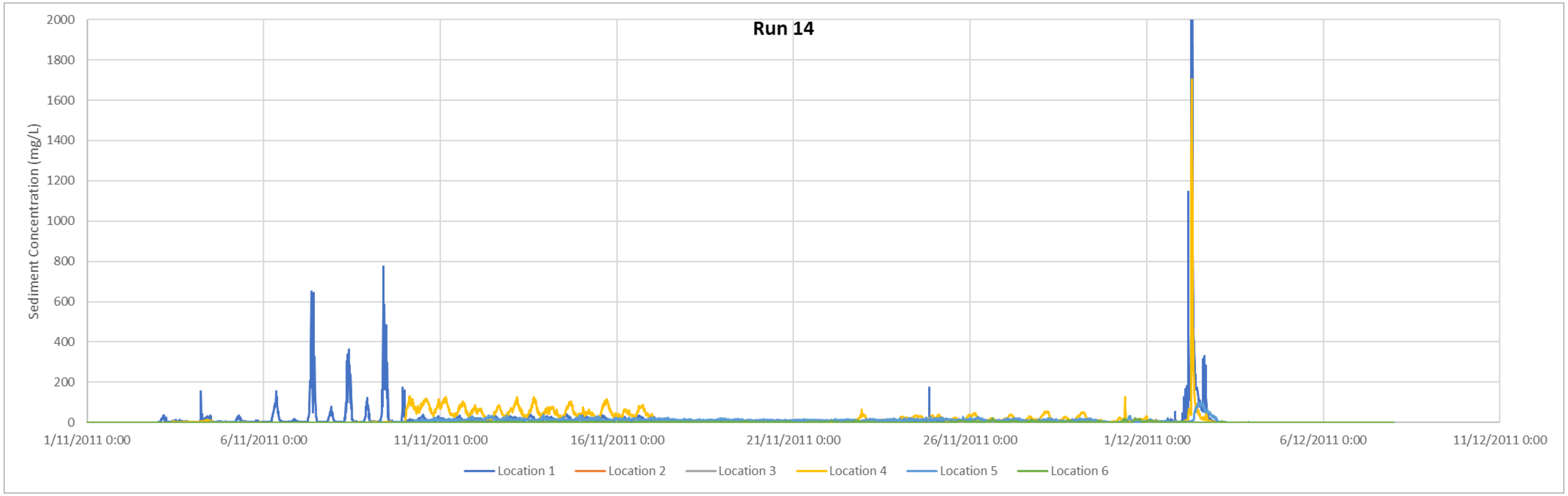
Sediment Concentration (mg/L)
10
9
8
7
6
5
4
3
2
1
0
1/11/2011 0:00
21/11/2011 0:00
11/12/2011 0:00
31/12/2011 0:00
20/01/2012 0:00
9/02/2012 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6


Run 9
Sediment Concentration (mg/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1/05/2011 0:00
6/05/2011 0:00
11/05/2011 0:00
16/05/2011 0:00
21/05/2011 0:00
26/05/2011 0:00
31/05/2011 0:00
5/06/2011 0:00
10/06/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6


Run 10
Sediment Concentration (mg/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1/05/2011 0:00
6/05/2011 0:00
11/05/2011 0:00
16/05/2011 0:00
21/05/2011 0:00
26/05/2011 0:00
31/05/2011 0:00
5/06/2011 0:00
10/06/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

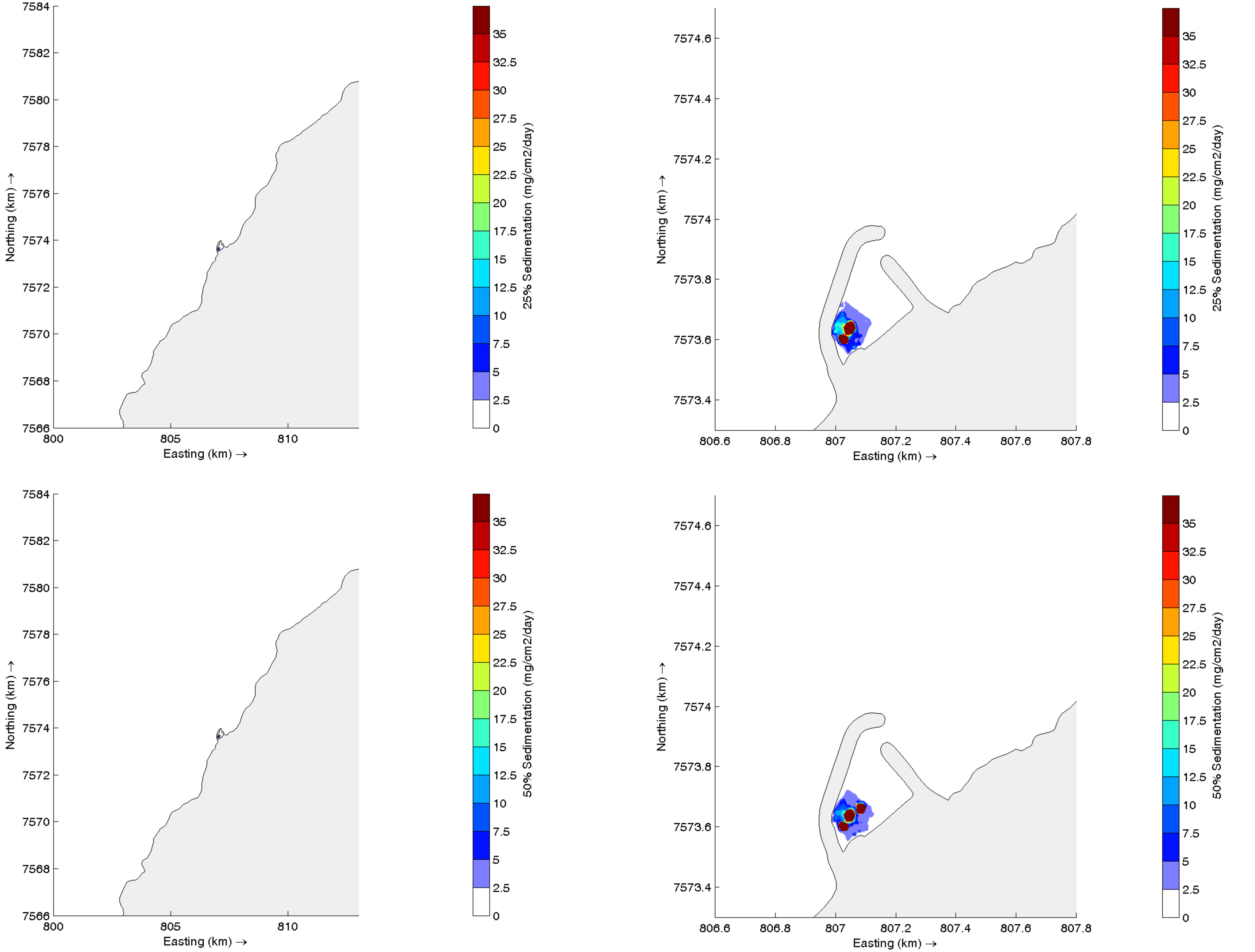

Run 11
Sediment Concentration (mg/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1/06/2011 0:00
6/06/2011 0:00
11/06/2011 0:00
16/06/2011 0:00
21/06/2011 0:00
26/06/2011 0:00
1/07/2011 0:00
6/07/2011 0:00
11/07/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6


Run 13
Sediment Concentration (mg/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1/11/2011 0:00
6/11/2011 0:00
11/11/2011 0:00
16/11/2011 0:00
21/11/2011 0:00
26/11/2011 0:00
1/12/2011 0:00
6/12/2011 0:00
11/12/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

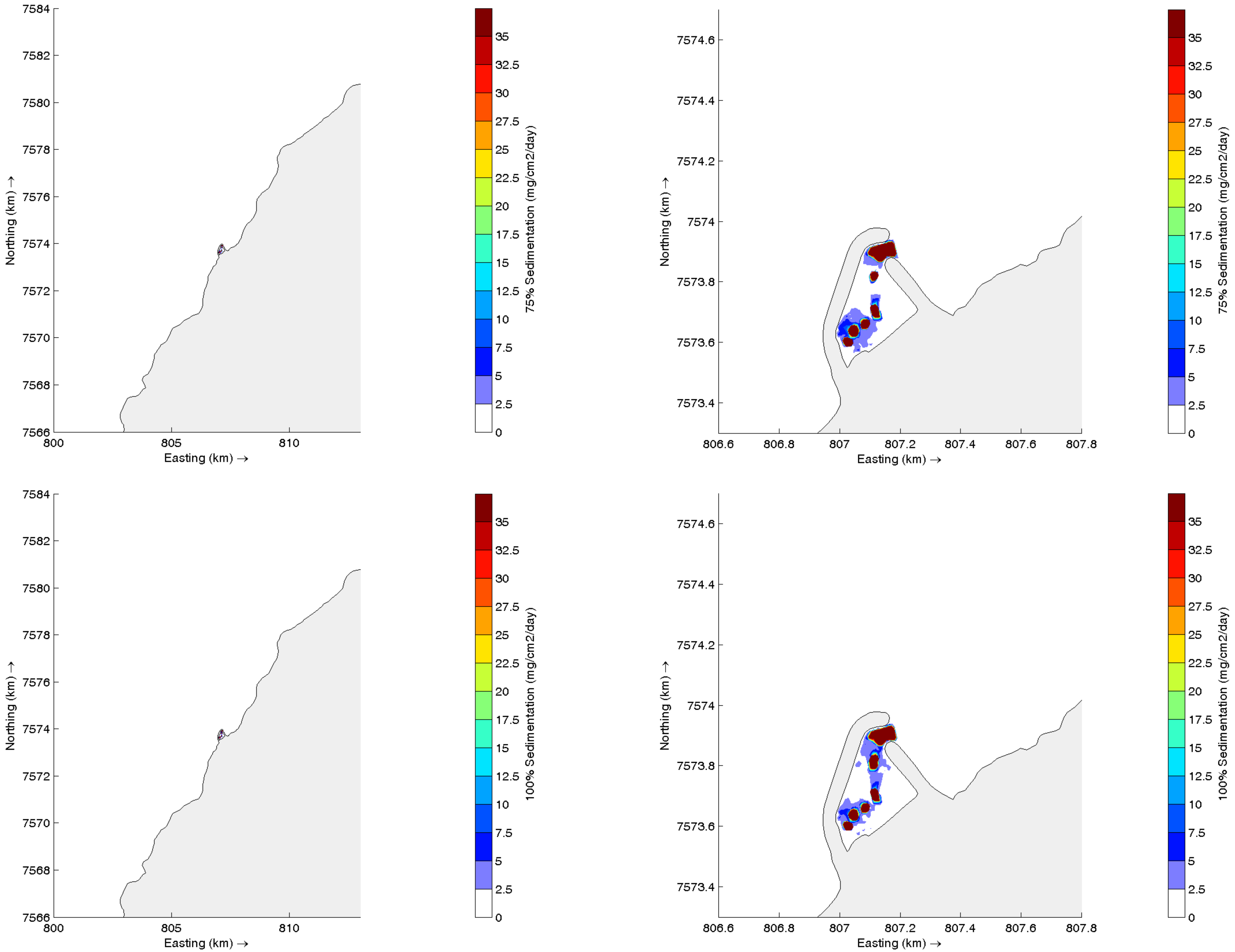

Run 14
Sediment Concentration (mg/L)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
1/11/2011 0:00
6/11/2011 0:00
11/11/2011 0:00
16/11/2011 0:00
21/11/2011 0:00
26/11/2011 0:00
1/12/2011 0:00
6/12/2011 0:00
11/12/2011 0:00
Location 1
Location 2
Location 3
Location 4
Location 5
Location 6

Appendix C Sedimentation Spatial Plots

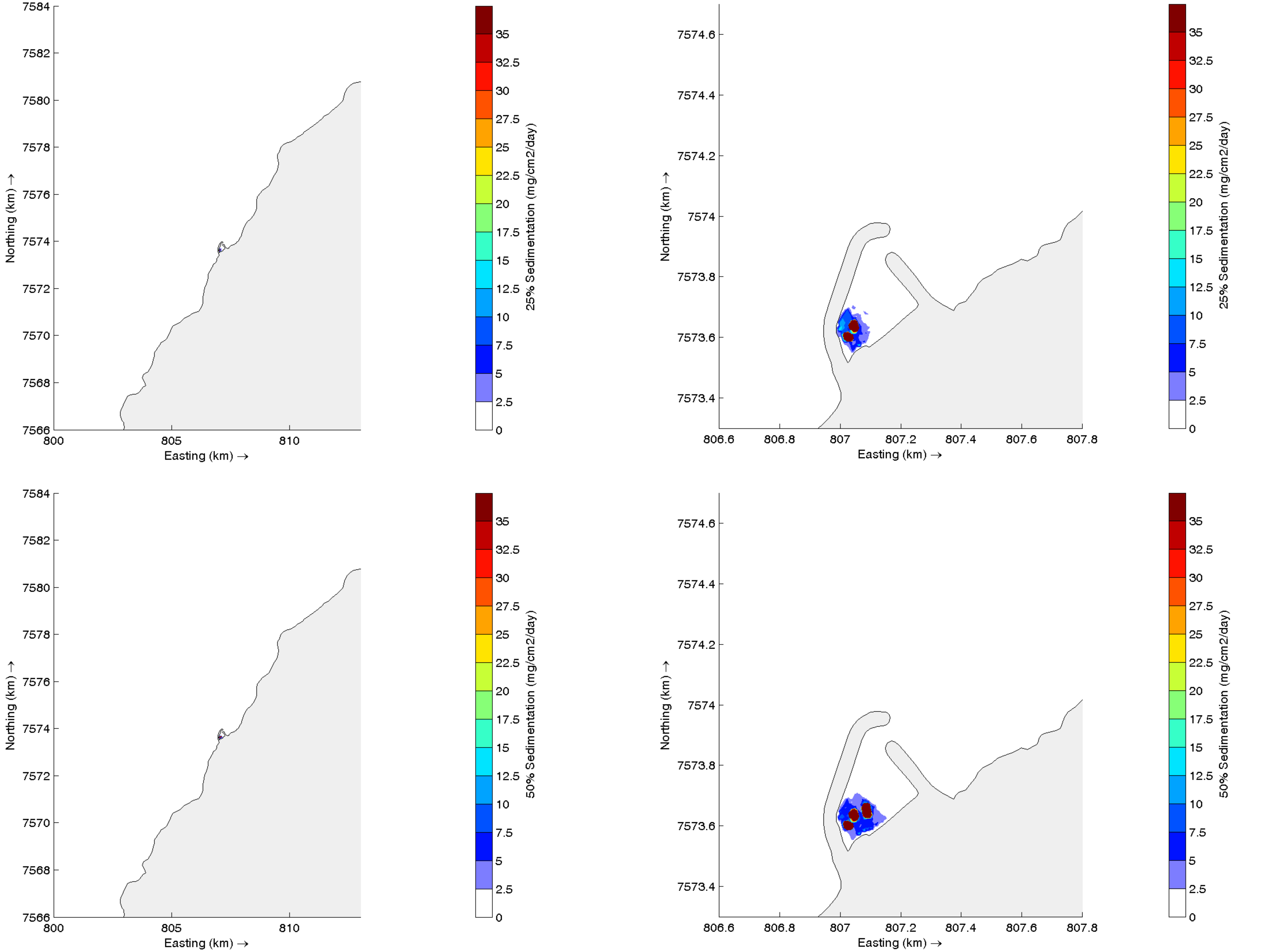
Run 1   25% (top) & 50% (bottom)



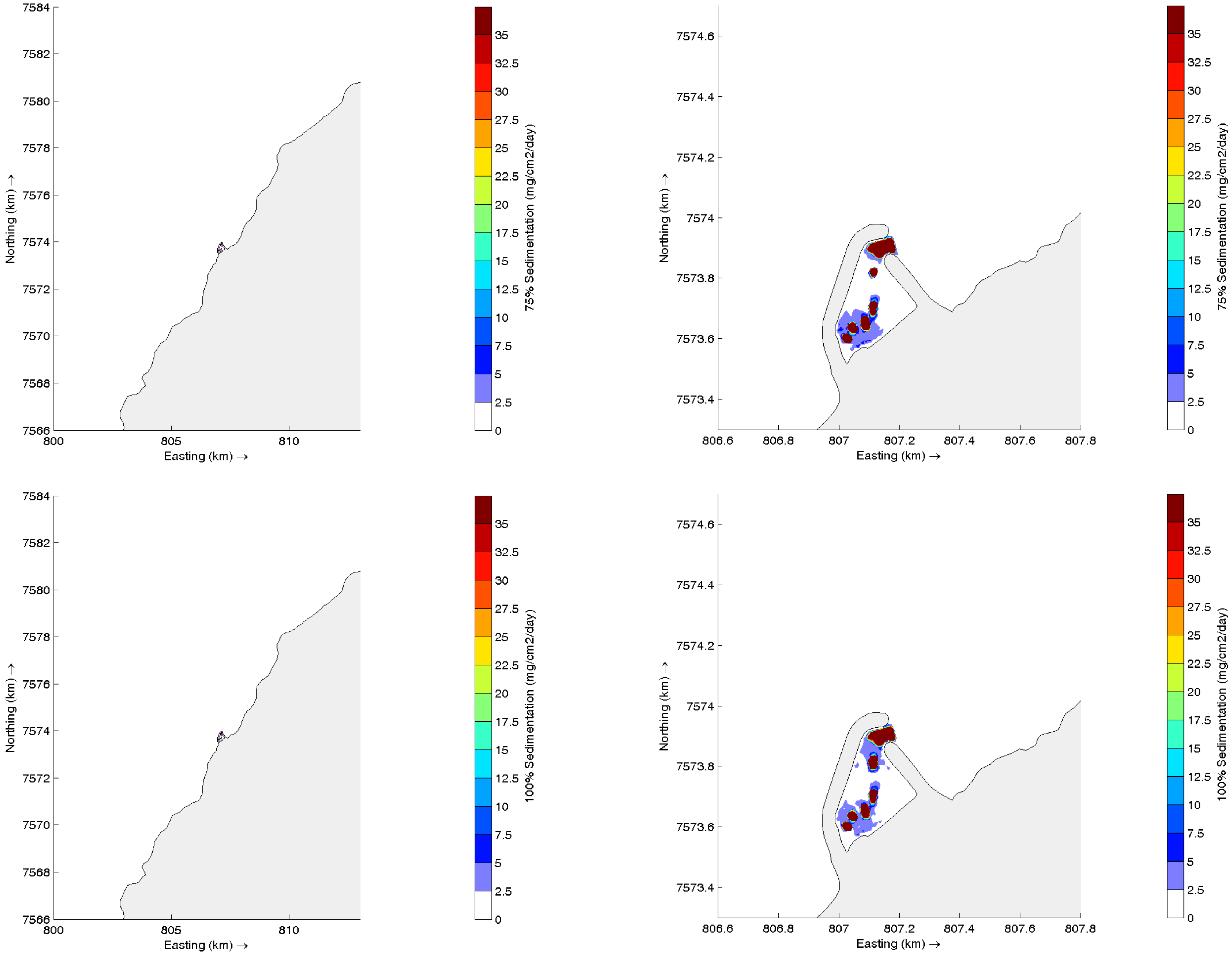
Run 1 75% (top) & 100% (bottom)



Run 2 25% (top) & 50% (bottom)

