(ACE-EIA Paper 3/2004)
For information

Permanent Aviation Fuel Facility
Methodology, Testing and Selection of a Bubble Jacket

Purpose

The Environmental Permit for the Permanent Aviation Fuel Facility (PAFF) requires bubble jacket trials to select a bubble jacket to be used in reducing underwater noise during percussive piling for the construction of the PAFF.

Background

2. The PAFF, to be located in Tuen Mun Area 38, will replace the existing Aviation Fuel Receiving Facility (AFRF) at Sha Chau and will provide a secure long-term means of supply of aviation fuel to the airport.

3. As part of the PAFF, a two berth jetty will be constructed in waters 17 metres deep approximately 200m off the existing sea wall. The main activity at the jetty will be berthing/unberthing of tankers and the pumping of aviation fuel to the tanks in the tank farm. A total of 106 piles will be required for the construction of the jetty and pile driving is expected to take about 6 weeks.

4. To reduce the potential impact on the local population of Indo-Pacific Humpback Dolphins (Sousa chinensis), the Environmental Permit (EP-139/2002/A) requires that the following underwater noise levels must be achieved during piling works and stipulates an overall reduction of 3dB or more from noise levels generated when no bubble jacket is in place:

The Mitigated Noise Level

Distance from Piling Work (m)	Noise Level (dB)
250	162
500	152
1000	145

5. To achieve the mitigated noise levels, several bubble jacket designs will

be tested in order to select the one achieving the greatest attenuation of underwater noise levels and which is practical to use. The noise reduction achieved by two previously used bubble curtain systems is reviewed in Attachment.

Proposed Bubble Jacket Design

6. In view of the greater depth of the water (approximately 17m) and stronger currents at the jetty near Tuen Mun Area 38 than at Sha Chau, three bubble jacket designs have been developed and will be tested.

Option 1 – Fixed Bubble Jacket

7. A tube (jacket) of 1200mm diameter, made of steel pipe with 8mm wall thickness, will be suspended from the pile barge. A 50mm inside diameter airline will be fixed inside the base of the jacket with 1.5mm diameter air release holes located every 180mm. To prevent the steel tube touching the side of the pile and transmitting noise into surrounding water, neoprene or rubber spacers will be fixed on the internal wall of the tube (see Figure 1). The pile will then be driven inside the tubewhilst air is pumped to the airlines to create the bubble jacket. The tube will be lifted off after the pile driving.

Option 2 – Canadian Model

8. The Canadian Model shown in Attachment consists of air distribution manifolds suspended at various depths from the pile barge below the water surface level. For piles that are to be driven in water deeper than 10m, and with the prevailing current velocities, three levels of manifolds will be used. A 50mm inside diameter air distribution manifold made of steel with 1.5mm diameter air release holes located every 180mm will be suspended from the piling barge at 3 different water depths (see Figure 2).

Option 3 – Bubble Curtain

9. Figure 3 presents a bubble curtain arrangement in which each individual pile will be encircled by an air distribution manifold made of air hose anchored or weighted to the seabed. Assuming that the deepest water depth would be 20m, with a rate of bubble rising at 2.5m/s and a maximum current at 1m/s, the minimum diameter of the bubble curtain along the line of the current will be 16m. The pattern of bubbles emerging at the surface will indicate the effectiveness of the bubble curtain in surrounding the pile.

Proposed Test Procedures

10. The trial will be conducted from 22 to 26 March 2004 in order to avoid the peak calving period of dolphins (April to August). The trial will be conducted at the actual jetty location at Tuen Mun Area 38. The proposed location is shown in Figure 4.

Requirements of Environmental Permit

11. All relevant requirements stipulated under the Environmental Permit (EP-139/2002/A) will be complied with during the testing procedure. As required under Condition 3.2 of EP, the effect on noise attenuation of the proposed bubble jacket will need to be tested prior to the actual pile construction. The performance of the proposed bubble jacket shall provide the same, if not better, noise attenuation compared to that provided by the AFRF bubble curtain (i.e. noise attenuation effect of 3dB or more).

