Memorandum

To:	Ministry for the Environment	Date:	12 June 2014
From:	Susan Clearwater, Chris Hickey – NIWA	Our Ref:	MFE13305
Copy:			
Subject:	**Review of "Water Quality and Ecotoxicity Assessment: Proposal to Leave the Remains of the MV Rena on Astrolabe Reef" May 2014 Version and ecotoxicity issues associated with the consent application. CONFIDENTIAL AND LEGALLY PRIVILEGED**		

This is our second review of the "Water Quality and Ecotoxicity Assessment" now updated to the May 2014 version that examines the consequences of leaving the remains of the MV Rena on the Astrolabe Reef, from the perspective of "effects on water quality and ecotoxicity". The report remains essentially unchanged from the September 2013 version with no substantive change that addresses any of the issues we raised about inadequacies of the ecotoxicity and water quality analysis, so for further information the reader is referred to our March 2014 review. Below we note some key issues from that initial review that should be pursued.

We have found that some of the concerns we raised about the potential ecotoxicity and water quality effects of Partial Wreck Removal (PWR) and the proposed resource consent were addressed in part, in either Volume 1 (V1) or Volume 3 (V3) of the resource consent application (Beca 2014, henceforward referred to by volume number). As a result we have considered information about the condition of the wreck and its remaining cargo as described in these documents and provide a brief analysis (as time has permitted) of the potential risks to water quality and ecotoxicity, and how these could be addressed, from the Crown's perspective, to ensure the best practicable outcome should a resource consent be granted for PWR to the owners of the MV Rena.

Our key recommendations are presented in Table 1 below.

Table 1: Issues and recommendations regarding negative effects on water quality and ecotoxicity as a result of the proposal to grant a consent to leave the remains of the Rena on the Astrolabe reef.

#	Issue/recommendation	Comment
1	Obtain complete list of all cargo remaining with the wreck.	A complete list of the cargo thought to be shipped in the 295 containers remaining at the wreck site (V3, Table 4, S 5.7) and the 34 containers dispersed around the wreck should be provided – and not just a list of the subset of cargo considered by the applicant to be potentially ecotoxic (i.e., identify each unrecovered container and its cargo in the manifest). This is despite the fact that additional information about the cargo remaining with the wreck has been provided (e.g., V3 Table 5) and because V1 Table 2 is not complete (e.g., cryolite is not listed). **A complete list will allow third parties to independently evaluate the ecotoxicity risk of the cargo remaining with and around the wreck.**

2	Review of complete cargo manifest	We have briefly reviewed aspects of the complete cargo manifest (V3), and other information provided about the wreck and provide a list (see Table 2 below) of our opinion regarding the likely fate of some of the cargo that might have ecotoxic effects should the cargo have remained with the wreck. Some key actions that should be taken are as follows (see notes in Table 2 for clarification): (i) Salvor should confirm that containers with cargo described as 'pentaerythritol mono', and 'paint' were recovered and in what condition; (ii) Applicant should provide further information on the form and identity of cargo described as 'aluminium'.
3	Define "reasonable mixing zone" as follows	We recommend that a "reasonable mixing zone" be defined each for water and sediments as per the narrative provided on page 6 below in order to provide clarity around the conditions of the consent and their enforcement – and the areal extent of reef that for practical reasons must be accepted as impacted by the long term presence of the wreck.
4	Define categories of ecotoxic effect for effective exercise of consent conditions	Terms such as "negligible", "no more than minor" for categorization of ecotoxic effects are used in multiple reports in V2 of the application (particularly the Ecotoxicity Assessment) but they have not been defined. These terms must be clearly defined with respect to measurable thresholds and how they relate to proposed resource consent conditions and their enactment/enforcement. This issue is mentioned in our earlier review.
5	Copper clove	Of the cargo currently described as potentially remaining with the wreck (see Issue 1 above) we agree with the consent applicant's conclusion that the copper clove has the most potential for ongoing effects. The resource consent conditions (or other legal mechanism) must specify that, should conditions at the wreck change, the copper clove should be removed if practical (and for clarity define 'practical' in the consent e.g., minimal health and safety risk to salvors).
6	Noting risk of acute event from organic material release – mitigation actions and related conditions.	It is likely that a large quantity of organic material remains confined within the remnants of Holds 5 and 6 in the wreck (see cargo list Table 2). Should this material be released in bulk it could cause an acutely toxic event (e.g., asphyxiation and chemical toxicity to recovering reef biota). Such a release could persist in the near field of the wreck (depending on local conditions e.g., calm) resulting in tidal movement of a plume repeatedly backward and forward over the reef, exacerbating toxicity etc. Attempts should be made to identify material confined in the remains of the Rena and if appropriate facilitate a 'slow release' of such material at a rate below the assimilation capacity of the local environment (e.g., by actively breaching confined areas in the hull - as noted for milk powder in our previous review).
7	Risk of 'undiscovered' toxic material	We note that some substances not adequately described in the cargo manifest (e.g., "paint") or other documents may remain with the wreck and could conceivably cause an acutely toxic event, or an unexpected chronic release, however this is considered unlikely. A chronic release will be detected by effective ongoing monitoring and we suggest some refinements to the proposed consent conditions to ensure appropriate action is taken should this occur. Little can be done to prevent an acute release, apart from actions recommended in Issue 5 above to

