11 Effects on soil, surface water and groundwater

This chapter describes the effects of the Transformation on soil, surface water and groundwater and identifies mitigation and management measures to address any potentially adverse impacts.

11.1 Introduction

The Transformation affects the main operational area of Nyrstar Port Pirie (the smelter) as defined in Chapter 6. The black sands emplacement area and intervening land parcels to the west are hydraulically isolated from the main operational area of the smelter and have been excluded from this discussion.

Assessment of surface water and subsurface environments at the smelter has been the subject of many studies over more than 15 years. Investigation has been relatively intensive in the last 2–3 years with Nyrstar adopting a formal SA EPA regulatory approach to risk management; including the voluntary appointment of a SA EPA accredited Contamination Auditor (the Auditor) (appointed December 2011) to oversee the process. This chapter relies mainly on the technical report presented in Appendix I.

Nyrstar is not only well prepared to assess the effects of the Transformation; its understanding of these environments is being proactively entrained in Transformation design to avoid future impacts.

11.2 Existing environment

The following sections summarise current understanding of the surface water, geology, and hydrogeology and associated contamination of Nyrstar Port Pirie. Additional information is provided in Appendix I.

11.2.1 Surface water

The main operational area sits within the Port Pirie River catchment, with much of the natural drainage reporting to the River. The smelter as a whole (including the black sands emplacement area) straddles a drainage divide, with parts of the westernmost portion of the smelter naturally draining to the Spencer Gulf.

The Port Pirie River is an estuary which drains north to the Spencer Gulf, with the river mouth located approximately 4 km north of the smelter. The Spencer Gulf and Port Pirie River are both tidal. The tidal range is moderate with an extreme spring tidal range of 3.44 m (AGSO 1998).

The majority of the Transformation demolition and construction works will occur in areas paved with concrete. Surface water (dust suppression water and rainfall) from the majority of this area is collected in a stormwater drainage system that reports to the smelter sedimentation pond and then discharges via First Creek to the Spencer Gulf. Discharges from the sedimentation pond are subject to an EPA Licence condition and are continuously monitored for compliance. Some of the key smelter features, including the sedimentation pond and First Creek are shown in Appendix I.
Rainfall in the western unpaved areas of the main operational area of the smelter (including the intermediate storage area) tends to infiltrate through the generally permeable surface recharging a shallow aquifer system (see geology and hydrogeology).

11.2.2 Geology and hydrogeology

The smelter is situated in a regional-scale basin of sediments overlying basement rock. Groundwater systems (aquifers) exist in the rock and sediments, and generally flow from the Mt Lofty and Flinders Ranges in the east to the Spencer Gulf in the west where groundwater discharge occurs. A generalised conceptual cross-section showing the setting of the smelter from the Mt Lofty Ranges in the east through to the Spencer Gulf in the west is presented in Figure 11-1.
Figure 11-1 Regional conceptual hydrogeological cross-section
The shallow basin sediments at the smelter generally comprise a sequence of natural clays and sandy clays overlain by a variable thickness of anthropogenic slag and other fill used to raise the low lying ground surface. The upper sequence of the natural formations is known to contain acid sulphate soil (CSIRO 2013).

The understanding of the local, shallow sedimentary sequence of the smelter is based on extensive drilling (see Appendix I) and can be summarised, chronologically from the surface, as follows:

- Slag (with intermittent fill of other type) to depths of approximately 4 to 5 m.
- Clays of the St Kilda Formation, with typical thicknesses between 2 and 3 m.
- Silty and sandy clays of the St Kilda Formation, with typical thicknesses of approximately 4 m.
- Mottled clays of the Hindmarsh Clay, including inter bedded sandy horizons (≥50 m).

The slag and other fill, the silty and sandy clays of the St Kilda Formation and the sandy portions of the Hindmarsh Clay all contain groundwater and are considered to be aquifers. These aquifers have been named the Fill Aquifer, Upper Natural Aquifer (UNA) and the Hindmarsh Clay Aquifer, respectively; the upper clay sequence of the St Kilda Formation (the ‘Samphire Clay’) forms an aquitard (restricts groundwater movement). These shallow aquifers and aquitard are of potential significance to Transformation.

The UNA and Hindmarsh Aquifers contain hyper saline groundwater which is consistently greater salinity than that of seawater, making it unsuitable for many uses. Groundwater salinity in the Fill Aquifer is much more variable, ranging from approximately 5,000 mg/L to >40,000 mg/L total dissolved solids (i.e. brackish to saline).

There are a number of natural and anthropogenic features that are considered important to the smelter’s hydrogeology due to the likely controlling influence they have on groundwater flow and contaminant movement. These are compiled, discussed and presented in Appendix I.

### 11.2.3 Existing contamination

For more than 120 years, smelter activities have resulted in contamination of the subsurface environment. Smelter site assessment and remediation to date has followed a regulatory process as defined by the SA EPA. Recently Nyrstar voluntarily appointed a Contamination Auditor accredited by the SA EPA to oversee the regulatory process.

As part of this regulatory process, a detailed site history has identified activities that may have resulted in subsurface contamination (BlueSphere 2012). This work underpins the impact assessment that Transformation may have on existing soil, groundwater and surface water quality.

Subsurface contamination is consistent with the historic use of the smelter, including a range of metals/metalloids (lead, zinc, cadmium, manganese, copper, silver and arsenic), acids and some hydrocarbons associated with fuel use and storage. Appendix I shows a summary of potential contamination sources across the smelter. The plans give an indication of the potential contaminants of concern that may be encountered during the Transformation.
The widespread deposition of slag and aerial deposition of site-derived dusts and other emissions has resulted in local background concentrations of primarily zinc and lead in the subsurface.

The Fill Aquifer is the main aquifer requiring consideration during Transformation. Contaminants in Fill Aquifer, including cadmium, lead, manganese and zinc, are generally most concentrated near the Zinc Plant, Lead Production Area, the Cadmium Plant and the existing sludge dewatering dams. From these areas, groundwater contamination extends down hydraulic gradient and in some cases underlies areas where Transformation works are planned.

These areas are the focus of remedial efforts by Nyrstar, which are being conducted as part of the overall Groundwater Management Plan. Transformation-related changes are being entrained into remedial planning and design to prevent compromise of remedial efforts by Transformation activities.

It is expected that the net result of the Transformation will be a positive impact on the current status of the smelter with respect to soil, groundwater and surface water.

11.2.4 Acid sulphate soils
Potential Acid Sulphate Soils associated with the St Kilda Formation have been defined by mapping in the area (CSIRO 2013). This formation has been substantially covered by slag and other fill beneath the main operational area, consequently most of the Transformation works will not disturb these sediments. However, north of the smelter and along the Port Pirie River margin, these natural sediments are either exposed or are close to ground surface during relatively low tides, and as such may be encountered during Transformation related activities. The risk and management measures associated with this issue are further discussed in Section 11.3.2 and Section 11.4.

11.3 Assessment methods
The assessment and remediation of the subsurface conditions has been conducted in accordance with industry standards and a defined regulatory (SA EPA) process. More recently Nyrstar have voluntarily appointed an SA EPA accredited Contamination Auditor to oversee all activities and assessment of the groundwater and subsurface of the smelter, inclusive of those activities related to the Transformation. Details of this process, including the relevant guidelines, assessment criteria and beneficial use assessment is provided in Appendix I.

11.3.1 Impact assessment
The Transformation is expected to deliver a net environmental benefit with respect to the soil, groundwater and on-site surface water environments. While some risks exist during the design, construction and operational phases of Transformation, these can be readily eliminated, mitigated or managed by adopting established environmental protocols.
11.3.2 Risks identified

The following tables identify the potential impacts to soil, groundwater (Table 11–1) and surface water (Table 11–2) associated with the design, construction and operational phases of Transformation. Further details of the risks identified and management measures are discussed in Appendix I.

These risks have been entrained in the overall risk assessment and control measures reported in Chapter 16 and the construction and operations environmental management plans in Chapter 18.

Table 11–1: Risks to soil and groundwater

<table>
<thead>
<tr>
<th>Activity</th>
<th>Task</th>
<th>Potential Groundwater Impact</th>
<th>Assessment/Mitigation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decommissioning and Demolition of Existing Plant</td>
<td>Stockpiling of building rubble/waste materials</td>
<td>Stored materials may be contaminated and form a groundwater contamination source</td>
<td>• Environmental Management Plan (EMP) (including stockpile management procedures)</td>
</tr>
<tr>
<td>Demolition</td>
<td></td>
<td>Excessive dust generation may lead to increased entrainment of metals and other contaminants in recharging groundwater</td>
<td>• EMP (including dust management)</td>
</tr>
<tr>
<td></td>
<td>Creation of open sealed and/or unsealed space</td>
<td>Increased runoff of potentially contaminated water could enter aquifers through unsealed surfaces or degraded drainage infrastructure increasing contaminant loads and/or hydraulic head in the groundwater system.</td>
<td>• EMP</td>
</tr>
<tr>
<td>Construction of New Facility</td>
<td>Feasibility Investigations</td>
<td>Potential breach of aquitard could lead to cross contamination of aquifers</td>
<td>• EMP (including management of geotechnical Scopes of Work)</td>
</tr>
<tr>
<td></td>
<td>Geotechnical Drilling and Test Pitting</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Excavation</td>
<td>Potential breach of aquitard could lead to cross contamination of aquifers</td>
<td>• EMP (including excavation procedures)</td>
</tr>
<tr>
<td></td>
<td>Stockpiling and disposal of contaminated spoil</td>
<td>Stored materials may be contaminated and form a groundwater contamination source</td>
<td>• EMP (including stockpile management procedures)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excavated spoil, particularly natural materials may be acid</td>
<td>• EMP (including Acid Sulphate Soils)</td>
</tr>
<tr>
<td>Activity</td>
<td>Task</td>
<td>Potential Groundwater Impact</td>
<td>Assessment/Mitigation Measures</td>
</tr>
<tr>
<td>----------</td>
<td>----------------------------------------------------------------------</td>
<td>---------------------------------------------------------------------------------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Dewatering</td>
<td>generating under oxidising conditions (i.e. Acid Sulphate Soils)</td>
<td>Could temporarily alter groundwater and contaminant flow paths</td>
<td>management procedures</td>
</tr>
<tr>
<td></td>
<td>Stored water could form a groundwater contaminant source if not appropriately managed</td>
<td>EMP</td>
<td></td>
</tr>
<tr>
<td>Emplacement of underground cooling water pipeline</td>
<td>Pipeline could interfere with contaminated groundwater flow paths, modifying the location or concentrations of discharge to boundaries</td>
<td>EMP, Modelling</td>
<td></td>
</tr>
<tr>
<td>Drilling</td>
<td>Potential breach of aquitard could lead to cross contamination of aquifers</td>
<td>EMP (including management of geotechnical Scopes of Work and specific piling design)</td>
<td></td>
</tr>
<tr>
<td>Stockpiling/storage of contaminated spoil and water</td>
<td>Stored materials may be contaminated and form a groundwater contamination source</td>
<td>EMP</td>
<td></td>
</tr>
<tr>
<td>Piling Emplacement</td>
<td>Piles may reduce aquifer transmissivity and alter groundwater and contaminant flow paths</td>
<td>Modelling, Groundwater Monitoring and Management Plan (GMMP), Piling design</td>
<td></td>
</tr>
<tr>
<td>Excavation</td>
<td>See previous</td>
<td>EMP</td>
<td></td>
</tr>
<tr>
<td>Caisson and Diffuser emplacement and associated pipelines</td>
<td>Caisson may affect aquifer transmissivity and alter groundwater and contaminant flow paths locally</td>
<td>EMP, GMMP</td>
<td></td>
</tr>
</tbody>
</table>

**Ongoing Operation**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Task</th>
<th>Potential Groundwater Impact</th>
<th>Assessment/Mitigation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increased Cooling Water Disposal</td>
<td>Additional water input to Sedimentation Pond and/or First Creek Drain</td>
<td>Increased head in the Sedimentation Pond and/or First Creek Drain could alter groundwater and contaminant flow paths and lead to flooding of low lying areas of the smelter through groundwater level increases</td>
<td>Modelling, GMMP</td>
</tr>
<tr>
<td>Rationalisation of Intermediate</td>
<td>Possible disposal of unused feedstocks</td>
<td>Stored materials may form a groundwater contamination source</td>
<td>EMP (including waste management)</td>
</tr>
<tr>
<td>Activity</td>
<td>Task</td>
<td>Potential Groundwater Impact</td>
<td>Assessment/Mitigation Measures</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-------------------------------------------</td>
<td>------------------------------------------------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
</tr>
<tr>
<td>Materials</td>
<td>Creation of open unsealed space</td>
<td>Increases in evaporation from the shallow water table may alter water balance and groundwater/contaminant flow paths</td>
<td>• Modelling&lt;br&gt;• GMMP</td>
</tr>
<tr>
<td>Storage of New Feedstocks</td>
<td>Storage of new, potentially contaminant-bearing feedstocks</td>
<td>Stored materials may form a groundwater contamination source</td>
<td>• Nyrstar Operating Procedure&lt;br&gt;• GMMP</td>
</tr>
<tr>
<td>Acid Management</td>
<td>Monitoring and prevention of acid ingress from historical releases entering the Transformation site</td>
<td>Groundwater barriers may alter groundwater and contaminant flow paths</td>
<td>• Modelling&lt;br&gt;• GMMP</td>
</tr>
<tr>
<td></td>
<td>Stockpiling and prevention of acid ingress from historical releases entering the Transformation site</td>
<td>Groundwater barriers may fail or be circumvented requiring contingency measures to be implemented</td>
<td>• GMMP</td>
</tr>
</tbody>
</table>

**Table 11–2: Risks to surface water**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Task</th>
<th>Potential Surface Water Impact</th>
<th>Assessment / Mitigation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decommissioning and Demolition of Existing Plant</td>
<td>Stockpiling/Disposal of building rubble/waste materials</td>
<td>Stockpiles may leach contamination and run-off into surface or water systems, including the Port Pirie River.</td>
<td>• EMP (including stockpile management procedures)</td>
</tr>
<tr>
<td>Demolition</td>
<td>Creation of open sealed and/or unsealed space</td>
<td>Increased runoff of potentially contaminated water could enter stormwater or surface water systems, including the Port Pirie River.</td>
<td>• EMP</td>
</tr>
<tr>
<td>Construction of New Facility</td>
<td>Geotechnical Drilling and Test Pitting</td>
<td>See Excavation Tasks below</td>
<td></td>
</tr>
<tr>
<td>Feasibility Investigations</td>
<td>Stockpiling and disposal of contaminated spoil</td>
<td>Stockpiled spoil may leach contamination and run-off into stormwater or surface water systems, including the Port Pirie River.</td>
<td>• EMP (including stockpile management procedures)</td>
</tr>
<tr>
<td>Excavation</td>
<td>Stockpiling and disposal of contaminated spoil</td>
<td>Excavated spoil, particularly natural materials may be acid generating under oxidising conditions (i.e. Acid Sulphate Soils) and may leach acid and metals into adjacent</td>
<td>• EMP (including Acid Sulphate Soil Management)</td>
</tr>
</tbody>
</table>

**Notes:**
- **GMMP** refers to Groundwater Management and Monitoring Plan.
- **EMP** refers to Environmental Management Plan.
<table>
<thead>
<tr>
<th>Activity</th>
<th>Task</th>
<th>Potential Surface Water Impact</th>
<th>Assessment / Mitigation Measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dewatering</td>
<td></td>
<td>Stormwater or surface water systems.</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Stored water could form a stormwater and/or surface water contaminant source if not appropriately managed.</td>
<td>EMP</td>
</tr>
<tr>
<td>Stockpiling/storage of contaminated spoil and water</td>
<td></td>
<td>Stored materials may be contaminated and form a stormwater/ surface water contamination source</td>
<td>EMP</td>
</tr>
<tr>
<td>Piling</td>
<td>Piling Emplacement</td>
<td>Piles may alter groundwater flow paths thereby potentially modifying the discharges of groundwater and contaminants to contiguous surface water systems such as the No.1 Drain, Sedimentation Pond and the Port Pirie River</td>
<td>Modelling, GMMP, Pile Design</td>
</tr>
<tr>
<td>Caisson and Diffuser emplacement and associated pipelines</td>
<td>Excavation</td>
<td>See Excavation Impacts above</td>
<td>EMP (including silt management procedures)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Excavation at the river margin and/or within the intertidal/subtidal zones may lead to sediment mobilisation and unacceptable turbidity and visual impacts</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Caisson, Diffuser and Pipeline Emplacement</td>
<td>Caisson may affect aquifer transmissivity, altering groundwater and contaminant flow paths locally thus potentially altering the flux of contaminants to the Port Pirie River</td>
<td>Modelling, GMMP</td>
</tr>
<tr>
<td>Ongoing Operation</td>
<td>Additional water discharges to the Sedimentation Pond, First Creek Drain and/or the Port Pirie River</td>
<td>Increased flow in the Sedimentation Pond and/or First Creek Drain could increase hydraulic heads in these systems, restricting groundwater drainage and potentially alter dissolved and particulate contaminant loads reporting to the Spencer Gulf</td>
<td>Hydrological Modelling conducted by others, Nyrstar Operating Procedure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>The volume, temperature and other physical properties of discharging cooling water</td>
<td>Hydrodynamic Modelling conducted by others</td>
</tr>
<tr>
<td>Activity</td>
<td>Task</td>
<td>Potential Surface Water Impact</td>
<td>Assessment / Mitigation Measures</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>----------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Rationalisation of Intermediate Materials</td>
<td>Possible movement and/or disposal of unused feedstocks</td>
<td>Stored materials may generate leachate or particulate-bearing run-off to stormwater and/or surface water systems</td>
<td>• EMP (including waste management as appropriate)</td>
</tr>
<tr>
<td>Storage of New Feedstocks</td>
<td>Storage of new, potentially contaminant-bearing feedstocks</td>
<td>Stored materials may generate leachate or particulate-bearing run-off to stormwater and/or surface water systems</td>
<td>• Nyrstar Operating Procedure • GMMP</td>
</tr>
<tr>
<td>Acid Management</td>
<td>Monitoring and prevention of acid ingress from historical releases entering the Transformation site</td>
<td>Groundwater barriers may alter rates of discharges of groundwater, acid and/or contaminants to contiguous surface water systems such as the No.1 Drain and Sedimentation Pond, altering contaminant loads at compliance points</td>
<td>• Modelling • GMMP</td>
</tr>
</tbody>
</table>

* GMMP = groundwater monitoring and management plan.

