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Bell Bay Pulp Mill Project

Expert witness statement of
Dr Ian Oliver Woodward

Prepared for

Resource Planning and Development Commission Inquiry

January 2007

Prepared by: Ian Woodward

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1. Name and address

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2. Area of expertise

My areas of expertise are environmental investigations, environmental impact assessment and mitigation and the technical supervision of multidisciplinary environmental projects.

My qualifications and experience are detailed in my CV in Attachment 1.

I am sufficiently expert to make this statement because I have 21 years experience in natural resource and environmental management, 13 of those in government as a regulator and 8 in private enterprise as a consultant. During that time I have undertaken a very wide range of tasks and projects. Examples of particular relevance to my work for the Gunns pulp mill project are as follows.

2.1 Landfill

I have undertaken and/or supervised conceptual designs, design reviews and environmental assessments for numerous landfills. These have focussed on leachate management, cell design, cell capping, closure and rehabilitation. As a regulator, the landfills included Hobart (McRobies Gully), Glenorchy (Jackson Street), Baretta, George Town, Dulverton, Port Latta, Huon, Carlton, Campania, Lauderdale, Orford and Devonport. As a consultant, the landfills have included Geeveston, Mangalore, Whitemark, Lady Barron, Killiecrankie, Lackrana, Burnie and Leven Banks (rehabilitation), and I have also prepared an environmental risk comparison of the four major landfills in southeast Tasmania (Hobart, Glenorchy, Baretta and Copping).

As a regulator, I supervised the preparation of the (then) Department of Environment and Land Management's landfill design guidelines, landfill rehabilitation guidelines and the hazardous waste management strategy and I authorised the final documents. I also had a supervisory role for the (then) Department of Environment and Land Management's Bell Bay Baseline Environmental Monitoring Program, which included the identification of potential landfill sites within the Bell Bay Major Industrial Zone. As a consultant, I co-wrote the draft of the government's current Sustainability Guide for the Siting, Design, Operation and Rehabilitation of Landfills.

I have also undertaken and/or supervised design reviews, design scoping and environmental assessments for numerous tailings dams and waste rock dumps, which have leachate control requirements similar to landfills. As a regulator, these included Henty, Savage River and Mt Lyell mines. As a consultant, these have included Henty, Savage River, Mt Lyell, Renison, Bischoff, Royal George, Storeys Creek and Hercules mines.

2.2 Tamar River water supply pipeline crossing

I have undertaken and/or supervised conceptual designs, design reviews and environmental assessments for numerous river crossing, river dredging and river bed drilling projects. As a regulator, these projects included acid sulphate soil risks from the Chinderah Bypass crossing of the Tweed River (NSW), sand dredging and dumping for the Tweed River (NSW) dredging program and contamination risks and silt disposal options for the Tamar River dredging program. As a consultant, these projects have included environmental assessment and management of: geotechnical investigations and piling of the Sorell Causeway (McGees) Bridge replacement, geotechnical investigations for the proposed Bridgewater Bridge replacement, geotechnical investigations and construction impact minimisation for the Leven Bridge duplication, and bridge crossings of Peggs Creek, Myrtle Creek, Biralee Creek and Black River. These investigations included an assessment of the consequences of sediment disturbance, which is the primary environmental issue for the Tamar River crossing of the water supply pipeline. I also undertook the technical review of Pitt & Sherry's Tamar River dredging optimisation and scour impact study report on the Tamar River. That report reviewed all technical reports Tamar River dredging available at that time.

3. Scope

3.1 Instructions

I was engaged by Gunns Ltd through Pitt & Sherry to use my expertise in landfill design best practice, Tamar River silt dredging impacts and the management of teams of environmental experts to prepare a concept design for the pulp mill's solid waste landfill and an environmental assessment of the water supply pipeline's crossing of the Tamar River.

I was assisted in this work by other experts within Pitt & Sherry. Following our investigations, I prepared two reports, which are appendices 55 and 56 respectively of the *Draft Integrated Impact Statement*:

- *Gunns Pulp Mill Solid Waste Landfill Conceptual Design* (June 2006), referred to subsequently in this statement as the landfill concept design report;

- *Gunns Pulp Mill Water Supply Tamar River Crossing Pipeline Installation* (June 2006), referred to subsequently in this statement as the Tamar crossing report.

My work addressed the following (*inter alia*) parts of the Scope Guidelines, to the extent that those parts apply to the concept design of the landfill and the assessment of the pipeline crossing:

- 4.4 Use and development of infrastructure and off-site ancillary facilities;
- 4.5 Construction phase;
- 7 Potential environmental impacts and proposed management measures
  - 7.8.5 Solid waste and hazardous waste management
  - 7.8.7 Hazardous analysis and risk assessment
  - 7.9.2 Water supply and associated infrastructure
  - 7.9.3 Raw water pump station, water storage dam and water supply pipeline
  - 7.9.5 Solid waste disposal site(s)
  - 7.10.10 dredging;
- 10 Monitoring.

No issues arose from the community consultation process that had not already been covered by our instructions and scope of work. However, a number of issues arose from this process that require clarification or further information, which is provided in this statement.

3.2 Process and methodology

For both the landfill and the Tamar River water supply pipeline crossing, at all stages I worked with other experts within Pitt & Sherry, in particular Jim Lockley (Industrial Chemist) and Dr Michael Pollington (Geologist and Environmental Scientist), and also Chris Weavers (Engineer), Evan Boardman (Planner), David Hugo (Engineer) and Andrew Turner (Engineer).

3.2.1 Landfill

For the landfill, with the assistance of Mr Lockley and Dr Pollington, I have:

- Confirmed the appropriateness of the landfill site nominated to me by Gunns.
- Confirmed with Gunns the nature of the solid waste to be disposed of.
- Determined the geological and hydrogeological setting of the landfill site based on site inspections and groundwater monitoring bore observations by Mr Lockley and Dr Pollington.

- Determined the appropriate landfill volume for the 20 year design life nominated to me by Gunns and at the request of Gunns also confirmed that there is sufficient area to expand the landfill to a 50 year design life if required.
- Determined the appropriate leachate control measures by reference to the (formerly) Department of Primary Industries, Water & Environment's *Sustainability Guide for the Siting, Design, Operation and Rehabilitation of Landfills 2004* and other technical literature.
- Developed a conceptual design of the landfill by reference to the *Sustainability Guide for the Siting, Design, Operation and Rehabilitation of Landfills 2004* and other technical literature.
- Undertaken a hazard risk analysis of the conceptual design.
- Written a *Gunns Pulp Mill Solid Waste Landfill Conceptual Design (June 2006)* report describing my findings (which is Appendix 55 to the DIIS).

In carrying out these tasks:

1. I obtained from Gunns a detailed description of the nature and volumes of the solid wastes that may be disposed of in the landfill and the nature of the leachate that would be expected to arise from those wastes. The waste types to be disposed of in the landfill are process solid wastes and putrescible wastes (such as from canteens).
2. I was advised by Gunns that wastes such as chemical plant sludge, paints, thinners, solvents, greases and oils will not be disposed of to the solid waste landfill but will instead be disposed of at an appropriately licensed commercial or municipal landfill. In my landfill concept design report, I use the term "hazardous waste" in a casual sense for these wastes, based on the characteristics of waste types included in Annex III to the Basel Convention, namely: explosive, flammable, poisonous, toxic, ecotoxic and infectious substances. Similarly, I described the wastes that will go to the solid waste landfill as non-hazardous, to distinguish them from the above waste characteristics, a difference highlighted by the process wastes being suitable for beneficial reuse as soil conditioner, for example. On reflection, my use of this casual hazardous/non-hazardous terminology could lead to confusion from a regulatory perspective. It is for reasons of avoiding confusion that Tasmanian regulatory authorities do not use the term "hazardous" and instead refer only to "controlled" wastes. However, my casual use of the hazardous terminology does not have any implications for the landfill design because I based the design parameters on a formal "controlled" waste classification.
3. I used waste volumes for the concept design of the landfill that are the maximum anticipated prior to beneficial reuse. Beneficial reuse would decrease the volume of the wastes that will be disposed of in the landfill and hence decrease the size of the required landfill. However, for the purposes of the conceptual design, I assumed that all the nominated wastes would go to the landfill, notwithstanding that Gunns have committed to maximising beneficial reuse.

4. I assessed the nature of the waste and anticipated leachate against the *National Environment Protection (Movement of Controlled Waste between States and Territories) Measure 2004* and determined that the waste would be classified as a controlled waste. I then referenced the *Sustainability Guide for the Siting, Design, Operation and Rehabilitation of Landfills 2004* and determined that because the waste is controlled waste the landfill would be classified as Category C (Secure), which is the highest level of landfill security under the *Sustainability Guide*. This classification sets design standards to be achieved for the landfill.
5. Gunns advised me of the location of the landfill site that Gunns preferred.
6. I undertook a review of the site location against other candidate sites and concluded that the site nominated by Gunns was the most appropriate.
7. I requested Mr Lockley and Dr Pollington to examine aerial photos and geological maps of the site and determine appropriate locations for groundwater bore holes. Dr Pollington subsequently visited the site in the presence of the drilling company Stacpooles and observed the installation of three boreholes by Stacpooles, one at the head and two at the foot of the notional landfill footprint. During his visit Dr Pollington also observed the digging (by excavator) of a number of test pits and he prepared logs of those pits, which are provided in Appendix D of my landfill concept design report.
8. Mr Lockley and Dr Pollington subsequently visited the site again and measured the depth of water in the bore holes and took water samples for chemical analysis. Approximately 5 months later, GHD also sampled the bores for chemical analysis. The depth results are reported in Table 2 of my landfill concept design report and the analytical results are provided in Appendix D of my landfill concept design report.
9. I prepared a number of objectives and design criteria for the landfill conceptual design, and I, together with Mr Lockley and Dr Pollington, then used these to prepare the concept design.
10. I requested Mr Weavers to prepare a Traffic Impact Assessment Report and Mr Boardman to prepare a draft planning scheme amendment. These are respectively Appendix J and Appendix L of my landfill concept design report.
11. I prepared the *Gunns Pulp Mill Solid Waste Landfill Conceptual Design* report describing my findings and the concept design, with review by Mr Lockley and Dr Pollington under Pitt & Sherry's Quality Management System. The landfill concept design report appears as Appendix 55 to the *Draft Integrated Impact Statement*.

3.2.2 Tamar River water supply pipeline crossing

For the pipeline crossing, with the assistance of Dr Pollington, Mr Lockley and also Mr David Hugo and Mr Andrew Turner (Engineers) of Pitt & Sherry, I have:

- Considered available crossing construction methodologies.
- Identified the most appropriate crossing construction methodology likely to be adopted by a construction contractor, taking into account practicality, environmental impacts, impacts on other services and order of cost.
- Developed a conceptual description of how a construction contractor is likely to approach the task.
- Identified the potential environmental impacts that could arise during the crossing construction.
- Considered the options for mitigating construction environmental impacts.
- Assessed the significance of residual environmental impacts on the Tamar River ecosystem.
- Written a *Gunns Pulp Mill Water Supply Tamar River Pipeline Installation (June 2006)* report describing my findings.

