Proceedings of 20th International Congress on Acoustics, ICA 2010

23-27 August 2010, Sydney, Australia

Noise Assessment of a Desalination Plant

Vincent Chavand (1), Craig Evenden (2)

(1) GHD, Newcastle NSW, Australia

(2) GHD, Newcastle NSW, Australia

PACS: 43.50.-x

ABSTRACT

Several desalination plants have been developed in Australia in the last few years. A thorough noise assessment has been undertaken for the reference design of the largest desalination plant in Australia, which is currently being constructed near Wonthaggi, Victoria. The plant is to deliver 150 billion litres of water a year by 2011, with capability to expand to 200 billion litres a year in the future. Operation of the plant also necessitates the construction of an approximately 80 kilometre pipeline and 80 kilometre power supply line. This development is an opportunity to review the environmental noise constraints associated with desalination plants and, in this case, major infrastructures in Australia.

The aim of this paper is to discuss the path to approval of a large-scale industrial noise assessment, from the noise monitoring regime to the iterative modelling process and the identification of noise control measures to meet the project noise targets. Victorian legislation currently in force to control environmental noise impacts is also discussed, in particular the possibility of applying different guidelines and/or policies at different periods of the day.

In this case, noise modelling was undertaken using Cadna-A noise modelling software. This is also the opportunity to present a modelling software package, which is not widely used in Australia at present. Modelling results outlined the noise control measures to be integrated in the plant design in order to meet a set of stringent noise criteria at the nearest sensitive receivers.

PROJECT BACKGROUND

In June 2007, the Victorian Government announced its intention to develop a seawater reverse osmosis desalination plant on the coast near Wonthaggi to augment Melbourne's water supply.

The plant is intended to provide up to 150 billion litres of additional water to Melbourne, Geelong, Westernport and South Gippsland with the potential to expand production to 200 billion litres per year.

Associated infrastructure includes tunnels connecting the plant to marine intake and discharge structures, an approximately 80 kilometre pipeline to connect the plant to Melbourne's water supply system.

The plant is to be powered by underground power cables co-located with the pipeline. The desalination plant will use approximately 90 Megawatts of electricity from the Victorian energy grid.

To date, the Victorian Desalination Project is the largest infrastructure project in the state's history and Australia's largest desalination plant. It will be capable of providing around a third of Melbourne's annual water supply from a source that is independent of rainfall.

The Victorian Government further announced that the Victorian Desalination Project would be delivered as a Public Private Partnership (PPP) under the Partnerships Victoria Policy, and would be operational by 2011.

An Environment Effects Statement (EES) was prepared for the Project. A Reference Project was developed as an integrated response to Performance Requirements developed by the State. It is used in the EES to demonstrate the Project's feasibility and ability to achieve acceptable environmental outcomes.

A noise assessment was conducted to establish the existing conditions of the Project area and, where specific potential impacts or interactions with the environment are identified, provide suggested management recommendations to mitigate the potential impacts that relate to the Reference Project primarily.

OBJECTIVES

The objectives of the Reference Project noise study were outlined in the Final EES scoping requirements (Department of Planning and Community Development, May 2008) as follows:

> Objective: To avoid or minimise to the extent practicable adverse effects on residents' and coastal users' amenity due to noise, dust and related off-site effects during construction and operation of the project.
>
> In relation to the potential effects on the amenity of nearby residents and coastal users, as well as other sensitive receptors, due to noise, dust and related off-site effects during construction and operation of the desalination plant, the EES should:
>
> - Describe current ambient noise conditions in the vicinity of the desalination plant at different periods of the day (24 hours), during varying weekly/seasonal activity periods and under different weather conditions;
> - Estimate the aggregate noise generation from all sources and at different periods during the day (24 hours) associated with the construction and operation of the desalination plant and its intake and discharge infrastructure, and assess the likely levels at sensitive receptors, particularly dwellings; and
> - Describe proposed noise management and mitigation measures during construction and operation of the desalination plant and ancillary infrastructure, to ensure compliance with applicable noise policy (including the Environmental Guidelines for Major Construction Sites (1996); Interim Guidelines for the Control of Noise from Industry in Country Victoria (1989) N3/89; and the SEPP (Control of Noise from Commerce, Industry and Trade) No. N1).

EXISTING ENVIRONMENT

The Desalination Plant site boundary is shown in Figure 1 below.

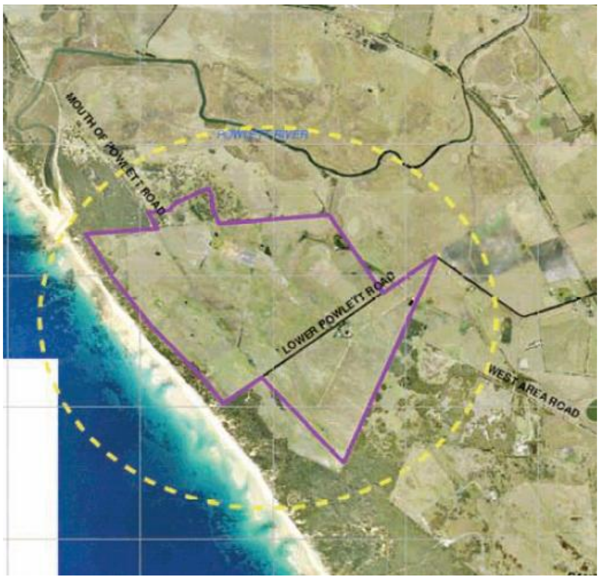

Figure 1 Site Location

The land surrounding the site is a mixture of public land (coastal reserve) and private land (clear farmland). Lower Powlett Road and Mouth of Powlett River Road provide access to the site.