**11.3.3 Potential benefits and opportunities**

With the current SA EPA accredited Contamination Audit process and Nyrstar’s continual improvement strategy it is expected that the Transformation will provide substantial environmental benefits to the soil, groundwater and surface water systems. This will be facilitated by the:

- reduction of metal-bearing airborne and dust emissions
- discontinuation of the use of the sludge dewatering dams and the subsequent recovery of metals-bearing materials
- decommissioning and demolition of the existing acid facility
- reduction in storage of metal-bearing intermediate materials in the intermediate storage area.

The likely significance of these changes for the local groundwater and surface water systems are detailed in Appendix I.

**11.4 Mitigation and management measures**

The risk identification process highlights some potential direct and indirect, impacts on soil, groundwater and surface water. Human health and environmental risks associated with these aspects of the environment have been assessed to the level of available information (Chapter 16) and will be re-evaluated through numerical modelling prior to construction.
The mitigation and management measures proposed in this report will be updated prior to construction to address any unexpected outcomes of the numerical models.

The mitigation and management measures for soil, groundwater and surface water will be documented in the Construction and Operations Environmental Management Plans (CEMP and OEMP) and the Groundwater Management and Monitoring Plan (GMMP). All of these measures will be independently reviewed and approved by the SA EPA accredited Contamination Auditor to confirm adherence to appropriate protocols and protections.

### 11.4.1 Management system and approach

Groundwater is currently managed in accordance with the current GMMP. This plan covers both the ongoing assessment and remedial programs and also strategic and operational risks based on Australian Standard risk ranking methodologies (AS/NZS 4260:2004).

Currently, the GMMP is subject to review and approval by the SA EPA accredited Contamination Auditor to confirm compliance with the relevant legislation and protocols. There is also regular interaction between Nyrstar and EPA representatives on groundwater matters.

Groundwater monitoring wells have been progressively installed at the smelter between 1994 and 2012, predominantly within the Fill Aquifer, but also in the UNA and Hindmarsh Clay. These have focused on the smelter boundary to characterise potential off-site discharges and associated risks and also to form a sentinel well network for ongoing compliance monitoring. Selected source zone characterisation has also been undertaken during these programs.

The smelter well network currently comprises 101 monitoring wells, more details and locations of these wells are presented in [Appendix I](#). Transformation activities will be incorporated to this existing and extensive management system in consultation with the SA EPA accredited Contamination Auditor.

### 11.4.2 Decommissioning and demolition of existing plant

All identified soil, groundwater and surface water risks associated with the decommissioning and demolition phases of Transformation will be managed in accordance with the CEMP. The final CEMP will address the:

- background and smelter summary information including site identification, scope of the proposed activity and Contaminants of Potential Concern (CoPC)
- roles and responsibilities
- health and safety requirements including management options and controls to mitigate occupational health and safety hazards
- regulatory, licensing and legislative requirements
- identification of potential environmental impacts associated with each activity, including dust, noise, vapour, soil contamination, groundwater contamination, surface water runoff, soil runoff and waste generation
- relevant environmental management quality control measures to minimise potential impacts associated with the each activity including operational objectives
- performance criteria, management strategies, monitoring, reporting and corrective actions
• emergency procedures and environmental incident response.

The CEMP will be subject to review and approval by the appointed SA EPA accredited Contamination Auditor with respect to soil, surface water and groundwater.

The key risks associated with this phase of the Transformation include the stockpiling and management of potentially contaminated waste materials and the creation of open sealed or unsealed space increasing runoff of potentially contaminated water and possibly aquifer recharge, respectively. In both cases the relevant CEMP will specify management protocols such as limiting the removal of pavements and detailing stockpile management procedures which will effectively manage these risks.

11.4.3 Design and construction of new plant

All identified soil, groundwater and surface water risks associated with the design and construction phases of Transformation will be assessed and/or managed using modelling, CEMPs and/or GMMPs.

Modelling will be utilised during the options assessment phase or following the determination of final design criteria. Current modelling scenarios related to Transformation are expected to include the following:

• the effects of the distribution of new piles during the Transformation
• the effects of the distribution of any foundations or other sub-surface infrastructure expected to be constructed below the water table
• the effects of any remedial measures such as groundwater interception or infrastructure management related to acid risk mitigation and management
• the effects of Caisson emplacement on the local groundwater system
• the effects of removing intermediate materials stockpiles from areas of shallow water table
• the effects of any additional evaporative lakes proposed in redundant areas of the intermediate storage area amphitheatre.

Due to the relative scale of the smelter compared to the anticipated subsurface features, the impacts to groundwater flow and contaminant fate are expected to be minimal. Where a potential risk is identified by the modelling, a risk assessment will be undertaken to determine appropriate elimination, mitigation or management approaches.

In addition to modelling and as part of the smelter-wide assessment program, a Groundwater Management and Monitoring Plan (GMMP) will be developed to monitor temporal and spatial changes in groundwater quality and to evaluate the impacts of Transformation activities at the smelter and verify the effectiveness of remedial or control measures.

The likely content of the GMMP is described in Appendix I, and summarised:

• definition of groundwater quality management objectives
• definition of roles and responsibilities
• identification of groundwater CoPC
• identification of relevant groundwater beneficial uses and permitted groundwater beneficial uses at and surrounding the smelter
• summary of groundwater management approach including health and safety protocols
• groundwater monitoring requirements including the rationale for groundwater sampling, location of groundwater wells to be sampled, groundwater sampling methodology and frequency of groundwater sampling
• definition of contaminant trigger levels to assess if relevant groundwater quality management objectives have been met
• contingency actions to be implemented where trigger levels are exceeded

The GMMP will be subject to review and approval by the SA EPA accredited Contamination Auditor.

The key risks associated with this phase of Transformation include the geotechnical testing and pile installations which may modify groundwater flow patterns and contaminant distributions and potentially interconnecting aquifers of differing quality. Some subsurface infrastructure, such as the proposed cooling water pipeline, may also alter groundwater flow paths and contaminant distributions.

These risks will be effectively managed by the CEMP and OEMP, which will specify drilling methodologies and pile design. Monitoring within the GMMP will verify the modelling used to assess the impact to groundwater flow path.

11.4.4 Ongoing operation

Soil, groundwater and surface water associated with the ongoing operation of the smelter after the Transformation will be assessed and managed using the OEMPs and the modelling verified by GMMP. Further information on these processes and protocols are provided in Appendix I.

The key risks associated with the operational phase of the Transformation with respect to soil and water include:

• increased cooling water disposal potentially altering groundwater and surface water interactions
• the management of new and possibly existing smelting feedstocks
• acid management infrastructure.

These risks will be effectively managed by a combination of the OEMP and the GMMP to monitor and changing conditions and document contingency actions if required.

11.5 Conclusions

The Transformation will have no net negative impacts on the surface water, soil or groundwater conditions, provided the identified risks are managed in accordance with the established protocols and standards.

The reduction in emissions and the removal of potentially contaminating materials from the intermediate storage area and the old sludge dewatering dams will reduce soil, groundwater and surface water contamination potential. Potential impacts associated with sub-surface acid will be reduced by replacing the existing acid plant, improved management and bunding design and appropriate foundation design, supported by strategic groundwater monitoring and contingency plans.
The removal of the intermediate process materials from the intermediate storage area is likely to provide a larger surface area for groundwater evaporation. This in turn will lower the groundwater levels reducing the potential for groundwater contamination.

The primary potential impacts identified from the Transformation and associated activities are:

- **Geotechnical testing and piling activities**
  This has the potential to interconnect aquifers and mobilise contaminants, particularly from the Fill Aquifer to underlying aquifers. This will be managed by dedicated pile design that will hydraulically isolate the aquifers and appropriate drilling methodologies. This has been successfully completed on the smelter to the satisfaction of the SA EPA accredited Contamination Auditor. Impedance of groundwater flow by piles can be assessed and managed based on results from a numerical groundwater model.

- **Pavements**
  Removing pavements will increase the rate of recharge and the risk of further groundwater contamination. Where required, pavement improvement will be designed to reduce the potential for groundwater recharge and contaminant migration.

- **Contaminated materials**
  Handling potentially contaminated materials, including acid sulphate soils and waste construction materials can have an impact on soil, groundwater and surface water. The CEMP and OEMP will outline strategies and procedures for handling contaminated materials. The SA EPA accredited Contamination Auditor will review and approve the CEMP and the OEMP.

- **Cooling water pipeline**
  The cooling water pipeline may alter groundwater flow potentially impacting groundwater quality. The cooling water pipeline will be designed with the aid of numerical modelling to avoid further contamination. The pipeline construction is being assessed as a potential opportunity to assist with groundwater contamination management.

In summary, the Transformation presents net benefits to soil, groundwater and surface water management on smelter. These benefits will be principally realised through the removal of some existing sources of contamination which currently impact these aspects of the environment. The risk of negative impacts will be managed by the implementation of a CEMP and an OEMP supplemented by other environmental management procedures approved by the SA EPA accredited Contamination Auditor.
12 Effects on coastal and marine communities

12.1 Introduction
This chapter assesses the effects the Transformation will have on the marine communities inhabiting First Creek, the Port Pirie River and Spencer Gulf. Specifically, the assessment focuses on effects associated with:

- the increased volume of cooling water being discharged
- increased shipping traffic during construction.

The specific issues addressed include:

- increased temperature effects of cooling water
- sediment erosion by cooling water flows and shipping traffic
- sediment re-suspension by cooling water flows and shipping traffic, and bio-availability of contaminants
- turbidity effects associated with winnowing of sediments by ships
- introduction of exotic species by ships.

12.2 Existing environment
The Nyrstar smelter is located on the Port Pirie River, which is a tidal estuary on the eastern shore of Spencer Gulf. Spencer Gulf is termed an ‘inverse estuary’ as, unlike most estuaries, its salinity increases with distance from the open ocean.

The sheltered and shallow conditions in Upper Spencer Gulf result in relatively warm seawater temperatures during much of the year and conditions that support many species with tropical or sub-tropical affinities.

The dominant coastal and marine habitats in the Port Pirie region are extensive mangrove woodlands, samphire shrubland and tidal creeks in the intertidal area, and extensive seagrass meadows to a depth of about 10 m, and deep water channels in the deeper areas.

With the exception of the ports of Port Pirie and Whyalla, the South Australian Upper Spencer Gulf Marine Park encompasses most of northern Spencer Gulf from Port Jarrold and Cowleds Landing in the south to Port Augusta (see Chapter 4).

This section discusses the existing environment in the Port Pirie region at a range of scales, including Spencer Gulf and Upper Spencer Gulf (north of Jarrold Point), Germein Bay (bounded by Ward Spit at the north and extending southwards to Fisherman’s Creek), and the potential cooling water intake and discharge sites in Port Pirie River and First Creek.

12.2.1 Oceanography

Tides and currents
The narrowing and shallowing of Spencer Gulf towards the north results in tidal ranges that are unusually high for southern Australia, being up to 4.3 m at Port Augusta and 3.4 m at
Port Pirie (compared with less than 1.8 m at Port Lincoln near the mouth of the Gulf). Storm surges can increase this range by more than 1 m (Noye 1984).

Currents in the vicinity of Port Pirie are driven mainly by the tides, with a maximum speed of around 0.5 m/s adjacent to Ward Spit and 1 m/s near the entrance to Germein Bay, although tidal flows within the bay itself are expected to be much less than this. Wind–driven currents and thermohaline (density) currents created by stratification in the northern reaches of the Gulf also contribute to water movement (Noye 1984; Nunes and Lennon 1986; Nunes Vas et al. 1990; Harris and O’Brien 1998).

**Temperature**

The seasonal temperature range of Spencer Gulf is typically 12–24°C (Nunes and Lennon 1986; Nunes Vaz et al. 1990).

Seawater temperatures in Spencer Gulf, however, can also vary markedly on a temporal scale of hours to days and a spatial scale of metres to kilometres, as the extensive areas of shallow water on the tidal flats of Upper Spencer Gulf respond much more rapidly to the prevailing air temperature than deeper off–shore waters.

On hot summer days the shallow water on the tidal flats can reach temperatures above 30°C, compared with offshore water temperatures of 23–24°C. For example, it is reported that the water in Port Paterson, which is a shallow embayment in Upper Spencer Gulf, reaches temperatures up to 33.5°C in summer (Ainslie et al. 1989).

Similarly, during cold winter nights, the water on the tidal flats can cool to approximately 8–10°C compared with the offshore water temperatures of about 12–13°C (D Wiltshire, personal observation, 10 June 2012).

During ebb tides when water drains from the shallow tidal flats, water masses of different temperatures often mix, sometimes resulting in temperature stratification and thermoclines developing in the deeper offshore areas (D Wiltshire, personal observation 9 July 2012).

**Salinity**

The warm to hot climate and high net evaporation in Spencer Gulf result in the formation of an inverse estuary with progressive increases in salinity and seasonal salinity range from south to north. Specifically, salinity increases from typical oceanic salinities of 35–36 g/L at Port Lincoln in the south to 43–48 g/L at Port Augusta in the north. Offshore from Port Pirie, the annual depth–averaged salinity range is about 40–42 g/L with the peak in autumn (Nunes 1985). In Port Pirie River, Johnston (1981) recorded salinities in the range 40–47 g/L, again probably influenced by water seeping from shallow tidal flats where much higher salinities have been recorded (Nunes and Lennon 1986).

**Turbidity**

Johnston (1981) made a series of 28 measurements of water clarity in Port Pirie River over a period of four years in the 1970s. On all except four occasions, the secchi disk depth exceeded 2 m, which equates to the EPA (1993) water quality guidelines threshold of 10 NTU for marine ecosystems (Coleman and Cook 2007). Although the EPA has undertaken a
small amount of turbidity monitoring in the region in recent years, the data is yet to published (S Gaylard, EPA, pers. comm., 20 June 2013).

12.2.2 Marine habitats and biota

Principal marine habitats

The eastern shorelines of Upper Spencer Gulf are characterised by wide intertidal flats frequently colonised by seagrass, mangroves and samphire, and interspersed with tidal creeks (Figure 12-1). The mangrove and samphire communities of Upper Spencer Gulf are the most extensive in South Australia.

Communities of the southern mangrove *Avicennia marina* occur at Port Germein and from Weeroona Island to Fisherman Creek, backed by samphire communities extending inland by up to five kilometres (Figure 12-2). There are numerous tidal creeks between Port Pirie River and Fisher Creek, and in Germein Bay. Intertidal sand flats extend 1–2 km offshore, often covered by the seagrass *Zostera mucronata* (particularly on the sand flats adjacent to mangroves southwest of Port Pirie). Ward Spit extends 8 km into Spencer Gulf, and Cockle Spit (4 km long) lies in the middle of Germein Bay. Ward Spit supports intertidal seagrass communities.

Offshore, the shallow, sheltered waters of Germein Bay support extensive communities of the seagrasses *Posidonia australis*, *P. sinuosa* and *Amphibolis antarctica*, with areas of unvegetated sand (Figure 12-2).

Associated communities

The marine habitats occurring in the Port Pirie region form a productive, detritus–based ecosystem which provides feeding, nursery and/or breeding habitat for a variety of fish and crustacean species (McDonald 2008, Bryars 2003). Species important to fisheries include the Western King Prawn *Melicertus latisulcatus* (King 1979), Blue Swimmer Crab *Portunus armatus*, King George Whiting *Sillaginodes punctatus*, Yellowfin Whiting *Sillago schomburgkii* (Jones 1979) and the razorfish *Pinna bicolor*. Razorfish are a dominant but patchily distributed benthic species (McLaren and Wiltshire 1984; Corbin and Wade 2004), which provide substrate for a variety of molluscs, bryozoans, soft corals, ascidians and sponges (Ward et al. 1982). The seagrass and sand habitats support an infauna community of moderate diversity but low density in comparison with other temperate regions (Hutchings et al. 1993). These communities comprise mainly polychaete worms, molluscs and crustaceans, and are most dense within intertidal seagrass habitat.

Upper Spencer Gulf supports numerous species with tropical or subtropical affinities (Baker 2004), including the brown macroalga *Hormophysa cunieformis*, the soft coral *Carijoa multiflora*, the Sponge Crab *Schizophrys aspera*, the sea pen *Virgularia gustaviana*, the goby *Bathygobius krefftii* (BHP Billiton 2009) and the Horseshoe Worms *Phoronis albomaculata* and *P. psammophila* known from Germein Bay (Emig and Roldan 1992). The turfing macroalga *Vaucheria conifera*, considered vulnerable by Cheshire et al. (2000) due to its narrow range (<500 km), has been recorded on the north bank of Port Pirie River, opposite Fishermans Jetty.
The tidal flats and mangrove woodlands provide nesting and feeding habitat for many species of waterbird, particularly at Ward Spit (Baker 2004; BHP Billiton 2009).

