Transport for NSW

Western Harbour Tunnel and Warringah Freeway Upgrade

Appendix C – Sediment and marine water quality memorandum

SEPTEMBER 2020

Transport for NSW

Western Harbour Tunnel and Warringah Freeway Upgrade

Appendix C1 – Responses to community issues

SEPTEMBER 2020

Memo

Project Name	:	Western Harbour Tunnel and Warringah Freeway Upgrade
Date	:	03 August 2020
Our reference	:	PA1694-102-104-N006F01
Subject	**:**	Submissions report – Responses to several matters raised by the community

This memo sets out a response to a number of matters raised by the community in relation to the Western Harbour Tunnel and Warringah Freeway Upgrade (WHT/WFU) environmental impact statement, and which have been referred to Royal HaskoningDHV (RHDHV).

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

Justification/explanation as to why it is not feasible to treat dredged sediments insitu for the tunnel

Response:
The option of treating sediments in situ prior to their removal, involving some form of relocatable bottom-sealed filter barrier anchored to the seafloor, then mixing with lime/cement or other substance, needs to be evaluated against methodologies that involve much less disturbance of sediments into the water column, as is the case for a backhoe dredger (BHD) fitted with a closed bucket (environmental clamshell). Use of a BHD and environmental clamshell is a proven methodology for removal of contaminated sediments. Hydrodynamic and dredge plume modelling has been carried out to predict water quality and ecological impacts associated with this methodology, as outlined in Appendix P (Technical working paper: Hydrodynamics and dredge plume modelling) of the environmental impact statement.

The proposed dredging equipment, environmental controls, and adaptive management of dredge operations through a tiered monitoring and management framework is considered effective.

Clarification as to whether localised (intense) weather impacts were considered during modelling, ie. how wind speeds were averaged or whether there was some allowance for higher wind speeds

Response:
Reference should be made to Section 5.4 'Wind sensitivity testing' and Section 7.4.2 'Sensitivity of dredge plumes to winds' within Appendix P (Technical working paper: Hydrodynamics and dredge plume modelling), for a discussion of how winds were considered in the modelling.

Intense winds are generally only short term; the more relevant winds for assessing effects on plumes are longer prevailing steady winds (as modelled). When winds become 'intense' and exceed a threshold magnitude, activities such as dredging operations, barge transport of dredged material, and unloading operations, would cease due to workability, safety risk or environmental risk, in accordance with the Dredge Management Plan which would from part of the Construction Environmental Management Plan (CEMP).

Have background suspended sediment concentrations been considered in the modelling

Response:
The modelling simulates the dispersion and deposition of sediments suspended due to dredging activities alone. For this reason, reference is made in Appendix P (Technical working paper: Hydrodynamics and dredge plume modelling) to the term SSC (suspended solids concentration) and not to TSS (total suspended solids). Background values of suspended solids in the water column, which can be variable depending on weather conditions, are then combined with the SSC due to dredging as part of the assessment of the potential impacts of dredging operations, eg. potential impacts to aquatic ecology.

Confirmation of what outputs the 'acoustic doppler current profiler' instrument provides – assume this instrument measures velocity profile through the water column

Response:
Yes, the 'acoustic doppler current profiler' (ADCP) measures the velocity profile through the water column.

Reasoning as to why spring tidal fluctuations are important for data collection and modelling. Is this about working out maximum tidal fluctuations to allow worst case conditions/dispersion to be considered in the modelling

Response:
Spring tide fluctuations are important as they generate higher tidal current speeds, which may be important for consideration of certain factors such as maximum dispersion of suspended sediments. Equally, neap tide fluctuations which generate lesser tidal current speeds are also important for consideration of certain factors which may include reduced dispersion (more accumulation) of suspended sediments. The collection of tidal data for the WHT/WFU project covered a number of spring (two weekly) and neap (alternate two weekly) tidal cycles, and the model has been used to predict outcomes for all tidal conditions.

Predicted water quality as a result of dredging at specific locations such as Dawn Fraser Baths and North Sydney Pool

Response:
The Dawn Fraser Baths and North Sydney Pool are located around 1500m upstream and 2300m downstream respectively from the project dredging location. The model domain extended well upstream of Dawn Fraser Baths and well downstream of North Sydney Pool and hence the impacts of dredging (as modelled by SSC) can be assessed at these locations (refer Figure 4-1 in Appendix P (Technical working paper: Hydrodynamics and dredge plume modelling) for the extent of the model domain).

The highest SSC values occur at the dredging location, as would be expected, and, at this location, at the bottom of the water column (near the bed of the harbour) as this is where contact is made between the dredging equipment and the sediments. At Dawn Fraser Baths and North Sydney Pool the SSC values due to dredging are substantially reduced as a result of the natural dispersion of suspended sediments by tidal currents and mixing which occurs between the dredging location and these two locations.

The following table sets out the predicted maximum SSC values from dredging activities at Dawn Fraser Baths and North Sydney Pool at the water surface and near the harbour bed, together with the corresponding value at the dredging location. The reductions in SSC value between the dredging location and the Baths and Pool are also shown (in brackets). The background (ambient) level of suspended solids in the absence of dredging, as determined from historical information and other water quality modelling in

Sydney Harbour presented in Appendix Q (Technical working paper: Marine water quality), are also given. Background concentrations in this area of Sydney Harbour have a total suspended solids median of 3.1 mg/L and peaks of around 8 mg/L to 40 mg/L, depending upon the rainfall intensity producing catchment runoff. Hence, the predicted maximum SSC values at the Baths and at the Pool are low, and comparable to background TSS values in dry weather. The maximum values are also not sustained over time but rather are spikes corresponding to less than 1-2 hours duration, and in most instances the SSC at the Baths and at the Pool would not be a noticeable addition to ambient concentrations.

Note: water quality results in the Technical working paper: Marine water quality, are expressed as TSS and correspond to measured natural background levels in the absence of dredging. Data were not available to determine the difference in background concentrations between the surface and near bed of the harbour, but given the depth range at this location, the differences would be expected to be small. 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 natural background level at the time and the contribution of suspended solids due to dredging.

Suspended Solids (mg/L)				
	Background data TSS (median)[1]	*Dredging location SSC*	*Dawn Fraser Baths SSC*	*North Sydney Pool SSC*
Surface	*3.1*	*30*	*1.9 (16:1)*	*2.4 (12:1)*
Near bed of the harbour	*3.1*	*540*	*2.1 (260:1)*	*2.8 (190:1)*

[1] These values are for waters of Sydney Harbour in the vicinity of the mainline tunnel alignment, and it is not expected that background concentrations at the Baths or at the Pool would differ substantially from these.

Volumes of material not suitable for offshore disposal as stated in the environmental impact statement

Response:
As noted in Section 4.4.3 of the environmental impact statement, the preferred corridor has the shortest harbour crossing, minimising the quantity of dredged material to be treated and disposed of offsite.

Chapter 24 (Resource use and waste management) of the environmental impact statement identifies that about 142,500 cubic metres of dredged material would be unsuitable for offshore disposal. The material would be dredged from the footprint of the immersed tube tunnel and transported to White Bay construction support site (WHT3) for treatment so it is spadeable, prior to disposal to an appropriately licensed facility. There would be no dredging carried out in the White Bay area for the project. A clarification has been included in Section A4.2 of this submissions report with regards to the source of the dredged material quantity not suitable for offshore disposal identified within the first row of Table 24-8 of the environmental impact statement.

