BURRUP ROCK ART MONITORING MANAGEMENT COMMITTEE

Report and Recommendations to the Minister for State Development

April 2009

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Summary

This report and recommendations of the Burrup Rock Art Monitoring Management Committee (BRAMMC) provides a summary of its findings in a style that can be readily understood by the general community.

The Burrup Peninsula is the location of rock art of major archaeological and cultural significance and of several major industrial facilities. The images have been created by Aboriginal people over many thousands of years by pecking and/or engraving into the surface-weathered coat of the rocks. These petroglyphs have cultural significance for the local Aboriginal people, as well as being of archaeological importance at national and international levels. As a part of the Dampier Archipelago, the rock art of the Burrup Peninsula was included on the Federal Government's National Heritage List in 2007.

In response to concerns expressed about possible adverse impacts on the rock art by industrial emissions to air, the Western Australian Government established the Burrup Rock Art Monitoring Management Committee in 2002. This Committee commissioned a number of environmental investigations to establish whether industrial emissions are having adverse impacts on the rock art on the Burrup Peninsula.

These studies included measurements of air quality, microclimate, dust deposition, colour change, mineral spectrometry, microbiological analyses, accelerated weathering studies, and air dispersion modelling studies.

To ensure these study reports were of the highest quality they were sent to the most eminent international scientists in the relevant fields in the US and Europe for review. These experts consider the program to be the most thorough and scientific study ever undertaken in Australia of possible impacts on rock art.

Dispersion modelling of emissions to air from a range of sources on the Burrup Peninsula was conducted in 2003 and 2009. The predicted concentrations of air pollutants on the Burrup Peninsula were small and the increases due to future emissions were modest.

Measurements of concentrations of air pollutants were conducted at ten sites in 2004/5 and 2007/8, close to and distant from industry on the Burrup Peninsula. The results showed that levels are generally very low, with the exception of atmospheric dust close to port loading facilities. The concentration of air pollutants at the background sites in the far north of the Burrup Peninsula were slightly lower than at sites closer to industry. As expected, airborne particle (dust) concentrations were highest close to Parker Point, where iron ore is loaded on ships. Deposition rates at all locations were found to be extremely low.

The acidity of the rainfall on the Burrup Peninsula is naturally variable and generally similar to other remote areas with small increases in levels of nitrogen and sulphur at sites close to industry.

Rock samples were exposed in the laboratory to concentrations of pollutants at current, and up to five to ten times the possible future estimates of air pollution near industry on the Burrup Peninsula. There were no detectable changes to the rock surface colour from exposure to pollutant concentrations at several times the concentrations likely to be experienced at the rock art locations near to industry on the Burrup Peninsula.

Seven sites were assessed for microbiological numbers and composition as microbial action has the potential to increase weathering of rock art. The results showed very low populations of microorganisms and no differences in the number and diversity of microorganisms when sites close to and distant from industry were compared. These microorganisms would contribute to the natural weathering processes.

The potential exists for the colour contrast between the petroglyphs and their background rocks to be reduced or lost. Selected petroglyphs were measured annually for four successive years, comprising nearly three thousand individual colour measurements, but no evidence of perceptible colour change over this period was found.

The mineralogy of each of the monitoring points established to measure colour change was also characterised using reflectance spectroscopy. Results indicated that the surface mineralogy of the rocks has not changed over four years of measurements.

Having reviewed all the evidence of the reports and the comments from an international peer review panel, the Committee reached the conclusion that at March 2009 there is no scientific evidence to indicate that there is any measurable impact of emissions on the rate of deterioration of the Aboriginal rock art in the Burrup. Since the rate of deterioration of rock surfaces is very time-dependent the present results act as a base line for continued and future monitoring programs.

Recommendations

1. That monitoring of the colour contrast and spectral mineralogy be continued on an annual basis for ten years and be reviewed after five years.

