Department of Defence | GHD Pty Ltd

0967 RAAF Base Pearce and 0965 Bullsbrook Training Area/3TU

Detailed Site Investigation

May 2020

This DCARM Stage 2 Detailed Site Investigation Report (“the report”) has been prepared by GHD for Department of Defence for the intended purpose in accordance with clause 2.2 of GHD’s terms of engagement and as set out in Section 1.3 of this report.

The services undertaken by GHD in connection with preparing this report are detailed in the report and are in accordance with the scope of Services of GHD’s terms of engagement.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report may necessarily be based on reasonable assumptions made by GHD, and if so, these will be clearly identified in this report. It is noted that to the extent the report relies on assumptions, these can give rise to discrepancies to the extent that they may or may not represent actual existing circumstances or eventuate to be correct assumptions.

GHD has prepared this report on the basis of information provided by Department of Defence and others who provided information to GHD (including Government authorities), which GHD has verified or checked to the extent required by the agreed scope of work. GHD identifies the sources of information in this report.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

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Executive summary

Background

GHD has been engaged by the Department of Defence (Defence) Directorate of Contamination Assessment Remediation and Management (DCARM) to undertake a three-year contamination investigation program for Defence properties in Western Australia (the *program*) between 2017 and 2020.

As part of the program, GHD has updated existing Stage 1 Preliminary Site Investigation (PSI) information and completed a Stage 2 Detailed Site Investigation (DSI) (the *project*) at Royal Australian Air Force (RAAF) Base Pearce (property ID 0967) and nearby Bullsbrook Training Area (No. 3 Telecommunications Unit, 3TU, property ID 0965) (herein referred to as the "properties" as a whole, or "*RAAF Base Pearce*" and "*3TU*" when differentiating between the two land parcels).

It should be noted that this DSI excludes the assessment of Per- and Poly-fluoroalkyl Substances (PFAS) at RAAF Base Pearce as PFAS impacts at the property are currently under investigation by Defence's PFAS Investigation Management Branch (PFASIMB). PFAS has been included in the frame of investigation at 3TU where available lines of evidence indicate that it is a contaminant of potential concern.

RAAF Base Pearce is located approximately 35 km north-east of Perth, as shown in Figure 1. The property has been continuously in operation as an Air Force Base since the 1930s and is used for flight training for pilots by both RAAF and Republic of Singapore Air Force (RSAF) personnel. It is understood that there are no plans at this time for a change in operational use or for disposal of the Pearce property. Numerous phases of environmental investigation have been undertaken since 1993, with 46 environmental reports known to have been prepared for the property.

3TU covers an area of approximately 1074 ha and is located approximately three kilometres west of RAAF Base Pearce (Figure 1). Before its closure in 1994, 3TU's function was to provide High Frequency communication to RAAF operations in Western Australia.

This Stage 2 DSI report details the investigations undertaken at RAAF Base Pearce and 3TU during Mobilisation 1 (March through May 2018) and Mobilisation 2 (April 2019).

Purpose

The purpose of the program is to:

- Identify and address data gaps where previous investigations have failed to adequately assess or quantify potential contamination risks.
- Achieve whole of property assessment including to identify and delineate contamination to better inform future developments, monitoring, property disposals; and the suitability of land for ongoing Defence activities.
- Enable DCARM to set the scope and priorities for future contamination management and remediation initiatives.

Objectives

Within the broader program context, the specific objectives of this project were to:

- Review existing desktop information and, where data gaps are identified, update the information in order to: (a) document the current and historical uses of the property to identify potential contamination sources, (b) understand the physical setting of the property,

(c) identify potential receptors and their vulnerability to contamination, and (d) determine whether a more detailed program of sampling and analysis is required.

- Complete a Stage 2 DSI to: (a) define the potential or actual extent of contamination (nature and extent), (b) assess the contamination risk to human health and the environment and (c) determine any requirements for remediation or contamination management.

Scope of works

Prior to completion of the Stage 2 DSI, a review of the site environmental setting and relevant historical reports/records was undertaken, followed by a site inspection and interviews with Defence personnel. Results were used to develop a preliminary Conceptual Site Model (CSM) and evaluate underpinning data gaps. The data gap evaluation was used to inform the development of Data Quality Objectives (DQO) and scope for the Stage 2 investigation undertaken at both RAAF Base Pearce and 3TU properties.

The scope of work completed at RAAF Base Pearce and 3TU during the Stage 2 DSI was completed across two main mobilisations (March/April/May 2018 and March/April 2019 with a small scope undertaken in September 2018 comprising end of winter surface water sampling at limited locations). The scope of work comprised the implementation of a soil, groundwater, sediment and surface water sampling program and associated program of field and laboratory analyses including the installation of 45 permanent monitoring wells at RAAF Base Pearce and seven at 3TU.

Sampling was focussed across multiple source areas where data gaps existed that precluded an adequate assessment of contamination risk to receptors under both current and future land-uses, including existing source areas identified in Defence's Contaminated Sites Register, and newly identified areas of environmental concern.

Representative samples were tested for relevant Contaminants of Potential Concern (CoPC) including: metals, Polycyclic Aromatic Hydrocarbons (PAH), Total Recoverable Hydrocarbons (TRH), Benzene, Toluene, Ethylbenzene, Xylenes and Naphthalene (BTEX-N), explosives residues, Polychlorinated Biphenyls (PCB), PFAS (at limited locations), Volatile Organic Compounds (VOC) including chlorinated hydrocarbons, PCBs, Methyl Tert-butyl Ether (MTBE), pesticides and phenols, nutrients and *E.coli*.

At RAAF Base Pearce, results were compared against applicable assessment criteria for the land-use including human health under a commercial/industrial land-use and residential at one Contaminated Site Record (CSR, former service station) proximal to residential areas and ecological criteria protective of an area of ecological significance due to the close proximity of sensitive surface water catchments (the Ellen Brook and Ki-It Monger Brook).

At 3TU results were compared against human health criteria under a commercial/industrial land-use, as well as public open space and residential as a conservative consideration of future land-use alternatives, and ecological criteria protective of an area of ecological significance due to the close proximity of sensitive surface water catchments (the Ellen Brook).

Key findings

Based on the results of the investigation, the following key findings were made with respect to contamination risk.

RAAF Base Pearce

The property slopes gently in a generally westerly direction towards the Ellen Brook and comprises three principal drainage catchments which direct surface water to open drainage channels that discharge to Ellen and Ki-It Monger Brooks.

Groundwater beneath the property is present both as a discontinuous, seasonal perched groundwater unit, present within an upper clay-rich layer, underlain by the superficial regional aquifer that occurs within a sandier unit. Beneath the majority of the property, groundwater is generally flowing in a south-westerly direction towards the Ellen Brook. Within the south-eastern portion of the property, near Ki-It Monger Brook, groundwater flows to the south-east and south. Data indicates that the Ellen Brook is both receiving from and discharging to groundwater depending on the location, intensity and duration of recent rainfall events, and the time of year.

Soil samples across the property broadly reported CoPC concentrations below applicable investigation levels with the following exceptions:

- Concentrations of hydrocarbons in soils at the grounds maintenance area (CSR_WA_000151), former service station (CSR_WA_000117) and former fuel farm (CSR_WA_000110) were above applicable ecological assessment levels however no associated pathways or receptors were identified at these facilities therefore the associated risk is low.
- The presence of elevated Benzo(a)pyrene (BaP) and dieldrin in surface soils in the north-western portion of the Dog Compound (CSR_WA_000083) is consistent with the unauthorised dumping of waste in this area. As the soil impacts are isolated to the fenced Dog Compound area, they do not present a significant exposure risk to the users of the fenced compound or downstream receptors.
- Although not above applicable investigation levels, lead concentrations in soils in the vicinity of the bullet catcher at the former 25 m small arms range (PCSR_0967_003) were elevated, whilst copper concentrations were above ecological assessment levels in localised shallow soils.

Groundwater investigations at RAAF Base Pearce have broadly indicated that where present, groundwater impacts are either delineated, or not posing a risk to identified receptors with the following exceptions or uncertainties:

- The extent of *E.coli* and copper impacts to groundwater down-gradient from the sewage treatment plant (CSR_WA_000106) is undelineated.
- The upgradient extent of Trichloroethylene (TCE) impacts to groundwater at the grounds maintenance area (CSR_WA_000151) is undelineated and the potential for Dense Non-aqueous Phase Liquid (DNAPL) has not adequately been investigated.
- The source (subsurface leak or aboveground spill) of TRH impact to groundwater at the current AVTUR fuel facility (PCSR_0967_002) is unknown and should be further assessed.

In addition, dissolved phase hydrocarbon plumes in groundwater at the former service station (CSR_WA_000117), former fuel farm (CSR_WA_000110) and AVTUR fuel facility (PCSR_0967_002) were assessed for plume stability and natural attenuation capacity. Results were generally supportive of plume shrinkage and the occurrence of natural attenuation.

Sediment samples across the property broadly reported CoPC concentrations below applicable investigation levels with the following exceptions:

- Elevated metals and minor TRH and PAH concentrations were identified in sediment immediately downstream of the former small arms range, fire fighting training/fuel storage areas, the Sounness Road landfill and the grounds maintenance area, however were not deemed to pose a risk to identified receptors.
- Benzo(a)pyrene concentrations in sediment in a drainage channel adjacent to the former fuel farm were above health criteria over an area of 150 m by 1 m by 0.5 m.

Surface water samples were taken from the drainage channel network over two events in 2018 – post summer (May 2018) and post winter (September 2018), although the majority of sample locations in the post summer event were dry. At locations where surface water was present it was noted that the water was generally stagnant and not representative of conditions which would support an ephemeral aquatic ecosystem. Results indicated:

- VOC, BTEX, Chlorinated Hydrocarbon (CHC), Organophospate Pesticides (OPP) were not detected above Limit of Reporting (LOR) in the surface water samples collected.
- In general, detections of hydrocarbons (PAH at the paint shop and TRH at the former fuel farm and runways and taxis), Organochlorine Pesticides (OCP), dieldrin at the former small arms range) and elevated ammonia (sewage treatment plant) in surface water on the property were not reported in any adjacent downstream locations or the receiving bodies of Ki-It Monger Brook and the the Ellen Brook.
- Post summer and post winter, trace concentrations of metals in surface water resembled regional groundwater concentrations (i.e. slightly elevated above the freshwater criteria) however this is not reflected at the discharge point to the Ellen Brook where concentrations of chromium, copper and zinc were not detected post summer. Post winter metals concentrations at the Ellen Brook indicate a potential upstream source of copper and zinc. Upstream concentrations of copper and zinc in Ki-It Monger Brook also suggest an upstream source.

3TU

The 3TU property is situated on a gently undulating, generally poorly drained sand plain, with elevation falling to the east. The Bulls Brook drainage system passes through the property, which experiences ephemeral flows during winter months, with low lying areas occurring as sump lands and damp lands. Geology underlying the 3TU property comprises unconfined surficial deposits of Bassendean Sands, with groundwater flow in an east to south-easterly direction towards the Ellen Brook.

Soil samples across the property broadly reported CoPC concentrations below applicable investigation levels with the following exceptions:

- Faecal coliforms in soils at the property exceeded adopted human health investigation levels at the former septic tanks area (CSR_WA_000019) and may potentially pose a risk to human health under a direct contact or residential land-use scenario. Exposure would be managed by application of industry standard health and safety measures during any civil works but may require management under a change of land-use.
- Asbestos Containing Material (ACM) fragments were identified in surface soils in the vicinity of the former workshop area (including incinerator (CSR_WA_000080), septic tanks (CSR_WA_000019) and diesel USTs (CSR_WA_000103). Any future civil works in this vicinity should be undertaken in accordance with an asbestos management plan.
- The detection of PFAS in surface soils at the asphalt stockpile area (PCSR_0965_002) poses a potential risk to future land users under more sensitive land use scenarios. Stockpiled material should be removed (under appropriate waste classification protocols) and underlying soil validated.

Groundwater investigations at 3TU have broadly indicated the following:

- Historical waste burial in the southern part of 3TU (CSR_WA_000081) has resulted in elevated zinc concentrations in groundwater above freshwater criteria. Currently the extent of zinc impacts is undelineated. Installation of additional monitoring wells hydraulically down gradient of the CSR area is considered warranted to adequately assess the potential for migration to the Ellen Brook.

- Localised PFAS and faecal coliform impacts to groundwater are present beneath the former workshop area. As such, restriction of groundwater abstraction in this area is recommended to mitigate potential exposure risk to future land users.
- PFAS impacts to groundwater are not well delineated either up-gradient or down-gradient. Further groundwater assessment should be undertaken between the source area and receptors (West Bullsbrook groundwater users) to improve the understanding of PFAS distribution in the sub-surface.

Sediment samples across the property broadly reported CoPC concentrations below applicable investigation levels with the following exceptions:

- Minor detects of TRH in sediments within nearby drainage features, which are considered to be related to the presence of organic material or other polar/non-petrogenic compounds and therefore not considered to pose risk to ecological receptors.
- Localised PFAS sediment impacts above residential health guidelines were detected at the asphalt stockpile area and downstream of the former workshop area.

Surface water sampling at 3TU was limited by lack of flow, but broadly indicated:

- Metals concentrations were elevated both upstream and on-site
- PFAS concentrations were present above drinking water guidelines and the 99 % freshwater protection level downstream of the former workshop area.

Further assessment of surface water (property wide) is considered warranted to more accurately assess surface water impacts during rain periods. Results should be interpreted in conjunction with the existing PFAS ecological risk assessment undertaken by PFASIMB for Pearce (including the Ellen Brook).

Our interpretation of the results - and those obtained by PFASIMB (GHD 2018b) - suggests that the PFAS contamination detected at 3TU is unlikely to be the source of PFAS detected in groundwater at the West Bullsbrook residential area and the Ellen Brook.

Conclusions

Based on the results of the investigation, the properties are considered suitable for ongoing commercial/industrial use by Defence in the context of the existing land use.

Recommendations

Based on the outcomes of the investigation, the following recommendations for further activities associated with contamination risk assessment are made (to be confirmed following discussion with Defence and other stakeholders):

- Installation of additional monitoring wells at the Sewage Treatment Plant and Grounds Maintenance areas at RAAF Base Pearce.
- Further investigation into the source (subsurface leak or aboveground spill) of TRH impacts to groundwater at the current AVTUR fuel facility including the installation of an additional well at the puraceptor discharge point.
- Installation of additional monitoring wells downgradient of the former waste burial area at 3TU.
- Further groundwater assessment between the 3TU former workshop area and down-gradient groundwater receptors (West Bullsbrook).

The following recommendations for contamination risk mitigation and management controls have been made:

- Remediation/validation of impacted sediment in the drainage channel adjacent to the Former Fuel Farm, estimated to be a volume of up to 75 m^3 (150 m by 1 m wide by 0.5 m deep).
- Removal/deleading of the bullet catcher at the RAAF Base Pearce Former 25 m Small Arms Range, estimated to comprise a volume of soil of up to 100 m^3.
- The asphalt stockpile at 3TU should be removed and validated in accordance with waste classification protocols.
- Any civil works in the vicinity of the 3TU the former workshop area should be undertaken in accordance with an asbestos management plan and an unexpected finds procedure.
- A site management plan including a restriction on groundwater abstraction beneath the former workshop area at 3TU should be developed to limit exposure to localised PFAS and faecal coliform impacts in groundwater by future users.
- Sewage treatment and disposal processes and infrastructure at Pearce should be reviewed to establish the cause of the E.coli presence in groundwater.
- Bund upgrades should be undertaken at Pearce ASTs (CSR_WA_000086) and at the ILS 18 and associated glide path (CSR_WA_000087 and CSR_WA_000088).
- Review and improvement of engineering controls (such as bunding) should be undertaken at the Grounds Maintenance Area to prevent further impact to the environment.
- Development of Site Management Plans (SMP) for the Former USTs 240 – 245 area and Power Station to manage residual risks to intrusive workers.

In addition, a program of ongoing groundwater monitoring should be implemented to address any outstanding uncertainties around plume stability and risks to receptors. This should include (but not be limited to) designated monitoring wells at the following CSRs:

- **RAAF Base Pearce**
  - CSR_WA_000110 (Former Fuel Farm)
  - CSR_WA_000117 (Former Service Station)
  - CSR_WA_000106 (Sewage Treatment Plant)
  - CSR_WA_000084 (Sounness Rd landfill)
  - CSR_WA_000107 (Former Fire Training Area 1960s)
  - CSR_WA_000151 (Grounds Maintenance Area)
  - CSR_WA_000160 (Hangar 95)
  - PCSR_0967_002 (New AVTUR Fuel Farm)
- **3TU**
  - CSR_WA_000080 (Incinerator – North of 3TU Workshop)
  - CSR_WA_000081 (Buried Waste Metals – 0.75 km south of 3TU)

It should be noted that groundwater monitoring may be required pending results of validation of underlying soil at the Asphalt Stockpile Area (PCSR_0965_002) following removal of the stockpile.

Further assessment of surface water is also considered warranted to more accurately assess surface water impacts during periods of flow at the following CSRs:

- **RAAF Base Pearce**
  - CSR_WA_000106 (Sewage treatment plant) – Collection of surface water samples from within the Ellen Brook (down gradient of 0967_MW223) to assess the potential

concentrations of E.coli and metals at the point of discharge to the receiving ecological receptor.

- **3TU**
  - Site wide assessment of surface water in drainage channels within and surrounding 3TU to adequately characterise surface water quality during periods of flow.

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Acronyms

3TU	No. 3 Telecommunications Unit
ABC	Ambient Background Concentration
ACL	Added Contaminant Limit
ACM	Asbestos Containing Material
ADF	Australian Defence Force
ADI	Acceptable Daily Intake
ADWG	Australian Drinking Water Guidelines
AF	Asbestos Fibres
AFFF	Aqueous Film Forming Foam
AHD	Australian Height Datum
AHIS	Aboriginal Heritage Inquiry System
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
ASC	Assessment of Site Contamination
ASS	Acid Sulfate Soils
AST	Aboveground Storage Tank
A/UST	Aboveground or Underground Storage Tank
AVTUR	Aviation Turbine
BaP	Benzo(a)pyrene
bgl	Below Ground Level
BoM	Bureau of Meteorology
BSR	Basic Summary of Records
BTEX	Benzene, Toluene, Ethylbenzene, Xylenes
BTEX-N	Benzene, Toluene, Ethylbenzene, Xylenes and Naphthalene
btoc	Below Top of Casing
CEC	Cation Exchange Capacity
cfu	Colony-forming Units
CHC	Chlorinated Hydrocarbons
CoC	Chain of Custody
CoPC	Contaminant of Potential Concern
CoT	Certificate of Title
CRAT	Contamination Risk Assessment Tool
CRC CARE	Cooperative Research Centre for Contamination Assessment and Remediation of the Environment
CSM	Conceptual Site Model
CSR	Contaminated Sites Record
DBCA	Department of Biodiversity, Conservation and Attractions
DCARM	Directorate of Contamination Assessment Remediation and Management
DDD	Dichlorodiphenyldichloroethane
DDE	Dichlorodiphenyldichloroethylene
DDT	Dichlorodiphenyltrichloroethane
DEE	Department of the Environment and Energy
Defence	Department of Defence
DER	Department of Environmental Regulation (now DWER)
DERP	Directorate of Environmental Remediation Programs, now DCARM
DMIRS	Department of Mines, Industry Regulations and Safety
DNAPL	Dense Non-aqueous Phase Liquids
DO	Dissolved Oxygen

DoD	Department of Defence
DoH	Department of Health
DoW	Department of Water (now DWER)
DPLH	Department of Planning, Lands and Heritage
DPP	Direct Push Probing
DQI	Data Quality Indicator
DQO	Data Quality Objective
DRF	Declared Rare Fauna
DSI	Stage 2 Detailed Site Investigation
DSO	Defence Support Operations
DWER	Department of Water and Environmental Regulation
Earth Tech	Earth Tech Engineering Pty Ltd
EC	Electrical Conductivity
ECC	Environmental Clearance Certificate
EIL	Ecological Investigation Level
EPBC	Environment Protection and Biodiversity Conservation
ERM	Environmental Resources Management Pty Ltd
ESA	Environmentally Sensitive Area
ESLs	Ecological Screening Levels
FA	Friable Asbestos
FF	Fuel Farm
FOI	Freedom of Information
FTS	Flight Training School
GDA	Geocentric Datum of Australia
GDE	Groundwater Dependent Ecosystem
GEMS	Garrison Estate Management System
GEMS EFM – CSR	Garrison Estate Management System Environmental Factor Management - Contaminated Site Register
GHD	GHD Pty Ltd
GIL	Groundwater Investigation Level
GIS	Geographic Information Systems
GME	Groundwater Monitoring Event
GPS	Global Positioning Systems
G-tek	G-tek Australia Pty Ltd
GW	Groundwater
HEPA	Heads of EPAs Australia and New Zealand
HHERA	Human Health and Environmental Risk Assessment
HIL	Health Investigation Level
HSE	Health, Safety and Environment
HSEMP	Health, Safety and Environment Management Plan
HSL	Health Screening Level
IL	Investigation Level
inHerit	Western Australian Heritage Council's Heritage Places Database
ISO	International Organisation for Standardisation
ISQG	Interim Sediment Quality Guideline
KPI	Key Performance Indicator
LDPE	Low Density Polyethylene
LNAPL	Light Non-aqueous Phase Liquid
LOR	Limit of Reporting
MEOMS	Mechanical Equipment Operations and Maintenance Section
MGA	Map Grid of Australia
MTBE	Methyl Tert-butyl Ether

MNA	Monitored Natural Attenuation
MAH	Monocyclic Aromatic Hydrocarbons
MW	Monitoring Well
N/A	Not Applicable
NationalMap	Map-based website for accessing spatial data from Australian government agencies
NATA	National Association of Testing Authorities
ND	No Detect
NDD	Non Destructive Drilling
NEMP	National Environment Management Plan
NEPC	National Environment Protection Council
NEPM	National Environment Protection Measures
NHMRC	National Health and Medical Research Council
NPUG	Non-potable Use Guidelines
NRMMC	National Resource Management Ministerial Council
NT	Northern Territory
OC/OP	Organochlorine/organophosphate
OCPs	Organochlorine Pesticides
OMP	Ongoing Monitoring Plan
OPPs	Organophosphate Pesticides
ORP	Oxidation-reduction Potential
PAHs	Polycyclic Aromatic Hydrocarbons
PB	Parsons Brinkerhoff
PCBs	Polychlorinated Biphenyls
PC-IR	Possibly Contaminated – Investigation Required
PCSR	Potential Contaminated Site Record
PDS	Project Delivery Services
PDWSA	Public Drinking Water Source Area
PFAS	Per- and Polyfluoroalkyl Substances
PFASIMB	PFAS Investigation Management Branch
PFBS	Perfluorobutane Sulfonic Acid
PFHxS	Perfluorohexane Sulfonate
PFOA	Perflourooctanoic Acid
PFOS	Perfluorooctane Sulfonic Acid
PID	Photo-ionisation Detector
PM	Program Manager
PMAP	PFAS Management Area Plan
POL	Petroleum, Oils and Lubricants
PSI	Stage 1 Preliminary Site Investigation
PTS	Pilot Training Scheme
QA/QC	Quality Assurance/Quality Control
RAAF	Royal Australian Air Force
RAP	Remediation Action Plan
Redox	Reduction/oxidation Potential
RESM	Regional Environmental and Sustainability Manager
RPD	Relative Percentage Difference
RSAF	Republic of Singapore Air Force
RSL	Regional Screening Level
SAQP	Sampling, Analysis and Quality Plans
SGCU	Silica Gel Clean Up
SIL	Soil Investigation Level
SMP	Site Management Plan

S-P-R	Source-Pathway-Receptor
SQG	Soil Quality Guidelines
STP	Sewage Treatment Plant
SVOC	Semi-volatile Organic Compounds
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TDS	Total Dissolved Solids
TEC	Threatened Ecological Community
TKN	Total Kjeldahl Nitrogen
TPH	Total Petroleum Hydrocarbons
TRH	Total recoverable Hydrocarbons
UST	Underground Storage Tank
UXO	Unexploded Ordnance
VOCs	Volatile Organic Compounds
WA	Western Australia
WSL	Western Service Locators
WHS Act	Work, Health and Safety Act
WIR	Water Information Reporting Database
w/w	Weight by Weight
WWII	Second World War
WWTP	Wastewater Treatment Plant
XRF	X-ray Fluorescence

1. Introduction

1.1 Background

GHD has been engaged by the Department of Defence (Defence) Directorate of Contamination Assessment Remediation and Management (DCARM) to undertake a three-year contamination investigation program for Defence properties in Western Australia (the *program*) between 2017 and 2020.

As part of the program, GHD has been tasked to update existing Stage 1 Preliminary Site Investigation (PSI) information and undertake a Stage 2 Detailed Site Investigation (DSI) (the *project*) at Royal Australian Air Force (RAAF) Base Pearce (property ID 0967) and nearby Bullsbrook Training Area (formerly known as No. 3 Telecommunications Unit, 3TU) (property ID 0965) (herein referred to as the "properties*"* as a whole, or "*RAAF Base Pearce*" and "*3TU*" when differentiating between the two land parcels).

RAAF Base Pearce is located approximately 35 km north-east of Perth, Western Australia, as shown in Figure 1. The property has been in continuous operation as an Air Force Base since the 1930s and is used for flight training for pilots by both RAAF and Republic of Singapore Air Force (RSAF) personnel. It is understood that there are no plans at this time for a change in operational use or for disposal of the property. Numerous phases of environmental investigation have been undertaken since 1993, with 46 environmental reports known to have been prepared for the property.

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1.2 Purpose of the program

The purpose of the program is to:

- Identify and address data gaps where previous investigations have failed to adequately assess or quantify potential contamination risks.
- Achieve whole of property assessment including the identification and delineation of contamination and understanding of associated risks to better inform future developments, monitoring, property disposals; and the suitability of land for ongoing Defence activities.
- Enable DCARM to set the scope and priorities for future contamination management and remediation initiatives, including specific risk reduction projects to be delivered via the National Program Services model in the Defence Service Delivery Division or directly through DCARM.

1.3 Project objectives

Within the broader 3 year program context, the specific objectives of this project were to:

- Update available Stage 1 PSI information and undertake a Stage 2 DSI in accordance with the National Environment Protection (Assessment of Site Contamination) Measures 1999, as amended in 2013 (the ASC NEPM)
- Document the current and historical uses of the property to identify potential contamination sources that may pose a risk to human health and/or the environment
- Understand the physical setting of the property including contamination migration pathways
- Identify potential receptors and their vulnerability to contamination
- Based on the outcomes of the updated Stage 1 PSI, complete a Stage 2 DSI to:
  - Define and map the potential or actual extent of contamination
  - Assess the contamination risk to human health and the environment
  - Determine any requirements for contamination risk mitigation measures (i.e. remediation or management controls).
- Based on the outcomes of the Stage 2 DSI, assess which of the following actions are required:
  - No further action
  - Implementation of pollution prevention or contamination management controls to reduce the contamination risk (under a Contamination Management Plan or Site Management Plan (SMP)
  - Further investigation of the nature and extent of contamination
  - Further assessment of human health or ecological risks
  - Remediation planning and implementation
  - Monitoring (e.g. surface water or groundwater).

1.4 Scope summary

1.4.1 Stage 1 PSI

The scope of works completed as part of the updated Stage 1 PSI, included the following tasks:

- Desktop review of available records to develop an up to date understanding of the natural environment of the property and surrounding areas to form the basis for the conceptual site model and identify possible contaminant receptors including:
  - Geology, hydrogeology, soils, topography and drainage of the property
  - A search of the Department of Planning, Lands and Heritage Aboriginal Heritage Inquiry System
  - Data on meteorological conditions for the property and surrounding area
- A review of property-specific history including:
  - Defence records including previous environmental reports
  - Available military history records
  - Current and historical fuel storage infrastructure and as-built diagrams
  - Current and historical photographs to look for evidence of potentially contaminating activities

  - Search of the Department of Water and Environmental Regulation (DWER) Contaminated Sites Database to obtain information on known contaminated sites in proximity to the properties
  - Title searches to identify current and previous landowners and former land uses
  - Environmental Protection and Biodiversity Conservation (EPBC) records
  - Aboriginal and European heritage records
- Review and validation of the Garrison Estate Management System Environmental Factor Management – Contaminated Site Register (GEMS EFM – CSR)
- A property inspection to validate Potential Contaminated Site Records (PCSR) identified in the desktop review and record information on the physical signs of contamination, potentially contaminating activities and facilities, and the potential for contamination to impact on the identified receptors
- A data gap analysis of information available
- Development of a preliminary Conceptual Site Model (CSM).

1.4.2 Sampling and Analysis Quality Plan

A Sampling and Analysis Quality Plan (SAQP) was initially issued on a preliminary basis to inform overall program scheduling and budget planning. The SAQP was updated with confirmed sampling locations and any other changes required to the Stage 2 DSI scope based on additional information obtained and data gaps identified following the site inspection. A finalised SAQP (GHD 2018a) was then issued to support the detailed scope and methodologies for the first mobilisation (Mobilisation 1, March to May 2018) of the Stage 2 DSI. Based on the preliminary findings, identified residual data gaps, and anecdotal information provided by Defence following completion of Mobilisation 1, further assessment of existing Contaminated Site Records (CSR) and additional PCSRs was deemed warranted. A revised SAQP (GHD 2018c) was subsequently developed to inform the scope for the second mobilisation (Mobilisation 2).

1.4.3 Stage 2 DSI

The scope and methodology for the Stage 2 DSI was consistent with the approach recommended by the *National Environmental Protection Measure* as amended in 2013 (ASC NEPM) and the Australian Standard (AS 4482.1-2005). A high-level summary of the implemented work scope is provided below (which is discussed in more detail in Section 6):

- Preparation of relevant documentation including an Environmental Clearance Certificate (ECC), Health, Safety and Environment Management Plan (HSEMP) and relevant property-specific permits for the fieldwork.
- Subsurface utility detection services to identify underground services prior to the commencement of any intrusive works.
- Implementation of a first round soil, groundwater, sediment and surface water sampling and analysis program (Mobilisation 1) from March to May 2018.
- Implementation of a second round soil, groundwater, sediment and surface water sampling and analysis program (Mobilisation 2) in April 2019.
- Survey of all newly installed groundwater monitoring wells for location and elevation in metres Australian Height Datum (AHD) by a licensed surveyor.
- Comparison of laboratory and field results to Tier 1 investigation levels considered to be protective of human health (commercial/industrial at both properties, and public open space

and residential at 3TU, with consideration of future land-use possibilities) and ecological receptors (terrestrial flora/fauna and fresh water aquatic ecosystems).

- Development of a refined CSM for each CSR/PCSR included in the Stage 2 DSI assessment.
- Evaluation of remediation/management options in response to any site conditions judged to pose immediate risk or concern to human health and/or the environment.
- Preparation of this report providing the methodology and findings of the investigation and conclusions and recommendations including management outcomes for each CSR location based on assessed contamination risk.
- Consideration of the Stage 2 investigation findings as part of a risk assessment undertaken in collaboration with Defence (and other relevant stakeholders) using the Defence Contamination Risk Assessment Tool (CRAT).
- Update of the GEMS EFM – CSR.

1.5 Regulatory and policy framework

1.5.1 Overview

Two key legislative instruments that guide Defence's approach to environmental management, including management of legacy contamination, are:

- Environment Protection and Biodiversity Conservation Act 1999 (the EPBC Act)
- National Environment Protection Council (NEPC) National Environment Protection Assessment of Site Contamination Measure (ASC NEPM)

Under the Commonwealth *Work, Health and Safety Act 2011* (WHS Act), Defence and its contractors have obligations to minimise the human health risks associated with workers and others operating within the vicinity of contaminated land that is on or near to a workplace under Defence control.

Defence and its contractors must operate to comply with all Commonwealth legislation, including the WHS Act, EPBC Act and the NEPM.

1.5.2 EPBC Act

The EPBC Act is the Australian Government's central piece of environmental legislation.

The EPBC Act provides legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places – defined in the EPBC Act as matters of national environmental significance.

The nine matters of national environmental significance to which the EPBC Act applies are:

- World heritage properties
- National heritage places
- Wetlands of international importance (often referred to Ramsar wetlands)
- Nationally threatened species and ecological communities
- Migratory species
- Commonwealth marine areas
- The Great Barrier Reef Marine Park
- Nuclear actions (including uranium mining)

- A water resource, in relation to coal seam gas development and large coal mining development

In addition, the EPBC Act confers jurisdiction over actions that have a significant impact on the environment where the actions affect, or are taken on, Commonwealth land, or are carried out by a Commonwealth agency (even if that significant impact is not on one of the nine matters of 'national environmental significance').

1.5.3 ASC NEPM

The National Environment Protection (Assessment of Site Contamination) Measure 1999, as amended in 2013 (the ASC NEPM) was made under the *National Environment Protection Council Act 1994*. The ASC NEPM (2013) is the national guidance document for the assessment of site contamination in Australia. It is given effect by the *NEPM (Implementation) Act 1998* for the Commonwealth and individual legislation and guidelines in each state and territory.

The purpose of the ASC NEPM is to establish a nationally consistent approach for the assessment of site contamination to ensure sound environmental management practices are adopted by the community, including regulators, site assessors, site contamination consultants, auditors, landowners, developers and industry parties.

The desired outcome of the ASC NEPM is to provide adequate protection of human health and the environment, where contamination has occurred, through the development of an efficient and effective national approach to environmental property assessment.

1.5.4 Commonwealth Workplace Health and Safety Act 2011

The Work, Health and Safety Act (Cth) 2011 (WHS Act 2011) and Regulations commenced in 2012 and is regulated by Comcare. This act provides for a nationally consistent framework to protect workers and other persons against harm to their health and safety through the elimination or minimisation of the risks to the extent reasonably practicable.

Under the WHS Act, Defence and its contractors have obligations to minimise the human health risks associated with workers and others operating within the vicinity of contaminated land that is on or near to a workplace under Defence control.

Model Codes of Practice administered by Safe Work Australia provide practical guides to achieve the standards of health, safety and welfare required under the WHS Act 2011.

Any controls outlined in the Defence Work, Health and Safety (WHS) Manual have been implemented when managing contaminated materials.

1.5.5 PFAS NEMP

The Heads of EPAs Australia and New Zealand (HEPA) have published a national guidance document, the National Environmental Management Plan (NEMP) for the investigation and management of PFAS, January 2018. It is a reference document on the state of knowledge related to the environmental regulation of PFAS. Future research will be used to support the NEMP and its revisions. A draft version 2.0 is currently in a consultation period, and due to be issued in late 2019.

1.5.6 Defence Contamination Management Manual

The project has been undertaken in accordance with the Department of Defence Contamination Management Manual (DoD March 2018, amended August 2019) which is an implementing document under the Defence Environmental Strategy 2016 through 2036. The Manual and supporting annexes provide guidance on specific technical aspects of contamination management that are relevant to Defence activities.

1.5.7 Western Australian regulations

Defence aims to comply with Western Australian and local government environmental regulations and guidelines to the extent that these do not conflict with Commonwealth legislative obligations. Local government enacted local laws that apply to the environmental management of City of Swan properties are:

- City of Swan Health Local Law 2002.

Although Crown Land is not subject to State and local requirements, this project has been undertaken in accordance with the following Western Australian regulations and guidelines:

- Contaminated Sites Act 2003 and Contaminated Sites Regulations 2006
- Department of Environment Regulation (DER[1]) Assessment and Management of Contaminated Sites Guideline (DER 2014)
- Western Australian Department of Health (DoH 2009) Guidelines for the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia.

1.5.8 Other national standards

Contamination investigations were also consistent with the following National standards:

- Commonwealth of Australia (2015). Work Health and Safety (How to Manage and Control Asbestos in the Workplace) Code of Practice 2015
- Commonwealth of Australia (2015). Work Health and Safety (How to Safely Remove Asbestos) Code of Practice 2015
- enHealth (2012). Environmental health risk assessment. Guidelines for assessing human health risks from environmental hazards. enHealth subcommittee (enHealth) of the Australian Health Protection Principal Committee
- Standards Association of Australia, AS 4482.2–1999: Guide to the Sampling and Investigation of Potentially Contaminated Soil – Part 2: Volatile substances
- Standards Association of Australia, AS 4482.1–2005: Guide to the Investigation and Sampling of Sites with Potentially Contaminated Soil – Part 1: Non-volatile and semi-volatile compounds
- Standards Association of Australia, AS 5667.11-1998: Water quality – Sampling – Guidance on sampling of groundwaters
- Standards Association of Australia, AS 5667.1-1998: Water quality – Sampling – Guidance on the design of sampling programs, sampling techniques and the preservation and handling of samples
- National Uniform Drillers Licensing Committee, 2011, Minimum Construction Requirements for Water Bores in Australia (NUDLC 2012)

1.6 Assumptions

In addition to those contained throughout this report, the following general assumptions apply:

- The properties are Commonwealth Land in the name of the State of Western Australia.

[1] Now Department of Water and Environment Regulation (DWER)

- RAAF Base Pearce is currently in use as an operational military air-base, will continue to be used by Defence for its current purpose and there will be no material change to its configuration or land-use. Should this alter, the findings of the report would need to reviewed and updated accordingly to take into consideration any new contamination exposure risks.
- 3TU no longer has an operational function but is maintained by Defence as a buffer to RAAF Base Pearce. Although fenced, it is accessed illegally by the public (trespassers) and therefore this land use is reflected in the risk assessment.
- Future land-uses at 3TU may include residential and public open space.

2. Property information

2.1 Property identification

2.1.1 RAAF Base Pearce

The property is comprised of 31 parcels of land registered on eight Certificates of Title (CoT) located in Bullsbrook, Western Australia. The property location and extent is shown in Figure 1 and Figure 2A. Key property identification details are presented in Table 1.

Table 1 Property identification details – RAAF Base Pearce

Parameter	Details	
Property location	Great Northern Highway, Bullsbrook WA, 6084	
Land description	RAAF Base Pearce	
Certificate of Title	A preliminary review by GHD revealed the property comprises multiple individual certificates of title. For the purposes of the DSI, it was considered that a review of current and historical certificates of title would not provide material benefit. Copies of historical and current CoTs were therefore not obtained and are not included in this report.	
Title identification details	CoT ID	Lot ID
	CT 2010/283	L2/D76276
	CT 2010/284 (22 Lots combined)	L1-L4/D6359 L123-125/D6359 L131-137/D6359 L142-147/D6359 L156-158/D6359
	CT 2010/286	L4/D11316
	CT 2010/287 (3 Lots combined)	L50-L52/D10736
	CT 2010/288	L200/DP33127
	CT 2624/456	L51/DP46014
	CT 2623/493	L2585/DP40151
	CT 2952/677	L137/DP408020
Property area (total)	Approximately 953 ha	
Property boundary coordinates[2]	NW corner: -31.6483, 115.9978 NE corner: -31.6485, 116.0178 E corner: -31.6707, 116.0312 SE corner: -31.6985, 116.0203 SW corner: -31.6985, 116.0152 W corner: -31.6687, 115.9993	
Registered proprietor	The Commonwealth of Australia	
Current property use	RAAF Base/Airforce Training Base	
Proposed property use	Ongoing use as RAAF Base	
Local government authority	City of Swan	

[2] Coordinates are in Geocentric Datum of Australia (1994), MGA Zone 50 and are approximate only

2.1.2 3TU

The property is comprised of 23 parcels of land (individual CoT) located in West Bullsbrook, Western Australia. All of the parcels are Commonwealth of Australia land. The property location and extent is shown in Figure 1 and Figure 2B. Key property identification details are presented in Table 2.

Table 2 Property identification details –3TU

Parameter	Details			
Property location	Neaves Road, Bullsbrook 6084			
Land description	Historic high frequency communications site including water treatment plant.			
Certificate of Title	A preliminary review by GHD revealed the property comprises 23 individual certificates of title. For the purposes of the Stage 2 DSI, it was considered that a review of current and historical certificates of title would not provide material benefit. Copies of historical and current CoTs were therefore not obtained and are not included in this report.			
Title identification details	CT 1443/873 CT 1443/874 CT 1703/107 CT 1532/265 CT 1532/264 CT 1532/283	CT 1020/760 CT 1676/525 CT 1703/108 CT 1026/863 CT 1265/394 CT 1150/929	CT 1703/102 CT 1854/536 CT 1029/483 CT 1703/103 CT 1647/776 CT 1647/777	CT 1866/461 CT 1769/673 CT 1703/104 CT 2153/143 CT 1568/110
Property area (total)	1074 ha			
Property boundary coordinates (approximate only)[2]	NW corner: -31.6551, 115.9606 WNW corner: -31.6631, 115.9473 WSW corner: -31.6828, 115.9487 SW corner: -31.6873, 115.9551 SE corner: -31.6873, 115.9828 NE corner: -31.6551, 115.9866			
Registered proprietor	The Commonwealth of Australia			
Current property use	Vacant			
Proposed property use	Potential for future development			
Local government authority	City of Swan			

2.2 Property description

2.2.1 RAAF Base Pearce

The property is located west of the Great Northern Highway near the township of Bullsbrook and within the upper reaches of the Ellen Brook catchment area. The property is a RAAF Base which has been in continuous operation since the 1930s. The property is used for pilot flight training by both RAAF and RSAF personnel. As one of the busiest RAAF Bases in the country in terms of total aircraft movements, RAAF Base Pearce has a significant logistics and training role and is a critical asset to the defence of Australia. It is understood there are no current plans for a change in operational use, or for disposal of the property.

The main property features are illustrated in Figure 2A and include:

- Aircraft runways and associated aprons
- Command control and communication facilities
- Navigational aids

- Bulk fuel storage areas (former and current)
- Ammunition storage facilities
- Aircraft maintenance facilities
- Vehicle maintenance facilities
- Aviation fuel farm
- Fire Training Areas
- Emergency power supply
- Sewage Treatment Plant and irrigation area
- Landfills (including Sounness Road Landfill, located 400 m to the north-east of the property boundary)
- Administration support facilities
- Medical centre
- Housing blocks
- Temporary accommodation and messes
- Recreational facilities including a swimming pool and golf course
- The Ellen Brook and Ki-It Monger Brook surface water courses and tributary drainage channels

Facilities are mainly located in the eastern portion of the property. A Sewage Treatment Plant and associated irrigation area is located in the northern portion of the property, whilst the runways (two main runways and one emergency runway) occupy the central and south-eastern areas.

2.2.2 3TU

The property covers an approximate area of 1074 ha and is located around three kilometres west of RAAF Base Pearce. During its operational history, activities included workshop facilities, waste disposal operations and associated septic tanks. A gas-fired incinerator was in operation for the destruction of classified materials for approximately 10 years during the 1980s and was demolished in approximately 2001. Before its closure in 1994, the property’s function was to provide High Frequency communication to RAAF operations in Western Australia. A bore field and water treatment plant was established at the property during development of RAAF Base Pearce, which has not been in operation since 2006. The layout of the property is shown in Figure 2B.

At present, the property is vacant and comprises remnant bushland and areas that have been cleared for grazing. Building rubble (i.e. bricks and concrete) and concrete slabs associated with former workshops and telecommunication buildings are present in the central-northern portion of the property. A former landfill is present in the central portion of the property, which appears to have been capped with sandy soil. An asphalt stockpile is present in the south-west portion of the property, understood to have originated from a former runway at RAAF Base Pearce. Fly-tipped waste which generally comprised domestic, inert material was observed sporadically across the property and most commonly at the asphalt stockpile location. The Dampier to Bunbury Gas Pipeline runs through the western portion of the property.

It is understood that there are no firm redevelopment plans at this time. However, for the purpose of receptor evaluation (Section 5.1.3), it is known the land is accessed illegally by the public and it has been conservatively assumed that future land-uses may include residential and public open space.

2.3 GEMS EFM – CSR numbering

Defence maintain a register for all potential contamination sources at their properties on the GEMS EFM – CSR. The CSRs are assigned a unique identifier number that has changed over several iterations of the database.

Table 3 provides a summary of the existing CSRs including previous and current identification details.

Based on the review of previous investigations, property walkover/interviews, and anecdotal information provided by Defence, the following should be noted:

- Not all of the existing CSRs were included in this Stage 2 DSI (detailed further in Section 5.2.4).
- In addition to the existing CSRs, GHD identified a number of Potential CSRs (PCSR) which were investigated as part of the Stage 2 DSI (detailed further in Section 5.2.4).

Table 3 CSR identification details

CSR Title	Original CSR ID	Previous CSR ID (prior to June 2018)	Current CSR ID
RAAF Base Pearce (0967)			
Fuel Storage NE Building 72 - Group of USTs and ASTs	WA0320	As per original ID	CSR_WA_000024
Dog Compound - Buried Waste	WA0060	As per original ID	CSR_WA_000083
Sounness Road Landfill	WA0064	As per original ID	CSR_WA_000084
Waste Oil Storage East of Building 134 (AST_039)	WA0343	As per original ID	CSR_WA_000085
Two ASTs 026 and 027	WA0333	As per original ID	CSR_WA_000086
Fuel Storage ILS 18 Glide Path (AST_032)	WA0339	As per original ID	CSR_WA_000087
Fuel Storage ILS 18 Localiser (AST_033)	WA0340	As per original ID	CSR_WA_000088
Former Hazardous Waste Store	WA0061	As per original ID	CSR_WA_000104
Hazardous Material Storage - Former Ammunition Bunker	WA0062	As per original ID	CSR_WA_000105
Sewage Treatment Plant and Effluent Discharge	WA0066	As per original ID	CSR_WA_000106
Former Fire Training Area (1960s)	WA0154	As per original ID	CSR_WA_000107
Former Fire Training Area (1980s)	WA0155	As per original ID	CSR_WA_000108
Near Building 239 - Former Group of USTs	WA0065	As per original ID	CSR_WA_000109
Former Fuel Farm	WA0057	WA0056	CSR_WA_000110
Aircraft Wash Down	WA0055	As per original ID	CSR_WA_000111
Radioactive Aircraft Former Wash Down Area	WA0054	As per original ID	CSR_WA_000112
Former Service Station	WA0341	WA0063	CSR_WA_000117
Grounds Maintenance Area	WA00GM	WA1032	CSR_WA_000151
Fire Training Area - Fire Station Centre of Base	WA0424	WA0067	CSR_WA_000153
Fuel Storage South of Building 13 (UST_030 and AST_031)	WA0337	As per original ID	CSR_WA_000154
Fuel Storage Power Station	WA0144	As per original ID	CSR_WA_000155
Paint Shop	WA0159	As per original ID	CSR_WA_000156
Waste Oil Storage East of Building 134 (UST_038)	WA0345	As per original ID	CSR_WA_000157
Waste Oil Sumps - Between Building A78 and A125	WA0POL-CP1	WA1026	CSR_WA_000158
Waste Oil Sumps - Building A116 and Hanger 95	WA0POL-CP2	WA1027	CSR_WA_000159
Hangar 95	WA0H95	WA1033	CSR_WA_000160
3TU (0965)			
Septic Tanks - Sewage Disposal Effluent	WA0088	As per original ID	CSR_WA_000019
North of 3TU Workshop - Incinerator	WA0070	As per original ID	CSR_WA_000080
South of 3TU - Buried Waste Metals	WA0068	As per original ID	CSR_WA_000081
Former 3TU Workshop - Buried Waste	WA0425	WA0143	CSR_WA_000101
South of Former Building 58 - Two A/USTs Diesel	WA0069	WA0348	CSR_WA_000103

2.4 Property features

A review of available property plans sourced from existing environmental assessment reports identified various buildings and features within each CSR area. Further details are provided in Table 4 and presented on Figure 12 through Figure 33.

Table 4 Relevant property feature summary

CSR	Building/feature ID	Name/observation
PCSR_0967_003 Former Small Arms Range	A0438	Amenities building
	A0119	Range grounds bullet catcher
	A0450	Firing shelter/platform
	A0114	Target storage shed (large)
	A0112	Storage shed (small)
	A0493	Shipping container (general storage)
CSR_WA_000106 Sewage Treatment Plant	A0113	Water treatment pump house
	A0431	South eastern pond
	A0432	South western pond
	A0433	North eastern pond
	A0434	North western pond
	A0425	Pump infrastructure
	A0499	Post chlorination storage
CSR_WA_000110 Former Fuel Farm	A0260	Fuel storage facility (former)
	A0309	Various infrastructure within former fuelling area
	A0310	
	A0313	
	A0314	
	A0315	
	A0316	
	A0317	
	A0320	
	A0321	
	A0322	
	A0323	
	A0324	AST pump house (former)
	A0306	Eastern diesel AST tank (former)
	A0307	Southern diesel AST tank (former)
	A0308	Western diesel AST tank (former)
CSR_WA_000156 Paint Shop	A0339	Paint Shop
	A0488	Brick shed (hazardous materials store)
CSR_WA_000153 Fire Training Area	A0274	Fire station building
	A0512	Amenities building
	A0289	Grounds to the west of building A0274
	A0286	Fire Training Area
	A0479	Brick building
	A0276	Concrete ramp
	A0066	Air traffic control tower

CSR	Building/feature ID	Name/observation
	A0070 and A0068	Air traffic control tower support buildings
	A0147	Sub-station #10
	A0069	Unknown
	A0301	
	A0385	Building (unknown purpose)
	A0513	Unknown
	A0071	Transmitter area
CSR_WA_000107 Former Fire Training Area	A0421	Air movements terminal
	A0416	Navy buildings (unknown purpose)
	A0417	
	A0418	
CSR_WA_000151 Grounds Maintenance Area	A0144	Undercover parking bays A1 –A4
	A0188	Hazardous chemical storage shed
	A0181	POL store/maintenance shed
	A0146	Vehicle ramp
	A0145	Storage shed/building
CSR_WA_000155 Power Station USTs	A0161	Power house building
CSR_WA_000024 Former Diesel USTs Northeast of Building 72	A0060	Building immediately south west of former UST area
	A0061	Building north east of former UST area
	A0072	Building north west of former UST area
	A0142	Unknown infrastructure south of former UST area
	A0063	Building east of former UST area
CSR_WA_000160 Hangar 95	A0095	Hangar Building

2.5 Surrounding land uses

RAAF Base Pearce

Most of the property is zoned as Public Purposes, with the north-west portion of the property zoned as 'General Rural'. The historical Perth Metropolitan Region Scheme Map indicates the area was historically zoned as 'Public – Commonwealth Government' (Department of Planning 1963). Surrounding land is zoned as a mixture of 'Residential', 'Recreation' and 'Public purposes' to the east, 'Special use' to the south, "General rural' to the west and 'General rural' and 'Recreation' to the north. Zoning details and land use descriptions of the surrounding land are summarised in Table 5 and are illustrated in Figure 4A.

Table 5 Existing surrounding land uses – RAAF Base Pearce

Direction	Land use
North	Directly adjacent to the property is Rutland Road, then vacant Commonwealth land, the RAAF Base Pearce landfill (Sounness Road Landfill), a golf course and Bullsbrook Nature Reserve (approximately 800 m north of the property). The Ellen Brook extends northward from the property.
East	Vacant Commonwealth Land, Commonwealth land leased to Water Corporation for use as a Waste Water Treatment Plant (WWTP), the Bullsbrook town centre, residential, rural properties and commercial/industrial properties, a sporting oval and the Bullsbrook Fire Station.
South	Rural residential land including paddocks. The Ellen Brook extends southward from the property and Twin Swamps Nature Reserve is present approximately 2.7 km south of the property.
West	The Ellen Brook runs along the southern portion of the western border of the property, with an associated buffer zone of native vegetation. Railway Parade runs directly adjacent to the northern portion of the western border. Beyond this, there are residential properties (West Bullsbrook) and rural residential land including horse, sheep and cattle paddocks.

3TU

Most of the property is zoned as 'General rural'. Surrounding land is zoned primarily as 'General rural'. Zoning details and land use descriptions of the surrounding land are summarised in Table 6 and are illustrated in Figure 4B.

Table 6 Existing surrounding land uses – 3TU

Direction	Land use
North	Directly adjacent to the property is Neaves Road, adjoined by a tributary of the Ellen Brook. Beyond this, small businesses are located, including Giacomo's Farm, Berry Sweet Strawberry Farm, an outdoor maze and adventure camp, equine clinic and alpaca farm. There are also some rural properties present. To the north-west, much of the land appears to consist of maintained fields and paddocks, whereas to the north-east, predominantly natural bushland and vegetation is present.
East	To the east of the property, the land predominantly consists of rural residential properties, paddocks and fields. A tributary to the Ellen Brook flows out to the east. Beyond Railway Parade, West Bullsbrook and RAAF Base Pearce are located. Major earthworks are being undertaken along Raphael Road as part of the Northlink construction project.
South	Immediately to the south of the property is Perth Turf Supplies and vegetated bushland. Beyond this, the land predominantly consists of fields and bushland including Bush Forever site 399.
West	To the west of the property are multiple farms, such as Pick Your Own Strawberry Farm, Snowpea Farm and Nguyen Vo Farmer. Beyond this is predominantly vegetated bushland including Bush Forever site 399

2.6 Property history

2.6.1 Land use history

RAAF Base Pearce

In 1934 the Commonwealth purchased a 260 ha portion of grazing land as a first step towards establishing RAAF Base Pearce. It is understood the property was initially developed in 1936 and became operational in late 1937. A number of new facilities were established during the Second World War (WWII) in response to Australia's operations and the need for aircrew training after the war entered the Pacific region. The property was used as a base for aircraft preparing for deployment and others engaged in the defence of south-west Australia (HLA 2005).

The property has continued to be active since WWII. However, since the end of the war a number of temporary war buildings have either been removed and replaced or upgraded.

The RSAF set up an operation to undertake flying training based in a series of buildings in the southern portion of the property in 1994.

The Aviation Turbine (AVTUR) bulk fuel farm, built in the 1970s, was decommissioned and demolished in 2014/2015. A replacement AVTUR facility was constructed immediately to the south-east and commissioned in 2014 (AECOM 2015). The establishment of this new facility is one the most recent, large scale developments that has been undertaken at the property in recent years. A new aircraft hangar, aircraft shelters and two Flight Training School (FTS) buildings are the most recent developments on the Base

More detailed property history specific to property features and activities is provided in Table 7.

3TU

The property was the location of a remote wireless receiving station for RAAF Base Pearce developed in 1941 and consisting of two “huts” and a reinforced concrete “igloo”. In October 1946, the property was selected as the site for the 3TU, replacing a number of wireless units at the end of WWII. 3TU became operational in September 1947 utilising a combination of existing WWII buildings, buildings transported from RAAF Base Pearce and some purpose built facilities.

The property comprises numerous land parcels including State road reserves, many of which feature sealed or gravel roads or dirt tracks. These roads provide access across the property and some pass through the property to provide access to adjoining properties. In addition, the northern section of a regional primary road upgrade, NorthLink WA, runs within the eastern portion of the property (Figure 4B). Construction commenced in 2017 and is due for completion in late 2019.

The property was closed in 1994 (EarthTech 2007), with remnant infrastructure remaining on site until approximately 2014 (as observed in historical aerials, refer to Section 2.6.3). Since decommissioning of the 3TU infrastructure, the property has been used for driver training, stockpiling of materials from Pearce (refer Section 4.2) and is currently vacant. Although the property is fenced, it is frequently broken into by trespassers and there is extensive fly-tipping of waste across the property.

2.6.2 Military history

G-tek Australia Pty Limited (G-tek) completed a desktop historical assessment of both properties. The key findings are summarised below. Copies of the reports are presented in Appendix A.

RAAF Base Pearce

- The property is the main Air Force Base in Western Australia. It was initially built between 1936 and 1939 and continues to be developed.
- In 1944, the property featured two sealed and one gravel runway, two hangars, capacity for approximately 216,000 L of petrol and 30,000 L of fuel oil for its power house. The report did not indicate where this fuel was stored.
- A plan dated 1944 indicated the presence of ‘explosives’ and bullet catchers (also known as stop butts) to the north of the airfield, adjacent to Great Northern Highway. The bullet catchers were used for aircraft gun testing. Their location appears consistent with current aerial photography (and GHD’s understanding of the Former 25 m Small Arms Range

(PCSR_0967_003) described in Section 5.2.4) understood to be most recently used for pistol shooting). The explosives area appears to be the location immediately north of a fenced portion of land where excess soil from various projects is currently stockpiled.

- A review of Base assets from 1944 indicated that a number of buildings were used to store explosives, though a plan showing the locations of the buildings could not be located.
- Although the property serves primarily for pilot training, it has a significant role in logistics. During WWII, explosive ordnance was stocked and maintained at the property as part of its operational role.
- There would be limited current requirement for storage of explosive ordnance at the property, though storage requirements would include aircraft pyrotechnics and personal weapon ammunition for both RAAF personnel and transiting aircraft. The current licenced ammunition and explosive storage capacity was not known.
- A review of the Defence Unexploded Ordnance (UXO) website indicates that the property does not fall within an area of potential UXO. The potential for remnant UXO from WWII activities is low.
- The potential for lost, discarded or deliberately disposed ammunitions containing high explosives or pyrotechnic fill material is low.
- The potential for lost, discarded or deliberately disposed small arms ammunition or pyrotechnics is low.

3TU

- The property was the location of a remote wireless receiving station for RAAF Base Pearce developed in 1941 and consisting of two “huts” and a reinforced concrete “igloo”.
- In October 1946, the property was selected as the site for the 3TU, replacing a number of wireless units at the end of WWII. 3TU became operational in September 1947 utilising a combination of existing WWII buildings, buildings transported from RAAF Base Pearce and some purpose built facilities.
- The property comprises numerous land parcels including State road reserves, most of which feature sealed or gravel roads or dirt tracks. These roads provide access for tenants on the property and some pass through the property to provide access to adjoining properties. The NorthLink WA corridor cuts through the eastern section of the property.
- Since closure and decommissioning of the facility in 1994, the property has been used for driver training.
- A review of the Defence UXO website indicates that the property does not fall within an area of potential UXO. The potential for remnant UXO from WWII activities is very low.
- The potential for lost, discarded or deliberately disposed ammunitions containing high explosives or pyrotechnic fill material is very low.
- The potential for lost, discarded or deliberately disposed small arms ammunition or pyrotechnics is very low.

2.6.3 Historical aerial photographs

Aerial photographs of the properties were reviewed in order to ascertain the development history and land use practices that may have led to potential contamination. Photograph observational summaries are provided in Table 7 (RAAF Base Pearce), Table 8 (3TU) and Table 9 (Areas to the south of 3TU). Copies of the photographs have been compiled and are presented in Appendix B.

RAAF Base Pearce

Aerial photographs between 1953 and 2005 were sourced and reviewed from Earth Tech (2007). Aerial photographs between 2012 and 2018 were sourced and reviewed from Landgate online. Aerial photographs of Sounness Road Landfill between 1965 and 2018 were sourced and reviewed from Landgate online. GHD notes that aerial photographs from multiple years in between were not available.

3TU

Aerial photographs between 1953 and 2005 covering CSRs within 3TU and surrounding areas were sourced and reviewed from Earth Tech (2007). Aerial photographs between 2012 and 2018 were sourced and reviewed from Landgate and NearMap online. GHD notes that aerial photographs from multiple years in between were not available.

Areas to the south of 3TU

Aerial photographs between 1965 and 2019 covering CSR/PCSRs to the south of 3TU (including CSR_WA_000081, PCSR_0965_001, and PCSR_0965_002) and surrounding areas were sourced and reviewed from Landgate and NearMap online. GHD notes that aerial photographs from multiple years in between were not available.

Table 7 Summary of historical aerial photographs (RAAF Base Pearce and Sounness Road Landfill)

Photograph/ Year	Observations
1953	**RAAF Base Pearce** The majority of the existing runways and taxi-ways had been established, with evidence of clearing or ground disturbance adjacent to them. The existing main drainage channels on either side of the main runway and in the northern portion of the airfield had been established. Five small buildings were present in the area to the east of the existing WWTP (CSR WA 000106) (possibly the explosives storage area described in Section 2.6.2). North of this was a cleared area with bushland to west and further north. Within the bushland to the north a small building was present at the location of the existing communications facility. Some of the existing hangars (including CSR_WA_000160, Hangar 95), administration buildings and roads appear to have been established in the north-eastern portion of the property. The northern, south-eastern and south-western portions of the property appear to be vegetated and traversed by a number of tracks. A series of rectangular structures appear to be present in the vicinity of the CSR WA 000107 and CSR_WA_000108 areas (Former Fire Training Areas). The Ellen Brook traversed western boundary of the airfield and formed the south-western property boundary. To the west of the Ellen Brook was the existing cleared land that is currently used for grazing, which features a creek extending east to west and connecting into the Ellen Brook. The existing sheds appear to be present in the south of the area. Ki-It Monger Brook traversed the south-eastern property boundary. **Property surrounds** The property is predominantly surrounded by vacant land, most of which is vegetated and traversed by numerous tracks. Discrete cleared areas were present to the north-east and east of the property. A series of buildings, possibly houses, were present along Chittering Road.
1965	**RAAF Base Pearce** Two or three small buildings have been established at the existing control tower and fire station (CSR WA 000153; fire training and Aqueous Film Forming Foam (AFFF) testing area). The hazardous waste store (i.e. CSR_WA_000104) and two other small buildings were present at the northern end of the airfield. Two small buildings had been established and ground disturbance was evident at the existing 25 m Small Arms Range (PCSR 0967 003), likely associated with the bullet catchers described in Section 2.6.2). Continued development in the north-eastern portion of the property (hangar and administration building area) had occurred, including the apparent establishment of the Grounds Maintenance Area (CSR_WA_000151), Former Fuel Farm (CSR_WA_000110) and many of the existing residential buildings. Most of the rectangular buildings in the vicinity of the Former Fire Training Areas (CSR WA 000107 and CSR WA 000108) were no longer present, though two new buildings had been established in the area. Vegetation had partially re-established in the cleared area north of the existing WWTP (CSR_WA_000106). **Sounness Road Landfill** In the 1965 photograph, the portion of land known as the Sounness Road Landfill (CSR_WA_000084) located approximately 500 m north of RAAF Base Pearce appears to be partially cleared (western area) with the remaining uncleared area comprising dense vegetation. The majority of the surrounding properties appear as uncleared land, apart from a large area immediately south east of the property which appears to be mostly cleared. The main roads in the vicinity of the property including Sounness Drive appear to be established. **Property surrounds** Largely unchanged from 1953, although further clearing of vegetation, possibly to allow for grazing, appears to have occurred to the south-east of the property (beyond Ki-It Monger Brook). Ground disturbance is evident to the north of the property at the Sounness Road Landfill (CSR_WA_000084), possibly indicating that it was operational at the time. A sporting ground appears to have been established to the east of the property.