Subsequent to the 2017 investigation by Golder-Douglas for the environmental impact statement, and at the request of Transport for NSW, RHDHV have been engaged to undertake additional sediment coring, sampling and testing at the harbour crossing to better understand the level and extent of contamination in sediments. Investigations into the level and extent of contamination have been carried out, and investigations are ongoing. The purpose of these investigations is to assess the suitability of dredged sediments for offshore disposal, an activity regulated under the Commonwealth Environment Protection (Sea Dumping) Act 1981. Further information is provided in Appendix C2 of this submissions report.

As a result of the ongoing RHDHV investigations, the original anticipated quantity of 142,500 cubic metres identified in the environmental impact statement is subject to further work and is likely to be revised by the project. It is expected that the final quantity of dredged material that is not suitable for offshore disposal will be less than this originally anticipated number.

Use of shallow silt curtains for backhoe dredging (BHD) operations

Response:
A backhoe dredge (BHD) with a closed environmental clamshell bucket supported by silt curtains has been proposed for removal of the surface layer of material with elevated levels of contaminants. These buckets have been specifically designed for dredging material with elevated levels of contaminants and provide three significant advantages compared to conventional open buckets, including, minimisation of suspended sediments during contact with the harbour bed, minimisation of spill as the bucket is raised through the water column, and precision (accurate dredging).

As discussed in Appendix P (Technical working paper: Hydrodynamics and dredge plume modelling), BHD dredging operations would be completed within a floating silt curtain enclosure (or 'moon pool') that is secured to the dredge barge. This would comprise a fixed or floating boom upon which a shallow-draft (two to three metres deep) silt curtain is attached to provide a controlled area for the dredge operator to work within. Silt curtains would also be deployed around any sensitive aquatic habitats that could be potentially impacted by dredging activities.

Use of deep draft (e.g. 12 metre) silt curtains is not possible, due to tidal currents and operational constraints associated with working in the channel. Deep silt curtains would also cause increased turbidity on the bed of the harbour due to the restriction of tidal flows (creating localised increases in tidal currents around and below the silt curtains); the placement, progressive relocation and ultimate removal of curtain anchoring devices on the harbour bed (e.g. anchors and chains); and the general movement of the curtains with the currents.

The use of the proposed silts curtains combined with the environmental clamshell bucket, together with other environmental control measures such as no overflow from transport barges and restricted working hours (thereby minimising the rate of sediment disturbance) is considered an effective dredging methodology.

Greg Britton
Technical Director - Water

Transport for NSW

Western Harbour Tunnel and Warringah Freeway Upgrade

Appendix C2 – Responses to Environment Protection Authority issues

SEPTEMBER 2020

Memo

Project Name	:	Western Harbour Tunnel and Warringah Freeway Upgrade
Date	:	31 July 2020
Our reference	:	PA1694-102-104-N005D01 (Final)
Subject	**:**	Submissions report – Response to supplementary submission received from NSW EPA dated 30 March 2020

This memo sets out a response to the supplementary submission made by NSW EPA dated 30 March 2020, to the Department of Planning, Industry and Environment, in relation to the Western Harbour Tunnel and Warringah Freeway Upgrade (WHT/WFU) environmental impact statement.

In their supplementary submission, the EPA noted that resuspension of sediment from the proposed dredging can result in the introduction of contaminants into the dissolved phase of the water column by releasing contaminants from the sediment pore water and by desorption of contaminants from suspended sediment particles. Once in the dissolved phase, released contaminants can be subject to far-field transport and therefore result in different exposures and risks than releases of contaminants attached to suspended sediment particles.

In the above context, the EPA requested information in relation to three matters:

- contaminant levels for any sediment sampling data and pore waters for all proposed dredging areas;
- modelling of the fate and transport of dissolved contaminants where there is a risk of exceeding the relevant sediment or water quality guidelines; and
- mitigation measures during dredging.

The response to the EPA supplementary submission is provided below in Sections 1, 2 and 3 according to each of the three matters raised.

Some additional information has also been provided in Section 4 of this memo regarding the handling of dredged material that is not suitable for offshore disposal.

1.0 Contaminant levels for any sediment sampling data and pore waters

The EPA requested that Transport for NSW provide contaminant levels for any sediment sampling data and pore waters for all the proposed dredging areas. It was noted that the environmental impact statement only provided general information on exceedances of guideline values and that the requested additional data will help inform whether concentrations are at levels that represent a potential risk to receptors.

The EPA also stated that guidance for assessing sediments is contained in *Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines*, CSIRO Land and Water Science Report 08/07 (Simpson, Batley and Charlton, 2013). The EPA requested that Transport for NSW applies these guidelines when assessing the sediment quality.

Sediment quality guidelines were included for the first time in the revised *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* released in 2000 (ANZECC/ARMCANZ, 2000). At the time, these sediment quality guidelines represented the latest in international thinking, however, in recognition that the science underpinning these guidelines required improvement, the guidelines were termed 'interim' with the intention being they would be significantly revised in the future (Simpson, Batley and Charlton, 2013).

The recommended application of the revised sediment quality guidelines continues to involve a tiered, decision-tree approach, consistent with the risk-based approach introduced in the water quality guidelines. Following this approach, the total concentrations of contaminants are compared to sediment quality guideline values (SQGVs) and if the contaminant concentrations exceed one or a number of the SQGVs, further investigation is initiated to determine whether there is indeed an environmental risk associated with the exceedance. The SQGVs are not to be used on a pass/fail basis (Simpson, Batley and Charlton, 2013).

<u>General</u>

The environmental impact statement for WHT/WFU includes information on sediment contamination based on the sampling carried out in May 2017 by Golder-Douglas (refer to Sediment Table B.1 of Appendix B of Appendix M (Technical working paper: Contamination)). The information comprises a tabulation of sediment sample locations and whether concentrations of a range of contaminant compounds at these locations exceed various published criteria. See also the reference to the Golder-Douglas (2017) data below.

Subsequent to the 2017 investigation by Golder-Douglas, and at the request of Transport for NSW, RHDHV have been engaged to undertake sediment coring, sampling and testing at the harbour crossing to better understand the level and extent of contamination in sediments. Investigations into the level and extent of contamination have been carried out, and investigations are ongoing. The purpose of these investigations is to assess the suitability of dredged sediments for offshore disposal, an activity regulated under the Commonwealth *Environment Protection (Sea Dumping) Act 1981*. The relevant Regulator for offshore disposal at the nominated disposal ground (Sydney Offshore Spoil Ground) is the Commonwealth Department of Agriculture, Water and Environment (DAWE) (formerly the Commonwealth Department of Environment and Energy [DoEE]).