**Biological surveys**

Biological surveys were undertaken to provide more detail on habitats within Port Pirie River and First Creek near potential intake and/or discharge sites. The vertical face of the wharf in Port Pirie River was dominated by the encrusting mussel *Trichomya hirsuta* and filamentous red algae, with ascidians, orange finger sponges and fan worms also present. Several Sea Sweep *Scorpis aequipinnis* and Snapper *Chrysophrys auratus* were observed. The seafloor adjacent to the wharf consisted of mud with a sparse cover of dead *Posidonia australis* leaves and other organic debris. North of the wharf, the relatively shallow sandy area (<2 m depth) between the shore and the shipping channel supported patches of *Zostera*, drift macroalgae including *Caulocystis cephalornithos*, calcareous tube worms and microphytobenthos inhabited by isopods. No living biota was observed on the floor of the shipping channel.
Figure 12-1: Overview of the regional coastal and marine habitats and sites of ecological importance (data source: DEWNR)
Figure 12-2: Coastal and marine communities near Port Pirie based on aerial photography interpretation
First Creek was surveyed for approximately half its length beginning approximately 1 km downstream of the existing cooling water discharge point at the 1M flume (i.e. the most easterly point accessible by boat). The muddy banks were lined by mangroves and a dense cover of aerial roots. Other than one yellow–eye mullet, no macrobiota were observed within the habitat provided by the aerial roots. The sediments varied between mud, sand and coarse shell fragments, and there were sections with a dense cover of filamentous turfing algae. Other than the Southern Longfin Goby *Favonigobius lateralis*, which was abundant in the sandy sediments, no biota was observed in the creek bed.

### 12.2.3 Significant or sensitive species

An EPBC Protected Matters search of a 10 km zone around the smelter (and supplementary searches) were undertaken and identified 58 species of national significance including 34 threatened species and 41 migratory species (with some overlap). Many of these species were also Listed Marine Species or Cetaceans under the EPBC Act. An additional 30 Listed Marine Species (including 24 pipefish and 3 cetaceans) were identified using the search. Many of the species were also listed as threatened or rare under the South Australian *National Parks and Wildlife Act 1972* (including one species not protected under the EPBC Act), or protected under the *Fisheries Management Act 2007*.

A search of DEWNR’s Biological Databases of South Australia (BDBSA) was also undertaken to determine the likely occurrence of listed flora and fauna within a 50 km radius of the smelter. Other key sources included Carpenter and Langdon (2013) and BHP Billiton (2009).

The listed species and their likelihood of occurrence are summarised in Appendix F. The listed species include:

- five coastal seabirds
- three terrestrial birds
- 14 waders
- six marine mammals
- the seagrass *Zostera mucronata*
- the Great White Shark *Carcharodon carcharias*
- 17 pipefish.

### 12.2.4 Fisheries and aquaculture

Upper Spencer Gulf supports important commercial and recreational fisheries. The zone between Whyalla and Port Pirie is particularly productive, with over 6,000 tonnes of seafood caught annually (Knight et al. 2005).

These species depend on a variety of habitats for at least part of their life cycle, including seagrass and unvegetated sand, intertidal flats, tidal creeks and mangroves (Bryars 2003). Most of them are caught within or near the seagrass meadows, which they use as feeding and refuge habitat. Two important species, the Western King Prawn and Snapper, are caught in the deep water channels of Upper Spencer Gulf.

Historically more than half of the South Australian recreational and commercial catch of Blue Swimmer Crab, Western King Prawn (commercial only), Yellowfin Whiting and Snapper has typically come from Upper Spencer Gulf (BHP Billiton 2009).

No aquaculture is permitted within Germein Bay. There is a production facility for the alga *Dunaliella salina* in False Bay near Whyalla, and limited aquaculture near the Port Augusta power station. There is currently no farming activity within the finfish zones in Fitzgerald Bay where kingfish aquaculture has occurred over the past decade.

### 12.2.5 Marine and coastal protected areas

The Upper Spencer Gulf Marine Park extends from Port Jarrod and Cowleds Landing in the south to Port Augusta in the north. The ports of Whyalla and Port Pirie are excluded from the park (Figure 12-1).

The park consists of a series of nested zones, including a Sanctuary Zone and a Habitat Protection Zone near Port Pirie (DEWNR 2012).

A Sanctuary Zone extends along the coast from Fifth Creek to 2 km north of Port Davis and inland over about 5 km of mangrove and samphire habitat. Sanctuary Zones protect habitats and biodiversity by prohibiting the removal of, or harm to, plants, animals or marine products. Specific provisions include the prohibition of water extraction and discharges that might otherwise be allowable under the *Environment Protection Act 1993*.

The Sanctuary Zone is buffered by a Habitat Protection Zone extending along the coast from just west of Second Creek to the park boundary and offshore by about 8 km. Habitat Protection Zones allow activities and uses that do not harm habitats or the functioning of ecosystems. Discharges in such zones will be managed in accordance with the *Environment Protection (Water Quality) Policy 2003*, taking reasonable and practicable measures to prevent harm.

A General Managed Use Zone that surrounds the Habitat Protection Zone and the port area aims to protect habitats and biodiversity whilst allowing ecologically sustainable development and use.

A Special Purpose Area has been overlaid over the entire park to provide for harbor, transport and the development of marine based infrastructure.

The mangrove, tidal flats and tidal creek habitats in the vicinity of Port Pirie also form part of the Northern Spencer Gulf Wetland which has been included in the Directory of Important Wetlands in Australia.
12.2.6 Existing levels of disturbance

Effluent has been discharged to the marine environment adjacent to the smelter via Port Pirie River and First Creek since 1889.

Metal–rich effluent has been discharged into First Creek since 1939 (and into Port Pirie River for fifty years prior to that). Other pathways for metals into the marine environment include spillage and fugitive dust emissions at the wharf during ship loading, direct atmospheric deposition to marine waters, and indirect deposition via contaminated groundwater flows and storm water runoff, which drain largely into Port Pirie River (Gaylard 2013).

Effluent volume and toxicity reached a peak in the mid–eighties and gradually decreased during the 1990s as effluent treatment and environmental controls initiated by the smelter owner and operator improved. Since the early 1990s, following the introduction of the Environmental Improvement Plan and environmental management systems, the concentrations of metals in the water discharged from the smelter were reduced significantly. In particular, the PETS facility, commissioned in 2002 to treat effluent being discharge to First Creek, has significantly reduced the load of metals entering the marine environment.

Since 1988 upgrades to operational procedures and systems have also significantly reduced airborne emission and spillage during loading. Consequently, the content of lead and zinc discharged has reduced by an order of magnitude over the past twenty years to about 6 and 23 t respectively for 2011/12 (NPI 2013).

Key studies

The environmental effects of smelting operations at Port Pirie have been studied since the early 1970s.


A 5 year marine monitoring program from 2002 to 2007 was undertaken to provide Nyrstar with information on the health of key environmental indicators (COOE 2008). This program targeted indicators that addressed issues of environmental significance and public concern, including metals and the health of marine organisms.

In recent years the EPA has undertaken assessments of metal contamination of biota in the Upper Spencer Gulf (Corbin and Wade 2004), and within the Port Pirie River (Gaylard et al. 2011).

Heavy metals

The initial CSIRO study during the early 1980s showed that the concentrations in marine sediments of the metals lead, zinc, cadmium, and to a lesser degree arsenic, copper, manganese and antimony, in exceeded background levels over 600 km² of Germein Bay and
Spencer Gulf. The highest concentrations occurred off First Creek where 25 km² of sediment was found to be contaminated by metals from 200 to 1,000 times background levels. The concentrations decreased to background levels about 10 km from the First Creek outfall (Ward et al. 1982, Ward et al. 1984).

The studies by COOE (2008) showed that metals in sediments had decreased to some degree over the five year monitoring period post commissioning of the PETS. Elevated metals were measurable 4–5 km offshore from First Creek, and elevated levels of cadmium and zinc extended 10–15 km along the coast southwest of First Creek.

Recent work in the Port Pirie River by the EPA has shown that the Port Pirie River continues to have a relatively high level of metal contamination. The lead, cadmium and zinc concentrations in the water were higher than those measured by Ferguson (1983) near the effluent discharge site in First Creek.

The EPA results have demonstrated that significant concentrations of metals remain biologically available in the estuary and that the harbour area may have shifted from being a metal sink to a source of metals in the adjacent marine waters. Metal concentrations in ambient seawater from the estuary were found to be toxic to sea urchin larvae (EPA, unpublished data).

Unpublished studies by the EPA (cited by Gaylard et al. 2011) show that the concentration of bioavailable metals in Port Pirie River is higher than historical levels in First Creek, with up to 98% of metals in the water column being bioavailable (dissolved). It is likely that the local estuarine ecosystem is adversely affected, with metals transported through the deep water shipping channel into Germein Bay.

The EPA’s assessments of metal levels in shellfish in the estuary have shown that the applicable food standard within the prohibition area is still exceeded for razorfish (Corbin and Wade 2004) and mussels (Gaylard et al. 2011). Furthermore, the lead concentrations in translocated mussels in the Port Pirie River were some of the highest recorded in the literature (Gaylard et al. 2011).

**Temperature, salinity and turbidity**

Four years of continuous water quality monitoring in and around First Creek (2003–2007) shows that seawater temperature and salinity offshore from First Creek is not significantly affected by warm saline water being discharged from the smelter (COOE 2008).

The approximately 15 GL of cooling water discharged per year to First Creek was 10°C above ambient in winter and less than 2°C in summer. Downstream monitoring found that water temperatures had returned to background levels by the creek mouth (COOE 2008), but recent observations indicate distinct thermoclines persisting to the mouth.

Although warm water plumes were measured in First Creek they rarely extended beyond its middle reaches. Water was warmer in winter than summer in First Creek (COOE 2008).

In general, salinity levels were higher in summer than winter, and creek salinity levels were higher than those recorded at offshore sites (COOE 2008).
Turbidity was generally higher near the mouth of First Creek and near the shipping channel compared with control sites (COOE 2008).

**Nutrients**

Southern Australian waters receive few nutrients via natural run-off from the land or oceanographic currents, and are therefore nutrient poor. With the Spencer Gulf ecosystem having evolved in response to low nutrient levels, it is highly susceptible to impacts associated with anthropogenic inputs.

The Port Pirie waste water treatment facility discharges 15 tonnes of nitrogen annually into Second Creek, resulting in frequent localized phytoplankton blooms (Gaylard 2013). This discharge is an order of magnitude lower than nutrient outputs from the Whyalla Steelworks and two orders of magnitude lower than the combined input from finfish aquaculture in southern Spencer Gulf (Gaylard 2013).

**Existing effects on marine communities**

A study by CSIRO in the early 1980s found clear evidence of metal accumulation in fish, molluscs and seagrasses, particularly lead, zinc, cadmium and manganese. Compared with control sites, lower abundance of some animal species from seagrass habitats, and of epifauna communities colonizing razorfish, were found at sites adjacent to the mouth of First Creek. Metals appeared to reduce or eliminate 20 of the most common species (mainly fish). Effects on fauna were detectable over 100 km² of seagrass meadows and a similar area of unvegetated sediments. Effects of metals on seagrass communities appeared to be minimal (Ward et al. 1982; Ward et al. 1984).

More recent studies focussing on the communities of organisms colonising artificial substrates deployed at the mouth of First Creek and at numerous sites radiating from First Creek found subtle evidence of ecological effects on biota at sites up to 10 km from First Creek. The effects were most pronounced at the site at the mouth of First Creek. It is suggested that some of these effects may be related to re-suspension of metals in the sediments related to historic discharges rather than ongoing discharges (COOE 2008).

These studies also found that the seagrass community at most sites in Germein Bay were as healthy as the control site at Port Broughton. The exceptions were a site just offshore from the mouth of First Creek where heavy metal levels were elevated in the sediments and seston, and in the shipping channel, where turbidity associated with shipping was higher than other sites (COOE 2008).

Other disturbances to seagrass in Germein Bay include impacts of boat propellers around Mangrove Point, and the loss of seagrass west of Second Creek, possibly associated with the nutrients in waste water discharge (COOE 2008).

**Introduced species**

Introduced marine pests found in Upper Spencer Gulf include the European Fan Worm *Sabella spallanzani*, the Pearl Oyster *Pinctada albina sugillata* and the cryptogenic Slime Featherduster Worm *Myxicola infundibulum* (Wiltshire et al. 2010). No introduced species were noted in the Port Pirie River or First Creek during the biological survey.
12.3 Cooling water requirements and characteristics

The current process includes a cooling water intake point located within the Port Pirie River and a discharge point located in First Creek adjacent to the site. The current cooling water intake is approximately 2 ML/hr (or 0.56 m³/s). The cooling water is currently discharged to a sediment basin, where it mixes with other treated process effluent and is discharged via the 1M flume to First Creek and Spencer Gulf at a combined rate of 2.62 ML/hr (or 0.73 m³/s) and at a temperature approximately 9°C higher than the intake water.

The Transformation will require an increased cooling water flow of approximately 5.8 ML/hr (or 1.62 m³/s), which will result in a total cooling water requirement of 7.8 ML/hr (or 2.18 m³/s). The discharge site for the Transformation’s cooling water has not yet been determined. Water will be discharged either directly into the Port Pirie River or into First Creek, downstream from the 1M flume. The proposed temperature increase of the cooling water above ambient will be 10°C for the Port Pirie River disposal option, and <10°C for the First Creek disposal option. The reason for the lower cooling water temperature for the First Creek option is that there is a much smaller volume of water in First Creek than Port Pirie River, resulting in poorer mixing and dispersion of the cooling water. A cooling tower would be used to achieve the lower cooling water temperature prior to disposal.

12.4 Modelling of cooling water dispersion

Modelling of the cooling water dispersion is presented in Appendix H. The new cooling water intake (PP01) and the potential cooling water outfall sites (PP02 in First Creek, and PP03, PP04 and PP05 in Port Pirie River) are shown in Figure 12-14.

12.4.1 Water quality guidelines

The modelling outcomes are assessed against appropriate water quality guidelines.

The existing Environment Protection (Water Quality) Policy 2003 does not have a specific guideline for temperature effects. Instead, the EPA negotiates appropriate guidelines on a case by case basis. Based on precedents in South Australia, the EPA is likely to require that temperatures resulting from the disposal of cooling water into the Port Pirie River are no greater than 2°C above the ambient temperature 20 m from the outfall (S Gaylard, EPA, pers. comm. 24 May 2013).

It is also relevant that a draft Environment Protection (Water Quality) Policy 2012, based on the ANZECC/ARMCANZ 2000 Water Quality Guidelines, is likely to replace the existing policy in 2014. The new policy requires that the resultant median water temperature does not exceed the 80th percentile of the ambient water temperature at the edge of the agreed mixing zone.

12.4.2 First Creek option

For the First Creek discharge option, the additional cooling water would be discharged directly to First Creek via the channel below the 1M flume. The existing discharge into First Creek via the 1M flume would be maintained. A diffuser would not be used as there is insufficient depth of seawater immediately below the 1M flume to enable a diffuser to operate. Instead the cooling water would flow along the earth channel for approximately 1.5
km before entering First Creek. Field measurements indicate that the temperature of the cooling water reduces by approximately 1°C before entering First Creek (A Gilbert, pers. comm. 28 June 2013).

BMT WBM used the TUFLOW-FV model to simulate dispersion of the cooling water in First Creek and the adjacent Spencer Gulf. TUFLOW-FV is a modern and extensively validated finite volume 3D hydrodynamic modelling package that has been successfully used in floodplain, estuarine, coastal and ocean environments both in Australia and overseas (see Appendix H).

BMT WBM deployed an Acoustic Doppler Current Profiler (ADCP) and three Conductivity-Temperature-Depth probes (CTD) off First Creek from 4 April to 8 May 2013 to collect oceanographic data for use in calibrating the model.

The following scenarios were modelled for one month in autumn and one month in summer:

- the existing discharge of cooling water to First Creek (i.e. impacted baseline)
- existing discharge + additional discharge at 10°C above ambient
- existing discharge + additional discharge at 5°C above ambient
- existing discharge + additional discharge at 2°C above ambient (see Appendix H).

The outputs for each cell within the model domain were provided as temperature exceedances expressed as percentiles (i.e. 0th, 10th, 20th and 50th percentiles). Subsequent post-processing of the model results provided the temperature changes in each cell relative to the existing temperature regime.

The results of each scenario for the autumn simulations are presented as absolute temperatures in Figure 12-3, Figure 12-4, Figure 12-5, and Figure 12-6, and as temperature changes from the existing regime in Figure 12-7, Figure 12-8 and Figure 12-9. To simplify the presentation the results have been summarized using only the 10th percentile outcomes, as these are relatively representative of the overall trends and are close to least optimistic outcomes.

For the discharge scenario with the cooling water at 10°C above ambient the 10th percentile comparisons revealed that:

- the temperature of First Creek would increase above the existing regime by 3 to 4°C for most of its length
- the temperature of First Creek would increase to 4–8°C above ambient for most of its length
- the section of First Creek where water temperatures would exceed the + 2°C over ambient guideline would extend several hundred metres beyond the mouth of First Creek (see Figure 12-4 and Figure 12-7).

For the discharge scenario with the cooling water at 5°C above ambient the 10th percentile comparisons revealed that:
• the temperature of First Creek would decrease below the existing regime by approximately 1°C in its upper reaches, and increase by 1–2°C in its lower reaches and 200 m beyond its mouth
• the temperature of First Creek would decrease to 3–4°C above ambient in its upper reaches, and increase to 2–3°C above ambient in its lower reaches
• the section of First Creek where water temperatures would exceed the + 2°C over ambient guideline would extend slightly beyond the mouth of First Creek (see Figure 12-5 and Figure 12-8).

For the discharge scenario with the cooling water at 2°C above ambient, the 10th percentile comparisons revealed that:

• the temperature of seawater in First Creek would decrease by up to 3°C in its upper reaches and remain unchanged in its lower reaches
• the temperature of First Creek would decrease to 1–2°C above ambient for most of its length
• the section of First Creek where water temperatures would exceed the + 2°C over ambient guideline would decrease to just its upper reaches (see Figure 12-6 and Figure 12-9).