In carrying out these tasks:

1. I obtained from Gunns the location of the crossing and the diameter of the pipeline.
2. I consulted with Dr Pollington, Mr Hugo and Mr Turner and identified the available crossing methodology options to be open trenching, jet trenching, pipe jacking, microtunnelling and horizontal directional drilling.
3. I consulted Dr Pollington, Mr Hugo and Mr Turner about the results of Pitt & Sherry's drilling program and about the characteristics of the sites and surrounds, and their conclusions about the consequential opportunities and constraints on construction options.
4. I reviewed a letter of advice from Atteris to Gunns, dated 21 April 2006, in which they recommended microtunnelling as the crossing option.
5. In consultation with Dr Pollington, Mr Hugo and Mr Turner I determined that pipe jacking, microtunnelling (notwithstanding the advice to Gunns from Atteris) and horizontal directional drilling were not viable options, leaving open trenching and jet trenching as the remaining potential methodologies.
6. I examined available reports on Tamar River silt, previously reviewed and summarised in a separate study by Dr Pollington in a Pitt & Sherry report *Launceston City Council Tamar and North Esk Dredging Optimisation and Scour Impact Study (September 1999).*

7. In consultation with Dr Pollington I concluded that constructing an open trench through the soft silt would be problematic and would also disturb and resuspend substantially more silt than jet trenching.
8. In consultation with Dr Pollington I therefore concluded that jet trenching was the preferred method of constructing the crossing.
9. I obtained information about jet trenching silt disturbance from reference projects and calculated the likely worst case quantities and concentrations of silt that would be resuspended by jet trenching the Tamar crossing.
10. I reviewed technical information about the potential use of silt curtains to reduce the extent and/or intensity of the silt plume that is likely to be created during pipeline installation, and concluded that they were not safely feasible.
11. I compared the likely quantities and concentrations of the worst case construction silt plume with historical observations and estimates of silt behaviour in the estuary.
12. I reviewed the Development Proposal and Environmental Management Plan *Proposed Tamar Dredging Project – Environmental Impact Statement* (SEMF February 2001), which deals with the environmental impacts of the ongoing Tamar dredging program, managed by the Upper Tamar River Improvement Authority.
13. I consulted with Mr Lockley about the likely chemical nature of the resuspended silts.
14. I reviewed reports on the biota of the aquatic biota of the Tamar River, including the Aquenal report *Aquatic Environmental Investigation at Proposed Tamar River Crossings for Gunns Pulp Mill Water Supply Pipeline (June 2006)* that was commissioned by Gunns for this project, and which appears as Appendix 26 of the *Draft Integrated Impact Statement*.
15. I concluded that the likely silt plume that would arise from construction would not be exceptional relative to natural scour plumes that might occur during Tamar flood events, although the construction plume would be occurring at flows substantially less than those at which flood scours of that magnitude would occur.
16. I concluded that the likely silt plume that would arise from the pipeline construction would not cause impacts on biota more significant than what would occur during natural flood scour events.
17. I concluded that jet trenching installation of the pipeline would therefore be both viable and environmentally acceptable.
18. I prepared the *Gunns Pulp Mill Water Supply Tamar River Pipeline Installation* report, with review by Dr Pollington, Mr Hugo, Mr Turner and Mr Lockley under Pitt & Sherry's Quality Management System. The Tamar crossing report appears as Appendix 56 of the Draft Integrated Impact Statement.

3.3 Reports reviewed

I was instructed by Gunns to consider or take into account the following reports and materials.

3.3.1 Landfill

- Jaakko Pöyry's process solid waste report, which appears as Appendix A to my landfill concept design report and as Annex VII in Volume 7 Appendix 9 of the *Draft Integrated Impact Statement*.
- Jaakko Pöyry's leachate characteristics information, which appears as Table 1 in my landfill concept design report.

3.3.2 Tamar River water supply pipeline crossing

- Pitt & Sherry's geotechnical bore logs from a March 2006 drilling program
- Atteris's Tamar River Crossing Concept Design advice to Gunns, dated 21 April 2006.
- Aquenal's *Aquatic Environmental Investigation at Proposed Tamar River Crossings for Gunns Pulp Mill Water Supply Pipeline (June 2006)*, which appears as Appendix 26 of the *Draft Integrated Impact Statement*.

3.4 Assumptions

3.4.1 Landfill

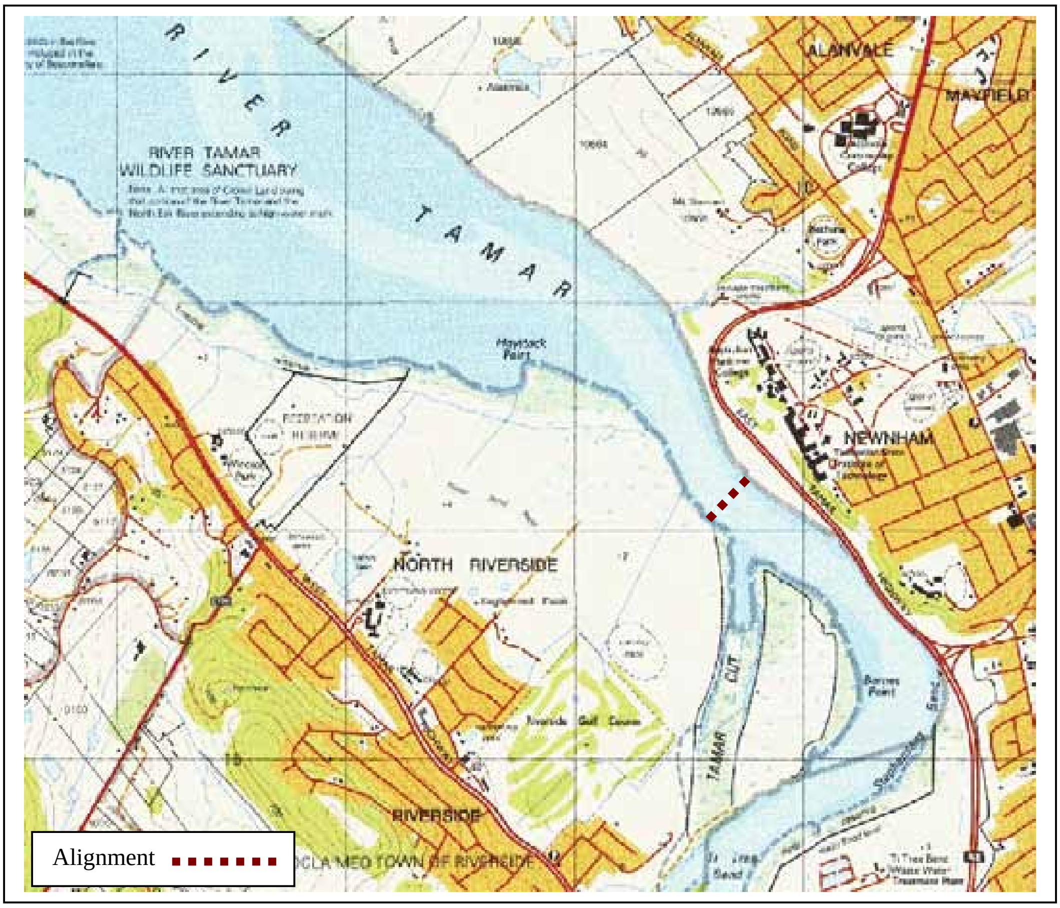
I was instructed by Gunns to make the following assumptions:

- A design life of 20 years;
- A worst case of no beneficial reuse of process solid waste, meaning 51,000 m^3 of process waste per year would be disposed of in the landfill;
- An amount of 5,000 m^3 of domestic putrescible waste (eg. canteen waste) per year that would also be disposed of in the landfill;
- An amount of 25,000 m^3 of inert construction waste that would be disposed of in the landfill during the pulp mill construction period.

3.4.2 Tamar River water supply pipeline crossing

I was instructed by Gunns to make the following assumptions:

- A pipeline diameter of 1 m;
- A crossing location from just north of the Tamar Cut across to Newnham, shown in Figure 1 of my Tamar crossing report, as shown in the figure below.



3.5 Limitations and exclusions

3.5.1 Landfill

The landfill design that I have prepared is a concept design. Design features will need to be confirmed during preliminary and then detailed design prior to the landfill being constructed.

I have not given detailed consideration to flora, fauna or heritage values in my landfill concept design report. I understand that these matters are dealt with separately by others.

3.5.2 Tamar River water supply pipeline crossing

My dismissal of pipe jacking, microtunnelling and horizontal directional drilling is based on my understanding of the characteristics and requirements of each.

I have not given detailed consideration to terrestrial flora, fauna or heritage values in my Tamar crossing report. I understand that these matters are dealt with separately by others.

4. Summary of opinions on landfill

4.1 Cell construction and layout

The conceptual design is based on a sequence of 10 landfill cells, each with a capacity of approximately 100,000 m^3. These cells would be constructed, used and closed by capping as required, depending on the rate of disposal of waste.

The conceptual design provides a landfill filling life of 20 years, assuming no beneficial reuse of process waste.

Any beneficial reuse of process waste will proportionally extend the filling life of the landfill. If high rates of beneficial reuse are achieved, it is possible that the full 20 year footprint may not be required, even over a 50 year mill life.

There is sufficient area below the 20 year landfill footprint for the landfill to be extended to a 50 year no-beneficial-reuse filling life if required.

The concept design's construction sequence is 'top-down', with the first cell to be constructed at the highest point of the footprint and the fourth cell at the lowest point. A second layer of 6 cells will be constructed on top of the lower layer cells.

4.2 Landfill liner and drainage system

The cells will be lined with highly impermeable leachate barriers and have a network of leachate collection pipes that will direct leachate to a buffer tank and pump system, which will pump the leachate to the pulp mill's effluent treatment plant.

Cutoff drains will divert surface water around the landfill. The top-down construction further minimises the ingress of internal surface water into the cells and hence into the leachate collection system.

The process wastes have a high pH and are classified as controlled wastes under the *Environment Protection (Movement of Controlled Waste between States and Territories) Measure 2004*. Accordingly, the design standard for the landfill is category C (secure landfill) under the *Sustainability Guide for the Siting, Design, Operation and Rehabilitation of Landfills 2004*.

Secure landfills require a clay liner, a geosynthetic composite liner and a geomembrane (e.g. HDPE).

There is unlikely to be enough suitable clay on site to construct a 1 m thick compacted clay liner, and a 300 mm prepared clay base with an overlying geosynthetic clay liner and HDPE membrane is therefore proposed.

The HDPE membrane is the primary leachate barrier. It will be overlain by porous aggregate within which will be a system of leachate collection pipes. Leachate will collect in the pipes and be directed to the leachate buffer tank and pump system and hence to the pulp mill's effluent treatment plant.

The geosynthetic clay liner will be underneath the HDPE membrane and is the backup liner, in case the HDPE membrane leaks (for example, due to minor imperfections in the manufacturing process or due to puncturing).

The HDPE membrane and geosynthetic clay liner provide a leachate barrier that betters the 1×10^{-9} m/sec maximum permeability standard of the *Sustainability Guide for the Siting, Design, Operation and Rehabilitation of Landfills 2004.*

The HDPE membrane, geosynthetic clay liner and the underlying prepared clay base will reduce to acceptable levels the potential for leachate to escape to groundwater, in accordance with the *Sustainability Guide for the Siting, Design, Operation and Rehabilitation of Landfills 2004*.

4.3 Groundwater management

Groundwater underlies the landfill site at varying depth.

