Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Appendix C – Sediment and marine water quality memorandums

November 2021

Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Appendix C1 – Responses to submissions on marine construction activities, sediment and water quality

November 2021

Royal HaskoningDHV
Enhancing Society Together

Memo

Project Name	:	Beaches Link and Gore Hill Freeway Connection
Date	:	22 June 2021
Our reference	:	PA1694-104-100-N001F01-BL&GH connection
Subject	**:**	Submissions report – Responses to submissions on marine construction activities, sediment, and water quality

This memo sets out responses to a number of matters raised in submissions on the Beaches Link and Gore Hill Freeway Connection environmental impact statement, specifically submissions relating to dredging activities in Middle Harbour. These submissions have been referred to Royal HaskoningDHV (RHDHV), who prepared Appendix P (Technical working paper: Hydrodynamic and dredge plume modelling) of the environmental impact statement, for a detailed response.

The matters are outlined below, followed by the RHDHV response.

Issue raised:

Deep draft silt curtains will not be effective at full containment of contaminated resuspended sediments. Requests for full length silt curtains anchored to the sea floor to be used during dredging operations.

Response:

The proposed deep draft silt curtains, which would be used around the proposed dredging activities for the Middle Harbour crossing, would extend to a depth of 12m below the water surface and have been demonstrated in the modelling to be effective in mitigating the movement of suspended sediments from the dredge site. The depth of the silt curtains is a balance between restricting the movement of suspended sediments, maintaining tidal flow, and being able to adequately hold the silt curtains in place.

There is a risk that full depth silt curtains which are anchored to the bed of the harbour would generate greater suspended sediment (turbidity) than lesser depth curtains, as a result of sediment disturbance caused by the general movement/drag of the curtains on the bed of the harbour with tidal currents, and as a result of sediment disturbance caused by their placement, progressive relocation and the ultimate removal of the curtain anchoring devices located on the harbour bed, eg. anchors and chains.

As detailed in Appendix P (Technical working paper: Hydrodynamic and dredge plume modelling) a range of management measures are proposed for the project to mitigate the generation and movement of suspended sediments due to dredging, as summarised below:

- *restricted working hours, thereby minimising the rate of sediment disturbance*
- *use of a closed environmental clamshell bucket for removal of the surface layer of sediments with elevated contaminant concentrations. These buckets have been specifically designed for dredging*

contaminated sediments and provide three significant advantages compared to conventional open buckets, including, minimisation of suspended sediment during contact with the harbour bed, minimisation of spill as the bucket is raised through the water column, and precision (accurate dredging) (refer to environmental management measure WQ16 in Table D2-1 of the submissions report)

- *use of two 12 metre deep silt curtains around the entire dredging operation (one on each side of the crossing) (refer to environmental management measure WQ16 in Table D2-1 of the submissions report)*
- *use of an additional shallower silt curtain ('moon pool'), about 2-3 metres deep, attached to the dredge barge within which the dredge bucket specifically operates(refer to environmental management measure WQ16 in Table D2-1 of the submissions report)*
- *use of shallow silt curtains around ecologically sensitive areas (eg. nearby seagrass and rocky reef habitat) that could be potentially impacted by dredging activities, to provide additional protection (refer to environmental management measure WQ16 in Table D2-1 of the submissions report)*
- *no overflow of dredged material permitted from transport barges.*

In addition, following exhibition of the environmental impact statement environmental management measure WQ12 (refer to Table D2-1 of the submissions report) for the project has been updated, as follows:

- *Monitoring during dredging activities will be carried out to validate the effectiveness of mitigation measures implemented to manage potential impacts on the water quality and sensitive marine vegetation and habitats of Middle Harbour. The use of real-time turbidity monitoring at both potential impact and background locations, as well as adoption of a tiered (trigger level) management approach for sensitive sites to manage any potential impacts, will be included in a dredge monitoring program. The dredge monitoring program will be developed in consultation with an appropriately qualified and experienced specialist, DPI Fisheries and the NSW EPA prior to its implementation.*

The use of the proposed 12 metre deep draft silts curtains combined with the environmental clamshell bucket, and other environmental control measures listed above such as no overflow from transport barges, restricted working hours (thereby minimising the rate of sediment disturbance) and real-time turbidity monitoring, is considered an appropriate and effective dredging methodology for the project. As such, full length silt curtains anchored to the sea floor are not considered to be required.

Issue raised:

Concern about disturbed contaminated sediment polluting the harbour and making it unsafe for recreational users of Middle Harbour including users of Clontarf Beach, Clontarf tidal pool, Clontarf Marina, Northbridge Baths, Sandy Bay, The Spit, Clive Park, Tunks Park and Sailors Bay.

Response:

General

The hydrodynamic and dredge plume modelling carried out by RHDHV for the Beaches Link and Gore Hill Freeway Connection project is described in Appendix P (Technical working paper: Hydrodynamic and dredge plume modelling).

The model developed for the project enables the prediction, at various locations within Middle Harbour, of the suspended solids concentration (SSC) due to dredging activities.

The magnitude of SSC can be an important consideration for recreational users of the harbour as it influences the aesthetic quality of the waterbody and poor water clarity may potentially affect user safety.

As described in the environmental impact statement, two rounds of contamination sampling and testing of the harbour sediment have been carried out for the project, namely Douglas Partners and Golder Associates (2018) as reported in Appendix M (Technical working paper: Contamination), and then subsequent investigation by RHDHV as discussed in Annexure C of Appendix M (Technical working paper: Contamination). The purpose of the RHDHV investigation was to assess the suitability of dredged sediments for offshore disposal, an activity regulated under the Commonwealth Environment Protection (Sea Dumping) Act 1981. The regulator for offshore disposal at the nominated disposal ground (Sydney Offshore Spoil Ground) is the Australian Government Department of Agriculture, Water and Environment (DAWE).

Texture and characteristics of sediments to be dredged can be divided into three main groups:

- *gravelly, muddy sand near the shoreline at the tunnel crossing;*
- *grey green mud 0.0-1.0 metres below the bed of the harbour;*
- *grey green mud greater than 1.0 metres below the bed of the harbour.*

The top 1 metre of the grey green mud is the sediment group that contains elevated levels of contaminants. Importantly, while the total dredging program is estimated to be 37 weeks, dredging of sediments with elevated levels of contamination would be completed within a period of about 4 weeks.