		examine the condition and identity of the cargo remaining and encourage slow release of material that would be acutely toxic in a bulk release, but will have 'negligible' chronic toxicity outside a 'reasonable mixing zone'.
8	Refine the consent conditions	(i) Ensure removal of the copper clove if conditions change to practical (if not done by time consent granted) (ii) Remove the plastic beads (if not done by time consent granted) ensure bead clean-up is provided for (preferably containment at source, extending to shoreline monitoring and cleanup)[A]. (iii) Include monitoring of fluoride in the sediments of the debris field and use as tracer for the likely extent of the debris field (V1, Appendix B, Table B2 On-reef sediment samples). Consider removal of severely contaminated sediments. (iv) Include monitoring of fluoride in fish bones and crustaceans (as fluoride accumulates in bones and exoskeletons) (add to V1 Appendix B Tables 4 and 5). (v) Our interpretation of proposed consent conditions (V1, S9.2, M.6) suggests that the applicant is seeking to lead the revision of the monitoring plan sampling frequency and location every 2 years. We recommend that this process should be led by the Council. (vi) (V1, S 9.6.1, R.1) the applicant seeks to prevent the council serving notice to review consent conditions within 6 months of receipt of a monitoring report. We recommend this is reduced to 2 months to allow the Council to require a timely response to new information on contaminant release. (vii) (V1 Appendix B, S3.3) – clarify "as this monitoring is volunteered, the contingency actions proposed as the result of consent monitoring do not apply", and ensure that if accepted this would not prevent action being taken on new findings (e.g., unexpected releases/impacts of contaminants) of such monitoring. (viii) (V1 Appendix B Figs B7 & B8) Flow chart for decision making around sediment and tissue monitoring. First decision diamond should ask if severe contamination has been detected (e.g., significantly above available guidelines or significantly greater than previous results [define as appropriate]) rather than starting with detection of increased contamination over 2 sample periods (because eventually this will require a year or more to elapse). (ix) (V1 Appendix B Fig B7) Last two action boxes (e.g. "relocate at risk ecology) responding to question "Species at risk/threatened". Yes/No should be swapped to correct a logical error. (x) Recommend a condition that the consent holder facilitates controlled slow release of any bulk organic matter contained within the hull to reduce the risk of a bulk release (e.g., by creating small controlled openings).
9	Proposed monitoring conditions	(i) Ensure frequency and locations of monitoring will detect chronic release of contaminants, particularly from the confined area of the hull which presents the most risk. (ii) Ensure the design for sediment sites is adequate to allow analysis of effects outside the reasonable mixing zone – and can accommodate a gradient design analysis. (iii) Some monitoring stations close to the wreck for 'consent monitoring' and volunteered 'other monitoring' (already underway) appear to be the same (V1, Appendix B [and appendix to this document]). As the applicant is seeking to differentiate actions taken upon information obtained from the two monitoring streams ensure that sites shared by the two work streams are preferentially assigned to 'consent

		monitoring' to allow appropriate mitigation to occur etc (i.e., clarify the sampling regimes).