Photograph/ Year	Observations
1975/1977	**RAAF Base Pearce** The existing WWTP (CSR_WA_000106) had been established at the northern end of the airfield and to its north, a circular area had been cleared. Additional buildings had been established at the existing control tower and fire station (CSR_WA_000153). Development had continued within the north-eastern portion of the property including establishment of the existing powerhouse (CSR_WA_000155), buildings in the vicinity of CSR_WA_000109 (Former USTs near Building 239) and more of the existing residential buildings. Additional development had also occurred at the Former Fuel Farm (CSR_WA_000110), including the apparent establishment of two large above-ground tanks. In the area of the Aircraft Shelters PCSR (PCSR_0967_001), four large rectangular aircraft shelter buildings have been developed some stage between 1965 and 1975. To the east of the airfield, land had been cleared and what appeared to be a laydown area had been established in the vicinity of the existing RAAF facilities. One of the existing police dog compound buildings appeared to have been established to the south of Dog Compound – Buried Waste (CSR_WA_000083). **Sounness Road Landfill** The 1977 aerial photograph shows further clearing appears to have taken place at the central portion of the property. The access road which adjoins the eastern property boundary is visible, as well as the access track which adjoins the western portion of the southern boundary. Properties to the north and south appear to have undergone further clearing. Properties to the east and west appear relatively unchanged since the 1965 aerial photo. **Property surrounds** The existing medium-density residential development was present to the east of the property. Otherwise, the surrounding areas were largely unchanged from the 1965 photograph.
1985	**RAAF Base Peace** The 1985 aerial photograph shows that the runway has been the subject of a number of modifications, in particular the eastern sector of the runway. A large concrete rectangular slab has been built that extends off the central eastern portion of the runway. This area (known as the Air Movements area) is located with the 1960s Fire Training Area to the north (CSR_WA_000107) and the early 1980s Fire Training Area (CSR_WA_000108) to the south. A second concrete sealed area, further south, has also been constructed to be used as an Aircraft Wash Down area (CSR_WA_000111). A large portion of the road base at the Aircraft Shelters (PCSR_0967_001) has been restored. The road way has been extended in the northern portion of the Aircraft Shelter area. The third above ground large fuel storage tank has been constructed in the vicinity of the fuel farm (CSR_WA_000110). The remainder of the Base remains relatively unchanged with similar features to those observed in the 1975 aerial photo. **Sounness Road Landfill** Further clearing of the central/eastern portion of the property appears to have been undertaken since the 1977 photograph. The surrounding properties appear as relatively unchanged since the 1977 photograph. **Property surrounds** A medium density residential development area is visible to the west of the property, developed at some stage between 1975 and 1985. The residential estate comprises minor streets, divided residential lots, and several established houses. Further land clearing and division of land in to lot areas/separated land parcels is visible south west of the property. Development of what appears to be a market garden has been established to the east of the property, south of the previously mentioned residential area at the east of the property. Further land clearing and division of land in to lot areas/separated land parcels is also visible to the north west of the property.

Photograph/ Year	Observations
1995	**RAAF Base Pearce** The 1995 aerial photograph shows significant development has occurred between the fuel farm (CSR_WA_000110) and the air movements area south of the former 1960s Fire Training Area (CSR_WA_000107), with the construction of three large rectangular hangars (PCSR_0967_001) and associated infrastructure noted (part of the RSAF training facility). The south western end of the east-west runway has been extended and the entire runway appears to have been restored since 1985. The remainder of the Base appears relatively unchanged compared with the features shown in the 1985 aerial photo. The footprints of the three explosive ordnance store/ammunition bunkers (CSR_WA_000104 and CSR_WA_000105) are still visible, although they appear to have been demolished. **Sounness Road Landfill** Aerial photography featuring the Soundness Road Landfill was not available for 1995. **Property surrounds** The 1995 aerial photograph shows that no significant changes have occurred at surrounding properties between 1985 and 1995. Surrounding land features appear relatively unchanged, apart from further land clearing and division of land into lot areas/separated land parcels to the south west, south, and south east of the property.
2000	**RAAF Base Pearce** The 2000 aerial photograph shows development has occurred at three areas of the property between 1995 and 2000. Two small areas to the west of the south-north runway appear to have been developed and comprise storage buildings as well as infrastructure features of unknown purpose. Construction of the 25 m Small Arms Range (PCSR_0967_003) located to the east of the waste water treatment plant (CSR_WA_000106) appears to be partially complete. Visible features include the firing platform and target storage shed The remainder of the Base appears relatively unchanged compared with the features shown in the 1995 aerial photo. **Sounness Road Landfill** The property appears relatively unchanged since the 1985 photograph. Development on surrounding properties to the north, east and south is evident, including further development of existing established properties to the north and east, and establishment of four water holding ponds on the property to the south. **Property surrounds** The 2000 aerial photograph shows that no significant changes have occurred at surrounding properties between 1995 and 2000, apart from further development of residential properties to the north east of the property.

Photograph/ Year	Observations
2004/2005	**RAAF Base Pearce** The 2005 aerial photograph shows that no significant changes have taken place at the property between 2000 and 2005 however a large rectangular building has been constructed in the middle of the Aircraft Shelter area (PCSR_0967_001). **Sounness Road Landfill** The 2004 aerial photograph shows that no significant changes have taken place at the property between 2000 and 2004. Development of an area to the west of the Great Northern Hwy/west of the property is visible and appears to comprise of a house/residential property. **Property surrounds** The 2005 aerial photograph shows that no significant changes have taken place between 2000 and 2005, apart from further development of properties to the west/south west of the property.
2012	**RAAF Base Pearce** The 2012 aerial photograph shows that a new mess, live-in accommodation buildings, 79SQN headquarters and Air Movements terminal had been completed, and the construction of the current fuel farm had commenced between 2005 and 2012. **Sounness Road Landfill** The 2012 aerial photograph shows that no significant changes have taken place at the property between 2004 and 2012 Further development of the residential property to the west of the property and Great Northern Hwy as well as on the property to the north appears to have occurred between 2004 and 2012. **Property surrounds** The 2012 aerial photograph shows that no significant changes have taken place between 2005 and 2012, apart from further development of properties to the east of the property.
2014	**RAAF Base Pearce** The 2014 aerial photograph shows that no significant changes have taken place at the property between 2005 and 2014. **Sounness Road Landfill** The property appears relatively unchanged since the 2012 photograph. The 2014 aerial photograph shows that no significant changes have taken place at the property between 2004 and 2014. A parcel of land adjacent to the north-east corner of the property appears to have been cleared since the 2012 photograph. **Property surrounds** The 2014 aerial photograph shows that no significant changes have taken place between 2005 and 2014, apart from further land clearing on a property to the north east of the property.

Photograph/ Year	Observations
2015	**RAAF Base Pearce** The 2015 aerial photograph shows that no significant changes have taken place at the property between 2014 and 2015, apart from the removal of the Former Fuel Farm infrastructure. **Sounness Road Landfill** The 2015 aerial photograph shows that no significant changes have taken place at the property between 2004 and 2015. Surrounding properties appear relatively unchanged since the 2014 photograph. **Property surrounds** The 2015 aerial photograph shows that no significant changes have taken place on surrounding properties, apart from further development of properties to the north east of the property.
2016	**RAAF Base Pearce** The 2016 aerial photograph shows that no significant changes have taken place at the property between 2005 and 2016. **Sounness Road Landfill** The 2016 aerial photograph shows that no significant changes have taken place at the property between 2004 and 2016. Surrounding properties appear relatively unchanged since the 2014 photograph. **Property surrounds** The 2016 aerial photograph shows that no significant changes have taken place on surrounding properties apart from further development of properties to the east of the property.
2017	**RAAF Base Pearce** The 2017 aerial photograph shows that no significant changes have taken place at the property between 2005 and 2017. **Sounness Road Landfill** The 2017 aerial photograph shows that no significant changes have taken place at the property between 2004 and 2017. Surrounding properties appear relatively unchanged since the 2014 photograph apart from further development of a property to the north-west. **Property surrounds** The 2005 aerial photograph shows that no significant changes have taken place between 2005 and 2017, apart from further development of properties to the east of the property.

Table 8 Summary of historical aerial photographs – 3TU

Photograph/ Year	Observations
1953	**Property** The 1953 photograph shows an area bounded by a cleared access track and separated in to three separate portions. The central portion contains infrastructure, including one large building and four smaller buildings in the south. A small cluster of buildings is present in the north-eastern corner of the property, which is where the entrance to the property appears to be. A track leads from the entrance to the infrastructure in the south. Three radial tracks are visible to the south of the property. **Property surrounds** The surrounding area consists of partially cleared to densely vegetated bushland.
1965	**Property** The central of the three portions of land has been further developed, with a new large rectangular building present in the central portion of the property. The Incinerator (CSR_WA_000080) is known to be located to the east of this building (not visible on resolution of aerial). A circular aboveground tank is evident to the north-east of this building (CSR_WA_000019 – Septic Tanks).In the north-western portion of the property an additional building has been constructed, along with a circular aboveground tank. Entrance to the property is on the northern border of the property, between multiple small buildings. The other two portions of land on either side of the property remain vegetated. **Property surrounds** The majority of the property is surrounded by vegetated bushland. The land to the west is generally more cleared. To the south, a stream is evident flowing in an east-west orientation.
1975	**Property** Some additional indistinct shapes are evident to the south of the central building on the property, indicating construction works are in progress. A new building is currently under construction on the western border of the property. A new building is evident in the north-eastern corner of the property, which is understood to be the location of the generator building (and probably the associated USTs – CSR WA 000103). One small new building is evident in the south-east corner of the property. **Property surrounds** No significant changes are evident since the previous 1965 photograph.
1985	**Property** The 1985 aerial photograph is in colour. The building in the southern portion of the property which had three sections has been demolished and replaced with a larger, rectangular building. This new building is understood to be a mechanical and electrical workshop. The area to the east of the workshop is known to be the waste disposal area (CSR WA 000101). The workshop is connected to the building in the centre of the property via a long, narrow corridor. The building in the centre of the property has been extended, and consists of an eastern and a western portion. Construction work on the building on the western border of the property is complete, with a square building evident. To the north of this (in the north-west corner), the previous building has been demolished and replaced with two rectangular buildings, which are located perpendicular to each other. A new carpark is evident along the north-western boundary of the property. The main entrance of the property appears to have been relocated to the carpark area from the former entrance in the north-eastern border of the property. What appears to be a cleared strip is evident in the south-western corner of the property. The aboveground tanks still remain. **Property surrounds** The plots of land to the west and east of the property remain unused. The plot to the east is partially vegetated, whereas the plot to the west is predominantly cleared.

Photograph/ Year	Observations
1995	**Property** Two of the small buildings in the southern portion of the property have been removed. The carpark has been extended in the north-western corner of the property. No other significant changes are evident since the 1985 photograph. **Property surrounds** A circular unsealed track is evident to the south-west of the property. What appear to be three radar tower are evident to the south-west, south and east of the property. Unsealed tracks provide access to each of these antennas. Dense vegetation is present to the south and south-east of the property.
2000	**Property** The majority of the infrastructure on the property has been demolished, with the exception of the two aboveground tanks, the generator building in the north-eastern corner of the property (CSR_WA_000103), two small structures along the eastern border of the property and a small rectangular structure in the southern portion of the property. Sealed surfaces remain adjacent to the generator building and in the central portion of the property. **Property surrounds** One antenna is evident to the west of the property. It is unclear on the photograph whether the other three antennas to the south-west, south and east of the property are still present.
2005	**Property** The property appears to be slightly overgrown. The structures identified in the previous 2000 photograph are still present on the property. **Property surrounds** The four antennas previously identified are no longer evident in the 2005 photograph.
2012	**Property** No changes are evident since the previous 2005 photograph. **Property surrounds** No changes are evident since the previous 2005 photograph.
2014	**Property** The infrastructure on the property appears to have been demolished/removed, with the exception of the two aboveground storage tanks. **Property surrounds** No changes are evident since the previous 2012 photograph.
2015	**Property** No changes are evident since the previous 2014 photograph. **Property surrounds** No changes are evident since the previous 2014 photograph.
2016	**Property** No changes are evident since the previous 2015 photograph. **Property surrounds** No changes are evident since the previous 2015 photograph.

Photograph/ Year	Observations
2017	**Property** No changes are evident since the previous 2016 photograph. **Property surrounds** No changes are evident since the previous 2016 photograph.
2018	**Property** No changes are evident since the previous 2016 photograph. **Property surrounds** No changes are evident since the previous 2016 photograph.

Table 9 Summary of historical aerial photographs – Areas to the south of 3TU

Photograph/ Year	Observations
1965	**PCSR_0965_001 – Former Fire Extinguisher Training Area** The 1965 historical aerial photograph is in black and white. The majority of the CSR area appears to be vegetated with a small portion of cleared land in the north. Three unsealed tracks are evident in the southern portion of the CSR area. Two of the tracks run parallel east west and the third track running north south connects to the other two tracks. A non-perennial watercourse is evident flowing in an east west orientation across the north east corner of the CSR area. **PCSR_0965_002 - Asphalt Stockpile Area** The PCSR area primarily consists of cleared land, with a few interspersed trees present in the northern and western portions of the PCSR area. Three structures which could be buildings are evident on the northern, eastern and southern borders of the PCSR area, although their use is unclear. **CSR_WA_000081 - Buried Waste Metals** In the 1965 aerial photograph, the CSR area appears to be vegetated with tracks running parallel along the northern and eastern boundary of the CSR area. **Property surrounds** To the northeast of the Fire Extinguisher Training Area, a small perennial waterbody is evident. The majority of the property surrounding the Fire Extinguisher Training Area and the Asphalt Stockpile Area appears to be cleared land with interspersed trees. The land surrounding the Buried Waste Metals Area comprises of low to medium dense vegetation, with the exception of the cleared land northeast of the CSR area. Numerous unsealed tracks are evident in the surrounding area.
1977	**PCSR_0965_001 – Former Fire Extinguisher Training Area** In the 1977 aerial photograph, it is evident that the PCSR area has been cleared with a few interspersed trees remaining. One unsealed access track running east west is evident in the southern portion of the PCSR area. **PCSR_0965_002 - Asphalt Stockpile Area** The PCSR area remains as cleared land with a few interspersed trees. The structure on the eastern border of the PCSR area has been removed. No other changes are evident within the PCSR area. **CSR_WA_000081 - Buried Waste Metals** The CSR area has been cleared sometime between 1965 and 1977. A small portion of vegetation remains along the eastern boundary and in the southwest corner. **Property surrounds** The majority of bushland between the Fire Extinguisher Training Area and the Asphalt Stockpile Area has been cleared, with the exception of a thin corridor of bush adjacent to the track running along the western border of the Asphalt Stockpile area. There is evidence of clearing south of the Buried Waste Metals area, where a rectangular structure/building has been established.

Photograph/ Year	Observations
1983	**PCSR_0965_001 – Former Fire Extinguisher Training Area** The 1983 aerial photograph is in colour. No significant changes are evident since the previous 1977 photograph. **PCSR_0965_002 - Asphalt Stockpile Area** All structures/buildings previously identified within the PCSR area have been removed. The land is cleared, with the exception of one patch of vegetation in the centre, and one darker patch (potential remnant vegetation) in the south-western corner. **CSR_WA_000081 - Buried Waste Metals** No significant changes are evident since the previous 1977 photograph. **Property surrounds** The 1983 aerial photograph indicates that numerous small buildings have been established east of the Fire Extinguisher Training Area along with unsealed access tracks south of the buildings. The use of the buildings is unclear. No other significant changes are evident on the surrounding properties.
1989	**PCSR_0965_001 – Former Fire Extinguisher Training Area** The 1989 aerial photograph indicates that two unsealed tracks have been established in the south east portion of the PCSR area. **PCSR_0965_002 - Asphalt Stockpile Area** No significant changes are evident since the previous 1983 photograph. **CSR_WA_000081 - Buried Waste Metals** No significant changes are evident since the previous 1983 photograph. **Property surrounds** The 1989 aerial photograph shows that no significant changes have occurred at the surrounding properties between 1983 and 1989. Surrounding land features appear relatively unchanged, apart from the removal of the rectangular building south of the Buried Waste Metals area.
2000	**PCSR_0965_001 – Former Fire Extinguisher Training Area** The 2000 aerial photograph shows an access track along the southern portion of the PCSR area has been established. The Dampier to Bunbury Natural Gas Pipeline aboveground infrastructure has been established at the south eastern portion of the PCSR. **PCSR_0965_002 - Asphalt Stockpile Area** No significant changes are evident since the previous 1989 photograph. **CSR_WA_000081 - Buried Waste Metals** No significant changes are evident since the previous 1989 photograph. **Property surrounds** The land to the south of the Asphalt Stockpile Area appears to be overgrown and no longer used for agricultural purposes. All buildings previously present in the Asphalt Stockpile Area have been removed. A rectangular building has been established north of the Fire Extinguisher Area.

Photograph/ Year	Observations
2004	**PCSR_0965_001 – Former Fire Extinguisher Training Area** No significant changes are evident since the previous 2000 photograph. **PCSR_0965_002 - Asphalt Stockpile Area** No significant changes are evident since the previous 2000 photograph. **CSR_WA_000081 - Buried Waste Metals** No significant changes are evident since the previous 2000 photograph. **Property surrounds** The 2004 aerial photograph shows that no significant changes have occurred at the surrounding properties since the previous 2000 photograph, apart from the removal of the two rectangular buildings previously identified north and east of the Fire Extinguisher Training Area.
2006	**PCSR_0965_001 – Former Fire Extinguisher Training Area** Several access tracks appear to have been established throughout the PCSR area. **PCSR_0965_002 - Asphalt Stockpile Area** An access track running east-west appears to have been established within the PCSR area. **CSR_WA_000081 - Buried Waste Metals** No significant changes are evident since the previous 2004 photograph. **Property surrounds** Several access tracks appear to have been established on the property north of Fire Extinguisher Training Area.
2007	**PCSR_0965_001 – Former Fire Extinguisher Training Area** An access track connecting to the existing road north of the PCSR area appears to have been constructed. Numerous small areas appear to have been cleared. **PCSR_0965_002 - Asphalt Stockpile Area** No significant changes are evident since the previous 2006 photograph. **CSR_WA_000081 - Buried Waste Metals** No significant changes are evident since the previous 2006 photograph. **Property surrounds** An access track running north south has been established on the portion of land north of the Fire Extinguisher Training area, with one small building visible along the track.

Photograph/ Year	Observations
2008	**PCSR_0965_001 – Former Fire Extinguisher Training Area** A large square pond/dam appears to have been constructed in the south west corner of the PCSR area, understood to be a lined pond used during the Dampier to Bunbury gas pipeline construction. It is understood that the liner was removed following completion of pipeline construction works (Defence comms). **PCSR_0965_002 - Asphalt Stockpile Area** A sandy area connected to an unsealed track is evident in the western corner of the PCSR area. The remainder of the PCSR area is grassland. **CSR_WA_000081 - Buried Waste Metals** No significant changes are evident since the previous 2007 photograph. **Property surrounds** No significant changes are evident since the previous 2007 photograph.
2010	**PCSR_0965_001 – Former Fire Extinguisher Training Area** The access track that connects to the road north of the PCSR area appears overgrown. The small cleared areas appear to be revegetated as they are no longer visible. **PCSR_0965_002 - Asphalt Stockpile Area** The sandy area in the western corner has increased in size with the remainder of the PCSR area remaining as grassland. **CSR_WA_000081 - Buried Waste Metals** No significant changes are evident since the previous 2008 photograph. **Property surrounds** A new access track running north south has been established on the portion of land north of the Fire Extinguisher Training area. Additional access tracks appear to have been established north of the Asphalt Stockpile area.
2011	**PCSR_0965_001 – Former Fire Extinguisher Training Area** No significant changes are evident since the previous 2010 photograph. **PCSR_0965_002 - Asphalt Stockpile Area** The previously identified sandy area in the western corner of the PCSR area appears as an uneven greyish colour, understood to comprise stockpiled asphalt (excess from runway upgrade works undertaken at RAAF Base Pearce) which extends towards the centre of the PCSR area. **CSR_WA_000081 - Buried Waste Metals** No significant changes are evident since the previous 2010 photograph. **Property surrounds** No significant changes are evident since the previous 2010 photograph.

Photograph/ Year	Observations
2014	**PCSR_0965_001 – Former Fire Extinguisher Training Area** No significant changes are evident since the previous 2011 photograph. **PCSR_0965_002 - Asphalt Stockpile Area** The asphalt stockpile remains visible, however the configuration of the stockpile has been altered and appears as a ring-like shape, as opposed to a mounded stockpile. **CSR_WA_000081 - Buried Waste Metals** No significant changes are evident since the previous 2011 photograph. **Property surrounds** No significant changes are evident since the previous 2011 photograph.
2017	**PCSR_0965_001 – Former Fire Extinguisher Training Area** The access road adjoining the eastern portion of the Fire Extinguisher Training Area at the southern boundary appears to have been further developed with road base. **PCSR_0965_002 - Asphalt Stockpile Area** The asphalt stockpile is still present to a similar extent to the 2014 photograph. Fly-tipped general waste is visible within the PCSR area. **CSR_WA_000081 - Buried Waste Metals** No significant changes are evident since the previous 2014 photograph **Property surrounds** The track that adjoins the Fire Extinguisher Training to the road north appears to have been further developed with road base.
2018	**PCSR_0965_001 – Former Fire Extinguisher Training Area** No significant changes are evident since the previous 2017 photograph. **PCSR_0965_002 - Asphalt Stockpile Area** No significant changes are evident since the previous 2017 photograph. **CSR_WA_000081 - Buried Waste Metals** No significant changes are evident since the previous 2017 photograph. **Property surrounds** No significant changes are evident since the previous 2017 photograph.

2.7 Dangerous goods licenses and documentation

A Freedom of Information (FOI) application was submitted to the Department of Mines, Industry Regulations and Safety (DMIRS) to undertake a search for records relating to RAAF Base Pearce and 3TU regarding:

- Current and historical copies of licenses to store flammable/dangerous goods
- Applications for a license to store flammable liquids/dangerous goods
- Inspection reports with orders relating to underground tanks
- Inspection reports with orders relating to fuel pumps
- Documents relating to the installation of liquid petroleum gas
- Property plans and illustrating locations (proposed or actual) of dangerous good storage areas and infrastructure.

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The DMIRS response dated 8 March 2018 reported that a search of the FOI records identified 13 items falling within the scope of the request. The documents consist of dangerous goods storage licences, applications for dangerous goods storage licences and site plans. A summary of all documents is provided in Table 10. It should be noted that the limited information held by the department in relation to this property does not necessarily mean the property does not, or has not, stored other dangerous goods.

A copy of the DMIRS correspondence and released documents is presented in Appendix C.

Table 10 Summary of dangerous goods storage documents release by DMIRS

Item no.	Description
1	**Dangerous Goods Storage Licence** –1.08 kL Chlorine, 0.72 kL Chlorine, 0.6 kL hydrochloric acid and 2 kL hypochlorite solution (for swimming pool)
2	**Application for a Licence to Store Dangerous Goods** – Application for quantities listed in Item 1
3	**Site Plan** – Storage location of hydrochloric acid and hypochlorite solution (Item 1 and 2)
4	**Dangerous Goods Storage Licence** – 5.2 kL flammable liquids, 4 kL flammable liquids, 0.6 kL corrosive substances, 0.6 kL flammable liquids, 0.1 kL flammable solids, 0.6 kL toxic substances, 3.3 kL non-flammable, non-toxic gases, 5.7 kL oxidizing gases, 0.5 kL toxic substances, 0.5 kL toxic substances, 2.5 kL flammable gases (2008)
5	**Dangerous Goods Storage Licence** – Duplicate of item 4 (2006)
6	**Dangerous Goods Storage Licence** – Duplicate of item 4 (2006)
7	**Site Plan** – Drawing of flammable liquids compound, corrosive goods store, cylinders and hazardous goods store
8	**Dangerous Goods Storage Licence** – 4.6 kL flammable liquid, 4.4 kL flammable liquid
9	**Site Plan** - Drawing of flammable liquids compound, corrosive goods store, cylinders and hazardous goods store
10	**Application for a Licence to Store Dangerous Goods** – Application for quantities listed in Item 8
11	**Dangerous Goods Storage Licence** – 20 kL diesel fuel (Thiess Contractors 1994)
12	**Dangerous Goods Storage Licence** – 2 kL diesel/distillate (Thiess Contractors 1994)
13	**Application for a Licence to Store Dangerous Goods and Site Plan** – Application and site plan for quantities listed in Item 12

3TU

The DMIRS response dated 22 February 2018 states that a search of their records failed to locate any documentation falling within the scope of the request. It should be noted that the lack of information held by the department in relation to this property does not necessarily mean the property does not, or has not, stored dangerous goods.

A copy of the DMIRS correspondence and released documents is presented in Appendix C.

2.8 Review of DWER contaminated sites database

The DWER *Contaminated Sites Database* (DWER 2018a) presents information on known contaminated sites that have been classified by the DWER as one of the following:

- Contaminated – remediation required
- Contaminated – restricted use
- Remediated for restricted use

The DWER *Contaminated Sites Database* does not provide details of the sites that are listed as 'Possibly Contaminated – Investigation Required' (PC-IR).

RAAF Base Pearce

A search of the Contaminated Sites Database identified that there is one registered contaminated site within one kilometre of the property. Lot 1 on Diagram 9938 is located approximately 100 m east of the property and is classified as '*Remediated for restricted use*'.

The site was historically used as a service station with hydrocarbon impacted soils identified beneath the building and forecourt area. The site was bituminised with all identified impacted soils being contained beneath the bitumen, limiting exposure to the impacted soils. No Contaminants of Potential Concern (CoPC) were identified in groundwater above relevant guidelines. As such contamination from this site is not anticipated to impact the property.

3TU

A review of the *Contaminated Sites Database* identified that there are no classified sites within one kilometre of the property.

The *Contaminated Sites Database* search results and Basic Summary of Records (BSR) are presented in Appendix D.

2.9 Review of council records

A search of the City of Swan website indicates that neither of the properties have been reported to the City in relation to the following aspects:

- Environmental investigations, monitoring, infringement notices and complaints
- Works approvals, notices or restrictions
- Operating licenses and conditions

The website search did not identify any information that would affect the outcomes of this investigation.

A direct request for council information was submitted to the City of Swan on 24 January 2018 (presented in Appendix E). Despite multiple attempts to follow up with the City, no response or information has been received by GHD to date.

2.10 Heritage database searches

2.10.1 Indigenous Australian heritage

The Aboriginal Sites Register is held under the State's *Aboriginal Heritage Act 1972.* It protects places and objects customarily used by, or traditional to, the original inhabitants of Australia.

RAAF Base Pearce

A search of the Department of Planning, Lands and Heritage (DPLH) Aboriginal Heritage Inquiry System (AHIS) (DPLH 2019) identified four Registered Aboriginal Sites within six kilometres of the centre of the property, which included a buffer distance of approximately two kilometres from the property boundary. Results from the Indigenous Australian Heritage search are presented in Appendix G.

Three of the registered sites are located within the property boundary (the Ellen Brook: Upper Swan, Ki-It Monger Brook 2, Bingham Road Creek Artefact Scatter) and one registered site (South Bullsbrook) is located south-east of the property (Plate 1). Details of each registered site is summarised in Table 11. Given these sites are considered limited to the surface soils, they are not considered receptors for contamination associated with groundwater impacts.

GEMS records state there is potential for Indigenous Heritage relating to the watercourses although surveying of sites prior to proposed developments has found no archaeological sites to date.

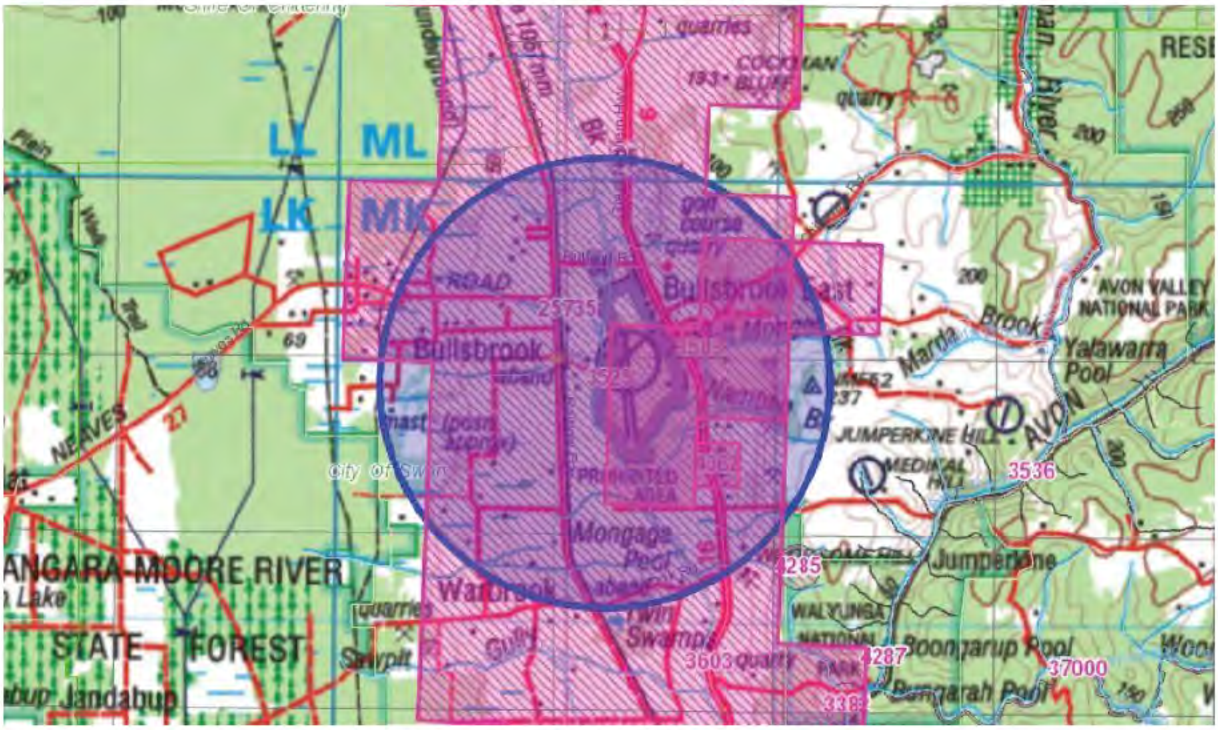

Plate 1 Registered Aboriginal sites at RAAF Base Pearce

Table 11 Registered Aboriginal sites at RAAF Base Pearce

Registered heritage site (site ID)	Description
The Ellen Brook: Upper Swan (3525)	Mythological
Ki-It Monger Brook 2 (3583)	Ceremonial, Modified Tree, Mythological
South Bullsbrook (4362)	Artefact/Scatter
Bingham Road Creek Artefact Scatter (25735)	Artefact/Scatter

3TU

A search of the DPLH AHIS (DPLH 2019) identified two Registered Aboriginal Sites within 4.5 km of the property centre, which included a buffer distance of approximately two kilometres from the property boundary. Results from the Indigenous Australian Heritage search are presented in Appendix G.

One of the registered sites is located within the property (the Ellen Brook: Upper Swan) and the other site (Bingham Road Creek Artefact Scatter) is located east of the property boundary (Plate 2). Details of each registered site is summarised in Table 12. Given these sites are considered limited to the surface soils, they are not considered receptors for contamination associated with groundwater impacts.

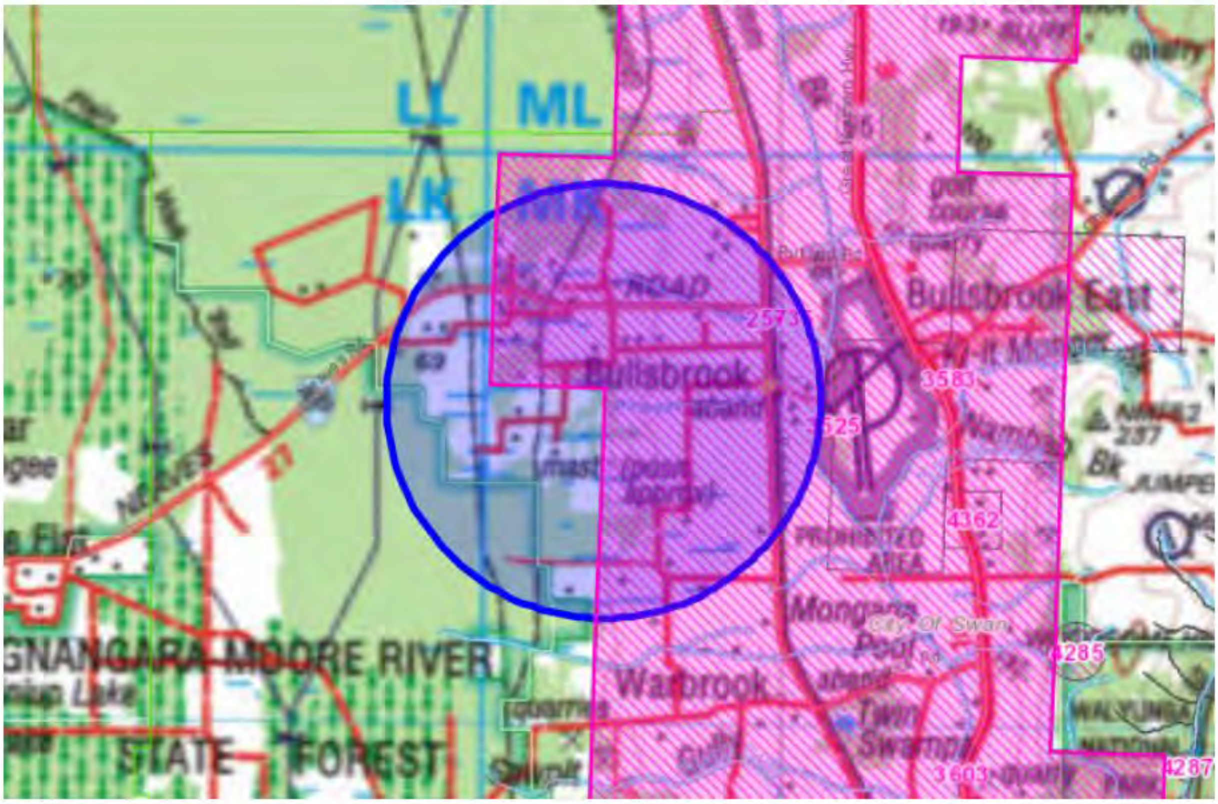

Plate 2 Registered Aboriginal sites at 3TU

Table 12 Registered Aboriginal sites at 3TU

Registered heritage site (site ID)	Description
The Ellen Brook: Upper Swan (3525)	Mythological
Bingham Road Creek Artefact Scatter (25735)	Artefact/Scatter

2.10.2 Other cultural heritage

RAAF Base Pearce

A search of the Western Australian Heritage Council's Heritage Places Database (inherit 2017) identified two listed sites on the property and three listed sites adjacent to the property boundary (Plate 3). The listed sites are summarised in Table 13 and results from the inHerit search are presented in Appendix G.

GEMS records include 24 heritage entries related to Pearce, most of which are small on-site buildings designated as 'historic value' only and 'unlisted' in the Commonwealth Heritage List.

Given the listed sites from the inherit search and GEMS heritage entries are physical aboveground structures that are utilised for operational purposes on the property, it is likely they will be maintained for ongoing use by Defence and are not likely to be impacted by contamination occurring beneath the ground surface.

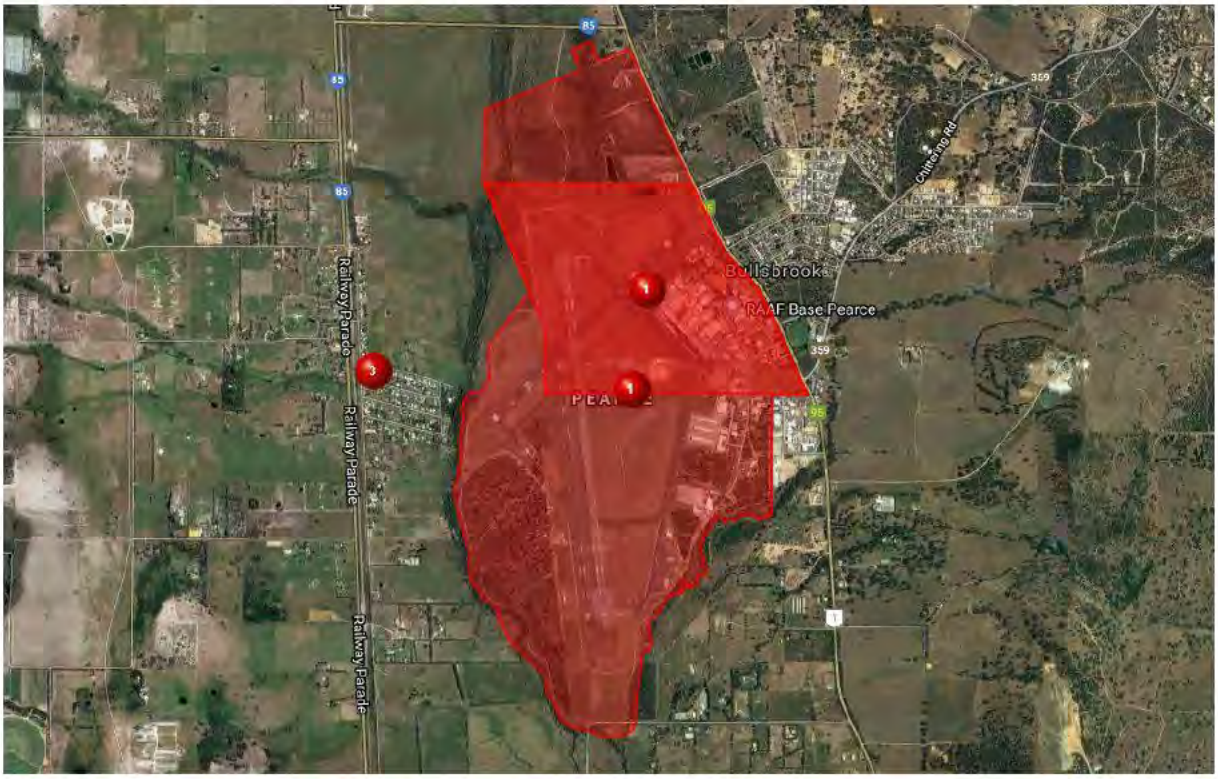

Plate 3 Listed sites on RAAF BASE Pearce

Table 13 Registered cultural heritage sites at RAAF Base Pearce

Registered heritage site (place number)	Location	Heritage listing/description
On-site		
Pearce Aerodrome and Adjacent Bushland (18713)	North-east section of the property	The site is listed as an 'Indicative Place' on the Register of the National Estate.
RAAF Base Pearce (16879)	Centre and southern portion of the property	The site is listed as 'Heritage List' and 'Art Deco Significant Building Survey'. Its red brick buildings were constructed in the 1930s and 1940s. The buildings represent the form and aesthetic associated with the districts significant World War II history.
Off-site[3]		
The West Bullsbrook Hall (25869)	Adjacent to the properties south-west boundary	The site is listed as 'Heritage List'. The site has considerable historic and social value reflecting the optimism and community spirit of the early twentieth century. Its subsequent additions and change of use indicate the changing patterns of community life.
Old Shop (25963)	Adjacent to the properties south-west boundary	The site is listed as 'Municipal Inventory'. The building has historical value to the local community and historically served as a corner store.

[3] The inherit search identified three listed sites adjacent to the property (Plate 3).However, the search only provided information on two of these sites.

3TU

A search of the Western Australian Heritage Council's Heritage Places Database (inherit 2017) identified no listed sites on the property. The search identified three listed sites within two kilometres of the property boundary (Plate 4). The listed sites are summarised in Table 14 and results from the inHerit search are presented in Appendix G. Given groundwater at 'Melaleuca Park' is up-hydraulic gradient of the property and that 'The West Bullsbrook Hall' and 'Old Shop' are physical aboveground structures, they are not likely to be impacted by contamination occurring either down-hydraulic gradient or beneath the ground surface.

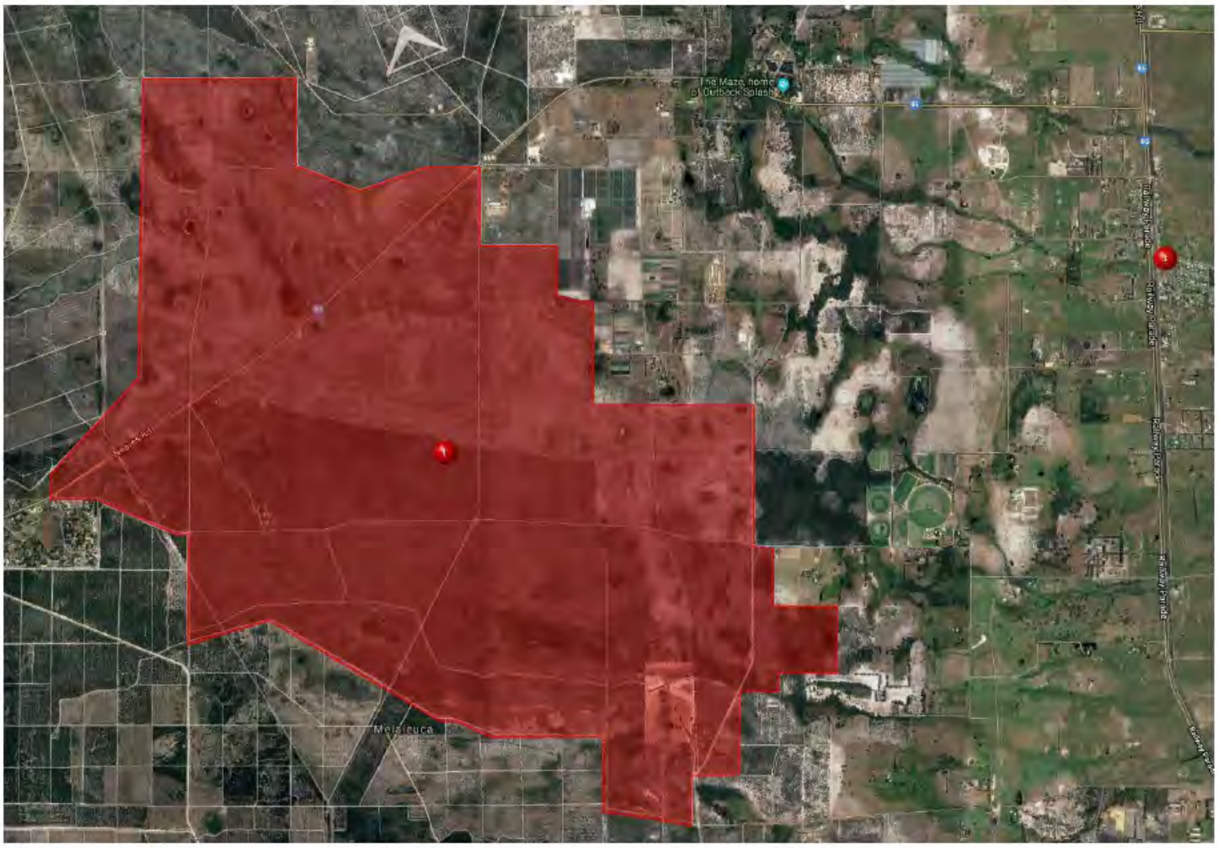

Plate 4 Listed sites on 3TU

Table 14 Registered cultural heritage sites

Registered heritage site (place number)	Location	Heritage listing/description
Off-site[4]		
Melaleuca Park (18693)	Adjacent to the property's south-west boundary	The site is listed as 'Registered' on the 'Register of the National State'.
The West Bullsbrook Hall (25869)	Approximately one and a half kilometres east of the property	The site is listed as 'Heritage List'. The site has considerable historic and social value reflecting the optimism and community spirit of the early twentieth century. Its subsequent additions and change of use indicate the changing patterns of community life.
Old Shop (25963)	Approximately one and a half kilometres east of the property	The site is listed as 'Municipal Inventory'. The building has historical value to the local community and historically served as a corner store.

[4] The inherit search identified three listed sites adjacent to the property (Plate 3).However, the search only provided information on two of these sites.

3. Environmental setting

3.1 Climate

The climate of the Perth Metropolitan region is classified as Mediterranean, with hot, dry summers and cool, wet winters. There is a meteorological monitoring station located on RAAF Base Pearce (Bureau of Meteorology station number 009053). A summary of the climate data statistics from this station is provided in Table 15 (BoM 2018a).

Table 15 Climate data summary

Station	Mean Annual Minimum Temperature Range (°C)	Mean Annual Maximum Temperature Range (°C)	Mean Annual Rainfall (mm)
RAAF Pearce (009053)	8.2 (Aug) – 17.6 (Feb)	17.9 (Jul) – 33.5 (Jan)	654.6

3.2 Topography & hydrology

3.2.1 RAAF Base Pearce

The Base is located immediately west of the convergence of the Darling Scarp and the Dandaragan Plateau, which significantly affects the hydrological characteristics of the property.

Regional mapping indicates the topography at the property is generally flat with an elevation ranging from approximately 55 to 35 m Australian Height Datum (AHD), generally grading from north-east to south-west (Landgate 2018). The eastern portion of the Base, which supports the main infrastructure, is relatively flat. Regional topography contours are presented in Figure 5A and in Appendix F.

The Ellen Brook flows in a general southerly direction along the western boundary of the property, and Ki-It Monger Brook, a tributary of the Ellen Brook, flows south along the south-eastern boundary (Figure 6A).

RAAF Base Pearce comprises three principal drainage catchments (Figure 6A):

- The northernmost section of the Base grades to the north and west towards a small tributary to the Ellen Brook. This catchment comprises the bulk of the administration, aircraft maintenance and accommodation, and part of the runway and open area. The catchment has a single discharge point to the Ellen Brook.
- Drainage from the western catchment containing the bulk of the runways, fire service buildings, other miscellaneous facilities and the bulk of the open areas is directed through surface drainage networks in a general south-westerly direction into the Ellen Brook. The catchment has eight discharge points to the Ellen Brook, and one discharge point to Ki-It Monger Brook.
- The eastern portion of the Base comprising the remainder of the Base administration, maintenance and accommodation, fuel farm, RSAF operations facilities and open area drains towards the Ki-It Monger Brook to the south-east, which discharges into the Ellen Brook to the south of the property. There are five discharge points into Ki-It Monger Brook.

Throughout the GHD PFAS investigation (GHD 2018b), GHD observed pooled surface water in a number of areas across the property, particularly within the bushland along the western and south-eastern property boundaries, near Ellen and Ki-It Monger Brooks respectively, and within bushland to the south of the aircraft washdown area. The observed surface water accumulation is likely the result of the high clay content of the near-surface soils across the property, which restricts infiltration of rainfall.

Groundwater and surface water level data obtained during the GHD PFAS investigation (GHD 2018b) suggests that the Ellen Brook is both receiving from and discharging to groundwater depending on factors such as location along of the course of the Ellen Brook, the intensity and duration of recent rainfall events, the duration of dry periods and the time of year. The monitoring data also indicated that groundwater could flow beneath Ki-It Monger Brook during both post-winter and post-summer conditions and it is also possible that surface water discharge to groundwater occurs beneath Ki-It Monger Brook (GHD 2018b).

There is a WWTP in the northern portion of the property which features two aerobic ponds and two anaerobic ponds. Historically, treated water was discharged to the Ellen Brook via open drains extending across the northern end of the airfield. However, in 2002 the system was modified to allow for disposal of treated effluent by irrigation to the grassed open space to the east of the WWTP (Earth Tech 2007). GHD understands that the WWTP was subject to further upgrades in 2018/2019.

3.2.2 3TU

Regional mapping indicates the topography at the 3TU area is gently undulating, with an elevation ranging from approximately 70 m AHD in the west to 40 m AHD in the east (Landgate 2018). The property generally slopes from west to east. Regional topography contours are presented in Figure 5B and Appendix F.

The Bulls Brook drainage system, which passes through the property, is situated on a flat, poorly drained sand plain (Earth Tech 2007). Most watercourses within the Bulls Brook catchment experience ephemeral flows which occur during winter months when rainfall is highest (Earth Tech 2007). Low lying areas of 3TU occur as sump lands and damp lands and the majority of the property is waterlogged or inundated during winter months (Earth Tech 2007).

3.3 Geology and soils

3.3.1 RAAF Base Pearce

The property is underlain by Guildford Formation sediments, predominantly comprising brown, silty and slightly sandy clays or clayey sands with subordinate sands and gravels (Gozzard 1982).

Previous environmental investigations have generally encountered alternate layers of firm sandy clay/clayey sand overlying stiffer sandy clay with some areas containing gravelly clay. In some instances, thin lenses of quartz/calcarenite and bands of ‘coffee rock’ were encountered above the sandy clay/clayey sand layers. This is supported by findings from the current Stage 2 DSI, described in more detail in Section 9.1.1. Previous and current investigations have drilled to a maximum depth of depth of 30 m bgl.

GHD’s PFAS drilling program indicated that the geological profile beneath the property is dominated by a succession of brown silty clays over a sandier basal unit. Within the upper clay rich unit, various lenses of gravelly clay and silty sand were observed. The distribution of these lenses could not be correlated to represent a single widespread lateral unit. Iron cemented silts and clays were found at various locations that are colloquially referred to as “coffee rock” and are associated with the existing/historic water table. The clay rich unit was found to be the thickest (up to 15 m) in the eastern area of the Base and thinned to approximately 5 m towards the Ellen Brook to the west.

The sand rich layer underlying the clays was found to be silty to clayey and generally grey to mottled brown, extending to at least 30 m bgl. This basal sand-dominant unit is considered likely part of the lower Guilford Clay formation.

It is noted that in the majority of drilling locations, the upper clay-dominant units were found to be dry to moist, whereas the basal sand-dominant unit was found to be saturated. Following first water strike in this unit, groundwater levels were noted to rise several metres, indicating confined/partly confined conditions. This is supported by the expected low permeability of the overlying clay unit.

Regional geological mapping is provided in Figure 7A and Appendix F.

3.3.2 3TU

Geology underlying the 3TU area comprises surficial deposits of Bassendean Sands or Muchea Limestone overlying the Guildford Formation (Earth Tech 2007).

Regional geological mapping indicates the geology beneath the property is variable, with interspersed fine to medium grained, sub-rounded quartz sand and peaty clay with variable sand content, of lacustrine origin (Gozzard 1982), which is generally supported by results of the current investigations (Section 9.1.1). Low-lying wetland areas of 3TU, within the Bassendean Dunes, comprise swamp deposits (Earth Tech 2007).

Regional geological mapping is provided in Figure 7B and Appendix F.

3.4 Acid Sulfate Soils

3.4.1 RAAF Base Pearce

A review of the Acid Sulfate Soils (ASS) risk mapping available through the Perth Groundwater Map (DWER 2018b) indicates that two portions of land within the property (along the Ellen Brook and on the north-western border of the property) are classified as ‘Moderate to low ASS disturbance risk (less than 3 m from surface). The remainder of the property is in an area classified as ‘No known ASS disturbance risk (less than 3 m from surface)’.

Search results and mapping from the Perth Groundwater Map are presented in Appendix F.

3.4.2 3TU

A review of the ASS risk mapping available through the Perth Groundwater Map (DWER 2017b) indicates that ASS risk is variable across the property. The majority of the land is classified as ‘Moderate to low ASS disturbance risk (less than 3 m from surface), however some regions in the southern portion of the property are classified as ‘High to moderate ASS disturbance risk (less than 3 m from surface).

Search results and mapping from the Perth Groundwater Map are presented in Appendix F.

3.5 Hydrogeology

RAAF Base Pearce and 3TU are underlain by a superficial aquifer, a major, generally unconfined regional aquifer extending throughout the Swan Coastal Plain. They are located on the eastern most part of the Gnangara Mound (north), a regional subdivision of the superficial aquifer that is formed mainly by regional topography, partially by the drainage pattern and partially by the hydraulic characteristics of the sediments (Davidson 1995). It should be noted that both properties are located outside the Priority 1 public drinking water source area (P1 PDWSA) proclaimed under the Metropolitan Water Supply, Sewerage and Drainage Act 1909 to be the Gnangara Underground Water Pollution Control Area.

Within the boundaries of RAAF Base Pearce, the Guildford Formation comprises much of the superficial aquifer whilst within 3TU, the Guildford Formation is overlain in most areas by Bassendean Sands or Muchea Limestone.

The superficial aquifer within the Guildford Formation is reported to overlie (in order of increasing depth) the following aquifer units (Gozzard 1982):

- The semi-confined Mirrabooka aquifer, occurring at approximate depths of between 30 and 60 m bgl
- The confined Leederville aquifer, a multi layered regional flow system in the Leederville and Osbourne Formations between 250 to 350 m bgl
- The South Perth Shale
- The Yarragadee aquifer, a major confined aquifer underlying the entire Perth Region
- It should be noted that only the superficial regional aquifer (and discontinuous perched aquifer overlying it, where present) have been considered in the scope of this Stage 2 DSI.

3.5.1 Groundwater levels

RAAF Base Pearce

Previous investigations (ERM 2013, GHD 2018b) have indicated that a discontinuous perched aquifer is present across the property within the upper portion of the Guildford Formation as a direct consequence of the presence of low permeability sediments and restricted vertical infiltration to the underlying aquifer. Perched groundwater transport to the open drainage channel network is expected to occur during the winter months, with associated discharges to both the Ellen Brook and Ki-It Monger Brook. Results from recent PFAS investigations (GHD 2018b) support this theory of localised, discontinuous lenses of groundwater that are not connected to the underlying regional (superficial) aquifer.

Interpolated regional groundwater data from the Department of Water (now Department of Water and Environment Regulation; DWER) (DoW 2016) suggests that beneath the eastern and north-eastern portion of the property, groundwater in the regional (superficial) aquifer flows in a general south-south westerly direction towards the Ellen Brook. In the western portion of the Base, the flow direction is generally towards the south-east, also towards the Ellen Brook. Groundwater monitoring data collected by GHD in September/October 2017 and March 2018 from 62 wells across the property was generally consistent with results of current investigations (described in Section 9.2.1 and the contours published by DoW (GHD 2018b). Interpolated groundwater contours from DoW (2016) and GHD (2018b) are presented in Appendix F.

During the 2017 groundwater monitoring event, depths to groundwater ranged from 0.37 m bgl in West Bullsbrook to 16.49 m bgl near the eastern property boundary (GHD 2018b). On average, the groundwater levels were 0.94 m lower in March 2018 (GHD 2018b) reflecting seasonal variation between post winter (September 2017) and post summer (March 2018) events.

Anecdotal evidence from Defence personnel suggests groundwater can be present as surface water in some low-lying areas during the wet winter season. It has also been observed that at times, groundwater (likely perched) can seep out of expansion joints in some concreted areas.

3TU

Regional groundwater contours indicate that groundwater flows in an easterly direction below the property, with groundwater levels ranging from 65 m AHD (5 m bgl) in the west to 40 m AHD (0 m bgl) in the east of the property (DWER 2018b). This is consistent with historical investigations, which recorded standing water levels of 1.8 to 2.6 m bgl across the property (Earth Tech 2007) and results of current investigations, described in Section 9.2.1. Similarly, registered bores located on the property identified in the DWER Water Information Reporting (WIR) database reported water levels between 0.11 to 4.78 m bgl.

Shallow groundwater levels of the Swan Coastal Plan are known to fluctuate seasonally by about 1 m (Earth Tech 2007). In winter, the water table around the Ellen Brook rises to the ground surface, and some areas inundate as groundwater discharges to form sheet flow over a large expanse of the catchment (Smith and Shams 2002).

DWER (2018b) groundwater contours are presented in Appendix F.

3.5.2 Background groundwater quality

RAAF Base Pearce

The Perth Groundwater Map (DWER 2018b) indicates that groundwater in the area is fresh in the west, with Total Dissolved Solids (TDS) ranging from 250 to 500 mg/L and marginal in the east (TDS 500-1000 mg/L). Groundwater monitoring data from GHD (2018b) however, reported fresh (perched aquifer) to saline groundwater (regional superficial aquifer), with TDS ranging from 225 to 6097 mg/L. The difference in salinity measured in the field may be related to the limited data and locations from which the Perth Groundwater Map extrapolates. The field measurements are considered to be more reliable.

Previous investigations (GHD 2018b, AECOM 2016) indicate that elevated concentrations of copper and zinc are present in groundwater entering the property (MW001, AECOM 2016 and BW_MW14 GHD 2018b) exceeding ANZECC Freshwater guidelines 95 % protection level. Further detail on the range of background groundwater quality is provided in Section 10.1.

3TU

The Perth Groundwater Map (DWER 2018b) indicates that regional groundwater is generally fresh, with Total Dissolved Solids (TDS) less than 250 mg/L. This is consistent with TDS recorded in registered DWER WIR groundwater bores located on the property, which reported TDS ranging from 137 to 300 mg/L (DWER 2018c).

3.5.3 Hydraulic properties

The hydraulic properties of the superficial regional aquifer vary significantly depending on prevailing lithological characteristics. The Guildford Formation, comprising predominantly clayey sediments, typically exhibits low hydraulic conductivities (less than 0.4 m/day), although some basal sandy lenses are reported to have conductivities in the order of 5 to 10 m/day (ERM 2013). Results from slug tests undertaken as part of GHDs recent PFAS investigations on RAAF Base Pearce (GHD 2018b) indicate hydraulic conductivities in the superficial aquifer ranging from 0.03 m/d to 0.3 m/d, equating to a formation description of clay to very fine sand (Davidson 1995). However, it can be noted that in three wells screened within sandy clays and clayey sands, the groundwater response was too rapid to allow a valid determination of aquifer properties, indicating an estimated hydraulic conductivity of greater than 1 m/d. Based on the range of hydraulic conductivities recorded, a horizontal groundwater velocity range in the region of less than 1 to 10 m per year was calculated (GHD 2018b).

3.5.4 Groundwater abstraction

RAAF Base Pearce

Groundwater is no longer abstracted from the Base for any purposes, with Scheme Water providing the water needs of the Base with the exception of drinking. Due to aging pipework and bacterial contamination, the water supply is unsuitable for drinking and bottled drinking water is supplied to the Base.

The DWER Water Information Reporting database indicates there are in excess of 100 licensed groundwater abstraction bores located within a five kilometre radius of the centre of the Base (refer to Figure 8A). The majority of these bores are used to supply domestic households and agricultural activities consistent with the surrounding land use. Lots to the west of the Base, predominantly around West Bullsbrook, currently do not have a mains water connection. Most of these bores (approximately 90 %) abstract groundwater from the regional superficial aquifer (GHD 2018b). It is pertinent to note that domestic groundwater abstraction (yield of less than 1500 kL/annum) does not require licensing and that unregistered bores are known to be used in many properties surrounding the Base.

The City of Swan holds a groundwater abstraction licence for irrigation purposes across 33 lots including at the Chequers Golf Club adjacent (north) to the Sounness Road Landfill. The bore location and licence summary is provided in Appendix F. The DWER Water Register indicates their licence is for the abstraction of water from the confined Leederville aquifer and therefore considered unlikely to have an impact on groundwater flow direction at the adjacent landfill. The licence allocation is 938,795 KL annually across the 33 lots.

In May 2016, GHD completed a water use survey of properties within the Investigation Area (GHD 2016b). The purpose of the survey was to obtain information from local Bullsbrook residents about bore water use at their properties, particularly in relation to household water use. A supplementary water use survey was carried out as part of the December 2016 Community Information Session to obtain information on the use of water for crop irrigation or animal feeding. The information obtained assisted in defining the sampling and analysis program and the resulting data was used in the human health risk assessment.

As part of GHD's PFAS investigation works, a water use survey of properties surrounding the Base was undertaken to obtain information from local Bullsbrook residents about bore water use at their properties, particularly in relation to household water use and use of water for crop irrigation or animal feeding. Results indicated that use of groundwater surrounding the property is extensive and comprises:

- Drinking water
- Domestic/household uses
- Irrigation of paddocks, vegetable gardens and fruit trees
- Commercial businesses/local growers
- Drinking water for chickens, pets (including rescue dogs), grazing horses, cattle and sheep.

Based on what is understood about groundwater flow direction and discharge from the superficial regional aquifer to the Ellen Brook (and to a lesser extent the Ki-It Monger Brook) (GHD 2018b), the identified bores located west of the Ellen Brook and east of the Ki-It Monger Brook are not considered to be receptors of potential contamination originating at the Base, and as such, commercial irrigation and livestock watering have not been included as groundwater uses in the receptor evaluation and application of relevant assessment criteria. The potential however does exist for domestic-scale use of groundwater to occur via unregistered bores.

3TU

The DWER Water Information Reporting database indicates there are in excess of 100 licensed groundwater abstraction bores located within a five kilometre radius of the centre of the property (refer to Figure 8B). The majority of these bores are used to supply domestic households and agricultural activities consistent with the surrounding land use. The majority of properties surrounding the site have groundwater abstraction licences.

3.6 Ecology

3.6.1 Surface water and wetlands

RAAF Base Pearce

Numerous sensitive ecological receptors are present in the vicinity of the base, as presented on Figure 9. The Ellen Brook extends along the western boundary of the Base and is a “conservation category” wetland as defined by the Department of Biodiversity, Conservation and Attractions (DBCA). As outlined in Section 4.2, the brook receives surface water runoff from the Base.

The Twin Swamps Nature Reserve is located approximately 2.7 km south of the southern property boundary and is a “conservation category” wetland as defined by the DBCA. Within the Reserve is the Ellen Brook Swamp System which is a Nationally Important Wetland, as defined by the Department of the Environment and Energy (DEE).

Based on advice provided by the DBCA, GHD understands that Twin Swamps Nature Reserve was established to assist with the conservation of the critically endangered Western Swamp Tortoise along with the Ellen Brook Nature Reserve, which surrounds a portion of the Ellen Brook approximately seven kilometres downstream of the southern property boundary of the Base. Both of these reserves are likely to be hydraulically connected to groundwater and/or surface water. Surface water in Twin Swamps is understood to be supplemented by groundwater from abstraction bores located within the northern portion of the reserve. Surface water in the Ellen Brook Nature Reserve is fed directly by the Ellen Brook.

Nationally Important Wetlands such as the Ellen Brook Swamp System and conservation category wetlands such as the Ellen Brook and Twin Swamps Nature Reserve are classified as Environmentally Sensitive Areas (ESA) by the WA Minister for Environment under Section 51B of the Environmental Protection Act 1986.

3TU

Mound springs of high conservation value are present on the western side of the Swan Coastal Plain, along the boundary between the Bassendean Sand and Guildford Formations. The springs are a result of regional hydraulic pressure that maintains continuous seepage of groundwater to create swamps, swamp springs and bogs. A mound spring is present at the head of the Bulls Brook drainage system, up stream of 3TU (Smith and Shams 2002).

Low-lying areas of 3TU occur as sump lands and damp lands and the majority of the property is waterlogged or inundated during winter months (URS 2001).

