Clarence Valley Council

Iluka Sewerage Scheme - Ebb Tide Release

Review of Environmental Factors

June 2009
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Executive Summary

Iluka is the largest unsewered town in New South Wales, predominantly relying on septic tank and absorption trench systems for wastewater disposal. The township has a permanent population in the order of 2,000 people, which is subject to large increases during holiday periods.

Previously, several environmental and health concerns have arisen with the level of wastewater treatment at Iluka. Over the past ten (10) years Clarence Valley Council (CVC) has been progressing through the formal process of proposed upgrades to the current methods and facilities that Iluka uses to treat wastewater. Various options for the environmental release of excess water have been investigated, including an ocean outfall and aquifer injection, but these have been rejected for various reasons. It is currently proposed to release the excess recycled water not able to be beneficially reused via ebb tide release in the lower Clarence River. This option has been approved previously but the revised proposal significantly increases the volume of recycled water to be discharged by ebb tide release.

The proposal involves releasing recycled water into the Clarence River during the ebb tide. The release point will be on the north side of the current shipping leads. The pipelines will be constructed using Horizontal Directional Drilling (HDD) under the Clarence River and the diffuser will be installed by either caisson or jet grouting.

The HDD technique proposed is trenchless, which will allow installation of pipework underneath the Clarence River with minimal impact upon the environment. The location of the drill rig is proposed to be at Queens Road, Iluka.

Due to the provisions of State Environmental Planning Policy (Infrastructure), the Proposal does not require development consent and the appropriate form of assessment is under Part 5 of the EP&A Act. Numerous other Acts, State Environmental Planning Policies and Plans apply to the Proposal. All of these have been considered and complied with where possible.

CVC formed the Iluka Consultative Working Group (ICWG) to provide an opportunity for Government Agencies, interest groups and the community to be involved in the proposed sewerage scheme. The ICWG, Government Agencies and the broader community have been regularly updated about the project over the past 10 years.

The main potential environmental and socio-economic impacts from the proposal include, water quality and noise. Based on the proposed diffuser configurations, the provided design flow rates, the estimated depth of the diffusers, outcomes of field investigations and the flow path modelling, Water Research Laboratory (WRL) have undertaken extensive water quality modelling. Based on the modelling, it was determined that the Iluka release could operate during normal flow conditions over a 3 hour window commencing 30 minutes after the onset of the ebb tide flow. Modelling results indicated that any recycled water released over this 3 hour window is unlikely to impact upstream sensitive receivers, even during high flow events.

An assessment of the potential noise and vibration impacts from the HDD activities at the Iluka launch site has been undertaken. Construction works at Iluka are expected to comply with noise goals at the surrounding residences.
The REF addresses the factors listed in Clause 228 of the Environmental Planning and Assessment Regulation 2000 and the matters of national environmental significance identified under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999.

The REF indicates that the proposed ebb tide release is unlikely to have a significant detrimental impact on the environment providing the recommended mitigation measures are implemented. An environmental impact statement is therefore not required.
1. Introduction

1.1 Background

Iluka is the largest unsewered town in New South Wales, predominantly relying on septic tank and absorption trench systems for wastewater disposal. The township has a permanent population in the order of 2,000 people, which is subject to large increases during holiday periods.

Several environmental and health concerns have arisen with the level of wastewater treatment at the town. In response, over the past ten (10) years, CVC has been progressing through the investigation and design of the new sewerage scheme. The process has included several studies and reports, which have assessed various options. The reports include:

- Sinclair Knight Merz, 2003, Iluka Sewerage Scheme – Environmental Impact Statement (EIS); and
- GHD, 2007, Iluka Sewerage Scheme, Supplementary Review of Environmental Factors.

The reports propose to treat and reuse the wastewater in a sustainable manner. The volume of recycled water that can be reused is limited and an alternative is required. Various options have been investigated, including ocean outfall and aquifer injection, but these have been rejected for various reasons. It is currently proposed to release the excess recycled water via ebb tide release in the lower Clarence River. This option has been approved previously through the EIS but the revised proposal significantly increases the volume of recycled water to be discharged by ebb tide release.

As these modifications differ from that approved under previous environmental assessments, the proposed amendments to the activity requires additional assessment to achieve project approval. It is our understanding that CVC will be the determining authority under Part 5 of the Environmental Planning and Assessment Act (EP&A Act) 1979. To determine if the impact is significant, the required form of assessment is a Review of Environmental Factors (REF).

1.2 Scope of Works

This REF has been prepared to identify and evaluate the impacts of the proposed works to determine if the impacts are likely to affect the environment by:

- Describing and justifying the proposed activities;
- Consulting relevant stakeholders;
- Reviewing the statutory requirements;
- Identifying and assessing the environmental and socio-economic impacts; and
- Providing recommendations to minimise any environmental impacts.

1.3 Structure of the REF

This document has been divided into eight sections.

Section 1: Introduces the scope and terms of reference to the REF report;
Section 2: Provides a brief site description;
Section 3: Provides an overview and breakdown of relevant aspects of the project;
Section 4: Review of legislation associated with Commonwealth, State and Local governments;

Section 5: Details the consultation undertaken;

Section 6: Assesses the environmental and socio-economic impacts associated with the proposed development, and the safeguards to be employed to mitigate potential adverse impacts;

Section 7: Considers Section 228 and EPBC Factors; and

Section 8: Provides conclusions, recommendations and certification.
2. Site Description

The Clarence River is located on the far north coast of NSW, approximately 300 km south of Brisbane and 680 km north of Sydney, as shown in Figure 1, Appendix A. The Clarence River is the largest coastal river in NSW and it has a catchment area of approximately 22,700 square kilometres (Healthy Rivers Commission of NSW, 1999 in SKM, 2005). The average annual flow from the Clarence River is approximately 4 million ML with an average daily flow of approximately 11,000 ML (Nornet, 2002 in Geolink, 2003a).

The mouth of the river is stabilised by breakwaters on the northern and southern sides. Slightly further upstream, training walls act to stabilise the location of harbour entrances and maintain their depth. Numerous islands lie in and about the estuary mouth. The largest island in the study area is Hickey Island, with smaller islands such as Dart, Pelican and Rabbit, lying to the west of Hickey Island. A rock reef is present at the river entrance, running in a north south orientation positioned approximately 100 m east of the middle training wall (Figure 2, Appendix A).

Iluka is a coastal town located north of the Clarence River. As shown in Figure 1, Appendix A, the township of Iluka is located on a narrow peninsular, approximately 2km wide, on the northern side of the Clarence River. It is bounded by the Pacific Ocean to the east, the Clarence River estuary to the west and the mouth of the Clarence River to the south. The township is constrained by conservation areas, preventing expansion beyond the existing town boundaries. Development is concentrated on the southern and western sides of the peninsular, which has a generally low relief and undulating surface. Most of the seaward side of the peninsular is characterised by a ridge of forested sand dunes reaching an elevation of between 10 m and 15 m Australian Height Datum (AHD). The eastern half of the peninsular is generally forested and broadly covered by an area of Crown Reserve, Iluka Nature Reserve and the Bundjalung National Park.

The Iluka area contains a diverse range of ecosystems including coastal dunes, coastal wetlands, heathland and woodlands. Mangrove areas and areas subject to periodic flooding at high tide are present along the length of the Clarence River. The study area has in the past experienced and continues to be subjected to the coastal processes of beach erosion, coastal inundation, dune and foreshore slope instability, wind and wave action. Added to this, the area, like much of the NSW coastline, has been subjected to growth and development, as well as increased pressure for public access and recreational opportunities.
3.  Project Description

3.1  General

As discussed earlier, a number of options for the environmental release of recycled water have been considered, however, further investigations have indicated that these options are unsustainable and that an ebb tide system is the preferred manner of environmental release for the proposed Iluka Sewerage Scheme.

The ebb tide release system was assessed previously as a precautionary measure but the revised proposal involves an ebb-tide release as the sole means of environmental release of excess recycled water not able to be beneficially reused.

The proposal involves releasing recycled water into the Clarence River during the ebb tide. The release point will be on the north side of the middle training wall, as shown as Location C on Figure 3, Appendix A. The pipelines will be constructed using Horizontal Directional Drilling (HDD) under the Clarence River and the diffuser will be installed by either caisson or jet grouting.

3.2  Project Objectives

The objectives of the ebb tide release system are:

- To provide a recycled water environmental release system that has minimal impact on the environmental values of the area;
- Minimise the impact of the system on residents during construction and operation; and
- To provide a recycled water environmental release option that complies with legislative requirements during construction and operation.

3.3  Project Description and Justification

CVC is currently undertaking major sewerage capital works in the form of:

- Construction of reticulated sewerage and a new Sewage Treatment Plant (STP) to service the currently unsewered town of Iluka.

It is proposed to release recycled water (that cannot be beneficially reused) into the Clarence River from the proposed STP via an ebb tide release system. The maximum volume of recycled water proposed to be released by the system (assuming no beneficial reuse is possible on a given day) is provided in Table 1 and the quality of the recycled water is shown in Table 2. As the name implies, the ebb tide release will only occur on an ebb tide, for a maximum of 3 hours, when the capacity of the estuary for dilution of recycled water is greatest.

<table>
<thead>
<tr>
<th>Design Flow</th>
<th>Iluka</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML/day~</td>
<td>1.95</td>
</tr>
<tr>
<td>L/sec over 3 hour release window</td>
<td>91</td>
</tr>
</tbody>
</table>

- Release is designed assuming all flow is being released (i.e. no beneficial reuse is possible, which may occur during extended periods of wet weather)
Table 2  Discharged Water Quality Concentrations for Accepted Modern Technology*

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Units</th>
<th>Recycled Water Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faecal Coliform</td>
<td>cfu/100mL</td>
<td>&lt;200#</td>
</tr>
<tr>
<td>DO</td>
<td>mg/L</td>
<td>2</td>
</tr>
<tr>
<td>BOD</td>
<td>mg/L</td>
<td>10</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>10</td>
</tr>
<tr>
<td>Oil and grease</td>
<td>mg/L</td>
<td>10</td>
</tr>
<tr>
<td>pH</td>
<td>Standard units</td>
<td>6.5 - 8.5</td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/L</td>
<td>2</td>
</tr>
<tr>
<td>Total N</td>
<td>mg/L</td>
<td>10</td>
</tr>
<tr>
<td>Total P</td>
<td>mg/L</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*Note values are 90th percentile values; mean values would be lower

#Flows for reuse will be treated to <10 cfu/100 mL

Estuary release of recycled water will involve a pipeline from the Iluka STP to the release site. To aid with dilution of the recycled water, a diffuser at the end of the release pipeline will be used to maximise mixing of the recycled water and the estuary water. The proposed location of the pipelines and diffuser are shown on Figure 3, Appendix A.

Hydraulic and hydrodynamic modelling of the estuary was undertaken by Water Research Laboratory (WRL) (see Appendix B). To minimise any adverse impacts on the estuary, the modelling information has been used to design a diffuser with optimum mixing and maximum dilution of the recycled water with the receiving water.

Other technical/engineering, environmental and social criteria considered in the design and location of the diffusers included:

- Is sufficiently deep to promote the majority of mixing as the recycled water moves towards the surface (buoyant mixing);
- Has sufficient ambient currents for plume mixing and transport so that recycled water is not detectable within approximately 50 m to 200 m of the release point;
- Is not subject to excessive movements in bed levels;
- Is close enough to the river entrance to ensure an adequate operational schedule;
- Is clear of environmentally and socially sensitive areas/sites such as the reef area downstream of the eastern end of middle wall;
- Is clear of the nominated navigation channel to avoid possible future dredging of the main river channel;
- Does not impede future maintenance of the breakwater structures, and
- Is located in a position acceptable to estuary stakeholders.
In addition to these technical concerns, any proposed ebb tide release must also (i) not interfere, limit or be a hazard to commercial or recreational waterway navigation, (ii) be constructed on land available to CVC, (iii) not interfere with the proposed electricity under crossing, (iv) be approved by representatives of the local Native Title Claimants and (v) not impact on commercial and/or recreational fishing.

Based on the above considerations the preliminary diffuser configurations proposed are:

- Two 300 mm ports orientated 90 degrees to the ebb tide flow.

Figure 4, Appendix A illustrates the proposed diffuser configuration. Additional information on the structural design, including riser circumference, is required to finalise the design configuration (WRL, 2009).

Taking into account all the considerations the optimum location of the ebb tide release is shown in Figure 3, Appendix A. The release structure will be located 3 m below Iluka Port Datum (IPD).

It should be noted that because the release will occur on the ebb tide, the recycled water would only need to be stored until the window of release occurs, therefore a storage area with several hours’ capacity would also be required at the STP. In addition, an automatic pumping station would then be required such that release occurs during the ebb tide for a period of up to 3 hours.

3.4 Project Alternatives

A number of project alternatives have been previously considered including aquifer injections, irrigation and ocean outfalls. Alternative release locations have also been investigated.

3.4.1 Aquifer Injection

Specialist personnel from the WRL carried out investigations to assist with the concept design of a proposed aquifer injection system for the Iluka scheme.

These investigations involved:

- Drilling of additional exploratory bores at North Spit;
- Sampling and testing from those bores to provide additional information on the subsurface geological conditions at North Spit; and
- Detailed numerical modelling of the behaviour of the aquifer under the influence of the proposed aquifer injection scheme.

The drilling confirmed the existence of deep sand and gravel layers to a depth of approximately 30 m on the site. A gravel layer was found which is particularly suitable for the operation of an aquifer injection system.

The modelling showed that although an aquifer injection system on the site would be feasible, there would be some groundwater fluctuations and it was not possible to assess what impact, if any, this will have on the flora and fauna of the region (WRL, 2005). A particular concern raised by DECC was that the management measure proposed (i.e. monitoring of groundwater levels) would only indicate that corrective action is required after adverse impacts had occurred. Also, approval under the Commonwealth Environmental Protection and Biodiversity Conservation (EPBC) Act is required when actions will potentially have a significant impact on matters of national environmental significance, which includes world heritage sites. Based on this, DECC indicated to CVC that the EPBC Act would likely apply in this instance based on the outcomes of the WRL investigation. Subsequent discussions with the
Commonwealth Department of Environment and Heritage indicated that it would be prudent for CVC to obtain approval for the Aquifer Injection System under the EPBC Act. Given the lengthy process for obtaining Commonwealth approval under the EPBC Act and the potential for damage to the Iluka World Heritage listed rainforest site, a decision was made to delete aquifer injection from the Iluka sewerage scheme.

3.4.2 Irrigation

The Iluka Sewerage strategies propose that recycled water reuse be maximised, although recognising that it is not currently feasible to have all recycled water reused.

Three municipal areas in Iluka were identified as being potentially suitable for recycled water irrigation, namely the golf course, the STP site and Iluka playing fields. On average it is estimated that municipal reuse would account for 39% of annual volume of recycled water from Stage 1 and 28% from the final stage. Soil and other environmental assessments had confirmed the suitability of these areas for recycled water irrigation. A dual reticulation system for residential reuse of recycled water is also being constructed as part of the scheme, although connection will only be mandatory for new developments.

Recycled water is to be treated and disinfected to a level that allows unrestricted public access to areas being irrigated and, therefore, the municipal areas will be able to be irrigated at any time.

3.4.3 Ocean Outfall

In 1997, the NSW Coastal Policy stated that “new ocean outfalls will be embargoed until a full investigation of alternative wastewater strategies has been undertaken and considered by the Government”. In that policy document goal 1.3.15 states “A public inquiry into ocean sewerage outfalls and effluent re-use opportunities will be undertaken and results used in formulating future Government policy on ocean disposal of effluent”. WRL has consulted with staff from the NSW Department of Environment and Climate Change and no related public inquiry has been conducted since the coastal policy was released. Therefore, based on the current state policy, proposed release locations situated in the ocean could not be considered until the estuarine locations were deemed unsatisfactory (WRL, 2009).

The establishment of ebb tide release is not only considered the most cost effective but also the most efficient and sustainable option available for the Iluka sewerage scheme.

3.4.4 Alternative Release Locations

As shown in Figure 3, a number of release locations have been investigated. The location of the release locations where determine with considerations of the factors outlined in Section 3.3. WRL (2009) investigated Location A (as shown on Figure 3), in detail as shown in the report in Appendix B. This location was ultimately rejected because it may have impacted on the navigation route of the Port of Yamba.

3.4.5 Do Nothing

The “do nothing” alternative is not considered to be appropriate because it would perpetuate the environmental and health issues that are related to the existing arrangement.
3.5 Construction

3.5.1 Methodology

The HDD technique proposed is trenchless, which will allow installation of pipework underneath the Clarence River with minimal impact upon the environment. The location of the drill rig is proposed to be at Queens Road, Iluka, as shown on Figure 3, Appendix A. The drill rig and associated equipment will require approximately 250m² in area and will be arranged similar to that shown in Figure 5, Appendix A.

HDD involves forward and backward reaming, sleeve pull backs and permanent pipe pull-throughs (also known as ‘stringing’). One entry and exit point is required at each end of the alignment. HDD is required to be undertaken as a continuous operation (24 hours per day, 7 days per week), to minimise the risk of unsuccessful bore.

HDD construction requires the use of a drilling “mud” to provide a medium for return of the drill cuttings and to stabilise the hole. Bentonite clay can be used for the drilling mud and is mixed into slurry which is pumped under pressure to the cutting face. The mud pressure required is a function of the surrounding earth pressure (i.e. the deeper the hole, the higher the pressure) and the length of the drill string (i.e. the longer the drill string, the higher the pressure required at the drill head) (PB, 2008).

The pipeline is most likely to be constructed from High Density Polyethylene (HDPE). The polyethylene pipeline would be floated on a barge and pulled onto the river bed and into the reamed hole.

The installation of the ebb-tide release pipeline would require the following construction works:

- Implementing and installing environmental controls (eg sediment and erosion controls, fauna and flora monitoring, noise controls);
- Establishment of directional drilling pads on the side of the Clarence River;
- Horizontal directional drilling;
- Cartage of cuttings from the directional drilling pad site with haulage trucks for off-site reuse or disposal;
- Installation (‘stringing’) of the pipeline;
- Fixing pipe to river bed and construction of the outlet structure;
- Pre commissioning monitoring;
- Pre commissioning tests; and
- Site clean-up.

Aecom (2009) have been engaged to provide a description of how the diffuser, manifold, riser and outlet ports would be constructed. The two options suggested are Jet Grouting or Caissons. A summary of the two options is provided below and a more detailed explanation is provided in the Aecom (2009) report. Both techniques would take approximately one month to complete.

**Jet Grouting**

The intention of jet grouting is to increase the strength of the soil by injecting cement grout into the soil structure. This is proposed to be done by:

- Establishing a barge;
Developing a grid system across the 50 m to 100 m diameter area;
- Insert jet grout drills into the sediment, at the grid intersections, until they reach the rock layer;
- Inject cement grout to form a cement grout column to the desired height;
- Remove drill rod;
- Scrape the area to the desired level;
- HDD the pipe exit point in the centre of the treated area;
- Establish rock anchors to the stabilized sand;
- Level the immediate area around the diffuser using leveling grout;
- Install the diffuser and diffuser structure; and
- Install any treatment for the diffuser and diffuser structure to serve as protection.

**Caissons**
Caissons use large diameter pipes that are installed vertically in the water column and driven into the river bed to form a watertight space. To construct the diffusers using this method, the steps involved include:
- Establishing a barge;
- Install the caisson vertically in the river and driven to about a metre into the rock layer.
- Pump water and sand out;
- Establish rock anchors to support the diffuser and diffuser structure;
- Excavate the area surrounding the pipe exit point and install a pipe bend fitting;
- Stabilise the structure with concrete;
- Level the immediate area around the diffuser using leveling grout;
- Install the diffuser and diffuser structure; and
- Cut the diffuser at the desired level and remove.

Two options for the construction of the diffusers have also been suggested, as follows:
- Separate – where the support structure is built and installed in place with the diffuser bolted on.
- Integrated – where the support structure is built, the diffuser bolted on and the complete structure installed into place.

Both methods of installing the diffusers can be used with both jet grouting and caisson methods of structure support and construction.

### 3.6 Resources
The following items of plant and equipment are typically necessary for the construction:
- HDD Rig – this will be used to drill the holes and will be operating constantly;
Mixing and Recycling System – this plant is used to feed fluids used in drilling to the rig and recycle those that are returned to the entry point. The Plant consists of pumps, generators and linear shakers. This runs at all times when the rig is operational.

Generators and Lighting Plants – these will be operational throughout the night providing power and lighting.

Pumps – used to return fluids to the recycler.

High flow external pumps - used to feed the fluids to the rig, these are pumps in addition to those found on the recycler.

Excavators – Used intermittently to dig holes, clean up thick slurry, remove spoil and load large drill rods on to the drill rig.

Trucks – used intermittently as transport, to remove spoil, to remove slurry and deliver materials.

Tools – onsite work shops may be set up to keep the HDD and operation running. Activities could include hammering, welding, grinding, oxy cutting and so on.

The exact plant and equipment will depend on the machinery owned and operated by the chosen contractor. Regardless, it will be the responsibility of the chosen contractor to operate within boundaries of the constraints detailed within this REF.

3.7 Access and Traffic

Access to the Iluka drill site will be from Queen Street, as shown in Figure 3, Appendix A. Signs and traffic controls will be implemented to improve the safety and efficiency of these intersections during construction works.

During the construction period it is anticipated that the site will be accessed by a range of vehicles. A breakdown of the vehicles proposed to access the site is provided in Table 3.

<table>
<thead>
<tr>
<th>Vehicle</th>
<th>Daily Movements</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Heavy Vehicles (eg excavators, cranes, drill rig)</td>
<td>0 - 8</td>
<td>Heavy vehicles are proposed to be moved to site early in the project and stored on site until they are no longer needed. It is therefore expected that heavy vehicle movements will be restricted to periods early and late in the project.</td>
</tr>
<tr>
<td>Haul Trucks</td>
<td>0 - 8</td>
<td>Haul trucks are expected to regularly access the site throughout the project to deliver pipes or remove spoil.</td>
</tr>
<tr>
<td>Passenger Vehicles</td>
<td>2 - 10</td>
<td>Regular passenger vehicle movements are expected throughout the project.</td>
</tr>
</tbody>
</table>

3.8 Timing

As the ebb tide release site will be the primary method of disposing of excess recycled water, the system will need to be established prior to commissioning of the STP upgrades. The pipelines required from the
Iluka STP will start construction during the construction works at the STPs. It is anticipated that this will commence between late 2009 to mid 2010.

HDD is required to be a continuous operation and therefore drilling works will be undertaken 24 hours per day, seven days a week until complete. The length of the construction works has been estimated by Trenchless (2009) as shown in Table 4.

**Table 4  Possible Construction Timeframes**

<table>
<thead>
<tr>
<th>Time Frame</th>
<th>1 Mth</th>
<th>2 Mth</th>
<th>3 Mth</th>
<th>4 Mth</th>
<th>5 Mth</th>
<th>6 Mth</th>
<th>7 Mth</th>
<th>8 Mth</th>
<th>9 Mth</th>
<th>10 Mth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iluka (24/7)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- Indicates timeframe given no issues
- Indicates probable added timeframe with some minor issues

3.9  Employment

The project is expected to employ approximately 10 people full time for the duration of the construction. The majority of people employed will be the primary Contractors employees who will be associated with the ebb-tide pipeline construction.

3.10  Environmental Controls

A range of environmental controls will be implemented to minimise the impact of the project on the environment and residents. The controls will address:

- Soil and water management;
- Community communications and liaison;
- Erosion and sediment control;
- Working hours and noise;
- River and land based traffic management;
- Waste management; and
- Monitoring

A summary of the recommended environmental controls is provided in Appendix C.
4. Strategic Assessment

4.1 Commonwealth Legislation

4.1.1 Environment Protection and Biodiversity Conservation Act 1999

The Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) applies to proposed development that may have a significant impact on a matter of national environmental significance or on Commonwealth land. The Act establishes those matters of national environmental significance that need to be considered when developments are proposed. A checklist that identifies these seven matters, which require assessment in this REF, is contained in Section 7. The impact the project will have on threatened species, populations or ecological communities is also discussed in more detail in Section 6.6.

4.2 State and Regional Planning

4.2.1 Environmental Planning and Assessment Act 1979

In New South Wales, assessment of proposed development is prescribed by the Environmental Planning and Assessment Act 1979 (EP&A Act) and the Environmental Planning and Assessment Regulations 2000 (EP&A Act Regulations).

Environmental assessment is undertaken under Part 3A, Part 4 or Part 5 of the EP&A Act:

- Part 3A – is for a ‘major project’ that requires the ministerial approval;
- Part 4 – where development consent is required from a consent authority; and
- Part 5 – where development consent is not required and a determination to approve the activity is made by a determining authority.

Assessment under Part 5 of the EP&A Act 1979

The Maclean Local Environmental Plan (LEP) 2001, adopts the EP&A Model Provisions 1980. However, these have been superseded by State Environmental Planning Policy (Infrastructure). As described in Section 4.2.3, this means the proposed development does not require development consent.

As the proposal constitutes an “activity” for the purposes of Section 110 of the EP&A Act, being carried out by (or on behalf of) a public authority, assessment under Part 5 of the EP&A Act is required.

Under the terms of the EP&A Act, the determining authority (i.e. CVC), must consider the likely environmental impact of the ebb tide release system. This REF provides information as specified in Clause 111 of the EP&A Act to enable CVC to assess whether the proposal has a significant effect on the environment. If the assessment concludes that there is not likely to be a significant effect on the environment, the proposal can proceed, subject to safeguards outlined in the REF.