In my landfill concept design report I used a variety of descriptions (page 24, 32 and 64) for the distance of groundwater below the ground surface. While these are not contradictory, they could have been better expressed. A more appropriate description to adopt for consistency would be 'the depth to groundwater below the ground surface is approximately 10 m at the head of the proposed landfill and approximately 2 m at the foot of the proposed landfill'.

The depth to groundwater at the foot of the landfill is less than the acceptable standard minimum distance (5 m) specified in the *Sustainability Guide for the Siting, Design, Operation and Rehabilitation of Landfills 2004*. In accordance with the principles of the *Sustainability Guide*, deviation from the acceptable standard will require appropriate investigation and detailed design. Because it will be approximately 8 years (longer if there is substantial waste reuse) before a landfill cell would need to be constructed at the foot of the landfill, there is adequate time to build a substantial groundwater monitoring database and prepare the necessary engineering design to manage groundwater in this location. Potential engineering solutions include the construction of a drainage layer below the landfill cell and/or the installation of groundwater pump out bores to lower the water table in this location.

4.4 Leachate management

The HDPE membrane and the geosynthetic clay liner will be very resilient to the chemical properties of the leachate, including its high alkalinity. HDPE has been demonstrated to be capable of withstanding alkalinities of up to pH 14 and geosynthetic clay liners have been demonstrated to be capable of withstanding alkalinities of up to pH 13. These alkalinities are respectively 100 and 10 times greater than the expected alkalinity of the leachate (pH is a logarithmic scale).

Like all landfill liners, there will be some leakage of leachate. For the fully developed landfill, the estimated average daily leakage rate is 10 litres, over a footprint area of approximately 9 hectares. The Victorian EPA's *Best Practice Environmental Management Siting, Design, Operation and Rehabilitation of Landfills* guideline maximum leakage rate is 10 litres per hectare (the Tasmanian *Sustainability Guide for the Siting, Design, Operation and Rehabilitation of Landfills 2004* does not specify a maximum leakage rate), equivalent to 90 litres over 9 hectares. The leakage rates will therefore be one order of magnitude lower than the Victorian EPA's maximum acceptable rates.

These leakage estimates were calculated using the Hydrologic Evaluation of Landfill Performance (HELP) model, as recommended by the *Sustainability Guide for the Siting, Design, Operation and Rehabilitation of Landfills 2004*.

Model inputs include:

- cell profile, including liner, drainage, sand, waste and capping layers;
- hydraulic characteristics, moisture content and thickness of the waste;
- rainfall patterns;
- HDPE and geosynthetic clay permeabilities, including allowance for manufacturing fault perforations, which can lead to leachate leakage.

The prepared clay base is a tertiary backup leachate barrier. It will have its own leachate collection sump, which will also flow to the leachate buffer tank and pumping system. Because this layer will be decoupled from the hydraulic head of the leachate in the overlying landfill cell, leachate here will be free draining, and the great majority of leachate leaked from above is therefore expected to drain to the sump and hence be collected. Only a small proportion of the expected daily average of 10 litres of leachate leakage would escape to the underlying soils and groundwater.

Local and regional groundwater movements will determine the fate of escaped leachate. Pitt & Sherry have recently prepared a groundwater assessment report for Gunns: Pitt & Sherry (November 2006) *Gunns Bell Bay Pulp Mill – Groundwater Assessment*. This report was largely written by Dr Michael Pollington, with assistance from Jim Lockley and myself.

As described in that report, groundwater movements would follow major structural features of the Tippogorree Hills and surrounds. In particular, groundwater movement directions will mirror surface drainage lines. These surface features have developed due to the underlying structural features.

Groundwater will therefore move down the valley that the landfill will be situated in until it meets the Williams Creek alignment. It will then flow along that alignment to the Tamar estuary.

The conceptual model for these movement patterns is shown in the figure on the following page, which is taken from the *Gunns Bell Bay Pulp Mill – Groundwater Assessment* report.

4.5 Leachate impact assessment

(a) Contaminants other than dioxins

The significance of leachate leakage needs to be judged against the requirements of the Tasmanian *State Policy on Water Quality Management 1997*. In section 8.3 of my landfill concept design report I described proposed Protected Environmental Values (PEVs) for the Tamar and North Esk catchments and stated that they had not yet been formalised. This was true at the time that I wrote section 8.3. I understand that the PEVs were subsequently formalised in December 2005. I did not update this section of my report to reflect this. The relevant PEVs that I describe in my report remain correct, however.

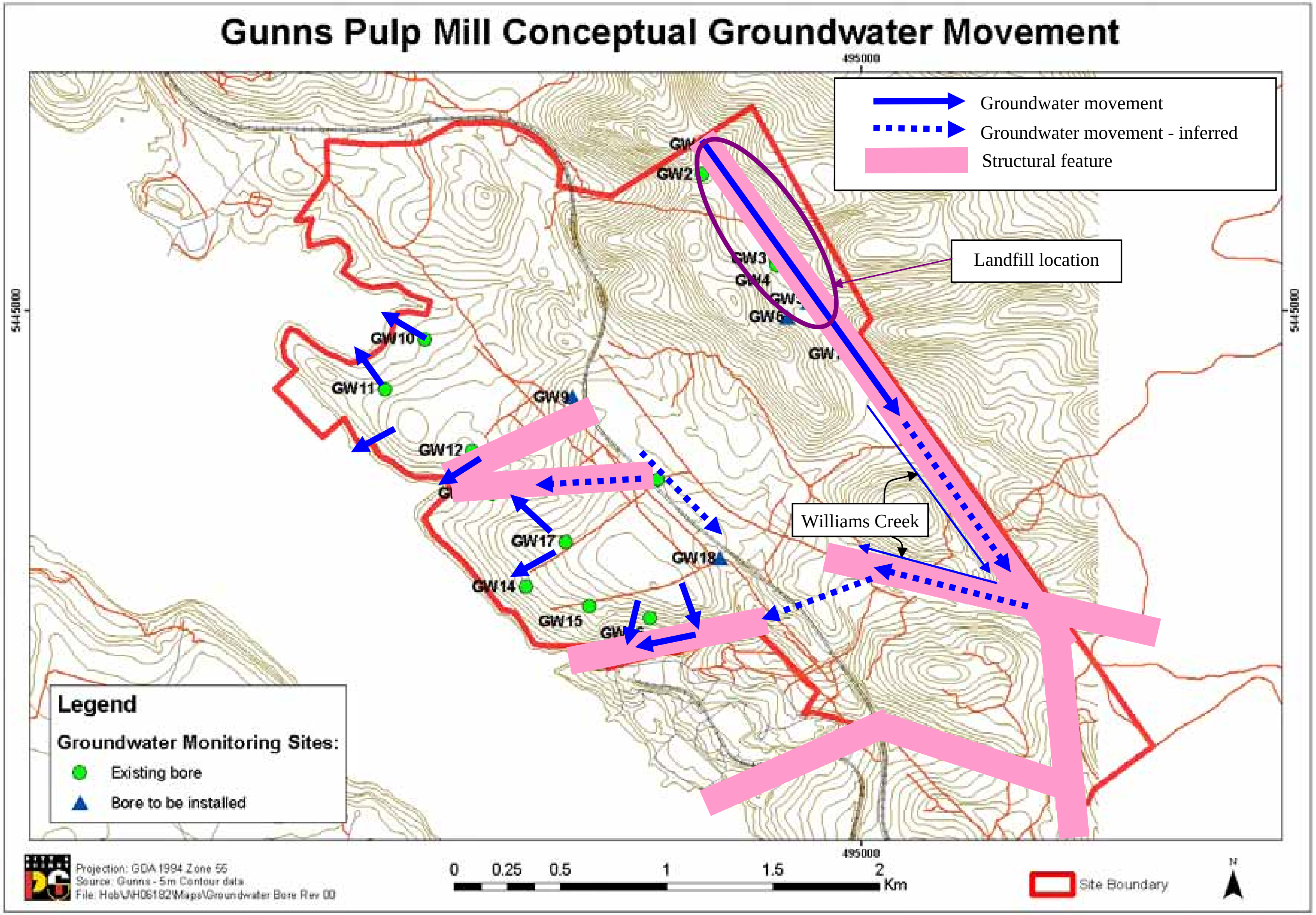
The leachate will contain a number of chemical substances. Some of these are considered to be ecosystem toxicants under the *ANZECC Guidelines for Fresh and Marine Water Quality 2000*.

In section 8.3 of my landfill concept design report I stated that in the absence of site specific water quality objectives, the *State Policy on Water Quality Management 1997* defers to the *ANZECC Guidelines for Fresh and Marine Water Quality* trigger values for the protection of 95% of aquatic ecosystems. On reflection, this is poorly worded for two reasons. Firstly, the ANZECC guidelines percentile protection relates to the percent of species in an ecosystem, not the percent of ecosystems. Secondly, the State Policy does not explicitly specify that the 95% protection trigger value should be adopted.

The ANZECC guidelines provide both 95% and 99% protection trigger values. Later in my report (footnote to section 9.1), in fact, I compare leachate concentrations with the 99% species protection trigger value.

For toxicants in the leachate, the dilution factor required to reduce the concentrations to below their respective ecosystem protection trigger values (protection of 99% of species) is one order of magnitude.

To consider a ‘worst case’ scenario, the average 10 litres of daily leaked effluent spread over the four base layer cells may all escape the tertiary backup and enter the environment and do so all at one point within each cell. There could then be 2.5 litres per day emerging from single holes in each of the four cells. The distance required to dilute this escaped leachate within the underlying groundwater by a factor of 10 would be in the order of a few metres.


Gunns Pulp Mill Conceptual Groundwater Movement
Groundwater movement
Groundwater movement - inferred
Structural feature
Landfill location
Williams Creek
GW2
GW3
GW4
GW6
GW9
GW10
GW11
GW12
GW14
GW15
GW17
GW18
495000
5445000
Legend
Groundwater Monitoring Sites:
Existing bore
Bore to be installed
Projection: GDA 1994 Zone 55
Source: Gunns - 5m Contour data
0 0.25 0.5 1 1.5 2 Km
Site Boundary
N

Escaped leachate would therefore be diluted to below the *ANZECC Guidelines for Fresh and Marine Water Quality 2000* trigger values for ecosystem protection (99% of species) within a few metres from the leakage point(s). With increasing distances, the dilution factors would increase.

There are no permanent surface expressions of groundwater downslope from the landfill site. However, observations of groundwater bores show that the watertable becomes progressively closer to the ground surface from the head to the foot of the landfill. If this trend continues further downslope, it is possible that there could be temporary surface expressions of groundwater into Williams Creek if prolonged rainfall raises the watertable sufficiently. While this could transport leaked leachate into Williams Creek, it would inevitably be accompanied by increased rates of dilution of contaminants. ANZECC trigger values would already be met within a few metres of a leakage point and this further dilution would reduce concentrations even further below trigger values. There would therefore be no significant risk to any ephemeral ecosystems in Williams Creek.

The nearest potentially affected permanent aquatic ecosystem is the Tamar River. This is approximately 2 km from the landfill. The leachate dilution factor over this distance would be several orders of magnitude and leachate concentrations at the Tamar River would correspondingly be several orders of magnitude below the ANZECC trigger values.

Leachate leakage therefore presents no credible significant risk to any ecosystem.

(b) Dioxins

Dioxins were not included in Table 1 of my landfill concept design report (which is Appendix 55 to the DIIS), which listed expected leachate constituents. Jaako Poyry provided this table to me.