Suspended Solids Concentration (SSC) at Locations of Interest for Recreational Users

The main locations of interest identified in submissions are shown in Figure 1 below.

As in the previous response above, the use of the proposed 12 metre deep draft silts curtains combined with the environmental clamshell bucket and other environmental control measures such as no overflow from transport barges, restricted working hours (thereby minimising the rate of sediment disturbance) and real-time turbidity monitoring, is considered an appropriate and effective dredging methodology for the project.

Consideration of mitigation provided by the proposed management measures for the dredging process has been taken into account when assessing the key input parameters included in the SSC modelling at locations of interest.

The SSC at the locations of interest have been extracted from the modelling results for the duration of the dredging activities (37 weeks). The value of SSC at any location varies over time due to a number of factors:

- *dredging is not continuous 24/7, it would take place only during the day (not at night) and from Monday to Friday only (not on weekends)*
- *the type of material being dredged, and the dredging equipment being used, varies over time, which influences the quantity of sediment that enters the water column to generate SSC*
- *natural variation of the magnitude and direction of the tidal currents which transport the suspended sediments throughout the waterbody.*

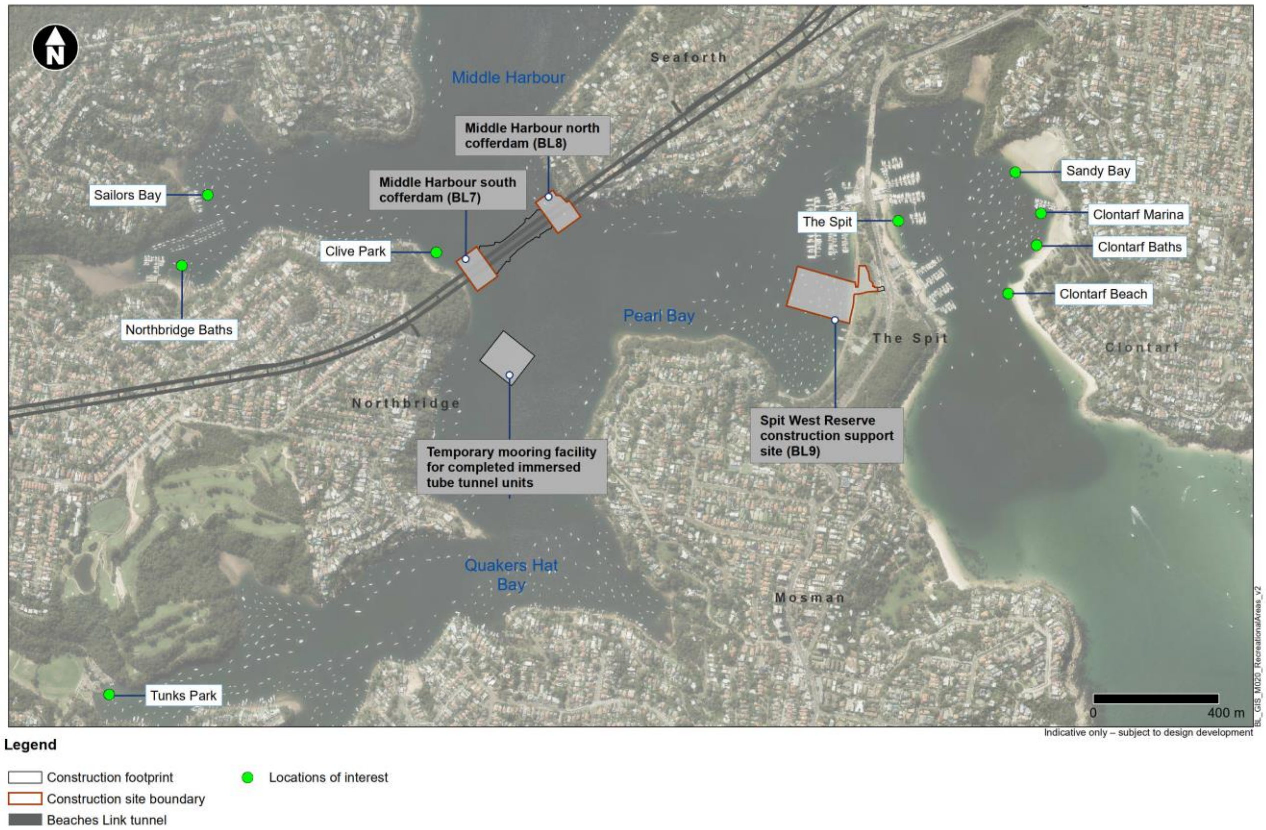

Figure 1 Locations adopted based on locations of interest identified in submissions

A typical example of the variation over time of SSC due to dredging is shown in Figure 2, corresponding to the location off Clive Park with a water depth of 5.5 metres at mid tide, for a period of one week around the expected peak SSC, expressed in milligrams per litre (mg/L). The SSC at both the water surface (black) and near the bed of the harbour (blue) are shown. Figure 2 indicates the following:

- *the peak SSC is only short-lived, having less than 1-2 hours duration due to the restricted dredging hours proposed and dispersion by tidal currents*

- *the SSC response shows a strong diurnal pattern, reflecting that dredging occurs only during the day and not at night*
- *the near-bed SSC is higher than the surface SSC, reflecting the fact that sediment entrainment in the water column due to dredging occurs mainly near the bed of the harbour.*