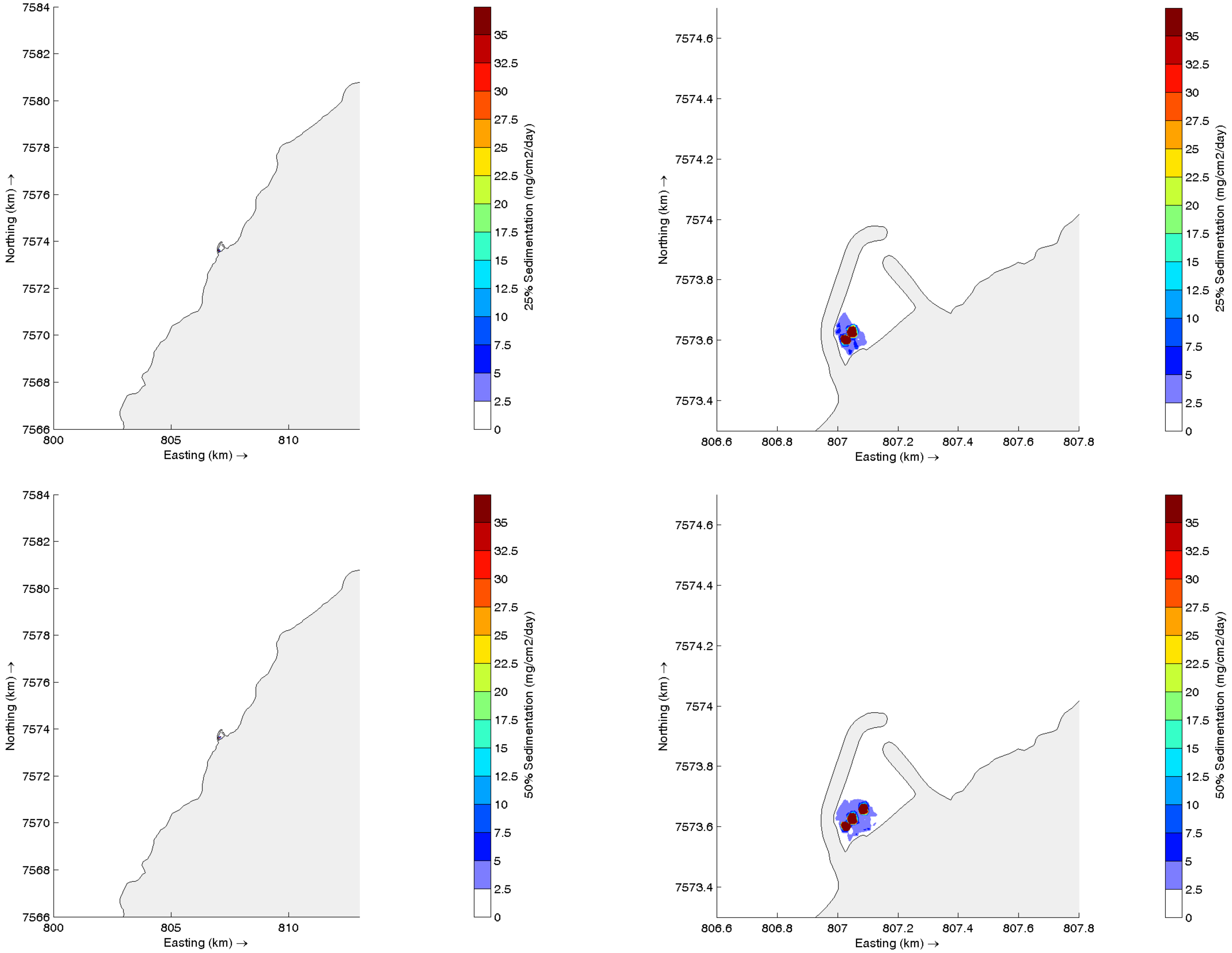


Run 2   75% (top) & 100% (bottom)

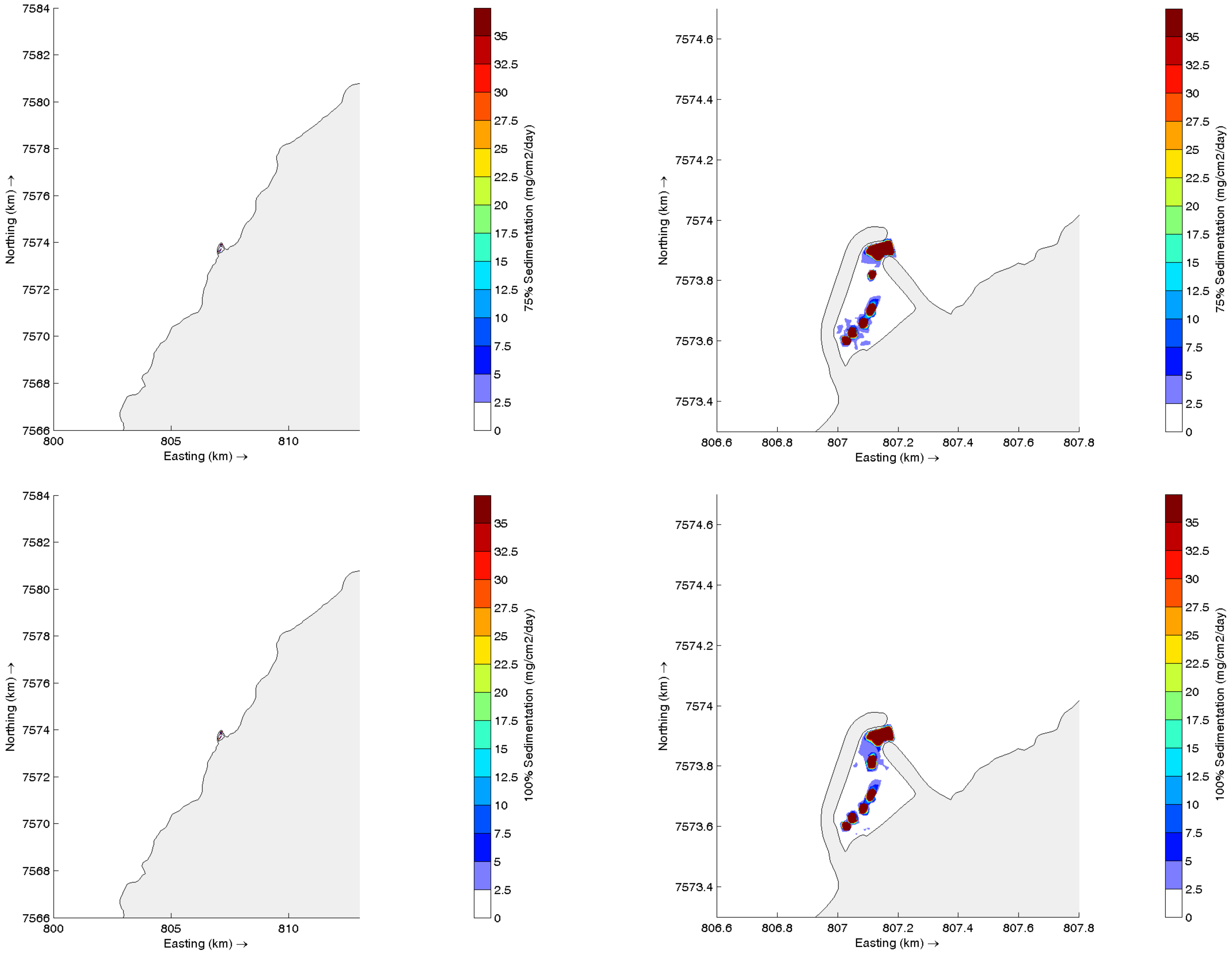


m p rogers & associates pl

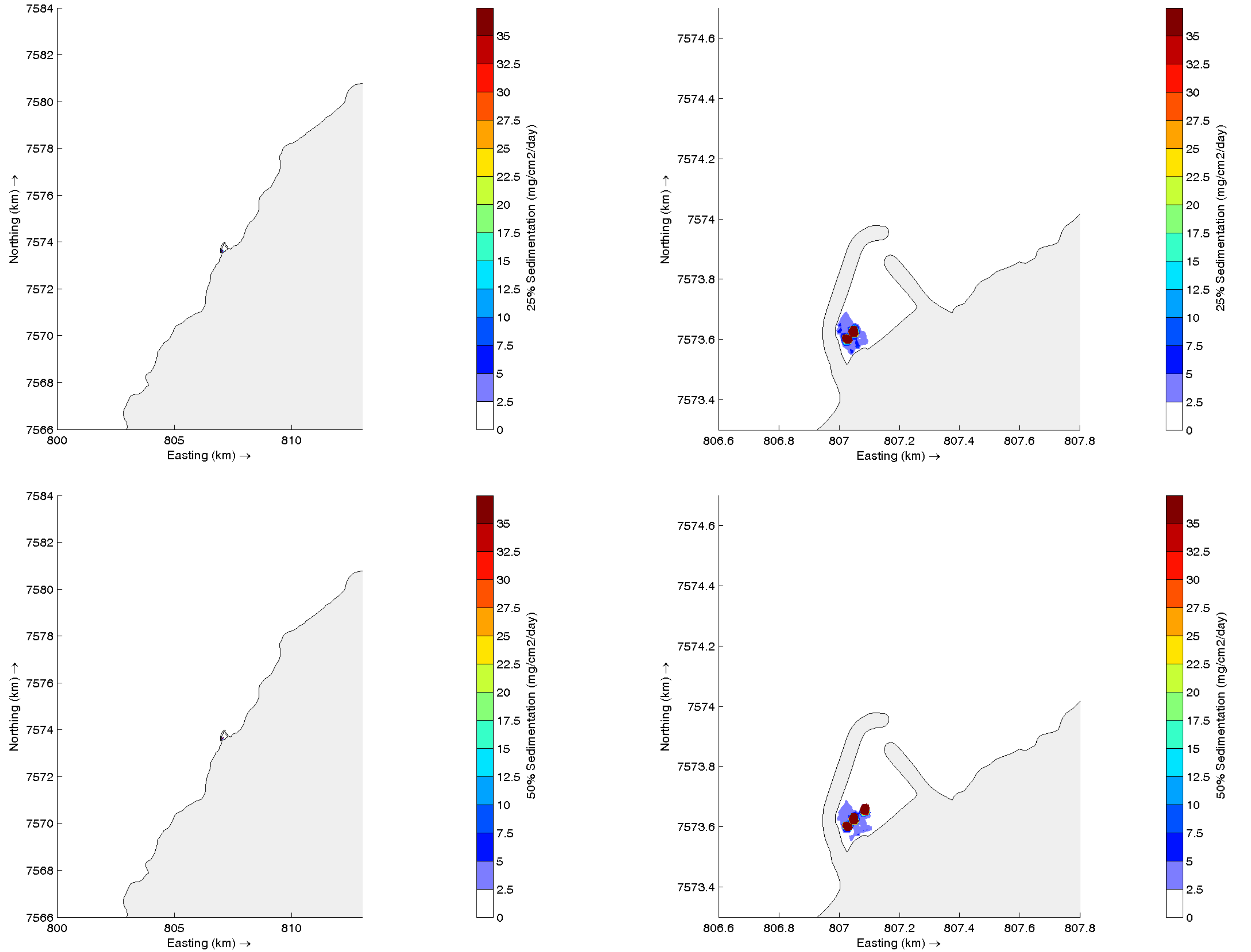
Run 3 25% (top) & 50% (bottom)



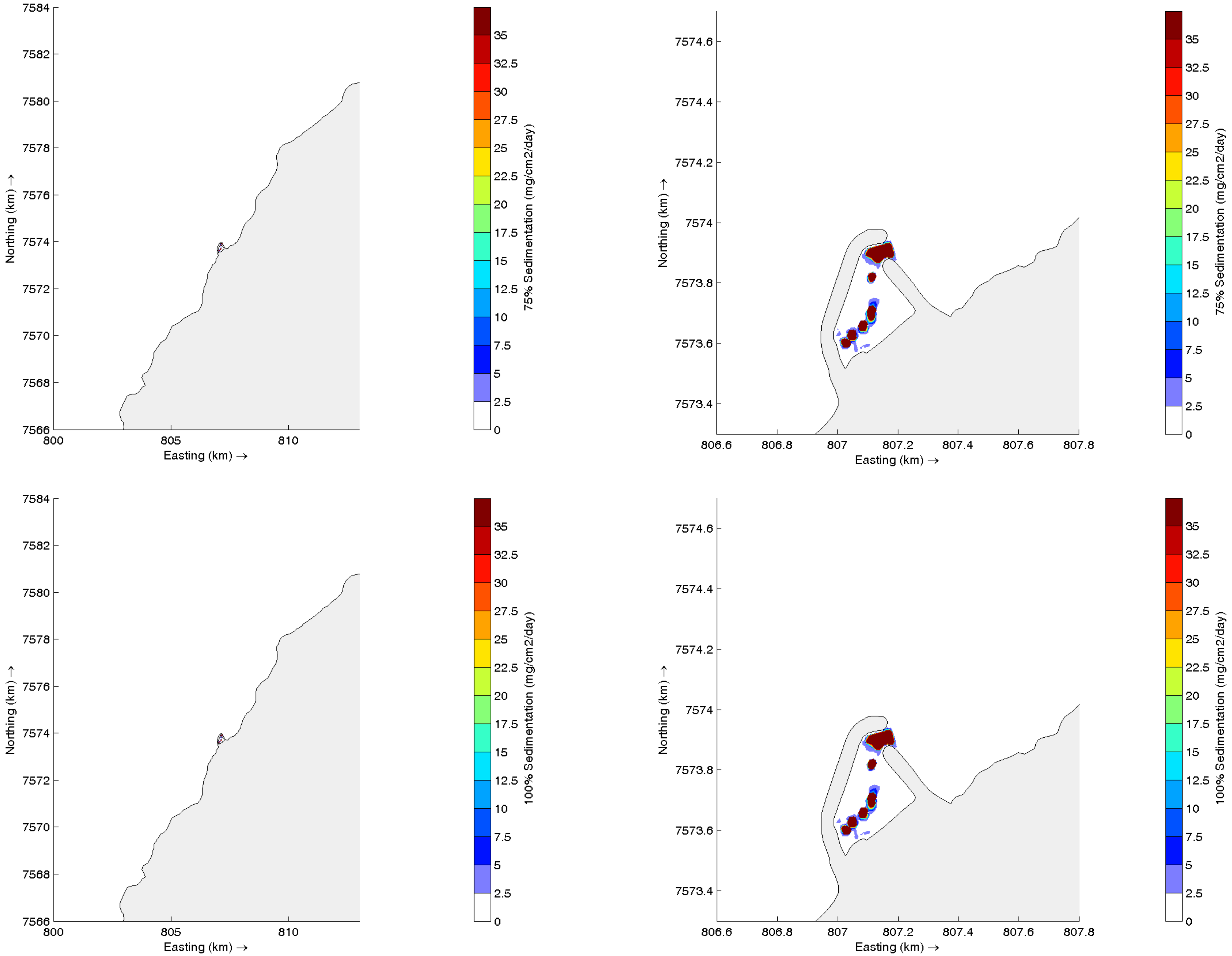
Run 3 75% (top) & 100% (bottom)



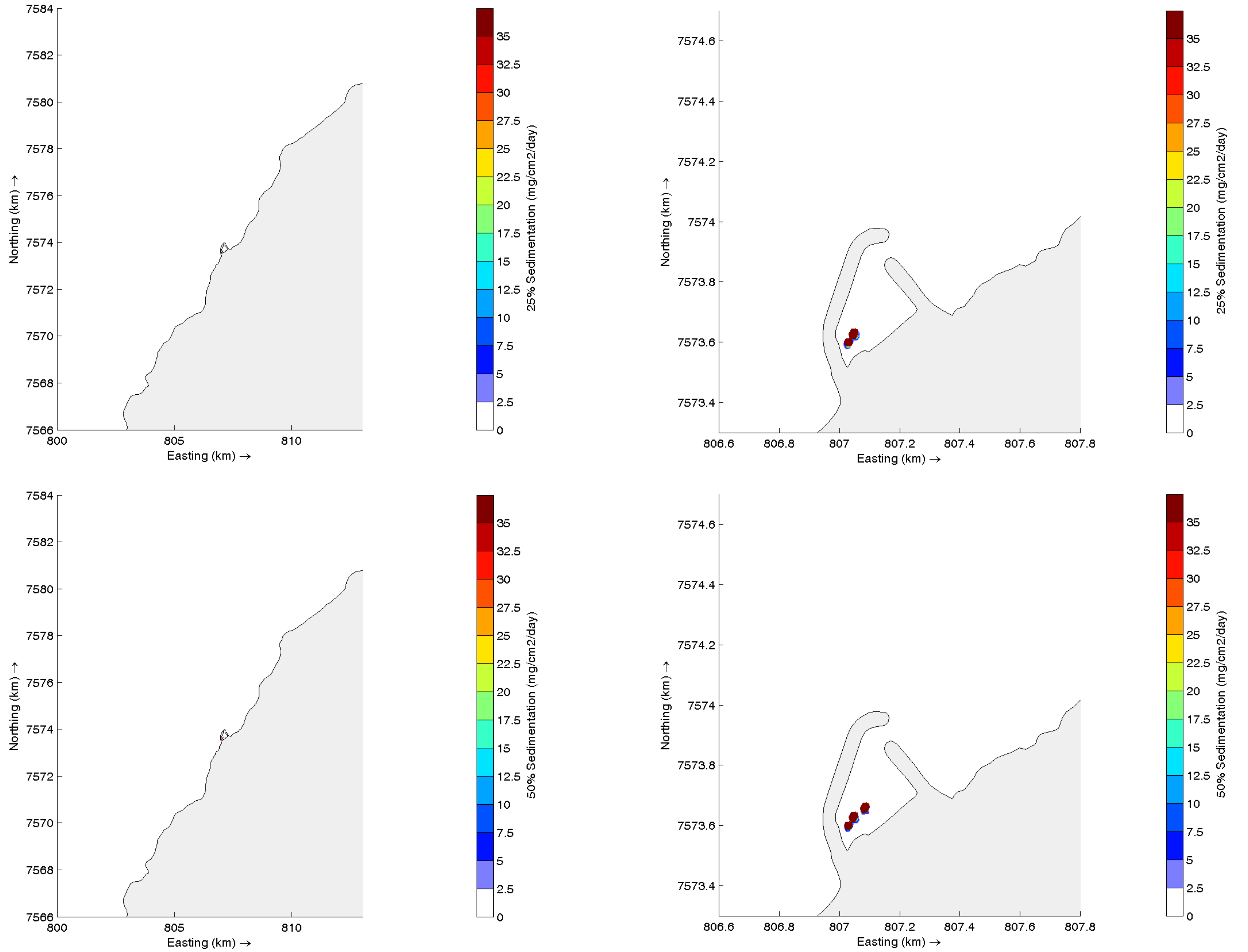
Run 4   25% (top) & 50% (bottom)



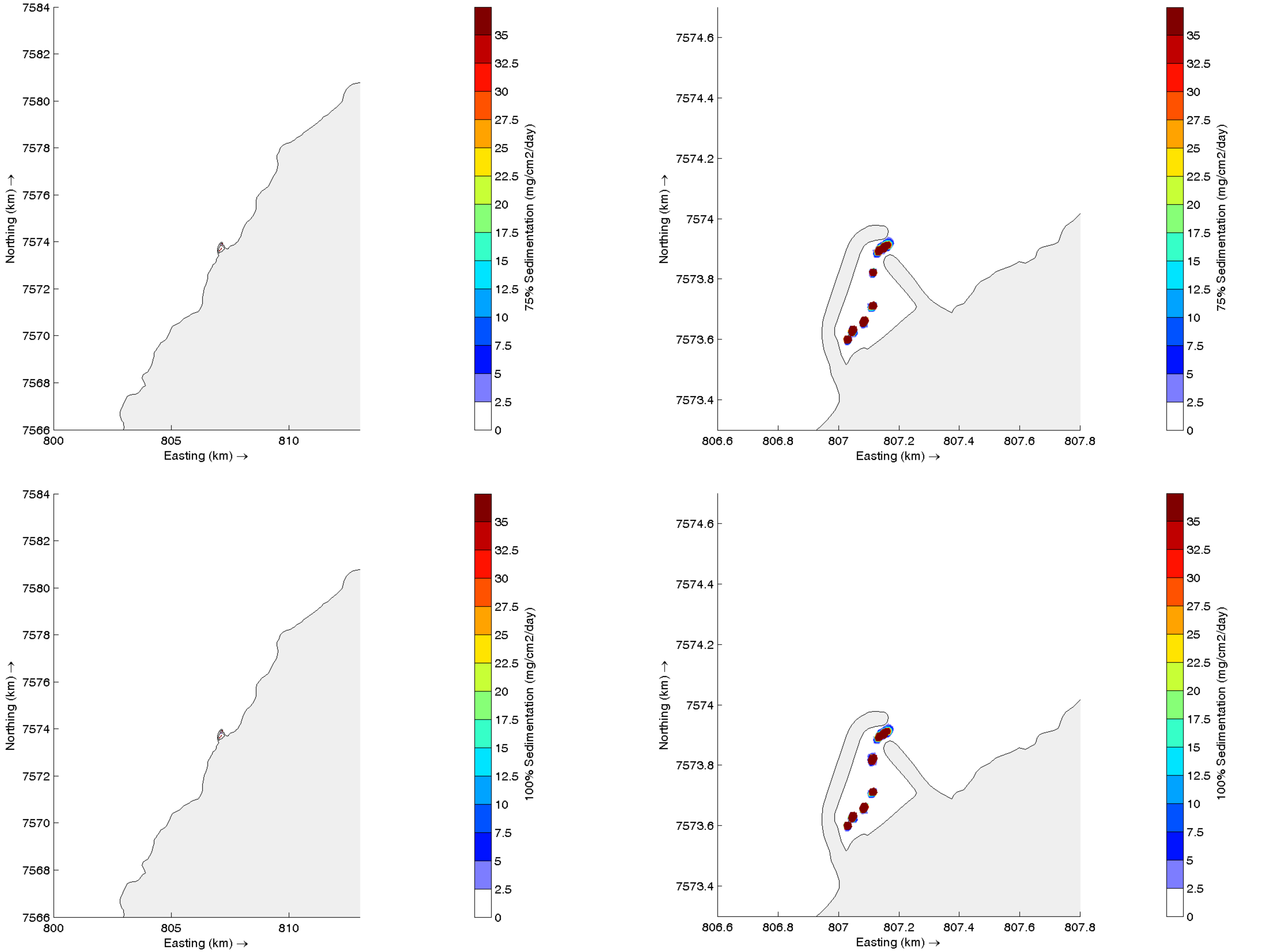
Run 4 75% (top) & 100% (bottom)



