

The Auditor considers that the leaching tests undertaken were sufficient to show that leaching of BTEX and lighter fraction TPH under neutral conditions is likely to occur within the natural soils at the Site. However, the Auditor does not consider that the results of a leaching test of one sample from beneath the Southern Gasholder to be sufficient to demonstrate that leaching from contaminants present in the natural soils in this area is unlikely to occur.

Similarly, the Auditor notes that due to its heritage status, the investigations conducted on the Southern Gasholder were limited to three angled boreholes that were completed to beneath the edge of the gasholder structure. The Auditor also notes that, unlike the investigations conducted at the Northern Gasholder, no trenches were able to be completed adjacent to the Southern Gasholder and no subsurface investigations were conducted within the annulus. Consequently, it is the Auditor's opinion that the nature and extent of the contamination present beneath the Southern Gasholder was not adequately defined and should, as a conservative measure, be based on the results of the limited investigation in this area and with consideration to the nature and extent of the contamination identified at the Northern Gasholder and other associated structures.

4.2 Groundwater Conditions

The RAP stated that both the shallow and deep groundwater systems present beneath the Site contained concentrations of PAHs, TPH ($C_{10} - C_{36}$), metals, phenols, and BTEX greater than the adopted Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) 2000 Australian and New Zealand Guidelines for Fresh and Marine Water Quality.

The RAP stated that contaminant concentrations were higher in the deeper groundwater system than in the shallow system and that this was a result of the contamination source being present at depth as "tarry waste and sludge accumulated in the Tar Wells and the base annulus of the Northern Gasholder".

Concentrations of TPH ($C_6 - C_9$) were stated to be greater than the water-solubility limit in the deeper groundwater present in the vicinity of the gasholders. However, it was stated that no light non-aqueous phase liquids (LNAPLs) or dense non-aqueous phase liquids (DNAPLs) had been encountered in any of the groundwater monitoring wells present on the Site or in off-site wells located down-gradient of the Site.

The contamination plume in the shallow groundwater was stated to extend 75 m to the south and 50 m to the east of the Site. The contamination plume in deep groundwater was stated to extend 160 m south and 50 m east of the Site. It was stated that off-site monitoring of both groundwater systems indicated that the plumes of contamination extended off-site, but were within land owned by RailCorp.

Metals, including cadmium, copper, nickel and zinc, were also stated to be present at elevated concentrations in background groundwater at the Site.

Auditor's opinion

The Auditor considers that the RAP provided an adequate description of the groundwater contamination present beneath the Site. The Auditor notes that while DNAPLs have not been observed at the Site, the concentrations of TPH, BTEX and PAHs in the deeper groundwater were indicative of the presence of DNAPLs.

4.3 Surface Water Conditions

The RAP stated that surface water had accumulated in some of the gasworks structures present on the Site, including the tar wells and gasholders, and in shallow fill materials. It was stated that the results of previous sampling and analysis of surface water indicated that it contained variable concentrations of COPCs including naphthalene, BTEX, TPH and metals.

4.4 Soil Vapour Conditions

The RAP stated that previous investigations undertaken at the Site included an assessment of soil gas that included the collection and analysis of soil gas samples and the application of a computer simulation of potential soil gas vapour generation based on the reported concentrations of BTEX and PAHs in the soil and groundwater at the Site.

It was stated that the assessment of soil gas concentrations measured in shallow bores concluded that the concentrations of BTEX and PAH were either less than the laboratory limits of reporting (LOR) or were less than the relevant WorkCover exposure guidelines and that the results of the computer simulation indicated the potential for significant contaminant concentrations to be present in soil gas at the Site.

The RAP concluded that there was "a potential for vapours to be generated by impacted soil and groundwater that may be a potential risk to human health if exposed".

Auditor's opinion

The Auditor concurs that the more conservative computer simulation for the potential for generation of vapours from contaminated soil and groundwater should be considered when assessing potential exposure to Site users and agrees that the inhalation of vapours is required to be considered a potential exposure pathway at the Site.

4.5 Sources of Contamination

Based on the results of the previous investigations, the RAP stated that the sources of contamination at the Site were identified as follows:

- Tar in tar wells;
- Tar residues in underground pipework;
- Tar residues in the base annulus of the Northern Gasholder;
- Tar in soil pores and fractures in former gasworks areas;
- Potential for tar residues in the base annulus of Southern Gasholder (not considered a major source);
- Demolition wastes containing asbestos sheeting; and
- Ash and coke fill materials in surface / shallow subsurface layers.