4.2.2 Other Acts

Numerous other Acts apply to the site and/or proposed works. Table 5 provides a summary of the main Acts and their relevance to the proposal.
### Table 5  Summary of Relevant Acts

<table>
<thead>
<tr>
<th>Legislation</th>
<th>Key Requirements</th>
<th>Relevance to the proposed activities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coastal Protection Act 1979</td>
<td>Section 38 of the Act states that a public authority requires concurrence of the Minister for certain development in the coastal zone.</td>
<td>The undercrossing is proposed to occur within the coastal zone. Under Section 44 of the Act concurrence is not required from the Minister to carry out the proposed activity as it is not inconsistent with the principles of ESD.</td>
</tr>
<tr>
<td>Threatened Species Conservation Act 1995</td>
<td>The Act requires any threatened plant or animal species, populations or ecological communities associated with a proposed development to be identified and that acceptable recovery and management strategies are implemented a likely significant impact would occur.</td>
<td>The pipeline route can be aligned to avoid impacts on threatened species, as necessary. As such, no impact on threatened species will occur.</td>
</tr>
<tr>
<td>Heritage Act 1977</td>
<td>Approval must be gained from the Heritage Council when making changes to a heritage place listed on the State Heritage Register, or when excavating any land in NSW where you might disturb an archaeological relic.</td>
<td>No known heritage items will be adversely affected by the project.</td>
</tr>
<tr>
<td>National Parks and Wildlife Act 1974</td>
<td>The Act aims to prevent the unnecessary or unwarranted destruction of relics and the active protection and conservation of relics of high cultural significance.</td>
<td>Under the Act a permit may be required if Aboriginal objects or places are uncovered during construction.</td>
</tr>
<tr>
<td>Native Vegetation Conservation Act 2003</td>
<td>The Native Vegetation Conservation Act 2003 requires development approval from the relevant Catchment Management Authority for the clearing of any natural vegetation. Approval can only be granted under this act for proposals that improve or maintain environmental outcomes.</td>
<td>The proposal may require the removal of minimal vegetation. Also, approval is not required if an activity is carried out by a determining authority within the meaning of Part 5 of the EP&amp;A Act, and the determining authority has complied with that Part of the EP&amp;A Act.</td>
</tr>
<tr>
<td>Protection of the Environment Operations Act 1997</td>
<td>The Act enforces licences and approvals formerly required under separate Acts relating to air, water and noise pollution and waste management with a single integrated licence. Development requires a license under the act, should it meet the assessment criteria outlined within Schedule 1 of the EPA-licensed activities.</td>
<td>A license under the Act is not considered necessary for construction. The overall sewerage scheme requires a licence for operation under this Act, which was noted as a requirement in the approved EIS.</td>
</tr>
<tr>
<td>Legislation</td>
<td>Key Requirements</td>
<td>Relevance to the proposed activities</td>
</tr>
<tr>
<td>-------------</td>
<td>-----------------</td>
<td>--------------------------------------</td>
</tr>
<tr>
<td>Water Management Act 2000.</td>
<td>The objectives of this Act are to provide for the sustainable and integrated management of the water sources of the State for the benefit of both present and future generations. Certain activities that may impact on those resources require approval and/or licences.</td>
<td>Approval under Part 3 of Chapter 3 of the Act is considered necessary for an activity involving the “penetration of an aquifer”.</td>
</tr>
<tr>
<td>Contaminated Land Management Act 1997</td>
<td>Provides a regime for investigating and, where appropriate, remediation of land affected by contamination, which represents a significant risk of harm to human health or the environment.</td>
<td>If the construction works uncovers contaminated land, it must be assessed and managed in accordance with the Act.</td>
</tr>
<tr>
<td>Roads Act 1993</td>
<td>Section 138 of the Roads Act 1993 requires that a person obtain the consent of the appropriate roads authority for the erection of a structure, or the carrying out of a work in, on or over a public road, or the digging up or disturbance of the surface of a public road. If the applicant is a public authority, the roads authority must consult with the applicant before deciding whether or not to grant consent or concurrence.</td>
<td>The proposed activity involves the crossing of Queens Road. An approval may be required under the Act, at the time of construction.</td>
</tr>
<tr>
<td>Crown Lands Act 1989</td>
<td>Governs the use of Crown land.</td>
<td>An easement or licence will need to be acquired over all Crown lands affected by the proposal.</td>
</tr>
<tr>
<td>Fisheries Management Act 1994</td>
<td>The Act seeks to preserve fish stocks and key fish habitats, including threatened species, populations and ecological communities. A further object of the Act is to promote sustainable fishing.</td>
<td>The proposal involves the dredging of water land where the diffusers will be installed. This will require a permit issued by the Minister.</td>
</tr>
<tr>
<td>Rural Fires Act 1997</td>
<td>The Act manages bushfire within the State and regulates development in bushfire prone areas.</td>
<td>The proposal is not for subdivision and is not a special fire protection purpose. Approval is not required under the Act.</td>
</tr>
</tbody>
</table>

### 4.2.3 State Environmental Planning Policies

**State Environmental Planning Policy (Infrastructure)**

The State Environmental Planning Policy (Infrastructure) 2007 assists the NSW Government, local councils and the communities they support by simplifying the process for providing infrastructure in areas such as education, hospitals, roads, railways, emergency services, water supply and electricity delivery. According to this SEPP:
“Development for the purpose of sewage reticulation systems may be carried out by, or on behalf of, a public authority or any person licensed under the Water Industry Competition Act 2006 without consent on any land.”

**State Environmental Planning Policy No. 14 – Coastal Wetlands**

The aim of SEPP 14 is to ensure coastal wetlands are preserved and protected for environmental and economic reasons. The policy applies to local government areas outside the Sydney metropolitan area that front the Pacific Ocean. The policy identifies over 1300 wetlands of high natural value from Tweed Heads to Broken Bay and from Wollongong to Cape Howe. Land clearing, levee construction, drainage work or filling may only be carried out within these wetlands with the consent of the local council and the agreement of the Director-General of the Department of Planning. Such development also requires an environmental impact statement to be lodged with a development application. The policy is continually reviewed. It has, for example, been amended to omit or include areas, clarify the definition of the land to which the policy applies and to allow minimal clearing along boundaries for fencing and surveying.

As shown on Figure 2, Appendix A, there is an area of SEPP 14 wetland located on or adjacent to Hickey Island. The wetlands are not expected to be impacted by the construction or operation of the ebb tide release.

**State Environmental Planning Policy No.26 – Littoral Rainforest**

SEPP 26 aims to provide a mechanism for the assessment of development proposals that are likely to damage or destroy littoral rainforest areas. The policy applies to certain mapped areas and includes a 100 metre buffer zone surrounding such areas. The policy requires that consent must be granted prior to the carrying out of any development within these areas. The likely effects of the proposal must be considered in an environmental impact statement.

A significant area of SEPP 26 Littoral Rainforest is located to the north of Iluka. This area is also listed as a World Heritage. The SEPP 26 will not be impacted by the construction or operation of the proposal.

**State Environmental Planning Policy No. 71 – Coastal Protection**

State Environmental Planning Policy No. 71 aims to:

- Foster a strategic and consistent approach to coastal planning and management
- Ensure that the coastal zone is managed and protected in accordance with ecologically sustainable development principles
- Facilitate the assessment of development proposals, and assess each proposal on its individual merits
- Set out matters for consideration by councils and consent authorities
- Develop a review process for significant coastal development proposals, which includes development proposed in sensitive locations
- Create a ‘master plan’ (now DCP) process to ensure developments in the coastal zone are consistent with the SEPP’s provisions

This policy identifies State significant development in the coastal zone and requires certain development applications to carry out development in sensitive coastal locations to be referred to the Director-General for comment. Additionally, it identifies master plan requirements for certain development in the coastal zone.
As the proposal will be assessed under Part 5 of the EP&A Act development consent is not being sought and as such there is no requirement for concurrence from the Director-General. However, it is considered that the proposal complies with the principles of SEPP 71.

4.2.4 North Coast Regional Environmental Plan 1988
The North Coast Regional Environmental Plan 1988 (REP) applies to the study area. The REP primarily identifies requirements for the preparation of Local Environmental Plans and for development assessment within the North Coast Region. It is considered that the proposal is consistent with the REP.

4.3 Other Relevant Policies

4.3.1 NSW Coastal Policy
The 1997 NSW Coastal Policy responds to the fundamental challenge to provide for population growth and economic development without placing the natural, cultural, spiritual and heritage values of the coastal environment at risk. To achieve suitable forms of growth the Policy has a strong integrating philosophy based on the principles of ecologically sustainable development (DoP, 2007).

The Policy addresses a number of key coastal themes including:
- population growth in terms of physical locations and absolute limits;
- coastal water quality issues, especially in estuaries;
- disturbance of acid sulfate soils;
- establishing an adequate, comprehensive and representative system of reserves;
- better integration of the range of government agencies and community organisations involved in coastal planning and management;
- Indigenous and European cultural heritage; and
- integration of the principles of ecologically sustainable development into coastal zone management and decision making (DoP, 2007).

The intent of the coastal policy is considered throughout this REF. Key environmental impacts of the activity have been identified and, where required, appropriate mitigation methods have been proposed to effectively manage potential environmental impact. The proposal accords with the intent of the NSW Coastal Policy.

4.4 Local Legislation

4.4.1 Maclean Local Environmental Plan 2001
As mentioned earlier, the Maclean Local Environmental Plan (LEP) 2001, adopts the EP&A Model Provisions 1980. However, these have been superseded by State Environmental Planning Policy (Infrastructure) and this means the proposed development does not require development consent.

Under the provisions of the Maclean LEP 2001, the site of the proposed HDD launch point in Iluka is zoned 1(i) Rural (investigation). The pipeline and diffuser will extend through an area zoned 1(w) Rural (Waterway). Zonings are shown in Figure 6, Appendix A.
Other relevant provisions of the Maclean LEP include:

- Clause 10  Bushfire hazard
- Clause 11  Flood liable land
- Clause 13  Development within the coastal zone
- Clause 18  Development on land identified on Acid Sulfate Soils Planning Maps

As mentioned earlier, the Maclean Local Environmental Plan (LEP) 2001, adopts the EP&A Model Provisions 1980. However, these have been superseded by SEPP (Infrastructure) and this means the proposed development does not require development consent.
5. Consultation

CVC formed the Iluka Consultative Working Group (ICWG) to provide an opportunity for Government Agencies, interest groups and the community to be involved in the proposed sewerage scheme. Government Agencies and interest groups that have also been consulted include:

- Planning NSW
- Department of Water and Energy
- Department of Environment and Climate Change
- Environment Australia
- NSW Tourism
- Heritage Office
- Birrigan Gargle Local Aboriginal Land Council
- NSW Fisheries
- NSW Maritime
- Yaegla Native Title Claimants
- NSW Coastal Council
- National Parks & Wildlife Services
- Northern Region Area Health Service (NSW Health)
- Country Energy
- Healthy Rivers Commission
- NSW Agriculture
- Clarence River Fishing Clubs Association Inc
- Clarence Rivers Fishermen Cooperative
- Northern Professional Fishermen's Association (NPFA).

The ICWG, above agencies and the broader community have been regularly updated about the project. A summary of the official stakeholder consultation to date for the ebb-tide release is provided in Table 6.

### Table 6 Consultation Activities

<table>
<thead>
<tr>
<th>Date</th>
<th>Consultation Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 November 2006</td>
<td>Stakeholder meeting attended by Lands, DECC, DPI Fisheries, Northern Rivers Professional Fishers Association, NPFA and Native Title Claimant representative identifying issues with ebb-tide release location and construction.</td>
</tr>
<tr>
<td>13 December 2006</td>
<td>Site inspection of ebb-tide release locations for ICWG members.</td>
</tr>
<tr>
<td>20 December 2006</td>
<td>Meeting with Native Title Claimants (including inspection) to discuss release location.</td>
</tr>
<tr>
<td>17 April 2007</td>
<td>&quot;Beyond Thunderdome&quot; newsletter #12 delivered to Iluka residents.</td>
</tr>
<tr>
<td>14 August 2007</td>
<td>ICWG meeting.</td>
</tr>
<tr>
<td>7 November 2007</td>
<td>Stakeholder meeting with representatives from recreational and professional fishers, NSW Maritime and NSW DPI - Fisheries to discuss release location.</td>
</tr>
<tr>
<td>17 December 2007</td>
<td>Meeting with Yaegl Native title claimants to discuss release location.</td>
</tr>
<tr>
<td>29 April 2008</td>
<td>Meeting with Yaegl Native Title claimants including presentation from WRL.</td>
</tr>
<tr>
<td>26 May 2008</td>
<td>Meeting with Yaegl Native Title claimants to discuss revised location.</td>
</tr>
<tr>
<td>Date</td>
<td>Consultation Activity</td>
</tr>
<tr>
<td>-------------------</td>
<td>------------------------------------------------------------</td>
</tr>
<tr>
<td>1 July 2008</td>
<td>ICWG meeting.</td>
</tr>
<tr>
<td>14 October 2008</td>
<td>Update presentation to Yaegl Native Title Claimants.</td>
</tr>
<tr>
<td>24 March 2009</td>
<td>ICWG meeting.</td>
</tr>
<tr>
<td>25 March 2009</td>
<td>Meeting with representatives.</td>
</tr>
</tbody>
</table>

In addition to the formal consultation, update e-mails have been semi-regularly sent to the key stakeholders (DPI-Fisheries, NPFA, Recreational Fishers, Native Title Claimants and NSW Maritime), as well as update newsletters to ICWG members and interested observers who have asked to be on the mailing list.
6. Environmental Assessment

6.1 Topography, Soils and Geology

6.1.1 Topography
The topography of the Iluka peninsula is largely flat, rising gradually towards the eastern side of the town, adjacent to the coast (GHD, 2007). Dunes, sandsheets and beach ridges are common features throughout the region.

6.1.2 Geology
The Clarence River estuary lies within a bedrock valley which has been gradually filled with terrestrial sediment over millions of years. Over this time, the estuary has also undergone multiple cycles of infilling by marine sediments and erosion in response to varying sea levels (DNR, n.d. in PB, 2008).

Reference to the Maclean 1:250,000 Geological Series Sheet SH 56-7 indicates the pipeline route alignment lies within Holocene marine-aeolian sand plains and beach ridges on the northern (Iluka) side of the river (PB, 2008).

Bundamba Group sandstones are exposed in the headlands at Clarence Head through to Yamba Point and at Barri Point at the southern end of Pippi Beach. Mapping of the outcrop reveals two principal joint vertical sets at a 1.5m spacing; one with a north south strike, the other striking at 95 to 120 degrees. A horizontal bedding defect with a spacing of 0.2m to 0.5m was also noted (PB, 2008).

A rock reef is present at the river entrance, running in a north south orientation positioned approximately 100 m east of the middle training wall (Figure 2, Appendix A). The reef would appear to be a sub-aqueous expression of the Bundamba Group sandstones exposed at Clarence Head (PB, 2008).

6.1.3 Soils
Soils in Iluka are principally sands, which have in some areas been mined. There is no evidence to indicate indurated or impervious layers within the sand profile. The soils are generally non-saline, neutral, non-sodic and of low fertility (GHD, 2007). Morand (2001) describes the soils of the Iluka landscape as typically deep (>200 cm) well-drained Aeric Podosols (Humus Podzols) and deep (>200 cm), poorly drained Aquic/Semiaquic Podosols. Their limitations are described as being acid, highly erodible, non-cohesive infertile soils with very low available water holding capacity and high permeability (Morand, 2001).

6.1.4 Acid Sulfate Soils
The Guidelines for Land Management in NSW Coastal Areas - Assessing and Managing Acid Sulfate Soils (EPA, 1995) define the following criteria for determining whether acid sulfate soils are likely to be present:

- Sediments of recent (Holocene) geological age;
- Soil horizons not more than 5m above high tide level; and
- Marine or estuarine settings.
Each of these characteristics describes the environment of Iluka.

PB (2006) conducted a geotechnical investigation that included the launching site on Hickey Island for the Country Energy transmission line. The launching site was found to have a low probability of occurrence of acid sulfate soil material to a depth of 3m. The bottom sediments of the Clarence River were found to have a high probability of occurrence of acid sulfate soils (PB, 2006).

As shown in Figure 7, Appendix A the CVC Online acid sulfate soil risk mapping, the proposed drilling pad site is mapped as having Class 5 acid sulfate soils (this was confirmed by Pers. Comm., Greg Mashiah, CVC, 16 February 2009).

6.1.5 Fluvial Geomorphology

Clean marine sands dominate the main channel with an upstream transition from marine to mixed fluvial sands (WRL, 2009). MHL (1996) states that these fine to medium grained sands extend from the ocean entrance to more than 10 km upstream and are moderately-well to well sorted and contain no fine (i.e. clay) sediments. PB (2008) confirmed this sediment composition through geotechnical investigations in the vicinity of the proposed location. Borehole logs that were undertaken along the proposed Country Energy line crossing (specifically BH6 and BH8 in PB, 2007) shown in Figure 8, Appendix A, indicate that in the vicinity of the proposed pipeline alignment it is underlain with a fine to medium-grained grey sands strata approximately 2 – 7 m in thickness that contains traces of shell fragments.

Underlying the grey sands is an indurated sand (i.e. coffee rock) of varying thickness ranging from approximately 15 m at BH6 (south of the middle wall) to approximately 9 m thickness at BH8 (489 m north of BH6 and approximately 300 m south of where the proposed Country Energy line reaches the Iluka foreshore). Underlying the coffee rock is an interbedded layer of sand, clay and silt, which is approximately 40 m in thickness (PB, 2008 in WRL, 2009). The proposed location of the ebb-tide release pipeline is immediately west of the proposed Country Energy line (see Figure 3, Appendix A).

6.1.6 Mitigation Measures

The effects of construction on geology and soils would be limited to disturbance at the HDD pad site, under boring of estuarine sediments and establishing foundations at the pipeline release location to secure pipework.

Spoil from these excavations is expected to be largely sand, and to be suitable as either backfill or as embankment material. However, acid sulfate soils that are disturbed during construction will need to be identified and correctly managed.

In this regard, prior to excavation and/or during construction, potential acid sulfate soils that may be disturbed by construction should be tested to assess the degree of acid generation. The potential impacts from acid sulfate soil runoff and the disposal of any acid sulfate soils should be managed by the preparation of an acid sulfate soil management plan based on the *Acid Sulfate Soil Manual* (ASSMAC 1998), and prepared in consultation with the DECC.

Contractors undertaking the drilling will need to consider contingency actions through the development of a Construction Environmental Management Plan (CEMP), and consider recovery operations for damaged equipment in the event of any breakages.

All attempts should be made to ensure the delivery pipeline is installed below the coffee rock and that the diffuser sections of the ebb tide release are adequately anchored to the river bed (WRL, 2009).
Construction activities associated with pipe installation including earthworks, HDD, spoil handling and storage, and concrete works, have the potential to cause erosion and sedimentation. An Erosion and Sediment Control Plan (ESCP) should be prepared and implemented. The ESCP should be consistent with the requirements of *Managing Urban Stormwater: Soils and Construction, Volume 1, 4th Edition*, 2004.

### 6.2 Climate and Air

The climatology and dispersion meteorology of the Iluka areas is strongly influenced by its latitude and proximity to the Pacific Ocean and can be broadly defined as humid sub-tropical. The region is characterised by warm to hot, humid summers with a mild maritime influence and mild, dry winters with cool nights. The sub-tropical climate is generally warm all year round with moderate maximum summer temperatures and most rain falling during the summer months.

Climate data has been obtained from the Bureau of Meteorology (BOM) from the Yamba Pilot Station between 1877 and 2009. The weather parameters for the locality are summarised below in Table 7.

**Table 7  Climate statistics for Yamba pilot station**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Annual Rainfall</td>
<td>1452.3 mm</td>
</tr>
<tr>
<td>Average Annual Rain Days</td>
<td>110.7</td>
</tr>
<tr>
<td>Mean Minimum Temperature</td>
<td>15.4 °C</td>
</tr>
<tr>
<td>Mean Maximum Temperature</td>
<td>23.3 °C</td>
</tr>
<tr>
<td>Average 9 am Wind Speed</td>
<td>13.0 km/h</td>
</tr>
<tr>
<td>Average 3 pm Wind Speed</td>
<td>19.4 km/h</td>
</tr>
</tbody>
</table>

(Source: BOM, 2009)

The largest impact from climate on the project may be caused by rainfall during construction. Heavy rainfall may cause delays during construction at locations where vegetation clearing may be required and where areas of soils are exposed. A mild monsoon season is considered to exist within the study area from February through to April (PB, 2008).

A detailed air assessment has not been undertaken prior to the preparation of this REF however, it is expected that the proposal may have the potential to impact air quality in the short term due to the following:

- Dust generation from construction vehicles driving over exposed soils;
- Strong winds blowing over stockpiles and exposed soils could generate dust; and
- Exhaust emissions from construction machinery.

#### 6.2.1 Mitigation Measures

The potential for air quality impacts would be minimised through the following:

- Minimising the area of soil exposed at any one time;
Water spraying of the unsealed access and exposed soils if dust is generated;

Stabilisation of exposed soils as soon as possible;

Ceasing works when it is not possible to control the dust generated;

All construction equipment and machinery would be maintained regularly to ensure efficient operation, including vehicle emissions; and

Where appropriate, all construction equipment and machinery would be turned off or throttled down when not in use.

6.3 Noise and Vibration

GHD assessed the noise and vibration conditions and impacts from the proposal. A summary of the assessment is provided below and a copy of the report is in Appendix D.

A background noise survey was undertaken from Friday 17th April to Monday 27th April 2009 in order to quantify the ambient noise environment in the vicinity of the construction site and potentially effected receivers. The noise logger was located adjacent to the Iluka launch site in order to capture the ambient noise environment.

The monitoring results and site observations indicate that the ambient noise environment is typical of a suburban environment. Site observations advise that the monitoring location is representative of the ambient noise environment of the area including the potentially effected receivers. However it should be noted that the background noise environment would vary depending on localised ambient noise sources.

Table 8 summarises the background noise levels $L_{A90}$ for the day, evening and night-time periods.

<table>
<thead>
<tr>
<th>Location</th>
<th>Day (7 am- 6 pm)</th>
<th>Evening (6 pm- 10 pm)</th>
<th>Night (10 pm- 7 am)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iluka Launch Site</td>
<td>39</td>
<td>41</td>
<td>38</td>
</tr>
</tbody>
</table>

6.3.1 Noise and Vibration Impacts

GHD (2009) has assessed the potential for noise and vibration impact from the HDD activities at the Iluka launch site. The assessment has been undertaken with consideration to the DECC New South Wales Construction Noise Guidelines: Draft for consultation, August 2008.

The DECC (2008) provides noise management levels for construction noise at residential receivers. These management levels have been calculated based on the background noise levels. Table 9 details the adopted construction noise goals for the proposed HDD activities.
Table 9 NSW DECC construction noise goals

<table>
<thead>
<tr>
<th>Time period</th>
<th>Management level L_{Aeq} (15 min) dB(A)</th>
<th>Background Noise Level L_{A90} dB(A)</th>
<th>Adopted noise goals L_{Aeq} (15 min) dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended standard hours:</td>
<td>Noise affected RBL + 10 dB(A)</td>
<td>39</td>
<td>49</td>
</tr>
<tr>
<td>Monday to Friday: 7am to 6pm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturday: 8 am to 1 pm</td>
<td>Highly noise affected 75 dB(A)</td>
<td>N/A</td>
<td>75</td>
</tr>
<tr>
<td>No work on Sundays or Public Holidays</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside recommended standard hours</td>
<td>Noise affected RBL + 5 dB(A)</td>
<td>38</td>
<td>43</td>
</tr>
</tbody>
</table>

The noise affected level during recommended construction hours and outside of recommended standard hours represents a point at which there may be some reaction to noise by the community. The highly noise affected level of 75 dB(A) represents a point where there may be a strong reaction to noise from the community.

Table 10 indicates that the noise affected level during and outside normal working hours, as a result of the construction works at Iluka are expected to comply with noise goals at the surrounding residences.

Table 10 Iluka Launch Site Noise Levels at Surrounding Residence, dB(A)

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Noise Level at Nearest Residence, dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>To the North</td>
<td>To the South</td>
</tr>
<tr>
<td>HDD drill rig, mixing and recycling system, generator and excavator.</td>
<td>37</td>
</tr>
<tr>
<td>HDD drill rig, mixing and recycling system, generator, excavator, workshop and dump truck.</td>
<td>41</td>
</tr>
</tbody>
</table>

The vibration assessment was undertaken with consideration to the DECC Assessing Vibration: A Technical Guideline, 2006. Energy from construction equipment is transmitted into the ground and transformed into vibrations, which attenuates with distance.

The excavator is the only item of equipment on site that is anticipated to generate appreciable vibration impacts. There is the potential for drilling equipment to cause ground vibrations though these are expected to be minimal.

The predicted ground vibrations at various distances are shown in Table 11 for typical excavators.
### Table 11  Estimated Excavator Vibration Levels (mm/s Peak)

<table>
<thead>
<tr>
<th>Plant Item</th>
<th>Vibration Level at Distances (mm/s Peak)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 m</td>
</tr>
<tr>
<td>Excavator</td>
<td>3</td>
</tr>
</tbody>
</table>

The nearest residences are located approximately 350 m to the north of the site therefore there is not anticipated to be any vibration impacts.

#### 6.3.2 Mitigation Measures

General noise and vibration mitigation measures should include:

- A CVC representative should make contact with affected local residents and communicate the construction program and progress on a regular basis.
- All site workers should be sensitised to the potential for noise and vibration impacts on local residents and encouraged to take practical and reasonable measures to minimise the impact during the course of their activities.
- Liaise with the potentially effected residents prior to the start of construction so that they are aware of the mechanism to lodge a complaint or feedback. All complaints lodged by nearby residents are logged on a complaints register, which would also document the investigation into the source of the emission giving rise to the complaint and any corrective actions taken to rectify the cause of complaint.

It is recommended that the following construction noise mitigation measures be implemented to reduce the impact on the surrounding residents:

- The construction sites should be laid-out in such a way that the primary noise sources are at a maximum distance from residences, with solid structures (sheds, containers, etc) placed between residences and noise sources (and as close to the noise sources as is possible).
- As far as possible, materials dropped from heights should be minimised.
- Where practical, machines should be operated at low speed or power and will be switched off when not being used rather than left idling for prolonged periods.
- Where possible equipment should be selected to minimise noise emissions, be fitted with appropriate silencers and be in good working order.
- An excavator likely to produce low noise emissions should be selected.
- Machines found to produce excessive noise compared to normal industry expectations should be removed from the site or stood down until repairs or modifications can be made.
- Reversing alarms noise emissions should be minimised, though satisfactory to achieve occupational health and safety requirements.
- Workshop, delivery and excavator activities should be limited to normal working hours if possible.
- A barrier surrounding the site should be constructed to mitigate the noise impacts on the surrounding residents. The effectiveness of the noise barrier will depend on the height and location of the barrier and the distance of the sources and receivers to the barrier.
The noise goals set by the DECC CNG should be achievable however it is recommended that construction noise monitoring be undertaken during the night time period to confirm noise modelling predictions.

The construction noise monitoring should be used as a guide when implementing the above mitigation measures to assess the most effective means of reducing noise impacts.

The results of the Iluka construction noise monitoring and mitigation design should be used to assess the potential impact at the proposed Yamba Launch site.

Additionally, attended noise monitoring should be undertaken upon receipt of a noise complaint, monitoring should be undertaken at the earliest convenience and reported within 3 to 5 working days. In the case that exceedances are detected, the situation should be reviewed in order to identify means to reduce the impact to acceptable levels.

In all cases, noise monitoring should be undertaken by a qualified professional with consideration to the relevant standards and guidelines.

6.4 Hydrology and Water Quality

Iluka is surrounded by the Clarence River and the Pacific Ocean. The Clarence River is used for recreational activities, fishing and water sports such as swimming, water skiing, sailing and windsurfing (SKM, 2005). The beaches north and south of the river entrance, Iluka Beach, Turners Beach and Yamba Beach, are popular for surfing (SKM, 2003).

The Clarence River is the largest coastal river in NSW and it has a catchment area of approximately 22,700 square kilometres (Healthy Rivers Commission of NSW, 1999 in SKM, 2005). The catchment is bounded by the Macpherson Ranges to the north, Baldblair, the Doughboy Ranges and the Dorrigo Plateau to the south and the Great Dividing Range to the west. Within the Clarence catchment, there are five main tributaries: the Timbarra, the Mann, the Guy Fawkes, the Nymboida and the Orara. The average annual flow from the Clarence River is approximately 4 million ML with an average daily flow of approximately 11,000 ML (Nornet, 2002 in Geolink, 2003a).

The general good health of the Clarence River is directly attributed to the large proportion of the catchment reserved as national parks and state forests. The upper parts of the catchment, however, are affected by land and water degradation, weed invasion, past mining activities, roads and poorly designed creek crossings. Flows and water quality in many sections of the river have been affected by the extraction of water for electricity generation, town supply, agriculture and rural use. Treated discharges from the sewered towns and untreated wastewater from the unsewered villages, rural residential development and grazing animals have affected the estuarine and freshwater reaches (SKM, 2005).

The Clarence River is a wave-dominated estuary with high sediment trapping efficiency, naturally low turbidity, partially mixed circulation and a high risk of sedimentation (Coastal CRC, undated in SKM, 2005). The estuary is in a state of quasi equilibrium between the forces of freshwater inflow and fluvial sediment at the landward end and tidal, wave forcing and marine sediment input at the sea end (SKM, 2003).
6.4.1 Water Quality Impacts

To understand the environmental conditions of the Clarence River estuary and apply this information to optimise the ebb-tide release system design, Water Research Laboratory (WRL) (2009) have undertaken extensive field studies and computer modelling.

Based on the proposed diffuser configurations, the provided design flow rates, the estimated depth of the diffusers, the outcomes of the field investigation and the flow path modelling, water quality modelling was undertaken. This modelling was focused on ensuring that the water quality criteria were met or exceeded within the near-field zone. The near-field zone is the region where the released fresh water is rising through the water column under its own buoyancy and is typically in the order of 50 - 150 m from the release (WRL, 2009).

WRL assessed the water quality impacts of the original release locations in detail – Detailed Concept Design of Yamba-Iluka Ebb Tide Release (WRL, 2009). An addendum to this assessment was undertaken for the revised release location. Both the original report and addendum are in Appendix B.