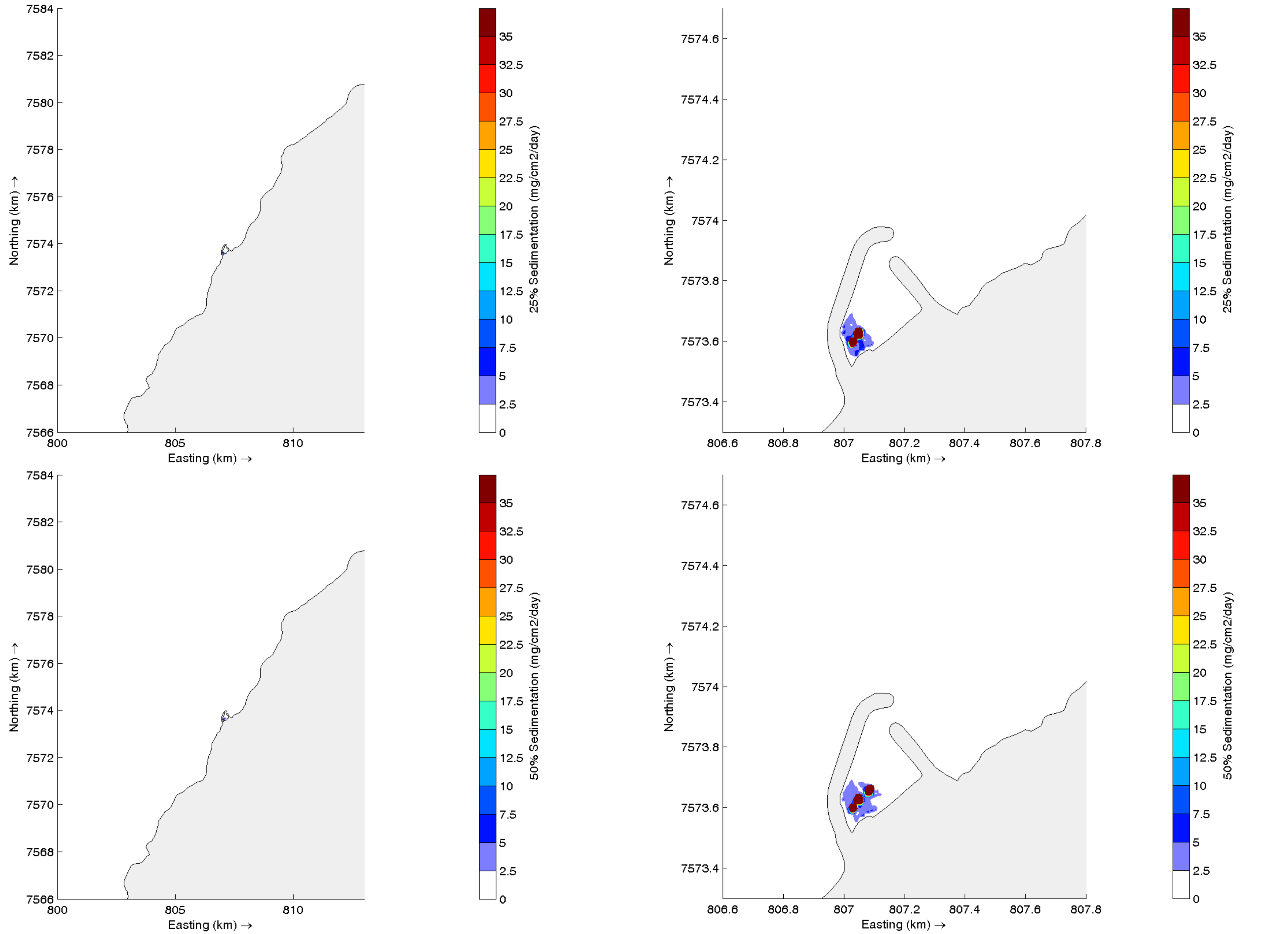
Run 5 25% (top) & 50% (bottom)



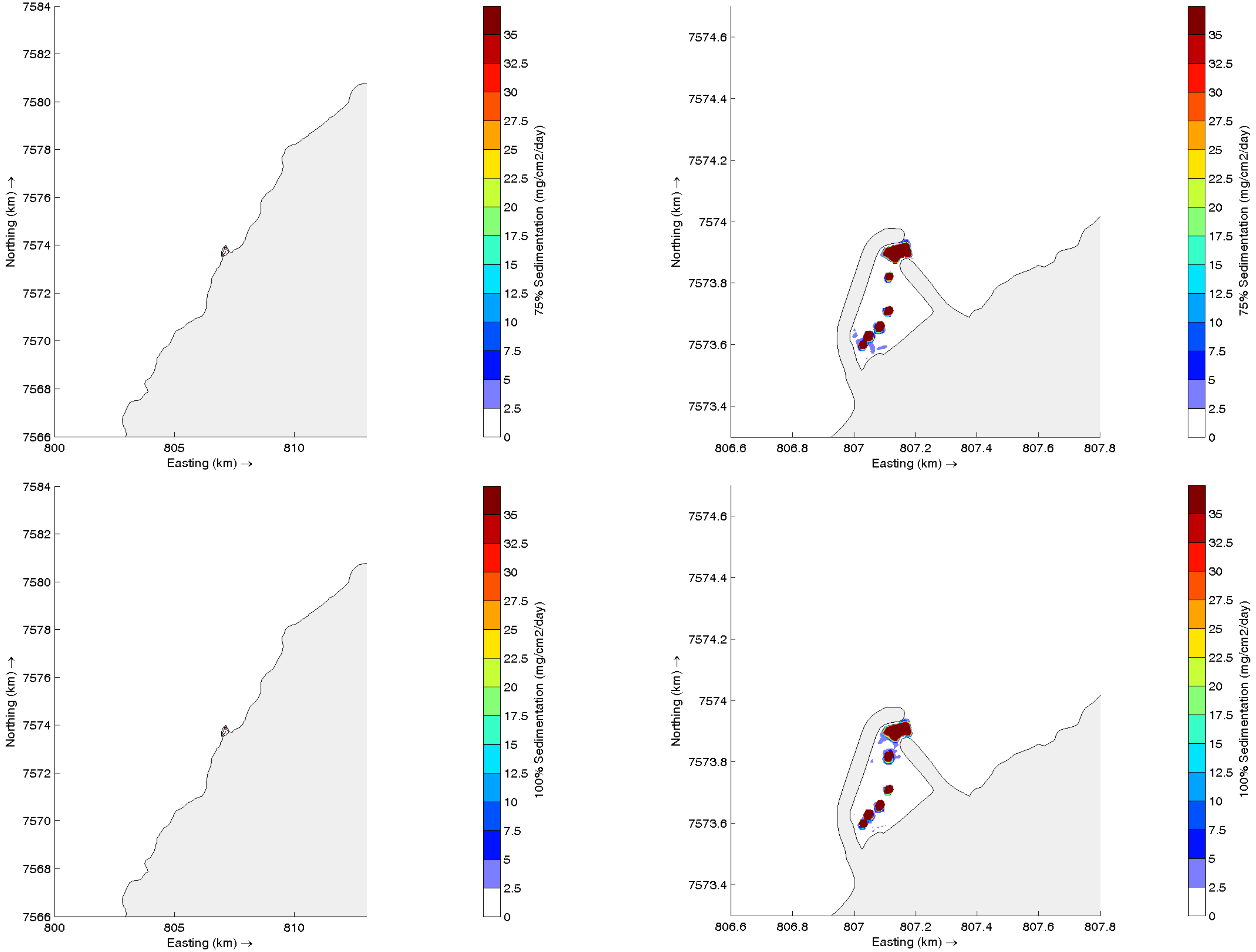
Run 5   75% (top) & 100% (bottom)



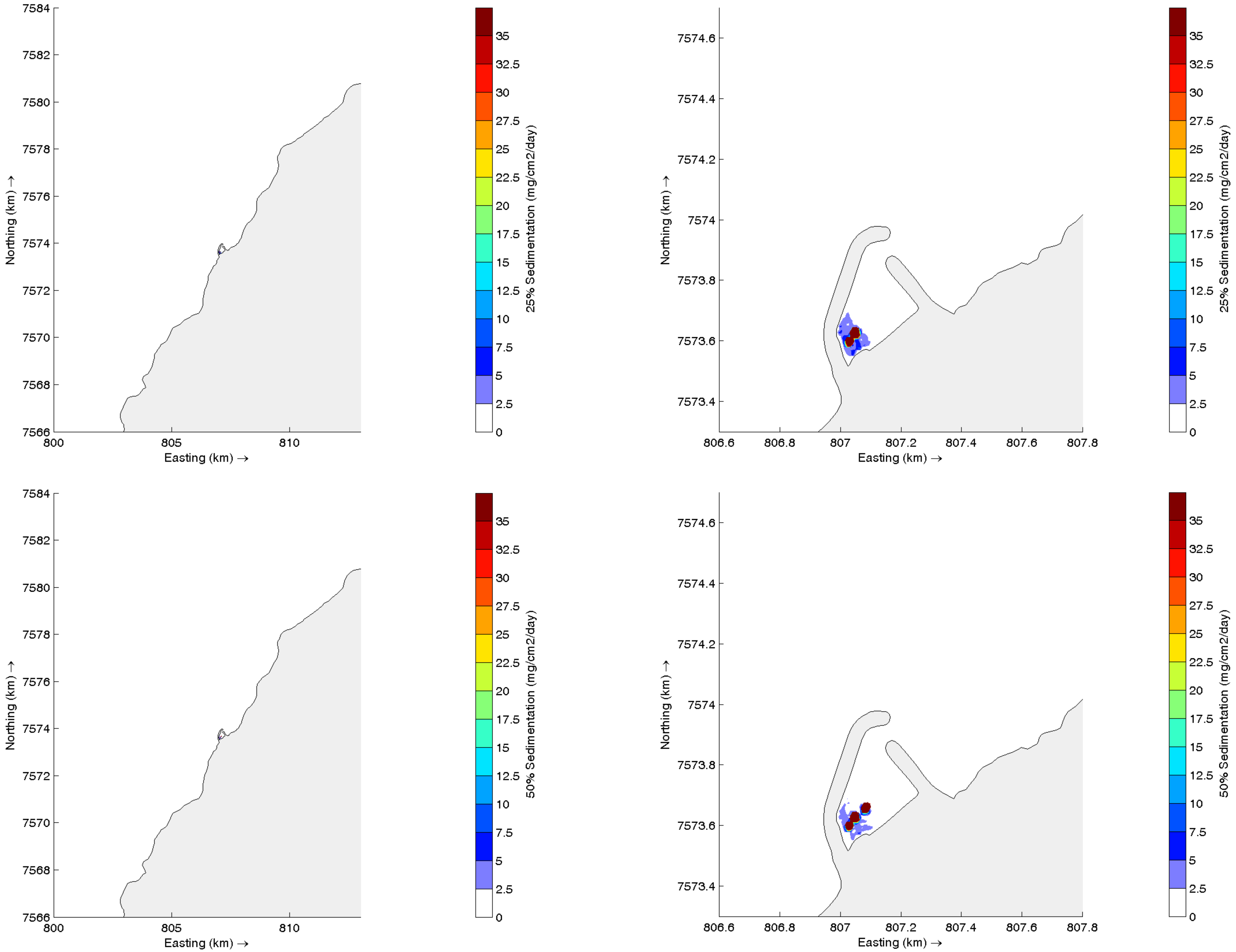
Run 6   25% (top) & 50% (bottom)



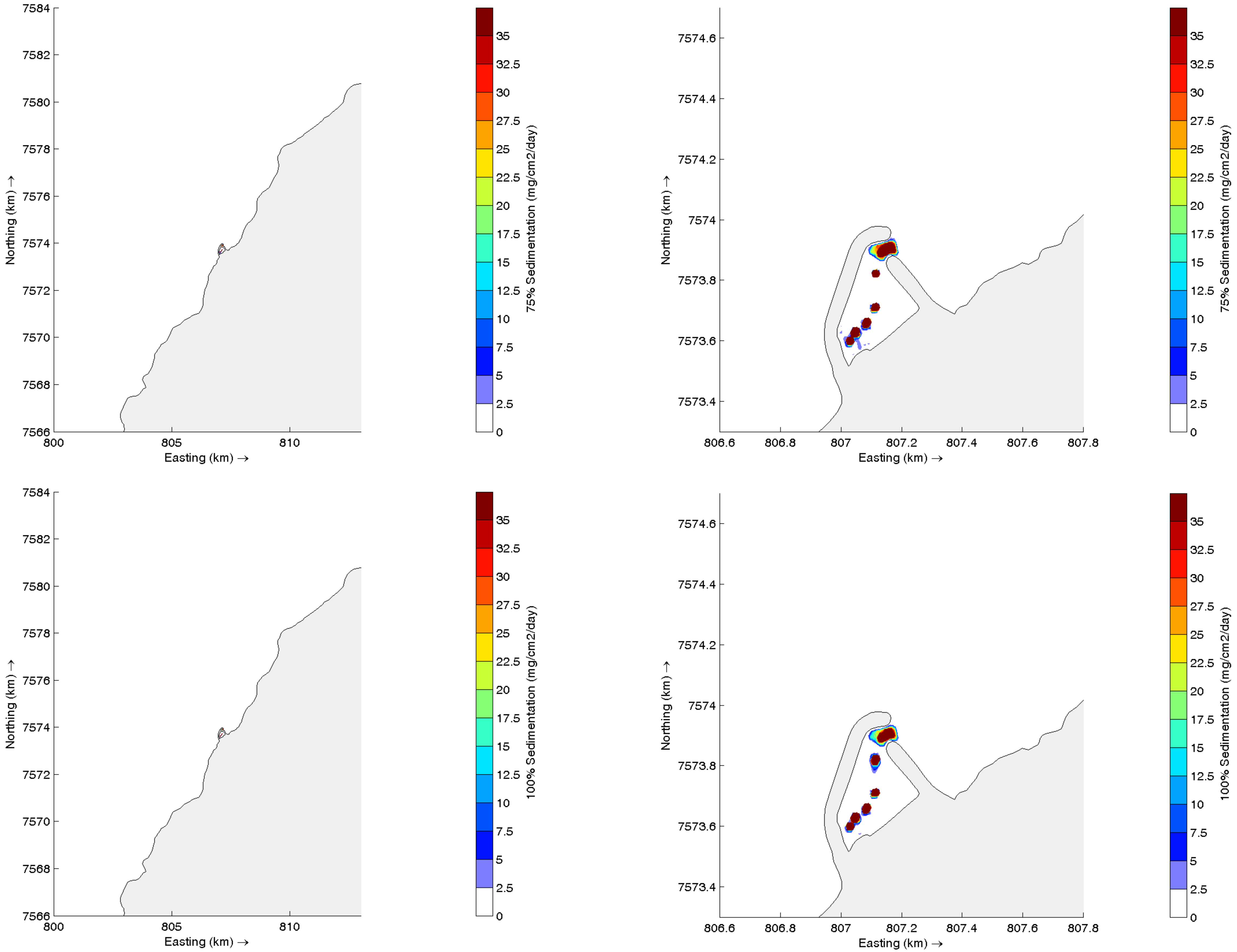
Run 6   75% (top) & 100% (bottom)



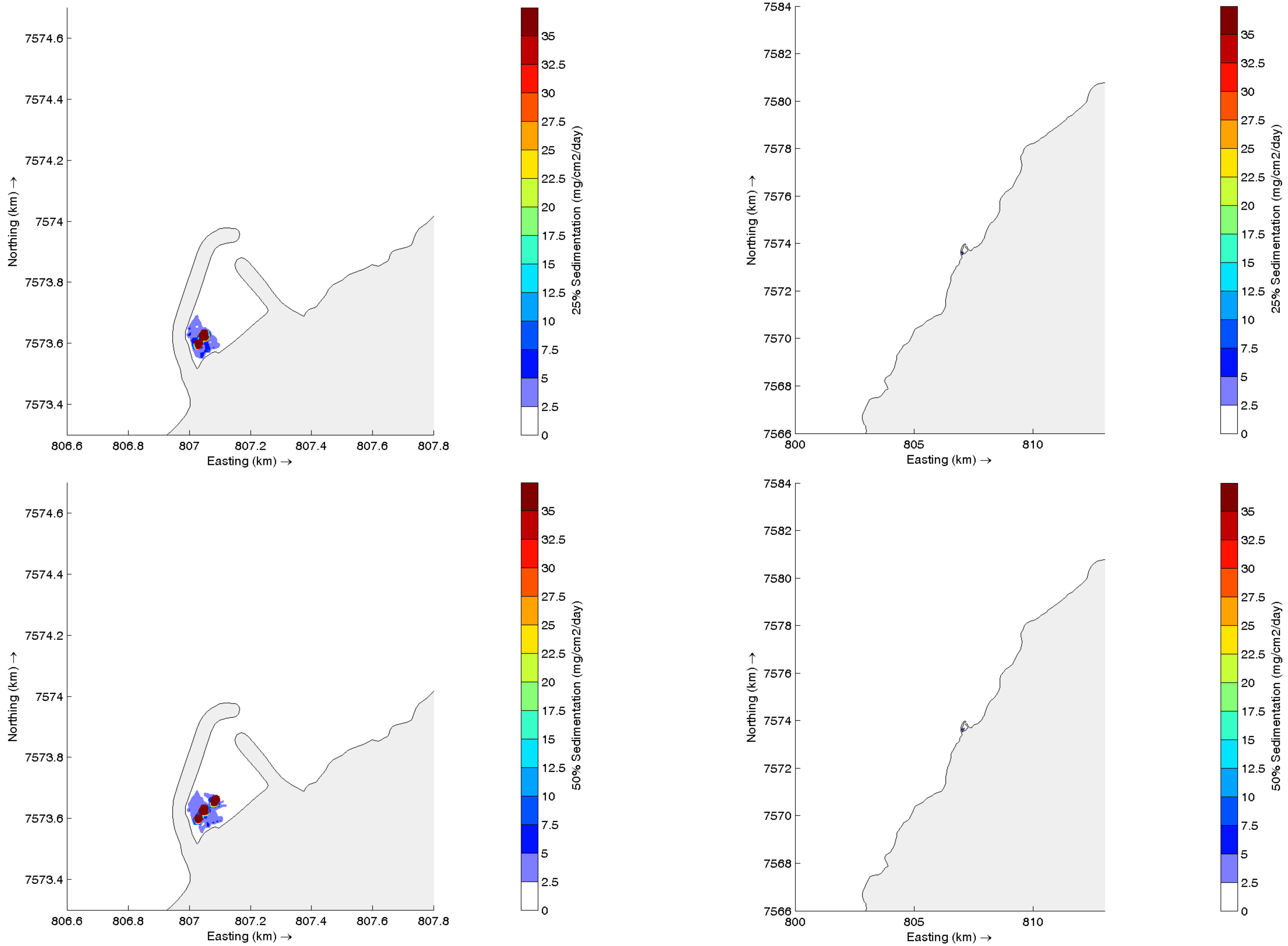
Run 7 25% (top) & 50% (bottom)



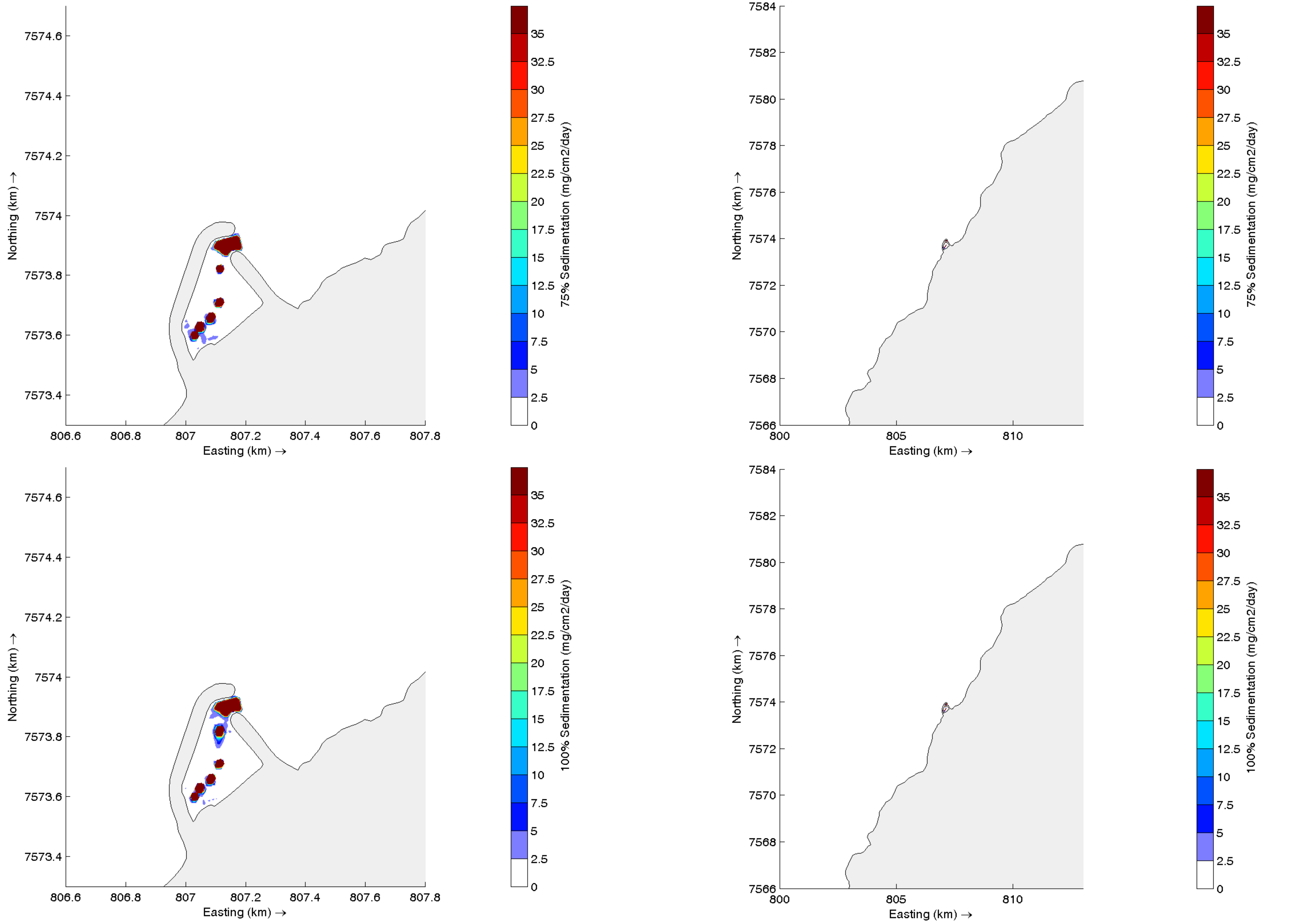
Run 7 75% (top) & 100% (bottom)