The RAP stated that the primary source of tar at the Site originated from the tar wells, the northern gasholder, the retort and gas purifier areas and the network of underground pipes and that "tar impacts are limited to the former gasworks footprint area" and were unlikely to be encountered in other parts of the Site. However, the RAP further stated that the full extent of gasworks-related pipework may not

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have been identified during previous investigations and, if additional structures including pipework were encountered during remediation that it would be likely that the fill materials and natural soils surrounding these structures would be impacted with tar.

4.6 Exposure Routes and Receptors

Based on the results of a previous health risk assessment conducted on the Site (SKM, 2006) the RAP identified the potential exposure routes for human receptors of contamination at the Site as follows:

- Dermal contact and/or ingestion of soils by long-term RailCorp employees;
- Dermal contact and/or ingestion of soils and dermal contact with groundwater by short-term construction/maintenance workers; and
- Inhalation of vapours by on-site long and short term site workers.

The RAP stated that, based on the risk assessment, the health risks to "other identified receptors including residents and construction workers at neighbouring residential properties and freshwater aquatic ecosystems at the head waters (stormwater drainage) of Alexandria Canal" were low.

Auditor's Opinion

The Auditor considers that the summary of the results of the previous investigations presented in the RAP was sufficient to describe the environmental condition of the Site for the purposes of the RAP and that the exposure pathways to human receptors of the Site were appropriate.

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5.0 Remedial Action Plan

Based on the results of the previous investigations and the proposed future use of the Site, the remediation goals, the extent of remediation required, remedial options, the preferred remedial option and the scope of remediation works to be conducted on the Site were presented in the RAP and are addressed in detail below.

5.1 Rationale for Remediation

Based on the results of the previous investigations, remediation of the contamination identified at the Site was stated to be required in order to meet RailCorp's long-term objectives for the Site which were stated as follows:

- Removal of the SRoH declaration;
- Removal of health risks to future users;
- Removal of risks to environmental receptors; and
- Beneficial re-use of the Site for rail-related activities.

The RAP stated that the contaminants posing the greatest health risks at the Site were the known carcinogens, benzene and BaP. The presence of the significant concentrations of these contaminants was stated to be directly due to the presence of tar materials and ash/coke surface fill present at the Site. It was stated that an approach to the remediation of the Site that "focussed on source removal and reduction in mass contamination" would mitigate the risk that these contaminants posed to the health of future users and to the environmental values of groundwater at the Site.

5.2 Remedial Goals

The RAP stated that the goals for the remediation of the Site were developed in accordance with RailCorp's objectives for the Site, as follows:

- To address the unacceptable risks to human health posed by the contamination present at the Site; and
- To protect groundwater beneath the Site from ongoing impacts.

5.3 Remedial Approach

To achieve the remediation goals for the Site the RAP stated that the remedial approach to be adopted was to remediate the sources of tar present at the Site to the extent practicable and that this was considered to be protective of sensitive receptors. Given the adoption of this "clean up to the extent practical" (CUTEP) remedial approach, the RAP stated that active groundwater remediation would not be required at the Site, however, the presence of residual soil and groundwater contamination at the completion of the remedial works would require the implementation of a long-term environmental management plan for the Site. These matters are addressed below.

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5.3.1 Rationale for CUTEF Approach

Given the nature and extent of the contamination present on the Site as a result of the historical operations of the gasworks, the requirement to retain the heritage listed Southern Gasholder, the proximity of adjacent residential properties and the limited size of the Site, the RAP stated that complete removal of the tar materials on the Site was "...impracticable when considering the limitations and constraints of site remediation...". The RAP stated that an appropriate remedial approach for the Site was to remediate the sources of tar ("free tar" and "tar impacted" fill materials and natural soils as defined in Section 4.1.3 of this SAR), to an extent that was considered to be protective of sensitive receptors.

The sensitive receptors for the Site were identified as the future users of the Site that would require protection from the identified exposure pathways of dermal contact, ingestion of impacted soils and potential inhalation of vapours. The RAP stated that the significance of the exposure pathways present at the Site were directly related to depth of contamination. It was stated that "beyond a certain depth" the exposure pathways would be incomplete or not existent and that the subsequent health risks from contamination present at such depths would be low or negligible and that the protection of groundwater would become the main objective rather than protecting human health.

