Data Gap Analysis

Tonkin Gap Project, Tonkin Highway, Perth, WA

Prepared for:
Main Roads Western Australia
Don Aitken Centre, Waterloo Crescent
East Perth, WA 6004

27 June 2019

Distribution

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Senversa Pty Ltd
ABN: 89 132 231 380
Level 17, 140 St Georges Terrace, Perth, WA 6000
tel: + 61 8 6324 0200 ; fax: + 61 3 9606 0074
www.senversa.com.au

Primary Author		**Project Manager**	
	Blaire Coleman Associate Geoscientist		**Blaire Coleman** Associate Geoscientist
Authorised Reviewer		**Project Director**	
	Jeremy Hogben Senior Principal		**Justin Lumsden** Principal

Executive Summary

Senversa Pty Ltd (Senversa) was engaged by Main Roads Western Australian (MRWA) to undertake a contaminated sites data gap analysis (DGA) to support MRWA planning for the Tonkin Highway Gap Project (TGP). The TGP involves upgrading the Tonkin Highway between Collier Road and the Great Eastern Highway (the site), with a target construction commencement date of early 2020.

MRWA were aware that numerous parcels of land located within the site boundary have been classified by the Department of Water and Environment Regulation (DWER) under the *Contaminated Sites Act 2003* (CS Act) as "*Contaminated – remediation required*" (CRR) due to legacy contamination issues associated with the adjacent former CSBP / Cresco fertiliser manufacturing site. Additionally, there are several land parcels located immediately adjacent to the site that have been classified as *"Potentially contaminated – investigation required"* (PCIR) or are known to be awaiting classification. If and how these known or suspected contaminated sites impact upon TGP was unknown.

The MRWA's objectives for the site and project are twofold:

1. Where possible, address relevant contamination classification requirements for the CRR classified land parcels prior to proposed TGP construction tendering in late 2019. In this regard, MRWA have nominated a target classification of "*Remediated – restricted use"* (RRU) or *"Contaminated - restricted use" (CRU)* permitting use as a road reserve.
2. To gain a broader understanding of contamination issues that may have implications for future TGP works at the site (including additional management measures requiring implementation).

Recognising that a range of historical investigations have been performed, the technical objective of this DGA is to establish an updated understanding of contaminated site issues, identification of conceptual site model (CSM) data gaps, and (where relevant) the recommended approach to resolving such data gaps in line with the above MRWA project objectives.

The scope of works undertaken as part of this DGA included the following:

- Consultation with MRWA to confirm and refine its TGP objectives.
- Obtaining a Detailed Summary of Records (DSR) with DWER for properties within the site and the adjacent former CSBP Cresco fertiliser manufacturing site.
- Review of background information (site identification, environmental setting, previous environmental reports, site history, prevailing classification and associated reasons under the CS Act, proposed TGP).
- Obtaining historical aerial photographs to verify the current and historical land use of the site.
- Reviewing additional information (supplied by MRWA) regarding additional sites immediately adjacent to the TGP footprint.
- Assessing the quality and validity of the existing data (including against prevailing standards and guidelines).
- Site walkover to inspect the current condition of the site.
- Updating the CSM including both the existing site scenario and future site scenario (post TGP).
- Review of current data gaps in relation to human health and environmental risk, including under the completed TGP CSM.
- Preparation of DGA report.

Key DGA outcomes are summarised under subheadings below.

Contaminated Site Issues Relating to Former CSBP / Cresco Site

Land parcels within TGP have previously been investigated and found to contain cinder deposits relating to former use by the adjacent Cresco/CSBP fertiliser site. Data has indicated that the cinder deposit material was unlikely to render the site unsuitable for its use as a road reserve in its original distribution; however, the works since undertaken on-site as part of the separate MRWA NorthLink project may have changed the distribution of cinder deposits and in turn may have also altered the risk profile.

Regardless of potential direct exposure risk, the presence of the cinder deposits has resulted in low pH and elevated concentrations of metals in groundwater both on- and off-site. As such, there is potential for down-gradient sites to be considered to be affected sites under the CS Act, with potential sites awaiting classification. Furthermore, Senversa understand that ongoing groundwater monitoring and risk assessment is being performed on behalf of CSBP as part of reclassification commitments associated with their former site. Given the common cinder deposit historical source between the two sites it is likely that the monitoring will be directly relevant to TGP; however, this has not been confirmed and the outcomes remain unknown.

Test pitting undertaken to support the Tonkin Grade Separation project (being part of the broader NorthLink project) indicated that it is unlikely that cinder ash material extended into Lot 300 to the north (identified to be ‘awaiting classification’ under the CS Act).

General Environmental Management Issues

The potential also exists for soils to have been impacted by surficial asbestos, fly tipping and uncontrolled filling as part of Tonkin Highway Construction. This is in keeping with the inner metropolitan nature of the site and typically managed via a construction environmental management plan rather than restriction under the CS Act.

Contaminated Site Issues Identified by the Forrestfield Airport Link (FAL) Project

Additional potentially contaminating sites located adjacent to the TGP footprint are as follows:

- Southern Main Drain (SMD) (PCIR).
- Wright Crescent (awaiting classification).

The above sites were reported to DWER based on preliminary investigations that were undertaken during the planning phases for the FAL project, which identified levels of per- and polyfluoroalkyl substances (PFAS) in surface water (SMD) and groundwater (Wright Crescent). In addition, the supplied information has indicated that concentrations of other analytes in groundwater (e.g. metal, nutrients and hydrocarbons) may also exceed assessment criteria in these areas.

Summary of Data Gaps

A summary of the data gaps identified and the recommended actions to address them are presented in **Table E.1**.

Table E.1: Summary of Data Gaps and Recommendations

Data Gap	Details	Recommended Action
1	**Nature and extent of cinder deposits within site (CRR classified land parcels)** Senversa consider there is sufficient good quality data available to characterise the bulk properties of the cinder deposits, including relevant contaminants of potential concern (CoPCs) and associated physiochemical properties. Historical documentation, including correspondence including from the then Department of Environment and Conservation (DEC) (now DWER), indicated that the cinder deposits posed a low human health risk to users of the site given the distribution and depth of the deposits at that time, and were suitable to remain in-situ. Recent earthworks undertaken at the site have the potential to have changed the depth and distribution of cinder deposits.	Prepare and implement a sampling and analysis quality plan (SAQP) for intrusive site investigation on CRR classified land parcels that assesses the current approximate extent of cinder deposits and update assessment of human health risk and associated management requirements.
2	**Nature and extent of cinder-ash derived groundwater impact both on- and off-site.** Available information indicates that groundwater beneath and down-hydraulic gradient of the site is impacted by substances including ammonia, fluoride, aluminium, arsenic, total iron and nickel. Senversa understand that ongoing groundwater monitoring and risk assessment is being performed on behalf of CSBP and under an auditor-approved monitoring plan as part of reclassification commitments associated with the adjacent former CSBP / Cresco fertiliser manufacturing site. Given the common cinder deposit source between the two sites it is likely that the monitoring will be directly relevant to TGP; however, this has not been confirmed and the outcomes remain unknown. DWER has advised that numerous properties down-hydraulic gradient of the site are awaiting classification [understood to be pending the outcomes of the above groundwater monitoring, including a supporting mandatory auditor report (MAR)].	• Obtain and review current off-site groundwater monitoring reports and assess their suitability to support TGP assessment and reclassification. CSBP have advised that such reports are expected to be made available in 2019; however, it is uncertain whether this enable reclassification of the site prior to tendering for TGP construction in late 2019. • Dependant on above, initiate discussions with DWER to confirm TGP groundwater assessment and management strategy (including how potential requirements for a MAR will be interpreted for this site). • Acknowledging timing and suitability uncertainties above, undertake an investigation of on-site cinder-ash derived groundwater impacts (as applicable) with the objective of complementing CSBP studies and to provide contemporary on-site groundwater quality conditions that aide in the development of appropriate management measures during future TGP works.
3	**The composition of imported fill used for the construction of Tonkin Highway is unknown.** While this material was not directly inspected as part of site investigation, the potential for contamination within mixed fill exists.	Prepare a future construction environmental management plan (CEMP) to outline procedures required during site works if potentially contaminated fill material is encountered.

Data Gap	Details	Recommended Action
4	**The presence of asbestos containing material (ACM) material in surface soils is unknown.** The available information suggests that ACM may be present in the road reserve at a frequency comparable to other Perth Metropolitan roads.	Prepare a future CEMP to outline procedures required during site works if ACM material is encountered.
5	**Fly tipping practises may have introduced contaminants to the site.** Evidence of small-scale fly tipping was observed at the southern-most portion of the site (on Railway Parade, under the Tonkin Highway Bridge).	Prepare a future CEMP to outline procedures required during site works if unexpected materials are encountered.
6	**The current nature and extent of PFAS in surface water is currently unknown** Preliminary information has indicated that PFAS may be present at concentrations greater than assessment criteria in the SMD. This may be relevant where site works are undertaken in the vicinity of the SMD, where surface water is sourced from a similar catchment requires redirection as part of site works; however, the potential risk in the context of the TGP works has not been evaluated.	Future CEMP should include management measures and water quality trigger values for disposal of surface water, where required. Collection of further baseline data from the SMD may aid in characterising conditions prior to works in the area.
7	**The current nature and extent of PFAS in groundwater beneath the site is currently unknown.** Preliminary investigations have indicated that PFAS has been detected in groundwater at concentrations greater than the adopted assessment criteria. This is particularly relevant between the SMD and Railway Parade. It is noted that some of the criteria applied were specific to the works to be undertaken as part of the FAL, and the relevance to the proposed works (and any associated site classifications within the TGP requires further evaluation)	Future CEMP will need to consider management of potential PFAS impacted groundwater where dewatering works are required. This should include a to include a review of criteria for PFAS in groundwater specific to the scope of site works.

Recommendations

In line Table E.1 Senversa recommends that an SAQP should be prepared and implemented to further characterise the distribution of cinder deposits on-site (Data Gap 1) and associated groundwater quality (Data Gap 2). These works should be performed in parallel with ongoing consultation with CSBP and DWER consultation (in particular) to ensure a consistent and coordinated approach towards resolving groundwater related issues. Given that the exact timing of CSBP groundwater monitoring reports and supporting MAR (and outcomes) are unknown, it is also unknown whether the resolution of Data Gap 2 is achievable within the desired timeframe and prior to tendering of TGP construction.

Data Gaps 3-7 are best addressed by preparing site-specific management plans specific to the works to be undertaken during TGP. Baseline groundwater and surface water sampling may aide in the development of such plans, particularly where dewatering is envisaged.

Contents

Figures

List of Acronyms

Acronym	Definition
ACL	Added contaminant limit
ACM	Asbestos Containing Material
AHD	Australian Height Datum
ASS	Acid sulfate soil
BOM	Bureau of Meteorology
BMD	Bayswater Main Drain
CoPC	Contaminant of potential concern
CRR	Contaminated-remediation required
CS	Contaminated Sites
CSM	Conceptual site model
DEC	Department of Conservation
DGA	Data Gap Analysis
DSI	Detailed Site Investigation
DSR	Detailed Summary of Records
DWER	Department of Water and Environment Regulation
EIL	Ecologically based investigation level
FAL	Forrestfield Airport Link
GME	Groundwater monitoring event
GSWA	Geological Survey of Western Australia
HIL	Health-based investigation level
MAR	Mandatory Auditors Report
m	Metre
m AHD	Metres Australian Height Datum
mBGL	Metres below ground level
mg/kg	Milligrams per kilogram
mg/L	Milligrams per litre
MRWA	Main Roads Western Australia
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measure

Acronym	Definition
NLWA	NorthLink WA
NPUG	Non potable use guideline
PB	Parsons Brinkerhoff
PSI	Preliminary Site Investigation
PSP	Principal Shared Pathway
PWDSA	Public Drinking Water Source Area
PFAS	Perfluoroalkyl and Polyfluoroakyl Substances
PFOA	Perfluorooctanoic Acid
PFOS	Perfluorooctane Sulfonate
PTA	Public Transport Authority
QA	Quality assurance
QC	Quality control
RRU	Remediated -restricted use
SAQP	Sampling analysis quality plan
SMD	Southern Main Drain
TGP	Tonkin Highway Gap Project
TPH	Total petroleum hydrocarbons
TRH	Total recoverable petroleum hydrocarbons
WIR	Water Information Register
WR	Water Register

1.0 Introduction

1.1 Background and Project Appreciation

Senversa Pty Ltd (Senversa) was engaged by Main Roads Western Australian (MRWA) to undertake a contaminated sites data gap analysis (DGA) to support MRWA planning for the Tonkin Highway Gap Project (TGP) (the site). The TGP involves upgrading the Tonkin Highway between Collier Road and the Great Eastern Highway (**Figure 1**), with a target construction commencement date of early 2020.

Numerous parcels of land located within the site boundary have been classified by the Department of Water and Environment Regulation (DWER) under the *Contaminated Sites Act 2003* (CS Act) as "*Contaminated – remediation required*" (CRR) due to legacy contamination issues associated with the adjacent former CSBP / Cresco fertiliser manufacturing site. Additionally, there are several land parcels located immediately adjacent to the site which have been classified as *"Potentially contaminated – investigation required"* (PCIR) or are known to be awaiting classification (**Figure 2**). If and how these known or suspected contaminated sites impact upon TGP was unknown.

1.2 Project Objective

The MRWA's objectives for the site and project are twofold:

1. Where possible, address relevant contamination classification requirements for the CRR classified land parcels within the site prior to proposed TGP construction tendering in late 2019. In this regard, MRWA have nominated a target classification of "*Remediated – restricted use*" (RRU) or "*Contaminated - restricted use*" (CRU) permitting use as a road reserve.
2. To gain a broader understanding of contamination issues that may have implications for future TGP works at the site including but not limited to land parcels classified as PCIR or awaiting classification (subject to which identify what additional management measures requiring implementation as part of TGP).

Recognising that a range of historical investigations have been performed, the technical objective of this DGA is to establish an updated understanding of contaminated site issues, identification of conceptual site model (CSM) data gaps, and (where relevant) the recommended approach to resolving such data gaps in line with the above MRWA project objectives.

1.3 Scope of Work

The scope of works undertaken as part of this DGA included the following:

- Consultation with MRWA to confirm and refine its TGP objectives.
- Obtaining a Detailed Summary of Records (DSR) with DWER for properties within the site and the adjacent former CSBP Cresco fertiliser manufacturing site.
- Review of background information (site identification, environmental setting, previous environmental reports, site history, prevailing classification and associated reasons under the CS Act, proposed TGP).
- Obtaining historical aerial photographs to verify the current and historical land use of the site.
- Reviewing additional information (supplied by MRWA) regarding additional sites immediately adjacent to the TGP footprint.
- Assessing the quality and validity of the existing data (including against prevailing standards and guidelines).
- Site walkover to inspect the current condition of the site.
- Updating the CSM including both the existing site scenario and future site scenario (post TGP).

- Review of current data gaps in relation to human health and environmental risk, including under the completed TGP CSM.
- Preparation of DGA report.

The preparation of a standalone DGA report does not form a routine reporting milestone under DWER contaminated sites guidelines, specifically DWER (2014) *Assessment and Management of Contaminated Sites*. The preparation of a DGA report in this case reflects the extensive contaminated sites investigation history of the site combined with the lapse in time since classification. A component of the DGA therefore is to consider whether these historical reports are of a standard that satisfy reporting requirements under the CS Act (or otherwise).

1.4 Report Structure

Section 2 of this report provides a summary of the information gained by searching DWER's Contaminated Sites database, in addition to information gained by MRWA inter-departmental enquiries with DWER.

Section 3 of this report details review of the environmental setting and site history for the group of land parcels that are classified as CRR relating to the former Cresco / CSBP fertiliser site. This detailed information (effectively a synthesis of earlier studies) is considered sufficient to address data required as part of eventual reclassification of the site (i.e. Objective 1 from **Section 1.2**), in addition to identifying any aspects that may require additional management during site works (Objective 2).

Information gained from reviewing the data relating to land parcels directly adjacent to the site and classified based on monitoring perform as part of the Forrestfield Airport Link (FAL) project is summarised in **Section 4**. As TGP works are not expected to extend off-site this information is reviewed in the context of its potential relevance to management of the site during TGP works, and as such, detailed information, environmental setting and site history of these off-site land parcels has not been reviewed.

Sections 5 and 6 of this report present a preliminary conceptual site model (CSM) for the site and TGP together with conclusions and recommendations, respectively.

2.0 Contaminated Sites Database Search Results

This section identifies sites that have been classified under the CS Act within the TGP footprint and its immediate surroundings.

2.1 Identification of Contaminated Sites

Senversa undertook a review of the Contaminated Sites database maintained by DWER to identify contaminated sites within the TGP footprint and its immediate vicinity. This database is limited to showing sites that are classified as *"Contaminated – remediation required"*, *"Contaminated – restricted use"* or *"Remediated - restricted use"* and hence MRWA undertook additional inter-departmental enquiries with DWER to identify any sites that were classified as "Potentially contaminated – investigation required" or sites that had been reported under the CS Act but are awaiting classification.

Classified (or reported) sites as listed in **Table 2-1,** and can be broadly categorised according to two issues as follows:

- Issues relating to the former CSBP Cresco site.
- Issues relating to (or identified via) the FAL project undertaken by the Public Transport Authority (PTA).