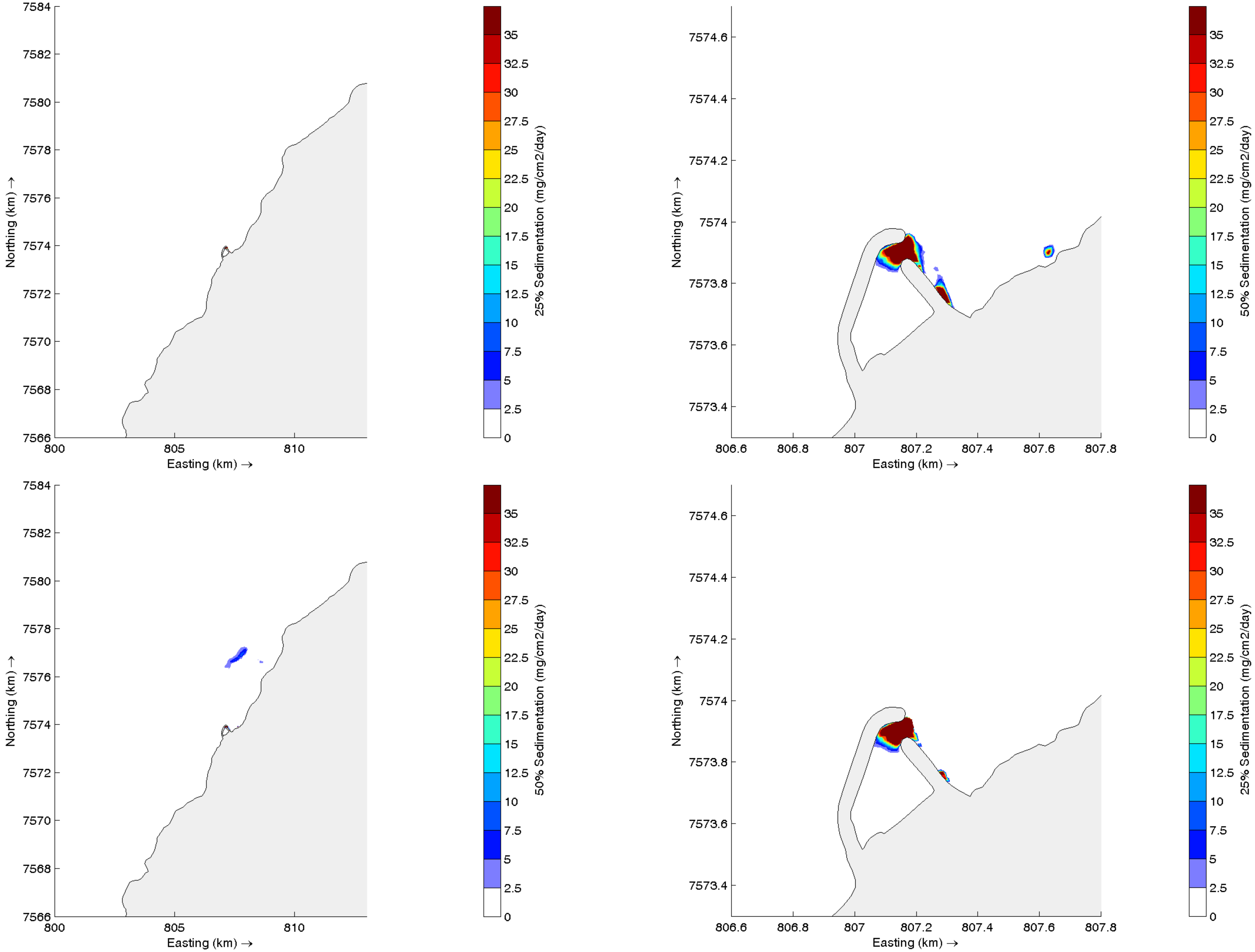
Run 8 25% (top) & 50% (bottom)



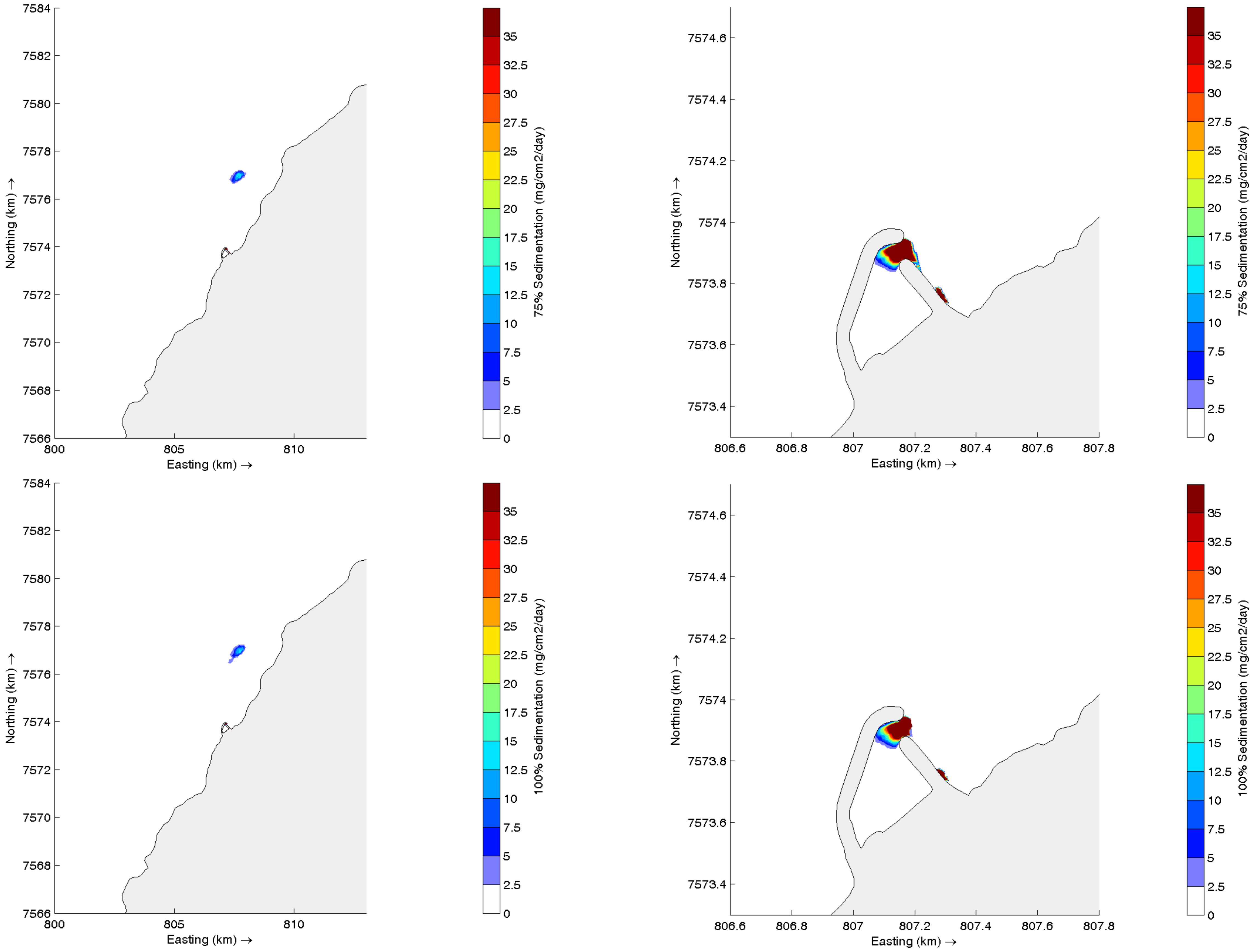
Run 8 75% (top) & 100% (bottom)



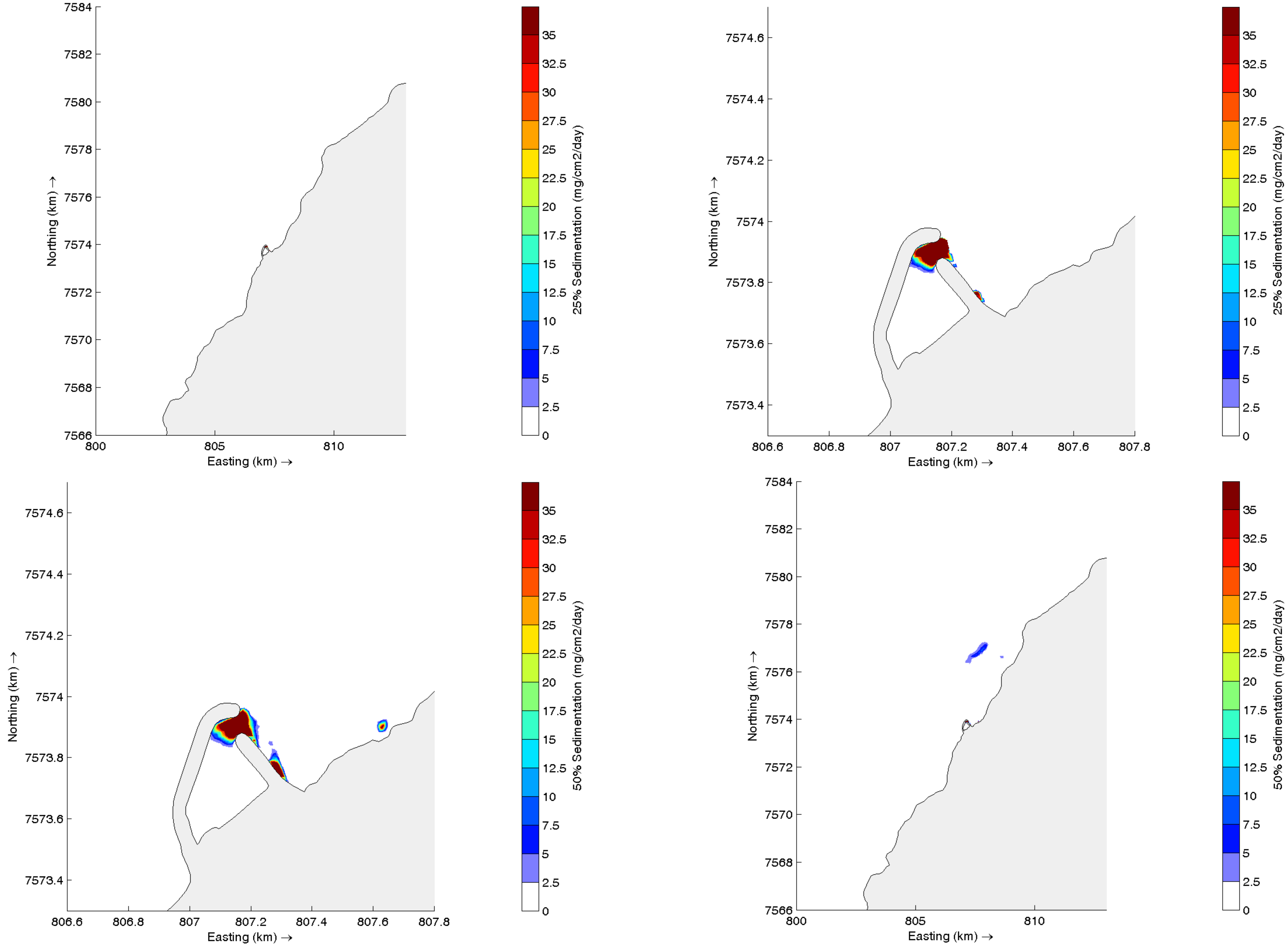
Run 9 25% (top) & 50% (bottom)



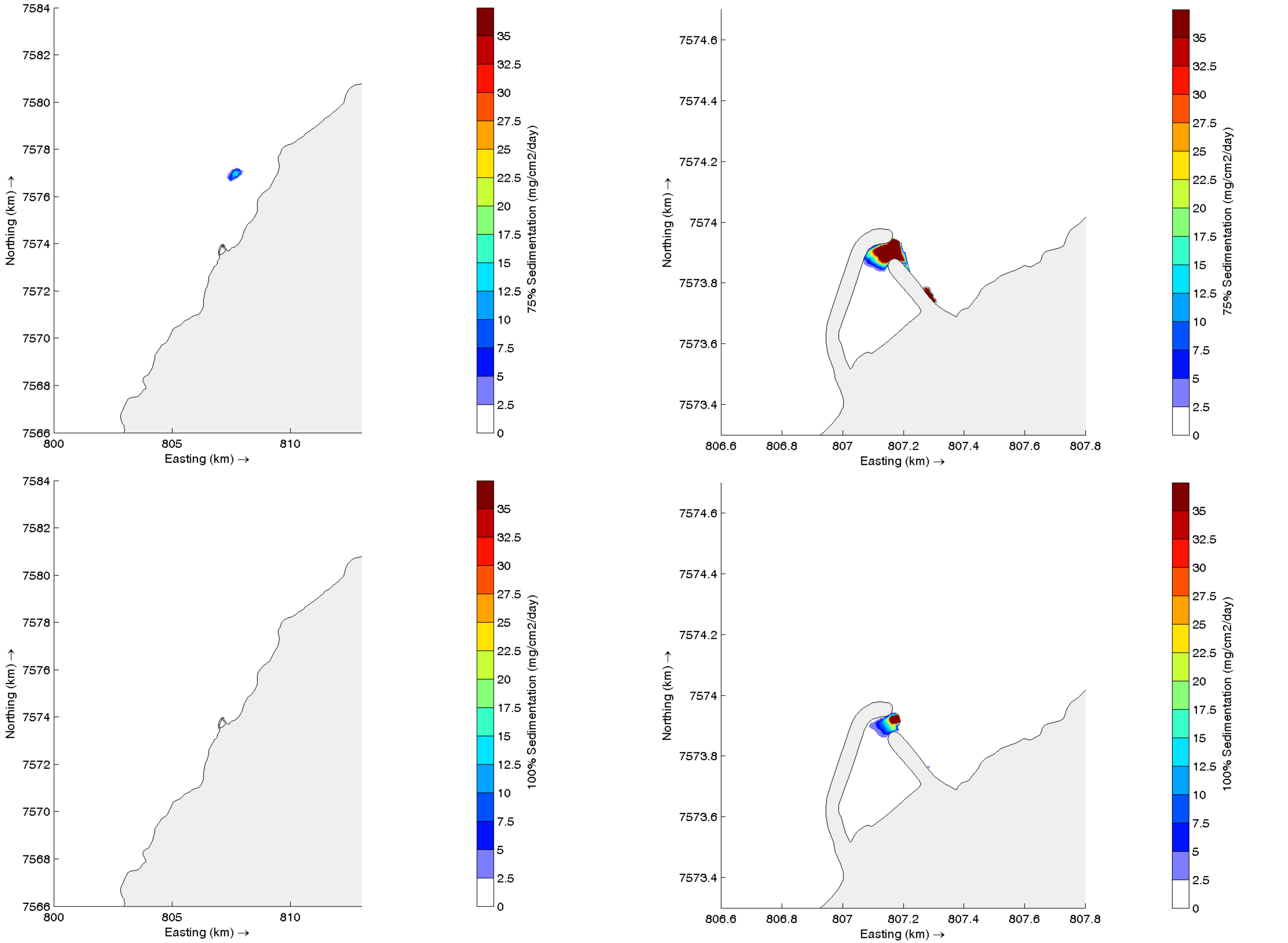
Run 9 75% (top) & 100% (bottom)



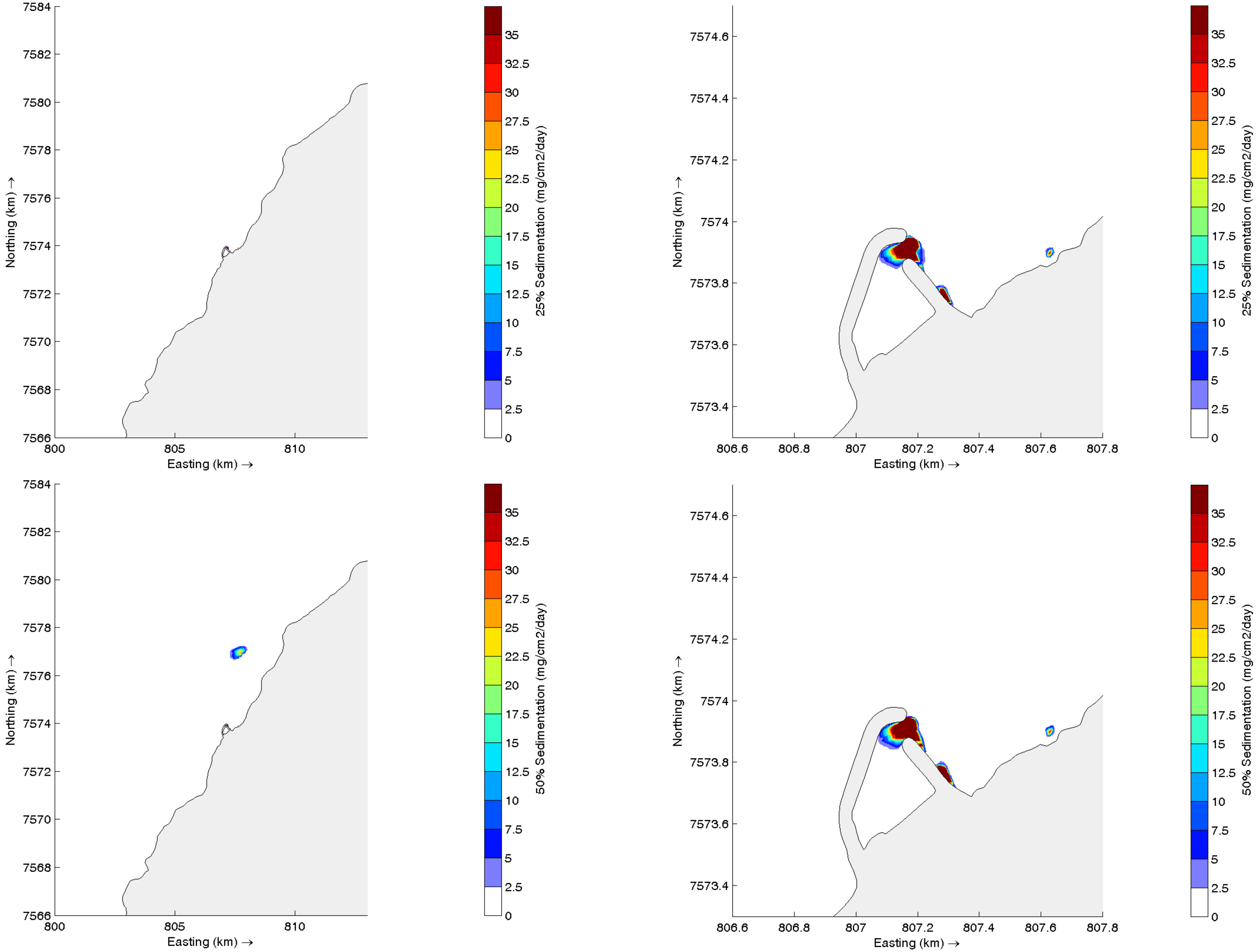
Run 10 25% (top) & 50% (bottom)