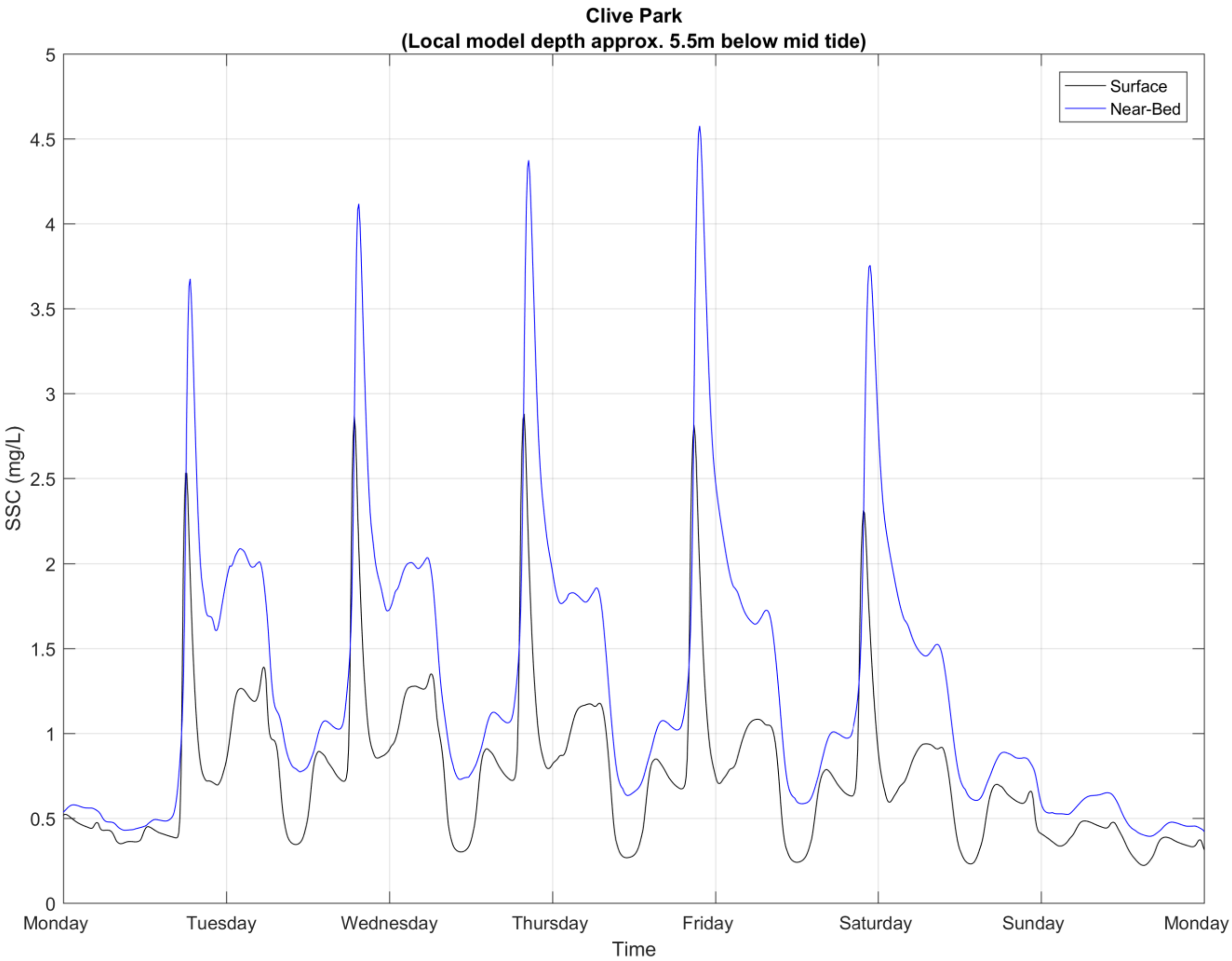

Figure 2 SSC variation off Clive Park over a one-week period around the peak SSC

Table 1 sets out the peak SSC, in mg/L, predicted at the locations of interest throughout the 37-week dredging period at the surface and near the bed of the harbour. Due to the variable magnitude of SSC over time, the 90th percentile SSC (SSC exceeded for 10% of the time throughout the 37 weeks dredging program) is also provided in Table 1. Note that the results for Tunks Park are not presented in Table 1 as SSC at this location were negligible due to its remoteness from the works.

Table 1 Predicted suspended solids concentrations (SSC) at locations of interest

Location	***Water Depth at Mid Tide (m)***	***Peak SSC (mg/L)***		***90th percentile SSC (mg/L)***	
		Surface	***Near-Bed***	***Surface***	***Near-Bed***
Upstream of Spit Bridge					
Sailors Bay	*11.0*	*0.03*	*0.06*	*0.02*	*0.03*
Northbridge Baths	*4.5*	*0.06*	*0.1*	*0.03*	*0.05*
Clive Park	*5.5*	*3.0*	*4.5*	*0.9*	*1.5*
Downstream of Spit Bridge					
Sandy Bay	*3.2*	*2.2*	*2.6*	*0.7*	*0.9*
The Spit	*5.5*	*1.8*	*1.9*	*0.6*	*0.6*
Clontarf Marina	*15.7*	*2.4*	*2.8*	*0.8*	*0.9*
Clontarf Baths	*4.0*	*2.0*	*2.1*	*0.7*	*0.7*
Clontarf Beach	*4.4*	*2.0*	*2.2*	*0.6*	*0.6*

Note: Results for Tunks Park not presented as SSC at this location were negligible.

The results in Table 1 indicate the following trends:

- *SSC is generally higher at those locations adjacent to the main channel of Middle Harbour and closer to the dredging activities*
- *SSC in the side bays is typically low (Northbridge Baths and Sailors Bay)*
- *SSC downstream of Spit Bridge is generally lower than for locations upstream of Spit Bridge adjacent to the main channel due to distance from the dredging activities and dispersion by tidal currents*
- *Differences between surface and near-bed SSC downstream are typically less indicating greater vertical mixing with distance from the dredging site.*

The background level of suspended solids in the absence of dredging, as determined from historical information presented in Appendix Q (Technical working paper: Marine water quality), needs to be considered alongside the predicted SSC due to dredging. The 90th percentile SSC predictions in Table 1 can be compared to the 90th percentile background value for Total Suspended Solids (TSS). The 90th percentile TSS value in Middle Harbour is 3.7mg/L, which is based on measured data (Upper Parramatta Trust Catchment Management Authority water quality monitoring program) presented in Table 3.6 of Appendix Q (Technical working paper: Marine water quality). Total suspended solids concentrations in Middle Harbour are generally low during extended dry periods with peaks of up to 30mg/L after heavy rainfall events (refer to Figure 3 below).