12. A 500m dolphin exclusion zone as required under Condition 3.22 of EP will also be implemented throughout the duration of the bubble jacket trial. Piling work will not be carried out until the qualified person certifies that the area is continuously clear of dolphins for a period of 30 minutes. Piling will cease if any dolphins move into the exclusion zone and will not resume until the qualified person confirms that the zone has been continuously clear of dolphins for a period of 30 minutes.

13. In addition, the piling hammer at the beginning of each piling session will be ramped up gradually. Piling activities will be continuous without short-break and will avoid sudden random loud noise emission (Condition 3.26 of EP).

14. To minimise the potential transmission of noise/vibration through the pile driving barge, all piling and related equipment installed on the piling barge will be acoustically decoupled from the hull of the barge (Condition 3.27 of EP).

Proposed Measurement Methodology

15. To test the effectiveness of each bubble jacket, underwater piling noise will be measured with and without each option for the bubble jacket. In addition, the ambient noise levels without the piling operations will also be measured for general reference. The piling hammer, guide system and piling method will simulate the actual construction method.

16. Underwater noise measurements will be undertaken at 250, 500 and 1000m from the piling work, using calibrated hydrophones with calibrated precision amplifiers, analog to digital converters and a high speed data-logging system (with frequency response approximately flat from 100Hz to 50kHz). As the measurement at surface or bottom may be affected by potential surface or bottom reflections, the noise measurements will be measured at a mid depth of 10m.

17. To establish the effectiveness of the bubble jacket, the following procedure will be followed:

- Record ambient noise level for one hour prior to any pile driving activities;
- Record noise levels at 3 recording locations (in front of, behind and along side of the pile barge, see Figure 5) while the pile is being driven with and without the three bubble jacket options before, during and after the air supply is turned on, to measure any change in noise level due to the depth of driving for each option;
- Record noise level at recording location 1with air supply on and no pile driving to measure the level of noise generated by the air supply for each option.

18. The records will be taken at a sampling rate of 100kHz. Both broadband and one octave bandwidth from 10Hz to 100kHz shall be measured.

19. The survey boat will be equipped with Digital Global Positioning System for measuring the distance from the pile driving operation. To minimise the source of noise from the survey boat during measurement, the engine, pumps, and miscellaneous gear shall be switched off. The survey boat will be at anchor.

20. During the bubble jacket trial, a qualified underwater acoustic expert will be on the survey boat to audit the measurement procedures.