Results of the searches and enquiries are shown in **Table 2-1**. Site locations are depicted in in **Figure 2a and 2b**. Further detail and discussion is provided in subsections thereafter.

Table 2-1 Summary of Classified (or reported) Contaminated Sites

Site	Description	Classification
Sites relating to the Former Cresco / CSBP Site Issues (Figure 2a)		
CRR Classified land parcels (within TGP Footprint)	24 parcels within the Tonkin Highway Road Reserve (individually listed in **Section 3.1**) Understood to be formerly part of the Cresco/CSBP operations.	*Contaminated – Remediation Required*
Former Cresco/CSBP Fertiliser Site	Immediately east of the site.	*Remediated - Restricted Use*
Lot 7 on Diagram 40329 (Stormwater Sump)	Stormwater Compensation Basin located immediately east of the site's northern portion. Formerly part of the Cresco/CSBP site.	*Contaminated – Remediation Required*
Lot 100 on Diagram 55519 (6 Railway Parade, Bayswater)	Vacant Land located immediately east of the site – formerly part of the CSBP/Cresco site.	*Contaminated – Remediation Required*
LOT 14091 on PLAN 27645	Located within the TGP footprint, immediately south of Guildford Road. Understood to be classified due to groundwater impacts from the former Cresco/CSBP operations.	Awaiting Classification[1]
Railway Parade Road Reserve[2]	Two land parcels located within the TGP footprint, immediately south of the CRR-classified site. Understood to be classified due to groundwater impacts from the former Cresco/CSBP operations	Awaiting Classification[1]

Site	Description	Classification
LOT 300 on PLAN 41002	Located within the TGP footprint, immediately north of the CRR classified site.	Awaiting Classification[1]
Sites Relating to / Identified by the FAL Project		
LOT 800 on Plan 67654 (Wright Crescent)	Immediately adjacent to western site boundary; north of Swan River	Awaiting Classification[1]
LOT 109 on Plan 9144 (Southern Main Drain)	Immediately east of site boundary; south of Swan River Portion of Southern Main Drain, owned by Water Corporation	*Possibly contaminated - investigation required*
LOT 108 on Plan 9144 (Southern Main Drain)	Immediately east of site boundary; south of Swan River Portion of Southern Main Drain, owned by Water Corporation	*Possibly contaminated - investigation required*
LOT 107 on Plan 9144 (Southern Main Drain)	Immediately east of site boundary; south of Swan River Portion of Southern Main Drain, owned by Water Corporation	*Possibly contaminated - investigation required*
LOT 368 on Plan 2252 Southern Main Drain)	Immediately east of site boundary; south of Swan River Portion of Southern Main Drain, owned by Water Corporation	*Possibly contaminated - investigation required*

Notes:

[1] "Awaiting classification indicates that the site has been reported to the DWER however the DWER are awaiting further information prior to determining an appropriate classification.

[2] Parcel Identification Number (PIN) not presented in information supplied by MRWA.

2.2 Tonkin Highway Road Reserve (On-site)

To better understand the rationale for the classification of the Site as CRR (and associated data gaps), Senversa undertook a Detailed Search of Records (DSR) for Lot 300 on Plan 41002. While the site comprises 24 parcels of land that are classified as CRR, a DSR was only undertaken for Lot 300, as the information regarding classification is relevant to all 24 lots. The DSR indicates that the 24 land parcels were classified by DWER on 1 December 2006 as CRR, with the nature and extent of contamination being described as follows:

"*Arsenic, cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc contamination is present in soils within the area along the Tonkin Highway reserve from the intersection the Railway Parade to Bassendean Road located approximately 600m to the north*".

Restrictions on use are as follows:

"*Industrial / Commercial Landuse – Highway Reserve only, no pedestrian access".*

The classification was based on information submitted to the Department by March 2006. It was understood that the land formed the western part of land that was historically used for the manufacture fertiliser (i.e. the Cresco/CSBP fertiliser plant). The DSR indicates that a site investigation was undertaken as part of a proposal to remediate the Tonkin Highway Road Reserve (PB, 2004). The investigation indicated the presence of widespread metal contamination at concentrations exceeding the Ecological Investigation Levels (EIL) from *Assessment Levels for Soil, Sediments and*

Groundwater (DoE, 2003). The DSR noted that an ecological and health risk assessment had been carried out to derive appropriate remediation objectives, although the conclusions were not agreed with by the Department of Environment and Conservation (DEC). On this basis, the DEC would not comment on the suitability of the site for the existing or future land use.

The information used for DEC to reach these conclusions was as follows:

- PB (2004) *Stage 1 Cinders Delineation- Tonkin Highway Reserve Bayswater* (Report, 1 March 2004).
- PB (2005) *Ecological and Human Health Risk Assessment, Tonkin Highway Road Reserve (Railway Parade) Bayswater*, 1 November 2005.
- Main Roads WA (2006) *MRWA response to DEC queries regarding Tonkin Highway Road Reserve ecological and health risk assessment* (letter report, 6 November 2006).

2.3 Former Cresco/CSBP Site (Off-site)

As the site was classified on the basis of the former CSBP / Cresco site to the east, Senversa undertook a DSR for 5 Wicks Street, Bayswater (Lot 168 on Plan 412675). It is noted that this site belongs to a site containing 20 parcels (representing a portion of land formerly known as 'Lot 10', which occupied 36 ha at the intersection of Railway Parade and Tonkin Highway in Bayswater). The DSR indicates that this land was classified as "*Remediated for restricted use*" on 26 June 2018, with the nature and extent of contamination being described as follows:

- *"Incidental fragments of asbestos-containing material (ACM) may be encountered in soils across the site.*
- *Cinder waste and soils impacted by metals such as arsenic, copper, nickel, manganese and lead remain in isolated locations at depths greater than 2 metres below ground level. Phosphorus impacted soils remain on the site which have been treated in-situ to limit the mobility and leachability of phosphorus.*
- *Groundwater beneath the site has been contaminated by historical industrial activities, including the burial of cinder waste. The groundwater contamination is characterised by high levels of acidity, metals, (such as aluminium, arsenic, nickel, zinc and iron), fluoride, sulphate and nutrients (such as ammonia and phosphorus)".*

The Cresco/CSBP site was originally reported to the Department prior to the commencement of the *CS Act* and was first classified on the basis of information submitted to the DWER by December 2005. The Cresco/CSBP site was reclassified in 2018 to reflect additional information submitted as of April 2018.

Historically, Lot 10 was used for the manufacturing and storage of superphosphate fertiliser and small volumes of associated chemicals between 1920 and 1993. By-products and residues produced at the site (including iron oxide cinders) were disposed of and buried at the site. Following the cessation of manufacturing operations, contaminated site investigations identified elevated heavy metal concentrations in soil at the Cresco/CSBP site (particularly along the western boundary and north of the former super bins) associated with the historical cinder burial. It is understood that historical cinder burial extended off-site to the west beneath land which was re-developed for the construction of Tonkin Highway in the 1960's (i.e. the site – which is managed separately under the *CS Act* as per above).

Since the late 1980's extensive soil remediation has been undertaken, which included the excavation and off-site disposal of contaminated soil and buried waste. Remedial works extended to approximately 3 m below ground level (BGL) - 4 mBGL. Remediation activities were successful across the majority of the site; however, minor soil impacts remain in isolated areas of the site as depths greater than 2 mBGL. The site is restricted for industrial/commercial use and is not suitable for more sensitive land uses.

Groundwater beneath the former Lot 10 is highly acidic and contains elevated concentrations of heavy metals, fluoride, sulphate and nutrients. Groundwater remediation activities undertaken at the Cresco/CSBP site included the removal of groundwater from the south western portion of Lot 10 in the vicinity of the former sodium bisulphate pit and the installation of a groundwater recovery system. Post operational groundwater monitoring indicated that the treatment system was effective in reducing metal concentrations in groundwater; however, groundwater still remained acidic and contained metal concentrations exceeding the non-potable use of groundwater guideline (DER, 2014). Due to the presence of groundwater contamination, groundwater abstraction and stormwater disposal is not permitted at the site.

The February 2017 groundwater data (being the most recent available at the time of reclassification in 2018) found that groundwater beneath former Lot 10 was still impacted by high levels of acidity, fluoride, ammonia and metals such as iron, aluminium, arsenic and nickel. The concentrations of these contaminants exceeded assessment levels for non-potable use of groundwater, as published in the *'Assessment and management of contaminated sites*' (DER, 2014). The groundwater impact is primarily in the south-western portion of former Lot 10 and extends off-site to the south-west (i.e. beneath the site). Ongoing groundwater monitoring is undertaken in accordance with the auditor-approved groundwater monitoring plan.

A risk assessment has indicated that the contamination present on the site does not pose an unacceptable risk to human health, the environment or environmental values under the proposed commercial/industrial land use, provided certain restrictions are imposed. Given that impacted groundwater extends off-site, it is understood that numerous sites were identified as potentially being affected and were reported to the DWER. Accordingly, in the MAR dated 2013 (AEA, 2013), the auditor recommended that the site (described as “numerous minor lots within the Tonkin Highway Road Reserve west of the site”), which had previously been reported to the DWER, should be classified as CRR.

The above information was summarised from numerous reports (too many to be reproduced herein, refer to the DSRs in **Appendix B**). Rather than review these primary reports, Senversa has undertaken review of the mandatory auditor reports (MARs) in the remainder of this DGA (noting that the MARs are relatively recent and considered the quality and completeness of the corresponding primary reports).

2.4 Stormwater Sump, Lot 7 on Diagram 40329 (Off-site)

This site is located adjacent the northwest portion of the site and was also part of the former CSBP Cresco fertiliser manufacturing plant. This Lot was classified as *“Contaminated – Remediation Required*” on 1 December 2007, with the nature and extent of contamination being described as follows:

“Heavy metal contamination, including arsenic, lead, chromium, and copper, is present within soils in the western and northern areas of the site. Groundwater beneath the site is contaminated with heavy metals including arsenic, lead, chromium, copper and fluoride”.

It is understood that remedial works have not been undertaken on this site to the satisfaction of the CS Auditor, and as such, the classification remains “*Contaminated – Remediation Required*”.

2.5 6 Railway Parade, Lot 100 on Diagram 55519 (Off-site)

This site is located immediately adjacent to the southeast portion of the TGP Study site and was also part of the former CSBP Cresco fertiliser manufacturing plant. This site was classified as “*Contaminated – Remediation Required*” on 1 December 2007, with the nature and extent of contamination being described as follows:

“Heavy metal contamination, including arsenic, lead, chromium, and copper, is present within soils in the western and northern areas of the site. Groundwater beneath the site is contaminated with heavy metals including arsenic, lead, chromium, copper and fluoride”.

It is understood that this Lot was not subject to remedial works along with the remainder of the former CSBP Cresco site, and as such, the classification remains "*Contaminated – Remediation Required*".

2.6 Additional Lots relating to the CSBP Site (Off-site)

Four additional lots in the vicinity of the former Cresco/CSBP site are understood to be "awaiting classification" by the DWER, according to MRWA's internal queries (**Figure 2a**). The relevant sites are:

- Lot 14091 on Plan 27645.
- Railway Parade Road Reserve.
- Railway Parade Road Reserve.
- Lot 300 on Plan 41002.

Requesting Basic Search of Records (BSR) or Detailed Search of Records (DSRs) for these particular land parcels was outside the scope of this work agreed with MRWA; however, Senversa understands that these sites were reported on the basis of the area likely related to potentially impacted groundwater emanating from the former Cresco/CSBP site. Whilst beyond the TGP footprint, the sites to the west/north west may be relevant to this project were they to be classified as 'affected sites' and related specifically to sites within the TGP footprint identified as 'source sites'.

2.7 Southern Main Drain (Off-site)

As shown on **Figure 2b**, four lots comprising the Southern Main Drain have been classified as *'Possibly contaminated – investigation required'*. Relevant sites are as follows:

- Lot 109 on Plan 9144.
- Lot 108 on Plan 9144.
- Lot 107 on Plan 9144.
- Lot 368 on Plan 2252.

These sites are located immediately east of the site boundary, south-west of the Swan River crossing. Based on MRWA's inter-departmental enquiries with the DWER, it is understood that the classification of these sites relates to the detection of Perfluoroalkyl and Polyfluoroakyl Substances (PFAS) in surface and groundwater during investigations that were undertaken for FAL. Obtaining a BSR or DSR for these sites was outside of the scope of works; however, MRWA has provided Senversa with copies of relevant documentation obtained from the PTA. This information is reviewed in **Section 4** of this report.

2.8 Wright Crescent, Lot 800 on Plan 67654 (Off-site)

As shown on **Figure 2b**, this site is located immediately east of the site boundary, on the north side of the Swan River Crossing. Based on MRWA's enquiries with the DWER, this site is "awaiting classification". Although no BSR or DSR was requested by Senversa, it is understood that this site was reported due to the presence of PFAS in groundwater during works related to FAL. A review of the information relating to this site that has been supplied by MRWA is presented in **Section 4** or this report.

3.0 Site Information Relating to CRR-Classified Parcels

This section provides a detailed review of the environmental setting and site history for the group of sites that are classified as CRR relating to the former Cresco / CSBP fertiliser site. This detailed information is considered sufficient, to a point, address data required as part of eventual reclassification of the site (i.e. Project Objective 1 from **Section 1.2**), in addition to identifying any aspects that may require additional management during site works (Project Objective 2).

3.1 Site Identification

The CRR site comprises the 24 land parcels that are currently classified as CRR within the TGP alignment (**Figure 2a**). Individual parcels of land are listed in **Table 3-1**. It is understood that these parcels, and potentially other parcels within TGP, will ultimately be amalgamated into one larger road reserve.

The area is zoned as 'primary regional roads' under the Metropolitan Regional Scheme (MRS) (DPLH, 2019a).

Table 3-1 Currently Classified Lots within TGP (relating to former Cresco / CSBP Site Issues)

Lot Number	Certificate of Title	Parcel ID
Lot 8 on Diagram 40328	1391/922	11437
Lot 301 on Plan 41002	222/376	11439
Lot 300 on Plan 41002	2227/375	11441
Lot 300 on Plan 41002	2227/375	11442
Lot 300 on Plan 41002	2227/375	11442
Lot 300 on Plan 41002	2227/375	11443
Lot 301 on Plan 41002	222/376	11444
Lot 15 on Plan 9542	1264/406	11445
Lot 311 on Plan 9542	LR3150/78	26367
Lot 312 on Plan 9542	LR3150/79	26368
Lot 313 on Plan 9542	LR3150/80	26369
Lot 310 on Plan 9542	LR3150/77	26371
Lot 17 on Plan 5389	LR3155/712	26372
Lot 18 on Plan 5389	LR3155	26373
Lot 19 on Plan 5389	LR3155/714	26374
Lot 20 on Plan 5389	LR3155/715	26375

Lot Number	Certificate of Title	Parcel ID
Lot 23 on Plan 5389	LR3155/716	26376
Lot 26 on Plan 5389	LR3155/717	26377
Lot 27 on Plan 5389	LR3155/718	26378
Lot 28 on Plan 5389	LR3155/719	26379
Lot 29 on Plan 5359	LR3155/720	26380
Lot 30 on Plan 5389	LR3155/721	26381
Lot 50 on Plan 9542	LR3155/725	26363
Lot 300 on Plan 41002	Vol 2227/375	

Additional information regarding the site is summarised in **Table 3-2**.

Table 3-2: Site Description

Item	Details
Site Owner	Main Roads WA
Site Occupier	Main Roads WA
Classification	CRR
Current Site Use	Road Reserve, including principal shared pathway (PSP)
Site Area	Approximately 79 010 m^2

3.2 Surrounding Land Uses

Land use surrounding the site can be summarised as follows:

- North: Continuation of Tonkin Highway.
- East: The Tonkin Highway Industrial Estate (which is predominantly vacant but under development), followed by more industrial land. This land was formerly occupied by a fertiliser manufacturing plant (CSBP/Cresco), and has been subject to several stages of contaminated site investigation and remediation.
- South: Railway Parade and Guildford Road reserves, and commercial/industrial zoned land and residential properties.
- West: commercial/industrial zoned land, with the Bayswater Main Drain (BMD) being located approximately 100 m west of the most southern portion of the site.

3.3 Environmental Setting

Information from numerous sources, including a site inspection and public reports and databases on regional information were reviewed to establish the environmental setting of the site. This information aids in the understanding the potential contaminant migration pathways and the sensitivity of the receiving environment (i.e. receptors). The environmental setting details are summarised in **Table 3-3** below.