3.6.2 Groundwater dependent ecosystems (GDE)

The Australian Government Bureau of Meteorology provides a mapping portal “Groundwater Dependent Ecosystem Atlas (BOM 2018b)” which contains a national inventory of ecosystems that depend on groundwater. For Western Australia, it includes ecosystems that rely on the surface expression of groundwater such as rivers, wetlands and springs (aquatic) and those that rely on subsurface groundwater including vegetation ecosystems (terrestrial). The search results are provided in Appendix F.

RAAF Base Pearce

The search results of the Groundwater Dependent Ecosystem Atlas indicated the following within a 500 m radius of the property:

- Moderate potential Groundwater Dependent Ecosystem (GDE, national assessment) for terrestrial groundwater dependent ecosystems in the south-western corner of the property, around the Ellen Brook.
- Known GDE (regional study) for aquatic groundwater dependent ecosystems to the north-west, west and south-west of the property and the Ellen Brook. High and moderate potential GDE (national assessment) for aquatic groundwater dependent ecosystems to the north, east and south-east of the property.

3TU

The search results of the Groundwater Dependent Ecosystem Atlas indicated the following within a 500 m radius of the property:

- High potential GDE (national assessment) for terrestrial groundwater dependent ecosystems surrounding the 3TU area.
- High potential GDE (national assessment) for aquatic groundwater dependent ecosystems surrounding the 3TU area.

3.6.3 Terrestrial ecology

Portions of RAAF Base Pearce (but not 3TU), including the vegetated areas to the north, south-east and south-west of the airfield (including portions of CSR CSR_WA_000107 - Former Fire Training Area and CSR CSR_WA_000083 – Dog Compound - Buried Waste), are Bush Forever areas (Bush Forever Site 294: Pearce aerodrome and adjacent bushland, Bullsbrook) as presented on Figure 9. Bush Forever is a Government conservation initiative aimed to retain and protect regionally significant bushland on the Swan Coastal Plain within the Perth Metropolitan Region. Bush Forever sites constitute ESAs under Section 51B of the EP Act. Previous studies have identified several Threatened Ecological Communities (TEC) and Declared Rare Flora (DRF) including:

- Corymbia calophylla – Xanthorrhoea preissii woodlands and shrublands of the Swan Coastal Plain
- Shrublands and Woodlands on Muchea Limestone of the Swan Coastal Plain.
- Endangered species Centrolepis caespitose.
- Vulnerable species Eleocharis keigheryi.

3.6.4 Remnant native vegetation

The Australian Government Department of Primary Industries and Regional Development holds a dataset containing vegetation extent polygons from the mapping of remnant vegetation in Western Australia entitled “Current Extent of Native vegetation – Western Australia”. The dataset which is updated annually was accessed using GIS application ArcGIS.

RAAF Base Pearce

Portions of remnant native vegetation are scattered throughout the property. Remnant vegetation was also identified within a 500 m radius around the property, primarily to the east and west of the property boundary. A screen capture showing these locations is provided in Appendix F.

A search of GEMS records indicates that ten vegetation communities are mapped across the Pearce property. All remnant vegetation across the property is considered of high conservation value. Flora includes Wandoo Woodlands (Eucalyptus wandoo) and Marri (Corymbia calophylla) which provides habitat for fauna including Carnaby's Cockatoo and is a critical habitat for the Matted Centrolepis (Centrolepis caespitosa).

Given the direction of groundwater flow from the property (south-south westerly to the Ellen Brook and south-east direction towards the Ki-it Monger Brook), the remnant vegetation to north and north-east are not considered potential receptors of potential contamination from the property (if identified).

3TU

No remnant native vegetation was identified within the property. However, remnant native vegetation was identified within 500 m south, south-west and east of the property boundaries. A screen capture showing these locations is provided in Appendix F.

GEMS records indicate that 3TU is mainly degraded farmland with limited areas of remnant vegetation particularly along watercourses of low intrinsic conservation value. A Bush Forever site (399) is present to the west and south of the property.

Given that the regional groundwater flows in an easterly direction below the property, the remnant vegetation to the east and south-east of the property are considered potential receptors of potential contamination from the property (if identified).

3.6.5 EPBC Act protected matters search tool

The Australian Government Department of Environment and Energy provides a Protected Matters Search Tool to retrieve information on matters of national environmental significance or other matters protected by the EPBC Act. Such matters may include areas such as Ramsar wetlands, nationally important wetlands, marine parks or reserves and Commonwealth, National or World heritage properties or places.

The search results provide a conservative output for matters of national environmental significance within 10 km of the search radius. The protected matters search report is provided in Appendix F. Only potential receptors within 500 m of the property are considered further in this assessment.

RAAF Base Pearce

The search showed there are 25 listed threatened flora and fauna species and four listed threatened ecological communities within the search output (conservative 10 km radius). Given the highly developed RAAF Base facility and the patchy sparsely distributed vegetation within the property, it is unlikely for the property to provide a viable habitat for these species. These threatened species were also recorded in GEMS.

3TU

The search showed that there are 20 listed threatened flora and fauna species and two listed threatened ecological communities within the search output (conservative 10 km radius), as per Table 16. Given the presence of vegetation within the property and the dense remnant vegetation within 500 m of property boundaries, it is possible for the identified species to be present in the area. These species are considered potential receptors of potential contamination from the property (if identified). These threatened species were not recorded in GEMS.

Table 16 Protected matters of national environmental significance

Protected Matter	Classification	Distance and direction from property
Various birds, various mammals and various plants	Threatened species (including vulnerable, endangered and critically endangered) – habitat, breeding or foraging likely to occur within area	Directly adjacent east, within 10 km radius south and south-west of property.

4. Potential for contamination

4.1 Previous environmental investigations

These reports were examined as part of the process of determining relevant data gaps that required addressing as part of this Stage 2 DSI (see Section 5.3). A full data integrity assessment of each report was outside the scope of this investigation, however as these reports were delivered to Defence under Defence's Contamination Directives, it would be expected that they are fit for purpose and as such have been relied upon.

The key reports considered to provide a relevant framework for the current site-wide understanding of contamination risk are summarised in Table 17.

Table 17 Summary of Previous Environmental Investigation Reports

Summary	Findings	GHD Comment (2019)
Stage 1 Environmental Investigation, RAAF Base Pearce (HLA 2005)		
HLA was engaged by Defence Corporate Services and Infrastructure Group to undertake a Stage 1 Environmental Investigation at the Base and 3TU, Bullsbrook, Western Australia. ***Objective(s)*** HLA's objectives were to assess whether past or current activities at identified potentially contaminated areas may have resulted in soil, surface water and/or groundwater contamination and provide a description of 12 identified potentially contaminated areas at the Base and 3TU with sufficient detail to guide the development of future actions. ***Scope*** The scope included: • A Stage 1 Contamination Investigation • Review and compilation of relevant information and records • Personnel interviews (Defence staff and civil employees) • Site inspections by an experienced environmental assessor • Qualitative risk assessment of issues, identifying potential human and environmental receptors and plausible pathways of exposure • Report preparation summarising potential contamination issues at the property including recommendations for sampling and analysis and/or remediation and rehabilitation for each identified site, based on the perceived environmental risk.	Following an initial review of existing reports, historical plans, aerial photographs, field investigations and interviews conducted with Defence and non-Defence personnel, the potential areas of concern were identified with respect to contamination risk which warranted further investigation: • Former and current Fire Training Areas • The sewage treatment plant, irrigation and discharge areas • The storage of Aviation fuels (including AVGAS) in aboveground storage tanks and waste AVGAS in below ground storage tanks • Hydrocarbon contaminated soils associated with a spill from Building 161 (Powerhouse) • The Former Radioactive Washdown Site • The 3TU workshop waste disposal area and potential septic tanks	• Stage 2 DSI investigations of identified areas of concern were progressed in 2007 (Earth Tech 2007). • Former and current Fire Training Areas were not included in the current DCARM DSI investigation
RAAF Base Pearce (Sounness Road) Landfill Investigation of Potential Contamination (GHD 2005a)		
The Department of Defence (DoD) commissioned GHD Pty Ltd (GHD) to undertake an Investigation of Potential Contamination at the RAAF Base Pearce Landfill site at Sounness Road. ***Objective(s)*** The objectives included: • Delineate the horizontal and vertical extent of the landfill • Delineate the horizontal and vertical extent of any contamination associated with past landfilling activities at the property • Determine the risks of impacts associated with the identified contamination • Outline remediation strategies appropriate to the contaminants and identified risks	The following key findings were identified: • The property is underlain by two aquifers, separated by an aquiclude of varying thickness. • Based on the relationship of the potentiometric groundwater elevation of the two aquifers, the potential for seepage from the shallow aquifer to the deep aquifer is present in the eastern extent of the property, whilst in the western extent of the property, the potential for vertical seepage from the deep aquifer into the shallow aquifer is present. • Of the 134 soil samples collected during test pit excavation and during monitoring well installation, analyte exceedances included: heavy metals (cadmium, chromium, copper, lead, mercury, nickel, titanium and zinc), Total Recoverable Hydrocarbons (TRH) and Semi-volatile organic compounds (SVOCs: DDT, DDD, DDE, and benzo(a)pyrene (BaP)). • Of the 36 soil samples containing analyte concentrations above adopted assessment criteria, only two samples (PTP45 and PTP46) were collected from the native fill and all other samples pertain to waste material deposited in the landfill. • Within the 14 groundwater monitoring wells, analytes exceedances included metals (cadmium, copper, nickel and zinc) and SVOC (aldrin, DDT and dieldrin). Both mercury and Volatile Organic Compounds (VOC) compounds experienced Limits of Reporting (LORs) above accepted guideline criteria. Thus it cannot be confirmed whether concentrations are below adopted assessment criteria. • Surface and intrusive investigations confirm anecdotal information that waste disposal commenced in the west near the Great Northern Highway and proceeded to the east over time • It appears that the landfill does not adversely affect groundwater and subsurface soils • It was considered that the identified groundwater contaminant concentrations above adopted assessment criteria presents a low risk to adversely affect human health and the environment due to the distance of the property from potential receptors and the low, trace concentrations identified	• The Stage 2 DSI investigations conducted by GHD across two mobilisations in 2018 and 2019 form the basis of this report and includes interpretation of previous investigation results screened against current (2019) investigation levels to confirm lack of risk to receptor. • This was achieved following compilation of Esdat database under a parallel data management project for DCARM. The findings are presented and discussed in Sections 10 and 11 of this report (GHD 2019).

Summary	Findings	GHD Comment (2019)
RAAF Base Pearce Police Dogs Training Area (GHD 2005b)		
The Department of Defence Corporate Services and Infrastructure Group commissioned GHD to undertake a DSI in the environs of the RAAF Base Pearce Police Dogs Training area. ***Objective(s)*** The objectives included: • Delineate the horizontal and vertical extent of any uncontrolled waste disposed at the site • Delineate the horizontal and vertical extent of any contamination associated with past waste disposal activities at the Site • Determine the risks of impacts associated with the identified contamination • Outline remediation strategies appropriate to the contaminants and identified risks ***Scope*** The scope of work to achieve the above objectives included: • A detailed geophysical investigation, including GEM2 electromagnetic survey and 2D Resistivity/IP survey methods • Based on the findings of the geophysical investigation, a total of 15 test pits were excavated, to a maximum excavation depth of 2.2 m bgl • A total of 35 soil samples were collected from the excavation pits to assess the potential for soil contamination. A total of 22 samples were submitted for analysis, including two duplicate quality assurance samples and a further two triplicate samples, to National Association of Testing Authorities (NATA) accredited laboratories for selective chemical analysis including the following: – Heavy metals – TRHs – VOCs – SVOCs	The following key findings were identified: • The GEM2 electromagnetic survey generated conductivity and resistivity data which delineated north-south trending conductive zones, as well as localised conductive anomalies. However, the test pitting of these anomalies did not indicate any areas of significant subsurface metallic waste. • Chemical analysis of test pit soil samples indicated that: • No heavy metal concentrations in the soil exceeded the assessment criteria. • The soil metals which exceeded their relevant LOR (but were below the assessment criteria) included arsenic, chromium, copper, lead and zinc. • Soil concentrations of TRH, VOCs and SVOCs (including total PCB) were all below LOR. • Soil dieldrin results were all reported below the LOR (less than 0.5 mg/kg) but exceeded the Ecological Investigation Level (EIL) criterion of 0.2 mg/kg. • Chemical analysis of surface and groundwater indicated that: • Groundwater was not encountered in either the intrusive soil or groundwater investigation, to a maximum investigation depth of 10 m bgl. • Water samples from the drains adjacent to the site exceeded the Fresh Water assessment criteria for copper, zinc, mercury, dieldrin and total Polychlorinated biphenyls (PCBs). Based on the results of the investigation, the following conclusions and recommendations were made: • In contrast to the Pearce main landfill area, systematic dumping within the Police Dogs Training Area site is restricted to the northern extent of the surveyed area. The waste includes sand, bitumen, roadbase, concrete and asbestos and is possibly an extension of a more extensive disposal area located to the north of the geophysical survey area, which was not test pitted. • The only other significant area of dumped material is in the vicinity of PPD 01 to PPD 03 and this consists predominantly of sand and roadbase. • There is considered to be a very low risk of contaminant impact in the groundwater beneath and beyond the site. • Due to the exceedance of multiple contaminants in the surface water of drains adjacent to the site, ongoing monitoring is required to confirm and further define the source and nature of any risks.	• The Stage 2 DSI investigations conducted by GHD across two mobilisations in 2018 and 2019 form the basis of this report and includes interpretation of previous investigation results screened against current (2019) investigation levels to confirm lack of risk to receptor. • This was achieved following compilation of Esdat database under a parallel data management project for DCARM. The findings are presented and discussed in Sections 10 and 11 of this report (GHD 2019). • No records of ongoing surface water monitoring of adjacent drains have been made available.

<table>
<tr><th>Summary</th><th>Findings</th><th>GHD Comment (2019)</th></tr>
<tr><td colspan="3">Stage 2 Environmental Investigation. RAAF Base Pearce and 3TU (Earth Tech 2007)</td></tr>
<tr><td>Earth Tech Engineering Pty Ltd (Earth Tech) was engaged by Defence Corporate Services Infrastructure Group to undertake a Stage 2 environmental investigation at the Base and 3TU. Quasi Stage 1 investigations were also carried out on specific areas of interest that were not considered by the preceding HLA Stage 1.
Objective(s)
The objectives included:
• Better characterise the environmental risks, including determination of the vertical and horizontal extent of any contamination that may be present; and
• Identify preferred strategies for the management of environmental and human health risks associated with identified contamination, including remediation where appropriate.
Scope
The scope included:
• Review of all available, relevant previous reports
• Preparation of a CSM and refinement during the course of the investigation
• Preparation of an SAQP
• Stage 2 Investigations (including intrusive fieldwork and laboratory analysis of samples) at 13 areas of interest
• Preparation of a risk assessment
• Preparation of preliminary remediation and management action cost estimates.
Areas of Investigation
• Radioactive Aircraft Former Wash Down Area (CSR_WA_000112)
• Aircraft Wash Down (CSR_WA_000111)
• Former Fuel Farm and associated hydrocarbon plume (CSR_WA_000110)
• Hazardous waste store (CSR_WA_000104)
• Former Ammunition Bunker (CSR_WA_000105)
• UST 240 to 245 (CSR_WA_000109)
• Sewage Treatment Plant and Discharge (CSR_WA_000106)
• Former and current Fire Training Areas (CSR_WA_000153, CSR_WA_000107, CSR_WA_000108), not included in current investigation
• 3TU Workshop Waste Disposal (CSR_WA_000101)
• 3TU disused and removed UST (CSR_WA_000101)
• Powerhouse fuel spill (CSR_WA_000155)
• Paint Shop (CSR_WA_000156)</td>
<td>The following key findings were identified:
• Investigations indicated that there were no observable radiological (or other) impacts to soil above background levels in the vicinity of the Radioactive Aircraft Former Washdown Area (CSR_WA_000112).
• Investigations at the Hazardous Waste Store (CSR_WA_000104) and Former Ammunition Bunker (CSR_WA_000105) reported no evidence of significant impact.
• Soil and groundwater impacts were reported above relevant guidelines in the vicinity of UST 240 to 245 (CSR_WA_000109).
• Soil and groundwater investigations at the Sewage Treatment Plant and Discharge area did not return results above expected background concentrations.
• Shallow soil impacts were reported above relevant (although conservative) guidelines at the Powerhouse fuel spill area (CSR_WA_000155), indicating the need to develop a SMP for this area under continued commercial/industrial use.
• Soil and groundwater concentrations in the vicinity of the Paint Shop (CSR_WA_000156) were not reported above background concentrations.

Based on the results of the investigation, the following conclusions and recommendations were made:
• Further delineation of hydrocarbon-impacted soils and groundwater is required in the vicinity of the Former Fuel Farm (CSR_WA_000110), including development of an ongoing groundwater monitoring program and SMP. Consideration to be given to preparation of a risk assessment and, if redevelopment is to occur, a Remediation Action Plan (RAP).
• A program of groundwater monitoring should be undertaken in the vicinity of UST 240 to 245, including development of a SMP, with consideration given to preparation of a risk assessment and, if redevelopment is to occur, a RAP.
• Investigations at the workshop waste disposal area at 3TU, following underground storage tank (UST) removal, indicated that additional investigation or management was not warranted.
• Groundwater was not able to be adequately assessed at the Powerhouse fuel spill area, therefore additional well installations were recommended down-gradient of the identified impact accompanied by a program of ongoing monitoring.</td>
<td>• No records of subsequent SMP, risk assessment or RAP development have been made available.
• Additional recommended investigations at the fuel farm, power house and UST 240 to 245 were undertaken as part of 2012 Stage 2 DSI works (ERM 2013).
• The Stage 2 DSI investigations conducted by GHD across two mobilisations in 2018 and 2019 form the basis of this report and includes interpretation of previous investigation results screened against current (2019) investigation levels to confirm lack of risk to receptor.
• This was achieved following compilation of Esdat database under a parallel data management project for DCARM. The findings are presented and discussed in Sections 10 and 11 of this report (GHD 2019).</td></tr>
</table>

Summary	Findings	GHD Comment (2019)
Stage 2 Investigation of a Liquid Waste Disposal Pit – RAAF Base Pearce (AECOM 2010)		
• AECOM was commissioned by Defence to conduct a Stage 2 Investigation of a former liquid waste disposal pit associated with a former petroleum service station (CSR_WA_000117) at the property. The investigation followed the excavation and removal of UPSS infrastructure and the removal of gross pollutants associated with a waste oil pit. • The intrusive investigation comprised installation of six groundwater monitoring wells (three shallow and three deep) and advancement of eight soil bores. Two of the three shallow wells did not encounter water bearing zones, indicating the presence of a discontinuous perched aquifer. ***<u>Objective(s)</u>*** The objectives included: • Delineate the nature and extent of contamination associated with a former liquid waste disposal pit; and • Recommend a preferred management or remediation strategy if the current risks to Defence are considered unacceptable.	The following key findings were identified: • Analytical results indicated that there is minimal impact to both soil and groundwater at the site arising from the former liquid waste oil pit. • Inconsistent low level metal impacts in exceedance of adopted guidelines were identified. These were considered likely to be attributable to background/regional conditions. • Hydrocarbon impact (Total petroleum hydrocarbons (TPH) C_{10}-C_{36}) was identified in up-gradient well MW04 (500 µg/L) indicating wider hydrocarbon impacts are present at RAAF Base Pearce. Based on the results of the investigation, the following conclusions and recommendations were made: • No further remedial works are required in regard to the former liquid waste oil pit. • A follow-up Groundwater Monitoring Event (GME) should be carried out to confirm the findings of this investigation. • Previously completed remedial works associated with the waste oil pit have caused no net-negative effect on groundwater quality in the investigation area.	• It is noted that sampling of the excavated sump pit and excavated bowser pit indicated that elevated hydrocarbon (C_{10}-C_{36} fractions) concentrations remained within the sump pit excavation faces. • Based on results of more recent groundwater investigations, GHD do not concur with the conclusion that identified hydrocarbon impacts in groundwater were a wider issue at RAAF Base Pearce. • No records of follow up GME/s are available. Analysis of trends in groundwater concentrations over time with consideration of seasonal variations would be required to confirm plume stability/delineation. • The Stage 2 DSI investigations conducted by GHD across two mobilisations in 2018 and 2019 form the basis of this report and includes analysis of trends in groundwater concentrations over time to assess plume stability/delineation. • This was achieved following compilation of Esdat database under a parallel data management project for DCARM. The findings are presented and discussed in Sections 10 and 11 of this report (GHD 2019).
Strontium Chromium Decontamination Recommendations – Building A0339 RAAF Base Pearce (Parsons and Brinkerhoff 2010)		
• Parsons Brickerhoff (PB) was engaged to undertake sampling throughout Building A0339 for the presence of chromium. Building A0339 houses spray booths and stripping rooms for painting maintenance works for aircraft.	The following key findings were identified: • Swab samples indicated levels in excess of the control values and were thought to be associated with use of a high chromium primer. • There were no standards to compare swab samples against. However, the American Conference for Governmental Hygienists indicates that the average amount of chromium (naturally occurring) ingested daily by adults is about 25 µg. The results from the swab samples showed that there was a high potential for worker to ingest greater than 25 µg/day. • Soil samples did not indicate any differences to control samples and therefore do no indicate contamination. Based on the results of the investigation, the following recommendations were made: • All internal components of the structure were to be cleaned appropriately. • Decontamination of the soil surrounding the building was not required	• Screening of soil results against current criteria (HIL- F) concurs with results from 2010.

<table>
<tr><th>Summary</th><th>Findings</th><th>GHD Comment (2019)</th></tr>
<tr><td colspan="3">Stage 2 Environmental Investigation (ERM 2013)</td></tr>
<tr><td>ERM Australia Pty Ltd was engaged by Defence to undertake a Stage 2 Environmental Investigation of the property.
<u>Objectives</u>
The overarching objective was to verify the nature, extent and risk ranking of areas of potential contamination, and provide management and remediation recommendations for each area investigated (where required).
<u>Scope</u>
The scope included:
• Desktop review of previous environmental reports including HLA 2005 Aboveground and Underground Storage Tank Management Plan
• Site inspections to identify indicators of potentially significant contamination and assess for any changes in site conditions (compared to those noted in previous investigations)
• Intrusive investigations involving soils and soil vapour sampling, groundwater monitoring well installation, development and sampling.
<u>Areas of Investigation (excluding Fire Training Areas)</u>
• Building 161 (Powerhouse) fuel spill/bulk fuel storage (CSR_WA_000155)
• Paint Shop (CSR_WA_000156)
• Diesel USTs (CSR_WA_000024 and CSR_WA_000154)
• Wastewater UST/Bulk Fuel Storage (CSR_WA_000157)
• Hangar 95 (aircraft storage and refuelling) (CSR_WA_000160)</td><td>The following key findings were identified:
• A total of 33 groundwater monitoring wells were installed; however, groundwater was only encountered in nine monitoring wells during dry summer conditions.
• 13 monitoring wells (including four existing wells) were sampled with groundwater encountered at depths ranging from 0.605 m bgl to 9.513 m bgl.
• Groundwater flow within the superficial aquifer was inferred to be in a south-west or west south-westerly direction.
• Ten USTs were identified that could not be assigned to areas previously investigated.
• There was no evidence of hydrocarbon impact associated with UST 0967A_UST_024, and only limited soil impact associated with UST 0967A_UST_030.
• Elevated hydrocarbon concentrations were reported in soils and perched groundwater associated with CSR_WA_000024 USTs, potentially a results of historical leakage from a faulty weld in a fuel line. Concentrations were below applicable health guidelines (HSL-D).
• Elevated hydrocarbon concentrations in shallow soils were reported at a number of investigation areas, generally below applicable criteria, with the exception of historical data associated with the Powerhouse fuel spill (CSR_WA_000155) and current data at the Contaminant Pit (WA0POL).
• 22 passive soil vapour sampling modules and two soil vapour monitoring wells were installed to assess potential soil vapour emissions beneath Hangar 95. Results indicated the presence of VOCs and residual hydrocarbons in shallow soils beneath the building, but at concentrations that do not indicate a vapour inhalation risk above applied screening criteria.
• A hydrocarbon sheen was observed at CSR_WA_000155-MW060 (Powerhouse fuel spill area), although laboratory analysis did not identify hydrocarbons above LOR.
• No significant soil or groundwater impacts were identified at the Paint Shop investigation area (CSR_WA_000156), despite a sheen recorded during sampling of CSR_WA_000156-MW016.
• Surface soils in the vicinity of the Grounds Maintenance Building (CSR_WA_000151) are impacted by concentrations of zinc, TPH and organochlorine pesticides, with zinc, and DDT+DDE_DDD concentrations marginally above EILs.
• Minor hydrocarbon soil impacts were reported in near –surface soils adjacent to former containment pits CP1 and CP2.

Based on the results of the investigation, the following recommendations (excluding those related to potential PFAS contamination) were made:
• CSR_WA_000024 USTs represent an ongoing potentially contaminating source which will require effective management via routine groundwater monitoring and implementation of institutional controls. Impacts to the superficial aquifer at this location were not investigated but were considered unlikely due to the presence of clays.
• The assessment of drain sediments should be undertaken for hexavalent chromium impact at CSR_WA_000156 (Paint Stripping and Treatment Building).</td><td>• The Stage 2 DSI investigations conducted by GHD across two mobilisations in 2018 and 2019 form the basis of this report and includes interpretation of previous investigation results screened against current (2019) investigation levels to confirm lack of risk to receptor.
• This was achieved following compilation of Esdat database under a parallel data management project for DCARM. The findings are presented and discussed in Sections 10 and 11 of this report (GHD 2019).
• Notwithstanding the above, GHD generally concurs with the recommendations made.
• Assessment of drain sediments for hexavalent chromium at CSR_WA_000156 was included in current Stage 2 DSI scope.
• Assessment of groundwater in the superficial aquifer at CSR_WA_000024 was included in current Stage 2 DSI scope.</td></tr>
</table>

Summary	Findings	GHD Comment (2019)
Detailed Site Investigation: RAAF Base Pearce Fuel Farm (CSR_WA_000110) Decommissioning (AECOM 2015)		
AECOM was commissioned by John Holland Group to conduct a DSI following decommissioning of the aviation fuel farm (CSR_WA_000110) at RAAF Base Pearce. At the time of the report, John Holland had completed the construction of a New AVTUR Fuel Farm facility immediately to the east of the former facility and had completed decommissioning of the Former Fuel Farm. ***Objective*** To assess the nature and extent of potential soil and groundwater contamination after the facility had been decommissioned, in order to determine remediation requirements (if any). ***Scope*** The scope included: • Preparation of a Health and Safety Plan that conformed to AECOM, John Holland and Defence requirements • Following decommissioning of the fuel farm, the excavation of 46 shallow and deep soil bores • Installation of six shallow and nine deep groundwater monitoring wells outside of the Former Fuel Farm area • Installation of two deep and one shallow groundwater monitoring wells inside the Former Fuel Farm area • Field screening and collection of representative samples for subsequent laboratory analysis for CoPC • Gauging, purging and collection of groundwater samples from existing and newly installed groundwater monitoring wells under summer conditions • Laboratory analysis of soil and groundwater samples by commercial analytical laboratories using methods registered by the National Association of Testing Authorities (NATA) • Comparison of analytical results from soil and groundwater analysis against applicable assessment criteria • Assessment of potential remedial actions, if any, based on comparison of analytical results • Preparation of this DSI report.	The following key findings were identified: • Reworked natural materials and natural soils were observed to be highly variable throughout the site. • Laboratory results of all collected soil samples returned concentrations of CoPC below the LOR with the exception of exceedances of ASC (2013) NEPM Ecological Screening Levels (ESLs) for TRH >C_{10}-C_{16} at 12 of the 46 soil bore locations. • ESL exceedances were primarily identified at depths ranging between 1 and 4 m bgl within the north-west and central portions of the Former Fuel Farm. Where EIL exceedances were recorded, analysis of all underlying material returning concentrations of all CoPCs less than LOR and/or the adopted assessment criteria with the exception of four locations, where collection of underlying samples was not possible due to refusal during drilling works. • Five shallow and seven deep groundwater wells were installed in a circular pattern outside of the site. One shallow and one deep well were installed along the eastern boundary of the site. Two deep and one shallow groundwater monitoring wells were installed within the site. • Laboratory results of collected groundwater samples showed exceedances for dissolved metals (cadmium, copper, iron, nickel and zinc) at the majority of wells and BaP at location D5. • Low level TRH was detected above LOR in one shallow groundwater monitoring well (D1) and four deep groundwater monitoring wells (B2, MW6, G1 and I1). At the time, MW6 was erroneously reported by AECOM as "B5". The highest TRH impacts were recorded within the vicinity of the former fuel storage infrastructure and corresponded to the highest reported concentrations of TRH in soils. Based on the results of the investigation, the following conclusions and recommendations were made: • The impacted groundwater is likely a result of the low level TRH impacted soils, which were impacted as a result of leakage or spills from the former fuel storage infrastructure. As the primary source of TRH was removed during site decommissioning works and the area is proposed to be redeveloped into a sealed aircraft parking area, an increase in concentrations from those recorded in the DSI were considered unlikely and the risk of harm to human health and/or the environment was assessed to be low. • Dissolved metal concentrations were considered to be consistent with those reported throughout the remainder of the RAAF Base Pearce property as detailed in the Earth Tech (2007) report. • No remediation is required to enable the proposed future land use.	• Conclusions are based on one round of groundwater sampling undertaken under summer water table conditions and may not reflect worst-case contaminant concentrations. • The Stage 2 DSI investigations conducted by GHD across two mobilisations in 2018 and 2019 form the basis of this report and includes analysis of trends in groundwater concentrations over time to assess plume stability/delineation. • This was achieved following compilation of Esdat database under a parallel data management project for DCARM. The findings are presented and discussed in Sections 10 and 11 of this report (GHD 2019).

<table>
<tr><th>Summary</th><th>Findings</th><th>GHD Comment (2019)</th></tr>
<tr><td colspan="3">Stage 2 Contamination Assessment: J0024 - Air 5428 Pilot Training System Scheme Facilities Project (Golder Associates 2015)</td></tr>
<tr><td>Golder Associates Pty Ltd (Golder) was engaged by Laing O'Rourke to conduct a Stage 2 contamination assessment to evaluate whether contamination is likely to be encountered as a result of proposed development of the AIR 5428 Pilot Training Scheme (PTS) Facilities Project which covers an area to the north, northwest and northeast of Hangar 95. Typical expected construction disturbances were considered to be up to 0.5 m in carparks, up to 1 m in taxiways and aprons and up to 2 m in building areas. The proposed redevelopment area included the following infrastructure:
• Temporary flight line shelters for 11 aircraft
• Administration building
• Aircraft storage and maintenance
• Flight line facility
• A.L.S.E. and maintenance bays
• FTS working accommodation
• Car parking
• Loading zone and F.T.Ds
• Temporary facilities
<u>Aims</u>
Project aims included:
• To evaluate whether contamination is likely to be encountered as a result of the proposed development works
• To determine where contamination is indicated:
– Evaluate the extent of contamination impacted soils and groundwater that may be disturbed by the development works
– Develop a Remediation Strategy
– Estimate volumes and costs associated with remediation works</td><td>The following key findings were identified:
• No groundwater was encountered during the investigation drilling and no monitoring wells were observed in the immediate vicinity of the project.
• Concentrations of CoPC in analysed soil samples did not indicate a human health or terrestrial ecology risk under a commercial/industrial land use setting.
• As an exception, hydrocarbon odours were noted in samples to the north of the existing aircraft shelters, from approximately 0.3 to 1.0 m bgl, although TRH was not detected above LOR.
• Concentrations of chromium, lead, nickel and PFOS were detected above WA DER "clean fill" waste classification guidelines, but at suitable concentrations for Class III landfill disposal.
Based on the results of the investigation, the following recommendations were made:
• As concentrations of the CoPC in analysed soil samples did not indicate a human health or terrestrial ecology risk under a commercial/industrial land use setting, Golder recommended that soils disturbed during the project works are retained on Base.
• Due to the hydrocarbon odours in samples to the north of the existing aircraft shelters, it was recommended that materials excavated in this area should be placed in skips and sampled before reuse.</td><td></td></tr>
<tr><td colspan="3">Regional Water Quality Monitoring Report (AECOM 2016)</td></tr>
<tr><td>• AECOM Australia Pty Ltd (AECOM) was engaged by Augility to conduct biannual water quality monitoring in September 2015 and March 2016 as part of the Regional Water Quality Monitoring Program at various Defence sites including RAAF Base Pearce.
<u>Objective</u>
• To assess potential environmental and health risks associated with groundwater contamination and whether identified risks have changed since previous monitoring.</td><td>The following key findings were identified:
• A significant number of monitoring wells and surface water sampling locations were dry and unable to be sampled during one or both of the monitoring rounds.
• Minor concentrations of TRH fractions and some Polycyclic Aromatic Hydrocarbons (PAHs) compounds were identified below the adopted health investigation levels at several wells within areas associated with underground fuel infrastructure including the Former Fuel Farm (CSR_WA_000110) and the Diesel USTs between Buildings A0012 and A0013 (CSR_WA_000024). TRH fractions were also identified at low concentrations at Hangar 95 (CSR_WA_000160).
• Dissolved concentrations of copper, iron, nickel and zinc exceeded the ANZECC freshwater guidelines (95 % protection) at the majority of wells.
• The DER (2014) Domestic Non-Potable Groundwater Use (NPUG) guidelines were exceeded by chloride at wells located with the Former Fuel Farm and Current Fire Training Area where concentrations have increased by at least an order of magnitude since 2014.
• E.coli and total coliform counts reduced during the FY15/16 monitoring in the Sewerage & Effluent Irrigation (CSR_WA_000106) area. It was however, recommended that further investigation of the area be undertaken as well as an assessment into the flow from the infiltration basin discharge into the creek.

Based on the results of the investigation, the following recommendations were made:
• Additional wells (H1, G1 and B2) were recommended at the Former Fuel Farm for the regional monitoring program.
• Further investigation of the area should be undertaken for E.coli and total coliform, as well as an assessment into the flow from the infiltration basin discharge into the creek.
• The Paint Shop's (CSR_WA_000156) program was recommended to be reduced to annual (September) and if Cr (VI) concentrations remain below LOR during FY16/17, the wells in this area should be considered for removal from the Regional Monitoring Program.
• Because the majority of wells in the Grounds Maintenance Area (CSR_WA_000151) and Contaminant Pit CP1 & CP2 (WA0POL) were dry during FY15/16, reinstallation of the wells in this area should be considered should they be dry again in FY16/17.</td><td>• The Stage 2 DSI investigations conducted by GHD across two mobilisations in 2018 and 2019 form the basis of this report and includes analysis of trends in groundwater concentrations over time to assess plume stability/delineation.
• This was achieved following compilation of Esdat database under a parallel data management project for DCARM. The findings are presented and discussed in Sections 10 and 11 of this report (GHD 2019).
• GHD were able to sample from wells noted as dry in 2018 and 2019 mobilisations.
• Synthesis of results of regional water quality monitoring program should be included in design of any future contamination assessments and vice versa in order to improve efficiency and focus in investigation design.</td></tr>
</table>

Summary	Findings	GHD Comment (2019)
Regional Water Quality Monitoring Draft Report (AGON 2017)		
• AGON Environmental (AGON) was engaged by Broadspectrum to conduct water quality monitoring in October/November 2016 as part of the Regional Water Quality Monitoring Program at various Defence sites including RAAF Base Pearce. ***Objective*** • To assess potential environmental and health risks associated with groundwater contamination and whether identified risks have changed since previous monitoring.	The following key findings were identified: • Minor PFOS/PFOA impacts were detected at CSR_WA_000110 and WA006. • Sites CSR_WA_000106, CSR_WA_000155, CSR_WA_000156, CSR_WA_000024 and CSR_WA_000154 had contaminant exceedances which were consistent with previous monitoring. • Sites CSR_WA_000151, WA0POL, CSR_WA_000160, CSR_WA_000109 and CSR_WA_000157 had dry monitoring wells during FY16/17. Based on the results of the investigation, the following recommendations were made: • Further assessment of the ammonia and other contaminants should be conducted at WA0PL, as levels appear to be increasing. • PFOS/PFOAs should be included in regional surface water monitoring. The inclusion of sediment sampling should also be considered at surface water locations.	• The Stage 2 DSI investigations conducted by GHD across two mobilisations in 2018 and 2019 form the basis of this report and includes analysis of trends in groundwater concentrations over time to assess plume stability/delineation. • GHD were able to sample from wells noted as dry in 2018 and 2019 mobilisations • This was achieved following compilation of Esdat database under a parallel data management project for DCARM. The findings are presented and discussed in Sections 10 and 11 of this report (GHD 2019). • Synthesis of results of regional water quality monitoring program into design of any future contamination assessments and vice versa will greatly improve efficiency and focus in investigation design.
Detailed Site Investigation: RAAF Base Pearce PFAS (GHD 2018b)		
• GHD Pty Ltd (GHD) was commissioned by Defence to undertake a Stage 2 DSI of the impacts of per- and poly-fluoroalkyl substances (PFAS) on and around RAAF Base Pearce in Bullsbrook. The investigation included sampling and analysis not only from RAAF Base Pearce, but also from the surrounding areas. • For the purpose of reference: • 'The property' was defined as comprising RAAF Base Pearce; and • 'The Investigation Area' was defined as comprising the property as well as a number of surrounding (off-site) waterways and privately owned and leased properties, including residential properties. ***Objective*** • The overarching objective for the Consolidated Stage 2 DSI was to characterise the nature, extent and magnitude of PFAS impacts on-site and within the Investigation Area to the extent required to inform a quantitative site-specific Human Health and Ecological Risk Assessment (HHERA) of risks from PFAS to human health and the environment. ***Project Context*** • The Stage 2 DSI forms part of the overall investigation into PFAS impacts within the Investigation Area. The overall investigation comprises the following: • A Stage 1 PSI, that was completed in September 2016 • A PFAS Consolidated Stage 2 DSI • Hydrogeological modelling • A HHERA, to be completed following submission and approval of the Stage 2 DSI ***Scope*** • The scope of work undertaken included a detailed program of on- and off-site soil, sediment, surface water, groundwater and biota sampling and analysis. The sampling design for the Stage 2 DSI aimed to characterise the presence of PFAS: • At the contaminant sources (e.g. soil and groundwater testing within identified source areas) • Within potential contaminant transport pathways (e.g. surface water sampling in drainage lines and brooks, plus sampling of groundwater across the wider Investigation Area) • At potential contaminant receptors (e.g. testing of private groundwater bores, biota such as fish in brooks, fruit and vegetables and eggs from poultry kept on private properties) • In addition, 25 % of samples were analysed for a suite of conventional contamination data. • The abovementioned sources, pathways and receptors were identified in the CSM that was developed as part of the previous Stage 1 PSI scope of works, and was refined based on key findings of the Stage 2 DSI investigation.	The following key findings were made: • Six Source Areas where PFAS was detected in soil or groundwater at concentrations exceeding the adopted assessment levels are considered to be the most impacted areas: • Source Area A – Fire Training Area. • Source Area B – Former Fire Training Areas. • Source Area C – Hangar 93 and foam disposal pit. • Source Area D – Grounds Maintenance Area. • Potential Source Area J – Former Fuel Farm. • Potential Source Area R – RAAF Pearce landfill. • The highest soil concentrations were recorded in Source Areas A, B and D. • PFOS, PFHxS and PFOA were detected in surface waters of the on-site drainage channels and the receiving Ellen Brook and Ki-It Monger Brook at concentrations exceeding the adopted assessment levels. • Sediment concentrations within the portions of the Brooks that are adjacent or within the property boundary were low (i.e. a maximum PFOS plus PFHxS concentration of 0.0792 mg/kg) and reduced further in the southern reaches of the Ellen Brook. • PFAS concentrations in surface water samples collected from the drainage channel that traverses the West Bullsbrook residential area and the creek that traverses Lot 200 in West Bullsbrook were relatively low (i.e. a maximum PFOS plus PFHxS concentration of 0.035 µg/L compared to a maximum of 11.3 µg/L recorded in Ki-It Monger Brook). • The highest groundwater PFAS concentrations were recorded in Source Areas A, B, C, D, J and R. Potential Source Areas F, K, N and S also had detectable concentrations of PFOS plus PFHxS in groundwater that were below the adopted health based assessment levels for the property (FSANZ non-potable and recreational) though were above the FSANZ drinking water assessment level of 0.07 µg/L. • PFAS was detected in groundwater collected from 16 off-site private bores. Concentrations of PFOS plus PFHxS exceeded the drinking water assessment level in three of these with a maximum concentration of 0.56 µg/L recorded. Fourteen of the detections were located in the West Bullsbrook area, one was located to the south of the property and the other to the south-east, on the eastern side of Ki-It Monger Brook up-stream of the property. At the request of some residents, specific data associated with some bores (recorded concentrations and bore location) was not presented in the Consolidated Stage 2 DSI report. • PFAS was detected within the aquatic biota samples (fish and crustaceans) collected from Ellen and Ki-It Monger Brooks. • PFAS including PFOS, PFHxS and PFOA were detected in the majority of the terrestrial biota samples (vegetation, invertebrate and animal scat samples) collected from Source Area A and Source Area B.	• A review of the PFAS Stage 2 DSI has been included as it informs groundwater flow and discharge mechanisms (i.e. contaminant migration pathways) and to enable a review of the 25 % of sample results analysed for conventional contaminants.

Summary	Findings	GHD Comment (2019)
	• PFAS including PFOS plus PFHxS were detected above the LOR, but below the adopted health based assessment level in one egg sample. • In addition to PFAS analysis, 25 % of the samples were also analysed for conventional contaminants. The main results of this analysis is as follows: – Monitoring well SD_MW12 (screened 11.9 – 17.9 m bgl) located at the Grounds Maintenance Area experienced a Trichloroethylene (TCE) concentration of 863 µg/L. – Monitoring wells BW_MW20 (Boundary), SC_MW07 (Source Area C) and SC_MW09 (Source Area C) exceeded dissolved aluminium DER NPUG criteria. – Multiple metal exceedances were experience in the surface water samples of the on-site drainage channels, the Ellen Brook and Ki-It Monger Brook. Based on the results of the investigation, the following conclusions and recommendations were made: • The groundwater and surface water level data obtained during the investigation suggests that the Ellen Brook is both receiving from and discharging to groundwater. The monitoring data also indicated that groundwater could flow beneath Ki-It Monger Brook and it is also possible that surface water discharge to groundwater occurs beneath Ki-It Monger Brook. • Where perched groundwater occurs, PFAS concentrations in the perched groundwater were higher than in the underlying regional superficial aquifer. This is evident in particular within Source Area A. It should be noted that the groundwater investigation component of the Stage 2 DSI focussed on impacts to the regional superficial aquifer, as this is the aquifer from which groundwater users are abstracting water. • PFAS was not detected in groundwater within any of the wells that targeted the deeper portions of the regional aquifer including the deeper wells installed along the down-gradient property boundary adjacent to the Ellen Brook. Similarly, PFAS was not detected above the LOR within the deeper wells installed in the West Bullsbrook area. • The most likely mechanisms by which the PFAS has migrated to the private bores in the West Bullsbrook residential area was reported to be primarily from the discharge of impacted surface water from the Ellen Brook to the underlying groundwater, particularly following flood events or sustained rainfall and secondarily, groundwater migration from the property. • The PFAS concentrations recorded at the two off-site private bores to the south and east of the property were considered likely to be the result of groundwater migration from the property. The interpreted groundwater contours indicate potential for impacted groundwater to migrate off-site, beneath Ki-It Monger Brook, towards these bores from Source Area B, Potential Source Area J and Potential Source Area S. • Management and remediation options will ultimately be informed by the findings of the HHERA, through consultation with Defence and affected stakeholders and the development of a PFAS Management Area Plan (PMAP). • The report provided high level summary of potential actions to manage areas identified as presenting a potentially elevated risk of exposure to receptors or where residual uncertainty remains. • It was recommended that periodic monitoring of PFAS in ground and surface water be incorporated into Defence's existing property monitoring program to provide Defence with a greater understanding of seasonal variability in PFAS concentrations and help to identify changes in risk profile triggering the need for further management or remediation.	

Summary	Findings	GHD Comment (2019)
PFAS Ongoing Management Plan: RAAF Base Pearce PFAS Investigation (GHD 2019a).		
GHD Pty Ltd (GHD) was commissioned by Defence to prepare an Ongoing Monitoring Plan (OMP) for per- and poly-fluoroalkyl substances (PFAS) impacts identified on and around RAAF Base Pearce in Bullsbrook. The investigation included sampling and analysis at the 'Management Area' defined as comprising RAAF Base Pearce (the property) as well as a number of surrounding (off-site) waterways and privately owned and leased properties, including residential premises. ***Background*** • Following completion of the PFAS DSI, it was recommended that periodic monitoring of PFAS in ground and surface water be incorporated into Defence's existing property monitoring program to provide Defence with a greater understanding of seasonal variability in PFAS concentrations and help to identify changes in risk profile triggering the need for further management or remediation. ***Objective*** • The objective of the OMP was to present the rationale and scope for the monitoring of the concentrations and extent of PFAS in groundwater, surface water and sediment originating from the Site. The findings of which will inform risk management decisions by Defence and the Western Australian Government to protect human health and the environment. ***Scope*** • The OMP was developed to provide guidance for preparation of a SAQP required to be implemented during monitoring events planned to be undertaken over a two year period. • Ongoing monitoring will generally be undertaken within the boundaries of the Management Area at select groundwater, surface water and sediment monitoring locations. Monitoring will be undertaken every six months, with one monitoring event post-summer (March/April) and one post-winter (September/October). An additional surface water and sediment monitoring event will take place following the first flush immediately (or as close as possible) following the first heavy rainfall event of the autumn to winter period.	***Project Context*** The OMP was developed following completion of the PFAS DSI in 2018 (GHD 2018b). The findings of the DSI identified PFAS in groundwater, surface water and sediment within the Management Area at concentrations exceeding the relevant assessment levels. As of May 2019, PFAS had been detected above the LOR (0.01 µg/L for the sum of PFAS) in groundwater collected from 25 out of 166 private bores sampled throughout the investigation, which incorporated additional residential bore sampling events conducted between 2018 and 2019. Concentrations of PFOS plus PFHxS exceeded the drinking water assessment level (0.07 µg/L) in 11 bores, with one of these exceeding the recreational assessment level (0.7 µg/L). The mechanisms by which PFAS has migrated off-site are considered to be primarily, surface water migration and secondarily, groundwater migration. It was recommended that ongoing monitoring be implemented across the Management Area to develop a robust dataset to assess trends in the nature, extent and magnitude of PFAS concentrations within sediment, surface water and groundwater, and to gain an understanding of the spatial and temporal variability of PFAS concentrations within the Management Area.	• Results of the PFAS OMP first flush surface water and sediment monitoring event undertaken in June 2019 have been reviewed and incorporated into this Stage 2 DSI to support the interpretation of PFAS results at 3TU.

4.2 GHD site inspection/interviews

GHD undertook a site walkover in February 2018 with the DCARM project manager and the site Regional Environment and Sustainability Manager (RESM). Photographs of property features were not authorised to be taken. It should be noted that the walkover was undertaken as a holistic consideration of the whole of both properties. Previously existing CSRs were visited to assess any significant changes in conditions which would alter potential contamination status. In addition to existing CSRs, three PCSRs were identified as described in Table 18.

Following completion of Mobilisation 1 undertaken between March and May 2018 (including limited sediment sampling in September 2018), two further PCSRs were identified as requiring assessment based on anecdotal information provided by Defence (one at RAAF Base Pearce and one at 3TU) as described in Table 19.

These PCSRs as well as select existing CSRs (requiring additional assessment to adequately address residual data gaps) were investigated during Mobilisation 2 undertaken in April 2019 (detailed further in Section 5.3).

Observations from the initial property walkover and anecdotal information pertaining to identified PCSRs obtained from Defence are noted in Table 18, and Table 19, with CSRs and PCSRs marked on Figure 3A and Figure 3B.

Table 18 Existing CSRs - Observations from site inspection and anecdotal information

CSR	CSR Name	Relevant observations (triggers, visual or olfactory evidence, incidents, spills) and anecdotal information
RAAF Base Pearce		
CSR_WA_000024	NE Building 72 – Group of USTs and ASTs	Subject of Augility's tank replacement program. USTs to be removed and replaced during the course of Stage 2 DSI works.
CSR_WA_000083	Dog Compound – Buried Waste	Waste burial area noted to extend further to the south, outside the marked CSR boundary.
CSR_WA_000084	Sounness Road Landfill	Existing monitoring wells were dipped and found to be largely serviceable. No monitoring reports have been found to be available post-2005.
CSR_WA_000085	Inside Building 13 – AST_039 Waste Oil	No current visual or olfactory evidence of contamination.
CSR_WA_000086	Two ASTs 026 and 027	No known spills or visual or olfactory evidence of contamination.
CSR_WA_000087	Fuel Storage ILS 18 Glide Path	No current visual or olfactory evidence of contamination.
CSR_WA_000088	Fuel Storage, ILS 18	No current visual or olfactory evidence of contamination.
CSR_WA_000104	Former Hazardous Waste Store	Based on location of building (constructed between 1953 and 1965, demolished between and 1995 and 2000), the CSR area should extend further northwards.
CSR_WA_000105	Former Ammunition Bunker – Toxic Waste	No current visual or olfactory evidence of contamination.
CSR_WA_000106	Sewage Treatment Plant Discharge Effluent	Civil project (refurbishment including lining of ponds 1 and 2) was reported due to commence at the Sewage Treatment Plant in March 2018.
CSR_WA_000107	Former Fire Training Area (1960s)	A sewage pit was observed at the Former Fire Training Area with very lush vegetation around it. Anecdotal information indicated that this pit has regularly overflowed and flooded the area.
CSR_WA_000108	Former Fire Training Area - AFFF	No current visual or olfactory evidence of contamination.
CSR_WA_000109	Former USTs 240 to 245 near Building 239	Civil upgrade works were observed to be underway related to the installation of a new puraceptor. Access to assess existing well condition was not possible.
CSR_WA_000110	Former Fuel Farm	Limited wells serviceable post-decommissioning. DCARM project manager expressed concern that former Light Non-aqueous Phase Liquid (LNAPL) plume may not have been adequately investigated and whether the remaining well network is fit for purpose. GHD notes that there is a lack of comprehensive monitoring data set for groundwater to enable a robust plume stability assessment.
CSR_WA_000111	Aircraft Wash Down ('Bird Bath')	Site inspection/interviews confirmed that only high-pressure de-ionised water used here, no surfactants. Run-off captured and contained and directed to wastewater treatment plant. No current visual or olfactory evidence of contamination.

CSR	CSR Name	Relevant observations (triggers, visual or olfactory evidence, incidents, spills) and anecdotal information
CSR_WA_000112	Radioactive Aircraft Former Wash Down Area	No current visual or olfactory evidence of contamination.
CSR_WA_000117	Former Service Station	No current visual or olfactory evidence of contamination. A significant volume of contaminated soil associated with the waste oil disposal pit was removed as part of decommissioning activities in 2009/2010 (AECOM 2010). No environmental investigations (including groundwater monitoring) are known to have occurred subsequently.
CSR_WA_000151	Grounds Maintenance Area	The earthen bund in the south-west corner of the Grounds Maintenance Area was observed to be compromised with multiple stains visible on the earthen ground surface. Anecdotal spillage or washdown/rinse out residue of herbicides outside the chemical storage shed immediately east of WA00GM-MW082.
CSR_WA_000153	Fire Training Area – Fuel Storage Facilities	No current visual or olfactory evidence of contamination.
CSR_WA_000154	South of Building 13 – UST_030 and AST_031	No current visual or olfactory evidence of contamination.
CSR_WA_000155	Power Station USTs	No current visual or olfactory evidence of contamination.
CSR_WA_000156	Paint Shop	No current visual or olfactory evidence of contamination
CSR_WA_000157	East of Building 134 – UST_038 Waste Oil	No current visual or olfactory evidence of contamination.
CSR_WA_000158	Waste Oil Sumps – between Buildings A78 and A125	No current visual or olfactory evidence of contamination.
CSR_WA_000159	Waste Oil Sumps – between Building A116 and Hangar 95	No current visual or olfactory evidence of contamination.
CSR_WA_000160	Hangar 95	With the exception of ambient olfactory evidence of use of volatile organic compounds within the hangar, no additional visual or olfactory evidence of contamination was observed.
3TU		
CSR_WA_000019	Septic Tanks – Sewage Disposal	No current visual or olfactory evidence of contamination.
CSR_WA_000080	Incinerator (North of 3TU Workshop)	No current visual or olfactory evidence of contamination.
CSR_WA_000081	South of 3TU – Buried Waste Metals	Existing monitoring wells (6) were dipped and found to be largely serviceable and fit for monitoring purposes.
CSR_WA_000101	Former 3TU Workshop – Buried Waste	No current visual or olfactory evidence of contamination.
CSR_WA_000103	South of Former Building 58 – 2 x Diesel A/USTs	No current visual or olfactory evidence of contamination.

Table 19 PCSRs - Observations from site inspection and anecdotal information

PCSR	PCSR Name	PCSR details based on anecdotal information
RAAF Base Pearce		
PCSR_0967_001	Aircraft shelters	A former fitter from the Mechanical Equipment Operations and Maintenance Section (MEOMS) reported that during the time the Macchi trainer jets were in use at RAAF Pearce up until 2000 there was significant venting of fuel from the rear of those aircraft onto the margin of the airfield (to the west of the current aircraft shelters). Reporting (Golder 2015) indicated strong hydrocarbon odours in this area from 0.3 m bgl to 1.0 m bgl in the vicinity of the shelters with no contamination analysis conducted.
PCSR_0967_002	AVTUR Fuel Farm	The current AVTUR fuel farm facility is adjacent (south-east) to the Former Fuel Farm (CSR_WA_000110) and was commissioned in 2014. It comprises two 2.4 ML ASTs and three 158 kL QC ASTs of F34 aviation turbine fuel with additives for high altitude flying and anti-static. Monthly fuel use is reportedly approximately 1.2 ML. A puraceptor to the west of the facility captures all run-off and is pumped out regularly. A 5000 L UST 'dump tank' is present on-site, used for waste fuel and lab waste (predominantly decon 90). A small spill (anecdotally approximately 20 L) of AVTUR occurred onto blue metal (subsurface unlined) at the western edge of the refuelling area in January 2018, with no subsurface excavation undertaken. Five monitoring wells were installed during construction. No LNAPL detected during weekly dipping, however no groundwater sampling known to have been undertaken of these five wells. Anecdotal information reported that free product was reported on one occasion near the puraceptor by the fuel farm operator early in the operation of the new farm (Defence comms).
PCSR_0967_003	Former Small Arms Range	A Former 25 m Small Arms Range was identified to the east of the Sewage Treatment Plant. This facility was reportedly operational between the 1950s and 2006 for pilot pistol firing training. Significant volumes of spent bullets were observed on the sandy bullet catcher. A concrete pad was present at the firing point. The exact nature of other activities and storage/usage was unknown but various small adjacent buildings observed including one brick building labelled 'Class 6 toxic PCB' storeroom observed with some staining on the interior concrete pad.
3TU		
PCSR_0965_001	Fire extinguisher training area	During the SAQP phase of the PFASIMB investigations at RAAF Base Pearce, advice indicated that fire extinguishers were historically used in the vicinity of a former telecommunications building (known as 3TU). Further advice also indicated that foam was transported to the site (possibly by the Bush Fire Brigade who also used AFFF). However, it is unknown whether this foam was discharged at 3TU. The location/area was noted to be just north-west of PCSR_0965_002.

PCSR	PCSR Name	PCSR details based on anecdotal information
PCSR_0965_002	Asphalt Stockpile	A large asphalt stockpile and fly-tipped waste was observed to be present in the south western area of 3TU. This was reported to contain asphalt that had been removed from runway sections at RAAF Base Pearce during recent upgrades but has also been subject to significant fly tipping over previous years. The asphalt stockpile covers an area of approximately 5000 m^2 of a parcel of land located at 248 Della Road. The area was flagged as an additional source area to be included in the assessment due to the potential for contamination associated with leachable contaminants within the asphalt and the source of the stockpiled asphalt (Pearce Base runway excess) and potential contaminants of concern associated with runway use, particularly the potential presence of PFAS in asphalt from former use of AFFF on runways and associated exposure risks to the environment.

5. Preliminary CSM and data gaps evaluation

5.1 Balance of property assessment

With a high degree of confidence it is determined that there are no additional PCSRs across the balance of the properties that have not been accounted for. The qualitative assessment of the balance of the properties has been based on previous investigations, the findings of the site walkover and interviews, and anecdotal information obtained as part of this investigation. On this basis no further works were considered to be warranted across the balance of the properties as part of this Stage 2 DSI.

5.2 Potential sources, pathways and receptors

5.2.1 Potential sources and contaminants of concern

Details of the principal potentially contaminating source areas of concern identified, together with an initial source-pathway-receptor linkage evaluation are summarised in the CSM in Table 22 and Table 23.

5.2.2 Potential pathways

Potential pathways by which release of potential contaminants to the environment may migrate within, and from the properties are summarised below:

- Property users (Defence personnel), maintenance workers and contractors working on the property and future property users may be exposed to potentially contaminated soil and groundwater via the dermal (direct contact), inhalation (dust, vapour and odour) and ingestion pathways (consuming food without washing hands)
- Migration of hydrocarbon vapours into trenches during excavation/intrusive works
- Uptake by plants
- Lateral migration of contaminants via surface runoff during heavy rainfall events
- Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer, drainage to superficial aquifer and discharge to surface water receiving body
- Lateral migration of contaminants in groundwater in the direction of groundwater flow
- Abstraction of groundwater

5.2.3 Potential receptors

Based on the review of currently available information with regard to the current and ongoing use of the properties and the current land uses of the surrounding areas, the human and ecological receptors identified for RAAF Base Pearce and 3TU are summarised in the following sections.

5.2.3.1 RAAF Base Pearce

Potential human and ecological receptors identified for RAAF Base Pearce are summarised in Table 20.

Table 20 Summary of human and ecological receptors (RAAF Base Pearce)

On-site	
Human	**Ecological**
• Property users (Defence personnel including residents), maintenance workers and contractors	• Groundwater dependent Remnant Native Vegetation (terrestrial) present in the south-eastern portion of the property. • Threatened terrestrial fauna species. • Surface water receiving bodies including: – Upper reaches of the Ellen Brook catchment area (runs along western boundary) – Ki-It Monger Brook (runs along south-eastern boundary) • Various threatened aquatic flora and fauna species within the Ellen Brook (south-west) and Ki-It Monger Brook (south-east) ecosystems.
Off-site	
Human	**Ecological**
• Users of surface water receiving bodies (the Ellen Brook and Ki-It Monger Brook watercourses) • Abstraction bore users	• Groundwater dependent Remnant Native Vegetation (terrestrial) located south-west and south-east. • Threatened terrestrial fauna species. • Surface water receiving bodies including: – Upper reaches of the Ellen Brook catchment area (west south-west) – Ki-It Monger Brook (south-east) • Various threatened aquatic flora and fauna species within the Ellen Brook (south-west) and Ki-It Monger Brook (south-east) ecosystems.

5.2.3.2 3TU

Potential human and ecological receptors identified for 3TU are summarised in Table 21.

Table 21 Summary of human and ecological receptors (3TU)

On-site	
Human	**Ecological**
• Property users (Defence personnel), maintenance workers/contractors, illegal trespassers and future property users	• Surface water receiving bodies: – Tributaries of the Ellen Brook – Bulls Brook drainage system
Off-site	
Human	**Ecological**
• Users of surface water body (the Ellen Brook catchment watercourses) • Abstraction bore users	• Groundwater dependent Remnant Native Vegetation (terrestrial) located east of the property • Threatened terrestrial fauna species. • Surface water receiving body: – Upper reaches of the Ellen Brook catchment area (east) – Bulls Brook drainage system/catchment area • Various threatened aquatic flora and fauna species within the Bulls Brook catchment and the Ellen Brook catchment ecosystems. • Higher order species/livestock

5.2.4 Potentially complete source-pathway-receptor (S-P-R) linkages

The initial Source-Pathway-Receptor (S-P-R) linkages considered potentially complete for the RAAF Base Pearce and 3TU properties are summarised in CSM Table 22 and Table 23.