It is a requirement of the Sea Dumping Act to assess potential impacts and put forward appropriate management and monitoring measures for consideration by the DAWE when determining an application and its suitability for offshore disposal. The sediment sampling and assessment carried out by RHDHV was commissioned to satisfy Commonwealth requirements, as part of Transport for NSW's application for offshore disposal, and due to the different planning pathway requirements, it was not included in the environmental impact assessment. The environmental impact statement addresses the Secretary's Environmental Assessment Requirements (SEARs) issued to the project by the NSW Department of Planning, Industry and Environment.

Determination of the offshore disposal permit(s) is subject to finalisation of the ongoing RHDHV investigations. Notwithstanding, a summary of the RHDHV investigations to date is included below to address comments received from the NSW EPA's supplementary submission.

Sediment Quality Guidelines

In order to satisfy Commonwealth requirements, sediment quality for the RHDHV investigations was assessed in accordance with sediment quality guidelines included in the National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia, Canberra, 2009). While the EPA has requested that Transport for NSW applies the guideline values in Simpson, Batley and Charlton (2013) to assess sediment quality, these guideline values are in fact identical to the guideline values in NAGD (2009), as noted in Part II Section 3.8 of Simpson, Batley and Charlton (2013). The EPA request in this regard has been met.

RHDHV investigations carried out subsequent to the Golder-Douglas (2017) investigations

The RHDHV investigations were preceded by planning that included:

- compilation and review of existing data, including identification of contaminants of potential concern (CoPCs);
- description of the dredging proposal;
- proposed sediment sampling and analysis;
- QA/QC procedures; and
- proposed reporting requirements.

Existing data reviewed by RHDHV included the results of the investigation by Golder-Douglas (2017). A plan showing sample locations from this investigation and a table comparing contaminant levels to Interim Sediment Quality Guidelines (ISQG) ISQG-High and ISQG-Low values are included in **Attachment A**.

RHDHV sampling was undertaken at eight new locations along the tunnel alignment, denoted WHT1 to WHT8, as shown in **Figure 1**. In addition, re-sampling was undertaken at four previous sampling locations from the Golder-Douglas investigation ('B' series in **Figure 1**)[1].

Figure 1 *Sediment sampling locations in the Golder-Douglas (2017) investigation and the subsequent RHDHV investigations*

[1] *It is noted that an upstream shift in the tunnel alignment occurred as a result of further assessment of geotechnical conditions, resulting in a number of the Golder-Douglas May 2017 sampling locations falling outside the revised dredging area.*

The RHDHV investigation findings considered:

- sediment physical characteristics;
- sediment chemical characteristics:
  - Phase II sediment contaminant concentrations (refer below),
  - Phase III testing (refer below),
  - TCLP testing[2],
  - comparison to previous testing, and
- data validation.

Phase II and Phase III refer to the tiered, decision – tree approach, for assessment of potential contaminants, as set out in NAGD (2009). This approach is summarised in Figure 3 of NAGD (2009) which is reproduced in **Attachment B**. In particular, Phase III refers to elutriate and bioavailability testing. Specifically the following testing was undertaken for Phase III:

- dilute acid extraction (DAE) testing;
- acid volatile sulphide (AVS) and simultaneous extracted metals (SEM) [AVS-SEM] testing;
- mercury speciation; and
- elutriate testing.

It is noted that it is not necessary to proceed to toxicity and bioaccumulation testing of sediments (Phase IV testing) if testing in earlier phases demonstrates the suitability of the sediments for offshore disposal.
A number of the key findings from the RHDHV investigations are outlined below:

- sediment along the majority of the proposed tunnel alignment, commencing at the Birchgrove side, comprises a relatively thin layer (0.1 to 2m, average approximately 0.5m) of grey brown silty sand with shell overlying stiff orange brown clay;
- towards the Waverton side of the alignment, the sediment comprises a deeper deposit of brown grey sandy mud which becomes firmer with depth;
- the sediment stratigraphy and key contaminant concentrations (95% Upper Confidence Limit (UCL) of the mean concentrations) are summarised in **Figure 2** and, together with Phase III testing and TCLP testing where relevant, led to the following conclusions:
  - the thin layer of grey brown silty sand along the majority of the tunnel alignment is suitable for offshore disposal,
  - the underlying stiff orange brown clay is suitable for offshore disposal,
  - the top 1.5m of the brown grey sandy mud is unsuitable for offshore disposal[3],
  - the brown grey sandy mud below 1.5m meets NAGD criteria for offshore disposal but further investigation is required regarding the significance of the dioxin concentrations below 1.5m in relation to offshore disposal[4],

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[2] *TCLP is Toxicity Characteristic Leaching Procedure and is a test to determine the classification of waste for land disposal.*

[3] *Phase III testing (DAE and AVS-SEM) indicated copper, lead and zinc may be bioavailable. A decision was taken by Transport for NSW not to proceed to toxicity and bioaccumulation testing (Phase IV testing) but rather dispose of this material to land. The sediment would be transported to White Bay, treated for acid sulfate soils and odour as required, made spadeable, and transported by truck to a licenced landfill.*

[4] *There is no guideline value for dioxin in NAGD (2009) thus necessitating further research.*

- based on the available sediment data, the top 1.5m of the brown grey sandy mud which would need to be disposed to land would be classified as general solid waste[5], and
- contaminant concentrations in the brown grey sandy mud reduce with depth.

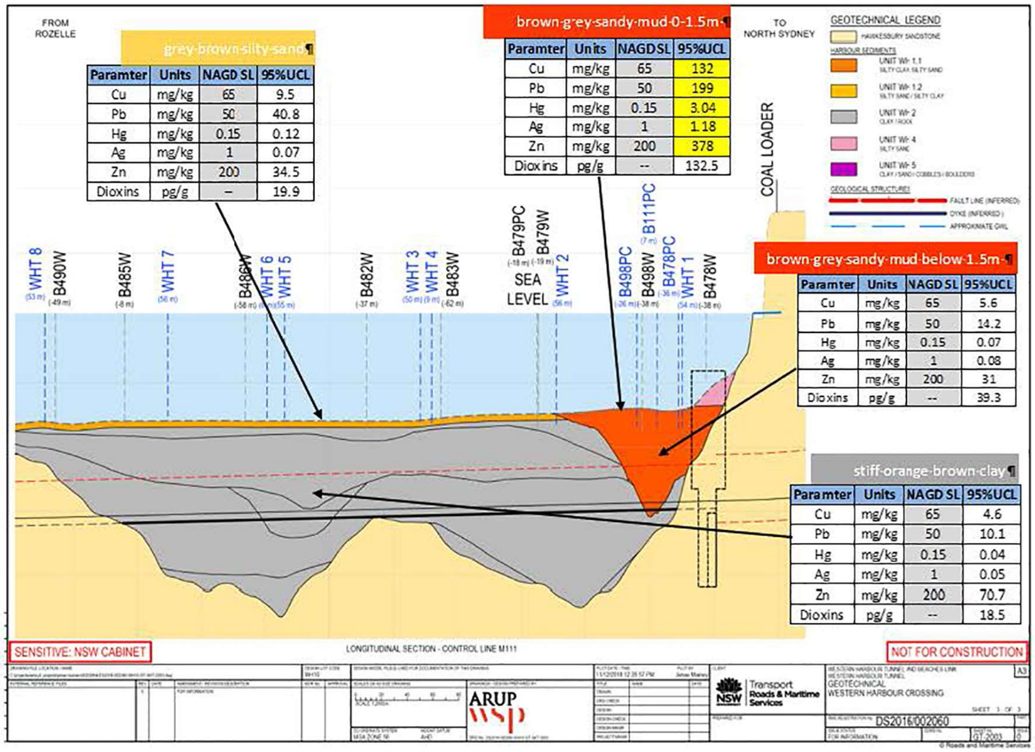

Figure 2 *Summary of sediment types and investigation findings from RHDHV investigations*

Further RHDHV investigations were then carried out and focused on the concentrations of dioxins in the brown grey sandy mud below 1.5m on the Waverton side of the tunnel alignment, to determine the interface between those sediments unsuitable and suitable for offshore disposal. The investigation of these sediments is ongoing and will be finalised prior to construction.