It is concluded that the average temperature regime within First Creek would be:

• significantly higher with the discharge of additional cooling water at 10°C above ambient
• generally slightly higher with the discharge of additional cooling water at 5°C above ambient
• generally lower with the discharge of additional cooling water at 2°C above ambient.
Figure 12-3: Existing temperature in First Creek (10\textsuperscript{th} percentile)

Figure 12-4: Resultant temperature in First Creek with additional discharge at 10\degree C above ambient (10\textsuperscript{th} percentile)
Figure 12-5: Resultant temperature in First Creek with additional discharge at 5°C above ambient (10th percentile)

Figure 12-6: Resultant temperature in First Creek with additional discharge at 2°C above ambient (10th percentile)
Figure 12-7: Temperature increase in First Creek with additional discharge at 10°C above ambient (10th percentile)

Figure 12-8: Temperature change in First Creek with additional discharge at 5°C above ambient (10th percentile)
12.4.3 Port Pirie River option

For the Port Pirie River disposal option, the additional cooling water would be discharged to the Port Pirie River via a linear diffuser installed on the channel floor at a depth of approximately 8 m. Upon discharge from the diffuser the warm, less dense cooling water plumes would rise to the surface, entraining and mixing with ambient seawater.

BMT WBM undertook both nearfield and farfield modelling of dispersion of the cooling water plume in the Port Pirie River. BMT WBM used two empirical models (CORMIX and Visual Plumes) to simulate the nearfield dispersion, and a three dimensional model (TUFLOW-FV) to simulate farfield dispersion (see Appendix H).

BMT WBM deployed an Acoustic Doppler Current Profiler (ADCP) and two Conductivity-Temperature-Depth probes (CTD) in Port Pirie River from 4 April to 8 May 2013 to collect oceanographic data for use in the models.

Nearfield modelling

The CORMIX and Visual Plumes models are recommended by the United States EPA and used to design diffuser outfalls in Australia and internationally. The models provide 'look-up tables' that describe output temperatures, dilutions and plume geometrical characteristics at various distances from the diffuser for numerous combinations of diffuser designs such as lengths, port numbers and port diameters, and ambient seawater characteristics, such as temperature and current speeds.
The model outcomes are summarized in Figure 12-10: Predicted temperatures 20 m from the diffuser for a 12 port diffuser for a range of current speeds and Figure 12-11.

![Figure 12-10: Predicted temperatures 20 m from the diffuser for a 12 port diffuser for a range of current speeds](image)

![Figure 12-11: Comparison of ambient temperatures (blue) with modelled temperatures (green) 20 m from the diffuser over four weeks (12 port diffuser). The blue straight line is the 80th percentile of ambient temperatures, and the green straight line is the 50th percentile of modelled temperatures](image)

The model runs show that for the diffuser configurations considered and the ambient conditions encountered in the Port Pirie River in April/May 2013, it is possible to design a diffuser that would meet the EPA’s suggested temperature guideline, and the draft Water Quality Guidelines 2012. The results indicate that a design with cooling water exit velocity of 7.7 m/s from a 48 m long diffuser with 12 ports of 15 cm diameter is likely to result in compliance with the guidelines at all times.

BMT WBM cautions that the near field modelling is preliminary and should not be used to design the diffuser as numerous other diffuser configurations and exit velocities are also
likely to be suitable. They recommend that Computational Fluid Dynamics (CFD) be used to
design and optimise the performance of the diffuser (see Appendix H).

**Farfield modelling**

The TUFLOW-FV model outcomes for discharges in the Port Pirie River are presented in
Appendix H. The 10th percentile (i.e. least optimistic) outcomes for one of the potential
outfall locations (PP05) are summarized in Figure 12-12 and Figure 12-13.

It should be noted that the farfield modelling does not take into account the use of a
diffuser to provide initial mixing and dispersion of the cooling water plume. Consequently,
the farfield model outcomes are too high within approximately 100–200 m of the diffuser
and should not be relied upon.

The farfield modelling indicates that the dispersion of cooling water in Port Pirie River is
considerably better than in the First Creek, despite a much larger volume of water being
discharged to the Port Pirie River (Figure 12-12). It is clear that the deeper and wider Port
Pirie River has a greater capacity to dilute the cooling water than First Creek.

A temperature increase of 0.5–1.5°C over ambient extends approximately 1.5 km north and
3 km south of the outfall, which indicates that flushing in the upper reaches of the estuary is
relatively poor.

The modelling also shows that there is potential for re-circulation of cooling water if the inlet
and outlets are too close together. During design of the cooling water infrastructure, careful
consideration will need to be given to providing sufficient separation of the inlet and outlet
and positioning the intake as close as feasible to the floor of the estuary where the water is
cooler. Additional modelling will be required to determine the optimal locations for the inlet
and outlet to minimize re-circulation.
Figure 12-12: Resultant temperatures in Port Pirie River with the new discharge at 10°C above ambient (10th percentile). Note ongoing First Creek discharge.

Figure 12-13: Temperature change with the new discharge at 10°C above ambient (10th percentile) to Port Pirie River.
12.5 Impact assessment and management

An impact assessment and recommended management has been completed for the potential environmental effects of thermal effluent, cooling water quality, potential sediment erosion by cooling water as well as other discharges to the marine environment. Additionally, entrainment and impingement of species at the cooling water intake is assessed, as well as the biosecurity and relevant invasive species. Effects from climate change and seagrass offsets are also considered.

12.5.1 Thermal effects

Potential environmental effects associated with the discharge of thermal effluent from the Nyrstar smelter may be predicted to some degree by examining impacts associated with operation of the Northern and Playford Power Stations at Port Augusta.

The relative size of the Nyrstar cooling water discharge is considerably smaller than the discharges associated with Northern and Playford Power Stations at Port Augusta (Table 12–1). Temperature increase at Nyrstar, however, is higher.

12.5.2 Cooling water quality

Seawater will be extracted from Port Pirie River, pumped through the cooling water system, and discharged back into Port Pirie River or into First Creek. Cooling water does not come into contact with any process waters and therefore physical water quality parameters other than temperature will remain the same.
12.5.3 Erosion of sediments by cooling water

The following sections describe the likely effects of erosion on sediments depending on whether cooling water is discharged via Port Pirie River or First Creek.

**Port Pirie River option**

Discharge of cooling water into the Port Pirie River would occur via a diffuser with numerous vertically oriented ports. The cooling water would be discharged under pressure vertically into the water column. The buoyant plume would rise to the surface and only interact with bottom sediments after initial mixing had occurred and the exit velocity of the plume had dissipated.

Discharge of cooling water into the Port Pirie River via a diffuser would therefore have no effect on the bottom sediments of the harbour and would therefore not result in the mobilization of heavy metals associated with sediments. Impacts from cooling water discharge are likely to be negligible given the distance of the diffuser from the nearby Upper Spencer Gulf Marine Park.

**First Creek option**

Discharge of almost 4 times more cooling water into First Creek will result in the velocity of cooling water in the confined sections of the earth channel and the upper reaches of First Creek increasing by about 3–4 times (from about 0.5 m/s to 2 m/s).

Contaminated sediments will be mobilized and moved down the earth channel and into the upper reaches of First Creek. As First Creek becomes wider and deeper approximately 1.5 km from its mouth, however, the velocity of the cooling water will quickly reduce back to ambient tidal flows and much of the entrained sediment will drop out. It is very unlikely that the increased cooling water flow would have any measurable effect on the velocity of tidal flows in the wider and deeper sections of First Creek.

It is concluded therefore that the increased cooling water flow will result in some movement of contaminated sediments along the upper reaches of First Creek, but that there would be little or no additional movement of sediments in the lower reaches of the creek. First Creek flows into Special Purpose Area-2 Harbor of Port Pirie within the Upper Spencer Gulf Marine Park and it is expected that the zone’s environmental, social and economic values will be maintained as per the Upper Spencer Gulf Marine Park Management Plan 2012 requirements.

If erosion occurs, the upper reaches of the earth channel immediately below the 1M flume can be protected by lining the channel with either concrete or rock.

12.5.4 Other discharges to the marine environment

The increased cooling water discharge will be dosed with the surfactant Mexel 432, which is currently used to dose the existing discharge. Rather than being toxic to fouling organisms, the non-toxic surfactant prevents the organisms from attaching to infrastructure.

The Mexel 432 technology is biodegradable and is non-toxic to mammals, bacteria, algae, crustaceans, molluscs and fish, and complies with international standards including the
Australian Pesticides and Veterinary Medicines Authority (Mexel Industries SAS, 2012). This would be less toxic than commonly used anti-fouling chemicals such as chlorine.

The Transformation will be planned and implemented so groundwater movement beneath the smelter is not adversely impacted. Consequently the change in discharge of contaminated groundwater to the Port Pirie River is expected to be negligible.

During demolition and construction operations there will be an increased risk of surface run-off becoming contaminated by sediments and metals and discharging into the marine environment. As with existing stormwater, run-off from demolition and construction will be controlled and directed as required to the sedimentary basin prior to discharge into First Creek. The details of how stormwater will be controlled will be described in the CEMP.

Similarly, during demolition and construction operations there will be an increased risk of contaminated dust blown into the marine environment. At these times, measures will be taken where necessary to minimise dust mobilisation from potentially dusty sites. The CEMP will provide more details of how dust will be controlled (Appendix J).

During the operational phase of the Transformation it is expected that airborne metal bearing dust and SO2 emissions will be reduced due to the elimination or significant reduction of intermediate product produced and better SO2 capture from the EBS oxidation furnace through the new acid facility. These design and operational strategies will significantly reduce contaminated airborne emissions from entering the marine environment.

### 12.5.5 Entrainment and impingement

Marine organisms with little or no ability to move actively, such as phytoplankton and zooplankton, including earlier stages of larval fish, may be impinged upon filter screens or entrained into the cooling water intake.

A review of studies assessing power station intakes in NSW found low rates of impingement of fish and crustaceans with relatively few species of socio-economic importance affected. It was suggested that impingement or entrainment would be minimised with an intake velocity of <0.6 m/s (The Ecology Lab 2005). The proposed intake would therefore be designed to achieve an intake velocity of velocity of <0.6 m/s.

Hodgson (1979) found that zooplankton suffered 50% mortality after exposure to temperatures of 35°C for one hour. With the output temperature of the cooling water varying seasonally from 20–35°C, and seasonal larval concentrations being highest during summer, the highest naturally occurring larval mortalities are likely to occur during summer.

The ecological significance of the loss of phytoplankton, zooplankton and larvae may be placed in perspective by considering the size of existing cooling water intakes in Spencer Gulf, the percentage of organisms lost and the breeding strategies of the organisms.

The volume of the proposed cooling water intake is at most one tenth of the intakes for the Northern and Playford Power Stations near Port Augusta (see Table 12–1).
The annual cooling water intake for the Nyrstar smelter would be about 0.01% of the volume Spencer Gulf, or 0.4% of the volume of Upper Spencer Gulf.

A larvae survey conducted over four different seasons off the coast from Point Lowly for a proposed desalination facility on the western coast of the upper Spencer Gulf found that the larval fish assemblage was dominated by grubfish (*Parapercis* spp.) and bluespot goby (*Pseudogobius olorum*) during spring and by anchovy (*Engraulis australis*) and bluespot goby during summer. Larvae of other fishes, including some of commercial fish species, were caught in very small numbers, such as early juveniles of southern calamary (*Sepioteuthis australis*) and the western king prawn (*Melicertus latisulcatus*) (BHP Billiton 2011).

The ecological significance of the loss of phytoplankton and zooplankton resulting from entrainment is considered to be low due to their high abundances, wide distribution and short generation times. It is expected that plankton lost by entrainment would be replaced within days to weeks (Steinbeck *et al.* 2007; CEE Consultants 2008). For example, no evidence of even a local reduction in zooplankton abundance was found near a power station intake in California with 75 times the proposed intake rate, despite up to 1,200 tonnes being entrained annually (Ambrose *et al.* 1996).

Reductions in larvae do not generally translate into a reduction in the adult population as few larvae naturally survive to adulthood (CEE Consultants 2008; Steinbeck *et al.* 2007). The natural daily mortality of larvae ranges from 1–50%, and commonly exceeds 10% (Houde and Bartsch 2009; Houde 2002; Houde 1989). The high natural mortality rate of larvae results in only 0.0001–1% becoming adults (i.e. cumulative mortality is 99–99.9999%), which is sufficient to sustain adult populations (DSE 2008, CEE Consultants 2008, Raimondi 2008) (Figure 12-15). Natural mortality is typically even higher for eggs (Houde and Bartsch 2009; Houde 2002).

Assuming 0.4% of the larvae in Upper Spencer Gulf are entrained, it is estimated that from about one in 25,000 to one in 250,000,000 adult fish or crustaceans (depending on the species) may be lost each year from Upper Spencer Gulf as a result of entrainment.

Based on the volume of water entrained, the daily mortality of larvae in Upper Spencer Gulf resulting from entrainment would be about 0.001%. The increase in mortality arising from the proposed intake would therefore be 1,000 to 50,000 times less than natural mortality in Upper Spencer Gulf.

The impact of entrainment in the proposed cooling water intake on natural populations in Upper Spencer Gulf would not be measurable.
12.5.6 Construction impacts

Depending on the option chosen, First Creek or Port Pirie River, a small amount of dredging of the Port Pirie River banks may be required to install the new cooling water inlet caisson and outlet pipeline. The scale of the dredging is likely to be of the order of 10 m x 10 m x 8 m for the inlet caisson (adjacent to the existing caisson), and 50 m x 5 m x 3 m for the outlet pipeline across the tidal flat adjacent to the north east corner of the smelter.

Construction of the outlet pipeline through a 10 m wide section of tidal flats is likely to result in the loss of some Eelgrass *Zostera* sp. (potentially 100 m² or 0.1 ha). Installation of the diffuser on the channel floor or against the wharf would not result in the loss of any seagrass.

The impact of silt plumes generated in the Port Pirie River during the dredging process and can be minimised using silt curtains. Sediment deposition from the construction plumes would occur mainly within about 200 m of the construction activities. Water turbidity would temporarily increase during dredging for probably up to a kilometre from the construction sites. Heavy metals in the surface sediments would inevitably be re-mobilized during dredging operations. The effects, however, would only occur for the duration of the dredging program (i.e. approximately 1–2 weeks), after which the sediments would fall out of suspension.

Effects of turbidity and sedimentation on the seagrass (*Zostera* sp.) communities would be minor as its extent near the construction sites is limited. Furthermore, *Zostera* sp. is an opportunistic seagrass that has the potential to recover rapidly. The mangrove communities would not be affected by dredging operations. Measures to mitigate impacts associated with dredging will be developed in the CEMP (Appendix J).

Increases in noise and vibration associated with construction of the new cooling water inlet caisson and outfall in Port Pirie River would be slight in the context of the ongoing operation of ships and other vessels, smelting operations and unloading and loading operations in the area. Short term aversion effects on some marine species such as dolphins may occur. However, the effects would be temporary and of negligible ecological consequences. The
potential to impact Special Purpose Area-2 Harbor or Port Pirie with the Upper Spencer Gulf Marine Park is considered negligible.

12.5.7 Increased shipping

During construction there will be an estimated 24 additional shipping movements in the Port Pirie River per year. This number is within the normal operating range for the port over the last 20 years. Additional shipping movements are expected to cease once the Transformation is complete.

The effect of the temporary increase in shipping operations during construction on the ecology of the Port Pirie River would be negligible as the slight increase in shipping traffic is unlikely to cause a significant short term or long term increase in turbidity, siltation or smothering of benthic communities within the estuary.

Heavy metals in the surface sediments would inevitably be re-mobilized during shipping movements. The effects, however, would be similar to those resulting from existing operations. The effects would be of short duration, with the sediments and associated metals probably falling out of suspension within hours.

The likelihood of whales and other threatened or protected species being impacted by shipping movements is expected to remain very low.

The operational phase following the Transformation would result in no additional impacts to the ecology of the Port Pirie River as production rates, storage, loading and shipping operations are expected to remain unchanged from existing operations.

12.5.8 Effects on significant species or protected areas

None of the listed species potentially occurring in the project area are at risk of being adversely affected by the Transformation for the following reasons.

- None of the listed species are likely to utilise the smelter for habitat, although some of the listed birds may fly over the smelter.
- None of the habitat potentially used by listed species will be cleared or adversely affected by the Transformation.
- The substantial reductions in emitted SO₂ may improve the quality of the coastal vegetation and habitat.
- The greater cooling water discharge will not result in an increase in the temperature of seawater in First Creek beyond existing levels. The sea birds known to use the habitat at the mouth of First Creek would not be affected. Similarly, listed marine species potentially using gulf waters off First Creek would not be affected.
- Discharge of cooling water into Port Pirie River via a diffuser would result in a temperature increase over ambient of less than 2°C within 20 m of the diffuser. Ecological effects are unlikely to be measurable beyond 20 m from the diffuser. Adverse effects on listed species potentially occurring in Port Pirie River would not occur. The vulnerable turfing macroalga *Vaucheria conifera* recorded in the Port Pirie River is not likely to be affected.
As discussed above the construction and operational impacts on marine flora and fauna would in general not be measurable. Consequently it is considered that there would be no adverse effects on the Upper Spencer Gulf Marine Park resulting from the Transformation project.

### 12.5.9 Biosecurity and invasive species

The risk of introducing invasive marine species would be minimised through adoption of the national ballast water management requirements (AQIS 2008) developed to meet Australia’s commitment to International Convention for the Control and Management of Ships’ Ballast Water and Sediments (IMO 2008).

Consistent with current procedures, Nyrstar would require that ships delivering materials during construction possess ballast water management plans that comply with international, Australian and local (Flinders Ports) requirements. Consequently, ballast water would be managed according to the recognised guidelines.

### 12.5.10 Climate change

Changes in the distribution and abundance of marine species and the timing of biological processes in response to temperature changes are well known (e.g. Brierley and Kingsford 2009; Hobday et al. 2006). There is also evidence that acidification associated with climate change can affect the ability of animals such as molluscs to produce shells and plates from calcium carbonate (Secretariat CBD 2009; Brierley and Kingsford 2009; The Royal Society 2005; Hobday et al. 2006; Kleypas et al. 2006). Additive or synergistic effects resulting from the cumulative impact of increases in salinity, temperature and acidity associated with climate change are also possible (Hobday et al. 2006; Brierley and Kingsford 2005).