The possibility of dioxins being present in the process waste that will be disposed of to the landfill, and hence being present in the landfill leachate, was raised in public submissions.

I understand from my discussions with Jaako Poyry that their exclusion of dioxins from the Table 1 list was based on industry research showing that amongst process solid wastes from modern pulp mills significant concentrations of dioxins are only likely to be found in primary sludge and secondary sludge (biosludge).

While some pulp mills dispose of primary and/or secondary sludge to landfill, this will not be the case for the Gunns pulp mill because primary sludge will instead be burned in the power boiler and secondary sludge will be burnt in the recovery boiler.

Jaako Poyry have advised me that they are not aware of any measurements that have shown the presence of dioxins in slaker grits or lime kiln ESP and that only trace amounts (less than detection limit) have been found in green liquor dregs.

A new publication has become available since I prepared my landfill concept design report (which is Appendix 55 to the DIIS): Uloth, V., Wenli, D., Leclerc, D., Karidio, I., Kish, J and Singbeil, D. (2005) *Investigations into the variability and control of dioxins formation and emissions from coastal power boilers*. Technical Association of the Pulp and Paper Industry - Engineering, Pulping, and Environmental Conference 2005.

That paper presents the results of measurements of dioxins in power boiler ash and landfill leachate at coastal pulp mills, and is therefore relevant to the Gunns pulp mill and its landfill.

Dioxins are tightly bound on the ash and hence not easily removed by water leaching.

The paper found that TEQ loadings were typically less than 5 pg TEQ/L (picograms per litre) in boiler ash landfill leachate. TEQ means toxic equivalent, and weights the toxicity of different forms of dioxins as a fraction of the toxicity of 2,3,7,8-TCDD (this nomenclature is the common abbreviation of 2,3,7,8-tetrachlorodibenzo-p-dioxin), the most toxic dioxin.

The ANZECC *Guidelines for Fresh and Marine Water Quality* do not specify trigger values for dioxins because there are insufficient data to derive a reliable trigger value. However, the guidelines (section 8.3.7) note that "concentrations of dioxins and related furans have been found at cleaner sites at between 1 and 5 pg/L and at up to 100 pg/L at more contaminated sites". These concentrations are mass concentrations of all dioxins. The ANZECC Guidelines note that TCDD is usually less than 15% of all dioxins, and so the TEQ of these observed concentrations would be proportionally less.

The ANZECC guidelines (section 8.3.7) also note that "available information indicates that acute effects for some freshwater animal species exposed to TCDD occur at concentrations greater than 1.0 µg/L. Chronic concentrations are less than 0.01 µg/L, with a chronic concentration for rainbow trout of less than 0.001 µg/L". In picograms, these concentrations are 1000000, 10000 and 1000 pg/L respectively.

Based on these ANZECC figures, the expected dioxin concentration in the leachate (before dilution) would therefore be 200 times less than the lowest of these concentrations.

The ANZECC guidelines (section 8.3.7) also note that the USEPA "considered that water concentrations >0.00001 µg/L TCDD could lead to excessive levels of dioxin in fish and shellfish for human consumption". In picograms, this concentration is 10 pg/L.

Based on these ANZECC figures, the expected dioxin concentration in the leachate (before dilution) would therefore be less than the concentration of concern for growing fish and shellfish for human consumption.

In preparing this statement, I discussed dioxin issues with Dr Roger Drew of Toxicos. Dr Drew advised me that the ANZECC figures are sourced largely from experiments in which organic carbon was not measured, and extrapolation to concentrations in leachate and water in the environment is therefore questionable. Dr Drew referred me to the USEPA publication USEPA (March 1993) *Interim Report on Data and Methods for Assessment of*

2,3,7,8-Tetrachlorodibenzo-p-dioxin Risks to Aquatic Life and Associated Wildlife EPA/600/R-93/055.

This paper notes that TCDD has extremely low solubility in water. Its environmental fate is largely determined by particulate organic matter, to which it binds strongly. The availability of TCDD to aquatic organisms is largely through uptake by ingestion or contact with sediments.

The USEPA paper establishes low risk water environmental guidelines for TCDD (ie. TEQ) of 0.6 pg TEQ/L for fish, 0.07 pg TEQ/L for birds and 0.008 pg TEQ/L for mammals, when the particulate organic carbon concentration is 0.2 mg/L. At a higher particulate organic carbon concentration of 1 mg/L, the guidelines are 3.1 pg TEQ/L for fish, 0.35 pg TEQ/L for birds and 0.04 pg TEQ/L for mammals.

A very significant mitigation of the environmental risk of escaped leachate is the fact that the organic particulates to which TCDD would bind if leachate escaped to groundwater would be quickly filtered out by the passage of groundwater through soil, and are very unlikely to be transported away from the immediate vicinity of the landfill itself. The likelihood of biota being exposed to leachate dioxins is therefore very low.

Even ignoring the filtering of particulates through the soil, using the lowest of the guideline values, a leachate dilution of 625 times, less than three orders of magnitude, is required to reduce the 5 pg TEQ/L in the leachate to the 0.008 pg TEQ/L guideline for protecting mammals. The nearest potentially affected permanent aquatic ecosystem is the Tamar River. This is approximately 2 km from the landfill. The leachate dilution factor over this distance would be more than three orders of magnitude and dioxin concentrations at the Tamar River would correspondingly be below the most sensitive of the guideline values.

Leachate leakage therefore presents no credible significant dioxin risk to any ecosystem or to human health.

4.6 Response to RPDC's Beca AMEC report

The RPDC has received a report from its advising consultants, Beca AMEC: *Gunns IIS Peer Review IU01 of Gunns Limited Bell Bay Pulp Mill Draft Integrated Impact Statement (Rev 01 October 2006).*

I provide responses to matters raised in that report relating to the landfill below.

1. Clarification was sought on where the process waste will be mixed, either at the mill or at the landfill (eg. Beca AMEC page 16). The location of mixing is not critical provided that the heat of hydration of lime kiln electrostatic precipitator dust is exhausted prior to it being deposited in the landfill. As described in section 10.3 of my landfill concept design report, this will be achieved by wetting the wastes before their temporary storage at the mill site. This wetting could be achieved by the actual mixing of the wastes but could also be done by simply watering the lime kiln dust. This will be determined as part of detailed design. For concept design

purposes, I have assumed that the wetting will be by watering and that the mixing of wastes will be during tipping into the landfill.

2. An error was identified in a leachate volume calculation in my landfill concept design report (eg. Beca AMEC page 44). In my leachate calculations, for convenience I used a nominal 1 ha cell as the base calculation unit. When I scaled this up to calculate expected leachate volumes for the full landfill I inadvertently retained this 1 ha cell size rather than adjusting for the actual cell size, which will average approximately 2 ha. My calculations thereby underestimate leachate volumes by a factor of about two. However, my calculations were conservative in that they assume that all cells in the landfill are on the same layer. In fact, the design is two layered. Leachate production in the bottom layer will be inconsequential, and the (corrected) volume calculations can be approximately halved again to reflect this, leaving the net volume figure essentially unchanged from what is in my report, despite my error.

3. Clarification was sought as to whether the landfill will accept putrescible waste (eg. Beca AMEC page 49). The landfill design assumes that 5000 m^3 of putrescible waste from the mill operations will be disposed of in the landfill per annum.

4. Comment was made that the proximity of the groundwater to the landfill base at its lower end does not meet the Landfill Sustainability Guide 2004 (eg. Beca AMEC page 50). The proximity of groundwater to the base of the landfill was identified and discussed in my landfill concept design report. While it is a fact that the proximity to groundwater at the lower end will not meet the acceptable standards of the Landfill Sustainability Guide 2004, this does not mean that it fails to meet the Guide. Rather, it means that it must be demonstrated that an acceptable environmental outcome can be achieved. This is addressed in section 9.1 of my landfill concept design report, which demonstrates that an acceptable outcome can be achieved.

5. Comment was made that although there are no permanent water bodies in proximity to the mill the proposed service reservoir will be within 500 m (eg. Beca AMEC page 50). This service reservoir is not a natural waterbody, and any aquatic biota that develops in it will be derivative rather than pre-existing. The water stored in the reservoir will, by design, be destined to be used in the mill processes if required. In my opinion, it would be unreasonable to place protection constraints on an artificial water body created only for the purposes of being used by the mill.

6. Comment was made that the soil suitability for the proposed septic tank system at the landfill site has not been assessed (eg. Beca AMEC page 52). In my landfill concept design report, I note (section 8.6.3) that the septic tank would be installed in accordance with George Town Council requirements, which at that time will include appropriate soil testing.

7. Comment was made that no estimate of gaseous emissions from the landfill was made (eg. Beca AMEC page 52). I do not expect the process wastes to generate gaseous emissions. The wastes are inorganic, and will

have been fully reacted through the mill process. I am not aware of any interactions between the waste types that could generate gas. There will be some gaseous emissions from the putrescible wastes that will be deposited in the landfill. However, as noted in my landfill concept design report (section 8.9), the amounts of these wastes are small (760 tonnes per year, about 2 tonnes per day) and landfill gas collection would not be economic.

8. Comment was made that no analysis of noise emissions from the landfill was made (eg. Beca AMEC page 63). Noise impacts are discussed in section 9.4 of my landfill concept design report.

9. Comment was made that there was no assessment of the visual impact of the lighting (eg. Beca AMEC page 64). The landfill has been sited and designed so as not to be visible from vantage points (section 9.6 of my landfill concept design report). I do not consider that night time operations will be necessary but, if they do occur, I would expect that the lights on the machinery will be sufficient. Large scale flood lighting would not be necessary. Light impacts would therefore be insignificant.

10. Comment was made that only generalised site plans are provided for the landfill (eg. Beca AMEC page 73). The plans provided are for a conceptual design, which are adequate and appropriate at an approval stage.

11. Comment was made that the power supply option for the landfill has not been determined yet (eg. Beca AMEC page 76). This will be a matter for detailed design.

12. Comment was made that there was no evaluation or discussion about local opportunities for reuse of mill waste streams (eg. Beca AMEC page 78). I discuss general waste reuse opportunities in detail in section 3 of my landfill concept design report. It is premature to identify actual local opportunities at this stage of the project. That would be a matter for negotiation between Gunns and relevant recyclers and/or reusers prior to the plant's commissioning.

13. Comment was made that construction waste includes plastics, copper, steel and wood and separating these at source for recycling is more appropriate than dumping in the landfill (eg. Beca AMEC page 85). In section 3 of my landfill concept design report, I note that only unrecyclable construction waste will go to the landfill.

14. Clarification was sought on the proposed operating hours for the landfill (eg. Beca AMEC page 91). The nominal operating hours (7am to 5 pm) are described in section 10.1 of my landfill concept design report, noting that these hours may change as mill operations dictate. In my opinion, there are no environmental or social reasons why 24 hour operation would be unacceptable but I do not believe that this will be necessary.

15. Comment was made that water monitoring for Landfill Sustainability Guide 2004 Group 4 parameters is proposed but that these parameters could accidentally enter the landfill via putrescible waste (eg. Beca AMEC page 125). In my opinion, the purported risk of this occurring is too low to warrant adding group 4 parameters to the monitoring requirement. It would be more appropriate to ensure that those types of contaminants

cannot get into the waste stream in the first instance. This would be achievable through work practice protocols.