Reporting

21. The test results will be submitted to the Director of Environmental Protection (DEP) for approval.

Airport Authority
March 2004

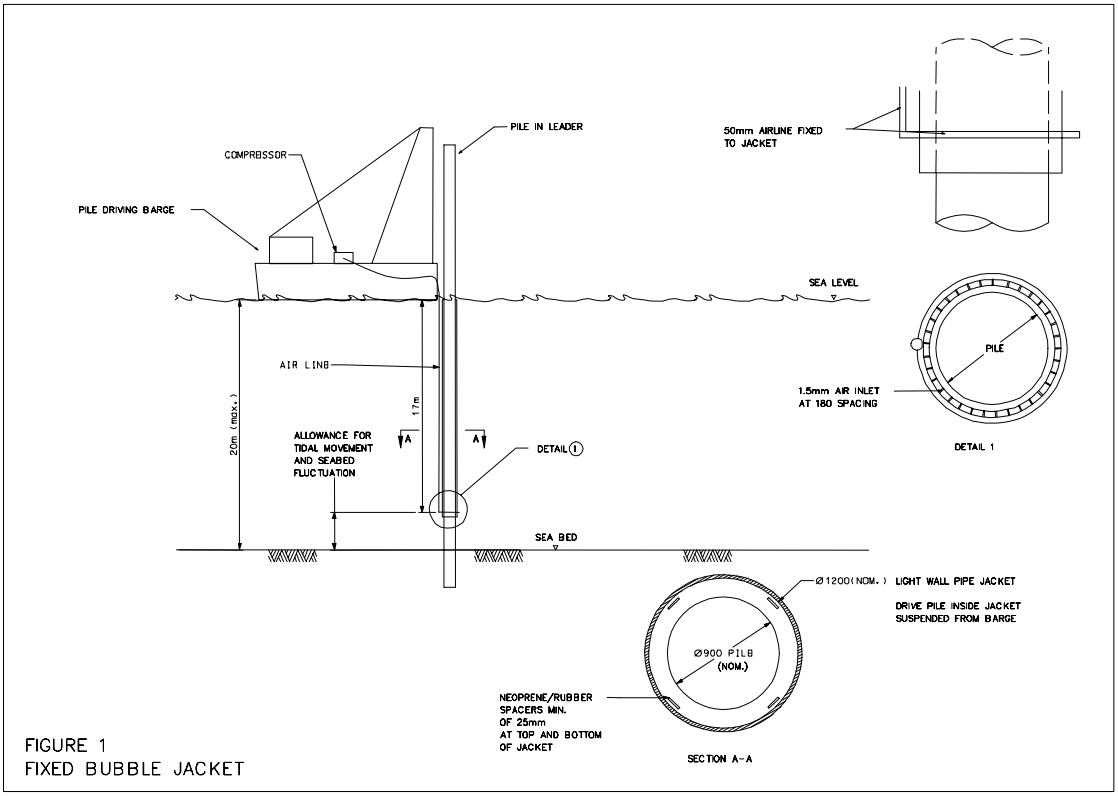

FIGURE 1
FIXED BUBBLE JACKET

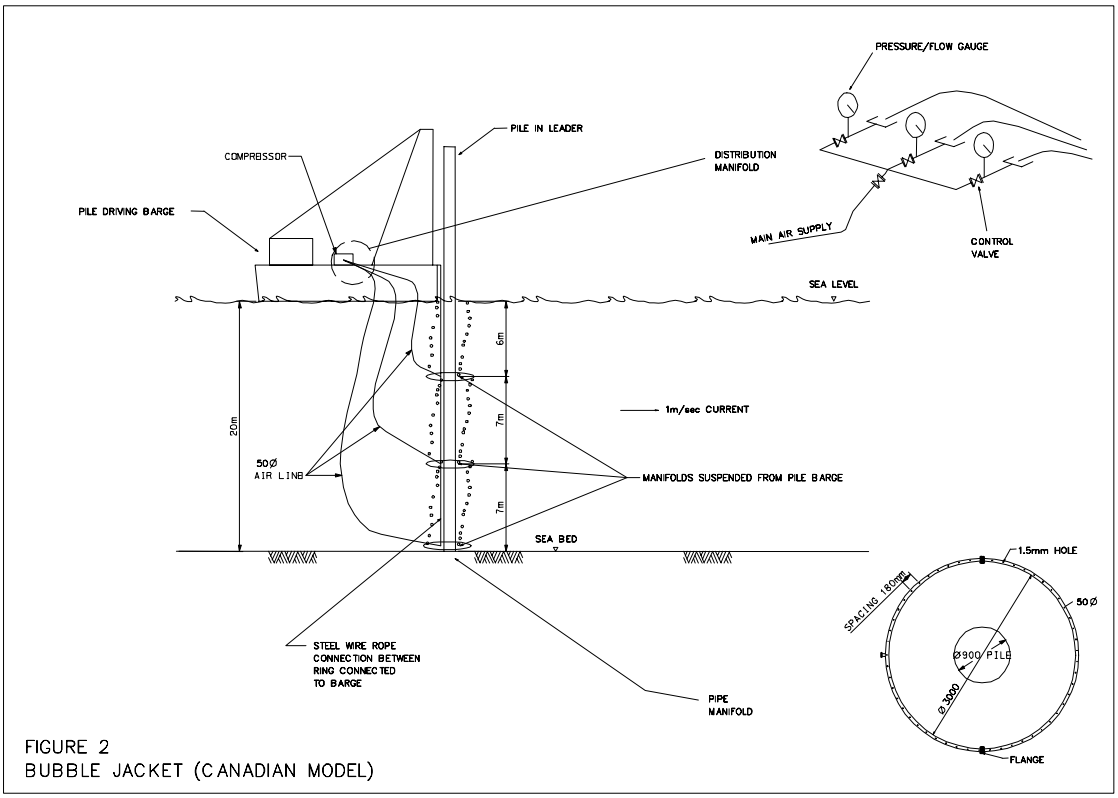

FIGURE 2
BUBBLE JACKET (CANADIAN MODEL)

