

DEPARTMENT OF WATER AND ENVIRONMENTAL REGULATION

Independent Peer Review Comments Sheet


Reviewer: Dr Patricia Warke (Queen's University, Belfast)	Review Comments Sheet ID:
Document Title: Murujuga Rock Art Monitoring Program: Conceptual Model	MRAMP3-2-1_PW_CM2020
Document Revision: Version 1 (July 2020); Version 2 (November 2020)	
Date of Review: 22 September 2020 (Version 1); 30 November 2020 (Version 2)	

Item No.	Section No.	Peer Reviewer Comment <i>[To be completed by Reviewer]</i>	Puliyapang Response	Peer Reviewer Close-out Comment <i>[To be completed by Reviewer]</i>
1	General Comment	<p>Although not specifically identified in the Request for Tender document, given the national and international cultural significance of the site, I feel that it will be important to include some measure of the more subjective characteristics of the Murujuga landscape unit as these may change over time in response to environmental degradation. Not surprisingly, this does not come across in the description of the Conceptual Model.</p> <p>I appreciate the need to focus on the technical specifications of the Rock Art Monitoring Program because that is core to the development of a future management strategy, but cultural sensitivities should be clearly acknowledged in experimental design and project development from the outset.</p> <p>The rock art that I have experience of working with in the UK and Ireland no longer has a direct 'connection' with the peoples or descendants of the peoples who created it and therefore its cultural significance within the contemporary landscape primarily reflects the archaeological value as discrete artefacts rather than any wider community connection with peoples of the past. This is clearly not the case with the Murujuga site and the rock art it contains, with descendants of those inhabitants of the region maintaining a strong line of 'ownership' and therefore cultural significance to the local and wider community.</p> <p>Placing the cultural significance of the rock art at the core of the investigative approach may have an impact on such matters as field site selection. For example, although the whole site is of great cultural significance, are there places of greater importance within the wider site that need to be monitored because of this or, alternatively, need to be avoided and left undisturbed by monitoring equipment? The analogy I would make is that the whole of a cathedral or church has religious significance but within that structure the altar has particular significance and is not generally accessible to the congregation.</p> <p>Also, I am interested to know if new rock art is being created by the present-day community or have those who have cultural ownership of the site stopped contributing to it?</p> <p><i>These comments are something for the investigative team to consider rather than being a criticism of the documentation submitted for review.</i></p>	<p>We wish to thank all the reviewers for their constructive comments which have been greatly appreciated. We have attempted to provide a balanced revision of the Conceptual Model, bearing in mind the diversity of comments received. The updated Conceptual Model is provided and will be referred to throughout our responses. A summary of the changes to the Conceptual Model is as follows:</p> <ul style="list-style-type: none"> • Updated Executive Summary and Background to provide more context, added emphasis on the cultural importance of the site and reference to previous studies. • Added section on "Introduction to Conceptual Models" that explains the role of the Conceptual Model in the overall project • A rationale regarding our approach to develop a Conceptual Model focused on model generality at this stage, with an extension to a detailed mechanistic model over the first three years of the project. • An additional Framework Model that provides greater emphasis on the processes occurring on the rock surface and the interactions between them. • Additional technical details with reference to previous studies have been added and resulted in a significantly extended reference list. <p>In line with the reviewer's comments regarding site selection, the Murujuga Aboriginal Corporation have already clearly indicated sites of particular significance that cannot be accessed as part of the project. These discussions will occur as the project progresses.</p> <p>There is no rock art being created by the current community.</p>	<p>I appreciate the level of engagement and thoughtfulness that the investigative team demonstrated in their responses to my comments</p> <p style="text-align: center;">Accepted</p> <p style="text-align: center;">Accepted</p>

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2	General Comment	<p>In several places throughout the Conceptual Model document there are references to 'natural' change (e.g. in the Pressure and Response diagram and table). However, it is important to remember that it will not be possible to identify truly 'natural' change if the site has already been impacted by the nearby industrial complex.</p> <p>It is probably more realistic to consider aiming to identify 'baseline' conditions against which change in future years can be assessed.</p> <p>I will pick this issue up again under Item 4.</p>	<p>The term 'natural' reflects the use of the term in tender documents, namely that the purpose of the monitoring program is to 'specifically determine whether anthropogenic emissions are accelerating the natural weathering / alteration / degradation of the rock art'. While we agree that it is not possible to identify truly natural change because of the impact that may have already occurred as a result of industrial emissions, site selection will include locations in close proximity and relatively remote from the industrial emissions and plumes, to provide a gradient of exposures. Analysis of previous data, dating back to 2004 may also be used to determine change to rock art pre-dating this project.</p> <p>Although comparison of future monitoring results with baseline conditions will certainly be an objective of the monitoring program, the project specifies the need to consider 'how anthropogenic emissions may alter these naturally occurring processes or trigger processes that are not naturally occurring.' The challenge of identifying 'truly natural change' in such a complex system dating thousands of years is acknowledged.</p>	Accepted
3	Page 4: Initial Conceptual Model	<p>I quite like the approach outlined on page 4 but for greater clarity it would be helpful to include a flow chart or equivalent diagram that shows the linkages between the key elements and sub-elements of the Conceptual Model framework. For example, Figure 1, while informative, is not clearly relatable to the Conceptual Model elements described on page 4 (i.e.; Pressure-Response Model, Sub-conceptual Models, Stressor Models etc.).</p> <p>Given the many parts of the Conceptual Model framework, clear communication of the proposed work will be essential but also quite challenging.</p>	<p>An overarching Framework Model has been developed.</p> <p>Figure 1 has been edited and is now located at the end of the document to provide a link to the detailed study design.</p>	Accepted
4	Pages 4-6	<p>Pressure /Response models are based on causality whereby change in one system variable leads to, or causes change in another system variable. In any multi-variable system, identifying clear causal relationships can be difficult as most 'natural' systems exhibit non-linear complex behaviours where system outputs are not necessarily proportionate to system inputs.</p> <p>My experience with the rock weathering system has shown that synergistic relationships between system components and lagged response times can make it impossible to clearly identify causal links between system elements. It is often more appropriate to acknowledge that establishing a baseline system condition is more achievable against which future change can be measured while accepting that such change may be driven by the proximity to internal stability/instability thresholds created by the many hundreds or thousands of years of past weathering-related deterioration rather than changes in external conditions. A useful analogy is that of genetics whereby particular genetic signatures indicate a potential susceptibility in some humans to specific disease processes while others remain unaffected even though they are exposed to the same environmental stressors. Equally, with rock and the art it hosts, some panels may contain mineralogical and/or structural weakness that predisposes them to deterioration under particular environmental</p>	<p>A new section entitled 'Introduction to Conceptual Models' has been added to explain the overall purpose and approach to the development of the Conceptual Model in this project.</p> <p>We agree that establishing a baseline system condition against which future change can be measured, may be more achievable than identifying clear causal relationships, especially in a system that is likely to exhibit non-linear complex behaviours. However, it is clear that the request for the conceptual model to underpin the Environmental Quality Management Framework (EQMF) requires more than a comparison to a baseline condition. Adjustment to this aspect would require approval from DWER. Given that approximately 15 years of prior monitoring exists, all parties understandably wish to move beyond purely baseline monitoring.</p> <p>We have a thorough understanding of complexities and non-linearities in such systems and Cressie and Baddeley (the lead statisticians on the project) have proposed from the outset that such a model be developed and furthermore that all study designs take this into account. It has not been possible to capture such detail in the Conceptual Model document,</p>	<p>I think there was some question over the reliability of some of the data collected in previous years, therefore what you are planning to do by creating this robust monitoring framework will create the go-to baseline dataset for future years. Informing the wider lay community of the difficulty of identifying causal links between environmental drivers and any condition change will be a challenging part of this complex project. (NO RESPONSE REQUIRED.)</p> <p>Accepted</p>