Based on the results of a previous human health risk assessment conducted on the Site (SKM, 2006) and the application of a risk analytical model, the RAP further identified that exposure risks to Site users from soil at depths of between surface level and 1.5 m bgs would be dermal contact and incidental soil ingestion. At depths of greater than 1.5 m bgs and up to 8.0 m bgs, the potential exposure pathway to Site users was identified to be the inhalation of vapours. Consequently, the RAP stated that at depths greater than 1.5 m bgs only contaminants that were sufficiently volatile were considered to be contaminants of concern to be addressed in the RAP. The RAP stated that based on these factors, the remedial approach would include the use of "generic" and "site-specific risk-based" depth validation criteria for the remediation works.

5.3.2 Rationale for Groundwater

The RAP stated that active groundwater remediation was not required as part of the remediation approach for the Site due to the following factors:

- Groundwater contamination was limited to RailCorp-owned land. Adjoining properties (the Burren Street residences) have not been impacted as migration was towards the south-east, away from these properties;
- No sensitive receptors were identified within the contaminant plume down-hydraulic gradient of the Site, which comprises operational railway land (the Illawarra line);
- Immediately beyond the RailCorp land down hydraulic gradient of the Site was the Groundwater Embargo area (Zone 2), which prohibits extraction of groundwater for domestic purposes;
- The environmental values of the groundwater at the Site in its regional context and resource value were considered to be low based on the following:
 - Beneficial use - both the shallow and deep aquifers at the Site were of low yield and were not sustainable groundwater resources;
 - Protection of aquatic ecosystems – due to the degraded nature of the urban groundwater system, direct protection of groundwater-dependant ecosystems (GDE) would not be possible. Avoiding further degradation by removing source contamination i.e. free tar and tar impacted fill materials and natural soils, would be the objective of protecting GDE;

- Potable water – groundwater is not a source of drinking water supply due to low yields and salinity levels and a groundwater embargo is current for the area down-hydraulic gradient, which prevents abstraction of groundwater for drinking water purposes;
- Other environmental values – low yields and low sustainability results in groundwater being unlikely to be used for agriculture or irrigation purposes. The contamination plume has only migrated 160 m off-site although the gasworks were in operations over 100 years ago. Groundwater was therefore considered unlikely to discharge into the nearest surface water receptor, the Alexandra Canal, approximately 1.5 km away. Aesthetic, aquaculture and recreational values were therefore not considered to need protecting; and
- Groundwater quality would be improved by removal of the contamination sources and contaminated fill and soil materials at the Site.

Application of the CUTEP approach to the soil remediation to affect source control was stated to be in compliance with the hierarchy of clean-up objectives presented in the NSW DEC (2007) *Guidelines for the Assessment and Management of Groundwater Contamination* and would "extend to the long-term objective of groundwater clean-up" at the Site. In addition, it was stated that as NSW DEC (2007) require that a remedial approach should ultimately strive to restore groundwater quality to its natural background condition and that groundwater restoration should be a remedial goal, the remedial approach for the Site included "a program of monitored natural attenuation (MNA)" for groundwater beneath the Site. The RAP stated that adopting MNA would complement the CUTEP approach and would allow for the long-term monitoring and assessment of the groundwater beneath the Site.

5.3.3 Requirement for Long-Term Environmental Management Plan

The RAP stated that following the adoption of a CUTEP approach to source removal some residual soil and groundwater contamination would remain at the Site at the completion of the remediation works and that for the Site to be suitable for the proposed future use, management of the residual contamination would be required. It was stated that at completion of validation works a long-term environmental management plan would be required to be developed that included a soil and groundwater management plan that detailed the requirements for the adoption of the MNA program.

Auditor's opinion

The Auditor agrees that complete remediation of the source of contamination on the Site, being the free tars and associated contaminated fill materials and natural soils is not a technically feasible or economically or environmentally justifiable approach to the remediation given the difficulty in removing all contamination from the fill materials and natural soils and the lack of access to remediate beneath the Southern Gasholder and the proposed future use of the Site. The Auditor considers that the RAP's adoption of a CUTEP remedial approach through the use of depth based validation criteria for the Site was appropriate given the remedial objectives and the nature and extent of the contamination at the Site.

Given the condition and environmental values of groundwater beneath the Site and surrounding area and that groundwater contamination is limited to within RailCorp owned land, the Auditor agrees that active remediation of groundwater is not required and that the approach to the remediation of the contaminated fill materials and natural soils will likely result in the improvement in groundwater quality at the Site and that the adoption of MNA would enable a long-term program of monitoring and assessment of the groundwater conditions at the Site post-remediation works.

The Auditor also agrees that the remedial approach will include the requirement for the development and implementation of a long-term environmental management plan for the Site.

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