There have been a number of predictions concerning increased air and water temperatures in Spencer Gulf. In particular:

- Suppiah et al. (2006) predicted air temperature changes of 1.6°C by 2030 and 4.7°C by 2070, with corresponding increases in water temperature being approximately half the air temperature rises.
- Bothelo et al. (2013) modelled climate change in Upper Spencer Gulf, and predicted an annual mean seawater temperature increase of about 0.9°C by 2030 and 2.8°C by 2070.

There have also been more general predictions for Australian sea waters, including:

- a sea surface temperature rise of 1–2°C by 2070 (Hobday et al. 2006)
- a decrease in pH (i.e. increase in acidity) of 0.14 by 2030 and 0.24 by 2070 (Hobday et al. 2006).

The temperature increase associated with the cooling water discharge into the Port Pirie River would be confined to no more than 2°C within 20 m of the diffuser. Should the discharge occur into First Creek, there would be no increase in seawater temperature (over that associated with the existing discharge) as a cooling tower would be used to cool the water prior to discharge. This may result in a decrease in temperature effects in First Creek.
Temperature effects associated with the proposed increased cooling water discharge would be negligible compared with potential increases in ambient temperatures predicted under climate change scenarios. Similarly, the contribution of the increased cooling water discharge to possible synergistic effects associated with climate change would be negligible.

12.5.11 Seagrass clearance offsets

To offset the potential loss of seagrass associated with the Port Pirie River option for cooling water disposal, Nyrstar will consider monetary payment to the Native Vegetation Fund, to achieve a Significant Environmental Benefit (SEB) and compliance with the Native Vegetation Act 1991.

12.5.12 Marine Users

There will be no impact from the Transformation on marine users such as aquaculture or commercial and recreational fishers.

Table 12–1: Nyrstar cooling water use compared with Northern and Playford Power Stations

<table>
<thead>
<tr>
<th></th>
<th>Flow rate (m³/s)</th>
<th>Temperature increase (°C)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nyrstar (existing and proposed)</td>
<td>2.18</td>
<td>10</td>
</tr>
<tr>
<td>Northern Power Station¹</td>
<td>47</td>
<td>7</td>
</tr>
<tr>
<td>Playford A²</td>
<td>7.5</td>
<td>5.8</td>
</tr>
<tr>
<td>Playford B²</td>
<td>14.5</td>
<td>6.6</td>
</tr>
</tbody>
</table>

¹ Source: Kinhill (1982)

The two power stations near Port Augusta increase the temperature of more than 800 GL of cooling water annually (5% of the volume of Upper Spencer Gulf) by 4–5°C. The cooling water from the power stations is discharged into a relatively shallow and enclosed part of Spencer Gulf and does not use a diffuser.

Extensive marine monitoring programs were undertaken in the late 1970’s and 1980s to determine the effects of the cooling water discharge from the power stations on adjacent marine communities. These studies revealed the following:

- Operation of the Playford Power Station had not affected seagrass or mangroves to a degree that could be observed qualitatively (E.R.A. 1973).
- The marine communities on six transects across the gulf did not appear to be greatly affected by the cooling water discharge (Johnson 1976).
- Subtidal communities near the power station were similar to those further south near Redcliff Point (Johnson 1976).
- Normal assemblages of marine communities, including infauna, inhabit the near vicinity of the power station. However, some species such as razorfish and sponges may be more abundant near the power station (ETSA 1977).
- Occasional incursions of warm water into the intertidal zone had no measurable impact on intertidal communities (Ainslie et al. 1989).
Seagrass communities near the power station appear to tolerate occasional incursions of seawater at 28°C. However, there was some evidence that 28°C is the threshold at which some reduction in total standing biomass, reduced leaf length and increased shoot production occurs (Ainslie et al. 1989).

Seagrass communities in Port Paterson, which is a large shallow embayment in northern Spencer Gulf, are subjected to natural temperatures up to 33.5°C in summer. The seagrass communities in Port Paterson appear to tolerate the occasional extreme temperatures. They are, however, characteristically stunted. It was concluded that the natural thermal stress in Port Paterson was considerably greater than the thermal stress near the power station and covered a much greater area (Ainslie et al. 1989).

Further south near Port Broughton, dieback of approximately 11,000 ha of intertidal and shallow subtidal seagrass was reported in 1993, probably due to heat stress associated with a hot El Nino summer (Seddon et al. 2000).

These studies indicate that existing cooling water discharges into Upper Spencer Gulf have had negligible effects on adjacent marine communities and that potential effects associated with the discharge of cooling water are minor compared with natural heat stress.

**Effects on mangrove and seagrass communities**

The hydrodynamic modelling of the cooling water discharge into the Port Pirie River via an appropriately designed diffuser (see Section 12.4) demonstrates that dispersion of the effluent plume will result in no more than a 2°C increase over ambient water temperature 20 m from the diffuser. The modelling indicates that the temperature increase (above the existing regime) would be less than 2°C at the nearest mangrove and seagrass communities. Studies of the effects of thermal effluent on mangroves at Torrens Island (De Guia 1982) and seagrasses near Port Augusta (Ainslie et al. 1989) suggest that neither community would be adversely affected by the possible 1–2°C temperature increases they may sometimes be exposed to.

**Effects on marine communities**

The hydrodynamic modelling of the additional cooling water discharge to First Creek demonstrates that, with the use of a cooling tower to provide an appropriate level of cooling prior to discharge, the average seawater temperature in First Creek will either be the same as at present, or decrease to some degree. Consequently, should the First Creek disposal option be chosen, the Transformation is likely to have no adverse effects on the marine communities inhabiting First Creek (including recreational and commercial species), and may result in some degree of improvement, depending on the level of pre-cooling prior to discharge that occurs.

Similarly, the hydrodynamic modelling of the cooling water discharge into the Port Pirie River via an appropriately designed diffuser demonstrates that dispersion of the effluent plume is likely result in no more than a 2°C increase over ambient water temperatures approximately 20 m from the diffuser, which will satisfy the appropriate water quality guidelines.
The modelling indicates that the temperature increase would be less than 2°C at the nearest mangrove and seagrass communities in the Port Pirie River. Studies of the effects of thermal effluent on mangroves at Torrens Island (De Guia 1982) and seagrasses near Port Augusta (Ainslie et al. 1989) suggest that neither community would be adversely affected by the possible 1–2°C temperature increases to which they may sometimes be exposed.

Similarly, the relatively small temperature increases in the Port Pirie River are unlikely to result in measurable effects on marine communities more than 20 m from the outfall. The fauna living on the estuary floor and in the sediment next to the diffuser are unlikely to be exposed to temperature increases greater than 2°C as the buoyant plume will rise to the surface on discharge.

The warm water plume near the diffuser is likely to attract some fish species (including recreational and commercial species). Being highly mobile, they would have the ability to avoid the thermal plume if it exceeds their thermal tolerances. Adverse effects on fish are therefore unlikely.

12.6 Conclusions
The following conclusions may be drawn concerning impacts on coastal and marine communities.

**Thermal effects**
- The much larger cooling water discharges at the Northern and Playford Power Stations near Port Augusta have had negligible impact on adjacent marine communities.
- Port Augusta seagrass communities near the power station appear to tolerate water temperatures of 28°C, which is considerably higher than seagrass communities near Port Pirie would be exposed.
- Seagrass communities in Port Paterson near Port Augusta tolerate natural temperatures up to 33.5°C in summer.
- Potential effects associated with the discharge of cooling water at Port Pirie are likely to be very minor compared with natural heat stress in Upper Spencer Gulf.
- Studies on the effects of thermal effluent on mangroves at Torrens Island and seagrasses near Port Augusta suggest that seagrass communities will not be adversely affected by the possible 2°C temperature increase above ambient levels in the Port Pirie River.

**First Creek**
- The average temperature regime in First Creek would be significantly higher with the discharge of additional cooling water at 10°C above ambient
- However, the temperature regime would be only slightly higher with the discharge of additional cooling water at 5°C above ambient, and lower with the discharge of additional cooling water at 2°C above ambient.

**Port Pirie River**
Nearfield modelling indicated that it is possible to design a diffuser that would meet the EPA’s suggested temperature guideline, and the draft *Water Quality Guidelines* 2012.

The results indicate that, with a 48 m long diffuser with 12 ports of diameter 15 cm, a cooling water exit velocity of about 7 m/s is likely to result in a temperature increase of no greater than 2°C 20 m from the diffuser.

Farfield modelling indicates that a temperature increase of 0.5–1.5°C over ambient would extend approximately 1.5 km north and 3 km south of the outfall, which indicates that flushing in the upper reaches of the estuary is relatively poor.

The modelling also shows that there is potential for re-circulation of cooling water if the inlet and outlets are too close together. The positioning of the inlet on the floor of the estuary is likely to minimise re-circulation.

**Marine communities**

With the use of a cooling tower to provide pre-discharge cooling to approximately 5°C above ambient, the Transformation is unlikely to result in further adverse effects on the marine communities inhabiting First Creek.

Similarly, with the use of an appropriately designed diffuser in Port Pirie River, the relatively small temperature increases (<2°C) in the Port Pirie River 20 m from the diffuser are unlikely to result in measurable effects on marine communities adjacent to the outfall.

**Cooling water quality**

Cooling water does not come into contact with any process waters and therefore physical water quality parameters other than temperature will remain the same.

**Erosion of sediments by cooling water**

Discharge of cooling water into the Port Pirie River via a diffuser would have no effect on contaminated sediments on the floor of the estuary.

The increased flow of cooling water in the confined upper reaches of First Creek may initially mobilise and move contaminated sediments down First Creek. However, the sediments would be re-deposited in the less confined middle reaches of First Creek as the velocity of cooling water decreased to ambient tidal levels.

**Other discharges to the marine environment**

The increased cooling water discharge will be dosed with a non-toxic surfactant to prevent fouling organisms from attaching to infrastructure, rather than the more toxic, conventional anti-fouling chemicals.

The movement of contaminated groundwater beneath the smelter will not change. Consequently, there will be no change in the discharge of contaminated groundwater to the Port Pirie River.

Run-off from demolition and construction sites will be controlled and directed to the existing sedimentation basin prior to discharge to the marine environment.

During demolition and construction, measures will be taken to minimise dust emissions to the marine environment from potentially dusty sites.
Entrainment and impingement

- The increase in mortality of larvae arising from entrainment would be 1,000 to 50,000 times less than natural mortality of larvae in Upper Spencer Gulf.
- It is estimated that from about one in 25,000 to one in 250,000,000 adult fish or crustaceans may be lost each year from Upper Spencer Gulf as a result of entrainment.
- The impact of entrainment in the proposed cooling water intake on natural populations of marine biota in Upper Spencer Gulf would not be measurable.

Construction impacts

- Limited dredging associated with the construction of new cooling water caisson and the outlet pipeline would result in a short term increase in turbidity in the Port Pirie River.
- Turbidity and sedimentation effects on the *Zostera* sp. seagrass communities in Port Pirie River would be minor as its extent near the construction sites is limited and recovery of *Zostera* sp. is likely to be good as it is an opportunistic species.
- Increases in noise and vibration associated with construction of the new cooling water inlet caisson and outfall in Port Pirie River would be slight in the context of the ongoing smelting and port operations. Effects would be temporary and ecologically negligible.
- Potential construction of the cooling water outfall pipeline through the 100 m wide tidal flats adjacent to the smelter would result in the loss of up 100 m² of Eelgrass *Zostera* sp. Loss of the seagrass may require an SEB offset payment to be made to the Native Vegetation Council.

Increased shipping

- During construction there will be an estimated 24 additional shipping movements in the Port Pirie River per year. Annual shipping movements will return to current levels after construction.
- The slight increase in shipping traffic will result in minor short term increases in the mobilization of contaminated sediments, turbidity and siltation in Port Pirie River. However, effects on marine communities would be negligible.

Effects on listed species

- The risk of listed marine or coastal species being adversely affected by the Transformation is considered to be negligible.
- None of the listed species are likely to utilise the smelter for habitat, and none of the habitat potentially used by listed species will be cleared or adversely affected by the Transformation.

Invasive species

- The risk of introduction of invasive marine species would be minimised by strict adherence to the national ballast water management guidelines by all shipping.
Climate change

- Temperature effects associated with the proposed increased cooling water discharge would be negligible compared with potential increases in ambient temperatures predicted under climate change scenarios.
13 Effects on native vegetation and fauna

13.1 Introduction

This chapter assesses the effects the Transformation may have on terrestrial vegetation, habitat and fauna in the vicinity of the smelter.

The specific issues addressed include:

- clearance of native vegetation during construction
- the effect of air emissions (particularly SO₂) on vegetation
- the effects of additional noise and light during construction on fauna.

13.2 Existing environment

13.2.1 Vegetation communities, habitats and fauna

The Transformation is located within an existing industrial site that was mostly cleared of natural vegetation in 1885 and sections likely to have been cleared earlier for shipping, fishing and agricultural activities. The smelter supports none of its original native vegetation and habitat. Prior to clearance the native vegetation at the smelter would probably have been similar to the tidally influenced communities adjacent to the smelter.

The intertidal and supratidal environment adjacent to the smelter support relatively intact mangrove and samphire communities that extend several kilometres inland along the eastern shore of Spencer Gulf. The mangrove and samphire communities near Port Pirie are some of the most extensive in southern Australia (Dittmann and Baggalley 2013).

The Port Pirie River estuary covers an area of approximately 15 km² and is part of the Northern Spencer Gulf Wetland which is included in the Directory of Important Wetlands in South Australia (ANCA 1996). They provide important habitat for native fauna, particularly waterbirds.

The distribution of mangroves and samphire on the tidal flats is influenced largely by micro-topography that may only vary by 0.6 m, but produces significant spatial variation in drainage and tidal flooding and therefore physical complexity (Fotheringham and Coleman 2008).

The Port Pirie River and First Creek support extensive Grey Mangrove Avicennia marina var. resinifera woodland that progressively becomes less dense and confined to the main tidal channels in their upper reaches. The supratidal zone adjacent to Port Pirie River and First Creek supports extensive samphire shrubland consisting of Grey Samphire Halosarcia halocnemoides, Sclerostegia spp., Sarcocornia spp. and Shrubby Glasswort Tecticornia arbuscula. Large areas of bare sand and clay flats occur within the samphire communities.

The coastal wetlands of Upper Spencer Gulf provides important habitat for waterbirds with significant populations of several species, including the migratory waders Red-necked Stint Calidris ruficollis, Red Knot Calidris canutus, Sharp-tailed Sandpiper Calidris acuminata, Curlew Sandpiper Calidris ferruginea, Banded Stilts Cladorhynchus leucocephalus and Red-capped Plovers Charadrius ruficapillus (Carpenter and Langdon 2013).
Upper Spencer Gulf also supports significant nesting colonies of some species, including the Crested Tern *Thalasseus bergii*, Caspian Tern *Hydroprogne caspia* and Fairy Tern *Sternula nereis*. Their main nesting site near Port Pirie is on Ward Spit. The Great Egret *Ardea alba* is reported to nest with Pied Cormorants *Phalacrocorax varius* in mangroves at Port Pirie and near Redcliffe Point north of Port Pirie (Carpenter and Langdon 2013).

### 13.2.2 Existing levels of disturbance

The Port Pirie region has been extensively cleared since European settlement for agriculture, housing and industry and now supports only remnant patches of native vegetation. The Port Pirie Environmental Association and Hundred of Pirie have only 3% and 4.6%, respectively, of their native vegetation remaining, which are considered to be very low.

More than 75% of the catchments of First, Second and Third Creeks have been cleared. Similarly, the catchments of Fisherman Creek and Port Pirie River have been substantially cleared. Each of these catchments is classified as severely modified (Barnett 2001).

The most intact communities of native vegetation in the region are the mangrove woodland and samphire shrubland in the intertidal and supratidal zones. Although the native vegetation and habitat adjacent to the western and northern boundaries of the smelter are largely intact, they have been degraded to some extent by recreational vehicles creating a network of tracks, effluent discharges into First and Second Creeks and the deposition of air pollutants, including SO₂ and heavy metals.

Similarly, the eastern side of the Port Pirie River is easily accessed from Port Pirie and as a consequence is heavily impacted by cars, fishers and walkers. Car tracks, rubbish and erosion are common in the area.

A revegetation program at the smelter commenced in 1993, and by 2000, approximately 200,000 plants were planted on the smelter to reduce fugitive dust emissions. Revegetation has predominantly involved the use of shrubs and grasses, such as Bluebush *Maireana sedifolia*, Old Man Saltbush *Atriplex nummularia* and speargrass *Austrostipa* sp.

### 13.3 Impact assessment and management

An impact assessment and recommended management has been completed for the clearance of vegetation and habitat, the effects of sulphur dioxide emissions on vegetation, effects on fauna and effects on listed species and communities.

#### 13.3.1 Clearance of vegetation and habitat

Other than the possible clearance of 0.1 ha of the Eelgrass *Zostera* sp., should an outlet pipe for cooling water be constructed (see Section 12.5.6), no terrestrial vegetation or habitat clearance will be required for the Transformation.

#### 13.3.2 Effects of sulphur dioxide emissions on vegetation

Sulphur dioxide emissions have the potential to damage vegetation through foliar injury and disruption of metabolic or physiological processes (O’Connor *et al.* 1974). The tall stack emissions are the main source of SO₂ emanating from the smelter. Although there is
currently no clear evidence of air emissions having had adverse effects on vegetation around the smelter, subtle effects are likely to have occurred.

The Transformation will reduce the tall stack emissions of SO₂ by 90% (see Chapter 7). Consequently, the vegetation in the vicinity of the smelter will be exposed to significantly lower concentrations of SO₂ than at present. It is expected therefore that the condition of vegetation adjacent to the smelter will improve to some degree as a direct consequence of the Transformation.

13.3.3 Effects on fauna

The potential effects from the Transformation on fauna from noise and light are described in the following sections.