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		<p>conditions while other panels of the same geology and age remain unaltered despite exposure to the same conditions.</p> <p>All rock exposed to sub-aerial conditions will have developed a weathering history and under arid environmental conditions this weathering history can be lengthy and complicated. The significance of a weathering history is that past events or conditions can influence present-day response which means that there may not be a simple identifiable causal link between present-day environmental changes (e.g. increased atmospheric pollution) and rock response.</p> <p>I did not pick this up in pages 4-6 of the Conceptual Model document and I would like to know how the investigative team plan to incorporate such complexity into their Process/Response models?</p> <p>An example of a useful paper which provides a good explanation of the complexity of geomorphic non-linear dynamical systems is; Phillips, J.D. 2003. Sources of nonlinearity and complexity in geomorphic systems. <i>Progress in Physical Geography</i>, Vol. 27 (1), 1–23.</p>	<p>however this will be explained in detail in the Monitoring Studies Data Collection Analysis Plan.</p> <p>We also agree that characteristics of some panels may predispose them to deterioration under certain conditions. The study design will attempt to take this into account through selection of different rock types, ages of art and the location of monitoring points with respect to proximity to industry and air pollution dispersion patterns.</p>	Accepted
5	Page 5	<p>In the text box on page 5 under the section titled; 'Rock Art Condition' I was wondering whether the team had considered a nested condition assessment scheme with different scales of rock art condition assessment? For example,</p> <ol style="list-style-type: none"> 1. Condition of an individual rock art panel (centimetre scale) 2. Condition of 'neighbourhood' rock art panels (i.e.; those in a group) (metre scale) 3. Condition of rock across the site (kilometre scale) <p>This point is also relevant to my comments in Item 10 below.</p>	<p>Condition assessment will be conducted at different scales, but not in a systematic manner applied equally to all culturally marked rocks. The study design calls for the detailed colorimetric study of up to 20 rocks, and each of these sites will be studied with the full suite of in-situ analytical tools – Spectrophotometry, XRF mapping and Micro-photogrammetry. The relevant techniques is micro-photogrammetry, which will scan selected surfaces on each of the detailed study sites (nominally one per site, but this may be increased as results determine) This detailed scan of an area 100 x 100 mm is developed into a three dimensional model that can be queried in a number of ways. The main aim so to detect morphological change within the study area at a resolution of around 2-10 micron resolution. Such a study does not speak for the entire block and nor does it speak for the ensemble overall.</p> <p>The whole block (the preferred description of the boulders), where seen to demonstrate instability, such as broad scale delamination or very shallow vulnerable engravings, will be studied at up to five selected sites, with RTI (reflectance transformation imaging) imaging the entire engraved surface. This technique images the rock surface at a whole block scale but does not speak for the entire ensemble.</p> <p>Connecting these macro-observations to the entire ensemble is achieved through the proposed condition survey protocols that will be carried out on up to 2,000 sites during the program, subject to MAC ranger input. The surveying protocol is a visual hands-off assessment of 40 key features and while it does not provide any of the analytical understanding gained from the precise imaging, it does expand the study 100-fold in lower level observations of instability and impact.</p>	Accepted
6	Page 7	<p>On page 7 with reference to the Environmental Pressures conceptual model, I was wondering if the team is going to incorporate the potential future impact of climate change?</p> <p>I'm not totally familiar with the climate change projections for Western Australia but such factors as increasing temperatures may influence bio</p>	<p>The potential effects of climate change are acknowledged but were initially considered to be outside the scope of the project description/tender, however DWER reviewers have raised similar questions, and DWER have advised in subsequent meetings that we should not exclude such effects.</p>	Accepted

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		<p>and geochemical interactions on rock surfaces and any increases in wind-speed or storm frequency may increase the potential for surface abrasion from windblown particulates.</p> <p>This may be outside the scope of the work outlined but it might be worth considering.</p>	<p>We have therefore added discussion on climate change in the updated Conceptual Model. However decoupling climate change and other distal anthropogenic effects from direct anthropogenic impacts and “baseline” (“natural”) rates of change remain a significant challenge and may not be possible to achieve.</p>	
7	Page 8	<p>The ‘Processes on Rock Surface’ sub-conceptual model diagram indicates a simple input/output model, which belies the complexity of non-linear responses, which is the norm in the majority of geomorphic systems (see my previous comments on this subject – Item 4).</p> <p>In the sample questions text box on page 8, mention is made again of ‘natural weathering’ but it is not clear to me how this is to be defined – see my previous comments under Items 2 and 4. I would suggest that establishing baseline system conditions is a more achievable goal.</p> <p>I am a little concerned that the sub-conceptual model identified on page 8 has insufficient prominence within the overall Conceptual Model. Understanding what is happening on the rock art panel surfaces is key to the success of this whole project. In my opinion the processes occurring on and interacting with rock art panels should be the core element of the Conceptual Model with all other data acquisition activities feeding into this.</p>	<p>Refer to Comment 5.</p> <p>Please refer to updated Conceptual Model, particularly the Framework Model and accompanying text.</p> <p>It is agreed that understanding what is happening on the rock surfaces is a key to the success of the project – as the outcomes of the pilot study inform each of the sample questions, a more detailed model highlighting the processes occurring on the rock surface will be developed.</p> <p>Refer back to comment 2 in response to the use of the term ‘natural’.</p> <p>We have provided a definition of natural weathering in the updated Conceptual Model.</p>	Accepted
8	Pages 9 and 10	<p>The presence of rock varnish provided the ideal surface for creation of the rock art in the first instance and presumably, given that the Murujuga rock art has been created by many generations over many thousands of years, there will be different ages of rock art and the associated re-varnishing of the pecked or carved surfaces? Will this be taken into account when analysing the biochemistry/mineralogy of the varnish?</p> <p>Determining whether rock varnish is deteriorating, stable or actively forming will be extremely difficult and it is quite possible that, across the whole site, there may be instances of these different surface conditions occurring in relatively close proximity, reflecting local micro-environmental conditions.</p> <p>Given the low rainfall conditions it is probable that any change in the stability status of rock varnish will occur very slowly over a time period outside the scope of the project. Has the team a Plan B if it is not possible to clearly determine whether change in the condition of the rock varnish is actively taking place?</p>	<p>Based on the motifs reproduced ((extinct)animals, ships), the petroglyphs appear to have been created from ~100 years ago to up to 50,000 years ago, however dating is not yet certain and is the subject of a separate project.</p> <p>Micro-environmental variables have been considered in selecting the expanded range of study sites, particularly solar orientation and surface slope. It is important to stress however that the study is limited to internal indicators of change only, and that there is no possibility to compare rock A with rock B in any meaningful way. It is only possible to compare PointA2020 with Point A2025 in a refined manner that may indicate change. It is also necessary to consider the fundamental aim, which is to determine whether change can be determined within the time frame of this and other studies, both past and future. It has been stated in one critique of previous studies that the engravings are eroding rapidly and that their complete loss could occur within a decade or so. This assertion needs to be probed and certainly a study of five years duration will very clearly detect change that has a termination point ten years hence and should be able to observe erosion that may take a century to erase all visual details.</p> <p>In terms of a Plan B, the aims of this project are to devise assessment methods that can detect change and to apply them to the Murujuga rocks over a 5-year term. That is not to say that results must be clear or that future studies are not required. If at the end of five years the conclusion is that there has been no measurable impact, this is simply a time marker in the long term study. No change at five years may develop into observable or significant change at 50 years. The study may</p>	<p>My opinion, for what it’s worth, is that change, if it is occurring, is probably progressing very slowly with considerable spatial variation across the entirety of the site. That means that the investigative strategy for condition assessment you are tasked with establishing within the constraints of this project is going to be extremely important for future generations of field scientists</p>

