DERBY TIDAL POWER AND PRAWN FARM PROPOSALS -

PROCEEDINGS OF A TECHNICAL WORKSHOP HELD ON 23 JUNE 1998

RAPPORTEUR'S REPORT

Prepared by Ms Sally Robinson
Deputy Chairman
Environmental Protection Authority

24 and 28 June 1998

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LIST OF ATTACHMENTS

DERBY TIDAL POWER AND PRAWN FARM PROPOSALS - WORKSHOP HELD ON 23 JUNE 1998

RAPPORTEUR'S REPORT

The workshop participants were:

Mr Bernard Bowen	Chairman, Environmental Protection Authority
Ms Sally Robinson	Deputy Chairman, Environmental Protection Authority
Mr Denis Glennon	Member, Environmental Protection Authority (part of morning)
Dr Roy Green	Member, Environmental Protection Authority (part of morning)
Professor Bruce Thom	Consultant to the EPA
Dr Mike Paul	Department of Transport
Ms Bev Walker	Department of Environmental Protection
Mr Ben Hollyock	Department of Environmental Protection
Mrs Marion Blackwell	ACTEPA
Ms Tina Thorne	Fisheries Department
Ms Verity Klem	Water & Rivers Commission
Mr Kevin Crane	CALM
Dr John Thomson	Proponent for the Prawn farm
Dr Ian LeProvost	ACTEPA
Dr David Gordon	Consultant to the DEP
Mr Kim Taylor	Department of Environmental Protection
Dr Tony Wright	Health Department of WA
Mr Wayne Jolley	Health Department of WA
Dr Eric Paling	Consultant to DTP proponent
Mr Howard Jones	Fisheries Department
Mr Brendan Corry	Proponent - Derby Tidal Power
Mr Peter Wood	Proponent - Derby Tidal Power
Mr Ian McCardle	Consultant to DTP proponent
Mr Robin Smith	Water & Rivers Commission (afternoon only)
Mr Peter Wharton	Rockwater (Consultant to DTP proponent, afternoon only)
Dr Barry Wilson	Marine Parks & Reserves Authority (afternoon only)
Dr Di Walker	Marine Parks & Reserves Authority
Mr Reinhold Hart	Department of Resources Development

1. PROTOCOL

The Chairman for the day was Mr Bernard Bowen, Chairman of the Environmental Protection Authority.

The agenda for the day is attached (Attachment 1).

Rapporteur was Ms Sally Robinson, Deputy Chairman of the Environmental Protection Authority.

2. PROCEEDINGS OF THE DAY

The proceedings of the day have been partially summarised separately and cover the key issues of geo-heritage and other issues (see Attachments 5 and 6 prepared by professor Bruce Thom).

Two projects were to be considered, both of which could have impacts on the Doctor's Creek area. The Tidal Power project was given most attention because it would utilise both of the Doctor's Creeks. On 22 June 1998, the EPA was informed by the proponent that the CER for this project is essentially being regarded as a conceptual proposal for the tidal power project because tenders for detailed design on a design and construct basis would be called shortly.

Therefore the actual design of the tidal power proposal would not be known until the design had been selected.

The direction for the day was provided by the Chairman. The purpose was to address several questions as well as to provide a forum in which key stakeholders could be exposed to various information and perspectives in a professional and transparent manner, as well as putting their own views. The three key questions were:

a) Is there a "fatal flaw" in relation to the tidal power station proposal, and if so does it also translate to the prawn farm proposal?

b) Are there any critical issues requiring more investigation or information and the timing of those requirements - specifically is this information required before the EPA reports to the Minister?

c) What are the critical management requirements of the projects?

3. OVERVIEW OF THE DERBY TIDAL POWER PROPOSAL BY THE PROPONENT (Peter Wood)

Mr Woods provided a summary of the history of the proposal beginning with the key findings of the Select Committee and the initial studies focusing on Cape Keraudren.

The following are key points made by the proponent:

Greenhouse Gas

- over its lifetime of 120 years the tidal power project would ameliorate 25 million tonnes of carbon dioxide by allowing closure of diesel plants at Derby, Fitzroy Crossing with some backup generation at Broome.

- the project would meet between 30% and 50% of Western Power's requirement to provide 2% of its output from renewable generation by 2010.

Benefits to WA

- the project would reduce the regional power subsidy.

- it would provide a high profile "green" project.

- prices would be competitive in the long term compared to alternative fuel costs.

- there would be lasting regional benefits including reliable power supply, a tidal lake of some 12 square km at Derby, employment and improved recreational fishing and boating.

Derby Hydro Power would be the bulk seller of power to Western Power which would then on-sell to domestic customers. DHP would have the power lines to Broome and Fitzroy Crossing and would provide the backup generation capacity to cover low generation periods such as neap tides and power outages.

In addition the proponent outlined the approvals process, drawing attention to the open approach they have taken throughout. The process is taking longer than anticipated, some $4 million has been spent so far mostly on engineering design and geo-technical work and as issues have been identified they have employed the necessary consultants to provide answers. The level of assessment for the power generation part of the project was CER and in response to appeals the level for the powerlines was increased from informal to CER also. However some people are now saying the Tidal Power concept should have been assessed as an ERMP.

The proponent outlined a perceived "window of opportunity". This is based on Western Power's losing approx $1 million per month in cross subsidy. The proponent ended by stating that "delays beyond the end of June 1998 would totally jeopardise the project" and that EPA will need to balance local concerns with the wider benefits that this project could bring to the region.

4. PROPONENT'S OVERVIEW OF THE ENVIRONMENTAL ISSUES

The proponent's consultant Mr Ian McCardle of Halpern Glick Maunsell provided a briefing on the key environmental issues that they considered remain to be addressed. These are:

i) King Sound Erosion (especially the issues of erosion in relation to the structures)
ii) Geo-heritage
iii) Basin Sedimentation
iv) Groundwater
v) Mosquitoes and Midges
vi) Barrage Construction

Erosion

Aerial photography back to 1949 has been examined to determine erosion rates (See Attachment 2). These are as follows:

- an average of 2-3 m/yr over the past 50 years around the coastline of King Sound
- The Derby Deepwater Jetty has eroded approx 100 m in the same time and up to 250 m in some creeks in that same period.

The creeks are eroding much faster than the coastline per se. However the proponent's consultant stated the view that there is no expectation that erosion over the next 120 years (the lifetime of the project) would be sufficient to jeopardise the barrages.

Geo-Heritage

The proponent commissioned A/Professor Colin Woodroffe to carry out a desk top review of the work of Dr Vic Semeniuk. The review agreed with some of the findings and disagreed with some. Mr McCardle identified the key conclusions put forward by Woodroffe (Attachment 3 - Executive Summary and extract from Woodroffe report of June 1998) as being:

- "King Sound is unique among numerous large macro-tidal, mangrove-dominated estuarine embayments of northern Australia, in that it experiences the largest tidal range" (Attachment 3, page 1).

- "The Doctor's Creek area is the best described part of King Sound in terms of stratigraphy, erosion of tidal flats and mangrove ecology. Further exploratory study would be needed to determine whether these features of Doctor's Creek are widespread throughout King Sound" (Attachment 3, page 1).

- "A strong case for geo-heritage value on the basis of groundwater relationships with hinterland has not been made" (Attachment 3, page 1).

- "Erosion of the Doctor's Creek tidal flats appears to be extensive". ... "Further consideration needs to be given to how extensively erosion is occurring elsewhere in Kind Sound, what the causes of erosion might be, the effect of erosion on mangrove ecology, and the implications for the tidal power project" (Attachment 3, page 1).

- "The results of research into the relationship between coastal (especially erosional) geomorphology and mangrove distribution provide a sound framework on which to

base further studies of this important interrelationship , to enable better modelling of the dynamics and ecology of mangrove shorelines in the Doctors Creek area in the context of this project" (Attachment 3, page 1).

- "Several other issues deserve attention" (Attachment 3, page 1).

Further, on the issue of geo-heritage, the Woodroffe report states:

".. the two arms of Doctors Creek form broad, long blind (receiving no freshwater input) creeks, and there appear to be no other features of comparable morphology in the estuary. They are very likely to differ hydrodynamically and ecologically from other creeks around the Sound. A somewhat similar creek system may occur in Stokes Bay, but without further investigations it would be difficult to rule out the possibility that there might be habitat represented in the Doctors Creek system that did not occur elsewhere in the region. I believe that some discussion of other creeks flanking King Sound would be needed to assess the significance of the Doctors Creek area within the King Sound area as a whole." (Woodroffe, June 1998, page 3 para 1).

Woodroffe in his summary also states:

"Further examination of the patterns of erosion and deposition, in detail in the Doctors Creek area, and in a broader fashion in the wider (King) Sound, would seem both environmentally desirable and technically wise before the project planning proceeds further." (page 7) and expresses three of his own views as being:

- "I believe that the mangrove modelling (productivity etc) is rather optimistic." (Woodroffe, June 1998 page 7)
- "The likelihood of sedimentation within the basins appears under-appreciated." (Woodroffe, June 1998 page 8)
- "I share the Critical Appraisal view that the difficulty of working in these estuarine clays has been greatly underestimated." (Woodroffe, June 1998 page 8).