[A] Our cursory read of the consent application documents suggest this has been provided for but time has not allowed us to confirm the details.

Table 2: List of some potential contaminants and substances in the complete cargo manifest (in the absence of a complete list of the subset of the cargo remaining with the wreck) and our recommendations regarding effects on water quality and potential ecotoxicity. The comments listed below about the fate and likely ecotoxicity risk presented by cargo remaining with the wreck assume that the information provided in Volumes 1, 2 and 3 of the consent application is accurate and complete.

#	Identity of cargo	Comment
1	Copper clove	Evidence presented suggest that this remains in remnants of hold 6, and has potential for chronic toxicity. Ensure consent conditions provide for removal should this become practicable.
2	Cryolite	20 containers (approx. 515 tonnes) described as distributed throughout the debris field – supported by sediment sampling results (Bioresearches 2014). Likely to be relatively inert by now, but will cause fluoride concentrations in sediments likely to exceed toxicity thresholds long term. Fluoride (F) can be used as a 'tracer' for dispersion of the debris field – and can provide an indicator of the areal extent of sediment/reef that for practical reasons must be accepted as subject to chronic impacts from the wreck. Outside this area, mitigation could be enforced. Much of the cargo is described as "aluminium" and some is described as "cryolite" – see aluminium note below.
3	TCCA (pool tablets)	Highly labile and relatively soluble, likely to have caused some acute toxicity, and have completely dispersed by now.
4	Potassium nitrate (KNO_3)	Likely to have caused some initial localized nutrient enrichment at the time the wreck sank, but likely inconsequential in the presence of multiple contaminants and biodegradation of the remaining cargo and rapid dilution and dispersion from the wreck site.
5	Aluminium	A large proportion of the cargo is describe as aluminium. We recommend that further detail is provided of the form of the aluminium cargo - specifically an assurance that it was not cryolite (an aluminium-rich ore). Was the aluminium present as ingots only (these have been described as recovered from the debris field), or was some of the cargo present in another, more labile form that should be independently evaluated for ecotoxicity risk?
6	Caustic calcined magnesia	Highly labile and relatively soluble, may have caused some acute toxicity, and have completely dispersed by now.
7	Plastic beads	-Present a potential risk of ecotoxic effects (e.g., to bird and fish life that ingest the beads) and aesthetic effects on the shoreline. Agree with approach described in V1 (?), that remaining container be retrieved pre-consent if possible and shoreline clean-up occurs at defined thresholds of bead presence. -Seek independent advice regarding the need for monitoring of wildlife for ecotoxicity due to ingestion of plastic beads as this does not appear to have been dealt with adequately in any report in V2.
8	Milk powder	A large proportion of the cargo was milk powder which if released in bulk to the water column would cause negative environmental effects through toxicity by causing anoxia (low dissolved oxygen) as it degraded, and decreased water clarity. More than two years after the sinking of the wreck it is likely that any containers remaining in the remnants of Holds 5 & 6 have been breached and