Noise

Increased noise can lower the value of habitat by disrupting the behaviour of fauna (e.g. Habib et al. 2007). Noise levels associated with the Transformation may increase to some degree during the construction phase, but would be similar to existing noise levels when construction is complete (Chapter 9). Noise emissions during construction may temporarily adversely affect fauna and reduce the value of habitat immediately adjacent to the smelter.

The effects of noise during construction on fauna are unlikely to result in a long-term reduction in habitat value near the smelter, particularly given the modified nature of the environment within and adjacent to the smelter. Noise modelling suggests that levels would be significantly attenuated within 500 m of the source.

The temporary reduction in habitat value immediately adjacent to the smelter resulting from construction noise would have negligible effect on the viability of fauna in the area.

Light

Artificial light at night can affect the foraging behaviour, predator prey interactions, reproduction, migration and social interactions of fauna (Rich and Longcore 2006). The amount of artificial lighting associated with the Transformation may temporarily increase during the construction phase, but would be similar to existing light emissions when construction is complete.

Depending on the types of lights used, the lights may attract large numbers of insects that would in turn provide foraging opportunities for bats, some birds and ground dwelling fauna. The effects, however, would be similar to existing light effects at the smelter are unlikely to result in a long-term reduction in habitat value near the smelter. Light spillage would be mitigated to some degree by using screens and directional lighting where appropriate.

The temporary reduction in habitat value immediately adjacent to the smelter resulting from light spill would have negligible effect on the viability of fauna in the area.
13.3.4 Effects on listed species and communities

Potential effects on listed terrestrial species are discussed collectively with marine and coastal species in Section 12.5.8 and Appendix F. There is negligible risk of listed terrestrial species being adversely affected by the project.

13.4 Conclusions

The following conclusions may be drawn concerning impacts on terrestrial flora and fauna communities.

- no vegetation or habitat removal will be required for the construction phase of the Transformation
- the Transformation will reduce the tall stack emissions of SO₂ by around 90%, and consequently, the health of the vegetation in the vicinity of the smelter may improve
- the temporary reduction in habitat value immediately adjacent to the smelter resulting from construction noise and light would have negligible effect on the viability of fauna in the area
- the risk of listed terrestrial species or communities being adversely affected by the Transformation is negligible.
14 Effects on transport and infrastructure

14.1 Introduction
The following section addresses the effects of the Transformation on transport and infrastructure, particularly those external to the smelter. Consideration has been given to the construction and operational phases of the Transformation.

14.2 Traffic and transport
Nyrstar Port Pirie can be accessed directly by road, rail and sea (Figure 14-1).

Road access, including heavy vehicle traffic, is from the Princess Highway to the Spencer Highway, Main Road and Ellen Street, with internal smelter roads from Ellen Street taking road traffic to the various parts of the smelter.

Rail access is via a rail line owned and operated by Genesee & Wyoming Australia Inc.

Sea access is via the Spencer Gulf with a shipping channel servicing the wharf facility. The shipping channel is 6.4 m deep, 90 m wide. The Port Pirie wharf facility is operated by Flinders Ports, which has a 99 year lease and port operating licence. Nyrstar currently subleases and operates Berths 8 and 9 to service the smelting operations.

Traffic and transport implications have been considered for the construction and operational phases of the Transformation.

14.2.1 Construction phase
Approximately 80% of the Transformation’s transport requirements during construction will be met using vessels carrying prefabricated modules by sea. The remaining 20% of equipment, materials and resources will be transported by road. Rail transport is not expected to be used for the construction phase of the Transformation.

Sea
The majority of material required for construction will be transported as modules by sea. Tug and barge combinations or self-propelled module carriers will be used to make scheduled deliveries over the course of the construction phase. They are capable of docking at the existing Port Pirie wharf facility at Berth 9. No wharf infrastructure changes are expected because of the Transformation.

Modules of varying size and configuration will be fabricated, fitted-out, tested and dry commissioned off-site. They will be transported complete with all equipment, cabling, instrumentation and piping.

Vessels berthing at the Port Pirie wharf facility range between 55 and 106 per year over the last ten years. Approximately 42 modules will be delivered in stages, with current project scheduling calling for two vessels per month carrying up to six modules each. Based on 2012 data the additional two vessels per month is within the historical range of shipping traffic to Port Pirie and is therefore unlikely to impact on the existing port operations.
Figure 14-1: Smelter access
Once the modules have been received at the wharf they will be transported directly to their final location or to a temporary laydown yard within the smelter using self-propelled hydraulic mobile trailers or similar transportation. The mobile trailers will travel via the wharf and internal smelter roads (Figure 14-2). Public roads will not be used for this process. Traffic impacts will not occur on public roads as a result of the on-shore module transport.
Figure 14-2: Module transport route from wharf to laydown yard
Road
Road transport will deliver equipment for demolition and construction purposes, minor construction materials including steel and concrete, and additional materials for module connection. Fuel for equipment will be delivered as required by mobile refuelling vehicles. Oversized loads are not anticipated, although road registered mobile cranes may be required for the positioning of the modules, and would access the smelter by road. These vehicles have no special requirements in terms of traffic management or infrastructure upgrades.

Nyrstar anticipates that buses will be used to transport construction personnel between their accommodation and the smelter, minimising traffic on public roads. This method has been used successfully during previous regular shutdowns.

Increased road traffic during the construction phase of the Transformation is likely to have intermittent and localised impacts in Port Pirie. It is estimated that construction phase road transport will increase road traffic by 20–40%. Impacts on public roads are expected to be negligible, particularly Main Road in Port Pirie. All parking requirements will be provided within the smelter. An appropriate traffic management plan will be developed prior to the construction phase to mitigate potential impacts. No modification to public traffic infrastructure will be required.

Car parking provisions
All car parking requirements for the construction and operational phases of the Transformation will be provided on-site. The construction workforce will be transported to the smelter by bus, minimising on-site car parking requirements.

Rail
Rail transport is not expected to be required for the construction phase of the Transformation. No impact on rail traffic is expected, and no rail infrastructure improvements will be required.

The type and volume of road traffic associated with the Transformation is not expected to impact the level crossings at or near Port Pirie.

14.2.2 Operational traffic
Operational traffic, via sea, road and rail will be similar to current traffic volumes.

Transport of product
No change to the transport of final product is anticipated. Product will continue to be transported by sea via the existing wharf facilities, which are suitable for the operational phase of the Transformation.

14.2.3 Transport infrastructure improvement requirements
At this stage of design and planning, no off-site transport infrastructure improvements are required to enable the construction or operational phases of the Transformation.
Construction modules, equipment and materials will be delivered by sea or road. The existing road transport infrastructure is suitable to service the types and volume of road traffic required for the construction and operational phases of the Transformation. In particular, the level crossings within Port Pirie are appropriate for the size, type and volume of traffic associated with the project and therefore do not require upgrading.

The temporary increase in traffic volume during the construction phase will be addressed through schedule management, with localised impacts addressed by a traffic management plan.

Vessels that are capable of entering and docking at the existing wharf facility will be used for module delivery during construction, and operational shipping will continue in the current manner. Therefore, no change to the current wharf facility will be required as a result of the Transformation.

It is not proposed to use rail transport for the construction phase of the project. No modification to existing rail infrastructure is required for the operational phase of the Transformation.

Some smelter roads and intersections will be upgraded as part of the Transformation to enable traffic movement of on-site and off-site visiting vehicles, including B-Double vehicles. Two lanes, with bi-directional vehicle access, are being considered for all new facilities.

### 14.3 Effects on infrastructure

Nyrstar Port Pirie is currently serviced by electricity, gas and water utilities and the smelter has sewerage infrastructure including a sewerage treatment facility.

#### 14.3.1 Water

Potable water requirements for the facility are supplied from Port Pirie mains water via an existing potable water ring main. The smelter currently uses approximately 5,167 kL per day.

In addition to the existing plant, the main uses of potable water will include the steam cogeneration facility and various facilities within the smelting process. Over the long term, the Transformation is expected to achieve a decrease in potable water requirements.

There may be a minimal increase in potable water required at the smelter for the construction phase of the Transformation, mainly associated with smelter's ablution blocks. At this stage of design, the existing potable water infrastructure can deliver an adequate supply for the construction and operational phases of the Transformation. This is unlikely to be any different to the current shutdown demand intensity.

#### 14.3.2 Gas

Natural gas mains supply to the Nyrstar Port Pirie Lead Smelter is provided at 700 kPa. The smelter currently consumes approximately 2,025,986 Nm$^3$ per month. The construction phase of the Transformation is not expected to impact on current gas demand.
During operations following the Transformation, gas demand will be higher than current use. New facilities consuming gas will include the cogeneration steam superheater, the EBS oxidation furnace standby burners, various burners for launder, taphole and ladle heating, and the acid facility pre-heater. If installed, an EBS reduction furnace and its standby burners will also consume additional gas.

Current estimates indicate that the existing gas infrastructure servicing the smelter is adequate to meet the increased demand for gas following the Transformation.

**14.3.3 Electricity**

Electricity is supplied to the smelter by SA Power Networks via the Allendale electricity substation. The smelter currently consumes approximately 300 MWh annually when operating at capacity.

Electricity demand during the construction phase of the project will be addressed through the use of generators. Following the Transformation, approximately 20 MW of additional electricity will be required, primarily for the EBS oxidation furnace and associated equipment and processes.

The pre-feasibility study has determined that the Allendale electricity substation is operating at capacity. Therefore new substation infrastructure and upstream augmentation will be required to meet the increased energy demands from the Transformation.

It is anticipated that a proportion of the additional electricity will be provided by a new cogeneration facility to be installed during the Transformation. The cogeneration facility will recover waste heat from EBS oxidation furnace and reduction furnace off-gas to produce electricity. High pressure steam, generated from the furnace waste heat boilers, will be superheated using a natural gas superheater. The superheated steam will then be converted to electricity by a condensing steam turbine and generator set. The cogeneration facility is expected to have a net operating electricity output of between 4.8 and 8.1 MW dependent on the configuration of the new equipment.

**14.3.4 Sewage**

The smelter is serviced by an on-site sewage treatment facility, where sewage is treated and used for irrigation purposes. There will be a temporary increase in sewage generation as a result of increased personnel involved with construction. The existing sewage system and sewage treatment facility is sufficient to meet this increased demand. No significant change in sewage volumes is expected as a result of operations following the Transformation.

**14.3.5 Stormwater**

All existing stormwater systems will remain functional during the construction and operational phases of the Transformation. Temporary stormwater control measures will be implemented during the construction phase of the project in accordance with the construction environmental management plan (CEMP).

Stormwater is discharged via the sedimentation pond through the 1M flume which is the licenced discharge point. The volume of stormwater generated as a result of the upgrade is
not expected to increase. Some changes will be made to stormwater infrastructure on-site during the Transformation. The new stormwater drains will connect into the existing infrastructure. The quantity of stormwater managed during and after the Transformation is not expected to vary significantly from typical seasonal volumes, which the existing system is designed to manage.

14.3.6 Communications

Communication systems which service the smelter are adequate to cope with the construction and operational phases of the Transformation and are not expected to be impacted or require upgrading.

14.3.7 Emergency services

During and following the Transformation, emergency services will continue in their current form. The smelter’s medical centre will be continuously staffed by a first aid attendant. The centre will continue to attend to minor incidents involving basic first aid, such as cuts, bruises and sprains etc. Incidents requiring first aid will be coordinated through the medical centre.

Serious incidents would be referred, through the medical centre, to the Port Pirie Regional Health Centre (Port Pirie Hospital). If required, an ambulance with paramedic staff can arrive at the smelter within approximately four minutes to transfer patients to the Port Pirie Hospital. Should the extent of injuries exceed the Hospital’s capability then patients would be flown to Adelaide for further treatment. If an incident involved fire or rescue, the Port Pirie Metropolitan Fire Service (MFS) would be engaged.

More serious incidents would be referred to an on-site Crisis Management Team that will also be continuously staffed. The Crisis Management Team will coordinate the response to serious incidents, such as serious injury, fire or infrastructure collapse.

During construction, the Transformation is not expected to require any additional personnel or resources with respect to emergency services. Following the Transformation, emergency response plans will be updated and additional hazard and risk analyses undertaken.
15 Sustainability and climate change

15.1 Introduction
The Transformation is focused on delivering an innovative and sustainable solution to the current environmental and technical challenges facing the smelter. This chapter discusses sustainability aspects of the Transformation.

Overview
The smelter has been in continuous operation since 1889, with many of the core production assets having been in service for up to sixty years. These assets are increasingly less capable of meeting the environmental and operational standards expected of a modern base metals facility.

The Transformation will involve the permanent decommissioning of a portion of the key infrastructure. Specifically the Transformation will replace the sinter plant with an EBS oxidation furnace, coupled to a heat recovery and electricity cogeneration facility and a modern sulphuric acid production facility. The project will facilitate recovery of materials from the intermediate storage area, improve concentrate storage handling, and introduce significant air hygiene improvements to the production process. Replacement of the blast furnace with an EBS reduction furnace is being considered: this

Sustainability, community health and environmental benefits and features of the Transformation include:

- significantly reducing airborne metal and dust emissions
- enclosing material transfer points and drafting emissions through a microfiltration baghouse
- substantially increasing capture of sulphur dioxide and conversion to useable sulphuric acid, significantly reducing instances of nuisance sulphur dioxide gas within the city of Port Pirie and the surrounding environment
- introducing a straight-through process
  - avoiding storage of large tonnages of metal-bearing intermediate materials on-site
  - eliminating a number of sources of metal dust being mobilised on high wind days
  - avoiding energy consumption involved with recirculating large tonnages of intermediate materials within the oxidation smelting process and around the smelter
- recovering energy from the oxidation smelting process, avoiding greenhouse gas emissions associated with equivalent energy generation from fossil fuels
- reducing carbon intensity from improving furnace design and energy efficiency and increasing sulphur dioxide capture and acid production
- reducing potable water consumption
- prefabricating construction modules off-site,
  - reducing construction waste and double handling of construction materials compared with in situ construction.
15.2 Auditing
Auditing of sustainability of activities will be conducted during the construction and operational phases of the Transformation.

A construction environmental management plan (CEMP) and an operations environmental management plan (OEMP) have been drafted (Appendices K and L) and will be finalised and implemented for the construction and operational phases of the Transformation, respectively. A Transformation environmental officer will conduct daily smelter inspections and scheduled internal audits of construction and commissioning activities to assess compliance with the CEMP and OEMP. Post-commissioning, the requirements of the OEMP will be incorporated into the Nyrstar Port Pirie environmental management system (EMS).

Nyrstar’s environmental management system is ISO 14001 certified, and is therefore regularly audited internally and externally against the ISO 14001 standard. The upgraded equipment associated with the Transformation will be incorporated into the EMS and will undergo regular review of environmental aspects and impacts, suitability of mitigation measures, and inclusion in regular internal and external auditing. The sustainability benefits of using ISO 14001 can include:

- reduced cost of waste management
- savings in consumption of energy and materials
- lower distribution costs
- improved corporate social responsibility, visible to regulators, customers and the public.

Nyrstar Port Pirie reports annually on sustainability performance under the National Greenhouse and Energy Reporting Scheme (NGERS) and National Pollution Inventory (NPI). NGERS and NPI reporting will continue post-Transformation and will include emissions associated with the upgraded processes.

15.3 Energy consumption
Efficient use of energy is central to sustainability and climate change mitigation. The Transformation will optimise energy consumption to maximise quality and quantity of products generated, while realising financial savings from energy efficiency.

15.3.1 Process mass balance
Energy efficiency during the operational phase is relative to the quantity of concentrate and residue to be processed and the quantity and quality of outputs generated. Figure 15-1 provides a simplified operational process flow diagram, with an indicative input and output mass balance for the facility. Processes affected by the Transformation are shown in green. Approximate masses involved are:

- 936,700 tpa smelting feed input
- outputs
- 638,400 tpa slag from the EBS oxidation furnace (which becomes feed for subsequent processes including the blast furnace)
- 262,000 tpa lead bullion from the blast furnace
- 293,580 tpa of acid from the acid facility
Smelter Operations –
Process Flow Diagram (option EBS + Blast Furnace)

Figure 15-1: Simplified process flow and mass balance, showing Transformation modifications in green
15.3.2 Energy efficiency

Energy efficiency gains as a result of the Transformation will include:

- avoidance of intermediate materials and the energy associated with processing them multiple times
- enclosure of the smelting process, retaining and concentrating heat
- recovery of heat energy and electricity cogeneration
- a reduction in greenhouse gas emissions per tonne of production.

15.3.3 Electricity

The Transformation will increase electricity demand by 20 MW per year. This demand will be supplemented by installing a heat recovery and electricity cogeneration facility. The cogeneration facility will have a net operating electricity output of between 4.8 and 8.1 MW dependent on the designed configuration.

The energy entrained in the waste heat produced by the oxidation smelting process is currently lost to atmosphere. The EBS oxidation furnace will generate off-gas of a higher temperature than the sinter process, making it economically feasible to capture the heat and convert it to electricity.

15.4 Climate change mitigation

Nyrstar Port Pirie seeks to contribute to South Australia’s climate change mitigation measures by minimising the emissions intensity of its operations.

During construction of the Transformation, emissions of greenhouse gas will be generated by combustion of fossil fuels by fixed or mobile equipment, including vehicles. Greenhouse gas emissions from the construction phase will be insignificant when compared with historical and post-Transformation greenhouse gas emissions of the smelting operation. Construction emissions are minimal, and would not differentiate the Transformation from current operations.

Operation of the upgraded process facilities will generate greenhouse gas emissions by operation of mobile equipment, and through combustion of coke, coal and natural gas in the smelting process. The EBS oxidation furnace will operate at a higher temperature than the sinter process, but will have efficiency benefits due to being enclosed, enabling the efficient capture of sulphur dioxide and heat, and generating high enough heat to enable cogeneration.