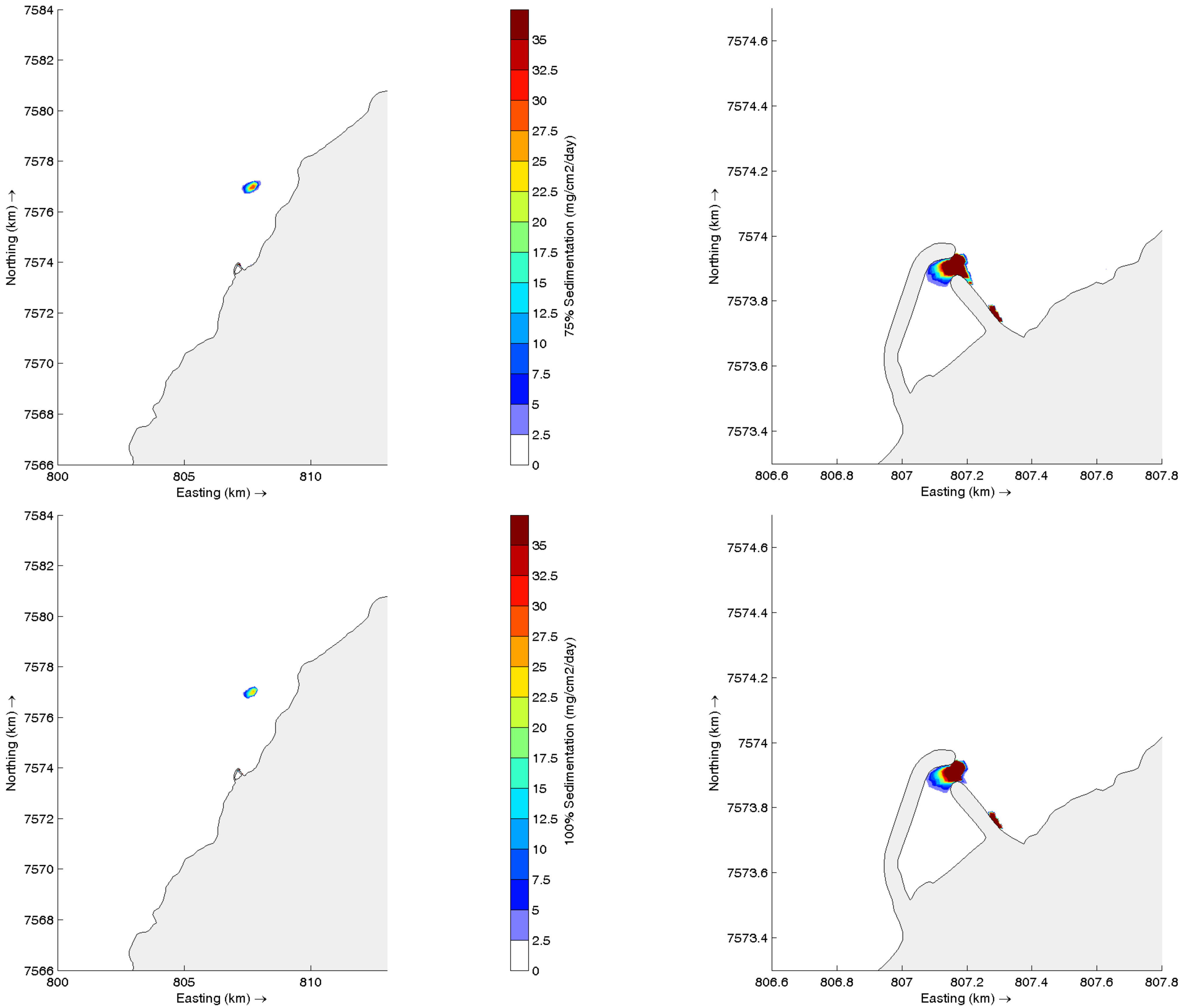
Run 10 75% (top) & 100% (bottom)



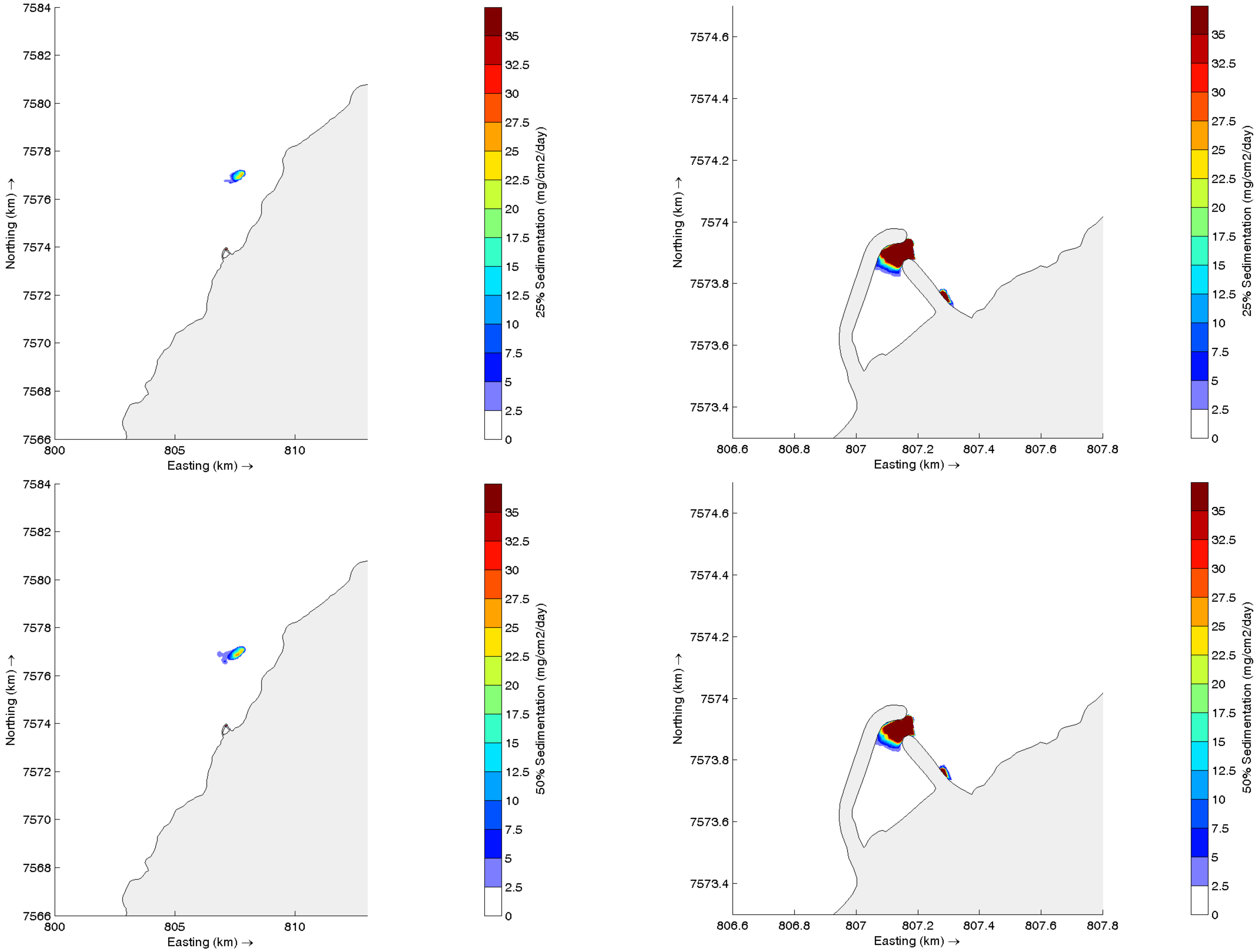
Run 11 25% (top) & 50% (bottom)



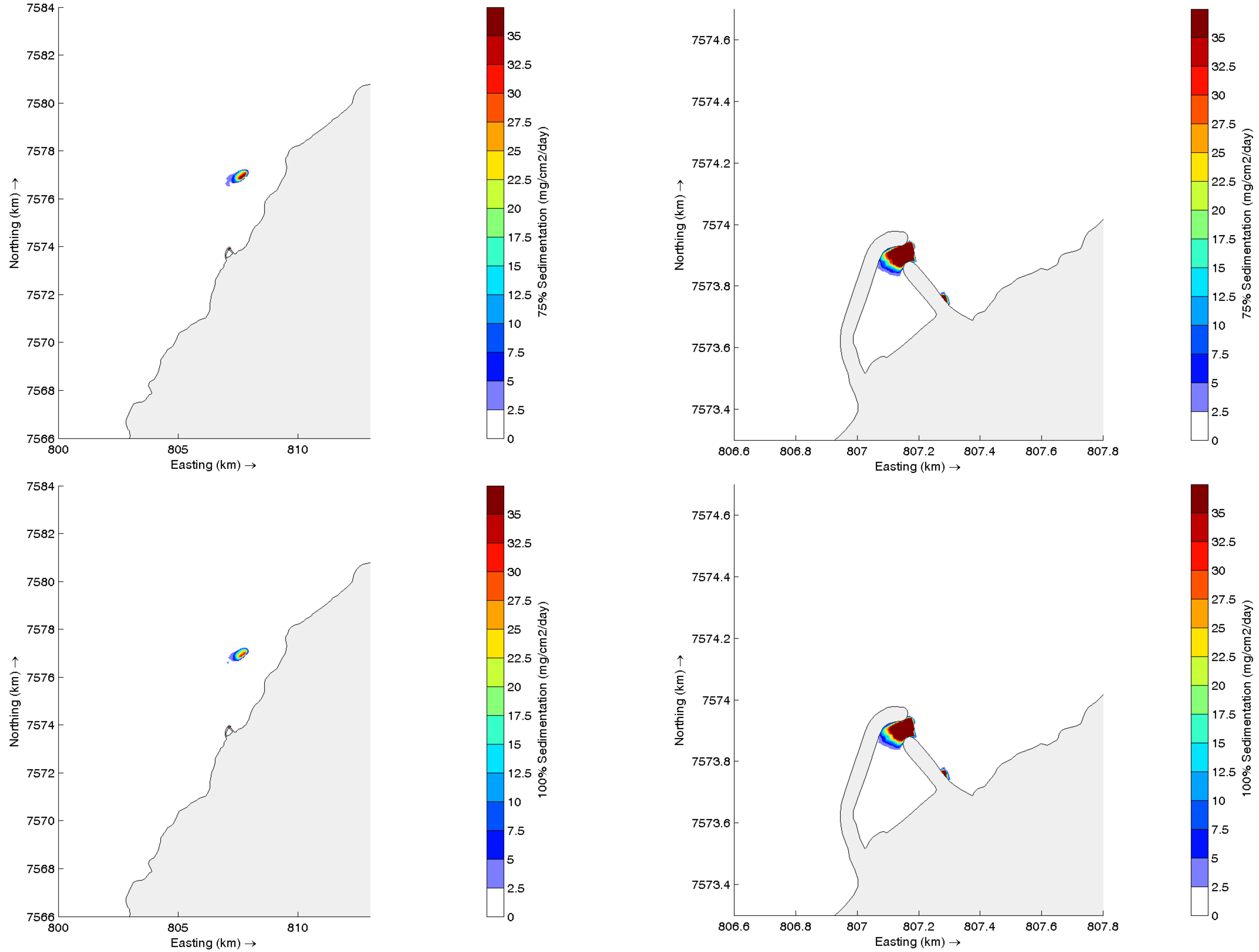
Run 11 75% (top) & 100% (bottom)



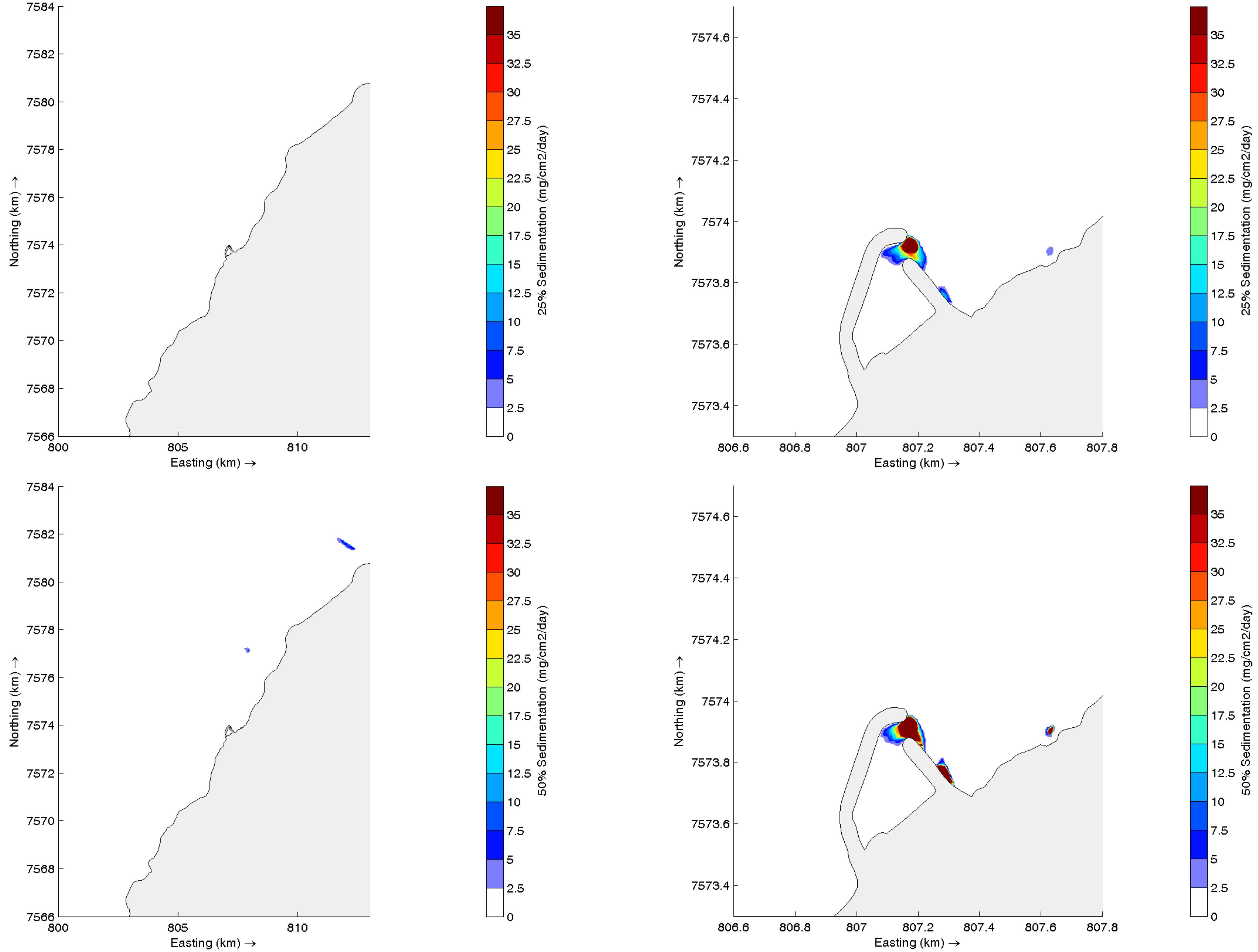
Run 12 25% (top) & 50% (bottom)



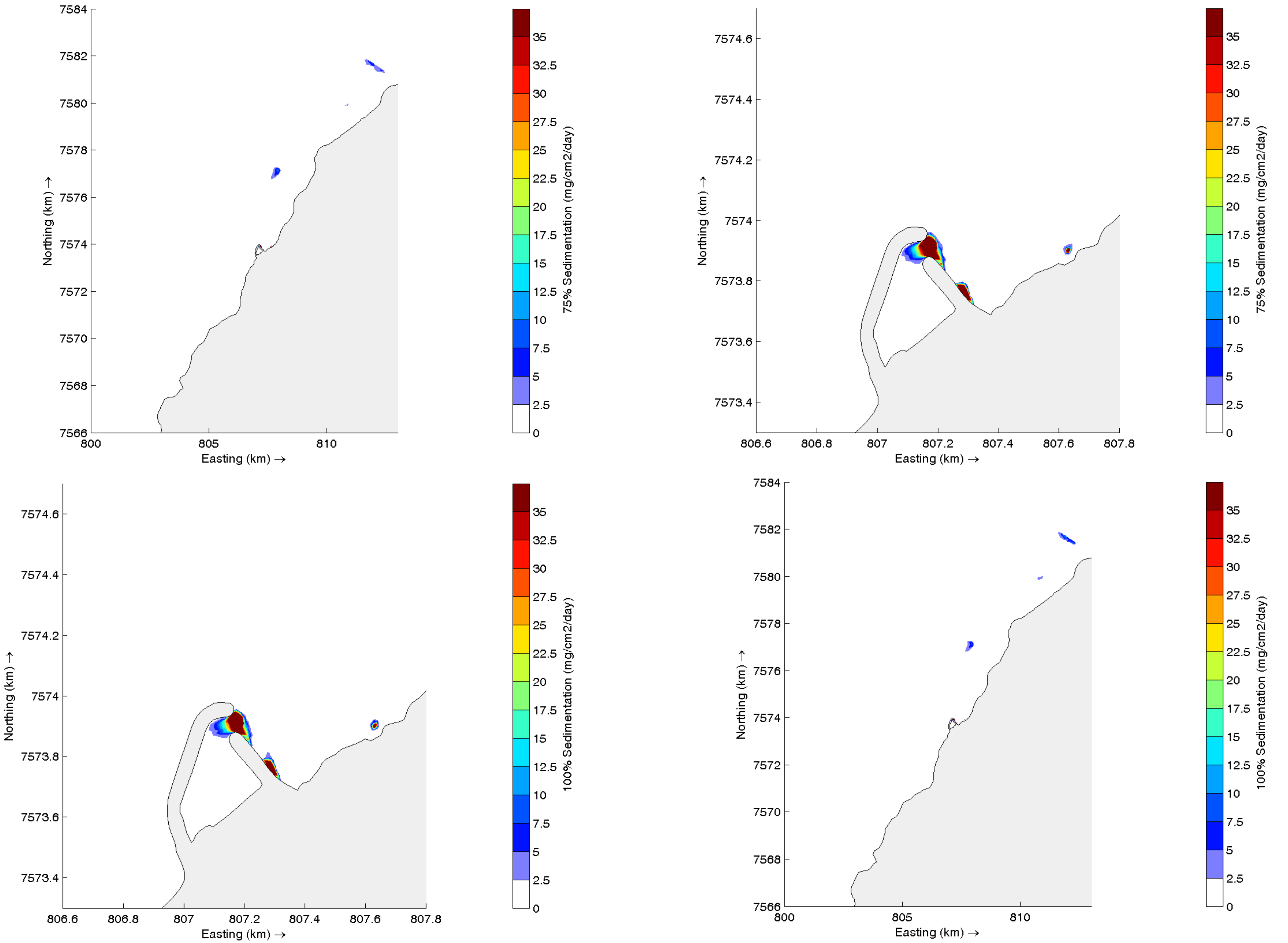
Run 12 75% (top) & 100% (bottom)



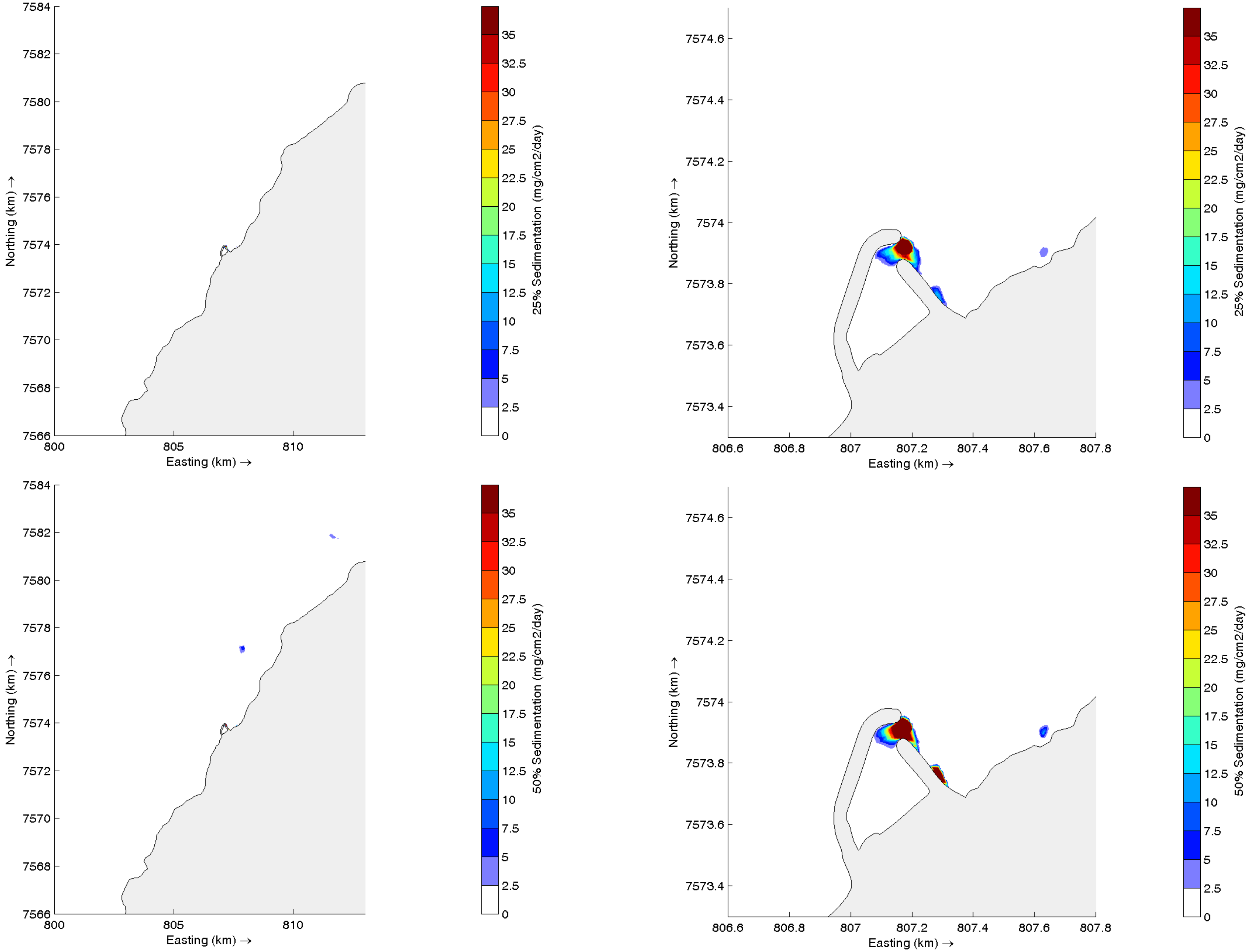
Run 13 25% (top) & 50% (bottom)