The addendum indicated that near-field modelling was undertaken using CORMIX. An ambient water depth of -4.0 m Iluka Port Datum (IPD) was assumed and a release depth of -3.0 m IPD was applied. Due to the distance of the location from the ocean, a 3 hour ebb tide release window was assumed. 50th percentile and 90th percentile flows over this 3 hour period were used to calculate near-field dilutions and the results are shown in Table 12.

Table 12 Two Port Diffuser Near-field Dilutions (WRL, 2009a)

<table>
<thead>
<tr>
<th>Port Angle</th>
<th>Dilution for 3 hour ebb discharge (50th %ile velocity)</th>
<th>Dilution for 3 hour ebb discharge (90th %ile velocity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90/270</td>
<td>91</td>
<td>58</td>
</tr>
</tbody>
</table>

Based on the dilutions calculated above, all analytes except for Total N and ammonia would satisfy water quality guidelines to meet the requirements for minimum dilution within the near-field zone. To satisfy the criteria for Total N (65 times dilution) and ammonia (~200 times dilution), additional dilutions are required. The distance from the release location required to meet ~200 times dilution was calculated as 97 m for 50th percentile ambient velocities, and 193 m for 90th percentile ambient velocities (Table 13 and Figure 9). It is worth noting that the dilution required for ammonia is highly conservative as it assumes that no chemical transformations would occur.

Table 13 Distance to 200 Times Dilution for Iluka: Two Port Diffuser (WRL, 2009a)

<table>
<thead>
<tr>
<th>Port Angle</th>
<th>Distance to 200x dilution for 3 hour ebb discharge (50th %ile velocity)</th>
<th>Distance to 200x dilution for 3 hour ebb discharge (90th %ile velocity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90/270</td>
<td>97m</td>
<td>193m</td>
</tr>
</tbody>
</table>

6.4.2 Drilling Fractures

The HDD has the potential to degrade the nearshore bed of the river and water quality by hydraulic fracture during the drilling process. If this occurred close to the bed of the river it could potentially cause...
a fracture in the bed of the river, mobilising riverbed sediments into the waterway, causing discolouration and temporary impacts to water quality.

As stated in Section 3.5.1 the HDD requires the use of a drilling "mud" to provide a medium for return of the drill cuttings and to stabilise the hole. The drilling mud will consist of bentonite clay mixed into slurry, which is pumped under pressure to the cutting face. The requirement of using slurry pumped under pressure brings with it a risk of hydraulic fracturing in the loose sands typical of the upper soil profile at the site. Where hydraulic fracturing occurs, and the mud breaks open the soil strata it can leak from the drill hole and potentially into the surrounding environment (PB, 2008).

6.4.3 Diffuser Structure Construction

The method of diffuser structure construction is currently uncertain but it is likely to be Jet Grouting or Caissons. Both of these techniques have the potential to disturb the sediments of the river and may result in increased turbidity in the estuary. However, it is assumed that the area disturbed would be small, short-term and consist of small to medium grained marine sands (WRL, 2009) that typically settle rapidly.

The cement grouting used in the Jet Grouting technique may leak into the water column. This could add to the turbidity of the water. Water extracted from the caisson may also contain high concentrations of suspended solids.

6.4.4 Mitigation Measures

To minimise the water quality impacts from the proposal it is recommended that:

- The ebb tide release system be operated as recommended by the WRL (2009) report;
- The ebb tide release system should be regularly maintained to ensure it operates efficiently;
- Water quality monitoring be undertaken at the STP to ensure the water quality meets the Accepted Modern Technology criteria. If this criteria is not achieved, ebb-tide release should, where possible, cease until resolved;
- A regular water quality monitoring program should be developed and implemented for the estuary and adjacent beaches;
- An ESCP should be prepared and implemented. The ESCP should be consistent with the requirements of Managing Urban Stormwater: Soils and Construction, Volume 1, 4th Edition, 2004;
- All effort should be made to ensure the HDD alignment is within or beneath the more fracture resistant coffee rock. If a fracture does occur, works should stop until the fracture is sealed;
- All drilling mud should be biodegradable;
- Cement grout should be non-toxic to aquatic organisms; and
- Disturbance of sediments during the construction of the release structure should be minimised and undertaken during the ebb-tide.

6.5 Groundwater

Manly Hydraulics Laboratory undertook a groundwater monitoring program between November 1997 and May 1998 for a separate proposal. The depth to groundwater in the locality varies with rainfall events;
however, it is generally quite close to the surface, with most of the standing water in drains and swampy areas that reflect the water table level (Manly Hydraulics, 1999).

The proposed pipe for the ebb tide release is anticipated to pass through groundwater for most of its length. The HDD technique provides for minimal potential impact on groundwater as the slurry injection assists to consolidate the walls of the drill hole. As the groundwater laden with cuttings travels back up the drillhole, it is captured, the cuttings removed and recycled, and consequently the fluid can be pumped back around the drilling loop (PB, 2008).

6.5.1 Mitigation measures

As for above, the contractors undertaking the drilling will need to consider management of extracted groundwater and spoil and contingency actions through the development of a CEMP.

6.6 Flora and Fauna

6.6.1 Terrestrial

The proposed Iluka Drilling Site is located adjacent to the Clarence River below Queens Street, in Iluka. The site is highly disturbed consisting of a flat area of former fill adjacent to a breakwall of an artificial harbour, and has a well-used unsealed road running through it. The native vegetation at the site is limited to regrowth on the bund of the adjacent Queen St and sparsely along the breakwall. The remainder is maintained parkland. This area appears to be frequented for fishing and picnicking, with crane mounts on the adjacent breakwall suggesting other historical uses (Darkheart Eco-Consultancy, 2007). Immediately to the east within the same area is the proposed exit site for the Country Energy under crossing.

6.6.2 Mitigation Measures

Environmental impacts upon existing terrestrial flora and fauna are assumed to be minimal due to the previous clearing and urbanisation that has already occurred at and around the site. However, suggested mitigation measures include:

- If vegetation needs to be removed, consult a qualified consultant prior to clearing; and

6.6.3 Estuarine

Endangered Ecological Communities

Seagrass beds occur within the study area. Past studies have identified that *Zostera capricorni* is the dominant seagrass species in the Clarence River estuary. Other seagrass species present in the Clarence River include the *Halophila* spp. and *Ruppia* spp.

The coastal saltmarsh vegetation is an endangered ecological community (EEC) as listed under the Threatened Species Conservation Act 1995 (TSC Act) and the Environmental Protection and Biodiversity Conservation Act 1999 (EPBC Act). Saltmarsh covers approximately 1.9km$^2$ of the river, equating to 2% of the estuary area.
The mangrove species present in the Clarence River include the *Avicennia marina*, *Aegicerus corniculatum*, *Exoecaria agallocha* and *Bruguiera gymnorrhiza*. Mangrove coverage in the Clarence River is estimated to be 5km² or 6% of the estuary area.

**Rocky Reef**

A reef within the mouth of the Clarence River estuary was assessed in 1995 by Marine Pollution Research Lab Pty Ltd. The reef was described as consisting of ‘terrace’ of a soft whitish ‘coffee rock’ material exposed above a marine sandy substratum. Most of the flat sand smothered reef supported little or no benthic life other than a few algae species (principally *Lenormandia sp.* and *Sargassum sp.*). The protruding rock supported a more diverse biota including algae, a number of encrusting sponge species and small tunicates (sea squirts). There were one or two coelenterates (cnidaria) species, a colonial anemone, a stalked hydroid and a sea fan.

Most of the reef is smothered in coarse marine sand. The total reef, as observed by Marine Pollution Research Lab, stood between one to two metres off the surrounding sand. As a consequence, flora and fauna inhabiting the reef was not considered to be diverse and comprises mostly species that are adapted to the conditions of high current and sandblasting.

**Fish**

Schedules 4 and 5 of the Fisheries Management Act 1994 lists aquatic species, populations and ecological communities that are endangered, vulnerable or presumed extinct. The Fisheries Management Act lists three species that may occur in the locality:

- Pygmy Perch (*Nannaperca oxleyana*): this species is a freshwater species and therefore would not occur in the study area;
- Black Cod (*Epinephelus daemenelii*): The Black Cod has been recorded from southern Queensland to Kangaroo Island in South Australia. In Australia it is found on coastal and offshore reefs and islands and is an aggressive territorial species that may occupy a particular cave for life. It is unlikely that suitable habitat is located within the study area; and
- Green Swordfish (*Pristis zijsron*): The Green Swordfish has previously inhabited the shallow waters at the mouth of the Clarence River, however, the last recorded specimen from NSW was in 1972. This species is a benthic species and its decline in numbers has been attributed to bycatch in shallow prawn trawling, targeted harvest for flesh, fins and saws and habitat degradation. With the Clarence River commercial fishery one of the largest in NSW, it is unlikely that species would still be present.

Juveniles of many of the commercially important species are common and widespread within the Clarence River. Subsequently, the species listed below were captured in a past study undertaken by Marine Pollution Research Lab Pty Ltd (1995) in the lower reaches of the Clarence River. Species included:

- Yellow fin bream (*Acanthopagrus australis*);
- Sea mullet (*Mugil cephalus*);
- Flat-tail mullet (*Liza argentea*);
- Tarwhine (*Rhabdosargus sarba*);
- Luderic (*Girella tricuspicata*);
Silver Biddy (*Gerres subfasciatus*); and
Sand whiting (*Sillago ciliata*).

Based on the proximity of the proposed discharge release point to the mouth of the Clarence river, an estuarine/marine ecological community comprised of any number of species listed above would most likely inhabit the area. Few if any freshwater organisms would be able to survive in this tidally influenced saline environment.

### 6.6.4 Potential Impacts

The construction of the ebb tide discharge structure may result in increased turbidity in the estuary due to the disturbance of bottom sediments, although it is assumed that the area disturbed would be small and consist of small to medium grained marine sands (WRL, 2009) that typically settle rapidly. Bottom sediment disturbing activities may smother sessile aquatic organisms or temporarily affect photosynthesis rates of flora.

The route of the proposed pipeline was selected to avoid any potential impact on marine vegetation in the locality. Given the nature of the project and the use of HDD, *zostera* beds and mangroves are not considered to be affected by the works.

Drilling operations for the HDD will occur in previously cleared areas and will not require the removal or damage of any saltmarsh vegetation. It is therefore assumed there would not be any adverse impact on the EEC.

NSW Fisheries policy requires that the point of treated wastewater discharge be located over 50 m from sensitive fish habitats such as seagrass beds, mangroves, saltmarsh or other marine vegetation. Based on supporting information, there are no sensitive fish habitats within 50 metres of the proposed ebb tide discharge location.

### 6.6.5 Mitigation Measures

Environmental impacts upon aquatic flora and fauna are considered negligible. However, suggested mitigation measures include:
- If mangroves, saltmarsh or seagrass needs to be removed, consult a qualified consultant prior to clearing; and
- Ensure the proposal does not deteriorate the water quality by implementing the mitigation measures outlined in Section 6.4.

### 6.7 Heritage

#### 6.7.1 Indigenous

The Yaegl people are the traditional inhabitants of the Yamba area and the Birrigan G gargle Local Aboriginal Land Council (LALC) is responsible for the Yamba region (SKM, 2005). Three major habitats occur within the Yaygir territory, littoral, estuarine and coastal plain. From habitats in traditional boundaries an abundance and variety of food would have been available. Early records of the Yaygir economy attest to the abundance of economic resources of the Yamba region (Heritage Concepts, 2007).
The Dirrangun Reef site is located immediately upstream of the southern breakwater (as depicted in Figure 2, Appendix A). The reef is a Dreaming place of great power and significance within the cultural landscape of the local Aboriginal people. As such, any impact on or near the reef will profoundly affect the spiritual beliefs of not only the local Aboriginal community but the wider Aboriginal communities along the Clarence River (Heritage Concepts, 2007).

A native title claim has been lodged over the Clarence River downstream of the Harwood Bridge, which includes the rock reef. Discussions with this group have indicated that they would not be amenable to any engineering works that may impact the rock reef. Further, the Native Title Claimants have requested that the release structure is not constructed east of the proposed Country Energy river undercrossing (WRL, 2009).

Heritage Concepts Pty Ltd prepared a report titled Assessment of Aboriginal and Historical Archaeological and Heritage Values - Proposed Yamba to Iluka River Under crossing (December 2007). The study area of the report includes the proposed drilling site and ebb-tide pipeline location.

A search of the DECC Aboriginal Heritage Information Management System (AHIMS) database conducted in October 2006 by Heritage Concepts revealed a total of 24 Aboriginal places located within the vicinity of the study area of the Country Energy river undercrossing (Heritage Concepts, 2007). The report does not identify any Aboriginal heritage places in the immediate vicinity of the proposed drilling site. The closest and most significant heritage place is the Dirrangun Reef to the east of the subject area.

Mitigation Measures

The alignment of the pipeline and release structure are to the west of the Country Energy river under crossing so as not to interfere with the Dirrangun Reef.

In addition to the applicable mitigation measures outlined in the 2003 Iluka EIS and the conditions outlined in the associated Determination Report, the following recommendations from the Heritage Concepts report (2007) are also considered relevant:

- CVC and the Traditional Aboriginal Owners enter into an agreement regarding the ongoing protection and conservation of the reef during construction, including provisions for the safety of the reef as part of ongoing operational maintenance of the pipeline. The agreement must be made prior to the commencement of construction works;
- Prepare a Cultural Heritage Management Plan prior to the commencement of construction works to safeguard and protect the heritage values of the reef; and
- Continue dialogue with the traditional Aboriginal owners as part of this project.

6.7.2 Non-Indigenous

According to the Maclean LEP there are no heritage items in the vicinity of the proposal but the Iluka Nature Reserve is listed on the Register of the National Estate.

6.7.3 Mitigation measures

All non-indigenous heritage items are sufficiently removed from the area of proposed construction so that there would not be any adverse impact as a result of construction or on-going operation. If, however, any items of European significance are found, work would cease immediately and the NSW Heritage Office should be contacted.
6.8 Traffic and Navigation

Queen Street, Iluka provides access to the beach and north breakwall of the Clarence River. This road has limited traffic volumes.

The construction works are predicted to create a maximum of 18 additional traffic movements per day (Table 3), eight of these will be heavy vehicles. This is unlikely to create a noticeable increase in traffic volumes on Queen Street, Iluka.

The Clarence River is a highly trafficked waterway with several large commercial vessels requiring navigation access. The Port of Yamba is Australia’s easternmost port and handles a range of imports and exports. The main port facilities are located at the Goodwood Island wharf approximately 10 kilometres upstream from the entrance to the Clarence River. Several plans have been previously proposed to expand commercial shipping traffic from the Port of Yamba (MHL, 2000), although no formal process is currently underway.

A formal navigation channel exists along the waterway. Potential disruption to the navigable waterway may occur during construction where stringing of each pipeline requires the pipeline to be floated on a barge within the channel of the Clarence River. The construction of the diffuser structure using either the Jet Grouting or Caissons technique may also create a temporary hazard to navigation.

The pipeline diffusers could also be potentially damaged during operation as a result of maintenance dredging or anchoring.

Advice received from NSW Maritime Authority stated that a release location at least 50 m from either side of the centreline of the channel would be considered appropriate to avoid any risk of damage that may occur during maintenance dredging (WRL, 2009). NSW Maritime have provided further advice that states that the proposed location of the diffuser is acceptable subject to adequate depth to provide for shipping being available.

6.8.1 Mitigation Measures

Mitigations measures proposed to reduce the traffic and navigation impacts include:

- A Traffic Management Plan is required to be prepared by the Contractor and submitted to CVC for approval prior to work along Queen Street, as necessary. Where construction requires closure of a road, affected landholders will require notification in accordance with the Traffic Management Plan;
- Ebb-tide release location to be installed at least 50 m beyond either side of the centreline of the channel (as shown in Figure 2, Appendix A) to minimise risk of damage from maintenance dredging activities; and
- Approval is received from NSW Maritime Authority for all works that may obstruct navigation.

6.9 Waste

Excavated material (spoil) would be generated by HDD and diffuser support structure during construction. On-site construction staff would also generate general construction waste. Potentially hazardous materials would also be used during construction, such as fuels, lubricants, solvents, oxy-acetylenes (used for welding), hydraulic fluids and other chemicals. If not managed properly, waste materials such as spoil and hazardous materials could be discharged into the environment or local waterways through surface run-off, wind or spillages.
6.9.1 Mitigation Measures

The following measures would be implemented to manage and mitigate the waste generated by the proposed construction activities:

- Prepare a Waste Management Plan as part of the CEMP;
- Ensuring all contractors remove their general garbage from the work site daily;
- Providing on-site emergency spill kits and training for all staff in their use;
- Ensuring no machinery maintenance is conducted at the site; and
- Ensuring the construction work site is left clean and free of debris and other rubbish at the completion of the proposed construction works.

6.10 Visual

The HDD for the Iluka pipeline will be launched from crown land to the west of Queen Street, Iluka. The site will be partially obscured to traffic on Queen Street by existing vegetation. The site will be visually evident from the boat harbour to the west and the marina to the north. The nearest residences are approximately 300m to the north of the HDD site and would be visually obscured by existing vegetation.

The construction site will be rehabilitated following the construction period. The resultant pipelines will be underground with the release points underwater. It is expected that a marker sign would be placed on the training wall within the river to notify vessels of the underwater release risers. Therefore, there will negligible change in the on-going visual amenity during operation.

The marker buoys denoting the site of the release point will be visible in the Clarence River but their impact on the amenity of the area is considered to be negligible.

6.10.1 Mitigation Measures

The visual impacts would be temporary and are not considered significant, however it is recommended that:

- Construction fencing be installed with shade cloth over the face of the fence to minimise views into the construction site;
- Night lighting of the construction site should be carefully considered to minimise impacts on adjoining residences and roads. The type of lighting is to be considered in the CEMP for the construction site; and
- Rehabilitate the construction site once works are complete.

6.11 Social and Economic Issues

The proposal will have both positive and negative social and economic impacts. The positive impacts relate to the short-term financial benefit to the local Iluka community, with some of the labour and resources sourced directly from the township. The ebb-tide release is an essential component of the implementation of the Iluka STP which will facilitate the development of the town.
The negative impacts will relate to the local residences, businesses and holidaymakers who would experience some minor disruptions during the construction period, such as increased noise, traffic, and a reduction in visual amenity. Although these impacts would be inconvenient for a short time, most are not expected to be significant.

6.11.1 Mitigation Measures

The mitigation measures in relation to social and economic issues include:

- Implement the mitigations measures outlined in Sections 6.3, 6.10 and 6.11 and the Acoustic Report in Appendix D; and
- Continue to consult the community on a regular basis throughout the project.
7. Clause 228 Considerations and EPBC Checklist

7.1 Clause 228 Considerations

Clause 228 of the EP&A Regulation 2000 provides a list of factors to be taken into account concerning the impact of an activity on the environment. The factors for consideration under Clause 228 are assessed in Table 14.

Table 14 Clause 228 Considerations

<table>
<thead>
<tr>
<th>Factor (NSW Legislation)</th>
<th>Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Any environmental impact on a community?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
</tr>
<tr>
<td>The proposed scheme is not expected to have any long term environmental impacts on the Iluka community.</td>
<td></td>
</tr>
<tr>
<td>b. Any transformation of a locality?</td>
<td>Positive</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
</tr>
<tr>
<td>The proposed scheme and associated modifications would allow for the centralised treatment and management of sewage within Iluka.</td>
<td></td>
</tr>
<tr>
<td>c. Any environmental impact on the ecosystems of the locality?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
</tr>
<tr>
<td>There is not expected to be any significant adverse impact on local ecosystems as a result of the proposed scheme.</td>
<td></td>
</tr>
<tr>
<td>d. Any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality?</td>
<td>Low (-ve)</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
</tr>
<tr>
<td>The proposed modifications will result in some aesthetic and recreational impacts during construction activities, including works associated with HDD launch pads. This is considered to be short-term and not significant if the mitigation measures are implemented.</td>
<td></td>
</tr>
<tr>
<td>e. Any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
</tr>
<tr>
<td>There is not expected to be any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations.</td>
<td></td>
</tr>
<tr>
<td>f. Any impact on the habitat of any protected fauna (within the meaning of the National Parks and Wildlife Act, 1974)?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments:</td>
<td></td>
</tr>
<tr>
<td>There are not expected to be any impacts on threatened species due to the proposal.</td>
<td></td>
</tr>
<tr>
<td>Factor (NSW Legislation)</td>
<td>Impacts</td>
</tr>
<tr>
<td>-----------------------------------------------------------------------------------------</td>
<td>-------------</td>
</tr>
<tr>
<td>g. Any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments:</td>
<td>As outlined in Section 6.6, no significant impact is expected on any species due to the proposed scheme.</td>
</tr>
<tr>
<td>h. Any long-term effects on the environment?</td>
<td>Positive</td>
</tr>
<tr>
<td>Comments:</td>
<td>The proposed modifications will improve the current management of sewage in Iluka that is expected to result in positive long-term effect on the environment.</td>
</tr>
<tr>
<td>i. Any degradation of the quality of the environment?</td>
<td>Low (-ve)</td>
</tr>
<tr>
<td>Comments:</td>
<td>Short-term degradation of the environment will occur due to construction works (noise, vibration, dust, estuarine sediment disturbance, etc). The proposed modifications will not result in any long term impact on the quality of the environment.</td>
</tr>
<tr>
<td>j. Any risk to the safety of the environment?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments:</td>
<td>The proposed modifications are not expected to result in any additional risks to the safety of the environment. Appropriate measures including the preparation of Construction and Operational EMPs, will be implemented to address identified risks.</td>
</tr>
<tr>
<td>k. Any reduction in the range of beneficial uses of the environment?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments:</td>
<td>No reduction in the range of beneficial uses of the environment are expected as a result of the proposal.</td>
</tr>
<tr>
<td>l. Any pollution of the environment?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments:</td>
<td>The proposed scheme is not expected to pollute the environment.</td>
</tr>
<tr>
<td>m. Any environmental problems associated with the disposal of waste?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments:</td>
<td>Waste may occur from unsuitable material, cleared vegetation, oils etc from servicing of machinery and sewage from portable toilets. All waste will be disposed of appropriately.</td>
</tr>
<tr>
<td>n. Any increased demands on resources, natural or otherwise, which are, or are likely to become in short supply?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments:</td>
<td>The proposal will require resources but these are not considered to be or likely to be in short supply in the near future.</td>
</tr>
<tr>
<td>o. Any cumulative environmental effect with other existing or likely future</td>
<td>NIL</td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
No cumulative environmental effects are expected as a result of the proposed scheme.

### 7.1.1 EPBC Checklist

The EPBC Act establishes those matters of national environmental significance that need to be considered when developments are proposed. Table 15 provides a checklist that assesses these matters.

<table>
<thead>
<tr>
<th>Factor (Commonwealth Legislation)</th>
<th>Impacts</th>
</tr>
</thead>
<tbody>
<tr>
<td>a. Any environmental impact on a World Heritage property?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments: There are no World Heritage properties within the site area. A World Heritage Area does exist to the north of Iluka be the construction and operation of the proposed ebb-tide release will not impact on this site. One of the reasons for abandoning the dune injection system originally proposed was to protect the World Heritage area.</td>
<td></td>
</tr>
<tr>
<td>b. Any environmental impact on wetlands of international importance?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments: There are no wetlands form part of the RAMSAR convention within the site area</td>
<td></td>
</tr>
<tr>
<td>c. Any environmental impact on Commonwealth listed threatened species or ecological communities?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments: No effect on Commonwealth listed threatened species or ecological communities are expected providing appropriate control measures are implemented.</td>
<td></td>
</tr>
<tr>
<td>d. Any environmental impact on Commonwealth listed migratory species?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments: No effect on Commonwealth listed migratory species is expected providing appropriate control measures are implemented.</td>
<td></td>
</tr>
<tr>
<td>e. Does any part of the proposal involve a nuclear action?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments: The proposal does not involve a nuclear action.</td>
<td></td>
</tr>
<tr>
<td>f. Any environmental impact on a Commonwealth marine area?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments: The proposed works are not within a Commonwealth marine area.</td>
<td></td>
</tr>
<tr>
<td>g. Any direct or indirect effect on Commonwealth land?</td>
<td>NIL</td>
</tr>
<tr>
<td>Comments: No effect on Commonwealth land is expected providing appropriate control measures are implemented.</td>
<td></td>
</tr>
</tbody>
</table>
8. Conclusions and Certification

This Review of Environmental Factors provides a true and fair review of the activity in relation to its likely effect on the environment. It addresses to the fullest extent possible, all of the factors listed in Clause 228 of the Environmental Planning and Assessment Regulation 2000 and the matters of national environmental significance identified under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999.

The REF indicates that the proposed Ebb Tide Release is unlikely to have a significant detrimental impact on the environment providing the recommended mitigation measures are implemented. An environmental impact statement is therefore not required.

Signature: ...................................................

Name: Ben Luffman
Designation: Environmental Consultant GHD
Date: 5 June 2009
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Appendix A

Figures
CLARENCE VALLEY COUNCIL
ILUKA EBB-TIDE RELEASE
REGIONAL LOCATION

PROPOSED LAUNCH SITES
PIPELINE
RELEASE LOCATION
Note: Flow is from left (upstream) to right (ocean)
REFER TO MACLEAN LEP

CLARENCE VALLEY COUNCIL
ILUKA EBB-TIDE RELEASE
ZONING

Figure 06

Disclaimer: The information displayed is not survey accurate and should be used as a guide only. Council accepts no responsibility for any errors or omissions. Any feedback on omissions or errors would be appreciated.

© Land and Property Information
© Clarence Valley Council
CLARENCE VALLEY COUNCIL
ILUKA EBB-TIDE RELEASE
COUNTRY ENERGY CABLE
AND BOREHOLES

Figure 08

Indicative Iluka ebb tide release route
Indicative Yamba ebb tide release route
Indicative Country Energy cable crossing route
Country Energy Geotech bore holes
PLUME EXTENT DURING 50% PERCENTILE FLOWS

PLUME EXTENT DURING 90% PERCENTILE FLOWS

SOURCE - WR1 (2009)

CLARENCE VALLEY COUNCIL
ILIKA EBB-TIDE RELEASE
PLUME EXTENTS

Figure 09
Appendix B
Detailed Concept Design of Yamba-Iluka
Ebb Tide Release
DETAILED CONCEPT DESIGN OF YAMBA-ILUKA
EBB TIDE RELEASE

by

W C Glamore, D S Rayner and B M Miller

Technical Report  2008/28
March 2009

------------------------
DETAILED CONCEPT DESIGN OF YAMBA-ILUKA EBB TIDE RELEASE

WRL Technical Report 2008/28

February 2009

by

W C Glamore, D S Rayner and B M Miller
The work reported herein was carried out at the Water Research Laboratory, School of Civil and Environmental Engineering, University of New South Wales, acting on behalf of the client.

Information published in this report is available for general release only with permission of the Director, Water Research Laboratory, and the client.
EXECUTIVE SUMMARY

Clarence Valley Council (CVC) is currently upgrading the sewage treatment systems for the townships of Iluka and Yamba. These towns are located at the mouth of the Clarence River (Figure 1.1), with Iluka to the north and Yamba to the south of the river entrance. The proposed systems involve the intake of varying volumes of sewage, the treatment of the waste water to tertiary standards and the sustainable disposal of the recycled water. The proposed sewage treatment plants (STP) will be a significant improvement on current systems and are designed to provide recycled water at a water quality equivalent to the Accepted Modern Technology.

The recycled water will be reused in a sustainable manner. The volume of reuse, however, is limited and recycled water in excess of demand will need to be sustainably released to the environment. It is currently proposed that the excess recycled water for both townships be discharged via ebb tide river releases in the lower Clarence River.

The New South Wales (NSW) state government has a range of criteria that must be adhered to when designing any river release. In addition to these criteria, local community stakeholders have requested further criteria on the design. In particular, the proposed releases must be designed so that in normal operation the released recycled waters clear the entrance of the Clarence River on each tide. These criteria have been adopted into the designs for both Yamba and Iluka releases.