2. That monitoring of ambient air quality and rock microbiology be suspended and only commenced if warranted by a major increase in emissions or if evidence becomes available to require further monitoring. Triggers to consider recommencement of monitoring of ambient air quality would include a major expansion or change in emissions characteristics of any existing emission source, a major new emission source, or if monitoring of rock surfaces suggests the possibility of changes.

3. That a small technical working group replace BRAMMC and meet annually to consider the results of monitoring of the colour contrast and spectral mineralogy, air quality monitoring results for the Burrup, modelling and other studies, and to make these results available to the public on an annual basis.

4. That no environmental management measures specifically to protect the rock art from air pollution are necessary at this time. If monitoring suggests the possibility of impacts of air pollutants on rock art the technical working group will report to Government so that appropriate action may be initiated.

Background

The 30 kilometre long Burrup Peninsula is located within the Pilbara region of Western Australia and consists of virtually treeless steep ridges and hills composed of boulders and smaller rocks. It is the location of several major industrial facilities. The most significant sources of emissions to air are:

- the North West Shelf Joint Venture (a liquefied natural gas – LNG, domestic gas and liquid petroleum gas (LPG) treatment plant and processing facility);
- Pilbara Iron (an iron ore export facility);
- The Port of Dampier (an export port with emissions from combustion of fuel oils on ships);
- Burrup Fertilisers (an ammonia plant);
- Urban emissions from the towns of Karratha and Dampier.

In addition, a number of industrial processing proposals are at various stages of feasibility studies, awaiting various decisions, or in the case of the Pluto gas plant, under construction. Natural sources of emissions in the Pilbara region are also substantial, including marine salts near the coast and land surface dust in this semi-arid environment.

The Burrup Peninsula is also the location of rock art of considerable archaeological and cultural significance. The images have been created by Aboriginal people over many thousands of years by pecking and/or engraving into the surface-weathered coat of the rocks (Figure 1). These petroglyphs have cultural significance for the local Aboriginal people, as well as being of archaeological importance at national and international levels. The rock art is important to the regional, State and national heritage and the Burrup Peninsula, as a part of the Dampier Archipelago was included on the Federal Government's National Heritage List in 2007.

FIGURE 1:
An example of the rock art of the Burrup Peninsula

In response to concerns expressed about possible adverse impacts on the rock art of industrial emissions to air, the Western Australian Government established the Burrup Rock Art Monitoring Management Committee in 2002. The Burrup Rock Art Monitoring Management Committee commissioned a number of environmental investigations to establish whether industrial emissions are having adverse impacts on the rock art on the Burrup Peninsula.

This report and recommendations of the Burrup Rock Art Monitoring Management Committee provides a summary of the findings of these studies in a style that can be readily understood by the general community.

Terms of Reference

Key Objectives

The Burrup Rock Art Monitoring Management Committee overseeing the monitoring study will:

- Investigate and report on any impacts of emissions from existing and proposed industrial development to Aboriginal rock art located on and adjacent to the Burrup Peninsula
- Ensure that this study is undertaken in an open and transparent manner engaging community input throughout the entire process
- Recommend management measures to the relevant management body, outlining mitigation and remediation measures for the preservation and conservation of the Aboriginal rock art, whether further industrial development on the Burrup Peninsula proceeds or not.

Outcomes

The Rock Art Monitoring Management Committee will seek to:

- Prepare a scientific report and associated rock art management recommendations for consideration by Government.

Composition

The Committee includes experts in atmospheric science, archaeology, chemistry, land conservation and mineral science from:

- The WA Museum
- The Chemistry Centre (WA)
- Department of Environment and Conservation
- Department of Indigenous Affairs
- Aboriginal Representatives
- Professionals
- Local Government Representatives
- Department of State Development (Observer and secretariat)

Associate Professor Frank Murray of Murdoch University is the independent chairman of the Committee.