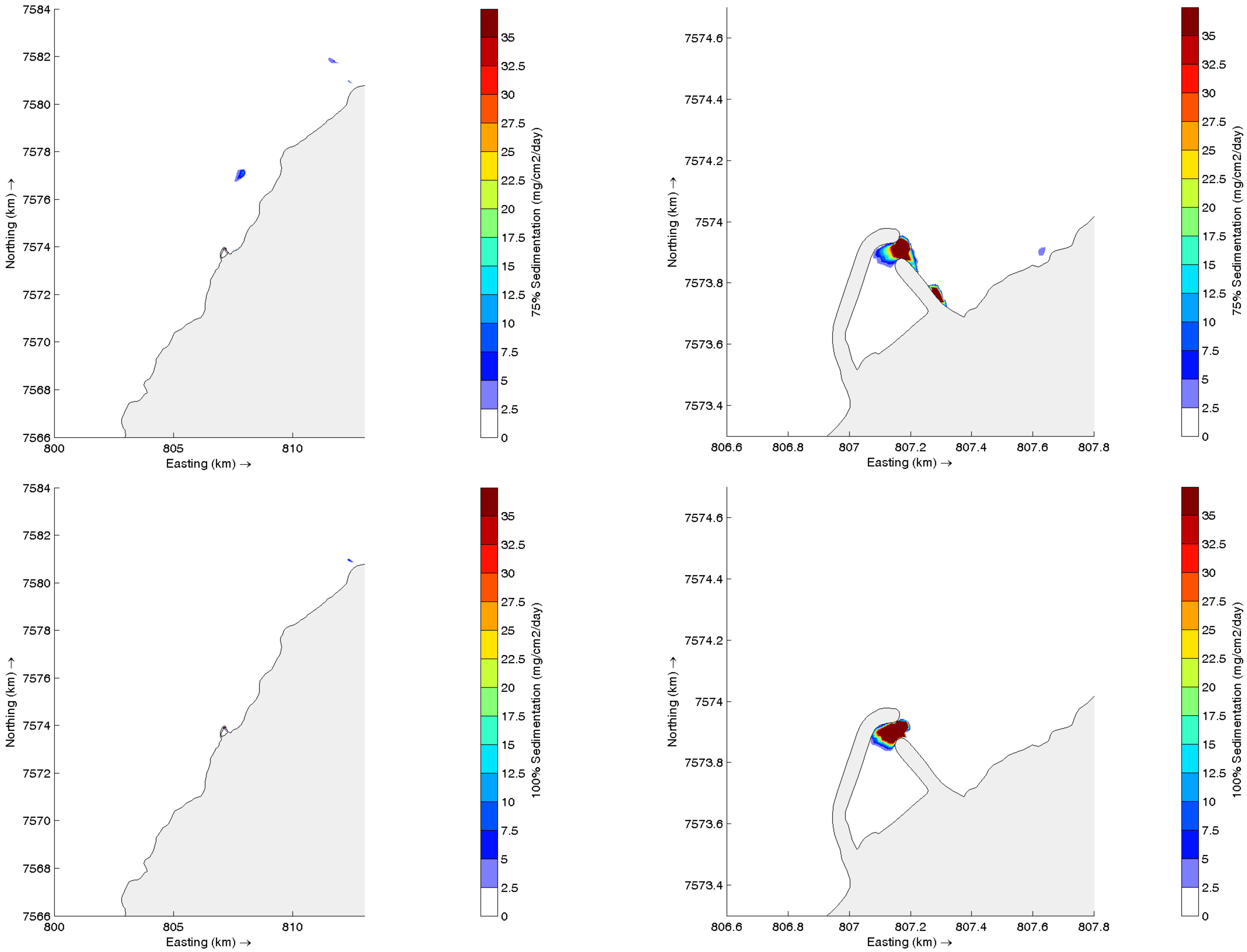
Run 13 75% (top) & 100% (bottom)



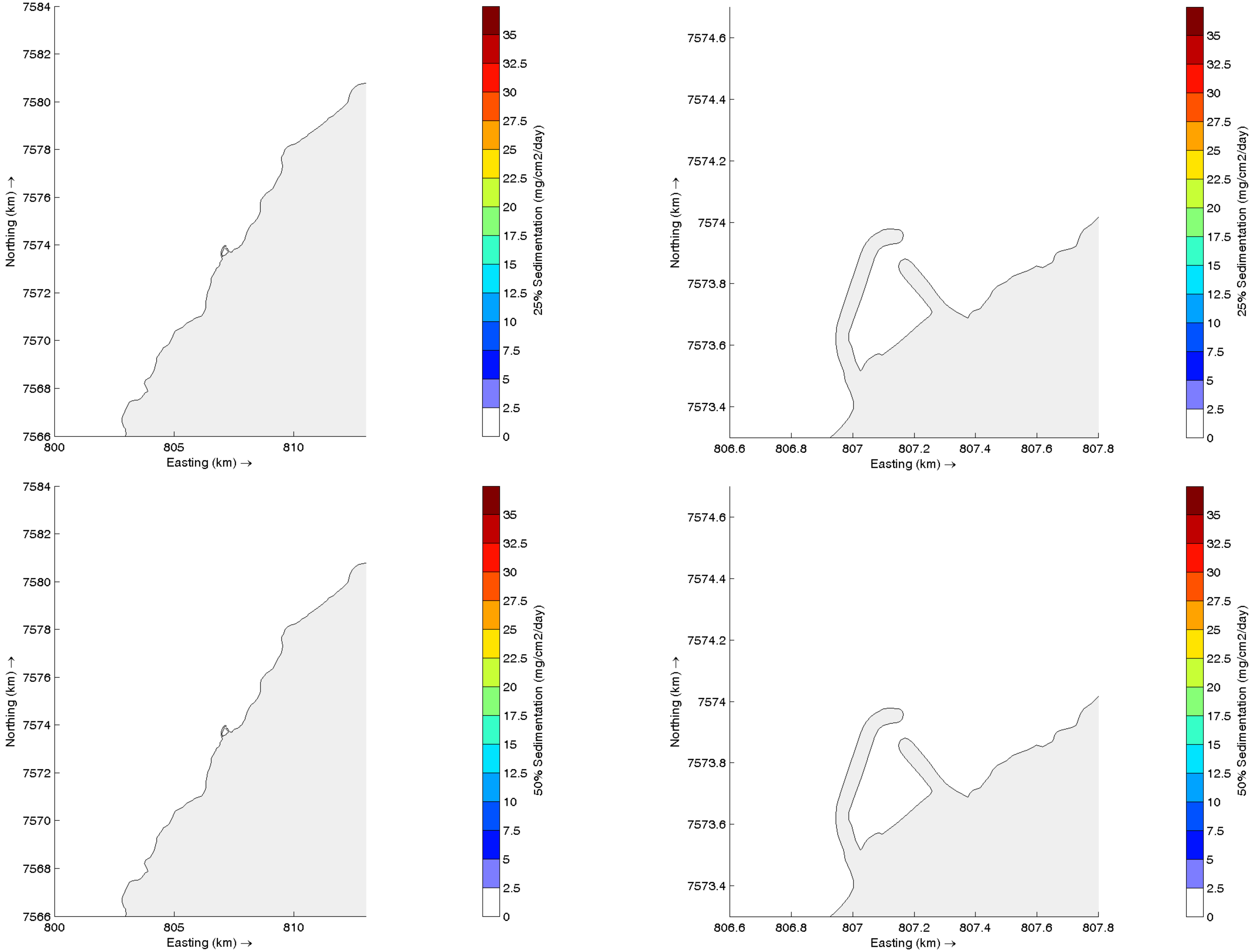
Run 14 25% (top) & 50% (bottom)



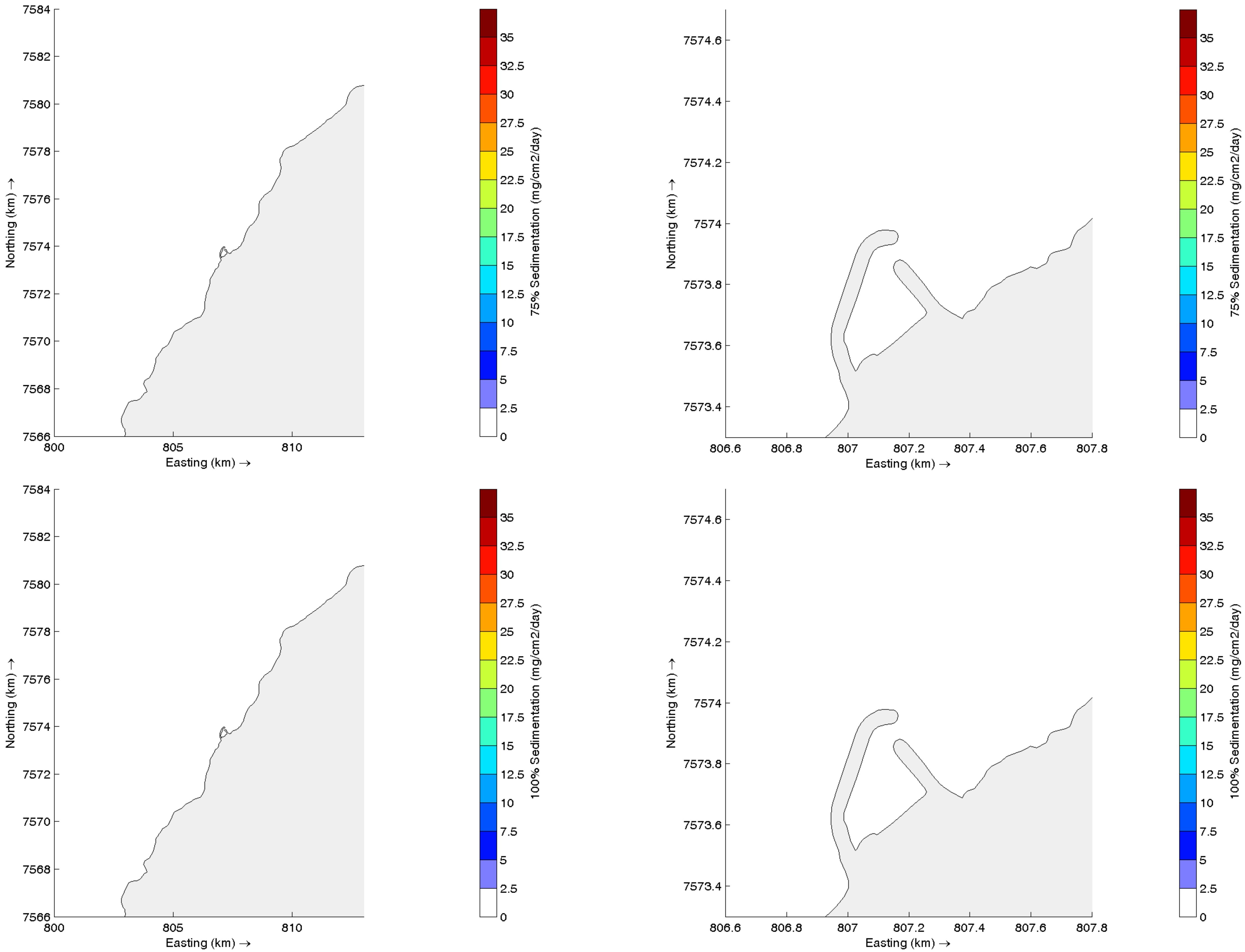
Run 14 75% (top) & 100% (bottom)



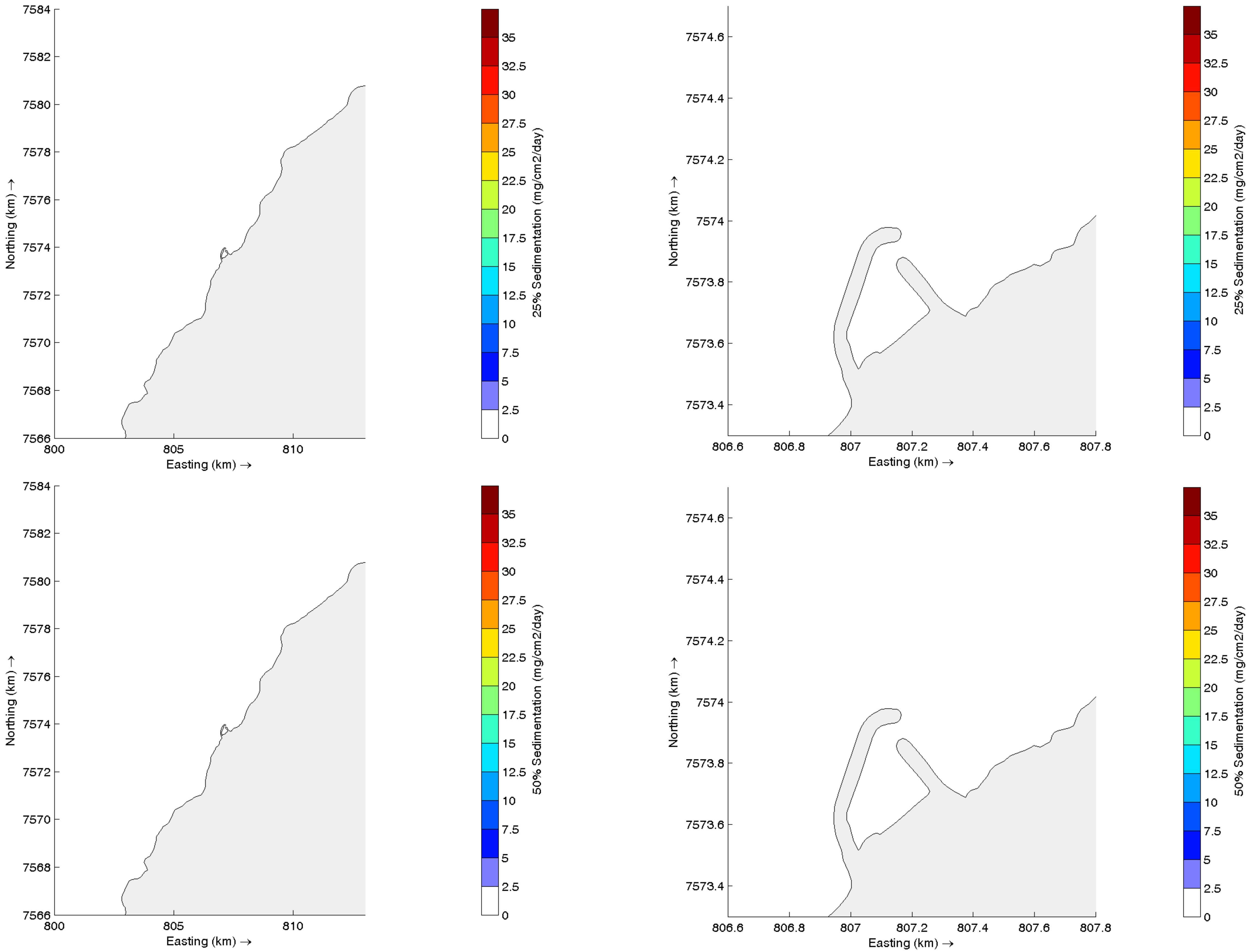
Run 15 25% (top) & 50% (bottom)



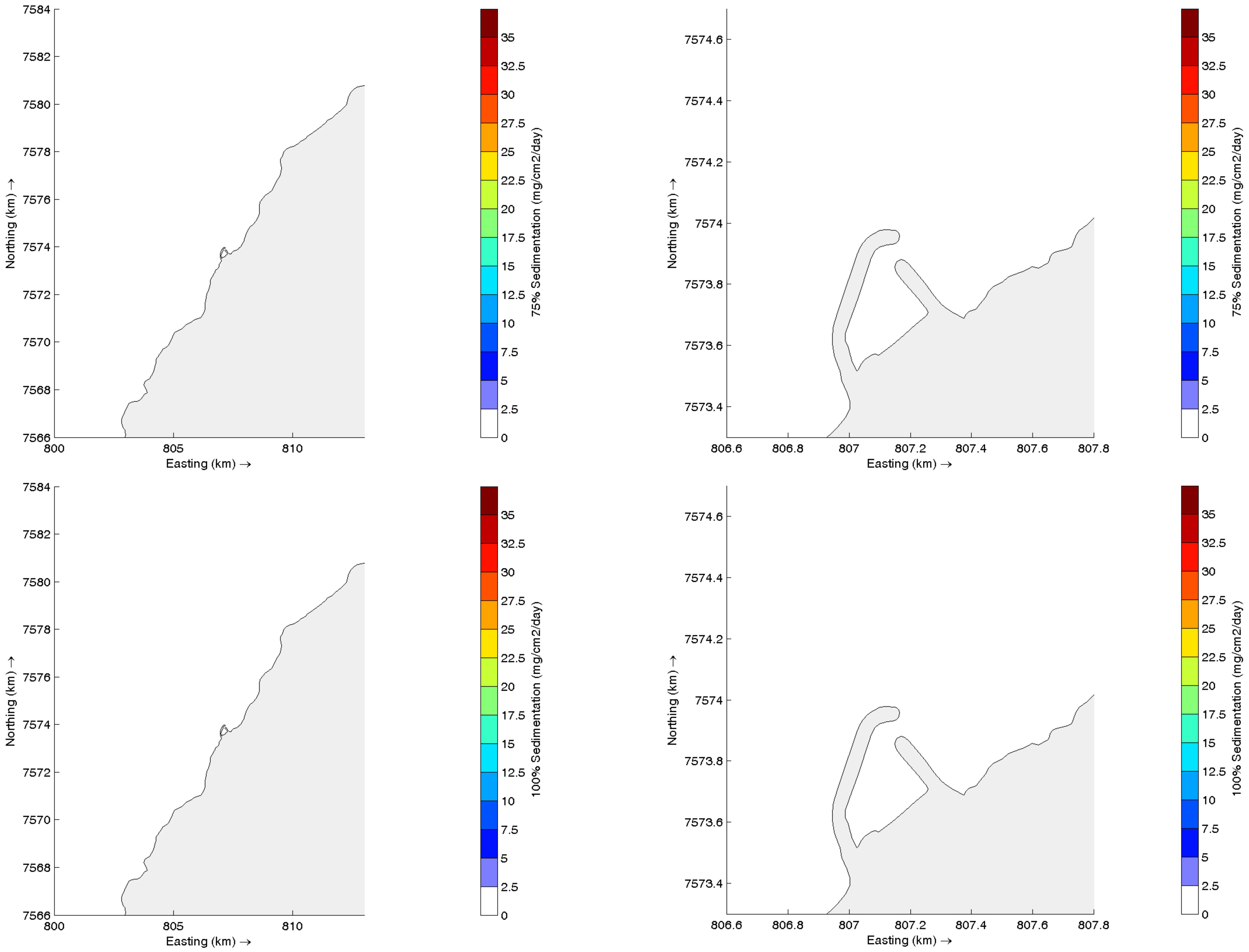
Run 1575% (top) & 100% (bottom)



Run 16 25% (top) & 50% (bottom)



Run 16 75% (top) & 100% (bottom)



Northing (km) →
Easting (km) →
75% Sedimentation (mg/cm2/day)
100% Sedimentation (mg/cm2/day)
7584
7582
7580
7578
7576
7574
7572
7570
7568
7566
800
805
810
7574.6
7574.4
7574.2
7574
7573.8
7573.6
7573.4
806.6
806.8
807
807.2
807.4
807.6
807.8
35
32.5
30
27.5
25
22.5
20
17.5
15
12.5
10
7.5
5
2.5
0

Appendix D Technical Note

m p rogers & associates pl ABN 14 062 681 252
creating better coasts and ports

R1964 Rev 0

July 2024

Department of Transport

Tantabiddi Benthic Habitat Modelling Technical Note

marinas
boat harbours
canals
breakwaters
jetties
seawalls
dredging
reclamation
climate change
waves
currents
tides
flood levels
water quality
siltation
erosion
rivers
beaches
estuaries

www.coastsandports.com.au

m p rogers & associates pl
creating better coasts and ports

Suite 1, 128 Main Street, Osborne Park, WA 6017
p: +618 9254 6600
e: admin@coastsandports.com.au
w: www.coastsandports.com.au

K2041/1, Report R1964 Rev 0
Record of Document Revisions

Rev	Purpose of Document	Prepared	Reviewed	Approved	Date
A	Draft for MRA review	M Peterson	C Doak	C Doak	30/07/24
0	Issued for Client Use	M Peterson	C Doak	C Doak	31/07/24

Form 035 18/06/2013

Limitations of this Document

Table of Contents

Table of Figures

Table of Tables

1. Introduction

The Tantabiddi Boat Ramp precinct is of regional significance and is a key asset as a gateway to the Ningaloo Reef tourism and recreational experiences. The location of the boat ramp relative to the North West Cape is shown in in Figure 1.1, below.