<u>Sampling of pore waters</u>

Sampling of pore waters was not undertaken as part of the investigations to date due to the difficulties of insitu sampling of pore water and obtaining sufficient samples for analysis, and the possibility of geochemical transformation of the pore water during processing of the samples[6].

Consequently, the option was taken, as recognised in Simpson, Batley and Charlton (2013) (refer Part I, Section 3.3.1) to conduct elutriate tests as an indication of potentially soluble contaminants. The elutriate testing is discussed below under the modelling of the fate and transport of dissolved contaminants.

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[5] *As tributyltin (TBT) was also detected in these sediments, land disposal would need to be in accordance with the NSW EPA chemical control order (CCO) for organotin waste materials. While dioxins were detected in these sediments, the dioxins were at concentrations below the criteria triggering the CCO for dioxin-contaminated waste materials.*

[6] *Refer to discussion in Part II Section 2.3 of Simpson, Batley and Charlton (2013), wherein it is stated that:*

- *all pore water isolation methods have been shown to alter pore water chemistry and affect metal contaminant bioavailability and toxicity; and*
- *because pore waters will generally contain very low dissolved oxygen concentrations, and often have high concentrations of easily oxidisable species, maintaining these properties following isolation from sediment is practically impossible.*

2.0 Modelling the fate and transport of dissolved contaminants

The EPA requested modelling of the fate and transport of dissolved contaminants where there is a risk of exceeding the relevant sediment or water quality guideline values, including any further laboratory (eg. elutriate) or desktop assessment of the potential concentrations of dissolved contaminants in the water column from sediment pore water and by desorption of contaminants from suspended sediments.

As noted above, elutriate testing was conducted as part of the RHDHV investigations as an indication of potentially soluble contaminants. The elutriate test is used to estimate the amounts of contaminants that would be released during dredging and during offshore disposal. It involves shaking a sediment sample with four times the volume of seawater at room temperature for 30 minutes, then allowing the samples to settle for one hour[7]. The supernatant is then centrifuged or filtered (0.45μm) within 60 minutes and analysed. The seawater used for the elutriate test is also analysed by the same methods, so that results for the elutriate can be corrected for contaminant levels in the seawater.

The corrected contaminant levels are compared to relevant water quality guideline values after allowing for natural initial dilution, defined as 'that mixing which occurs within four hours of dumping' (NAGD, 2009). It is necessary to consider initial dilution, as the elutriate test results themselves will greatly overestimate water quality impacts given that, within a four-hour period, dilutions of the order of a hundred times or more (and often much more) would normally be expected in the case of disposal at an offshore disposal ground (NAGD, 2009).

In a similar way, natural initial dilution needs to be considered when assessing the potential for water quality impacts to occur at the dredging site based on the results of elutriate testing. The results are therefore corrected for the calculated dilution factor at the dredging site after the four-hour mixing period (taking account of the test dilution of 1:4) to assess whether or not water quality guideline values would be exceeded.

A summary of the results of the elutriate testing) is presented in Table 1. Five sediment samples were tested in accordance with requirements in the NAGD (2009). The following was concluded:

- all metals released during the elutriate test were at concentrations below laboratory detection and/or below the ANZG (2018) water quality trigger values for marine water (95% species protection level) without applying any further dilution. A 95% species protection level is considered appropriate for Sydney Harbour on the basis of it being a slightly to moderately disturbed system. The question that arises is whether the test dilution in the elutriate testing procedure (1:4) would be achieved in practice at the dredging site. This is discussed below; and
- there is no ANZG (2018) water quality trigger values for dioxins. ANZG (2018) notes that the toxicity data reviewed by USEPA (as referenced in the NAGD, 2009) were not in a suitable form to derive guideline values for aquatic life. USEPA did not derive a guideline figure but considered that water concentrations > 10pg/L TCDD[8] could lead to excessive levels of dioxin in fish and shellfish for human consumption, assuming a bioconcentration factor (BF) > 5000. Measurable elutriate TCDD concentrations were observed in the RHDHV testing at concentrations above the USEPA guideline value. The observed TCDD concentrations were a maximum of 2 to 3 times the USEPA guideline value. Hence, the question that arises is whether the natural initial dilution at the dredging site would be sufficient for the TCDD concentrations to be below the USEPA guideline value, ie. a further dilution of 2 to 3 times, taking account of the elutriate test dilution of 1:4, ie. overall dilution of 8 to

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

[8] *TCDD is 2, 3, 7, 8 – Tetrachlorodibenzo-p-dioxin.*

12, say 12. This is discussed below. It can also be seen that the TCDD concentrations and not metal concentrations control the required initial dilution.

Initial dilution can be calculated by numerical modelling, of varying complexity, or by adopting simple conservative assumptions. As an example of the latter approach, the NAGD (2009) for example, in the case of initial dilution at the disposal ground, states that this can be approximated by assuming the liquid and suspended particulate phases of the dredged material are evenly distributed after four hours over a column of water bounded on the surface by the release zone and extending to the ocean floor, thermocline or halocline, if one exists, or to a depth of 20m, whichever is the shallower. This approach is based on reporting by the USEPA and US Army Corps of Engineers (as referenced in the NAGD, 2009). Knowing the volume of material dumped on any occasion, the minimum initial dilution can be readily calculated.

The above calculation method is a useful simple approach which, if it shows adequate initial dilution would be achieved, is all the calculation necessary. The approach is conservative as it ignores the advection and further dilution of the liquid and suspended particulate phases beyond the boundaries of the release zone due to natural currents.

A similar simple conservative approach can be adopted at the dredging site. The volume of dredged material released into the water column during dredging (not 'captured' in the dredging process) can be estimated based on the production rate of the dredging equipment and the so-called 'source term', which is the percentage of material 'lost' into the water column. The source term is a function of factors such as the method of dredging and properties of the material being dredged.

As described in Section 4 of this memo, dredging of the sediments with elevated contaminants would be undertaken by a backhoe dredger (BHD) using a closed bucket (environmental clamshell). The production rate for the BHD would be approximately $300m^3$ insitu per hour. The source term for this activity is estimated to be 1.5% as noted in Table 7-2 of Appendix P (Technical working paper: Hydrodynamics and dredge plume modelling) of the environmental impact statement. Accordingly, over a period of four hours the volume of dredged material released into the water column would be approximately $18m^3$ ($300m^3$/hr x 4hrs x 1.5%).