It should be noted that water quality results in Appendix Q (Technical working paper: Marine water quality), are expressed as TSS and correspond to measured background levels in the absence of dredging. As noted earlier, the term SSC refers to the contribution to total suspended solids of dredging activities alone. During dredging activities, the total suspended solids is made up of the background level at the time and the contribution of suspended solids due to dredging.

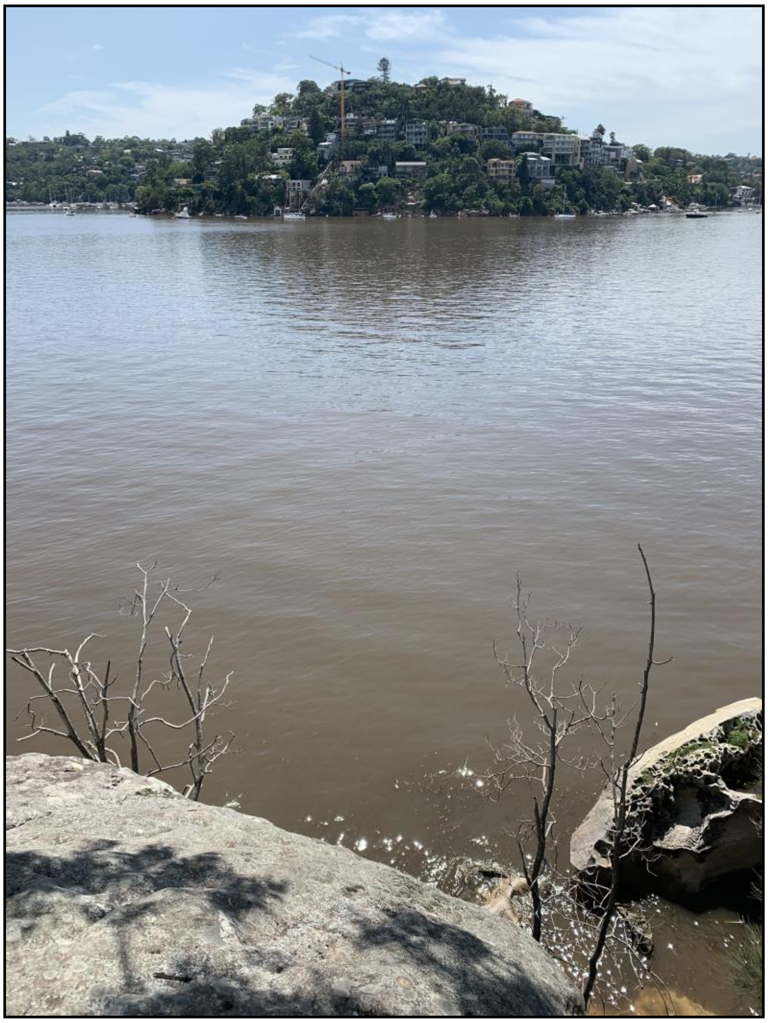

Figure 3 Evidence of increased turbidity at Clive Park (looking north) after heavy rain in February 2020 (Source: Figure 3-4 of Appendix Q (Marine Water Quality) of the environmental impact statement).

Based on the modelling results presented in Table 1, the predicted SSCs due to dredging activities at the locations of interest, at the 90th percentile level, for both the surface and the near-bed results, are less than the background TSS value of 3.7mg/L. As such, it would not be expected that SSC due to dredging would be a noticeable addition to background concentrations at the locations of interest.

Peak SSCs are unlikely to be visible at the surface at the locations of interest, if so this would only be the case for a short duration (likely less than 1-2 hours) having regard to the results in Figure 2.

Release of Contaminants into the Water Column

As part of the environmental impact statement, investigation into the potential for release of contaminants into the water column when sediments are disturbed by dredging was carried out, as described in Annexure C of Appendix M (Technical working paper: Contamination).

The resuspension of sediments during dredging can potentially result in the introduction of contaminants into the dissolved phase of the water column by releasing contaminants from the sediment pore water and *by separation of contaminants from suspended sediment particles. Once in the dissolved phase, released contaminants can be subject to migration, by tidal currents for example, and can therefore result in different exposures and risks compared to contaminants attached to suspended sediment particles. Suspended sediment particles settle back to the bed of the harbour more quickly compared to contaminants in the dissolved phase and can also be restricted in migration by environmental control measures such as silt curtains.*

Elutriate testing provides an indication of the potentially soluble contaminants that are susceptible to migration and assesses the risk to the environment from these soluble contaminants. The laboratory elutriate testing involves shaking a representative sediment sample with four times the volume of seawater at room temperature for 30 minutes, then allowing the samples to settle for one hour[1]*. The elutriate (liquid lying above the settled solids) is then centrifuged or filtered within 60 minutes and analysed. The seawater used for the elutriate test is also analysed by the same methods, so that the results for the elutriate can be corrected for contaminant levels in the seawater. Prior to comparison of the elutriate test results to water quality criteria, account is taken of the natural dilution which would occur at the dredging site (which is always much greater than that adopted in the laboratory test).*

Douglas Partners and Golder Associates (2018) carried out elutriate testing of the grey green muds as part of their marine contamination investigations for the project. RHDHV also carried out elutriate testing of the grey green muds, as part of the assessment of the suitability of the dredged sediments for offshore disposal. The elutriate testing carried out as part of the RHDHV investigation reported in Annexure C of Appendix M (Technical working paper: Contamination) involved three samples of the top 1m of the grey green mud containing elevated levels of contaminants.

As described in Section 4.0 of Annexure C of Appendix M (Technical working paper: Contamination), the elutriate test results, when corrected for contaminant levels in the seawater and adjusted for natural dilution at the dredging site, were below the relevant water quality criteria.