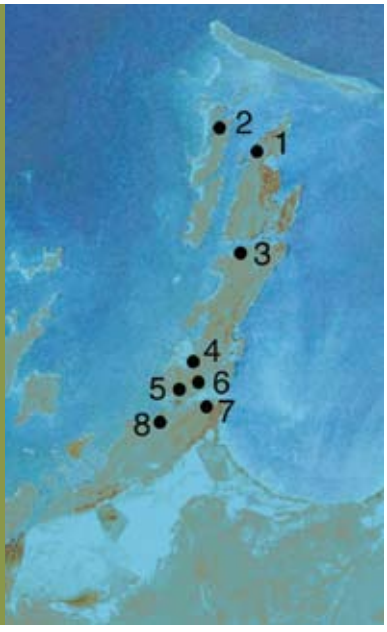
The Studies

The Committee commissioned a program to investigate the potential for industrial emissions (from new and existing industrial development on the Burrup Peninsula) to impact on the rock art. CSIRO, Sinclair Knight Merz Pty Ltd and Professor Graham O'Hara (Murdoch University) undertook the studies, commencing in 2004. They included measurement of air quality, microclimate, dust deposition and colour change; assessment of rock surface mineralogy and microbiological activity, as well as accelerated weathering studies, and air dispersion modelling studies.

Interim and final study reports, for each of the studies, were provided to the Committee and released publicly. To ensure these interim and final study reports were of the highest quality they were sent to the most eminent scientists in the relevant fields in the US and Europe for review.

International experts consider the program to be the most thorough and scientific study ever undertaken in Australia of possible impacts on rock art.

FIGURE 2: The location of rock art monitoring sites on the Burrup Peninsula



Summary of Results

Modelling of air pollutants

Dispersion modelling of emissions to air from a range of sources on the Burrup Peninsula was conducted in 2003 and 2009. Ground level concentrations and deposition rates of a number of pollutants were estimated. Assessments were made of current emissions, using data available at the time of the 2003 modelled scenario, and future predicted scenarios of emissions to air, assuming the proposed additional emissions sources were operating. Concentrations and deposition rates were predicted to increase for the future modelled scenario, consistent with the predicted increase in industrial activity on the Burrup Peninsula.

There are no known impact assessment criteria for the impact of air pollutants on rocks of the type that exist on the Burrup with the rock art. However modelled concentrations from both existing and future scenarios were small relative to assessment criteria for human health and vegetation and the increases due to future emissions were modest, with maximum annual nitrogen dioxide concentrations from the total of both existing and future sources predicted to be 5.2 parts per billion, and for sulphur dioxide, 1.6 parts per billion. An updated modelling study was conducted by SKM in 2009 using the most recent emissions data, refining the modelling input data and comparing them with the most recent monitoring data. The conclusions were unchanged from the study conducted in 2003 and the predicted ground-level concentrations of air pollutants were generally similar.

Monitoring of air pollutants

Measurement of concentrations of air pollutants was conducted at ten sites in 2004/5 and 2007/8, close to and distant from industry on the Burrup Peninsula. A typical monitoring site is shown in Figure 3. The results showed that levels are generally very low, with the exception of atmospheric dust close to port loading facilities. The

FIGURE 3:
An air pollutant monitoring site on the Burrup Peninsula

concentration of air pollutants at the background sites in the far north of the Burrup Peninsula and distant island and mainland sites were slightly lower than at sites closer to industry. As expected, airborne particle (dust) concentrations were highest close to Parker Point, where ship-loading of iron ore is located.

The chemical composition of dust collected from surfaces at the rock art sites on the Southern end of the Burrup Peninsula, close to industrial activity, was generally consistent with iron ore dust. Dust collected from rock art surfaces at the northern sites (far from industrial activity) was consistent with that of local soil-derived dust and sea salt. Deposition rates at all locations were found to be extremely low, close to the limits of detection.