The column of water adopted for calculation purposes as the 'dredging zone' can be conservatively taken to be the area within which the BHD bucket would operate, around 15m by 15m, and the depth of water at the dredging site of, say, typically 12m. This would give a water volume of $2,700m^3$. This value is conservative as it ignores the advection and further dilution of the liquid and suspended particulate phases beyond the adopted boundaries of the dredging zone due to tidal currents.

The above approach would give an initial dilution (wet sediment: seawater) of approximately 150. This is well in excess of the required initial dilution of 12 to meet the USEPA TCDD guideline.

Based on the elutriate test results and available initial dilution, water quality impacts at the dredging site due to dissolved contaminants would not be expected and modelling of the fate and transport of dissolved contaminants is not considered necessary.

Table 1 Elutriate test results from RHDHV Investigations

Sample location and depth	Copper	Lead	Zinc	Silver	Mercury	Total TCDD
	µg/L	µg/L	µg/L	µg/L	µg/L	pg/L
GUIDELINE	ANZG 95% Species Protection					
	1.3	4.4	15	--	0.4	-
WHT11.1-1.8	< 0.1	2.5	< 1	< 1	< 0.1	26.3
WHT 20.5-1.0	< 0.1	0.7	5	< 1	< 0.1	9.08
WHT 60-0.44	< 0.1	3.1	< 1	< 1	< 0.1	4.18
BIIPC	< 0.1	0.6	< 1	< 1	< 0.1	19.6
B478PC	< 0.1	< 0.1	< 1	< 1	< 0.1	12.6

3.0 Mitigation measures during dredging

In their submission the EPA has raised the matter of mitigation measures that may be required during dredging, particularly in relation to sediments containing elevated levels of contaminants. The EPA includes as mitigation examples:

- options to minimise the resuspension levels generated by any specific dredge methods such as slowing the dredge head descent just before impact with the sediment bed;
- reduced dredging rate or intensity in known contaminant hotspots or near sensitive areas;
- any needed restrictions of access to certain areas;
- warning signs for certain areas and times; or
- any additional key monitoring locations.

As described in the environmental impact statement and noted earlier, dredging of the sediments with elevated contaminants proposed for land disposal would be undertaken by a backhoe dredger (BHD) using a closed bucket (environmental clamshell) (refer Chapter 6 of the environmental impact statement). These buckets have been specifically designed for dredging contaminated sediments and provide three significant advantages compared to conventional open buckets:

- minimisation of suspended sediments[9];
- minimisation of spill[5]; and
- precision (accurate dredging).

Accurate dredging is achieved by real time monitoring and control systems and the fact that the environmental clamshell closes horizontally to provide a level cut as opposed to a conventional semi-circular or arched cut. In this way, relatively thin layers of contaminated material can be removed in a controlled manner.

[9] *Minimisation of suspended sediments and spill is achieved by several features:*
- *a target fill quantity of 80-90% of the bucket capacity is removed per bucket load (this is possible to manage due to the accuracy of dredging) thus avoiding any 'squeeze' of sediment out of the bucket during closing due to overfill of the grab which would cause sediment to be washed out of the bucket during lifting;*
- *the bucket is fitted with vent pipes, in this way entrapped air can escape just below the water surface when the grab is lowered, and not during closing, when escaping air would generate suspended sediment;*
- *the bucket is closed with covers, hence no sediment will wash out whilst lifting the bucket to the surface;*
- *the BHD is fitted with a controllable rotator between the boom and the bucket; the bucket can be positioned in such a way that the dredging pattern consists of adjoining, parallel rectangles. This minimises turbidity and spill.*

A schematic showing the horizontal closing mechanism of the environmental clamshell is provided in **Figure 3**. An example environmental clamshell (16m^3 capacity) is shown on a wharf in **Figure 4** and in operation removing petroleum contaminated sediments in **Figure 5**.

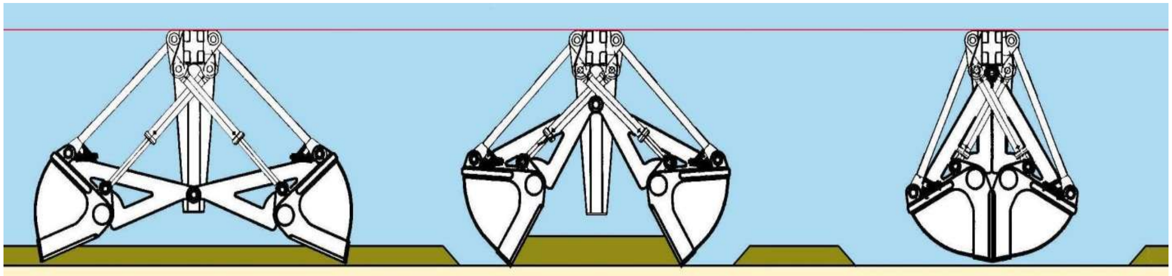

Figure 3 *Schematic of horizontal closing mechanism of environmental clamshell (source: Boskalis)*

Figure 4 *Environmental clamshell (source: Boskalis)*

Figure 5 *Example environmental clamshell in operation (source: Boskalis)*

In regard to the specific mitigation measures referred to by the EPA, the following can be stated:

- *minimising resuspension by slowing dredge head descent*:
  A modern BHD of the type proposed for dredging contaminated sediments in the WHT project is equipped with an accurate positioning system, such as RTK (Real Time Kinematic), which provides the operator with real time positioning of the dredging bucket relative to the bed (displayed on a monitor in the cabin) to allow precision dredging. Using these monitoring and control systems the operator is able to slow the descent of the bucket to minimise disturbance and avoid damage to the equipment, which is normal practice. The actual surface level of the bed is also continually updated by survey;

- *reduced dredging rate or intensity in known contaminant hotspots or near sensitive areas:*
  Dredging operations would not be undertaken 24/7 on the WHT project which is otherwise common on larger dredging projects. The BHD is proposed to operate five days per week (Monday to Friday, avoiding weekends) for a total of 10 hours per day. Actual dredging hours would be approximately 7.5 hours per day, allowing for an average time for start-up activities and downtime of 2.5 hours per day. This reduced dredging intensity reduces the mass rate of sediment entering the water column. This mass rate would be low in any case due to the special dredging bucket proposed, as outlined above. In the event water quality monitoring indicates the potential for

exceedance of a water quality limit the dredging rate could be reduced (as per environmental management measure WQ6 in the environmental impact statement). These management actions would be included in the project Construction Environmental Management Plan (CEMP);

- *restriction of access to certain areas and warning signs for certain areas and times*:
  Navigation access at the dredge site would be managed in accordance with the Navigation Impact Assessment included in Appendix F (Technical working paper: Traffic and transport) of the environmental impact statement, and in agreement with the Port Authority of NSW. Based on plume modelling carried out for the environmental impact statement, it is not necessary to limit access to waterway areas to limit human exposure but in any case this would be addressed by monitoring and management actions included in the project CEMP; and

- *any additional key monitoring locations*:
  A detailed water quality monitoring program would be prepared in consultation with the EPA which would include, among other things, consideration of key monitoring locations. Selection of monitoring locations would be informed by Appendix P (Technical working paper: Hydrodynamics and dredge plume modelling) of the environmental impact statement.