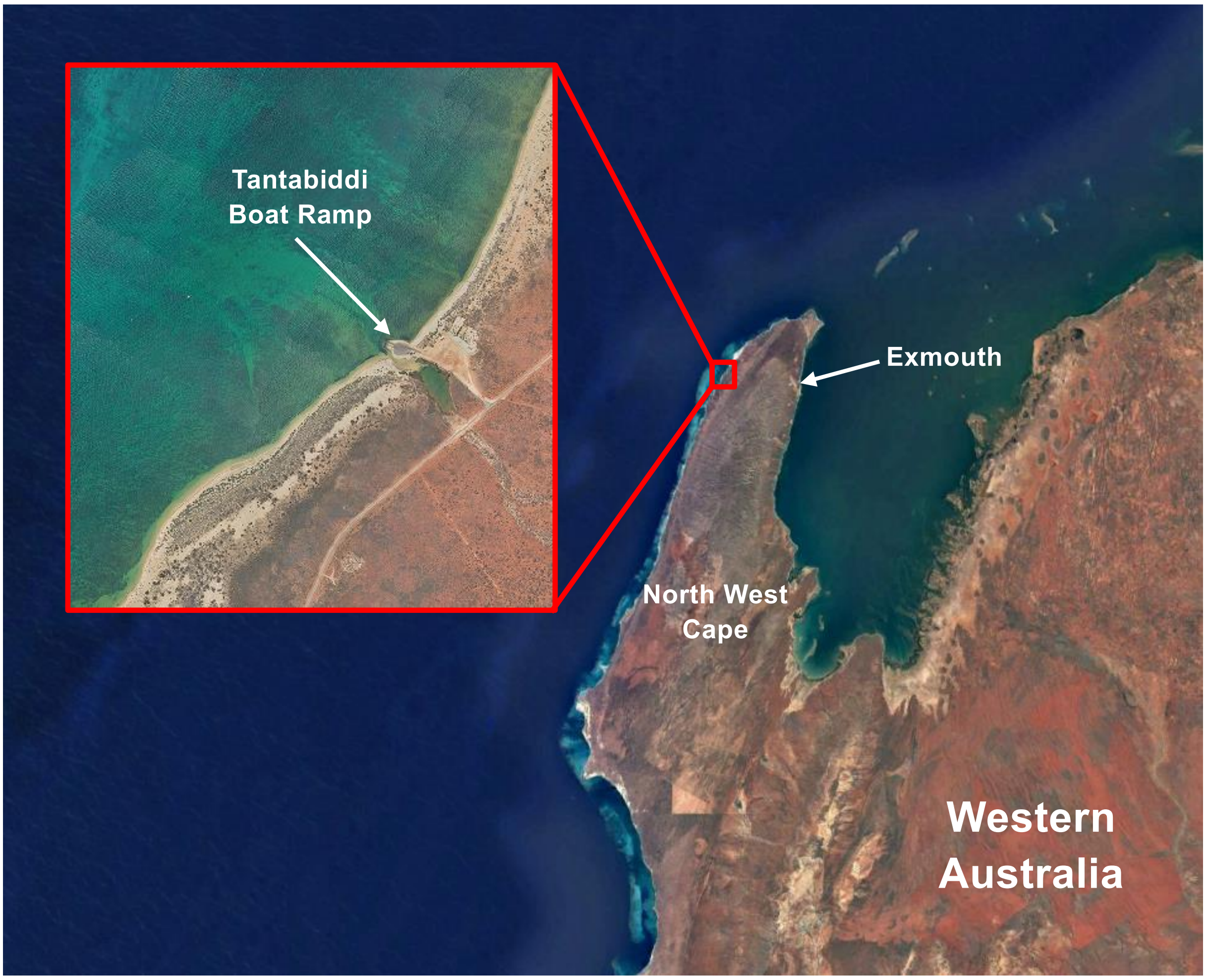


Figure 1.1 Location Plan

To address capacity limitations and maintenance issues associated with the existing Tantabiddi ramp, the Department of Transport (DoT) in collaboration with the Shire, DBCA, Department of Primary Industries and Regional Development (DPIRD), and Tourism WA have resolved to identify the planning, investigations and approvals necessary to develop a new facility at Tantabiddi.

This has involved significant assessment of the coastal processes of the area and the development of a concept for the Tantabiddi Boating Facility (TBF), which is shown in Figure 1.2.

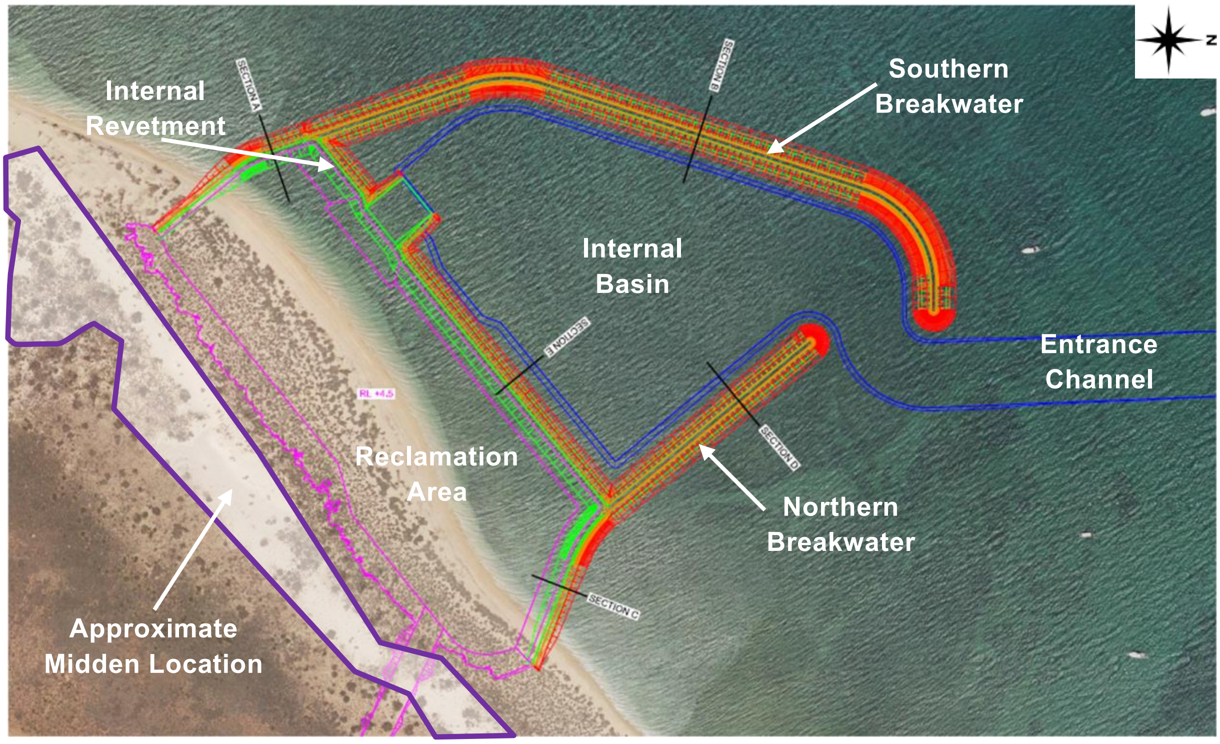


Figure 1.2 Proposed TBF Concept Layout

DoT previously engaged specialist coastal and port engineers M P Rogers & Associates Pty Ltd (MRA) to assess the constructability of the required dredging and coastal structures for the proposed TBF concept and complete plume dispersion modelling for the dredging works.

Since the completion of these works, review and analysis by Stantec has determined that additional plots of the plume dispersion and sedimentation will be required to meet the requirements for Environmental Protection Agency Referral. MRA have thus been engaged to post process the results of the previous plume dispersion modelling in line with the requirements with the EPA's *Technical guidance – EIA of Marine Dredging Proposals* (EPA 2021).

2. Previous Modelling

MRA have previously completed plume dispersion modelling for the proposed dredging associated with the proposed TBF. The methodology, assumptions and results of that work are discussed in MRA (2024). A brief outline of the works is included below for reference. The plume dispersion works generally included the following items.

- Setup, calibrate and validate the Delft3D hydrodynamic model to numerically model the wave and hydrodynamic conditions of the site.
- Use the validated Delft3D model to simulate the wave and hydrodynamic conditions over 16 selected periods corresponding to the proposed dredging activities.
- Set up the Delft3D PART model for the simulation of the dredge plume dispersion.
- Simulate 16 selected metocean periods using Delft3D PART, and assess the resulting dredge plumes.
- The provision of recommendations on the results of the modelling.

Spatial plots of the dredge plume dispersion were produced for the 50, 80 and 95% exceedance levels and an example is presented in Figure 2.1.

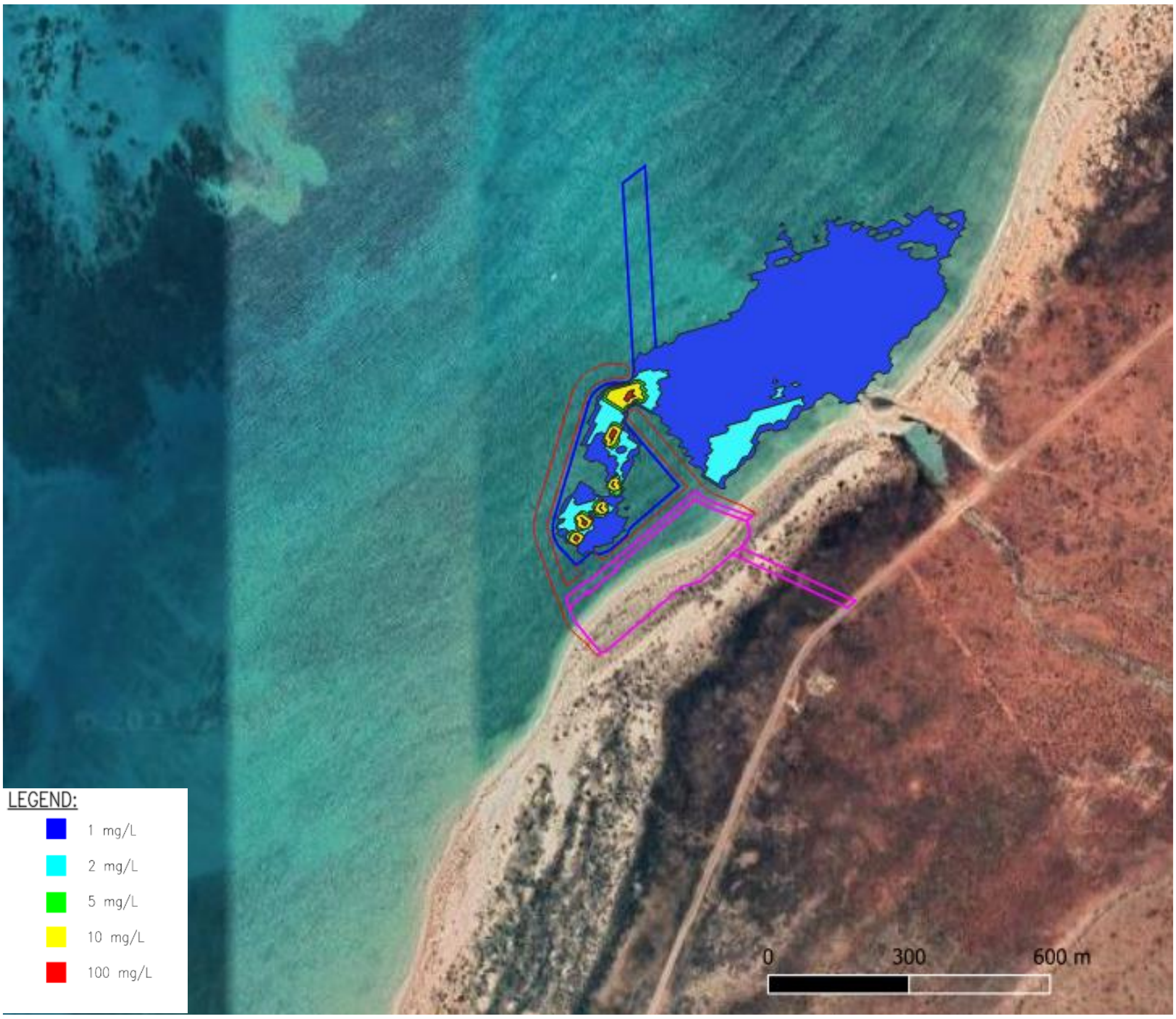


Figure 2.1 Run 1 - 95% Exceedance Plot (MRA 2024)

3. Turbidity Plots

Following review of the previous modelling works and the EPA guidelines by Stantec the following zones of impact for turbidity have been recommended for analysis. These values have been considered for corals only at this stage and assume a baseline Total Suspended Solids (TSS) concentration of 1.37 mg/L. As the plume dispersion modelling considers the impact of the dredging only, the baseline concentration of 1.37 mg/L has been subtracted from the usual TSS concentrations for the Zones of Impact. The relevant levels for the Zones of Impact for turbidity are outlined in Table 3.1.

Table 3.1 Turbidity Zones of Impact (Corals)

Zone	Boundary	Percentile	TSS (mg/L)	Days
Zone of Influence	Outer	95	3.63	Entire Duration
Zone of Moderate Impact	Outer	95	7.93	28
	Inner	95	11.83	28
Zone of High Impact	Outer	95	68.63	10
	Inner	95	68.63	20

After discussion with Stantec and DoT it was decided that the new model outputs would be applied for only three of the completed model runs. From the previous modelling works it was apparent that the main impacts from turbidity are observed during runs 9 through 14 (refer Table 3.2) given that the proposed dredging works are unlikely to take place during severe storm or cyclone events, runs 9, 11 and 13 were selected for further analysis.

Table 3.2 Plume Dispersion Modelled Events (MRA 2023)

Run	Dredge Event	Period	Conditions	Simulation Start Date	Duration (days)	Dredging Start Date	Duration (days)
1	Internal Basin	Winter	Typical	1st May	105	8th May	91
2			Typical with Silt Curtain	1st May	105	8th May	91
3			Abnormal	1st May	105	8th May	91
4			Abnormal with Silt Curtain	1st May	105	8th May	91
5		Summer	Typical	1st November	105	8th November	91
6			Typical with Silt Curtain	1st November	105	8th November	91

7			Abnormal (cyclone)	1st November	105	8th November	91
8			Abnormal (cyclone) with Silt Curtain	1st November	105	8th November	91
9	Entrance Channel	Winter	Typical	1st May	37	3rd May	28
10			Abnormal	1st May	37	3rd May	28
11		Winter Alternate	Typical	1st June	37	3rd June	28
12			Abnormal	1st June	37	3rd June	28
13		Summer	Typical	1st November	37	3rd November	28
14			Abnormal (cyclone)	1st November	37	3rd November	28
15	Resuspension	NA	Seabreeze & Swell	20th July	12	NA	NA
16			50 year ARI Cyclone	1st November	8	NA	NA

For each zone the 95% exceedance was used to determine the boundaries. As such the TSS concentrations at each location within the model were assessed and if at least 5% of the time points within the assessment period met or exceeded the relevant concentration limit they were included in that zone.

If the number of days for the assessment of the zone of impact is less than the dredge duration then a running average of the data was conducted prior to the assessment of the 95% exceedance.

Plots presenting the zones of impact for runs 9, 11 and 13 are presented in Figures 3.1 to 3.3.

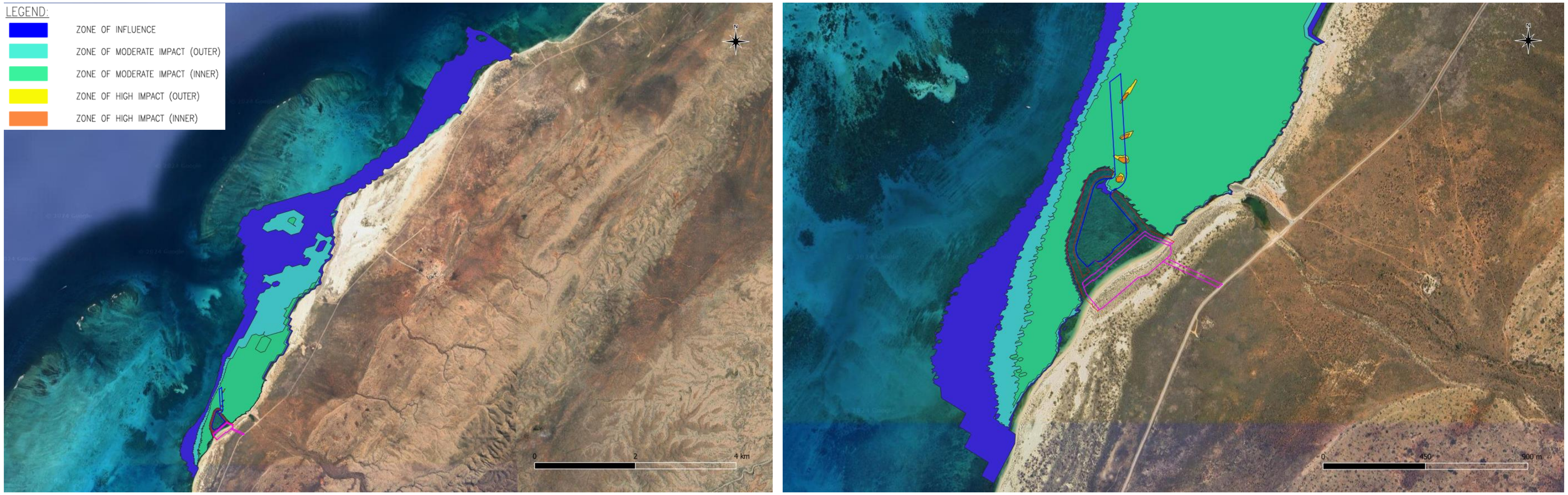


Figure 3.1 Run009 Turbidity 95% Exceedance Plots Far Field (left) & Near field (right)

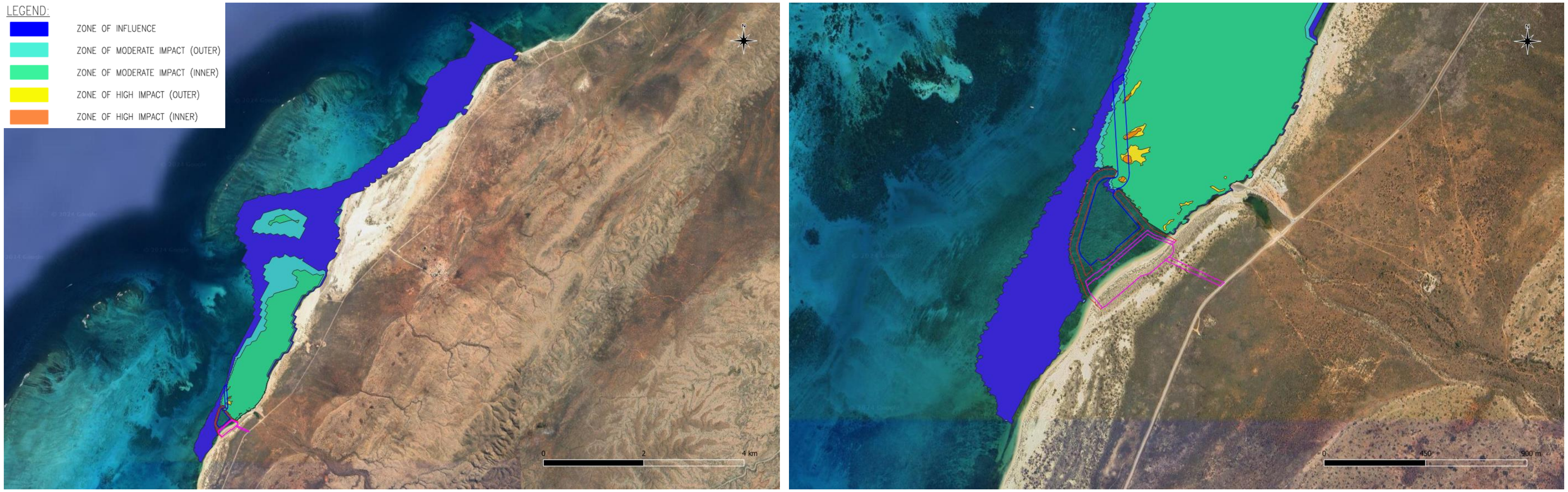


Figure 3.2 Run011 Turbidity 95% Exceedance Plots Far Field (left) & Near field (right)