There are scattered rural dwellings to the east and southeast. The township of Dalyston is north of the plant site, while Wonthaggi and Kilcunda townships are west and east respectively.

A total of 12 potentially noise sensitive residences (R1 to R12) have been identified outside the plant site boundary within a distance of 1.5 km of the study area.

Inspections of the study area found primary environmental noise sources to be surf and wind. During periods of low swell and wind, ambient noise was observed to be low. Local industry consists of agriculture (grazing and dairy), with minimal associated noise emissions.

Noise Monitoring

Long-term unattended noise monitoring was conducted at five locations for a period of two weeks with the intention of determining existing background noise levels in the vicinity of the proposed facility. Five locations representative of the site and surrounding receivers were identified (N1 to N5).

As wind and rain are prominent features of the area, noise data recorded during periods when wind speed was over 5 m/s or during periods of rain were excluded from this assessment. Wind and rain influence was accounted for through the installation of weather station on site to provide site-specific meteorological data concurrent to the unattended noise monitoring.

In coastal areas, surf/swell noise can significantly vary depending on conditions. This has been taken into account by tracking swell conditions on a daily basis during the monitoring period and via the placement of one unattended noise logger nearby the shorefront (N3). The resultant information was taken into consideration in the analysis of background noise levels recorded as part of the initial study.

Data obtained from the unattended monitoring regime confirmed that existing ambient noise in the study area is dominated by natural sources.

Specifically, the influence of atmospheric conditions upon the propagation of surf/swell noise appears to dominate the diurnal distribution of ambient noise.

In general, night-time noise levels were seen to be slightly higher and more consistent than day-time levels. Minimum noise levels tended to occur at around 10am and, to a lesser degree, around 4 to 6 pm. These features are related to diurnal meteorological trends, as discussed below:

- Night-Time Noise Levels - During night-time hours, relative humidity increases and radiative cooling of the earth's surface can generate a temperature inversion. Such conditions, if they occur, are conducive to the propagation of noise in the atmosphere. The differences in mean night-time noise levels between the 5 monitoring locations suggest that surf/swell is the dominant noise source during these hours.

- Day-Time Noise Levels – The lower and more erratic noise levels exhibited during daytime hours are believed to be due to two influencing factors. Firstly, increased atmospheric mixing and lower relative humidity (as occur during day-time hours) are less conductive to the propagation of noise (such as from surf/swell). Secondly, wind speed is 2m/s higher (on average) during the day than at night and is therefore more likely to influence noise levels and wind is inherently more variable than swell. As wind generally increases with altitude, wind blowing towards a receiver from the source will refract sound waves downwards, resulting in increase noise levels. Conversely, wind blowing in the opposite direction will refract sound waves upward, resulting in reduced noise levels. Nevertheless, the influence of surf/swell over ambient noise levels is still considered a major factor in the differing noise levels between monitoring locations.

PERFORMANCE REQUIREMENTS

Performance requirements were derived from the Victorian EPA regulations and guidelines in force at the time of the assessment and the findings of site noise monitoring.

Construction Noise Targets

The following EPA guidelines all address construction noise impacts in various ways:

- Where background noise levels are within the limits of N3/89, N3/89 allows an additional 10 dB(A) during the construction period of an industrial facility for the day period only and no adjustments for other time periods;
- Clause 12 of the EPA Noise Control Guidelines (TG 302/92) is relevant to the construction of industrial premises. These guidelines place no restriction on construction noise during normal working hours (07:00 – 18:00 Monday to Friday, 07:00 – 13:00 Saturdays), but require:
    - Construction noise to exceed background by no more than 10 dB(A) outside normal working hours (for up to 18 months after construction commencement);
    - Construction noise to exceed background by no more than 5 dB(A) outside normal working hours (after 18 months duration); and
    - Construction noise to be inaudible inside a dwelling between 22:00 and 07:00.
- TG302/92 allows for construction works to continue through the night when it is a matter of necessity and provided that residents are given notification; and
- Section 5 (Noise and Vibration) of the EPA Environmental Guidelines for Construction Sites is relevant to the construction of major developments. The EPA Environmental Guidelines for Construction Sites outlines the following:

    > While no specific statutory controls exist for noise from construction sites, all noise nuisance should be reduced wherever possible from vehicles, fixed machinery, within the site, blasting, general construction activities, and from movements of vehicles servicing the site.

The above guidelines all have different approaches in dealing with construction noise issues. The noise assessment considered TG302/92 for all receivers. However, where normal work is proposed outside the provisions of the TG302/92 guidelines, specific provisions addressing targetted measures to minimise the impact of noise that might cause sleep disturbance or extreme amenity loss at night are required.