A number of additional environmental mitigation measures not referred to above are also proposed for the project as listed below:

- BHD dredging operations would be completed within a floating silt curtain, as described in Appendix P (Technical working paper: Hydrodynamics and dredge plume modelling) of the environmental impact statement;
- no overflow would be permitted from transport barges taking contaminated material to White Bay for unloading and land disposal;
- additional silt curtains would be located around sensitive foreshore areas, eg. seagrass areas; and
- works would be completed under a full time supervision and inspection regime.

Details regarding the management of dredging operations and dredge material during the construction period would be included in a Dredge Management Plan, which would form part of the CEMP.

4.0 Dredge material that is not suitable for offshore disposal

As requested by Transport for NSW, additional information regarding the handling of dredged material that is not suitable for offshore disposal is provided below.

Dredged material unsuitable for offshore disposal would be loaded into barges using a closed bucket (environmental clamshell) and transported to the White Bay construction support site WHT3 as described in Chapter 6 (Construction work) of the environmental impact statement. Barges may be self-propelled or towed. No overflow from the barges would be permitted during loading operations and during transit to White Bay. Barges would follow the navigation route for construction traffic shown in Map 8 of the Navigation Impact Assessment (refer Appendix F (Technical working paper: Traffic and Transport). It would be a requirement for the barges to be fitted with an automatic identification system (AIS) and for the Sydney Harbour Master to be notified before barges move between construction sites.

After berthing of the barges at White Bay, lime and/or an inorganic polymer would be mixed with the dredged material while in the barge, prior to unloading, for management of acid sulfate soils and odour (as required), and to make the material spadeable. Mixing would take place by means of an excavator located on the adjacent wharf. The dredging process would not add any significant quantities of water to the material (being a mechanical process with closed bucket) and the addition of lime and/or the inorganic polymer would significantly reduce moisture content. Accordingly, management of water/leachate in the dredged material at White Bay would be minimal or may not be required. Following the mixing process, material within the barges would be loaded either directly into trucks for transport to landfill or temporarily stockpiled on the wharf deck within a bunded area prior to loading into trucks for transport to landfill. The bunded area would incorporate a leachate collection and treatment system in the event of any leachate from the temporary stockpile.

Due to the existence of tributyltin in the dredged material proposed for land disposal, the disposal would need to be in accordance with the NSW EPA Organotin Waste Materials Chemical Control Order 1989. As such, the selected landfill would need to be a controlled landfill approved by the EPA.

Further information on management of dredged material that is not suitable for offshore disposal would be included in a Dredge Management Plan (for handling in transit to White Bay) and Waste Management Plan (detailing management at White Bay and landfill disposal requirement), which would form part of the CEMP.

References

ANZECC/ARMCANZ (2000). *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*

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Douglas Partners and Golder Associates (2017), *Western Harbour Tunnel and Beaches Link Geotechnical Investigation, Contamination Factual Report – Marine Investigations.*

Simpson, Batley and Charlton (2013). *Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines*, CSIRO Land and Water Science Report 08/07.

Yours faithfully,

Greg Britton
Technical Director - Water

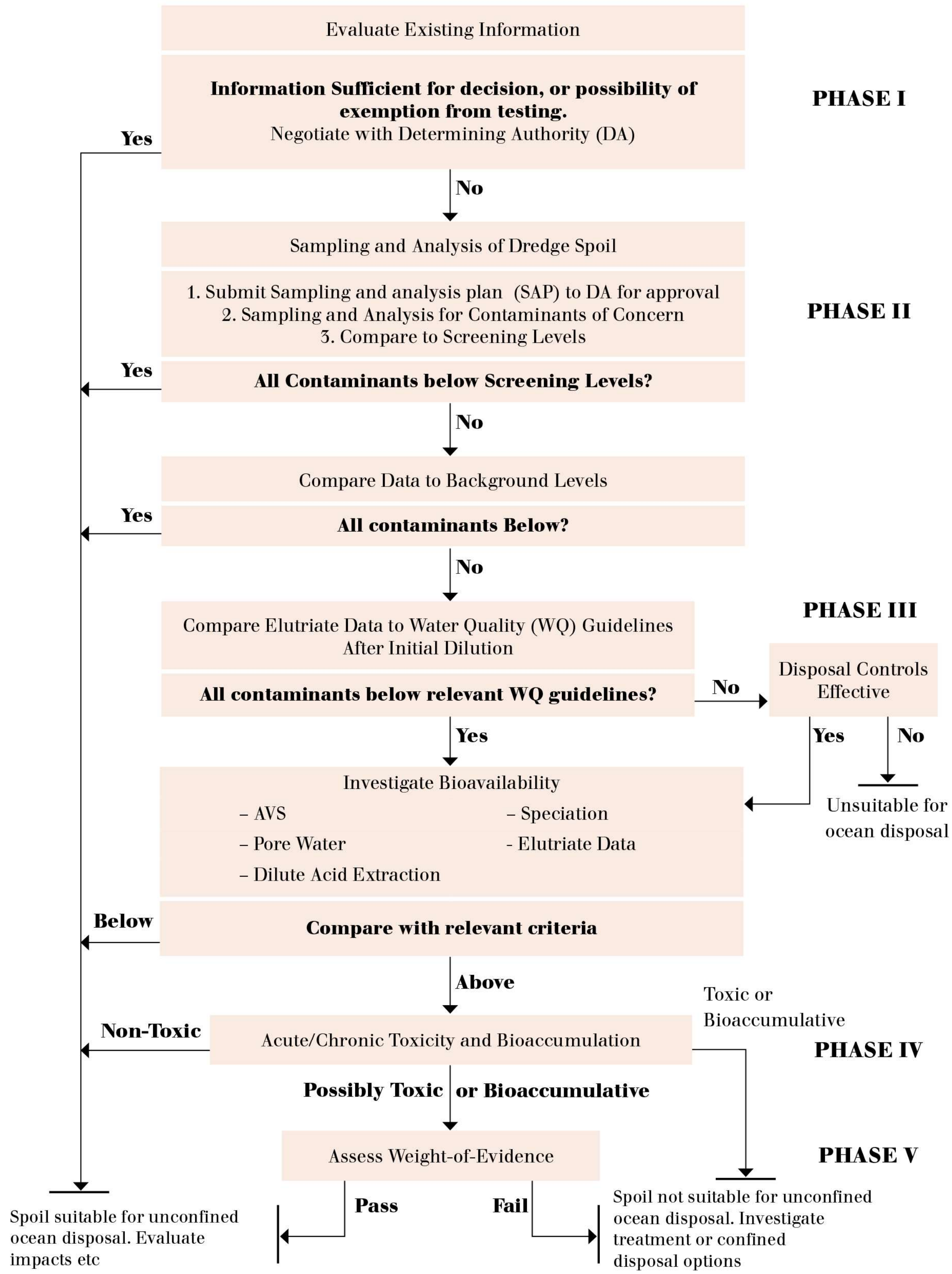
Attachment A – Information from Golder-Douglas Investigation