Mr McCardle identified the key issue as being one of whether or not all of the special attributes of the area add up to enough to say it is so significant that the development should not go ahead. He asked if this the only area where this is occurring all together and stated that the answer is yes it is, and the next question is therefore being whether this is sufficient reason for protecting it?

Basin Sedimentation

Mr McCardle pointed out that sediment movement had not been modelled as sediment modelling is "notoriously inaccurate". This statement was challenged by Mr Roy Green who said it can be done if the hydrodynamics and sediment load are measured and that useful results could be obtained.

The proponent's approach to sedimentation is that it will occur and that they will take a management approach of using a dredge to remove it, as necessary.

Groundwater

Mr McCardle provided cross sections outlining his understanding of the groundwater situation (see Attachment 4). Discussion on this issue was deferred until the afternoon when relevant experts would be present (see Groundwater under section 5).

Mosquitoes and Midges

Mr McCardle pointed out that the greatest extent of breeding is at the maximum tidal range as *Aedes vigilax* lays its eggs above the waterline and relies on fluctuations in maximum water height. The proponent anticipates that there would not be an increase in mosquitoes given that the area flooded by water at high tide will not increase. An increase in the residence time of pooled, stagnant water would increase numbers, however this is also unlikely to occur.

Midges lay their eggs around neap high tides. The potential for increased frequency of breeding by midges would be from prolonging neap tidal conditions.

Dr Tony Wright from the WA Health Department pointed out that there would be more likely to be a decrease in mosquitoes than an increase. (This is discussed in more detail later in section 6.8).

Barrage Construction

Various issues were raised. Tenders are likely to be let soon for a "design and construct" project.

The proponent's consultant pointed out that a great deal of geo-technical work was being done and that ultimately an engineered structure would result, with appropriate design and review.

5. REPORT BY PROFESSOR BRUCE THOM

Professor Bruce Thom gave an oral briefing on his discussions with Dr Vic Semeniuk, A/Professor Colin Woodroffe, and the proponent and provided his professional observations resulting from these and the submission by Dr Graham Daborn.

He identified the 7 key issues as being:

1. Geo-heritage (addressed in a separate document prepared by Professor Thom, see Attachment 5)
2. Land surface stability
3. Sedimentation
4. Geotechnical
5. Mangrove dynamics
6. Water quality
   - estuary
   - groundwater
7. Fish and other fauna.

Issues 2-7 have been addressed by Professor Thom in a separate document dealing with project uncertainties (Attachment 6).

Later acid sulphate soils and disposal of dredged sediment were identified as additional major issues that had not been considered by the proponent.

On the issue of geo-heritage, Professor Thom asked two key questions in relation to this matter:

1. "What case is there for the protection in a natural state of an area that has been studied extensively and can provide a benchmark for monitoring environmental change?"

2. "What are the environmental gains if an area of such environmental value is to be sacrificed?"

He also stated the view that Dr Semeniuk had produced a very exciting hypothesis, based on stratigraphy, that needs further testing. Semeniuk had identified a pattern of deposition and erosion but the driving processes have not been identified yet.

Groundwater

This issue was discussed in some detail by the Water and Rivers Commission and Rockwater (consultants to the proponent).

The Water and Rivers Commission hydrologist (Robin Smith) provided a general picture of the groundwater system stating that salt water from King Sound has access to the aquifer at all levels and their concern is that saline water may be drawn into the aquifer in the Derby area. A problem is that the town water supply is drawing from the distal end of a freshwater system, where it is close to and surrounded by a saltwater system. Although they would feel more secure if the aquifer was known for sure to be confined by clay.

Additional new developments to the east will put more stress on the shallow aquifer. A deeper aquifer (the Erskine sandstone) is used also and at present some 60 percent of this is diverted to the town borefield. Although the risk of problems may be regarded as low, the Water and Rivers Commission would prefer to see more work done before commissioning of the project.

Rockwater (Phil Wharton) explained that two things control saltwater intrusion:

- sea level; and
- groundwater abstraction.

He acknowledged that the Water and Rivers Commission view was that loading a couple of additional metres of head may be enough to cause saltwater intrusion but considered the likelihood of this occurring to be very low risk.

The cross section of the Derby Peninsula and West Doctors Creek area and map of Munkayarra Shale provided by Rockwater are attached (Attachment 7).

Professor Thom also raised the issue of micro-aquifer aspects, in particular the interfingering of the sand dunes and the tidal flats to the east of Doctors Creek east, where the Pindan dunes and tidal flats meet. This results in micro relief and mangrove "ghosts" growing out onto the flats. The consequences for the Tidal Power project and Prawn Farm are not known but these eastern sand dunes are important in terms of recharge to the aquifers. They act as blotting paper and removing them would mean more direct runoff and reduced recharge into the Derby aquifer.

Professor Thom stated at the workshop that he knew of nowhere else in Australia where this style of dune/tidal flat interaction occurred. He has since reported that he has found out that a similar situation occurs at Exmouth. However, he would anticipate that is likely to be quite different, given that the area is in the Pilbara arid zone.

6. ADVICE FROM AGENCIES ON ENVIRONMENTAL ISSUES

The Chairman invited representatives from agencies to raise issues and/or make any points not already covered in written agency submissions.

6.1 Dr Di Walker - Marine Parks and Reserves Authority (MPRA)

As no submission had been received from the MPRA, and in the absence of Dr Barry Wilson (who joined the meeting later), Dr Walker provided the background to the marine reserve planning for the Kimberley region, and pointed out the Kimberley area was looked at in 1986 before she joined the review group and before the criteria had been finalised, and that attitudes

to marine reserve planning had changed significantly during the later part of the review by the Wilson Committee.

She pointed out that:

- type sites are important in terms of geological processes and that unique processes (both singly and collectively) are occurring in Doctors Creek;
- a reserves system is supposed to provide representative examples of ecological processes; and
- proximity to Derby would make the area attractive as a marine park in terms of ease of access and opportunities for interpretive signage.

Specific issues she raised about the project were:

- impacts on adjacent water bodies and ecosystem function;
- she would be concerned if construction of the project meant that an area that should have been a marine park could then not be made because of the development

6.2 Dr Mike Paul - Department of Transport

Dr Paul expressed the view that King Sound area is an "environmentally friendly" source of power because of its excellent tidal characteristics. The earth embankments, which form a major component of the project, are in a technical sense similar to an earth fill dam, but with a much reduced "head" or differential water pressure. His view was that the various issues which may arise in relation to the tidal power structures were technically solvable. Particular issues, such as those relating to settlement of the structures or the possible need to provide for energy dissipation at outlets, could be licked up and handled in the detailed engineering design.

On the issue of adequate sources of rock for use as construction materials, he expressed the view that this could be dealt with in the design process, and may involve the injection of sufficient money. he believed that dredging was the best means of handling the sedimentation issue. Sediment would largely be transported in suspension rather than as bed load. Accordingly, it may be possible to identify the "worst case scenario" based on an assumption that all water suspended sediment brought into the High Basin would drop out of suspension.

He saw no fatal flaw from an engineering point of view and anticipated that all issues could be resolved through normal engineering investigation and design processes.

6.3 Ms Bev Walker - Department of Environmental Protection

Dr Walker identified several issues that she considered required attention:

- effects of potential sea level rise and storm surge
- how the acid sulphate soils would be dealt with, in particular impacts on productivity and biota;
- the inference that increasing the area of lake would lead to an increase in tourism raised the issue of sourcing additional water supply from an already heavily exploited aquifer to service increased population;
- the visual impact of the powerlines as they would largely be paralleling tourist roads. She would like to see undergrounding of lines weighed up against the maintenance costs of overhead lines; and

- the potential for a greater number of migratory waterbirds from increased productivity and the need to manage this within the project.

The proponent responded to the above and provided additional information as follows:

- they have looked at the 500-year event in terms of design for storm surge;
- the project involves some 450 km of powerlines. There are Native Title problems in taking them by the shortest route, hence the lines making use of existing corridors. The lines would be some 100 m from the roads;
- undergrounding of AC transmission lines would cost in the order of 10 times more, so a $50 million cost would become $500 million. They have considered the question of converting the power to DC as this is easier to underground technically;
- pole design has been considered in terms of visual impact. The proponent favours using a single pole over lattice towers but there are limitations in terms of length of span between poles if they do and lattice towers may be needed to achieve the crossings over the Fitzroy River itself.

6.4 Ms Verity Klem - Water and Rivers Commission

Ms Klem provided information from an updated submission sent the previous week which raised the following issues:

- there appears to be a unique combination of geological and ecological events occurring in Doctors Creek;
- although these components may happen elsewhere in the north west they do not occur all together in one spot;
- concern about changes in water quality that may occur in the short and long term associated with loss of mangroves, deoxygenation of the sediments and water etc;
- uncertainty about toxic phytoplankton that may occur in the ponded nutrient-enriched waters which may pose a problem for aquaculture;
- the general lack of knowledge about toxic phytoplankton in the north west;
- the need for more modelling to be done;
- need to know more about impacts on fauna, in particular what is there now and what it would change to if the project proceeds.