Table 22 Summary of potentially complete source-pathway-receptor linkages (RAAF Base Pearce)

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000024 Fuel Storage NE of Building 72 (ASTs and USTs)	Medium	Potential contamination associated with leaking UST/s	Anecdotal information provided by Defence suggested one of three USTs (the northernmost UST) has been suspected as leaking. USTs were decommissioned and removed as part of Augility's tank replacement program undertaken during the course of the GHD Stage 2 Investigation works.	Metals BTEX TRH PAHs	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Soil and groundwater impact uncertainty*** ***Vapour risk uncertainty*** Given the potential contamination associated with UST leakage, investigation of soil and groundwater is considered necessary to assess the current status of potential risk associated with fuel storage infrastructure.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
					Vapour intrusion	NA	Vapour inhalation	✓	✗	✗	✗	✗	✗	
CSR_WA_000083 Dog compound - Buried Waste	Medium	Impacts associated with historical waste disposal practices. There has been systematic dumping within the compound: including asbestos, sand, bitumen, road base and concrete. Systematic dumping was originally thought to be restricted to the northern extent of the area.	Waste burial area extends further south than existing CSR boundary.	Metals TRH PAHs Organo-chlorine Pesticides (OCPs) Asbestos	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater	✓	✓	✗	✓	✗	✓	***Soil impact uncertainty*** Investigation of the area south of the existing CSR boundary is considered necessary to adequately assess the defined CSR area and all potential CoPCs and determine the potential risk associated with historical waste disposal
					Wind dispersion	Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
						NA	Inhalation of dust	✓	✗	✗	✗	✗	✗	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000084 Sounness Road Landfill	Medium	Prior to closure in 2001, the property was used for uncontrolled land filling over 50 years by Defence and public. The categories of waste include: construction material, metal automotive, industrial and domestic waste. It is reported that hazardous waste (chemicals, solvents, PCBs, asbestos and paint) was also dumped at the property	A review of the previous Stage 2 investigation identified that the waste extended to a depth of 2.0 m bgl beneath a sand fill cap layer (approximately 0.5 m depth) with limited pockets of waste extending to 3.3 m bgl. The analytical results identified heavy metal contamination above EILs, one lead concentration above HILs, TPH (minor) at one location and SVOCs in two soil samples. The analytical results for groundwater identified minor exceedances of Freshwater guidelines for Cadmium, Copper, Nickel and Zinc, as well as TPH in three samples. However, it was reported that the landfill did not adversely affect subsurface soils or groundwater. No monitoring reports have been made available post-2005.	Metals TRH VOCs SVOCs OCPs Asbestos	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	**Groundwater impact uncertainty** Further investigation is considered necessary to assess the current status of potential risk arising from historical landfill operations. Recent well gauging undertaken by GHD as part of PFAS preliminary works indicated most wells were in serviceable condition.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
					Vapour intrusion	NA	Vapour intrusion	✗	✗	✗	✗	✗	✗	
CSR_WA_000085 Waste Oil Storage East of Building 134 (AST_039)	Low	Waste oil AST (039) less than 1000 L capacity. AST_039 bunding does not meet applicable standards.	Review of previous reports, site inspection and interviews confirmed that risk remains low.	TRH PAHs BTEX-N Metals	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✗	✗	✗	✗	✗	✗	No identified data gaps, CSR considered low risk. No driver for inclusion in Stage 2 investigations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment)	Direct contact with surface water.	✗	✗	✗	✗	✗	✗	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000086 Fuel storage – 2 x ASTs 026 and 027	Medium	Two ASTs (026 and 027). Both ASTs were installed prior to 1975, 550 L and 850 L capacity respectively. There is superficial damage to AST 26. Bunding for both ASTs does not meet applicable standards	Considering capacity of ASTs (less than 1000 L each), lack of visible staining, and location in centre of airfield, contamination risk is considered low.	TRH PAHs BTEX-N Metals	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✗	✗	✗	✗	✗	No identified data gaps, CSR considered low risk. No driver for inclusion in Stage 2 investigations. Manage risk via upgrade of bunding and review of operation and maintenance procedures
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✗	✗	✗	✗	
CSR_WA_000087 Fuel Storage ILS 18 Glide Path	Medium	Potential contamination associated with leaking AST Diesel AST (032). AST_032, less than 1000 L capacity.	The bunding of diesel AST (032) does not meet applicable standards. Sensitivity of the nearby surface water receptor is significant.	Metals TRH PAHs	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Soil impact uncertainty*** Given the potential for contamination associated with AST leakage and the proximity of the nearby surface water receptor, further investigation is considered necessary to assess the current status of potential risk associated with fuel storage infrastructure. Evidence of soil impacts will drive requirement for groundwater investigation.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000088 Fuel Storage ILS 18	Medium	Potential contamination associated with leaking AST Diesel AST (033).	The bunding of diesel AST (033) does not meet applicable standards. Sensitivity of the nearby surface water receptor is significant.	Metals TRH PAHs	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Soil impact uncertainty*** Given the potential for contamination associated with AST leakage and the proximity of the nearby surface water receptor, further investigation is considered necessary to assess the current status of potential risk associated with fuel storage infrastructure. Evidence of soil impacts will drive requirement for groundwater investigation.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
CSR_WA_000104 Former Hazardous Waste Store	Medium	Historical leakage/spills associated with handling and storage of hazardous wastes.	A review of historical aerials indicates that based on the location of the building (constructed between 1953 and 1965, demolished between and 1995 and 2000), the CSR area should extend further north of the existing CSR boundary. Previous soil sampling undertaken in 2007 (Earthtech) is not considered to have adequately defined the former building area/footprint and all potential CoPCs.	Metals TRH VOCs SVOCs PCBs Explosive residues	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✗	***Soil impact uncertainty*** Further investigation is considered necessary to adequately assess the defined CSR area and all potential CoPCs.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment)	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
					Vapour intrusion	NA	Vapour inhalation	✗	✗	✗	✗	✗	✗	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000105 Former Ammunition Bunker - Toxic Waste	Low	Former Ammunition Bunkers: Three are two former ordnance stores. A deep surface drain runs from east to west north of the Former Ammunition Bunkers and discharges into The Ellen Brook. A second perpendicular drain runs between the two bunkers.	A review of previous reports indicates: Soil: All concentrations were below the adopted criteria. Groundwater - Heavy metal exceedances were detected however at concentrations consistent with background concentrations.	Metals, TRH, explosive residues	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✗	✗	✗	✗	✗	✗	No identified data gaps, CSR considered low risk. No driver for inclusion in Stage 2 investigations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✗	✗	✗	✗	
CSR_WA_000106 Sewage Treatment Plant Discharge Effluent	Medium	Potential contamination associated with the Sewage Treatment Plant ponds and infrastructure, and Sewage Treatment Plant effluent discharge. Ponds include 2 aerobic and 2 anaerobic ponds.	Requirement for assessment of the current status of potential risk arising from sewage treatment and disposal. Sewage Treatment Plant ponds subject to refurbishment (March 2018).	Metals Nutrients Pathogens E. coli Total coliforms	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Groundwater and surface water impact uncertainty*** Although limited wells are subject to regular groundwater monitoring as part of regional monitoring program, results have not been assessed holistically to ascertain if operations are posing an ongoing risk to receptors. Assess the current status of potential risk arising from sewage treatment and disposal
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
CSR_WA_000107 Former Fire Training Area (1960s)	High (based on PFAS risk)	Former Fire Training Area (1960s): The area is inferred to be approximately 0.2 ha and was used for training in the extinguishing of fires directly on the ground and fuelled by various flammable hydrocarbons.	Review of conventional CoPC data collected during PFAS Stage 2 DSI (GHD 2017) indicated no significant hydrocarbons detected in soils or groundwater. During the recent site visit, a sewage pit was observed at northern extent of the area (outside existing CSR boundary). Anecdotal information reported the sewage pit as having a history of overflowing.	Metals PAHs OCPs Nutrients Pathogens	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Groundwater and surface water impact uncertainty*** Further investigation is considered necessary to assess the current status (with respect to conventional contamination issues) of potential risk arising from sewage effluent release.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000108 Former Fire Training Area – AFFF	Low	Former Fire Training Area (1980s): The area is inferred to be approximately 0.2 ha and was used for training in the extinguishing of fires directly on the ground and fuelled by various flammable hydrocarbons.	Review of existing reports indicates: Soil: Concentrations of TPH and BTEX were detected exceeding the adopted criteria in two near surface samples taken from the former training area (1980s) (centre of the site). Sediment - All sediment concentrations were below the adopted criteria. Surface Water - All surface water concentrations were below the adopted criteria with the exception of copper, however this value was consistent with background levels. Groundwater - concentrations of heavy metals were detected exceeding the adopted criteria however they were consistent with background conditions.	Metals TRH Benzene, Toluene, Ethylbenzene, Xylenes and naphthalene (BTEX-N)	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater	✗	✗	✗	✗	✗	✗	No identified data gaps, with respect to conventional contamination (non-PFAS); CSR considered low risk. No driver for inclusion in Stage 2 investigations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment)	Direct contact with surface water	✗	✗	✗	✗	✗	✗	
CSR_WA_000109 Former USTs 240 – 245 near Building 329	Medium	Potential contamination associated with Former USTs (240 – 245) known to have leaked historically. USTs have since been decommissioned/removed and replaced with ASTs.	It is understood contamination remains in situ beneath former bowsers. During site walkover (February 2018) civil upgrade works underway in this area (installation of new puraceptor).	Metals TRH BTEX PAHs	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Soil and groundwater impact uncertainty*** Further investigation considered necessary to assess the current status of potential risk arising from underground fuel storage and delineate any remaining impact within soil and/or groundwater.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
					Vapour intrusion	NA	Vapour inhalation	✓	✗	✗	✗	✗	✗	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000110 Former Fuel Farm	Medium	Historical leakage/spills associated with former fuel infrastructure. Fuel Farm included 3 x 1.5 ML ASTs (within 1.2 m high vertical concrete bund walls); 7 x 5 kL to 55 kL ASTs (within low earthen bunds); 2 x USTs (in the northern corner of the Fuel Farm (FF)). UST from FF are to be replaced by AST. UST reported to leak. History of spills/surface staining.	AECOM DSI (2015) indicated soil contamination risk was well defined. The remaining well network may not be fit for purpose and it is unknown whether the former LNAPL plume has been adequately defined AGON 2017 Regional Water Quality Monitoring indicated minor TRH (C10-C36 250 µg/L) in one of five monitored wells.	Metals TRH Benzene, Toluene, Ethyl-benzene and Xylenes (BTEX) PAHs	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✗	✗	✓	✗	✓	***Groundwater impact delineation uncertainty*** ***Plume stability uncertainty*** Further investigation considered necessary to delineate current extent of groundwater impact from fuel storage and historical leakage post decommissioning phase
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
CSR_WA_000111 Aircraft Wash Down (Bird bath)	Medium	The wash down consists of two paved loops each including a concrete pad on which aircraft are washed. Two high pressure water jets between which aircraft pass to be washed are present either side of the concrete pads. The pads are graded to drain directly to the ground surface of the surrounding areas. A small brick building adjacent to the area acts as a pump house. Three above ground tanks adjacent to the pump house store demineralised water to wash the planes. The facility drains to a pit approximately 80 m to the south and from here is pumped to the Sewage Treatment Plant.	Review of previous reports indicated all soil concentrations were below the adopted criteria with the exception of sulphate which is believed to be naturally occurring. Sediment - All sediment concentrations were below the adopted criteria. Surface Water - All surface water concentrations were below the adopted criteria with the exception of copper, however this value was consistent with background levels. Groundwater - concentrations of heavy metals were detected exceeding the adopted criteria however they were consistent with background conditions Site inspection/interviews confirmed that only high-pressure de-ionised water used here, no surfactants. Run-off captured and contained and directed to waste water treatment plant. No current visual or olfactory evidence of contamination.	Metals VOCs TRH	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✗	✗	✗	✗	✗	✗	No identified data gaps, CSR considered low risk. No driver for inclusion in Stage 2 investigations. (Note that the Medium CRAT risk pre-DSI was based on compliance risk not environmental risk)
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✗	✗	✗	✗	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000112 Radioactive Aircraft Former Jet Wash Down Area	Low	Potential former radioactive aircraft wash down area. The area has been historically used to wash down equipment including planes used to test atomic bombs in the Montebello Islands in the 1950s.	Soil sample analysis and field surface radiation results were consistent with background levels (Earth Tech 2007). There was no measurable radiological activity in the area that would lead to adverse health for residents of members of the public. The area was free from any measurable anthropogenic radioactive material. Heavy metal concentrations in groundwater exceeded the adopted criteria but were consistent with background conditions. All sediment concentrations were below the adopted criteria.	Radio-active elements, Metals	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✗	✗	✗	✗	✗	✗	No identified data gaps, CSR considered low risk. No driver for inclusion in Stage 2 investigations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✗	✗	✗	✗	
CSR_WA_000117 Former Service Station	High	Potential spill/leakage associated with operation of former (decommissioned/ removed 2009) underground fuel storage tanks and associated infrastructure: UST_034 (16,800 L, petrol), UST_035 (11,700 L, diesel) and UST_036 (less than 1000 L, waste oil).	Review of historical reports indicated a significant volume of contaminated soil associated with the waste oil disposal pit was removed as part of decommissioning activities in 2009/2010 (AECOM 2010). Complete validation of excavation not achieved.	Metals TRH PAHs VOCs Methyl Tert-butyl Ether (MTBE)	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Soil and groundwater impact delineation uncertainty*** Further investigation is considered necessary to delineate extent & magnitude of hydrocarbon contamination in soil and groundwater associated with decommissioning activities and Former Service Station operations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
					Vapour intrusion	NA	Vapour inhalation	✗	✗	✗	✗	✗	✗	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000151 Grounds Maintenance Area	High	The Grounds Maintenance Area comprises a compound primarily of soft ground with a number of buildings. General equipment and plant are stored within the compound as well as hazardous chemicals (pesticides/herbicides) and POL. Historical small leaks of chemicals have occurred and during the sloping nature of the site towards the adjacent drain, an earthen bund has been installed to mitigate off-site impacts.	Historical small leaks of chemicals are known to have occurred on the property and considered likely to drain/run-off in the direction of a drain located adjacent to the boundary. The earthen bund in the south-west corner of the Grounds Maintenance Area (CSR WA 000151) was observed to be compromised. Anecdotal information provided by Defence suggest spillage or washdown residue of herbicides may have extended outside of the chemical storage shed which is immediately east of WA00GM-MW082. PFAS well SD-MW12 (screened 11.9 to 17.9 m bgl) reported TCE concentration of 863 µg/L in September 2017.	Metals TRH VOCs Herbicides Pesticides Chlorinated hydro-carbons	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Soil and groundwater impact delineation uncertainty*** Further investigation including the collection of additional surface soil samples within compound area and sediment samples from adjacent drain outside compound is considered necessary to assess the current status of potential risk associated with historical chemical leaks, chemical and fuel storage operations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
CSR_WA_000153 Fire Training Area – Fuel Storage Facilities	High (based on PFAS risk)	Potential for contamination associated with use as a Fire Training Area and infrastructure including: four underground gas lines connected to an above ground gas tank and two diesel ASTs installed prior to 1975: AST 025 = 750 L capacity and UST_024 = 9,000 L capacity.	A review of ERM Stage 2 DSI (2013) indicated no evidence of soil impact associated with diesel use. However, further investigation is considered necessary to assess the current status of potential risk arising from ongoing diesel storage and use.	Metals TRH PAHs	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Soil and groundwater impact uncertainty*** Further investigation is considered necessary to assess the current status (with respect to conventional contamination issues) of potential risk arising from diesel storage and use.
						Direct contact with surface water.	Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	✗	✗	✓	✗	✓	✓	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000154 Fuel storage – South of Building 13 (UST_030 and AST_031)	Low	This comprises of one AST (AST_031) and one UST (UST_030). The AST bunding does not meet applicable standards. The AST is a 320 L diesel tank and the UST is a 9,000 L diesel tank.	Stage 2 (2013) investigations identified minor detections of TRH impact within the shallow soils (although below HSL-D) however no evidence of TRH impact within groundwater monitoring wells were identified. No hydrocarbon impact reported during ongoing regional groundwater monitoring program. Site inspection and interviews confirmed that risk remains low.	TRH PAHs BTEX-N Metals	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	×	×	×	×	×	No identified data gaps, CSR considered low risk. No driver for inclusion in Stage 2 investigations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	×	×	×	×	×	×	
CSR_WA_000155 Power Station USTs	Medium	Known source of contamination: Overflow of day tank (diesel AST) (AST_016) located inside powerhouse building occurred in 2004. Approximately 2000 L of diesel leaked out of the building and infiltrating into the ground and the adjacent surface water drain. Potential contamination associated with existing fuel storage infrastructure: Two USTs located south- east of the building, below an asphalt hardstand/parking area (UST_014 and UST_015).	A review of ERM Stage 2 DSI (2013) indicated soil quality is acceptable provided a site management plan is developed to manage exposure risk and to continue a program of groundwater (GW) monitoring. There is a low risk that the leak may have caused impact beneath the building slab however indoor inhalation risk is considered low based on anecdotal evidence that the floor is in good condition. Comparison of historical shallow soil data (GHD 2004) to present day TRH criteria identified contamination above HSL - D (direct contact criterion for commercial/industrial settings).	Metals BTEX TRH PAHs	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	×	✓	×	✓	***Soil, groundwater and vapour risk uncertainty*** Further investigation is considered necessary to assess the current status of potential risk associated with fuel storage and spill including vapour exposure assessment
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	×	×	✓	×	✓	✓	
					Vapour intrusion	NA	Vapour inhalation	✓	×	×	×	×	×	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000156 Paint Shop	Medium	Contamination associated with waste sump AST_037 which overflowed in 2011. Presence of a sump containing sewage adjacent to the liquid waste sump.	Requirement for inclusion of aluminium and iron analysis in groundwater and incorporation of CSR_WA_000156-MW016 and WAO159-MW017 into regional monitoring program following observation of a sheen in MW016 during the 2016 monitoring program. Additionally, the potential for sediment to be impacted by hexavalent chromium is considered likely however has not been assessed to date.	Metals TRH VOCs Nutrients	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Soil, groundwater, sediment and surface water impact uncertainty*** Further investigation considered necessary to assess the current status of potential risk associated with Paint Shop operations including potential chromium VI impact to sediment in the Ellen Brook and to follow up on observation of a sheen in MW016 during the 2016 monitoring program
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
					Vapour intrusion	NA	Vapour inhalation	✓	✗	✗	✗	✗	✗	
CSR_WA_000157 Waste Oil Storage East of Building 134 (UST_038)	Low	Waste oil (less than 1000) UST 038. UST believed to be waste liquid (oil/water) from the mechanics pit within building A0134. Anecdotal evidence suggests the UST is pumped out as required	Review of previous reports, site inspection and interviews confirmed that risk remains low.	TRH PAHs BTEX-N Metals	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✗	✗	✗	✗	✗	✗	No identified data gaps, CSR considered low risk. No driver for inclusion in Stage 2 investigations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment)	Direct contact with surface water.	✗	✗	✗	✗	✗	✗	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000158 Waste Oil Sumps between Building A78 and A125	Low	A former containment pit (now concreted and sealed) used for the temporary disposal of waste oils, greases and liquids and capturing runoff from the holding areas.	Review of previous reports, site inspection and interviews confirmed that risk remains low.	TRH PAHs BTEX-N VOCs Metals	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✘	✘	✘	✘	✘	✘	No identified data gaps, CSR considered low risk. No driver for inclusion in Stage 2 investigations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✘	✘	✘	✘	✘	✘	
CSR_WA_000159 Waste Oil Sumps between Building A116 and Hangar 95	Low	A former containment pit (now concreted and sealed) used for the temporary disposal of waste oils, greases and liquids and capturing runoff from the holding areas.	Review of previous reports, site inspection and interviews confirmed that risk remains low.	TRH PAHs BTEX-N VOCs Metals	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✘	✘	✘	✘	✘	✘	No identified data gaps, CSR considered low risk. No driver for inclusion in Stage 2 investigations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✘	✘	✘	✘	✘	✘	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
CSR_WA_000160 Hangar 95	High	Contamination associated with potentially reported hydrocarbon impact at each end of the building and inferences also beneath the building. Contamination associated with operation of defueling and a containment pit adjacent to the south of the Hangar Building.	BTEX/VOCs detected in soil vapour adjacent to Hangar but at concentrations below HSL-D. Goresorbers installed within Hangar slab also registered VOCs impacts in soil vapour, but indicative of concentrations below HSL-D or adjusted Regional Screening Level (RSL). Groundwater only identified within one monitoring well (at down gradient south western end of Hangar) and did not contain any CoPC (ERM 2013).	Metals TRH BTEX PAHs VOCs Solvents MTBE	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Groundwater impact delineation uncertainty*** ***Vapour risk uncertainty*** Further investigation is considered necessary to assess the current status of potential risk associated with workshop operations and historical spills
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment.)	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
					Vapour intrusion	NA	Vapour inhalation	✓	✗	✗	✗	✗	✗	
PCSR_0967_001 Aircraft Shelters	Medium	Potential contamination associated with reported venting of fuel aircraft onto the margin of the airfield, as well as hydrocarbon odour in soil reported in previous investigation. Potential hydrocarbon impacted soil and groundwater to the west of the current aircraft shelters	Anecdotal information provided by a former fitter from the Mechanical Equipment Operations and Maintenance Section reported that during the time the Macchi trainer jets were in use at RAAF Pearce up until 2000 there was significant venting of fuel from the rear of the aircraft onto the margin of the airfield (to the west of the current aircraft shelters). Previous investigations (Golder 2015) reported strong hydrocarbon odours in soil from 0.3 m to 1.0 m in the vicinity of the aircraft shelters, however no confirmatory analysis was conducted.	Metals TRH BTEX, PAHs VOCs	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Soil and groundwater impact uncertainty*** Investigation of soil and groundwater is considered necessary to assess the current status of potential risk associated with historical venting of fuel from aircraft onto the margin of the airfield, particularly the potential contamination of surface soil/likelihood for vertical migration to groundwater.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential Exposure Routes	Onsite Receptors			Off-site Receptors			Data Gaps
								Property users (Defence), visitors, and contractors	Groundwater dependant remnant native vegetation and associated terrestrial threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	Abstraction bore users	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened flora and fauna species.	
PCSR_0967_002 New AVTUR Fuel Farm (DFI)	High	Facility was commissioned in 2014 and comprises 2 x 2.4 ML ASTs, 3 x 158 kL QC ASTs. Fuel stored is all F34 aviation turbine fuel with additives for high altitude flying and anti-static. Monthly fuel use approximately 1.2 ML. Puraceptor captures all run-off from the bunded areas as well as the hardstand tanker movement area which includes the tanker parking area and the offload/upload bay. The puraceptor is checked regularly and pumped out on an as-required basis. A 5000 L UST 'dump tank' for waste fuel and lab waste/sinks is present.	A small spill (anecdotally approximately 20 L) of AVTUR occurred onto blue metal (subsurface unlined) at the western edge of the refuelling area in January 2018, with no subsurface excavation undertaken. Small fuel spills occur within the bunded area during maintenance. Five monitoring wells were installed during construction. No LNAPL detected during weekly visual dipping, however no groundwater sampling known to have been undertaken to date. The integrity of the dump tank has not been established as there is no inspection hatch.	Metals TRH BTEX PAHs VOCs	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Soil and groundwater impact uncertainty*** Investigation of soil and groundwater is considered necessary to assess the current status of potential risk associated with the historical fuel leak and fuel storage operations, particularly the potential contamination of surface soil/likelihood for vertical migration to groundwater.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	
PCSR_0967_003 Former 25 m Small Arms Range	Medium	Range reportedly operated from 1950s until 2006 for small arms training. Significant volumes of spent bullets observed on sandy bullet catcher. A 'Class 6 toxic PCB' store-room observed with some staining on concrete pad.	No previous investigation undertaken to date.	Metals (principally lead) Explosive residues PCBs TRH VOCs	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater Incidental ingestion of impacted soil and/or groundwater.	✓	✓	✗	✓	✗	✓	***Soil, groundwater and sediment/surface water impact uncertainty*** Investigation is considered necessary to assess the current status of potential risk associated with historical small arms range operations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✓	✗	✓	✓	

Table 23 Summary of potentially complete source-pathway-receptor linkages (3TU)

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential exposure routes	Onsite receptors		Off-site receptors			Data Gaps
								Property users, construction workers and trespassers	Future property users if property is divested	Users of down gradient bores (non potable/irrigation use) including higher order species (non potable/livestock use) Registered Aboriginal sites	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened fauna and flora species	
CSR_WA_000019 Septic Tanks – Sewage Disposal	Medium	Septic Tanks – Sewage Disposal. One septic tank observed to south of building 58.	Potential contamination of soil and/or groundwater associated with former septic tank use. Current contamination status of soil and/or groundwater is unknown and requires assessment.	Metals Nutrients Pathogens Asbestos PFAS	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake	Direct contact with impacted soil and/or groundwater	✓	✓	✓	✓	✗	***Soil and groundwater impact uncertainty*** Soil and groundwater investigation considered necessary to assess the current status of potential risk/presence of contamination associated with former septic tank use.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment)	Direct contact with surface water	✗	✗	✗	✓	✓	
					Wind dispersal	NA	Inhalation of dust	✓	✓	✗	✗	✗	
CSR_WA_000080 Incinerator (North of 3TU Workshop)	Medium	Incinerator (North of 3TU Workshop) Incinerator demolished in 2001.	Potential contamination of soil and/or groundwater associated with former incinerator operations. Current contamination status of soil and/or groundwater is unknown and requires assessment.	Metals TRH PAHs Dioxins Asbestos PFAS	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater	✓	✓	✓	✓	✗	***Soil and groundwater impact uncertainty*** Soil and groundwater investigation considered necessary to assess the current status of potential risk/presence of contamination associated with former incinerator operations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water	✗	✗	✗	✓	✓	
					Wind dispersal	NA	Inhalation of dust	✓	✓	✗	✗	✗	
CSR_WA_000081 South of 3TU – Buried Waste Metals	Medium	South of 3TU: Buried Waste Metals. Potential contamination of soil and/or groundwater.	Potential contamination associated with buried waste including metals and concrete footings associated with former aerial farms. Current contamination status of soil and/or groundwater is unknown and requires assessment.	Metals TRH VOCs PAHs PFAS	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake	Direct contact with impacted soil and/or groundwater	✓	✓	✓	✓	✗	***Groundwater impact uncertainty*** Sampling and assessment of existing monitoring network considered necessary to determine current status of groundwater quality and assess the current status of potential risk associated with former landfilling.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water	✗	✗	✗	✓	✓	
					Wind dispersal	NA	Inhalation of dust	✓	✓	✗	✗	✗	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential exposure routes	Onsite receptors		Off-site receptors			Data Gaps
								Property users, construction workers and trespassers	Future property users if property is divested	Users of down gradient bores (non potable/irrigation use) including higher order species (non potable/livestock use) Registered Aboriginal sites	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened fauna and flora species	
CSR_WA_000101 Former 3TU Workshop – Buried Waste	Low	Located in the south of the previously built-up area at 3TU.	Review of previous reports, site inspection and interviews confirmed that risk remains low and no further investigation required.	Metals TRH PAHs BTEX VOCs PFAS Asbestos	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater.	✗	✗	✗	✗	✗	No identified data gaps, CSR considered low risk. No driver for inclusion in Stage 2 investigations.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✗	✗	✗	
CSR_WA_000103 South of Former Building 58 – 2 x Diesel A/USTs	Medium	South of Former Building 58 – 2 x Diesel A/USTs. Former 4,500 L diesel UST (UST 001) decommissioning, removed and validated in 2007. Former diesel AST, limited information.	Assess groundwater status and confirm soil risk status remains low. Investigate former AST contents and validation.	Metals TRH PAHs Asbestos PFAS	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation). Plant uptake.	Direct contact with impacted soil and/or groundwater.	✓	✓	✓	✓	✗	***Soil and groundwater impact uncertainty*** Soil and groundwater investigation considered necessary to assess the current status of potential risk/presence of contamination associated with former fuel storage
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✗	✓	✓	
					Wind dispersal	NA	Inhalation of dust	✓	✓	✗	✗	✗	
PCSR_0965_001 Fire Extinguisher Training Area	Medium	Potential former use as a fire extinguisher/AFFF foam discharge training area. Located to the north-west of the asphalt stockpile area (PCSR_0965_002)	Potential contamination of soil and/or groundwater associated with potential former use as a fire extinguisher/AFFF foam discharge training area. Current contamination status of soil and/or groundwater is unknown and requires assessment.	PFAS	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation). Plant uptake.	Direct contact with impacted soil and/or groundwater.	✓	✓	✓	✓	✗	***Soil and groundwater impact uncertainty*** Soil and groundwater investigation considered necessary to assess the current status of potential risk/presence of PFAS contamination associated with potential former use as a fire extinguisher/AFFF discharge area.
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✗	✓	✓	

CSR/PCSR	CRAT risk pre-DSI	Potential source	Potential and Known Impacts	CoPC	Potential primary pathway	Potential secondary pathway	Potential exposure routes	Onsite receptors		Off-site receptors			Data Gaps
								Property users, construction workers and trespassers	Future property users if property is divested	Users of down gradient bores (non potable/irrigation use) including higher order species (non potable/livestock use) Registered Aboriginal sites	Groundwater dependant remnant native vegetation and associated threatened fauna species	Surface water receiving bodies and associated threatened fauna and flora species	
PCSR_0965_002 Asphalt Stockpile Area	Medium	Potential for contamination associated with leachable contaminants within the asphalt and the source of the stockpiled asphalt (Pearce Base runway excess) and potential contaminants of concern associated with runway use.	No previous investigations undertaken. Potential for PFAS in asphalt from use of AFFF on runways. Potential for PFAS to leach out or wash off asphalt into adjacent soils. Should PFAS be identified in soils, further groundwater investigations may be required.	Metals TRH PAHs Asbestos PFAS	Leaching and migration of contaminants laterally and/or vertically through the soil profile into the underlying perched groundwater aquifer and subsequent drainage to superficial aquifer.	Migration within groundwater Abstracted groundwater (drinking water/irrigation) Plant uptake.	Direct contact with impacted soil and/or groundwater.	✓	✓	✓	✓	✗	***Soil, sediment/surface water impact uncertainty*** Investigation considered necessary to determine the current status of potential risk associated with leachable contaminants within the asphalt and the source of the stockpiled asphalt (Pearce Base runway excess).
						Groundwater discharge to receiving surface water body (the Ellen Brook catchment).	Direct contact with surface water.	✗	✗	✗	✓	✓	

5.3 Summary of GEMS EFM CSR entries

At the commencement of the project, records for 32 CSR locations situated within RAAF Base Pearce and 3TU were listed in the GEMS CSR database. These included:

- 27 existing CSRs at RAAF Base Pearce
- Five existing CSRs at 3TU.

As mentioned in Section 2.3, following review of previous reports, initial site inspections and development of the preliminary CSMs (Table 18 and Table 19), 11 CSR locations were removed from the Stage 2 DSI scope of work and five PCSRs were identified for inclusion in the scope of works. Details are summarised in the following sections.

5.3.1 CSR locations not included in the Stage 2 DSI

- 10 of the 27 original CSR locations at RAAF Base Pearce and one of the five original CSR locations at 3TU were removed from the scope of GHD site investigations based on the rationale provided in Table 22 and Table 23 and the associated low risk. It is recommended that these CSRs (listed below) can be archived:
  - **CSR_WA_000112** Radioactive Aircraft Former Jet Wash Down Area
  - **CSR_WA_000111** Aircraft Wash Down (‘Bird Bath)
  - **CSR_WA_000105** Former Ammunition Bunker - Toxic Waste
  - **CSR_WA_000108** Former Fire Training Area
  - **CSR_WA_000086** Fuel Storage – 2 x ASTs 026 and 027
  - **CSR_WA_000154** Fuel Storage South of Building 13 (UST 030 and AST 031)
  - **CSR_WA_000085** Waste Oil Storage East of Building 134 (AST_039)
  - **CSR_WA_000157** Waste Oil Storage East of Building 134 (UST_038)
  - **CSR_WA_000158** Waste Oil Sumps between Building A78 and A125
  - **CSR_WA_000159** Waste Oil Sumps between Building A116 and Hangar 95
  - **CSR_WA_000101** Former 3TU Workshop – Buried Waste

5.3.2 PCSRs included in the Stage 2 DSI

- Prior to implementation of Mobilisation 1 of the Stage 2 DSI, three PCSRs (two located at RAAF Base Pearce and one located at 3TU) were identified as requiring investigation and were included in the Stage 2 scope of work. These were:
  - **PCSR_0967_002** New AVTUR Fuel Farm (RAAF Base Pearce)
  - **PCSR_0967_003** Former 25 m Small Arms Range (RAAF Base Pearce)
  - **PCSR_0965_002** Asphalt Stockpiles (3TU)
- Following completion of Mobilisation 1, two additional PCSRs requiring investigation were identified based on information provided by DCARM and the Defence PFASIMB investigations (GHD 2018b). The following additional PCSRs were investigated during Mobilisation 2 of the Stage 2 DSI:
  - **PCSR_0967_001** Aircraft Shelters (RAAF Base Pearce)
  - **PCSR_0965_001** Former Fire Extinguisher Training Area (3TU)

The rationale for inclusion of the abovementioned PCSRs in the Stage 2 DSI scope of work are based on the details provided in Table 22 and Table 23.

5.4 Summary of data gaps

In order to meet the purpose and objectives of the project (as listed in Section 1.2 and 1.3), data gaps have been identified in the preliminary CSMs in Table 18 and Table 19, based on the collective review of available data, site walkover observations and anecdotal advice provided by persons knowledgeable of former property activities. They can be summarised as follows:

- ***Soil impact uncertainty***. This data gap applies to a range of CoPC (including TRH, BTEX-N, PAHs, phenols, VOCs/SVOCs, metals, Organochlorine/organophosphate (OC/OP) pesticides and PCBs) at a number of CSRs (listed in Table 20) where previous investigations have not fully assessed the nature and extent of soil contamination to adequately enable an understanding of potential risk to current and future land-uses.
- ***Groundwater impact uncertainty***. This data gap applies to a range of CoPCs (including TRH, BTEX-N, PAHs, chlorinated hydrocarbons, VOCs/SVOCs, metals and OC/OP pesticides) at a number of CSRs (listed in Table 22 and Table 23) where previous investigations have not fully assessed the nature and extent of groundwater contamination beneath and down gradient of potential historical source areas (including groundwater flow characterisation) to adequately enable an understanding of potential risk to current and future land-uses.
- ***Plume stability uncertainty***. This data gap applies to a limited number of CSRs (listed in Table 22 and Table 23) where historical data sets exist but have not been adequately interrogated to inform a quantitative assessment of groundwater trends under seasonal variation and therefore an assessment of plume stability.
- ***Surface water/sediment impact characterisation uncertainty****.* This data gap applies to most CSRs as in many cases there has been no holistic assessment of potential risk of contamination and associated exposure risks in surface water and sediment within the surface water drainage channel networks located on and immediately surrounding the RAAF Base Pearce and 3TU properties. An assessment of the potential contamination status of the surface water drainage channel network (within and immediately surrounding the RAAF Base Pearce and 3TU property boundaries) is considered necessary given the range of CoPCs and existing contamination on the properties and the potential to impact surface water which subsequently discharges to the nearby ecologically sensitive surface water receiving bodies (Ki-It Monger Brook and the Ellen Brook – Upper Swan catchment).
- ***Vapour risk uncertainty****.* This data gap applies to a limited number of CSRs (listed in Table 22 and Table 23) where further investigations required to assess the potential for vapour risk to property users.

5.5 Stage 2 DSI data quality objectives

The amount, nature and quality of the data are determined by establishing Data Quality Objectives (DQOs). The major advantage of the DQO approach is that the investigation planning is carried out in a structured way with the questions of environmental significance identified and posed at an early stage and timely, necessary and purpose driven data are collected to resolve the identified uncertainties.

The DQOs provide the framework for the investigation design and are intended to ensure that representative data are collected to address residual data uncertainties in the CSM.

In accordance with AS 4482.1 *'Guide to the Investigation and Sampling of Sites with Potentially Contaminated Soil Part 1: Non-volatile and semi-volatile compounds'* (Standards Australia 2005) and the National Environmental Protection Measure and its amendment (NEPM, 1999 and 2013) for the assessment of property contamination, the DQOs for the targeted Stage 2 DSI are qualitative and quantitative criteria that:

- Clarify study objectives
- Define appropriate types of data to collect
- Specify the tolerable levels of potential decision-making errors

The DQO process, as defined in AS 4482.1 (Standards Australia 2005) and NEPM (2013), consists of seven distinct steps, as shown below:

- State the problem
- Identify the decision
- Identify inputs to the decision
- Define the study boundaries
- Develop a decision rule
- Specify limits on decision errors
- Optimise the design for obtaining data

The DQO process underpinning the SAQP for the Stage 2 DSI is documented in Table 24 and the scope of works is detailed in Section 6.

Table 24 Stage 2 data quality objectives

Step	Data Gap 1: Soil impact uncertainty	Data Gap 2: Groundwater impact uncertainty.	Data Gap 3: Plume stability uncertainty	Data Gap 4: Surface water/sediment impact characterisation uncertainty.	Data Gap 5: Vapour risk uncertainty
Step 1: Problem statement	There are a number of CSRs where previous investigations have not fully assessed the nature and extent of soil contamination to adequately enable an understanding of potential risk to current and future land-uses. Additional soil investigation was required to adequately inform the assessment of potential contamination risk to identified current and future human health and ecological receptors.	There are a number of CSRs where previous investigations have not fully assessed the nature and extent of groundwater contamination beneath and down gradient of potential historical source areas (including groundwater flow characterisation to adequately enable an understanding of potential risk to current and future land-uses.	There are a limited number of CSRs where historical data sets exist but have not been adequately interrogated to inform a quantitative assessment of groundwater trends under seasonal variation and therefore an assessment of plume stability.	No previous holistic assessment of potential risk of contamination in surface water and sediment within the surface water drainage channel networks located on and immediately surrounding the RAAF Base Pearce and 3TU properties. An assessment of the potential contamination status of the surface water drainage channel network (within and immediately surrounding the RAAF Base Pearce and 3TU property boundaries) is considered necessary given the range of CoPCs and existing contamination on the properties and the potential to impact surface water which subsequently discharges to the nearby ecologically sensitive surface water receiving bodies (Ki-It Monger Brook and the Ellen Brook – Upper Swan catchment).	Direct vapour assessment may be required to verify the absence of on-site vapour risks to site users at a limited number of CSRs where previous investigations indicate there may be a risk.
Step 2: Decision Identification	*Have soils been sufficiently characterised to inform (i) the assessment of risk to identified human health and ecological receptors for both current and future land-use and (ii) is further assessment and remediation and/or management required to render the property suitable for its intended ongoing and future use?*	*Has groundwater been sufficiently characterised to inform (i) the assessment of risk to identified human health and ecological receptors and (ii) is further assessment and remediation and/or management required to render the property suitable for its intended ongoing use?*	*Are known groundwater plumes adequately characterised to allow decision making as to whether management actions/remediation/Monitored Natural Attenuation (MNA) is required to mitigate risk?*	*Has surface water receiving environment (including sediment) been sufficiently characterised to inform (i) the assessment of risk to identified human health and ecological receptors and (ii) is further assessment and remediation and/or management required to render the property suitable for its intended ongoing use?*	*Have risks associated with soil vapours been sufficiently characterised to inform (i) the assessment of risk to identified human health and ecological receptors and* *(ii) Is further assessment and remediation and/or management required to render the site suitable for its intended ongoing use (commercial/industrial)?*
Step 3: Decision Inputs	Review of historical and current site activities has been undertaken to inform potential contamination source areas and CoPC as outlined in Section 5. Media to be sampled is soil, with samples scheduled for analysis based on field observations including PID readings, and results used to assess the requirement for sampling of additional media (e.g. soil vapour assessment). **The following data inputs are required**: • Understanding of the current and former land use practices at the properties via review of previous reports and available desktop information (Section 2 of this report) • Understanding of the geology, hydrogeology and topography of the properties via review of previous reports and available desktop information (Section 3 of this report) • Understanding of the sources (including CoPC), pathways and receptors on- and off-site (Sections 4 and 5 of this report) • Identification of appropriate Tier 1 assessment criteria (Section 8 of this report) **Confirm that appropriate analytical methods exist to provide the necessary data** • National Association of Testing Authorities (NATA) accreditation is available for all identified CoPC from the nominated laboratories.	Review of historical and current site activities has been undertaken to inform potential contamination source areas and CoPC as outlined in Section 5. Media to be sampled is groundwater, with samples scheduled for analysis based on review of existing data set, and results used to assess the requirement for sampling of additional media (e.g. surface water). **The following data inputs are required**: • Understanding of the current and former land use practices at the properties via review of previous reports and available desktop information (Section 2 of this report) • Understanding of the geology, hydrogeology and topography of the properties via review of previous reports and available desktop information (Section 3 of this report) • Understanding of the sources (including CoPC), pathways and receptors on- and off-site (Sections 4 and 5 of this report) • Identification of appropriate Tier 1 assessment criteria (Section 8 of this report) **Confirm that appropriate analytical methods exist to provide the necessary data** • NATA accreditation is available for all identified CoPC from the nominated laboratories.	Review of historical groundwater monitoring results and trends has been undertaken to inform investigations. A SAQP was developed to target areas of uncertainty. Interpretation of results would benefit from trend analysis (including assessment of seasonal variation) against historical data set. This can be achieved following compilation of Esdat database under parallel data management project for DCARM. Complete data set anticipated late 2018, and results will be discussed in updated version of this Stage 2 DSI report.	Review of historical and current site activities has been undertaken to inform potential contamination source areas and CoPC as outlined in Section 5. Media to be sampled is sediment and surface water, with samples scheduled for analysis based on review of existing data set, and results used to assess the requirement for additional delineation sampling. **The following data inputs are required**: • Understanding of the current and former land use practices at the properties via review of previous reports and available desktop information (Section 2 of this report) • Understanding of the geology, hydrogeology and topography of the properties via review of previous reports and available desktop information (Section 3 of this report) • Understanding of the sources (including CoPC), pathways and receptors on- and off-site (Sections 4 and 5 of this report) • Identification of appropriate Tier 1 assessment criteria (Section 8 of this report) **Confirm that appropriate analytical methods exist to provide the necessary data** • NATA accreditation is available for all identified CoPC from the nominated laboratories.	Review of historical and current site activities has been undertaken to inform potential vapour risk areas and CoPC as outlined in Section 5.

Step	Data Gap 1: Soil impact uncertainty	Data Gap 2: Groundwater impact uncertainty.	Data Gap 3: Plume stability uncertainty	Data Gap 4: Surface water/sediment impact characterisation uncertainty.	Data Gap 5: Vapour risk uncertainty
Step 4: Study Boundaries	**Spatial**: The study boundary comprises the following CSRs/PCSRs at both RAAF Base Pearce and 3TU properties as shown in Figure 3A and 3B: **CSR_WA_000083** (Dog compound - Buried Waste). **CSR_WA_000104** (Former Hazardous Waste Store) **CSR_WA_000117** (Former Service Station) **CSR_WA_000109** (Former USTs 240-245) **CSR_WA_000153** (Fire Training Area) **CSR_WA_000155** (Power Station USTs) **CSR_WA_000156** (Paint Shop) **CSR_WA_000024** (Fuel Storage NE of Building 72) **CSR_WA_000087** (Fuel Storage ILS 18 Glide Path) **CSR_WA_000088** (Fuel Storage ILS 18) **CSR_WA_000151** (Grounds Maintenance Area) **PCSR_0967_002** (New AVTUR Fuel Farm) **PCSR_0967_003** (Former Small Arms Range) **CSR_WA_000080** (Incinerator North of 3TU workshop) **CSR_WA_000019** (Septic Tanks) **CSR_WA_000103** (South of Former Building 58 – 2 x Diesel A/USTs) **PCSR_0965_002** (Asphalt Stockpiles) **Temporal:** Sampling undertaken in March - May 2018 (Mobilisation 1) (post summer conditions). Results were used to inform need for additional sampling undertaken in April 2019 (Mobilisation 2) to address residual data gaps and assessment of additional PCSRs.	**Spatial**: The study boundary comprises the following CSRs/PCSRs at both RAAF Base Pearce and 3TU properties as shown in Figure 3A and 3B **CSR_WA_000110** (Former Fuel Farm) **CSR_WA_000117** (Former Service Station) **CSR_WA_000084** (Sounness Rd landfill) **CSR_WA_000109** (Former USTs 240-245) **CSR_WA_000106** (Sewage Treatment Plant) **CSR_WA_000153** (Fire Training Area) **CSR_WA_000155** (Power Station USTs) **CSR_WA_000107** (Former Fire Training Area) **CSR_WA_000156** (Paint Shop) **CSR_WA_000024** (Fuel Storage NE of Building 72) **CSR_WA_000151** (Grounds Maintenance Area) **CSR_WA_000160** (Hangar 95) **PCSR_0967_001** (Aircraft Shelters) **PCSR_0967_002** (New AVTUR Fuel Farm) **PCSR_0967_003** (Former Small Arms Range) **CSR_WA_000081** (South of 3TU – Buried Waste Metals) **CSR_WA_000080** (Incinerator North of 3TU workshop) **CSR_WA_000019** (Septic Tanks) **CSR_WA_000103** (South of Former Building 58 – 2 x Diesel A/USTs) **PCSR_0965_001** (Former Fire Extinguisher Training Area) **Temporal:** GME undertaken in April/May 2018 (Mobilisation 1) (post summer conditions). Results were used to inform need for additional sampling subsequently undertaken in April 2019 (Mobilisation 2) to address residual data gaps and assessment of additional PCSRs.	**Spatial:** The study boundary comprises the following CSRs/PCSRs at both RAAF Base Pearce and 3TU properties as shown in Figure 3 and 3B: **CSR_WA_000110** (Former Fuel Farm) **CSR_WA_000117** (Former Service Station) **Temporal:** GME undertaken in April/May 2018 (Mobilisation 1) (post summer conditions). Results were used to inform need for additional sampling subsequently undertaken in April 2019 (Mobilisation 2) to address residual data gaps regarding plume delineation and stability assessment.	**Spatial**: The study boundary comprises the sampling locations at the Ellen Brook, Ki-It Monger Brook and tributaries including on-site drainage channels at both RAAF Base Pearce and 3TU properties as shown in Figure 6A and 6B. **Temporal:** Sampling undertaken in April/May 2018 (Mobilisation 1) (post summer conditions). Additional sampling was undertaken in September 2018 (supplementary sampling) to capture end of winter (flow) conditions. Results were used to inform need for additional sampling undertaken in April 2019 (Mobilisation 2) to address residual data gaps.	**Spatial**: The study boundary comprises the following CSRs/PCSRs at both RAAF Base Pearce and 3TU properties as shown in Figure 3A and 3B: **CSR_WA_000155** (Power Station USTs) **CSR_WA_000024** (Fuel Storage NE of Building 72) **CSR_WA_000160** (Hangar 95) **Temporal:** No direct vapour sampling undertaken to date as part of this Stage 2 DSI. Results of soil and groundwater assessment undertaken in 2018 (Mobilisation 1) were used to inform the decision not to include soil vapour sampling in the scope of work for the subsequent Mobilisation 2 undertaken in 2019.
Step 5: Decision Rule	The results from this investigation will be compared to relevant assessment criteria (where available) as defined in NEPC, 1999, *National Environment Protection (Assessment of Site Contamination) Measure (as amended 2013)*, *Assessment and Management of Contaminated Sites* (DER 2014), and Guidelines for *the Assessment, Remediation and Management of Asbestos-Contaminated Sites in Western Australia* (DoH 2009). Appropriate criteria will be selected based on current and proposed land use and site specific factors including: • Sample depth • Soil Type • pH • Background sample (to be collected from non-impacted area. Location to be confirmed in the field) • % clay content • Cation Exchange Capacity (CEC) Where exceedances of adopted assessment criteria are reported further interrogation of data will be undertaken to the extent relevant to the scope of the investigation. If the results are above the adopted assessment criteria, further assessment or remediation works may be required. A field quality control program will include the collection of trip spikes, trip blanks rinsate blanks, field duplicates and field triplicates. Acceptable limits for CoPC detected in trip spikes are recoveries between 70 to 130 % (depending on analyte). Acceptable limits for CoPC detected in rinsate blanks and trip blanks are less than LOR. Acceptable limits for field duplicates and triplicates are Relative Percentage Difference (RPD) results less than 30 %. Laboratory method blanks, matrix spike additions, surrogate samples and laboratory control samples will be determined as acceptable/unacceptable by the laboratory.				

Step	Data Gap 1: Soil impact uncertainty	Data Gap 2: Groundwater impact uncertainty.	Data Gap 3: Plume stability uncertainty	Data Gap 4: Surface water/sediment impact characterisation uncertainty.	Data Gap 5: Vapour risk uncertainty
Step 6: Decision Error Limitation	Data is considered valid if an average 95 % compliance of the following Data Quality Indicators (DQI) is achieved: • Completeness: Completeness is achieved if samples have been taken from all the required sampling locations and analysed for the CoPC. Preparation of sampling documentation also forms part of the data completeness. • Comparability: Methodologies for sampling and sample analysis will be consistent throughout the assessment to ensure that data can be reliably compared. • Representativeness: The soil and soil vapour assessment is considered to be representative of site conditions if all samples have been collected and analysed in accordance with this SAQP. • Precision: RPD results for field and laboratory duplicates and triplicates are calculated and expected to be generally less than 30 %. • Accuracy: Accuracy is achieved if results for field and laboratory blanks, matrix spike, surrogate and Laboratory Control Samples (LCS) are of acceptable quality. Blanks are generally expected to have results below the laboratory's LOR and laboratory spike and surrogate recoveries are expected to be between 70 to 130 % (depending on analyte).				
Step 7: Design Optimisation	Design optimisation will be ensured by adopting the following: • Proposed investigation locations have been optimised to target multiple data gaps where possible. • Sampling and analytical schedules based on review of historical data findings and selection of targeted bores for ongoing sampling to reduce costs. • The design of the intrusive investigation has been made based on the previous investigations, desk based review, site inspection findings, and anecdotal information obtained from Defence personnel. • As additional information is gathered during the course of this investigation, it may be beneficial for the proposed investigation to be altered from the initial design. Changes to the proposed investigation, if considered necessary, will be made in consultation with the Defence Project Manager. Other factors that will optimise the design for obtaining data will include: the use of NATA accredited laboratories, experienced field scientist(s), the collection of more samples than is required for initial analysis, and the use of a Photoionization Detector (PID) (and XRF at the Former Small Arms Range) to screen samples in the field.				

6. Scope of work – Stage 2 DSI

6.1 Introduction

Sampling locations for the Stage 2 DSI were selected to address the identified data gaps based on the outcomes of the review of previous reports, site walkover, interviews, updated desktop assessments and additional anecdotal information.

In addition to the existing CSRs at RAAF Base Pearce and 3TU, five PCSRs were identified that had not been previously assessed (Aircraft shelters, AVTUR fuel farm, former small arms range, former fire extinguisher training area, and asphalt stockpile area). With a high degree of confidence, it is considered that there are no additional unidentified CSRs present across the balance of both property areas. The qualitative assessment of the balance of the properties is based on; previous investigations; the findings of the Stage 1 PSI, the site walkover and interviews undertaken as part of this investigation as well as anecdotal information provided by Defence.

6.2 Sample locations

The sampling rationale for each CSR/PCSR area investigated as part of the Stage 2 DSI undertaken across two mobilisations (Mobilisation 1 undertaken in March-May 2018 and Mobilisation 2 undertaken in April 2019) at RAAF Base Pearce and 3TU is outlined in Table 25 and Table 26 respectively. Further details are provided in Section 10.

Table 25 RAAF Base Pearce sample location details and rationale

CSR/PCSR	Stage 2 DSI Mobilisation	Sample Location ID[5]	Rationale
CSR_WA_000024 Fuel Storage (NE Building 72, USTs and ASTs) (Figure 14A)	Mobilisation 1 – 2018	0967_MW070 0967_MW141	Assess the potential for groundwater contamination associated with storage and reported leakage of diesel fuel USTs. In addition to this CSR warranting contamination investigation, due to identified data gaps associated with soil, groundwater and vapour impact uncertainty following a reported leak from a former UST, GHD also completed an inspection and validation sampling following the removal of four diesel USTs by Defence contractor, Duratech Australia in March 2018. Preliminary results have been reported in a separate letter report dated 29 March 2018 (GHD 2018d). Although soil analytical results reported TRH, BTEX-N and PAHs below LOR from samples collected from the base of the excavation, PID readings indicated the presence of volatile compounds up to 15 ppm, and visual observations indicated the presence of staining/residual hydrocarbon impacts in tank pit soils at approximately 3.2 m depth. Due to the proximity of the tank pit to existing buildings, following a workshop session with Defence and Duratech, further excavation was deemed impractical/unsafe without significant structural assessment and management. An agreement was reached to assess the residual risk via groundwater and (if required) vapour assessment.
	Mobilisation 2 – 2019	0967_MW068 0967_MW070 0967_MW141 0967_MW252 P/S 0967_MW253 P/S 0967_MW254 P/S 0967_MW255 P/S	Installation of additional wells and subsequent sampling of existing and newly installed wells (targeting perched groundwater and the upper portion of the regional superficial aquifer) was conducted during Mobilisation 2 to establish the nature and extent of potential groundwater impacts associated with the former UST pit, and risks posed to receptors (such as via vapour intrusion to adjacent buildings) from the residual soil impacts.
CSR_WA_000083 Dog Compound - Buried Waste (Figure 15A)	Mobilisation 1 – 2018	0967_BH301 – 0967_BH313 0967_MW145 0967_MW150	Assess current status of potential soil and groundwater contamination associated with historical disposal of waste material including asbestos, sand, bitumen, road base and concrete.
	Mobilisation 2 – 2019	0967_BH377 - 0967_BH380 0967_MW149	Systematic dumping was originally understood to be restricted to the northern extent of the CSR area, however anecdotal information obtained following completion of Mobilisation 1 suggested the waste burial area extends further south, beyond the existing CSR boundary. This area was therefore investigated as part of Mobilisation 2 to assess current status of potential soil and groundwater contamination associated with historical disposal of waste.
		0967_SW107 0967_SD107	Assess potential for impacts to adjacent drainage channel/s.
CSR_WA_000084 Sounness Road Landfill (Figure 16A)	Mobilisation 1 – 2018	0967_MW201 – 0967_MW204 0967_MW208 0967_MW210 0967_MW216 0967_MW217	Assess current status of potential groundwater contamination associated with historical landfill operations. No groundwater monitoring reports have been made available post-2005, therefore requirement to undertake monitoring of existing serviceable GW network to assess the current status of potential risk arising from historical landfill operations.
		0967_SD110 0967_SD111	Assess potential for impacts to adjacent drainage channel/s.
CSR_WA_000087 Fuel Storage ILS 18 Glide Path (Figure 17A)	Mobilisation 1 – 2018	0967_BH330 – 0967_BH332	Assess the potential for soil contamination associated with storage and reported leakage of diesel fuel AST (032).
		0967_SD127	Assess potential for impacts to adjacent drainage channel/s.
CSR_WA_000088 Fuel Storage ILS 18 (Figure 18A)	Mobilisation 1 – 2018	0967_BH333 – 0967_BH335	Assess the potential for soil contamination of associated with storage and reported leakage of diesel fuel AST (033).
		0967_SD128 (Figure 13A)	Assess potential for impacts to adjacent drainage channel/s.
CSR_WA_000104 Former Hazardous Waste Store (Figure 19A)	Mobilisation 1 – 2018	0967_BH314 – 0967_BH317 0967_MW033 0967_MW231	Assess potential for soil and groundwater contamination associated with historical storage and handling (incidental spills/leaks) of explosive ordnance and hazardous waste (between 1960s and 1990s). Review of historical aerials indicates the CSR area should extend further north.
		0967_SW137 0967_SD137 See Figure 13A	Assess potential for impacts to adjacent drainage channel/s.
CSR_WA_000106 Sewage Treatment Plant Discharge Effluent (Figure 20A)	Mobilisation 1 – 2018	0967_MW142 0967_MW166 0967_MW218 0967_MW219 0967_MW221 0967_MW222 0967_MW241	Assess current status of potential groundwater contamination associated with the Sewage Treatment Plant ponds and infrastructure and reported overflow of effluent.
		0967_SW112 0967_SW119 0967_SD112 - 0967_SD120	Assess potential for impacts to adjacent drainage channel/s.
	Mobilisation 2 – 2019	0967_MW142 0967_MW166 0967_MW219 0967_MW221 - 0967_MW225	The findings of the groundwater assessment undertaken during Mobilisation 1 detected concentrations of E-Coli in groundwater directly adjacent and down gradient of Pond 4 at greater than 1000 cfu/100 mL exceeding DoH criteria. Further groundwater assessment including installation of additional wells and sampling of the existing and newly installed well network was undertaken during Mobilisation 2 to further characterise the impact to groundwater from the Sewage Treatment Plant (STP).

5 BH = Soil bore; MW = Monitoring well; SD = Sediment; SW = Surface water

CSR/PCSR	Stage 2 DSI Mobilisation	Sample Location ID[5]	Rationale
CSR_WA_000107 Former Fire Training Area (1960s) (Figure 21A)	Mobilisation 1 – 2018	0967_BH326 - 0967_BH329 0967_MW103 0967_MW117 0967_MW238	Assess the potential for soil and groundwater contamination associated with former use as a fire training area and potential overflow of a sewage pit located at northern extent of the former fire training area (outside existing CSR boundary).
		0967_SD122 – 0967_SD124 0967_SD139	Assess potential for impacts to adjacent drainage channel/s.
	Mobilisation 2 – 2019	0967_MW103 0967_MW117 0967_MW238	The findings of the groundwater assessment undertaken during Mobilisation 1 detected concentrations of chromium, copper, nickel and zinc in groundwater exceeding background concentrations, freshwater ILs and drinking water Investigation Levels (IL) (nickel) (March 2018). Given the increased risk of metals impacted groundwater to migrate to the Ki-It Monger Brook surface water receiving body, further groundwater assessment was undertaken during Mobilisation 2 to further characterise the heavy metals impacts within groundwater.
CSR_WA_000109 Former USTs 240 – 245 near Building 329 (Figure 22A)	Mobilisation 1 – 2018	0967_MW022 0967_MW023 0967_MW236 0967_MW237	Assess current status of potential groundwater contamination associated with Former USTs (240 – 245) known to have leaked historically. USTs have since been decommissioned/removed (2018) and replaced with ASTs. It is understood contamination remains in situ beneath former bowsers. Civil upgrade works were completed in 2018 and included installation of a sub-surface puraceptor.
CSR_WA_000110 Former Fuel Farm (Figure 23A)	Mobilisation 1 – 2018	0967_MW144 0967_MW151 P/S 0967_MW153 - 0967_MW157 0967_MW227 P/S - 0967_MW230 P/S	Assess current status of potential groundwater contamination associated with bulk fuel storage and historical leakage/spills of former UST infrastructure. Fuel farm decommissioned by John Holland in 2015 (AECOM 2015).
		0967_SD101 – 0967_SD104	Assess potential for impacts to adjacent drainage channel/s.
	Mobilisation 2 – 2019	0967_MW144 0967_MW151 P/S 0967_MW153 - 0967_MW157 0967_MW227 P/S - 0967_MW230 P/S	Further groundwater monitoring undertaken to enable "lines of evidence"-based assessment and trend analysis in determining plume stability and to support monitored natural attenuation of the TRH plume.
CSR_WA_000117 Former Service Station (Figure 24A)	Mobilisation 1 – 2018	0967_BH318 – 0967_BH323 0967_MW232 P/S 0967_MW233 S 0967_MW234 S 0967_MW235 S 0967_MW242	Assess current status of potential soil and groundwater contamination associated with operation of former (decommissioned/removed 2009) underground fuel storage tanks and associated infrastructure: UST 034 (16,800 L, petrol), UST 035 (11,700 L, diesel) and UST 036 (less than 1000 L, waste oil).
		0967_SD108 0967_SD109	Assess potential for impacts to adjacent drainage channel/s.
	Mobilisation 2 – 2019	0967_MW146 0967_MW226 0967_MW240 0967_MW242 0967_MW232 P/S 0967_MW233 P/S 0967_MW234 P/S 0967_MW235 P/S	Following completion of Mobilisation 1, additional groundwater assessment including installation of groundwater wells further south and west of the CSR area was considered warranted to delineate the extent of the dissolved phase hydrocarbon plume and to inform risk assessment. Continued groundwater monitoring was deemed necessary to enable further "lines of evidence"-based assessment and trend analysis in determining plume stability and to support monitored natural attenuation of the hydrocarbon plume.
CSR_WA_000151 Grounds Maintenance Area (Figure 25A)	Mobilisation 1 – 2018	0967_BH336 – 0967_BH348 0967_MW112 0967_MW113 0967_MW243 0967_MW244 0967_MW245	Assess the potential for soil and groundwater contamination associated with storage and reported spillage of hazardous chemicals (pesticides/herbicides) and POL fuel storage.
		0967_SD129 (Figure 13A)	Assess potential for impacts to drainage features associated with previous detection of TCE in sediment (SD-MW12) during the GHD PFAS investigation undertaken in September 2017.
	Mobilisation 2 – 2019	0967_MW243 0967_MW244 0967_MW245 0967_MW112 0967_MW113	The findings of the groundwater assessment undertaken during Mobilisation 1 detected concentrations of metals (chromium, copper, nickel and zinc) exceeding background levels and drinking water (health) levels (nickel only). Minor concentrations (not exceeding criteria) of VOCs and pesticides were also detected in groundwater. Further groundwater assessment of the existing monitoring well network was undertaken during Mobilisation 2 to further characterise the impact to groundwater.
CSR_WA_000153 Fire Training Area – Fuel Storage Facilities (Figure 26A)	Mobilisation 1 – 2018	0967_MW015 0967_MW053 0967_MW056 0967_MW101 0967_MW102	Assess the current status of potential groundwater contamination associated with use as a Fire Training Area and associated fuel storage infrastructure including: four underground gas lines connected to an above ground gas tank and two diesel ASTs installed prior to 1975.
		0967_SD121 0967_SD134 0967_SD135	Assess potential for impacts to adjacent drainage channel/s.
CSR_WA_000155 Power Station USTs (Figure 27A)	Mobilisation 1 – 2018	0967_BH324 0967_BH325 0967_MW029 0967_MW061 0967_MW062	Assess the current status of residual for soil and groundwater contamination associated with the historical overflow of a diesel AST (AST_016) inside the powerhouse building which occurred in 2004. Additionally, assess potential contamination associated with existing fuel storage infrastructure including two diesel USTs located south east of the powerhouse building.

CSR/PCSR	Stage 2 DSI Mobilisation	Sample Location ID[5]	Rationale
CSR_WA_000156 Paint Shop (Figure 28A)	Mobilisation 1 – 2018	0967_MW016 0967_MW017 0967_MW058 0967_MW239	Assess the potential for groundwater contamination associated with the waste sump AST_037 understood to have overflowed in 2011 and assess current status of sheen reported at MW016 in 2016.
		0967_SS125 0967_SS126	Assess potential for impacts to adjacent drainage channel/s.
CSR_WA_000160 Hangar 95 (Figure 29A)	Mobilisation 1 – 2018	0967_MW076 0967_MW077	Assess the potential for groundwater contamination associated with possible hydrocarbon impact inferred to be present beneath the Hangar building, historical and ongoing defueling operations, and identification of a containment pit to the south of the Hangar Building.
	Mobilisation 2 – 2019	0967_MW074 0967_MW075 0967_MW076 0967_MW077 0967_MW246 0967_MW247 0967_MW248	The findings of the groundwater assessment undertaken during Mobilisation 1 detected concentrations of chlorobenzene in groundwater beneath the hangar exceeding IL criteria. Further groundwater assessment including installation of additional groundwater wells was undertaken during Mobilisation 2 to delineate the extent of chlorobenzene impact and assess the potential risk to property users.
PCSR_0967_001 Aircraft Shelters (Figure 30A)	Mobilisation 2 – 2019	0967_BH381 – 0967_BH385 0967_MW249 – 0967_MW251	Assess the potential for soil and groundwater contamination associated with reported venting of fuel from aircraft onto the margin of the airfield.
PCSR_0967_002 New AVTUR Fuel Farm (Figure 31A)	Mobilisation 1 – 2018	0967_BH349 – 0967_BH351 0967_MW006 0967_MW158 0967_MW160 - 0967_MW162 0967_MW164 0967_MW165	Assess the potential for soil and groundwater contamination associated with bulk fuel storage (aviation turbine fuel) including a small spill of AVTUR at the western edge of the refuelling area in January 2018.
		0967_SD101 0967_SD102 See Figure 13A	Assess potential for impacts to adjacent drainage channel/s.
	Mobilisation 2 – 2019	0967_MW006 0967_MW158 0967_MW160 - 0967_MW165 0967_MW153 P/S 0967_MW230 P/S	Based on the findings of Mobilisation 1, further groundwater assessment was undertaken during Mobilisation 2 to enable further “lines of evidence”-based assessment and trend analysis in determining plume stability and to support monitored natural attenuation of the TRH plume.
PCSR_0967_003 25 m Small Arms Range (Figure 32A)	Mobilisation 1 – 2018	0967_BH352 – 0967_BH367 0967_BH368 – 0967_BH376 (XRF only) 0967_MW241	Assess the potential for soil and groundwater contamination associated with historical small arms range operations (not previously investigated).
		0967_SW132 0967_SD132 0967_SD133 See Figure 13A	Assess potential for impacts to adjacent drainage channel/s.
Property wide Sediment and surface water quality characterisation (Figure 13A)	Mobilisation 1 – 2018	0967_SW103 0967_SW104 0967_SW107 0967_SW112 0967_SW113 0967_SW116 0967_SW119 0967_SW120 0967_SW132 0967_SW137 0967_SW146 0967_SW147 0967_SW149 0967_SW152 – 0967_SW157 0967_SD101 - 0967_SD104 0967_SD107 0967_SD112 – 0967_SD124 0967_SD127 0967_SD128 0967_SD132 – 0967_SD135 0967_SD137 0967_SD139 - 0967_SD145	Assess the potential risk of contamination in surface water and sediment within the drainage channel networks located on and immediately surrounding RAAF Base Pearce. Sampling undertaken in 2018 to capture post summer (March 2018) and post winter (September 2018) conditions.