16. Comment was made that there is no discussion of back up facilities if the leachate pump fails at the landfill (eg. Beca AMEC page 127). In section 8.8.1 of my landfill concept design report I note that in the event of a prolonged shutdown of the leachate pump, excess leachate would be pumped out of the leachate buffer tank and taken by road tanker to the pulp mill's wastewater treatment plant.

17. Comment was made that there is no breakdown of relevant waste streams going to the landfill (eg. Beca AMEC page 151). A breakdown of waste streams is provided in Appendix A of my landfill concept design report.

18. Comment is made that disposal of putrescible waste to landfill is a questionable practice that would not be allowed in many countries (eg. Beca AMEC page 152). The Landfill Sustainability Guide 2004 allows landfilling of putrescible waste.

19. Comment is made that mixing process wastes in the landfill is contrary to the 2004 Emission Guidelines (eg. Beca AMEC page 152). In my understanding of those Guidelines, there is in fact no restriction against mixing wastes in the landfill. The Guidelines do specify separate collection and intermediate storage so as to maximise reuse opportunities, and this will be done, but this does not relate to any wastes that cannot be reused and that will therefore need to go to the landfill. In section 3 of my landfill concept design report I provide a discussion about the advantages and disadvantages of keeping wastes separate in the landfill, and conclude that mixing the wastes prior to their deposition in the landfill is the preferred option.

20. Comment is made that landfilling household waste with process waste is not recommended (eg. Beca AMEC page 153). As described in section 8.2 of my landfill concept design report, the putrescible waste will be kept separate from the process waste by an earthern wall.

21. Comment is made that it would be desirable to fence the landfill in (eg. Beca AMEC page 155). The landfill will be located on property that has restricted access, and in my opinion additional security fencing over and above safety fencing around the leachate collection system is unwarranted.

22. Comment is made that there are no details on odour, litter and pest control (eg. Beca AMEC page 158). Odour, litter and pest control are not issues for the process waste but could be for the putrescible waste. However, it will not be a public landfill, and waste management and deposition will be carefully controlled. I anticipate that putrescible waste will be placed in the landfill no more frequently than once a day, and could immediately be covered with daily cover. That daily cover, noted in section 10.5 of my landfill concept design report, will therefore prevent these problems becoming significant.

23. Comment is made that measures to handle/treat leachate when the mill is ultimately stopped have not been discussed (eg. Beca AMEC page 159). As described in section 8.12 of my landfill concept design report, a closure

management plan will be prepared following the detailed design of the landfill. Ongoing leachate management will form part of that plan.

24. Comment is made that a fire storage dam of at least 100,000 m^3 is proposed but that no detail is provided (Beca AMEC page 185). In fact, section 8.6.3 of my landfill concept design report describes a total fire water storage volume of 100,000 litres, not cubic metres, and notes that this will be made up by a combination of tanks and a pond.

25. Comment is made that venting gas rather than biotreating it to reduce methane production is contrary to the Landfill Sustainability Guide (eg. Beca AMEC page 187). As noted in my landfill concept design report (section 8.9), the amounts of putrescible wastes are small and landfill gas collection would not be economic. However, the suggestion that the gas could be biotreated (which would be done by using composts and mulches to oxidise emissions through the landfill cap) could be examined as part of detailed design.

5. Summary of opinions on Tamar River water supply pipeline crossing

5.1 Crossing options

The available crossing methodology options are open trenching, jet trenching, pipe jacking, microtunnelling and horizontal directional drilling.

(a) Pipe jacking

Pipe jacking is a generic term for pushing a pipe through undisturbed ground. It is only suited for soft ground but directional control is difficult for very soft material. Concrete shafts (probably approximately 7 m diameter) would need to be installed to the depth of the rock layer that underlies the estuarine silt, approximately 10 m below natural ground level.

A jacking machine would be installed in one of the shafts and the pipe would be pushed through the silt across to the other side of the estuary, with pipe sections progressively added inside the shaft. Silt would be removed from inside the pipe as it lengthened.

Because the silts are very soft, directional control would be problematic, particularly given the length of the crossing. The available space to install a vertical shaft on the eastern bank of the estuary is very limited due to the proximity of the East Tamar Highway to the estuary bank. There is a high risk that excavating such a large structure in close proximity to the highway would lead to instability of the highway embankment. These concerns have been confirmed in a letter to Gunns from the Department of Infrastructure, Energy & Resources, which is attached to my Tamar crossing report in Appendix 56 of the *Draft Integrated Impact Statement*.

I do not consider pipe jacking to be a viable option.

(b) Microtunnelling

Microtunnelling is a guided pipe jacking method and was proposed by Atteris in their report to Gunns. Concrete shafts (approximately 7 m diameter) would need to be installed to the depth of the rock layer that underlies the estuarine silt, approximately 10 to 15 m below natural ground level.

A tunnel boring machine would then be lowered into one of the shafts and jacked against the shaft side while it bores the tunnel. Jacking pipes are inserted into the tunnel behind the boring machine to form the pipeline. The available space to install a vertical shaft on the eastern bank of the estuary is very limited due to the proximity of the East Tamar Highway to the estuary bank.

There is a high risk that excavating such a large structure in close proximity to the highway would lead to instability of the highway embankment. These concerns have been confirmed in a letter to Gunns from the Department of Infrastructure, Energy & Resources, which is attached to my Tamar crossing report in Appendix 56 of the *Draft Integrated Impact Statement*.

I do not consider microtunnelling to be a viable option.

(c) Horizontal directional drilling

Horizontal directional drilling would involve drilling a directionally guided pilot hole from one side of the estuary to the other, through the rock that underlies the estuarine silt. This hole would then be back reamed to expand the hole to the 1 m plus diameter needed. The water pipeline would then be pulled or pushed through the reamed hole.

After consultation with Dr Pollington about the results of the geotechnical drilling results, I concluded that directional drilling through the conglomerate rock would not be feasible. This is due to the nature of the conglomerate rock, which in many places has a low competency. This would mean that the drill head could easily be jammed or diverted from its intended course by rock spalls breaking off at the drilling face. The low rock competency also creates a significant risk of a blowout of the drilling fluids into the surrounding environment (these fluids are pumped into the drill hole under hydrostatic pressure to maintain the hole open during drilling).

Obtaining a suitable footing for the pulling or pushing apparatus would be difficult due to the space constraints on the eastern bank of the estuary and the soft soils on the western bank. I am also not aware of any horizontal directional drilling installations that have installed such a large pipeline (1 m diameter) over such a large distance (300 m).

I do not consider horizontal directional drilling to be a viable option. This conclusion agrees with that of Atteris in their report to Gunns.

(d) Open trenching

Open trenching would involve removing silt along the crossing alignment to the burial depth of the pipeline. To maintain an open trench, the trench would need to be wide enough to stand open against the natural tendency of the silt to settle to its angle of repose (14^o underwater and 5^o in intertidal areas). The trench width would need to be at least 50 m underwater and 100 m in intertidal areas.

Approximately 30,000 m^3 of silt would need to be removed and permanently stored on the river banks (backfilling the silt into the trench would not be viable due to its slow settling characteristics). Backfilling would need to be with rock, which would settle through the underlying silt, making backfilling problematic.

I do not consider open trenching to be an environmentally acceptable option.

(e) Jet trenching

Jet trenching (the form proposed in my Tamar crossing report) would involve floating the pipeline across the estuary then sinking it onto the silt bed. A water jetting machine would then run back and forth along the pipeline, fluidising the silts in the vicinity of the pipe. The pipe would then settle through the fluidised silts until the desired depth is reached.

Jet trenching requires no removal of silt, although the silt disturbance would lift some silt into suspension, where it would be carried down current.

I concluded that jet trenching is the only option that would be viable and environmentally acceptable.

5.2 Tamar River silt

There is a long history of silt dredging in the Tamar River, and a large number of studies of silt behaviour have been undertaken over the last 20 to 30 years. These studies provide a sound foundation upon which the potential impacts of the pipeline installation can be assessed.

I understand that the Launceston City Council has commissioned WBM Oceanics Australia to develop a three dimensional numerical model of the Tamar River to allow predictions of silt movements, to assist the management of the ongoing Tamar dredging program. From my discussions with Council, I understand that this model may be serviceable early in 2007.

In the current absence of a sophisticated three dimensional numerical model for the estuary, I used a simple two dimensional model to calculate the potential worst case extent and concentrations of the silt plume that might develop during the jet trenching activities. I consider it to be worst case because I conservatively assumed that 20% of disturbed silt will be lifted into suspension and that none of that suspended silt will settle during the modelling period. The model calculates the dilution of concentrations with distance from the jetting machine due to spreading downstream and across the estuary. In my opinion, the actual concentrations would therefore be less than those predicted by the model but the model is useful to provide order of magnitude concentrations for comparison with concentrations from natural scour events.

Under my conservative assumptions, I calculated that each pass of the jet trenching machine along the pipeline could resuspend 190 m^3 of silt and that concentrations of suspended silt downstream could be in the order of 400 to 500 mg/L.

These concentrations are considerably higher than typical concentrations experienced in the estuary.

A submission has pointed out that in my Tamar crossing report I inadvertently read the wrong value from Figure 5 into my text (figure is on page 12 and text is on page 36 of the Tamar crossing report, Appendix 56 of the DIIS) to state that typical silt concentrations in Tamar water range from 100 to 400 mg/L. The correct range is 25 to 200 mg/L. This is supported by data provided to me by the Environment Division of the Department of Tourism, Arts and Environment which shows, for example, a median concentration of 41 mg/L and a 95%ile concentration of 85 mg/L during a December 2003 to March 2005 monitoring period at a site in the vicinity of the Trevallyn power station tail race.

However, my error does not affect my conclusion that concentrations of 400 to 500 mg/L would not be exceptional relative to concentrations that might occur during occasional natural flood scouring of the silt bed.

Scouring occurs only when the river flow exceeds approximately 180 cumecs. Flows of this magnitude occur only 2 to 3 times a year on average. Over the whole of the Environment Division's monitoring period, for example, the scour threshold was exceeded only 10 times, based on flow data provided to me by Hydro Tasmania, and never coincident with a monitoring run.

During the Environment Division's monitoring period the peak concentration was 277 mg/L. In the days preceding this high value, the South Esk discharge was approximately 80 cumecs, less than 50% of the scour threshold of 180 cumecs. The fact that suspended silt concentrations can reach 277 mg/L even without silt scour supports my conclusion that concentrations of 400 to 500 mg/L would not be exceptional relative to concentrations following scour.

The amount of silt likely to be released during the crossing construction would in my opinion not be exceptional relative to natural scour events but the construction silt release would occur at times of low river flow whereas the natural scour releases would occur at the occasional times of high river flow. The concentrations of suspended silt will show a similar pattern. Concentrations will be high during and after (until the silt has resettled) the occasional scour events and the crossing construction but will be much lower for most of the year, in between those occasional events.

5.3 Silt suspension mitigation options

I have considered the potential use of silt curtains, settling ponds and thickeners to reduce the amount of silt that enters suspension during the crossing construction. I have concluded that none are viable.

Silt curtains cannot safely or practically be deployed in current velocities greater than about 0.5 m/sec. Even without river flow, peak tidal velocities in the Tamar are 0.67 m/sec, and even with low river flow could readily exceed 1 m/sec.