Table 3-3: Environmental Site Setting Information

Item	Detail
Topography	As shown on **Figure 3**, the DWER Perth Groundwater Map (2019) indicates that the topography of the site is slightly undulating from approximately 15 m above Australian Height Datum (AHD) at the intersection of Guilford Road and Tonkin Highway to 35 m AHD in the northern portion of the site at Collier Road. During the site walkover, the site was observed to be mostly flat in the northern portion of the site, with the exception of large drainage swales immediately adjacent the road. The site slopes down to the industrial properties located to the east. In the southern portion of the site, a steep embankment was present on both the western and eastern boundaries of the road.
Geology	Geological information from the Geological Survey of Western Australia (GSWA) Perth Region 1:50,000 Environmental Geology Series Maps (1986) indicate that the geology comprises Quaternary Bassendean Sand underlain by the Guilford Formation. Bassendean Sands are described as pale grey to white, fine to coarse but predominately medium grained sand (Davidson, 1995). An investigation undertaken within the vicinity of the site by Coffey (2015) identified the surface geology comprised brown/white/yellow poorly graded sand underlain by mixed fill material of approximately 2 m thickness, which comprised crushed cement, limestone and building rubble. Brown/grey, poorly graded sand was present underlying the mixed fill material from depths of approximately 0.5 – 3 mBGL.
Hydrogeology	*Groundwater Levels/Elevations* The site is underlain by the superficial Swan aquifer which is hosted within the Bassendean Sand and Tamala Limestone. A search of the DWER Information Water Information Register (WIR) database and Perth Groundwater Atlas undertaken by Senversa indicated that groundwater beneath the TGP project area is likely to be encountered between 6 mBGL and 17 mBGL. Regional groundwater is inferred to generally flow to the south with varying flow to the south, south-south west and south east towards the Swan River. A site-specific investigation undertaken by Parsons Brinkerhoff (PB) (2004) reported that groundwater flow direction and hydraulic gradients vary across the site. Groundwater flow was interpreted to generally flow in a south westerly direction and a westerly direction along the western boundary of the former CSBP/Cresco site. *Drinking Water* DWER Perth Groundwater Map (2019) indicated that the site is not located within a Public Drinking Water Source Area (PWDSA). *Groundwater Quality* BoM (2018) indicates that groundwater salinity beneath the site is likely to range between 500 milligram per litre (mg/L) and 1,000 mg/L indicating fresh water suitable for drinking. Groundwater in the area has a high risk of iron staining. *Registered Bores* A search for registered bores within 500 m of the site was undertaken by Senversa using the DWER Water Information Reporting (WIR) database. The DWER search identified 35 registered bores located within a 500 m radius of the site. These bores are used for the following purposes: • Two bores located on the former Cresco site are used for water supply and one bore is used for manufacturing and industrial purposes. • Four bores located to the west of the site are used for monitoring purposes. • Ten bores to the south are used for domestic garden purpose. The use/purpose of the remaining bores is unknown.

Item	Detail
	It is noted that formal registration of domestic groundwater bores is currently not compulsory in Western Australia and unregistered bores may exist that were not identified during the completion of the search *Licensed Bores* The DWER Water Register (WR) online database indicated that there were no licenced abstraction bores within the TGP area. The former Cresco site to the east of the site has a licence (179286) under the Bayswater Industrial Estate Pty Ltd to abstract 80,000 kL of groundwater per year until 22 February 2027. A Groundwater Usage and Monitoring Closure report was prepared for the 'NorthLink WA' (NLWA) project (Southern Section) (John Holland, 2018) and provides details of monitoring and production bores located in the vicinity of the Tonkin Highway Road Reserve between Guilford Road and Reid Highway. Four production bores are located west of Harvest Road (PB02), east of Wright Street (PB05) and west of Bassendean Road (PB04) (100 m east of the northern portion of the TGP area). The groundwater abstraction licence [183292 (2)] allowed the extraction of 560,000 kL. Abstraction of groundwater from the production bores ceased between 2016 and 2018. Locations of surrounding groundwater bores are presented in **Figure 4**. *Groundwater / Surface Water Interaction* 360 Environmental (2014) reported that Bayswater Main Drain is located approximately 100 m west of the TGP area. The drain receives water from four surface water drainage systems within the greater Bayswater area and discharges into the Swan River.
Hydrology, Wetlands and Sensitive Ecosystems	Several intermittent wetlands classified as 'dampland multiple use" are located in the vicinity of the TGP area although are not considered to be of high environmental significance (**Figure 5**). 360 (2014) reported that the closest wetland of environmental significance is the Gobba Lake, located approximately 1.5 km south of the TGP area. The wetland is classified in the Geomorphic Wetland Database as a resource enhancement area. The Swan River is classified as a conservation wetland is located approximately 1.6 Km south, south-west and south-east of the TGP area.
Acid Sulfate Soil	A review of the Perth Groundwater Map (2019) indicates that majority of the site has a moderate to low risk (<3 m from surface) of acid sulfate soil (ASS) with two isolated pockets in the northern and southern western portion which have a high to moderate risk of ASS (**Figure 5**).
Vegetation	Vegetation including grass, small trees and shrubs are present within the site. Coffey (2015) noted during the site inspection there was no evidence of stress to vegetation.
Aboriginal Heritage	A search of the Aboriginal Heritage Inquiry System database (DPLH, 2019) undertaken on 25 January 2019 indicated that there are no registered Aboriginal Sites within the site. The search did show the presence of two Aboriginal Heritage Places known as "Bayswater Camp 1" (Place ID 3749) and "Bayswater 1-3" (Place ID 3326) within the TGP area (**Figure 5**).
European Heritage	A search of the Heritage Council of Western Australia (2019) State Heritage Register undertaken on 25 January 2019, indicated that no registered Sites are located within the site.

3.4 Aerial Photographs and Historical Site Use

Historical aerial photographs of the site and surrounds dating back to the early 1950's were obtained from Landgate and the 360 Environmental Preliminary Investigation report (2014). Review of these photographs was undertaken to identify relevant site developments, features and changes over time

Copies of a selection of these aerial photographs are provided in **Appendix A** and are summarised in **Table 3-4** below.

Table 3-4. Historical Aerial Photograph Summary

Photograph	Source	Observations	
		Site	Surrounding Land
1953	360 (2014)	The site appears to be covered by vegetation and possibly farmland. The disturbed soil shows operations from the adjacent site extent into the Site.	Industrial activities are being undertaken on the land to the east of the site (CSBP Cresco Site). Numerous buildings and surface water sumps can be observed Land to the west of the site is cleared but no infrastructure is evident.
1974	MRWA	The disturbed ground from the adjacent site extends further onto the Site, and cinder disposal pits appear to be visible.	Additional buildings / covered storage areas have been constructed on the CSBP site, and soils appear to be more disturbed compared to the previous photographs. Two sumps are easily visible also visible. Land to the south and south-east of the former CSBP site has been developed for industrial purposes, while land to the south-west has been used for residential purposes.
1985	MRWA	Tonkin Highway has been constructed connecting to Guilford Road in the south and extending further north. It appears that construction of the highway has involved substantial earthworks. Stockpiles are also present in the south western portion of the site, assumed to be for construction of the bridge across the railway and Guildford Road.	There are no significant changes over the former CSBP / Cresco site since the previous photograph.
1995	360 (2014)	Roadworks within the Tonkin Highway Road reserve, with the bridge being completed, and vegetation being restored in the verge.	Site operations continue on the CSBP site to the east; however, stockpiles, disturbed soil and surface water basins are no longer visible.
2000	MRWA	Vegetation is now present along the Tonkin Highway road alignment.	No significant change from the 1995 aerial.
2008	360 (2014)	No major changes from the previous photograph.	The former CSBP/Cresco site to the east is in the process of being decommissioned, with the majority of buildings removed.
2018	MRWA	Swales/sumps are now present along the Tonkin Highway road alignment.	The former CSBP/Creso site has been decommissioned, remediated and subdivided. Sealed roads are present between the subdivisions. It appears some industrial activities may be operating in the eastern portion of the CSBP site.

3.5 Proposed Changes to Site during TGP

It is understood that, within the site, the TGP will involve widening of the Tonkin highway, construction of drainage swales, and widening of the existing bridge over Railway Parade and Guildford Road, and an up-grade of the Guildford Road on- and off-ramps. It is anticipated that the project will involve a net import of fill, and excavations will be limited to drainage swales and bridge footings.

3.6 Summary of Site History

The information relating to site history can be summarised as shown in **Table 3-5**.

Table 3-5: Summary of Site History

Date	Detail
C1928	The adjacent Cresco/CSBP site operated from 1928 for the manufacture of single superphosphate, sulphuric acids and small volumes of other chemicals. Historical aerial photographs show that the site was used for the disposal of waste products in two disposal pits.
1980-2016	Several phases of assessment and remedial works are undertaken at the former Cresco/CSBP site
1984	Tonkin Highway is constructed
1993	Manufacturing ceases at the former Cresco/CSBP site.
2004-2005	MRWA engages PB undertakes site specific characterisation (including delineation and risk assessment) into the presence of cinders on-site. While PB concludes that there the site is suitable for its intended land use, and remediation is not required, this recommendation is not endorsed by the DWER.
2006	The site is re-classified by the DWER as "*Contaminated – Remediation Required*"
2016	The former Cresco/CSBP site is reclassified as "*Remediated – Restricted Use*"
2016	Roadworks are undertaken along Tonkin Highway as part of the NorthLink project. Of particular relevance to the site was the widening of lanes along the alignment and the excavation of soil for the construction of drainage swales within the road reserve.

3.7 Current Site Conditions

The site was inspected by Senversa staff (Blaire Coleman and Justin Lumsden) on 5 March 2019. The inspection comprised walking the boundary of the site using the principal shared pathway, with no direct access to the road reserve itself. The walkover also involved discussion with John Braid and David Goodram, both of MRWA, who provided input on conceptual plans for TGP.

The majority of the road reserve traversed has recently been subject to earthworks as part of the NorthLink project, where the highway was widened, and large drainage swales were installed. The exception to this is the southern part of the alignment (approximately 350 m from the railway parade intersection) where the highway is yet to be widened. Numerous monitoring wells were also observed on the walkover; however, in the absence of detailed information from the DSR results, these were unable to reconciled with available figures, or examined for their integrity and suitability for future sampling.

Current features observed and their potential implications for the contamination status of the site are summarised in **Table 3-6**.

Table 3-6: Summary of Significant Features from Site Walkover

Feature	Potentially Contaminating Activity	COPC	Comments	Photo (Appendix C)
Drainage Swales	Excavation of cinder deposits Oxidation of ASS	Arsenic, cadmium, chromium, cobalt, copper, lead, manganese, nickel and zinc ASS	Drainage swales constructed along the majority of the site are up to approximately 2m depth. Drainage swales appear to coincide with the location of the northern cinder pit. It is understood that this material was treated as per the ASSDMP (John Holland, 2018) and re-used within the NorthLink project area.	1, 2
Uncontrolled Fill	Importation of potentially contaminated material	Various	The level of the Tonkin Highway is raised from the natural ground level. While a detailed observation could not be made due to the access restrictions, material appears to contain gravel and fragments of concrete and construction waste	3
Fly tipping	Dumping of contaminated material	Various	Evidence of small-scale fly tipping was observed at the southern-most portion of the site (on Railway Parade, under the Tonkin Highway Bridge).	5

3.8 Review of Previous Investigations

Numerous investigations have been undertaken on the site and also on the surrounding contaminated sites. This section presents an evaluation of the quality and relevance of the available data and any gaps in understanding of the site. Previous investigations generally comprised: (a) site-specific investigation into the Tonkin Highway road reserve; (b) additional investigations or reports on works undertaken as part of the NorthLink project and (c) assessments relating to the former Cresco/CSBP fertiliser plant.

3.8.1 Tonkin Highway Road Reserve (On-site)

As noted in the DSR results (**Section 2.2**) numerous investigations have been undertaken within the TGP study area site, as follows:

- PB (2004) *Stage 1 Cinders Delineation- Tonkin Highway Reserve Bayswater* (Report, 1 March 2004).
- PB (2005) *Ecological and Human Health Risk Assessment, Tonkin Highway Road Reserve (Railway Parade) Bayswater*, 1 November 2005.
- Main Roads WA (2006) *MRWA response to DEC queries regarding Tonkin Highway Road Reserve ecological and health risk assessment* (letter report, 6 November 2006).

In addition to the above, while it was not obtained via the DSR, the following document was also provided by MRWA:

- Department of Environment and Conservation (2007) *Tonkin Highway Road Reserve – In-Situ Retention of Metals/arsenic impacted soils* (Reference 04/36 DD6, 4 April 2007).

These reports contain useful information regarding the characteristics of the cinder deposits that are located on-site and additional information regarding the classification process for the site. Review of the information is provided in **Table 3-7**.

Review of the information includes comparison against the most recent guidance from the National Environment Protection Measure (NEPM) Assessment of Site Contamination (ASC) ((National Environmental Protection Council (NEPC), 2013)). For the purposes of this comparison, the most relevant assessment criteria in the context of the current and ongoing uses as a road reserve and PSP are considered to be as follows:

- Health Investigation Level (HIL-D) for road reserve workers.
- Health Investigation Level (HIL-C) for road reserve access (e.g. users of PSP).
- Ecological Investigation Levels (EILs) for urban, residential and open space (URPOS) and Industrial/Commercial land uses.[1]

[1] For the purposes of the data evaluation ambient background concentration (ABC) assumed to be zero and hence the EIL equates to the lowest added contaminant limit (ACL) stated in NEPC ASC.

Table 3-7: Review of Site-Specific Environmental Investigations (CRR-Classified Site)

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
Stage 1 Cinders Delineation, Tonkin Highway Road Reserve, Bayswater (PB, 2004)	PB undertook an investigation to determine the extent of pyritic cinder deposits suspected to be buried in the portion of Tonkin Highway road reserve, which was originally part of the Cresco/CSBP fertiliser site. The scope of works involved a geophysical survey to identify areas at high risk of containing cinders, supported by ground-truthing through drilling 11 soil bores to a maximum depth of 8 mBGL and analysis of 35 primary soil samples. Key findings of the investigation were as follows. • The distribution of cinders coincides with two disposal pits (north and south), with cinders in the southern disposal pit interpreted to extend west beneath the fill used to construct the Tonkin Highway. • Of the associated metals, only arsenic was present in soil at concentrations exceeding the adopted human health assessment criteria. • Arsenic, cobalt, chromium, cadmium, lead, manganese, nickel and zinc were detected in soil at concentrations greater than the adopted ecological assessment criteria.	The investigation was generally consistent with current guidance and more generally provided an appropriate characterisation of issues with respect to the stated objectives. A review of QA/QC data indicates that the data is generally of good quality. Minor deficiencies noted include the lack of rinsate or field blank samples. The data is therefore considered to provide a reliable indication of the quality of the cinders present on-site. While relevant and appropriate at the time, assessment criteria have been superseded by the ASC NEPM (NEPC, 2013). Updated evaluation of the soil analytical results indicates that of the 35 primary samples, HIL-C and HIL-D for metals were exceeded at one location (SB11) at depths of 5.5-6 mBGL and 6.5 – 7 mBGL Senversa also screened the soil analytical results against the most conservative EILs for Public Open Space and Industrial/Commercial use. EILs were exceeded in six soil samples collected from three locations (SB1, SB5 and SB11) at depths ranging from 1.0 to 7 mBGL; however, only two of the soil samples were collected in the upper 2 m of the soil profile.	Potential for cinder material to have been disturbed due to earthworks associated with the later NorthLink project. The acid generating potential of the material was not determined. Groundwater quality was not assessed.

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
Ecological and Human Health Risk Assessment, Tonkin Highway Road Reserve (Railway Parade), Bayswater (PB, 2005)	PB assessed the immediate and potential risk posed by the cinder deposits at the site to the environment and to human health. Key findings of the investigation were as follows: • Surface soils at the site did not exceed the adopted screening criteria for industrial / commercial land use and hence there was not considered to be a risk to human health receptors under the existing land use scenario. • Soils at depth (5.5 – 7.0 mBGL) contained arsenic at concentrations that exceeded the adopted screening criteria for industrial / commercial land use, and hence a site management plan (SMP) was recommended for intrusive works at greater than 5 mBGL. • Arsenic, cobalt, chromium, cadmium, lead, manganese, nickel and zinc were detected in soil at concentrations greater than the adopted ecological assessment criteria. • Concentrations of fluoride, manganese, iron, and pH of groundwater exceeded the adopted assessment criteria; however, concentrations were considered to be representative of groundwater quality in the area. • Ground disturbing activities on the site had the potential to expose pyritic cinders, which could result in increased oxidation, chemical solubility and contamination mobilisation, which could potentially impact the Swan River ecosystem via the Bayswater Main Drain. PB concluded that it was unnecessary to conduct soil remediation activities on-site as the site met the standards set for its current land use, and the risk to down-stream receiving environments was minimal.	The risk assessment was generally consistent with guidance at the time of completion. The assessment did not consider users of the PSP who may access surface soils at the site. The industrial assessment criteria, while relevant and appropriate at the time, have been superseded by the ASC NEPM (NEPC, 2013). Updated evaluation of the soil analytical results indicate that the arsenic concentrations exceeded HIL-C (300 mg/Kg) and HIL-D (3,000 mg/Kg). The highest concentration of arsenic detected in soil was 19,000 mg/Kg which exceeds both HIL-C and HIL-D by one order of magnitude.	The risk assessment did not consider receptors for users of the PSP.