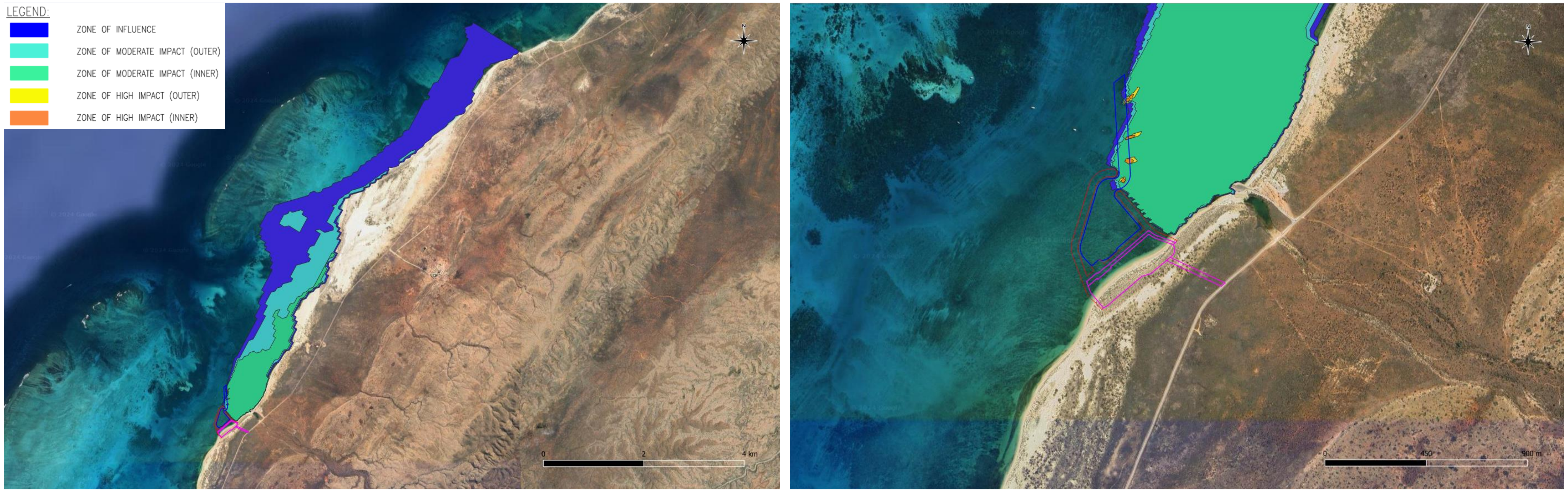


Figure 3.3 Run013 Turbidity 95% Exceedance Plots Far Field (left) & Near field (right)

The truncations of the northern edge of the dredge plume observed in each of the three runs is due to the dredge plume reaching the edge of the modelled area. As such the Zone of Influence would likely extend further north if the modelled domain was increased. No truncation of the Zones of Moderate and High Impact is observed.

The Zone of High Impact for each of the assessed scenarios is highly localised with the majority of the zone occurring adjacent to the sediment input locations within the model. Thus, the highly restricted and localised location of the Zone of High Impact is likely due to the limitations of the modelling. As such the Zone of High Impact from actual dredging works is expected to impact a larger but still highly localised area than is indicated by the modelling. An example of the potential Zone of High Impact from the dredging works is presented as a black polygon in Figure 3.4.

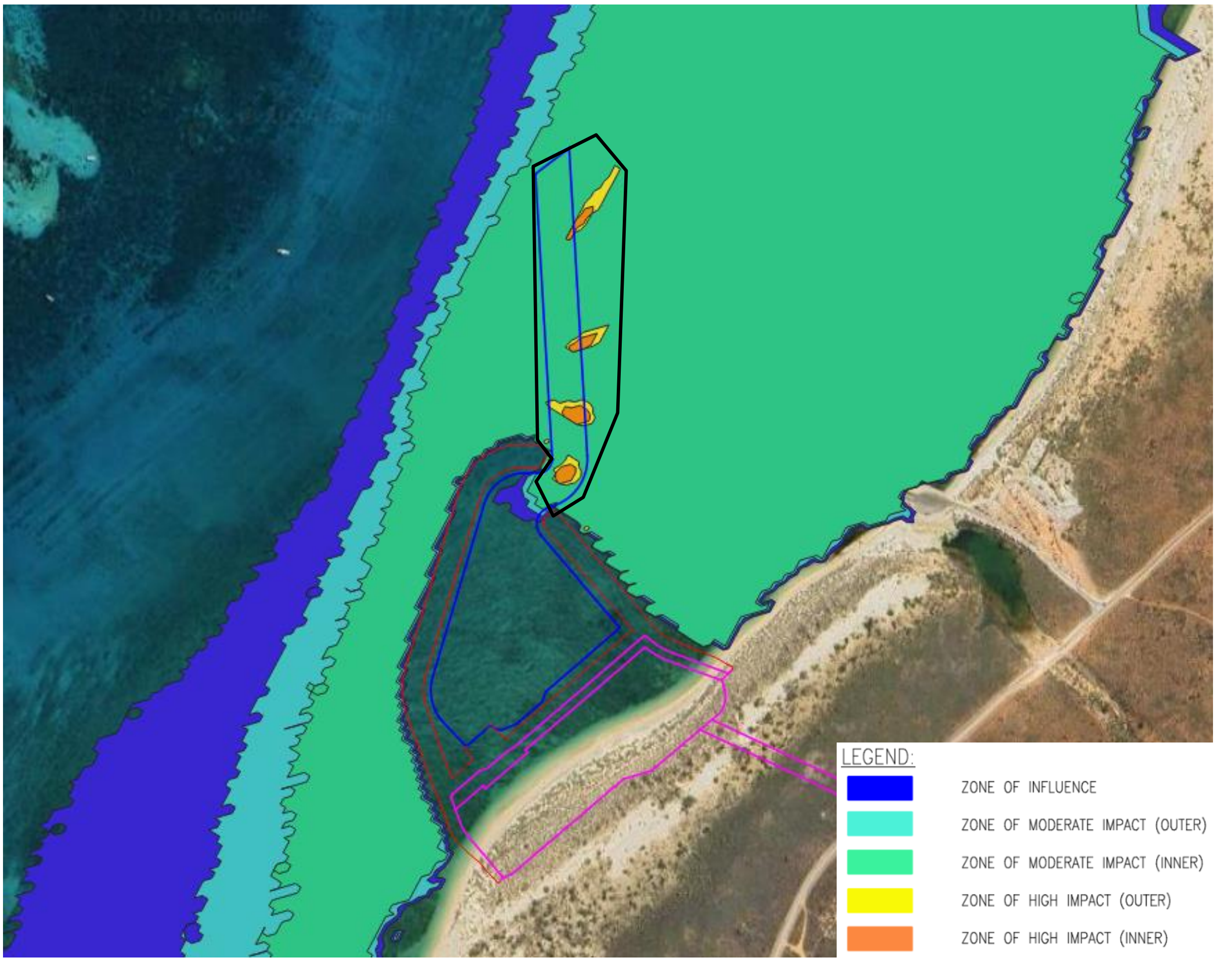


Figure 3.4 Expected Potential Zone of High Impact (black polygon) Run009

The completed modelling has assumed that the dredging is completed using a backhoe dredge over a period of four weeks (MRA 2023). It is noted that any changes to the dredge approach and methodology will likely result in significant change to the Zones of Impact and in particular the Zone of High Impact. As such the determined spatial plots are to be taken as indicative of the potential Zones of Impact for the assumed methodology.

4. Sedimentation Plots

In addition to the potential impacts of turbidity, high levels of sedimentation can also negatively impact the corals present at the site. As such the sedimentation Zone of High Impact also needed to be assessed. As per the EPA requirements the sedimentation boundaries need to be determined using the 95% exceedance in $mg/cm^2/day$ (EPA 2021). To achieve this the difference between each time step was computed to give a rate of sedimentation and this was subsequently converted to $mg/cm^2/day$.

A running mean was computed following the same approach as for the turbidity assessment and from this the 95% exceedance was determined. The relevant levels for the Zone of High Impact for sedimentation are outlined in Table 4.1.

Table 4.1 Sedimentation Zones of Impact (Corals)

Zone	Boundary	Percentile	Sedimentation ($mg/cm^2/day$)	Days
Zone of High Impact	Outer	95	20	10
	Inner	95	40	20

Plots presenting the Zone of High Impact for the three runs are presented in Figures 4.1 to 4.3. For all three runs the sedimentation Zone of High Impact are primarily located within the mouth of the TBF and adjacent to the northern breakwater with a small area also located at the existing Tantabiddi Boat Ramp. No significant sedimentation for the Zone of High Impact is observed outside these areas.

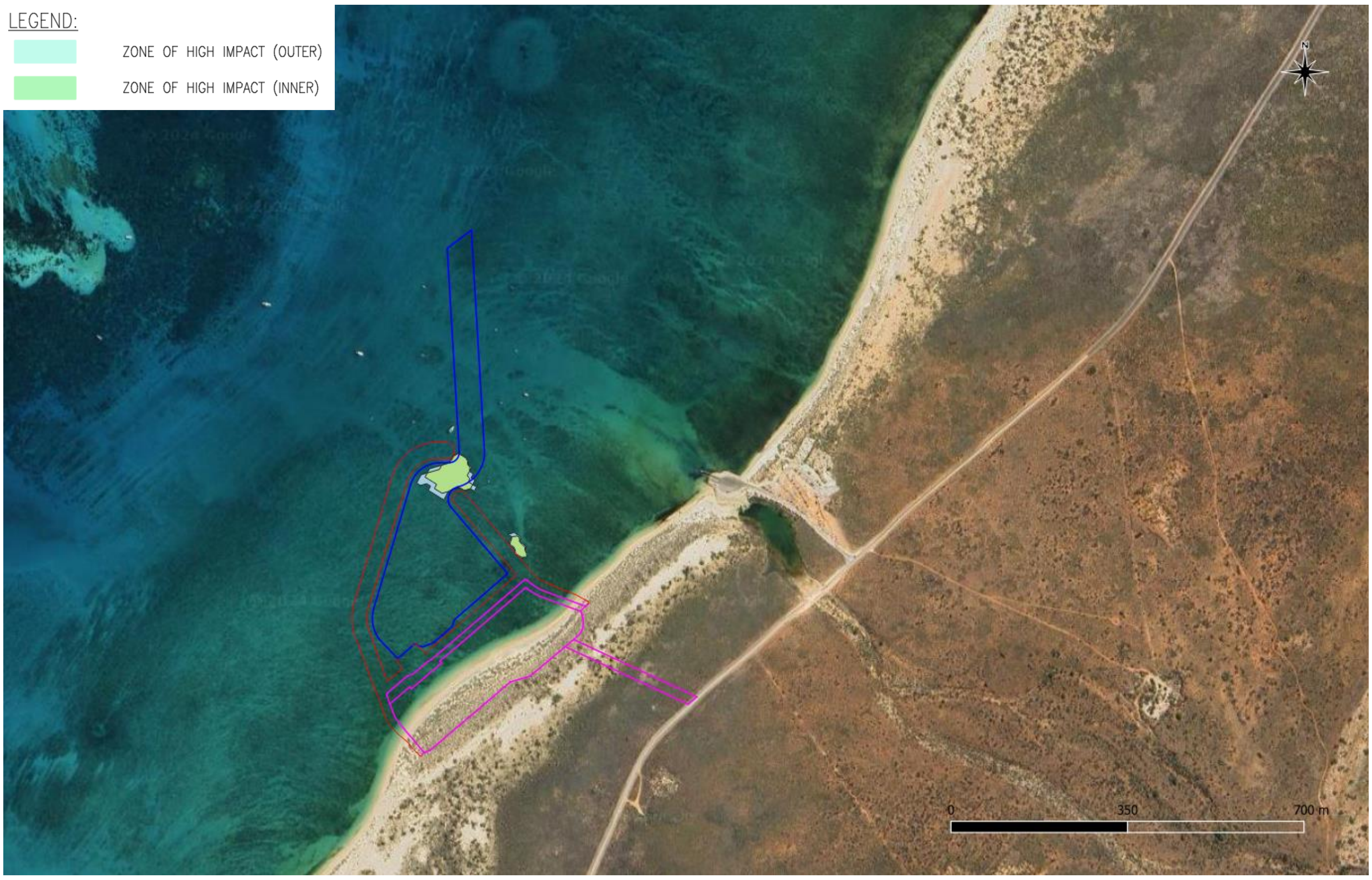


Figure 4.1 Run009 Sedimentation 95% Exceedance Plot

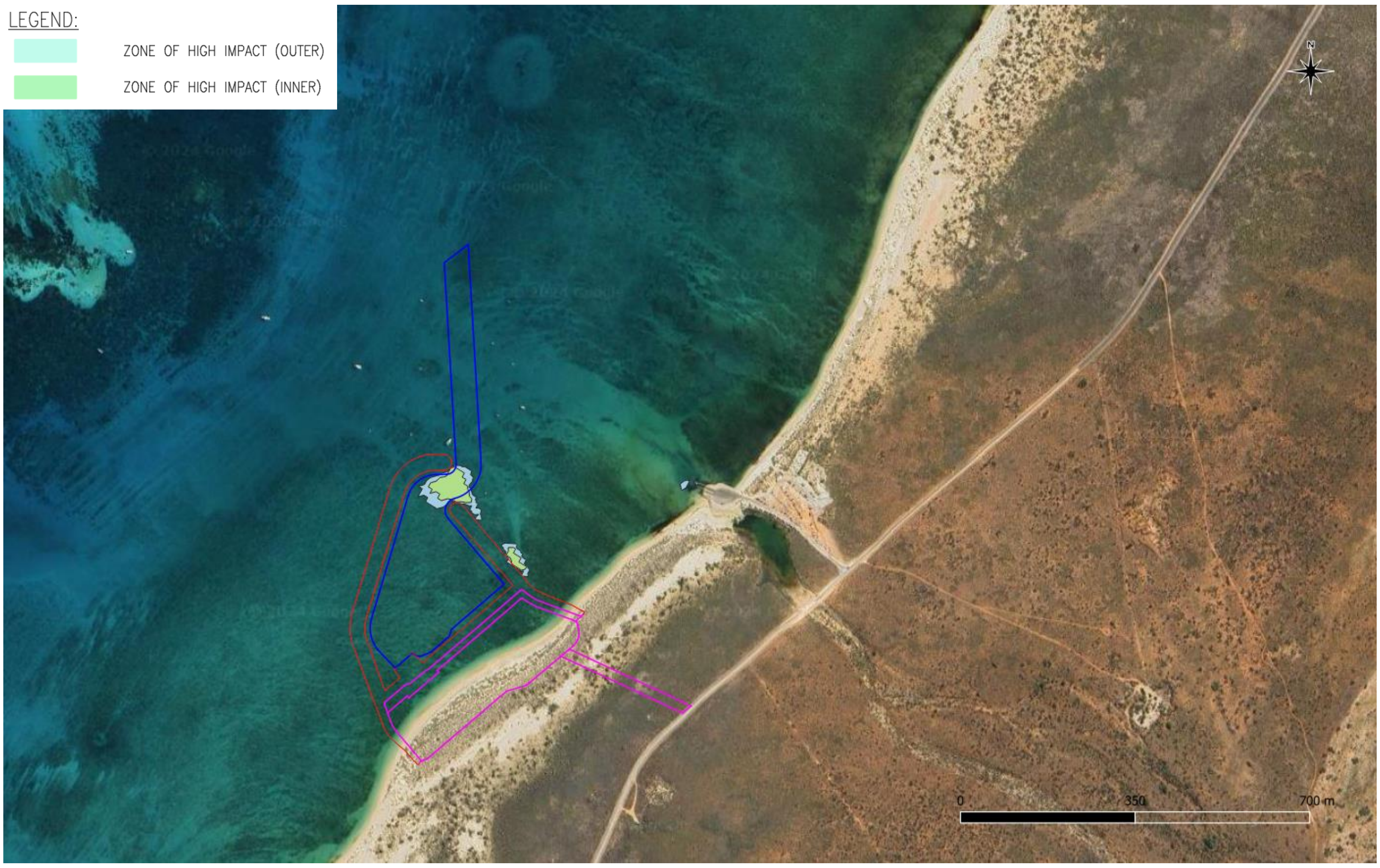


Figure 4.2 Run011 Sedimentation 95% Exceedance Plot

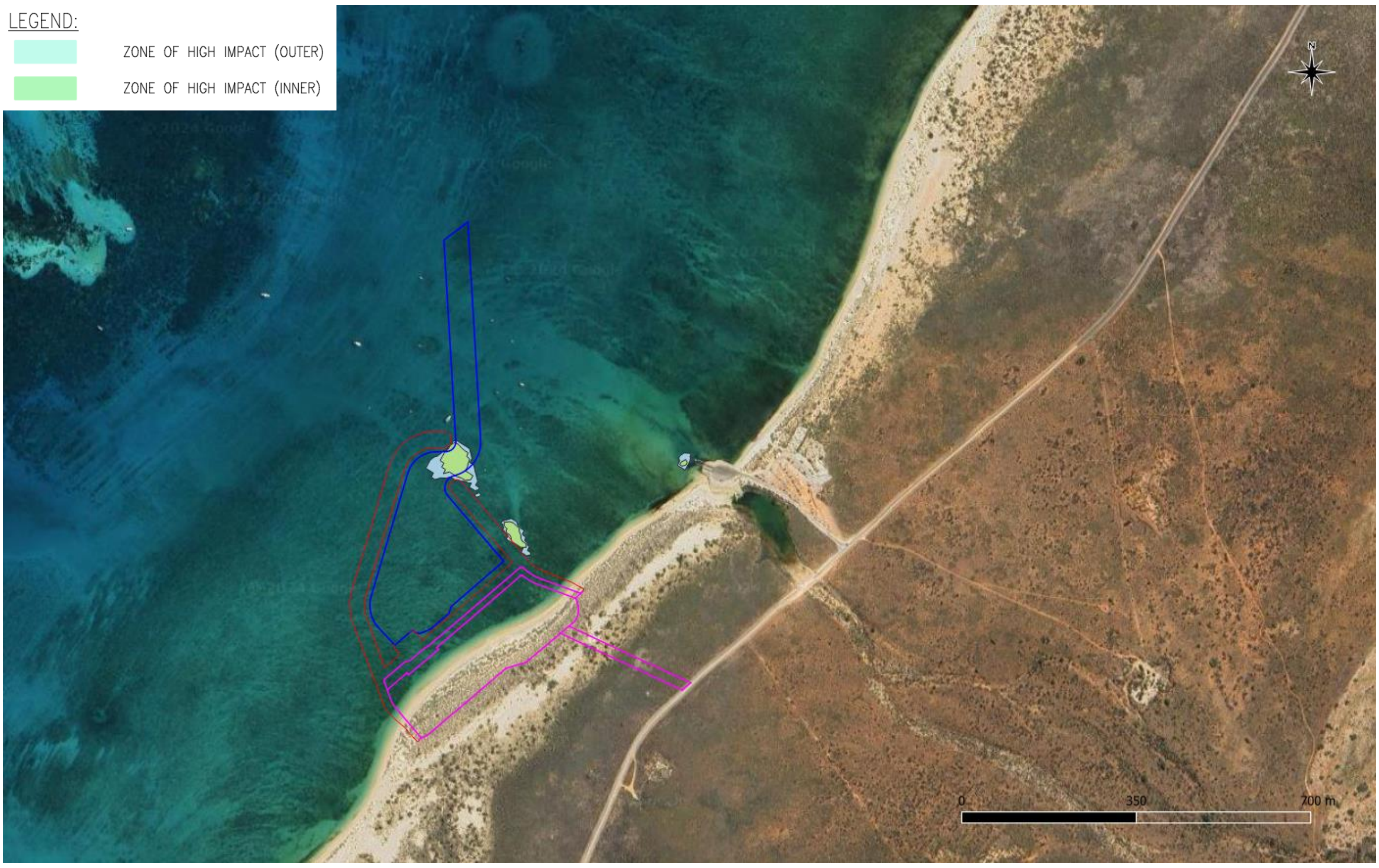


Figure 4.3 Run013 Sedimentation 95% Exceedance Plot

5. References

Environmental Protection Agency 2021. *Technical guidance – EIA of Marine Dredging Proposals.*

M P Rogers & Associates 2024. *Tantabiddi Dredge Plume Modelling Report*. R1817 Rev 2. Prepared for the Department of Transport, Perth, Western Australia.

m p rogers & associates pl

www.coastsandports.com.au

m p rogers & associates pl

www.coastsandports.com.au