Table 26 3TU sample location details and rationale

CSR/PCSR	Stage 2 DSI Mobilisation	Sample Location ID[6]	Rationale
CSR_WA_000019 Septic Tanks – Sewage Disposal (Figure 34A)	Mobilisation 1 – 2018	0965_BH101 0965_BH102 0965_BH103 0965_MW104	Assess the potential for soil and groundwater contamination associated with former septic tank use.
		0965_SD101 – 0965_SD104 (Figure 33A)	Assess potential for impacts to adjacent drainage channel/s.
	Mobilisation 2 – 2019	0965_MW104 0965_SW101 – 0965_SW104, 0965_SW108 0965_SD101 – 0965_SD104 (Figure 33A)	Based on the findings of Mobilisation 1, faecal coliforms were identified as present in soil and groundwater and has the potential to pose a risk to future site users. Further groundwater monitoring was undertaken during Mobilisation 2 to confirm these results. Addition of PFAS as potential CoPC in accordance with guidance provided by DCARM. Further sampling undertaken to assess potential risk of PFAS contamination and associated exposure risks in soil, groundwater, surface water and sediment.
CSR_WA_000080 Incinerator (North of 3TU Workshop) (Figure 34A)	Mobilisation 1 – 2018	0965_BH104 – 0965_BH106 0965_MW102	Assess the potential for soil and groundwater contamination associated with former incinerator operations.
		0965_SD101 – 0965_SD104 (Figure 33A)	Assess potential for impacts to adjacent drainage channel/s.
	Mobilisation 2 – 2019	0965_MW102 0965_SW101 – 0965_SW104, 0965_SW108	Addition of PFAS as potential CoPC in accordance with guidance provided by DCARM. Further sampling undertaken to assess potential risk of PFAS contamination and associated exposure risks in soil, groundwater, surface water and sediment.
		0965_SD101 – 0965_SD104 (Figure 33A)	
CSR_WA_000081 South of 3TU – Buried Waste Metals (Figure 35A)	Mobilisation 1 – 2018	0965_MW001 0965_MW004 0965_MW005	Assess the current status of potential groundwater contamination associated with historic landfilling/burial of waste metals.
	Mobilisation 2 – 2019	0965_MW001 0965_MW002 0965_MW004 0965_MW005	Based on the findings of Mobilisation 1, groundwater beneath the landfill indicates a contribution to metals impacts (namely zinc) from historic landfilling activities. Further groundwater monitoring was undertaken during Mobilisation 2 to confirm these results and inform the requirement for installation of additional down-gradient monitoring wells. Addition of PFAS as potential CoPC in accordance with guidance provided by DCARM. Further sampling undertaken to assess potential risk of PFAS contamination and associated exposure risks in groundwater.
CSR_WA_000103 South of Former Building 58 – 2 x Diesel A/USTs (Figure 34A)	Mobilisation 1 - 2018	0965_BH107 – 0967-BH111 0965_MW101 0965_MW103	Assess the potential for soil and groundwater contamination associated with former fuel storage.
		0965_SD101 – 0965_SD104 (Figure 33A)	Assess potential for impacts to adjacent drainage channel/s.
	Mobilisation 2 - 2019	0965_MW101 0965_MW103 0965_SW101 – 0965_SW104, 0965_SW108 0965_SD101 – 0965_SD104	Addition of PFAS as potential CoPC in accordance with guidance provided by DCARM. Further sampling undertaken to assess potential risk of PFAS contamination and associated exposure risks in soil, groundwater, surface water and sediment.
PCSR_0965_001 Former Fire Extinguisher Training Area (Figure 36A)	Mobilisation 2 - 2019	0965_BH118 – 0965_BH125 0965_MW105 – 0965_MW107	Assess the potential for soil and groundwater contamination associated with possible former use as a fire extinguisher/AFFF foam discharge training area.
		0965_SD110 – 0965_SD113 (Figure 33A)	Assess potential for impacts to adjacent drainage channel/s.
PCSR_0965_002 Asphalt Stockpile Area (Figure 37A)	Mobilisation 1 - 2018	0965_BH112 – 0965_BH117 0965_OTH001 0965_OTH002	Assess the potential for soil and groundwater contamination associated with possible leachable contaminants within the asphalt stockpile and potential contaminants of concern associated with runway use (source of asphalt) (including PFAS).
		0965_SD105 0965_SD106 (Figure 33A)	Assess potential for impacts to adjacent drainage channel/s.
	Mobilisation 2 - 2019	0965_SD105 0965_SD106 (Figure 33A)	Further sediment sampling undertaken during Mobilisation 2 to assess the current risk of PFAS impacts to adjacent drainage channel/s
Property wide Surface water and sediment sampling (Figure 33A)	Mobilisation 1 – 2018	0965_SD101 – 0965_SD106 (Figure 33A)	Assess potential risk of contamination in surface water and sediment within the drainage channel networks located on and immediately surrounding the 3TU properties.
	Mobilisation 2 – 2019	0965_SW101 – 0965_SW104 0965_SW108 0965_SW109 0965_SW115 0965_SW118	Addition of PFAS as potential CoPC in accordance with guidance provided by DCARM. Assess potential risk of PFAS contamination and associated exposure risks in surface water and sediment at most CSRs and nearby drainage channels within and immediately surrounding at the 3TU.
		0965_SD101 – 0965_SD106 0965_SD110 - 0965_SD120	

6 BH = Soil bore; MW = Monitoring well; SD = Sediment; SW = Surface water, OTH = Asphalt

6.3 Field activities

Field activities undertaken during Mobilisation 1 (2018) and Mobilisation 2 (2019) of the Stage 2 DSI at RAAF Base Pearce and 3TU are summarised in Table 27 and Table 28.

Table 27 Mobilisation 1 - Summary of works

Dates	Activities	Field personnel/contractors
12 to 15 March 2018	Clearing of all intrusive soil bore and groundwater well locations by a qualified subsurface utility detection contractor at both 0967 and 0965.	SubTera/GHD
12 March 2018	Commencement of the drilling program in accordance with the approved SAQP	DPP/Ecoprobe/GHD
RAAF Base Pearce - 0967		
13 to 20 March 2018	Drilling of soil bores at CSR areas as per SAQP	DPP/GHD
15 March to 4 April 2018	Collection of sediment and surface water samples	GHD
26 to 28 March 2018	Monitoring and sampling of existing groundwater monitoring wells	GHD
26 March 2018	Drilling and installation of one groundwater well at PCSR_0967_003	Ecoprobe/GHD
27 March 2018	Drilling and installation of groundwater wells at CSR_WA_000104	Ecoprobe/GHD
27 March 2018	Initial soil validation and waste classification sampling at CSR_WA_000024 following decommission/removal of the USTs north-east of Building 72	GHD
28 to 29 March and 3 to 6 April 2018	Drilling and installation of groundwater wells at CSR_WA_000117	Ecoprobe/GHD
9 April 2018	Drilling and installation of one groundwater well at CSR_WA_000107	Ecoprobe/GHD
10 and 11 April 2018	Drilling and installation of one groundwater well at CSR_WA_000110	Ecoprobe/GHD
12 April 2018	Additional soil validation and waste classification sampling at CSR_WA_000024	GHD
19 April 2018	Drilling of soil bores at PCSR_0967_002	Ecoprobe/GHD
23 to 26 April 2018	Drilling and installation of additional targeted groundwater wells at CSR_WA_000151	Ecoprobe/GHD
3 to 9 May 2018	Monitoring and sampling of newly installed groundwater monitoring wells	GHD
13 and 14 September 2018	Supplementary post-winter limited surface water sampling	GHD
3TU - 0965		
12 and 13 March 2018	Drilling of soil bores at CSR areas as per SAQP	DPP/GHD
19 and 20 March 2018	Collection of sediment and surface water samples	GHD
20 March 2018	Collection of surface soil and sediment samples from PCSR_0965_002	GHD

Dates	Activities	Field personnel/contractors
6 April 2018	Monitoring and sampling of existing groundwater monitoring wells at CSR_WA_000081	GHD
19 and 20 April 2018	Drilling and installation of groundwater wells at CSR_WA_000103, CSR_WA_000080, CSR_WA_000019	Ecoprobe/GHD
8 May 2018	Monitoring and sampling of newly installed groundwater monitoring wells	GHD
14 September 2018	Supplementary surface water and sediment sampling	GHD

Table 28 Mobilisation 2 - Summary of works

Dates	Activities	Field personnel/contractors
9 to 12 March 2019	Clearing of all intrusive soil bore and groundwater well locations by a qualified subsurface utility detection contractor at both 0967 and 0965.	Prime Locate/GHD
9 March 2019	Commencement of the drilling program in accordance with the revised SAQP (GHD 2018c)	National Geotech/ Ecoprobe/GHD
RAAF Base Pearce - 0967		
9 to 12 March 2019	Drilling of soil bores at select CSR areas as per revised SAQP (GHD 2018c)	National Geotech/ GHD
14 and 15 March 2019	Drilling and installation of two groundwater wells at CSR_WA_000117	Ecoprobe/GHD
18 to 22 and 25 to 26 March 2019	Drilling and installation of eight groundwater wells at CSR_WA_000024	Ecoprobe/GHD
23 to 24 and 30 to 31 March 2019	Drilling and installation of three groundwater wells at PCSR_0967_001	Ecoprobe/GHD
27 March 2019	Drilling and installation of one groundwater well down gradient of CSR_WA_000106	Ecoprobe/GHD
1 April 2019	Drilling and installation of one groundwater well to the west of CSR_WA_000106	Ecoprobe/GHD
2 to 5 April	Monitoring and sampling of existing and newly installed groundwater monitoring wells	GHD
6 and 7 April 2019	Drilling and installation of two groundwater wells at CSR_WA_000160	Ecoprobe/GHD
8 to 14 April 2019	Monitoring and sampling of existing and newly installed groundwater monitoring wells	GHD
16 to 17 April 2019	Survey of newly installed groundwater monitoring wells	GHD
3TU - 0965		
11 March 2019	Drilling of soil bores at select CSR areas as per revised SAQP (GHD 2018b)	National Geotech/GHD
12 March 2019	Drilling and installation of groundwater wells at PCSR_0965_001	National Geotech/GHD
13 March 2019	Collection of sediment and surface water samples as per revised SAQP (GHD 2018c)	GHD
1 April 2019	Monitoring and sampling of existing and newly installed groundwater monitoring wells	GHD
17 April 2019	Survey of newly installed groundwater monitoring wells	GHD

7. Methodology

Methodologies adopted for the scope of work undertaken during Mobilisation 1 (2018) and Mobilisation 2 (2019) of the Stage 2 DSI are outlined in the following sections.

7.1 Subsurface clearance procedures

Subsurface utility detection services were engaged to identify underground services prior to the commencement of the drilling programs conducted during Mobilisation 1 (2018) and Mobilisation 2 (2019) (soil bores and groundwater well installation). Furthermore, all soil bore and groundwater monitoring well locations were cleared to a depth of 1.5 m bgl using hand auger prior to mechanical drilling.

7.2 Soil investigation methodology

Soil bores were advanced using a hand auger to 1.5 m bgl or refusal which was typically 1.0 m bgl. A Geoprobe mechanical drill rig was used to progress soil bores to the required depths and achieve collection of samples from the designated depths soil profile via push tube.

7.2.1 Drilling methods

Non Destructive Drilling (NDD)

All soil investigation locations were advanced from surface to 1.0 to 1.5 m bgl using a hand auger (NDD technique) to minimise the risk of encountering subsurface services. Although hand augering is not recommended by AS4482.2-1999 for sampling of volatiles in soil, it was considered the safety of the field team outweighed any losses of VOCs by the sampling technique. Furthermore, the potential for surface air leakage within the first 1.5 m of the soil profile is high, meaning volatiles are readily lost from near surface soil samples. Sampling technique is therefore unlikely to have further significant effect on VOC concentrations. The sampling technique would still be able to detect gross VOC contamination for example from a recent spill.

Geoprobe mechanical drilling

Soil locations selected for push tube continuous sampling (in accordance with AS4482.2-1999 for sampling of volatiles) were advanced using a Geoprobe® mechanical drilling rig continuous core push tube method. The push tube technique removed cores of soil enabling direct visible assessment of the soil profile enabling detailed logs to be made as well as allowing for discrete samples to be collected.

7.2.2 Soil lithology logging and sampling

Each bore was logged for soil and rock type classifications and descriptions based on the Unified Soil Classification System and AS4482.1-1997 guidelines. Colour changes, odours and the occurrence of fill (if present) were noted on each soil bore log. Soil descriptions for the lithology encountered during drilling are presented in the bore logs provided in Appendix I.

A PID was used to screen samples for the presence of VOCs. Soil was sampled and placed in zip lock bags before the PID was inserted into the bag to screen for VOCs.

Soil samples were collected from near surface (0.0 to 0.1 m), 0.5 m and then every 0.5 m or changes in lithology or if visual or olfactory signs of contamination was observed until the target depth was reached or refusal was encountered.

Representative samples were placed into laboratory prepared glass sample jars, with Teflon-lined lids. For soil samples specifically for PFAS analysis, laboratory specified plastic polypropylene jars were used. Soil samples were collected using new disposable nitrile gloves for each sample and then placed directly into laboratory provided sample jars. Sealed jars were placed into ice-filled eskies immediately following collection for subsequent delivery to the nominated primary laboratory under Chain of Custody documentation (CoC). Split samples were forwarded to the nominated secondary laboratory by the primary laboratory.

Soil sampling locations were surveyed in the x-y plane using a GPS with an accuracy of 5 to 10 m.

7.2.3 X-ray Fluorescence (XRF) sampling

Field measurement of metals using XRF were undertaken at targeted locations across PCSR_0967_003 (25 m Small Arms Range) to supplement laboratory analytical data in accordance with US EPA 2007 (referenced in NEPM Schedule B2) as per the following:

- A representative sample of soil will was collected from a 0.1 by 0.1 m square that was 0.03 m deep
- The sample was sieved through a 2 mm sieve and homogenised to ensure a uniform particle size
- The sample was placed into a 250 mL sample jar, ensuring that the soil was tightly compacted within the jar
- The XRF was positioned against the soil and a shot was measured over a minimum count time of 10 seconds
- A total of five shots were undertaken for each sample
- Samples with varying lead concentrations by XRF were selected to provide data-spread and allow a correlation assessment between field and laboratory results
- Standard reference materials (standard containing certified concentrations of metals in soil) were used for accuracy and performance checks of XRF analyses. Standard reference material readings were taken every 20 locations.

7.3 Groundwater investigation methodology

7.3.1 Drilling methods

NDD

All groundwater monitoring well locations were advanced from surface to 1.0 to 1.5 m using a hand auger (NDD technique) to minimise the risk of encountering subsurface services.

Sonic Drilling

A sonic drill rig was used to achieve the final depths of each monitoring well. Final depths were determined based on the depth groundwater encountered during drilling and/or whether the purpose of the location was to target the perched or regional groundwater aquifer.

After each stage of drill stem advancement, the inner string was removed with a core of drill cuttings while the temporary ‘casing’ string remained insitu to hold the borehole open. The cuttings were laid out in sequence from surface to base for examination of the stratigraphy prior to sampling or storage for subsequent disposal. Observations recorded during the drilling program are detailed in Section 9.1. Lithology descriptions for each monitoring well were logged and are provided in Appendix I.

7.3.2 Groundwater monitoring well installation

50 mm permanent groundwater monitoring wells

Monitoring well construction comprised a 50 mm diameter PVC screen and plain casing with screw fittings installed in an approximately 120 mm diameter borehole. A slotted screen length of 3.0 m was generally used, with approximately 2.0 m installed below the water table and 1 m above. Screened sections were installed in a gravel filter pack, which was placed to approximately 0.5 to 1.0 m above the top of the screen and isolated with a bentonite seal, with the remaining void to the ground surface backfilled with non-impacted drill cuttings based on visual and olfactory observations. Smear zone soils or those form the shallow fill horizons were not used as backfill at any well location. Where non-impacted drill cuttings were used, they were placed above the bentonite seal, further reducing the potential for any contamination to occur. Wells were fitted with steel monument covers and secured into position with concrete. A water tight ‘enviro-cap’ was installed on the top of each well casing to prevent accidental blockage of the well.

Post-construction well development

Wells were developed following installation using a submersible pump to purge any accumulated sediment or introduced water. At least three well volumes were developed at a minimum, until the water ran clear. Development water was contained in 220 L drums and disposed off-site to an appropriate off-site facility by a licensed waste carrier.

Decontamination and stabilisation

Decontamination of drill rig equipment was carried out between all monitoring well locations. Wells were left for a minimum of one week to allow stabilisation between installation/development and commencement of the GMEs (2018 and 2019).

7.3.3 Groundwater monitoring events

Details of GME activities are summarised in Table 29.

Table 29 Summary of GME activities

Activity/Item	Details
Well gauging	All monitoring wells were gauged using an oil/water interface probe to determine the depth to groundwater, the potential presence of LNAPL and the total depth of the well prior to the commencement of purging. Where practical wells at each CSR were gauged in a single event prior to sampling. The groundwater gauging data is presented Appendix J.
Well purging and sampling method	Groundwater was purged and sampled using low flow sampling techniques, with a bladder pump, flow through cell, water quality meter and Low Density Polyethylene (LDPE) tubing and disposable bladders. All wells were purged until water quality parameters are stabilised or until a total of at least three well volumes were purged prior to sampling. LDPE tubing and bladders were replaced after sampling each monitoring well. Groundwater sampling was conducted using GHD's SOP-14 Groundwater Well Sampling and Quality Assurance and Quality Control (QA/QC) procedures, which are in accordance with relevant guidelines. All samples collected for dissolved metals analysis were filtered on-site before transfer to laboratory prepared sample bottles. Once collected the samples were immediately placed in ice chests and chilled for transport to the nominated NATA accredited laboratory. Chain of custody documentation was prepared for sample transfer from the property to the laboratory.
Well survey	The newly installed groundwater monitoring well locations were surveyed for location and elevation in metres AHD by a licensed surveyor, to obtain accurate levels for determining groundwater flow direction. The groundwater monitoring wells were surveyed to Map Grid of Australia (MGA) grid to accuracy of ±0.05 m in the X-Y plane and to an accuracy of ±0.002 m in the Z axis, relative to m AHD. Well survey data is presented in Appendix K.
Sample preservation	Samples were placed in laboratory-supplied bottles containing appropriate preservatives. Samples were stored on ice in an esky while on-site and in transit to the laboratory.
Decontamination procedure	The interface probe and bladder pump was washed in Decon 90™ and rinsed with potable water between measurements/sampling. Dedicated tubing, filters and disposable nitrile gloves were used for each well.
Disposal of purged groundwater	Purged water was contained on-site in IBC containers prior to disposal.

7.4 Surface water and sediment investigation methodology

7.4.1 Surface water sampling methodology

Surface water samples were collected from several locations within surface water drainage channels (where accessible) within and in close vicinity of both RAAF Base Pearce and 3TU properties. Samples were collected from the surface of the water column directly in to laboratory supplied sample bottles. Disposable nitrile gloves were worn during sample collection and were changed at each sample location to limit the potential for cross-contamination. Observations recorded during surface water sampling are detailed in Section 10.3.

7.4.2 Sediment sampling methodology

Sediment samples were collected from several locations within surface water drainage channels (where accessible) within and in close vicinity of both RAAF Base Pearce and 3TU properties. Samples were collected using a trowel which was decontaminated between each sample location to limit the potential for cross-contamination. In the majority of sample locations, drains were observed to be dry and samples were collected from the centre of the drain at a low point where possible. In instances where surface water was present, sediment samples were collected from an accessible saturated zone below the surface of the water (the water was typically very shallow). Observations recorded during sediment sampling including lithology and any olfactory evidence of contamination are detailed in Section 10.4.

7.5 Data QA/QC procedures

7.5.1 Background

QA/QC were adopted during the fieldwork based on the minimum requirements detailed in the Australian Standard AS4482.1-2005, and on the recommendations given in the ASC NEPM. The QA/QC system allows the collected data to be assessed to provide evidence that the data is fit for interpretive use. QA/QC sampling was carried out by GHD field personnel during the fieldwork together with sampling, handling and decontamination procedures as detailed below.

7.5.2 Summary of compliance

Field QA/QC procedures and compliance during the investigation are summarised in Table 30, with laboratory QA/QC procedures and compliance summarised in Table 31. Further discussion and detail surrounding data QA/QC undertaken for this investigation is provided in Appendix O.

For the reasons described in Appendix O, the reported QA/QC non-compliances are not considered to significantly influence the reliability of the analytical data.

The overall review of the QA/QC results indicates that the data are of an acceptable quality upon which to enable assessment of the property.

Table 30 Field method validation activities

QA/QC element	Requirement	Requirement adhered to?	Information/data acceptable?
Equipment calibration	Where relevant, all field equipment is to be calibrated by the equipment supplier and certification provided.	Yes	Yes, see Appendix H
Sampling methods	All sampling methods outlined in the SAQP (GHD 2018a) must be adhered to.	Yes	Yes
Record keeping	Detailed records of field activities were maintained with the use of borehole logging electronic-based applications, surface water sampling sheets, and quality control sample registers.	Yes	Yes
Portable XRF instrument usage	Readings were taken in a consistent manner as described in Section 7.2.3.	Yes	Yes
CoC documentation	The CoC documentation was completed for each batch of samples, identifying the names of the samplers, the type of sample, the collection date, the analyses to be performed, sample preservation methods, and time the samples were relinquished to the courier.	Yes	Yes
Sample labelling	Samples were properly labelled, showing reference number, sample ID, date of collection, sampler name and preservation techniques.	Yes	Yes
Sample containers	Samples were collected in appropriate laboratory-supplied containers with suitable preservation methods (where required).	Yes	Yes
Sample storage and transport	Samples were stored in a chilled esky immediately after sampling prior to submission to the laboratory. Samples were kept in a chilled esky during delivery with CoC documentation. Samples were received at the laboratory within recommended temperature range (4 ± 2 °C).	Yes, with exceptions.	Yes, see Appendix O.
Decontamination	Reusable field equipment, including the hand auger were appropriately decontaminated using Decon Neutracon between each sampling location.	Yes	Yes
Rinsate blanks	Rinsate samples were collected by the sampler on each day following decontamination of reusable sampling equipment. Analysis of rinsate blanks reported concentrations below laboratory LOR indicating equipment was decontaminated appropriately.	Yes, with exceptions.	Yes, see Appendix O.

QA/QC element	Requirement	Requirement adhered to?	Information/data acceptable?
Transport blanks	Transport blanks were prepared by the laboratory and submitted with each batch of samples (at a frequency of at least one transport blank per esky) to estimate potential cross-contamination between samples and contamination introduced during transport of samples to the laboratory. Analysis of transport blanks reported concentrations below laboratory LOR indicating no cross-contamination occurred within the eskies.	Yes	Yes
Field blanks	Field blanks were collected by the sampler on each day to estimate potential contamination of a sample during the collection procedure. Analysis of field blanks reported concentrations below laboratory LOR indicating no cross-contamination occurred during sampling.	Yes, with exceptions.	Yes, see Appendix O.
Duplicate samples	Blind and split duplicate samples were collected for analysis by the primary and secondary laboratories, respectively (at a frequency of at least one pair per 20 primary samples, or one pair per 20 primary samples for PFAS analysis). RPDs calculated for the duplicate samples were at or below 30 %.	Yes, with exceptions.	Yes, see Appendix O.

Table 31 Laboratory QA/QC compliance summary

QA/QC element	Requirement	Requirement adhered to?	Information/data acceptable?
NATA accreditation	Analysis of CoPC performed under NATA accreditation or equivalent government-endorsed provider of accreditation.	Yes	Yes
Holding times	Laboratory to complete sample extraction and analysis of CoPC within method specifications.	Yes, with exceptions.	Yes, see Appendix O.
Analytical methods	Sample analyses are to use appropriate methods for each CoPC with regard to Schedule B(3) of the *ASC NEPM* and in accordance with the laboratory's NATA accreditation.	Yes	Yes
Laboratory LORs	Laboratory LORs are below adopted assessment criteria.	Yes, with exceptions.	Yes, see Appendix O.
Laboratory QC results	Laboratory quality control performance will comply with internal laboratory standards.	Yes, with exceptions.	Yes, see Appendix O.

8. Assessment criteria

8.1 Relevant guidelines

Soil and groundwater data collected during the Stage 2 DSI have been evaluated by comparison with appropriate Tier 1 risk screening criteria adopted from the following Australian guidelines:

- NEPM (2013) Schedule B(1) – Guideline on Investigation Levels for Soil and Groundwater
- CRC CARE Technical Report No. 10 (2011) Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater
- DER (2014) Assessment and management of contaminated sites: Contaminated sites guidelines
- DoH (2011) Guidelines for the Non-potable Uses of Recycled Water in Western Australia
- HEPA (2018) PFAS National Environmental Management Plan (PFAS NEMP)
- ANZECC & ARMCANZ (2000). National water quality management strategy. Australian and New Zealand guidelines for fresh water, marine water and livestock drinking water quality.
- NHMRC & NRMMC (2017) Australian Drinking Water Guidelines
- NHMRC (2008) Guidelines for managing risks in recreational waters

Where authoritative Australian guidelines were not available for assessment purposes, alternative guideline criteria were adopted from other regulatory jurisdictions which have been applied on other sites within the Western Australian regulatory jurisdiction including:

- United States Environmental Protection Agency – Regional Screening Levels, May 2018 (explosives, PAHs, phenols, VOCs, BTEX and dioxins & furans) (USEPA 2018).

8.2 Assessment criteria – RAAF Base Pearce

8.2.1 Soil Investigation Levels (SIL)

8.2.1.1 Factors affecting Tier 1 criteria selection for soil quality

Land use scenario

All Tier 1 criteria used to evaluate human health risks in this report are based on a commercial/industrial land use scenario. The Former Service Station (CSR_WA_000117) is located immediately south-east of the housing blocks on the property and it may potentially have a residential future land use, therefore this CSR has been further assessed for human health risks based on a residential land use scenario as a conservative measure.

Soil type

As detailed in Section 3.3.1, the soil beneath the property has been recorded either as sandy clay or clayey sand in previous and current environmental investigations. For the screening risk assessments presented in this report, either a clay or sand soil type has been selected depending on the dominant soil characteristics observed in each CSR.

8.2.1.2 Human health criteria – soil

Heavy metals and other inorganic compounds

NEPM (2013) Schedule B (1). Guideline on Investigation Levels for Soil and Groundwater:

- *Health Investigation Level HIL-D* – for chronic exposure via direct contact pathways including dermal contact, ingestion and dust inhalation in a commercial/industrial land use scenario.
- *Health Investigation Level HIL-B* – for chronic exposure via direct contact pathways including dermal contact, ingestion and dust inhalation in a residential land use scenario with minimal opportunities for soil access.

United States Environmental Protection Agency (May 2018) Regional Screening Levels:

- *Regional Screening Levels RSL - Soil: Composite worker* – for direct contact exposure pathways (TR[2]=1x10^{-06}, THQ[3]=1.0) (USEPA 2018).
- *Regional Screening Levels RSL – Soil: Residents* – for direct contact exposure pathways (TR[7]=1x10^{-06}, THQ[8]=1.0) (USEPA 2018).

Health Investigation Levels (HIL) are applicable to soil depths of up to three metres below ground level. HILs for a commercial/industrial land use scenario (HIL-D) were used for assessment at all CSRs at RAAF Base Pearce. Additionally, the Former Service Station (CSR_WA_000117) was compared to HILs for a residential land use scenario (HIL-B) due to its proximity to housing blocks immediately north-west of the CSR. A summary of the soil assessment criteria applied to each CSR is provided in Table 35.

Where Australian-derived soil investigation levels were not available, alternative Tier 1 criteria were adopted from other regulatory jurisdictions and applied for screening purposes for the following parameters:

- BTEX
- PAHs
- Phenols
- VOCs
- Dioxins & furans
- Explosives residues

Petroleum hydrocarbon compounds

Health Screening Levels (HSLs) developed by CRC CARE for selected petroleum compounds and fractions published in NEPM (2013) were adopted (except for direct contact HSLs and intrusive maintenance workers HSLs, which were taken from CRC CARE (2011)) to assess human health risks to potentially sensitive receptors under a commercial/industrial land-use scenario via the following exposure pathways:

- *Soil HSL-Intrusive Maintenance Worker* – for chronic exposure of shallow trench worker (trench depth less than 1 m bgl) via direct contact pathways, including dermal contact, ingestion and dust inhalation
- *Soil HSL-D (direct contact) Commercial/Industrial* – for direct contact pathways, including dermal contact, ingestion and dust inhalation

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[7] Target Risk (TR) provided by the user in site-specific mode

[8] Target Hazard Quotient (THQ) provided by user in site-specific mode

- *Soil HSL-D (vapour) Commercial/Industrial, clay or sand soil type* – for chronic exposure via vapour intrusion pathways

Asbestos

Asbestos samples were collected from the Dog Compound (CSR_WA_000083) and were only tested for presence/absence, not %w/w. Hence, comparison to guidelines was not applicable.

8.2.1.3 Ecological criteria – soil

Heavy metals and inorganic compounds

NEPM (2013) Schedule B(1) Guideline on Investigation Levels for Soil and Groundwater:

- *Ecological Investigation Level EIL* – to assess risks to terrestrial ecosystems in commercial/industrial setting
- *Ecological Investigation Level EIL* – to assess risks to terrestrial ecosystems in an area of ecological significance

Ecological Investigation Levels (EIL) are applicable to soil depths of up to two metres corresponding to the root-zone and habitation zone of many species. EILs are conservative because they have been developed on the basis of fast growing species under generic soil conditions, regardless of whether a particular species occurs at the property. Regional Ambient Background Concentrations (ABC) in combination with site-specific soil parameters can be used to calibrate EIL values to site-specific soil conditions using the following calculation:

EIL = ACL + ABC

where *ABC = Ambient Background Concentration*

ACL = Added Contaminant Limit

Added Contaminant Limits (ACL) are dependent on pH, CEC and clay content of the soils. Soil samples were collected from the property and submitted for analysis of NEPM soil parameters to help derive site-specific EILs, as shown in Table 32.

Table 32 Summary of NEPM soil parameters (RAAF Base Pearce)

CSR	Location ID	Depth (m bgl)	pH ($CaCl_2$ method)	CEC (meq/100g)	Clay content (%)
PCSR_0967_003	0967_BH359	0.5	6.2	0.4	4
	0967_BH361	1.0	7.5	16.7	20
CSR_WA_000151	0967_BH341	1.0	5.7	6.2	31
	0967_BH348	0.5	6.4	5.6	31
	0967_MW243	0.5	5.8	6.0	47
Average			6.3	7.0	26.6
Rounded average values[9]			6	7	25

In determining ABC values, it is relevant to note that the results of the desktop study and anecdotal information from Defence indicate that the entire property has potentially been disturbed by site activities. Therefore, soil samples collected as part of this investigation were not considered to be representative of background conditions suitable for determining ABCs. A conservative approach was therefore adopted in which the ABC values were calculated based on the LOR for each metal. The LOR and rounded values adopted for calculating the EILs are detailed in Table 33.

[9] Rounding applied according to ASC NEPM rounding rules

Table 33 Summary of ABCs (RAAF Base Pearce)

	Depth (m bgl)	Chromium (III+VI; mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)
LOR	-	2	5	5	2	5
Rounded values[10]		2	5	5	2	5

The EILs calculated from the NEPC EIL calculation spreadsheet (using the LOR as the ABC concentration) are presented Table 34 and have been used to evaluate the contamination status of all CSR locations at RAAF Base Pearce. A summary of the soil assessment criteria applied to each CSR is provided in Table 35.

Table 34 Site-specific EILs (RAAF Base Pearce)

Contaminant of potential concern (CoPC)	RAAF Base Pearce rounded EILs[10] (mg/kg)	
	Commercial/industrial	Areas of ecological significance
Chromium III	660	130
Copper	150	35
Nickel	60	7
Lead	1800	480
Zinc	370	55

Petroleum hydrocarbon compounds

NEPM (2013) Schedule B (1). Guideline on Investigation Levels for Soil and Groundwater:

- *Ecological Screening Levels ESL Commercial/Industrial, Coarse or Fine soil type* – ecological risk screening criteria for the protection of terrestrial ecosystems in a commercial/industrial land use scenario
- *Ecological Screening Levels ESL Areas of Ecological Significance, Fine soil type* – ecological risk screening criteria for the protection of terrestrial ecosystems in areas of ecological significance

Ecological Screening Levels (ESL) are applicable to soil depth of up to two metres and have been developed for TRH fractions, BTEX and BaP compounds. For assessment purposes, the ESLs for a commercial/industrial end use were applied for either a coarse or fine soil type, depending on the dominant soil characteristics of each CSR. The Dog Compound (CSR_WA_000083) and the Former Fire Training Area (CSR_WA_000107) were additionally compared against the ESLs for areas of ecological significance due to their proximity to Bush Forever areas (as described in Section 3.6.3). A summary of the soil assessment criteria applied to each CSR is provided in Table 35.

8.2.1.4 Soil assessment criteria per CSR

A summary of applied soil assessment criteria per CSR is provided in Table 35.

[10] Rounding applied according to ASC NEPM rounding rules

Table 35 Soil assessment criteria by CSR (RAAF Base Pearce)

Assessment Criteria	Human Health						Ecological				
CSR	HSL-D Commercial/Industrial Soil for Direct Contact	Soil Direct Contact for Intrusive Works (Shallow Trench)	HIL-B Residential Soil	HIL-D Commercial/Industrial Soil	HSL-D Commercial/Industrial Soil for Vapour Intrusion		EILs for Areas of Ecological Significance	EILs for Commercial/Industrial Soil	ESLs for Areas of Ecological Significance	HSL-D Commercial/Industrial Soil for Vapour Intrusion	
					Clay	Sand			Fine	Coarse	Fine
CSR_WA_000024 Fuel Storage NE Building 72	✓	✓		✓		✓		✓		✓	
CSR_WA_000083 Dog Compound - Buried Waste	✓	✓		✓	✓		✓	✓	✓		✓
CSR_WA_000087 Fuel Storage ILS 18 Glide Path (AST_032)	✓	✓		✓	✓			✓			✓
CSR_WA_000088 Fuel Storage ILS 18 Localiser (AST_033)	✓	✓		✓	✓			✓			✓
CSR_WA_000104 Former Hazardous Waste Store	✓	✓		✓	✓			✓			✓
CSR_WA_000107 Former Fire Training Area (1960s)				✓			✓	✓			
CSR_WA_000109 Near Building 239 - Former Group of USTs	✓	✓		✓	✓			✓			✓
CSR_WA_000110 Former Fuel Farm	✓	✓		✓		✓		✓		✓	
CSR_WA_000117 Former Service Station	✓	✓	✓	✓	✓			✓			✓
CSR_WA_000151 Grounds Maintenance Area	✓	✓		✓		✓		✓		✓	
CSR_WA_000155 Fuel Storage Power Station	✓	✓		✓	✓			✓			✓
CSR_WA_000156 Paint Shop	✓	✓		✓	✓			✓			✓
PCSR_0967_002 AVTUR Fuel Farm	✓	✓		✓		✓		✓		✓	
PCSR_0967_003 Former 25 m Small Arms Range	✓	✓		✓		✓		✓		✓	
PCSR_0967_001 Aircraft Shelters	✓	✓		✓	✓			✓			✓

8.2.2 Groundwater Investigation Levels (GIL)

8.2.2.1 Factors affecting Tier 1 criteria selection for water quality

Tier 1 selection criteria for groundwater quality was determined on a property-wide basis. Adopted assessment criteria were tailored to each CSR based on encountered soil types (sand/clay) and groundwater depths, as detailed below and summarised in Table 36.

Groundwater use

As described in Section 3.5.4, groundwater is no longer abstracted from the Base for any purposes, with scheme water providing the non-potable water needs of the Base and bottled drinking water supplied for potable needs.

Results of a water-use survey conducted as part of GHDs PFAS investigation works (GHD 2018b) indicate that use of groundwater surrounding the property is extensive and comprises:

- Drinking water
- Domestic/household uses
- Irrigation of paddocks, vegetable gardens and fruit trees
- Commercial businesses/local growers
- Drinking water for chickens, pets (including rescue dogs), grazing horses, cattle and sheep.

Based on what is understood about groundwater flow direction and discharge from the superficial regional aquifer to the Ellen Brook (and to a lesser extent Ki-It Monger Brook) (GHD 2018b), the identified bores located west of the Ellen Brook and east of the Ki-It Monger Brook are not considered to be receptors of potential contamination originating at the Base, and as such, commercial irrigation and livestock watering have not been included as groundwater uses in the receptor evaluation and application of relevant assessment criteria. The potential however does exist for domestic-scale use of groundwater to occur via unregistered bores.

Groundwater depth

As described in Section 3.5.1 and Section 9.2.1, groundwater at the property is generally encountered in two separate aquifers:

- ‘Perched aquifer’ refers to seasonal unconfined groundwater held above the water table by a layer of impermeable material (e.g. clay), present within localised areas.
- ‘Regional aquifer’ refers to the superficial aquifer that is present throughout the property, typically below the localised perched aquifer lenses. Based on consultation undertaken during the PFASIMB DSI (GHD 2018b), this aquifer is the main source of groundwater used by the community in the area surrounding the Base. As monitoring wells were installed across the property targeting both the perched and regional groundwater aquifers, groundwater depth is considered on a well by well basis for screening risk assessments for vapour intrusion. The following categories of groundwater depths were used for assessment criteria evaluation (adopted from NEPM 2013):
- 2 to less than 4 m bgl
- 4 to less than 8 m bgl
- Greater than 8 m bgl

Soil Type

For the vapour intrusion screening risk assessment presented in this report, soil type (sand/clay) was determined on a CSR basis, based on the predominant (greater than 50 %) soil type encountered during drilling. In the CSRs where no soil investigation was conducted, a soil type of 'sand' was assumed as a conservative measure.

Environmental status of the Ellen Brook-Upper Swan catchment (surface water receiving body)

The primary surface water receiving environments are the Ellen Brook and the Ki-It Monger Brook. The brooks receive surface water run-off from the RAAF Base as well as surrounding areas, where a range of commercial/industrial activities occur. Furthermore, much of the Ellen Brook catchment has been cleared for agriculture, and monitoring conducted has identified nutrient concentrations within surface water of the Brook in excess of their nominated target levels (Department of Water and Swan River Trust 2011). It is therefore considered appropriate to categorise the Ellen Brook and Ki-It Monger Brook as a 'slightly to moderately disturbed' system.

8.2.2.2 Human health criteria – groundwater

NHMRC & NRMMC (2017) Australian Drinking Water Guidelines

- *Guideline values for physical and chemical characteristics – Aesthetic*
- *Guideline values for physical and chemical characteristics* – Health
- NHMRC (2008) Guidelines for managing risks in recreational waters
- *Non-potable groundwater use (NPUG)*
- Department of Health (DoH 2011) Guidelines for the Non-potable Uses of Recycled Water in Western Australia
- *Microbiological assessment levels, urban recreational areas, open spaces, parks and gardens* – for the assessment of municipal use with some restricted access and application

CRC CARE Technical Report No. 10 (2011) Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater

NEPM (2013) Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater

- *Groundwater HSL-D Commercial/Industrial, sand/clay soil type* - for the assessment of vapour intrusion risks.

8.2.2.3 Ecological criteria – groundwater

ANZECC & ARMCANZ (2000). National water quality management strategy. Australian and New Zealand guidelines for fresh and marine water quality.

NEPM (2013) Schedule B (1). Guideline on Investigation Levels for Soil and Groundwater

- *Groundwater Investigation Levels GILs – Fresh Waters* to assess risks to aquatic ecosystems in slightly to moderately disturbed systems – 95 % species protection level

8.2.2.4 Groundwater assessment criteria per CSR

A summary of applied groundwater assessment criteria per CSR is provided in Table 36.

Table 36 Groundwater assessment criteria per CSR (RAAF Base Pearce)

Assessment Criteria	Human Health						Ecological
CSR	Australian Drinking Water Guidelines (Aesthetic)	Australian Drinking Water Guidelines (Health)	Non-potable Groundwater Use (NPUG)	Microbiological Assessment Levels	HSL-D Commercial/Industrial for Vapour Intrusion		Fresh Water (95 % species protection)
					Sand	Clay	
CSR_WA_000024 Fuel Storage NE Building 72	✓	✓	✓		✓		✓
CSR_WA_000083 Dog Compound - Buried Waste	✓	✓	✓			✓	✓
CSR_WA_000084 Sounness Road Landfill	✓	✓	✓		✓		✓
CSR_WA_000104 Former Hazardous Waste Store	✓	✓	✓			✓	✓
CSR_WA_000106 Sewage Treatment Plant and Effluent Discharge	✓	✓	✓	✓	✓		✓
CSR_WA_000107 Former Fire Training Area (1960s)	✓	✓	✓			✓	✓
CSR_WA_000109 Near Building 239 - Former Group of USTs	✓	✓	✓			✓	✓
CSR_WA_000110 Former Fuel Farm	✓	✓	✓		✓		✓
CSR_WA_000117 Former Service Station	✓	✓	✓			✓	✓
CSR_WA_000151 Grounds Maintenance Area	✓	✓	✓		✓		✓
CSR_WA_000153 Fire Training Area - Fire Station Centre of Base	✓	✓	✓		✓		✓
CSR_WA_000155 Fuel Storage Power Station	✓	✓	✓			✓	✓
CSR_WA_000156 Paint Shop	✓	✓	✓			✓	✓
CSR_WA_000160 Hangar 95	✓	✓	✓		✓		✓
PCSR_0967_002 AVTUR Fuel Farm	✓	✓	✓		✓		✓
PCSR_0967_003 Former 25 m Small Arms Range	✓	✓	✓		✓		✓
PCSR_0967_001 Aircraft Shelters	✓	✓	✓			✓	✓

8.2.3 Sediment trigger levels

Sediment assessment criteria have been selected from:

- ANZECC & ARMCANZ (2000). National water quality management strategy. Australian and New Zealand guidelines for fresh and marine water quality.
- Simpson and Batley (2016). *Sediment Quality Assessment, A Practical Guide, Second Edition*. CSIRO. Clayton South, Victoria

The Interim Sediment Quality Guideline (ISQG) presented by ANZECC & ARMCANZ (2000) are referenced and revised by Simpson and Batley (2016). The guidelines present two guideline concentrations for bioavailable contaminants in sediments, the soil quality guideline (SQG)-Low concentration and the SQG-High concentration. Below the SQG-Low concentration the frequency of adverse effects is expected to be very low. The SQG-High concentration represents a guideline above which adverse chronic biological effects to sensitive species may be expected to occur more frequently.

The application of these criteria requires the following procedure:

- Where bioavailable concentrations are less than SQG-Low, no action is required
- Where bioavailable concentrations are between the SQG-Low and SQG-High concentration, an assessment against background bioavailable metal concentrations should be made
- Where the bioavailable concentrations are found to exceed the SQG-High, then direct biota toxicity testing may be required and where contaminants are found to be toxic remediation may need to be conducted
- As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment guidelines as well as soil guidelines considered relevant for each CSR (refer to Section 8.2.1 – Soil Investigation Levels).

8.2.4 Surface water trigger values

As per the Department of Defence Water Quality Monitoring Manual (DoD 2016), site-specific trigger values for surface water assessment should be applied to flowing natural waterways, and are not applicable to standing water, water in drainage lines or stormwater runoff. Surface water samples collected during this investigation were collected from drainage lines only, and were not observed to be flowing due to the dry, post-summer conditions. The development of site-specific trigger levels was therefore not considered appropriate.

Considering the Ellen Brook and Ki-It Monger Brook as receptors of surface water draining from site, the following Tier 1 assessment criteria were determined for surface water samples:

- ANZECC & ARMCANZ (2000). National water quality management strategy. Australian and New Zealand guidelines for fresh and marine water quality.
- *Groundwater Investigation Levels GILs – Fresh Waters* to assess risks to aquatic ecosystems in slightly to moderately disturbed systems - 95% species protection level
- DER (2014) Assessment and management of contaminated sites: Contaminated sites guidelines
- *Non-potable groundwater use (NPUG)* – for recreational use of the Ellen Brook and Ki-It Monger Brook

8.3 Assessment criteria – 3TU

8.3.1 Soil Investigation Levels

8.3.1.1 Factors affecting Tier 1 criteria selection for soil quality

Land use scenario

As discussed in Section 2.2.2, 3TU is currently vacant and comprises remnant bushland and areas that have been cleared for grazing. In addition, certain areas of the property contain building rubble, concrete slabs, a former landfill, an asphalt stockpile, and general fly-tipped waste across the property.

It is understood that although there are no current re-development plans, it has been conservatively assumed that future land-uses may include rural agricultural, residential and public open space. It is also known that the public illegally access the property. Hence, Tier 1 criteria used to evaluate human health risks in this report are based on a low density residential and recreational/open space land use scenarios as well as commercial/industrial guidelines applicable to current site usage.

Soil type

As described in Section 3.3.2 and Section 9.1.1, soil beneath the property comprises Bassendean Sands in shallow soils (up to 5 m bgl). For the screening risk assessments presented in this report, a sand soil type has been selected as being most representative of site conditions.

8.3.1.2 Human health criteria – soil

Heavy metals, asbestos and other inorganic compounds

NEPM (2013) Schedule B (1). Guideline on Investigation Levels for Soil and Groundwater:

- *Health Investigation Level HIL-A* – for chronic exposure via direct contact pathways including dermal contact, ingestion and dust inhalation in a low density residential land use scenario.
- *Health Investigation Level HIL-C* – for chronic exposure via direct contact pathways including dermal contact, ingestion and dust inhalation in a recreational/open space land use scenario.

United States Environmental Protection Agency (May 2018) Regional Screening Levels:

- *Regional Screening Levels RSL - Soil: Residents* – for direct contact exposure pathway (TR=1x10-06, THQ=1.0) (USEPA 2018).

HILs are applicable to soil depths of up to 3 metres below ground level. HILs for low density residential (HIL-A) and recreational/open space land use scenarios were used for assessment at all CSRs at 3TU.

Where Australian-derived soil investigation levels were not available, alternative Tier 1 criteria were adopted from other regulatory jurisdictions and applied for screening purposes for the following parameters:

- BTEX
- PAHs
- Phenols
- VOCs

- Dioxins & furans
- Explosives residues

Petroleum hydrocarbon compounds

HSLs developed by CRC CARE for selected petroleum compounds and fractions published in NEPM (2013) were adopted (except for direct contact HSLs and intrusive maintenance workers HSLs, which were taken from CRC CARE (2011)) to assess human health risks to potentially sensitive receptors under low density residential and recreational/open space land-use scenarios via the following exposure pathways:

- *Soil HSL-Intrusive Maintenance Worker* – for chronic exposure of shallow trench worker (trench depth less than 1 m bgl) via direct contact pathways, including dermal contact, ingestion and dust inhalation
- *Soil HSL-A (direct contact) Low Density Residential* – for direct contact pathways, including dermal contact, ingestion and dust inhalation
- *Soil HSL-C (direct contact*) *Recreational/Open Space* – for direct contact pathways, including dermal contact, ingestion and dust inhalation
- *Soil HSL-A/B (vapour) Residential, sand soil type* – for chronic exposure via vapour intrusion pathways

Per- and poly-fluoroalkyl substances (PFAS)

HEPA (2018) PFAS National Environment Management Plan (NEMP):

- *Human Health Screening Values* for *Public Open Space* – for human exposure through direct contact pathways
- *Human Health Screening Values* for *Residential Accessible Soil* – for human exposure through direct contact pathways

Asbestos

Asbestos samples collected at 3TU were only tested for presence/absence, not %w/w given the infrequent occurrence of ACM. Hence, comparison to guidelines was not applicable.

8.3.1.3 Ecological criteria – soil

Heavy metals and inorganic compounds

NEPM (2013) Schedule B(1) Guideline on Investigation Levels for Soil and Groundwater:

- *Ecological Investigation Level EIL* – to assess risks to terrestrial ecosystems in urban residential or public open space settings

EILs are applicable to soil depths of up to 2 metres corresponding to the root-zone and habitation zone of many species. EILs are conservative because they have been developed on the basis of fast growing species under generic soil conditions, regardless of whether a particular species occurs at the property. Regional ABCs in combination with site-specific soil parameters can be used to calibrate EIL values to site-specific soil conditions using the following calculation:

EIL = ACL + ABC

where *ABC = Ambient Background Concentration*

ACL = Added Contaminant Limit

ACLs are dependent on pH, CEC and clay content of the soils. Soil samples were collected from the property and submitted for analysis of NEPM soil parameters to help derive site-specific EILs, as shown in Table 37.

Table 37 Summary of NEPM soil parameters (3TU)

CSR	Location ID	Depth (m bgl)	pH ($CaCl_2$ method)	CEC (meq/100g)	Clay content (%)
CSR_WA_000019	0965_BH104	0.5	4.0	0.3	3
	0965_BH104	1.0	5.3	0.1	3
	0965_BH104	2.0	5.8	0.3	3
	0965_BH105	0.1	7.2	10.6	4
	0965_BH105	0.5	7.4	5.1	3
	0965_BH105	1.0	7.4	3.0	3
	0965_BH106	0.1	7.4	8.5	3
	0965_BH106	1.0	7.4	3.1	3
	0965_BH106	2.0	6.4	0.1	2
CSR_WA_000103	0965_BH107	0.5	5.1	0.3	2
Average			6.3	3.1	2.9
Rounded average values[11]			6	3	3

In determining ABC values, it is relevant to note that the results of the desktop study and anecdotal information from Defence indicate that the entire property has potentially been used for training activities. Therefore, soil samples collected as part of this investigation were not considered to be representative of background conditions suitable for determining ABCs. A conservative approach was therefore adopted in which the ABC values were calculated based on the LOR for each metal. The LOR and rounded values adopted for calculating the EILs are detailed in Table 38.

Table 38 Summary of ABCs (3TU)

	Depth (m bgl)	Chromium (III+VI; mg/kg)	Copper (mg/kg)	Lead (mg/kg)	Nickel (mg/kg)	Zinc (mg/kg)
LOR	-	2	5	5	2	5
Rounded values[11]		2	5	5	2	5

The EILs calculated from the NEPC EIL calculation spreadsheet (using the LOR as the ABC concentration) are presented Table 39 and have been used to evaluate the contamination status of all CSR locations at RAAF Base Pearce. A summary of the soil assessment criteria applied to each CSR is provided in Table 35.

Table 39 Site-specific EILs (3TU)

Contaminant of potential concern	3TU rounded EILs[11] (mg/kg)	
	Urban residential/ public open space	Areas of ecological significance
Chromium III	250	80
Copper	100	35
Nickel	30	7
Lead	1100	480
Zinc	240	55

[11] Rounding applied according to *ASC NEPM* rounding rules

Petroleum hydrocarbon compounds

NEPM (2013) Schedule B (1). Guideline on Investigation Levels for Soil and Groundwater:

- *Ecological Screening Levels ESL Areas of Ecological Significance, Coarse soil type* – ecological risk screening criteria for the protection of terrestrial ecosystems in areas of ecological significance
- *Ecological Screening Levels ESL Urban Residential, Coarse soil type* – ecological risk screening criteria for the protection of terrestrial ecosystems in urban residential settings

ESLs are applicable to soil depth of up 2 metres and have been developed for TRH fractions, BTEX and BaP compounds. For assessment purposes, the ESLs for areas of ecological significance and an urban residential end use (assuming coarse soil type) were applied to all CSRs at 3TU.

PFAS

HEPA (2018) PFAS NEMP:

- *Ecological Values* for *Public Open Space (Direct Exposure)* – to assess the possibility of harm to plants and soil organisms through direct exposure pathways
- *Ecological Values* for *Residential (Indirect Exposure)* – to assess the possibility of harm to plants and soil organisms through indirect exposure pathways, including bioaccumulation and off-site transport

8.3.2 Groundwater investigation levels (GILs)

8.3.2.1 Factors affecting Tier 1 criteria selection for water quality

Property use

As described in Section 2.2.2, 3TU is currently vacant and comprises remnant bushland and areas that have been cleared for grazing. In addition, certain areas of the property contain building rubble, concrete slabs, a former landfill, an asphalt stockpile, and general fly-tipped waste across the property.

For the purpose of groundwater assessment criteria evaluation, it has been conservatively assumed that future land-uses may include rural agricultural, residential and public open space.

Groundwater use

A number of groundwater abstraction bores are located within the property boundaries. Based on information from the WIR database (DWER 2018c) it is understood that the majority are owned by private owners or the DoW (now DWER). As described in Section 3.5.4, results of a water-use survey conducted as part of GHD's PFAS investigation works (GHD 2018b) indicate that use of groundwater surrounding the property (particularly in West Bullsbrook) is extensive and comprises:

- Drinking water
- Domestic/household uses
- Irrigation of paddocks, vegetable gardens and fruit trees
- Commercial businesses/local growers
- Drinking water for chickens, pets (including rescue dogs), grazing horses, cattle and sheep.

In addition, more than 20 groundwater licences are present to the east (down-hydraulic gradient) of the property boundary. The potential therefore exists for domestic and commercial-scale use of groundwater for the above mentioned purposes to occur.

Groundwater depth

As described in Section 3.5.1 and Section 9.2.1, groundwater beneath the property is typically shallow and ranges between 0 and 5 m bgl across the property. As a conservative measure, for groundwater assessment criteria evaluation, a groundwater depth of 2 to less than 4 m bgl was adopted across the whole property (adopted from NEPM 2013).

Soil type

- As described in Section 3.3.2 and Section 9.1.1, soil beneath the property comprises Bassendean Sands in shallow soils (up to 5 m bgl). For the vapour intrusion screening risk assessment presented in this report, the soil type 'sand' was therefore adopted for comparison against assessment criteria.

Environmental status of the Ellen Brook – Upper Swan catchment (surface water receiving body)

The primary surface water receiving environment for the property is the Ellen Brook, located approximately three kilometres east (down-gradient) of the property. The Brook receives surface water run-off from 3TU, the RAAF Base as well as surrounding areas, where a range of commercial/industrial activities occur. Furthermore, much of the Ellen Brook catchment has been cleared for agriculture, and monitoring conducted has identified nutrient concentrations within surface water of the Brook in excess of their nominated target levels (Department of Water and Swan River Trust 2011). It is therefore considered appropriate to categorise the Ellen Brook as a 'slightly to moderately disturbed' system.

8.3.2.2 Human health criteria – groundwater

- NHMRC & NRMMC (2017) Australian Drinking Water Guidelines
  - *Guideline values for physical and chemical characteristics – Aesthetic*
  - *Guideline values for physical and chemical characteristics – Health*
- NHMRC (2008) Guidelines for managing risks in recreational waters
  - *Non-potable Groundwater Use (NPUG)*
- Department of Health (DoH 2011) Guidelines for the Non-potable Uses of Recycled Water in Western Australia
  - *Microbiological assessment levels, urban recreational areas, open spaces, parks and gardens* – for the assessment of municipal use with some restricted access and application
- CRC CARE Technical Report No. 10 (2011) Health Screening Levels for Petroleum Hydrocarbons in Soil and Groundwater
- NEPM (2013) Schedule B(1) - Guideline on Investigation Levels for Soil and Groundwater
  - *Groundwater HSL-A/B Residential, sand soil type, groundwater depth 2 - <4 m* - for the assessment of vapour intrusion risks to potential future residential tenants
  - *Groundwater HSL-C Public Open Spaces, sand soil type, groundwater depth 2 - <4 m* - for the assessment of vapour intrusion risks to potential future public open space users
- ANZECC & ARMCANZ (2000). National water quality management strategy. Australian and New Zealand guidelines for fresh water, marine water and livestock drinking water quality
- *Irrigation – Long term trigger values* – for the maximum concentration of contaminant in the irrigation water which can be tolerated assuming 100 years of irrigation

- *Irrigation – Short term trigger values* – for the maximum concentration of contaminant in the irrigation water which can be tolerated for a shorter period (20 years) of irrigation
- *Stock Watering – livestock drinking water quality* – for the assessment of the suitability of waters for livestock consumption

Per- and poly-fluoroalkyl substances (PFAS)

HEPA (2018) PFAS National Environment Management Plan (NEMP):

- *Health-based guidance values for Drinking water*
- *Health-based guidance values for Recreational water*

8.3.2.3 Ecological criteria - groundwater

ANZECC & ARMCANZ (2000). National water quality management strategy. Australian and New Zealand guidelines for fresh and marine water quality.

NEPM (2013) Schedule B (1). Guideline on Investigation Levels for Soil and Groundwater

- *Groundwater Investigation Levels GILs – Fresh Waters* to assess risks to aquatic ecosystems in slightly to moderately disturbed systems – 95 % species protection level

PFAS

HEPA (2018) PFAS NEMP:

- *Ecological Values for Aquatic ecosystems* to assess freshwater 95 % species protection – slightly to moderately disturbed systems
- *Ecological Values for Aquatic ecosystems* to assess freshwater 99 % species protection – slightly disturbed systems as a conservative measure at the property boundary

8.3.3 Sediment trigger levels

Sediment assessment criteria have been selected from:

- ANZECC & ARMCANZ (2000). National water quality management strategy. Australian and New Zealand guidelines for fresh and marine water quality.
- Simpson and Batley (2016). *Sediment Quality Assessment, A Practical Guide, Second Edition*. CSIRO. Clayton South, Victoria

The Interim Sediment Quality Guideline (ISQG) presented by ANZECC & ARMCANZ (2000) are referenced and revised by

Simpson and Batley (2016). The guidelines present two guideline concentrations for bioavailable contaminants in sediments, the soil quality guideline (SQG)-Low concentration and the SQG-High concentration. Below the SQG-Low concentration the frequency of adverse effects is expected to be very low. The SQG-High concentration represents a guideline above which adverse chronic biological effects to sensitive species may be expected to occur more frequently.

The application of these criteria requires the following procedure:

- Where bioavailable concentrations are less than SQG-Low, no action is required
- Where bioavailable concentrations are between the SQG-Low and SQG-High concentration, an assessment against background bioavailable metal concentrations should be made

- Where the bioavailable concentrations are found to exceed the SQG-High, then direct biota toxicity testing may be required and where contaminants are found to be toxic remediation may need to be conducted
- As sediment samples were generally collected from dry surface water drainage channels they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment guidelines as well as soil guidelines considered relevant for each CSR (refer to Section 8.3.1– Soil Investigation Levels).

PFAS

HEPA (2018) PFAS NEMP:

- *Ecological Values* for *Public Open Space (Direct Exposure)* – to assess the possibility of harm to plants and soil organisms through direct exposure pathways
- *Ecological Values* for *Residential (Indirect Exposure)* – to assess the possibility of harm to plants and soil organisms through indirect exposure pathways, including bioaccumulation and off-site transport

8.3.4 Surface water trigger values

As per the Department of Defence Water Quality Monitoring Manual (DoD 2016), site-specific trigger values for surface water assessment should be applied to flowing natural waterways, and are not applicable to standing water, water in drainage lines or stormwater runoff. Surface water samples collected during this investigation were collected from drainage lines only, and were not observed to be flowing due to the dry, post-summer conditions. The development of site-specific trigger levels was therefore not considered appropriate.

Considering the Ellen Brook and Ki-it Monger Brook as receptors of surface water draining from site, the following Tier 1 assessment criteria were determined for surface water samples:

- ANZECC & ARMCANZ (2000). National water quality management strategy. Australian and New Zealand guidelines for fresh and marine water quality.
- *Groundwater Investigation Levels GILs – Fresh Waters* to assess risks to aquatic ecosystems in slightly to moderately disturbed systems – 95 % species protection level
- DER (2014) Assessment and management of contaminated sites: Contaminated sites guidelines
- *Non-potable groundwater use (NPUG)* – for recreational use of the Ellen Brook and Ki-It Monger Brook.

PFAS

HEPA (2018) PFAS NEMP:

- *Ecological Values for Aquatic ecosystems* to assess freshwater 95 % species protection – slightly to moderately disturbed systems
- *Ecological Values for Aquatic ecosystems* to assess freshwater 99 % species protection – slightly disturbed systems as a conservative measure at the property boundary.

9. Field observations

9.1 Soil

9.1.1 Property specific lithology

General lithologies encountered during the soil investigations undertaken at select CSR/PCSRs as part of the Stage 2 DSI (Mobilisation 1 and Mobilisation 2) are summarised in Table 40 and illustrated on the soil bore logs presented in Appendix I.