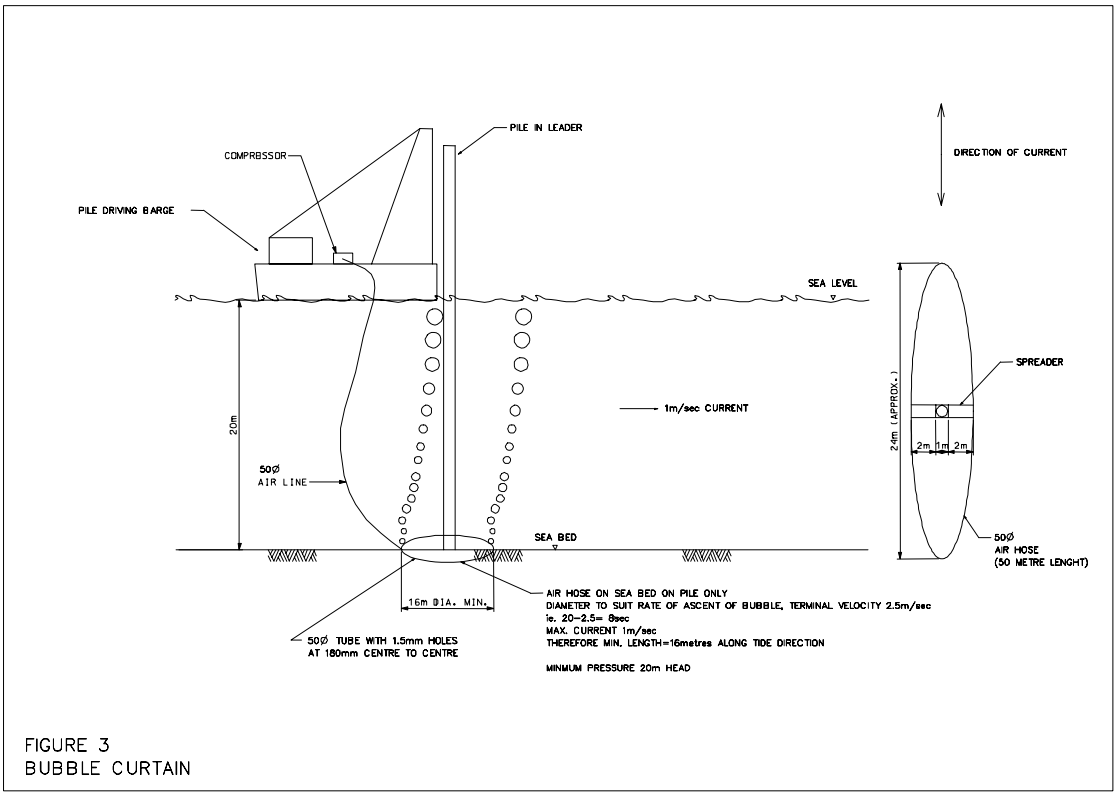

FIGURE 3
BUBBLE CURTAIN

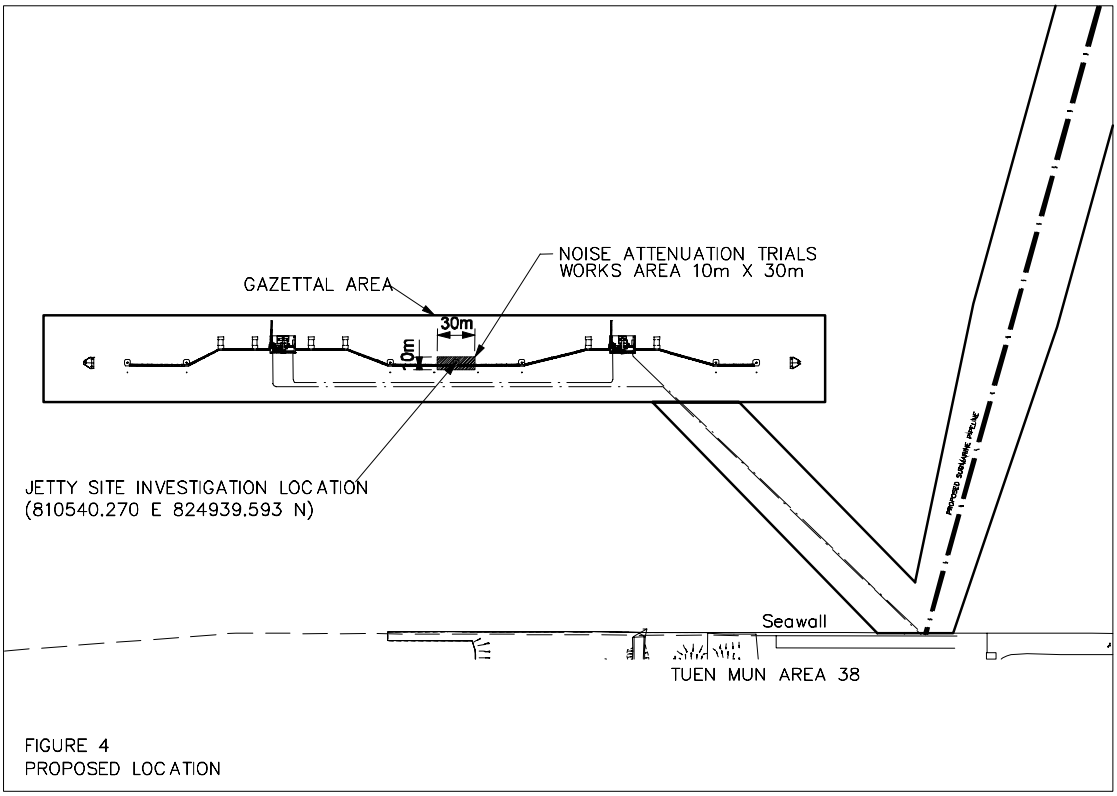

FIGURE 4
PROPOSED LOCATION

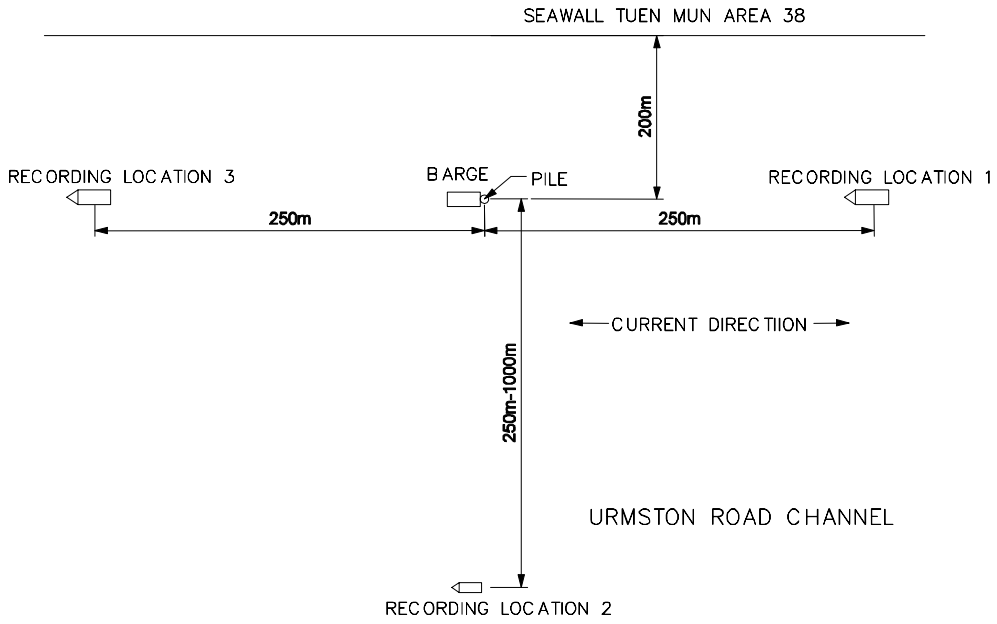

FIGURE 5
PROPOSED RECORDING LOCATIONS

Attachment

Review of Bubble Jacket Designs

Construction of AFRF

A.1. During the construction of the AFRF at Sha Chau, a bubble curtain consisting of an approximately 25m radius circle of perforated air hose was anchored to the seabed. A 50mm inside diameter air hose was used, with 3mm diameter air release holes located every 0.3m to 0.4m. This pipe surrounded a pile group and a supply of compressed air was pumped into the pipe to form the bubble curtain (see Figure A1).