Professor Thom asked if the Water and Rivers Commission has looked at the issue of acid sulphate soils. They have not done so to date but will.

6.5 Mr Kevin Crane - Department of Conservation and Land Management

Mr Crane said that the tidal power proposal would cause major changes to the ecology of the area.

He identified the key issue as being whether the benefits outweigh the environmental costs, rather than whether or not the impacts can be managed.

Issues of concern raised by CALM included:

- possible impacts on the proposed Nature Reserve in the Doctors Creek area, particularly in relation to groundwater flows and salinities (and that CALM does not have the expertise to assess this);

- CALM would ask that the EPA consider the proposed Nature Reserve as a legitimate "beneficial use", and not just limit consideration of beneficial uses to drinking water;

- the community types occurring in the proposed reserve are not unique but are not well represented in the reserve system;

- CALM is concerned about impact on birds, especially migratory waders;

- the CER states that 228 species use the area;

- death of mangroves will occur over 5 years, however growth to maturity will be 10 years - what will the impact be on avifauna from this time lag?

- that although impacts on fish entering the sluices and turbines has been considered, possible impacts on dugongs and turtles needs to be addressed; and

- that CALM will take no responsibility for the management or removal of possible problem crocodiles.

In terms of the prawn farm proposal, CALM had fewer concerns. They identified the project as having less impact on the area as a whole but were concerned about:

- nutrient impacts; and

- changes to surface hydrology flows from the bunding around the prawn farm area.

6.6 Mr Howard Jones - Department of Fisheries

Two submissions have been sent by Fisheries - one from Mr Howard at head office and one from the local Fisheries officer. Issues raised were:

- very little is known about tidal power generation and its effects on fish;

- little is known about the biota of Doctors Creek;

- changes are to be expected but Fisheries has not idea whether they are important;

- there may be impacts on mud crabs such as effects on females which would change the population numbers;

- inflow and outflow from the Doctors Creeks will be much reduced:

- Fisheries expects that, overall, there will be an increase in fish which would have a beneficial effect on recreational fishing.

In terms of possible aquaculture within the ponds behind the barrages, Fisheries comments were:

- that mangroves will probably grow again around the edge but the effects of a 10 year lag on productivity are not known;

- phytoplankton are to be expected to develop in what would be clearer water;

- in terms of the proponent's commitments, more are required as they have not addressed the issue of effects of dredging on benthic communities, or of fish in turbines;
- Fisheries Department would expect to have a say over the use of the Creeks;
- there may be concern over the use of anti-foulings (although they may not be used);
- they would want to know more about the acid sulphate soil issue;
- local fishing people are concerned that their entry to the Creeks and King Sound will be stopped and would like access to both Creeks and to King Sound guaranteed; and
- there are three special Aboriginal fishing licences in the King Sound area (for *Trochus*, Beche de Mer and mudcrabs) and these people would like the proponents to talk to them.

6.7 Mr Reinhold Hart - Department of Resources Development

The Department of Resources Development did not raise any issues additional to their written submission.

6.8 Dr Tony Wright - Health Department of WA

Dr Tony Wright of the Health Department outlined in some detail the likely scenario incorporating his expertise on the life history and breeding habits of the particular mosquito and midge species in the area. The primary nuisance mosquito is *Aedes vigilax*, adults of which regularly fly up to 20km, and occasionally up to 400km (wind assisted), and breeds at the extremity of the highest Spring tides. This species is also the major vector of Ross River virus in coastal regions of northern Australia. With the project in place, the height of normal high tide would become limited but the extremes of high tide (the highest high tides) will remain the same. The likely impact on mosquito breeding would be to perhaps slightly reduce it on normal tides and to increase or not change it on the highest high tides.

A second mosquito *Culex sitiens* lays its eggs in rafts on water and will colonise more persistent pools when they have been there for a few days. This is more likely to be a problem for the prawn farm project and ponds will need to be designed to prevent breeding of this species. This could be achieved by either water movement/agitation or predation of mosquito larvae by secondary aquaculture species. Another potential site for breeding of this species would be the bund wall area, as extreme rain events will result in pooling and flooding within the bund and ditch areas that fill from seepage.

In the case of midges such as *Culicoides ornatus* in mangrove systems, Mr Peter Whelan at the Northern Territory Department of Health and Community Services is an expert. Midges in mangrove systems breed in a range of the neap tides with the larvae being in the mud. It is possible that the Tidal Power project may create more of this mid-range tidal habitat.

6.9 Dr Barry Wilson - Marine Parks and Reserves Authority (MPRA)

Dr Wilson was responsible for the Wilson Report to Government which recommended areas for reservation as marine parks. He outlined the history of how the King Sound area was handled. The committee's approach was to try and recognise "distinctive coastal types" and then look within those areas to recognise areas with a high diversity of habitats.

In this filtering, King Sound was recognised as a distinctive coastal type - the only one of its type. The IUCN criteria were then applied including:

- representativeness
- high diversity of species

- presence of endangered species
- presence of special species/communities

It was felt that on what was known about the area at the time (1986) there was not a good enough reason to select areas within the Sound as opposed to the Buccaneer Archipelago/mouth of the King Sound area which demonstrated a very wide range of different habitat types. Had they had geomorphological criteria as one of the criteria used by the group, it probably would have made a difference.

Dr Wilson stated the view that if they were looking at the area again, the geomorphology would be properly taken into account and would be likely to lead to a different outcome, as the area is important geomorphologically in its own right, and to that extent the Committee could be accused of "muffing it".

7. CHAIRMAN'S SUMMARY AND SYNTHESIS OF ISSUES

The workshop covered an array of issues. Professor Thom listed the major environmental issues requiring consideration and Ian McCardle covered the same ground in a different manner.

The main issues identified were:

- Geo-heritage
  - King Sound in a regional context
  - Significance of Doctor's Creek
  - Doctor's Creek as a type site
  - Doctor's Creek as a benchmark for change
  - Relationship of old Pleistocene dunes to tidal flats (Fairbridge work)
- Land surface stability
- Sedimentation
  - Sediment transport
  - Barrage impact on sediment
  - Dredge spoil discharge
- Geo-technical aspects (including risk of failures)
- Mangrove dynamics
- Water quality
  - Estuary
  - Groundwater
  - Acid sulphate soils
- Fish and other fauna, including mangrove avifauna and migratory waterbirds

Other issues arising from agency input and covered in some detail included:

- Mosquitoes and midges
- Barrage construction
- Changes to ecological processes and productivity from loss of the mangroves
- Potential sea level rise and storm surge especially from cyclones
- Need for increased water supply to meet demand from increased tourism
- Visual impact from powerlines and possibility of undergrounding
- Risk of toxic phytoplankton developing in side the barrage
- Possible impacts on the proposed nature reserve
- Possible effects on turtles and dugongs and management of nuisance saltwater crocodiles

From his reading of the discussions throughout the day, the Chairman identified that there is a 2 or 3 stage decision-making process for Government, depending on the advice the EPA provides.

One issue that the EPA will have to consider is geo-heritage. It was noted that it is a pity that it was not considered fully back in 1986 when the group was making recommendations on potential marine parks for the Kimberley but it is understandable why, given that the major thrust in selecting areas for possible Marine Parks was biological rather than geomorphological. Although King Sound was recognised as a distinctive coastal type, geological criteria were not used. When the IUCN ecological criteria were applied it was felt that there was not sufficient reason to select King Sound as against other areas. The predominant criteria used included:

- representativeness
- high diversity of species and habitats
- presence of endangered species
- presence of special species and communities

In addition, the Kimberley area was the first to be considered and this was before the criteria for selection of potential areas were fully developed. Areas considered later with high geological and geomorphological values, such as Hamelin Pool in Shark Bay, were included on the list for reservation. Notwithstanding this background, the geo-heritage values of King Sound and Doctor's Creek are now firmly on the table and must be properly considered.

EPA will need to look at the environmental impacts on geo-heritage versus the environmental benefits on the other side. Specifically it will need to ask what case is there for the protection, in a natural state, of an area that has been studied extensively (for at least 30 years) and can provide an important benchmark area for monitoring environmental and climate change? It will also need to balance this with the potential environmental gains that would result from an area of such environmental value being sacrificed.

The proponent's consultant stated well the task before the EPA when he said the following, as recorded by Bernard Bowen:

The key issue is the one of whether or not all of the "special" attributes of the area add up to enough to say it is so significant that the development should not go ahead. An associated question is whether this is the only area where this is occurring all together - and the answer is "yes it is". Is this sufficient reason for protecting it?

It is clear that the King Sound and Doctor's Creek areas contain an array of attributes which makes it important. Several of these attributes are individually distinctive in the region but it is the occurrence of a number of such attributes in the one location, and well studied, that together make the area significant. From what was heard from Dr Semeniuk, Associate Professor Woodroffe and Professor Bruce Thom, the King Sound and Doctor's Creek areas are likely to be judged as of special importance. Although geo-heritage sites were probably not given much attention when the Wilson Report was prepared, Dr Wilson has said today that if it was being looked at now, geomorphological criteria would be given much more weight. The proximity of the area to Derby adds to its attraction as a potential marine park because of the tourist access that this provides as well as the opportunity for interpretive signs.