		the organic material within has been subject to significant microbial degradation – if not degradation by the feeding of invertebrates and other organisms. **Recommendation:** That a definitive statement as to the inventory and condition of the milk powder containers should be supplied as part of this consent application. Should there be a bulk release of a large quantity of decaying organic matter it is possible that the near-field environment of the reef (e.g., ~200-500 m from the release point) could be subject to anoxia and toxic by-products of biodegradation (e.g., ammonia and sulphides etc). We note that a) a bulk release and breach is most likely to occur during a storm when high water movement would rapidly dilute and disperse the material thus reducing its toxicity and b) this risk could be mitigated by identifying the cargo remaining in the wreck and encouraging slow release of any decaying organic matter so that it would be diluted and dispersed within a 'reasonable mixing zone'. **Recommendation:** That an appropriate risk assessment be undertaken for the potential near-field effects of milk powder release be undertaken if containers of milk powder remain on the wreck. A consent condition is proposed (Table 1, 8(x)) to address the issue of a controlled release of milk powder – there may be another mechanism available.
9	Milk fat	As for milk powder a large proportion of the cargo was milk fat, and could be contributing to decaying organic matter confined in the wreck. See note for milk powder.
10	Ferrosilicone	We agree that ferrosilicone is likely to have degraded and be relatively inert & consolidated by now – with some slow release of contaminants. Retrieve from the wreck if practical.
11	DA-HFP	DA-HFP: possibly "linear alkyl benzene sulphonic acid" – ingredient for industrial manufacture of detergent derivative. One container listed as recovered. If this is inaccurate, some ecotoxicity likely, but likely to have been dispersed and/or biodegraded by now, and if not, would be difficult to retrieve from the wreck.
12	Pentaerythritol mono	One container (22.6 T) listed in the manifest, but not in the cargo remaining with the wreck nor described as recovered or potentially toxic. Examination of a MSDS suggests would have been shipped as a solid, partially soluble in cold water that would cause some toxicity if released – and that biodegradation products are more toxic. Seek clarification about whether this cargo has been recovered.
13	Food stuffs, organic matter	This includes fresh, frozen, & packaged food, mechanically deboned meat (MDM), stock feeds etc. As for milk powder a large proportion of the cargo was food or organic matter and could be contributing to decaying organic matter confined in the wreck. See note for milk powder.
14	TBT from antifouling paint	This will continue to be released from the hull in relatively low concentrations but there is little that can be done to physically mitigate this effect. We note that the encrusting community that will continue to colonise the hull will be characterized by contaminant tolerant species and will not necessarily represent the pre-wreck reef community nor demonstrate 'recovery'.
15	Cu from antifouling paint	The antifouling report fails to reference recent New Zealand based research (e.g., commissioned by EPA) on Cu release from antifoulants. Same comments as for TBT release. See comments in our review of Ecotoxicity Assessment regarding inadequacy of analysis of Cu release.
16	Paint	One container – has this been recovered and in what state? If not recovered seek further detail about the composition/type of paint to allow ecotoxicity analysis.

The following documents were considered in updating this review, and in particular the issue of 'reasonable mixing':

Beca (2014). Application for Resource Consent (MV Rena). Sections of volumes one and three.

Elvines, D.; Barter, P.; Tremblay, L.A. (2014). *Dated May 2014* Water quality and ecotoxicity assessment: proposal to leave the remains of the MV *Rena* on the Astrolabe Reef. Prepared for P & I Services Ltd. Cawthron Report No. 2407. 32 p. plus appendices.

Elvines, D.; Barter, P.; Tremblay, L.A. (2013). *Dated September 2013* Water quality and ecotoxicity assessment: proposal to leave the remains of the MV *Rena* on the Astrolabe Reef. Prepared for P & I Services Ltd. Cawthron Report No. 2407. 48 p. plus appendices.

MetOcean (2014). Dispersal of Pollutants: Numerical modelling of the dispersal of pollutants discharged to the sea from the wreck of the Rena. No. P0119-04. MetOcean Solutions Ltd report for Beca, pp. 43.

Safinah (2014). Antifouling Assessment: Proposal to Leave the Remains of the *MV Rena* on Astrolabe Reef. No. 0917CLAL005R. Safinah Ltd report for Lowndes Associates, pp. 43.

Reasonable mixing

The areas of "reasonable mixing" should be specified in the consent application. This applies both to consideration of chemical contaminant effects in the local oceanic water and to accumulation in sediments. The location of the wreck on the sensitive Astrolabe Reef environment necessitates that the size of these reasonable mixing zones must be specified.

The necessity for specifying the size of these areas is for two primary reasons: (i) predictions of water column concentrations for significant adverse effects assessment relative to water quality guideline exceedance after initial mixing – presently this analysis has not been undertaken; and (ii) sediment contaminant accumulation – assessment relative to background concentrations or sediment quality guidelines.