Operational Noise Targets

At the time of the assessment, there were no regulations or State Environment Protection Policies (SEPPs) that imposed industrial noise limits in regional Victoria (i.e. in and around the study area). The EPA Victoria Interim Guidelines for Control of Noise from Industry in Country Victoria (N3/89) were used as a guide to determine operational noise goals applicable at residential premises.

With consideration to the guidance provided in N3/89, the selection of appropriate noise goals for locations in regional Victoria can be summarised as followed:

- For cases where the recorded background sound levels (L_{A90}) at rural locations are very low (i.e. less than 25 dB(A) at night or 30 dB(A) during the day), N3/89 provides a list of the minimum applicable sound level goals for comparison against the effective industrial noise impact (L_{Aeq});
- In cases where the recorded background sound levels at residential locations are comparable to Metropolitan Melbourne, N3/89 makes reference to the procedures for determining noise limits outlined in the SEPP-N1. These limits are also comparable against the L_{Aeq}; and
- Finally, in cases where the recorded background is *not* very low (i.e. *greater* than 25 dB(A) at night or 30 dB(A) during the day), but is *not* considered to be comparable to Metropolitan Melbourne, N3/89 makes no recommendations. The identification of project specific noise goals in such situations is therefore, by necessity, a discretionary decision based on professional judgement between the goals outlined in N3/89 and the SEPP N-1.

Background noise levels (as determined with consideration to SEPP N-1) and applicable regulation (subject to the above discussion) are summarised in Table 1 below.

Table 1 Summary of Background Noise Levels L_{A90} at Monitoring Locations

Monitoring Location	Day	Evening	Night	Applicable Regulation
N1	42	39	38	SEPP N1
N2	37	37	38	SEPP N1
N3	41	42	45	Not applicable (shore front)
N4	33	35	37	N3/89 (Day, Evening), SEPP N1 (Night)
N5	32	34	34	N3/89 (Day, Evening), SEPP N1 (Night)

Based on the above, and an approach agreed with the Victorian EPA, the approach adopted to determine applicable noise criteria for the plant site operational noise emissions was as follows:

- Application of N3/89 for the day-time and evening-time period at all receivers. Although it is noted that SEPP N1 would be applicable during the day-time and evening-time period at receivers representative of monitoring locations N1 and N2, application of N3/89 provides a measure of conservatism and consistency for all receivers; and
- Application of SEPP N1 for the night-time period for all receivers. The SEPP N1 procedure enables determination of criteria based on local zoning and background noise levels.

As a result of the above, project-specific operational noise criteria are outlined in Table 2.

Table 2 Operational Noise Limits dB(A)

Receiver	Representative Monitoring Location	Day	Evening	Night
R1	N1	45	37	41
R2	N1	45	37	41
R3	N2	45	37	41
R4	N5	45	37	40
R5	N2	45	37	42
R6	N5	45	37	39
R7	N5	45	37	39
R8	N5	45	37	39
R9	N5	45	37	39
R10	N5	45	37	39
R11	N5	45	37	39
R12	N5	45	37	39

It should be noted that the noise limits used in the operational noise assessment assume no penalty due to tonality or other character adjustments. Tonality and other character adjustments were recommended to be addressed at detailed design stage with the following consequences if found present:

- Reduced noise limits with consideration to the relevant provisions of SEPP N1; or
- Additional noise control to be integrated to the plant design so as to eliminate tonality and other character adjustments.

CONSTRUCTION NOISE ASSESSMENT

Construction of the plant is to occur over several years. Major construction activities include the following:

- Clearing of vegetation;
- Excavation of the shafts and tunnels;
- General earthworks (including topsoil stripping, excavation, filling, topsoil spreading and rehabilitation works);
- Building construction, including piling of foundations;
- Drainage installation (including, where required, measures to protect water quality and groundwater flows);
- Power connection; and
- Equipment fabrication and installation.

Construction noise impacts associated with the Project were conservatively estimated using a well-known distance attenuation relationship described in Equation (1).

Typical noise levels produced by the types of construction plants anticipated to be used were sourced from Australian standard AS 2436: 1981 *Guide to Noise Control on Construction, Maintenance and Demolition Sites* and from GHD's internal database.

The magnitude of off-site noise impact associated with construction is dependent upon a number of factors, including:

- The intensity and location of construction activities;
- The type of equipment used;
- Existing local noise sources;
- Intervening terrain; and
- The prevailing weather conditions.

In addition, construction machinery typically moves about area construction work site, variously altering the directivity of the noise source with respect to individual receivers. During any given period the machinery items to be used in the study area would operate at maximum sound power levels for only brief stages. At other times the machinery may produce lower sound levels while carrying out activities not requiring full power. It is unlikely that all construction equipment would be operating at their maximum sound power levels at any one time. Finally, certain types of construction machinery will be present in the study area for only brief periods during construction.

Nevertheless, on the basis of night-time background noise levels in the order of 35-40dB(A) (as monitored), calculations indicated that construction noise impacts exceeding background + 10dB(A) would be likely to occur within approximately 400m from a residence.