The Water Research Laboratory (WRL) at the University of New South Wales has been commissioned by CVC, via the NSW Department of Commerce, to develop a detailed concept design of the ebb tide releases at Yamba and Iluka. The detailed concept designs presented within this report have been developed based on results gathered from a focused field program and a range of computer modelling simulations undertaken solely for this project.

The detailed concept design presented within this report has been developed to comply with the NSW standard criteria and exceed the community stakeholder’s higher requirements. A brief outline of the design parameters and project findings is detailed below. Further detailed information is provided within the technical report. It is important to note that water levels throughout this report are referred to as either Iluka Port Datum (IPD) or Australian Height Datum (AHD). IPD is 0.92 m below AHD (i.e. 0 m IPD is equivalent to the lowest standing water level likely to be measured in the river entrance).
Following consideration of stakeholder constraints, CVC adopted the area shown in Figure 1.2 for further investigation of the ebb tide releases. Within this area, it was determined that the optimal position for the releases is a location nearest to the most easterly extent. Based on limited available information, it was estimated that the mid-line of the release structure (i.e. the diffuser ports) should be located 6 m below Iluka Port Datum (IPD). Due to a range of hydraulic and construction criteria, it was determined that the Yamba and Iluka releases would be independently designed and operated.

Based on findings from the field investigation and flow path (i.e. hydrodynamic) modelling, it was determined that both Yamba and Iluka could operate during normal flow conditions over a 3 hour window commencing 30 minutes after the onset of the ebb tide flow. Modelling results indicated that recycled water released over this 3 hour window will clear the Clarence River entrance. Further, the released water is unlikely to impact upstream sensitive receivers during high flow events. Modelling of the lower Clarence River flow paths also assisted in calculating a design ebb tide velocity of 0.5 m/s (50th percentile) for the 3 hour operational window. A 90th percentile flow velocity of 0.24 m/s (i.e. the current velocity that would occur 10% of the time or less) was used to demonstrate a worst case scenario.

The sediment composition in the main channel, near the proposed ebb tide releases, is dominated by fine to medium grained marine sands. Tidal currents in the lower estuary were shown to have the potential to mobilise these bed sediments. Conservative estimates suggest that floods of a magnitude of the 5 year Average Recurrence Interval or greater have the potential to scour sand at the proposed release sites to the coffee rock strata. All attempts should therefore be made to ensure the delivery pipelines are installed below the coffee rock and that the diffuser sections of the ebb tide release are adequately anchored to the river bed.

A range of diffuser configurations (including port size, number and angle) were developed and tested for the Yamba and Iluka releases. Based on hydraulic considerations (i.e. head loss and exit velocity), diffuser configuration was determined for both sites. For the Iluka release the optimal diffuser configuration was two 300 mm ports orientated 90 degrees to the ebb tide flow. For the Yamba release the optimal diffuser configuration consists of dual four port, 300 mm diffusers. An alternative design consists of a single eight port, 300 mm configuration, although there is potential for plume interaction with this design. Additional information on the structural design, including riser circumference, is required to finalise the design configuration. The dual four port design for Yamba, with port angles of 0, 90, 180 and 270 degrees to the flow, would not have plume interactions.
Based on the proposed diffuser configurations, the provided design flow rates, the estimated depth of the diffusers, the outcomes of the field investigation and the flow path modelling, water quality modelling was undertaken. This modelling was focused on ensuring that the water quality criteria were met or exceeded within the near-field zone. The near-field zone is the region where the released fresh water is rising through the water column under its own buoyancy and is typically in the order of 50 - 150 m from the release.

Water quality modelling results indicated that dilutions varied with background (or ambient) flow conditions. A minimum dilution of 65 times was required for the majority of analytes, although a dilution of approximately 200 times was required to adequately dilute ammonia. Modelling results indicated that average dilutions for both sites would exceed 250 times based on a 50\textsuperscript{th} percentile ebb tide flow. These dilutions would occur at the end of the near-field zone, which is calculated at approximately 40 m from the Iluka release and 50 m from the Yamba release. Under 90\textsuperscript{th} percentile ebb tide flow velocities, adequate dilutions would occur within 150 m of both releases. It is important to note that all of the water quality modelling was undertaken conservatively assuming the lowest astronomical tide.

The detailed concept design described within the attached report provides information on the location, operation and impact of the proposed ebb tide releases. Based on available information, the investigation indicates that recycled water released from separate ebb-tide releases for Yamba and Iluka, located approximately 50 m west of the proposed Country Energy alignment, will clear the Clarence River entrance and meet water quality dilution requirements in normal operating conditions. Additional information on the release pipeline hydraulics, including purging calculations and design forces, and the detailed diffuser configuration will be provided once further information is available concerning the geotechnical and structural design.
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1. INTRODUCTION

Clarence Valley Council (CVC) is currently upgrading the sewage treatment systems for the townships of Iluka and Yamba. These towns are located at the mouth of the Clarence River (Figure 1.1), with Iluka to the north and Yamba to the south of the river entrance. The proposed systems involve the collection of varying sewage volumes, the treatment of this waste water to tertiary standards and the sustainable disposal of the treated recycled water. The proposed sewage treatment plants (STP) will be a significant improvement on current systems and are designed to provide recycled water at a water quality equivalent to the Accepted Modern Technology.

The recycled water will be reused in a sustainable manner. The volume of reuse, however, is limited and recycled water in excess of demand will need to be sustainably disposed. It is currently proposed that the excess recycled water for both townships be disposed of via ebb tide river releases in the lower Clarence River.

Detailed discussions have been undertaken to determine a socially acceptable location for the recycled water releases. These discussions have involved a range of stakeholders including (but not limited to) representatives from local recreational fishing groups, local commercial fishing cooperatives, the NSW Maritime Authority, the NSW Department of Lands, the NSW Department of Primary Industries (including NSW Fisheries), the NSW Department of the Environment and Climate Change, local Aboriginal Land Claimants and local community working groups. Based on these discussions the heretofore agreed region of consideration, as displayed on Figure 1.2, is immediately west of the proposed energy transmission cable undercrossing route and approximately 100 m north of the middle training wall.

Community working groups for both Yamba and Iluka have determined that to encourage the efficient removal of the recycled water from the estuary, the releases should operate predominately during the ebb tide. An ebb tide release was defined by both the Yamba and Iluka working groups as “when there is an outgoing flow which clears the entrance” to the Clarence River. As such, all recycled water released must be transported beyond the end of the training walls of the Clarence River (a distance of approximately 1800 m) even though complete mixing of the recycled water would be achieved within 150 m of the release structure.

Independent diffuser systems are required for Iluka and Yamba. The releases are proposed to be emergent structures located on the bed of the river. Both diffuser systems must be
designed to achieve water quality concentrations that comply with the NSW Environmental Protection Authority’s guidelines and the additional requirements of the local stakeholders.

Based on the above background information, the Water Research Laboratory (WRL) at the University of New South Wales was commissioned by Clarence Valley Council (via the Department of Commerce) to develop a Detailed Concept Design (DCD) for the Yamba-Iluka ebb tide release.

The primary tasks of the Detailed Concept Design study are to:

1. Increase the understanding of how water circulates and is transported in the lower Clarence River estuary via literature review, data gap analysis and computer modelling
2. Undertake field studies to collect river flow data critical for the design of the ebb tide release
3. Develop a calibrated and verified computer model of the Clarence River
4. Use the computer model to simulate a range of environmental conditions and apply this information to optimise the ebb tide release designs
5. Develop a conceptual design of the release that incorporates sedimentation, water quality, hydraulics and design forces concerns
6. Conduct consultation workshops with construction and stakeholder groups to assess design feasibility and construction options
7. Report and present results of the study to Clarence Valley Council and relevant community groups.

This report details the outcomes from the tasks listed above. Specifically, this report covers the data available for assessment, the relevant flow and circulation processes of the Clarence River important to the design of the ebb tide release, the outcomes of the field studies and the development, calibration and scenario testing of a computer model that simulates the flow paths (i.e. hydrodynamics) in the lower Clarence River. Based on these computer simulations, hydraulic calculations and water quality modelling, a preliminary design is provided for Iluka and Yamba. The proposed designs satisfy the required water quality criteria but due to the complexity of the environment, further information on securing the diffuser to the river bed is required. These tasks are currently underway and once completed the detailed concept design can be finalised.

This Technical Report is divided into 7 sections. Following this introduction, Section 2 outlines the rationale behind the site selection process. Section 3 provides an analysis of
the available scientific studies and the implications of this data on the ebb tide releases. Section 4 discusses the field work programme and outcomes. Section 5 outlines the computer modelling process and the range of scenario tests undertaken to finalise the design parameters. Section 6 details the hydraulic calculations and water modelling simulations completed to design the diffuser sections including port size and angles. Finally, Section 7 summarises the preliminary detailed concept designs and outlines specific recommendations.
2. **RATIONALE FOR EBB TIDE RELEASE LOCATION**

2.1 **Background Information**

The location proposed for the ebb tide release has been selected through an extensive consultation process. Stakeholder groups involved in the discussions included Clarence Valley Council, the Water Research Laboratory, NSW Department of Lands, NSW Department of Commerce, NSW Maritime Authority, NSW Department of Primary Industries (Fisheries), NSW Department of the Environment and Climate Change, Native Title Claimants, local Recreational Fishing Associations, Clarence Professional Fishing Association, the Yamba Water Recycling Management Committee, the Iluka Consultative Working Group, GHD Pty Ltd, Worley Parsons Pty Ltd and other local groups.

From a technical/engineering perspective the ideal location for an ebb tide release:

- Is sufficiently deep to promote buoyant mixing
- Has sufficient ambient currents for plume mixing and transport
- Is not subject to excessive movements in bed levels
- Is close enough to the river entrance to ensure an adequate operational schedule.

In addition to these technical concerns any proposed ebb tide release must also (i) not interfere, limit or be a hazard to commercial or recreational waterway navigation, (ii) be constructed on land available to Council, (iii) not interfere with the proposed electricity undercrossing, (iv) be approved by representatives of the local Native Title Claimants and (v) not impact on commercial and/or recreational fishing.

This section of the report outlines the rationale behind the selection of the proposed ebb tide release location based on feedback from the above stakeholders and the technical requirements discussed above. Figure 2.1 shows the lower Clarence River and outlines the range of competing interests in this section of the river. Starting from the ocean, the influence of these stakeholders on the decision making process is detailed below.

2.2 **Rationale for Ebb Tide Release Location**

In 1997, the NSW Coastal Policy stated that “new ocean outfalls will be embargoed until a full investigation of alternative wastewater strategies has been undertaken and considered by the Government”. In that policy document goal 1.3.15 states “A public inquiry into
ocean sewerage outfalls and effluent re-use opportunities will be undertaken and results used in formulating future Government policy on ocean disposal of effluent”. WRL has consulted with staff from the NSW Department of Environment and Climate Change and no related public inquiry has been conducted since the coastal policy was released. Therefore, based on the current state policy, proposed release locations situated in the ocean could not be considered until the estuarine locations were deemed unsatisfactory.

As noted in Figure 2.1, on the north and south side of the river entrance are large breakwaters. These breakwaters are administered by the NSW Department of Lands and fall within Crown Land jurisdiction. Advice was received from the NSW Department of Lands that due to the dynamic nature of the breakwaters, construction of a release structure would be prohibited. In addition, the construction of an ebb tide release on the southern breakwater would likely involve drilling through the sub-soil to secure the infrastructure. Local Native Title Claimants have lodged a native title claim on the rock reef immediately upstream of the southern breakwater (as depicted in Figure 2.1) and discussions with this group have indicated that they would not be amenable to any engineering works that may impact the rock reef. Further, the Native Title Claimants have requested that the release structure is not constructed east of the proposed Country Energy river undercrossing.

On the northern side of the river, upstream from the main breakwater, there are a series of smaller breakwaters, relic training walls and a ‘wave trap’ beach. The wave trap beach is used by commercial fisherman to haul in large schools of mullet that annually migrate down the river. Concern was raised by representatives of the Clarence River Professional Fishermans Association that any release located in this area may have the potential of diverting the mullet run towards the middle of the channel and thus, away from the fishing haul nets. In combination with the NSW Department of Lands previous concerns, and the Native Title Claimants requests, the northern breakwaters area was deemed not suitable for construction of an ebb tide release.

As marked on Figure 1.2, a training wall exists down the middle of the Clarence River. This training wall was part of series of entrance works (known as the Sir John Coode’s Scheme (Mashiah, 2008)) and was largely completed by 1914. This area is now a popular recreational fishing area and has been gazetted a ‘recreational fishing haven’ by NSW Department of Primary Industries. Due to concerns that the ebb tide release may interfere with recreational fishing access, the ebb tide release could not be situated within 100 m of the middle training wall. Further, due to concerns regarding the transport of recycled water through the gap in the middle wall, and potentially upstream towards the oyster leases (and
eventually Wooloweyah Lagoon), all efforts have been made to locate the ebb tide release structure downstream of this gap.

In addition to the above concerns, the Clarence River is a highly trafficked waterway with several large vessels requiring navigation access. The Port of Yamba is Australia’s easternmost port and handles a range of imports and exports including a shipping service to Lord Howe Island. The main port facilities are located at the Goodwood Island wharf approximately 10 kilometres upstream from the entrance to the Clarence River. Several plans have been previously proposed to expand commercial shipping traffic from the Port of Yamba (Manly Hydraulics Laboratory (MHL), 2000), although no formal process is currently underway. A formal navigation channel exists along the waterway and advice received from NSW Maritime Authority stated that a release location at least 50 m from either side of the centreline of the channel would be considered appropriate to avoid any risk of damage that may occur during maintenance dredging.

Based on the navigation issues outlined above, all attempts were made to move the release location away from the main channel. However, the further the release is located upstream of the river mouth the less amount of time is available for releasing the recycled water. This is due to the imposed constraint agreed to by the relevant local working groups which states that the outgoing flow must clear the entrance. To satisfy this requirement, and still provide sufficient time for the release to operate, the system should be located as close to the river mouth as possible.

Due to the above constraints the proposed location, as shown on Figure 2.1, was selected. The proposed location is outside of the recreational fishing zone, does not interfere with current commercial fishing operations, is beyond the distances required by NSW Maritime and Native Title Claimants and would not be adjoining any breakwaters administered by the NSW Department of Lands. The proposed site is also within sufficient distance from the river mouth to effectively operate as an ebb tide release and information recently obtained for the proposed electricity cable undercrossing could be used to assist the geotechnical tasks. Technical issues associated with bed movements, ambient currents, release depths and general constructability of the proposed site are discussed in subsequent sections of this report.
3. CLARENCE RIVER ESTUARY CHARACTERISTICS

A limited number of recent references are available to characterise the lower Clarence River estuary. This section outlines and briefly discusses the available data and, where appropriate, highlights key data gaps. Particular attention is given to the processes that are fundamental to the operation of an ebb tide release namely, geology/fluvial geomorphology, currents/tide and wave climate. A full analysis of all the data available for the entire Clarence River estuary can be found in MHL (2000).

3.1 Geology and Fluvial Geomorphology


Sediments in the main channel are dominated by clean marine sands with an upstream transition from marine to mixed to fluvial sands. MHL (1996a) states that these fine to medium grained sands extend from the ocean entrance to more than 10 km upstream and are moderately-well to well sorted and contain no fine (i.e. clay) sediments. PB (2008) confirmed this hypothesis through geotechnical investigations in the vicinity of the proposed location. As shown in borehole logs BH6 and BH8 in PB (2007) (which are located along the proposed Country Energy line crossing shown in Figure 2.1), the region of the proposed site is underlain with a fine to medium-grained grey sands strata approximately 2 – 7 m in thickness that contains traces of shell fragments. Underlying the grey sands is an indurated sand (i.e. coffee rock) of varying thickness ranging from approximately 15 m at BH6 (south of the middle wall) to approximately 9 m thickness at BH8 (489 m north of BH6 and approximately 300 m south of where the Country Energy line reaches the Iluka foreshore). Underlying the coffee rock is an interbedded layer of sand, clay and silt, which is approximately 40 m in thickness. The proposed location of the release, as marked on Figure 1.1, is due west of the proposed Country Energy line.

Longitudinal sections (BH3-BH9) prepared by PB (2007) suggest that in the region immediately north of the middle wall, and thus in a location similar to the one proposed for the release, the sand layer overlying the coffee rock is potentially 2 – 5 m thick. Analysis of the bathymetric surveys given below, however, suggests that sand accumulates with distance heading upstream (at an approximate rate of 1 m vertical per 100 m horizontal) and it is reasonable to assume that more sand would overlay the coffee rock strata in the
The transport of sediment within the channel is dominated by tidal and flood currents. In low-flow periods there is a bias of net transport of marine sand into the estuary under the influence of wave action and a flood tide bias in the tidal flows. Indeed, MHL (2000) estimated a gross annual net sediment transport rate in the upstream direction due to tidal currents of 200,000 m$^3$/year at the entrance. During high-flow flooding periods, sand can be scoured from the estuary and deposited either in the entrance or further offshore. Sediments may be completely scoured away during these events, resulting in an exposed layer of indurated sand or rock reef. Depending on the magnitude of the flooding event, some of the scoured sand may be completely removed from the estuarine system. In this case the sand is likely to become part of the northward littoral drift that supplies sand to Iluka Beach. Conversely, if the sand is not completely removed from the entrance it may be reworked back into the various shoals that form in the lower estuary.

Based on available data, the proposed site appears to be presently located downstream of the confluence of two sand shoals. These shoals are located on the northern side of the middle wall and on the southern side of the main channel. When these shoals converge sand accumulates in the middle of the channel and eventually this accretion zone moves downstream. The channel bed likely fluctuates between a moderate scour zone and an accretion zone depending on river discharge levels.

The location of the sand shoals and their likely impact on the proposed release site can be assessed by analysing previous bathymetric surveys. A range of bathymetric surveys were obtained and analysed for this study dating back to 1979. Of these surveys only a limited number covered the vicinity of the proposed release location. The relevant surveys, including two surveys undertaken by WRL in 2007 and 2008, were assessed for this study. The analysis, shown in Figures 3.1 and 3.2, indicated different results for the proposed release area depending on the western versus eastern extent of the proposed area.

In general, the available water depth increased with increasing distance downstream. As shown in Figure 1.2, the proposed release location is orientated parallel to the middle training wall in a predominately NW-SE direction. The NW corner of the proposed area is located on the downstream lobe of the southern shoal and during periods of strong accretion
(i.e. as shown in the 1979 hydrographic survey in Figure 3.1) the water depth can be less than 2 m. Conversely, the SE corner of the proposed release location has been consistently in deeper water (7 -10 m) since 1979 and less fluctuations in depth are apparent with time. Table 3.1 further emphasises this point by providing the recorded depths on the western versus eastern extent of the proposed release location.

### Table 3.1
**Recorded Depths at the Proposed Release Location**

<table>
<thead>
<tr>
<th>Survey</th>
<th>Western extent depth (m IPD)</th>
<th>Eastern extent depth (m IPD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986 - Maritime Services Board of NSW (April)</td>
<td>3.15</td>
<td>7.5</td>
</tr>
<tr>
<td>1988 - Maritime Services Board of NSW (21-23 June)</td>
<td>2.2 to 2.6</td>
<td>7.1 to 7.8</td>
</tr>
<tr>
<td>1993 - Australian Army (15 September)</td>
<td>3.2 to 3.6</td>
<td>5.9 to 7.6</td>
</tr>
<tr>
<td>1999 - Sydney Ports (digital data, month unknown)</td>
<td>3.2</td>
<td>7.5 to 7.7</td>
</tr>
<tr>
<td>2002 - Department of Land and Water Conservation (May)</td>
<td>3.2 to 3.8</td>
<td>5.8 to 7.8</td>
</tr>
<tr>
<td>2004 - NSW Waterways Authority (March)</td>
<td>not surveyed</td>
<td>not surveyed</td>
</tr>
<tr>
<td>2006 - NSW Maritime (November)</td>
<td>not surveyed</td>
<td>not surveyed</td>
</tr>
<tr>
<td>2007 - DECC Coastal Unit (May)</td>
<td>not surveyed</td>
<td>not surveyed</td>
</tr>
<tr>
<td>2007 - Water Research Laboratory (July)</td>
<td>4.5 to 5.2*</td>
<td>7.4 to 7.8</td>
</tr>
<tr>
<td>2008 - Water Research Laboratory (October)</td>
<td>4.5</td>
<td>7.5</td>
</tr>
</tbody>
</table>

*Note Iluka Port Datum (IPD) is 0.92 m below local Australian Height Datum (AHD)

It is important to note that the recorded depths given in Table 3.1 are in Iluka Port Datum (IPD), which is 0.92 m below Australian Height Datum (AHD). As such, 0 m IPD is approximately equivalent to the lowest astronomical tide (the lowest water level likely to occur in the river) or -0.92 m AHD. It is also important to note that on the far eastern extent of the proposed release location, the seven applicable surveys (as shown in Table 3.1) indicated a minimum value of 7.5 m IPD. Therefore, based on the available data and channel sedimentation processes outlined above, a maximum depth of 6.0 m IPD was estimated as a reasonable depth for the releases (i.e. mid-line depth for ports). Based on the available information, this depth provides approximately 1.5 m of clearance (or freeboard) from the previous minimum measured depths. Note that the seven surveys over 22 years only provide a snapshot of conditions onsite and this recommended depth does not ensure that the releases will always be free from sediment build-up. Additional in-depth sedimentation studies would be required to provide further information and confidence on localised sedimentation patterns.
3.2 Currents and Tides

The Clarence River tidal limit is approximately 106 km in length. The average river depth of the main channel is 6 m (MHL, 2000), with large shallow off-channel storages including the Broadwater and Lake Wooloweyah. MHL (2000) state that the tidal prism of the river is $40 \times 10^6$ m$^3$, while the river surface area is $62 \times 10^6$ m$^2$. Tidal velocities in the lower estuary typically exceed 1 m/s and peak flood flows at the entrance have been estimated to exceed 6 m/s (PWD, 1988).

The development of the natural and artificial channel network within the lower section of the Clarence River estuary has had a significant impact on the tidal and flood current regime. Soros-Longworth and McKenzie (1978) detailed the evolution of the lower estuary from the mid 19th century to its current form. As shown in Figure 3.3, this evolution process has primarily involved the installation of training walls and breakwaters. The installation of training walls focused the flow into the middle of the channel, thus increasing discharge velocities. As shown in Figure 3.4, the increased discharge rates in the main channel appear to have virtually eliminated the sand shoals that previously existed in the main channel. Importantly, due to the lack of development in the lower estuary since the mid 1970s, the currents in the channel are likely to be in dynamic equilibrium; oscillating with the tides and floods.

Since 1963 there have been a series of tidal surveys undertaken, often with limited success, at a range of locations in the lower Clarence River estuary. MHL (2004) states that measurements were undertaken in March 1963, October 1964, August 1977, September 1978, May 1979, March 1984 and October-November 1996. The most comprehensive source of information is from MHL Report 798 (MHL, 1998). This report outlines a data collection exercise undertaken in October-November 1996 at a number of locations along the Clarence River. During this investigation water level data was obtained from seven permanent stations and sixteen temporary stations and basic water quality parameters were measured at nine sites. On 24th October 1996 current velocity and discharge measurements were gathered over a spring ebb-flood semi-diurnal tidal cycle. On this day, tidal discharge was monitored at nine sites and water levels were monitored at an additional two sites. A summary of the water level and discharge data is given in Figure 3.5 (MHL Figure).

Analysis of the data within MHL (1998) provides some background information on the lower river estuary. Overall, MHL (1998) state that “the estuary acts like a typical river system, with maximum tidal flows usually recorded during the two hours following mid-tide and minimum tidal flows (or slack water) usually recorded within one hour after high and low tide.” The report showed that the tidal range decreased from a mean range of
1.07 m in the ocean to 0.95 m at the entrance and 0.40 m at Maclean, and then slightly increasing to 0.51 m at Grafton and 0.57 m at Rogan Bridge. The tidal range then decreased again to 0.42 m at Tindal Bridge on the Orara River. A 13 minute tidal phase lag was evident at the entrance, while at Maclean and Grafton the lag was 137 and 279 minutes, respectively. A full summary of tidal ranges and tidal phase lags is given in the MHL report.

Over the one-day sampling period, MHL (1998) provided useful information on current velocities and discharge. Throughout the entire river, peak current velocities were measured within the vicinity of the proposed ebb tide release (1.51 m/s on the ebb tide and 1.46 m/s on the flood tide at ~700 m inland from the entrance). Tidal prism calculations at the river entrance suggest that the tidal volume is orders of magnitude greater than typical upland inflows with the ebb tide calculated as 39.72 m$^3$ x 10$^6$ versus 41.34 m$^3$ x 10$^6$ for the flood tide. The Acoustic Doppler Current Profiler (ADCP) measurements also confirmed suggestions that the main channel of the lower river has a largely vertically uniform (i.e. depth averaged) current velocity distribution.

WRL was able to obtain the raw data records of the entire 1996 field investigation undertaken by MHL (1998). This information was analysed and subsequently employed to calibrate the hydrodynamic computer model discussed in Section 5. In addition to this information, data from all of the permanent water level stations currently run by MHL was obtained for the 2008 calendar year. The available water level data and the date since the station commenced are provided in Table 3.2. Historical and flood level data available from other locations was not used in this study.

<table>
<thead>
<tr>
<th>Location</th>
<th>Date Commenced Sampling</th>
</tr>
</thead>
<tbody>
<tr>
<td>Entrance Breakwater</td>
<td>July 1986</td>
</tr>
<tr>
<td>Maclean</td>
<td>February 1990</td>
</tr>
<tr>
<td>Brushgrove</td>
<td>September 1989</td>
</tr>
<tr>
<td>Grafton</td>
<td>July 1987</td>
</tr>
<tr>
<td>Rogans Bridge</td>
<td>July 1993</td>
</tr>
<tr>
<td>Palmers Island</td>
<td>April 1990</td>
</tr>
<tr>
<td>Empire Vale Creek</td>
<td>May 1999</td>
</tr>
<tr>
<td>Sportsman Creek</td>
<td>April 2000</td>
</tr>
</tbody>
</table>
Though the available references provide useful information on the entire river, there is only limited data regarding recent current velocity and discharge measurements in the lower estuary, particularly in the vicinity of the proposed outfall. Therefore, due to the evolving nature of the channel (as discussed previously), the limited time span of the available current data (1 day) and the lack of specific data in the area of interest, further onsite data was required. The primary data gaps relate to updated current velocity measurements undertaken concurrently with bathymetric surveys (i.e. to calculate discharge) and further information on the flow patterns downstream of the proposed release structure (i.e. to determine the circulation patterns of the released recycled water). These data gaps were addressed during the field investigations discussed in Section 4. Once obtained, the data was also used to verify the computer model (Section 5).

3.3 Wave Climate

A preliminary assessment of the wave climate was undertaken to determine if the wave forces were significant in comparison to the current velocities. An assessment of the wave climate at the site includes an understanding of the wind, boat and ocean waves to determine a design wave.

3.3.1 Wind Wave Climate

Wind wave analysis was previously undertaken in MHL (2005) for a location very close to the proposed site and is applicable to this site due to the standard methods used to calculate the wind wave climate (AS/NZS1170.2:2002). The primary components of concern when determining the wind wave climate are the adjusted 10-minute average wind speeds (Table 3.3) and the estimated fetch data.

<table>
<thead>
<tr>
<th>Return Period (Years)</th>
<th>3-Second Gust (m/s)</th>
<th>Adjusted 10-minute Average (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>28</td>
<td>20</td>
</tr>
<tr>
<td>25</td>
<td>39</td>
<td>27</td>
</tr>
<tr>
<td>50</td>
<td>44</td>
<td>31</td>
</tr>
<tr>
<td>100</td>
<td>48</td>
<td>33</td>
</tr>
</tbody>
</table>
Taking into account the large number of shoals within the river, the primary fetch of interest for the site is an easterly fetch of approximately 2000 m. Therefore, by using the shallow water forecasting curves presented in the Shore Protection Manual (CERC, 1984), the maximum hindcast wind wave heights at the proposed site are given in Table 3.4 (as per MHL, 2005).