Within the areas of reasonable mixing there will be an expectation of elevated concentrations of contaminants associated with discharges from the wreck. Some of these may now be historic, associated with release from the wreck or cargo, while others are ongoing (e.g., copper from antifouling). The elevated sediment concentrations of multiple contaminants provides an indication of the extent of possible dispersion and sediment accumulation – some of which may be ongoing. An example of a possible dispersion of the 550 tonnes of cryolite (Beca 2014, V3, Table 5) which will result in elevated sediment fluoride concentrations (Bioresearches 2014; as measured in near-field sediment in 2012, Figure 8; no 2013 measurements). The presence of the substantive debris field, with associated physical and chemical contaminants, is a major reason to require a designated reasonable mixing zone for sediments.

Within the mixing zone there may be elevated concentrations of multiple contaminants and potential adverse effects associated with those contaminants. An assessment of the nature of effects (i.e., species affected, nature of effect, magnitude of effects) should be made on the basis of site measurements or predicted concentrations (including "worst case scenarios"). These species-specific measurements will facilitate meaningful narrative conclusions related to both the absence of effects and the magnitude of likely effects.

The monitoring programme should also be tailored to addressing potential effects relating to areas inside and outside of the reasonable mixing zones. This would include sampling locations (e.g., using

a gradient of sediment monitoring sites with increasing distance away from the wreck) and in the decision matrix for actions should specific thresholds be exceeded.

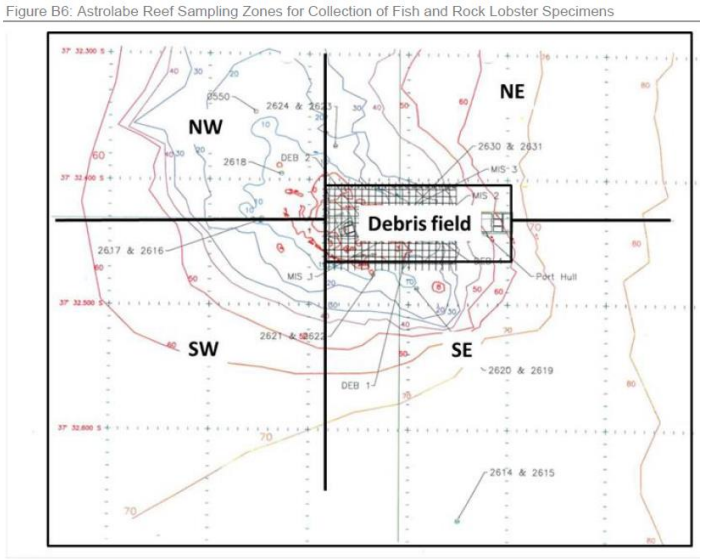
The size of the water and sediment mixing zones needs to have a pragmatic approach relative to sizing. The sediment area could be some nominal distance outside of the debris field – say 10 to 20 m beyond the currently mapped area (Figure 1). The water column reasonable mixing could be a distance of 100 to 250 m, with the grid size of the existing MetOcean (2014) model providing a useful first approach for establishing predicted contaminant concentrations.

Specific comments

1. Safinah (2014) provides conclusions relating to the likely levels of ongoing leaching (or lack of leaching). The primary basis for concluding a lack of ongoing leaching is the visual evidence from the hull photographic record showing colonisation (Conclusion, p36). We do not consider this analysis convincing. We consider that the published data for long-term leaching of copper-based antifouling is convincing and that a measurable leaching will occur. A key publication in this regard is that of Valkirs et al. (2003) who did extensive work on US Navy ships. We also consider that the biofouling organisms shown in the photographic record are likely to be tolerant organisms rather than those representative of sensitive reef-dwelling species.

2. Bioresearches (2014) provide monitoring data for various sediment-associated contaminants. Unfortunately no scales are provided on the site maps and so the locations are difficult to translate for consideration of a potential reasonable mixing zone. We note that the sediment fluoride was high near the wreck in 2012 but not measured in 2013. We consider that sediment fluoride should be included in the ongoing monitoring programme based on the release of large quantities of cryolite. Both water and sediment quality guidelines are available for the marine environment and would be applicable to analysis of fluoride effects (Hickey et al. 2004).

Figure 1: Site map from Beca (2014) showing location of debris field.



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