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
MRWA Response to DEC Queries regarding Tonkin Highway Road Reserve Ecological and Health Risk Assessment (MRWA letter, 6 November 2006)	In response to queries from the DEC regarding the Ecological and health risk assessment (PB, 2005), MRWA drafted a letter to DEC providing additional lines of evidence regarding potential risk from the site. In particular, the DEC queried whether the risk assessment was valid for exposure pathways involving the bike path that passes along the eastern boundary of the road reserve. As part of the exercise, PB progressed an additional 8 soil bores to 1.5 mBGL in the areas of impact to more thoroughly characterise the human health risk in the shallow soil profile. Key findings of the assessment were as follows. • Arsenic concentration in soil in the northern cinders pit did not exceed assessment criteria for public open space and were unlikely to pose a risk to human health users of the bike path • Arsenic concentrations in the southern cinders pit exceeded assessment criteria at a shallow depth, but none over a distance of more than 25 m along the path. Since the exposure was at a depth of 0.5 m outside of a cyclone fence, it was not considered that a complete exposure pathway existed in this area. • An evaluation of leachability data from the neighbouring former Cresco/CSBP site indicated that arsenic and nickel were considered leachable under acidic conditions. • Data from six groundwater monitoring sites that were present within the Tonkin Highway road reserved indicated that groundwater conditions were as follows: ▪ pH was acidic (pH between 2.1 and 3.1). ▪ Dissolved metals were present at concentrations that exceeded marine water and irrigation trigger values. ▪ Fluoride, sulfate and nutrients were also elevated. • The potential risk of groundwater impacts to ecological receptors (namely the Swan River) was considered to be effectively characterised by works undertaken on the adjacent Cresco site. The investigations indicated that although soil impacts had had an adverse effect on groundwater quality, adverse impacts were not detected at the identified receptors. • MRA concluded that remediation was not required at the site; however, an SMP was required to address potential risk that may arise due to future disturbance of soils at the site.	Field and laboratory QA / QC procedures were deficient with reference to current guidance. Deficiencies include a lack of QA / QC samples and laboratory analytical certificates. On this basis, the information is considered useful in further contextualising cinder impacts at the site; however, is not of a quality suitable and verifiable for the basis of risk assessment decisions. While relevant and appropriate at the time, assessment criteria have been superseded by the ASC NEPM (NEPC, 2013). Senversa screened the soil analytical results against the updated NEPM assessment criteria which indicated the following: • Arsenic concentrations in five soil samples exceeded HIL-C (300 mg/Kg). • Concentrations of nickel in three soil samples were above HIL-C (1,200 mg/Kg) and EIL for public open space (30 mg/Kg). • EIL (commercial/industrial) value for nickel (55 mg/Kg) was exceeded in two soil samples.	The original response from DEC was not provided as part of the DSR however subsequent DEC correspondence (below) indicates that they were satisfied with the MRWA response.

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
Tonkin Highway Road Reserve – In-Situ Retention of Metals/arsenic impacted soils (DEC, 2007)	This response from the DEC indicated that they found MRWA's arguments regarding the retention of the impacted cinder material within the site acceptable. The following recommendations were made by DEC: • Wind, water and bicycle disturbance to exposed soil on either side of the cycle strip should be prevented by covering with a 5 cm thickness of mulch or similar. • Given the retained cinders are likely to continue to leach and contribute to the contamination of the underlying groundwater, the proposed approach was consistent with the soil remediation strategy approved by the Environmental Protection Agency in relation to the former Cresco/CSBP site. • MRWA should liaise closely with CSBP to determine the implications of groundwater treatment and monitoring occurring at the CSBP site, and the establishment of responsibility for groundwater remediation should the future quality of groundwater discharging to the BMD deteriorate. DEC noted its intention to reclassify the site as *"Remediated - restricted use",* with restrictions to be as follows: • Use of the site for a highway reserve with cycle/footpath, • No groundwater abstraction without appropriate testing, • No disturbance of soil below 5.5 mBGL without further investigations and risk assessment. In order to complete the reclassification as noted above, DEC required that MRWA submit a management plan that included the following: • Details for the management of future soil disturbance works. • A long-term commitment to undertake groundwater monitoring to assess the continued effectiveness of contaminant attenuation. • Contingency/remediation plan to address any future non-compliance or deterioration in groundwater quality.	n/a	DEC [including inter-departmental advice via Department of Health (DoH)] advice took into account the distribution and depth of contamination at that time. Nonetheless, the distribution and depth may have since changed due to the NorthLink project. No subsequent evidence of consultation with CSBP regarding resolution of groundwater contamination issues.

3.8.2 NorthLink Documentation

The NorthLink project included grade separation of the intersections of Tonkin Highway with Collier Road, together with widening of the existing Tonkin Highway lanes. A large portion of the site was subject to earthworks as part of the NorthLink project. Of particular relevance to the site was the excavation of soil for the construction of drainage swales within the road reserve (Photographs 1 and 2; **Appendix C**). It is considered that the locations of the former cinder disposal pits correspond with the locations of the constructed drainage swales, and hence there is the potential that impacted material was excavated and moved on-site.

The documents listed below were prepared as part of the scope of works for the NorthLink project.

- 360 Environmental (2014) Tonkin Grade Separation Project – Preliminary Investigation on Site Contamination (Reference 345 BA, client draft, April 2014).
- Coffey (2015a) Detailed Site Investigation, Tonkin Grade Separations (Reference NLWA-01-EN-RP-0027, Rev0, 12 May 2015).
- Coffey (2015b) Asbestos-in-Soil Site Inspection, Tonkin Grade Separations (Reference NLWA-01-EN-RP-0033, Rev 0, 20 July 2015).
- Galt Environmental (2018) Installation of Groundwater Monitoring Bores, Northlink WA Southern Section, Guildford Road to Reid Highway (technical memorandum, dated 18 May 2018).
- John Holland (2018a) NorthLink WA Southern Section, Guildford Road to Reid Highway, Acid Sulfate Soil Closure Report (3 May 2018).
- John Holland (2018b) Groundwater Usage and Monitoring Closure Report 2016-2017, Construction Water Supply GWL 183292(2) (8 August 2018).

While these documents were not prepared specifically for the purposes of defining contamination on-site, they contain useful information and data regarding background conditions that can be extrapolated to TGP. Review of the information is provided in **Table 3-8.**

Table 3-8: Review of Off-Site Information for NorthLink Project

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
Tonkin Grade Separation Project, Preliminary Investigation on Contamination (360, 2014)	A preliminary investigation on contamination was undertaken by 360 on contaminated sites that may affect the Tonkin Grade Separation (TGS) project which involved works at the separation of Tonkin Highway with Collier Road, Morley Drive and Benara Road. Seven contaminated sites were identified within 500 m of the project area. Of the seven contaminated sites identified, the following two are relevant to the site. • The southern portion of the Tonkin Highway Reserve (north of Guilford Road) which contains soil impacted by pyritic cinders and groundwater containing elevated concentrations of iron, fluoride and manganese (i.e. the site). • The former Cresco/CSBP site located adjacent east of the southern portion of the project area where groundwater contains elevated concentrations of heavy metals, chloride and ammonia. The investigation concluded that a site management plan (SMP) be prepared in order to appropriately manage soil and groundwater contamination beneath the project area.	An evaluation of the report indicates that is generally complete and consistent with DWER guidance. The report contains useful information regarding site background and contaminating land activities.	No relevant data gaps identified.
Detailed Site Investigation, Tonkin Grade Separations (Coffey, 2015a)	As part of the TGS project, soil investigations were undertaken by Coffey to determine the environmental, human health and financial risk associated with potential contamination if identified within the TGS project area. A total of 25 soil bores were progressed as part of the investigation. Key findings were as follows. • Soil samples collected revealed minor concentrations of hydrocarbons exceeding the limit of reporting near the Collier Road intersection. Concentrations of hydrocarbons in soil samples did not exceed the adopted assessment criteria. • No asbestos was identified during field works. Coffey concluded that it was unlikely that neighbouring contaminated sites have impacted soil at either of the two study areas. However, the potential to encounter discrete impacted hotspots including buried asbestos, fly tipping and pyritic cinders) along the broader project alignment was acknowledged.	Field measures used were accurate and in general accordance with the DWER Contaminated Sites Guidelines and NEPC (2013). A comparison of the sample locations to the interpreted locations of the cinder deposits (**Figure 6**) indicates that the cinder deposits were not intersected during site specific fieldwork. The lack of detection of major CoPCs may give an indication of the degree of historical spreading of cinder deposits up to this point and suggest that Lot 300 (currently awaiting classification) was not impacted by the presence of cinder materials.	No relevant data gaps identified.

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
Coffey (2015b) Asbestos-in-Soil Site Inspection, Tonkin Grade Separations (Reference NLWA-01-EN-RP-0033, Rev 0, 20 July 2015).	Coffey was engaged to further investigate the presence of asbestos within the road reserve based on the findings of the previous Detailed Site Investigation (DSI) (Coffey, 2015a). The investigation involved site walkovers and inspections at each major intersection along the TGS alignment. Key findings were that ACM was identified in surface soil at all intersections inspected. Coffey concluded that, in general, the presence of ACM was consistent with the likelihood of finding ACM along major arterial roads within the Perth Metropolitan area.	The investigation was undertaken using simplified version of the data quality objective process from NEPC (2013) and methodologies applied are appropriate for the investigation.	The presence of ACM within the site is considered likely to be consistent with the findings of this report.
Acid Sulfate Soil Closure Report (John Holland, 2018a)	This report details the measures that were undertaken to manage ASS and groundwater during widening of Tonkin Highway (i.e. the NorthLink project). The report concludes that as only localised dewatering works were undertaken, no groundwater monitoring was undertaken. In addition, all disturbed ASS was appropriately treated and verified.	The quality of the ASS investigations and management measures was not reviewed for its completeness and compliance with guidelines; however, of particular relevance is the identification of AASS / PASS within the road reserve to the east and west of Tonkin Highway, below approximately 11 mAHD, within the vicinity of the stormwater detention basins.	The location of the drainage swales observed on-site coincide with the excavations described as being excavated and treated for ASS. There is potential for cinder material to have been disturbed.
Groundwater Usage and Monitoring Closure Report (John Holland, 2018b)	John Holland prepared a Groundwater Usage and Monitoring Closure report, which provides details of monitoring and production bores located in area along the Tonkin Highway Road Reserve; west of Harvest Road (PB02), east of Wright Street (PB05) and west of Bassendean Road (PB04). Abstraction of groundwater from PB04 ceased on the 8 June 2018. Following the completion of the NorthLink Southern Section, groundwater monitoring was undertaken in July 2018. pH and iron in groundwater at PB04 exceeded adopted freshwater screening criteria and alkalinity of the groundwater was above the adopted DWER trigger values. Groundwater analytical exceedances were in the same order of magnitude as what was reported in baseline studies.	Groundwater bores reported are outside of the TGP Study Area and are located up-gradient of the impacted soil on-site. The factual information in this report provides useful background information on regional groundwater quality in the area.	No relevant data gaps identified.

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
Installation of Groundwater Monitoring Bores (Galt Environmental, 2018)	As part of the NorthLink project Galt Environmental (Galt) were engaged by the contractor (John Holland) in May 2018 to install eight groundwater monitoring wells across the Tonkin Highway road reserve between Collier Road and Guilford Road. Five of the groundwater wells installed by Galt appear to be located within the TGP site.	The memorandum is factual in nature and provides well construction information for the eight groundwater wells. The soil profile was logged consistent with USCS terminology and wells appear appropriately constructed for environmental monitoring. One of the eight wells (H017-C68.14-GW01) is located within the site, within the road reserve to the west of Tonkin Highway, and may provide a useful groundwater sampling location.	The purpose of the monitoring wells is not documented; however, they are understood to be for environmental monitoring. The exact location and operational status of GW01 is currently unknown.

3.8.3 Former Cresco/CSBP Fertiliser Site Documentation

A large volume of documentation is available regarding the assessment and remediation of the former Cresco/CSBP fertiliser site located immediately to the east of the Tonkin Highway Road Reserve. This site is the principal reason that the land within the site is classified as CRR, as contaminating activities extended onto the site prior to the construction of Tonkin Highway. Senversa has undertaken review of the MARs available for this site, in addition to selected primary investigations and management plans, to understand the risk presented by such contamination. The following reports were reviewed.

- Australian Environmental Auditors (2013) *Interim Mandatory Auditor's Report, 2-4 (Lot 10) Railway Parade and Lot 7 Mooney Street, Bayswater, Western Australia* (Reference: EA0209, 29 August 2013). This MAR covers the historical reporting of the site (reports are too numerous to list herein).
- Australian Environmental Auditors (2016) *Mandatory Auditor's Report, 2-4 (Lot 10) Railway Parade (Former Cresco Site) Bayswater, Western Australia* (Reference EA0209, 18 May 2016). Reports relevant to the TGP Study site reviewing within this MAR include the following:
    - Parsons Brinckerhoff (2014a) CSBP Bayswater Annual Groundwater Monitoring Report 2014, for Groundwater Monitoring Events conducted on August 2013 and February/April 2014 (Reference 2204026A_PR2_25242 Rev C).
    - Parsons Brinckerhoff (2014b), Groundwater Management Plan - CSBP Bayswater, WA. (Reference 2162328B-DMS-LTR-001 RevB, 5 June 2014.
    - AECOM (2015), CSBP Bayswater Biannual Groundwater Monitoring Report 2015 - August 2014 and February 2015 Groundwater Monitoring Events (Reference 60329741-ENV-PER-RPT-001, 17 August 2005).
- Australian Environmental Auditors (2018) *Mandatory Auditor's Report, 2-4 Railway Parade, Bayswater, WA* (Reference EA0548, 12 April 2018). Reports relevant to the TGP Study site reviewing within this MAR include the following:
    - Strategen Environmental (9 February 2017) *Lot 10 Railway Parade Bayswater, Construction Environmental Management Plan* (Reference: LPR16285_01 R001 Rev C);
    - Strategen Environmental (2017a) *Precinct 3 – Cinder History, Characterisation, Risk Assessment and proposed sampling and analysis program – Tonkin Highway Industrial Estate* (Reference: LPR16285.01 M023 Rev c,19 September 2017)
    - Strategen Environmental (2017b) *Precinct 3 – Cinder Characterisation and Risk Assessment – Tonkin Highway Industrial Estate* (Reference: LPR16285_01_M027_Rev2, dated 12 December 2017).
    - JDA Consultant Hydrogeologists (2017) *Tonkin Highway Industrial Estate, Urban Water Management Plan* (Reference: J6238b, dated 17 May 2017)
    - Strategen Environmental (2018c) *Tonkin Highway Industrial Estate, Area 3, Site Management Plan* (Reference: LPR16285_01 R006 Rev 2, 24 January 2018).

In addition to the above documents, Senversa also reviewed the following document:

- Cardno (2017) Groundwater Monitoring Report, CSBP Bayswater – Railway Parade, Bayswater, WA (Reference: V161162PReport01.4, 26 July 2016).

This document does not appear to have been reviewed by the Auditor when preparing any of the three MARs listed above. It is assumed that this information will be reviewed and included in the pending MAR that will address classification of potentially impacted sites.

A summary of the reviewed information and its relevance to assessment of the site is presented in **Table 3-9**.

Table 3-9: Review of Off-Site Information (CSBP / Cresco Site)

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
Interim Mandatory Auditor's Report (AEA, 2013)	Charlie Barber, of Australian Environmental Auditors, was commissioned to audit the former Cresco/CSBP site in 2005, prior to the adoption of the CS Act, with the dual purpose of ensuring that the Conditions of Ministerial Statement 691 were met and assisting with future classification under the CS Act. The interim MAR primarily provided comment on the appropriateness of the suitability of the assessment/remediation works undertaken post-appointment; however, information from investigations and remedial works undertaken prior to auditor appointment were also reviewed to provide relevant background information. The key CoPCs comprised heavy metals in soil and groundwater, with low pH, ammonia and fluoride also above adopted site assessment criteria. ACM was also identified on-site as a result of demolition of site buildings. Remediation comprised excavation and removal of cinder material and associated impacted soil to landfill, between March 2006 to April 2007 and April 2008 to November 2009. The soil removal strategy comprised removal of material to depths of approximately 3 mBGL to meet the adopted site clean-up criteria (HIL-F). With regards to the cinder deposits on the site area, the MAR notes: • The soil remediation program did not assess the material located within the MRWA road reserve (the site), and as such, buried cinder deposits are still present under Tonkin Highway Road Reserve on the western boundary of the former CSBP/Cresco site. • These cinder deposits may serve as a source of continuing contamination for groundwater (in particular, low pH and metals). A review of groundwater remediation indicated the following: • Monitored natural attenuation was undertaken in accordance with the requirements in the Ministerial Conditions. • Statistical analysis demonstrated that there was an overall decrease in CoPC from the pre- to post-remediation period; however seasonal fluctuations were still noted. • The presence of remnant cinder deposits along the western boundary of the former Cresco/CSBP site resulted in low pH (1-3) in bores closest to the site. Based on the groundwater data provided from 2003 to 2012, it appeared that regardless of the residual soil impact remaining under the Tonkin Highway road reserve, the groundwater contamination plume was stable. Migration of the low pH and elevated CoPCs appeared to have stopped, with attenuation noted at the edges of the plume.	Senversa did not review the primary documents in detail; however, it is considered that the information contained in this MAR provides a robust description of the site conditions, particularly with respect to groundwater within the vicinity of the TGP study site.	The Auditor's recommendation regarding classification of potentially affected sites does not appear to have been enacted by DWER, as these sites are not currently listed on DWER's contaminated sites database. As per MRWA's internal inquiries with DWER, all sites within Group B and some within Group A are currently listed as "awaiting classification" (**Section 2.1**). It is understood that a MAR that addresses the recommended classifications for these sites is currently pending. In addition, MRWA's internal DWER search also identified the lot immediately north of the site as also being listed as "awaiting classification". This does not appear to be a result of the recommendations of this MAR.