<table>
<thead>
<tr>
<th>Return Period (Years)</th>
<th>$H_s$ ($H_{1%}$) (m)</th>
<th>$T_p$ (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>0.6 (0.9)</td>
<td>2.3</td>
</tr>
<tr>
<td>25</td>
<td>0.83 (1.26)</td>
<td>2.6</td>
</tr>
<tr>
<td>50</td>
<td>0.97 (1.47)</td>
<td>2.7</td>
</tr>
<tr>
<td>100</td>
<td>1.04 (1.57)</td>
<td>2.8</td>
</tr>
</tbody>
</table>

### 3.3.2 Boat Wave Climate

Boat waves also have the potential to impact a marine structure. Currently commercial vessels that operate in the lower Clarence River are restricted by both water depth (with approval given to deepen the navigation channel to 4 m below Iluka Port Datum) and beam (with a typical guide of 3 - 4.5 times the beam being the limiting channel dimension). Discussion with NSW Maritime Authority suggest that the Port of Yamba may be expanded in the moderate future and that larger ships may have access to the lower Clarence River. Therefore, to provide a conservative estimate of the boat wave climate, it is assumed that a vessel as large as a Sydney Ferry First Fleet Vessel may be encountered on the river. As per Edwards and Lords (1998), a vessel of this size would generate a wave with a maximum wave height of 0.54 m and a maximum wave period of 4.3 seconds.

### 3.3.3 Ocean Wave Climate

A design wave height of 3 m ($T_p = 12$ s) was estimated by MHL (1996b) for the wave trap beach. As the channel depth is likely to be maintained at or around 4.0 m below Iluka Port Datum it is reasonable to suggest that a wave of this magnitude would reach the proposed site as an unbroken wave.

Based on the above assessment of all wave types, the maximum wave that would impact the structure is likely to be the ocean wave, with a 3.0 m wave height and 12 second wave period. Random effects of wave grouping may lead to larger waves of limited duration.
4. FIELD WORK

A series of field experiments were undertaken on October 13 - 16 2008 to better characterise the circulation patterns and to fill in key data gaps in the vicinity of the proposed ebb tide release.

The field experiments were undertaken to measure:

- **Water Velocity and Direction**: An RDI 1200 kHz ADCP was used to measure water velocity and associated direction at various locations within the lower section of the Clarence River. The ADCP was attached to the vessel (downward looking) and had bottom tracking enabled. Measurements were taken predominantly during the ebb tide, however, some flood tide measurements were obtained. Field calibration checks were undertaken prior to deploying the instrument.

- **River Discharge**: At various times during the ebb tide, river discharge measurements were undertaken at predetermined transects using the ADCP. Three transect locations were repeated at locations (i) upstream, (ii) in the vicinity and (iii) downstream of the proposed ebb tide release (Figure 4.1)

- **Flow paths**: GPS drifter drogues were deployed during various stages of the ebb tide to measure flow paths in the vicinity of the proposed ebb tide release. The GPS drifter drogues consisted of a mesh ‘sail’ set 2 m below the surface connected to a steel line and small surface float. Delorme Earthmate Blue Logger GPS units were attached to the surface float and internally recorded their location at preset intervals. The drogues were released slightly upstream of the proposed release site and retrieved after being transported approximately 1200 m (inside the entrance breakwater walls)

- **Bathymetric information**: Subsurface bathymetry data was acquired for the lower Clarence River estuary in the vicinity of the proposed ebb tide release. This data was collected using a Ceestar Echo sounding unit coupled with a Trimble RTK-GPS. Collected data was quality controlled and adjusted to meters Australian Height Datum.

- **Salinity**: Salinity measurements were taken using the salinity probe attached to the Seabird 19 plus.

- **Diffusion**: Diffusion was measured using standard tracer techniques. Rhodamine WT was released from a stationary vessel at a known rate. The dye plume was measured using a calibrated Chelsea Scientific fluorimeter attached to the Seabird 19 plus.
4.1 Environmental Conditions During Sampling

The field work was undertaken in conditions typical of low river flows (i.e. low base flow). In the 10 days preceding the field work there was no significant rainfall in the catchment and inflows were all below minor flood levels. These inflow conditions suggest that the measurements collected are representative of dry periods when the tidal prism dominates the discharge volume exiting the river mouth. In relation to the ebb tide release, this provides conservative velocity and discharge estimates (i.e. the discharge is not affected by flood waters) and provides a good representation of how the release would operate under average (or low flow) conditions.

Sampling was conducted to coincide with moderate spring tide conditions. Figure 4.2 depicts the recorded water level at the Yamba entrance (as provided by the MHL water level recorder) and the time of representative ADCP transects during the field study. A peak high tide of 0.745 m AHD was obtained on 16 October at 10:45 and the minimum ebb tide of -0.965 m AHD was reached at 03:30 on the 15th October. The tidal range at the Yamba entrance on 14th October, when the majority of ADCP transects were undertaken, was 1.37 m. In contrast, long term analysis of water level data at the MHL sensor located at the entrance from 1990 to 2005 indicated that the average mean tidal range is 0.95 m (MHL, 2005).

A field program was developed to maximise the amount of data collected during the three days of testing. On the first day, October 14th, the field program focused on obtaining bathymetric data and conducting ADCP transects. The second day of testing, October 15th, completed the bathymetric and ADCP data collection and included drogue releases and CTD profiles. The final day, October 16th, focused on dye testing and further CTD profiles. While the first two days were undertaken during daylight hours, the final day of testing was conducted between 0200 am and 0900 am to maximise the ebb tide prism, minimise wind mixing of the surface plume and ensure that the dye tracing was not interrupted by other passing boats.

A variety of wind conditions were experienced during the three days of testing. As shown in Table 4.1, strong north-easterly winds were prevalent on October 14th. During the late afternoon of October 14th a southerly system came through and on October 15th strong south to south-easterly conditions prevailed. These conditions persisted throughout the testing on October 16th. Despite the windy conditions, only a minor amount of rain was recorded during the entire field investigation.
## Table 4.1

Weather Conditions at Yamba Pilot Station During Field Study

<table>
<thead>
<tr>
<th>Date/Time EDT</th>
<th>Temp °C</th>
<th>Dir</th>
<th>Speed km/h</th>
<th>Gust knots</th>
<th>Speed km/h</th>
<th>Gust knots</th>
<th>Press hPa</th>
<th>Rain since 9 am mm</th>
</tr>
</thead>
<tbody>
<tr>
<td>14 Oct/03:00pm</td>
<td>21.7</td>
<td>NNE</td>
<td>30</td>
<td>43</td>
<td>16</td>
<td>23</td>
<td>1017.1</td>
<td>0</td>
</tr>
<tr>
<td>15 Oct/09:00am</td>
<td>20</td>
<td>S</td>
<td>17</td>
<td>32</td>
<td>9</td>
<td>17</td>
<td>1018.3</td>
<td>5.2</td>
</tr>
<tr>
<td>15 Oct/03:00pm</td>
<td>21.9</td>
<td>SSE</td>
<td>32</td>
<td>43</td>
<td>17</td>
<td>23</td>
<td>1016.6</td>
<td>0</td>
</tr>
<tr>
<td>16 Oct/03:00am</td>
<td>18.7</td>
<td>SSE</td>
<td>24</td>
<td>35</td>
<td>13</td>
<td>19</td>
<td>1020.2</td>
<td>0</td>
</tr>
<tr>
<td>16 Oct/09:00am</td>
<td>17.5</td>
<td>S</td>
<td>19</td>
<td>30</td>
<td>10</td>
<td>16</td>
<td>1022.7</td>
<td>0.2</td>
</tr>
</tbody>
</table>

### 4.2 Field Study Observations

A large number of ADCP transects were undertaken throughout the three days of field testing. Three transects were established to represent the upstream boundary, the conditions at the proposed site and the conditions at the entrance. These three transects are labelled on Figures 4.1 and 4.2 as the west, middle and east transects. Data recovery was near 100% and due to the large data set recovered, representative samples from each series of data sets were selected and are depicted (as red dots on the tidal water level graph) on Figure 4.2.

Representative ADCP transects from each of the three sampling locations (west, middle and east) are depicted in Figures 4.3, 4.4 and 4.5. Each of these figures detail the velocity magnitude (in m/s), the velocity direction (degrees), the depth averaged velocity transect and the water level at which the sample was taken. Importantly, all three of these transects were taken within 40 minutes of each other and at the commencement of the ebb tide. Gaps in the eastern transect dataset (as shown in Figure 4.5) were associated with large waves penetrating into the entrance, physically lifting the ADCP from the water.

The ebb discharge in the lower portion of the estuary significantly lagged behind the changing water levels. For example, though water levels indicated a falling (or ebb) tide commenced at the Yamba entrance at approximately 08:45 on the October 14th, ebb flows were not recorded in the main channel until approximately 11:00; nearly 135 minutes after the tide changed. This lag in discharge is not a fixed rate but varies depending on upstream inflows, previous tidal levels (i.e. tidal inequities) and a range of other factors. Further analysis of the ebb flows and tidal levels was undertaken with the calibrated numerical model and is discussed in Section 5.4.3.
Interestingly, ebb flows were noted discharging from south of the main training walls at approximately 10:00 and finished discharging approximately an hour before the main channel. This is likely due to the draining/filling of Lake Wooloweyah and its relative isolation from the main channel system. Further analysis of the discharge versus water level timings is provided in Section 5.4.5.

As discussed above, the ADCP transects shown in Figures 4.3 – 4.5 were taken at the commencement of the ebb tide. As such, these figures show weak tidal currents and slight inconsistencies in the velocity direction. However in the time taken to sample between the western and eastern transects (Figure 4.3 versus Figure 4.5) an increase in velocity magnitude is apparent. Further, as the currents increase, the water column became completely depth averaged with very little difference in velocity magnitude or direction with depth. Indeed, within 1 hour of the ebb discharge commencing, the flow was completely depth averaged and remained this way until within 30 minutes of the end of the ebb discharge. These findings are in line with previous field observations at the river mouth (MHL, 1998).

Measured current velocities in the channel were similar to previously measured values. Based on findings from drogue tracking undertaken by SLM (1978) and from ADCP measurements shown in MHL (1998) and MHL (2005) suggested an average tidal current velocity of 0.3 m/s for the neap tide and 0.4 m/s for the mean tide at a location in close proximity to the proposed release. These estimates were based on the ADCP measurements undertaken in October 1996 when the tidal range was 1.28 m. In contrast, the tidal range on October 14th 2008 when the majority of ADCP transects were undertaken was 1.37 m. As such, the average velocity measured for this study of 0.6 m/s is slightly higher due to the larger tidal range. Table 4.2 provides the ebb tide current velocity statistics for all the measurements taken at the middle transect. As this data only represents the ebb tide currents measured onsite over three days of testing, additional current velocity statistics were generated from the calibrated computer model. This information is discussed further in Section 5.4.2.
### Table 4.2
**Measured Ebb Tide Current Velocity Statistics**

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Velocity (m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>0.59</td>
</tr>
<tr>
<td>Minimum</td>
<td>0.25</td>
</tr>
<tr>
<td>Maximum</td>
<td>1.05</td>
</tr>
<tr>
<td>99th %ile</td>
<td>0.30</td>
</tr>
<tr>
<td>90th %ile</td>
<td>0.37</td>
</tr>
<tr>
<td>50th %ile</td>
<td>0.60</td>
</tr>
<tr>
<td>10th %ile</td>
<td>0.81</td>
</tr>
<tr>
<td>1st %ile</td>
<td>0.93</td>
</tr>
</tbody>
</table>

The release of the GPS drifter drogues provided useful information regarding the flow paths in the lower estuary. As shown in Figure 4.6, on the 15th October 2008, four GPS drifter drogues were released at various locations across the river. This release was undertaken approximately 30 minutes after the ebb tide release commenced in the main channel. As depicted in Figure 4.6, the four drogues converged in the middle of the channel and were transported to the north of the entrance channel. This is likely due to water discharging from Yamba Channel, which commenced flowing approximately 40 minutes before the main channel. In the beginning of the ebb tide it was evident that the flows discharging from Yamba Channel had a greater velocity than the main channel and thereby, forced flows in the main channel towards the north.

Conversely, during the same ebb tide once the discharge velocities in the main channel increased, the main channel flow paths were not affected by water discharging from Yamba Channel. As shown in Figure 4.7, a drogue release undertaken at 16:00 on October 15th did not depict strong discharges from the south. This drogue release was undertaken from the approximate location of the proposed release and indicated that no major eddy circulations exist downstream of the release. This information is also useful in calibrating the numerical model.

The additional information obtained from the field study primarily relates to variables that are required for the numerical modelling. In particular, the Rhodamine WT tracer findings are discussed in the numerical modelling Section 5.3. This data was used to verify the diffusivity parameters.

Overall, the field study provided a large amount of useful data to better characterise the lower estuary. The intensive bathymetry survey covered the entire vicinity of the proposed release and was subsequently used as the base layer in the numerical model. The current profiling and drogue releases indicated that:
• There is a significant lag (in the order of 30 – 120 minutes) between tidal water levels and the onset of discharge from the main channel

• Yamba channel commences to discharge earlier, and finishes earlier, than the main channel

• Flows within the main channel were largely depth-averaged within 1 hour of the ebb tide discharge commencing

• The flows from Yamba channel impact the main channel in the beginning of the ebb tide by directing the flow northwards

• The impact of Yamba channel on the main channel is not evident during subsequent periods of the ebb tide

• The flow path from the release to the entrance is nearly due easterly with no apparent large eddies

• Upstream of the proposed release structure, at the west transect, ebb tide flow moves in a southerly direction which is then redirected into an easterly direction around the middle transect

• Velocities in the study are generally in line with previous estimates (0.5 m/s average velocity).

While the above information was useful to characterise the region of interest, it only provides information on the days that the study was undertaken. To further understand the estuarine hydrodynamics, a computer or numerical model was developed, calibrated, verified and subsequently tested to simulate a range environmental conditions. The numerical model is based on the real world data from previous studies and detailed above. Further information on the numerical model is provided in Section 5.
5. NUMERICAL MODEL OF THE ESTUARINE HYDRODYNAMICS

Numerical models simulate the hydrodynamic processes in an estuary by using local data and relevant equations that represent physical processes. Once constructed, the model is calibrated to the available real-world data. This model is then verified against additional field data to prove that it can adequately simulate a range of environmental conditions. In addition to the hydrodynamic outputs, water quality modules can be used to simulate changes in water quality.

A range of commercial programs are available for simulating complex hydrodynamic processes in estuarine environments. For this study, the RMA suite of models was employed. WRL has successfully used the RMA models, including RMA-2 and RMA-11, to recently simulate estuarine flows in several other locations including (but not limited to) the Richmond River, the Hawkesbury-Nepean River, the Shoalhaven River, Darwin Harbour and the Manning River.

RMA-2 is a two-dimensional (2-D) hydrodynamic finite element model for depth averaged flow (King, 2002). The model solves the Navier-Stokes equations in two dimensions, together with the continuity equation, to obtain velocities and water surface elevations at each node on the finite element mesh. The model is used throughout the world and is the primary hydrodynamic model employed by the US Army Corps of Engineers. RMA-11 is a finite element model that uses RMA-2 hydrodynamic outputs to simulate water quality processes in estuaries, bays, lakes and rivers.

For this study a numerical model of the Clarence River was established using RMA-2 from upstream of Grafton to the ocean boundary. Extensive bathymetric data was used to simulate the river channel. Water level data from multiple sites throughout the river were used in conjunction with discharge and current velocity data (from the 1996 and 2008 field studies) to calibrate and verify the hydrodynamics. Once it was shown that the model could effectively simulate the circulation patterns in the vicinity of the lower estuary, a range of scenarios were tested. These scenarios primarily used the water quality model RMA-11 to optimise the operation of the proposed ebb tide release.

The remainder of this section details the modelling process including initial set-up, calibration, verification and scenario testing. Although a pilot model was initially set-up to provide preliminary information prior to the field investigation, the results presented in this section are focused on the final outcomes. Data from the hydrodynamic model was also used within the near-field water quality modelling discussed in Section 6.
5.1 Model Set-Up

The finite element mesh was constructed with the best available data to characterise presently existing real world conditions in the Clarence River estuary. Cross sections from the 1978-1979 PWD river hydro-survey data (in AHD as supplied by Greg Rogencamp of BMT-WBM) were used to define the river bed dimensions in the main channel from upstream of Grafton (near the junction with Whiteman Creek) to the lower parts of the estuary (Figure 5.1). In the vicinity of the proposed release, the 2008 WRL bathymetric survey data of the lower Clarence estuary was employed.

The finite element mesh for the entire model is shown in Figure 5.2. As depicted, the model consists of 1-D elements that represent the hydraulic radius of the main river channel from the junction with Whiteman Creek to upstream of Goodwood Island in the lower estuary. 1-D elements were also included for the tidal sections of Coldstream River, Sportsman Creek, the South Arm, the Broadwater, the Back Channel and the Esk River. Detailed 2-D elements exist further downstream, throughout the vicinity of the proposed release and within Wooloweyah Lake and the entrance to the Oyster Channel. The 2-D elements also extend approximately 2 km offshore (i.e. beyond the extent of the breakwaters). Element resolution varies throughout the 2-D sections with the mesh refined in the lower regions of the estuary to better simulate flow paths and water quality processes.

The model was run with 1996 and 2008 data. The 1996 data was used to calibrate the model as it had a better spatial extent of real data. The 2008 data was used to verify the model, particularly in relation to flow paths and velocity in the vicinity of the proposed releases. In both simulations a time transient tidal condition was applied to the offshore mesh boundary. For the 1996 model runs, measured water level (i.e. tidal) data from offshore of Yamba was obtained from MHL. This data was subsequently applied to the ocean boundary (in m AHD) without manipulation. For the 2008 model runs, predicted offshore water level data was provided by MHL. Measured data for 2008 was not available as the Yamba offshore monitoring site was moved to a location near the Tweed River between 1998 and 2008. To ensure the predicted data accurately represented the real conditions, MHL also provided actual data measured offshore of the Tweed River until July 2008. As shown in Figure 5.3, the 2008 predicted data at Yamba was largely in close agreement with the measured Tweed River data. Discrepancies were associated with high and low pressure systems acting on the measured data and were not included in the tidal predictions. The predicted Yamba data for 2008 was subsequently applied as a oceanic boundary condition.
In addition to the tidal boundary, an upland inflow boundary was applied to the main channel at the junction near Whiteman Creek. As no discharge data is available for this location, and only limited discharge data is available for adjacent waterways, an assumed volume of 50 m$^3$/s of freshwater base flow was applied at this boundary. Sensitivity testing of this inflow value (± 100%) did not have an appreciable impact on the model calibration within the lower sections of the estuary as the tidal prism is orders of magnitude greater than upland inflows during non-flooding periods. No further boundary conditions were applied within the model.

Channel roughness (or Manning’s ‘n’) values were set within the model to simulate different environmental conditions. Throughout the majority of the model including the main channel, Lake Wooloweyah, and the large left/right bank creeks Manning’s ‘n’ was set to 0.02. In Palmers Channel Manning’s ‘n’ was set to 0.045. In the area within and around the entrance to the Oyster Channel Manning’s ‘n’ was set to 0.045 and in the South Arm and in the upper reaches of the main channel (upstream of Brushgrove) Manning’s ‘n’ was set to 0.025. Eddy viscosity was set at 0.50 Pascal-sec throughout the modelling domain. Diffusion was set at 0.5 m$^2$/sec for all water quality simulations.

5.2 Calibration

The numerical model was calibrated to water level and discharge measurements undertaken during 1996. The location of the sites where data was available for calibration is given in Figure 5.4. As depicted, the water level sites cover the length of the river from Grafton to Yamba and include two sites in the entrance to the Oyster Channel and one site in Palmers Channel. Discharge measurements are also available at a range of upstream and downstream locations (as noted in red on Figure 5.4).

Figures 5.5, 5.6, 5.7, and 5.8 provide a snapshot of water level data for the calibration period with numerical modelling results overlying measured field results. This data indicates that the modelled water level data is in phase with the measured tide throughout the estuary and that the model reasonable produced the tidal levels. The accuracy of the model varied depending on the location and the age of the bathymetric data.

The model also calibrated to discharge and current velocity measurements, which are the most relevant data for an ebb tide release. Figures 5.9, 5.10 and 5.11 depict the modelled and measured discharge curves at Yamba and Maclean, Brushgrove and Grafton, and at the entrance to the Oyster Channel, respectively. Positive discharge values in these figures are representative of the flood tide, whereas negative discharge numbers represent the ebb tide.
As shown, modelled discharge at Yamba is in good agreement with measured discharge. This implies that the velocity of water, the tidal volume exchange and the cross-sectional area of the model are well calibrated. Discrepancies in discharge between modelled and measured values in the upper estuary such as shown in Figure 5.10 are likely due to variations in the cross-sectional area, noting that the majority of the upper estuary is characterised by bathymetric data from 1978-79.

To ensure that the model adequately represents the flow paths in the lower section of the estuary, in vicinity of the proposed release, the 1996 modelled flow paths were plotted against the ADCP transect data. As shown in Figures 5.12a, 5.12b and 5.12c, the model predicts both the measured velocity and direction of the depth averaged currents across the entrance at Yamba. The calibration data shown above suggests that the model is fit for the purpose of designing an ebb tide release as it can adequately predict flow paths, flow speeds and tidal volume in the lower sections of Clarence River.

5.3 Verification

The data obtained in the 2008 field investigation was used to verify the calibrated model. As shown in Figure 5.13, the 2008 verification data sites cover the extent of the estuary. Due to the large number of ADCP profiles undertaken in the 2008 field study, and the importance of accurately simulating flow paths in the lower estuary, the verification procedure focused primarily on the circulation patterns in the lower estuary.

The 2008 model runs were simulated by applying the 2008 boundary condition to the calibrated model with the adopted 1996 calibration parameters. Model accuracy for the 2008 period was similar to the calibration data, with tidal phasing at Yamba (Figure 5.14) well simulated. Tidal phasing was also well simulated at Grafton (Figure 5.15), Maclean and Brushgrove. Water levels at all locations are over predicted by up to 0.2 m during spring tides. The over/under prediction of tidal levels is likely due to discrepancies within the predicted tidal values applied at the ocean boundary versus the measured data used verify the model and exacerbated by the dated bathymetry used in the upper estuary. In contrast, the 1996 calibration process had measured data for both the tidal boundary condition and at the measured sites and the bathymetric data, while still dated, was of a more comparable era.

Discharge and current velocity measurements undertaken in 2008 were also verified with the calibrated model. Calculated discharge was in-line with modelled discharge during the flood and ebb tides at the western, middle and eastern transects (Figure 5.16 and 5.17).
Further, comparison of measured versus modelled velocity vectors (Figures 5.18a and 5.18b) indicates that the model effectively reproduces channel hydrodynamics, including velocity and flow direction in the immediate vicinity of the proposed release (Figure 5.18b).

As an additional verification procedure, the drogue tracking and dye tracing experiments undertaken during the 2008 field investigation were compared against water quality model outputs from RMA-11. In these tests, RMA-11 was run using the hydrodynamic outputs from RMA-2 to depict how a plume discharged from the proposed release site would be transported within the lower estuary on an ebb tide. As shown in Figure 5.19, the drogues tracked largely in line with the released plume. This further verified the hydrodynamic predictions and confirmed that the model was fit for the purpose intended.

To confirm the diffusivity coefficients applied in the model, the dye tracing experiment results were compared against a simulated release. As depicted in Figure 5.20, the Rhodamine WT dye diffused in a pattern similar to that of the model. Upon release, the dye was highly concentrated and located in a small area but with further distance downstream the dye diffused over a wider area. Based on this assessment, the diffusivity coefficient in the model was set at 0.5 m²/s.

5.4 Model Outputs

The calibrated and verified numerical model was subsequently used to resolve a number of technical concerns relating to the proposed release. These concerns include:

- Where is the optimal location for the ebb tide release?
- What is the design ebb tide velocity?
- Is there a relationship between the ebb tide water level and the time when discharge commences in the lower estuary?
- What is the maximum amount of time that the ebb tide discharge could operate without impacting upstream sites?
- What is the risk of released recycled water being transported into the entrance of the Oyster Channel and/or Lake Wooloweyah during tidal or flood flows?
- Based on the flow patterns under spring tides and high flows, what are the conceptual sand transport dynamics?
- What is the maximum scour likely to occur onsite and the resultant minimum depth of the pipeline?
These concerns are addressed below.

5.4.1 Optimal Location of the Ebb Tide Release

With regards to hydrodynamics, the optimal location for the ebb tide release (within the constraints of the proposed area for consideration, Figure 1.2) is a location furthest to the east. In an easterly location the proposed release would be:

- Closer to the river mouth, thereby allowing for an extended discharge window
- In a region with predominately easterly currents, versus further upstream where the currents have a northerly component
- Downstream of the gap in the middle training wall, which would reduce the likelihood of recycled water being funnelled into the entrance of the Oyster Channel.

Based on these criteria the approximate mid-line location is Easting 534310 and Northing 6744822 in MGA coordinates (Zone 56). This location would be the centreline point with the Iluka diffuser located to the north and the Yamba diffusers located to the south. The above location also complies with the range of constraints identified in Section 3. Further information on the conceptual design of the ebb tide release is given below and summarised in Section 7.

5.4.2 Design Ebb Tide Current Velocity

Previous ebb tide current velocity estimates have been based on field investigations. Though this information is useful it only provides a snapshot of the conditions that occurred on the day of testing. As such, the numerical model was used to provide a better understanding of the ebb tide velocities over the full spring/neap tidal cycle. In these simulations 15 minute time variant velocities were extracted from the model at the proposed ebb tide release location over a 29 day period. Results were selected for both the entire ebb tide (i.e. 6 hours) and a 3 hour ebb tide discharge window. The 3 hour window commenced 30 minutes after the ebb tide began. The results from this simulation are given in Table 5.1.
Table 5.1
Ebb Tide Current Velocity

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Velocity for entire ebb tide at $X^{th}$ percentile (in m/s)</th>
<th>Velocity for 3 hour ebb tide at $X^{th}$ percentile (in m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50$^{th}$</td>
<td>0.40</td>
<td>0.50</td>
</tr>
<tr>
<td>90$^{th}$</td>
<td>0.09</td>
<td>0.24</td>
</tr>
<tr>
<td>99$^{th}$</td>
<td>0.02</td>
<td>0.13</td>
</tr>
</tbody>
</table>

As shown in Table 5.1, the velocities for the entire ebb tide current are less than the 3 hour ebb tide window. The increase in velocity for the 3 hour ebb tide window is largely associated with precluding the first 30 minutes of the ebb tide when the velocities are the lowest. Since the lowest velocities are generated during this period, the 90$^{th}$ and 99$^{th}$ percentiles are particularly effected, with very low velocities evident over the entire ebb tide. Reducing the operating window to the middle of the ebb tide (i.e. 1 hour after the ebb tide commences) would further increase the ebb tide current velocities.

The values listed in Table 5.1 are also slightly below previous field measurements. This difference is due to previous measurements being undertaken during spring tides, which may overestimate the average velocity. It is important to note, however, that the velocities provided in Table 5.1 were generated at the proposed location for the ebb tide release and that further downstream the velocities are likely to be slightly higher due to the constrained channel. Therefore the velocities noted above are deemed conservative estimates.

Based on these results, and length of time required for the release (discussed in Section 5.4.4), the 3 hour ebb discharge velocity was selected as the design velocity.

5.4.3 Ebb Tide Water Level versus Ebb Tide Discharge

As noted in the field investigation, there is a varying lag between the time when the tidal water level begins to decrease and the time when the ebb tide currents in the main channel start flowing. This lag is related to a range of factors including the physical dimensions of the estuary, the tidal prism, the tidal wave shape/celerity, upland inflows and channel roughness. As discussed in the calibration and verification process, the numerical model accurately predicts this lag in the vicinity of the proposed ebb tide release.