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		<p>Figure 6 on page 12 indicates some form of linear relationship between increasing inputs of anthropogenic air pollutants and accelerated weathering of rock art panels but such a clear relationship may be difficult if not impossible to establish because of the complexity of the system under investigation.</p> <p>Does the team have a Plan B if it is not possible to identify a causal link between atmospheric pollutants and 'accelerated' weathering of panel surfaces?</p> <p><i>Some thoughts:</i> <i>I guess that you are aiming to eventually establish some 'measure' of rock art panel stability whereby individual panels representative of larger groups/populations can be placed somewhere on a condition scale such as;</i></p> <p> <ol style="list-style-type: none"> 1. surface stability (positive indicators of varnish development identified) 2. surface stability (indicators of varnish development not detectable) 3. unstable surface (detectable indicators of varnish deterioration) </p> <p><i>Surface change may not be a one-way direction of travel as panel surfaces could move back to a condition of re-established stability albeit temporarily, in response to changing/improving environmental conditions. Such transitioning between states would most likely be exhibited by panels that are on or close to a threshold of long-term change. Instead of exact measures of surface change it might be more achievable to provide an index of potential sensitivity to change?</i></p>	<p>of a more mechanistic model that will depict the nature of the relationships in more detail. The "Introduction to Conceptual Model" section also addresses general points about this topic.</p>	
11	Page 13	<p>I like the idea of using a Stressor Model as illustrated on page 13 but I remain concerned by the emphasis on this stress-response approach to a highly complex system.</p> <p>I come back to the point mentioned previously that the rock weathering system exhibits many of the characteristics of a non-linear dynamical system where change in a system output (e.g. rock breakdown, varnish deterioration) may not be proportional to the change in the input (e.g. increased atmospheric pollution).</p> <p>In the Stressor Model all the 'Effects' are identified by change in a range of system components but what happens if no statistically significant change is detected within the project timeframe? Can the team be sure that if there is an absence of detectable change this may be taken to infer system stability or is it possible that lab-based experimental design or field data collection might be insufficiently sensitive?</p> <p>Air pollution plumes may be detected but may not translate into detectable change in the condition of rock art panels in the field. Great caution will have to be exercised when attempting to extrapolate laboratory derived simulation data to 'real-world' settings</p> <p>In geomorphological process studies, the limitations of deterministic approaches to experimental design and model development has led to the recognition that much laboratory derived weathering simulation data do not reflect the complexities of 'real world' system behaviour.</p> <p>We now accept that a better understanding could potentially be achieved through the adoption of more complex probabilistic approaches to</p>	<p>This is indeed the approach being proposed in our Detailed Study Design report. Team members Baddeley and Cressie are world-leading in the development of such models in a wide variety of scientific studies. The study-design report gives details of how the results from component studies will be used to build conditional probability distributions for the component processes, and how they will be integrated into a probabilistic underpinning of the entire system.</p> <p>The lab-based experiments are intended to demonstrate accelerated deterioration and, if it occurs, to characterise how it occurs. The lab experiments will inform our analysis of the field observations by "telling us what to look for," resulting in an increased ability to detect low-level/gradual degradation. If no effects are observed, the lab experiments will give greater confidence that no accelerated degradation is occurring.</p> <p>Findings from the monitoring study will inform the development of a more mechanistic model that provides more detailed depiction of the dynamics of the system.</p>	Accepted

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		<p>modelling in which the incorporation of 'random' system perturbations might enable more accurate predictions of system behaviour or at least aid in identifying the probability of a system behaving in a particular way.</p> <p>I appreciate that I could be accused of playing 'devil's advocate' here because the complexity of the challenge almost forces you to focus on more straightforward investigative methods in order to achieve results.</p> <p>The points I have made here are really aimed at stimulating discussion of your approach to experimental design and the conceptual starting point for the project.</p>		
12	General Comment	<p>The Conceptual Model proposed is ambitious and complex and I applaud the efforts of the investigative team to address the challenge of developing a robust monitoring model for this internationally important site.</p> <p>I think a little more thought needs to be given to aspects of the structure of the Conceptual Model but I can see the foundation of a really significant investigative and monitoring framework.</p>	Definitely – as per the timeline, the Conceptual Model will be developed over years 1 to 3	Accepted

In making these comments, I have endeavoured to be constructive – however, it's easier to be critical than to be constructive but I have tried to veer towards the latter.