The EPA will need to consider this information in formulating its advice. This will have to include consideration of the area's possible land use for tidal power generation vis a vis its use as a marine park. There may be different views in this room in this regard and there may be different views among EPA members.

It could be said that the tidal power project would not change all of the geo-heritage values in Doctor's Creek/King Sound as parts of the system would remain and parts would be lost, but it would change the environmental processes operating in the area that have given rise to its attributes, in particular the full extent of the erosion processes.

It could also be argued that 120 years is only a short period of time geologically speaking, in an area where it may take 1000 years to bring about the changes we are now observing, and that the tidal power project is therefore not significant in that longer timeframe.

Another consideration is that Senator Robert Hill, Federal Minister for the Environment, has said that the tidal power project could be seen as a significant symbol in terms of Greenhouse gas savings - more significant than other alternatives such as windpower and the like. His view is also that the project would attract significant international interest, and this is another reason why the EPA has to consider fully the international context of the proposal - both the potential positives and the potential negatives.

At the State level, Western Power has said the tidal power project would contribute between 30% and 50% towards the voluntary 2% reduction in Greenhouse gas emissions they have committed to. They also need to reduce their considerable financial subsidy burden in Broome, Derby and Fitzroy Crossing by having access to power at a reasonable cost as well as having to replace old power generation infrastructure very soon.

The possibility of tourism benefits from the tidal power project are too vague to factor into the equation because we really do not know which way they might go. It is better to just look at the project on its merits as a proposal to produce power from tidal energy.

The Derby Shire President made an interesting response to a question from Senator Robert Hill last week. When asked if power from the tidal power project ended up being dearer than power from gas, would they still want the tidal project. The "bottom line" for the community was that they would move away from the tidal project to the cheapest power.

All of the above are factors in the EPA's consideration of the issues and its advice to the Minister. EPA's view will not be decided until Thursday this week. It will also be difficult to write the report to the Minister and this project will challenge EPA's ability to do so.

EPA's task is to "find the truth and tell the truth environmentally" and it is up to Governments to decide which way they wish to go on a proposal. EPA would not challenge the authority of international experts.

In terms of specific issues, such as land surface stability and sediment dynamics, it has to be asked whether the sediment issue is really as simple as dredging the basins if/when sedimentation happens.

In terms of mangrove dynamics, there seems to be no question that 1500 ha would be lost and there is agreement about that. There is also common ground that the new environment created is likely to be suitable for re-invasion by mangroves, as long as the substrate is right and there is sufficient nutrient supply to maintain them and keep them growing in the long term.

All this leads to a "leap of faith" compared with other projects that are more straightforward such as HBI plants, sand mining etc.

The specific issues requiring management are, in a hierarchical sense lower down the scale. These can be regarded as issues needing proper investigation, project design and management to ensure that the environmental is adequately protected, but they are at a different level from the higher level, over-arching question of the international significance of King Sound and Doctor's Creek.

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Woodroffe, C, 1998, A Review of the Critical Appraisal of the Consultative Environmental Review: Derby Tidal Power Project, Doctors Creek, Kimberley: Associate Professor Colin Woodroffe, School of Geosciences, University of Wollongong, NSW 2521.

Attachment 1

Agenda for Workshop on Tidal Power Station and Prawn Farm near Derby, for 23 June 1998

1. Welcome by the Chairman (Bernard Bowen)

2. Introduction by Rapporteur, Deputy Chairman (Sally Robinson)

3. Overview of the Derby Tidal Power proposal by the proponent (Peter Wood)

4. Overview of the environmental issues (Proponent Consultants)

5. Report by Professor Bruce Thom on:

   - Discussions with Dr Semeniuk
   - Discussions with the proponent
   - Professional observations
   - The key issues requiring the advice of this group

6. Agreed issues to be considered (Chairman)

7. Advice from specialist agencies on environmental issues primarily with respect to the tidal power station but also having regard for the prawn farm.

   (a) Is there a "fatal flaw" in relation to the tidal power station proposal, and if so does it also translate to the prawn farm proposal?

   (b) Critical environmental issues requiring more information, and the timing of that information.

   (c) Critical management requirements.

   List agencies. eg

   - Water & Rivers Commission
   - Fisheries
   - Health Dept
   - CALM
   -

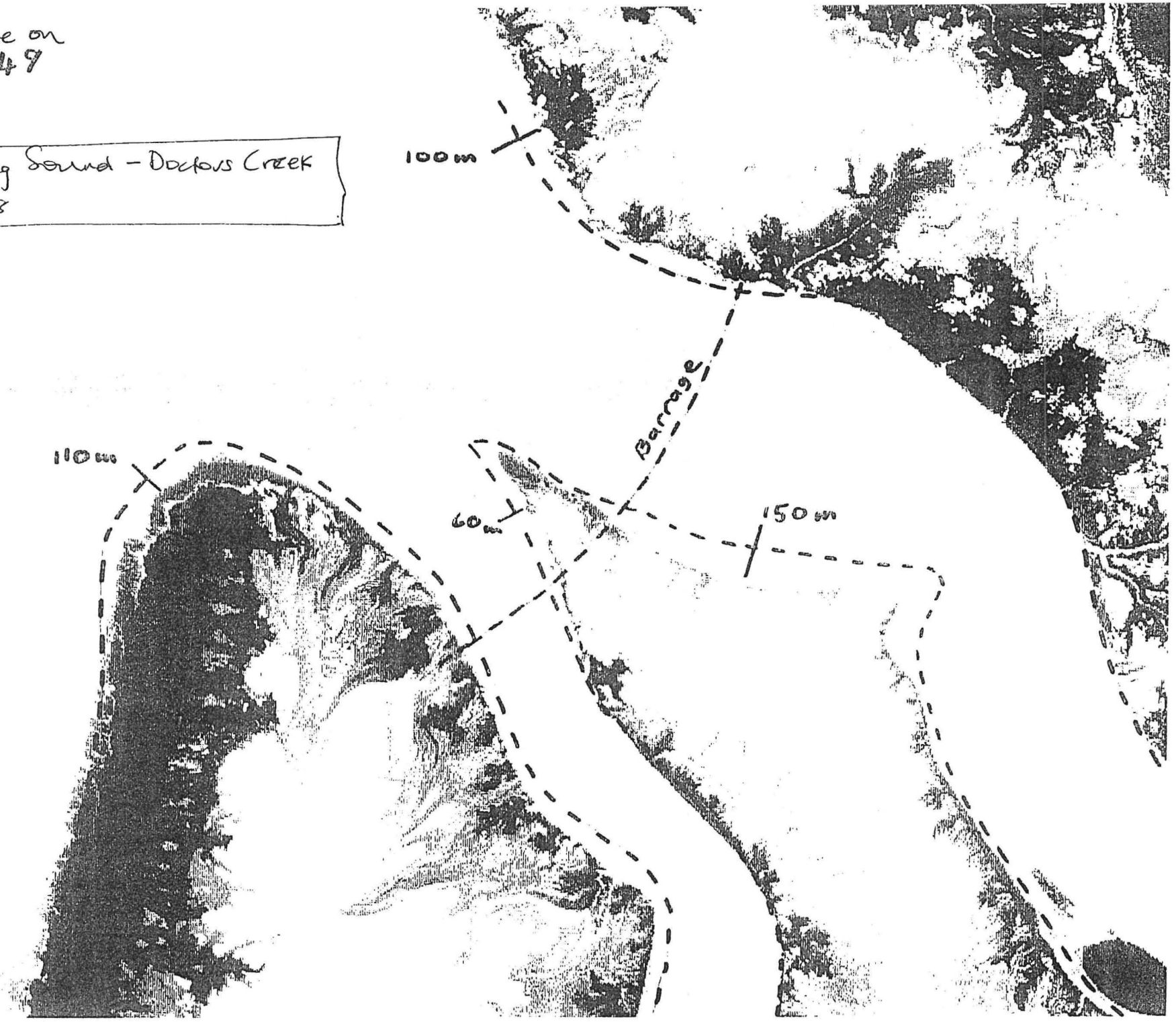
   etc

8. General discussion of matters already covered.

9. Summary and synthesis of issues (Chairman)

coastline on
- - - 6.7.49

Erosion in King Sound - Doctors Creek
1949 - 1998



Attachment 2

Att 3

A Review of the Critical Appraisal of the Consultative Environmental Review: Derby Tidal Power Project, Doctors Creek, Kimberley

Report to: Helpern, Glick & Maunsell,
PO Box 81, Leederville, WA 6902

By Associate Professor Colin Woodroffe
School of Geosciences, University of Wollongong, NSW 2521

June 1998

Executive Summary:

- King Sound is unique among numerous large macrotidal mangrove-dominated estuarine embayments of northern Australia, in that it experiences the largest tidal range.
- The Doctors Creek area is the best described part of King Sound in terms of stratigraphy, erosion of tidal flats and mangrove ecology. Further exploratory studies would be needed to determine whether those features of Doctors Creek are widespread throughout King Sound.
- If the Christine Point Clay mangrove mud unit is of Pleistocene age it would be an extremely important deposit of significant geoheritage value; if it is Holocene, and has been deposited 5000-6500 years ago, equating with big swamp deposits in other north Australian estuaries, and found elsewhere in King Sound, it would not be particularly significant. Radiometric dating could resolve this.
- A strong case for geoheritage value on the basis of groundwater relationships with hinterland has not been made.
- Erosion of the Doctors Creek tidal flats appears to be extensive. Whether this exceeds erosion in other estuaries is not clear; this may be related to greater tidal currents associated with the large tidal range. Further consideration needs to be given to how extensively erosion is occurring elsewhere in King Sound, what the causes of erosion might be, the effect of erosion on mangrove ecology, and the implications for the tidal power project.
- The results of research into the relationship between coastal (especially erosional) geomorphology and mangrove distribution provide a sound framework on which to base further studies of this important interrelationship, to enable better modelling of the dynamics and ecology of mangrove shorelines in the Doctors Creek area in the context of this project.
- Several other issues deserve attention.