Settling ponds would require the permanent alienation of an area of approximately 140 x 140 m of land (nominal). The only available land in the vicinity is freehold land. Permanent alienation of freehold land to achieve a questionable environmental benefit for a transient environmental issue is in my opinion unwarranted and unjustifiable. The available land would also be vulnerable to flooding, which would return the silt into suspension. The use of settling ponds for jet trenching would also be problematic because it would require suspended silt to be sucked from the estuary as it becomes suspended by the action of the jetting machine. Even if this could somehow be achieved, it inevitably would also suck in additional water, increasing the total volume of silt recovered, and hence increasing the required size of the settling ponds beyond the above nominal figure.

A previous study commissioned by the Tamar River Improvement Committee estimated that the cost of a thickener sized to deal with 5 tonnes of silt per hour would be in the order of $2 to 3 million (dewatering in a thickener typically involves gravity acting on the density difference between the solid particles and the carrier water, enabling the solid particles to settle). The crossing construction could generate silt at 10 times this rate. A thickener sized to deal with this rate would be prohibitively expensive and would also only achieve a questionable environmental benefit for a transient environmental issue. In my opinion, use of a thickener is unwarranted and unjustifiable. The use of a thickener for jet trenching would also be problematic because it would require suspended silt to be sucked from the estuary as it becomes suspended by the action of the jetting machine. Even if this could somehow be achieved, it inevitably would also suck in additional water, increasing the total volume of silt recovered, and hence increasing the required size of the thickener.

In my opinion, the only practical option to reduce suspended silt concentrations would be to time the use of the jet trenching machine to coincide with the optimum settling conditions. From my calculations, I have concluded that the first passes of the machine should be timed to coincide with the start of the ebb tide so that silt will be carried downstream, where it will gradually settle out in the Tamar delta, as natural suspended silt does. A much more refined examination of the optimum timing will be possible when the WBM Oceanics Australia hydrodynamic model becomes available and such an examination could be undertaken as part of the detailed crossing design.

I do not believe that the disturbance and suspension of silt during the crossing construction will have a significant environmental impact because occasional scouring and silt plumes are a natural phenomenon in the Tamar River. The benthic biota in the vicinity of the crossing is dominated by opportunistic species well adapted to disturbance and recolonisation. The wetland ecosystems in the areas where the suspended silt is likely to settle out have been created by natural silt deposition in the first instance, and the additional deposition from a short term artificial generation of silt will have no significant consequence.

Due to historical activities in the catchment of the Tamar River, the Tamar silt is contaminated, particularly by heavy metals. In my opinion, the exposure of biota to this contamination due to the crossing construction will not be significantly different to the exposure that would occur due to natural scour events.

5.4 Response to RPDC's Beca AMEC report

The RPDC has received a report from its advising consultants, Beca AMEC: *Gunns IIS Peer Review IU01 of Gunns Limited Bell Bay Pulp Mill Draft Integrated Impact Statement (Rev 01 October 2006).*

I provide responses to matters raised in that report relating to the Tamar crossing below.

1. Comment is made that an explanation should be provided as to why Appendices 26, 44 and 56 are in apparent contradiction over the construction methodology to be used for the Tamar crossing (eg. Beca AMEC page 178). Of these reports, I am only the author of Appendix 56 but presume that the differences are due to different timing of the production of the different reports in the concept design process.
2. An explanation is sought as to why the "least friendly" (in Beca AMEC's opinion) of the three methodology options has been selected (eg. Beca AMEC page 178). A discussion of the rationale for the selection of jet trenching over other options is provided in section 3.1 of my Tamar crossing report.

6. Summary of opinions on alternatives

6.1 Landfill

The site nominated by Gunns was one of three that had been identified approximately 10 years ago by the (formerly) Department of Environment and Land Management's Bell Bay Baseline Environmental Monitoring Program. I was aware of these three sites because during the time of the Program I was Director of Environmental Management in that Department.

I identified another candidate site as being adjacent to the George Town Municipal Tip, located at the foot of Mount George, bringing the total of candidate sites to four.

I also considered a number of more general alternative locations for the landfill, these being: adjacent to the pulp mill; on Cimitiere Plain (north of George Town); east of the Tippogoree Hills; between East Arm and the Batman Bridge; on the opposite shore of Long Reach (Rowella); and, at Big Bay. I dismissed these sites from being candidates due to either unsuitable geology, conflict with other components of the pulp mill, transport distances or potential environmental impact.

For the four candidate sites, I prepared a site description matrix and a weighted multicriteria site comparison matrix, which are respectively provided as Appendices B and C to my landfill concept design report. The criteria used for the comparison included those specified in the Guide for the Siting, Design, Operation and Rehabilitation of Landfills 2004. Based on the multicriteria analysis I concluded that the site nominated by Gunns was the most suitable.

The landfill concept design is based on an assumption of no beneficial reuse of waste. I understand, however, that Gunns may beneficially reuse some of the process waste rather than disposing of it to landfill. In my opinion, this is an appropriate alternative use of that waste.

6.2 Tamar River water supply pipeline crossing

I was not involved in the engineering consideration of the pipeline alignment. However, in my opinion:

- there is no practical alternative but for a water supply pipeline from Trevallyn Dam to Bell Bay to cross the Tamar River.
- there is no practical alternative but for a pipeline crossing of the Tamar River to be buried in or under the estuarine silts.
- the selected crossing site is the most practical.

The only potentially practical construction options are open trenching or jet trenching. I consider open trenching to be problematic due to the physical characteristics of the silt, which would require the construction of an open trench 50 m wide in subtidal areas and 100 m wide in the intertidal areas, and due to the consequential environmental impacts. In my opinion, jet trenching is therefore the preferred construction method.

7. Management recommendations

7.1 Landfill

The design that I present in my landfill concept design report is a concept design. Detailed design and construction should be based on this concept design but design features will need to be confirmed prior to construction.

The already installed groundwater bores and a number of additional groundwater bores should be installed and regularly monitored for water depth and water quality during the operation of the landfill. The additional bores should not be installed until the final design of the landfill is completed, so as to ensure that they can be optimally located with respect to the landfill structures.

Groundwater investigations undertaken to date have established that while the *Sustainability Guide for the Siting, Design, Operation and Rehabilitation of Landfills 2004*'s desirable separation distance between the landfill liner and the water table is readily achieved at the head of the landfill it may not be achieved at the foot of the landfill. Ongoing monitoring will be required over the first approximately 8 years of the landfill's life prior to the construction of the lowermost cell to determine whether special engineering, such as an underlying drainage layer, is required for that cell.

Prospective suppliers of geosynthetic clay liners should be required to demonstrate that their offered liner can withstand the high alkalinity and chemical nature of the pulp mill's leachate. This testing will need to be undertaken using a synthesised leachate. In the unlikely event that no geosynthetic clay liners satisfy the test, a 1 m constructed clay liner would need to be used instead. On the basis of site investigations undertaken to date, there is unlikely to be adequate reserves of suitable clay on site and the clay would need to be sourced from elsewhere.

The Mitigation Management Plan for the landfill construction, contained in Volume 4 of the DIIS, should be implemented.

7.2 Tamar River water supply pipeline crossing

Detailed design and construction should be based on jet trenching methodology.

As part of the detailed design of the crossing, the WBM Oceanics Australia hydrodynamic model of the Tamar River could be used if and when it becomes available, to refine the optimum timing of construction relative to tides and river flows so as to maximise the settling rate of suspended silt. The model could also be used to inform the selection of silt plume monitoring locations.

To avoid the inadvertent relocation of the pest species, including mosquito fish and rice grass, from the Tamar to other water bodies, the jet trenching machine should be washed free of mud, silt and vegetation prior to removal from the crossing site to another location.

All machinery should be operated with appropriate controls to prevent pollution of waters by oils and other pollutants.

The Mitigation Management Plan for the water supply pipeline construction, contained in Volume 4 of the DIIS, should be implemented.

8. Conclusions

8.1 Landfill

1. The concept design for the landfill meets the best practice design guidelines of the Tasmanian *Sustainability Guide for the Siting, Design, Operation and Rehabilitation of Landfills 2004.*
2. As with all landfills, there will be some leakage of leachate through the cell liners but predicted leakage rates are an order of magnitude lower than the Victorian EPA's *Best Practice Environmental Management Siting, Design, Operation and Rehabilitation of Landfills* recommended maximum leakage rates.

3. The concentration of substances in the leachate that are considered to be ecosystem toxicants require an order of magnitude dilution to be below applicable *ANZECC Guidelines for Fresh and Marine Water Quality 2000* trigger values for ecosystem protection (99% of species), which will be achieved within a few metres of any leakage point.
4. Transport of any leaked leachate in groundwater will lead to further dilution and the concentration of ecosystem toxicants that may over time reach the Tamar River will be several orders of magnitude lower than the *ANZECC Guidelines for Fresh and Marine Water Quality 2000* trigger values for ecosystem protection (99% of species).
5. The *ANZECC Guidelines for Fresh and Marine Water Quality 2000* do not have trigger levels for dioxins. However, the USEPA provides dioxin guidelines for aquatic biota.
6. A very significant mitigation of the environmental risk of dioxins in escaped leachate is the fact that the organic particulates to which dioxins would bind if leachate escaped to groundwater would be quickly filtered out by the passage of groundwater through soil, and are very unlikely to be transported away from the immediate vicinity of the landfill itself. The likelihood of biota being exposed to leachate dioxins is therefore very low.
7. Even ignoring the filtering of particulates through the soil, using the lowest of the guideline values, a leachate dilution of 625 times, less than three orders of magnitude, is required to reduce the expected 5 pg TEQ/L in the leachate to the most sensitive USEPA guideline of 0.008 pg TEQ/L guideline for protecting mammals. The nearest potentially affected permanent aquatic ecosystem is the Tamar River. This is approximately 2 km from the landfill. The leachate dilution factor over this distance would be more than three orders of magnitude and dioxin concentrations at the Tamar River would correspondingly be below the most sensitive of the guideline values.
8. Leachate leakage presents no credible significant risk to any ecosystem.

8.2 Tamar River water supply pipeline crossing

1. Jet trenching is the most appropriate construction method for the crossing.
2. The volume and rate of silt disturbance and the consequential suspended silt concentrations during construction will not be exceptional relative to what occurs during natural scour events but the crossing construction will occur at a time of low flow whereas natural scours occur at times of high flow.
3. Benthic biota disturbed during the crossing construction are naturally adapted to physical disturbance, and therefore will not be significantly impacted.
4. Disturbed silt will gradually settle out, predominantly in the wetland and delta areas of the estuary, as occurs following natural scours. These ecosystems have been created by silt deposition and the additional

deposition due to the crossing construction will have no significant consequence relative to natural deposition events.

9. Provisional opinion

The opinions that I have expressed in this statement are based on my experience and the experience and advice provided to me by Gunns and the consultants engaged to carry out specialist studies for the Bell Bay Pulp Mill Project. Subject to any limitations and exclusions identified in this statement, my opinions are complete and accurate in every respect.

I am satisfied through my inquiries that the opinions I have expressed are reasonable in regard to my involvement with the concept design of the landfill and the assessment of the Tamar crossing of the water supply pipeline.

10. Declaration

I have made all the inquiries that I believe are desirable and appropriate and no matters of significance which I regard as relevant have, to my knowledge, been withheld from the Commission.