Post-Transformation operational greenhouse gas emissions were estimated in accordance with the National Greenhouse and Energy Reporting Act 2007 (NGER Act 2007) and associated guidelines. Annual greenhouse gas emissions will be approximately 500 kt of carbon dioxide equivalent emissions (ktCO₂-e). This is an increase in carbon footprint from approximately 350 kt (assuming the facility is operating at capacity).

Assuming an operational life of 30 years for Nyrstar Port Pirie, the greenhouse gas emissions for the lifetime of the facility would be approximately 15 Mt CO₂-e. This is a theoretical estimation, as in practice many parameters will change over those 30 years of life.
Carbon intensity is a measure of carbon emissions per unit of production. The current facility would generate approximately 350 ktCO₂-e emissions to produce 365 kt of product, giving a carbon intensity of approximately 0.96 tCO₂-e/tonne of product.

While the carbon emissions will be higher following the Transformation, more product will be made. The higher carbon emissions of 500 ktCO₂-e will be generated in the manufacture of almost 600 kt of product, including lead, zinc, copper, sulphuric acid, silver and gold. Therefore the carbon intensity of Nyrstar Port Pirie following the Transformation will be approximately 0.84 tCO₂-e/tonne of product, 0.12 tCO₂-e/tonne of product lower than the carbon intensity of current operations.

The significant change in production volumes is primarily due to higher volumes of sulphuric acid manufacture. This is enabled by the capture of over three times as much sulphur dioxide from the EBS oxidation furnace as was possible from the sinter plant, and the ability of the modern acid production facility to convert more of the captured sulphur dioxide into acid than the current facility can achieve.

The Transformation will deliver significant reductions in sulphur dioxide emissions, and major improvements in the air quality of Port Pirie, as well as reducing carbon intensity.

15.5 Climate change adaptation

Nyrstar Port Pirie has considered climate change adaptation in designs for the Transformation. Like Port Pirie, the smelter is on low lying land adjacent to the Port Pirie River. The elevation of the smelter varies from 2 m above Australian Height Datum (AHD) to 14 m AHD.

Due to these low elevations, flooding by coastal inundation is an issue for the Port Pirie Regional Council (PPRC) and Nyrstar. Inundation of some operational, although non-plant, areas of the smelter has occurred in the past during king tides, especially when accompanied with storm surges and/or high river flows. King tides have been observed to reach in excess of 1.7 m AHD (BlueSphere 2012).

The Inter-governmental Panel on Climate Change (IPCC) has modelled global climate and climate influences and produced scenarios of accelerated sea level rise. Based on this work, South Australia’s Coastal Protection Board recommends that a mid-range sea level rise of 0.3 m by 2050 be assumed for South Australia. Additionally, the IPCC has emphasised increased magnitude and frequency of extreme events, such as storm surges, as part of the likely climate change scenarios (Coastal Protection Board 2004).

DEWNR has recommended that, to meet the requirements of the Coastal Protection Board’s minimum site levels and floor levels for coastal developments, the site be raised by a further 0.7 m or be practically protected against a further 0.7 m of sea level rise (T. Huppatz, 2013, pers. comm., 14 June 2013). Where raising a site is impractical, such as at Nyrstar Port Pirie, DEWNR may accept an alternative management option. A levee bank is an alternative and acceptable option to protect from sea level rise and wave effects (T. Huppatz, 2013, pers. comm., 14 June 2013).
PPRC have constructed a levee bank to protect various areas of the city, including the CBD, from coastal inundation. Nyrstar is currently investigating the best options for extension of the PPRC levee into the smelter’s boundaries as part of the Site Levee Bank project. The options under consideration will protect the smelter from inundation, the CBD against floodwaters flowing through the smelter and the possibility of contaminated liquors entering the Port Pirie River as floodwaters ebb. The location of the proposed levee bank is shown in Figure 15-2. Nyrstar will continue to work with the PPRC to address this issue.

Climate change adaptation is an ongoing issue that is being addressed by the Site Levee Bank project, separate from the Transformation.

### 15.6 Water usage

The current operation consumes approximately 5,164 m$^3$ per day of potable water. The Transformation is expected to achieve a reduction in potable water requirements of up to 1,300 m$^3$/day dependent on final configuration.

In addition to potable water, five water systems are associated with the upgraded facility as follows:

- sea water for the cooling system
- process water
- Process Effluent Treatment System (PETS) water
- demineralised water
• sewage treatment system.

These systems form the major components of a complex system of water use and recycling at Nyrstar Port Pirie. The cooling water system is a single pass system and the sewage is treated and redeployed for irrigation. The process water, PETS water and demineralised water are recirculated and recycled through the various process facilities, wastes from one system providing inputs to another. This process of recirculation, recycling and feeding between the various systems reduces potable water consumption and treated process wastewater discharge.

At present rainwater harvesting is not included as part of the scope of the Transformation, although other initiatives for rainwater and stormwater harvesting are being investigated.
16 Hazard and risk management

16.1 Introduction
This chapter summarises Nyrstar’s existing risk management framework and discusses the framework’s relevance and application to the Transformation. Specific risks during construction and operation are highlighted along with their proposed risk mitigation measures.

16.2 Established risk management
Nyrstar has an established risk management framework aligned with AS/NZS ISO 31000:2009 — as would be expected of an internationally listed company. It has embedded systems of management, governance, standards and guidelines integral to the identification, assessment and continued management of risk.

Management is responsible for evaluating existing controls and the control effectiveness and determines whether the level of risk being accepted is consistent with the level of risk approved by the board of directors.

Management takes action where it is determined that the Company is being exposed to unacceptable levels of risk and actively encourages all Nyrstar employees to communicate freely risks and opportunities identified.

The Transformation is, in itself, an outcome of sound risk management principles. Its design and implementation aims to reduce the long term risk exposure to the local community, whilst delivering beneficial economic and social outcomes for the local population.

16.3 Risk evaluation
To identify, assess and manage the risks associated with the project, a risk assessment was necessary, with outcomes documented in a risk profile. The risk assessment (Appendix G) consisted of a series of semi-quantitative risk workshops facilitated by a risk management consultant from COOE Pty Ltd. The risk workshop panel included environmental specialists external to Nyrstar and with knowledge of the Transformation and Port Pirie area, as well as project managers from Nyrstar. The use of a single risk consultant enabled consistency across the workshops and in the compilation of the risk profile.

To aid in the identification of potential significant risks, the approach to the workshop was aligned with the risk management process ISO 31000:2009 (Figure 16-1), as follows:

- **Establish the Context**
  - identified the scope of the profile and the activities involved with the project
- **Risk Identification**
  - identified potential events, during each activity, with the ability to impact the environment
- **Risk Analysis and Risk Evaluation**

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assessed the most likely consequences of each potential event and the likelihood of the event occurring
potential synergistic effects are considered for multiple risk events, where the combined risk of two or more independent events may be more than the sum of the individual risks
• Risk Treatment
  o where the inherent level of risk for an event was assessed as intolerable, identified appropriate control measures until the residual risk was reduced to a level that was acceptable
• Monitoring and Review
  o identified appropriate tracking mechanisms to monitor implementation of agreed controls.

Risk management process

Figure 16-1: Risk management process (AS/NZS ISO 31000:2009)

Those activities which were identified as having the potential to impact the environment or local community were included in the risk profile. Due to the scope and intent of this Public Environmental Report, where operational risks and occupational health and safety risks were
identified, yet had no impact on the environment or community, these were excluded from this risk profile but noted for inclusion on separate risk profiles. This approach was deemed appropriate since both risk types have risk management systems already established within the business (Section 16.2).

The reference tables used for the risk assessment (Table 16–1 and Table 16–2) were taken from the corporate risk assessment criteria currently in use within Nyrstar. Utilising these existing tables in the workshop provided the benefit of increased ease at transferring assessed risks into existing project risk profiles as well as the high degree of familiarity that many of the workshop participants had with the tables from previous use.

Consequence levels were chosen on the basis of the expected (most likely) impact on the environment. Emphasis was placed on the Environment and Community consequence criteria due to the nature of risk profile. Although consideration was given to the other criteria classifications, they did not drive the overall consequence level since it was deemed that these were more operational concerns and would not have aided in informing the community.

Some activities or events were considered where the activity would not proceed unless the fundamental design of the associated infrastructure was inherently safe. Where inherently safe designs were required as a consideration or assumption, these were noted in the risk identification section of the risk profile.
<table>
<thead>
<tr>
<th>Level</th>
<th>Financial (EBITDA)</th>
<th>Growth (NPV)</th>
<th>People</th>
<th>Environment and community</th>
<th>Reputation</th>
<th>Legal</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>&gt;€100m loss or gain</td>
<td>&gt;€500m loss or gain</td>
<td>Multiple fatalities or significant irreversible effects on 10’s of people</td>
<td>Regional and long term impact on an area of significant environmental value. Destruction of an important population of plants and animals with recognised conservation value. Complete remediation impossible. Complete loss of trust by affected community threatening the continued viability of the business</td>
<td>Prominent International media coverage. Long term impact on share price. Leads to changes at NMC or Board level.</td>
<td>Public inquiry taking up considerable resources and Executive management time. Major litigation or prosecution with damages/fines of &gt;€50m+ plus significant costs. Custodial sentence for a manager. Suspension of shares by the FSMA.</td>
</tr>
<tr>
<td>5</td>
<td>&gt;€10m, &lt;€100m loss or gain</td>
<td>&gt;€50m - &lt;€500m loss or gain</td>
<td>Single fatality and/or severe irreversible disability to one or more persons</td>
<td>Destruction of an important population of plants or animals or of an area of significant environmental value. Complete remediation not practical or possible. Long-term community unrest and outrage significantly impacting business performance</td>
<td>National media coverage over several days. Shareholders and Board exercise control. Potential for class action. Major customers cancel key contracts.</td>
<td>Major litigation or prosecution with damages or fines of &lt;€50m+ plus significant costs. Imposition of a fine by the FSMA. Major breach of regulation leading to cancellation of operating license.</td>
</tr>
<tr>
<td>Level</td>
<td>Monetary Thresholds</td>
<td>Extent of Impact</td>
<td>Consequences</td>
<td>Mitigation Activities</td>
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<td>4</td>
<td>&gt;€1m, &lt;€10m loss or gain</td>
<td>Extensive injuries/illnesses or irreversible disability or impairment to one or more persons</td>
<td>Extensive and medium-term impact to an area, plants or animals of recognised environmental value. Remediation possible but may be difficult or expensive. Community protest requiring intervention and substantial management attention</td>
<td>State media coverage over several days. Publicly disclosed involvement by regulator(s). Litigation or prosecution costing &lt;€5m or involving substantial management time (Manager level and above). Publishing of a warning by the FSMA. Breach of regulation leading to suspension of operating license.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>&gt;€100k, &lt;€1m loss or gain</td>
<td>Medium term reversible disability to one or more persons. Significant medical treatment, disabling or lost time injury</td>
<td>Localised and medium term impact to areas, plants or animals of significant environmental value. Remediation may be difficult or expensive. Persistent community complaints</td>
<td>State media coverage. Interest by regulator(s) and NGOs. Major breach of regulation with punitive fine. Involvement of senior management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>&gt;€10k, &lt;€100k loss or gain</td>
<td>Recordable injuries or illnesses with up to one week of job restrictions or lost time</td>
<td>Localised and short term impact to an area, plants or animals of environmental value. Minor remediation is required. Complaints from interested parties</td>
<td>Local media coverage interest by local NGOs. One or two community complaints. Breach of regulation with investigation or report to authority with possible prosecution and fine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>&lt;€10k loss or gain</td>
<td>Minor injury or illness, first aid or medical treatment without job restrictions</td>
<td>Localised and short term environmental or community impact requiring no or very minor remediation</td>
<td>Kept on site. No media or community interest. Minor legal issues, non-compliances and breaches of regulation.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Legend:**
- "<" and "<" signify less than.
- "<" and "<" signify less than or equal to.
- "<" and "<" signify less than or equal to.
Likelihood refers to the probability of frequency of an event occurring. The likelihood category was selected on the basis of the chance that the environment could be affected at the chosen level of consequence.

**Table 16–2: Risk Likelihood**

<table>
<thead>
<tr>
<th>Level</th>
<th>Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Is expected to occur in most circumstances, or could occur within days to weeks</td>
</tr>
<tr>
<td>E</td>
<td>Could occur in most circumstances, or could occur within weeks to months</td>
</tr>
<tr>
<td>D</td>
<td>Has occurred before in Nyrstar, or could occur within months to years</td>
</tr>
<tr>
<td>C</td>
<td>Has occurred before in the industry, or could occur within the next few years</td>
</tr>
<tr>
<td>B</td>
<td>Has occurred elsewhere, or could occur within decades</td>
</tr>
<tr>
<td>A</td>
<td>Requires exceptional circumstances and is unlikely, even in the long term or only occurs as a “100 year event”</td>
</tr>
</tbody>
</table>

A matrix combining consequence and likelihood levels is used to establish the overall risk level. The Risk Matrix (Table 16–3) shows risk levels from low to very high and determines the level of response required to adequately manage the risk.

**Table 16–3: Risk matrix**

<table>
<thead>
<tr>
<th>Likelihood Rating</th>
<th>Consequences</th>
</tr>
</thead>
<tbody>
<tr>
<td>F</td>
<td>Medium</td>
</tr>
<tr>
<td>E</td>
<td>Low</td>
</tr>
<tr>
<td>D</td>
<td>Low</td>
</tr>
<tr>
<td>C</td>
<td>Low</td>
</tr>
<tr>
<td>B</td>
<td>Low</td>
</tr>
<tr>
<td>A</td>
<td>Low</td>
</tr>
</tbody>
</table>

In total, 64 unique and inherent risks were identified during the workshop. These risks were identified as having a potential impact to the environment if not mitigated. Of these 64 inherent risks, 13 risks were identified as having an unacceptable (high) potential risk to the
environment, and 27 risks were identified as acceptable (medium) but would require ongoing monitoring.

Importantly, of all 64 unique risks identified, all were assessed and managed to an acceptable residual/mitigated risk level where a status of ALARP (as low as reasonably practicable) was achieved. This was achieved via design criteria, management plans or existing monitoring procedures and protocol.

Risks mitigated through the implementation of controls will have an associated tracking mechanism to monitor effectiveness of implemented controls.

16.4 Construction

The construction phase presents risks for Nyrstar as the Transformation transitions the plant from its current state to an up-to-date, safer, and more efficient mode of operation.

The risk profile highlights many of the legacy issues that the plant faces from its many decades of operation. These issues are well known by Nyrstar, the local community and external agencies. Nyrstar’s partnerships with environmental specialists and the ever increasing availability of technology and techniques in construction, will allow Nyrstar to manage risks to an acceptable level.

Environmental impacts on air, soil and water quality will be tracked using the existing environmental monitoring program already in place in the plant and in the surrounding area.

Several risks were identified for the construction phase that may impact upon acid sulphate soils and groundwater in the area. Mitigation and control measures are being designed with environmental consultants. The existing environmental monitoring program will be leveraged to monitor and track the efficacy of implemented control measures and achievement of expected outcomes.

Though no unique hazardous materials or dangerous substances were identified during the risk assessment, storage arrangements for existing materials and any new materials will be managed according to existing Nyrstar procedures and guidelines for hazardous materials.

The smelter is an industrial site closed to the general public. Nyrstar have safety systems in place to facilitate the safe management and control of personnel onto the smelter, their safety and site inductions and, where required, escort. Safety of all personnel on-site will continue to be managed under Nyrstar’s existing Occupation Health and Safety Management system.

16.5 Operation

The PER outlines the reduced risks to the community from operating the new facility. However, Appendix G highlights several risks inherent in the operation of the new facility that will require ongoing management.

Where these can be mitigated through better engineering they have been recorded and are to form the basis of further discussion at the design phase. Other risks are inherent to the design of the facility and require further mitigation. Where a control measure is required to
mitigate the risk to an acceptable level, a corresponding tracking mechanism has been identified to monitor the ongoing implementation of that particular control measure.

The prevention, management and mitigation of spills or leaks will remain an ongoing activity for Nyrstar. Current practices to prevent environmental contamination will be augmented by the Transformation outcomes, which currently include improvements to bunding, water collection and re-use pits. The expectation remains that there is no further significant contamination to the environment and the existing environmental monitoring program will be used to track and monitor the achievement of these outcomes.

### 16.6 Seismic risks

The preliminary design analysis that Nyrstar has undertaken for each of the major structures for the Transformation have considered all principal loading conditions (including earthquake loading) and the required load combinations in accordance with the relevant Australian codes.

### 16.7 Proposed risk management

Risk management is an ongoing process and as the project progresses and information becomes available, or changes, the relevant risk profiles will be managed through Nyrstar’s existing risk management framework.

The controls required to mitigate all risks to a level acceptable for stakeholders were discussed, agreed and recorded in the risk profile. Alongside each risk, the environmental outcomes expected during the Transformation were recorded, along with the tracking mechanisms necessary to monitor these commitments.

These expected environmental outcomes, controls and mechanisms for tracking will be used to inform the strategies, which will be documented in the Environmental Management Plan. To enable ongoing management of the risks and implementation at the project level, the risks identified in the annex will be transferred to the relevant project risk register for the relevant project phase.

### 16.8 Proponent’s commitment

Nyrstar is committed to the operation of the smelter with minimal risks to the surrounding environment. The Transformation offers very significant improvement to the smelter’s environmental performance including the halving of lead-based emissions and a ten-fold reduction of SO$_2$ emissions from the tall stack. There are also a number of other environmental performance improvements outlined in this PER.

This hazard and risk identification process has identified a number of control measures to enable mitigation of risks to an acceptable level. The implementation of these control measures is achievable and practical, and where the residual risk levels are medium, there will be ongoing environmental performance monitoring and implementation of trigger mechanisms should they be required.
17 Waste management

17.1 Introduction
This chapter describes the waste management and recycling practices and procedures currently operating at the smelter. It then outlines the waste management strategies for the construction and operational phases of the project and discusses how the waste hierarchy principals will be incorporated.