Environmental Review, and share the view that it would be necessary for effective hydrodynamic modelling of the creeks, but also that future mangrove distributions cannot be adequately predicted without such a map. For instance in the low basin, the elevational range within which mangrove is anticipated in the future must be in the elevational range of around 0 to -2m AHD. This is a zone of which the extent can only be adequately known if this part of the tidal range has been mapped; my experience would lead me to expect that the creeks have particularly steep banks in this elevational range, and I would not expect extensive mangrove to develop around the low basin, even if mangrove trees could establish in the substrate conditions, which might also be unlikely (see below).

The Critical Appraisal questions whether mangroves will recover from the extensive mortality which is likely to accompany the change of flooding regime. I share the reservations expressed in the Critical Appraisal, and believe that the Consultative Environmental Review maps mangrove recovery and future establishment rather generously. Indeed the establishment of mangroves is a very specialised process. The percentage of time inundated (submergence curves) may be less related to mangrove species occurrence than the length of time of inundation during particular flooding events.

Summary

In summary, King Sound is unique because it experiences such a high tidal range. It is my view that the Doctors Creek area is internationally significant as a result of the important sedimentological and ecological work done there by Semeniuk. However, there is a need to establish whether what has been observed in the Doctors Creek area is also found across a broader area of the Sound. The Christine Point Clay, and its stratigraphic relationships, would be unique if it is Pleistocene in age, but would appear to be widespread throughout the Fitzroy estuary if it equates to the Holocene big swamp mangrove muds. The patterns of erosion appear, from published descriptions, to be extreme, but again further exploratory description and mapping may show that these, and the mangrove patterning that results, are widespread throughout King Sound. Further examination of the patterns of erosion and deposition, in detail in the Doctors Creek area, and in a broader fashion in the wider Sound, would seem both environmentally desirable and technically wise before the project planning proceeds further. As a result of Semeniuk's studies here, there is an unparalleled opportunity to ensure that the project is based upon a far sounder geomorphological and ecological foundation than is presented in the Consultative Environmental Review, or would be possible for a project planned in almost any other part of a semiarid macrotidal Australian estuary. Further survey needs to address how similar the stratigraphy, chronology, erosional and mangrove patterns are elsewhere in the Sound to the Doctors Creek area. This should form one aspect of consideration as to whether the Doctors Creek area plays an indispensable geoheritage, hydrodynamic or ecological role in the estuary as a whole.

In addition, I would like to add three of my own views:

i) I believe that the mangrove modelling (productivity etc) is rather optimistic. As indicated above, I do not believe that enough is known about the elevational ranges, inundation characteristics, substrate tolerances, or establishment capabilities of mangroves in this environment to map the extensive areas which are shown as future mangrove areas. The initial death of large areas of mangrove seems likely, as forecast, leading to an early public perception of ecosystem loss; while re-establishment of mangroves may well be unrealistic over such extensive areas as are shown.

ii) The likelihood of sedimentation within the basins appears under-appreciated. The dynamic equilibrium referred to (p22) is one between tidal creek processes and creek morphology. The considerable altered, dampened tidal flows are likely to lead to a considerably altered channel morphology, accompanied by rapid infill. The tidal waters entering the basin will still be extremely turbid and the recognition that waters will clear in the basins appears to acknowledge the rapid flocculation and settling of large volumes of sediment, and 'ongoing siltation of basins'.

iii) I share the Critical Appraisal view that the difficulty of working in these estuarine clays has been greatly underestimated. Several of these sedimentary units are pyrite-rich estuarine clays, and I am surprised that no consideration has been given to the potential acid sulphate soil issue. As a result of oxidation of these deposits, highly acidic waters may be released. This would seem to be a problem associated with the disposal of spoil which is inadequately covered in the Consultative Environmental Review, and may become acute in the low basin with prolonged exposure of mangrove muds in the channel banks. The potential acid sulphate soil problem is likely to have implications for construction work also: further stratigraphic and geotechnical work is needed.

In my view there is scope for considerable geomorphological study to augment the pioneering studies of Semeniuk and to clarify these issues.

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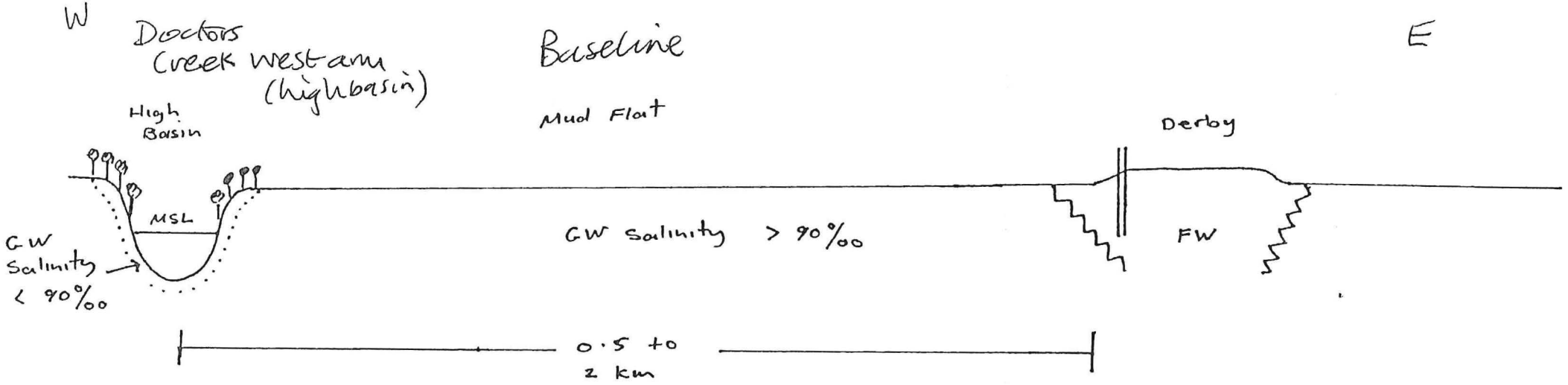
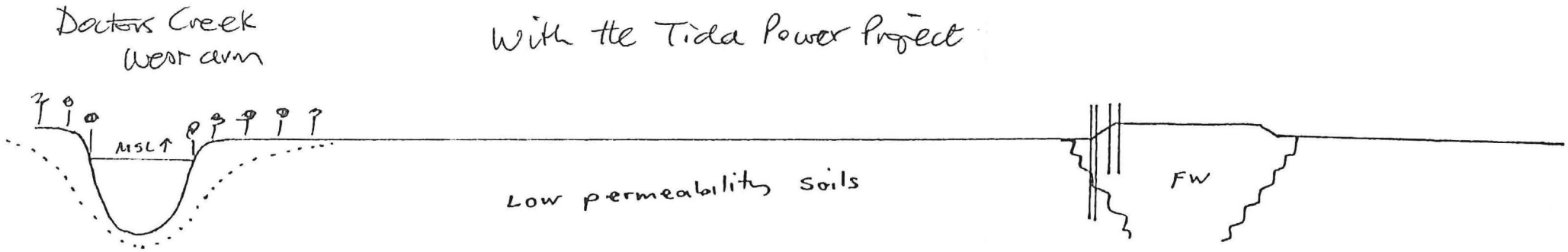
Groundwater - Doctors Creek to Derby Cross Section