Table 40 General Lithology Encountered

CSR/PCSR	Location ID	General Lithology Encountered
RAAF Base Pearce (0967)		
CSR_WA_000024 Fuel Storage NE of Building 72	0967_MW068 0967_MW070 0967_MW141 0967_MW252S 0967_MW253S 0967_MW254S 0967_MW255P 0967_MW255S	The geology encountered at the Fuel Storage NE of Building 72, generally consisted of various lenses of dense clayey sand. At a depth of 6 to 7 m bgl, a clayey sand layer was encountered, consisting of fine to coarse-grained sand.
CSR_WA_000083 Dog Compound -Buried Waste	0967_BH301 to 0967_BH313 0967_BH377 to 0967_BH380	In the Dog Compound, the geology encountered from the surface to approximately 1.5 m bgl generally consisted of sand and clayey sand, fine to medium-grained, well graded. The deeper portion of the soil profile from approximately 1.5 to 2 m bgl generally consisted of clay with trace sand, low to medium plasticity, fine-to coarse-grained.
CSR_WA_000087 Fuel Storage ILS 18 Glidepath	0967_BH330 to 0967_BH332	The geology encountered at the ILS glidepath generally consisted of firm to very stiff sandy clay to a depth of 2 m bgl.
CSR_WA_000088 Fuel Storage ILS 18	0967_BH333 to 0967_BH335	The geology encountered at the ILS 18 generally consisted of firm to stiff sandy clay to a depth of 2 m bgl.
CSR_WA_000104 Former Hazardous Waste Store	0967_MW231 0967_BH314 – 0967_BH317	The geology encountered at the Former Hazardous Waste Store generally consisted of firm to stiff sandy clay with medium to high plasticity to a depth of 12 m bgl.
CSR_WA_000106 Sewage Treatment Plant Discharge Effluent	0967_MW223 0967_MW224	The geology encountered at the Sewage Treatment Plant Discharge Effluent generally consisted of various lenses of dense clayey sand. This clayey sand layer was often interspersed by sandy clay with medium to high plasticity. At a depth of 8 m bgl, a sand-rich layer was encountered, consisting of fine-to medium-grained, well graded, loose sand.
CSR_WA_000107 Former Fire Training Area – 1960'2	0967_MW238 0967_BH326 to 0967_BH329	In the former Fire Training Area, the geology encountered generally consisted of very stiff sandy clay, with low to medium plasticity. A sandy layer was encountered underlying the clay at approximately 15 m bgl.
CSR_WA_000109 Former USTS 240 – 245 (near Building 239)	0967_MW236 0967_MW237	In the former UST area the geology encountered generally consisted of stiff to hard sandy clay with low to medium plasticity to a depth of approximately 18 m bgl. Thin layers containing more sandy material were encountered around 16 to 18 m bgl.

CSR/PCSR	Location ID	General Lithology Encountered
CSR_WA_000110 Former Fuel Farm	0967_MW227P 0967_MW227S 0967_MW228P 0967_MW228S 0967_MW229P 0967_MW229S 0967_MW230P 0967_MW230S	In the Former Fuel Farm area, the geology encountered from surface generally consisted of various lenses of dense clayey sand and firm to hard sandy clay. The distribution of these lenses was variable across the area. Underlying the clays, typically at a depth of 15 to 17 m bgl, a sand-rich layer was encountered, consisting of medium-grained, well graded, loose sand. At some locations, shallow wells were installed where lenses of sandy material were encountered at shallower depths and indicated the presence of perched groundwater.
CSR_WA_000117 Former Service Station	0967_MW232P 0967_MW232S 0967_MW233P 0967_MW233S 0967_MW234P 0967_MW234S 0967_MW235P 0967_MW235S 0967_MW242 0967_BH318 to 0967_BH323 0967_MW226 0967_MW240	In the Former Service Station area, the geology encountered generally consisted of a red, stiff to hard sandy/silty clay layer to a depth of approximately 15 m bgl. This hard clay layer was often interspersed by thin lenses of dense clayey sand. Underlying the clay, a loose clayey sand layer was encountered, with medium-to coarse-grained, angular sand.
CSR_WA_000151 Grounds Maintenance Area	0967_MW243 0967_MW244 0967_MW245 0967_BH336 to 0967_BH348	In the Grounds Maintenance Area the geology encountered generally consisted of various lenses of medium-dense clayey sand and firm to hard sandy clay to a depth of approximately 13 m bgl. Below this a layer of clayey sand was encountered to approximately 18 m bgl.
CSR_WA_000155 Power Station USTs	0967_BH324 0967_BH325	The geology encountered to a depth of 4 m bgl near the Power Station USTs generally consisted of very stiff sandy clay, with low to medium plasticity and traces of fine gravel.
CSR_WA_000156 Paint Shop	0967_MW239	In the Paint Shop area the geology encountered generally consisted of various lenses of dense clayey sand and firm to hard sandy clay to 15 m. Below this, the clay layer was underlain by a loose sand layer.
CSR_WA_000160 Hangar 95	0967_MW246 0967_MW247 0967_MW248	At Hangar 95, the geology encountered generally consisted of interchanging lenses of sandy clay, fine to medium-grained, of low plasticity, and clayey sand well graded, fine- to medium-grained. Gravel intrusions were observed throughout the soil profile.

CSR/PCSR	Location ID	General Lithology Encountered
PCSR_0967_001 Aircraft Shelters	0967_BH381 0967_BH382 0967_BH383 0967_BH384 0967_BH385 0967_MW249 0967_MW250 0967_MW251	At the Aircraft Shelters, the geology encountered generally consisted of firm to stiff sandy clay, with low to medium plasticity and traces of fine to medium gravel.
PCSR_0967_002 New AVTUR Fuel Farm (DFI)	0967_BH349 to 0967_BH351	In the New AVTUR Fuel Farm, the soil was investigated to a depth of 2 m bgl. The geology generally consisted of a layer of coarse gravel fill overlying loose sand (fill), followed by a stiff layer of sandy clay/clayey sand.
PCSR_0967_003 Former 25 m Small Arms Range	0967_MW241 0967_BH352 to 0967_BH367	At the Former 25 m Small Arms Range, the geology encountered generally consisted of approximately 0.5 m of sand overlying firm to stiff sandy clay to a depth of 16.5 m bgl.
3TU		
CSR_WA_000019 Septic Tanks – Sewage Disposal	0965_MW104 0965_BH104 to 0965_BH106	The geology encountered up to 6 m bgl generally consisted of sand, medium-grained, well-graded, dark grey to pale grey/white with depth.
CSR_WA_000080 Incinerator (North of 3TU Workshop)	0965_MW102 0965_BH101 to 0965_BH103	The geology encountered up to 5 m bgl generally consisted of sand, fine- to medium-grained, poorly-graded, brown grading to grey and white with depth.
CSR_WA_000103 South of Former Building 58 – 2 x Diesel A/USTs	0965_MW101 0965_MW103 0965_BH107 to 0965_BH111	The geology encountered up to 5 m bgl generally consisted of brown-grey sand, medium-grained, well graded. A layer of gravel was encountered between 3 to 5 m bgl at 0965_MW101 in the eastern portion of the property.
PCSR_0965_001 Former Fire Extinguisher Training Area	0965_BH118 0965_BH119 0965_BH120 0965_BH121 0965_BH122 0965_BH123 0965_BH124 0965_BH125 0965_MW105 0965_MW106 0965_MW107	In the Former Fire Extinguisher Training Area the geology encountered up to 2 m bgl generally consisted of dark grey to pale white sand, medium- to coarse-grained, well graded.
PCSR_0965_002 Asphalt Stockpile Area	0965_BH112 to 0965_BH117	Below the layer of asphalt and in the surrounding area, the geology encountered generally consisted of pale grey/white to brown sand, fine- to medium-grained, poorly graded.

9.1.2 Visual and olfactory indicators

Visual and olfactory observations in soil recorded at each CSR/PCSR investigated during Mobilisation 1 (2018) and Mobilisation 2 (2019) are summarised in Table 41.

Table 41 Summary of soil visual and olfactory indicators/observations

CSR/PCSR	Olfactory indicators	Visual observations
RAAF Base Pearce (0967)		
CSR_WA_000024 Fuel Storage NE of Building 72	No discernible odour	No visible signs of impact
CSR_WA_000083 Dog Compound - Buried Waste	No discernible odour	No visible signs of impact
CSR_WA_000087 Fuel Storage ILS 18 Glidepath	No discernible odour	No visible signs of impact
CSR_WA_000088 Fuel Storage ILS 18	No discernible odour	No visible signs of impact
CSR_WA_000104 Former Hazardous Waste Store	No discernible odour	No visible signs of impact
CSR_WA_000106 Sewage Treatment Plant Discharge Effluent	No discernible odour	No visible signs of impact
CSR_WA_000107 Former Fire Training Area – 1960s	No discernible odour	No visible signs of impact
CSR_WA_000109 Former USTS 240 – 245 (near Building 239)	No discernible odour	No visible signs of impact
CSR_WA_000110 Former Fuel Farm	0967_MW228D – Distinct hydrocarbon odour from 0.1 – 6.0 m bgl 0967_MW228S - Distinct hydrocarbon odour from 1.5 – 6.0 m bgl 0967_MW229D - Weak to distinct hydrocarbon odour from 2 - 6.0 m bgl 0967_MW229S - Weak hydrocarbon odour from 0 – 3 m bgl and 3 – 6.0 m bgl 0967_MW230D - Distinct hydrocarbon odour from 0 – 2.0 m bgl and sweet odour from 2.0 – 3.0 m bgl 0967_MW230S - Weak to distinct hydrocarbon odour 0 – 6.0 m bgl	0967_MW228D – Hydrocarbon staining from 0.1 – 6.0 m bgl 0967_MW228S – Iron oxide staining from 1.5 – 6 m bgl 0967_MW229D – Hydrocarbon staining from 2 – 6 m bgl 0967_MW229S – Hydrocarbon staining from 0 – 3.0 m bgl 0967_MW230D – Hydrocarbon staining from 0 – 2.0 m bgl. Iron oxide staining 14.5 – 15 m bgl 0967_MW230S – Hydrocarbon staining from 0 – 3.0 m bgl
CSR_WA_000117 Former Service Station	0967_MW242 - Very strong hydrocarbon odour and staining from 3 – 6.0 m bgl 0967_BH318 - Distinct hydrocarbon odour from 4.3 – 5.0 m bgl 0967_BH320 - Strong hydrocarbon odour from 3 – 5.0 m bgl	0967_MW242 – Hydrocarbon staining from 3 – 6.0 m bgl 0967_BH318 – Hydrocarbon staining from 4.3 – 4.5 m bgl 0967_BH320 - Hydrocarbon staining from 3 – 5.0 m bgl

CSR/PCSR	Olfactory indicators	Visual observations
CSR_WA_000151 Grounds Maintenance Area	No discernible odour	0967_MW243 - Iron oxide staining between 0.5 – 1.5 m bgl and 4.5 – 14.5 m bgl 0967_MW244 - Iron oxide staining between 1.5 – 7.0 m bgl and 11.5 – 18.0 m bgl 0967_MW245 - Iron oxide staining between 1 – 3.0 m bgl, 4.5 – 5.5 m bgl and 6 – 13.0 m bgl
CSR_WA_000155 Power Station USTs	No discernible odour	No visible signs of impact
CSR_WA_000156 Paint Shop	No discernible odour	No visible signs of impact
CSR_WA_000160 Hangar 95	No discernible odour	No visible signs of impact
PCSR_0967_001 Aircraft Shelters	No discernible odour	0967_MW249 – Iron oxide staining between 5 – 12 m bgl
PCSR_0967_002 New AVTUR Fuel Farm (DFI)	0967_BH350 - Distinct hydrocarbon odour between 0.2 – 0.3 m bgl	No visible signs of impact
PCSR_0967_003 Former 25 m Small Arms Range	No discernible odour	0967_BH355 - Bullet casing observed at 0.3 m depth. General evidence of weathered small arms bullets and bullet fragments across bullet catcher
3TU		
CSR_WA_000019 Septic Tanks – Sewage Disposal	No discernible odour	No visible signs of impact
CSR_WA_000080 Incinerator (North of 3TU Workshop)	No discernible odour	No visible signs of impact
CSR_WA_000103 South of Former Building 58 – 2 x Diesel A/USTs	0965_MW101 - Very weak hydrocarbon odour between 5 – 6 m bgl 0965_MW103 - Distinct hydrocarbon odour between 3 – 4.5 m bgl, weak hydrocarbon odour from 4.5 – 5 m bgl	0965_MW103 – Hydrocarbon staining between 3 – 4.5 m bgl, iron oxide staining between 5-5.5 m bgl 0965_MW103 - 3 potential ACM fragments at surface
PCSR_0965_001 Fire Extinguisher Training Area	No discernible odour	No visible signs of impact
PCSR_0965_002 Asphalt Stockpile Area	0965_BH112 - Weak organic odour between 0 -2.0 m bgl 0965_BH113 - Weak organic odour between 0 – 0.2 m bgl	No visible signs of impact

9.2 Groundwater

9.2.1 Groundwater levels and flow direction

RAAF Base Pearce

Based on the results of historical investigations, including the PFAS Stage 2 DSI (GHD 2018b), GHD has adopted the following terminology to describe the hydrogeology at RAAF Base Pearce:

- ‘Perched aquifer’ refers to seasonal unconfined, discontinuous groundwater held above the water table by a layer of impermeable material (e.g. clay), present within localised areas.
- ‘Regional aquifer’ refers to the superficial aquifer that is present through the property, as described in Section 3.5. This aquifer is considered to be the likely source of groundwater used by the community in the area surrounding the Base.

All groundwater monitoring wells were gauged prior to sampling using an oil/water interface probe. Groundwater gauging and sampling was undertaken during Mobilisation 1 (between 26 March and 9 May 2018) and Mobilisation 2 (1 through 14 April 2019). Based on the recorded depths and top-of-well casing survey data, groundwater levels were calculated relative to m AHD. Groundwater depth and elevations for each monitoring well are presented in Appendix J.

Groundwater monitoring wells on the property target both the perched and regional aquifers. Monitoring well construction details (including those installed during previous investigations where available) are presented in Appendix K.

Perched aquifer

A total of 27 wells were sampled across the property targeting the perched aquifer (approximate well depth ranging from 2 to 8 m bgl). Groundwater levels across this aquifer ranged from 0.48 to 7.56 m bgl (34.83 to 50.837 m AHD) and were very consistent between the first and second mobilisation. Interpolated groundwater contours were plotted based on data obtained from well gauging and survey data, indicating that groundwater in the perched aquifer is generally migrating to the west towards the Ellen Brook. However, as the perched aquifer is known to be discontinuous, it is not considered that there is a hydraulic connection to the Ellen Brook. Groundwater elevations are presented in Figure 11A and Figure 11B. The perched groundwater elevations have not been contoured as the perched groundwater is a discontinuous system.

Regional aquifer

A total of 46 wells were sampled across the property targeting the regional aquifer (approximate well depth ranging from 12 to 25 m bgl). Groundwater levels across this aquifer ranged from 1.21 to 16.66 m Below Top of Casing (btoc) (33.40 to 44.87 m AHD during mobilisation 1, and 32.64 to 40.14 m AHD during mobilisation 2). It should be noted that in some instances groundwater was encountered in a confined system (i.e. under pressure) resulting in higher water levels following installation of the monitoring well (in particular in the northern portion of the property, e.g. groundwater dipped at 1.21 to 2.66 m btoc at 0967_MW142, 0967_MW231 and 0967_MW241). Interpolated groundwater contours were plotted based on the data obtained from well gauging and survey data in the investigation area, and are presented in Figure 10A and Figure 10B. Although the current area of investigation does not cover the entire property, the contours are generally consistent with those previously published (GHD 2018b – refer to Section 3.5.1).

The groundwater contours indicate that beneath the majority of the property, groundwater is generally flowing in a south-westerly direction towards the Ellen Brook. Within the south-eastern portion of the property, the groundwater generally flows in a more south to south-easterly direction towards the Ki-It Monger Brook.

3TU

Groundwater levels were measured at eight monitoring wells across the property during mobilisation 1 and ranged from 2.07 to 3.87 m btoc (50.02 to 52.79 m AHD). During mobilisation 2, 11 monitoring wells were included in the groundwater monitoring program and elevation ranged from 49.98 to 60.86 m AHD. Interpolated groundwater contours plotted from 2018 well gauging data indicated a south-easterly groundwater flow direction, with groundwater generally migrating towards the Ellen Brook. Interpolated groundwater contours including additional monitoring wells from mobilisation 2 are presented in Figure 12 and indicate an easterly flow direction. This is generally consistent with regional groundwater mapping (refer to Section 3.5.1).

9.2.2 Visual and olfactory observations

Visual and olfactory observations in groundwater from the most recent sampling event for each CSR are summarised in Table 42. Complete results from both mobilisations are included in Appendix J.

Table 42 Summary of groundwater visual and olfactory observations

CSR	Olfactory indicators	Visual observations
RAAF Base Pearce (0967)		
CSR_WA_000024 Fuel Storage NE of Building 72 April 2019	0967_MW068 – No discernible odour 0967_MW070 – light hydrocarbon odour 0967_MW141 – no discernible odour 0967_MW252S – no discernible odour 0967_MW253S – slight hydrocarbon odour 0967_MW254S – no discernible odour 0967_MW255P – no discernible odour 0967_MW255S – no discernible odour	0967_MW068 – no sheen observed 0967_MW070 – clear light grey, no sheen observed, low sediment load 0967_MW141 – moderate sediment load, slight sheen 0967_MW252S – no sheen observed 0967_MW253S – no sheen observed 0967_MW254S – no sheen observed 0967_MW255P – no sheen observed 0967_MW255S – no sheen observed
CSR_WA_000083 Dog Compound - Buried Waste April 2019	0967_MW149 – no discernible odour detected	0967_MW149 – no sheen observed noted
CSR_WA_000084 Sounness Road Landfill April 2018	0967_MW201 – slight sulphurous odour noted	None recorded
CSR_WA_000104 Former Hazardous Waste Store April 2018	0967_MW231 – strong hydrocarbon odour	0967_MW231 – black, no sheen observed
CSR_WA_000106 Sewage Treatment Plant Discharge Effluent April 2019	0967_MW024 – moderate organic odour 0967_MW142 – no discernible odour 0967_MW218 – no discernible odour 0967_MW219 – no discernible odour 0967_MW221 – no discernible odour 0967_MW222 – no discernible odour 0967_MW223 – no discernible odour 0967_MW224 – no discernible odour 0967_MW225 – slight organic odour	0967_MW024 – no sheen observed 0967_MW142 – no sheen observed 0967_MW218 – no sheen observed 0967_MW219 – no sheen observed 0967_MW221 – no sheen observed 0967_MW222 – no sheen observed 0967_MW223 – no sheen observed 0967_MW224 – no sheen observed 0967_MW225 – no sheen observed
CSR_WA_000107 Former Fire Training Area – 1960s April 2019	0967_MW103 – no discernible odour 0967_MW117 – no discernible odour 0967_MW238 – no discernible odour	0967_MW103 – no sheen observed 0967_MW117 – no sheen observed 0967_MW238 – no sheen observed

CSR	Olfactory indicators	Visual observations
CSR_WA_000109 Former USTS 240 – 245 (near Building 239) April to May 2018	None recorded	None recorded
CSR_WA_000110 Former Fuel Farm April 2019	0967_MW144 – no discernible odour 0967_MW151S – no discernible odour 0967_MW151P – no discernible odour 0967_MW153S – no discernible odour 0967_MW154P – no discernible odour 0967_MW155 – no discernible odour 0967_MW156 – no discernible odour 0967_MW157 – no discernible odour 0967_MW227P – no discernible odour 0967_MW227S – no discernible odour 0967_MW228P – slight hydrocarbon odour 0967_MW228S – no discernible odour 0967_MW229P – slight hydrocarbon odour 0967_MW229S – slight hydrocarbon odour 0967_MW230P – no discernible odour 0967_MW230S – no discernible odour	0967_MW144 – no sheen observed 0967_MW151S – no sheen observed 0967_MW151P – no sheen observed 0967_MW153S – no sheen observed 0967_MW154P – no sheen observed 0967_MW155 – no sheen observed 0967_MW156 – no sheen observed 0967_MW157 – no sheen observed 0967_MW227P – no sheen observed 0967_MW227S – slight sheen observed 0967_MW227S – no sheen observed 0967_MW228P – no sheen observed 0967_MW228S – no sheen observed 0967_MW229P – pale orange/yellow, no sheen observed 0967_MW229S – no sheen observed 0967_MW230P – no sheen observed 0967_MW230S – no sheen observed
CSR_WA_000117 Former Service Station April 2019	0967_MW226 – no discernible odour 0967_MW232D – moderate sulphurous odour 0967_MW232S – no discernible odour 0967_MW232P – no discernible odour 0967_MW233D - strong sulphurous/hydrocarbon odour 0967_MW233S – no discernible odour 0967_MW234D –slight sulfurous/hydrocarbon odour 0967_MW234S –no discernible odour 0967_MW235S – no discernible odour 0967_MW240 – no discernible odour 0967_MW242 – moderate hydrocarbon odour	0967_MW226 – no sheen observed 0967_MW232D – grey, moderate sheen observed 0967_MW232S – no sheen observed 0967_MW232P – no sheen observed 0967_MW233D – grey, no sheen observed 0967_MW233S – no sheen observed 0967_MW234S –no sheen observed 0967_MW235S – no sheen observed 0967_MW240 – no sheen observed 0967_MW242 – grey, slight sheen

CSR	Olfactory indicators	Visual observations
CSR_WA_000151 Grounds Maintenance Area April 2019	0967_MW112 – no discernible odour 0967_MW113 – No discernible odour 0967_MW243 – no discernible odour 0967_MW244 – no discernible odour 0967_MW245 – no discernible odour	0967_MW112 – no sheen observed 0967_MW113 – no sheen observed 0967_MW243 – no sheen observed 0967_MW245 – no sheen observed 0967_MW244 – no sheen observed
CSR_WA_000155 Power Station USTs April 2018	None recorded	None recorded
CSR_WA_000156 Paint Shop April 2018	0967_MW016 – slight hydrocarbon odour	0967_MW016 – black, slight sheen, lots of particulate matter observed 0967_MW017 – slight sheen observed
CSR_WA_000160 Hangar 95 April 2019	0967_MW076 – no discernible odour 0967_MW077 – no discernible odour 0967_MW246 – no discernible odour 0967_MW247 – no discernible odour 0967_MW248 – no discernible odour	0967_MW076 – no sheen observed 0967_MW077 – no sheen observed 0967_MW246 – no sheen observed 0967_MW247 – no sheen observed 0967_MW248 – no sheen observed
PCSR_0967_001 Aircraft Shelters April 2019	0967_MW249 – no discernible odour 0967_MW250 – no discernible odour 0967_MW251 – no discernible odour	0967_MW249 – no sheen observed 0967_MW250 – no sheen observed 0967_MW251 – no sheen observed
PCSR_0967_002 New AVTUR Fuel Farm (DFI) April 2019	0967_MW158 – no discernible odour 0967_MW161 – no discernible odour 0967_MW162 – no discernible odour 0967_MW164 – low hydrocarbon odour 0967_MW165 – no discernible odour	0967_MW161 – no sheen observed 0967_MW162 – no sheen observed 0967_MW164 – grey, medium sediment load, no sheen observed 0967_MW165 – no sheen observed
PCSR_0967_003 Former 25 m Small Arms Range April 2018	0967_MW241 – slight sulphurous odour noted	None recorded
3TU (0965)		
CSR_WA_000019 Septic Tanks – Sewage Disposal April 2019	0965_MW104 – no discernible odour	0965_MW104 – no sheen observed

CSR	Olfactory indicators	Visual observations
CSR_WA_000080 Incinerator (North of 3TU Workshop) April 2019	0965_MW102 – no discernible odour detected	0965_MW102 – no sheen observed
CSR_WA_000081 South of 3TU – Buried Waste Metals April 2019	0965_MW001 – no discernible odour	0965_MW001 – no sheen observed
CSR_WA_000103 South of Former Building 58 – 2 x Diesel A/USTs April 2019	0965_MW101 – metallic odour 0965_MW103 – metallic odour	0965_MW101 – no sheen observed 0965_MW103 – no sheen observed
PCSR_0965_001 Fire extinguisher training area April 2019	0965_MW105 – no discernible odour 0965_MW106 - no discernible odour 0965_MW107 - no discernible odour	0965_MW105 – no sheen observed 0965_MW106 - no sheen observed 0965_MW107 - no sheen observed

9.2.3 Field water quality parameters

Field water quality parameters from the most recent monitoring event conducted at each CSR and summarised post-purge are presented in Table 43. Groundwater monitoring field records are provided in Appendix J.

Table 43 Field water quality parameters

CSR	Water quality parameter	Range
RAAF Base Pearce (0967)		
CSR_WA_000024 Fuel Storage NE of Building 72 April 2019	pH	5.34 – 6.86 (slightly acidic)
	EC (µS/cm)	995 – 3861
	Dissolved oxygen (DO, mg/L)	0.91 – 2.38 (generally aerobic)
	Redox (mV)	-71.3 – 158.9 (reducing to oxidising)
	Temperature (°C)	23.2 – 28.8
	TDS (mg/L)[12]	624 – 2600 (marginal to brackish)
CSR_WA_000083 Dog Compound - Buried Waste April 2019	pH	6.42 – 11.23 (slightly acidic to alkaline)
	EC (µS/cm)	2033 – 3776
	DO (mg/L)	0.29 – 1.3 (generally aerobic)
	Redox (mV)	-2.9 – 39.4 (slightly oxidising)
	Temperature (°C)	23.8 – 24.1
	TDS (mg/L) [12]	1352 – 2496 (brackish)
CSR_WA_000084 Sounness Road Landfill April 2018	pH	4.76 – 6.31 (generally acidic)
	EC (µS/cm)	370.8 – 2530
	DO (mg/L)	0.6 – 3.85 (generally aerobic)
	Redox (mV)	-79.4 – 128.5 (slightly reducing to oxidising)
	Temperature (°C)	22.4 – 24.3
	TDS (mg/L) [12]	247.65 – 1664 (fresh to brackish)
CSR_WA_000104 Former Hazardous Waste Store April 2018	pH	4.97 – 7.53 (acidic to neutral)
	EC (µS/cm)	816 - 1092
	DO (mg/L)	0 – 0.35 (anaerobic to slightly aerobic)
	Redox (mV)	-326.6 – 49.5 (strongly reducing to slightly oxidising)
	Temperature (°C)	24.2 – 27
	TDS (mg/L) [12]	513.5 – 721.5 (marginal)
CSR_WA_000106 Sewage Treatment Plant Discharge Effluent April 2019	pH	5.26 – 6.39 (generally acidic)
	EC (µS/cm)	351.4 – 3275
	DO (mg/L)	0.24 – 2.83 (generally aerobic)
	Redox (mV)	65.6 – 147.6 (oxidising)
	Temperature (°C)	21.9 – 25.8
	TDS (mg/L) [12]	253.5 – 2184 (fresh to brackish)
CSR_WA_000107 Former Fire Training Area – 1960s April 2019	pH	4.69 – 6.09 (generally acidic)
	EC (µS/cm)	1943 – 4506
	DO (mg/L)	0.38 – 1.2 (generally aerobic)
	Redox (mV)	-271.7 – 100.7 (strongly reducing to oxidising)
	Temperature (°C)	20.1 – 22.9
	TDS (mg/L) [12]	1397.5 – 3139.5 (brackish)

[12] 0-500 mg/L; marginal: 501-1000 mg/L; brackish: 1001-5000 mg/L and saline >5000 mg/L

CSR	Water quality parameter	Range
CSR_WA_000109 Former USTS 240 – 245 (near Building 239) April 2019	pH	5.49 – 9.72 (acidic to alkaline)
	EC (µS/cm)	1197 – 7034
	DO (mg/L)	0.22 – 0.94 (generally aerobic)
	Redox (mV)	-412 – 89.5 (strongly reducing to oxidising)
	Temperature (°C)	24.4 – 27.6
	TDS (mg/L) [12]	741 – 4446 (marginal to brackish)
CSR_WA_000110 Former Fuel Farm April 2019	pH	5.22 – 12.06 (acidic to alkaline)
	EC (µS/cm)	673 – 7815
	Dissolved oxygen (DO, mg/L)	0.07 – 2.23 (generally aerobic)
	Redox (mV)	-203.9 – 132.1 (reducing to oxidising)
	Temperature (°C)	23.2 – 25.9
	TDS (mg/L)[12]	429 – 5107 (fresh to saline)
CSR_WA_000117 Former Service Station April 2019	pH	5.05 – 6.88 (generally acidic)
	EC (µS/cm)	616 - 6348
	DO (mg/L)	0.34 – 1.09 (generally aerobic)
	Redox (mV)	-204.2 – 169.2 (reducing to oxidising)
	Temperature (°C)	21.8 – 24.9
	TDS (mg/L) [12]	409.5 – 4309.5 (fresh to brackish)
CSR_WA_000151 Grounds Maintenance Area April 2019	pH	5.06 – 9.53 (acidic to alkaline)
	EC (µS/cm)	1746 – 3925
	DO (mg/L)	0 (anaerobic)
	Redox (mV)	-184.6 – 134.4 (reducing to oxidising)
	Temperature (°C)	22.8 – 25.9
	TDS (mg/L) [12]	1183 – 2593.5 (brackish)
CSR_WA_000153 Fire Training Area – Fuel Storage Facilities April 2018	pH	4.96 – 6.47 (generally acidic)
	EC (µS/cm)	447 – 7867
	DO (mg/L)	0.21 – 2.39 (generally aerobic)
	Redox (mV)	67.1 – 227.5 (oxidising)
	Temperature (°C)	22.1 – 27.6
	TDS (mg/L) [12]	296.4 – 5265 (fresh to saline)
CSR_WA_000155 Power Station USTs April 2018	pH	4.46 – 6.12 (generally acidic)
	EC (µS/cm)	716 – 12784
	DO (mg/L)	0.68 – 4.46 (generally aerobic)
	Redox (mV)	91.8 – 293.9 (oxidising)
	Temperature (°C)	24.3 – 26.3
	TDS (mg/L) [12]	455 – 8437 (fresh to saline)

CSR	Water quality parameter	Range
CSR_WA_000156 Paint Shop March-May 2018	pH	6.13 – 6.97 (slightly acidic)
	EC (µS/cm)	830 – 2140
	DO (mg/L)	0.08 – 1.97 (generally aerobic)
	Redox (mV)	-146.9 – 132.9 (reducing to oxidising)
	Temperature (°C)	24.2 – 29.1
	TDS (mg/L) [12]	500.5 – 1492 (marginal to brackish)
CSR_WA_000160 Hangar 95 April 2019	pH	6.39 – 7 (generally neutral)
	EC (µS/cm)	549 – 1252
	DO (mg/L)	0.11 – 0.44 (slightly aerobic)
	Redox (mV)	-66 – 125.8 (slightly reducing to oxidising)
	Temperature (°C)	26.9 – 27.7
	TDS (mg/L) [12]	338 – 786.5 (fresh to marginal)
PCSR_0967_001 Aircraft Shelters April 2019	pH	6.12 – 6.85 (slightly acidic)
	EC (µS/cm)	3114 – 5999
	DO (mg/L)	0.15 – 0.56 (slightly aerobic)
	Redox (mV)	-153.3 – -9.5 (reducing to slightly reducing)
	Temperature (°C)	23.9 – 26.2
	TDS (mg/L) [12]	2028 – 3802 (brackish)
PCSR_0967_002 New AVTUR Fuel Farm (DFI) April 2019	pH	5.59 – 6.83 (generally acidic)
	EC (µS/cm)	880 – 11933
	DO (mg/L)	0.15 – 2.44 (generally aerobic)
	Redox (mV)	-161.7 – 81.3 (reducing to slightly oxidising)
	Temperature (°C)	24.9 – 27
	TDS (mg/L) [12]	572 – 7468.5 (marginal to saline)
PCSR_0967_003 Former 25 m Small Arms Range April 2018	pH	9.12 (alkaline)
	EC (µS/cm)	1187
	DO (mg/L)	0.95 (aerobic)
	Redox (mV)	-126.4 (reducing)
	Temperature (°C)	20.8
	TDS (mg/L) [12]	838.5 (marginal)
3TU (0965)		
CSR_WA_000019 Septic Tanks – Sewage Disposal May 2018	pH	6.19 (slightly acidic)
	EC (µS/cm)	242.2
	DO (mg/L)	0.87 (aerobic)
	Redox (mV)	-102.3 (reducing)
	Temperature (°C)	23.2
	TDS (mg/L) [12]	163.15 (fresh)

CSR	Water quality parameter	Range
CSR_WA_000080 Incinerator (North of 3TU Workshop) May 2018	pH	6.27 (slightly acidic)
	EC (µS/cm)	285
	DO (mg/L)	0.35 (slightly aerobic)
	Redox (mV)	-123.5 (reducing)
	Temperature (°C)	22.0
	TDS (mg/L) [12]	185.25 (fresh)
CSR_WA_000081 South of 3TU – Buried Waste Metals April 2019	pH	4.39 – 5.25 (acidic)
	EC (µS/cm)	210 – 281
	DO (mg/L)	0.15 – 0.3 (slightly aerobic)
	Redox (mV)	-16.4 – 24.3 (generally neutral)
	Temperature (°C)	22.7 – 24.1
	TDS (mg/L) [12]	141.7 – 191.1 (fresh)
CSR_WA_000103 South of Former Building 58 – 2 x Diesel A/USTs May 2018	pH	5.91 – 5.95 (acidic)
	EC (µS/cm)	206 – 207.8
	DO (mg/L)	0.01 – 0.24 (slightly aerobic)
	Redox (mV)	-130.7 – -109.8 (reducing)
	Temperature (°C)	22.5 – 23.9
	TDS (mg/L) [12]	137.15 – 141.35 (fresh)
PCSR_0965_001 Fire Extinguisher Training Area April 2019	pH	3.81 – 5 (acidic)
	EC (µS/cm)	137.8 – 173.3
	DO (mg/L)	0.59 – 0.85 (aerobic)
	Redox (mV)	-93.2 – 246.9 (reducing to oxidising)
	Temperature (°C)	20.9 – 24.7
	TDS (mg/L) [12]	89.7 – 122 (fresh)

9.3 Surface water

9.3.1 Visual and olfactory indicators

RAAF Base Pearce

Surface water samples were collected over two events in 2018 – post summer (4 samples March 2018) and post winter (17 samples September 2018).

The majority of sample locations in the post summer event were observed to be dry. At locations where surface water was present it was noted that the water was generally stagnant and not representative of conditions which would support an ephemeral aquatic ecosystem.

All visual/olfactory observations are provided in Appendix J. No notable visual and olfactory indicators of contamination were observed however dead fish were present at location 0967_SW112 during the post summer event (which may potentially affect nutrient and E.coli results).

3TU

Surface water samples were collected over two events – post winter (6 samples in September 2018) and post summer (2 samples in April 2019).

As per the RAAF Base Pearce post summer sampling, the majority of sample locations in the post summer event were observed to be dry. At locations where surface water was present it was noted that the water was generally stagnant and not representative of conditions which would support an ephemeral aquatic ecosystem.

All visual/olfactory observations are provided in Table 43. No notable visual and olfactory indicators of contamination were observed.

9.4 Sediment

9.4.1 Visual and olfactory indicators

Sediment samples were collected over two events in 2018 – post summer (between 15 March and 18 April 2018) and post winter (September 2018), and one event in 2019 – post summer (April 2019).

No visual or olfactory observations of contamination were identified at any of the sediment sampling locations at RAAF Base Pearce or 3TU.

10. Results and discussion – RAAF Base Pearce

All laboratory reports are provided in Appendix N and results summary tables in Appendix L.

10.1 Background groundwater quality

Background groundwater quality assessment is based upon data from monitoring well 0967_MW235P&S (Figure 10B), installed during this investigation and BW_MW14 (GHD 2018b) and 0967_MW218 (Figure 10B), previously MW001 (AECOM 2016) of previous investigations. These wells are located up hydraulic gradient along the north eastern boundary of the property.

Water quality is noted to be fresh in the perched water and saline in the regional superficial aquifer.

Chloride concentrations in groundwater at 0967_MW235S (regional aquifer) were reported as elevated above aesthetic drinking water and non-potable groundwater use criteria and below the GILs in perch water. The elevated chloride in the regional aquifer is attributed to the higher salinity of this aquifer.

CoPCs (BTEX-N, PAH, VOCs, nutrients) are generally not present or not exceeding adopted GILs. The majority of metals (arsenic, aluminium, barium, boron, beryllium, cadmium, chromium, cobalt, iron, lead, manganese, mercury, nickel, selenium, vanadium) are also generally not present or not exceeding adopted GILs. Elevated concentrations of copper (up to 0.06 mg/L) and zinc (up to 0.105 mg/L) exceeding freshwater GILs were reported, reflecting the urbanised land use setting.

Table 44 Background groundwater quality (detects only)

Analyte	Concentration (mg/L)
pH	5.85-7.02 (pH units)
Electrical conductivity	330 – 4290 (µS/cm)
Total dissolved solids	214 – 2790
Ammonia (as N)	0.04 – 0.08
Nitrate (as N)	<0.01 – 0.01
Total Nitrogen	1.3
Total Phosphorus	0.28
Chloride	53 - 1320
Arsenic	<0.001 – 0.002
Barium	0.057
Cobalt	0.001
Copper	<0.001 – 0.012
Manganese	0.05
Nickel	<0.001 – 0.022
Zinc	0.014 – 0.192

10.2 Site wide - Sediment and surface water in on-site drainage channels

Data gap - No previous holistic assessment of potential risk of contamination in surface water and sediment within the surface water drainage channel networks located on and immediately surrounding RAAF Base Pearce.

10.2.1 Sediment

Sediment results from surface drains considered to be receptors for individual CSRs are presented in the relevant CSR results sections below. As some sediment locations were located in areas generally considered up-stream or down-stream of the property as a whole, these results are summarised below as part of a site wide assessment. Results summary tables are presented in Table L20-1 (Appendix L) and other respective CSR specific tables in the individual sections of this report.

Due to sample collection occurring at the end of summer, sediment samples collected across the property were generally collected from dry surface water drains or stagnant pools and not representative of conditions which would support an ephemeral benthic ecosystem. The results can however indicate presence or absence of CoPCs which have accumulated via surface run-off in these areas.

CoPCs comprising BTEX-N, phenols, phthalates, organophosphate pesticides, herbicides and fungicides, PCBs, explosives and the majority of organochlorine pesticides were not reported above the LOR in any of the sediment samples across RAAF Base Pearce.

Concentrations of CoPCs in sediment samples at upstream locations (0967_SD120, 0967_SD108, 0967_SD111) downstream exit points to the Ellen Brook (0967_SD110, 0967_SD112, 0967_SD128) and downstream exit points to the Ki-It Monger Brook (0967_SD140 to 0967_SD145) (Figure 13A) were generally observed to be below ISQG criteria with the exception of Zinc at 0967_SD140 exceeding ISQG high criteria. Sediment sample 0967_SD140 also reported minor concentrations of TRH.

Within the property, elevated metals and minor TRH and PAH concentrations were generally reported immediately downstream of the former small arms range, fire fighting training/fuel storage area, Former Fuel Farm, the former Sounness Road Landfill and the Grounds Maintenance Area. Further discussion is provided in respective sediment sample subsections.

Key Outcomes

Whilst the results of sediment sampling undertaken across the property indicates localised impacts to drainage features, impacts are delineated in a downstream direction with no indications of chronic risk to the aquatic ecosystems of the Ki-It Monger Brook and the Ellen Brook. An upstream source of elevated copper and zinc may also be present.

10.2.2 Surface water

Surface water samples were collected over two events in 2018 – post summer (5 samples May 2018) and post winter (18 samples September 2018). Results are summarised in Table L20-2, Appendix L.

The majority of sample locations in the post summer events were observed to be dry. At locations where surface water was present it was noted that the water was generally stagnant and not representative of conditions which would support an ephemeral aquatic ecosystem. Therefore it is considered nutrients, biological and physicochemical parameter results are unlikely to provide valuable insight into the quality of surface water entering and exiting the property as these parameters are highly influenced by depleted oxygen in stagnant water.

CoPCs in general (VOC, BTEX, Chlorinated Hydrocarbon (CHC), OP pesticides) were not detected above LOR in the surface water samples collected.

In general, detections of hydrocarbons (PAH at the Paint Shop and TRH at the former Fuel Farm and runways, aprons and Taxiways), OCPs (dieldrin at Small Arms Range) and elevated ammonia (Sewage Treatment Plant) in surface water on the property were not reported in any adjacent downstream locations or the receiving bodies of the Ki-It Monger Brook and the Ellen Brook.

Post summer and post winter, trace concentrations of metals (chromium, copper and zinc) are noted to resemble regional groundwater concentrations (i.e. slightly elevated above the freshwater GILs) however this is not reflected at the discharge point 0967_SW112 to the Ellen Brook where concentrations of chromium, copper and zinc were not detected post summer. Post winter metals concentrations at the Ellen Brook indicate a potential upstream source of copper and zinc given the concentrations in the upstream sample (0967_SW146) are in the same order of magnitude as the onsite and downstream concentrations. Upstream concentrations of copper and zinc in the Ki-It Monger Brook (0967_SW153) are also elevated above freshwater GILs and not elevated further downstream (0967_SW152 & 0967_SW157), again suggesting an upstream source of elevated copper and zinc.

10.3 CSR_WA_000024 – Fuel Storage NE Building 72 – Group of USTs and ASTs

10.3.1 Summary of data gaps

In addition to this CSR warranting contamination investigation, due to identified data gaps associated with soil, groundwater and vapour impact uncertainty following a reported leak from a former UST, GHD also completed an inspection and validation sampling following the removal of four diesel USTs at Building 72 by Defence contractor, Duratech Australia in March 2018.

Preliminary results have been reported in a separate letter report dated 29 March 2018 (GHD 2018d). Although soil analytical results reported TRH, BTEX-N and PAHs below LOR from samples collected from the base of the excavation, PID readings indicated the presence of volatile compounds up to 15 ppm, and visual observations indicated the presence of staining/residual hydrocarbon impacts in tank pit soils at approximately 3.2 m depth.

Due to the proximity of the tank pit to existing buildings, following a workshop session with Defence and Duratech, further excavation was deemed impractical/unsafe without significant structural assessment and management. An agreement was reached to assess the residual risk via groundwater and (if required) vapour assessment. Excavations were subsequently backfilled after treating the pit with a TRH biogradation agent.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 14A.

CoPC: Metals, TRH, BTEX-N, PAHs.

10.3.2 Groundwater laboratory results

Groundwater analytical results for the Fuel Storage NE of Building 72 were compared against the relevant assessment criteria in Table L1-1 Appendix L. Results confirm that the following CoPC in groundwater were all below LOR:

- PAHs
- BTEX-N
- TRH (excluding F3 (>C_{16}-C_{34} fraction), >C_{10}-C_{40} (sum of total))

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (arsenic, cadmium, chromium, lead, mercury, nickel) were variably detected at multiple locations.
- TRH (F3 (>C_{16}-C_{34} fraction), >C_{10}-C_{40} (sum of total).

Groundwater sampling locations with concentrations exceeding the adopted GILs are summarised in Table 45. A graphical representation of the groundwater analytical results is presented in Figure 14B.

Table 45 Groundwater sample exceedances – Fuel Storage NE Building 72 (CSR_WA_000024)

Analyte	Monitoring Round	Location ID	Concentration range	Investigation level	Criteria exceeded
Copper	May 2018	0967_MW070 0967_MW141	0.003-0.021 mg/L	0.0014 mg/L	ANZECC 2000 MW 95 %
	April 2019	0967_MW068 0967_MW070 0967_MW141 0967_MW253S 0967_MW254S 0967_MW255P 0967_MW255S	0.003-0.024 mg/L		
Zinc	May 2018	0967_MW141	0.047 mg/L	0.008 mg/L	ANZECC 2000 MW 95 %
	April 2019	0967_MW070 0967_MW141 0967_MW252S 0967_MW253S 0967_MW254S 0967_MW255P 0967_MW255S	0.019 – 0.147 mg/L		

MNA parameters

MNA parameters were analysed from groundwater collected at eight monitoring wells in the Fuel Storage NE Building 72. A summary of the MNA parameters is provided in Table 46.

Table 46 Summary of MNA parameters - Fuel Storage NE Building 72 (CSR_WA_000024)

Location ID	Monitoring Round	TRH > C_{10}-C_{40} (µg/L)	Sulfate as SO_4 (mg/L)	Ferrous iron (mg/L)	Methane (µg/L)	Nitrate (as N) (mg/L)	DO (field) (mg/L)	ORP[13] (field) (mV)
0967_MW068	May 2018	<100	103	<0.05	<10	0.19	0.85	15.6
0967_MW070	May 2018	140	37	-	-	-	1.2	23.1
	April 2019	160	45	2.68	<10	<0.01	0.91	-40.5
0967_MW141	May 2018	<100	125	-	-	-	2.31	158.9
	April 2019	<100	114	0.06	<10	0.16	0.69	213.4
0967_MW252S	April 2019	<100	92	6.85	11	<0.01	1.94	-71.3
0967_MW253S	April 2019	260	69	19.1	32	<0.01	0.18	114.6
0967_MW254S	April 2019	<100	72	0.15	<10	<0.01	1.75	46.1
0967_MW255P	April 2019	110	97	<0.05	<10	1.09	2.38	21.8
0967_MW255S	April 2019	<100	81	<0.05	<10	0.05	2.27	118.7

10.3.3 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

[13] Oxidation-reduction potential

Groundwater

- Based on the interpolated groundwater flow direction (to the south-southwest), groundwater beneath the Fuel Storage NE of Building 72 is likely to discharge to the Ki-It Monger Brook in the south. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- Metals concentrations (copper and zinc) were reported above fresh water guidelines and also exceed background groundwater quality ranges (Table 45).
- Groundwater beneath the site does not indicate significant impact from historic and/or current fuel storage activities.

10.3.4 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.3.5 Key outcomes

- Potential residual soil impact in the tank pit at 3.0 m bgl as visually observed during soil validation activities has not been confirmed by laboratory analysis which indicated results below LOR.
- Although residual soil impact is likely to be present, the sealing of the ground surface with hardstand following tank removal, and the presence of a confining clay layer appears to be preventing migration of the soil impact to groundwater. Groundwater at the CSR indicates no significant impact from historic and/or current fuel storage activities however copper and nickel exceed background levels.
- The lack of hydrocarbon (including BTEX-N) impacts to groundwater, and laboratory results for soils do not indicate the presence of a soil vapour risk to users of nearby buildings.
- Concentrations of elevated copper and zinc in groundwater are unlikely to impact property users under the current land-use scenario nor are they likely to migrate to the sensitive ecosystem of the Ki-It Monger or the Ellen Brook given the distance (1.4 km).
- The Fuel Storage NE of Building 72 area is suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management.
- Groundwater monitoring at the Fuel Storage NE of building 72 area should be incorporated into future monitoring programs.

10.4 CSR_WA_000083 – Dog Compound – Buried Waste

10.4.1 Summary of data gaps

Although this area was investigated during mobilisation 1, subsequent information received from Defence indicated that the waste burial area extended further south than the original (2018) CSR boundary and was not adequately assessed in the first mobilisation (March 2018). Previous testing further to the south (GHD 2005b) did not include PAHs and OCPs. Soil impact uncertainty remains.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 15A.

CoPC: Metals, BTEX, TRH, PAHs, OCPs, asbestos.

10.4.2 Soil laboratory results

Soil samples were collected at 14 soil bore locations during the first DSI mobilisation and, three additional locations during the second DSI mobilisation. Soil analytical results for the Dog Compound area were compared against the relevant assessment criteria in Table L2-1 of Appendix L. Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (arsenic, cadmium, mercury)
- BTEX
- TRH (F1 (C_6-C_{10} minus BTEX), C6-C10 fraction, F4 (>C_{34}-C_{40} fraction))
- PAHs (acenaphthene, acenaphthylene, anthracene, dibenz(a,h)anthracene, naphthalene, fluorene, PAHs (sum of total))

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (chromium, copper, iron, lead, nickel, zinc) were variably detected at all locations.
- TRH (F2 (>C_{10}-C_{16} minus naphthalene), F3 (>C_{16}-C_{34} fraction), >C_{10}-C_{40}) were variably detected at two locations
- OCPs (4, 4'-DDE, aldrin + dieldrin, DDT+DDE+DDD)
- PAHs (sum of polycyclic aromatic hydrocarbons, benz(a)anthracene, benzo[b+j]fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-c,d)pyrene, phenanthrene, pyrene, total 8 PAHs (as BaP TEQ)(zero LOR), total 8 PAHs (as BaP TEQ)(half LOR), total 8 PAHs (as BaP TEQ)(full LOR))

Table 47 provides a summary of the soil analytical results which exceeded the adopted SILs.

Table 47 Soil sample exceedances – Dog Compound (CSR_WA_000083)

Analyte	Monitoring Round	Location ID	Depth (m bgl)	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
>C_{10}-C_{16} Fraction	March 2018	0967_BH310	0.1	55	25	NEPM 2013 Table 1B(6) ESLs for Areas of Ecological Significance, Fine Soil
Benzo(a) pyrene	March 2018	0967_BH302	0.1	0.8	0.7	NEPM 2013 Table 1B(6) ESLs for Areas of Ecological Significance, Fine Soil
		0967_BH307	0.1	0.9		
		0967_BH308	0.1	0.7		
Dieldrin	March 2018	0967_BH307	0.1	0.21	0.14	NEPM 2013 Table 1A(1) HIL D Comm/Ind (w/USEPA THQ1.0 RSL Ind Soil - May 2019)

Asbestos in soil

Soil samples were collected at seven borehole locations at varying depths to assess for the presence or absence of asbestos in soil. Results confirm that no asbestos was identified in any of the soil samples.

10.4.3 Sediment laboratory results

Three sediment sampling locations were located in a drainage channel in close proximity to the Dog Compound which is considered to be servicing the area. Of these three sample locations, two could not be accessed due to fencing restrictions (0967_SD105, 0967_SD106). Sediment analytical results from the accessible sample location (0967_SD107) were compared against the relevant assessment criteria in Table L2-2 (Appendix L). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems though could be transported to the receiving water body via surface run-off. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in the sediment were all below LOR:

- Metals (arsenic, cadmium, mercury)
- BTEX
- TRH
- PAHs
- OCPs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines at a few locations:

- Metals (chromium, copper, lead, nickel)

Table 48 provides a summary of the sediment analytical results which exceeded the adopted sediment and soil screening guidelines.

Table 48 Sediment sample exceedances - Dog Compound (CSR_WA_000083)

Analyte	Location ID	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
Zinc	0967_SD107	66	55	EIL – Ecological significance

10.4.4 Groundwater laboratory results

Groundwater analytical results for the Dog Compound area were compared against the relevant assessment criteria in Table L2-3 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (chromium, mercury)
- TRH
- PAHs
- OCPs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (arsenic, cadmium, lead)

Table 49 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 49 Groundwater sample exceedances – Dog Compound (CSR_WA_000083)

Analyte	Monitoring Round	Location ID	Concentration (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Copper	March 2018	0967_MW145 0967_MW150	0.002-0.006	0.0014	ANZECC 2000 FW 95 %
	April 2019	0967_MW149	0.015		
Nickel	March 2018	0967_MW145	0.02	0.011	ANZECC 2000 FW 95 %
	April 2019	0967_MW149	0.028		
		0967_MW149	0.028	0.02	ADWG 2011 Health
Zinc	March 2018	0967_MW145	0.065	0.008	ANZECC 2000 FW 95 %
	April 2019	0967_MW149	0.101		

A graphical representation of the distribution of groundwater impacts is presented on Figure 15C.

10.4.5 Surface water laboratory results

Surface water analytical results from 0967_SW107 downstream from the Dog Compound are compared against the relevant assessment criteria Table L20-2 (Appendix L). Results confirm that the following CoPC in surface water were all below LOR:

- Metals (arsenic, cadmium, chromium, lead, mercury)
- TRH
- PAHs

- OCPs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (iron, nickel)

Table 50 provides a summary of the surface water analytical results which exceeded the adopted screening guidelines.

Table 50 Surface water sample exceedances – Dog Compound (CSR_WA_000083)

Analyte	Monitoring Round	Location ID	Concentration	Criteria limit	Criteria exceeded
Copper	September 2018	0967_SW107	0.002 mg/L	0.0014 mg/L	ANZECC 2000 FW 95 %
Zinc	September 2018	0967_SW107	0.013 mg/L	0.008 mg/L	ANZECC 2000 FW 95 %

10.4.6 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- The majority of soil CoPC concentrations were reported below the human health guidelines. Additional soil sampling from three soil bores in April 2019 to the south of the Dog Compound reported all CoPC below LOR. Concentrations of CoPC (excluding OCPs) in soils across the majority of the Dog Compound do not indicate a contamination risk to property users under the current land-use scenario.
- A single occurrence of dieldrin marginally above HIL-D was detected in surface soils at 0967_BH307 in the north west of the compound. Although dieldrin was not detected at depth, another organochlorine pesticide, 4,4–DDE was present marginally above the LOR at 0.5 m bgl.
- Localised PAH concentrations with BaP exceeding the ESL (0.7 mg/kg) were also identified within surface soils (0.1 m bgl) at three locations (0967_BH302, 0967_BH307 and 0967_BH308) in the north western portion. Concentrations of TRH were not present at depth (≥0.5 m bgl).
- The presence of elevated BaP and dieldrin in surface soils in the north western portion of the site is consistent with the unauthorised dumping of waste such as bitumen or concrete building footings in this area. The elevation of these CoPCs above human health and ecological criteria are not observed in downstream sediment or surface water samples (i.e. at the receptor) or in groundwater and are considered to be minimal and isolated. The soil impacts at the Dog Compound do not present a significant exposure risk to the users of the compound or downstream receptors. Furthermore, exposure opportunities are minimised by the presence of fencing around the compound, which should be maintained to minimise exposure pathways.

Sediment

- Sediment samples in locations directly adjacent to the Dog Compound could not be accessed.

- Sediment CoPC concentrations from one sample in the adjacent drain, further down-stream of the Dog Compound (0967_SD107), were all reported below LOR or relevant the ISQG levels.
- Zinc concentrations at this location marginally exceeded the EIL as zinc also does in the majority of surface water drain locations across the site. Zinc was not reported above the EIL in soils within the Dog Compound suggesting its derivation is not attributed to the historic and/or current waste disposal activities at the site but has accumulated in this area over time from upgradient sources.

Surface water

- The surface water sample collect downstream from the Dog Compound - Buried Waste area did not report any of the associated CoPC above LOR (excluding metals).
- Elevated copper and zinc concentrations in surface water downstream from the Dog Compound - Buried Waste area did not exceed upstream background the Ki-It Monger Brook concentrations. Copper and zinc impacts were not reported in the proximal downstream sample location in the Ki-It Monger Brook (0967_SW152), indicating onsite impacts to surface water are not being transported off site or are sufficiently diluted at the receiving surface water body.

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the Dog Compound is likely to discharge to the Ki-It Monger Brook in the south east. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses, irrigation, stock feed.
- Metals concentrations (copper, nickel, zinc) were reported above fresh water ILs and in new well 0967_MW149 also marginally above background groundwater quality ranges (Table 44 nickel and copper). The Ki-It Monger Brook is 100 m south of 0967_MW149 though did not report any elevated metals in surface water sample 0967_SW152 indicating onsite impacts to groundwater are not migrating offsite or are sufficiently diluted at the receiving surface water body.

10.4.7 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.4.8 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- The presence of elevated BaP and dieldrin in surface soils in the north-western portion of the Dog Compound is consistent with the unauthorised dumping of waste such as bitumen or concrete building footings in this area. The soil impacts are considered to be minimal and isolated to the fenced Dog Compound area and do not present a significant exposure risk to the users of the fenced compound or downstream receptors.
- CoPC in the southern portion of the compound were all below LOR or relevant ILs indicating the waste disposal/burial area has been delineated to the south.

- Although sediment samples directly adjacent to the Dog Compound could not be collected, the sediment sample in the drain down-stream of the Dog Compound reported no impact from historic and/or current waste disposal activities.
- Surface water samples immediately downstream of the Dog Compound-Buried Waste area reported CoPC concentrations consistent with upstream Ki-It Monger Brook samples which reported elevated copper and zinc. Copper and zinc concentrations were not elevated in downstream Ki-It Monger Brook samples, indicating onsite impacts to surface water are not being transported off site or are sufficiently diluted at the receiving surface water body.
- Groundwater beneath the Dog Compound is potentially impacted from historic activities surrounding the former fill or gravel stockpiles reporting elevated copper and nickel however impacts are not observed at the receiving surface water body 100 m to the south. The lack of reported impact in the Ki-It Monger Brook indicates impacts to groundwater are not migrating offsite or are sufficiently diluted at the receiving surface water body.
- The Dog Compound is suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management or monitoring and as such should be archived from the CSR database.

10.5 CSR_WA_000084 – Sounness Road Landfill

10.5.1 Summary of data gaps

This landfill was closed in 2001.

A review of the previous Stage 2 investigation (Earthtech 2007) identified that the waste extended to a depth of 2.0 m bgl beneath a sand fill cap layer (approximately. 0.5 m depth) with limited pockets of waste extending to 3.3 m bgl. The analytical results identified heavy metal contamination above EILs, one lead concentration above HILs, TPH (minor) at one location and SVOCs in two soil samples. The analytical results for groundwater identified minor exceedances of Freshwater guidelines for Cadmium, Copper, Nickel and Zinc, as well as TPH in three samples. However, it was reported that the landfill does not adversely affect subsurface soils or groundwater.

No monitoring reports have been made available post-2005.

The PFASIMB assessed PFAS at the landfill separately.

Further groundwater monitoring is considered necessary to assess the current status of potential risk arising from historical landfill operations.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 16A.

CoPC: Asbestos, VOCs, SVOCs, OCPs, metals, TRH.

10.5.2 Sediment laboratory results

Two sediment sampling locations are located in drainage channels in close proximity to the Sounness Rd landfill which are considered to be servicing the area. These sample locations include 0967_SD110 and 0967_SD111. Sediment analytical results from these locations are compared against the relevant assessment criteria in Table L3-1 (Appendix L). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in sediments were all below LOR:

- Metals (cadmium, mercury)
- BTEX-N
- PAHs
- VOCs
- SVOCs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines at a few locations:

- Metals (arsenic, chromium, copper, lead, nickel)
- TRH (F2 (>C_{10}-C_{16} minus Naphthalene), F3 (>C_{16} – C_{34} Fraction) F4(>C_{34}-C_{40} Fraction))
- OC pesticides (Aldrin + dieldrin)

Table 51 provides a summary of the sediment analytical results which exceeded the adopted sediment and soil investigation levels.

Table 51 Sediment sample exceedances –Sounness Rd landfill (CSR_WA_000084)

Group	Analyte	Locations IDs	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
Metals	Zinc	0967_SD110	79	55	EIL - Ecological significance
TRH	>C_{10}-C_{16} Fraction	0967_SD110 0967_SD111	250 160	25 170	ESL – Ecological Significance ESL -Comm/Ind

10.5.3 Groundwater laboratory results

Groundwater analytical results for the Sounness Road Landfill were compared against the relevant assessment criteria in Table L3-2 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (cadmium, chromium, mercury)
- TRH
- VOCs
- SVOCs
- OCPs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (arsenic, lead)

Table 52 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 52 Groundwater sample exceedances – Sounness Rd landfill (CSR_WA_000084)

Analyte	Monitoring Round	Location ID	Concentration range(mg/L)	Criteria limit (mg/L)	Criteria exceeded
Copper	April 2018	0967_MW201 0967_MW208 0967_MW216 0967_MW217	0.002 – 0.038	0.0014	ANZECC FW
Nickel	April 2018	0967_MW201 0967_MW203	0.012 – 0.013	0.011	ANZECC FW
Zinc	April 2018	0967_MW201 0967_MW203 0967_MW216 0967_MW217	0.01 – 0.061	0.008	ANZECC FW
1,2-dichlorobenzene	April 2018	0967_MW202	0.006	0.001	NPUG

A graphical representation of the distribution of groundwater impacts is presented on Figure 16B.

10.5.4 Surface water laboratory results

0967_SW110 and 0967_SW111 did not have sufficient surface water for sampling.

10.5.5 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- Soil sampling did not form part of the scope of work for the Sounness Road Landfill as this aspect of investigation was considered adequately characterised.

Sediment

- The majority of sediment CoPC concentrations from two samples in the up-gradient and down-gradient drain were all reported below LOR or ISQG levels indicating no contamination risk to property users and ecological receptors from the sediment under the current land-use scenario.
- Zinc and TRH concentrations were observed to exceed ecological ILs at both locations. Given the industrial landuse setting and the location of 0967_SD110 adjacent to the Great Northern Highway, it is reasonable to assume the impacts reflect a diffuse source of contamination related to urbanisation and not the landfill itself.

Surface water

- No surface water sampling locations had sufficient surface water for sampling in the drainage channels located in close proximity to the Sounness Road Landfill.

Groundwater

- Based on the interpolated groundwater flow direction from groundwater elevation data collected by GHD in April 2018, groundwater flow beneath the former Sounness Road Landfill is westerly and likely to discharge to the Ellen Brook in the west. Groundwater at the property is not used for any purpose, although is abstracted from the confined Leederville Formation immediately to the north for irrigation. There is no indication of groundwater flow in the superficial aquifer being influenced by this abstraction regime. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- Concentrations of metals copper, nickel and zinc exceed freshwater ILs but are within background concentrations, reflecting the urbanised land-use setting.
- Volatile organic chemical 1,2-dichlorobenzene (0.006 mg/L) was reported above the non-potable groundwater use criteria (NPUG 0.001 mg/L) in 0967_MW202 located directly beneath the landfill. 1,2-dichlorobenzene can be found in landfill leachate as it is a widely used solvent however no other potential indicators of landfill impacts such as elevated TDS or high potassium to chloride ratios were observed.
- Given the lack of contamination impact indications associated with the landfill, it is considered unlikely that the landfill is a significant source of 1,2-dichlorobenzene that would warrant any further investigation into potential Dense Non-aqueous Phase Liquids (DNAPL).
- Groundwater beneath the site does not indicate any significant impact from historic land filling activities and is considered to be adequately characterised.

10.5.6 Refined conceptual site model

Given CoPCs have not been identified at elevated concentrations in sediment downstream and groundwater beneath the landfill, it is considered there is no active pathway from the source and therefore no complete source, pathway, receptor linkages.

10.5.7 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- The sediment sample in the drain down-stream of the Sounness Road Landfill indicated no reported impact from historic land-filling activities (as compared with sediment results up-stream).
- Groundwater beneath the landfill indicates no significant impact from historic landfilling activities.
- There are no residual data gaps regarding the current contamination risk (low) associated with the landfill.
- Given the ongoing presence of the landfill (closed in 2001) as a potential contamination source, groundwater monitoring at the Sounness Landfill should continue and be incorporated into future monitoring programs. However, as the results suggest little or no impact from the landfill, the monitoring frequency may be reduced from annually to two to five yearly.

10.6 CSR_WA_000087 – Fuel Storage ILS 18 Glidepath (AST_032)

10.6.1 Summary of data gaps

Given the potential for contamination associated with AST leakage (diesel AST bunding is considered inadequate) and the sensitivity of the nearby surface water receptor, further investigation was considered necessary to assess the potential risk associated with fuel storage infrastructure.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 17A.