17.2 Existing waste management
As described in Chapter 3, the smelter is licenced by the EPA for a variety of waste management and recycling activities (EPA licence 775). Nyrstar’s existing procedure — Nyrstar Port Pirie Procedure: Recycling and Waste Management — describes how site-generated waste material is appropriately recycled or disposed of, to comply with company standards and the EPA licence. The procedure applies to the collection, recycling and disposal of waste across the smelter and refers to other Nyrstar procedures including:

- landfill management
- asbestos and synthetic mineral fibres
- asbestos removal and disposal permit
- waste transport certificates
- waste oil and grease disposal
- office paper recycling
- scrap metal recycling.

Nyrstar manages on-site waste according to a waste management hierarchy that prescribes a preferred order of waste management practices. The order, from most to least preferred, is: avoid, reduce, reuse, recycle, recover, treat and dispose. Nyrstar have a significant number of waste streams and many of these are reused or recycled on-site.

17.2.1 Landfill management
The smelter contains a licenced landfill occupying approximately 17,000 m$^2$ which accepts solid industrial waste generated by the smelter as well as minor amounts of putrescible food wastes that are collected from crib rooms and a separate dedicated and licenced cell accepts waste asbestos.

A survey of the landfill was conducted in November 2009 to develop a proposed final contour plan and determine the airspace remaining. The landfill’s available airspace was calculated to be 34,000 m$^3$ and so has an expected life in excess of 10 years based on current filling rates. The current waste disposal rate is approximately 1,000 tonnes per annum.

17.3 Construction wastes
Due to the proposed construction methodology of prefabricated modules, construction waste will be minimised. Construction wastes will mainly arise from decommissioning, demolition and civil works associated with the preparation of the smelter for module installation, and from construction of the additional sea water intake.
17.3.1 Modular construction

The majority of the equipment associated with the upgrade will be fabricated in modules, and fitted out at the manufacturers’ premises. The modules will be delivered in the sequence that they are required.

The modules will be shipped to the smelter via the Port Pirie wharf facility, off loaded and transported into their final location (via the temporary laydown yard when required). The modules will be levelled, grouted in position and interconnecting piping, cables and instrumentation will be installed.

The prefabrication of modules significantly reduces construction waste and impact on the environment, aligning this construction methodology with sustainability principals. Prefabrication has been shown to reduce construction waste by over 50% (Jaillon et al. 2009).

17.3.2 Demolition

Some existing structures and/or equipment will become redundant and be decommissioned during the Transformation. Demolition of some structures will entail the removal of the structure while leaving the foundations, while others will also require removal of the foundations. Some redundant buildings will be left standing to be reused for an alternative purpose or removed at a later date.

Demolished materials will be salvaged for reuse or recycling where possible. They will be separated into waste streams and stockpiled on-site. Materials that cannot be reused or recycled will be disposed of at the smelter’s landfill.

Steel and concrete from decommissioning and demolition will form the bulk of the waste generated during the construction phase. An estimate of the volume of these wastes is provided in Table 17–1, along with the amount of asbestos proposed to be removed.

Table 17–1: Major construction wastes

<table>
<thead>
<tr>
<th>Waste</th>
<th>Amount</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>582 Tonnes</td>
</tr>
<tr>
<td>Concrete</td>
<td>1980 m³</td>
</tr>
<tr>
<td>Asbestos</td>
<td>1500 m²</td>
</tr>
</tbody>
</table>

17.3.3 Earthworks

Excavations will be required for various purposes, including for cabling, pipe work and footings. Excavations will generate waste spoil which will be stockpiled at the smelter. A range of management options may be employed to deal with waste spoil including decontamination (if required), processing through the smelter to recover metals or use as fill elsewhere on-site. Earthworks will be undertaken in consultation with the voluntarily appointed SA EPA accredited Contamination Auditor.
17.3.4 Contaminated wastes

Wastes from the decommissioning, demolition and earthworks associated with the construction phase may be contaminated. The bulk of these wastes including steel, concrete, and spoil can be decontaminated, reused or recycled on-site. Metals can be recovered from some materials, such as spoil, by processing through the smelter.

17.3.5 Summary

A summary of the wastes likely to be generated, their sources and planned management measures is presented in Table 17–2.

**Table 17–2: Construction waste summary**

<table>
<thead>
<tr>
<th>Waste</th>
<th>Sources</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steel</td>
<td>Demolished equipment and buildings</td>
<td>Recycle</td>
</tr>
<tr>
<td>Concrete</td>
<td>Demolished footings, over pour</td>
<td>Recycle</td>
</tr>
<tr>
<td>Spoil</td>
<td>Excavations for footings, pipes and cabling, and road upgrades</td>
<td>Decontaminate (process to recover metals)</td>
</tr>
<tr>
<td>Wood</td>
<td>Buildings, formwork</td>
<td>Chipping and mulch for revegetation on-site</td>
</tr>
<tr>
<td>Asbestos</td>
<td>Demolished equipment and buildings</td>
<td>In accordance with the smelter Asbestos Management Procedure¹</td>
</tr>
<tr>
<td>Cardboard</td>
<td>Packaging</td>
<td>Recycle</td>
</tr>
<tr>
<td>Plastics</td>
<td>Packaging</td>
<td>Recycle, disposal</td>
</tr>
<tr>
<td>Cabling</td>
<td>Infrastructure</td>
<td>Recycle, disposal</td>
</tr>
<tr>
<td>General mixed waste</td>
<td>Construction, cribs, abolition areas</td>
<td>Recycle, disposal</td>
</tr>
<tr>
<td>Oil and grease (including filters)</td>
<td>Vehicle and equipment maintenance</td>
<td>Recycle, disposal</td>
</tr>
</tbody>
</table>

¹Nyrstar is licenced to remove and dispose of Asbestos at the smelter.

In accordance with the smelter’s EPA Licence (775), there is a landfill on-site, part of which is licenced to receive asbestos. Materials that are unable to be reused or recycled will be deposited in the smelter’s landfill in accordance with Nyrstar’s Landfill Management Procedure.

17.4 Operational wastes

The major operational waste stream from Nyrstar Port Pirie is spent slag, which is on-sold. There will be no additional operational wastes associated with the Transformation.

The Transformation is focused on the upgrade of the primary lead smelting process. Outputs from the transformed process will provide feed for the refinery, and copper and zinc production processes.

Process water from the new facilities will be transferred to the existing Process Effluent Treatment System (PETS), which removes contaminants including metals. Treated water is returned to the process water system for reuse, or discharges via the sedimentation ponds and the licenced discharge from smelter.
The Transformation includes the construction and operation of an additional sea water cooling system. This system will be a single pass non-contact heat exchanger and includes a trim cooler to adjust the sea water return temperature. The potential impact of heat emissions on the marine environment and controls are discussed in Chapter 12. General maintenance wastes, such as grease, oil and packaging, will continue to be generated and managed in accordance with existing smelter waste management protocols.
18 Environmental management

18.1 Introduction

Nyrstar Port Pirie operates an Environmental Management System (EMS) certified to Australian Standards (AS/NZS ISO 14001, 2004). Transformation activities, from construction to the operational phase, will be managed through the development and implementation of Environmental Management Plans (EMP) aligning with the existing management systems.

A separate construction environmental management plan (CEMP) and an operations environmental management plan (OEMP) will be developed prior to commencement of the relevant phase. These will incorporate specific control measures designed to suit the plant and equipment selected in the final design. Both the CEMP and OEMP will address comments from the public review and approvals process.

The CEMP and OEMP will describe the controls proposed to prevent, monitor and manage potential impacts and will be incorporated with the existing Environmental Monitoring and Reporting Program (EMRP). The CEMP, OEMP and modified EMRP will be integrated into the Nyrstar EMS and submitted to relevant authorities for approval prior to the commencement of each phase.

A draft construction environmental management plan (draft CEMP) and a draft operations environmental management plan (draft OEMP), have been developed to provide a basis for the public review and approvals process. These are provided in Appendix J and Appendix K and summarised in the following sections.

18.2 Draft construction environmental management plan

The draft CEMP outlines the responsibilities of the Nyrstar Project Manager in protecting the community and environment during the construction phase (including decommissioning, demolition and construction activities). The draft CEMP provides a framework for the implementation of appropriate control measures and practices to achieve risk levels that are as low as reasonably practicable (ALARP).

The aim of the draft CEMP is to provide a framework of proposed environmental management and monitoring during construction activities of the Transformation, as identified from the Risk Assessment (Chapter 16). The draft CEMP will feed into the final CEMP to implement the strategies and control measures identified during the PER Risk Assessment.

The draft CEMP addresses the following:

- background and smelter summary information
- roles and responsibilities of parties involved
- regulatory, licensing and legislative requirements
- identification of potential environmental and social aspects
- identification of quality control measures to manage impacts and achieve risk levels ALARP for each aspect.
Health and safety requirements for employees and organisational risks will be addressed by updating the current operational Nyrstar Management System information.

18.2.1 Responsibilities for implementing the draft CEMP

The following responsibilities have been assigned:

**Nyrstar Project Manager**
- Overview the implementation of the draft CEMP and the development and implementation of the CEMP.
- Allocate sufficient funds and resources to fully implement every component of the CEMP.

**Contractors**
- Contribute to the development of the CEMP to ensure that every environmental aspect covered in the draft CEMP is fully incorporated.
- The contractor is responsible for any environmental or social impacts attributed to any work, plant and equipment that fall within the boundaries of their contract.
- Ensure Nyrstar’s intent to significantly reduce the current environmental and social impacts during and after construction.

**Consultants**
- Contribute to the development of the CEMP to ensure that every environmental aspect covered in the draft CEMP is fully incorporated.
- The consultant is responsible for any environmental or social impacts that may be attributable to specialist advice that they provide.
- Ensure Nyrstar’s intent to significantly reduce the current environmental and social impacts during and after construction.

**Supervisors**
- All supervisors are responsible for implementing the control measures and, directly or through specially trained environmental specialists, monitor that the management systems are working as intended.

**Employees**
- All persons working on the construction of the Transformation are responsible for understanding the environmental and social management systems.
- All persons working on the construction phase will fully understand and implement the control measures and follow the procedures associated with their work.

18.2.2 Management objectives during the construction phase

The Risk Assessment (Chapter 16) identified 11 environmental and social aspects that are potentially at risk and in need of continual control measures. The draft CEMP specifies activities and procedures or strategies that will be employed to achieve the objectives identified for each aspect as summarised below.

- Air Quality
Air quality is maintained within current levels by prevention of lead emissions from any additional sources during the construction phase.

To be in compliance with site-specific South Australian EPA Licence agreements.

To receive no complaints from adjoining commercial/industrial neighbours or smelter personnel.

- **By-products and waste**
  - To prevent any spills or leakage.
  - To minimise impacts on existing waste facilities.
  - To minimise environmental impacts associated with waste generation and accidental spills.
  - To maximise waste minimisation, recycling, reuse and recovery.

- **Community health**
  - To reduce lead, sulphur dioxide and particulate emissions to below current levels.
  - To be in compliance with the relevant State regulatory instruments, namely Environment Protection (Air Quality) Policy 1994.
  - To be in compliance with site-specific South Australian EPA Licence agreements.
  - Community amenity
  - To receive no community amenity complaints.

- **Noise**
  - To receive no noise complaints from the community.

- **Natural resources**
  - Achieve no adverse impacts on flora and fauna from the Transformation.
  - To be in compliance with the relevant State regulations.
  - To be in compliance with site-specific South Australian EPA Licence agreements.

- **Sub-surface soil quality**
  - To achieve no adverse impacts to soil from the Transformation.
  - To be in compliance with site-specific South Australian EPA Licence agreements.
  - Water quality
  - To achieve no contamination of surface water from the Transformation.
  - To be in compliance with site-specific South Australian EPA Licence agreements.

- **Groundwater**
  - To achieve no contamination of groundwater from the Transformation.
To be in compliance with site-specific South Australian EPA Licence agreements.

- Vibration
  - To receive no complaints relating to vibration from the community.
  - Visual amenity
  - To receive no visual amenity complaints from the community.

### 18.3 Draft operations environmental management plan

The draft OEMP outlines the responsibilities of the Nyrstar Project Manager in protecting the community and environment during the Operational Phase (commissioning, operations and maintenance). The draft OEMP provides a framework for the implementation of appropriate control measures and practices to achieve risk levels that are as low as reasonably practicable (ALARP).

The aim of the draft OEMP is to provide a framework of environmental management and monitoring proposed for the Transformation post-construction, as identified from the Risk Assessment (Chapter 16). The draft OEMP is intended to be a precursor for the OEMP, which is designed to provide strategies and control measures identified during the PER Risk Assessment to protect the community and environment.

The draft OEMP addresses the following:

- background and smelter summary information
- roles and responsibilities of parties involved
- regulatory, licensing and legislative requirements
- identification of potential environmental and social aspects
- identification of quality control measures to manage impacts and achieve risk levels ALARP for each aspect.

Health and safety requirements for employees and organisational risks will be addressed by upgrading the current operational Nyrstar Management System.

#### 18.3.1 Responsibilities for implementing the draft OEMP

The following responsibilities have been assigned:

**Project Manager**

- Overview the implementation of the draft OEMP and the development and implementation of the OEMP.
- Allocate sufficient funds and resources to fully implement every component of the OEMP.

**Contractor**

- Contribute to the development of the OEMP to ensure that every environmental aspect covered in the draft OEMP is fully incorporated.
- The contractor is responsible for any environmental or social impacts attributed to any work, facility and equipment that fall within their contract.
• Ensure Nyrstar’s intent to significantly reduce the current environmental and social impacts.

**Consultant**

• Contribute to the development of the OEMP to ensure that every environmental aspect covered in the draft OEMP is fully incorporated.
• The consultant is responsible for any environmental or social impacts that may be attributable to specialist advice that they provide.
• Ensure Nyrstar’s intent to significantly reduce the current environmental and social impacts.

**Supervisors**

• All supervisors are responsible for implementing the control measures and directly or through specially trained environmental specialist monitor that the management systems are working as intended.

**Employees**

• All employees are responsible for understanding the environmental and social management systems.
• All employees will fully understand and implement the control measures and follow the procedures associated with their work.

18.3.2 Management objectives during the operational phase

The Risk Assessment (Chapter 16) identified a number of environmental and social aspects that are potentially at risk. The draft OEMP specifies activities and procedures or strategies that will be employed to achieve the objectives identified for each aspect, as summarised below.

• Air Quality
  o To reduce lead, sulphur dioxide and particulate emissions to below the current levels and to be in compliance with the relevant State regulatory instruments, namely Environment Protection (Air Quality) Policy 1994.
  o To be in compliance with site-specific South Australian EPA Licence agreements.
  o To receive no complaints from adjoining commercial/industrial neighbours or smelter personnel.

• By-product and waste generation
  o To prevent any spills or leakage.
  o To minimise impacts on existing waste facilities.
  o To minimise environmental impacts associated with waste generation and accidental spills.
  o To maximise waste minimisation, recycling, reuse and recovery.

• Community health
  o To reduce lead, sulphur dioxide and particulate emissions to below current levels.
o To be in compliance with the relevant State regulatory instruments, namely Environment Protection (Air Quality) Policy 1994.
  o To be in compliance with site-specific South Australian EPA Licence agreements.
  
- Community amenity
  o To receive no noise, odour or visual amenity complaints from the community.
  o To not adversely affect Port Pirie skyline, beyond that outlined in the Port Pirie (Regional Council) Development Plan (DPTI, 2013).
  
- Noise
  o No receive no noise complaints from the community.
  
- Natural resources
  o No achieve no adverse impacts on flora and fauna from the Transformation.
  o To be in compliance with the relevant State regulations.
  o To be in compliance with site-specific South Australian EPA Licence agreements.
  
- Odour
  o To be in compliance with relevant State regulatory instruments, namely Environment Protection (Air Quality) Policy 1994.
  o To receive no complaints of odour from the community.
  
- Sub-surface soil quality
  o To achieve no adverse impacts on soil from the Transformation.
  o To be in compliance with site-specific South Australian EPA Licence agreements.
  
- Surface water quality
  o To achieve no contamination of surface water from the Transformation.
  o To be in compliance with relevant State regulatory instruments, namely Environment Protection (Water Quality) Policy 2003.
  o To be in compliance with site-specific South Australian EPA Licence agreements.
  
- Groundwater
  o To achieve no contamination of groundwater from the Transformation.
  o To be in compliance with relevant State regulatory instruments, namely Environment Protection (Water Quality) Policy 2003.
  o To be in compliance with site-specific South Australian EPA Licence agreements.
  
- Visual amenity
  o To receive no visual amenity complaints from the community.
  o To not adversely affect Port Pirie skyline beyond that outlined in the Port Pirie (Regional Council) Development Plan (DPTI, 2013).
18.4 Draft environmental monitoring and reporting plan

The draft CEMP and draft OEMP, presented in Appendix J and Appendix K, provide details of the monitoring and reporting that will be undertaken by Nyrstar and its representatives to track the performance of the management measures put in place to protect the social and environmental impacts.

Once the designs are finalised and the facility and equipment are selected the monitoring and reporting components of the draft CEMP and draft OEMP will be refined and transferred to the Nyrstar EMRP.

18.5 Conclusions

The Transformation is expected to reduce the overall environmental and social impacts from Nyrstar Port Pirie. A comprehensive Environmental Risk Assessment was undertaken (Chapter 16), identifying control measures that would minimise the environmental footprint of Transformation activities.

The draft CEMP and draft OEMP have been developed as precursors to the CEMP, OEMP and upgraded EMRP to provide a basis for the public review and approvals process. The objectives for protecting the environment and community are summarised in Sections 18.2 and 18.3 with more detail provided in Appendix J and Appendix K, the basis of updating the current EMRP to address activities related to the Transformation is presented in Section 18.4.

Nyrstar intent of reducing the impacts on the environment and community from the current smelter operations is clearly demonstrated by this project and proposed control to reduce the level of impact to as low as reasonably practicable.
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