Sampling locations in Golder-Douglas 2017 investigation

Contaminant concentrations from Golder-Douglas (2017) Investigation

WESTERN HARBOUR TUNNEL 2017			TOC	Tributyltin	Radionuclides	Antimony	Arsenic	Cadmium	Chromium	Copper	Lead	Mercury	Nickel	Silver	Zinc	TPH	TRH	DDD	DDE	DDT	Dieldrin	Endrin	Lindane	Chlordane	Total PAH	Total PCB
				normalised	Sum of gross alpha & beta											normalised	normalised								normalised	
		Units	%	mg/kg	Bq/g	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
		LOR	0.02	0.0005	0.5	0.018	0.02	0.001	0.002	0.002	0.006	0.00004	0.003	0.002	0.005	3.0	3.0	0.0005	0.0005	0.0005	0.0005	0.0005	0.00025	0.00025	0.004	0.005
ISQG-High	Sample	Sample		0.07		25	70	10	370	270	220	1	52	3.7	410			0.02	0.027	0.046	0.008	0.008	0.001	0.006	45	
ISGC-Low (NAGD SL)	Date	Depth		0.005	35	2	20	1.5	80	65	50	0.15	21	1	200	550.0	550.0	0.002	0.0022	0.0016	0.00002 (0.28)	0.00002 (0.01)	0.00032	0.0005	10	0.023
B108WA_VC-A	27/05/17	0-0.5	0.55	0.001	1.41	<0.5	2.6	<0.1	7.4	7.4	25	0.19	1.5	<0.1	31.6	212.7	230.9	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	1.1	<0.005
B111WA_VC-A	24/05/17	0-0.5	3.13	0.005	0.78	<0.5	21.3	0.1	81.8	152	288	2.47	15.6	2	576	116.0	135.1	0.00102	0.00054	0.00152	<0.0005	<0.0005	<0.00025	<0.0005	0.3	<0.0062
B111WA_VC-B	24/05/17	0.5-1.0	3.59	0.002	1.26	<0.5	25.7	0.2	76.6	122	257	3	14.7	1.6	513	129.0	150.7	0.00127	0.00068	0.00152	<0.0005	<0.0005	<0.00025	<0.0005	0.5	<0.005
B111WA_VC-C	24/05/17	1.0-1.5	4.24	ND	1.43	<0.5	26.3	0.3	66.8	123	276	5.18	15.2	1.9	517	227.4	259.4	0.00154	0.00106	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.4	<0.005
B111WA_VC-D	24/05/17	1.5-2.0	2.22	ND	1.22	<0.5	14.7	<0.1	27.3	6.2	16.2	0.1	9.8	<0.5	33.2	36.0	41.0	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.1	<0.005
B111WA_VC-E	28/05/17	2.0-2.5	1.49	ND	<0.5	<0.5	15.5	0.2	21.7	5	11.6	0.03	7.7	<0.1	23.9	8.1	6.0	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.0	<0.005
B212WA_VC-A	28/05/17	0-0.5	3.15	0.001	0.92	<0.5	21.8	0.2	31.5	102	302	6.11	12	1.1	450	117.5	127.3	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	6.7	<0.0062
B216W_VC-A	27/05/17	0-0.5	0.34	0.024	<0.5	<0.5	5.02	<0.1	5.9	14.9	28.3	0.13	1.7	<0.1	50.6	417.6	461.8	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	2.5	<0.005
B216W_VC-B	27/05/17	0.5-1.0	0.18	ND	0.63	<0.5	3.59	<0.1	14.9	1.6	6.6	0.02	1.7	<0.1	2.2	61.1	55.6	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	ND	<0.005
B216W_VC-C	27/05/17	1.0-1.5	0.11	ND	0.57	<0.5	2.57	<0.1	10.2	2.2	4.5	<0.01	1.1	0.5	1.8	200.0	190.9	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	ND	<0.005
B216W-VC-D	27/05/17	1.5-2.0	0.12	ND	0.85	<0.5	3.66	<0.1	13.3	3	7.2	0.02	1.1	0.1	3	208.3	233.3	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	ND	<0.005
B478W-A	28/05/17	0-0.5	10.9	0.003	<0.5	<0.5	10.5	<0.1	21.5	43.5	129	1.78	12.6	0.4	182	34.7	38.9	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	1.4	<0.005
B478W-B	28/05/17	0.5-1.0	2.6	ND	<0.5	<0.5	6.82	<0.1	8.9	11.8	26.7	0.26	3.8	0.2	39.1	13.5	13.8	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.3	<0.005
B479W-A	24/05/17	0-0.5	1.22	0.006	<0.5	<0.5	11.1	<0.1	30.4	55	104	1.17	5.8	0.8	206	355.7	423.0	0.0009	0.00059	0.00157	<0.0005	<0.0005	<0.00025	<0.0005	3.4	<0.005
B479W-B	24/05/17	0.5-1.0	0.35	ND	0.51	<0.5	8.02	<0.1	4.5	2	5.2	0.02	1.4	<0.1	7.8	48.6	54.3	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.2	<0.005
B479W-C	24/05/17	1.0-1.5	0.16	ND	0.68	<0.5	5.49	<0.1	12	3	8.2	0.02	<1	<0.1	3.9	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	ND	<0.005
B479W-D	24/05/17	1.5-2.0	0.13	ND	0.82	<0.5	7.82	<0.1	10.8	3.6	12.8	0.02	<1	<0.1	125	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	ND	<0.005
B479W-D	28/05/17	1.5-2.0	0.1	ND	1.05	<0.5	5.31	<0.1	10.2	2.8	7	<0.01	<1	<0.1	2.6	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.9	<0.005
B481W-A	25/05/17	0-0.5	2.26	0.004	0.71	<0.5	20.5	0.1	57.8	101	179	1.99	12.2	1.5	368	309.3	360.2	0.00052	0.00061	0.00122	<0.0005	<0.0005	<0.00025	<0.0005	1.3	<0.0062
B481W-B	25/05/17	0.5-1.0	0.84	ND	0.88	<0.5	16.3	0.2	25.3	6.2	13.6	0.05	8.9	<0.1	30	65.5	75.0	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.4	<0.005
B481W-C	25/05/17	1.0-1.5	0.88	ND	1.51	<0.5	15.6	0.2	25.6	5.3	12.4	0.01	9.3	<0.1	23.9	26.1	31.8	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005		<0.005
B482W-A	26/05/17	0-0.5	0.67	0.001	0.6	<0.5	17.2	<0.1	18.1	10.2	21.4	0.15	6.3	<0.1	38.9	117.9	129.9	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.4	<0.005
B482W-B	26/05/17	0.5-1.0	0.26	ND	0.76	<0.5	9.12	<0.1	9.3	2.6	6.8	0.01	2.6	<0.1	7.8	123.1	134.6	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005		<0.005
B482W-C	26/05/17	1.0-1.5	0.14	ND	1.42	<0.5	8.59	<0.1	16.4	3.9	9.8	0.01	2.2	<0.1	5	107.1	85.7	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005		<0.005
B483W-A	28/05/17	0-0.5	0.42	ND	0.78	<0.5	10.5	<0.1	7.5	2.1	6.1	<0.01	2.7	<0.1	7.9	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005		<0.005
B483W-B	28/05/17	0.5-1.0	0.42	ND	0.71	<0.5	8.23	<0.1	5.6	2.5	5.2	0.01	1.4	<0.1	3	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005		<0.005
B483W-C	28/05/17	1.0-1.5	0.18	ND	0.68	<0.5	3.2	<0.1	9	3.8	5.6	<0.01	1.3	<0.1	4.3	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005		<0.005
B484W-A	26/05/17	0-0.5	0.7	0.002	0.98	<0.5	11.7	<0.1	23.5	37.8	67.5	0.73	5.4	0.3	134	530.0	627.1	0.0006	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	5.2	<0.005
B484W-B	26/05/17	0.5-1.0	0.36	ND	1.51	<0.5	7.41	<0.1	6.1	2.4	5.7	0.01	1.9	<0.1	6.5	63.9	69.4	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005		<0.005
B484W-C	27/05/17	1.0-1.5	0.1	ND	0.87	<0.5	1.33	<0.1	7.6	3.8	5.5	<0.01	1.1	<0.1	3.7	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005		<0.005
B485W-A	25/05/17	0-0.5	0.2	0.003	0.67	<0.5	15.7	<0.1	20	5.9	17.7	0.12	2.5	<0.1	23.8	155.0	170.0	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	1.5	<0.005
B485W-B	25/05/17	0.5-1.0	0.12	ND	0.95	<0.5	24.6	<0.1	25	2.6	14	0.05	2.2	<0.1	31.8	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.0	<0.005
B486W-A	26/05/17	0-0.5	0.24	ND	1.91	<0.5	5.75	<0.1	18.4	5.4	38	0.05	2.1	<0.1	10.6	125.0	133.3	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.2	<0.005
B487W-A	27/05/17	0-0.5	0.26	0.004	0.57	<0.5	3.65	<0.1	9.1	6.9	13.7	0.12	1.5	0.1	21.4	307.7	361.5	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	3.1	<0.005
B487W-B	27/05/17	0.5-1.0	0.1	ND	1.12	<0.5	4.1	<0.1	13	4	19.1	0.03	1.2	<0.1	5	170.0	150.0	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	ND	<0.005
B488W-A	25/05/17	0-0.5	0.47	ND	1.09	<0.5	14.3	<0.1	15.7	15.9	27.9	0.25	3	<0.1	40	93.6	104.3	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	1.7	<0.005
B490W-A	25/05/17	0-0.5	0.44	0.001	0.61	<0.5	5.29	<0.1	4.4	4.6	8.7	0.07	1.6	<0.1	13.9	81.8	100.0	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	1.7	<0.005
B490W-B	25/05/17	0.5-1.0	0.07	ND	<0.5	<0.5	2.31	<0.1	9.2	1.5	5.2	0.01	1.8	<0.1	4.5	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	ND	<0.005
B490W-C	25/05/17	1.0-1.5	0.11	ND	0.85	<0.5	3.71	<0.1	12.7	2.1	6.7	0.02	1.8	<0.1	8.4	ND	ND	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	ND	<0.005
B491W-A	26/05/17	0-0.5	0.12	ND	1.85	<0.5	4.02	<0.1	12	5.4	6.8	0.01	<1	<0.1	6.3	125.0	108.3	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.3	<0.005
B493W-A	25/05/17	0-0.5	0.4	0.004	<0.5	<0.5	7.76	<0.1	10.3	14.4	32	0.29	3.1	<0.1	49.8	262.5	310.0	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	4.0	<0.005
B497W-A	26/05/17	0-0.5	0.26	0.005	1.33	<0.5	14.7	<0.1	15.2	13.2	22.6	0.06	1.9	<0.1	39.6	273.1	300.0	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	1.4	<0.005
B497W-B	26/05/17	0.5-1.0	0.09	ND	0.85	<0.5	15.8	<0.1	10.9	1.9	2.5	<0.01	1.3	<0.1	6	133.3	111.1	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	ND	<0.005
B498W-A	24/05/17	0-0.5	3.48	0.005	0.55	<0.5	18.6	0.1	67.8	129	235	2.31	12.9	1.7	506	117.0	136.8	0.00082	0.00063	0.00097	<0.0005	<0.0005	<0.00025	<0.0005	0.3	<0.0062
B498W-B	24/05/17	0.5-1.0	3.2	0.000	1.4	<0.5	25	0.2	59.5	99.2	228	4.42	13.5	1	418	318.8	362.5	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.5	<0.005
B498W-C	24/05/17	1.0-1.5	2.67	ND	1.59	<0.5	20.2	0.1	34.1	62.7	170	3.38	11.4	1.2	273	134.1	152.1	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	6.1	<0.005
B498W-D	28/05/17	1.5-2.0	0.7	ND	<0.5	<0.5	14.6	<0.1	19.3	4.9	11.9	0.07	6.8	<0.1	27.5	5.7	8.6	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.1	<0.005
B498W-E	28/05/17	2.0-2.5	1.05	ND	<0.5	<0.5	16.1	0.1	23.2	5.1	11.2	0.02	8.2	0.1	22.5	3.8	6.7	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	0.0	<0.005
B513W-A	27/05/17	0-0.5	0.58	0.002	<0.5	<0.5	13.9	0.2	18	40.7	114	1.31	4.8	0.4	189	125.9	139.7	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005	1.6	<0.005
B513W-B	27/05/17	0.5-1.0	0.09	ND	0.74	<0.5	10.6	<0.1	15	1.3	6.4	0.04	1.6	0.1	3.9	255.6	244.4	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005		<0.005
B513W-C	27/05/17		0.12	ND	<0.5	<0.5	10.8	<0.1	10.5	<1	4.9	0.02	1.1	<0.1	3.2	41.7	66.7	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005	<0.00025	<0.0005		<0.005