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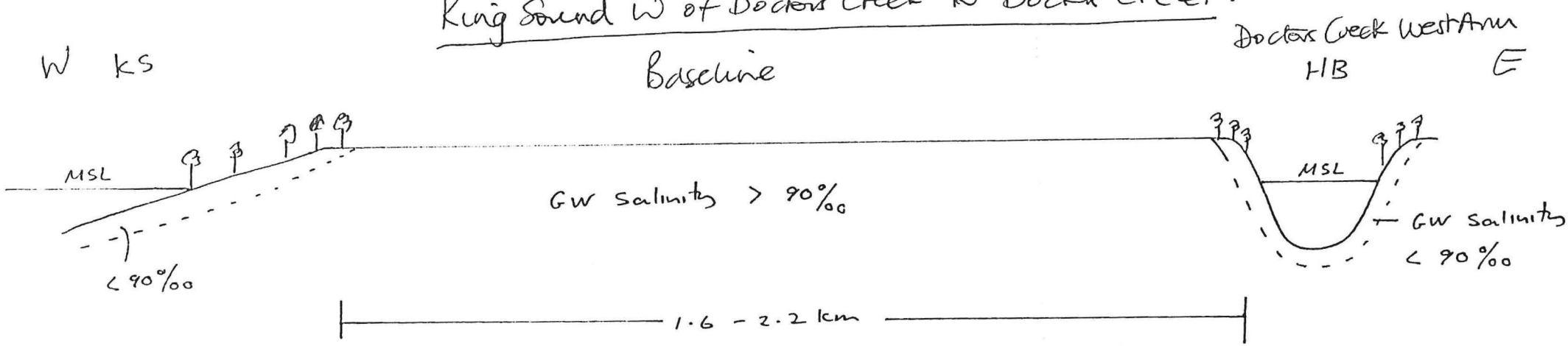
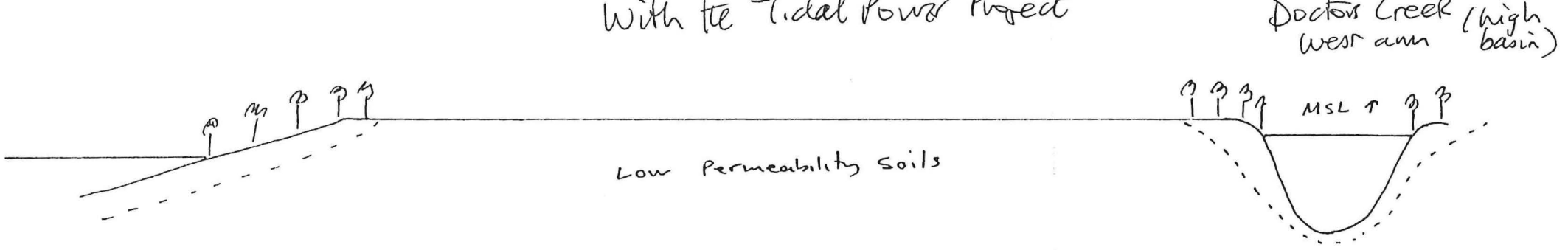
- monitoring bore established to monitor wedge
- commitment - desal water
  - funds for additional bores
  - funds for additional headworks inland

Groundwater.

King Sound W of Doctors Creek to Doctor Creek.



With the Tidal Power Project



ATTACHMENT 5

GEOHERITAGE VALUES

1. KING SOUND IN A GLOBAL CONTEXT

From a general biophysical perspective there are very few high tidal deltaic systems with tidal ranges in excess of 10m. They are not common in semi-arid environments. The most studied "super" high tidal areas surround the Bay of Fundy; this area lacks a major river and possesses a very different geologic history. Geologists and ecologists require areas where documentation of the system can test hypotheses and provide general contexts for examination of other areas and theories. For instance the Mississippi Delta has long been the "type" site for delta sedimentation as geologists use the present as a key to the past. Yet it has no tide! In recent decades geologists have explored other contemporary environments to expand their range of "types". Work in King Sound has provided useful knowledge of conditions near the end of the spectrum of deltaic types where tides are very high and river discharge is periodic and quite large.

2. KING SOUND IN A REGIONAL CONTEXT

Only two deltaic areas with high tides exist in Northwest Australia : the Ord-Victoria and Fitzroy-King Sound. Although King Sound is not the area of highest tide, it certainly exceeds that of the Ord region. Therefore it possesses a distinctive character based on two highly dynamic physical processes : the exchange of massive volumes of semi-diurnal tidal water and periodic high river discharge. Both processes involve enormous sediment movement, both in suspension and as bedload, producing distinctive geomorphological and sedimentologic imprints on sub-tidal, intertidal and supertidal environments. That these imprints are different from those seen elsewhere in Western Australia (except for an overlap with less extreme Ord conditions) has now been well established by scientific work.

The regional context is further enhanced by the linkage between geology, climate and plant ecology. Semeniuk and others have defined regional contrasts associated with the ecosystems which characterise the different environments of the Northwest. King Sound's distinctiveness is quite pronounced.

3. SIGNIFICANCE OF DOCTORS CREEK

As a flanking tidal-flat environment to the King Sound/Fitzroy deltaic complex, Doctors Creek offers scientists an accessible array of sub-environments and habitats which can be used to document biophysical conditions and processes. This has occurred over the last three decades, especially as a result of Semeniuk's work. It is an array which is not in itself "unique" but can be used to examine past and present conditions typical of the region's tidal flats and creeks.

Various researchers have pointed to the special assemblage of vegetated dunes (Pleistocene linear-type) and tidal flats of eastern King Sound. This conjunction deserves consideration in any assessment of areas deserving protection. Although the dunes will not be directly impacted by the project, they form part of the basin into which sea level has risen and tidal flats have extended, "drowning" their western tips. This conjunction of dunes and tidal flat development is unique in the world to my knowledge.

(Note: Professor Thom later informed the EPA that a similar situation occurs at Exmouth Gulf and made the observation that as this is in an arid zone quite distinct from the Kimberley, the processes and resultant features are likely to be different).

Doctors Creek has become a type site for geologic/ecologic research into tidal flats in high-tidal, semi-arid deltaic areas. As such it has value in the future as an area of reference. This means it can serve as a laboratory to research natural processes within a "known" framework, and as a "benchmark" site for monitoring future change (e.g. those induced by Greenhouse Effect). The more such sites exist around the Australian coast the better can we assess impacts. By being close to Derby there are opportunities for future researchers to utilise the site for understanding processes and changes to sediments, landforms, water movements and biota. The inter-relationship of various phenomena can be best assessed in a site which has a background of research where new hypotheses can be tested.

There are uncertainties surrounding the interpretations reached by Jennings and Semeniuk on climate change, depositional histories and erosional trends. More work must be done to test their ideas which have regional and perhaps continental scale significance.

In summary, a case can be developed for the protection of not just a type site of a geologic record, but more broadly an area that has been studied extensively from a geologic, geomorphologic and ecologic perspective. Had such broader criteria been applied by the Wilson

review of marine/parks, it is possible that Doctors Creek may have achieved protected status of an earlier time. It is perhaps fortunate that an assessment such as this by the EPA can highlight the importance of considering type processes and ecological relationships in a studied area, as a basis for environmental protection.

ATTACHMENT 6

PROJECT UNCERTAINTIES

1. TIDAL FLAT SURFACE INSTABILITY

1.1 There are three fundamental scales for evaluating landform dynamics: geologic, engineering, immediate. Interaction between scales occurs, leading to trends, switches in state (erosion-deposition), and pulses and cycles (flood vs ebb tide). Semeniuk (and to some extent Jennings) propose that King Sound over the past 5,000-6,000 years (geologic scale) passed from general deposition (or tidal flat growth) to erosion (or tidal flat destruction). Acceptance by Semeniuk that the "Christine Point Clay is Holocene not Pleistocene in age adds a further complication to this model by requiring two phases in geologic time of deposition (Christine Point Clay and Doctors Creek Formation) separated by a phase of erosion. The more recent depositional unit (Doctors Creek Formation) was followed by the contemporary geologic phase of erosion which blends into the engineering time scale (c.100 years). Measurements of shoreline/bank erosion by Semeniuk and the proponents (2-3m per year), plus headward tidal creek erosion (3-4m per year), plus sheet erosion of flats (several cm per year), highlight an eroding trend into the engineering scale at Doctors Creek. Superimposed on this trend are localised depositional sites along banks and on islands within channels and the Sound which are subject to mangrove colonisation.

1.2 If this "erosonial" model is accepted then there are uncertainties as to the stability of surfaces where structures are to be built at the proposed project site. It could be argued that further field studies by geomorphologists are needed to test the "erosional" trend model.

The model invokes questions as to impacts of barrages and tidal flow changes, sediment redistribution, creek position and bank stability on the area, both in the vicinity of the barrages (nearfield), and at a distance from it in King Sound (farfield). The necessity for engineering safeguards and modifications during the

life of the project (120 years) should not be underestimated given the inherent instability of the tidal flat land surface.

2. GREENHOUSE IMPLICATIONS ON TIDAL FLAT CONDITIONS

2.1 Recommendations, which flowed from the coastal engineering panel which advised the National Research Council in the USA in 1987. highlighted the need for proponents of infrastructure proposals to consider the implication of Greenhouse-stimulated changes to environmental conditions. These changes operate at the engineering time scale and involve not only rise in sea level (20 to 50 cm over next 50+ years), but also changes in frequency, location and magnitude of cyclonic storms (with consequential impacts on runoff and river sediment discharge). The erosional trends noted above (1.1) may be modified in unknown ways by Greenhouse conditions.