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
	Surface water gauging undertaken on the BMD and the Swan River indicated that flow-weighted mean concentrations of contaminants were below the background conditions outlined in the Ministerial Conditions. In addition, a key finding was that there was minimal measurable impact on the nutrient load emanating from the site to the Swan River. The Auditor recommended the former Cresco/CSBP site was suitable for commercial/industrial use with the following restrictions: • Groundwater cannot be abstracted for any use. • The site is suitable for commercial/industrial use. • An auditor-endorsed groundwater monitoring plan must be implemented. • An auditor-endorsed long-term asbestos management plan must be implemented. With respect to impacted groundwater migrating from the CSBP/ Cresco site, the MAR identified three groups of sites that had either previously been reported to the DWER, or required reporting based on the findings of the MAR, as follows: • **Group A**: “low risk” based on aluminium and iron in groundwater at concentrations greater than assessment criteria. The auditor recommended that these sites either be classified as RRU or wait for additional monitoring data for some sites. • **Group B**: “moderate risk” based on the presence of aluminium, arsenic, iron, nickel, fluoride greater than assessment criteria. The auditor recommended that these sites, located immediately west and southwest of the site (**Appendix D**), be classified as “Remediated – Restricted Use” • **Group C**: “low risk” properties located to the south of Guildford Road. The auditor recommended that these sites did not require classification. In addition to these potentially affected sites, the MAR indicated that the site (described as “numerous minor lots within the Tonkin Highway Road Reserve west of the CSBP/Cresco site”), which had previously been reported to the DWER, should be classified as CRR.		

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
Mandatory Auditor's Report (AEA, 2016)	The auditor prepared an additional MAR for the former Cresco/CSBP site 2016 in response to the requirement to remediate outstanding issues identified during the previous MAR. The issues primarily related to asbestos impacts in surficial soil and were not directly relevant to the site; however, the MAR included an assessment of the groundwater monitoring plan prepared for the former CSBP/Cresco site. Groundwater monitoring indicated that highest concentrations of CoPCs (aluminium, arsenic and iron) were in the central-southwest portion of the site adjacent to Tonkin Highway, indicating that the presence of the cinder deposits continue to provide a source of metal contamination to groundwater. The following restrictions relevant to the site include: • Groundwater cannot be abstracted for any use.	Senversa did not review the primary documents in detail; however, it is considered that the information contained in this MAR provides a robust description of the site conditions, particularly with respect to groundwater within the vicinity of the TGP study site.	This MAR provides no further update on the status of potentially affected sites located down-gradient of the site.
Groundwater Monitoring Report (Cardno, 2017)	Cardno undertook surface and groundwater monitoring in accordance the former Cresco/CSBP site's Groundwater Monitoring Plan. Key findings were as follows: • Numerous bores were decommissioned in 2016 and 2017 as part of the NorthLink site works. • Groundwater flow was to the south-west. • Groundwater impacts included ammonia, fluoride, aluminium, arsenic, total iron and nickel, predominantly in the southern portion of the former CSBP/Cresco site, where residual soil impacts are present. • Increasing contaminant trends were observed in some bores. • Surface water samples from drains located west and south-west of the site contained concentrations below the adopted criteria. Cardno recommended that some bores be decommissioned, and additional bores should be installed, and a new Groundwater Monitoring Plan be prepared to incorporate recent changes to the monitoring network.	Data quality was not assessed in detail; however, the groundwater monitoring event appears to have been conducted a in accordance with the GMP and relevant guidance. The report included a detailed data quality review, which indicated that the quality was suitable for its intended purpose.	None identified regarding the report; however, Senversa understands from informal discussions with CSBP that numerous monitoring wells may be missing or damaged.

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
Mandatory Auditor's Report (AEA, 2018)	This MAR was prepared for the ongoing management of the former Cresco site post-development, as the site was developed into smaller commercial/industrial lots. The site was divided into three areas, which had slightly different on-going management plans. Of particular relevance to the site was Area 3, (in the south-western portion of the former Cresco/CSBP site), and which was to subject to cutting operations during site development. This area was investigated by the primary consultant to establish if the top 2 m of the soil profile was suitably free of cinders. The soils in Area 3 were assessed and found to contain no soil contamination exceeding HIL-D criteria within the surface 2 m and were not determined to pose a threat to human health or ecological receptors. The MAR also outlined management measures to be undertaken in excavation and handling of material. Amongst the recommendations for Area 3 was the recommendation that dewatering to undertake earthworks should be avoided where feasible, but where required, it should be undertaken in accordance with the Acid Sulfate Soils Dewatering Management Plan (ASSDMP) prepared for the site.	Given that the auditor has reviewed the quality of the data collected, it is considered that this provides useful up-to date information on the likely composition of the cinder material present beneath the TGP road reserve. Senversa reviewed the data against HIL-C assessment criteria (to be protective of potential road reserve users) and found: • Concentrations of arsenic exceeded the HIL-C (300 mg/kg) in soil samples collected at two locations (TP17-1) at 1.92-2.25 mBGL and TP26-1 at 1.35-1.60 mBGL) with concentrations of 870 mg/kg and 350 mg/kg, respectively. • Concentrations of lead exceeded the above HIL-C in soil collected from TP18-1 at 1.90-2.0 mBGL	While this provides additional robust data to characterise the in-situ cinders deposits, the current extent is not known. This MAR provides no further update on the status of potentially affected sites located down-gradient of the site.

4.0 Other Contaminated Sites (FAL) – Review of Previous Investigations

The FAL tunnel approximately aligns with the TGP in the area extending from the Southern Main Drain in the south to Railway Parade in the north. As indicated in **Section 2.1**, MRWA's enquiries with the DWER have indicated that additional potentially contaminated sites are located close to the boundary of the TGP site and were identified during investigations associated with the FAL. It is understood that TGP works will not extend into these sites; and hence reviewing the classification of these sites is not a current objective for MRWA. Nonetheless, it is possible that aspects of these sites may be relevant for TGP works within the area, and hence information regarding these sites that may have implications for TGP has been reviewed and is summarised below.

Although no basic or detailed records searches were undertaken for this site, Senversa has undertaken a review of the MARs available for this site (as supplied by MRWA). The following reports were reviewed:

- Senversa (2016) Mandatory Auditor's Report: Pre-Construction Contamination Investigations, Forrestfield Airport Link (Reference: P11586_RPT003_Rev0_MAR, 1 September 2016). Reports relevant to the identified sites are as follows:
  - GHD (2013) Perth Airport Rail Link – Preliminary Site Investigation. October 2013.
  - Golder Associates (2014) Contamination and ASS Investigation – Forrestfield Airport Link Sampling and Analysis Quality Plan Addendum. December 2014.
  - Western Environmental Pty Ltd (2016a) Forrestfield Airport Link – PFOS, Contamination and ASS Groundwater Monitoring & Analysis Results. 15 March 2016.
  - RPS (2016) Stage 5 Environmental Site Investigation, Perfluorinated and Polyfluorinated Alkyl Substances – Forrestfield-Airport Link. June 2016.
  - Western Environmental Pty Ltd (2016b) Forrestfield Airport Link. Stage 6 Investigation. Quarterly Monitoring. 4 August 2016.

Senversa has reviewed the above reports to further evaluate the rationale behind the reporting and classification of the SMD and Wright Crescent sites. In addition, other relevant information contained in the reports that may have implications for future TGP site management is also presented.

4.1 Southern Main Drain

As mentioned in **Section 2.7**, it is understood that the lots comprising the SMD were reported to the DWER due to the presence of PFAS in a surface water sample adjacent to the Swan River (GSWE05). It was noted that similar concentrations were also detected in surface water samples collected from the Southern Main Drain immediately down-gradient of the Perth Airport. Further information relating to analytical results for the Southern Main Drain is presented in **Table 4-1**.

4.2 Wright Crescent (Lot 800)

As mentioned in **Section 2.8**, it is understood that this site was reported to the DWER due to the presence of PFAS in groundwater samples collected from a monitoring well installed as part of works for the excavation of the Wright Crescent emergency egress shaft (EES). Further information on sample results is presented in **Table 4-1**.

Table 4-1: Review of Additional Information - Sites Associated with Perth Airport Link Investigations

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
Contamination and ASS Investigation (Golder 2015b)	This investigation was undertaken to provide the PTA with an indication of potential site contamination issues and baseline environmental data. Sampling and analysis of PFAS was not included in the scope. The following findings may be relevant to the site between the Southern Main Drain and Railway Parade: The soil profile identified comprised pale brown to grey sand over dark brown to grey clay / clayey silts over dark grey silty sand / sandy clays over dark grey silty sandstone. Coffee rock was identified at one location and a "rotten egg odour was noted at three locations at various depths within the soil profile. Soil analytical results can be summarised as follows: • Analytical results indicate that ASS is generally present below the water table. • Concentrations of all analytes were below the adopted assessment levels in soil samples, with the exception of copper, nickel and zinc in a minor amount of soil samples. • ACM containing amosite and chrysotile was identified on the ground surface near MW3-145 (between houses and the existing Tonkin Road alignment). • The depth to groundwater in the Superficial Aquifer ranged from 0.46 m BGL to 4.47 m BGL (0.33 m AHD to 5.22 m AHD). There were no visual or olfactory observations of contamination in groundwater. • Concentrations of all analytes were below the adopted assessment levels in groundwater samples, with the exception of the following: ▪ Chloride, total iron, zinc, silver, hexavalent chromium, lead and zinc all exceeded the adopted assessment criteria for non-potable use, fresh water or marine water ecosystems. ▪ Ammonia, total nitrogen and total phosphorous exceeded the adopted assessment criteria for freshwater ecosystems. ▪ TRH was detected in the deep well sample, with a concentration of 790 µg/L (below relevant assessment criteria). ▪ Methane was not recorded in any landfill gas samples. The maximum landfill gas readings were recorded in LG3-149 (carbon dioxide - 2.3 % and hydrogen sulphide - 37 ppm). The maximum methane concentration detected in groundwater was 19 mg/L (BH2-18).	Senversa did not review this primary document in detail; however, it is considered that the information contained in the MAR (Senversa, 2016) provides a good indication of the site conditions, particularly with respect to groundwater within the Wright Crescent Site, and surface water within the SMD.	The presence of ACM within the site is considered likely to be consistent with the findings of this report. While analytes were observed in soil and groundwater at concentrations that exceed the relevant assessment criteria, no specific risk assessment has been undertaken in the context of the site and its development.

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
Stage 4 Environmental Site Investigation – PFAS (WEPL, 2016c)	Western Environmental undertook an environmental assessment to cross-check previous groundwater results and assess PFAS concentrations in surface water and sediment. The scope of work included: • Groundwater sampling and laboratory analysis at 22 existing groundwater wells for PFAS. • Surface water sampling at three locations (unlined open drain up-stream of the airport, SMD within the airport and SMD down-stream of CAFWP area / immediately up-gradient of Swan River). Relevant surface water results for the **SMD** can be summarised as follows: • Surface water samples were generally clear with low turbidity and a yellow / orange colour. PFAS were detected in all surface water samples, with the highest concentrations reported in the sample collected at the Swan River discharge point (GSWE05). • The following exceedances of site-specific risk-based criteria (RBC) were reported for PFAS compounds in surface water: ▪ PFHxS exceeded the Domestic Use (Potable) RBC (0.1 µg/L) at one location (GSWE05). The PFHxS concentration was 0.30 µg/L (GSWE05). ▪ PFOS exceeded the Aquatic Environment RBC (0.00023 µg/L) and Fish Consumption RBC (0.007 µg/L) at all three surface water sampling locations. PFOS also exceeded the Domestic Use (Potable) RBC (0.1 µg/L) at one location. The maximum PFOS concentration was 0.32 µg/L (GSWE05). Relevant groundwater results for the **Wright Crescent Site** (Lot 800) can be summarised as follows: • Concentrations of PFHxS exceeded the domestic non-potable groundwater use guideline (0.7 ug/L) in one location to the north of the Swan River (MW3-136S; 1.6 ug/L).	Senversa did not review this primary document in detail; however, it is considered that the information contained in the MAR (Senversa, 2016) provides a robust description of the site conditions, particularly with respect to groundwater within the Wright Crescent Site, and surface water within the main drain.	The current nature and extent of PFAS within surface water is unknown. The current nature and extent of PFAS in groundwater is unknown. While contaminants were observed in soil and groundwater at concentrations that exceed the relevant assessment criteria, no specific risk assessment has been undertaken in the context of the TGP site and its development.

Report Reference	Summary of Findings	Data Evaluation	Data Gaps
RPS (2016) Stage 5 Environmental Site Investigation, Perfluorinated and Polyfluorinated Alkyl Substances – Forrestfield-Airport Link. June 2016.	RPS undertook a groundwater and surface water monitoring event, with the objective of assessing groundwater for PFAS and to characterise the concentrations of groundwater analytes. The scope of work included surface water monitoring at seven locations and groundwater sampling at four locations. Relevant analytical results are as follows: • No PFAS compounds were detected in MW3-136S, at the **Wright Crescent** site. • PFHxS and PFHxA were not detected at concentrations greater than the assessment criteria at surface water sample GSWE05 (i.e. relevant to the **Southern Main Drain**), with concentrations being lower than those obtained previously at this location. • Concentrations of PFOS exceeded the assessment criteria for aquatic ecosystems in well MW3-156 and MW3-165, immediately south of the lot within the TGP footprint that is classified as CRR.	Senversa did not review this primary documents in detail; however, it is considered that the information contained in the MAR (Senversa, 2016) provides a good description of the site conditions, particularly with respect to groundwater within the Wright Crescent Site, and surface water within the main drain.	Concentrations of PFAS within the Southern Main Drain appear to be variable, and further data would be required to ascertain whether the levels of contaminants identified would require any site-specific management. Concentrations of PFAS within groundwater at the Wright Crescent (Lot 800) site are variable, and further site-specific assessment would be required to ascertain whether groundwater would require any particular management measures during site works (e.g. during dewatering).

5.0 Preliminary Conceptual Site Model

The preliminary conceptual site model (CSM) based on information summarised above is summarised in the following sections.

5.1 Potential Sources of Contamination

Potential sources of contamination and associated COPCs (as applicable) comprise the following:

- Cinder deposits [potential comprising elevated metals (arsenic, cadmium, chromium, cobalt, copper, nickel, lead, manganese, mercury, zinc), fluoride and ammonia].
- ACM in surface soils.
- Uncontrolled fill (most commonly metals and asbestos above but also volatile semi-volatile compounds and pesticides).
- Fly tipping (most commonly metals and asbestos above but also volatile semi-volatile compounds and pesticides).
- PFAS in groundwater and surface water nearby to the site.

5.2 Potential Migration Pathways

Potential migration pathways comprise the following.

- Airborne transport of particulates.
- Vertical migration of contaminants from soil into underlying groundwater.
- Lateral migration of impacted groundwater, beneath industrial and residential areas, towards the BMD, SMD and the Swan River.
- Runoff of impacted surface water into on-site drainage system, and subsequent discharge to BMD and drainage systems.
- Abstraction of impacted groundwater.

Potential exposure routes include the following.

- Dermal contact with impacted soil, surface water and groundwater (where abstracted).
- Incidental ingestion of impacted soil, surface water and groundwater (where abstracted).
- Ingestion of contaminated groundwater (where abstracted).
- Inhalation of impacted soils or dust.

5.3 Potential Receptors

- Current and future site visitors (including users of the PSP near the CRR-classified land parcel).
- Current and future construction and intrusive maintenance workers.
- Current and future off-site residents and property occupants in the vicinity of the site.
- On- and off-site groundwater users.
- On-site terrestrial ecology.
- The ecology of the down-gradient Swan River.

5.4 Source-Pathway-Receptor Linkages

Source-pathway-receptor (SPR) linkages have been assessed in detail for CRR-classified land parcels on-site relating to the former CSBP / Cresco site. Source-pathway-receptor linkages are presented in **Table 5-1**, and a schematic representation of the site is presented in **Figure 7a** and **7b**.

The following exclusions apply to **Table 5-1** and **Figure 7a** and **7b**:

- While ACM in surface soil, uncontrolled fill and fly tipping have all been identified as potential on-site issues in the context of TGP and the proposed ongoing land use, they are not known or suspected as constituting contamination. It is reasonably expected that these issues can be readily managed via a construction environmental management plan (CEMP). This is reflected in the DGA conclusions and recommendations presented in **Section 6.**
- Potential PFAS impacted groundwater and surface water (as detected nearby via FAL project studies) are not included since PFAS has not been detected beneath the site whilst off-site investigations are ongoing (as reflected by the PCIR classification of applicable lots). In the context of TGP construction it is reasonably expected that these issues can be readily managed via a CEMP. This is reflected in the DGA conclusions and recommendations presented in **Section 6.**

Table 5-1 Source-Pathway-Receptor Linkages for Contamination Associated with Cinder Deposits

Source	Pathway	Exposure Route	Receptor	Pathway Complete/Potentially Complete	Comments
Cinder Deposits	Airborne transport of particulates Direct Contact	Inhalation Dermal contact Ingestion	Current and future on-site road reserve users	Yes	Available data indicates that exceedances of relevant criteria occurred at depths greater than 5 mBGL and hence this pathway was unlikely to be complete; however recent works undertaken as part of the NorthLink project have likely changed the soil profile and depth to impact.
			Current and future construction workers and Intrusive Maintenance Workers	Yes	Available data indicates that CoPCs are not likely to be present at concentrations greater than HIL-D criteria; however recent works undertaken as part of the NorthLink project have likely changed the soil profile
			Terrestrial ecology	Yes	Available data indicate that there were some exceedances of ecological criteria (mostly at depths greater than 2 mBGL); however recent works undertaken as part of the NorthLink project have likely changed the soil profile.
			Swan River Ecology	No	Pathway not relevant given distance from site.
	Vertical migration to groundwater, lateral migration of impacted groundwater	Dermal contact Ingestion Inhalation	Current and future on-site road reserve users	No	No groundwater will be plausibly abstracted within the road reserve outside of construction dewatering (see below)
			Current and future on-site construction workers and intrusive maintenance workers	Yes	Available data indicates that CoPCs in groundwater exceed non-potable use criteria. Workers may be exposed via direct contact with groundwater in deep excavations or abstraction of groundwater for dewatering purposes.