As detailed in Appendix P (Technical working paper: Hydrodynamic and dredge plume modelling) a range of management measures are proposed for the project to mitigate the generation and movement of suspended contaminated sediments due to dredging, as summarised below:

- *restricted working hours*
- *use of a closed environmental clamshell bucket for removal of the surface layer of sediments with elevated contaminant concentrations. These buckets have been specifically designed for dredging contaminated sediments and provide three significant advantages compared to conventional open buckets, including, minimisation of suspended sediment during contact with the harbour bed, minimisation of spill as the bucket is raised through the water column, and precision (accurate dredging) (refer to environmental management measure WQ16 in Table D2-1 of the submissions report)*
- *use of two 12 metre deep silt curtains around the entire dredging operation (one on each side of the crossing) (refer to environmental management measure WQ16 in Table D2-1 of the submissions report)*
- *use of an additional shallower silt curtain ('moon pool'), about 2-3 metres deep, attached to the dredge barge within which the dredge bucket specifically operates (refer to environmental management measure WQ16 in Table D2-1 of the submissions report)*

[1] *The elutriate test hence uses a dilution of 1:4, wet sediment:seawater.*

- *use of shallow silt curtains around ecologically sensitive areas (eg. nearby seagrass and rocky reef habitat) that could be potentially impacted by dredging activities, to provide additional protection (refer to environmental management measure WQ16 in Table D2-1 of the submissions report)*
- *no overflow of dredged material permitted from transport barges*
- *monitoring during dredging activities will be carried out to validate the effectiveness of mitigation measures implemented to manage potential impacts on the water quality and sensitive marine vegetation and habitats of Middle Harbour. The use of real-time turbidity monitoring at both potential impact and background locations, as well as adoption of a tiered (trigger level) management approach for sensitive sites to manage any potential impacts, will be included in a dredge monitoring program. The dredge monitoring program will be developed in consultation with an appropriately qualified and experienced specialist, DPI Fisheries and the NSW EPA prior to its implementation (refer to environmental management measures WQ12 in Table D2-1 of the submissions report).*

Accordingly, water quality impacts for recreational users would not be expected.

It is also relevant that dredging of contaminated sediments would be completed within a period of about 4 weeks thus reducing the risk to recreational users further.

Issue raised:

Concern for safety of workers carrying out dredging work due to the potential exposure to contamination.

Response:

The dredging work for the project would operate in accordance with the NSW Work Health and Safety Act 2011 and construction activities including dredging works would be regulated by SafeWork NSW. A project safety and health management plan would be prepared taking into account the potential risks to the health and safety of workers and other persons put at risk from work carried out, which would include consideration of the risks associated with dredging of contaminated sediments.

The dredging activity would not involve the workers coming into direct contact with the sediments. The sediments would be removed from the bed of the harbour by the dredging equipment and placed directly in barges for transport to the unloading site.

The dredged material would be removed and placed in the barges in a saturated condition, hence generation of dust is not an issue. A film of water would form over the dredged material in the barge which would limit the generation of odours. Where dredged material is to be disposed of to land at a licensed facility, lime and polymers would be mixed into the dredged material in the barge to make it spadeable. This would also limit the potential for odour emission. Testing of this material has shown it is suitable for disposal at a licensed facility as general solid waste.

At a minimum all workers would wear Personal Protective Equipment (PPE), including high visibility vests, safety glasses and suitable footwear. In the event that any required cleaning of the equipment posed a risk of contact by workers with the sediments, protective gloves would form part of the PPE. Any additional PPE and/or mitigation will be considered and determined during risk assessment in the lead up to carrying out the works.

Issue raised:

Concern that the EIS does not adequately describe the method for treating contaminated sediments from dredging.

Response:

The contaminated sediments that are not suitable for offshore disposal would be removed by a backhoe dredge (BHD) fitted with a closed bucket (environmental clamshell) and loaded into transport barges located adjacent to the BHD[2]. Overflow from the barge would not be permitted (refer Section 8.2 of Appendix P (Technical working paper: Hydrodynamic and dredge plume modelling)).

The material would be transported to a land-based load-out facility, outside of Middle Harbour, for transport by truck to land disposal at a licensed facility. Testing of the contaminated dredged material has shown it is suitable for disposal at a licensed facility as general solid waste.

Additives such as lime and polymers would be mixed into the dredged material while in the barge prior to unloading. These additives achieve a number of benefits; they ensure the dredged material is spadeable for disposal at the licensed facility and also address any odour concern and acid sulfate soils potential.

Transport for NSW has prepared a Preferred Infrastructure Report (PIR) to describe the method for treating contaminated sediments from dredging and the associated load-out facility to be located at Port of Newcastle.

Issue raised:

Concern about the combined impact of disturbed contaminated sediment and sewage and stormwater discharge events.

Response:

Water quality impacts not related to the project due to sewage overflows and stormwater discharge would occur in heavy rainfall events. At such times suspended solids concentrations would be naturally elevated from stormwater discharge and, therefore, the contribution to total suspended solids by project dredging SSC would be proportionally reduced.

Current NSW Government advice is to avoid swimming during and for up to three days after heavy rain at estuarine swimming areas such as Middle Harbour.

Accordingly, it is considered unlikely that combined impacts due to disturbed contaminated sediment from project dredging and external sewage and stormwater discharge events would be a significant issue, noting also that dredging of contaminated sediments would be expected to be completed within a period of about 4 weeks.

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[2] *A BHD comprises an excavator mounted on a barge.*

Regards

Greg Britton
Technical Director - Water

Transport for NSW

Beaches Link and Gore Hill Freeway Connection

Appendix C2 – Review of recreational exposures during dredging activities

November 2021

MEMO

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Project: **Beaches Link and Gore Hill Freeway Connection**

Date: **16 September 2021**

Subject: **Review of recreational exposures during dredging activities**

1.0 Introduction

This memo has been prepared in response to matters raised in submissions on the Beaches Link and Gore Hill Freeway Connection project (the project) environmental impact statement, and presents further review of potential recreational exposures that may occur during proposed dredging activities for the project.

Royal HaskoningDHV (RHDHV) has provided detailed responses to submissions raised in relation to dredging activities for the project in a separate memo dated 22 June 2021 which is included in Appendix C1 of this submissions report. This EnRiskS memo has been prepared to provide additional information that specifically addresses questions raised in relation to recreational exposures to sediments in Middle Harbour. This review draws on the technical information presented in the RHDHV memo included in Appendix C1 of this submissions report and associated technical working papers from the environmental impact statement.

In particular, the following technical reports from the environmental impact statement are relevant for this review:

- Appendix P – Technical working paper: Hydrodynamic and dredge plume modelling
- Appendix M - Technical working paper: Contamination.