Schematic of Bubble Curtain Use in AFRF

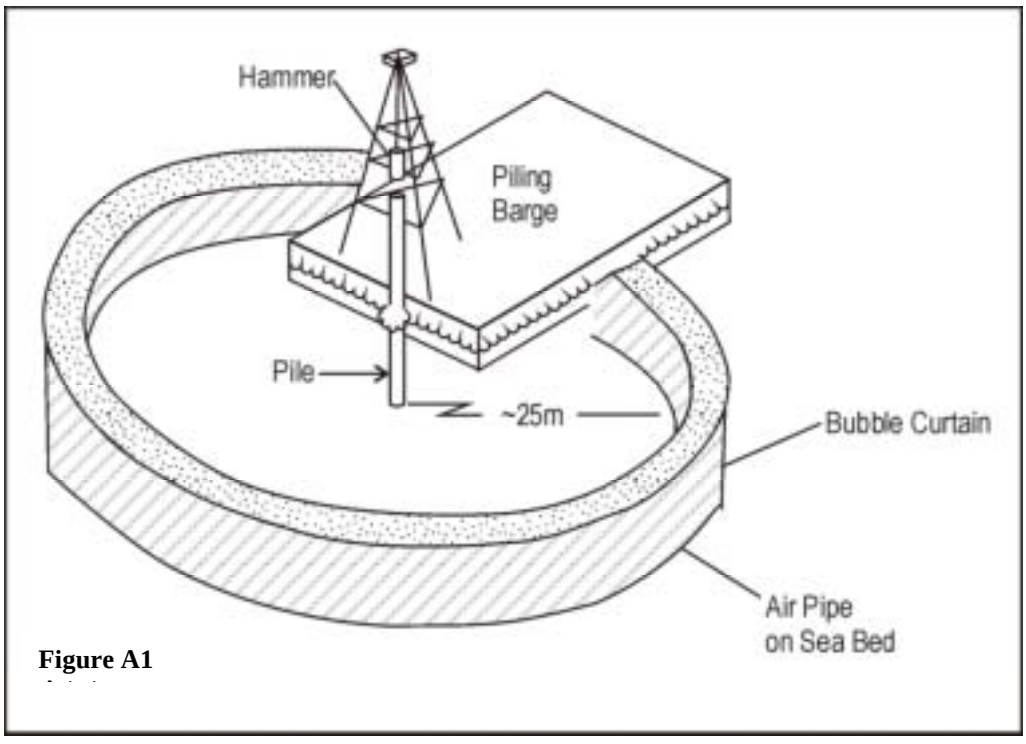

Figure A1

A.2. Noise measurements were undertaken on two days. Three survey boats were used to undertake the noise measurements, located at 250m, 500m and 1000m east of the piling barge. On day 1, the barge was aligned so that the barge straddled the bubble curtain towards the boats to the east (see Figure A2). On day 2, the barge was repositioned such that the barge straddled the bubble curtain only towards the north to ensure a continuous uninterrupted bubble curtain between the pile and the survey boats (see Figure A2).