Source	Pathway	Exposure Route	Receptor	Pathway Complete/Potentially Complete	Comments
		Dermal contact Ingestion Inhalation	Current and future off-site bore users	Yes	Available data indicates that CoPCs in groundwater exceed non-potable use criteria. Cumulative groundwater impacts from the site and the adjacent CSPB/Cresco site may extend beyond the site boundary and beneath private properties where groundwater abstraction may plausibly occur
		Direct Contact	Terrestrial Ecology	No	As a road reserve, terrestrial ecology is highly modified. Additionally, surrounding terrestrial ecology is unlikely to have direct contact with groundwater given the depth to groundwater.
	Vertical migration to groundwater, lateral migration of impacted groundwater Discharge to BMD		Swan River Ecology	No	While in-situ deposits have resulted in impacts to groundwater, a separate Mandatory Auditor Report MAR (AEA, 2013) prepared on behalf of CSBP notes no impacts were observed at the Swan River ecosystem.

6.0 Conclusions and Recommendations

6.1 Conclusions

6.1.1 Contaminated Site Issues Relating to CRR Classified Land Parcels

Land parcels within TGP have previously been investigated and found to contain cinder deposits relating to former use by the adjacent Cresco/CSBP fertiliser site. The information reviewed has indicated that the cinder deposit material was unlikely to render the site unsuitable for its use as a road reserve in its original distribution; however, the works since undertaken on-site as part of the NorthLink project may have changed the distribution of cinder deposits and in turn may have also altered the risk profile.

Test pitting undertaken to support the Tonkin Grade Separation project (being part of the broader NorthLink project) indicated that it is unlikely that cinder ash material extended into Lot 300 to the north (identified to be 'awaiting classification' under the CS Act).

Regardless of potential direct exposure risk, the presence of the cinder deposits has resulted in low pH and elevated concentrations of metals in groundwater both on- and off-site. As such, there is potential for down-gradient sites to be considered to be affected sites under the CS Act and potential sites are therefore awaiting classification. Furthermore, Senversa understand that ongoing groundwater monitoring and risk assessment is being performed on behalf of CSBP as part of reclassification commitments associated with the adjacent former CSBP / Cresco fertiliser manufacturing site. Given the common cinder deposit historical source between the two sites it is likely that the monitoring will be directly relevant to TGP; however, this has not been confirmed and the outcomes remain unknown.

6.1.2 General Environmental Management Issues

The potential also exists for soils to have been impacted by surficial asbestos, fly tipping and uncontrolled filling as part of Tonkin Highway Construction. This is in keeping with the inner metropolitan nature of the site and typically managed via a construction environmental management plan rather than restriction under the CS Act.

6.1.3 Contaminated Site Issues Identified by the Forrestfield Airport Link (FAL) Project

Additional potentially contaminated sites are located adjacent to the TGP footprint, as follows:

- SMD (PCIR).
- Wright Crescent (awaiting classification).

The above sites were reported to DWER based on preliminary investigations that were undertaken during the planning phases for the FAL project, which identified levels of PFAS in surface water (SMD) and groundwater (Wright Crescent). In addition, the supplied information has indicated that concentrations of other analytes in groundwater (e.g. metal, nutrients and hydrocarbons) may also exceed assessment criteria in these areas.

6.2 Summary of Data Gaps

While several site-specific investigations have been undertaken to characterise site, and there is a significant volume of documentation regarding remediation and monitoring or the former Cresco / CSBP site, the following gaps remain regarding characterisation of the site.

1. Current nature and extent of cinder deposits within the site.
2. Nature and extent of groundwater impact both on- and off-site. In particular, the relationship between potentially affected sites and the site with respect to its current classification is currently unknown.
3. The contamination status of imported fill used for the construction of Tonkin Highway is unknown.
4. The potential for ACM to be present in soils that may be disturbed by development works exists as a detailed assessment of this issue has not been completed.
5. Fly tipping may have introduced contamination to the site.
6. The current nature and extent of PFAS in surface water is currently unknown (within the vicinity of the SMD).
7. The current nature and extent of PFAS in groundwater beneath the site is currently unknown (it has previously been identified in groundwater close to the TGP alignment between the SMD and Railway Parade.

These data gaps are expanded upon in **Table 6-1**, and the recommended action to address them are also presented.

Table 6-1 Data Gaps and Recommended Actions

Data Gap	Details	Recommended Action
1	**Nature and extent of cinder deposits within CRR classified site.** Senversa consider there is sufficient good quality data available to characterise the bulk properties of the cinder deposits, including relevant contaminants of CoPCs and associated physiochemical properties. Historical documentation, including correspondence including from the then (DEC) (now DWER), indicated that the cinder deposits posed a low human health risk to users of the site given the distribution and depth of the deposits at that time, and were suitable to remain in-situ. Recent earthworks undertaken at the site have the potential to have changed the depth and distribution of cinder deposits.	Prepare and implement a sampling and analysis quality plan (SAQP) for intrusive site investigation that assesses the current approximate extent of cinder deposits and update assessment of human health risk and associated management requirements.
2	**Nature and extent of cinder-ash derived groundwater impact both on- and off-site.** Available information indicates that groundwater beneath and down-hydraulic gradient of the site is impacted by substances including ammonia, fluoride, aluminium, arsenic, total iron and nickel. Senversa understand that ongoing groundwater monitoring and risk assessment is being performed on behalf of CSBP and under an auditor-approved monitoring plan as part of reclassification commitments associated with the adjacent former CSBP / Cresco fertiliser manufacturing site. Given the common cinder deposit source between the two sites it is likely that the monitoring will be directly relevant to TGP; however, this has not been confirmed and the outcomes remain unknown.	• Obtain and review current off-site groundwater monitoring reports and assess their suitability to support TGP assessment and reclassification. CSBP have advised that such reports are expected to be made available in 2019; however, it is uncertain whether this enable reclassification of the site prior to tendering for TGP construction in late 2019. • Dependant on above, initiate discussions with DWER to confirm TGP groundwater assessment and management strategy (including how potential requirements for a MAR will be interpreted for this site).

Data Gap	Details	Recommended Action
	DWER has advised that numerous properties down-hydraulic gradient of the site are awaiting classification (understood to be pending the outcomes of the above groundwater monitoring, including a supporting MAR).	Acknowledging timing and suitability uncertainties above, undertake an investigation of on-site cinder-ash derived groundwater impacts (as applicable) with the objective of complementing CSBP studies and to provide contemporary on-site groundwater quality conditions that aide in the development of appropriate management measures during future TGP works.
3	**The composition of imported fill used for the construction of Tonkin Highway is unknown.** While this material was not directly inspected as part of site investigation, the potential for contamination within mixed fill exists.	Prepare a future CEMP to outline procedures required during site works if potentially contaminated fill material is encountered.
4	**The presence of ACM material in surface soils is unknown.** The available information suggests that ACM may be present in the road reserve at a frequency comparable to other Perth Metropolitan roads.	Prepare a future CEMP to outline procedures required during site works if ACM material is encountered.
5	**Fly tipping practises may have introduced contaminants to the site.** Evidence of small-scale fly tipping was observed at the southern-most portion of the site (on Railway Parade, under the Tonkin Highway Bridge).	Prepare a future CEMP to outline procedures required during site works if unexpected materials are encountered.
6	**The current nature and extent of PFAS in surface water is currently unknown** Preliminary information has indicated that PFAS may be present at concentrations greater than assessment criteria in the SMD. This may be relevant where site works are undertaken in the vicinity of the SMD, where surface water is sourced from a similar catchment requires redirection as part of site works; however, the potential risk in the context of the TGP works has not been evaluated.	Future CEMP should include management measures and water quality trigger values for disposal of surface water, where required. Collection of further baseline data from the SMD may aid in characterising conditions prior to works in the area.
7	**The current nature and extent of PFAS in groundwater beneath the site is currently unknown.** Preliminary investigations have indicated that PFAS has been detected in groundwater at concentrations greater than the adopted assessment criteria. This is particularly relevant between the SMD and Railway Parade. It is noted that some of the criteria applied were specific to the works to be undertaken as part of the FAL, and the relevance to the proposed works (and any associated site classifications within the TGP requires further evaluation)	Future CEMP will need to consider management of potential PFAS impacted groundwater where dewatering works are required. This should include a to include a review of criteria for PFAS in groundwater specific to the scope of site works.

6.2.1 Recommendations

In line with Table 6-1 Senversa recommends that an SAQP should be prepared and implemented to further characterise the distribution of cinder deposits on-site (Data Gap 1) and associated groundwater quality (Data Gap 2). These works should be performed in parallel with ongoing CSBP and DWER consultation (in particular) to ensure a consistent and coordinated approach towards resolving groundwater related issues. Given the exact timing of CSBP groundwater monitoring reports and supporting MAR (and outcomes) are unknown, it is also unknown whether the resolution of Data Gap 2 within the desired timeframe and prior to tendering of TGP construction is achievable.

Data Gaps 3-7 are best addressed by preparing site-specific management plans specific to the works to be undertaken during TGP. Baseline groundwater and surface water sampling may aide in the development of such plans, particularly where dewatering is envisaged.

7.0 Principles and Limitations of Investigation

7.1 General Principles and Limitations of Investigation

The following principles are an integral part of site contamination assessment practices and are intended to be referred to when resolving any ambiguity or exercising such discretion as is accorded the user or site assessor.

Table 7-1 Principles and Limitations of this Report

Area	Principle and Limitation
Elimination of Uncertainty	Some uncertainty is inherent in all site investigations. Furthermore, any sample, either surface or subsurface, taken for chemical testing may or may not be representative of a larger population or area. Professional judgment and interpretation are inherent in the process, and even when exercised in accordance with objective scientific principles, uncertainty is inevitable. Additional assessment beyond that which was reasonably undertaken may reduce the uncertainty.
Failure to Detect	Even when site investigation work is executed competently and in accordance with the appropriate Australian guidance, such as the National Environment Protection (Assessment of Site Contamination) Amendment Measure ('the NEPM'), it must be recognised that certain conditions present especially difficult target analyte detection problems. Such conditions may include, but are not limited to, complex geological settings, unusual or generally poorly understood behaviour and fate characteristics of certain substances, complex, discontinuous, random, or heterogeneous distributions of existing target analytes, physical impediments to investigation imposed by the location of services, structures and other man-made objects, and the inherent limitations of assessment technologies.
Limitations of Information	The effectiveness of any site investigation may be compromised by limitations or defects in the information used to define the objectives and scope of the investigation, including inability to obtain information concerning historic site uses or prior site assessment activities despite the efforts of the user and assessor to obtain such information.
Chemical Analysis Error	Chemical testing methods have inherent uncertainties and limitations. Senversa routinely seeks to require the laboratory to report any potential or actual problems experienced, or non-routine events which may have occurred during the testing, so that such problems can be considered in evaluating the data.
Level of Assessment	The investigation herein should not be considered to be an exhaustive assessment of environmental conditions on a property. There is a point at which the effort required to obtain information is outweighed by the time required to obtain that information, and, in the context of private transactions and contractual responsibilities, may become a material detriment to the orderly conduct of business. If the presence of target analytes is confirmed on a property, the extent of further assessment is a function of the degree of confidence required and the degree of uncertainty acceptable in relation to the objectives of the assessment.
Comparison with Subsequent Inquiry	The justification and adequacy of the findings of this investigation in light of the findings of a subsequent inquiry should be evaluated based on the reasonableness of judgments made at the time and under the circumstances in which they were made.
Data Useability	Investigation data generally only represent the site conditions at the time the data were generated. Therefore, the usability of data collected as part of this investigation may have a finite lifetime depending on the application and use being made of the data. In all respects, a future reader of this report should evaluate whether previously generated data are appropriate for any subsequent use beyond the original purpose for which they were collected or are otherwise subject to lifetime limits imposed by other laws, regulations or regulatory policies.
Nature of Advice	The investigation works herein are intended to develop and present sound, scientifically valid data concerning actual site conditions. Senversa does not seek or purport to provide legal or business advice.

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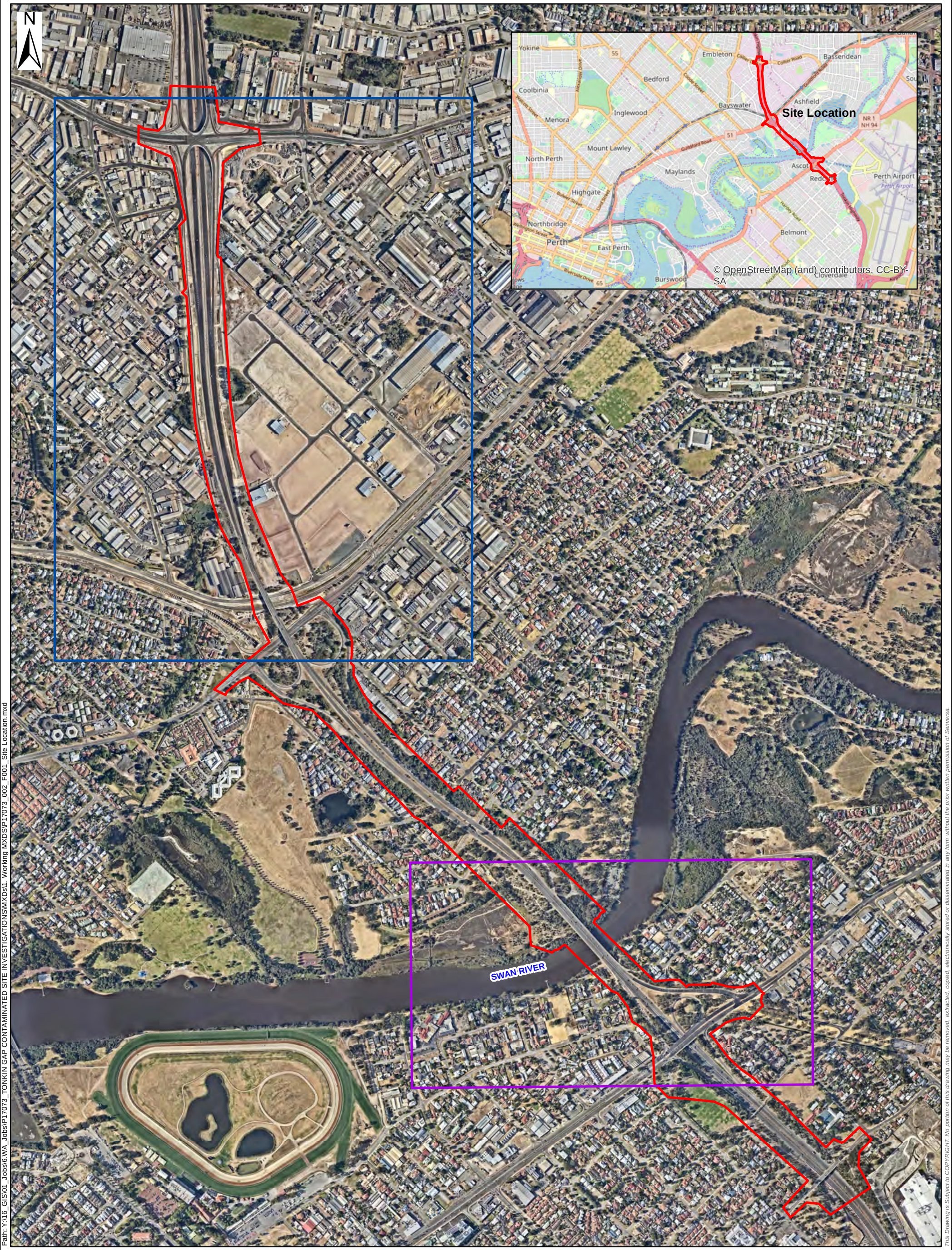
Figures



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Address: Level 17, 140 St Georges Tce, Perth WA 6000
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Legend

- Site Boundary
- Refer to Figure 2a
- Refer to Figure 2b

Aerial imagery sourced from Nearmap

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Drawn:	M. Byrne	Revision:	0
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Datum GDA 1994, Projection MGA Zone 50