Dr Ian Woodward

12 January 2007

Attachment 1

Qualifications

See attached CV

Curriculum Vitae
Ian Woodward
Principal Environmental Scientist

Date of Birth: 26 January 1958

Nationality: Australian

Education:
Bachelor of Science (First Class Honours)
Doctor of Philosophy (Zoology - Mathematical Ecology)

Language & Degrees of Proficiency:
English - fluent written and spoken

Professional Development and Memberships:
Environmental Institute of Australia

Countries of Work Experience:
Australia

Key Skills:
Ian Woodward joined Pitt & Sherry in 1998 as Principal Environmental Scientist from his position as statutory Director of Environmental Management and General Manager Environment and Planning with the Tasmanian Department of Environment and Land Management.

As statutory Director of Environmental Management and member of the Board of Environmental Management and Pollution Control, Ian was the primary decision making authority for environmental approvals, management and regulation in Tasmania. Ian held similar responsibilities for the North Coast region of NSW as Regional Manager with the NSW Environment Protection Authority.

Ian was also a member of numerous high level environmental and planning committees, including the National Environment Protection Council, the Sustainable Development Advisory Council (now the Resource Planning and Development Commission), the Marine Farm Planning Review Panel, the Agricultural and Veterinary Chemicals Advisory Council, and the National Oil Spill Contingency Plan Advisory Committee.

Ian has strong skills in environmental policy and regulation, environmental modelling, mathematical ecology, data analysis and scientific report writing.

With Pitt & Sherry, Ian has lead the environmental assessment of numerous projects, and has a widely recognised reputation for preparing rigorous and high quality environmental assessment reports and environmental management plans, and for providing sound strategic environmental policy, planning and approval advice.

EXPERIENCE:

29 June 1998 to present – Principal Environmental Scientist, Pitt & Sherry
Primary Tasks:

- Undertake and/or manage environmental investigations and assessments for a wide variety of development projects, including wastewater treatment plants, landfills, mine sites, roads, bridges, subdivisions, industrial developments, transmission lines and pipelines, including:
  - Ranelagh, Dover, Lewisham and Cambridge wastewater treatment plants
  - Geeveston, Burnie, Whitemark, Lady Barron, Killiecrankie, Lackrana, Mangalore, Copping, Hobart, Glenorchy and Baretta landfills
  - Preparation of Code of Practice for Siting, Design, Operation and Rehabilitation of Landfills in Tasmania
  - Hercules, Bischoff, Savage River mines waste rock dumps and tailings dams
  - Tamar and North Esk dredging optimisation and scour impact study
  - Bass and West Tamar highways, Ipswich motorway
  - Sorell, Bridgewater and Leven River bridges
  - Scamander Sanctuary subdivision
  - Boags boiler upgrade air emission modelling
  - Basslink and Waddamana-Risdon Vale transmission lines
- Technical review and authorisation of Pitt & Sherry environmental reports
- Preparation and authorisation of planning approval supporting documentation.

23 June 1997 to 26 June 1998 – Director of Environmental Management and General Manager Environment & Planning, Tasmanian Department of Environment and Land Management (State Executive Service Band 2)
Primary Tasks:

- Provide high level strategic advice to the Minister, Secretary and Central State Service Agencies on a range of issues which have strategic and/or critical impact on both government policy and corporate objectives.
- Plan, manage and coordinate the delivery of a complex and extensive range of activities including statutory, operational, client service, employee relations and resource management.
- Provide leadership to Managers within the Division, ensuring that their roles are focussed on delivering best practice in resource management and service delivery/performance and compliance with the principles of Equal Employment Opportunity.
- Ensure that efficient, effective and equitable customer focussed services are delivered to internal and external customers by the Division.
- Contribute as a member of the Corporate Management Group to the Agency's policy development, operational management, strategic planning, and direction.
- Liaise with other Government Agencies and contribute proactively to whole-of-Government issues.
- Represent the Agency and the Secretary and be a strong advocate for Agency and Government policy across a wide range of forums in high level, complex and often sensitive negotiations encompassing a variety of issues affecting both the Agency and the Government of the day.
- Manage the Division, comprising 74 permanent staff with an annual Consolidated Fund operating budget of $7.5 million within a total Environment and Planning Output of 108 staff and a budget of $11.8 million.
- Perform the statutory duties of Director of Environmental Management and Chairperson State Marine Pollution Committee (and State Oil Spill Commander).
- Member of statutory committees: Board of Environmental Management and Pollution Control; Agricultural and Veterinary Chemicals Advisory Council; Marine Farming Planning Review Panel.
- Other Committee membership included:
- National Plan Advisory Committee
- Sustainable Development Advisory Council
- Sustainable Development Advisory Council - State of the Environment Panel
- State Coastal Policy Advisory Committee
- State Policy on Water Quality Management Steering Committee (Chair)
- Strategic Planning Directions Steering Committee (Chair)

19 February 1996 to 22 June 1997 Manager Environmental Operations, Division of Environmental Management, Tasmanian Department of Environment & Land Management (State Executive Service Band 1)

Primary Tasks:

- Provide high level policy advice to Government and Board of Environmental Management and Pollution Control.
- Manage the human, physical and financial resources of the Environmental Operations Branch, including:
- Development assessment
- Monitoring and enforcement of environmental performance
- Liaison with industry and other stakeholders
- Provision of technical advice
- Committee membership included:
- Savage River Redevelopment Negotiating Task Force
- Radiation Store Expert Committee
- Waste Management Advisory Committee
- Environment & Planning Sustainable Development Review Team (Chair)
- Marine Farm Environmental Advisory Committee

11 April 94 to 5 February 1996: Regional Manager North Coast, New South Wales Environment Protection Authority (Environment Protection Officer Band 13)

Primary Tasks:

- Accountable for the management and coordination of the activities of the region, for the development and implementation of regional planning and strategic policy, implementation of pollution reduction programs, enforcement of EPA environmental legislation, authorisation of EPA statutory instruments and for the delivery of service to the community, regional industry and local authorities.
- Plan the region's work program to meet key outcomes, monitor progress in relevant areas and took remedial action where necessary. Developed regional targets and performance indicators and contributed to the Operation Division's input to the EPA's Corporate Plan.
- Contribute to Division planning and input into relevant policies/procedures developed either in Operations Division or in other Divisions of the EPA.
- Provide advice to other parts of EPA, to senior management, and to Minister's Office through Regional Director.
- Participate in region's public and media interface on EPA environmental management issues, under broad direction of Regional Director and consistent with EPA policy.
- Responsible for regional planning, strategy development and implementation of major issues that impact and affect the region. Key activity areas included:
- Regional Environment Improvement Plans
- Total Catchment Management planning and land degradation issues
- Economic mechanisms
- Waste management strategies
- Compliance audit strategies
- Regional education and community liaison programs
- State of Environment Reporting
- Strategies developed to address specific major regional issues, eg. sewage treatment, intensive agriculture, specialised industry, forestry, etc.
- Supervise approximately 20 staff
- Committee membership and involvement included:
- Nambucca Catchment Management Committee
- Clarence Catchment Management Committee
- Brunswick Catchment Management Committee
- Macleay Catchment Management Committee
- Clarence Estuary Management Committee
- Woolli Estuary Management Committee
- Trial Bay Steering Committee
- NSW North Coast Regional Planning Steering Committee
- Acid Sulphate Soils Management Advisory Committee

- Cattle Tick Dip Management Advisory Committee
- Contaminated Agricultural Lands Management Advisory Committee
- Baryugil Asbestos Mine Steering Committee
- WWTP Planning focus meetings & value management studies

11 March 1993 to 4 April 1994: Manager Studies and Investigations, Division of Environmental Management, Tasmanian Department of Environment & Land Management (S120 Award, Class A(2)V-1/V-2 [top of Scientific Award])

Primary Tasks:

- Co-ordinate the investigation of all environmental complaints and incidents within the state. Managed the investigation of major environmental incidents.
- Co-ordinate the design, implementation, review and interpretation of monitoring programs in order to provide timely advice and support to other branches of the Division.
- Prepare and supervise the preparation of Ministerial correspondence and Ministerial briefings.
- Represent the Department on committees and at meetings withindustry and other tiers of Government.
- Monitor the development of monitoring, analytical and incident response procedures in other jurisdictions.
- Supervise approximately 20 staff and manage Branch resources and the Division's laboratory.
- Committee membership included:
  - Program Management Committee - Huon River Sustainable Development Strategy
  - Scientific Reference Group - Huon River Sustainable Development Strategy
  - Atrazine Technical Working Group
  - State Assessment Panel - National Landcare Program
  - Macquarie Harbour/King River Steering Committee
  - Toxic Algal Bloom Task Force
  - Monitoring River Health Steering Committee
  - Orielton Lagoon Remediation Advisory Committee
  - Coastal and Marine Steering Program
  - Inter-Departmental Catchment Working Group

4 December 1989 to 8 March 1993: Senior Management Officer (Marine Farming), Division of Sea Fisheries, Tasmanian Department of Primary Industry & Fisheries (SO76 Award, Class IV-I/IV-2)

Primary Tasks:

- Responsible for the overall regulatory functions of the Department as they applied to the administration and management of the marine farming industry.
- Member Marine Farm Management Committee.
- Advise Minister on marine farm applications and management issues.
- Represent Minister as expert witness in marine farm appeals.
- Develop policy, administrative procedures and draft legislation relating to the management of the marine farming industry.
- Develop and maintain GIS database for marine farm administration.
- Supervise marine farm environmental monitoring program.
- Supervise 3 administrative staff and 5 field staff around the state.

27 February 1989 to 3 December 1989: Manager Finfish, Marine Farming Branch, Tasmanian Department of Sea Fishers (SO76 Award Class IV)

Primary Tasks:

- Design, implement and supervise Tasmania's environmental program monitoring for growing waters in and around marine farms.
- Supervise finfish aquaculture research and development.
- Develop numerical current modeling software to predict current movements in bays and estuaries in south east Tasmania.
- Supervise 11 research staff and 3 administrative staff.

6 April 1988 to 26 February 1989: Manager Finfish Farming, Marine Farming Branch, Tasmanian Department of Sea Fisheries (SO76 Award, Class III)

Primary Tasks:

- Supervise the Department's environmental program monitoring for growing waters in and around marine farms.
- Develop computer software for the capture and analysis of current monitoring data.
- Develop numerical (2D finite difference) current modeling software to predict current movements in bays and estuaries in south east Tasmania.
- Supervise 11 research staff and 3 administrative staff.

3 February 1988 to 5 April 1988: Post-Doctoral Fellow Marine Biologist, Marine Farming Branch, Tasmanian Department of Sea Fisheries (SO76 Award, Class II)

Appointed as research fellow for research project assessing impact of salmon farming on the environment. Shortly thereafter a Department restructure led me to be invited to fill the above position from which I supervised this position.

3 September 1987 to 2 February 1988: Senior Research Officer (Aquaculture), Marine Farming Branch, Tasmanian Department of Sea Fisheries (SO76 Award, Class III)

Responsible for supervising all aquaculture research projects covering a wide variety of fields. Designed and obtained funds for a research project to assess the impact of salmon farming on the environment.

1 November 1985 to 2 September 1987: Fisheries computer and statistical consultant with own company, Iotas Pty Ltd

Developed computer software for aquaculture industry. Publisher of Fisheries Software Register. Employed as consultant by Department of Sea Fisheries on a FIRTA Grant for 12 months analysing catch and effort data for the south western sector of the Australian southeast trawl fishery.

1 January 1985 to 31 October 1985 Fisheries Mathematician, Tasmanian Fisheries Development Authority

Undertook numerical analysis of catch statistics. Provided analytical support to research scientists. Developed a corporate plan for the Authority's future computing and statistical requirements.