Orientation of survey boats

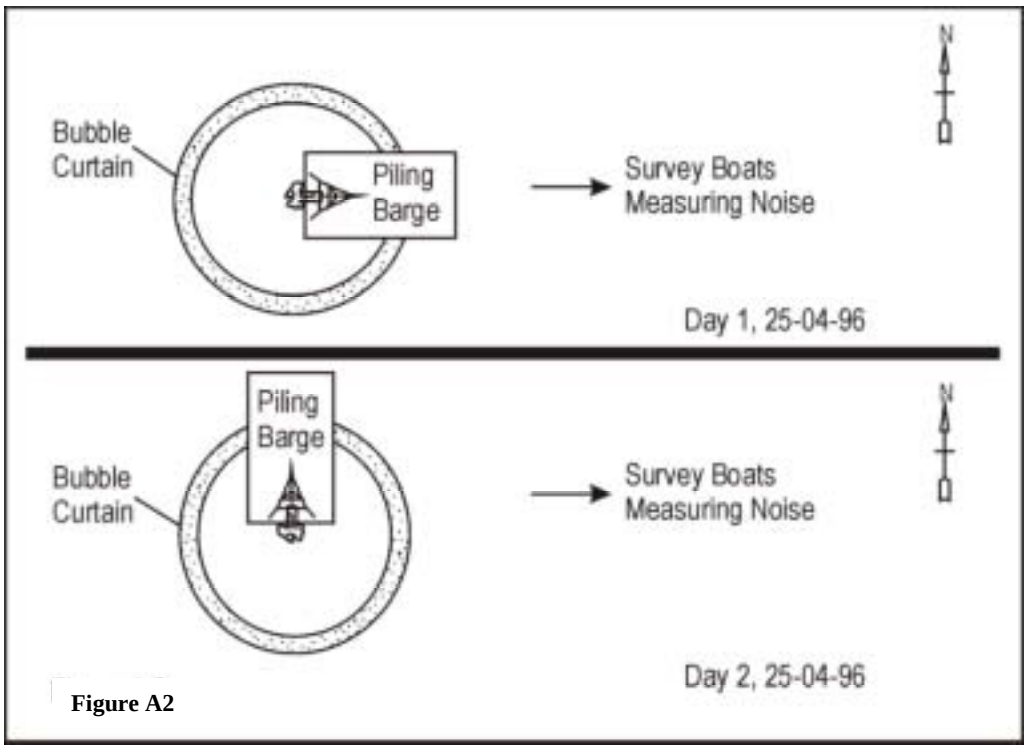

Figure A2

A.3. Results indicated that when the barge was not in the sound propagation path, a reduction of 3 to 5 dB was achieved in the overall broadband levels and up to 20 dB in the one octave band of 1.6 to 6.4 kHz.

Construction of Marine Terminal in British Columbia

A.4. In 1999, during the construction of a marine terminal in British Columbia, Canada, a modified bubble curtain was adopted, where each individual pile was encircled by air distribution manifold at various depths below the water surface level

(see Figure A3). The bubble curtain adopted distributed air bubble around 100% of the perimeter of a pile over the full depth of the water column. Noise measurements showed that the bubble curtain reduced noise levels by 19 psi (pounds per square inch) i.e. equivalent to 17 dB).

Proposed Test Locations

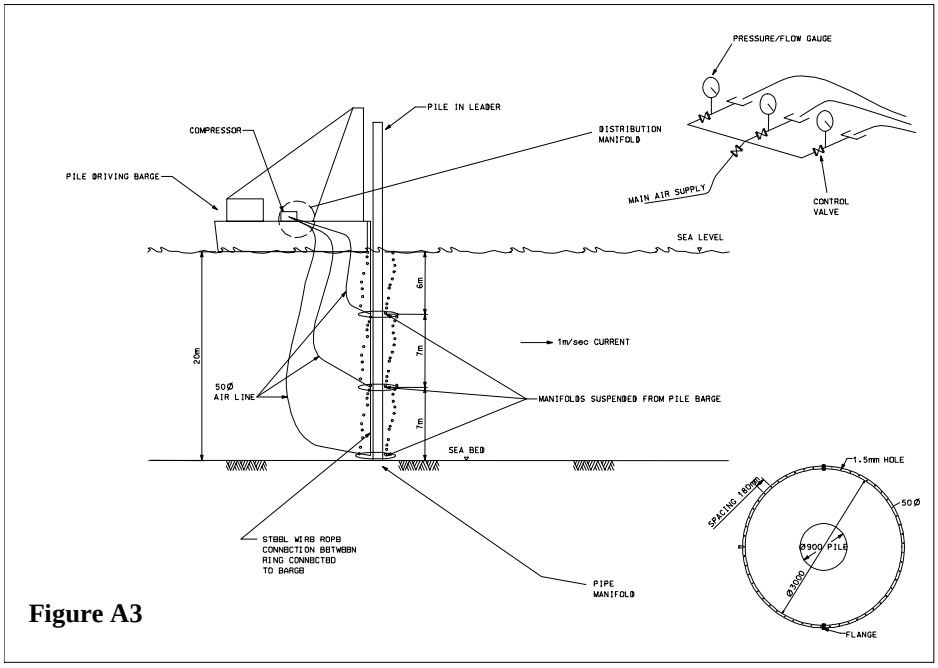

Figure A3