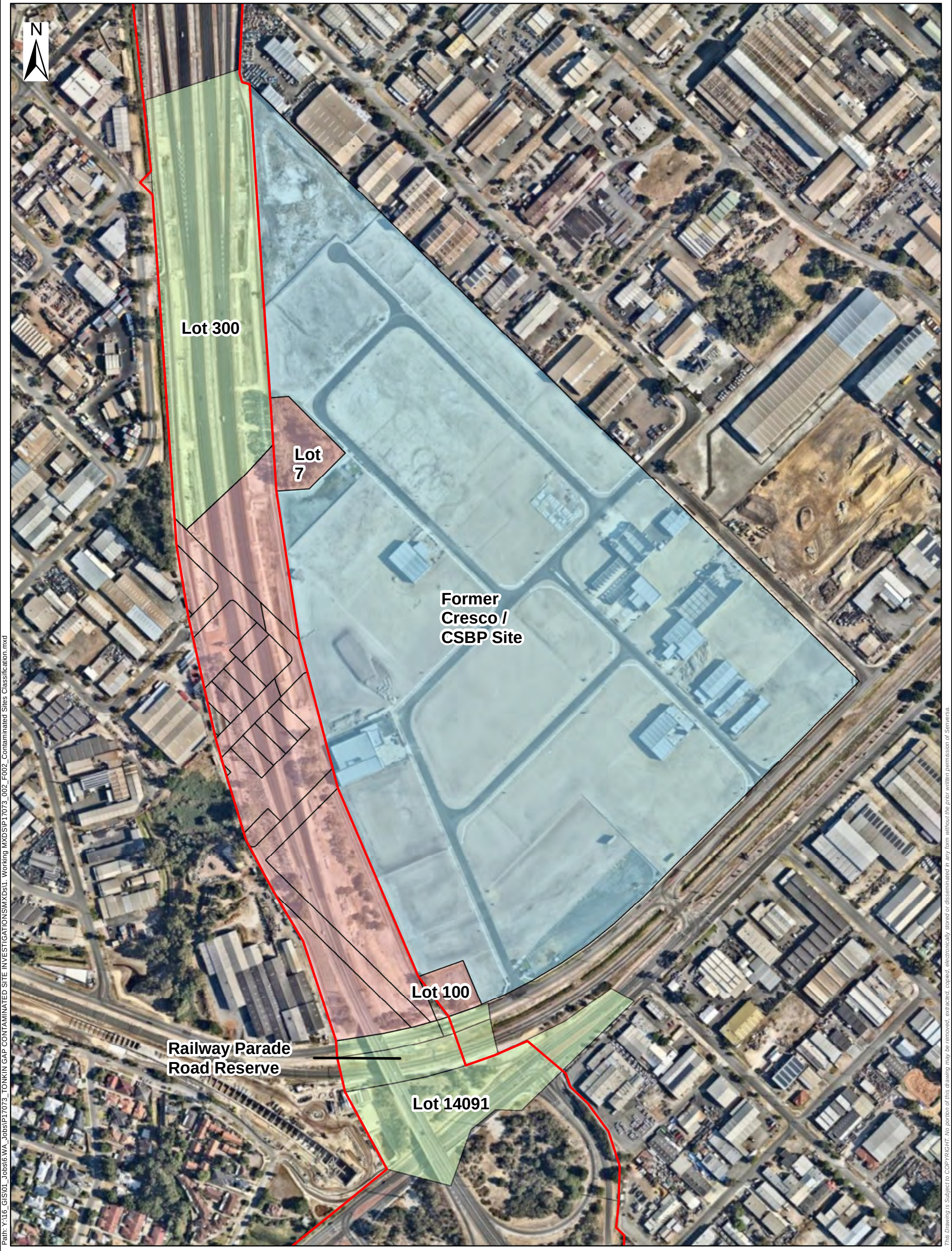
Figure No: 1

Title: Site Location

Project: Data Gaps Assessment

Location: Tonkin Highway Gap Project

Client: Main Roads Western Australia



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Legend

- Site Boundary
- Remediated - Restricted Use
- Contaminated - Remediation Required
- Awaiting Classification
- Decontaminated
- Possibly Contaminated- Investigation Required

Aerial imagery sourced from Nearmap

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0 25 50 100 150 200 Metres

Datum GDA 1994, Projection MGA Zone 50

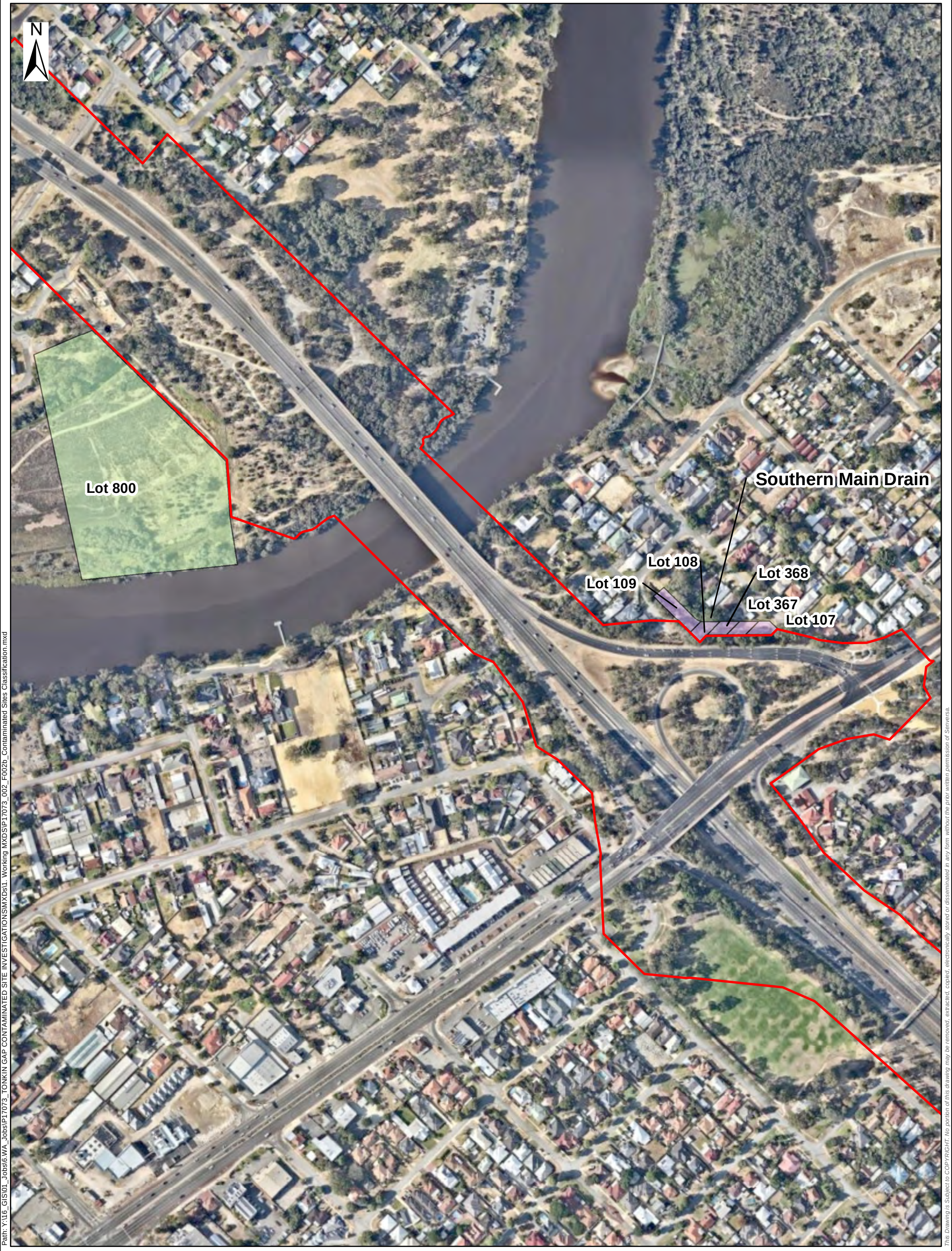
Figure No: 2a

Title: Contaminated Sites Classification - North

Project: Data Gaps Assessment

Location: Tonkin Highway Gap Project

Client: Main Roads Western Australia



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Legend

- Site Boundary
- Remediated - Restricted Use
- Contaminated - Remediation Required
- Awaiting Classification
- Decontaminated
- Possibly Contaminated- Investigation Required

Aerial imagery sourced from Nearmap

Designed:	G. Hefron	Date:	26/06/2019
Drawn:	M. Byrne	Revision:	0
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File: P17073_002_F002b_Contaminated Sites Classification

0 25 50 100 150 200 Metres

Datum GDA 1994, Projection MGA Zone 50

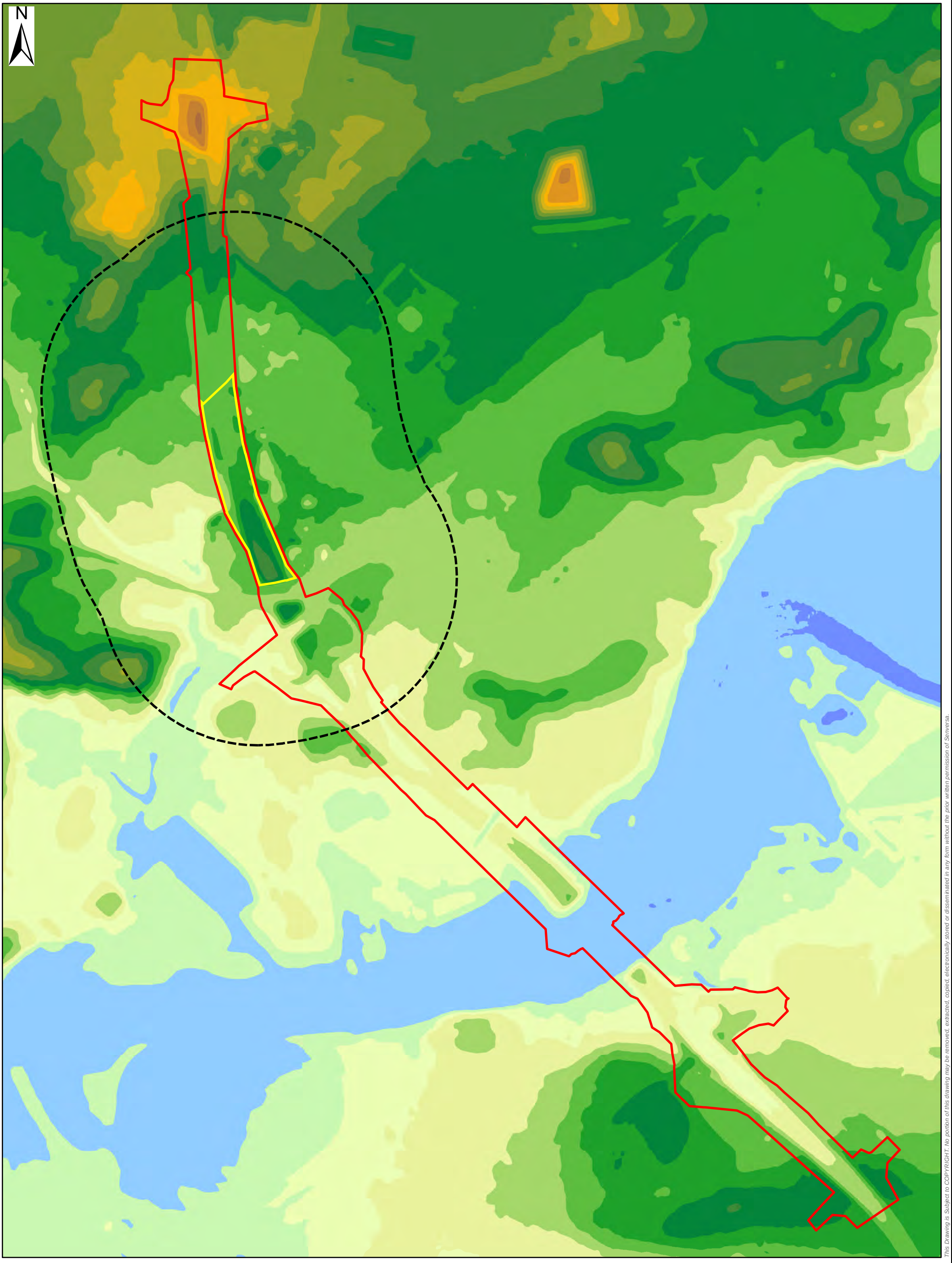
Figure No: 2b

Title: Contaminated Sites Classification - South

Project: Data Gaps Assessment

Location: Tonkin Highway Gap Project

Client: Main Roads Western Australia



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Legend

- Buffer - 500m
- Site Boundary
- On-site Parcels classified as CRR

Elevation mAHD

- -2.50 - 0.0
- 0.01 - 2.5
- 2.51 - 5
- 5.01 - 7.5
- 7.51 - 10
- 10.01 - 12.5
- 12.51 - 15
- 15.01 - 17.5
- 17.51 - 20
- 20.01 - 22.5
- 22.51 - 25
- 25.01 - 27.5
- 27.51 - 30
- 30.01 - 32.5
- 32.51 - 35
- 35.01 - 37.5
- 37.51 - 40

Designed:	G. Hefron	Date:	17/06/2019
Drawn:	M. Byrne	Revision:	0
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File:	P17073_002_F003_Topography		

0 70 140 280 420 560 Metres

Datum GDA 1994, Projection MGA Zone 50

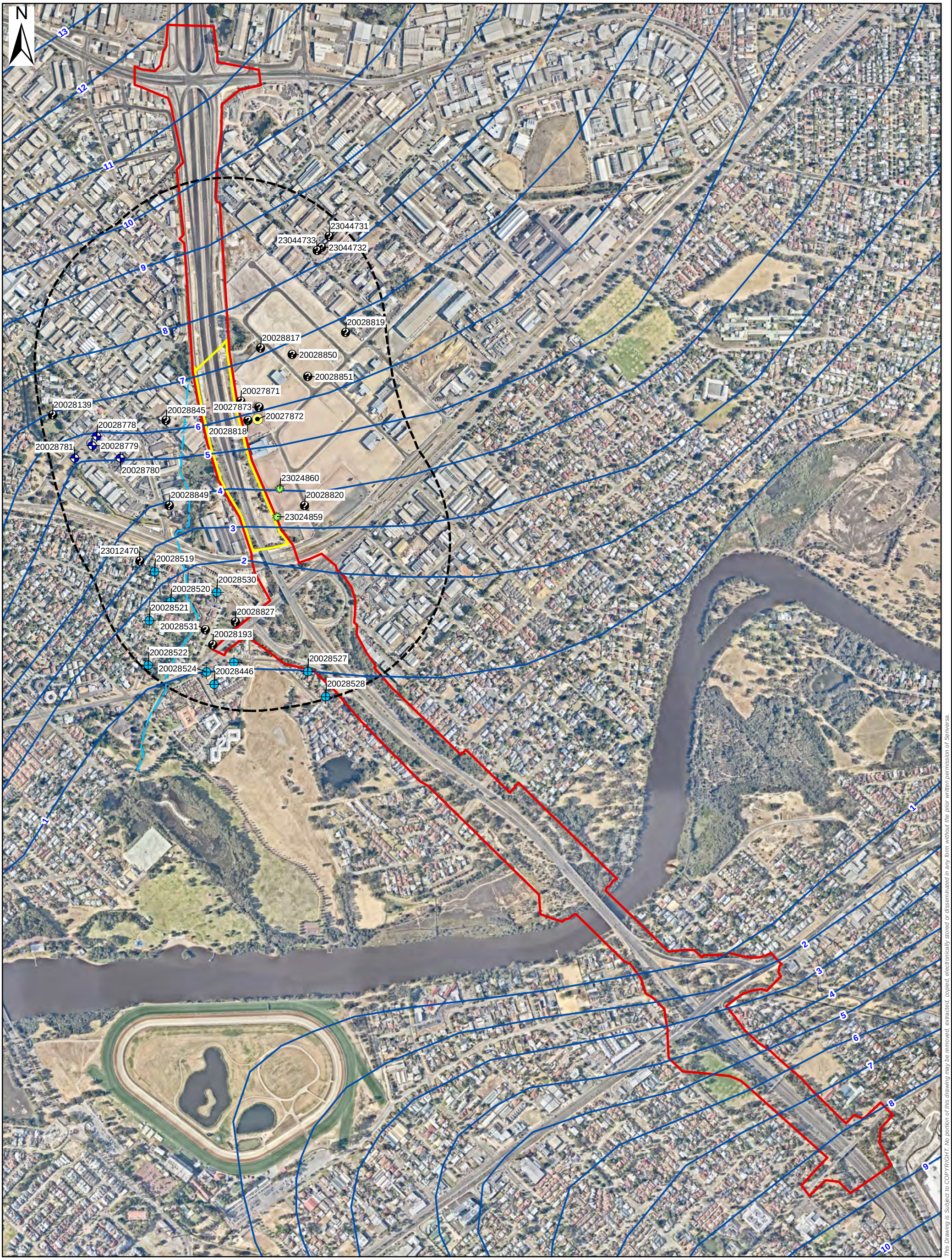
Figure No: 3

Title: Topography

Project: Data Gaps Assessment

Location: Tonkin Highway Gap Project

Client: Main Roads Western Australia



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Legend

Registered Bore
- Domestic Garden
- Manufacturing and Industry
- Monitoring
- Unknown Use
- Water Supply

- Groundwater Elevation Contours mAHD
- Bayswater Main Drain
- Buffer - 500m
- Site Boundary
- On- Site Parcels classified as CRR

Aerial imagery sourced from Nearmap
Bore Search: http://www.bom.gov.au/water/groundwater/ngis
Contours Sourced from Department of Water and Environmental Regulation - WA

Designed:	G. Hefron	Date:	17/06/2019
Drawn:	M. Byrne	Revision:	0
Checked:		Scale:	1:11,000 (A3)