An example of the tidal water level versus ebb tide discharge plot is given in Figure 5.21. When reading this chart it is important to note that while the tide changes when the water level begins to fall, the ebb tide does not commence to flow until the discharge becomes negative. With this information, the numerical model can adequately simulate the lag and
provide forecasts for when the ebb tide release should operate. However, due to varying upstream inflows, actual flow data from the river may be the preferred option for triggering the operation of the ebb tide release. Long-term analysis of tidal flows could then be used to confirm the model’s ability to accurately predict ebb tide flows.

5.4.4 Ebb Tide Release Operational Window

An ebb tide release was defined by both the Yamba and Iluka working groups “as when there is an outgoing flow which clears the entrance”. As such, all recycled water released must be transported beyond the end of the training walls of the Clarence River (regardless of water quality or mixing efficiencies). Therefore, to determine the duration of time that the release could operate, without compromising the agreed operating criteria, a range of scenario tests were devised and undertaken.

The modelling scenarios involved discharging a diffusive plume solely during ebb tides from the proposed release location over a full spring/neap tidal cycle (29 days). The different scenarios tested are provided in Table 5.2. Once the plume was released a range of sites (as shown in Figure 5.22) were monitored to determine if the plume ever reached these locations. For the scenarios listed in Table 5.2, failure to conform with the operational criteria would occur when any site upstream of the release, including those in the entrance of the Oyster Channel, had a measurable plume concentration. It is important to note that once the plume cleared ~150 m seaward of the entrance, it was removed from the model (i.e. not allowed to return on the flood tide). This is in line with MHL (2000), which stated that, ‘only a small fraction of the water ejected from the estuary during the ebb is returned on the subsequent flood’.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Length of discharge (in hours)</th>
<th>Time when discharged commenced</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>3</td>
<td>30 mins after change in flow</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>30 mins after change in flow</td>
</tr>
<tr>
<td>3</td>
<td>5</td>
<td>At the change in flow</td>
</tr>
<tr>
<td>4</td>
<td>4</td>
<td>1 hour prior to flow change</td>
</tr>
</tbody>
</table>

Results from the above scenarios indicated that the 3 hour ebb tide release (commencing 30 minutes after change in flow) was the only operational scenario that satisfied all criteria. Though measurable concentrations were noted at the sites immediately south of the middle training wall, no measurable concentrations were noted at the site near the gap in the middle wall, in the entrance to the Oyster Channel or upstream in the main channel.
The other scenario worth noting is #4 (4 hour release commencing 1 hour prior to change in flow). During this scenario the plume was not measured at any site south of the middle training wall or in the entrance to the Oyster Channel but was measured at the sites immediately upstream of the release. However, as this scenario permits discharge during the flood tide, the reduced current velocities prevalent during the slack tide would result in reduced mixing efficiencies.

The modelling results indicated that releases over 4 or 5 hours (i.e. Scenarios 2 and 3) did not comply with the testing criteria. In these scenarios the plume was transported through the gap in the middle wall and into the entrance of the Oyster Channel. This predominantly occurred during periods when a small amplitude tide was followed by a large amplitude tide (i.e. large tidal inequity). In these situations the lag in the ebb tide discharge, combined with the quickly rising large amplitude tide, results in a short release window. In theory this could be effectively managed by reducing the release window during these periods and increasing it during other periods when the tidal inequity is reduced.

The outcome of this scenario testing is that the 3 hour release (commencing discharge 30 minutes after the change in flow) satisfies the operational criteria established by the working groups and would not impact upstream sites.

5.4.5 Transport of Recycled Water During Flood Periods

WBM (2004) conducted a flood study of the lower Clarence River examining a range of flood scenarios including overbank flows. This study included 6 flooding events as noted in Table 5.3. WBM (2004) stated within their report that the flooding behaviour of the Lower Clarence River floodplain is dominated by the flow from the catchment upstream of Grafton and that the smaller tributaries in the lower floodplain only play a minor role in the flood behaviour.

<table>
<thead>
<tr>
<th>ARI</th>
<th>Inflows (m3/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>9,360</td>
</tr>
<tr>
<td>20</td>
<td>16,280</td>
</tr>
<tr>
<td>100</td>
<td>19,060</td>
</tr>
<tr>
<td>500</td>
<td>20,000</td>
</tr>
<tr>
<td>Extreme flood 1</td>
<td>29,160</td>
</tr>
<tr>
<td>Extreme flood 2</td>
<td>57,180</td>
</tr>
</tbody>
</table>
The numerical model presented in this study is solely designed for the purpose of developing a detailed conceptual model of the ebb tide release. One of the major concerns related to the release was that during significant flooding events Lake Wooloweyah and the main channel would be out of phase (i.e. the water level of one will lag behind the other). If this was to occur there could be the potential for released recycled water to be transported upstream and eventually into the Lake. While the modelling discussed in Section 5.4.4 indicated that this would not happen under normal tidal flows, additional modelling was undertaken to evaluate conditions during a flood event.

Based on the flooding scenarios undertaken by WBM (2004), a five year flood hydrograph was developed (using the shape of 100 year hydrograph to simulate the rate of rise) and simulated within the model. Since the lower Clarence River floodplain is dominated by flow from the upstream catchment, the five year hydrograph was applied on the upstream boundary. The model was then run over the 2008 field investigation period and the flow paths were analysed.

Results from the flood scenarios indicated that although Lake Wooloweyah and the main channel go out of phase, no water from the proposed ebb tide release would be transported into the entrance of the Oyster Channel. Figure 5.23 shows the indicative flow paths generated by the computer model when Lake Wooloweyah is out of phase with the main channel during a flood. The modelling snapshot provided in Figure 5.23 shows that the lower section of the estuary is dominated by high velocity flows in a seaward direction. During the peak of the flood, current velocities in the vicinity of the proposed release remain seaward regardless of the tidal level. As floodwaters recede, Lake Wooloweyah tides becomes out of phase with the main channel tides. Modelling results indicate that water from upstream of Freeburn Island (i.e. the island in the middle of the channel which the middle training walls is connected), versus water from the lower sections of the main channel, is directed into the entrance of the Oyster Channel during these periods. This circulation pattern continues until the flood passes and the normal ebb/tide cycle resumes. Importantly, the model results show that at no time during the flood hydrograph is water in the vicinity of the proposed ebb tide release transported upstream. (Animations of the flooding process are also available to provide additional information on the flow paths.)

5.4.6 Sediment Scour and Minimum Pipeline Depths

Figure 5.24 provides bed velocities at hourly intervals over an entire spring ebb tide. As evident in Figure 5.24 (hour 0) at the slack tide, velocities across the lower section of the estuary are low. At hour 1 the tidal velocity increases and continues to increase until hour 5
when the ebb flows start to reduce. The highest velocities experienced during the middle of
the ebb flow (> 1.0 m/s) are most prevalent in the lower or eastern section of the estuary
where the flow is confined between the middle training wall and the northern breakwater.
As the proposed release would be located upstream of Moriarty’s Wall, the bed velocities
experienced at this site are slightly less than the downstream velocities.

The velocities experienced during a spring ebb tide are sufficient to generate sediment
transport. Using standard practices (i.e. Shield’s diagram for particle motion), and an
average particle diameter (i.e. d₅₀) of 0.26 mm (based on bore logs from PB, 2007), it can
be determined that velocities greater than 0.6 m/s are sufficient to generate particle
transport. As such, sand particles are likely to be in suspension throughout the ebb tide
cycle for much of the lower estuary. These particles are likely to be transported
downstream with the ebb tide and upstream with the flood tide. Since the estuary has a
slight flood tide dominance, the net particle movement would be in the flood tide direction,
however large floods have the potential to reset the system.

To determine the minimum depth that the delivery pipeline could be positioned, an
assessment was made of the potential scouring that could occur onsite during a flood. A
range of assumptions were made for these calculations. First, the width of the site was
assumed to be a fixed distance between Moriarty’s Wall and the middle training wall.
Second, due to the very shallow nature of the channel south of the training wall, it was
assumed that the majority of the floodwater would be conveyed via the main channel.
Third, the depth of the coffee rock was set at 15 m below the water level (and
approximately 6.5 m below the sand bed). Finally, it was assumed that once sand was
removed from the site no sand was available for infill.

Based on the above assumptions, and using the 5-year average recurrence interval (ARI)
flooding event, it was determined that the site has the potential to scour down to the coffee
rock strata. Indeed, even with the increased cross-sectional area provided by the scoured
section, discharge velocities would be greater than 1.5 m/s during the 5 year ARI flooding
event. These calculations are based on current velocities much less then the reported flood
velocities which can increase to upwards of 6 m/s. It is therefore recommended that the
minimum pipe depth for the delivery pipeline be set below the coffee rock strata.
5.5 Summary

A hydrodynamic model was developed, calibrated and verified for the lower Clarence River. The model was shown to adequately describe the hydrodynamics in the vicinity of the proposed ebb tide release and is fit for the intended purpose of providing base data and analysis for the release designs. A range of model simulations were tested to optimise the design of the ebb tide release.

The main findings of the modelling include:

- Based on flow paths and circulation patterns (and the area available for consideration), the optimal location for the ebb tide release is furthest to the east, downstream of the gap in the middle training wall.
- The design velocity over a 3 hour ebb tide release (commencing 30 minutes after the ebb tide flow commences) was determined to be 0.50 m/s and 0.24 m/s for the 50th and 90th percentile, respectively. Further precluding the operating window to avoid more of the slack tide would likely increase the design velocities.
- The hydrodynamic model could be used as a forecasting tool to predict the time lag between the falling water levels and the ebb tide flows during dry periods but additional field data is necessary to predict the lag during wet periods.
- Regardless of near-field dilutions, a plume discharged during base flow conditions from the proposed release site could operate over a 3 hour window, commencing 30 minutes after the ebb tide flow starts, without impacting upstream locations.
- In flooding periods a plume from the proposed ebb tide release site would not be directed towards the entrance of the Oyster Channel or Lake Wooloweyah despite Lake Wooloweyah water levels being out of phase with the main channel.
- Ebb tide velocities are sufficient to scour sediment from the bed during spring tide conditions.
- Conservative estimates suggest that floods of a magnitude of the 5 year ARI or greater have the potential to scour sand at the proposed release site to the coffee rock. All attempts should therefore be made to ensure the delivery pipelines are installed below the coffee rock.

It is important to note that all discussions of plume transport provided above do not take into account the dilutions that would be achieved during the buoyant rise of the plume and hence, are only provided for design and illustrative purposes. Further information on these processes and predicted dilutions are provided below.
6. NEAR-FIELD MODELLING AND DIFFUSER DESIGN

This section describes the near-field modelling undertaken to design the release diffuser and comply with the water quality criteria. Information provided throughout this report and by the Department of Commerce have been used in the design process.

Throughout this section the term near-field zone is commonly used. The near field zone is defined as the region centred around the outfall, extending out to the point at which the mixture of river water and recycled water reaches its level of neutral buoyancy or the water surface. At the end of the near-field boundary, the plume is travelling with the speed of the surrounding waters and is of a similar density. The near-field zone is important as the dilutions are achieved predominately during the buoyant rise of the plume. In many locations in NSW, water quality concentrations are regulated at the end of the near-field zone.

Near-field modelling was undertaken using a commercially available model, JETLAG. JETLAG is a near-field model developed for the prediction of three dimensional trajectories of buoyant jets in a stratified ambient current. The model treats the unknown jet trajectory as a series of ‘plume elements’ that rise due to buoyancy, while gaining mass through entrainment of the ambient fluid. The performance of JETLAG has been verified for multiport releases similar to those proposed for Yamba/Iluka (Horton et al., 1996).

In addition to JETLAG, additional near-field modelling was undertaken with CORJET and VISJET to further substantiate the near-field modelling and provide additional visualisation of the near-field plumes. It is worth noting that the absolute accuracy of the concentrations (or dilutions) predicted by any near-field model is within ± 30 % when compared to controlled laboratory experiments (Jirka et al., 1996). This value may be greater when comparing with field data due to the inherent complexities of the ambient site conditions. This absolute accuracy should be acknowledged when interpreting the model results.

During the detailed concept design process it was determined that the Yamba and Iluka systems would operate independently. As such, the hydraulics of each system can be designed as standalone units. Further, the Department of Commerce advised that each system would discharge under pressure at a single pumping rate. Based on previously mentioned findings, the pumping rate is based on releasing recycled water over a 3 hour ebb tide window (twice per day). The advised rates for each system are provided in Table 6.1.
Table 6.1
Ebb Tide Release Design Flow Rates

<table>
<thead>
<tr>
<th>Design Flow</th>
<th>Iluka</th>
<th>Yamba</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML/day</td>
<td>1.95</td>
<td>7.92</td>
</tr>
<tr>
<td>L/sec over 3 hour release window</td>
<td>91</td>
<td>367</td>
</tr>
</tbody>
</table>

6.1 Diffuser Requirements

Based on the design flow rates provided in Table 6.1, a range of diffuser designs were developed and tested. Standard and duckbill valves were tested for each design to calculate exit velocities and head loss. The results for the Yamba simulations with standard ports is given in Table 6.2, whereas the results for duckbill valves are given in Table 6.3. The results for the Iluka simulations with standards ports is given in Table 6.4 and with duckbill valves are given in Table 6.5.

Table 6.2
Yamba Ebb Tide Release Design: Standard Ports

<table>
<thead>
<tr>
<th>Number of Ports</th>
<th>NOZZLE Port Diameter (mm)</th>
<th>Total Flow Rate (m3/s)</th>
<th>Flow Rate per Port (m3/s)</th>
<th>Exit Velocity (m/s)</th>
<th>Head Loss Riser (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>100</td>
<td>0.3670</td>
<td>0.1835</td>
<td>23.36</td>
<td>27.82</td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>0.3670</td>
<td>0.0918</td>
<td>11.68</td>
<td>6.96</td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>0.3670</td>
<td>0.0612</td>
<td>7.79</td>
<td>3.09</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>0.3670</td>
<td>0.0459</td>
<td>5.84</td>
<td>1.74</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>1.3670</td>
<td>0.1367</td>
<td>17.41</td>
<td>15.44</td>
</tr>
<tr>
<td>2</td>
<td>150</td>
<td>0.3670</td>
<td>0.1835</td>
<td>10.38</td>
<td>5.50</td>
</tr>
<tr>
<td>4</td>
<td>150</td>
<td>0.3670</td>
<td>0.0918</td>
<td>5.19</td>
<td>1.37</td>
</tr>
<tr>
<td>6</td>
<td>150</td>
<td>0.3670</td>
<td>0.0612</td>
<td>3.46</td>
<td>0.61</td>
</tr>
<tr>
<td>8</td>
<td>150</td>
<td>0.3670</td>
<td>0.0459</td>
<td>2.60</td>
<td>0.34</td>
</tr>
<tr>
<td>10</td>
<td>150</td>
<td>0.3670</td>
<td>0.0367</td>
<td>2.08</td>
<td>0.22</td>
</tr>
<tr>
<td>2</td>
<td>200</td>
<td>0.3670</td>
<td>0.1835</td>
<td>5.84</td>
<td>1.74</td>
</tr>
<tr>
<td>4</td>
<td>200</td>
<td>0.3670</td>
<td>0.0918</td>
<td>2.92</td>
<td>0.43</td>
</tr>
<tr>
<td>6</td>
<td>200</td>
<td>0.3670</td>
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## Table 6.3
Yamba Ebb Tide Release Design: Duckbill Ports

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<th>DUCKBILL Port Diameter (mm)</th>
<th>Total Flow Rate (m³/s)</th>
<th>Flow Rate per Port (m³/s)</th>
<th>Exit Velocity (m/s)</th>
<th>Head Loss Riser (m)</th>
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### Table 6.4
Iluka Ebb Tide Release Design: Standard Ports

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<th>Exit Velocity (m/s)</th>
<th>Head Loss Riser (m)</th>
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Table 6.5
Iluka Ebb Tide Release Design: Duckbill Ports

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<th>Number of Ports</th>
<th>DUCKBILL Port Diameter (mm)</th>
<th>Total Flow Rate (m3/s)</th>
<th>Flow Rate per Port (m3/s)</th>
<th>Exit Velocity (m/s)</th>
<th>Head Loss Riser (m)</th>
</tr>
</thead>
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<td>0.0455</td>
<td></td>
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<td>0.0228</td>
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<td>0.0228</td>
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<td>1.15</td>
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</table>

As both system are designed to operate for a total of 6 hours each day it was determined that duckbill valves would be better suited. Based on WRL’s experience elsewhere and factory recommendations, exit velocities below 3.0 m/s were deemed ideal for the long term operation of the release and to minimise head loss. Minimising the numbers of ports was also a key criteria in the release design.

Based on the above calculations and design criteria, optimal designs were selected for both locations. These designs are highlighted in Tables 6.3 and 6.5 and are provided for clarity in Table 6.6. Each design ensures exit velocities are below 2.7 m/s (thus minimising head loss). For Yamba the optimal configuration is an 8 × 300 mm port configuration. For Iluka a 2 × 300 mm port configuration is optimal. For the Yamba design the 8 port configuration could either be a single 8 port release or dual 4 port releases, depending on onsite design constraints.
### Table 6.6
**Final Release Configuration**

<table>
<thead>
<tr>
<th>Location</th>
<th>Number of Ports</th>
<th>Duckbill Port Diameter (mm)</th>
<th>Total Flow Rate (m³/s)</th>
<th>Flow Rate per Port (m³/s)</th>
<th>Exit Velocity (m/s)</th>
<th>Head Loss Riser (m)</th>
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<td>0.0459</td>
<td>2.7</td>
<td>0.36</td>
</tr>
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<td>Iluka</td>
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<td>0.0455</td>
<td>2.65</td>
<td>0.36</td>
</tr>
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</table>

*Note this design could be either a single 8 port release or dual 4 port releases

### 6.2 Water Quality

#### 6.2.1 Water Quality Criteria

The water discharged from the proposed ebb tide releases will be at a water quality equivalent to the Accepted Modern Technology (AMT). The water quality concentrations achieved for this high standard of treatment are provided in Table 6.7.

### Table 6.7
**Discharged Water Quality Concentrations for Accepted Modern Technology**

<table>
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<tr>
<th>Analyte</th>
<th>Units</th>
<th>Recycled Water Quality</th>
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<tr>
<td>Faecal Coliform</td>
<td>cfu/100mL</td>
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<tr>
<td>DO</td>
<td>mg/L</td>
<td>2</td>
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<tr>
<td>BOD</td>
<td>mg/L</td>
<td>10</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>10</td>
</tr>
<tr>
<td>Oil and grease</td>
<td>mg/L</td>
<td>10</td>
</tr>
<tr>
<td>pH</td>
<td>Standard units</td>
<td>6.5 - 8.5</td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/L</td>
<td>2</td>
</tr>
<tr>
<td>Total N</td>
<td>mg/L</td>
<td>10</td>
</tr>
<tr>
<td>Total P</td>
<td>mg/L</td>
<td>0.3</td>
</tr>
</tbody>
</table>

*Note values are 90th percentile values; mean values would be lower
#Flows for reuse will be treated to <10 cfu/100 mL.

Water quality objectives for the Clarence River are based on public health, aquatic ecosystem and aquaculture criteria. The adopted water quality criteria are set out in Table 6.8.
### Table 6.8
**Water Quality Criteria**

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Units</th>
<th>Criteria</th>
<th>Trigger Value</th>
</tr>
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<tbody>
<tr>
<td>Faecal Coliform</td>
<td>cfu/100mL</td>
<td>ANZECC - Primary contact&lt;br&gt;ANZECC - Human consumer of seafood&lt;br&gt;Safe Foods - Oyster Ecology</td>
<td>150&lt;br&gt;14&lt;br&gt;70</td>
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<tr>
<td>DO</td>
<td>mg/L</td>
<td>ANZECC - Aquatic Ecology (Estuarine Waters)</td>
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</tr>
<tr>
<td>BOD</td>
<td>mg/L</td>
<td>ANZECC - Aquatic Ecology (Estuarine Waters)*</td>
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<tr>
<td>TSS</td>
<td>mg/L</td>
<td>ANZECC - Aquaculture (Estuarine Waters)</td>
<td>10</td>
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<tr>
<td>Oil and grease</td>
<td>mg/L</td>
<td>ANZECC - Aquaculture (Estuarine Waters)</td>
<td>0.3</td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/L</td>
<td>ANZECC - Aquatic Ecology (Estuarine Waters)</td>
<td>0.015&lt;br&gt;0.1&lt;br&gt;0.03</td>
</tr>
<tr>
<td>Total N</td>
<td>mg/L</td>
<td>ANZECC - Aquatic Ecology (Estuarine Waters)&lt;br&gt;1.5 x background</td>
<td>0.3&lt;br&gt;0.45</td>
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<tr>
<td>Total P</td>
<td>mg/L</td>
<td>ANZECC - Aquatic Ecology (Estuarine Waters)&lt;br&gt;1.5 x background</td>
<td>0.03&lt;br&gt;0.045</td>
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*primarily freshwater criteria

The ambient water quality concentrations in the lower Clarence River have been derived from a number of references. A list of analytes relevant to the release is provided in Table 6.9.
### Table 6.9
Ambient Water Quality Concentrations

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<td>0.3</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.01</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.17</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td></td>
<td>0.3</td>
<td>0.3</td>
<td>0.2-0.4</td>
<td>0.17</td>
<td>0.14</td>
<td>0.17</td>
<td></td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/L</td>
<td></td>
<td>0.03</td>
<td>0.03</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total N</td>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total P</td>
<td>mg/L</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Due to the adopted background values above being greater than or equal to the criteria level for protection of aquatic ecology for ammonia, total nitrogen and total phosphorus, a local criteria of 1.5 times background was adopted for dilution modelling as per MHL (2005).

#### 6.2.2 Dilutions Required

The required dilutions to satisfy water quality criteria are computed by the formula:

\[ D = \frac{C_a - C_b}{C_c - C_b} \]

Where, \( D \) = Dilution; \( C_a \) = concentration of recycled water; \( C_b \) = background concentration of ambient water; \( C_c \) = water quality criteria concentration.

On this basis, the dilutions required to satisfy the criteria are provided in Table 6.10.
Table 6.10
Required Dilutions to Satisfy Water Quality Criteria

<table>
<thead>
<tr>
<th>Analyte</th>
<th>Units</th>
<th>Recycled Water Quality</th>
<th>Dilutions Required</th>
</tr>
</thead>
<tbody>
<tr>
<td>Faecal Coliform</td>
<td>cfu/100mL</td>
<td>200</td>
<td>22</td>
</tr>
<tr>
<td>DO</td>
<td>mg/L</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>BOD</td>
<td>mg/L</td>
<td>10</td>
<td>N/A</td>
</tr>
<tr>
<td>TSS</td>
<td>mg/L</td>
<td>10</td>
<td>N/A</td>
</tr>
<tr>
<td>Oil and grease</td>
<td>mg/L</td>
<td>10</td>
<td>33</td>
</tr>
<tr>
<td>pH</td>
<td>Standard units</td>
<td>6.5 - 8.5</td>
<td>N/A</td>
</tr>
<tr>
<td>Ammonia</td>
<td>mg/L</td>
<td>2</td>
<td>198</td>
</tr>
<tr>
<td>Total N</td>
<td>mg/L</td>
<td>10</td>
<td>65</td>
</tr>
<tr>
<td>Total P</td>
<td>mg/L</td>
<td>0.3</td>
<td>18</td>
</tr>
</tbody>
</table>

Based on the dilution calculated above, all analytes except for ammonia would be satisfied with a dilution of 65. To satisfy the criteria for ammonia, a dilution of ~200 is required. It is worth noting that the dilution required for ammonia is highly conservative as it assumes that no chemical transformations would occur.

6.2.3 Dilution Modelling

Based on the release configurations and required dilutions outlined above, near-field modelling was undertaken to determine the resultant dilutions that could be achieved for each design. Note that a mid-line port depth of 6 m was assumed for the diffusers based on the sedimentation analysis discussed in Section 3.1. This is a conservative value as the releases will operate during the ebb tide and not the low tide (i.e. a depth of 6 m is based on an average water level of 0 m IPD or -0.92 m AHD).

The results from the Yamba modelling are provided in Table 6.11 (for a single 8 port design) and Table 6.12 (for dual 4 port designs). The results from the Iluka modelling are provided in Table 6.13. Modelling results are presented for the 50th and 90th percentile flows (0.50 and 0.24 m/s, respectively) and for each port angle with respect to the ebb current. Note that a 300 mm duckbill has an effective diameter of 148 mm and that the average dilution is the sum of the dilutions from each port angle divided by the total number of ports.
Table 6.11
Yamba Release Dilutions: Single Eight Port Diffuser

<table>
<thead>
<tr>
<th>Port Angle</th>
<th>Dilution for 3 hour ebb discharge (50th %ile velocity)</th>
<th>Dilution for 3 hour ebb discharge (90th %ile velocity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>179</td>
<td>68</td>
</tr>
<tr>
<td>45/315</td>
<td>232</td>
<td>132</td>
</tr>
<tr>
<td>90/270</td>
<td>304</td>
<td>145</td>
</tr>
<tr>
<td>135/225</td>
<td>188</td>
<td>84</td>
</tr>
<tr>
<td>180</td>
<td>391</td>
<td>154</td>
</tr>
<tr>
<td>Average</td>
<td>252</td>
<td>118</td>
</tr>
</tbody>
</table>

Table 6.12
Yamba: Dual Four Port Diffusers

<table>
<thead>
<tr>
<th>Port Angle</th>
<th>Dilution for 3 hour ebb discharge (50th %ile velocity)</th>
<th>Dilution for 3 hour ebb discharge (90th %ile velocity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>179</td>
<td>68</td>
</tr>
<tr>
<td>90/270</td>
<td>304</td>
<td>145</td>
</tr>
<tr>
<td>180</td>
<td>391</td>
<td>154</td>
</tr>
<tr>
<td>Average</td>
<td>295</td>
<td>128</td>
</tr>
</tbody>
</table>

Table 6.13
Iluka: Two Port Diffuser

<table>
<thead>
<tr>
<th>Port Angle</th>
<th>Dilution for 3 hour ebb discharge (50th %ile velocity)</th>
<th>Dilution for 3 hour ebb discharge (90th %ile velocity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90/270</td>
<td>306</td>
<td>146</td>
</tr>
</tbody>
</table>

In summary, for the 50th %ile ebb tide flow, the average dilution at Yamba is 252 and 295 times for the single (8 ports) and dual (2 × 4 ports) diffuser configurations, respectively. However, a single eight port diffuser is likely to have some plume interactions at the end of the near-field zone which are not included in these dilutions. These interactions would reduce plume dilution and therefore, the average dilution for the 8 port diffuser would likely be lower than calculated in Table 6.11. For the two port diffuser at Iluka the calculated dilution is 306 and 146 for the 50th and 90th percentile flow, respectively.

6.2.4 Plume Visualisation

Figures 6.1 – 6.5 assist in visualising the buoyant plumes in the near-field for the Yamba diffuser options. A visualisation of one of the dual 4 port diffuser is provided in Figure 6.1. In this figure the ports are at 0, 90, 180 and 270 degrees to the ebb tide flow and no plume
interactions are evident. An alternative design with ports at 45, 135, 225 and 315 degrees is provided in Figure 6.2. In this design some plume interaction is evident at the top of the near-field zone. 3-D visualisation of these two designs is provided in Figure 6.3.

The single eight port diffuser is a combination of the two above 4 port diffusers with ports located at angles of 0, 45, 90, 135, 180, 225, 270 and 315 degrees. As depicted in Figure 6.4, the single 8 port diffuser design has the potential for plume interactions, although the degree of interaction is dependent on the circumference of the diffuser head, with a larger diffuser spreading the plume over a wider area and minimising plume interaction. Further visualisation of the single 8 port diffuser and the dual 4 port diffuser designs is provided in Figure 6.5. The final design of the diffuser would largely depend on the construction methods developed for securing the diffuser to the river bed.