The issue of potential noise exceedances is practically best addressed by the implementation of a range of noise control measures and monitoring adapted to the construction activities occurring at any one time.

The measures below are generally consistent with TG302/92 and the EPA Environmental Guidelines for Major Construction Sites. They are expected to protect the amenity of local noise and vibration sensitive receivers throughout the construction period. These measures were recommended for incorporation in the Project Construction Environmental Management Plan (CEMP).

Work Ethics / Community Relations:

- Where practicable, all typically noisy construction activities should be kept within the daytime working hours. This includes haul trucks not accessing and leaving site before 7:00 am and after 10:00 pm. This is important to minimise noise impacts at receivers located along Lower Powlett Road;
- All site workers (including subcontractors and temporary workforce) should be sensitised to the potential for noise and vibration impacts upon local residents and encouraged to take all practical and reasonable measures to minimise noise during the course of their activities;
- The constructor or site developer (as appropriate) should establish contact with the local residents and communicate the construction program and progress on a regular basis, particularly when noisy or vibration generating activities are planned;
- Documentation justifying out-of-hours work should be maintained and authorised by site management. Local

residents potentially affected by such activities should be notified before hand;

- The constructor or site developer (as appropriate) should provide a community liaison phone number and permanent site contact so that noise and/or vibration related complaints, if any, can be received and addressed in a timely manner; and

- Consultation and cooperation between the site and neighbours to the site will assist in minimising uncertainty, misconceptions and adverse reactions to noise and vibration.

Construction Program:

- Review work methods with a preference for quieter and non-vibration generating methods wherever possible. This is particularly important for any night-time activities;

- Review fixed and mobile equipment fleet with a preference for more recent and silenced equipment wherever possible. Equipment used on site would typically be in good condition and good working order; and

- Use equipment that is fit for the required tasks in terms of power requirements.

Construction Site Configuration / Equipment Use and Siting:

- Spoil berms should be erected as a priority so they assist in reducing noise impacts throughout the construction period;

- All plant on site should be operated in accordance with the manufacturer's instructions;

- Fixed equipment (i.e. pumps, generators, compressors) should be located as far as practicable from the nearest residences;

- Material dumps should be located as far as practicable from the nearest residences;

- Whenever possible, loading and unloading areas should be located as far as practicable from the nearest residences;

- Equipment which is used intermittently should be shut down when not in use;

- All engine covers should be kept close while equipment is operating; and

- As far as possible, materials dropped from heights into or out of trucks should be minimised.

Night-time Construction Activities:

Where normal work is proposed outside the provisions of the TG302/92 guidelines, the noise mitigation strategy should have specific provisions addressing targetted measures to minimise the impact of noise that might cause sleep disturbance or extreme amenity loss at night.

These measures could include:

- Community engagement prior to commencement with targetted discussion about preferred noise impact minimisation;

- 24 hour hotline for complaints;

- An expert communications officer to liaise with the community and other affected stakeholders;

- Provisions for temporary acoustic barriers (where effective) specifically for noise control;

- Provision for temporary relocation of affected residents for the duration of specific noisy activities; and

- In extreme cases consider offsite attenuation measures such as upgrading glazing.

Vibration Controls:

- Condition Surveys should be undertaken at all potentially impacted dwellings prior to commencement of vibration generating works. These should be repeated at works completion, if it is suspected that cosmetic or structural damage may have occurred.

- Pile Driving and Blasting. Should they be used on site, blasting and pile-driving should be subject to vibration control plans, as they generally are the major sources of vibrations found on construction sites.

Noise and Vibration Monitoring:

- Noise and vibration monitoring should be undertaken by a qualified professional and with consideration to the relevant standards and guidelines. Attended noise and vibration monitoring should be undertaken in the following circumstances:

- When vibration-generating activities are conducted within 30 metres of a residence. Prior to works, establish whether there is a risk for building damage. If a building damage risk is identified, alternative work methods should be implemented so the vibration impacts are reduced to acceptable levels. Monitoring results should be reported;

- Upon receipt of a noise and/or vibration complaint. Monitoring should be undertaken and reported within (say) 3 to 5 working days. If exceedances are detected, the situation should be reviewed in order to identify means to reduce the impact to acceptable levels; and

- Night-time noise measurements should be undertaken on a regular basis during the first few months of the construction works to provide an understanding of acceptable night-time work activities to site management.

OPERATIONAL NOISE ASSESSMENT

Process Overview

The Reference Project is based on desalination by reverse osmosis. This typically involves the following components / processes:

- Tunnel shafts including seawater pumps and intake screens. Seawater from the intake is passed through fine screens prior to pumping to the pre-treatment plant. Once screened the water is lifted by the seawater pump station from below sea level to a distance above sea level, at which the seawater is able to gravitate through the pre-treatment plant;

- Pre-treatment plant. Seawater must be conditioned to ensure it is of a suitably high quality for use in the reverse osmosis plant. The pre-treatment plant process needs to:

- Remove gross solids, seaweed and marine biota;
- Remove turbidity and suspended solids;
- Manage risks from human activities such as oil leaks from shipping; and
- Manage risks from naturally occurring events such as algal blooms.