File: P17073_002_F004_Surrounding GW Bore Search

0 70 140 280 420 560 Metres

Datum GDA 1994, Projection MGA Zone 50

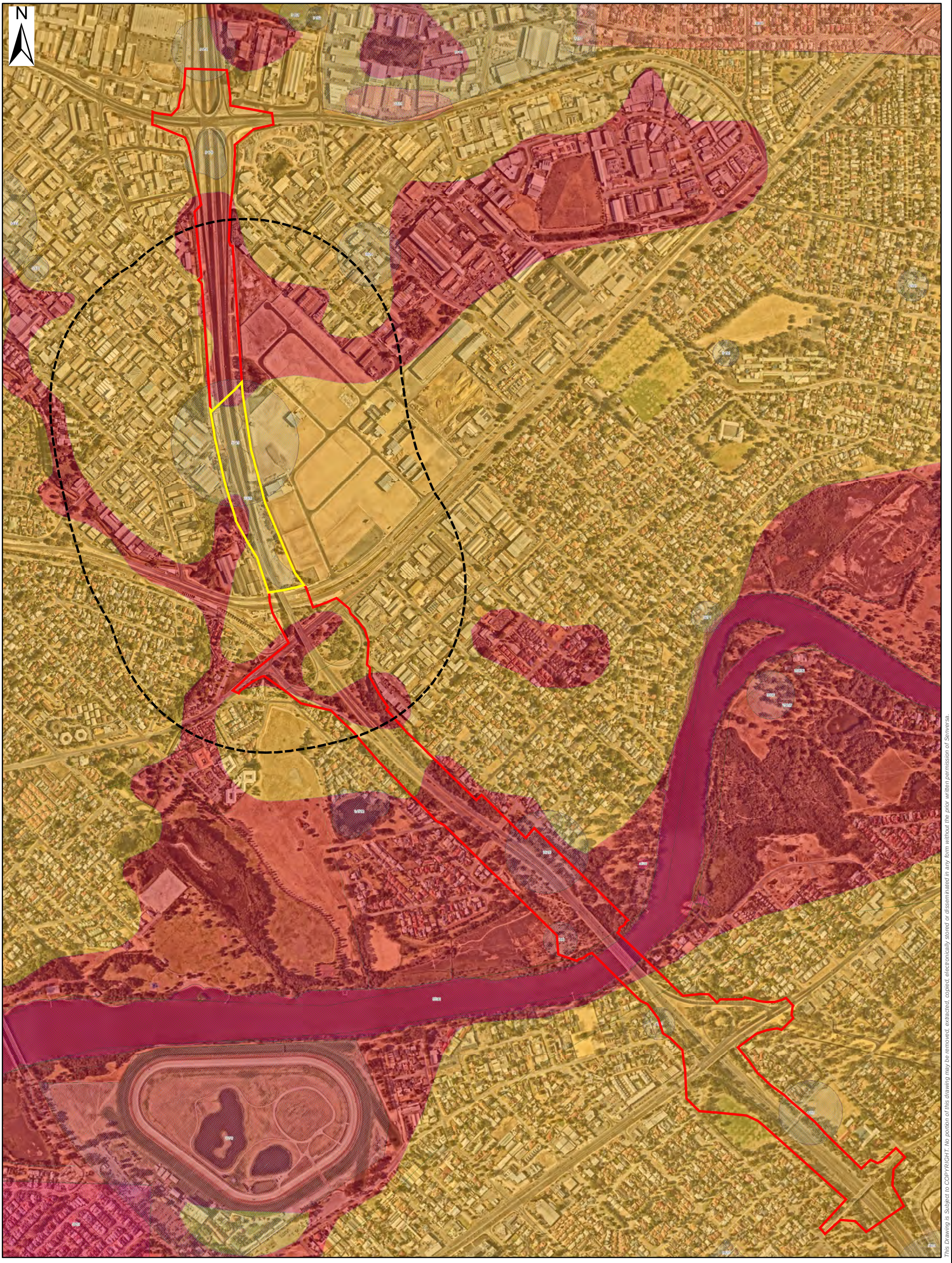
Figure No: 4

Title: Groundwater Contours and Groundwater Bore Search Results

Project: Data Gaps Assessment

Location: Tonkin Highway Gap Project

Client: Main Roads Western Australia



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Legend

- Buffer - 500m
- Site Boundary
- On- site parcels classified as CRR
- Aboriginal Heritage Place - Other Heritage Place
- High to Moderate Risk of ASS occuring within 3m of Natural Soil Surface
- Moderate to Low Risk of ASS occuring within 3m of Natural Soil Surface, but High to Moderate Risk of ASS beyond 3m of Natural Soil Surfaces
- Wetland - Multiple Use

Aerial imagery sourced from Nearmap
Data Source: https://data.wa.gov.au

Designed:	G. Hefron	Date:	17/06/2019
Drawn:	M. Byrne	Revision:	0
Checked:		Scale:	1:11,000 (A3)

File: P17073_002_F005_Wetlands, Heritage and ASS

0 70 140 280 420 560 Metres

Datum GDA 1994, Projection MGA Zone 50

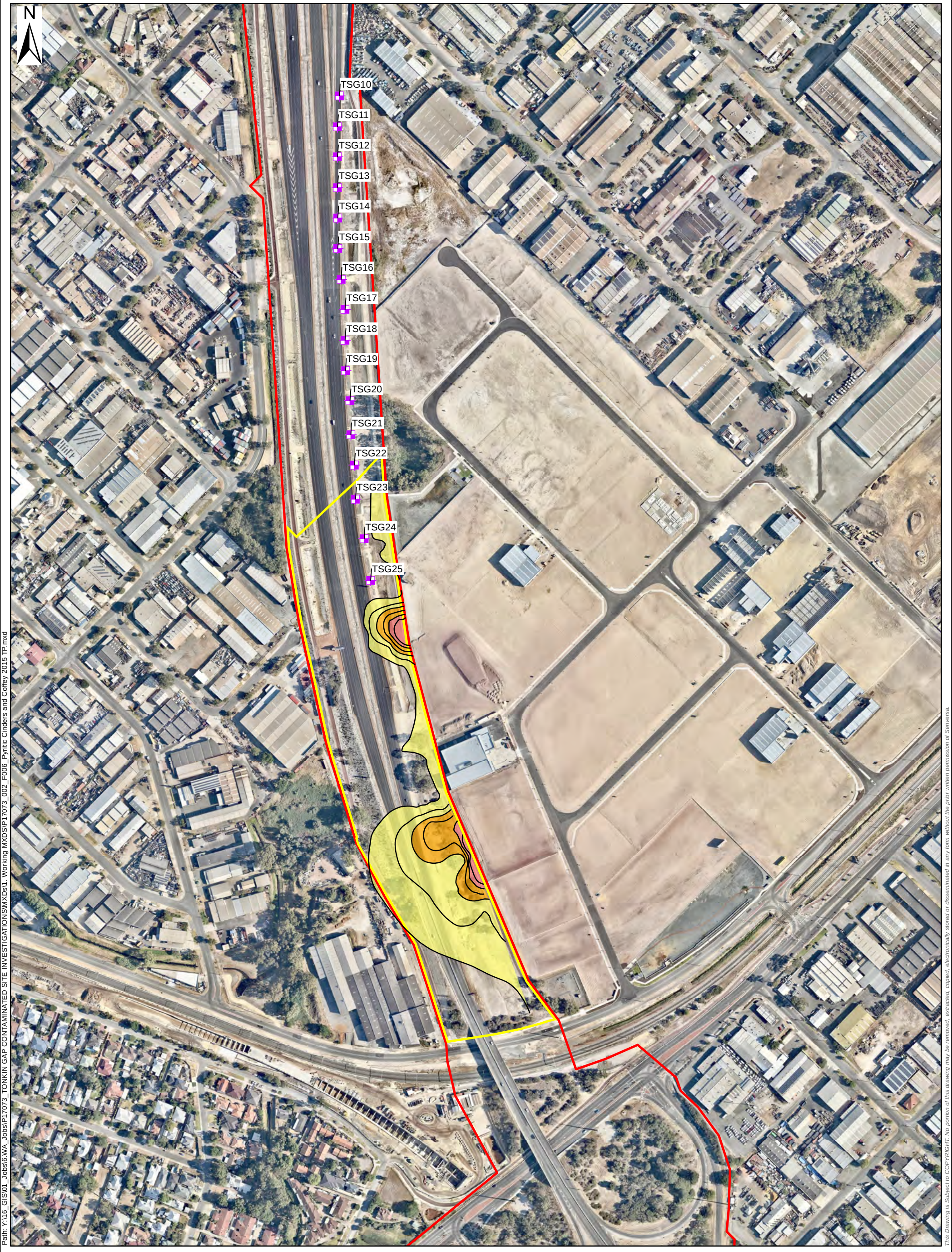
Figure No: 5

Title: Wetlands, Heritage and Acid Sulfate Soils

Project: Data Gaps Assessment

Location: Tonkin Highway Gap Project

Client: Main Roads Western Australia



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Legend

- Coffey 2015 DSI Test Pit Location
- Contour
- Site Boundary
- On- site parcels classified as CRR

Pyritic Cinders/Iron Oxide Concentration (%Fe2o3) (Parsons Brinckerhoff 2004)

- 0-10
- 10-20
- 20-30

Aerial imagery sourced from Nearmap
All results in mg/kg

Designed:	G. Hefron	Date:	28/06/2019
Drawn:	M. Byrne	Revision:	0
Checked:		Scale:	1:4,000 (A3)

File: P17073_002_F006_Pyritic Cinders and Coffey 2015 TP

0 25 50 100 150 200 Metres

Datum GDA 1994, Projection MGA Zone 50

Figure No: 6

Title: Pyritic Cinders Distribution and Coffey 2015 Test Pit Locations

Project: Data Gaps Assessment

Location: Tonkin Highway Gap Project

Client: Main Roads Western Australia

West

East

Commercial Properties

Road Reserve

Tonkin Highway

Road Reserve

Tonkin Highway Industrial Estate (Former Cresco/CSBP Fertiliser Site)

Commercial Properties

PSP

Fence

Drainage Swale

Drainage Swale

Fence

PSP

Possible Mixed Fill

High Pressure Gas

Heavy Metal Impacted Soil (Cinder Deposits)

Bassendean Sand

Inferred Groundwater Flow Direction

Groundwater ~7-12 mbgl

Heavy Metal and Fluoride Impacted Groundwater

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Legend

- Groundwater Level ~7-12 mbgl
- Inferred Groundwater Flow Direction
- Commercial Properties
- Heavy Metal Impacted Soil (Cinder Deposits)
- Heavy Metal and Fluoride Impacted Groundwater
- High Pressure Gas
- Clean Fill
- Bassendean Sand
- Possible Mixed Fill

Designed:	B. Coleman	Date:	27/06/2019
Drawn:	M. Byrne	Revision:	0
Checked:	.	Scale:	(A3)
File:	P17073_002_F007A_CSM North		

Not to Scale

Figure No: 7A

Title: Conceptual Cross Section – Northern Portion of CRR Classified Parcels

Project: Data Gaps Assessment

Location: Tonkin Highway Gap Project

Client: Main Roads Western Australia

West

East

Road Reserve

Tonkin Highway

Road Reserve

Tonkin Highway Industrial Estate (Former Cresco/CSBP Fertiliser Site)

PSP

PSP

Commercial Properties

Possible Mixed Fill

Fence

Commercial Properties

High Pressure Gas

Clean Fill

Heavy Metal Impacted Soil (Cinder Deposits)

Inferred Groundwater Flow Direction

Bassendean Sand

Groundwater ~7-12 mbgl

Heavy Metal and Fluoride Impacted Groundwater

Path: Y:\16_GIS\01_Jobs\6.WA_Jobs\P17073_TONKIN GAP CONTAMINATED SITE INVESTIGATIONS\MXDs\1. Working MXDs\P17073_002_F007B_CSM South.mxd

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Legend

- Groundwater Level ~7-12 mbgl
- Inferred Groundwater Flow Direction
- Commercial Properties
- Heavy Metal Impacted Soil (Cinder Deposits)
- Heavy Metal and Fluoride Impacted Groundwater
- High Pressure Gas
- Bassendean Sand
- Possible Mixed Fill
- Clean Fill

Designed:	B. Coleman	Date:	27/06/2019
Drawn:	M. Byrne	Revision:	0
Checked:	.	Scale:	(A3)
File:	P17073_002_F007B_CSM South		

Not to Scale

Figure No: 7B

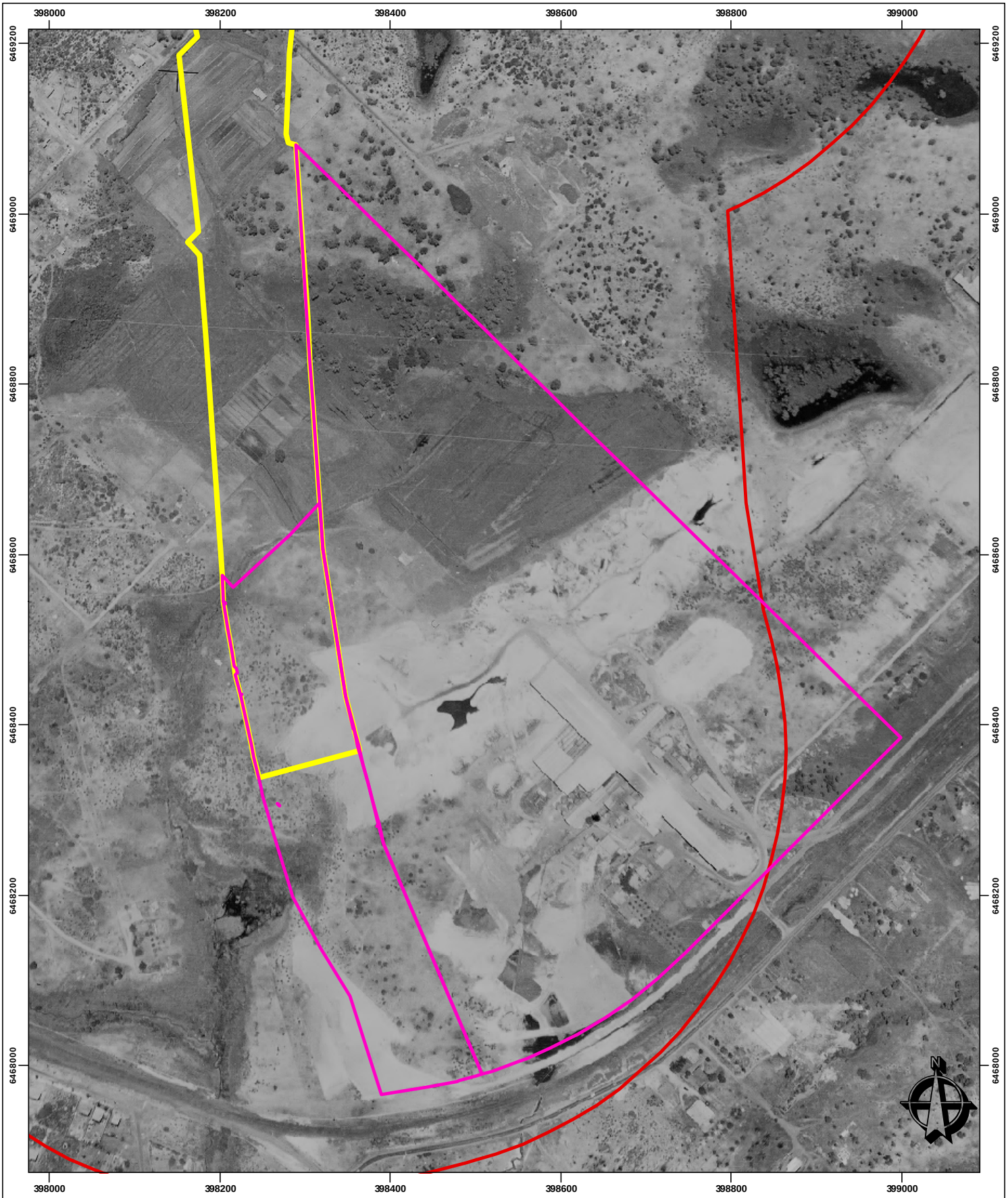
Title: Conceptual Cross Section – Southern Portion of CRR Classified Parcels

Project: Data Gaps Assessment

Location: Tonkin Highway Gap Project

Client: Main Roads Western Australia

Appendix A: Historical Aerial Photographs



Legend

- Contaminated Sites
- Site Location
- Proposed Clearing Footprint (500m boundary)

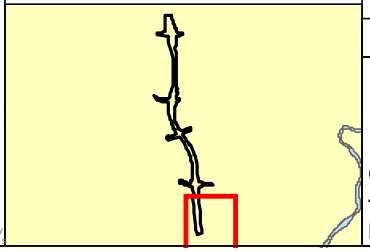
0 25 50 100 150 200

Metres

1:6,000 @ A4

- NOTE THAT POSITION ERRORS CAN BE >5M IN SOME AREAS

LOCALITY MAP



360 Environmental
a 10 Bermondsey St, West Leederville, 6007 WA
t (08) 9388 8360
f (08) 9381 2360
w www.360environmental.com.au

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HORIZONTAL DATUM AND PROJECTION
GDA 1994 MGA Zone 50

CREATED	CHECKED	APPROVED	REVISION
CS	DR	SB	0

Main Roads Western Australia
Tonkin Highway

Contaminated Sites Investigation

CSBP Bayswater and

Tonkin Highway Road Reserve
Historical Imagery 1953

- LOCALITY MAP SOURCED FROM LANDGATE 2006
- STREET DIRECTORY MAP SOURCED FROM STREETSMART 2008
- CONTAMINATED SITES SOURCED DER 2014
- IMAGERY SOURCED LANDGATE SLIP 1953 IN 2014

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