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1	INTRODUCTORY COMMENTS.	<p>The principal goal of the Murujuga Rock Art monitoring program is stated to be <i>“Monitor and Evaluate whether rock art is subject to accelerated change due to anthropogenic emissions”</i>. This is noted and endorsed.</p> <p>The monitoring and measurement program to be undertaken is planned to be based on an understanding of the main processes that influence the condition of rock art and which can be represented in a Conceptual Model. Using the Conceptual Model as the “framework” or guide a pilot measurement project is proposed that will lead to the development of Environmental Quality Objectives and an appropriate set of Environmental Quality Criteria that will subsequently be used to assess whether changes have/are occurring in rock art condition.</p> <p>It is anticipated that the Conceptual Model and its various components will form an important base and an integral part of the Communication Program that is planned for the monitoring program.</p> <p>This peer review of the Conceptual Model on based on this understanding of its role.</p>	<p>We wish to thank all the reviewers for their constructive comments which have been greatly appreciated. We have attempted to provide a balanced revision of the Conceptual Model, bearing in mind the diversity of comments received. The updated Conceptual Model is provided and will be referred to throughout our responses. A summary of the changes to the Conceptual Model is as follows:</p> <ul style="list-style-type: none"> • Updated Executive Summary and Background to provide more context, added emphasis on the cultural importance of the site and reference to previous studies. • Added section on “Introduction to Conceptual Models” that explains the role of the Conceptual Model in the overall project • A rationale regarding our approach to develop a Conceptual Model focused on model generality at this stage, with an extension to a detailed mechanistic model over the first three years of the project. • An additional Framework Model that provides greater emphasis on the processes occurring on the rock surface and the interactions between them. • Additional technical details with reference to previous studies have been added and resulted in a significantly extended reference list. 	NOTED.
2	THE CONCEPTUAL MODEL	<p>The relevant and significant components of a suitable Conceptual Model are well presented in the document. The authors of the Conceptual Model have shown an understanding of the main processes taking place and their interactions.</p> <p>However this reviewer is of the view that the presentation of the Conceptual Model and the interactions that are identified and</p>	<p>The addition of a Framework Model at the start of the Conceptual Model and reorganisation of other elements address these comments.</p>	<p style="text-align: center;">NOTED.</p> <p>The revised document addresses the very many and diverse comments and suggestions made by the various reviewers.</p>

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		<p>that will lead to the proposed pilot study could benefit significantly by a reconsideration of the sequence in which the information is presented. Specifically, it would more intuitive, as well as helpful in communication, to commence the document with a broad (“Big Picture”) presentation of the Conceptual Model, to be followed by the greater detail of the so-called “Sub-Conceptual Models” and then finally, the process of bringing the parts together and implementing the proposed Pilot Monitoring Program.</p> <p>This reviewer would like to suggest an approach for the team to consider.</p> <p>The diagram presented as Element Three-Stressor Model (p13 of the report) is the basis of the Conceptual Model, being a simplified/summarised diagrammatic representation of the main relationships in place and processes that occur, and which are instrumental in influencing weathering processes, the formation of rock patina, and in the alteration of rock patina condition.</p> <p>On this basis this diagram is the “framework” of the Conceptual Model of the system, and warrants presentation (with supporting narrative) at the start of the document.</p>		<p>This reviewer commends the project team on its response and regards the current Conceptual Model as “almost there”.</p> <p>An observation. This reviewer, having read the revised Conceptual Model document but also and perhaps more importantly, all of the other reviewers comments and the specific responses by Puliyapang to these, as well as the draft study design, is more informed of the proposed program than from reading only the Conceptual Model document itself.</p> <p>This is not surprising but does provide further emphasis for the need of a significant communication program to be part of this venture, and to be taking place concurrently with the development of the monitoring program.</p>
3	<p>“Pressure - Response Model and Narrative” and “Sub-Conceptual Models”</p>	<p>The sections in the report titled “Pressure -Response Model and Narrative” and “Sub-Conceptual Models” presents information that is essential and extremely valuable and necessary in describing in greater detail the components of the Conceptual Model.</p> <p>It is noted that similar and, in some cases, duplicate information is provided in these sections. Consideration is warranted on combining these 2 sections.</p> <p>These sections also present the coloured arrow system to depict level of impact or change. These coloured arrows have immediate visual impact and are readily interpreted. The use of this system of “reporting” the information obtained from monitoring is strongly supported.</p> <p>Note: The assignment of colour with associated values of measured “indicators” is still to be undertaken and will need to be expressed in terms of Environmental Quality Objectives and Environmental Quality Criteria. It is recognised that this will be a complex task.</p> <p>The diagram presented on p3 as Figure 1, Overall Conceptual framework and Study Components describes the procedures that will occur in gathering information and taking decisions leading to the design and implementation of the pilot study. Figure 1 demonstrates an appropriate level of organisation of the program, is valuable and would be helpful and informative in communicating the approach and structure of the early stages of this program. Figure 1 is less about the Conceptual Model and</p>	<p>Modifications have been made to the sequence and content along these lines. Please refer to the updated Conceptual Model for more detail.</p> <p>To note – each of the elements in the Conceptual Model serve a different purpose and in some circumstances may be used independently. For example, the Pressure-Response diagram and narrative is essentially a stand-alone element that has been developed as a ‘one-pager’ capturing the key elements of the system without delving into greater detail. While this approach has resulted in a level of duplication, we believe that the flexibility of using different elements of the Conceptual Model for different purposes/audiences, warrants this.</p> <p>Ease of interpretation was also a key consideration, so we are pleased to receive your endorsement of this approach.</p>	NOTED

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		<p>more about the organisation and planning of the work and would better follow after the presentation of the Conceptual Model, rather than before.</p> <p>Hence this reviewer is proposing that the report could be modified, not so much in content, but in the sequence of presenting the components.</p> <p>Specifically,</p> <ul style="list-style-type: none"> • Introduction (what is the goal of the project and why) • Presentation of Concept Model (“Big Picture” such as e.g. enhanced diagram on p13.) • Sub-Concept models and further detail • Organisation and timetable (i.e. Figure 1) 		
4	Executive Summary	<p>This is more a summary of the Table of Contents than an Executive Summary. Rather, it should be a summary of the content of the report.</p> <p>It is worth considering including in the Executive Summary the following: Objective of Project, very brief description of Conceptual Model and perhaps some specific detail of what is rock art, weathering and degradation and proposed program of monitoring. For example, Figure 6 on p12 and some of the text associated with it, encapsulates this very well.</p>	Noted and updated.	NOTED AND ACCEPTED
5	Background	<p>As stated above, Figure 1 summarises activities and procedures to be used to develop the proposed Trial Monitoring Program. This reviewer is of the view it would have more relevance if the Conceptual Model is presented before this organisation diagram</p> <p>Is the timetable (Yr1, Yr2 activities) still achievable?</p>	<p>Noted, Figure 1 has been relocated to after the presentation of the Conceptual Model.</p> <p>Regular meetings with DWER to discuss the timetable are held. Adjustments will be made if necessary. Many of the monitoring activities will need to be designed wet and dry climate seasons. Delays due to COVID-19 have also impacted the timetable and we are mindful that further impacts may occur as a result of COVID-19.</p>	NOTED.
6	Development of the Initial Conceptual Model	As previously stated, this reviewer is of the view that the “Stressor Model” best represents the description of the “Conceptual Model” provided in the first few paragraphs of p4.	Noted	NOTED
7	Pressure-Response Model and Narrative and Sub-Concept Models.	<ol style="list-style-type: none"> 1. There is much similarity between these two sections including common text. Consider option for combining these two sections 2. Text on p6 provides an excellent summary with sufficient detail. 3. Suggestion on use of technical terms. Word “element” is used in paragraph under “Environmental Pressures” In a document like this with technical terms such as compounds, minerals, acid gases, and others all having a specific meaning, suggest replace word “element” 4. Why are “Inorganics” not specifically identified while “Organics” are in Processes on Rock Surfaces? as inorganics are identified as a significant contribution to pH reduction in section “Environmental Pressures”. Is there a 	<p>These comments have been addressed in the updated Conceptual Model.</p> <p>In particular, Figure 6 has been transferred to the background section to provide an early introduction to how the petroglyphs are created, and the effect of weathering.</p>	<ol style="list-style-type: none"> 1. Additional editing in the revised document noted. There is still a need for some final editing. 2. Noted 3. Noted 4. This comment was made by other reviewers but does not seem to have been addressed. Why not simply identify that inorganics are also part of the “Emissions” shown in Figure 3, figure in section 6 and Figure 6. For example, lightning fixes atmospheric nitrogen; sulfates and chlorides occur in marine aerosols and so forth. No need to identify every chemical type but expand definition of Emissions. The study group is clearly aware of the