The results of these reports show that:

- Concentrations of ammonia ranged from 0.5 – 3 parts per billion (ppb), nitrogen dioxide ranged from 0.6 – 3.8 ppb and sulphur dioxide ranged from 0.019 – 0.37 ppb. Nitric acid concentrations were also very low ranging from 0.02 to 0.63 ppb.
- Levels of dust were elevated at sites close to industry and the highest dust concentrations with an annual average of about 51 micrograms of dust per cubic metre of air ($\mu g\ m^{-3}$) were associated with a prevailing wind direction from iron ore loading operations. Most dust measurements of the Burrup Peninsula

were found to be typical of dust levels throughout the entire Pilbara region at about 22 µg m^{-3}.

- The acidity of the rainfall on the Burrup Peninsula is naturally variable and generally similar to other remote areas with small increases in levels of nitrogen and sulphur-containing compounds at sites close to industry.

Accelerated weathering

Rock samples were exposed in the laboratory to fumigation with concentrations of pollutants at current, possible future and at five to ten times the possible future estimates of air pollution near industry on the Burrup. There were no changes to the rock surface colour from pollutant concentrations at several times the concentrations likely to be experienced at the rock art locations near to industry on the Burrup Peninsula.

Microbial corrosion

Seven sites were assessed for microbiological numbers and composition as microbial action has the potential to accelerate rock surface weathering. The results of monitoring of rock surfaces over a four-year sampling period (2004–2008) at five sites close to and at two sites distant from the industrial emission sources showed very low populations of microorganisms and no differences in the number and diversity of microorganisms when sites close to and distant from industrial emissions were compared.

Changes in colour contrast and surface mineralogy

A key issue of concern is the potential for colour change of the rock art, causing the colour contrast between the petroglyphs and their background rocks to be reduced or lost. A study to measure changes in the colour and colour contrast of selected rock art images involved annual monitoring of selected petroglyphs with a spectrophotometer that provides information about the colour using an artificial light source.

This method removes errors associated with seasonal and diurnal variations in light levels and the natural differences in colour perception characteristic of the human eye. After examining four successive years of measurement, comprising nearly three thousand individual colour measurements, no evidence of perceptible colour change over this period was found.

Each of the monitoring points established to measure for colour change was also characterised for spectral mineralogy using reflectance spectroscopy to measure whether changes in mineralogy were occurring on rock surfaces. Reflectance spectroscopy uses a special light source to provide information about the chemistry of a mineral from its reflected light. Results indicated that the surface mineralogy of the rocks has not changed over four years of measurements.

The analyses have established a baseline to assess any possible future changes in the rock art.

International experts have reviewed this work and they all agreed that the science is of good quality and the conclusions are sound and not misleading.

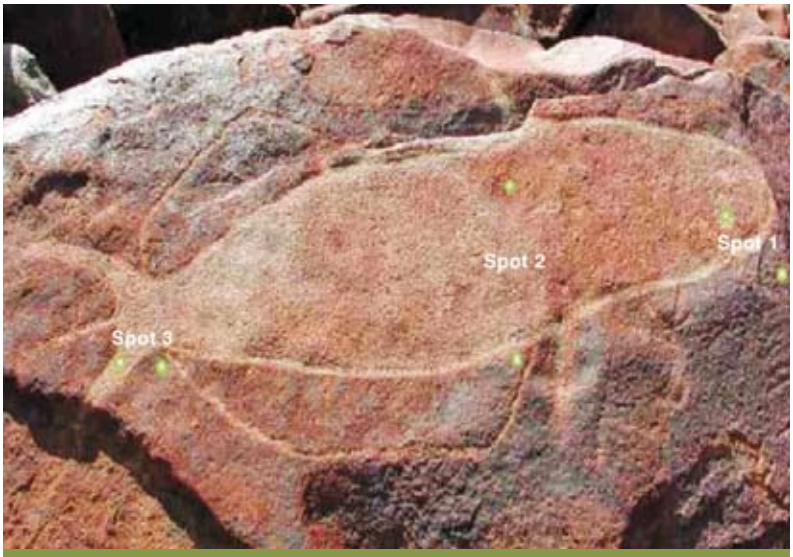


FIGURE 4:
A petroglyph used for colour contrast and surface mineralogy measurements without harming the rock art image

Conclusions

The committee investigated and reported on any impacts of emissions from existing and proposed industrial development to Aboriginal rock art located on and adjacent to the Burrup Peninsula.