2.2 Uncertainties of Greenhouse climatic and hydrologic conditions have not been incorporated into the CER. However the proponent is aware of the implications in requiring design to accommodate 1:500 extreme events and elevated surfaces for electrical equipment to withstand such impacts. What is less clear is how changing conditions stimulated by the Greenhouse Effect will impact on the hydrodynamics of the estuary and on tidal flat stability, requiring modifications to structures during the life of the project.

3. SEDIMENTATION — PATTERNS AND CIRCULATION

3.1 In his critical review of the CER, Dr Daborn of Canada stated:

> *The least convincing, and in some ways most crucial aspect of the CER is the account of the sedimentary nature of the system...From the CER I have identified several critical uncertainties about the sedimentary regime of the Doctors Creek ecosystem that seem to me to be potentially devastating for the project (p.3).*

At issue here is whether the proponents require more knowledge of sediment dynamics (including a better understanding of hydrodynamics) for the project to be viable. Daborn argues that in the absence of such information:

> *....it is impossible at this time to make any judgement beyond pure guesswork about the effect of the barrages, the channel and the filling/discharging operations that would be involved in building this project (p.6). .*

Experience in the Bay of Fundy suggests different modes of sediment behaviour for barrages depending on variation in conditions: this experience emphasises the uncertainty of what might happen in King Sound/Doctors Creek.

3.2 The extent to which field observations of processes responsible for sediment transport coupled with hydrodynamic models are both needed to provide a firmer base for project planning and management, is a vital question which needs more informed debate. In Australia there are experts who can offer advice on this matter. Clearly the proponents are taking a "minimalist" approach. Difficulties in doing such work (time, cost, etc,), plus a view that there is sufficient engineering experience and "flexible" management practices, have meant the proponents are prepared to live with uncertainties of outcome with barrage construction — is that acceptable? This question has broader implications than just viability of the project ("nearfield" impacts) because the Canadian experience suggests possible "farfield" effects on bank stability and/or shoaling many kilometres distant (e.g. the Derby area).

4. DREDGE SPOIL DISPOSAL

4.1 An uncertain element of the project is the amount of dredging required at the time of construction and during the life of the project. Peter Woods informed us that dredging is needed in the low basin to excavate it further so more water can be stored. In addition there will be headwall accumulation as experienced in Canada. He indicated to me three likely disposal sites : in "holes" in the basin, over the barrage wall into the Sound, and up onto tidal flats (least preferred option).

4.2 It is not at all clear as to what will be the consequences of spoil disposal at any of the three sites. Growing vegetation on tidal flat spoil in this climate, given the uncertain chemistry of the material, must require experiments and development of management techniques before being acceptable. I do not think the proponents have developed their proposal to a sufficient extent to address uncertainties associated with dredge spoil disposal.

5. GEOTECHNICAL UNCERTAINTIES

5.1 We were well briefed by the proponent's geotechnical consultants (Coffeys) who are very experienced in evaluating the viability of engineering projects from a geotechnical perspective. Although the consultant (Michael Hillman) accepted that the project as "challenging" given the conditions, there are engineering solutions which can be designed to meet the difficulties. Risks posed by environmental factors such as tidal currents, sediment movement, bank instability, surges, earthquakes, etc, are not insurmountable according to Hillman. The fact that structures can be anchored on underlying clays and not bedrock was a surprise to me, but I accept their professional judgement. However, the fact that they had not considered at this point the impact of acid soils on concrete suggests to me that they have still a lot to learn about the environmental conditions of such a site.

5.2 The proponents are going to tender on construction using the "design and construct" approach. This means the successful tenderer will have the option of adjusting the design as construction proceeds. Already a new design has emerged on the location and lining of sluices. This new design has not been subject to external review. What is worrying is that any new designs may have environmental impacts different from those which have been canvassed in the CER and evaluation by the EPA.

6. WATER QUALITY

6.1 Creation of two "basins" with modified water levels and tidal ranges raises questions on water quality. The natural system involves semidiurnal flushing and exchange of water (including sediments in suspension). It is an extremely efficient system for dilution and mixing of contaminants. However, the new "basins" are expected to create quieter waters leading to reduced turbidity and consequential biological changes in the water column. The proponents have developed a view as to what might happen given this new aquatic ecosystem, but our capacity to predict at two stages (initial basin filling and long-term basin establishment) is very limited. The proponents state that they have the ability to "manage" water quality given their capacity to handle discharges in and out of basins with a degree of flexibility during the construction phase and during operations (e.g. less power needed at night giving the opportunity to allow more flushing).

6.2 The proponents have provided little data on possible nutrient changes associated with mangrove die-back (see 7.1) and less turbidity. Uncertainties associated with generation of acid (and toxic aluminium) from oxidation of potential acid soils (e.g. Christine Point Clay) are not considered in the CER. Work in Netherlands and Gambia are suggestive of problems with acid liberation following changes to the environment. However, as the proponents argue, such problems may be quite insignificant given a flexible flushing regime. Uncertainties raised by some, concerning groundwater intrusion from high water levels in one of the basins, do not rate very highly according to the advice received, but do require monitoring if the project was to proceed.

7. MANGROVES

7.1 Eric Paling, a consultant for the proponents, has stated that a "central question" for the proposal is whether mangroves will return to areas surrounding the newly created "basins." There is no precedent for saying that this will or will not occur although salt pans in the Pilbara provide some guidance. Undoubtedly mangroves

have the capacity to quickly colonise and become established as dense thickets on newly-emerged land. This has occurred in historic time in tidal deltaic areas of the Ord and King Sound. There will be created in the new basins new levels for colonisation with lower tidal ranges. What is not clear is whether these new surfaces will be sufficiently flushed to facilitate growth, and whether, following the initial loss of 1500ha of mangroves, seed sources are available for colonisation? Again management of water levels can assist recovery, but the proponents are aware that they are engaged in a long-term natural experiment in plant regeneration with consequences on water quality and estuarine productivity.

7.2 There will be severe visual impacts resulting from mangrove death near a township which will be long lasting and have the potential for adverse comment. Expected mangrove establishment and continued growth are thwart with uncertainties even though intuitively there are good reasons to expect recovery. However, the timing, extent and types of mangrove that appear on the new surfaces is most unclear and the failure of recovery, if it does not proceed as expected, would most probably result in severe public criticism.

8. FISH AND OTHER FAUNA

8.1 The question of the area to be affected by the power project and its role in the aquatic ecosystem of King Sound (and beyond) is very open. The proponents take a view on the relative size of impact area to the whole and conclude relatively little impact. This may or may not be correct. Again there is limited knowledge of the system (organisms present, food chain, productivity, migrations etc.) to make any clear statements of what might occur once the barrages and turbines are in place. Experience from Canada is helpful although may be misleading given the different environmental conditions.

Dr Daborn is adamant that the proponents have underestimated the importance of the system just as they did in the seventies in the Bay of Fundy. He concludes:

> *However, in more than two decades of work in macrotidal estuaries on three continents I have come to the conclusion that they are all*

exceptionally biologically productive. I am confident that some real and intelligent research on the Doctors Creek ecosystem would show that much of its richness has been overlooked (p.9).

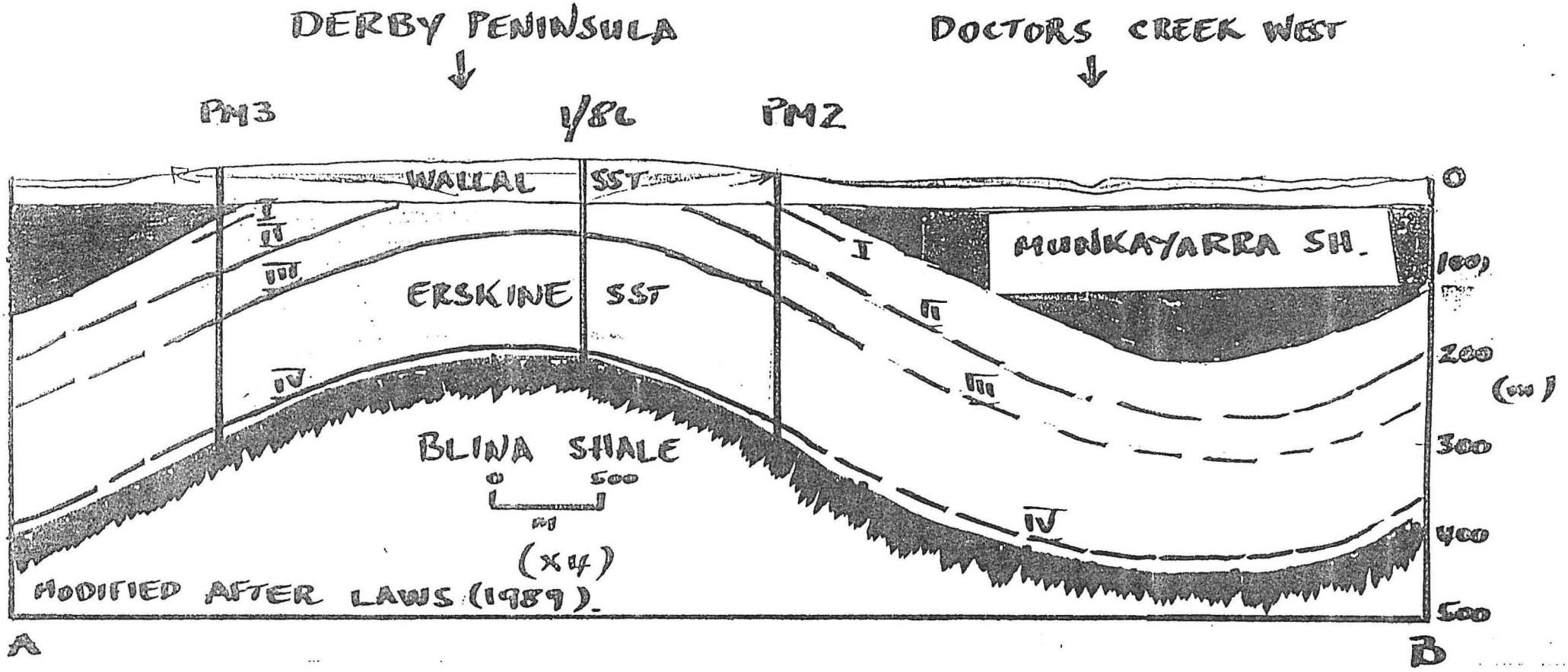
There is the further issue of mortality in turbines which Dr Daborn claims the proponents have underestimated in the CER. Peter Woods has indicated that knowledge from France and UK offers solutions to this problem, but without assessment of details of design by those who are experienced with such matters it is impossible to define potential impacts.