Item No.	Section No.	Peer Reviewer Comment <i>[To be completed by Reviewer]</i>	Puliyapang Response <i>[To be completed by Puliyapang]</i>	Peer Reviewer Close-out Comment <i>[To be completed by Reviewer]</i>
		<p>need for this separation of these chemical types or perhaps a more inclusive description?</p> <p>5. Rock art condition...include considering a few words on not only of loss of patina but potential for accelerated formation of patina</p> <p>6. Number and Title should be included for all Figures (see untitled/unnumbered Figure on p8)</p> <p>7. Figure 6 contained in section Rock Art Condition Sub-Conceptual model is an excellent contribution to this document. It is one of the most relevant diagrams presented as it encapsulates the processes of weathered rind and patina formation, engraving through the layers to produce an optical contrast and the effects of weathering, including the potential for an accelerated rate of production of patina. This diagram will form an excellent part of the detail of the Conceptual Model and also the proposed communication program</p> <p>8. The Conceptual Model will need to also address some of the issues related to variability of rock art condition and variability in change in condition. For example, there will be a substantial range in "age" of petroglyphs and this difference in age will need to be considered in the selection of sample sites and the interpretation of any changes observed.</p>		<p>significance of these components as its measurement program includes them.</p> <p>5. Noted</p> <p>6. Noted</p> <p>7. The "elevation" of this diagram is noted.</p> <p>8. Noted. Answered in responses to other reviewers.</p>
8	General	<p>1. The document does need some further editing. Relatively minor</p> <p>2. A cautionary word is warranted on the limitation of laboratory simulations and experimentation. The ability to replicate all the vagaries of a natural system in a controlled laboratory environment is notoriously difficult</p> <p>3. The peer reviewers of the Conceptual Model have been provided with a copy of Detailed Study Design Part A to read. This document demonstrates that the study team has already taken a number of important issues into account, and also demonstrates the value of the Conceptual Model in establishing the framework for the Pilot work and its importance to the communication program.</p> <p>4. The project team is encouraged to regularly review the Conceptual Model and confirm that the project investigations are contributing directly to the stated objectives and goals of this work.</p> <p>5. The team is extremely well qualified and appropriately experienced to achieve these significant and demanding objectives. We wish them well.</p>	<p>Noted and agreed.</p> <p>With respect to point 2, studies will be carefully designed with this in mind. However given previous field studies in the area have been inconclusive, we have no guarantee that a field study of any size will provide all the required information to inform the Environmental Quality Management Framework. Therefore we believe that carefully designed laboratory studies are needed, at minimum to provide upper bounds for exposure response relationships.</p>	<p>1. Noted. See also comment in section above. Still needing a final edit</p> <p>2. Noted. The teams response that the laboratory studies will have as a major objective, informing the Environmental Quality Management Framework is reasonable.</p>

DEPARTMENT OF WATER AND ENVIRONMENTAL REGULATION

Independent Peer Review Comments Sheet

Reviewer: J GROSS	Review Comments Sheet ID:
Document Title: Murujuga Rock Art Monitoring Program: Conceptual Model	MRAMP3-2-1_JG_CM2020
Document Revision: Version 1 (July 2020); Version 2 (November 2020)	
Date of Review: 18 September 2020 (Version 1); 14 December 2020 (Version 2)	

Item	Section	Peer Reviewer Comment <i>[To be completed by Reviewer]</i>	Puliyapang Response	Peer Reviewer Close-out Comment <i>[To be completed by Reviewer]</i>
1	Overall Comments:	<p>This version of the conceptual models represents a beginning, but as noted by the authors there are a number of deficiencies and a need to refine the models as the project progresses. As a reference for evaluation of the conceptual model, I used the statement on p. 11 of the Monitoring Program Request:</p> <p style="padding-left: 40px;">The successful development and implementation of a world best practice Rock Art Monitoring Program on Murujuga requires the combination and continuity of a range of skills, qualifications and experience in the Contractor and its Specified Personnel. The Customer requires that the skills, experience and expertise, and the identified roles and responsibilities, of any nominated Specified Personnel are clearly and unambiguously described, and the availability of nominated Specified Personnel for the five-year Contract Term is explicitly articulated.</p> <p>and information in the review request:</p> <p>As outlined in the monitoring program request document (Attachment 2), the Conceptual Model:</p> <ul style="list-style-type: none"> • must inform the scientific framework for the monitoring studies required to underpin the design of the monitoring program and the development and implementation of the EQMF (Attachment 3). This includes the identification of the relevant indicators of environmental quality, and the development of clear, measurable and auditable Interim Environmental Quality Criteria (Interim EQC) for the selected indicators. • will include the elements of the overall conceptual model (e.g. narrative text, pictorial diagrams, conceptual sub-models for finer scale representation), documentation of the process used to develop the conceptual model and the evidence base underpinning the conceptual model. • should communicate an understanding of the Murujuga Rock Art system to a lay audience. • must demonstrate how the results from the pilot study will provide further input into the model that will underpin the EQMF. 	<p>We wish to thank all the reviewers for their constructive comments which have been greatly appreciated. We have attempted to provide a balanced revision of the Conceptual Model, bearing in mind the diversity of comments received. The updated Conceptual Model is provided and will be referred to throughout our responses. A summary of the changes to the Conceptual Model is as follows:</p> <ul style="list-style-type: none"> • Updated Executive Summary and Background to provide more context, added emphasis on the cultural importance of the site and reference to previous studies. • Added section on “Introduction to Conceptual Models” that explains the role of the Conceptual Model in the overall project • A rationale regarding our approach to develop a Conceptual Model focused on model generality at this stage, with an extension to a detailed mechanistic model over the first three years of the project. • An additional Framework Model that provides greater emphasis on the processes occurring on the rock surface and the interactions between them. • Additional technical details with reference to previous studies have been added and resulted in a significantly extended reference list. 	<p>On the revised Conceptual Models (note plural): These and the accompanying text are a huge improvement, and in short, I think they sufficiently addressed my concerns/comments and are adequate to proceed with designing the monitoring program. The authors clearly acknowledged the need to refine these models and add additional, more detailed models as the program progresses, and I certainly agree with that.</p> <p>I reviewed the SRG/John Black comments, and I think the revised models sufficiently addressed his concerns for this phase of the program. Development of quantitative models is really beyond “conceptual model development”. One form of the “old-style” models I referred to (the ones I like) are Forrester diagrams, which are commonly used to accurately represent simulation and other computer models. To construct a Forrester model, it is critical to correctly identify the elements of the system to be modelled (state variables, rates, inputs, drivers, etc.) and their relationships. These relationships may be known or they may represent hypotheses. Such a model is extremely helpful when working with statisticians and quantitative scientists, who will be asking very specific and detailed questions that are important to determining what is to be measured, where, how, how often, etc.</p> <p>Here are a few minor comments. These do not constitute any sort of comprehensive review – just a few easy fixes. Fig. 2 and associated text. The description of Fig. 2 seems rather incomplete, and it appears to include only the loss of the patina. But section 4.2.2 also describes a process that would enhance the rate of patina formation, thereby reducing the contrast. These competing hypotheses both results in the loss of contrast, but for via</p>