2.0 Background

Sediments with elevated levels of contamination have been identified within Middle Harbour and The Spit due to the contamination associated with historical industrial use (over 150 years) of the harbour and the addition of polluted stormwater runoff originating from nearby urbanised catchments (refer Section 6.5 of Appendix M (Technical working paper: Contamination)).

The background level of suspended solids in the absence of dredging, as determined from historical information, is presented in Appendix Q (Technical working paper: Marine water quality). The 90th percentile total suspended solids (TSS) value in Middle Harbour is 3.7mg/L, which is based on measured data (*Upper Parramatta Trust Catchment Management Authority water quality monitoring program*) presented in Table 3.6 of Appendix Q (Technical working paper: Marine water quality). Total suspended solids concentrations in Middle Harbour are generally low during extended dry periods with peaks of up to 30 milligrams per litre (mg/L) after heavy rainfall events (refer to Figure 3 of Appendix C1 of this submissions report for photo of increased turbidity in Middle Harbour after heavy rain). During the wetter months, total suspended solids are at around three to five mg/L.

3.0 Potential for exposure

There are a number of existing recreational areas identified by the community and government agencies in the vicinity of the proposed works in Middle Harbour. These recreational areas are shown in Figure 1. The project involves an immersed tube tunnel crossing of Middle Harbour from Clive Park, Northbridge in the south to Seaforth Bluff, Seaforth in the north.

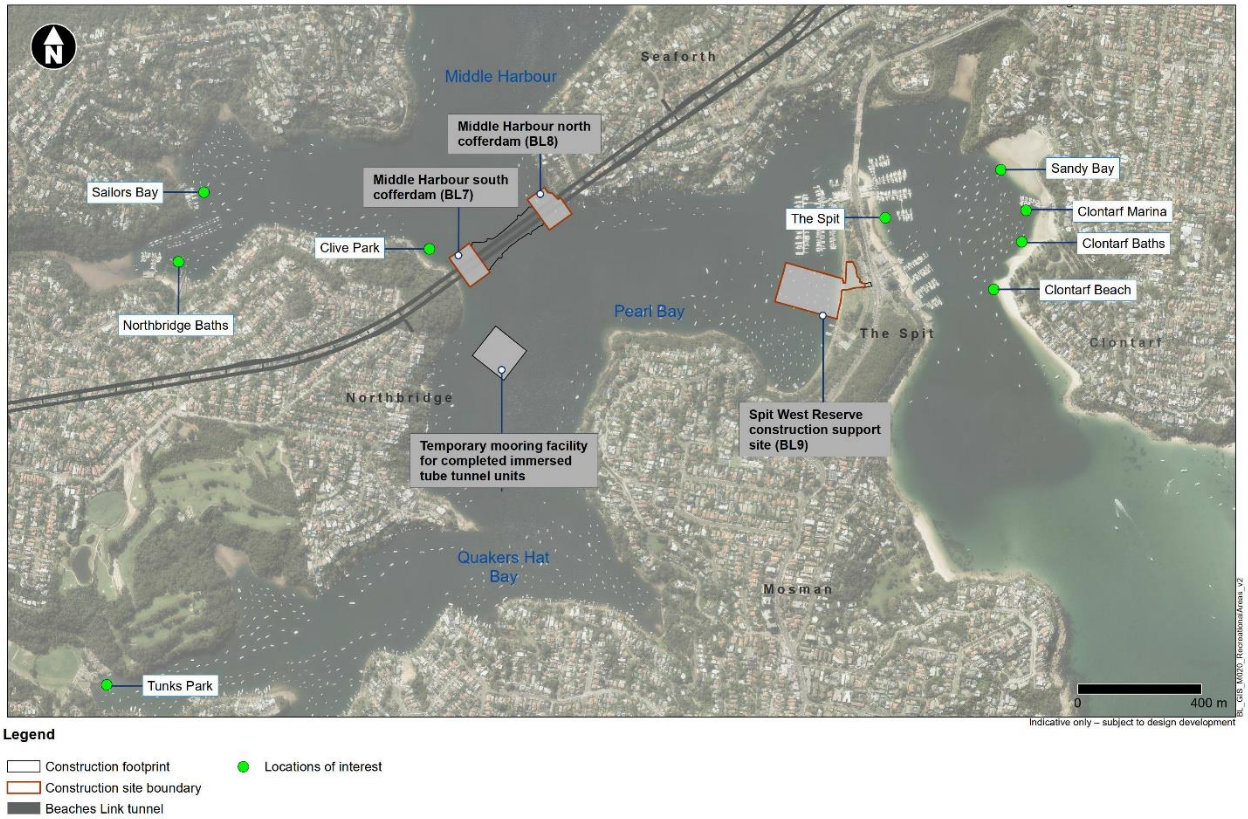

Figure 1 Project construction areas and recreational locations of interest in Middle Harbour (Source: RHDHV memo dated 22 June 2021)

The proposed works required for the harbour crossing are described in detail in Chapter 6 (Construction works) of the environmental impact statement and Appendix P (Technical working paper: Hydrodynamic and dredge plume modelling). There are a number of management measures that are proposed to be implemented to minimise the movement of disturbed sediments to any significant distance away from the construction footprint. This does not mean that no sediments would be mobilised into the water, however it means that most of the sediments disturbed would be contained within close proximity to the proposed works.

For recreational areas that are located outside of the construction footprint, the ways in which human exposure to sediments disturbed by the project may occur is as follows:

- incidental ingestion of water that contains suspended sediments and dissolved phase chemicals (from disturbed sediments)
- dermal contact (i.e., skin contact) with water that contains suspended sediments and dissolved phase chemicals (from disturbed sediments).

Water in Middle Harbour is saline/marine water that is not palatable and hence any ingestion during recreational activities would be incidental (i.e. minor amounts or small mouthfuls) only.

4.0 Evaluation of recreational exposures

To evaluate whether there are any risk issues of concern for recreational exposures to sediments disturbed by the project, the concentrations that people may be exposed to at recreational areas needs to be estimated. As noted above, the concentrations that are relevant to recreational exposures relates to the concentrations of chemicals in surface water as suspended sediment and dissolved in water.