Pre-treatment processes are typically similar to the processes utilised for treating fresh water (in surface drinking supplies). These include coagulation, flocculation and Dissolved Air Flotation and Filtration (DAFF) treatment of the seawater;

- Reverse Osmosis (RO) plant. Spiral-wound RO membranes are used to remove the salt from the seawater. The RO process is pressure-driven. Filtered seawater feed is pumped up to a point at which the osmotic pressure of the solution is overcome and the water molecules of the seawater are able to pass through the membrane surface (permeate). To achieve the required final treated water, permeate from the first pass can be treated with a second RO system (second pass). The Reference Project includes two passes of typical membranes;
- Potabilisation. Water from the RO process has very low residual hardness or alkalinity, and is therefore considered aggressive to some materials including steel and concrete. Before water is supplied to Melbourne it needs to be stabilised to prevent corrosion of new and existing transfer and storage assets. Potabilisation is achieved by chemical treatment/dosing including carbon dioxide and lime (calcium). Chlorination is also involved to provide disinfection residual in the transfer infrastructure, to minimise biofilm growth and mitigate the risk of recontamination. Fluoride is also added; and
- Transfer Pump Station. In concept, all pumping could occur via the Transfer Pump Station located at the desalination plant site. However, this would mean high pressures at the start of the pipeline. Therefore the reference design includes the use of a booster pump to split pumping along the route and reduce the maximum pressure the pipe must handle.

The Reference Project is based on three parallel modules, each module producing a third of the initial plant capacity (50GL/year). 200GL capacity would be achieved by the construction of a fourth module. Each module consists of four plant components:

- Pre-treatment;
- Reverse Osmosis desalination;
- Potabilisation; and
- Treated water storage.

Figure 2 shows the Reference Project Layout, with the fourth module to the left of the site.

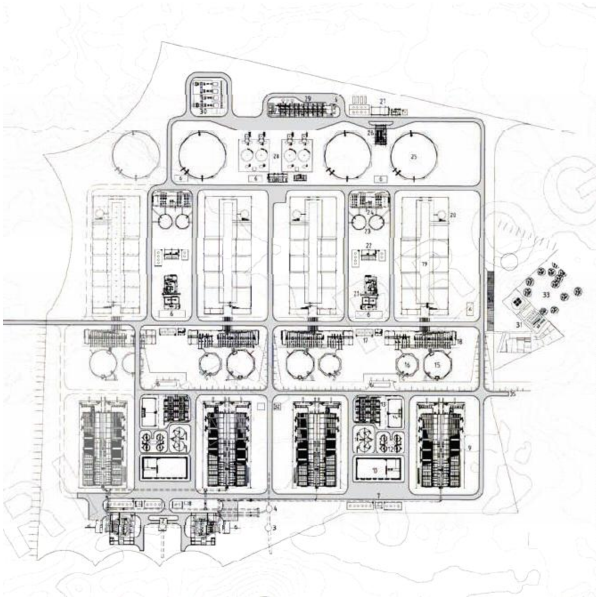

Figure 2 Reference Project Layout

Operational Noise Model Objectives

The objective of the operational noise modelling exercise is to determine the requirements enabling the desalination plant in its 200GL configuration to achieve 37dB(A) at the identified sensitive receivers under neutral and adverse weather conditions (as applicable).

37dB(A) is the most stringent criterion applicable to the site noise emissions (see Table 2).

Noise Modelling Software Package

Acoustic modelling was undertaken using Computer Aided Noise Abatement (Cadna-A) software to predict the effects of industrial noise generated by the desalination plant operational activities.

Cadna-A, by Datakustik, is a computer program for the calculation, assessment and prognosis of noise exposure. Cadna-A calculates environmental noise propagation according to ISO 9613-2:1996 *Attenuation of sound during propagation outdoors Part 2: General method of calculation.*

Cadna-A considers local topography, weather conditions, reflection, ground absorption, relevant building structures, site sources and the location of the receiver areas to predict received noise levels. The method specified in ISO 9613-2 consists specifically of octave-band algorithms (with nominal midband frequencies from 31.5 Hz to 8 kHz) for calculating the attenuation of sound.

In assessing meteorological conditions, the CONCAWE method has been applied instead of ISO 9613-2 weather correction.

Modelling Assumptions

In building the noise model, a number of assumptions have been made.

Major Noise Sources

Table 3 outlines the major noise sources on site. Generally, all major sources have been enclosed under the Reference Project design.

Table 3 Major Operational Noise Sources

Sources	Power Consump-tion kW	Duty Units No. / Module	Type
Seawater Pump	761	2	Vertical Turbine
Backwash Air Blower	169	1	
Clarified Water Return Pump	75	1	Vertical turbine
Backwash Pump	60	3	Vertical Centrifugal
Feed Booster Pump RO	780	8	Multistage vertical cen-trifugal
Feed Booster Pump ERD	142	8	Vertical Centrifugal
HP Pump 1st Pass	1400	8	Multistage Centrifugal
ERD Booster Pump	199	8	Centrifugal
Feed Pump Second Pass	1103	4	Multistage Centrifugal
RO Ventilation	71	4	
RO Ventilation	71	4	
CIP	209	0.5	Centrifugal
RO Flushing Pumps	209	1	Centrifugal
Chemical Ser-vice Pumps	90	2	Centrifugal
Permeate pumps	200	2	Vertical Centrifugal
Treated Water Transfer Pump	2604	2	Centrifugal

In the absence of specific manufacturer data, sound power levels for each site source considered in the assessment were determined from Cadna-A Sound Emissions and Transmission (SET) module. SET allows the determination of sound power spectra based on technical system parameters of a sound source.