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		<ul style="list-style-type: none"> may be reviewed and refined in subsequent years following implementation of the monitoring program. <p>My interpretation is that, as an integral component of the monitoring program, the conceptual models should thus meet the standard of “world best practice”. Currently, the <i>draft</i> conceptual models presented for review do not meet this standard.</p> <p>The authors (20 of them!) clearly laid out the main purposes of the model (I suggest referring to these as ‘models’, since there are many of them) in the Executive Summary, but for the reasons below the draft models currently do not achieve these goals. I do not know the context of these models relative to other supporting documents, and that context has some impact on what needs to be included in the conceptual model documentation versus elsewhere. I.e., because the conceptual models have a primary purpose to support other reports and plans, it is not clear what (1) is required to be included in the documentation of the conceptual model, (2) what should be in another reports or documents and simply be referenced here, and (3) what should perhaps be duplicated in multiple places so each document can stand on its own. My recommendation is for the conceptual model document be inclusive and comprehensive, to the extent that a stakeholder or an external reviewer unfamiliar with the site does not need to locate and read additional documents to fully understand the context and the key messages that are represented in the models. I can imagine, e.g., that consulting statisticians or chemists will need to understand the models, but may be from an international audience completely unfamiliar with the context of the site. Alternatively, another (less preferred) option would be to cite references for the information and provide persistent URLs so they are easily accessed.</p> <p>For an excellent example and illustrations of some of the points I make below, see: Dennison, W. C., T. R. Lookingbill, T. J. B. Carruthers, J. M. Hawkey, and S. L. Carter. 2007. An eye-opening approach to developing and communicating integrated environmental assessments. <i>Frontiers in Ecology and the Environment</i> 5:307-314.</p> <p>Also see Fandel et al. (2018) for a very relevant discussion of the strengths and weaknesses of a broad range of water cycle models: Fandel, C. A., D. D. Breshears, and E. E. McMahon. 2018. Implicit assumptions of conceptual diagrams in environmental science and best practices for their illustration. <i>Ecosphere</i> 9:e02072</p> <p>Crafting good and attractive conceptual models requires special skills. In the past, I have participated in workshops where Bill Dennison’s group was engaged to craft the models, which they did incredibly quickly and with a very high level of professionalism. If they still offer these services the investigators may wish to inquire – for us, it was a very economical and efficient way to dramatically improve project outcomes.</p>		<p>very different processes. This could easily be addressed in a more informative figure caption. P. 6, first line: change “central” to “bottom”</p> <p>Fig 4. The diagram could be simplified by (1) reversing the positions of the Stresses (to reduce the crossing of arrows), and (2) using a single arrow between the stresses and intermediary effects and between intermediary effects and rock art conditions. All those arrows are just confusing since all possible paths between boxes occur.</p>

Item	Section	Peer Reviewer Comment <i>[To be completed by Reviewer]</i>	Puliyapang Response	Peer Reviewer Close-out Comment <i>[To be completed by Reviewer]</i>
2	Provide context	As someone unfamiliar with the area, I needed to seek other sources to get a general feeling for the area, resources, and surroundings before I felt that I could even begin to evaluate the models. The document really needs an introductory section that provides critical context, including citations for more detailed information. This should include one or more maps of the area showing locations of mining and other geography, photographs that illustrate key resources, values, features, and setting. Along with an area map, it would be very helpful to include basic information on key drivers such as rainfall, wind speed and dominant directions. This does not need to be highly detailed, but such information is critical to interpret and understand the conceptual models and their relevance to this specific project. This is not difficult and need not be long, so I recommend this be included in the conceptual models, and probably be duplicated in other documents and plans. It is really important.	We agree. We were unaware that this document would be sent out for review without appropriate supporting material for context. As above, additional context and other information has been provided in the updated Conceptual Model.	Refer closeout comments on item 1
3	More detailed narratives	While this is an early draft, I expected the narratives to be much more informative and detailed. Based on e.g. the identification of specific indicators, the authors clearly have a sophisticated understanding of stressors likely to be important, and the (sometimes) complex mechanical, biological, and chemical processes that are important to the preservation and degradation of the art, but nowhere are these either described in the document nor are there adequate citations. A common process for developing conceptual models is to e.g. create and develop diagrams/illustrations in a setting with subject-matter experts, and then to “verify” the models via a literature search subsequent to the workshop. Although this is early in the project, I would expect the narrative to include evidence that supports the models. These are simply absent. The details provide scientific credibility and support for the graphics. It may be acceptable for narratives for the most general models, presumably based on ‘generally understood dynamics’, to be absent of citations. Narratives for the detailed models must include citations, particularly where a model illustrates processes that are poorly known, controversial, or that represent a hypothesis.	We believe these comments have been addressed in the updated Conceptual Model.	Refer closeout comments on item 1
4		There are many ways to illustrate conceptual models, and I cannot say that one approach is necessarily better than another. But I can say that I did not find the illustrations to be very informative or imaginative, and I felt the terminology used could, and should, be more precise. For example, the Pressure-Response model (p. 5) has the category “Processes on the rock surface”, which has Organics, Microbial Communities, and Minerals. It is not intuitively obvious that any of these categories is a “process”. I was not clear on precisely what Organics included, but my impression is that it includes e.g. nitrogenous air pollutants, which are not even organic compounds (i.e., using the traditional chemical definition, an organic compound must include carbon). If nitrogenous (and sulfuric) compounds are not organics, would these be minerals? The point is that further documentation and clarity is needed. I also felt there were important elements not included or otherwise represented in the ‘base’ model, for example substrate, location or ‘setting’ (e.g., is the site well protected), and the type and	Please refer to amendments to the Pressure-Response model, as well as the addition of the Framework Model. The updated Background and new section on Introduction to Conceptual Models expands on the approach used for the ongoing development of the Conceptual Models across the project, including significant input from the Pilot Study. We have attempted to ensure that terminology is more intuitive and consistent and included a glossary.	Refer closeout comments on item 1