Suspended sediments

Appendix C1 of this submissions report provides a review of the suspended solids concentrations (SSC) at the recreational areas in Figure 1. The SSC is the concentration of sediments (as a mass of sediment in mg) per litre of water (mg/L). The evaluation provides a peak (maximum) and 90th percentile SSC in each of the surrounding recreational areas due to works in the construction footprint. To evaluate the concentration of chemicals that may be present in the water and present on the suspended solids, the SSCs are combined with information on the concentrations of metals and organics in the sediments to be disturbed.

The concentrations of chemicals in the sediments to be disturbed are summarised in Table 1 of Annexure C of Appendix M (Technical working paper: Contamination). This table provides the 95% upper confidence level (UCL) concentrations for sediments near the shoreline, the muds/sediments that are 0 to 1 m depth and the muds/sediments that are deeper than 1 m. The maximum 95% UCL concentrations reported from any of these depths has been used in this assessment to provide a worst-case outcome.

The maximum peak SSCs for surface water (most relevant to recreational exposures), which is 3 mg sediment/L water (refer to Table 1 of Appendix C1 of this submissions report) at Clive Park, has then been used to calculate a maximum or peak concentration for chemicals present in suspended sediments in surface water.

The maximum concentration calculated is presented in Table 1 below. All concentrations in other recreational areas will be lower than this maximum as the peak SSC for all other locations is lower than 3 mg/L. Annexure A presents the calculated concentrations for chemicals in suspended sediments in surface water at the recreational areas in Figure 1.

Dissolved concentrations

Appendix C1 of this submissions report also provides a summary of the movement of chemicals from sediments into the water as dissolved phase concentrations. The concentrations that may be dissolved in the water have been estimated from elutriate testing of sediments (as described in detail in Annexure C of Appendix M (Technical working paper: Contamination)). The maximum elutriate concentration has been used in this assessment. This is the concentration directly adjacent to the sediment particles. The dissolved concentration would then be diluted as it is mixed with water in and adjacent to the construction footprint. In the construction work area the minimum amount of dilution (the ratio of wet sediment to seawater) that would occur was estimated to be 200 (as described in detail in Annexure C of Appendix M (Technical working paper: Contamination). This dilution has been applied to the maximum elutriate concentration to determine a worst-case dissolved phase concentration, close to the construction footprint (e.g. Clive Park).

The maximum dissolved phase concentrations are listed in Table 1 below. Concentrations in all other recreational areas will be lower due to additional mixing in Middle Harbour.

Recreational water guidelines

The worst-case concentrations in recreational water estimated from suspended sediments and dissolved phase have been directly compared against recreational water quality guidelines – refer to Table 1.

Recreational water guidelines for chemicals used in this assessment are based on guidance from National Health and Medical Research Council (NHMRC 2008). This guidance uses drinking water guidelines and applies a 10-fold factor to account for the ingestion of 0.2 mL water each day (for recreational exposures), rather than 2 L water every day (for drinking water). The drinking water guidelines are derived using an approach that accounts for other exposures such as dermal (skin) absorption from water and intakes from other sources (not just water). The drinking water guideline represents a concentration in water that all members of the public can be exposed to every day for a lifetime with no adverse health effects. Similarly, the recreational water guidelines are protective of the health of all members of the community for exposures to recreational water every day for a lifetime. These guidelines are conservative for recreational use of marine water (where water is less palatable than freshwater) and for harbour locations where recreational use would not occur every day.

It should also be noted that these guidelines have been directly compared against water concentrations estimated on the basis of peak concentrations for works that are expected to only occur for a short period of time. The dredging of contaminated sediments would be expected to be completed within a period of about 4 weeks, and within this period, peak concentrations (which have been evaluated in this assessment) are short-lived, having likely less than 1 – 2 hours duration. Exposures that may occur as a result of these activities are significantly less than assumed in the recreational water guidelines (which are every day for a lifetime).

Hence the recreational water guidelines provide a conservative value for the assessment of potential exposures from the proposed dredging activities.

Assessment of potential risks from recreational exposure

Review of Table 1 indicates that all maximum (or worst-case) concentrations of chemicals in water, as a result of the presence of suspended sediments or dissolved phase concentrations from dredging activities, are well below (at least 1000 times below) recreational water guidelines.

This table relates to predicted worst-case concentrations at the closest recreational area of Clive Park. Concentrations in all other locations, which are further away from the construction footprint, will be lower due to increased dilution or mixing in larger volumes of water.

It is noted that the calculations presented in Table 1 relate to sediments to be disturbed during the construction works. Background levels of suspended sediments are also present in waterways, including Middle Harbour. These background levels (90^{th} percentile background TSS value of 3.7mg/L in Middle Harbour) are higher than the suspended sediment levels predicted from the dredging activities. The background levels of suspended sediments in Middle Harbour would be derived from a range of sources including sediments from the floor of the harbour and sediments washed into the harbour from stormwater runoff. Even if it was assumed that 100% of all suspended sediments, background plus the worst-case contribution from the project dredging activities, were derived from contaminated sediments the concentrations in the closest recreational area would remain well below the recreational water guidelines.

On this basis there are no risk issues of concern for recreational use of areas surrounding the project in relation to exposure to chemicals derived from proposed dredging activities.

Table 1 Worst-case concentrations of chemicals from dredging activities in the closest recreational area (Clive Park), and comparison against recreational water guidelines

Chemical detected in sediments	Units	Worst-case concentration in suspended sediments from dredging[1]	Worst-case dissolved phase concentration from dredging[2]	Worst-case total: suspended sediments + dissolved phase	Recreational water guideline – protective of community exposures every day for a lifetime [3]
Tributyltin	mg/L	1.8×10^{-8}	--	1.8×10^{-8}	0.01 [R]
Arsenic	mg/L	0.000044	--	0.000044	0.1 [A]
Cadmium	mg/L	0.0000037	--	0.0000037	0.02 [A]
Chromium	mg/L	0.00018	--	0.00018	0.5 [A] (assume all more toxic Cr VI)
Copper	mg/L	0.00027	0.00012	0.00039	20 [A]
Lead	mg/L	0.00049	0.000060	0.00055	0.1 [A]
Mercury	mg/L	0.0000054	3.5×10^{-6}	0.0000089	0.01 [A]
Nickel	mg/L	0.000033	--	0.000033	0.2 [A]
Silver	mg/L	0.0000068	0.000008	0.000015	1 [A]
Zinc	mg/L	0.00062	0.00043	0.0011	3 [A] (aesthetic)
TPH	mg/L	0.00048	--	0.00048	0.9 – 3 [W]
Total PAH	mg/L	0.000019	--	0.000019	0.0001 [A] (assume all more toxic benzo(a)pyrene)
Dioxins and furans as WHO TEQ	pg/L	0.14	0.045	0.19	160 [R]