Attachment B – Decision-tree approach for assessment of potential contaminants (Figure 3 from NAGD (2009))


Evaluate Existing Information
Information Sufficient for decision, or possibility of exemption from testing.
Negotiate with Determining Authority (DA)
PHASE I
Yes
No
Sampling and Analysis of Dredge Spoil
1. Submit Sampling and analysis plan (SAP) to DA for approval
2. Sampling and Analysis for Contaminants of Concern
3. Compare to Screening Levels
PHASE II
Yes
All Contaminants below Screening Levels?
No
Compare Data to Background Levels
Yes
All contaminants Below?
No
PHASE III
Compare Elutriate Data to Water Quality (WQ) Guidelines After Initial Dilution
All contaminants below relevant WQ guidelines?
No
Disposal Controls Effective
Yes
Yes
No
Unsuitable for ocean disposal
Investigate Bioavailability
– AVS
– Speciation
– Pore Water
- Elutriate Data
– Dilute Acid Extraction
Below
Compare with relevant criteria
Above
Toxic or Bioaccumulative
Non-Toxic
Acute/Chronic Toxicity and Bioaccumulation
PHASE IV
Possibly Toxic or Bioaccumulative
Assess Weight-of-Evidence
PHASE V
Spoil suitable for unconfined ocean disposal. Evaluate impacts etc
Pass
Fail
Spoil not suitable for unconfined ocean disposal. Investigate treatment or confined disposal options