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		<p>perhaps age of art. My questions also emphasize the need for much more detailed and comprehensive narratives.</p> <p>Questions posed by the authors on pages 7-10 are central to the program. The authors express a misconception that the conceptual models will be developed as these questions are answered. In my opinion, this is a fundamentally wrong. The monitoring program, and/or external research, will presumably be designed to shed light on these questions. I.e., no answer currently exists for many of the questions. The conceptual models, along with the narratives, need to articulate what we know, AND what we do not know. They should illustrate the key relationships, indicate uncertainties, and illustrate and support hypotheses that monitoring data, and likely external research, will presumably address. While the models need to reflect the current state of understanding, that understanding will of course always be incomplete, and the models can reflect this.</p>		
5	Stakeholders	<p>This report notes that 'stakeholders' have been consulted, but these are never identified or defined. The models appear to be very strongly directed towards an audience with what I will call 'western' thinking, and not for e.g. the traditional native landowners. For example, it is not clear that traditional knowledge or beliefs are represented or acknowledged. This may or may not be important, but given the context of the project I would think some acknowledgement of how or why traditional knowledge was or was not included would be important. I.e., it should be explicitly dealt with. I would hope that the traditional landowners are an important audience, and at least one of the more general models would reflect their perception of the world and help us 'outsiders' consider the context in which they will perceive the monitoring program and its protocols and activities.</p> <p>Views of the traditional landowners could, and likely will, have very significant consequences for the monitoring program. They may, e.g., dictate times or places that are unacceptable for sampling, affect how or who is permitted to access sites, etc. I.e., this both respects the heritage of the area and its inhabitants and potentially provides important information to statisticians and others that must develop and defend a spatially and temporally complex sampling protocol that operates within physical, economic, jurisdictional, and cultural constraints.</p>	<p>Please refer to the updated Conceptual Model for more detail. While the development of the initial Conceptual Model has focused on the key technical requirements of the tender, the incorporation of traditional knowledge is considered an integral part of the process.</p> <p>Face to face consultation with Traditional Owners and Custodians was hampered by travel restrictions due to COVID-19, however this is considered a critical next step in the process.</p> <p>Any sampling conducted as part of the project (locations, times, access etc.) requires the approval of Murujuga Aboriginal Corporation and the Circle of Elders who represent the Traditional Owners and Custodians of Murujuga.</p>	Refer closeout comments on item 1
6	Abbreviations	The document needs a table that lists and defines all abbreviations and acronyms .	Refer to updated Conceptual Model.	Refer closeout comments on item 1
7	Model Diagrams	I could say more about the specific diagrams, but I think these comments are sufficient to communicate my overall impression. For a complex system or monitoring program, multiple types of model and illustrations are typically needed to best communicate the system, its dynamics, and monitoring priorities. To their credit, the authors followed this and used different types of illustrations. I think they could take it much farther, particularly as they develop more technical models that e.g. represent complex chemical interactions between atmospheric elements and geological substrates. Personally, I really like 'old-style' models that are	<p>The team will develop more technical and detailed models as the monitoring studies continue. An important element of this will increase interactions with different audiences.</p> <p>Consideration will also be given to the sourcing specialist skills to assist with the ongoing development of the illustrations.</p>	Refer closeout comments on item 1

Item	Section	Peer Reviewer Comment <i>[To be completed by Reviewer]</i>	Puliyapang Response	Peer Reviewer Close-out Comment <i>[To be completed by Reviewer]</i>
		<p>technically correct in their representation of state variables, rates, feedbacks, external drivers, etc., although I understand these frequently do not work well for non-technical audiences. I guess a point here is that there needs to be routine interactions between the model producers and the [clients, stakeholders, other scientists – whoever is important to the program] to determine which model forms best represent and communicate the key points. In my experience, developing good models is an iterative process, and (particularly) the person drafting the illustrations needs to be skilled in knowing the content of the model, and have (sometimes unusual) abilities to draft the figure. It is not enough to be the subject matter expert – someone has to have the ability to put it into a figure. And it is time-consuming.</p>	<p>It is agreed that the process is time consuming and ongoing planning will ensure that adequate resources are employed for this task.</p>	
8	<p>Figure 2 (p. 7).</p>	<p>As a sub-model, I expected this to be sufficiently detailed and informative that I would be able to identify relationships between key elements (preferably mechanistic relationships), and have some ability to identify which relationship/processes/states/objects were most important. It is not clear from the figure if the size of arrows, for example, has any information content. Furthermore, the (cursory) narrative describes characteristics of weather that I would think could be very important (e.g. wind direction that carries atmospheric pollutants from the mine to art works), but these are not even mentioned in the figure. My impression is that the weather and air pollutant sub-model is extremely important to the monitoring program. This version of the model is useful for an initial stage setting, but it fails to illustrate, in adequate detail, the complex processes that are important to the study.</p> <p>A more useful model would include everything in the current model, and illustrate feedbacks and whether the feedbacks are positive or negative.</p>	<p>Please refer to the updated Conceptual Model.</p>	<p>Refer closeout comments on item 1</p>
9	<p>Figure 3</p>	<p>Of all the model illustrations, this was by far the most informative. It clearly identified key sources of pollutants, what I assume are the most important physical and chemical processes acting with/on the pollutants, and the potential effects and impacts on the art. With minor modification, it might also be possible to include key weather effects also. Having said that, the diagram would greatly benefit from editing. Some fonts are too small, and the white lettering on a light background is difficult to read on screen, impossible to read on hard copy, and will be completely illegible when projected. This model also re-emphasized my concern about imprecise language – this model seems (appropriately) to include atmospheric pollutants and processes that would not be included in an organic chemistry course (e.g. nitrate chemistry, top centre in diagram).</p> <p>“Natropogenic” is not a word defined in any dictionary on my shelf, nor have I seen this in the ecological literature. I suggest replacing it with e.g. ‘naturally occurring compounds’. Given the sparse vegetation of the region, I would like to see a citation that documents the potential importance of biogenic aerosols in that environment.</p> <p>I suggest using either patina or varnish, but not both. Simplicity and consistency are virtues when communicating with non-science audiences.</p>	<p>This model has been retained and amendments related to language made. Further improvements will be undertaken as part of consultation with the Traditional Owners and Custodians of Murujuga and as part of ongoing development.</p> <p>Figure 3 is now presented as pictorial representation of the entire system, rather than being labelled as “Organics”.</p>	<p>Refer closeout comments on item 1</p>