CoPC: Metals, TRH, PAHs.

10.6.2 Soil laboratory results

Soil samples were collected at three soil bore locations. Soil analytical results for the Fuel Storage Glidepath area were compared against the relevant assessment criteria in Table L4-1 (Appendix L). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (arsenic, cadmium, mercury, zinc)
- TRH
- PAHs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (chromium, copper, lead, nickel)
- No soil analytical results exceeded the adopted SILs.

10.6.3 Sediment laboratory results

One sediment sampling location (0967_SD127) is located in a drainage channel in close proximity to the Fuel Storage ILS 18 Glidepath area which is considered to be servicing the area. Sediment analytical results from this location are compared against the relevant assessment criteria in Table L4-2 (Appendix L). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in soils were all below LOR:

- Metals (arsenic, cadmium, copper, mercury, nickel)
- BTEX-N
- TRH
- PAHs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (chromium, lead, zinc)

No sediment analytical results exceeded the adopted sediment and soil investigation guidelines.

10.6.4 Surface water laboratory results

0967_SW127 did not have sufficient surface water for sampling however it is considered surface water sampling across the airbase in general is sufficient to illustrate surface water quality flowing off site as discussed in Section 10.2.1.

CoPC associated with the Fuel Storage ILS 18 Glidepath were reported below LOR downstream in the Ellen Brook sample 0967_SW149 (Table L20-2, Appendix L). Copper and zinc were elevated above fresh waters ILs in the Ellen Brook samples, however this was also reported in the upstream the Ellen Brook sample 0967_SW146 making it unlikely that the impacts are attributed to the CSR.

10.6.5 Discussion

All soil and sediment CoPCs were reported below the LOR or below adopted ILs indicating no impact from the AST at the ILS 18 glidepath and no risk of impact to property users or the down-stream ecosystem of the Ellen Brook under the current land-use scenario.

10.6.6 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.6.7 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- Soil, sediment and surface water testing has indicated no impact from the AST at the ILS 18 glidepath.

- There is no contamination risk to property users or the down-stream ecosystem of the Ellen Brook under the current land-use scenario.
- There are no residual data gaps regarding the current contamination risk (low) and no further investigations are required at the Fuel Storage ILS 18 Glidepath CSR and as such should be archived from the CSR database.
- To ensure contamination risk remains low, the bunding of the AST should be upgraded to meet current standards, following which the CSR can be archived.

10.7 CSR_WA_000088 – Fuel Storage ILS 18 Localiser (AST_033)

10.7.1 Summary of data gaps

Given the potential contamination associated with AST leakage (diesel AST bunding is considered inadequate) and the high sensitivity of the nearby surface water receptor, further investigation was considered necessary to assess the current status of potential risk associated with fuel storage infrastructure.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 18A.

CoPC: Metals, TRH, PAHs.

10.7.2 Soil laboratory results

Soil samples were collected at 3 soil bore locations. Soil analytical results for the Fuel Storage Area are compared against the relevant assessment criteria in Table L5-1 (Appendix L). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (arsenic, cadmium, mercury)
- TRH

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (chromium, copper, lead, nickel, zinc)
- PAHs (total 8 PAHs (as BaP TEQ)(half LOR) and total 8 PAHs (as BaP TEQ)(full LOR)
- No soil analytical results exceeded the adopted SILs.

10.7.3 Sediment laboratory results

One sediment sampling location (0967_SD128) is located in a drainage channel in close proximity to the Fuel Storage ILS 18 area which is considered to be servicing the area. Sediment analytical results from this location are compared against the relevant assessment criteria in Table L20-1 (Appendix L). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in soils were all below LOR:

- Metals (arsenic, cadmium, copper, lead, mercury, nickel)
- BTEX-N
- TRH
- PAHs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (chromium, zinc)

No sediment analytical results exceeded the adopted sediment and soil guidelines. However, it is relevant to note that the laboratory LOR for the detection of multiple analytes exceeded relevant guidelines, triggering a potential exceedance. Therefore, although concentrations were reported below the LOR, it is not possible at this time to confirm that the concentration of the analyte in sediments is less than the relevant adopted assessment criteria.

10.7.4 Surface water laboratory results

0967_SW128 did not have sufficient surface water for sampling.

CoPC associated with the Fuel Storage ILS 18 Localiser were reported below LOR downstream in the Ellen Brook sample 0967_SW156 (Table L20-2, Appendix L). Copper and zinc were elevated above fresh waters ILs in the Ellen Brook however this was also reported in the upstream the Ellen Brook sample 0967_SW146 making it unlikely that the impacts are attributed to the CSR.

10.7.5 Discussion

All soil and sediment CoPCs were reported below the LOR or below adopted ILs indicating no impact from the AST at the ILS 18 CSR_WA_000088 and no risk of impact to property users or the down-stream ecosystem of the Ellen Brook under the current land-use scenario.

10.7.6 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.7.7 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- Soil, sediment and surface water testing has indicated no impact from the AST at the ILS 18 CSR CSR_WA_000088.
- There is no risk of impact to property users or the down-stream ecosystem of the Ellen Brook under the current land-use scenario.
- There are no residual data gaps regarding the current contamination risk (low) and no further investigations are required at the Fuel Storage ILS 18 Localiser CSR and as such should be archived from the CSR database.
- To ensure contamination risk remains low, the bunding of the AST should be upgraded to meet current standards.

10.8 CSR_WA_000104 – Former Hazardous Waste Store

10.8.1 Summary of data gaps

A review of historical aerials indicates that based on the location of the building (constructed between 1953 and 1965, demolished between and 1995 and 2000), the CSR area should extend further north of the existing CSR boundary.

Although demolished and potentially containing asbestos, no reports or visual observations to date suggest any residual building material be present to the extent to warrant any further investigation into asbestos contamination.

As such, previous soil sampling undertaken in 2007 (Earthtech) is not considered to have adequately defined the former building area/footprint and all potential CoPCs. Further investigation was considered necessary to adequately assess the defined CSR area and all potential CoPCs.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 19A.

CoPC: Metals, TRH, VOCs, SVOCs, PCBs, explosive residues.

10.8.2 Soil laboratory results

Soil samples were collected at four soil bore locations. Soil analytical results for the hazardous waste store are compared against the relevant assessment criteria in Table L6-1 (Appendix L). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (cadmium, mercury)
- VOCs
- PCBs
- Explosives

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (arsenic, chromium, copper, lead, nickel, zinc)
- TRH
- PAH
- SVOCs

No soil analytical results exceeded the SILs.

10.8.3 Sediment laboratory results

Two sediment sampling locations (0967_SD114, 0967_SD137) are located in a drainage channel in close proximity to the Former Hazardous Waste Store which is considered to be servicing the area (as well as being directly down gradient from the sewage treatment plant). Sediment analytical results from these locations are compared against the relevant assessment criteria in Table L6-2 (Appendix L). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in the sediment were all below LOR:

- Metals (arsenic, cadmium, mercury, nickel)
- BTEX-N
- TRH
- PAH
- OCPs
- E coli

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines at a few locations:

- Nutrients (nitrate, nitrite, total nitrogen, Total Kjeldahl Nitrogen (TKN), phosphorus (total))
- Metals (chromium, copper, lead, zinc)

No sediment analytical results exceeded the adopted SILs.

10.8.4 Groundwater laboratory results

Groundwater analytical results for the Former Hazardous Waste Store were compared against the relevant assessment criteria in Table L6-3 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (cadmium, chromium, lead, mercury)
- TRH (excluding F2 (>C_{10}-C_{16} minus naphthalene), >C_{10}-C_{16} fraction, >C_{10}-C_{40} (sum of total))
- PAHs
- VOCs
- SVOCs
- PCBs
- Explosives

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (arsenic, nickel)
- TRH (F2 (>C_{10}-C_{16} minus naphthalene), >C_{10}-C_{16} fraction, >C_{10}-C_{40} (sum of total))

Table 53 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 53 Groundwater sample exceedances – Former Hazardous Waste Store (CSR_WA_000104)

Analyte	Monitoring Round	Location ID	Concentration (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Copper	April 2018	0967_MW231	0.006	0.0014	ANZECC FW
Zinc	April 2018	0967_MW231	0.022	0.008	ANZECC FW

A graphical representation of the distribution of groundwater impacts is presented on Figure 19C.

10.8.5 Surface water laboratory results

Surface water analytical results from 0967_SW148 are compared against the relevant assessment criteria Table L20-2 (Appendix L). Results confirm that the following CoPC in surface water were all below LOR:

- Metals (cadmium, lead, mercury, nickel, zinc)
- TRH
- PAHs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (arsenic)

Table 54 provides a summary of the surface water analytical results which exceeded the adopted screening guidelines.

Table 54 Surface water sample exceedances – Former Hazardous Waste Store (CSR_WA_000104)

Analyte	Monitoring Round	Location ID	Concentration	Criteria limit	Criteria exceeded
Copper	September 2018	0967_SW148	0.004 mg/L	0.0014 mg/L	ANZECC FW

10.8.6 Discussion

Soil

- The extent of soil sampling from the current and previous Stage 2 DSI (Earthtech 2007) is considered adequate to define the CSR area.
- Soil CoPC concentrations were all reported below the human health and ecological guidelines indicating no contamination risk to property users and ecological receptors under the current land-use scenario.

Sediment

- Sediment CoPC concentrations from one sample in the adjacent drain, further down-stream of the Former Hazardous Waste Store (0967_SD114) and up-stream (0967_SD137) were all reported below LOR or relevant the ISQG levels.

Surface water

- Sample 0967_SW148 did not report any CoPC impacts relevant to the Former Hazardous Waste Store.
- Elevated copper concentrations exceeding freshwater ILs were reported in 0967_SW148 and also in upstream location 0937_SW137 from the runway and in the upstream Ellen Brook location 0967_SW146 and are therefore not likely to be attributed to historic practices at the CSR.

Groundwater

Based on the interpolated groundwater flow direction, groundwater beneath the Former Hazardous Waste Store is likely to discharge to the Ellen Brook in the south west. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.

- Metals concentrations (copper, zinc) were reported above fresh water criteria however within background groundwater quality ranges (Table 44). All other CoPC were not detected above the LOR.
- Groundwater beneath the site does indicates no impact from historic waste storage activities.

10.8.7 Refined conceptual site model

Given CoPCs have not been identified in soil, sediment, surface water and groundwater, it is considered there is no source of contamination from the CSR and therefore no complete source, pathway, receptor linkages.

10.8.8 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- The extent of soil sampling from the current and previous Stage 2 DSI (Earthtech 2007) is considered adequate to define the CSR area.
- Soil CoPC concentrations were all reported below the human health and ecological guidelines indicating no contamination risk to property users and ecological receptors under the current land-use scenario.
- The sediment sample in the drain down-stream of the Former Hazardous Waste Storage indicated no observable impact from historic waste storage activities.
- Surface water and groundwater beneath the Former Hazardous Waste Store indicates no impact from historic and/or current waste disposal activities.
- The hazardous waste store area is suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management or monitoring and as such should be archived from the CSR database.

10.9 CSR_WA_000106 – Sewage Treatment Plant and Effluent Discharge

10.9.1 Summary of data gaps

Potential contamination associated with the Sewage Treatment Plant ponds and infrastructure, and Sewage Treatment Plant effluent discharge. Ponds included two aerobic and two anaerobic ponds. Requirement for assessment of the current status of potential risk arising from sewage treatment and disposal.

Although limited wells are subject to regular groundwater monitoring as part of regional monitoring program, results have not been assessed holistically to ascertain if operations are posing an ongoing risk to receptors.

Sewage Treatment Plant ponds were refurbished in 2018/2019 with ponds 1 and 2 being lined as part of remediation works. There are four functioning ponds present.

Following the first mobilisation, dry or missing wells were recommended to be replaced and monitored to confirm the E.coli presence, establish the E.coli plume extent and stability and potential for migration to the Ellen Brook.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 20A.

CoPC: Metals, nutrients, pathogens.

10.9.2 Sediment laboratory results

Nine sediment sampling locations were collected from drainage channels in close proximity to the Sewage Treatment Plant which are considered to be servicing the area. These sample locations include 0967_SD112 – 0967_SD120. Sediment analytical results from these locations are compared against the relevant assessment criteria in Table L7-1 (Appendix L). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in sediments were all below LOR:

- Metals (cadmium, mercury, nickel)

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Nutrients (nitrate, nitrite, total nitrogen, TKN, phosphorus (total))
- Metals (arsenic, chromium, copper, lead, zinc)
- Biological (E.coli)

No sediment analytical results exceeded the adopted sediment and soil guidelines.

10.9.3 Groundwater laboratory results

Groundwater analytical results for the Sewage Treatment Plant and Discharge area were compared against the relevant assessment criteria in Table L7-2 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (arsenic, cadmium, mercury)
- Nutrients (nitrite (as N))

- The following CoPC were detected slightly above the LOR but were below the applied guidelines:
- Metals (lead, nickel)
- Nutrients (excluding nitrite (as N))

Table 55 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 55 Groundwater sample exceedances – Sewage Treatment Plant (CSR_WA_000106)

Analyte	Monitoring Round	Location ID	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Sulfate	March 2018	0967_MW166	364	250	ADWG (aesthetic)
Copper	March 2018	0967_MW166 0967_MW219 0967_MW221 0967_MW222	0.002 – 0.024	0.0014	ANZECC FW
Zinc	March 2018	0967_MW166 0967_MW142 0967_MW218 0967_MW219 0967_MW221 0967_MW222	0.008 – 0.116	0.008	ANZECC FW
E.coli	March 2018	0967_MW222 0967_MW166	140 - >1000 colony-forming units (cfu)/100 mL	1 cfu/100 mL 10 cfu/100 mL	ADWG DoH Microbiological (Municipal use some restricted access and application)
	April 2019	0967_MW166 0967_MW142 0967_MW222 0967_MW223	1 – 29000 colony-forming units (cfu)/100 mL		

A graphical representation of the distribution of groundwater impacts is presented on Figure 20B and C.

10.9.4 Surface water laboratory results

Surface water was collected post summer and post winter in 2018 around the STP. Surface water analytical results from these locations are compared against the relevant assessment criteria in Table L20-2 (Appendix L). Results confirm that the following CoPC in surface water were all below LOR:

- Metals (cadmium, mercury)

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Nutrients (nitrate (as N) nitrite (as N), nitrogen (total oxidised) (as N), total nitrogen, total phosphorus, TKN)
- Metals (arsenic, chromium, iron, lead, nickel)

Table 56 provides a summary of the surface water analytical results which exceeded the adopted screening guidelines.

Table 56 Surface water sample exceedances – Sewage Treatment Plant (CSR_WA_000106)

Analyte	Location ID	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Ammonia as N	0967_SW112 0967_SW147	1.26-1.42	0.388	NPUG
			0.9	ANZECC FW
Copper	0967_SW120 0967_SW113 0967_SW147	0.0016-0.003	0.0014	ANZECC FW
Zinc	0967_SW120 0967_SW113 0967_SW116 0967_SW147 0967_SW112	0.02-0.049	0.008	ANZECC FW
E.coli	0967_SW120 0967_SW113 0967_SW116 0967_SW119 0967_SW147 0967_SW112	24-2100 (CFU/100 mL)	1 CFU/100 mL 10 CFU/100 mL	ADWG DoH Microbiological (Municipal use some restricted access and application)

10.9.5 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Sediment

- Concentrations of CoPC in sediment samples were generally below LOR or the health and ecological ILs.
- Phosphorus concentrations across the CSR were elevated above those observed in background and entry point 0967_SD120, indicating minor impact from the waste water treatment ponds though did not exceed the adopted ILs.

Surface water

- With the exception of E.coli, concentrations of CoPC in surface water samples were generally below LOR or health and ecological ILs.
- Concentrations of metals exceeding ecological ILs did not exceed the upstream Ellen Brook concentrations, suggesting inputs to the Ellen Brook may not be solely attributed to the STP.
- Ammonia was reported in sample 0967_SW147 immediately downstream from the STP exceeding the health (NPUG) and freshwater ILs however was reported not exceeding the ILs or LOR in the proximal downstream location 0967_SW113.
- Ammonia was reported at the exit point to the Ellen Brook (0967_SW112) exceeding the health (NPUG) and freshwater ILs post summer 2018. Given this sample was collected from a stagnant pool, nutrients, biological and physicochemical parameter results are unlikely to provide valuable insight into the quality of surface water entering and exiting the site as these parameters are highly influenced by depleted oxygen in stagnant water. A

follow-up sample collected at the same location post winter (September 2018) reported ammonia well below the adopted ILs.

- E.coli concentrations in surface water were present up and down stream of the STP exceeding both ADWG and NPUG investigation levels. The E.coli concentrations were notably elevated in post summer surface water samples collected from stagnant pools not considered to be representative of conditions during high-flow surface water flow events.
- The concentrations of E.coli in surface water drains on the property are generally lower than that observed at the receptor, the Ellen Brook. E.coli concentrations in the Ellen Brook were elevated above NPUG and ADWG ILs upstream (0967_SW146) and down stream of the property indicating the property may not be the sole source of elevated E.coli in the Ellen Brook.

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the Sewage Treatment Plant is likely to discharge to the Ellen Brook in the south west. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- Metals copper and zinc exceeded the freshwater ILs and copper marginally exceeded background concentrations in wells directly adjacent and down gradient of the wastewater treatment ponds (0967_MW166 and 0937_MW021). The copper concentration may potentially pose an increased risk to ecological receptors given the proximity to the Ellen Brook (600 m).
- E.coli was reported exceeding ADWG and NPUG ILs in groundwater at 0967_MW166 directly adjacent and down gradient of Pond 4 at greater than 1000 cfu/100 mL and at 0967_MW222 at 140 cfu/100 mL in 2018 however were significantly reduced and not reported exceeding ILs in 2019 (1 CFU/100 mL). This may indicate the source of E.coli is not ongoing given that ponds 1 and 2 were lined during refurbishment works in 2018/2019.
- E.coli approximately 80 m down gradient of the STP at 0967_MW223 however reported significant concentrations (29000 CFU/100 mL) exceeding background levels and the DoH criteria for municipal use with some restricted access and application and drinking water criteria. The lack of E.coli in up-gradient wells and historically at the site (not detected prior to 2015) suggests compromise of the pond liners at ponds 3 or 4 occurred since the last regional monitoring event in November 2016 (Argon 2017). The extent of the E.coli impact in groundwater is not delineated given no further wells are present down gradient of 0967_MW223.

10.9.6 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.9.7 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- The Sewage Treatment Plant area is suitable for ongoing use from a contamination risk perspective however the current groundwater monitoring network is considered insufficient to characterise the downgradient impact to groundwater from the Sewage Treatment Plant.

- Groundwater monitoring at the Sewage Treatment Plant area should continue and include analysis of nutrients, E.coli and metals.
- Further groundwater investigation including installation of further monitoring wells should be carried out to establish the E.coli and copper extent and potential for migration to the Ellen Brook.
- Surface water samples in the Ellen Brook down gradient of 0967_MW223 should be sampled and tested for E.coli and metals to confirm concentration at the receptor.

10.10 CSR_WA_000107 – Former Fire Training Area (1960s)

10.10.1 Summary of data gaps

Review of conventional CoPC data collected during PFAS Stage 2 DSI (GHD 2018b) indicated no significant hydrocarbons detected in soils or groundwater.

During the site visit, a sewage pit was observed at northern extent of the area (outside existing CSR boundary). Anecdotal information reported the sewage pit as having a history of overflowing.

Further investigation was therefore considered necessary to assess the potential risk to identified receptors arising from sewage effluent release.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 21A.

CoPC: Metals, PAHs, OCPs, nutrients, pathogens.

10.10.2 Soil laboratory results

Soil samples were collected at four soil bore locations and one groundwater monitoring well location. Soil analytical results for the Former Fire Training Area were compared against the relevant assessment criteria in Table L8-1 (Appendix L). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Nutrients (ammonia as N)
- Metals (cadmium, mercury)

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Nutrients (nitrate (as N), nitrite (as N), nitrogen (total oxidised) (as N), nitrogen (total), kjeldahl nitrogen total), phosphorus
- Metals (arsenic, chromium, copper, lead, nickel, zinc)
- Pathogens

No soil results exceeded the adopted SILs.

10.10.3 Sediment laboratory results

Four sediment sampling locations were located in drainage channels in close proximity to the Former Fire Training Area which are considered to be servicing the area. These sample locations include 0967_SD122, 0967_SD123, 0967_SD124 and 0967_SD139. Sediment analytical results from these locations were compared against the relevant assessment criteria in Table L8-2 (Appendix L). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in sediments were all below LOR:

- Metals (arsenic, cadmium, mercury)
- BTEX-N (analysed at 0967_SD139 only)
- TRH (analysed at 0967_SD139 only)
- PAHs

- OCPs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines at a few locations:

- Nutrients (nitrate, total nitrogen, TKN, phosphorus (total))
- Metals (chromium, copper, lead, nickel)
- Biological (thermotolerant coliforms – no E.coli present above LOR)

Table 57 provides a summary of the sediment analytical results which exceeded the adopted sediment and soil investigation levels.

Table 57 Sediment sample exceedances –Former Fire Training Area (1960s) (CSR_WA_000107)

Group	Analyte	Locations IDs	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
Metals	Zinc	0967_SD122	56	55	EIL – Ecological significance

10.10.4 Groundwater laboratory results

Groundwater analytical results for the Former Fire Training Area were compared against the relevant assessment criteria in Table L8-3 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (arsenic, mercury)
- PAHs
- OCPs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (cadmium, lead)

Table 58 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 58 Groundwater sample exceedances – Former Fire Training Area (CSR_WA_000107)

Analyte	Monitoring Round	Location ID	Concentration (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium	May 2018	0967_MW238	0.003	0.001	ANZECC FW
Copper	April 2018	0967_MW103 0967_MW117	0.002 – 0.027	0.0014	ANZECC FW
	May 2018	0967_MW238	0.002		
	April 2019	0967_MW103 0967_MW117 0967_MW238	0.008-0.039		
Nickel	April 2018	0967_MW103 0967_MW117	0.015-0.02	0.011	ANZECC FW
	May 2018	0967_MW238	0.036	0.02	ADWG (health)
				0.011	ANZECC FW
	April 2019	0967_MW103 0967_MW117 0967_MW238	0.023-0.046	0.02	ADWG (health)
				0.011	ANZECC FW
Zinc	April 2018	0967_MW103 0967_MW117	0.011 – 0.039	0.008	ANZECC FW
	May 2018	0967_MW238	0.017		
	April 2019	0967_MW103 0967_MW117 0967_MW238	0.04-0.299		

A graphical representation of the distribution of groundwater impacts is presented on Figure 21C and D.

10.10.5 Surface water laboratory results

No surface water sampling locations had sufficient surface water for sampling in the drainage channels located in close proximity to the former Fire Training Area.

Downstream location 0967_SW154 approximately 500 m south of the Fire Training Area reported no CoPC exceeding LOR and/or ILs (Table L20-2, Appendix L).

10.10.6 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- CoPC were generally not detected above LOR and/or the relevant health and ecological ILs at the Former Fire Training Area indicating no risk of impact from soil to property users under the current land use scenario.

Sediment

- CoPC concentrations in sediment samples did not exceed LOR, ILs or background levels indicating no impact to the sediment surface water drain from fire fighting activities or septic waste disposal with regards to conventional contamination.

Surface water

- No surface water sampling locations had sufficient surface water for sampling in the drainage channels located in close proximity to the former Fire Training Area however it is considered surface water sampling across the airbase in general is sufficient to assess surface water quality flowing off site as discussed in Section 10.2.1. CoPC concentrations in downstream locations did not exceed LOR and or ILs indicating impacts from the Fire Training Area were not detected.

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the Former Fire Training Area is likely to discharge to the Ki-It Monger Brook in the south. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- The majority of CoPC concentrations were reported below the LOR or relevant ILs with the exception of metals (chromium, copper, nickel and zinc) which exceeded background concentrations (copper and nickel), freshwater ILs and drinking water ILs (nickel).
- There is no risk to property users from impacts to groundwater beneath the CSR under the current land-use scenario however the elevated metals concentrations in groundwater present an increased risk to the ecology of the Ki-It Monger Brook which runs approximately 200 m downgradient from the CSR.

10.10.7 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.10.8 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- Soil, surface water and sediment testing indicates that there is no risk of impact to property users from soil, surface water or sediment under the current land-use scenario.
- Groundwater monitoring indicates metal impacted groundwater which exceeds freshwater ILs and background concentrations have the potential to migrate to the Ki-It Monger Brook and present an increased risk to this ecosystem.
- The Former Fire Training area is suitable for ongoing use from a contamination risk perspective.
- Groundwater monitoring at the Former Fire Training area should be incorporated into future monitoring programs.

10.11 CSR_WA_000109 – Near Building 239 – Former Group USTs

10.11.1 Summary of data gaps

It is understood potential contamination remains in situ beneath former fuel bowsers. Further investigation was considered necessary to assess the current status of potential risk arising from underground fuel storage and delineate potential remaining impact within soil and/or groundwater.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 22A.

CoPC: Metals, TRH, BTEX, PAHs.

10.11.2 Soil laboratory results

Soil samples were collected at two monitoring well locations during drilling and installation of the monitoring wells. Soil analytical results for the former UST area were compared against the relevant assessment criteria in Table L9-1 (Appendix L). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (cadmium, mercury)
- BTEX-N
- TRH
- PAHs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (arsenic, chromium, copper, lead, nickel, zinc)

No soil analytical results exceeded the adopted SILs.

10.11.3 Groundwater laboratory results

Groundwater analytical results for the former UST area were compared against the relevant assessment criteria in Table L9-2 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (mercury)
- BTEX-N
- TRH
- PAHs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (arsenic, cadmium, lead)

Table 59 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 59 Groundwater sample exceedances – Former USTs (CSR_WA_000109)

Analyte	Monitoring Round	Location ID	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium	May 2018	0967_MW236	0.002	0.001	ANZECC FW
Copper	April 2018	0967_MW022 0967_MW023	0.009 – 0.047	0.0014	ANZECC FW
	May 2018	0967_MW236 0967_MW237	0.016-0.017		
Nickel	April 2018	0967_MW022	0.016	0.011	ANZECC FW
	May 2018	0967_MW236	0.023	0.02	ADWG (health)
				0.011	ANZECC FW
Zinc	April 2018	0967_MW022 0967_MW023	0.044	0.008	ANZECC FW
	May 2018	0967_MW236 0967_MW237	0.026		

A graphical representation of the distribution of groundwater impacts is presented on Figure 22B.

10.11.4 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- CoPC were not detected above LOR and/or the relevant health and ecological ILs at the Former USTs 240 – 245.
- Access limitations prevented the intrusive investigation of areas in the immediate vicinity of the former USTs/bowsers where unidentified impacts may be present.

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the Former USTs 240 – 245 is likely to discharge to the Ki-It Monger Brook in the south east. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- Concentrations of metals copper, chromium nickel and zinc exceed freshwater ILs and marginally exceeded background concentrations, reflecting the industrial land-use setting.
- Groundwater beneath the CSR could not be sampled due to the existing wells being destroyed. The four groundwater wells located down-hydraulic gradient of the Former USTs were not impacted and it is considered if residual impact is present, it is localised to the source area.

10.11.5 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.11.6 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- Groundwater immediately down-gradient of the facility indicates no significant impact from fuel storage and handling activities.
- Although the possibility remains that localised residual soil and groundwater impacts may remain in the immediate vicinity of the former USTs/bowsers, as the area is paved and in the open air, there is no currently identified exposure pathway or subsequent risk to commercial/industrial users via direct contact or inhalation.
- A site management plan should be developed to manage potential risks to intrusive/maintenance workers within the immediate vicinity of the USTs and bowsers from potential residual localised soil and groundwater impacts, unless these can be confirmed to have been removed during 2018 upgrade works.

10.12 CSR_WA_000110 – Former Fuel Farm

10.12.1 Summary of data gaps

Uncertainty surrounds the remaining monitoring well network and whether it is fit for purpose and whether the former LNAPL plume has been adequately defined. There was lack of a comprehensive data set for delineation of groundwater impacts including perched and regional aquifers.

Further investigation was therefore considered necessary to delineate the extent of groundwater impact from fuel storage and historical leakage following the decommissioning phase to enable an adequate assessment of risk to receptors.

Further "lines of evidence"-based assessment and trend analysis in determining plume stability to support monitored natural attenuation of the TRH plume was also required.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 23A.

CoPC: Metals, TRH, BTEX, PAH.

10.12.2 Soil laboratory results

Soil samples were collected during monitoring well installation and opportunistically if contamination indicators were observed during drilling. Soil analytical results for the Former Fuel Farm are compared against the relevant assessment criteria in Table L10-1 (Appendix L). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (arsenic, cadmium, mercury)
- BTEX-N
- PAHs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (chromium, copper, lead, nickel and zinc)

Table 60 provides a summary of the soil analytical results which exceeded the adopted SILs.

Table 60 Soil sample exceedances – Former Fuel Farm (CSR_WA_000110)

Analyte	Monitoring Round	Location ID	Depth (m bgl)	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
TRH >C_{10}-C_{16} Fraction	April 2018	0967_MW228S	2.0	220	170	ESL[14]
	April 2018		4.5	180		

10.12.3 Sediment laboratory results

Four sediment sampling locations are located in drainage channels in close proximity to the Former Fuel Farm which are considered to be servicing the area. These sample locations include 0967_SD101, 0967_SD102, 0967_SD103 and 0967_SD104. Sediment analytical results from these locations are compared against the relevant assessment criteria in Table L10-2 (Appendix L). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may

[14] ESL – NEPM 2013 ESL for Commercial/Industrial – coarse soil

support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in the sediment were all below LOR:

- Metals (mercury)
- BTEX-N
- VOCs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines at a few locations:

- Metals (arsenic, chromium, copper, nickel)
- TRH (F3 (>C_{16}-C_{34} Fraction))

Table 61 provides a summary of the sediment analytical results which exceeded the adopted sediment and soil investigation levels. A graphical representation of the distribution of metal exceedances in sediments is presented on Figure 13B.

Table 61 Sediment sample exceedances –Former Fuel Farm (CSR_WA_000110)

Group	Analyte	Locations IDs	Concentration range (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
Metals	Cadmium	0967_SD103	2	1.5	ISQG - Low
	Lead	0967_SD103 0967_SD104	52	50	ISQG - Low
	Zinc	0967_SD104	284 – 400	200	ISQG – Low EIL – Comm/Ind
		0967_SD103	1100 - 1290	410	ISQG – High EIL – Comm/Ind
PAHs	Pyrene	0967_SD103 0967_SD104	5 – 8.5	2.6	ISQG - High
	Benz(a)anthracene	0967_SD103 0967_SD104	1.0 – 1.2	0.261	ISQG - Low
	BaP	0967_SD103 0967_SD104	2.1 – 2.9	0.43/1.6 2.1 1.4	ISQG – Low/High USEPA RSL ESL
	Chrysene	0967_SD103 0967_SD104	4.2 – 7.4	2.8	ISQG - High
	Dibenz(a,h)anthracene	0967_SD103 0967_SD104	0.6 – 1.0	0.26	ISQG - High
	Fluoranthene	0967_SD103 0967_SD104	6.9 – 12.3	5.1	ISQG - High
	Phenanthrene	0967_SD103 0967_SD104	2.0 – 4.3	1.5	ISQG - High
	PAH – Sum of total	0967_SD103	52.6 – 54.2	45	ISQG - High
		0967_SD104	33.2 – 39.4	4	ISQG - Low

10.12.4 Groundwater laboratory results

Groundwater analytical results for the Former Fuel Farm area were compared against the relevant assessment criteria in Table L10-3 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (mercury)

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (arsenic, cadmium, lead)
- TRH
- BTEX-N
- PAH (naphthalene)

Table 62 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 62 Groundwater sample exceedances – Former Fuel Farm (CSR_WA_000110)

Analyte	Monitoring Round	Location ID	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium	May 2018	0967_MW227D 0967_MW229D	0.029-0.048	0.001	ANZECC FW
	April 2019	0967_MW227S 0967_MW228P	0.004-0.015		
Copper	March 2018	0967_MW151 0967_MW156 0967_MW157	0.002	0.0014	ANZECC FW
	May 2018	0967_MW227D 0967_MW228D 0967_MW229D 0967_MW229S	0.019-0.077		
	April 2019	0967_MW151S 0967_MW153S 0967_MW154S 0967_MW155 0967_MW156S 0967_MW157 0967_MW227S 0967_MW228P 0967_MW228S 0967_MW229P 0967_MW229S 0967_MW230P	0.002-0.024		
Nickel	March 2018	0967_MW153S	0.012-0.016	0.011	ANZECC FW
	May 2018	0967_MW229S	0.012		
	April 2019	0967_MW144S 0967_MW151P 0967_MW153S 0967_MW229S	0.012-0.02		

Analyte	Monitoring Round	Location ID	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
	March 2018	0967_MW144S 0967_MW156 0967_MW157	0.03-0.043	0.02	ADWG (health)
	April 2019	0967_MW155S 0967_MW156S 0967_MW157 0967_MW228 0967_MW230	0.024-0.04		
Zinc	March 2018	0967_MW144S 0967_MW153S 0967_MW155S 0967_MW156S 0967_MW157S	0.015-0.172	0.008	ANZECC FW
	May 2018	0967_MW228S 0967_MW229P 0967_MW229S	0.023 – 0.174		
	April 2019	0967_MW144S 0967_MW151S 0967_MW153S 0967_MW154P 0967_MW155S 0967_MW156S 0967_MW157S 0967_MW227S 0967_MW228P 0967_MW228S 0967_MW229P 0967_MW229S 0967_MW230P 0967_MW230S	0.026 – 0.192		

A graphical representation of the distribution of groundwater impacts is presented on Figure 23B and C.

MNA parameters

MNA parameters were analysed from groundwater collected at eight monitoring wells in the Former Fuel Farm area. A summary of the MNA parameters is provided in Table 63.

Table 63 Summary of MNA parameters - Former Fuel Farm (CSR_WA_000110)

Location ID	Date	TRH > C_{10}-C_{40} (µg/L)	DO (field) (mg/L)	Nitrate (as N) (µg/L)	ORP[15] (field) (mV)	Sulfate as SO_4 (µg/L)	Ferrous iron (µg/L)	Methane (µg/L)
0967 MW144S	March 2018	<100	0.51	<10	-26.9	386	19.4	<10
	April 2019	<100	0.18	20	-20.6	-	31.0	<10
0967 MW151P	April 2019	120	6.67	80	143.5	-	ND	<10
0967 MW151S	March 2018	380	1.62	10	77.7	34	0.20	<10
	April 2019	300	2.63	<10	72.4	-	1.85	<10
0967 MW153S	March 2018	<100	0.78	80	25.9	448	11.10	<10
	April 2019	<100	1.24	450	104.7	-	3.30	<10
0967 MW154P	April 2019	120	0.19	-	-15.8	-	-	-
0967 MW155S	March 2018	<100	0.36	80	95.9	220	8.26	<10
	April 2019	170	0.46	140	12	-	3.61	<10
0967 MW156S	March 2018	<100	0.78	-	132.1	153	-	-
	April 2019	<100	1.31	-	146.9	-	-	-
0967 MW157S	March 2018	<100	1.39	<10	11.5	222	12.40	<10
	April 2019	<100	9.53	-	67.8	-	-	-
0967 MW227P	May 2018	180	2.23	20	-108.2	27	0.90	46
	April 2019	170	0.13	<10	-43.6	109	1.04	70
0967 MW227S	May 2018	150	0.12	10	-203.9	47	0.32	<10
	April 2019	300	7.1	40	-125.5	45	<0.05	<10
0967 MW228P	April 2019	730	0.05	10	-169.3	141	1.66	65
0967 MW228S	May 2018	<100	0.31	-	-90.2	194	-	-
	April 2019	<100	1.64	90	51.7	152	0.96	<10
0967 MW229P	May 2018	1140	0.27	-	-119.2	3	-	-
	April 2019	1440	0.1	-	-143	-	-	-
0967 MW229S	May 2018	330	0.07	-	-162.6	55	-	-
	April 2019	<100	0.5	-	0.7	-	-	-
0967_ MW230P	April 2019	270	0.66	-	159.3	-	-	-
0967_ MW230S	May 2018	<100	0.67	70	-67.3	177	2.29	<10
	April 2019	<100	0.58	460	0.9	141	0.56	<10

10.12.5 Plume stability assessment

A groundwater plume stability and trend assessment (including MNA parameters) with regards to identified TRH impacts was undertaken for the purpose of evaluating and quantifying the potential risk of contamination associated with bulk fuel storage and use in the area.

The findings of the assessment of MNA conditions augmenting the existing dataset has been used to determine plume stability and the extent of primary and secondary lines of evidence of MNA processes occurring within the CSR area is discussed in the following sections.

[15] Oxidation-reduction potential

Plume degradation behaviour

Natural attenuation processes in a dissolved hydrocarbon plume include dispersion, dilution, volatilisation, sorption as well as aerobic and anaerobic biodegradation. As detailed in the Contaminated Sites Management Series '*Use of Monitored Natural Attenuation for Groundwater Remediation'* (Department of Environment [DoE] 2004) there are three lines of evidence for remediation by natural attenuation. The primary and secondary lines of evidence are reviewed below to confirm the effectiveness of natural attenuation as the key component of the remediation of residual TRH impacts in groundwater beneath the CSR area.

Primary lines of evidence

Primary lines of evidence for natural attenuation are provided by observed reductions in plume geometry and/or contaminant concentration/mass over time and/or distance (DER 2004). A plume that is reducing in extent or concentration, or that is stable, is considered to be primary evidence of natural attenuation occurring.

Spatial Distribution of Impacts

Time-series spatial impact distribution analysis of TRH fractions was undertaken to evaluate primary lines of evidence using the groundwater dataset obtained between August 2007 and April 2019 using the Groundwater Spatio-Temporal Data Analysis Tool (GWSDAT Version 2.1).

TRH concentration distribution plots generated for each monitoring event to demonstrate plume spatial characteristics such as migration and depletion are presented in Appendix P.

The available dataset has been impacted by the decommissioning of the former fuel farm in 2014/2015 and many wells were decommissioned or no longer present. However, the distribution plots collectively indicate the following:

- The TRH plume in the superficial aquifer was at its most concentrated in 2014 at the time of decommissioning and has demonstrably reduced in mass over time to negligible concentrations.

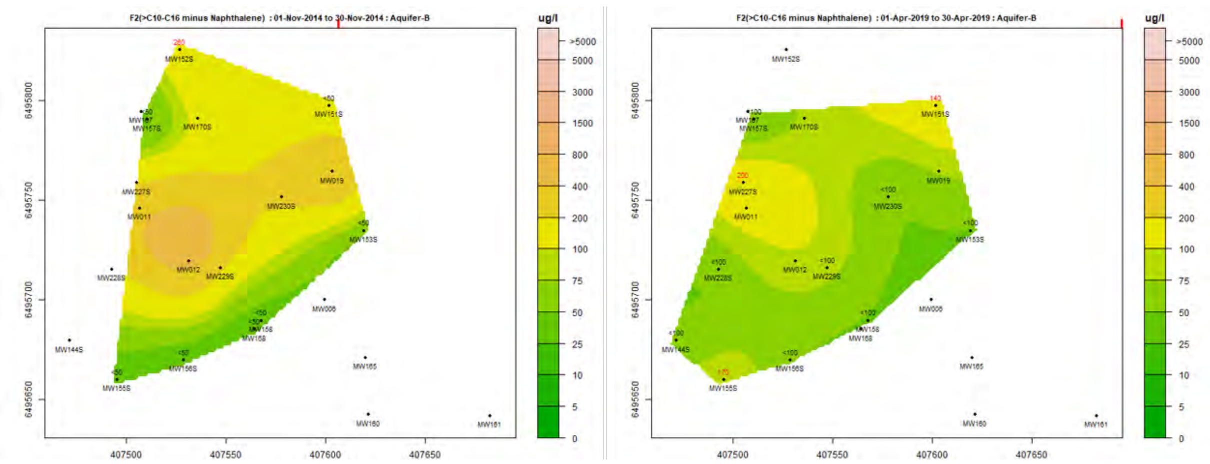

Plate 5 Contour plot of F2 TRH $>C_{10}$-C_{16} minus Naphthalene 2014 (left) and 2019 (right) in the superficial aquifer

- The TRH plume in the perched aquifer was not investigated until the recent 2018 and 2019 monitoring events and is indicated to be stable and concentrated around MW229P, though it is not adequately delineated to the south or south east.

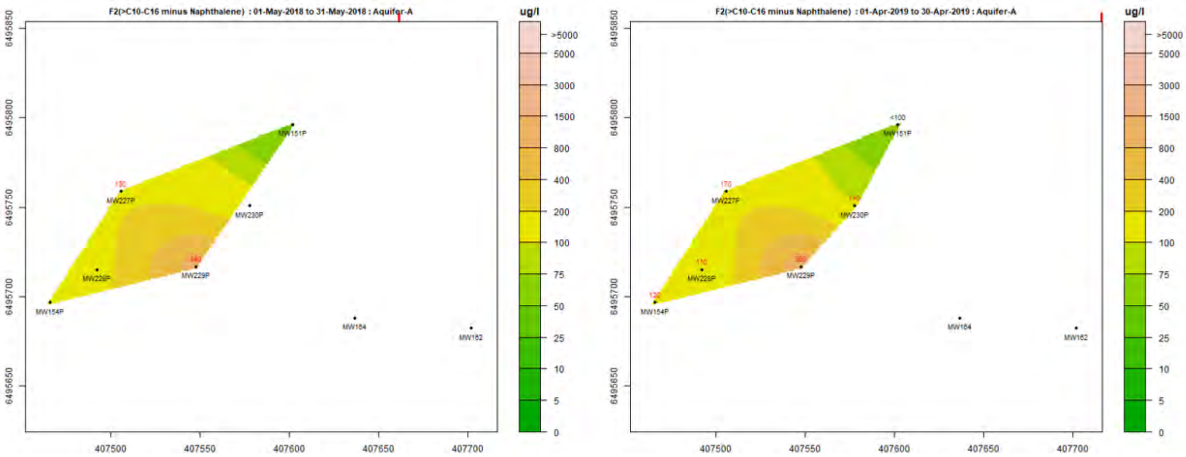

Plate 6 Contour plot of F2 TRH >C_{10}-C_{16} minus Naphthalene May 2018 (left) and April 2019 (right) in the perched aquifer

Spatio-Temporal trend analysis

Graphical time-series plots of TRH concentrations were generated using GWSDAT to analyse temporal trends in dissolved phase concentrations between 2007 and 2019, however the plots proved less useful to depict trends as the dataset was discontinuous with well locations destroyed or decommissioned during the demolition of the Former Fuel Farm and each monitoring location had only one or two monitoring events in total.

Mann-Kendell analysis was undertaken on each TRH dataset at each groundwater monitoring well location where detectable concentrations of TRH were identified. The statistical significance of the trend is assessed by means of obtaining a p-value below 0.05. If the p-value is obtained below 0.05, then the sample population is deemed to be statistically significant.

Note, the LOR value was used for non-detects, which offer a more conservative trend (as opposed to a zero value or adopting half the LOR), which can affect statistical confidence.

Where a p-value above 0.05 is identified for the sample population, then the data should be interpreted as meaning that that a statistically significant trend is not present. Notwithstanding the above, evidence of declining or increasing trends may still be deduced by qualitative professional judgement of the time-series data in the well trend plots

Spatio-temporal trend evaluation outcomes for all wells with detectable TRH concentrations were performed. Given the discontinuity of the dataset, all generated plots containing only two data points failed the Mann-Kendall test. The one plot with more than two data points (F2 at MW151S) also failed to be statistically significant with a p-value of 1. The plots are not provided in this report as they are considered not beneficial to the overall assessment.

Secondary lines of evidence

Secondary evidence of natural attenuation can be demonstrated by evaluation of various geochemical indicators of biodegradation, including depletion of electron acceptors such as DO (aerobically), and nitrate, sulfate and carbon dioxide (anaerobically) with consequent increases in concentrations of degradation by-products, including ferrous iron and methane.

Secondary lines of evidence of hydrocarbon degradation were evident within the perched and superficial aquifers based on the assessment of the March-May 2018 GME and April 2019 GME datasets. The findings are discussed in the following sections.

Electron acceptors - Perched aquifer

Redox - Redox potential within the plume and down-gradient monitoring wells were recorded in the negative range as anticipated, representative of mildly reducing and therefore low-energy anaerobic conditions.

DO – Source zone groundwater monitoring wells (0967_MW227P, 0967_MW228P and 0967_MW229P) recorded a decrease in DO concentrations from the 2018 to 2019 monitoring events ranging from 0.05 mg/L to 0.13 mg/L in April 2019 indicative of oxygen reduction and anaerobic aquifer conditions. Conversely upgradient well 0967_151P was oxygen rich with a concentration of 6.67 mg/L in April 2019.

Nitrate – Nitrate was also depleted (0.01-0.02 mg/L) in perched groundwater within the source zone (0967_MW227P, 0967_MW228P) and slightly higher up gradient (0.08 mg/L at 0967_MW151P) indicating nitrate reduction has taken place.

Sulfate – Concentrations of sulfate did not vary significantly in perched aquifer and do not demonstrate that sulfate reduction is taking place. It is considered the mild reducing (-150 mV to 50 mV) conditions in the perch aquifer are more favourable for nitrate reduction than sulfate reduction which generally occurs below -200 mV.

Electron acceptors – shallow regional aquifer

Redox - Redox potential within the plume and down-gradient monitoring wells were recorded in the negative range as anticipated, representative of mildly reducing and therefore low-energy anaerobic conditions.

DO –Concentrations of DO in the superficial aquifer were generally low (less than 1 mg/L) however a few anomalies where DO exceeded 2 mg/L both within and outside the TRH plume were also recorded.

Nitrate –Depletion of nitrates in the superficial was not completely observed, indicating a potential for a replenishment of electron acceptors within the residual plume.

Sulfate – Concentrations of sulfate in groundwater ranged from 45 (0967_MW227S) to 485 mg/L (0937_MW144S) in the groundwater monitoring well network screened within the superficial aquifer. Importantly, sulphate concentrations were higher in upgradient monitoring well locations and in wells which did not contain detectable concentrations of TRH. This indicates sulfate is likely being utilised for biodegradation of TRH in the aquifer.

Degradation by-products – perched and shallow aquifer

Ferrous iron – Concentrations of ferrous iron were present at high concentrations at the majority of groundwater locations and was not indicative of ferric iron reduction in the perched or superficial aquifer.

Dissolved methane – Concentrations of dissolved methane was detected in the perched aquifer at 0967_MW227P and 0967_MW228P. The presence of dissolved methane at these location and in association with reduced concentrations of nitrate and sulphate indicates methanogenesis is occurring within the perched aquifer.

Dissolved methane was not detected in any superficial aquifer monitoring locations indicating this advanced process of natural attenuation is not occurring in the superficial aquifer.

Plume degradation summary

Primary and secondary lines of evidence for natural attenuation processes demonstrate the following:

- Statistically derived and qualitative trends for TRH were not achievable with the dataset which was observed to be discontinuous due to the decommissioning of key wells during site decommissioning.
- A stable TRH plume in the perched aquifer and a shrinking TRH plume in the superficial aquifer to almost negligible concentrations.
- Absence of any significant TRH concentrations in outermost perimeter wells in the superficial aquifer (below the LOR).
- Consumption of dissolved oxygen, nitrates and the presence of degradation by-product methane in the perch aquifer, which provides a further line of evidence for degradation of TRH in the groundwater.
- Whilst secondary lines of evidence were less consistent than the primary lines of evidence in the superficial aquifer, TRH concentration contouring evidently indicated the plume has reduced to insignificant quantities unlikely to generate a significant biological response within the aquifer.

10.12.6 Surface water laboratory results

Of the four proposed surface water sampling locations in drainage channels located in close proximity to the Former Fuel Farm, only one was found to have sufficient surface water for sampling (0967_SW103) post summer and post winter. Surface water analytical results from 0967_SW103 post summer and post winter (September 2018) were compared against the relevant assessment criteria Table L20-2 (Appendix L). Results confirm that the following CoPC in surface water were all below LOR:

- Metals (cadmium, copper, lead, mercury)
- BTEX-N
- PAHs
- TRH C_6-C_{16} and TRH >C_{34}-C_{40}

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (arsenic, nickel)
- TRH (F3 (>C_{16}-C_{34} fraction)

Table 64 provides a summary of the surface water analytical results which exceeded the adopted screening guidelines.

Table 64 Surface water sample exceedances – Former Fuel Farm (CSR_WA_000110)

Analyte	Monitoring Round	Location ID	Concentration mg/L	Criteria limit mg/L	Criteria exceeded
Chromium	April 2018	0967_SW103	0.002	0.001	ANZECC FW
Zinc	April 2018	0967_SW103	0.018	0.008	ANZECC FW
	September 2018		0.028		

10.12.7 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- Soil concentrations were all reported below the human health guidelines for ongoing commercial/industrial usage. Concentrations of CoPC in soils across the balance of the Former Fuel Farm do not indicate a contamination risk to property users under the current land-use scenario.
- Localised TRH C_{10}-C_{16} concentrations exceeding the ESL (170 mg/kg) were identified at depth (greater than 2 m bgl) at one location (0967_MW228S). Concentrations of TRH were found to decrease marginally with depth from 220 mg/kg at 2.0 m bgl to 180 mg/kg at 4.5 m bgl. ESLs are generally applicable to the top 2 m of soil. Shallower samples were not collected at this location however it is noted from the borelogs (Appendix I) that a hydrocarbon odour was present from 1.5 m bgl to the depth of termination (6.0 m bgl). Given the lack of terrestrial ecological receptors in contact with the soils of the fuel farm, concentrations of CoPC in soils across the balance of the Former Fuel Farm do not indicate a contamination risk to ecological receptors.
- It is considered the extent of soil impact has been adequately defined to enable an appropriate assessment of risk to identified receptors.

Sediment

- Sediment impacts were reported above the ISQG low guidelines for cadmium, lead and zinc (also exceeding ISQG high). PAH concentrations also exceed ISQG low and high with BaP also exceeding soil RSL and ESL.
- The presence of a thriving benthic community within the site drainage channel adjacent to the Former Fuel Farm is unlikely and therefore it is considered unlikely to be at risk from the elevated concentrations of metals and PAH identified. During periods of increased rainfall, there is potential for these sediments to be transported to the Ki-It Monger Brook increasing the potential exposure risk to the aquatic biota of the Ki-It Monger Brook. It is noted however that down-stream point from the Former Fuel Farm (0967_SD122) has not been impacted by PAH with all PAH concentrations below LOR indicating impacts from the Former Fuel Farm are localised to this area.
- There is also potential for Base workers to be exposed to impacted sediments (exceeding HIL-D/RSL) at 0967_SD103 and 0967_SD104 during maintenance activities such as clearing of obstructed drainage channels.

Surface water

- The surface water sample reflected a similar metals concentration profile to the sediment with elevated chromium and zinc exceeding freshwater investigation levels (ILs). PAHs were not detected above LOR in the surface water albeit being elevated and exceeding the majority of ILs in the corresponding sediment sample.
- Chromium and zinc impacts were not reported in the proximal downstream sample location in the Ki-It Monger Brook (0967_SW152), indicating onsite impacts to surface water are not being transported off site or are sufficiently diluted at the receiving surface water body.

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the Former Fuel Farm is likely to discharge to the Ki-It Monger Brook in the south east. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses and irrigation.

- Metals concentrations were reported above fresh water criteria and marginally exceeded background concentrations (Section 10.1). Metals exceeding groundwater ILs were either not present in soil or not present at significant concentrations, however were noted to be present in sediment samples from surface water drains indicating the pathway for contamination to be transported from the site is possibly dominated by surface run-off to nearby drains and subsequent infiltration from these areas to groundwater. It also indicates the elevated metals concentrations in groundwater are likely the result of diffuse source contamination from general industrial land use.
- TRH concentrations were present in all perched aquifer sample locations and four (2018) to three (2019) of ten monitoring locations in the superficial aquifer. The greatest concentration of TRH was observed at 0967_MW229P. No LNAPL was observed within any of the monitoring wells however a sheen was noted at 0967_MW227P and 0967_MW227S in 2018 and only 0967_227S in 2019. Monitoring wells screened in the superficial aquifer further south and down gradient of impacts did not report TRH concentrations above LOR.
- TRH concentrations in the perched aquifer are not delineated toward the south however it is considered unnecessary to install any further wells in the perched aquifer given the following:
  - Lack of TRH presence down-gradient within the superficial aquifer
  - Unlikely event that the TRH plume will migrate from the discontinuous perched aquifer to a down-gradient receptor
  - Lack of infrastructure to the south of the perched aquifer plume which would give rise to increased vapour risk.
- Given the inferred groundwater flow being southerly in this portion of the site and no TRH impacts observed in the monitoring wells in the down-gradient fringes of the CSR it is considered the extent of the TRH plume in the superficial aquifer is adequately delineated. The data gap regarding the adequacy of the monitoring network is therefore considered closed.
- Natural attenuation of TRH in the perched aquifer is supported by evidence of consumption of DO, nitrates and the presence of degradation by-product methane in the source areas.
- Primary lines of evidence support TRH plume shrinkage in the superficial aquifer to negligible concentrations. Secondary lines of evidence were less consistent than the primary lines of evidence in the superficial aquifer however the plume has reduced to insignificant quantities unlikely to generate a significant biological response within the aquifer. The aquifer does however have the capacity to support MNA evidenced by the presence of electron acceptors which can be utilised during biodegradation processes if necessary.

10.12.8 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.12.9 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- It is considered the extent of soil impact has been adequately defined and there is no significant residual soil impact from fuel storage and historical leakage following the decommissioning phase.
- Clearing and appropriate disposal of impacted sediments in surface water drain at 0967_SD103 and 0967_SD104 (an area of up to 150 m x 1 m x 0.5 m) where PAH (BaP) concentrations exceed health criteria should be undertaken.
- The current groundwater monitoring network is considered adequate.
- Multiple lines of evidence support MNA has and is occurring at the Former Fuel Farm. Given the Former Fuel farm has been decommissioned, no further sources of contamination are considered present and it is considered natural attenuation will continue in the perched aquifer and can be monitored for a two further annual events to clearly demonstrate this, subject to the outcomes of the future monitoring rounds.

10.13 CSR_WA_000117 – Former Service Station

10.13.1 Summary of data gaps

Review of historical reports indicated a significant volume of contaminated soil associated with the waste oil disposal pit was removed as part of decommissioning activities in 2009/2010 (AECOM 2010), although no soil validation results available.

Further investigation was considered necessary to confirm current extent and magnitude of hydrocarbon contamination in soil and groundwater associated with decommissioning activities and Former Service Station operations, and to assess plume stability.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 24A.

CoPC: Metals, TRH, VOCs, PAH, MTBE.

10.13.2 Soil laboratory results

Soil samples were collected at six soil bore locations and two surface locations as part of the GHD assessment in 2019. Soil analytical results for the Former Service Station were compared against the relevant assessment criteria in Table L11-1 (Appendix L). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (cadmium)
- Explosives

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (arsenic, chromium, copper, lead, mercury, nickel, zinc)
- PAHs
- VOCs

Table 65 provides a summary of the soil analytical results which exceeded the adopted SILs.

Table 65 Soil sample exceedances – Former Service Station (CSR_WA_000117)

Analyte	Monitoring Round	Location ID	Depth (m bgl)	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
TRH F3	March 2018	0967_BH320	4.0	3480	2500	ESLs[16]

10.13.3 Groundwater laboratory results

Groundwater analytical results for the Former Service Station were compared against the relevant assessment criteria in Table L11-2 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (mercury)

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (arsenic, lead)

[16] ESLs – NEOM 2013 ESLs for commercial/industrial soil, fine

- TRH

Table 66 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 66 Groundwater sample exceedances – Former Service Station (CSR_WA_000117)

Analyte	Monitoring Round	Location ID	Concentration range	Criteria limit	Criteria exceeded
Cadmium	March 2018	0967_MW146	0.0003 mg/L	0.0002 mg/L	ANZECC FW
Chromium	May 2018	0967_MW233D	0.002 mg/L	0.001 mg/L	ANZECC FW
Copper	March 2018	0967_MW146	0.022 mg/L	0.0014 mg/L	ANZECC FW
	May 2018	0967_MW233D 0967_MW234D	0.002-0.021 mg/L		
	April 2019	0967_MW226 0967_MW232S 0967_MW233S 0967_MW234S 0967_MW235S 0967_MW242	0.002-0.017 mg/L		
Nickel	March 2018	0967_MW146	0.053 mg/L	0.011 mg/L 0.02 mg/L	ANZECC FW ADWG (health)
	April 2019	0967_MW232S 0967_MW233S 0967_MW234S 0967_MW235S	0.013-0.035 mg/L		
Zinc	March 2018	0967_MW146	0.587 mg/L	0.008 mg/L	ANZECC FW
	May 2018	0967_MW233D 0967_MW234D 0967_MW235D	0.014-0.074 mg/L		
	April 2019	0967_MW226 0967_MW232P 0967_MW232S 0967_MW233S 0967_MW234S 0967_MW235S 0967_MW240 0967_MW242	0.011-0.192 mg/L		
Benzene	April 2019	0967_MW242	6 µg/L	1 µg/L	ADWG (health)
Ethylbenzene	May 2018	0967_MW242	53 µg/L	25 µg/L	ADWG (aesthetic) NPUG
	April 2019	0967_MW242	5 µg/L		
Naphthalene	May 2018	0967_MW242	62 µg/L	16 µg/L	ANZECC FW
MTBE	May 2018	0967_MW242	69 µg/L	20 µg/L	NPUG

A graphical representation of the distribution of groundwater impacts is presented on Figure 24C and D.

MNA parameters

MNA parameters were analysed from groundwater collected at seven monitoring wells in the Former Service Station area. A summary of the MNA parameters is provided in Table 67.

Table 67 Summary of MNA parameters - Former Service Station (CSR_WA_000117)

Location ID	Date	TRH >C_{10}-C_{40} (µg/L)	Sulfate as SO4 (mg/L)	Ferrous iron (mg/L)	Methane (µg/L)	Nitrate (as N) (mg/L)	DO (field) (mg/L)	ORP (field) (mV)
0967_MW146	March 2018	<100	107	0.23	<10	1.96	0.91	169.2
0967_MW226	April 2019	<100	136	<0.05	<10	0.04	1.1	-241.3
0967_MW232S	March 2018	<100	6	58.8	771	<0.01	0.34	-155.8
	April 2019	<100	101	9.12	21	0.03	0.81	-50.2
0967_MW232P	March 2018	130	1	56.7	277	<0.01	0.47	-143.7
	April 2019	<100	22	11.3	308	<0.01	0.30	-71.3
0967_MW233S	March 2018	380	16	71	251	0.68	0.91	-204.2
	April 2019	<100	44	10.9	251	0.29	7.62	18.0
0967_MW234S	March 2018	<100	197	17.3	<10	1.84	0.94	-27.6
	April 2019	370	138	11	<10	0.1	0.40	99.7
0967_MW235S	March 2018	<100	120	17.1	<10	<0.01	1.09	-59.4
	April 2019	140	122	31.1	<10	0.01	0.43	56.1
0967_MW240	April 2019	<100	107	9.14	<10	0.02	1.85	-26.1
0967_MW242	March 2018	22,600	<2	31.1	3620	3.06	0.43	-98.4
	April 2019	6440	179	21.6	1680	0.18	0.12	-105.7

10.13.4 Plume stability assessment

A groundwater plume stability and trend assessment (including MNA parameters) with regards to identified TRH impacts was undertaken for the purpose of evaluating and quantifying the potential risk of contamination associated with bulk fuel storage and use in the area.

The findings of the assessment of MNA conditions augmenting the existing dataset has been used to determine plume stability and the extent of primary and secondary lines of evidence of MNA processes occurring within the CSR area is discussed in the following sections.

Plume degradation behaviour

Natural attenuation processes in a dissolved hydrocarbon plume include dispersion, dilution, volatilisation, sorption as well as aerobic and anaerobic biodegradation. As detailed in the Contaminated Sites Management Series 'Use of Monitored Natural Attenuation for Groundwater

Remediation' (Department of Environment [DoE] 2004) there are three lines of evidence for remediation by natural attenuation. The primary and secondary lines of evidence are reviewed below to confirm the effectiveness of natural attenuation as the key component of the remediation of residual TRH impacts in groundwater beneath the CSR area.

Primary lines of evidence

Primary lines of evidence for natural attenuation are provided by observed reductions in plume geometry and/or contaminant concentration/mass over time and/or distance (DER 2004). A plume that is reducing in extent or concentration, or that is stable, is considered to be primary evidence of natural attenuation occurring.

Spatial distribution of impacts

Time-series spatial impact distribution analysis of TRH fractions was undertaken to evaluate primary lines of evidence using the groundwater data obtained between September 2009 and April 2019 and to provide a statistical evaluation of groundwater conditions at the Site.

TRH concentration contour plots generated for each monitoring event to demonstrate plume spatial characteristics such as migration and depletion are presented in Appendix P.

The available dataset has been impacted by the lack of available digital data between 2009 and 2018. However, the contour plots demonstrate the following:

- The TRH plume in the perched aquifer was not investigated until the recent 2018 and 2019 monitoring events and is indicated to be concentrated around 0967_MW242 (22600 µg/L in May 2018 to 6440 µg/L in April 2019) has decreased from 2018 to 2019 however is not delineated to the south west.
- The TRH plume in the superficial aquifer is concentrated within the centre of the former service station at 0967_MW234S and 0967_MW235S however remains at negligible concentrations (TRH $>C_{10}-C_{40}$ 140 µg/L to 370 µg/L in April 2019).

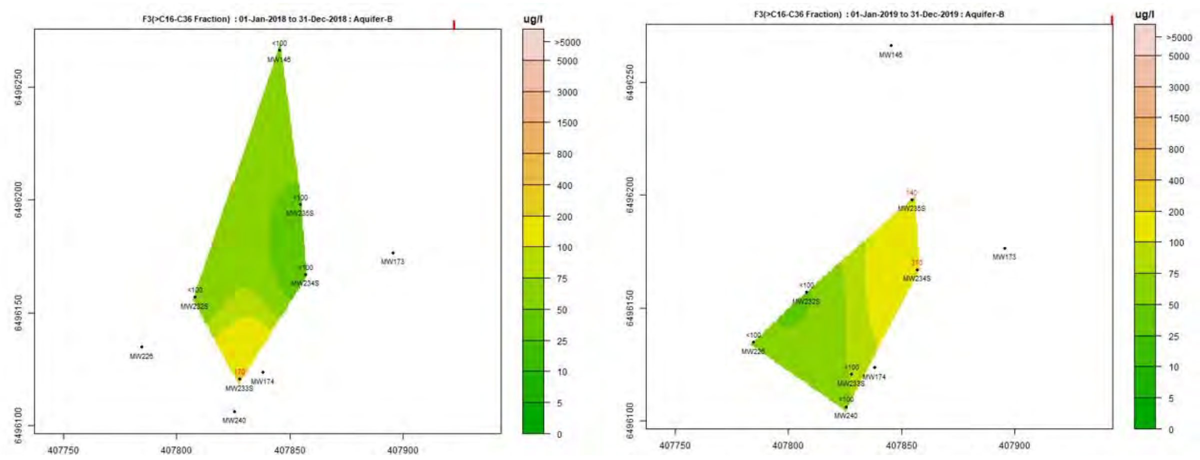

Plate 7 Contour plot of F3 TRH $>C_{16}-C_{34}$ in 2018 (left) and 2019 (right) in the superficial aquifer

Spatio-Temporal trend analysis

Graphical time-series plots of TRH concentrations were generated using GWSDAT to analyse temporal trends in dissolved phase concentrations however proved less useful as the dataset was discontinuous, each monitoring location only having one or two monitoring events in total.