Further to the above, Cadna-A calculation protocols were used to determine internal noise levels in all buildings containing indoor sources. Estimated internal noise levels are presented in Table 4.

Table 4 Estimated Internal Sound Pressure Levels dB(A)

Building	Internal Noise Level dB(A)
Seawater Pump Station - 1 module serviced	81
Seawater Pump Station - 2 modules serviced	84
DAFF Building	82
Sludge Dewatering Building (pump room only) - 1 module serviced	76
Sludge Dewatering Building (pump room only) - 2 modules serviced	79
Cartridge and Feed Booster Pumps	101
Permeate Pump Station - 1 module serviced	93
Permeate Pump Station - 2 modules serviced	95
RO Clean in Place - 1 module serviced	92
RO Clean in Place - 2 modules serviced	95
Treated Water Pump Station - 3 modules serviced	108
Treated Water Pump Station - 4 modules serviced	110
RO Membrane Hall	80
RO Bunker	105

Building Details and Building Component Transmission Loss

Major site structures (buildings and tanks) with a potential to affect noise propagation by means of screening or reflection have been incorporated in the model, with consideration to the Reference Project.

Architectural drawings were referred to in determining the construction details of the buildings containing indoor noise sources. Besides their structures acting as noise screens and/or reflectors, such buildings were also modelled as distinct area sources (eg. four radiating walls and one radiating roof). The sound power of an area source is dependent on the indoor noise levels within the building, the wall or roof sound transmission loss (in other terms, its capacity to attenuate sound levels) and overall surface.

Iterative modelling based on the plant architectural drawings led to define six main building components on site:

- 200 mm precast concrete walls;
- Access doors - assumed closed;

- Metal roller doors (MRD) – assumed closed;
- Aramax™ cladding or roofing;
- Trimdek™ roofing; and
- Ventilation openings.

Table 5 below presents the sound transmission loss used in the assessment for each of the above.

Table 5 Transmission Loss (TL) Assumptions of Plant Construction Materials

Building Component	Assumptions
200mm precast concrete wall	Equivalent to R_w58
Aramax™ cladding/ roofing	Equivalent to 1mm steel sheeting
Trimdek™ roofing	Equivalent to 0.42mm steel sheeting
Access door	Equivalent to R_w35, assumed closed
MRD	Equivalent to R_w30, assumed closed
Ventilation opening	Equivalent to weatherproof louvres

In general, site building roofs entirely consist of either concrete slab, Aramax™ or Trimdek™ roofing except for the Reverse Osmosis building, which contains a number of vents. However, walls are generally a more complex mixture of precast concrete, Aramax™ cladding, access doors and/or MRD's, each having their own transmission loss.

For this reason, a composite sound transmission loss was determined for each area source, based on *Engineering Noise Control* (Bies and Hansen, 2003) Equations 8.65 and 8.66. These equations take into account the transmission loss and proportion of each building material constituting a given area source.

Resulting composite sound transmission losses used in the noise model are detailed in Table 6 below.

Table 6 Transmission Loss (TL) of Individual Building Components dB

Building	Wall/Roof	Octave Band Centre Frequency (Hz) / Sound Transmission Loss dB								
		31	63	125	250	500	1k	2k	4k	8k
Seawater Pump Station and Screening Building	North/South	6	11	18	21	26	31	36	41	47
	East	6	9	12	15	16	16	17	17	17
	West	6	10	16	18	20	21	21	21	21
	Roofing	3	8	15	17	22	27	32	38	45
Pre-treatment Building (DAFF)	North/South	7	12	19	21	26	31	36	42	49
	East/West	6	11	18	21	26	31	36	42	48
	Roofing	3	8	15	17	22	27	32	38	45
Sludge Dewatering Building - Compressor and Pump Room	North/South	Not applicable								
	East	20	25	32	41	48	51	52	57	57
	West	Not applicable								
	Roofing	0	3	8	14	20	23	26	27	35
Cartridge filters and feed booster pumps	North/South	Not applicable								
	East	18	23	30	39	46	49	50	55	55
	West/Roof	28	33	40	49	56	59	60	65	65
RO Bunker	North/South	28	33	40	49	56	59	60	65	65
	East wall	10	15	22	31	38	41	42	47	47
	West wall	23	28	35	44	51	54	55	60	60
	Roofing	28	33	40	49	56	59	60	65	65
RO Building	North/South	8	13	20	22	27	32	37	43	50
	East wall	7	12	19	22	27	32	37	43	48
	West wall	8	13	20	22	27	32	37	43	50
	Roofing	3	8	15	17	22	26	30	33	34
RO Clean in Place	North Wall	28	33	40	49	56	59	60	65	65
	South/East	Not applicable								
	West/Roof	28	33	40	49	56	59	60	65	65
Permeate Pump Station	North/East	7	12	19	21	26	31	36	42	49
	South Wall	Not applicable								
	West wall	6	11	18	21	26	31	36	41	47
	Roofing	28	33	40	49	56	59	60	65	65
Treated Water Pump Station	North/South	Not applicable								
	East wall	15	20	27	36	43	46	47	52	52
	West wall	25	30	37	46	53	56	57	62	62
	Roofing	28	33	40	49	56	59	60	65	65

Review of Table 6 against architectural drawings confirms that the presence of vents, Aramax™ cladding, access doors, vents or MRD's in an otherwise precast concrete wall can have a substantially detrimental effect on the overall wall transmission loss performance.