Figure 6.6 depicts 2-D and 3-D visualisations of the 2 port diffuser proposed for Iluka. As each port would be at 90 degrees to the flow (and 180 degrees from each other) no plume interactions is anticipated. Similar to the Yamba diffuser, the final detailed concept design, including riser dimensions, would be developed in conjunction with the construction methods determined for securing the diffuser to the river bed.

The plume visualisations depicted in Figures 6.1 – 6.6 also provide an indication of the distance from the release structures to the end of the near-field zone. For the Yamba diffuser this distance is approximately 50 m, whereas for Iluka this distance is approximately 40 m. Both distances are based on the 50th percentile ambient flow rates and will vary under alternative ambient flow velocities.

6.2.5 Recycled Water Plume Performance

As stated in Section 6.2.2, a dilution of 65 times would satisfy the water quality criteria for all analytes except ammonia, which requires a dilution of approximately 200 times. Based on a 50th percentile current velocity (0.5 m/s), a dilution level of 200 times is exceeded at the end of the near-field zone for all concept designs tested (for both Yamba and Iluka).

In the 90th percentile flow velocity scenarios (0.24 m/s), the dilution level is exceeded for all analytes except ammonia. Further modelling was therefore undertaken to calculate the additional far-field mixing required to obtain the sufficient dilutions. These modelling results indicated that >200 times dilution would be achieved within 150 m of the release at both locations.
The dilution results presented in Tables 6.11 – 6.13 are based on a water elevation of 0 m IPD, the 50th and 90th percentile flow velocities and the 90th percentile recycled water quality concentrations. Ambient flows below the 90th percentile (i.e. flows that will occur ~10 % of the time) will result in reduced dilutions. Further, water quality concentrations worse than predicted could occur 10 % of the time. However, based on conjunctive probability, the chances of these two independent events occurring at the same time is 1 %. It is worth noting that all recycled water, regardless of background currents and quality, would be released at a water level greater than 0 m IPD (i.e. allowing for a greater mixing zone).

Within the above discussion it is important to note that the lowest ambient current velocities occur during the beginning of the discharge window when the water levels are the highest. Additional analysis may be required to determine if the higher water levels that occur during this period are sufficient to offset the lower ambient current velocities. Alternatively, if the 3 hour operating window could be shortened, then the time until when the release commences could be increased from 30 minutes to say 60 or 90 minutes. This would ensure that the recycled water is released during the highest ambient current velocities. Refinement of the release window and near-field modelling should be undertaken once the structural and operational issues are finalised.

### 6.3 Hydraulic Assessment

The head loss calculations for each of the conceptual designs are provided in Tables 6.2 - 6.4. Preliminary estimates for the delivery pipelines suggest a 315 mm Outside Diameter (OD) HDPE pipe for Iluka and a 560 mm OD HDPE pipe for Yamba. Length and orientation of the pipeline is currently being calculated by Trenchless Advisors Pty Ltd. The hydraulic assessment of the design forces and purging characteristics would be undertaken once the construction details of the concept design have been finalised.

### 6.4 Summary

This section provides detailed conceptual designs for the diffuser configurations. Exit velocity and head loss calculations were used to develop optimal configurations for Yamba and Iluka (Table 6.6). Water quality modelling in the near-field zone was then employed to calculate the dilutions that would be achieved with these diffuser configurations under different ambient flow regimes. Both configurations were shown to provide the dilutions required in the near-field zone (approximately 50 m from the release) under 50th percentile flows. Under 90th percentile flows (i.e. the tidal velocities that would occur 10% of the
time), the dilution requirements would be achieved within 150 m of the releases. Additional information on the diffuser support structures (connecting the diffusers with the directional drilled HDPE pipelines) are required prior to finalising the hydraulic assessment.
7. CONCLUSION

Clarence Valley Council is currently upgrading the sewage treatment systems for the towns of Yamba and Iluka, located at the mouth of the Clarence River. As part of this upgrade, excess recycled water will be discharged to the lower Clarence River via independently operating ebb tide releases. Local stakeholder groups have established a range of operating criteria and a proposed area for consideration (Figure 1.2). WRL at the University of New South Wales were commissioned by Clarence Valley Council (via the Department of Commerce) to develop a detailed concept design for both releases.

This report outlines the preliminary findings of the detailed concept design. The specifications of the designs and the relevant report sections are provided in Table 7.1. These specifications were determined via a targeted field work investigation, computer modelling and analytical calculations in the lower estuary and particularly in the immediate vicinity of the proposed ebb tide releases.

<table>
<thead>
<tr>
<th>Table 7.1</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Detailed Concept Design Specifications</strong></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>General Circulation and Operational Issues</th>
</tr>
</thead>
</table>

<table>
<thead>
<tr>
<th>Section</th>
<th>Design Specification</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.4.1</td>
<td>Location</td>
<td>The releases should be located approximately 50 m upstream of the easterly extent of the proposed area (Figure 1.2). The releases should be spaced at a minimum of 15 m apart (in a N-S configuration). The final location is dependent on geotechnical findings. The current approximate location is Easting 534310 and Northing 6744822 in MGA coordinates.</td>
</tr>
<tr>
<td>3.1</td>
<td>Depth</td>
<td>Using limited sedimentation data, it is proposed that the mid-line depth of the diffuser ports be set at 6 m below Iluka Port Datum; approximately 1.5 m above the bed level.</td>
</tr>
<tr>
<td>5.4.4</td>
<td>Operational Timeframe</td>
<td>During average (or base) flows the releases can effectively operate for 3 hours, commencing 30 minutes from the start of the ebb tide flow.</td>
</tr>
<tr>
<td>5.4.2</td>
<td>Design Velocity (for Water Quality)</td>
<td>Based on the operational timeframe: A 50th percentile ebb tide velocity of 0.50 m/s A 90th percentile ebb tide velocity of 0.24 m/s Design forces will be determined based on the final structure.</td>
</tr>
<tr>
<td>3.1</td>
<td>Preliminary Sedimentation Analysis</td>
<td>Sediments are actively being mobilised in the lower estuary. Further information is required to ensure that the proposed location is not subject to excessive sedimentation or accretion.</td>
</tr>
</tbody>
</table>
5.4.6 Scouring Dynamics

Spring ebb and flood tides have the potential to mobilise sediment. During flood flows there is the potential for scouring to the coffee rock strata. Therefore, the delivery pipelines should be secured within the coffee rock strata.

5.4.5 Circulation Processes during High Flows

Modelling simulations indicate that recycled water released during high flows will not be transported upstream or in the vicinity of the Oyster Channel.

### Diffuser Design and Near-Field Modelling

<table>
<thead>
<tr>
<th>6.1</th>
<th>Exit Velocity</th>
<th>The exit velocity of the preferred diffuser configuration is &lt; 3.0 m/s (Table 6.6)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6.1</td>
<td>Headloss</td>
<td>Headloss per riser is &lt;0.4 m (Table 6.6)</td>
</tr>
</tbody>
</table>
| 6.1  | Number of Ports | Iluka: 2 ports  
Yamba: 8 ports  
(preferred option is a dual 4 port configuration) |
| 6.1  | Port Size     | Port sizes are 300 mm duckbill valves                                        |
| 6.2.4| Port Angle    | Iluka: 90 and 180 degrees  
Yamba: 0, 45, 90, 135, 180, 225, 270 and 315                               |
| 6.2.2| Required Dilutions | Required Dilutions: 65 for most parameters;  
~200 for Ammonia                                                           |
| 6.2.3| Achieved Dilutions (50th percentile flow) | Iluka: Average near-field dilution > 300  
Yamba: Average near-field dilution is 295 for dual design and 252 for single design (does not include plume interaction). |
| 6.2.5| Achieved Dilutions (90th percentile flow) | Both configurations achieve required dilutions within 150 m of release location for 90th percentile flows.  
Flows >90th percentile require further analysis. |
| 6.2.4| Near-field Plume Dynamics | Near-field zone ends at 40 m for Iluka and 50 m for  
Iluka based on 50th percentile ambient flows. |
| 6.3  | Hydraulic Assessment | To be determined based on construction issues. |

Additional information is required concerning the sedimentation dynamics and the construction of the delivery pipeline and diffuser support structure. Preliminary consultation with relevant engineering groups has been undertaken and the relevant investigations are either underway or in the process of being commissioned. Once this data is available, further specifications regarding the hydraulics and the diffuser configurations will be developed, including detailed conceptual drawings. The final configuration would be presented and discussed with the various stakeholder groups.
8. REFERENCES


Manly Hydraulics Laboratory (1996b), Northern Clarence Breakwater Design Wave heights and Armour Sizes, Report No. MHL742, April.


STUDY SITE LOCATION

NEW SOUTH WALES

Grafton

Yamba

Iluka

LOWER CLARENCE RIVER

The Broadwater

South Arm

Maclean

Back Channel

Oyster Channel

Lake Wooloweyah

Freeburn Island

Main Channel

Grafton

Yamba

Iluka
Proposed Country Energy Line
Approximate Navigation Channel
Proposed Area for Consideration of Ebb Tide Release
Middle Training Wall
Moriarty’s Wall
Physical Reef
Iluka
Yamba

PROPOSED RELEASE LOCATION

Figure 1.2

WRL
Report No. 2008/28
SITE CONSTRAINTS AND PREFERRED RELEASE LOCATION

Figure 2.1

Proposed Country Energy Line
Commercial and Recreational Navigation
Oyster Channel
Preferred Ebb Tide Release Location
Recreational Fishing Haven
Cultural Significance Reef
Dept of Land’s Breakwater
Proposed Area for Consideration
Commercial Fishing (Mullet Run)

Yamba
Iluka

0 200 400 800 1,200 1,600 Metres
SUMMARY OF ENTRANCE HYDROGRAPHIC SURVEYS
(PROPOSED AREA OF INTEREST INDICATED BY RECTANGLE)
2008 WRL BATHYMETRIC SURVEY RESULTS (in m IPD)
Figure 3.3

NATURAL AND INDUCED SITE GEOMORPHOLOGY
Source of photos: Soros-Longworth & McKenzie

1946

1958

1969

1976

Scale

0 1 2 3 km

TRAINING WORKS AT ILUKA

Figure 3.4
2008 ADCP TRANSECT LOCATIONS

Figure 4.1

TR2008_28_5-13.mxd

2008 Discharge/Velocity Measurement Locations
Representative Western ADCP Transect
(Transect: West 03 14/10/2008 11:11:50)
Figure 4.4

Representative Middle ADCP Transect
(Transect: Middle 03 14/10/2008 11:32:59)
Figure 4.5

Representative Eastern ADCP Transect

(Transect: East 03 14/10/2008 11:50:07)
SURVEY DATA USED TO CONSTRUCT NUMERICAL MODEL

Figure 5.1
Figure 5.3

COMPARISON OF MEASURED AND PREDICTED 2008 OFFSHORE WATER LEVELS

Water level measured at Tweed Heads offshore
Water level predicted at Yamba offshore

Water Level (m AHD)
MEASUREMENT LOCATIONS USED FOR CALIBRATION OF NUMERICAL MODEL

Figure 5.4
COMPARISON OF MODELLED AND MEASURED 1996 WATER LEVELS AT YAMBA AND MACLEAN
COMPARISON OF MODELLED AND MEASURED 1996 WATER LEVELS AT BRUSHGROVE AND GRAFTON
COMPARISON OF MODELLED AND MEASURED 1996 WATER LEVELS ALONG THE OYSTER CHANNEL
COMPARISON OF MODELLED AND MEASURED 1996 WATER LEVELS IN PALMERS CHANNEL

WRL Report No. 2008/28

Figure 5.8

Palmers Channel

Water level (m AHD)

Modelled Measured
COMPARISON OF MODELLED AND MEASURED 24TH OCT1996 DISCHARGE AT YAMBA AND MACLEAN

Modelled Measured
Figure 5.10

COMPARISON OF MODELLED AND MEASURED
24TH OCT 1996 DISCHARGE AT BRUSHGROVE AND GRAFTON
COMPARISON OF MODELLED AND MEASURED 24TH OCT 1996 DISCHARGE AT OYSTER CHANNEL

Modelled Measured
COMPARISON OF MEASURED AND MODELLED
24-OCT-1996 VELOCITIES AT YAMBA

Figure 5.12a

(WRL TRANSECT 3 SITE 2)
COMPARISON OF MEASURED AND MODELLED 24-OCT-1996 VELOCITIES AT YAMBA

Figure 5.12b

(MHL TRANSECT 5 SITE 2)
COMPARISON OF MEASURED AND MODELLED 2008 VELOCITIES AT YAMBA

(ADCP Transect: East 03 14/10/2008 11:50:07)
2008 MEASUREMENT LOCATIONS USED FOR VERIFICATION OF NUMERICAL MODEL
COMPARISON OF MODELLED AND MEASURED 2008 WATER LEVELS AT YAMBA AND MACLEAN

Modelled Measured
COMPARISON OF MODELLED AND MEASURED 2008 WATER LEVELS AT BRUSHGROVE AND GRAFTON
COMPARISON OF MODELLED AND MEASURED 2008 DISCHARGE AT THE WESTERN AND MIDDLE TRANSECT SITES

**Western Transect**

**Middle Transect**

- Discharge (m$^3$/s)

- Measured
- Modelled

Figure 5.16
COMPARISON OF MODELLED AND MEASURED 2008 DISCHARGE AT THE EASTERN TRANSECT SITE

Eastern Transect
COMPARISON OF MEASURED AND MODELLED
2008 VELOCITIES AT YAMBA

(ADCP Transect: West 03/14/10/2008 11:11:50)
COMPARISON OF MEASURED AND MODELLED
2008 VELOCITIES AT YAMBA

(ADCP Transect: Middle 03/10/2008 11:32:59)
WRL
Report No. 2008/28

GPS DROGUE TRACKING RELEASE # 2
COMPAARED TO NUMERICAL MODELLING OF RELEASE
(15/10/2008)

Figure 5.19
Figure 5.20

WRL Report No. 2008/28

RHODAMINE DYE TRACING (3:30AM 16/10/2008)
COMPARISON TO NUMERICAL MODEL RESULTS
WATER LEVEL VS DISCHARGE AT YAMBA

Measured Discharge
Modelled Discharge
Measured Water Level
FLOW PATHS IN LOWER CLARENCE ESTUARY DURING FLOOD EVENT (day 245 19.75hrs)
VELOCITIES AROUND PROPOSED RELEASE LOCATION OVER A SPRING EBB TIDE
Note: Flow is from left (upstream) to right (ocean)
Note: Flow is from left (upstream) to right (ocean)
Note: Flow is from left (upstream) to right (ocean)
PLUME PROFILES:
YAMBA DIFFUSER CONFIGURATION, 8 PORTS

Note: Flow is from left (upstream) to right (ocean)
Note: Flow is from left (upstream) to right (ocean)
PLUME PROFILES:
ILUKA DIFFUSER CONFIGURATION, 2 PORTS

Note: Flow is from left (upstream) to right (ocean)
This letter contains preliminary findings regarding the feasibility assessment of a revised Iluka ebb tide release location. The proposed site (E534292 N6745050) is located on the northern side of the NSW Maritime dredge channel (Figure 1).

The depth at the previous location was approximately -7.5 m IPD (Iluka Port Datum), with the Iluka diffuser positioned at -6 m IPD. Based on the results of this investigation, the depths at the revised Iluka location are approximately -4 m IPD and -3 m IPD respectively, with depths varying over time from -5.7 m IPD to -4.0 m IPD (Table 1).

<table>
<thead>
<tr>
<th>Survey</th>
<th>Iluka E:534292 N:6745050 (m IPD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1986 - Maritime Services Board of NSW (April)</td>
<td>5.1</td>
</tr>
<tr>
<td>1988 - Maritime Services Board of NSW (21-23 June)</td>
<td>4.1</td>
</tr>
<tr>
<td>1993 - Australian Army (15 September)</td>
<td>4.2</td>
</tr>
<tr>
<td>1999 - Sydney Ports (digital data, month unknown)</td>
<td>4.1</td>
</tr>
<tr>
<td>2002 - Department of Land and Water Conservation (May)</td>
<td>5.2</td>
</tr>
<tr>
<td>2004 - NSW Waterways Authority (March)</td>
<td>not surveyed</td>
</tr>
<tr>
<td>2006 - NSW Maritime (November)</td>
<td>not surveyed</td>
</tr>
<tr>
<td>2007 - DECC Coastal Unit (May)</td>
<td>5.2</td>
</tr>
<tr>
<td>2007 - Water Research Laboratory (July)</td>
<td>5.7</td>
</tr>
<tr>
<td>2008 - Water Research Laboratory (October)</td>
<td>4.0</td>
</tr>
</tbody>
</table>

# Note Iluka Port Datum (IPD) is 0.92 m below local Australian Height Datum (AHD)

Design conditions for the ebb tide release are unchanged from WRL Technical Report 08/28, with release flows (Table 2), ambient current velocities (Table 3) and release hydraulic design (Table 4) remaining the same as previously stated.
Table 2
Ebb Tide Release Design Flow Rates

<table>
<thead>
<tr>
<th>Design Flow</th>
<th>Iluka</th>
<th>Yamba</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML/day</td>
<td>1.95</td>
<td>7.92</td>
</tr>
<tr>
<td>L/sec over 3 hour release window</td>
<td>91</td>
<td>367</td>
</tr>
</tbody>
</table>

Table 3
Ebb Tide Current Velocity

<table>
<thead>
<tr>
<th>Percentile</th>
<th>Velocity for entire ebb tide at Xth percentile (in m/s)</th>
<th>Velocity for 3 hour ebb tide at Xth percentile (in m/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>50th</td>
<td>0.40</td>
<td>0.50</td>
</tr>
<tr>
<td>90th</td>
<td>0.09</td>
<td>0.24</td>
</tr>
<tr>
<td>99th</td>
<td>0.02</td>
<td>0.13</td>
</tr>
</tbody>
</table>

Table 4
Iluka Ebb Tide Release Design: Duckbill Ports

<table>
<thead>
<tr>
<th>Number of Ports</th>
<th>DUCKBILL Port Diameter (mm)</th>
<th>Total Flow Rate (m3/s)</th>
<th>Flow Rate per Port (m3/s)</th>
<th>Exit Velocity (m/s)</th>
<th>Head Loss Riser (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>100</td>
<td>0.0910</td>
<td>0.0455</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>100</td>
<td>0.0910</td>
<td>0.0228</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>100</td>
<td>0.0910</td>
<td>0.0152</td>
<td>4.60</td>
<td>1.10</td>
</tr>
<tr>
<td>8</td>
<td>100</td>
<td>0.0910</td>
<td>0.0114</td>
<td>3.90</td>
<td>0.75</td>
</tr>
<tr>
<td>10</td>
<td>100</td>
<td>0.0910</td>
<td>0.0091</td>
<td>3.20</td>
<td>0.60</td>
</tr>
<tr>
<td>2</td>
<td>150</td>
<td>0.0910</td>
<td>0.0455</td>
<td>5.40</td>
<td>1.50</td>
</tr>
<tr>
<td>4</td>
<td>150</td>
<td>0.0910</td>
<td>0.0228</td>
<td>4.20</td>
<td>0.90</td>
</tr>
<tr>
<td>6</td>
<td>150</td>
<td>0.0910</td>
<td>0.0152</td>
<td>2.90</td>
<td>0.45</td>
</tr>
<tr>
<td>8</td>
<td>150</td>
<td>0.0910</td>
<td>0.0114</td>
<td>2.40</td>
<td>0.30</td>
</tr>
<tr>
<td>10</td>
<td>150</td>
<td>0.0910</td>
<td>0.0091</td>
<td>2.20</td>
<td>0.25</td>
</tr>
<tr>
<td>2</td>
<td>200</td>
<td>0.0910</td>
<td>0.0455</td>
<td>4.00</td>
<td>0.85</td>
</tr>
<tr>
<td>4</td>
<td>200</td>
<td>0.0910</td>
<td>0.0228</td>
<td>3.20</td>
<td>0.50</td>
</tr>
<tr>
<td>6</td>
<td>200</td>
<td>0.0910</td>
<td>0.0152</td>
<td>2.20</td>
<td>0.25</td>
</tr>
<tr>
<td>8</td>
<td>200</td>
<td>0.0910</td>
<td>0.0114</td>
<td>1.80</td>
<td>0.15</td>
</tr>
<tr>
<td>10</td>
<td>200</td>
<td>0.0910</td>
<td>0.0091</td>
<td>1.70</td>
<td>0.12</td>
</tr>
</tbody>
</table>

| 2*              | 300                        | 0.0910                 | 0.0455                    | 2.65               | 0.36                |
| 4               | 300                        | 0.0910                 | 0.0228                    | 1.85               | 0.17                |
| 6               | 300                        | 0.0910                 | 0.0152                    | 1.50               | 0.12                |
| 8               | 300                        | 0.0910                 | 0.0114                    | 1.30               | 0.09                |
| 10              | 300                        | 0.0910                 | 0.0091                    | 1.15               | 0.07                |

*Selected design for Iluka ebb tide release

Near-field modelling was undertaken using CORMIX, with the site conditions outlined in Tables 1 to 4. An ambient water depth of -4.0 m IPD was assumed and a release depth of -3.0 m IPD was applied. Due to the distance of the location from the ocean, a 3 hour ebb tide release window was assumed. This 3 hour operational timeframe will be confirmed with subsequent hydrological modelling. 50th percentile and 90th percentile flows over this 3 hour period were used to calculate near-field dilutions are shown in Table 5.
Table 5  
Iluka: Two Port Diffuser Near-field Dilutions

<table>
<thead>
<tr>
<th>Port Angle</th>
<th>Dilution for 3 hour ebb discharge (50th %ile velocity)</th>
<th>Dilution for 3 hour ebb discharge (90th %ile velocity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90/270</td>
<td>91</td>
<td>58</td>
</tr>
</tbody>
</table>

Based on the dilutions calculated above, all analytes except for Total N and ammonia would satisfy water quality guidelines to meet the requirements for minimum dilution within the near-field zone. To satisfy the criteria for Total N (65 times dilution) and ammonia (~200 times dilution), additional dilutions are required. The distance from the release location required to meet ~200 times dilution was calculated as 97 m for 50th percentile ambient velocities, and 193 m for 90th percentile ambient velocities (Table 5 and Figure 2). It is worth noting that the dilution required for ammonia is highly conservative as it assumes that no chemical transformations would occur.

Table 6  
Distance to 200 Times Dilution for Iluka: Two Port Diffuser

<table>
<thead>
<tr>
<th>Port Angle</th>
<th>Distance to 200x dilution for 3 hour ebb discharge (50th %ile velocity)</th>
<th>Distance to 200x dilution for 3 hour ebb discharge (90th %ile velocity)</th>
</tr>
</thead>
<tbody>
<tr>
<td>90/270</td>
<td>97m</td>
<td>193m</td>
</tr>
</tbody>
</table>

The dilutions achieved in the near-field, and distances to ~200 times dilution, for the revised Iluka ebb tide release location are significantly lower than those predicted for the previous Iluka location (Figure 1, Location A). The distances required to meet these dilutions are graphically displayed in Figure 2.
(a) Plume extent during 50% percentile flows