Dispersion modelling of emissions to air from a range of sources on the Burrup Peninsula was conducted in 2003 and 2009. The predicted concentrations of air pollutants on the Burrup Peninsula from both modelling studies were small and the increases due to future emissions were modest.

Measurement of concentrations of air pollutants was conducted at ten sites in 2004/5 and 2007/8, close to and distant from industry on the Burrup Peninsula. The results showed that levels were generally very low, with the exception of atmospheric dust close to port loading facilities. The concentration of air pollutants at the background sites in the far north of the Burrup Peninsula and distant island and mainland sites were slightly lower than at sites closer to industry. As expected, airborne particle (dust) concentrations were highest close to Parker Point, where iron ore is loaded on ships. Deposition rates at all locations were found to be extremely low.

The acidity of the rainfall on the Burrup Peninsula is naturally variable and generally similar to other remote areas with small increases in levels of nitrogen and sulphur at sites close to industry.

Rock samples were exposed in the laboratory to concentrations of pollutants at current, and up to five to ten times the possible future estimates of air pollution near industry on the Burrup. There were no changes to the rock surface colour from pollutant concentrations at several times the concentrations likely to be experienced at the rock art locations near to industry on the Burrup Peninsula.

Seven sites were assessed for the level of microbial activity as this has the potential to increase the rate of weathering of rock art. The results showed very low populations of microorganisms and no differences in the number and diversity of microorganisms when sites close to and distant from industrial emissions were compared.

The potential exists for the colour contrast between the petroglyphs and their background rocks to be reduced at a faster rate than that associated with normal weathering. Selected petroglyphs were measured annually for four successive years, comprising nearly three thousand individual colour measurements, but no evidence of perceptible colour change over this period was found.

The rock surface mineralogy at each of the monitoring points established to measure for colour change was also characterised using reflectance spectroscopy. Results indicated that the surface mineralogy of the rocks has not changed over four years of measurements.

Having reviewed all the evidence of the reports and the comments from an international peer review panel, the Committee reached the conclusion that at March 2009 there is no scientific evidence to indicate that there is any measurable impact of emissions on the rate of deterioration of the Aboriginal rock art in the Burrup. Since the rate of deterioration of rock surfaces is very time-dependent the present results act as a base line for continued and future monitoring programs.

The committee ensured that this study was undertaken in an open and transparent manner engaging with community input throughout the entire process. Public meetings were held in Karratha and Perth to discuss the issues and to seek opinion about possible studies that should be conducted. Meetings were held with key stakeholders, including meetings with representatives of the Aboriginal community in Roebourne. The interim results of the studies were discussed with key stakeholders, presented at numerous public meetings, released to the media every year and put on a dedicated, open, searchable, website (www.dsd.wa.gov.au/burruprockart).

Recommendations

1. That monitoring of the colour contrast and spectral mineralogy be continued on an annual basis for ten years and be reviewed after five years.

2. That monitoring of ambient air quality and rock microbiology be suspended and only commenced if warranted by a major increase in emissions or if evidence becomes available to require further monitoring. Triggers to consider recommencement of monitoring of ambient air quality would include a major expansion or change in emissions characteristics of any existing emission source, a major new emission source, or if monitoring of rock surfaces suggests the possibility of changes.

3. That a small technical working group replace BRAMMC and meet annually to consider the results of monitoring of the colour contrast and spectral mineralogy, air quality monitoring results for the Burrup, modelling and other studies, and to make these results available to the public on an annual basis.

4. That no environmental management measures specifically to protect the rock art from air pollution are necessary at this time. If monitoring suggests the possibility of impacts of air pollutants on rock art the technical working group will report to Government so that appropriate action may be initiated.

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