As such, all access doors and MRD's have been assumed to be closed for the prupose of the modelling. With respect to the previous comment, open doors would further reduce the performances of the wall they are comprised in.

Topography and Ground Absorption Effects

In line with the proposed location of the plant within the study area, the ground topography for the site surrounds were modelled using 0.5m ground contours based on LIDAR spatial data. Site topography (including earthworks and relocation of fill) was also taken into account.

Contours within the site wall boundaries are reduced to 2 slabs at RL 8m and RL 12m, which support the plant structures.

A default ground absorption of 0.5 was used in the modelling for all land outside the site wall boundaries. A ground absorption of 0 (reflective surfaces) was used within the site wall boundary.

Meteorology

Although not explicitly stated in the Victorian EPA guidelines, weather conditions should be factored in the assessment where they may enhance noise levels for more than 20% of the time, by reference to Clause 4.2 of EPA Victoria Publication 280 *A Guide to the Measurement and Analysis of Noise*. On that basis, local weather trends and patterns were reviewed to determine if such conditions exist.

Review of wind and stability roses representative of the plant site and surroundings highlights the following:

- Wind speed in the subject area is generally high with a mean wind speed of approximately 5m/s;
- Weather conditions with a potential to enhance noise emissions occur in two general occurrences:
    - In summer, southerly winds occur more than 25% of the time; and
    - In autumn, F-class Pasquill stability occurs more than 20% of the time over the night-time period. This would typically result in the worst-case temperature inversions in the subject area.

As a result, modelling included the following separate scenarios:

- Neutral weather conditions;
- 5m/s southerly wind; and
- F-Class Pasquill stability (simulating temperature inversion).

Base Model Representation and Iterations

The 200GL base model, subject to the assumptions outlined previously, are shown in Figure 3 and Figure 4.

Figure 3 Model Representation

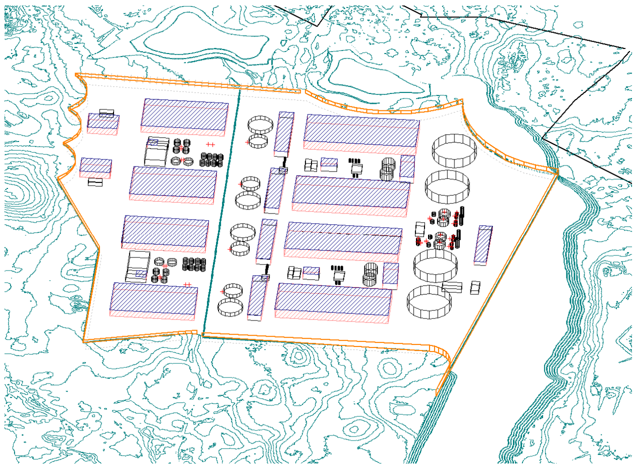

Figure 4 Model Representation (3D View)

The 200GL base models were progressively modified until site noise emissions were compliant with the adopted noise goals at the sensitive receivers.

This involved continued consultation with the architects and structural engineers to determine suitable construction options.

As an example, the last recommendation incorporated to the Reference Project design involved the transmission loss upgrade of Module 4's DAFF Building Roof and RO Building Roof, as shown in Table 7 below.

Table 7 Module 4 Roof Transmission Loss Upgrades

Building	Current/Required Transmission Loss	Octave Band Center Frequency (Hz) / Sound Transmission Loss dB								
		31.5	63	125	250	500	1k	2k	4k	8k
DAFF Building	Current design	3	8	15	17	22	27	32	38	45
	Required Transmission Loss	8	13	20	22	27	32	37	43	50
RO Building	Current design	3	8	15	17	22	26	30	33	34
	Required Transmission Loss	8	13	20	22	27	31	35	38	39

MODELLING RESULTS

Modelling scenarios are detailed in Table 8 below.

Table 8 Detail of Modelling Scenarios

Scenario	Scenario Details
200GL-1	200GL site configuration; Neutral weather conditions; and Base model subject to the assumptions outlined in this report with the following modifications: Module 4 Upgraded Roofs (as per Table 7).
200GL-2	As per 200GL-1; and 5m/s southerly wind.
200GL-3	As per 200GL-1; and Temperature inversion (F-class Pasquill stability).

Modelling results as per Scenario 200GL-1, 200GL-2 and 200GL-3 are shown in Figure 5, Figure 6 and Figure 7, respectively.