Item	Section	Peer Reviewer Comment <i>[To be completed by Reviewer]</i>	Puliyapang Response	Peer Reviewer Close-out Comment <i>[To be completed by Reviewer]</i>
		As much as I liked the diagram, I was (am) disappointed there was no detailed narrative with this. This figure really peaked my interest, and I would love to know more about the processes, relationships, and interactions that the diagram illustrates.		
10	Figure 4 (and Fig 5)	A big disappointment after Fig. 3. I found this rather uninformative, despite the interesting questions and relationships described in the narrative. As a scientist, I would be very interested in seeing a mechanistically correct diagram that actually represented the processes. To me, these are more tables than models.	Please refer to the above comments and the updated Conceptual Model.	Refer closeout comments on item 1
11	P. 12 – Rock art condition	This is very important, foundational information. In my opinion, the narrative and figures on p. 12 are not a conceptual model, but it is a very concise description of some of the key elements and attributes of the art work and it nicely illustrates and describes/defines things that are important throughout this entire document. I suggest moving Fig. 6. and accompanying narrative to the introduction. This would be a great place to include photographs of the features described in Fig. 6.	The suggestion that Figure 6 provides an important introduction to the document was echoed by other reviewers. The Figure has been relocated to the Background section. A photograph of an example of the rock art at Murujuga has been added with the permission of the Murujuga Aboriginal Corporation.	Refer closeout comments on item 1

DEPARTMENT OF WATER AND ENVIRONMENTAL REGULATION

Independent Peer Review Comments Sheet

Reviewer: Dr Jillian Huntley with quality assurance/internal review by Associate Professor Lynley Wallis	Review Comments Sheet ID: MRAMP3-8-4A_JHWHC
Document Title: Murujuga Rock Art Monitoring Program: Conceptual Model and Detailed Study Design – PART A	
Document Revision: Version 1 (July 2020)	
Date of Review: 27 October 2020; 17 February 2021 (close out report). A full copy of Dr Huntley's close out report will be included in the review of the Monitoring Studies Data Collection and Analysis Plan	

CONCEPTUAL MODEL

Item No.	Section No.	Peer Reviewer Comment <i>[To be completed by Reviewer]</i>	Puliyapang Response	Close-out Comment
1	Conceptual Model	<p>The objectives of the overarching and sub-conceptual models are to develop a framework to communicate current understandings of the Murujuga rock art system to a lay audience, as well as demonstrate links to the Murujuga Rock Art monitoring program and; show how the results from the program will underpin the Environmental Quality Management Framework described by DWER, 2019b. The Conceptual Models presented by Puliyapang acquit these criteria.</p> <p>The team is to be congratulated for developing thoughtful, interconnected frameworks and for their approach of collective design, which will only serve to enhance collaborations by their individual specialists, benefiting the Murujuga Rock Art monitoring program going forward. The introduction to the conceptual modelling makes clear that these are adaptable and will be revised as new information about the Murujuga rock art system is acquired as a part of the detailed studies and data collection in the Murujuga Rock Art monitoring program.</p> <p>I see no major elements in the Conceptual Model that require revision, noting Puliyapang have clearly stated the critical caveat that: "While the Pilot Study is likely to increase our knowledge of many aspects of the system, it is important to note that the aim is not to develop a model that captures the complexity of the entire system, but one that underpins a feasible management system." I do, however, provide the following specific feedback on the Conceptual Model to Puliyapang for their consideration.</p>	<p>Acknowledged.</p> <p>We wish to thank all the reviewers for their constructive comments which have been greatly appreciated. We have attempted to provide a balanced revision of the Conceptual Model, bearing in mind the diversity of comments received. The updated Conceptual Model is provided and will be referred to throughout our responses. A summary of the changes to the Conceptual Model is as follows:</p> <ul style="list-style-type: none"> • Updated Executive Summary and Background to provide more context, added emphasis on the cultural importance of the site and reference to previous studies. • Added section on "Introduction to Conceptual Models" that explains the role of the Conceptual Model in the overall project • A rationale regarding our approach to develop a Conceptual Model focused on model generality at this stage, with an extension to a detailed mechanistic model over the first three years of the project. • An additional Framework Model that provides greater emphasis on the processes occurring on the rock surface and the interactions between them. • Additional technical details with reference to previous studies have been added and resulted in a significantly extended reference list. 	No further comment in relation to this item.
2	Conceptual Model Element One: Pressure-Response Model and	<p>Element One: Pressure-Response Model and Narrative</p> <p>The model narrative does not specifically talk about human-accelerated climate change which appears to be an important oversight. While increased local pollution is mentioned, the specific consideration of increasing global temperatures, and more frequent and severe weather events from global green-house gas emissions have serious implications for the acceleration of rock art weathering. That is to say that stress in the global scale environmental system will change 'natural' weather patterns</p>	<p>We acknowledge the potential impact of climate change. Comments relating to this have been added to the Background section.</p> <p>Agreed. This was outside the scope of the original contract, however it was agreed with DWER based on similar peer review comments to the Conceptual Model document that such interactions would be included. This has been added to the document. Unintentional or</p>	<p>I have not been provided with a copy of the revised Conceptual Model document, but I am pleased that anthropogenic acceleration of climate change will be captured.</p> <p>Comment from DWER: Noted, no response required from reviewer</p>

Item No.	Section No.	Peer Reviewer Comment <i>[To be completed by Reviewer]</i>	Puliyapang Response	Close-out Comment
	Narrative	<p>and weathering catalysts, especially sunlight and moisture, in the local Murujuga rock art system, which is in turn being stressed by local anthropogenic activities (industry, tourism, shipping and associated pollution).</p> <p>The pressure response narrative shows a deep understanding by the Puliyapang team of the complex processes of rock art degradation/preservation. While this is plainly written, I heartily agree that this output should be tested by a non-specialist audience to assess clarity of communication (p.4).</p> <p>Element Two: Sub-Conceptual Models These elements are designed to provide detailed (technical information) about the variables, processes and interactions. The use of example questions to illustrate the reasons for investigating, measuring and monitoring the variables contributing to the condition of the rock art works very well. Where a sub-conceptual model is not addressed below, I have no suggestions for consideration.</p> <p>Processes on Rock Surface The sample questions refer to natural weather conditions. As previously stated, Puliyapang may wish to clarify that natural conditions (especially evaporation rates and dew points) are likely to change in the short and medium terms as a result of human-induced, green-house gas climate forcing (see details in the review of the Detailed Study Design to follow).</p>	malicious impacts by tourists/direct human action on the rocks are not explicitly within the scope of the project, but may be observed if they occur at monitoring sites.	