(b) Plume extent during 90% percentile flows
Appendix C

Environmental Controls
Table 16  Summary of Mitigation Measures

<table>
<thead>
<tr>
<th>Issue</th>
<th>Mitigation Measures</th>
</tr>
</thead>
</table>
| Topography, Soils and Geology | The effects of construction on geology and soils would be limited to disturbance at the HDD pad site, under boring of estuarine sediments and establishing foundations at the pipeline release location to secure pipework.  
  » Spoil from these excavations is expected to be largely sand, and to be suitable as either backfill or as embankment material. However, acid sulfate soils that are disturbed during construction will need to be identified and correctly managed.  
  » In this regard, prior to excavation and/or during construction, potential acid sulfate soils that may be disturbed by construction should be tested to assess the degree of acid generation. The potential impacts from acid sulfate soil runoff and the disposal of any acid sulfate soils should be managed by the preparation of an acid sulfate soil management plan based on the Acid Sulfate Soil Manual (ASSMAC 1998), and prepared in consultation with the DECC.  
  » Contractors undertaking the drilling will need to consider contingency actions through the development of a Construction Environmental Management Plan (CEMP), and consider recovery operations for damaged equipment in the event of any breakages.  
  » All attempts should be made to ensure the delivery pipeline is installed below the coffee rock and that the diffuser sections of the ebb tide release are adequately anchored to the river bed (WRL, 2009).  
  » Construction activities associated with pipe installation including earthworks, HDD, spoil handling and storage, and concrete works, have the potential to cause erosion and sedimentation. An Erosion and Sediment Control Plan (ESCP) should be prepared and implemented. The ESCP should be consistent with the requirements of Managing Urban Stormwater: Soils and Construction, Volume 1, 4th Edition, 2004. |
| Climate and Air            | Minimising the area of soil exposed at any one time;  
  » Water spraying of the unsealed access and exposed soils if dust is generated;  
  » Stabilisation of exposed soils as soon as possible;  
  » Ceasing works when it is not possible to control the dust generated;  
  » All construction equipment and machinery would be maintained regularly to ensure efficient operation, including vehicle emissions; and  
  » Where appropriate, all construction equipment and machinery would be turned off or throttled down when not in use. |
| Noise and Vibration        | A CVC representative should make contact with affected local residents and communicate the construction program and progress on a regular basis.  
  » All site workers should be sensitised to the potential for noise and vibration impacts on local residents and encouraged to take practical and reasonable measures to minimise the impact during the course of their activities. |
<table>
<thead>
<tr>
<th>Issue</th>
<th>Mitigation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Liaise with the potentially effected residents prior to the start of construction so that they are aware of the mechanism to lodge a complaint or feedback. All complaints lodged by nearby residents are logged on a complaints register, which would also document the investigation into the source of the emission giving rise to the complaint and any corrective actions taken to rectify the cause of complaint.</td>
</tr>
<tr>
<td></td>
<td>The construction sites should be laid-out in such a way that the primary noise sources are at a maximum distance from residences, with solid structures (sheds, containers, etc) placed between residences and noise sources (and as close to the noise sources as is possible).</td>
</tr>
<tr>
<td></td>
<td>As far as possible, materials dropped from heights should be minimised.</td>
</tr>
<tr>
<td></td>
<td>Where practical, machines should be operated at low speed or power and will be switched off when not being used rather than left idling for prolonged periods.</td>
</tr>
<tr>
<td></td>
<td>Where possible equipment should be selected to minimise noise emissions, be fitted with appropriate silencers and be in good working order.</td>
</tr>
<tr>
<td></td>
<td>An excavator likely to produce low noise emissions should be selected.</td>
</tr>
<tr>
<td></td>
<td>Machines found to produce excessive noise compared to normal industry expectations should be removed from the site or stood down until repairs or modifications can be made.</td>
</tr>
<tr>
<td></td>
<td>Reversing alarms noise emissions should be minimised, though satisfactory to achieve occupational health and safety requirements.</td>
</tr>
<tr>
<td></td>
<td>Workshop, delivery and excavator activities should be limited to normal working hours if possible.</td>
</tr>
<tr>
<td></td>
<td>A barrier surrounding the site should be constructed to mitigate the noise impacts on the surrounding residents. The effectiveness of the noise barrier will depend on the height and location of the barrier and the distance of the sources and receivers to the barrier.</td>
</tr>
<tr>
<td></td>
<td>The noise goals set by the DECC CNG should be achievable however it is recommended that construction noise monitoring be undertaken during the night time period to confirm noise modelling predictions.</td>
</tr>
<tr>
<td></td>
<td>The construction noise monitoring should be used as a guide when implementing the above mitigation measures to assess the most effective means of reducing noise impacts.</td>
</tr>
<tr>
<td></td>
<td>The results of the Iluka construction noise monitoring and mitigation design should be used to assess the potential impact at the proposed Yamba Launch site.</td>
</tr>
<tr>
<td></td>
<td>Additionally, attended noise monitoring should be undertaken upon receipt of a noise complaint, monitoring should be undertaken at the earliest convenience and reported within 3 to 5 working days. In the case that exceedances are detected, the situation should be reviewed in order to identify means to reduce the impact to acceptable levels.</td>
</tr>
<tr>
<td></td>
<td>In all cases, noise monitoring should be undertaken by a qualified professional with consideration to the relevant standards and guidelines.</td>
</tr>
<tr>
<td>Hydrology and</td>
<td>The ebb tide release system be operated as recommended by the WRL</td>
</tr>
<tr>
<td>Issue</td>
<td>Mitigation Measures</td>
</tr>
<tr>
<td>--------------------------</td>
<td>----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td><strong>Water Quality</strong></td>
<td>(2009) report;</td>
</tr>
<tr>
<td></td>
<td>- The ebb tide release system should be regularly maintained to ensure it operates efficiently;</td>
</tr>
<tr>
<td></td>
<td>- Water quality monitoring be undertaken at the STP to ensure the water quality meets the Accepted Modern Technology criteria. If this criteria is not achieved, ebb-tide release should, where possible, cease until resolved;</td>
</tr>
<tr>
<td></td>
<td>- A regular water quality monitoring program should be developed and implemented for the estuary and adjacent beaches;</td>
</tr>
<tr>
<td></td>
<td>- An ESCP should be prepared and implemented. The ESCP should be consistent with the requirements of <em>Managing Urban Stormwater: Soils and Construction, Volume 1, 4th Edition, 2004</em>;</td>
</tr>
<tr>
<td></td>
<td>- All effort should be made to ensure the HDD alignment is within or beneath the more fracture resistant coffee rock. If a fracture does occur, works should stop until the fracture is sealed;</td>
</tr>
<tr>
<td></td>
<td>- All drilling mud should be biodegradable;</td>
</tr>
<tr>
<td></td>
<td>- Cement grout should be non-toxic to aquatic organisms; and</td>
</tr>
<tr>
<td></td>
<td>- Disturbance of sediments during the construction of the release structure should be minimised and undertaken during the ebb-tide.</td>
</tr>
<tr>
<td><strong>Groundwater</strong></td>
<td>- The contractors undertaking the drilling will need to consider management of extracted groundwater and spoil and contingency actions through the development of a CEMP.</td>
</tr>
<tr>
<td><strong>Terrestrial Flora and Fauna</strong></td>
<td>- If vegetation needs to be removed, consult a qualified consultant prior to clearing; and</td>
</tr>
<tr>
<td></td>
<td>- An ESCP should be prepared and implemented. The ESCP should be consistent with the requirements of <em>Managing Urban Stormwater: Soils and Construction, Volume 1, 4th Edition, 2004</em>;</td>
</tr>
<tr>
<td><strong>Estuarine Flora and Fauna</strong></td>
<td>- If mangroves, saltmarsh or seagrass needs to be removed, consult a qualified consultant prior to clearing; and</td>
</tr>
<tr>
<td></td>
<td>- Ensure the proposal does not deteriorate the water quality by implementing the mitigation measures outlined in Section 6.4.</td>
</tr>
<tr>
<td><strong>Indigenous Heritage</strong></td>
<td>- The alignment of the pipeline and release structure are to the west of the Country Energy river under crossing so as not to interfere with the Dirrangun Reef.</td>
</tr>
<tr>
<td></td>
<td>- CVC and the Traditional Aboriginal Owners enter into an agreement regarding the ongoing protection and conservation of the reef during construction, including provisions for the safety of the reef as part of ongoing operational maintenance of the pipeline. The agreement must be made prior to the commencement of construction works;</td>
</tr>
<tr>
<td></td>
<td>- Prepare a Cultural Heritage Management Plan prior to the commencement of construction works to safeguard and protect the heritage values of the reef; and</td>
</tr>
<tr>
<td></td>
<td>- Continue dialogue with the traditional Aboriginal owners as part of this project.</td>
</tr>
<tr>
<td>Issue</td>
<td>Mitigation Measures</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Non-Indigenous</td>
<td>All non-indigenous heritage items are sufficiently removed from the area of proposed construction so that there would not be any adverse impact as a result of construction or on-going operation. If, however, any items of European significance are found, work would cease immediately and the NSW Heritage Office should be contacted.</td>
</tr>
</tbody>
</table>
| Traffic and Navigation        | A Traffic Management Plan is required to be prepared by the Contractor and submitted to CVC for approval prior to work along Queen Street, as necessary. Where construction requires closure of a road, affected landholders will require notification in accordance with the Traffic Management Plan;  
|                               | Ebb-tide release location to be installed at least 50 m beyond either side of the centreline of the channel (as shown in Figure 2, Appendix A) to minimise risk of damage from maintenance dredging activities; and  
|                               | Approval is received from NSW Maritime Authority for all works that may obstruct navigation.                                                                                                                                 |
| Waste                         | Prepare a Waste Management Plan as part of the CEMP;  
|                               | Ensuring all contractors remove their general garbage from the work site daily;  
|                               | Providing on-site emergency spill kits and training for all staff in their use; and  
|                               | Ensuring no machinery maintenance is conducted at the site; and  
|                               | Ensuring the construction work site is left clean and free of debris and other rubbish at the completion of the proposed construction works.                                                                 |
| Visual                        | Construction fencing be installed with shade cloth over the face of the fence to minimise views into the construction site;  
|                               | Night lighting of the construction site should be carefully considered to minimise impacts on adjoining residences and roads. The type of lighting is to be considered in the CEMP for the construction site; and  
|                               | Rehabilitate the construction site once works are complete.                                                                                                                                                         |
| Social and Economic Issues    | Implement the mitigations measures outlined in Sections 6.3, 6.10 and 6.11 and the Acoustic Report in Appendix D; and  
|                               | Continue to consult the community on a regular basis throughout the project.                                                                                                                                         |
Appendix D

Construction Noise and Vibration Assessment
Clarence Valley Council
Iluka Sewerage Scheme – Ebb Tide
Release
Construction Noise and Vibration Assessment
June 2009
# Figure Index

<table>
<thead>
<tr>
<th>Figure</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Figure 1-1</td>
<td>Indicative Location of the Iluka Launch [source: Trenchless Advisors Report]</td>
<td>2</td>
</tr>
<tr>
<td>Figure 4-1</td>
<td>Construction Site Details (Not to Scale) [source: Trenchless Advisors Report]</td>
<td>8</td>
</tr>
</tbody>
</table>
Glossary – Acoustic Terms

**dB**
Decibel, which is 10 times the logarithm (base 10) of the ratio of a given sound pressure to a reference pressure; used as a unit of sound.

**dB(A)**
Frequency weighting filter used to measure ‘A-weighted’ sound pressure levels, which conforms approximately to the human ear response, as our hearing is less sensitive at very low and very high frequencies.

**L\text{N}**
Statistical sound measurement recorded on the linear scale.

**L\text{AN}**
Statistical sound measurement recorded on the “A” weighted scale.

**L_{A10} (Period)**
The sound pressure level that is exceeded for 10% of the time for which the given sound is measured.

**L_{A10} (1 hour)**
The L_{A10} level measured over a 1-hour period.

**L_{A10} (18 hour)**
The arithmetic average of the L_{10} levels for the 18-hour period between 0600 and 2400 hours on a normal working day. It is a common traffic noise descriptor.

**L_{Aeq} (Time)**
Equivalent sound pressure level: the steady sound level that, over a specified period of time, would produce the same energy equivalence as the fluctuating sound level actually occurring.

**L_{Aeq} (15 hr)**
The L_{Aeq} noise level for the period 7 am to 10 pm.

**L_{Aeq} (9 hr)**
The L_{Aeq} noise level for the period 10 pm to 7 am.

**L_{Aeq} (1 hr)**
The L_{Aeq} noise level for a one-hour period. In the context of the NSW DECC environmental criteria for road traffic noise, it represents the highest tenth percentile hourly A-weighted L_{eq} during the period 7 am to 10 pm, or 10 pm to 7 am, (whichever is relevant). If this cannot be defined accurately, use the highest A-weighted L_{eq} noise level.

**L_{A90} (Period)**
The A-weighted sound pressure level that is exceeded for 90 per cent of the time over which a given sound is measured. This is considered to represent the background noise e.g. L_{A90} (15 min).

**L_{A10} (Period)**
The A-weighted sound pressure level that is exceeded for 10 per cent of the time over which a given sound is measured.

**L_{Amax} (Period)**
The maximum sound level recorded during a specified time interval.

**L_{Amin} (Period)**
The minimum sound level recorded during a specified time interval.
Noise Sensitive Place

*Noise sensitive place* means any of the following places—

(a) a dwelling;

(b) a library, childcare centre, kindergarten, school, college, university or other educational institution;

(c) a hospital, surgery or other medical institution;

(d) a protected area, or an area identified under a conservation plan as a critical habitat or an area of major interest, under the *Nature Conservation Act 1992*;

(e) a marine park under the *Marine Parks Act 1982*; and

(f) a park or garden that is open to the public (whether or not on payment of money) for use other than for sport or organised entertainment.

Rating Background Level (RBL)

The overall single-figure background level representing each assessment period (day/evening/night) over the whole monitoring period (as opposed to over each 24 hour period used for the assessment background level). This is the level used for assessment purposes. It is defined as the median value of:

All the day assessment background levels over the monitoring period for the day; (7 am to 6 pm);

All the evening assessment background levels over the monitoring period for the evening; (6 pm to 10 pm) or

All the night assessment background levels over the monitoring period for the night. (10 pm to 7 am).

Sound Pressure Level (SPL)

20 times the logarithm to the base 10 of the ratio of the RMS sound pressure level to the reference sound pressure level of 20 micropascals.
1. Introduction

1.1 Project Summary

A construction noise and vibration assessment has been prepared for the Horizontal Directional Drilling (HDD) at the Iluka launch site as part of the Iluka Sewerage Scheme Project. The construction noise and vibration assessment has been prepared with consideration to the DECC Draft construction Noise Guidelines (CNG) and the DECC Assessing Vibration: A technical Guideline. This report discusses the following:

- Potential construction noise and vibration impacts.
- Noise and vibration mitigation measures to minimise impact on the surrounding residents.

The equipment associated with the HDD activities include the following:

- HDD rig.
- Mixing and Recycling System which consists of pumps, generators and linear shakers.
- Generator for lighting plant.
- Excavator.
- Dump trucks.
- Workshop tools including hammers, welders and grinders.

A glossary of acoustic terms can be found at the beginning of the report.

1.2 Site Location and Surrounding Sensitive Receivers

The Iluka site is located on the shore line of the Clarence River with bushland to the east as shown in Figure 1-1. The closest residences are located approximately 350 m to the north and partially shielded by bushland and terrain. The nearest residences to the west and south in Yamba are located over 2000m away.

1.3 Limitations

This report has been prepared for Clarence Valley Council to assess the potential noise and vibration impact associated with the proposed HDD activities for the Iluka Sewage Scheme Project.

It is not the intention of the assessment to cover every element of the acoustic environment, but rather to conduct the assessment with consideration to the prescribed work scope.

In conducting this assessment and preparing the report, current guidelines for noise and vibration were referred to. This work has been conducted in good faith with GHD’s understanding of the client’s brief and the generally accepted consulting practice.

No other warranty, expressed or implied, is made as to the information and professional advice included in this report. It is not intended for other parties or other uses.
Figure 1-1  Indicative Location of the Iluka Launch [source: Trenchless Advisors Report]
2. Existing Environment

2.1 Noise Monitoring Methodology

A background noise survey was undertaken from Friday 17\textsuperscript{th} April to Monday 27\textsuperscript{th} April 2009 in order to quantify the ambient noise environment in the vicinity of the construction site and potentially affected receivers. Noise monitoring was undertaken with consideration to Australian Standard AS1055.1, “Acoustics – Description and measurement of environmental noise – Part 1: General Procedures”. Background noise monitoring at the Iluka site was undertaken using one Rion NL-21 Type 2 Sound Level Metre (SLM) noise logger. The noise logger was programmed to record 15-minute A-weighted sound levels, $L_{A90}$, $L_{Aeq}$ and $L_{A10}$.

All equipment used carries current calibration certification. A calibration check was performed before and after the noise logging and was within the acceptable limits of $\pm 1$ dB(A).

Noise monitoring data was filtered to remove data influenced by adverse weather conditions.

2.2 Monitoring Location

The noise logger was located adjacent to the Iluka launch site in order to capture the ambient noise environment and is shown in Figure 1-1.

The monitoring results and site observations indicate that the ambient noise environment is typical of a suburban environment. Site observations advise that the monitoring location is representative of the ambient noise environment of the area including the potentially affected receivers. However, it should be noted that the background noise environment would vary depending on localised ambient noise sources.

2.3 Background Noise Levels

Table 2-1 summarises the background noise levels $L_{A90}$ for the day, evening and night-time periods.

<table>
<thead>
<tr>
<th>Location</th>
<th>Day 7 am- 6 pm</th>
<th>Evening 6 pm- 10 pm</th>
<th>Night 10 pm- 7 am</th>
</tr>
</thead>
<tbody>
<tr>
<td>Iluka Launch Site</td>
<td>39</td>
<td>41</td>
<td>38</td>
</tr>
</tbody>
</table>
3. Noise Criteria

3.1 Construction Noise Criteria

The noise assessment has been undertaken with consideration to the Department of Environment and Climate Change (DECC) *New South Wales Construction Noise Guidelines (CNG): Draft for consultation, August 2008*.

This guideline recommends standard hours for construction activity as follows:

- Monday to Friday: 7 am to 6 pm.
- Saturday: 8 am to 1 pm.
- No work on Sundays or Public Holidays.

GHD understand that the preferred option for the proposed HDD activities is for 24 hours per day operation. Although time frames of construction can vary due to ground conditions, environmental issues and construction constraints, they have been estimated as follows for 24 hour per day and general construction hour operations:

- Iluka launch site with 24 hour per day operations – 1 to 2 months.
- Iluka launch site with general construction hour operations – 2 to 4 months.

Due to the 24 hour per day operations a quantitative assessment has been undertaken with consideration to the CNG.

The DECC CNG provides noise management levels for construction noise at residential receivers. These management levels have been calculated based on the background noise levels. Table 3-1 details the adopted construction noise goals for the proposed HDD activities.
Table 3-1 NSW DECC construction noise goals

<table>
<thead>
<tr>
<th>Time period</th>
<th>Management level $L_{Aeq}$ (15 min) dB(A)</th>
<th>Background Noise Level $L_{A90}$ dB(A)</th>
<th>Adopted noise goals $L_{Aeq}$ (15 min) dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recommended standard hours:</td>
<td>Noise affected RBL + 10 dB(A)</td>
<td>N/A</td>
<td>49</td>
</tr>
<tr>
<td>Monday to Friday: 7 am to 6 pm</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Saturday: 8 am to 1 pm</td>
<td>Highly noise affected 75 dB(A)</td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>No work on Sundays or Public Holidays</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outside recommended standard hours</td>
<td>Noise affected RBL + 5 dB(A)</td>
<td></td>
<td>43</td>
</tr>
</tbody>
</table>

The noise affected level during recommended construction hours and outside of recommended standard hours represents a point at which there may be some reaction to noise by the community. The highly noise affected level of 75 dB(A) represents a point where there may be a strong reaction to noise from the community.

3.2 Construction Vibration Criteria

Vibration criteria have been set with consideration to the DECC “Assessing Vibration: A Technical Guideline, 2006”. BS 6472 – 1992, “Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)” is recognised by the DECC as the preferred standard for assessing the “human comfort criteria” for residential building types.

The BS 6472 human comfort peak vibration limits are shown in Table 3-2 for the frequency range of 1 Hz to 80 Hz which is applicable to construction works. These values are limits that may cause loss of amenity to the occupant however for short duration construction projects they are considered conservative.

BS 6472 also recognises that higher vibration levels are tolerable for short-term construction projects as undue restriction on vibration levels can significantly prolong construction works and result in greater annoyance.
Table 3-2  BS 6472 human comfort vibration limits from 1 Hz to 80 Hz (mm/s Peak\(^1\))

<table>
<thead>
<tr>
<th>Receiver Type</th>
<th>Period(^2)</th>
<th>Continuous Vibration (mm/s Peak(^3))</th>
<th>Impulsive Vibration (mm/s Peak)</th>
<th>Intermittent Vibration Dose Value (m/s(^{1.75}))</th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential</td>
<td>Day</td>
<td>0.28</td>
<td>8.6</td>
<td>0.2</td>
</tr>
<tr>
<td></td>
<td>Night</td>
<td>0.20</td>
<td>2.8</td>
<td>0.13</td>
</tr>
</tbody>
</table>

It is recommended that construction activities aim to meet the human comfort limits.

\(^1\) Based on sinusoidal vibration sources

\(^2\) Day is between 7 am and 10 pm and night is between 10 pm and 7 am.

\(^3\) Based on sinusoidal vibration sources
4. Construction Impact Assessment

4.1 Construction Noise Impact Assessment

The noise emissions at the Iluka launch site has been assessed at the surrounding residences for 24 hour per day and general construction hour operations. A quantitative assessment has been undertaken with consideration to the DECC CNG.

A typical layout of the site, provided by Trenchless Advisors is shown in Figure 4-1. Descriptions of the noise sources likely to operate on the site are as follows:

- HDD drill rig – This is considered a constant noise source with no tonal or impulsive noise characteristics.

- Mixing and Recycling System – This consists of pumps, generators and linear shakers. Its noise output has been calculated based on two 70 Horse Power (HP) pumps, one 50 HP pump and a 120 kW 150 kVA 1500 rpm diesel generator. This is considered a constant noise source with no tonal or impulsive noise characteristics.

- Generator for lighting system - This is a constant noise source with no tonal or impulsive noise characteristics.

- Excavator – This will be used intermittently to remove spoil and load drill rods. There is the potential for impulsive noise characteristics when loading drill rods.

- Dump trucks - This will be used intermittently to transport spoil from the site and should not have any tonal or impulsive characteristics.

- Workshop – Workshop noise will consist of welding, grinding, hammering and oxy cutting and is likely to have impulsive noise characteristics.
4.1.1 Construction Scenarios

Ideally all equipment would operate continuously through the night-time period, however this may not be possible due to environmental issues such as noise impacts to surrounding residences. There may be the potential for some equipment to operate during the general construction hours only as opposed to operating continuously through the night-time period such as workshop and dump truck activities. Therefore the following scenarios for different equipment operating have been assessed for each site:

- HDD drill rig, mixing and recycling system, generator and excavator.
- HDD drill rig, mixing and recycling system, generator, excavator, workshop and dump truck.

4.1.2 Construction noise sources

Sound power levels, including frequency contact where available, are provided in Table 4-1 for all equipment. This data has been obtained from several locations and has been referenced accordingly in the Table.
### Table 4-1 Construction Noise Sources – Sound Power Levels (dB)

<table>
<thead>
<tr>
<th>Plant Item</th>
<th>Frequency [Hz]</th>
<th>dB(A)</th>
<th>dB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>31.5</td>
<td>63</td>
<td>125</td>
</tr>
<tr>
<td>HDD Drill Rig D300 operating at normal speed⁴</td>
<td>101</td>
<td>111</td>
<td>110</td>
</tr>
<tr>
<td>Excavator 15t 71 kW⁵</td>
<td>-</td>
<td>79</td>
<td>86</td>
</tr>
<tr>
<td>Diesel Generator for Lighting 7.5 kW⁴</td>
<td>-</td>
<td>105</td>
<td>100</td>
</tr>
<tr>
<td>Dumper 5t 56 kW (idling)⁴</td>
<td>-</td>
<td>96</td>
<td>84</td>
</tr>
<tr>
<td>Mixing and Recycling System - Diesel Generator 120 kW 150 kVA 1500 rpm</td>
<td>-</td>
<td>107</td>
<td>102</td>
</tr>
<tr>
<td>Mixing and Recycling System - Pump 50 HP⁶</td>
<td>85</td>
<td>86</td>
<td>86</td>
</tr>
<tr>
<td>Mixing and Recycling System - Pump 75 HP⁵</td>
<td>88</td>
<td>88</td>
<td>88</td>
</tr>
<tr>
<td>Workshop - Hand held welder (welding pipes)⁴</td>
<td>-</td>
<td>95</td>
<td>96</td>
</tr>
<tr>
<td>Workshop – Hand held grinder⁷</td>
<td>No spectrum available;</td>
<td>105</td>
<td></td>
</tr>
<tr>
<td>Workshop – Hammer⁸</td>
<td>No spectrum available;</td>
<td>106</td>
<td></td>
</tr>
</tbody>
</table>

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⁴ Trenchless Advisor, “Yamba and Iluka under bore HDD construction noise and mitigation brief”; February 2009
⁶ KSB, “Questions on acoustics when using centrifugal pumps, 1.4.86 issue”.
⁸ GHD’s internal database
4.1.3 Modifying Factor Corrections

It is unlikely that any of the noise sources will have tonal or low frequency characteristics therefore no adjustments have been incorporated into the model.

An adjustment of 5 dB(A) has been incorporated into the model to account for potential impulsive noise generated by the excavator and workshop activities.

4.1.4 Construction Noise Predictions

Construction noise predictions were undertaken using Computer Aided Noise Abatement (CadnaA) to predict the effects of construction noise from the proposed Iluka launch site on the surrounding residence.

CadnaA is a computer program for the calculation, assessment and prognosis of noise propagation. CadnaA calculates environmental noise propagation according to ISO 9613-2, “Acoustics – Attenuation of sound during propagation outdoors”. Ground absorption, reflection, terrain and relevant shielding objects are taken into account in the calculations.

The following assumptions were made in regard to the noise model:

- Noise receivers were modelled 1.5m above ground level, as per DECC guidelines.
- The exact location of equipment on site has been estimated.
- Digital ground topography was included in the model at 2 metre intervals.
- The noise sources were modelled as operating continuously at their defined output.
- Water was modelled as having a ground absorption coefficient of 0.
- Surrounding land was modelled as having a ground absorption coefficient of 1.
- Foliage of dense bushland provides attenuation as per ISO 9613 – 2.

4.1.5 Iluka Launch Site Results

The predicted noise levels for the Iluka launch site at the nearest surrounding residences are shown in Table 4-2.

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Noise Level at Nearest Residence, dB(A)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>To the North</td>
</tr>
<tr>
<td>HDD drill rig, mixing and recycling system, generator and</td>
<td>37</td>
</tr>
<tr>
<td>excavator.</td>
<td></td>
</tr>
<tr>
<td>HDD drill rig, mixing and recycling system, generator,</td>
<td>41</td>
</tr>
<tr>
<td>excavator, workshop and dump truck.</td>
<td></td>
</tr>
</tbody>
</table>

The noise affected level during recommended construction hours is 49 dB(A) therefore construction activities at the Iluka launch site are expected to comply at the surrounding residence during these times.
The noise affected level outside of recommended construction hours is 43 dB(A) therefore construction activities at the Iluka launch site are expected to comply at the surrounding residence during these times.

Even though noise goals are likely to be met at the Iluka site it is recommended that the mitigation measures detailed in Section 5 should be considered and implemented where feasible and reasonable to reduce potential noise impacts.

4.2 Construction Vibration Impact Assessment

Energy from construction equipment is transmitted into the ground and transformed into vibrations, which attenuates with distance. The magnitude and attenuation of ground vibration is dependent on the following:

- The efficiency of the energy transfer mechanism of the equipment (i.e. impulsive; reciprocating, rolling or rotating equipment).
- The frequency content.
- The impact medium stiffness.
- The type of wave (surface or body).
- The ground type and topography.

Due to the above factors, there is inherent variability in ground vibration predictions without site-specific measurement data. The NSW Roads and Traffic Authority Environmental Noise Management Manual provides typical construction equipment ground vibration levels at 10m. The rate of vibration attenuation can be calculated from the following regression analysis formula:

\[ V = kD^{-n} \]

where

- \( V \) = PPV
- \( D \) = Distance
- \( n \) = attenuation exponent. The value of \( n \) generally lies between 1 and 2 with a relatively common value of 1.5\(^9\)

The excavator is the only item of equipment on site that is anticipated to generate appreciable vibration impacts. There is the potential for drilling equipment to cause ground vibrations though these are expected to be minimal.

The predicted ground vibrations at various distances are shown in Table 4-3 for typical excavators.

<table>
<thead>
<tr>
<th>Plant Item</th>
<th>Vibration Level at Distances (mms Peak)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10 m</td>
</tr>
<tr>
<td>Excavator</td>
<td>3</td>
</tr>
</tbody>
</table>

The nearest residences are located approximately 350 m to the north of the site therefore there is not anticipated to be any vibration impacts.

\(^9\) Construction Vibrations: State of the Art, John Wiss, 1981
5. Mitigation Measures

Although construction activities are predicated to meet the noise goals for the project construction activities can be further minimised through the implementation of the following mitigation measures.

5.1.1 Noise Mitigation Measures

The NSW CNG also provides a summary of potential noise mitigation measures. It is recommended that the following construction noise mitigation measures be implemented to reduce the impact on the surrounding residents:

- The construction sites should be laid-out in such a way that the primary noise sources are at a maximum distance from residences, with solid structures (sheds, containers, etc) placed between residences and noise sources (and as close to the noise sources as is possible).
- As far as possible, materials dropped from heights should be minimised.
- Where practical, machines should be operated at low speed or power and will be switched off when not being used rather than left idling for prolonged periods.
- Where possible equipment should be selected to minimise noise emissions, be fitted with appropriate silencers and be in good working order.
- An excavator likely to produce low noise emissions should be selected.
- Machines found to produce excessive noise compared to normal industry expectations should be removed from the site or stood down until repairs or modifications can be made.
- Reversing alarms noise emissions should be minimised, though satisfactory to achieve occupational health and safety requirements.
- Workshop, delivery and excavator activities should be limited to the recommended construction hours if possible.

5.1.2 Complaints, Work Ethics and Community Relations

- All site workers should be sensitised to the potential for noise and vibration impacts on local residents and encouraged to take practical and reasonable measures to minimise the impact during the course of their activities.
- A council representative should make contact with affected local residents and communicate the construction program and progress on a regular basis.
- Liaise with the potentially effected residence prior to the start of construction so that they are aware of the mechanism to lodge a complaint or feedback. All complaints lodged by nearby residents are logged on a complaints register, which would also document the investigation into the source of the emission giving rise to the complaint and any corrective actions taken to rectify the cause of complaint.
5.1.3 **Construction Noise Monitoring**

The noise goals set by the DECC CNG should be achievable however it is recommended that construction noise monitoring be undertaken during the night time period to confirm noise modelling predictions.

The construction noise monitoring should be used as a guide when implementing the above mitigation measures to assess the most effective means of reducing noise impacts.

The results of the Iluka construction noise monitoring and mitigation design should be used to assess the potential impact at the proposed Yamba Launch site.

Additionally, attended noise monitoring should be undertaken upon receipt of a noise complaint, monitoring should be undertaken at the earliest convenience and reported within 3 to 5 working days. In the case that exceedances are detected, the situation should be reviewed in order to identify means to reduce the impact to acceptable levels.

In all cases, noise monitoring should be undertaken by a qualified professional with consideration to the relevant standards and guidelines.
GHD has assessed the potential for noise and vibration impact from the HDD activities at the Iluka launch site.

This noise assessment has been undertaken with consideration to the DECC New South Wales Construction Noise Guidelines: Draft for consultation, August 2008. This vibration assessment has been undertaken with consideration to the DECC Assessing Vibration: A technical Guideline, 2006.

The Iluka launch site is expected to comply with noise and vibration goals at the surrounding residences during and outside of recommended construction hours.

It is recommended that the mitigation measures detailed in Section 5 should be considered and implemented where feasible and reasonable to further minimise the risk of noise impacts.
7. References


British Standard, BS 6472 – 1992, “Guide to Evaluation of Human Exposure to Vibration in Buildings (1 Hz to 80 Hz)”.


Trenchless Advisor, “Yamba and Iluka under bore HDD construction noise and mitigation brief”, February 2009.


KSB, “Questions on acoustics when using centrifugal pumps, 1.4.86 issue”.

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Document Status

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<th>Reviewer</th>
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Iluka Sewage Scheme
Construction Noise and Vibration Assessment
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