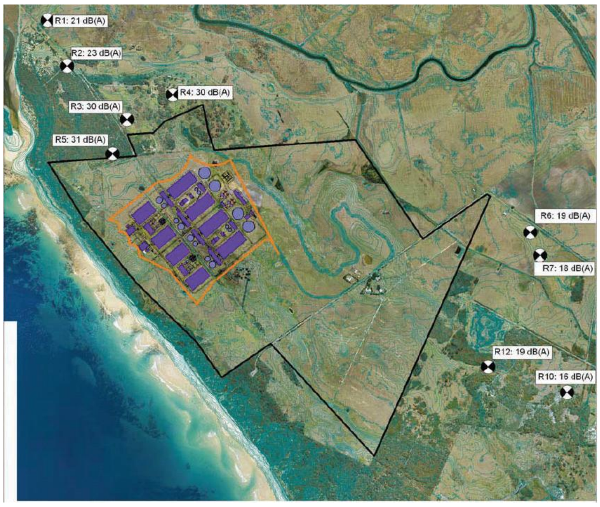

Figure 5 Scenario 200GL-1 Noise Modelling Output

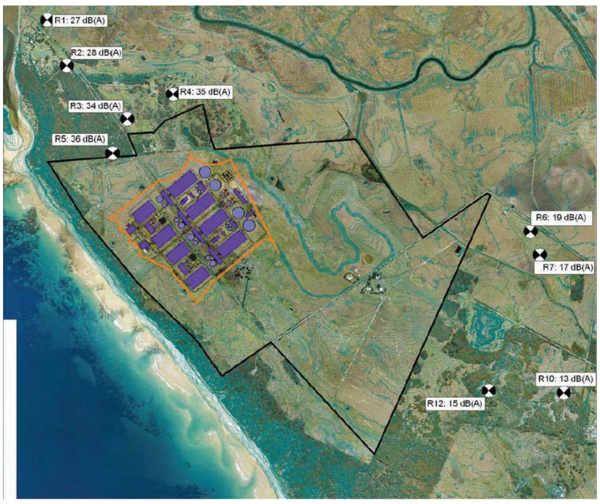

Figure 6 Scenario 200GL-2 Noise Modelling Output

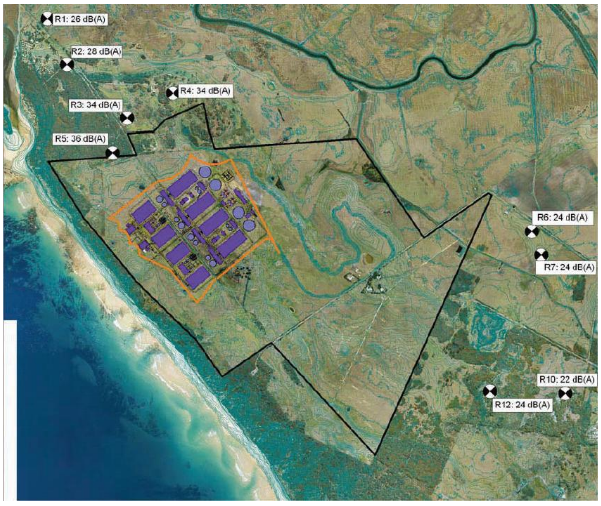

Figure 7 Scenario 200GL-3 Noise Modelling Output

Summary of Findings and Recommendations

Results indicate that, under the modelling assumptions, the Reference Project is expected to comply with the 37dB(A) target at all identified sensitive receivers (under neutral and adverse weather conditions).

CONCLUSION

This paper details the process towards approval of a major project, from site monitoring to modelling of noise impacts.

Modelling of the Reference Project allowed to demonstrate the feasibility of the project from the noise point of view and to refine the relevant Project Requirements. This information was in turn provided to the PPP tenderers.

At the time of writing this paper, design and construction of the Victorian Desalination Project is underway and on track for completion in 2011.

REFERENCES

Bies & Hansen (2003) *Engineering Noise Control 3rd Edition* Available from: Spon Press.

Department of Planning and Community Development (2008) *Scoping Requirements – Desalination Project Environment Effects Statement.*

EPA Victoria (1996) *Environmental Guidelines for Major Construction Sites* Available online from: http://www.epa.vic.gov.au.

EPA Victoria (1989) *Interim Guidelines for the Control of Noise from Industry in Country Victoria, EPA Victoria, Publication N3/89* Available online from: http://www.epa.vic.gov.au.

EPA Victoria (1992) *Technical Guideline TG302/92 Noise Control Guideline* Available online from: http://www.epa.vic.gov.au.

EPA Victoria (1991) *A Guide to the Measurement and Analysis of Noise, EPA Publication 280* Available online from: http://www.epa.vic.gov.au.

ISO Standards (1996) *ISO Standard 9613-2:1996 Attenuation of sound during propagation outdoors Part 2: General method of calculation.*

Standards Australia (1997) *Australian Standard AS 1055.1 - 1997 Acoustics – Description and Measurement of Environmental Noise.*

Victoria Government (1989) *State environment protection policy (Control of Noise from Commerce, Industry and Trade) No. N-1 (SEPP-N1)* Available online from: http://www.epa.vic.gov.au.