8.2 Uncertainties related to impacts on aquatic fauna (including fish, crabs, crocodiles, etc.) and birds as they may be affected by vegetation changes, as well as impacts on benthic fauna are extremely difficult to assess given current knowledge. Whether power operational procedures would overcome adverse impacts cannot be judged at this stage and would be limited in future without baseline studies.

9. OTHER UNCERTAINTIES

9.1 The workshop canvassed possible increases in mosquitoes and midges resulting from the project, and the advice was that such an effect was unlikely, given an understanding of breeding conditions. Control measures could be put in place.

9.2 Another issue relates to responsibility for the management plan of area impacted by the project given leasehold status of the area. It was indicated that the proponents will seek to be responsible only for infrastructure. What are their responsibilities over the life of the lease (any beyond)?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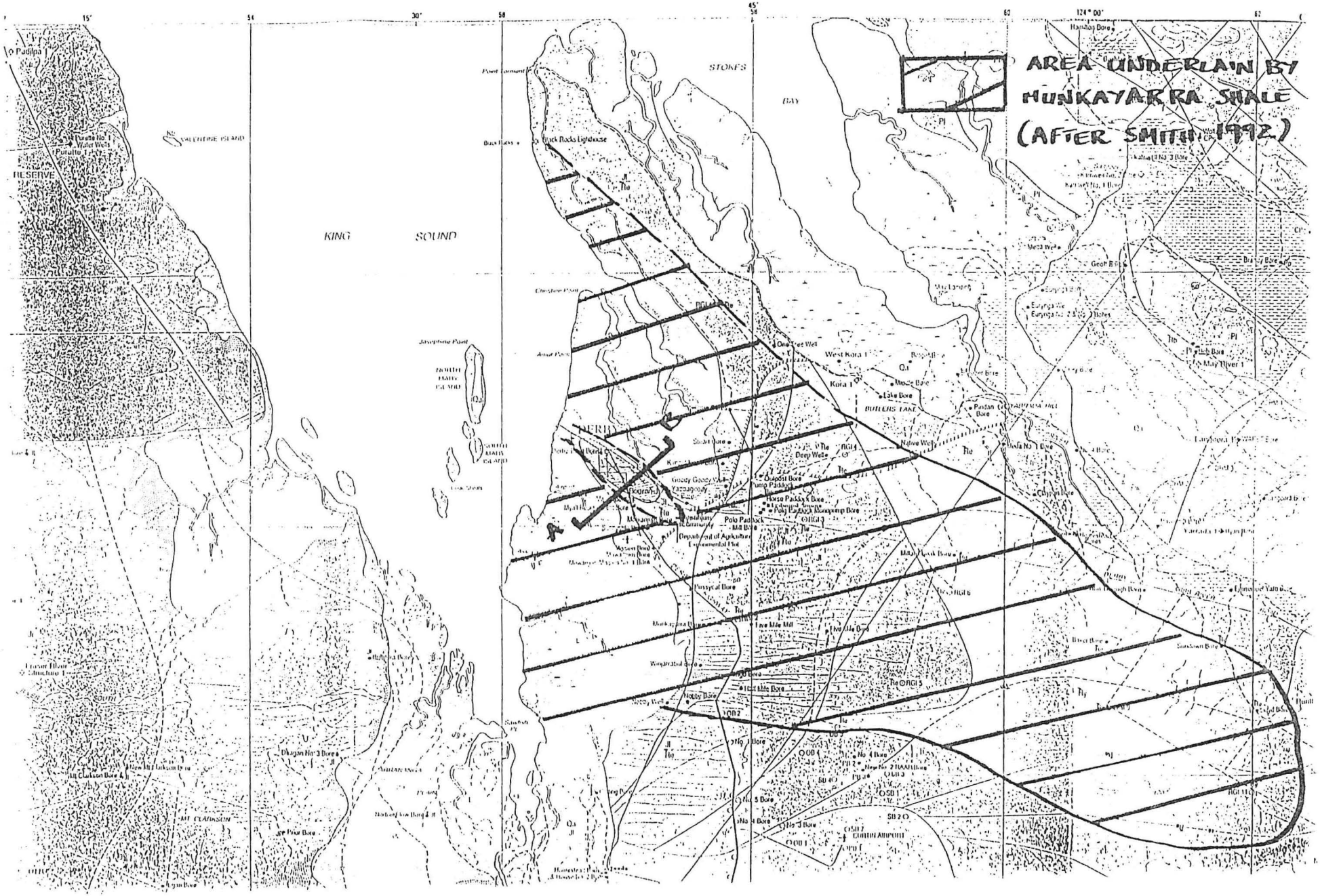
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NORTH MAIN ISLAND
SOUTH MAIN ISLAND
PERTH
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Horse Paddock Bore
Polo Paddock Mill Bore
Department of Agriculture Experimental Plot
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PRAWN FARM PROJECT
Notes by Professor Bruce Thom, 25 June 1998

1. GEOHERITAGE

Points raised on the geoheritage values of eastern parts of King Sound in the vicinity of Derby, including Doctors Creek and the proposed nature reserve site, as described in my report on the tidal power project, have equal relevance to the prawn farm project. The proposed site of the prawn farm, as far as I am aware, is contiguous both with tidal creeks extending east and south of the well-studied Doctors Creek system, and the nature reserve. The linear dunes of Pleistocene age extend east to west onto (and under) the broad high-tidal flat which merges into the creek system. The complex Pleistocene/ Holocene interfingering of dunes and tidal deposits, first identified here by Fairbridge in 1961, and studied in detail by Jennings in 1975, is the only known occurrence of such and geologic-geomorphic relationship in the world. The prawn project is situated on flats where this relationship is best expressed. It is a relationship which deserves further investigation and consideration as a protected site even in terms of not permitting the use of the sands for construction materials and as sources of water.

2. TIDAL FLAT SURFACE STABILITY

Tidal flats in the Derby-Doctors Creek area have been documented by Semeniuk as undergoing erosion through bank collapse, tidal creek headward incision and surface sheet erosion. The dynamic relationship between erosion and deposition on broad surfaces marginal to the creeks requires further investigation. The likelihood of further headward extension of creeks must also be considered in terms of stability of embankments and channels feeding the ponds. More particularly, the interference of very high tidal flows ("king tides") across these flats by the embankments may stimulate new patterns of creek and surface erosion. It is uncertain as to what may be the consequences of "diverted" flows during "king tides"; for instance, could there be acceleration of creek erosion in the vicinity of Derby by those feeding West Doctors Creek?

3. GREENHOUSE IMPLICATIONS ON TIDAL FLAT CONDITIONS

As noted in the report on the power station project, sea-level rise and change in cyclonic storm patterns are uncertainties which any coastal project must take into consideration in planning. How do the proponents seek to address such uncertainties and risks?

4. EXCAVATION AND WATER QUALITY

The proposal involves shallow excavation to form the pond embankments. It is indicated that sediments from the flats are suitable for this purpose and there will be no significant geotechnical or water quality implications. The Code of Practice used for Australian Prawn Farmers suggests an appreciation of problems caused by acid sulphate soil be considered in areas where a potential threat exists. I am not convinced that the proponent has followed the advice of the Code on such matters. Stratigraphic studies by Semeniuk suggest organic-rich, reduced clays underlie these flats. These are prime materials for generating acid when oxidised as well as toxic aluminium. I strongly recommend the proponent undertake an acid sulphate soil management plan following a more detailed study of stratigraphy and geochemistry. Advice should be obtained from those expert in this field. study of stratigraphy and geochemistry. Advice should be obtained from those expert in this field.