1 – Worst-case concentration based on the maximum 95% UCL concentration reported in all sediments (all depths) to be dredged (Table 1 of Annexure C, Appendix M of the EIS) and the highest peak SSC predicted for surface water from all recreational areas (Table 1 of Appendix C1 of this submissions report), noting the highest peak is predicted for Clive Park – refer to Annexure Afor predicted concentrations in other recreational areas)

2 – Worst-case concentration based on the maximum elutriate concentration reported (Annexure C, Appendix M (Technical working paper: Contamination) of the environmental impact statement) and application of a minimum dilution factor of 200 to determine the maximum concentration in and directly adjacent to the construction footprint. Not all chemicals listed in Table 1 were detected/reported in the elutriate analysis. Concentrations away from the construction footprint will be lower due to additional mixing/dilution.

3 – Recreational water guidelines as per NHMRC (NHMRC 2008): A – based on Australian Drinking Water Guideline (NHMRC 2011 updated 2021), W – based on range of values for petroleum hydrocarbons in drinking water (WHO 2008), R – based on drinking water guidelines presented in Recycled Water Guidelines (NRMMC 2008)

Yours sincerely,

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References

NHMRC (2008), *Guidelines for Managing Risks in Recreational Water*, National Health and Medical Research Council, Canberra.

NHMRC (2011 updated 2021), *Australian Drinking Water Guidelines 6, Version 3.6 Updated March 2021, National Water Quality Management Strategy*, National Health and Medical Research Council, National Resource Management Ministerial Council, Canberra.

NRMMC (2008), *Australian Guidelines for Water Recycling: Managing Health and Environmental Risks (Phase 2) Augmentation of Drinking Water Supplies*, Natural Resource Management Ministerial Council, Environment Protection and Heritage Council and National Health and Medical Research Council. <http://waterquality.gov.au/guidelines/recycled-water>.

RHDHV (2021), Response to submissins on marine construction activities, sediment and water quality. Appendix C1 of Beaches Link and Gore Hill Freeway Connection project submissions report.

WHO (2008), *Petroleum Products in Drinking-water*, World Health Organization, Geneva.

Annexure A. Concentrations in suspended sediments in all recreational areas

Table A-1 presents the calculated worst-case concentration of chemicals in suspended sediments, based on the peak SSC for surface water for each location and the maximum 95% UCL concentration for all sediments proposed to be disturbed. The assessment presented in Table 1 of this memo utilises the maximum from all these locations, i.e., at Clive Park.

Table A-1 Worst-case concentrations in suspended sediments in recreational water at locations of interest[1]

Chemical detected in sediments	Maximum 95% UCL sediment concentration* (mg/kg)	Concentrations in water from suspended sediments at each location (mg/L)[2]							
		Sailors Bay	Northbridge Park	Clive Park	Sandy Bay	The Spit	Clontarf Marina	Clontarf Baths	Clontarf Beach
		Peak surface SSC (mg/L)							
		0.03	**0.06**	**3**	**2.2**	**1.8**	**2.4**	**2**	**2**
Tributyltin	0.00617	1.9E-10	3.7E-10	1.9E-08	1.4E-08	1.1E-08	1.5E-08	1.2E-08	1.2E-08
Arsenic	14.53	4.4E-07	8.7E-07	4.4E-05	3.2E-05	2.6E-05	3.5E-05	2.9E-05	2.9E-05
Cadmium	1.22	3.7E-08	7.3E-08	3.7E-06	2.7E-06	2.2E-06	2.9E-06	2.4E-06	2.4E-06
Chromium	59.88	1.8E-06	3.6E-06	1.8E-04	1.3E-04	1.1E-04	1.4E-04	1.2E-04	1.2E-04
Copper	89.39	2.7E-06	5.4E-06	2.7E-04	2.0E-04	1.6E-04	2.1E-04	1.8E-04	1.8E-04
Lead	162.9	4.9E-06	9.8E-06	4.9E-04	3.6E-04	2.9E-04	3.9E-04	3.3E-04	3.3E-04
Mercury	1.81	5.4E-08	1.1E-07	5.4E-06	4.0E-06	3.3E-06	4.3E-06	3.6E-06	3.6E-06
Nickel	11.02	3.3E-07	6.6E-07	3.3E-05	2.4E-05	2.0E-05	2.6E-05	2.2E-05	2.2E-05
Silver	2.27	6.8E-08	1.4E-07	6.8E-06	5.0E-06	4.1E-06	5.4E-06	4.5E-06	4.5E-06
Zinc	207.7	6.2E-06	1.2E-05	6.2E-04	4.6E-04	3.7E-04	5.0E-04	4.2E-04	4.2E-04
TPH	159.6	4.8E-06	9.6E-06	4.8E-04	3.5E-04	2.9E-04	3.8E-04	3.2E-04	3.2E-04
Total PAH	6.4	1.9E-10	3.7E-10	1.9E-08	1.4E-08	1.1E-08	1.5E-08	1.2E-08	1.2E-08
	pg/g	pg/L	pg/L	pg/L	pg/L	pg/L	pg/L	pg/L	pg/L
Dioxins and furans as WHO TEQ	48.32	0.0014	0.0029	0.14	0.11	0.087	0.12	0.097	0.097

1 – Worst-case concentration based on the maximum 95% UCL concentration reported in all sediments (all depths) to be dredged (Table 1 of Annexure C, Appendix M (Technical working paper: Contamination) of the environmental impact statement) and the highest peak SSC predicted for surface water from all recreational areas (Table 1 of RHDHV memo (Appendix C1 of this submissions report))

2 - Note that results for Tunks Park are not presented in Table A1 as the suspended sediment at this location were negligible, due to its remoteness from the works (as noted in Table 1 of RHDHV memo (Appendix C1 of this submissions report)).