1980-84 – Demonstrator in the Zoology Department, University of Tasmania

1979-80 – 4 months vocational employment on jarosite program in the Research Division of the Electrolytic Zinc Company of Australasia (now Pasminco Metals Hobart)

1977-79 – Mathematics and biology tutor for high school students

GRANTS:

1986/87 Fishing Industry Research Trust Account (FIRTA) Grant to my company, Iotas Pty. Ltd. for the establishment of an Australia wide register for the collection and dissemination of fisheries computer software ($24,000).

PUBLICATIONS

1. Woodward, I.O. and White, R.W.G. (1981) Effects of temperature and food on the fecundity and egg development rates of *Boeckella symmetrica* Sars (Copepoda: Calanoida). *Aust.J.Mar.Freshw.Res.* **32**: 997-1002.
2. Woodward, I.O. (1982) Modelling the lineage of a growing population as an age-dependent branching process. *Aust.J.Ecology* 7: 389-394.
3. Woodward, I.O. (1982) Modelling population growth in stage grouped organisms: a simple extension to the Leslie model. *Aust.J.Ecology* 7: 389-394.
4. Woodward, I.O. and White, R.W.G. (1983) Effects of temperature and food on instar development rates of *Boeckella symmetrica* Sars (Copepoda: Calanoida). *Aust.J.Mar.Freshw.Res.* 34:927-932.

5. Woodward, I.O. (1986) The construction and analysis of life tables for natural populations in G.D. McLean, R.G. Garret and W.G. Ruesink (eds) *Plant Virus Epidemics: Monitoring, Modelling and Predicting Outbreaks*, pp. 217-248. Academic Press.
6-17. Woodward, I.O. (1986-87) *Fisheries Software Register*, Vol. 1-12 (editor and publisher).
18. Woodward, I.O. (1987) An analysis of catch statistics from the south-western sector of the Australian South-east Demersal Trawl Fishery. *DSF Tech.Rep.* 23, 90pp.
19. Woodward, I.O. (1989) Finfish farming and the environment: a review. *DSF Tech.Rep.* 35, 43 pp.
20. Woodward, I.O. (1989) Code of Practice for Finfish Farming. *DSF Public Discussion Paper*, 24 pp.
21. Woodward, I.O. (1989) *Hole in Water*, Pan Books, 96 pp. (fiction - nominated for Australian Children's Book Council Awards 1990).
22. Woodward, I.O. (1989) Management issues for the Tasmanian marine farming industry. *Paper presented to Royal Australian Institute of Planners Workshop*, November 1989.
23. Woodward, I.O., Gallagher, J.B., Rushton, M.J., Machin, P.J. and Mihalenko, S. (1992) Salmon farming and the environment of the Huon estuary, Tasmania. *DSF Tech.Rep.* 45, 58 pp.
24. Woodward, I.O. (1992) Bonamia. *DPI Information Bulletin*, 25 pp.
25. Woodward, I.O. (1992) Future management and regulation of the marine farming industry. *Submission to RAC Coastal Inquiry and Public Discussion Paper*, 59 pp.
26. Woodward, I.O. (1994) State of the Environment Reporting. Paper presented to *NSW North Coast Vegetation and Biodiversity Workshop*, Lismore, August 1994.
27. Woodward, I.O. (1994) Role of the NSW Environment Protection Authority in Environmental Education. *Paper presented to NSW North Coast Environmental Education Workshop*, Grafton, November 1994.
28. Bingham, R.E. and Woodward, I.O. (1995) Tasmanian approaches to environmental offences.*Australian Institute of Criminology Proceedings* 26, pp. 49-56. *Paper presented by IOW to National Environmental Crime Conference*, Hobart, September 1993.
29. Woodward, I.O. (1995) Lessons from a community consultation process overseeing the remediation of hydrocarbon contamination of groundwater. *Paper presented to NSW EPA Conference*, Sydney, May 1995.
30. Woodward, I.O. (1995) Environment Protection Authority objectives and directions. *Paper presented to NSW State Chamber of Commerce Workshop*, Coffs Harbour, July 1995.
31. Woodward, I.O (1995) The EPA's approach to water management. *Paper presented to NSW Department of Water Resources Conference*, Lismore, September 1995.
32. Woodward, I.O. (1996) Best Practice Environmental Management. *Paper presented to Tasmanian Environmental Auditing and Management Systems Conference*, Launceston, 1996.
33. Woodward, I.O. (1997) Environmental Rights and Responsibilities. *Key Note Address, Tasmanian International Aquaculture Exchange*, Hobart, July 1997.
34. Vandenberg, J., Goldstone, M., & Woodward, I. (1997) New mine for old – the redevelopment of the Savage River iron ore resource. *Paper presented to the Sustainable Economic Growth in Regional Australia Conference*, Geelong, September 1997.
35. Woodward, I.O. (1998) Position paper for the Tasmanian Agricultural and Silvicultural Chemicals Advisory Council. *Draft paper prepared for ASCHEM Council.*
36. Woodward, I.O. & Todd, J.T. (1998) Discussion Paper and Proposed Policy for an Air Quality Management Policy for Tasmania. *Paper prepared for Department of Primary Industries, Water & Environment.*
37. *Woodward, I.O. (2001) Submission on Draft Marine Farming Development Plan for Pittwater.* Paper and oral presentation prepared for Sorell council for submission to Marine Farm Planning Review Panel.
38. Woodward, I.O. (2002) *Cradle Mountain Tourist Road.* Paper presented to IEAust National Conference – Engineering a Sustainable Future.
39. Woodward, I.O. (2003) *The Affordability of Best Practice Environmental Man*agement. Paper presented to the IPWEA National Conference.
40. Woodward, I.O. (2003) Best Practice Environmental Management. Paper presented to the LGAT Councillor Development Weekend.

CONSULTING REPORTS (with Pitt & Sherry, examples)

1. 1998 Review of Effluent Reuse Proposals for the Tasmanian Riverworks Program (Department of Environment & Land Management)
2. 1998 Scoping Development Proposal and Environmental Management Plan for Dover Sewage Treatment Plant Upgrading (Huon Valley Council)
3. 1998 Crest-Multiplex magnesite mine (draft) Development Proposal and Environmental Management Plan
4. 1998 Ranelagh Sewage Lagoon Sewerage Strategy (Huon Valley Council)
5. 1998 PASSLOM – Pitt & Sherry Sewage Lagoon Optimisation Computer Model
6. 1998 Eastern Shore Main Road Network – Summary of Options and Key Outstanding Issues (Department of Infrastructure, Energy & Resources)
7. 1998 Member Tasmanian State of the Environment Standing Committee (Resource Planning & development Commission)
8. 1998 Member Wastewater Reuse Environmental Guidelines Working Group
9. 1998 Tasmanian Alkaloids Wastewater Treatment Upgrading – Development Application Supporting Document
10. 1999 Westbury-Hagley Bypass review of construction environmental management plan
11. 1999 Tamar and North Esk dredging optimisation and scour impact study
12. 1999 Huon Valley Council – Ranelagh Sewerage Strategy
13. 1999 Huon Valley Council – Ranelagh WWTP Upgrade Development Proposal and Environmental management Plan
14. 1999 Department of Primary Industries, Water and Environment – Discussion Paper on an Air Quality Policy for Tasmania
15. 1999 Department of Infrastructure, Energy and Resources – Promoting Sustainable Development in Tasmania
16. 1999 Crest-Multiplex Magnesite Mine Development Proposal and Environmental Management Plan
17. 1999/2000 Environmental Advisor to Basslink Development Board
18. 1999/2000 Pittwater Golf Club Treated Effluent Irrigation Management Plan
19. 2000 Sorell causeway bridge replacement environmental constraints
20. 2000 Sorell causeway bridge replacement geotechnical drilling environmental management plan
21. 2000/2002 Ranelagh sewage treatment plant upgrade
22. 2000/2002 Management of Basslink corridor environmental studies in Tasmania
23. 2001 Submission for Sorell Council against marine farming in southern Pitt Water
24. 2001 Cradle Mountain Tourist Road
25. 2001 Black River bridge replacement environmental impact assessment
26. 2001 Carlton landfill clay liner materials testing for new cell
27. 2001 Peggs Creek bridge replacement environmental assessment
28. 2001/2002 Long Marsh Dam feasibility investigations
29. 2001/2002 Content development for TIGERS Planning Applications Online web site
30. 2001/2002 Dover sewage treatment plant upgrade
31. 2002 Lewisham sewerage scheme
32. 2002 Bridgewater Bridge replacement geotechnical drilling environmental management plan
33. 2002 Code of Practice for Siting, Design, Operation and Rehabilitation of Landfills in Tasmania
34. 2003 Bridgewater Bridge upgrade multicriteria analysis
35. 2003 Bass Highway Penguin to Ulverstone Planning Scheme Amendment, EPBC referral and Development Proposal and Environmental Management Plan
36. 2003 Scamander Sanctuary ecotourism development
37. 2003 Geeveston landfill closure and rehabilitation plan
38. 2003 Burnie (Mooreville Road) landfill extension design assessment of leachate management and controls
39. 2003/05 Land Use Development Applications Online web site
40. 2004 Neal Edwards contaminated site assessment
41. 2004 Impact of materials placement on the Levens Banks landfill
42. 2004 Elwick Racecourse redevelopment noise modelling
43. 2004 Boags brewery second bottling line noise modelling
44. 2004 Burnie sewage treatment plant noise assessment
45. 2004 Vestas Portland blade factory environmental approval advice
46. 2004 Environmental Management Plan for Whitemark, Lady Barron, Killiecrankie and Lackrana Landfill Sites

47. 2004 Cuthbertsons Tannery noise assessment
48. 2004 Sheffield Road noise assessment
49. 2004 West Tamar Highway upgrade noise assessment
50. 2004 Kingston Interchange noise assessment
51. 2004 Frankford Main road vegetation assessment
52. 2004 Mangalore landfill site review of design and environmental management plan
53. 2004 Bryn Mawr Boulevard noise assessment
54. 2004/05 Tasmanian Alkaloids effluent reuse investigation
55. 2005 Leven River bridge replacement geotechnical drilling environmental management plan
56. 2005 Cambridge sewerage options analysis
57. 2005 Leven River Bridge replacement Development Proposal and Environmental Management Plan
58. 2005 Western Approaches to Scottsdale environmental assessment
59. 2005 Environmental risk comparison of Hobart, Glenorchy, Baretta, Copping landfills
60. 2005 Ulverstone Bypass environmental management plan
61. 2005 Ulverstone Bypass traffic noise modelling
62. 2005 Boags boiler replacement air emission modelling
63. 2006 Gunns pulp mill landfill conceptual design
64. 2006 Gunns pulp mill water supply pipeline Tamar River crossing
65. 2006 Gunns pulp mill effluent pipeline shore crossing
66. 2006 Llanherne sand mining Development Proposal and Environmental Management Plan
67. 2006 Cygnet wastewater treatment plant odour buffer modelling
68. 2006 Transend Waddamana to Risdon Vale transmission line environmental assessment
69. 2006 Cambridge wastewater treatment plant Development Proposal and Environmental Management Plan
70. 2006 Goodwood Road traffic noise modelling
71. 2006 Seven Mile Beach aquifer recharge feasibility assessment
72. 2006 Ipswich Motorway Alternative Northern Corridor multicriteria assessment of options