Mann-Kendell analysis was undertaken on each TRH dataset at each groundwater monitoring well location where detectable concentrations of TRH were identified. The statistical significance of the trend is assessed by means of obtaining a p-value. If the p-value is obtained below 0.05, then the sample population is deemed to be statistically significant.

Note, the LOR value was used for non-detects, which offer a more conservative trend (as opposed to a zero value or adopting half the LOR), which can affect statistical confidence.

Where a p-value above 0.05 is identified for the sample population, then the data should be interpreted as meaning that that a statistically significant trend is not present. Notwithstanding the above, evidence of declining or increasing trends may still be deduced by qualitative professional judgement of the time-series data in the well trend plots.

Given the discontinuity of the dataset, all generated plots containing only two data points failed the Mann-Kendall test. The plots are not provided in this report as they are considered not beneficial to the overall assessment.

Secondary lines of evidence

Secondary evidence of natural attenuation can be demonstrated by evaluation of various geochemical indicators of biodegradation, including depletion of electron acceptors such as DO (aerobically), and nitrate, sulfate and carbon dioxide (anaerobically) with consequent increases in concentrations of degradation by-products, including ferrous iron and methane.

Secondary lines of evidence of hydrocarbon degradation were evident within the perched and superficial aquifers based on the assessment of the March-May 2018 GME and April 2019 GME datasets. The findings are discussed in the following sections.

Electron acceptors - Perched aquifer

Two wells screened in the perched aquifer we able to be sampled in both 2018 and 2019.

Redox - Redox potential within the plume and down-gradient monitoring wells were recorded in the negative range as anticipated, representative of mildly reducing and therefore low-energy anaerobic conditions.

DO – Dissolved oxygen in the perched aquifer was low (less than 0.5 mg/L) indicative of anaerobic conditions.

Nitrate – Nitrate was depleted in the perched aquifer in 2019, having reduced from 3.06 mg/L at source zone location 0967_MW242 to 0.18 mg/L.

Sulfate – Concentrations of sulfate were depleted in 2018 (less than 2 mg/L) and had increased slightly in 2019. It is likely Sulfate reduction was occurring in 2018 and when depleted, other electron donors such as DO and nitrate were utilised for biodegradation, allowing the sulfate concentrations to recover.

Electron acceptors – shallow regional aquifer

Redox - Redox potential within the plume and down-gradient monitoring wells were recorded in the negative range as anticipated, representative of mildly reducing and therefore low-energy anaerobic conditions. Conversely, positive oxidising conditions were recorded upgradient at 0967_MW146.

DO –Concentrations of DO in the superficial aquifer were generally low and anaerobic (less than 1 mg/L) however one anomaly was recorded at 7.62 mg/L at the downgradient plume fringe (0967_MW233S April 2019).

Nitrate – Nitrate in the superficial aquifer was depleted in 2019 recorded below 0.29 mg/L at all locations. The previous year, nitrate was present at 1.96 mg/L in upgradient well 0967_MW146 and 1.84 mg/L in downgradient well 0967_MW234S, indicating nitrates are available in the aquifer but likely have been utilised for biodegradation.

Sulfate – Concentrations of sulfate in groundwater ranged from 6 mg/L (0967_MW232S) to 197 mg/L (0967_MW234S) in the groundwater monitoring well network screened within the superficial aquifer. Importantly, sulphate concentrations were depleted in downgradient monitoring wells (0967_MW232S and 0967_MW233S) when redox was strongly reducing (-204.2 mV and -155.8 mV). This indicates sulfate is likely being utilised for biodegradation of TRH in the aquifer when reducing conditions allow.

Degradation by-products – perched and shallow aquifer

Ferrous iron – Concentrations of ferrous iron were present above 9 mg/L across the Former Service Station however were notably low at upgradient (0967_MW146) and distal down-gradient (0967_MW226) locations where they were recorded below 0.23 mg/L. This indicates ferrous iron production has likely been taking place within the TRH plume. The highest ferrous iron concentrations (greater than 50 mg/L) were noted to be associated with presence of TRH (excluding MW232S), depleted sulfate, nitrate and strongly reducing conditions (redox -204.2 mV to -143.7 mV).

Dissolved methane – High concentrations of dissolved methane were detected in the perched aquifer. Dissolved methane was recorded at its highest (3620 µg/L) at MW242 when TRH was also its peak (22600 µg/L) indicating methanogenesis was occurring at the source zone.

The presence of dissolved methane in the superficial aquifer was not always associated with TRH presence and may indicate biological activity not related to the TRH plume.

Plume degradation summary

Primary and secondary lines of evidence for natural attenuation processes demonstrate the following:

- Statistically derived and qualitative trends for TRH were not achievable with the dataset which was observed to be discontinuous due to the loss/damage of key wells following site inactivity.
- A reducing TRH plume in the perched aquifer and to almost negligible concentrations in the superficial aquifer
- Absence of any significant TRH concentrations in outermost downgradient perimeter wells in the superficial aquifer (below the LOR).
- Consumption of dissolved oxygen, nitrates, sulfate and the presence of degradation by-products ferrous iron and methane in the perched and superficial aquifers, which provides a further line of evidence for degradation of TRH in the groundwater.

10.13.5 Surface water laboratory results

No surface water sampling locations had sufficient surface water for sampling in the drainage channels located in close proximity to the Former Service Station.

10.13.6 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- The extent of soil sampling from the current and previous Stage 2 DSI (AECOM 2010) is considered adequate to define the potential contamination risk to the CSR area for soils.
- Soil CoPC concentrations were all reported below the human health guidelines for commercial/industrial use and the majority below ecological guidelines indicating no

contamination risk to property users and ecological receptors under the current land-use scenario.

- Localised TRH C_{16}-C_{34} concentrations exceeding the ESL (2500 mg/kg) were identified at depth (4.0 m bgl) at one location (0967_BH320) beneath the former fuel station infrastructure and liquid waste pit. Concentrations of TRH were not present between ground surface and 2.0 m bgl or at 5.0 m bgl. ESLs are generally applicable to the top 2 m of soil. Given the lack of terrestrial ecological receptors in contact with the soils of the Former Service Station at this depth, concentrations of CoPC in soils across the balance of the Former Fuel Farm do not indicate a contamination risk to ecological receptors.

Sediment

- Sediment CoPC concentrations from two samples in the adjacent drain were all reported below LOR or relevant the ISQG levels indicating no contamination risk to property users and ecological receptors from the sediment in the adjacent drain under the current land-use scenario.

Surface water

- No surface water sampling locations had sufficient surface water for sampling in the drainage channels located in close proximity to the Former Service Station however it is considered surface water sampling across the airbase in general is sufficient to illustrate surface water quality flowing off site as discussed in Section 10.2.1. Furthermore, results from soil and sediment sampling indicate that the risk of contamination downstream via surface run-off from the Former Service Station is low.

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the Former Service Station flows south west however as it gets further from the service station is likely to migrate toward and discharge to the Ki-It Monger Brook in the south east. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- Metals concentrations were reported above fresh water criteria and marginally exceeded background concentrations (Section 10.1). Metals exceeding groundwater ILs were not necessarily present in soil or not present at significant concentrations indicating the elevated metals concentrations are likely the result of diffuse source contamination from general industrial land use.
- TRH concentrations were present in both perched aquifer sample locations (however only in one in 2019) and were significantly reduced in concentration from 2018 to 2019.
- The greatest concentrations of TRH and BTEX-N were observed at 0967_MW242 in the perched aquifer, in the vicinity of the former waste oil UST. No LNAPL was observed within any of the monitoring wells however a slight sheen was noted at 0967_MW242 in April 2019.
- TRH concentrations in the perched aquifer are not delineated toward the south however it is considered unnecessary to install any further wells in the perched aquifer given the following:
  - Lack of TRH presence down-gradient within the superficial aquifer
  - Unlikely event that the TRH plume will migrate from the discontinuous perched aquifer to a down-gradient receptor (downgradient well 0967_234P was reported to be dry in 2019).

  - Lack of infrastructure down-gradient of the perched aquifer plume which would give rise to increased vapour risk.
- TRH concentrations in the superficial aquifer were low (less than LOR to 380 µg/L) and have reduced slightly from historic (2009) concentrations.
- Given the inferred groundwater flow being south-westerly in this portion of the site and no TRH impacts observed in the monitoring wells in the down-gradient fringes of the CSR it is considered the extent of the TRH plume in the superficial aquifer is adequately delineated. The data gap regarding the adequacy of the monitoring network is therefore considered closed.
- Natural attenuation of TRH in the perched and superficial aquifers is supported by evidence of consumption of dissolved oxygen, nitrates, sulphates and the presence of degradation by-products ferrous iron and methane in the source areas.
- The groundwater impacts detected in 0967_MW242 (ethylbenzene, MTBE and naphthalene) exceeding health and ecological ILs in 2018 were not present in 2019 above LOR or were significantly reduced (ethylbenzene) and have likely naturally attenuated as supported by the secondary lines of evidence presented in section 10.13.4.

10.13.7 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.13.8 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- It is considered the extent of soil impact has been adequately defined to enable an assessment of risk to ongoing site users and indicate no contamination risk to property users and ecological receptors under the current land-use scenario.
- The groundwater impacts (benzene, ethylbenzene, MTBE and naphthalene) exceeding health and ecological ILs are limited to the area beneath the residual source zone and are not migrating from the boundary of the CSR. Given groundwater is not abstracted at the site and the impacts are localised to the source zone, show significant attenuation in a down-gradient direction and therefore are unlikely to migrate as far as Ki-It Monger Brook or the Ellen Brook, the risk presented to human health and ecological receptors from the hydrocarbon plume is considered low.
- The current groundwater monitoring network is considered adequate.
- Multiple lines of evidence support MNA has and is occurring at the Former Service Station. Given the Former Service Station has been decommissioned, no further primary sources of contamination are considered present and it is considered natural attenuation will continue in the perched and superficial aquifers and can be monitored for a maximum of two further annual events to clearly demonstrate this.

10.14 CSR_WA_000151 – Grounds Maintenance Area

10.14.1 Summary of data gaps

Historical small leaks of chemicals are known to have occurred on the property and considered likely to run-off in the direction of a drain located adjacent to the boundary. The earthen bund in the south-western corner of the Grounds Maintenance Area was observed to be compromised.

PFAS well SD-MW12 (screened 11.9 to 17.9 m bgl) reported TCE concentration of 863 µg/L in September 2017.

Further investigation including the collection of additional surface soil samples within compound area, sediment samples from adjacent drain outside compound and installation of additional down-gradient monitoring wells was therefore considered necessary to assess the current status of potential risk associated with historical chemical leaks, chemical and fuel storage operations.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented on Figure 25A.

CoPC: TRH, metals, PAHs, herbicides, pesticides, VOCs, dioxins and furans.

10.14.2 Soil laboratory results

Soil samples were collected at 14 soil locations and at three monitoring well installation locations. Soil analytical results for the Grounds Maintenance Area are compared against the relevant assessment criteria in Table L12-1 (Appendix L). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (mercury)
- PAHs (naphthalene)
- TRH (F1 (C_6-C_{10} minus BTEX-N), C_6-C_{10} fraction)
- VOCs
- OPPs
- Fungicides
- Dioxins and Furans

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (chromium, copper, lead, nickel, zinc)
- TRH (F2 (>C_{10}-C_{16} minus naphthalene), F4 (>C_{34}-C_{40} fraction), >C_{10}-C_{40} (sum of total))
- OCPs (4,4-DDE, DDT+DDE+DDD - lab calc)
- Herbicides (atrazine, tebuthiuron)

Table 68 provides a summary of the soil analytical results which exceeded the adopted SILs.

Table 68 Soil sample exceedances – Grounds Maintenance Area (CSR_WA_000151)

Analyte	Monitoring Round	Location ID	Depth (m bgl)	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
TRH >C_{10}-C_{16} Fraction	March 2018	0967_BH345	0.1	200	170	ESLs
TRH F3 (>C_{16}-C_{34} Fraction)	March 2018	0967_BH342	0.1	1960	1700	ESLs

10.14.3 Groundwater laboratory results

Groundwater analytical results for the Grounds Maintenance Area were compared against the relevant assessment criteria in Table L12-2 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (cadmium, mercury)
- OCPs
- OPPs
- Dioxins & Furans
- TRH >C_{10}-C_{40}

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (arsenic, lead)
- BTEX (Toluene)
- TRH (F1 (C_6-C_{10} minus BTEX-N))
- PAHs (naphthalene)
- VOCs (1,2,3-trichlorobenzene, bromodichloromethane, dibromomethane, TCE)
- Chlorinated hydrocarbons (chloroform)
- Herbicides (bromacil)
- Pesticides (atrazine, simazine)
- Fungicides (benomyl, paclobutrazol)

Table 69 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 69 Groundwater sample exceedances – Grounds Maintenance Area (CSR_WA_000151)

Analyte	Monitoring Round	Location ID	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium	March 2018	0967_MW243 0967_MW244 0967_MW245	0.002 - 0.004	0.001	ANZECC FW
Copper	March 2018	0967_MW243 0967_MW244 0967_MW245 0967_MW112 0967_MW113	0.002 – 0.028	0.0014	ANZECC FW
	April 2019	0967_MW243 0967_MW244 0967_MW245 0967_MW112 0967_MW113	0.004 – 0.017		
Nickel	March 2018	0967_MW112	0.016	0.011	ANZECC FW
	April 2019	0967_MW112 0967_MW113 0967_MW243 0967_MW244	0.015 – 0.017		
	March 2018	0967_MW113	0.023	0.02	ADWG (health)
	April 2019	0967_MW112 0967_MW113	0.023 – 0.038		
Zinc	March 2018	0967_MW243 0967_MW244 0967_MW245 0967_MW112 0967_MW113	0.011 – 0.04	0.008	ANZECC FW
	April 2019	0967_MW243 0967_MW244 0967_MW245 0967_MW112 0967_MW113	0.011 - 0.079		

A graphical representation of the distribution of groundwater impacts is presented on Figure 25C and D.

10.14.4 Surface water laboratory results

Proposed location 0967_SW129 did not have sufficient surface water for sampling.

10.14.5 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- All CoPC in soil were reported below human health ILs indicating no impact to property users under the current land-use scenario.

- Concentrations of TRH exceeded the ESLs in surface soils (0.1 m bgl) adjacent to the machinery storage bays (0967_BH345) and lay-down area (0967_BH342). Deeper samples (greater than 0.5 m bgl) did not report any TRH above the LOR indicating the impacts are limited to the surface.
- Given the lack of terrestrial ecological receptors in contact with the soils of the Grounds Maintenance Area, concentrations of CoPC in surface soils across the balance of the Grounds Maintenance Area do not indicate a contamination risk to ecological receptors.

Surface water

- Proposed surface water location 0967_SW129 did not have sufficient surface water for collection of a representative sample of this matrix however it is considered surface water sampling across the airbase in general is sufficient to illustrate surface water quality flowing off site is not impacted by the grounds maintenance area (as discussed in Section 10.2.1).

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the Grounds Maintenance Area is likely to discharge to the Ellen Brook to the west. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- Metals concentrations were reported above fresh water criteria (chromium, copper, nickel and zinc), drinking water (health) criteria (nickel) and background concentrations (Section 9.1). Given the distance from the Grounds Maintenance Area and the Ki-It Monger and the Ellen Brooks (>1.0 km) it is considered unlikely the elevated concentrations of metals exceeding ecological ILs will migrate to these sensitive ecological receptors.
- Groundwater beneath the Grounds Maintenance Area also reported minor concentrations (not exceeding ILs) of VOCs typically associated with solvents comprising 1,2,3-trichlorobenzene, bromodichloromethane, dibromomethane, chloroform and TCE along with pesticide compounds comprising atrazine, simazine, bromacil, paclobutrazol and benomyl. Trace concentrations of pesticides were also noted in soil and sediment samples.
- TCE concentrations have fluctuated at 0967_MW112 (previously MW12) since its detection by the PFASIMB in 2017 (section 4.1). The elevated concentrations are centred around 0967_MW112 and 0967_MW243 while minor concentrations were reported at downgradient monitoring wells 0967_MW244 and 0967_MW245. The upgradient extent of the TCE plume is not adequately delineated.
- Existing wells are screened at the top of the superficial aquifer and may not detect DNAPL (if present). Further investigation into potential DNAPL presence should consider installation of deeper wells.

10.14.6 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.14.7 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- Concentrations of elevated CoPC detected in soil, sediment and groundwater are unlikely to impact property users under the current land-use scenario nor are they likely to migrate to the sensitive ecosystem of Ki-It Monger or the Ellen Brook given the distance (greater than one kilometre).

- The soil and groundwater data does however indicate that chemical storage and handling practices at the Grounds Maintenance Area has had an impact, albeit minor, on the environment.
- Chemical storage and handling practices including potential for engineering controls at the Grounds Maintenance Area should be reviewed and improved to prevent further impact to the environment.
- Groundwater monitoring at the Grounds Maintenance area should be incorporated into future monitoring programs.
- Two further monitoring wells are recommended to be installed north of 0967_MW112 and 0967_MW243 to delineate the upgradient reaches of the TCE plume.
- One further monitoring well should be installed within the source zone and screened at the base of the superficial aquifer to investigate the potential for presence of DNAPL.

10.15 CSR_WA_000153 – Fire Training Area – Fire Station Centre of Base

10.15.1 Summary of data gaps

Investigation was required to address groundwater quality uncertainty, assess the current status of potential risk arising from continued diesel storage and use.

All sampling locations within this CSR and sampling rationale are detailed in Section Table 25 and are presented in Figure 26A.

CoPC: Metals, TRH, PAHs.

10.15.2 Sediment laboratory results

Three sediment sampling locations are located in drainage channels in close proximity to the Fire Training Area which are considered to be servicing the area. These sample locations include 0967_SD121, 0967_SD134, and 0967_SD135. Sediment analytical results from these locations are compared against the relevant assessment criteria in Table L13-1 (Appendix L). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in sediments were all below LOR:

- Metals (arsenic, cadmium, mercury)
- BTEX-N

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines at a few locations:

- Metals (chromium, copper, lead, nickel)
- TRH (F3 (>C_{16}–C_{34} Fraction), F4 (>C_{34}-C_{40} Fraction))
- PAHs (benzo(b+j)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, indeno(1,2,3-c,d)pyrene)

Table 70 provides a summary of the sediment analytical results which exceeded the adopted sediment and soil investigation levels. A graphical representation of the distribution of metal exceedances in sediments in presented on Figure 33B.

Table 70 Sediment sample exceedances – Fire Training Area – Fuel Storage Facilities (CSR_WA_000153)

Group	Analyte	Locations IDs	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
Metals	Zinc	0967_SD121	220	200	ISQG - Low
PAHs	Pyrene		2.5	0.665	
	BaP		0.9	0.43	
	Chrysene		2	0.384	
	Fluoranthene		3.2	0.6	
	Phenanthrene		1.1	0.24	
	PAHs – Sum of total		15.4	4	

10.15.3 Groundwater laboratory results

Groundwater analytical results for the Fire Training Area were compared against the relevant assessment criteria in Table L13-2 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (cadmium, mercury)
- BTEX-N
- TRH
- PAHs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (arsenic)

Table 71 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 71 Groundwater sample exceedances – Fire Training Area – Fuel Storage Facilities (CSR_WA_000153)

Analyte	Monitoring Round	Location ID	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium	April 2018	0967_MW053	0.017	0.001	ANZECC FW
Copper	April 2018	0967_MW015 0967_MW053 0967_MW101	0.024 – 0.128	0.0014	ANZECC FW
Lead	April 2018	0967_MW053	0.007	0.0034	ANZECC FW
Nickel	April 2018	0967_MW101 0967_MW102	0.016	0.011	ANZECC FW
Zinc	April 2018	0967_MW015 0967_MW053 0967_MW101 0967_MW102	0.008 – 1.24	0.008	ANZECC FW

A graphical representation of the distribution of groundwater impacts is presented on Figure 26B.

10.15.4 Surface water laboratory results

No surface water sampling locations had sufficient surface water for sampling in the drainage channels located in close proximity to the Fire Training Area.

10.15.5 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- Soil was not sampled at this CSR given previous investigations (ERM 2013) indicated no impact to soil in this area.

Sediment

- Sediment sample 0967_SD121 collected within the CSR reported zinc and PAH concentrations exceeding the ISQG Low criteria. Sediment samples further downstream did not report any CoPC above LOR or the ISQG criteria which indicates the impacts are localised to within or immediately down-stream of the CSR.
- The presence of a thriving benthic community within the site drainage channel adjacent to the Fire Training Area is unlikely and therefore it is considered unlikely to be at risk from the elevated concentrations of metals and PAH identified. The lack of identification of any PAH or elevated metals down-stream indicates the down-stream receptors of the Ellen Brook are also unlikely to be at risk from the impacts observed at the Fire Training Area.

Surface water

- No surface water sampling locations had sufficient surface water for sampling in the drainage channels located in close proximity to the Fire Training Area however it is considered surface water sampling across the airbase in general is sufficient to illustrate surface water quality flowing off site as discussed in Section 10.2.1.

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the Fire Training Area is likely to discharge to the Ellen Brook in the south west. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- Metals concentrations were reported above fresh water criteria and exceeded background concentrations (Section 9.1) at well 0967_MW053. The monitoring well immediately down gradient of 0967_MW053 (0967_MW052) could not be sampled as it was dry. It is noted 0967_MW053 is screened in the discontinuous perched aquifer.
- Metals exceeding ILs were also present in sediment at the CSR. PAH concentrations which were elevated in the sediment samples were not detected above the LOR in groundwater.
- Given the assumed groundwater flow being south westerly in this portion of the site and down-gradient well from the area of impact being dry, it is considered the extent of the elevated metals is not fully delineated and it cannot be confirmed if groundwater impacts are migrating to the Ellen Brook. It is however considered unlikely to be migrating given the impacts are only observed in the discontinuous perched aquifer.

10.15.6 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.15.7 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- CoPCs in sediment and groundwater did not exceed any human health ILs. On this basis a contamination risk to property users under the current land-use scenario has not been identified.
- Elevated metals concentrations above ecological ILs and background concentrations have not been fully delineated. However, given the concentrations were reported in the discontinuous perched aquifer, it is unlikely impacts could migrate from the Fire Training

Area to the Ellen Brook and are therefore the groundwater impacts are considered unlikely to pose a risk to this ecosystem.

- Further conventional contamination investigation of the Fire Training Area is considered not required although PFAS investigations are ongoing.

10.16 CSR_WA_000155 – Fuel Storage Power Station

10.16.1 Summary of data gaps

A review of ERM Stage 2 DSI (2013) indicated soil quality is acceptable provided a site management plan is developed to manage exposure risk and to continue a program of GW monitoring. The review by ERM included soil testing outside of the area of impact and is therefore irrelevant.

There is a low risk that the leak may have caused impact beneath the building slab however indoor inhalation risk is considered low based on anecdotal evidence that the floor is in good condition. Comparison of historical shallow soil data (GHD 2004) to current TRH criteria identified contamination above HSL – D (direct contact criterion for commercial/industrial settings).

Further investigation is therefore considered necessary to assess the current status of potential risk associated with fuel storage and spill including vapour exposure assessment

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 27A.

CoPC: Metals, TRH, BTEX, PAHs.

10.16.2 Soil laboratory results

Soil samples were collected at two soil bore locations. Soil analytical results for the Power Station UST area are compared against the relevant assessment criteria in Table L14-1 (Appendix L). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (mercury)
- BTEX-N
- TRH
- PAHs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (arsenic, chromium, copper, lead, nickel, zinc)

No soil analytical results exceeded the adopted SILs.

10.16.3 Groundwater laboratory results

Groundwater analytical results for the Power Station UST area were compared against the relevant assessment criteria in Table L14-2 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (arsenic, chromium, mercury)
- BTEX-N
- TRH
- PAHs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (lead)

Table 72 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 72 Groundwater sample exceedances – Power Station USTs (CSR_WA_000155)

Analyte	Monitoring Round	Location ID	Concentration (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Cadmium	April 2018	0967_MW062	0.001	0.0002	ANZECC FW
Copper	April 2018	0967_MW061 0967_MW062	0.006 – 0.022	0.0014	ANZECC FW
Nickel	April 2018	0967_MW062	0.029	0.011 0.02	ANZECC FW ADWG (health)
Zinc	April 2018	0967_MW029 0967_MW061 0967_MW062	0.021 – 0.026	0.008	ANZECC FW

A graphical representation of the distribution of groundwater impacts is presented on Figure 27C.

10.16.4 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- Historic sampling (GHD 2004) indicated soil impacts from a fuel spill exceeded HSL-D. The impacts were not confirmed to have been completely remediated. The current Stage 2 DSI and previous Stage 2 DSI (ERM 2013) did not report any CoPC in soil exceeding LOR or the relevant criteria however, the locations tested were outside of the immediate spill area due to access restrictions. Soil vapour wells were unable to be installed adjacent to the building due to the presence of underground services and infrastructure, therefore the potential vapour risk that residual soil impacts in the spill area may pose to property users under the current land-use scenario is therefore not fully understood. However, based on the fact that the spill was diesel fuel, and that the slab of the Power Station building was observed to be in good condition, and that personnel only work within the building on a temporary short term basis, if at all, it is considered unlikely that there is a vapour risk to users.

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the Power Station is likely to discharge to the Ellen Brook in the south west. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- Three monitoring wells located down gradient of the CSR were sampled. Of these, none reported any CoPC above LOR or ILs with the exception of metals which were within background levels.

- TRH has not been reported above LOR in wells down-gradient of the CSR since 2013. Residual contamination from the historic spill is therefore considered to be localised to within the spill area and not migrating (if present).

10.16.5 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.16.6 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- Soil and groundwater testing is inconclusive with regards to the risk posed to property users from impacted soil, groundwater and vapours in the vicinity of the historic spill area as access was limited.
- Soil and groundwater testing carried out has however indicated the following:
  - No impacts in groundwater further down-gradient of the impact area since 2013
  - No risk is posed to down-gradient ecosystem of the Ellen Brook as contamination (if present) is not migrating from the CSR and
  - No impacts in soil adjacent to the historic spill area.
- Based on multiple lines of evidence, i.e. the fact that the spill was diesel fuel and occurred in 2004, that the slab of the Power Station building was observed to be in good condition, and that personnel only work within the building on a temporary short term basis, if at all, it is considered unlikely that there is a vapour risk to users.
- As per recommendations from the 2013 Stage 2 DSI, a Site Management Plan should be developed to manage potential exposure risk to intrusive workers (if not already in place).

10.17 CSR_WA_000156 – Paint Shop

10.17.1 Summary of data gaps

Historical investigations have not identified any significant soil or groundwater contamination however a sheen was observed in MW016 during the 2016 regional monitoring program.

Historical investigations did not include the assessment of sediment in adjacent surface drains near the Paint Shop. The potential for sediment to be impacted by hexavalent chromium is considered likely however has not been assessed to date.

Further investigation was therefore considered necessary to assess the current status of potential risk associated with Paint Shop operations including potential chromium VI impact to sediment in the Ellen Brook.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 28A.

CoPC: Metals, VOCs, TRH, nutrients.

10.17.2 Soil laboratory results

Soil samples were collected at one groundwater monitoring well location and two surface soil locations in the adjacent drain (in the absence of sediment sample locations). Soil analytical results for the Paint Shop area are compared against the relevant assessment criteria in Table L15-1 (Appendix L). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (hexavalent chromium, arsenic, cadmium, copper, mercury, nickel, zinc)
- TRH
- VOCs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (barium, copper, chromium, lead, manganese, strontium, nickel, vanadium, zinc)
- PAH (BaP, benzo(g,h,i)perylene, chrysene, fluoranthene, indeno(1,2,3-c,d)pyrene, pyrene)

No soil laboratory results exceeded the adopted SILs.

10.17.3 Groundwater laboratory results

Groundwater analytical results for the Paint Shop were compared against the relevant assessment criteria in Table L15-2 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (cadmium, lead, mercury)
- TRH
- VOCs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Nutrients
- Metals (arsenic, nickel, strontium)

Table 73 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 73 Groundwater sample exceedances – Paint Shop (CSR_WA_000156)

Analyte	Monitoring Round	Location ID	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium	March 2018	0967_MW016	0.002	0.001	ANZECC FW
Copper	May 2018	0967_MW239	0.003	0.0014	ANZECC FW
Zinc	May 2018	0967_MW239	0.009	0.008	ANZECC FW

A graphical representation of the distribution of groundwater impacts is presented on Figure 28B.

10.17.4 Surface water laboratory results

Proximity to the Paint Shop. Surface water analytical results from this location are compared against the relevant assessment criteria Table L20-2 (Appendix L). Results confirm that the following CoPC in surface water were all below LOR:

- Metals (arsenic, cadmium, lead, mercury, nickel)
- Nutrients (nitrite (as N))
- TRH

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (arsenic, nickel)
- Nutrients (excluding nitrite (as N))
- TRH (F3 (>C_{16}-C_{34} fraction))

Table 74 provides a summary of the surface water analytical results which exceeded the adopted screening guidelines.

Table 74 Surface water sample exceedances – Paint Shop (CSR_WA_000156)

Analyte	Monitoring Round	Location ID	Concentration mg/L	Criteria limit mg/L	Criteria exceeded
Chromium	September 2018	0967_SW104	0.004	0.001	ANZECC FW
Copper	September 2018		0.002	0.0014	
Zinc	September 2018		0.066	0.008	

10.17.5 Discussion

Soil

- Soil CoPC concentrations (including hexavalent chromium) from the three tested locations were all reported below the human health, ecological guidelines and background concentrations. This confirmation in conjunction with historic sampling (ERM 2013) indicates no risk of impact to property users from soil under the current land-use scenario.

Surface water

- The surface water sample reflected a similar metals concentration profile to the surface soils at the CSR with elevated chromium, copper and zinc exceeding freshwater ILs. PAHs were not detected above LOR in the surface water albeit being present in surface soils.
- Chromium concentrations in the surface water were also somewhat elevated above upstream concentrations in the Ellen and Ki-It Monger Brooks. The minor chromium impact to surface water in the vicinity of the Paint Shop was not reported downstream in the Ellen and Ki-It Monger Brooks indicating onsite impacts to surface water are not being transported off site or are sufficiently diluted at the receiving surface water body.

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the Former Paint Shop is likely to discharge to the Ki-It Monger Brook in the south. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- Metals concentrations were reported above fresh water criteria however were within background concentrations (Section 9.1) reflecting the urbanised land-use setting.
- Groundwater beneath the Paint Shop does not appear to be impacted by Paint Shop activities.

10.17.6 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.17.7 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- Soil, surface water and groundwater testing indicates that there is no risk of impact to property users or the down-gradient ecosystem of the Ki-It Monger Brook from soil, groundwater or surface water under the current land-use scenario.
- The Paint Shop area is suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management or monitoring and as such should be archived from the CSR database.

10.18 CSR_WA_000160 – Hangar 95

10.18.1 Summary of data gaps

Anecdotal evidence suggests the presence of hydrocarbon impact at each end of the building and inferences have also been made suggesting impact beneath the building.

Further investigation was therefore considered necessary to assess the current status of potential contamination risk associated with workshop operations and historical spills. Groundwater impact uncertainty remained following the initial mobilisation prompting further investigation in mobilisation 2.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 29A.

CoPC: Solvents, TRH, BTEX-N, VOCs, MTBE, metals, PAHs, phenols, anion, cations.

10.18.2 Groundwater laboratory results

Groundwater analytical results for the hangar area were compared against the relevant assessment criteria in Table L16-1 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (cadmium, mercury)
- Benzene, ethylbenzene, xylenes
- TRH (F4 (>C_{34}-C_{40} fraction))
- PAHs
- VOCs
- CHCs (excluding chlorobenzene)

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (chromium, arsenic, lead)
- TRH (excluding F4 (>C_{34}-C_{40} fraction))

Table 75 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 75 Groundwater sample exceedances – Hangar 95 (CSR_WA_000160)

Analyte	Monitoring Round	Location ID	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Copper	April 2018	0967_MW076 0967_MW077	0.002-0.041	0.0014	ANZECC FW
	April 2019	0967_MW076 0967_MW077 0967_MW246 0967_MW247 0967_MW248	0.002-0.018		
Nickel	April 2019	0967_MW247 0967_MW248	0.016	0.011	ANZECC FW
Zinc	April 2018	0967_MW076	0.039	0.008	ANZECC FW
	April 2019	0967_MW076 0967_MW077 0967_MW246 0967_MW247 0967_MW248	0.042-0.062		
Toluene	April 2019	0967_MW246 0967_MW247	0.029-0.036	0.025	ADWG (aesthetic) NPUG
Chlorobenzene	April 2018	0967_MW077	0.023	0.10	ADWG (aesthetic) NPUG

A graphical representation of the distribution of groundwater impacts is presented on Figure 29A and B.

10.18.3 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the Hangar 95 is likely to discharge to the Ellen Brook in the south west. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- Metals concentrations were reported above fresh water criteria (chromium, copper zinc) and slightly elevated above background concentrations (Section 9.1) reflecting the urbanised land-use setting.
- Chlorobenzene was detected in monitoring well 0967_MW077 down-gradient of the Hangar exceeding drinking water (aesthetic) and NPUG criteria during 2018 but did not exceed LOR in 2019.
- Toluene was detected in new monitoring wells 0967_MW246 and 0967_MW247 down-gradient of the Hangar exceeding drinking water (aesthetic) and NPUG criteria during April 2019 (23 to 36 µg/L). The extent of toluene in groundwater beneath the hangar is delineated by downgradient monitoring wells at the Aircraft Shelters (0967_MW249 and 0967_MW251) which reported only trace toluene concentrations (2 to 6 µg/L). Given the distance to the Ellen Brook (1.5 km) it is unlikely to migrate to the receptor at these concentrations.

- Although concentrations of volatile organic compounds have been detected in groundwater down-gradient of the hangars, it is considered the vapour risk to on-site receptors is low and sufficiently managed by existing occupational hygiene indoor air quality monitoring procedures.

10.18.4 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.18.5 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- The extent of toluene in groundwater beneath the hangar is delineated by down-gradient monitoring wells at the Aircraft Shelters and given the distance (1.5 km) it is unlikely to migrate to the Ellen Brook.
- Although concentrations of volatile organic compounds have been detected in groundwater down-gradient of the hangars, it is considered the vapour risk to on-site receptors is low and sufficiently managed by existing indoor air quality monitoring procedures.
- Groundwater monitoring from the existing network and incorporating new wells installed at the aircraft shelters (09687_MW249, 0967_MW250, 0967_MW251) should continue (including analysis for toluene and chlorobenzene) at this location to ensure the impact which fuel handling practices have on the environment is effectively monitored.

10.19 PCSR_0967_001 – Aircraft Shelters

10.19.1 Summary of data gaps

Anecdotal evidence relates to venting of significant volumes of aviation fuel in the area to the west of the aircraft shelters.

Reporting (Golder 2015) indicated strong hydrocarbon odours in this area from 0.3 to 1.0 m with no contamination analysis conducted.

Soil and groundwater impact uncertainty is present.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 30A.

CoPC: Metals, TRH, BTEX-N, VOCs, PAHS, chlorinated hydrocarbons

10.19.2 Soil laboratory results

Soil samples were collected at eight soil bore locations. Soil analytical results for the Aircraft Shelters are compared against the relevant assessment criteria in Table L17-1 (Appendix L). All soil samples were below the adopted guidelines at this location. Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (arsenic, cadmium, mercury)
- BTEX-N
- VOCs
- Monocyclic Aromatic Hydrocarbon (MAH)
- Halogenated Hydrocarbons
- Chlorinated Hydrocarbons

The following CoPC were detected above the LOR but were below the applied guidelines:

- Metals (chromium, copper, iron, lead, nickel, zinc)
- TRH (F1 (C_6-C_{10} minus BTEX), C_6-C_{10} Fraction, F2 (>C_{10}-C_{16} minus Naphthalene), >C_{10}-C_{16} Fraction
- PAHs (Total 8 PAHs (as BaP TEQ)(half LOR) and Total 8 PAHs (as BaP TEQ)(full LOR)

No soil laboratory results exceeded the adopted SILs.

10.19.3 Groundwater laboratory results

Groundwater analytical results for the Aircraft Shelters were compared against the relevant assessment criteria in Table L17-2 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (cadmium, mercury)
- BTEX-N (Benzene, Ethylbenzene)
- TRH (F1 (C_6-C_{10} minus BTEX), F4 (>C_{34}-C_{40} Fraction)
- PAHs (Naphthalene)

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (arsenic, lead)

- BTEX-N (Toluene, Xylene (o), Xylene (m & p), Xylene Total, BTEX (Sum of Total).
- TRH (C_6-C_{10} Fraction), F2 (>C_{10}-C_{16} minus Naphthalene), >C_{10}-C_{16} Fraction, F3 (>C_{16}-C_{34} Fraction), >C_{10}-C_{40} (Sum of Total)
- VOCs (Acetone, Dibromomethane)
- Chlorinated Hydrocarbons (Bromochloromethane)

Table 84 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 76 Groundwater sample exceedances – Aircraft Shelters (PCSR_0967_001)

Analyte	Monitoring Round	Location ID	Concentration (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium	April 2019	0967_MW249	0.001	0.001	ANZECC FW
Copper		0967_MW249	0.004	0.0014	
		0967_MW250	0.011		
		0967_MW251	0.013		
Nickel		0967_MW250	0.017-0.023	0.011	
				0.02	ADWG 2011 Health
Zinc		0967_MW249	0.089	0.008	ANZECC FW
		0967_MW250	0.066		
		0967_MWQC143	0.024		
		0967_MW251	0.088		

10.19.4 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- All CoPC tested across the PCSR were below the relevant human health ILs and therefore soils at the Aircraft Shelters do not pose a risk of impact to property users under the current land-use scenario.

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the Aircraft Shelters is likely to discharge to the Ellen Brook in the south west. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- Metals concentrations were reported above fresh water criteria (chromium, copper, nickel, zinc) and slightly elevated above background concentrations (Section 9.1) reflecting the urbanised land-use setting.
- Minor concentrations of hydrocarbons (toluene, xylenes, TRH C_6-C_{34}) not exceeding ILs were detected in groundwater in 0967_MW249 and 0967_MW250. Trace concentrations of VOCs (dibromomethane, bromochloromethane, acetone) were also reported. Given the lack of credible receptors in the area and the Ellen Brook being 1.25 km from the Aircraft

Shelters, these hydrocarbon concentrations are considered minor and do not warrant any further investigation.

10.19.5 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.19.6 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- CoPCs in soil and groundwater did not exceed any human health ILs. On this basis a contamination risk to property users under the current land-use scenario has not been identified.
- Groundwater monitoring data indicates that aircraft maintenance and fuelling practices at the aircraft shelters area has had an impact, albeit minor, on the environment and do not warrant any further investigation.
- The Aircraft Shelters area is suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management or monitoring and generation of a new CSR in the CSR database is not recommended.
- Monitoring wells installed at this location are to be incorporated into the monitoring network targeting the Hangar 95 CSR.

10.20 PCSR_0967_002 – AVTUR Fuel Farm

10.20.1 Summary of data gaps

Five monitoring wells were installed during construction of the facility in 2014. No LNAPL detected during weekly dipping, however no groundwater sampling known to have been undertaken. Anecdotal evidence of free product near the puraceptor reported by the fuel farm operator in the early operation of the new fuel farm (Defence comms).

A small spill (anecdotally approximately 20 L) of AVTUR occurred onto blue metal (subsurface unlined) at the western edge of the refuelling area in January 2018, with no subsurface excavation undertaken.

Investigation of soil and groundwater was considered necessary to assess the current status of potential risk associated with the historical fuel spill and fuel storage operations, particularly the potential contamination of surface soil/likelihood for vertical migration to groundwater and plume stability.

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 31A.

CoPC: Metals, TRH, BTEX, VOCs, PAHs.

10.20.2 Soil laboratory results

Soil samples were collected at three soil bore locations. Soil analytical results for the fuel farm area are compared against the relevant assessment criteria in Table L18-1 (Appendix L). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (arsenic, cadmium, mercury)
- BTEX-N
- TRH
- PAHs
- VOCs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (chromium, copper, lead, nickel, zinc)

No soil analytical results exceeded the adopted SILs.

10.20.3 Sediment laboratory results

Four sediment sampling locations are located in drainage channels in close proximity to the New AVTUR Fuel Farm which are considered to be servicing the area. These sample locations include 0967_SD101, 0967_SD102, 0967_SD103 and 0967_SD104. Sediment analytical results from these locations are compared against the relevant assessment criteria in Table L18-2 (Appendix L). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in the sediment were all below LOR:

- Metals (mercury)
- BTEX-N

- VOCs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines at a few locations:

- Metals (arsenic, chromium, copper, nickel)
- TRH (F3 (>C_{16}–C_{34} Fraction))
- PAHs (benzo(b+j)fluoranthene, benzo(k)fluoranthene, benzo(g,h,i)perylene, indeno(1,2,3-c,d)pyrene)

Table 77 provides a summary of the sediment analytical results which exceeded the adopted sediment and soil investigation levels. A graphical representation of the distribution of metal exceedances in sediments is presented on Figure 33B.

Table 77 Sediment sample exceedances –New AVTUR Fuel Farm (PCSR_0967_002)

Group	Analyte	Locations IDs	Concentration range (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
Metals	Cadmium	0967_SD103	2	1.5	ISQG - Low
	Lead	0967_SD103 0967_SD104	52	50	ISQG - Low
	Zinc	0967_SD103	1100 - 1290	410 370	ISQG – High EIL – Comm/Ind[17]
		0967_SD104	284 – 400	200 370	ISQG – Low EIL – Comm/Ind
PAHs	Pyrene	0967_SD103 0967_SD104	5 – 8.5	2.6	ISQG - High
	Benz(a)anthracene	0967_SD103 0967_SD104	1.0 – 1.2	0.261	ISQG - Low
	BaP	0967_SD103 0967_SD104	2.1 – 2.9	0.43/1.6 2.1 1.4	ISQG – Low/High USEPA RSL ESL – Comm/Ind
	Chrysene	0967_SD103 0967_SD104	4.2 – 7.4	2.8	ISQG - High
	Dibenz(a,h)anthracene	0967_SD103 0967_SD104	0.6 – 1.0	0.26	ISQG - High
	Phenanthrene	0967_SD103 0967_SD104	2.0 – 4.3	1.5	ISQG - High

10.20.4 Groundwater laboratory results

Groundwater analytical results for the fuel farm area were compared against the relevant assessment criteria in Table L18-3 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (mercury)
- TRH (F1 (C_6-C_{10} minus BTEX), F4 (>C_{34}-C_{40} fraction))
- PAHs
- VOCs

[17] Only the split sample exceeded the EIL – Comm/Ind

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (arsenic, cadmium, chromium, lead)
- BTEX-N (ethylbenzene, naphthalene (BTEX-N), BTEX (sum of total))
- TRH (excluding F1 (C_6-C_{10} minus BTEX), F4 (>C_{34}-C_{40} fraction)

Table 78 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 78 Groundwater sample exceedances – New AVTUR Fuel Farm (DFI) (PCSR_0967_002)

Analyte	Monitoring Round	Location ID	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Copper	March 2018	0967_MW160 0967_MW161	0.005 - 0.021	0.0014	ANZECC FW
	April 2019	0967_MW158 0967_MW161 0967_MW162 0967_MW164	0.002 – 0.029		
Nickel	March 2018	0967_MW158 0967_MW165	0.014 – 0.015	0.011	ANZECC FW
		0967_MW161	0.071	0.02	ADWG (health)
	April 2019	0967_MW158	0.012	0.011	ANZECC FW
		0967_MW161 0967_MW165	0.033-0.05	0.02	ADWG (health)
Zinc	March 2018	0967_MW006 0967_MW158 0967_MW160 0967_MW161	0.017-0.097	0.008	ANZECC FW
	April 2019	0967_MW158 0967_MW161 0967_MW162 0967_MW164 0967_MW165	0.03-0.128		

A graphical representation of the distribution of groundwater impacts is presented on Figure 31C and D.

MNA parameters

MNA parameters were analysed from groundwater collected at seven monitoring wells in the New AVTUR Fuel Farm. Locations 0967_MW006 and 0967_MW160 were dry during the second mobilisation and could not be resampled. A summary of the MNA parameters is provided in Table 79.

Table 79 Summary of MNA parameters – New AVTUR Fuel Farm (PCSR_0967_002)

Location ID	Date	TRH >C_{10}–C_{40} (µg/L)	Sulfate as SO4 (mg/L)	Ferrous iron (mg/L)	Methane (µg/L)	Nitrate (as N) (mg/L)	DO (field) (mg/L)	ORP (field) (mV)
0967_MW006	May 2018	5880	<5	1.97	5610	0.01	0.19	-216.9
0967_MW158	March 2018	<100	180	1.58	<10	0.02	1.49	29.3
0967_MW158	April 2019	<100	168	0.55	<10	0.02	0.64	141.8
0967_MW160	March 2018	<100	1160	2.8	<10	0.08	NR[18]	NR[18]
0967_MW161	April 2019	400	600	<0.05	<10	0.12	2.07	23.8
0967_MW162	March 2018	<100	32	2.11	<10	2.4	NR[18]	NR[18]
0967_MW162	April 2019	<100	37	<0.05	<10	1.27	2.80	148.9
0967_MW164	March 2018	150	5	1.08	407	<0.01	0.15	-161.7
	April 2019	120	<1	0.82	1720	<0.01	0.17	-87.6
0967_MW165	March 2018	4030	584	25.2	37	0.02	NR[18]	NR[18]
	April 2019	1190	607	11.2	NR[18]	0.44	1.71	124.7

10.20.5 Plume stability assessment

A groundwater plume stability and trend assessment (including MNA parameters) with regards to identified TRH impacts was undertaken for the purpose of evaluating and quantifying the potential risk of contamination associated with bulk fuel storage and use in the area.

The findings of the assessment of MNA conditions augmenting the existing dataset has been used to determine plume stability and the extent of primary and secondary lines of evidence of MNA processes occurring within the CSR area is discussed in the following sections.

Plume degradation behaviour

Natural attenuation processes in a dissolved hydrocarbon plume include dispersion, dilution, volatilisation, sorption as well as aerobic and anaerobic biodegradation. As detailed in the Contaminated Sites Management Series 'Use of Monitored Natural Attenuation for Groundwater Remediation' (DoE 2004) there are three lines of evidence for remediation by natural attenuation. The primary and secondary lines of evidence are reviewed below to confirm the effectiveness of natural attenuation as the key component of the remediation of residual TRH impacts in groundwater beneath the CSR area.

Primary lines of evidence

Primary lines of evidence for natural attenuation are provided by observed reductions in plume geometry and/or contaminant concentration/mass over time and/or distance (DER 2004). A

[18] NR = not recorded due to limited water in the well

plume that is reducing in extent or concentration, or that is stable, is considered to be primary evidence of natural attenuation occurring.

Spatial distribution of impacts

Time-series spatial analysis of TRH fractions was undertaken to evaluate primary lines of evidence using the groundwater data obtained between November 2014 and April 2019 and to provide a statistical evaluation of groundwater conditions at the CSR.

TRH concentration contour plots generated for each monitoring event to demonstrate plume spatial characteristics such as migration and depletion are presented in Appendix P

The available dataset has been impacted by the lack of available data between 2014 and 2018 and by wells being noted as dry. However, the contour plots demonstrate the following:

- The perched aquifer is typically dry post summer however, TRH in the perched aquifer is at very low concentrations (TRH >C_{10}-C_{40} 120 µg/L -150 µg/L).

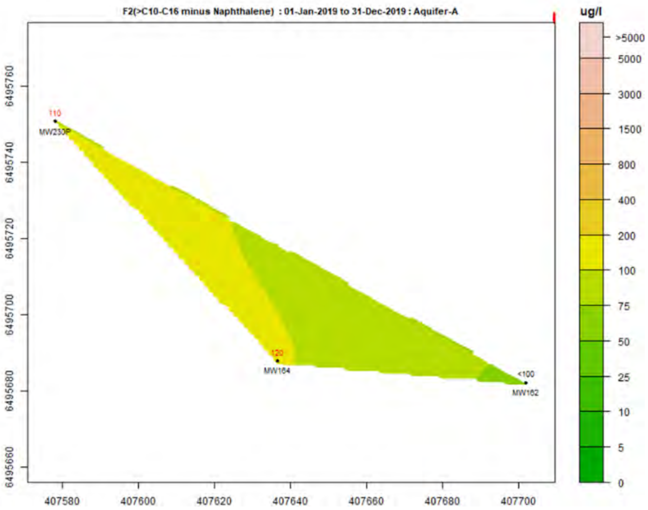

Plate 8 Contour plot of TRH F3 >C_{16}-C_{34} in 2019 in the perched aquifer

- The TRH plume in the superficial aquifer is concentrated at 0967_MW165 west of VST1 indicated to be (TRH >C_{10}-C_{40} 1190 µg/L in April 2019) and decreased in concentration from 2018 to 2019.

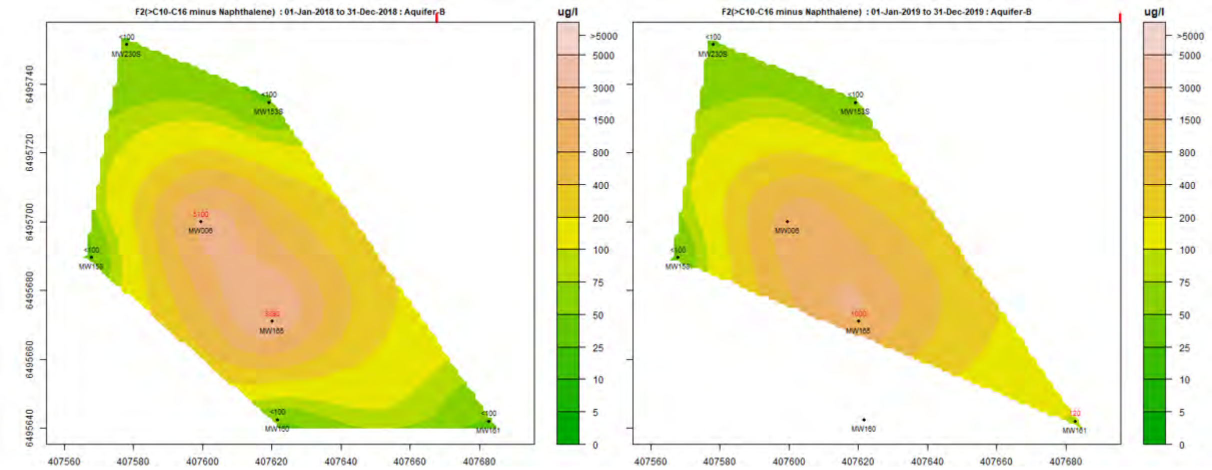

Plate 9 Contour plot of TRH F2 >C_{10}-C_{16} in 2018 (left) and 2019 (right) in the superficial aquifer

Spatio-temporal trend analysis

Graphical time-series plots of TRH concentrations were generated using GWSDAT to analyse temporal trends of dissolved phase concentrations however proved less useful as the dataset was discontinuous, each monitoring location only having one or two monitoring events in total.

Mann-Kendell analysis was undertaken on each TRH dataset at each groundwater monitoring well location where detectable concentrations of TRH were identified. The statistical significance of the trend is assessed by means of obtaining a p-value. If the p-value is obtained below 0.05, then the sample population is deemed to be statistically significant.

Note, the LOR value was used for non-detects, which offer a more conservative trend (as opposed to a zero value or adopting half the LOR), which can affect statistical confidence.

Where a p-value above 0.05 is identified for the sample population, then the data should be interpreted as meaning that that a statistically significant trend is not present. Notwithstanding the above, evidence of declining or increasing trends may still be deduced by qualitative professional judgement of the time-series data in the well trend plots.

Given the discontinuity of the dataset, all generated plots containing only two data points failed the Mann-Kendall test. The plots are not provided in this report as they are considered not beneficial to the overall assessment.

Secondary lines of evidence

Secondary evidence of natural attenuation can be demonstrated by evaluation of various geochemical indicators of biodegradation, including depletion of electron acceptors such as DO (aerobically), and nitrate, sulfate and carbon dioxide (anaerobically) with consequent increases in concentrations of degradation by-products, including ferrous iron and methane.

Secondary lines of evidence of hydrocarbon degradation were evident within the perched and superficial aquifers based on the assessment of the March-May 2018 GME and April 2019 GME datasets. The findings are discussed in the following sections.

Electron acceptors - Perched aquifer

Two wells screened in the perched aquifer we able to be sampled in both 2018 and 2019.

Redox - Redox potential in 0967_MW164 was negative and representative of mildly reducing and therefore low-energy anaerobic conditions in 2018 and 2019. Positive redox was recorded at upgradient 0967_MW162.

DO, Nitrate, Sulfate – Dissolved oxygen, nitrate and sulfate were all reduced in the perched aquifer in the presence of TRH concentrations. Conversely, upgradient well 0967_MW162 recorded higher dissolved oxygen, nitrate and sulphate levels in the absence of TRH.

Electron acceptors – shallow regional aquifer

Redox - Redox potential within the superficial aquifer was generally reported as positive however a number of locations could not be measured due to lack of available sample volume from dry wells. A strongly reducing redox was however measured at 0967_MW006 in 2018 also associated with high TRH concentration. 0967_MW006 was recorded as dry in 2019.

DO – Concentrations of DO in the superficial aquifer were generally moderate (0.64 mg/L to 2.07 mg/L) and notably anaerobic (less than 0.19 mg/L) in 0967_MW006 in 2018 also associated with high TRH concentration.

Nitrate – Nitrate in the superficial aquifer was depleted in all locations regardless of TRH concentration or plume location and do not adequately represent nitrate reduction during natural attenuation.

Sulfate – Concentrations of sulfate were generally moderate to high (168 mg/L to 1160 mg/L in the superficial aquifer however were notably depleted at 0967_MW006 in 2018 also associated with high TRH concentration.

Degradation by-products – Ferrous iron and methane

Perched aquifer – Concentrations of ferrous iron and methane were notably higher in the perched aquifer in the presence of TRH at 0967_MW164 and conversely, ferrous iron and methane were not reported above LOR in the upgradient well 0967_MW162.

Superficial aquifer – Concentrations of ferrous iron and methane were notably higher in the superficial aquifer in the presence of high TRH concentrations and otherwise generally not reported above the LOR.

Plume degradation summary

Primary and secondary lines of evidence for natural attenuation processes demonstrate the following:

- Statistically derived and qualitative trends for TRH were not achievable with the dataset which was observed to be discontinuous due to dry wells in the post summer monitoring rounds.
- No notable TRH concentrations in the perched aquifer.
- Absence of any significant TRH concentrations in outermost downgradient perimeter wells in the superficial aquifer (below the LOR).
- Consumption of dissolved oxygen, nitrates (perched only), sulfate and the presence of degradation by-products ferrous iron and methane in the perched and superficial aquifers, which provides a further line of evidence for degradation of TRH in the groundwater.

10.20.6 Surface water laboratory results

Of the four proposed surface water sampling locations in drainage channels located in close proximity to the AVTUR Farm, only one was found to have sufficient surface water for sampling (0967_SW103) post summer (April 2018). Surface water analytical results from 0967_SW103 post summer and post winter (September 2018) are compared against the relevant assessment criteria Table L20-2 (Appendix L). Results confirm that the following CoPC in surface water were all below LOR:

- Metals (cadmium, copper, lead, mercury)
- BTEX-N
- PAHs
- TRH C_6-C_{16} and TRH >C_{34}-C_{40}

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (arsenic, nickel)
- TRH (F3 (>C_{16}-C_{34} fraction)

Table 80 provides a summary of the surface water analytical results which exceeded the adopted screening guidelines.

Table 80 Surface water sample exceedances – AVTUR Fuel Farm (PCSR_0967_002)

Analyte	Monitoring Round	Location ID	Concentration mg/L	Criteria limit mg/L	Criteria exceeded
Chromium	April 2018	0967_SW103	0.002	0.001	ANZECC FW
Zinc	April 2018	0967_SW103	0.018	0.008	ANZECC FW
	September 2018		0.028		

10.20.7 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- Soil CoPC concentrations did not exceed ILs indicating no impact from the minor AVTUR spill in January 2018.
- Multiple lines of evidence (age of facility, observed condition of infrastructure and ground surface, lack of reported incidents, product reconciliation records) did not indicate that there is a contamination risk associated with soils through the balance of the facility (although no sampling was undertaken).

Sediment

- Sediment CoPC concentrations immediately adjacent to the New AVTUR Fuel Farm did not exceed ILs.
- Downstream of the New AVTUR Fuel Farm and also receiving run-off from the Former Fuel Farm, sediment impacts were reported above the ISQG low guidelines for cadmium, lead and zinc (also exceeding ISQG high). PAH concentrations also exceed ISQG low and high with BaP also exceeding soil RSL and ESL. This is not attributed to the New AVTUR Fuel Farm. Sediment impacts are not present above LOR further downstream at 0967_SD122.
- The presence of a thriving benthic community within the site drainage channel adjacent to the Former Fuel Farm is unlikely and therefore it is considered unlikely to be at risk from the elevated concentrations of metals and PAH identified. During periods of increased rainfall, there is potential for these sediments to be transported to the Ki-It Monger Brook increasing the potential exposure risk to the aquatic biota of the Ki-It Monger Brook. It is noted however that down-stream point from the Former Fuel Farm (0967_SD122) has not

been impacted by PAH with all PAH concentrations below LOR indicating impacts from the Former Fuel Farm are localised to this area.

- There is also potential for Base workers to be exposed to impacted sediments (exceeding HIL-D/RSL) at 0967_SD103 and 0967_SD104 during maintenance activities such as clearing of obstructed drainage channels.

Surface water

- PAHs were not detected above LOR in the surface water albeit being elevated and exceeding the majority of ILs in the corresponding sediment sample.
- The surface water sample which was collected downstream of the New AVTUR Fuel Farm and also receiving run-off from the Former Fuel Farm reflected a similar metal concentration profile to the sediment with elevated chromium and zinc exceeding freshwater ILs and also the presence of nickel and arsenic.
- Arsenic, chromium, nickel and zinc impacts were not reported in the proximal downstream sample location in the Ki-It Monger Brook (0967_SW152), indicating onsite impacts to surface water are not being transported off site or are sufficiently diluted at the receiving surface water body.

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the New AVTUR Fuel Farm is likely to discharge to the Ki-It Monger Brook in the south east. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- The majority of CoPC concentrations in groundwater were below the relevant ILs. Provided the land-use scenario is retained and groundwater is not abstracted for any purpose, the groundwater quality - including where human health ILs are exceeded (nickel exceeding drinking water ILs) - does not pose a risk of impact to property users.
- Elevated hydrocarbon concentrations (TRH C_{10}-C_{34} though not exceeding ILs) were reported at 0967_MW006 (5.8 mg/L) and 0967_MW165 (4.03 mg/L) beneath unsealed ground south west of the AVTUR fuel farm in 2018 but were reduced in 2019 sampling to 1.19 mg/L at 0967_MW165 and 0967_MW006 reported as dry. The extent of the TRH plume in this area is adequately delineated by the existing well network however the source is not known.
- Further lines of evidence based assessment and trend analysis have indicated the potential for MNA to be occurring however the dataset is could be enhanced with further sampling.

10.20.8 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.20.9 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- Soils are not considered to pose a contamination risk to receptors under current site usage.

- Provided the land-use scenario is retained and groundwater is not abstracted for any purpose, the groundwater quality - including where human health ILs are exceeded (nickel exceeding drinking water ILs) - does not pose a risk of impact to property users.
- A TRH plume is present beneath unsealed ground on the western side of the CSR boundary south of the separator system and west of VST 1. Although delineated by the current well network, the source of the plume (subsurface leak or aboveground spill) is not known. Information regarding the source of the TRH plume should be sought and if deemed required, further soil and groundwater investigations in this area should be undertaken such as installation of another monitoring well near where the water from the puraceptor is discharged.
- MNA assessment supports the occurrence of degradation of TRH in the groundwater.
- It is recommended monitoring at the AVTUR fuel farm continues into the future whilst the AVTUR fuel farm remains active and incorporates post winter sampling to reduce the impact that dry wells have on the value of the dataset.

10.21 PCSR_0967_003 – Former 25 m Small Arms Range

10.21.1 Summary of data gaps

No previous investigation has been undertaken to date at this CSR. Investigation is considered necessary to assess the potential for contamination risk associated with historical small arms range operations

All sampling locations within this CSR and sampling rationale are detailed in Table 25 and are presented in Figure 32A.

CoPC: Metals (principally lead), explosive residues, PCBs, TRH, VOCs.

10.21.2 Soil laboratory results

Soil samples were collected at 16 soil bore locations. Soil analytical results for the former small arms range are compared against the relevant assessment criteria in Table L19-1 (Appendix L). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (arsenic, cadmium, mercury)
- BTEX-N
- PAHs
- MAH
- Halogenated Hydrocarbons

The following CoPC were detected above the LOR but were below the applied guidelines:

- Metals (chromium, lead, nickel, zinc)
- TRH (F3 (>C_{16}-C_{34} Fraction), >C_{10}-C_{40} (Sum of Total))
- Explosive (nitroglycerine)

Table 81 provides a summary of the soil analytical results which exceeded the adopted SILs.

Table 81 Soil sample exceedances – Former 25 m Small Arms Range (PCSR_0967_003)

Analyte	Monitoring Round	Location ID	Depth (m bgl)	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
Copper	March 2018	0967_BH355	0.3	201	150	EIL

In addition to the above, it is also relevant to note that the laboratory LOR for the detection of some analytes (VOCs and chlorinated hydrocarbons) exceeded relevant guidelines, triggering a potential exceedance. It is unlikely however that VOCs would be present in the surface soils tested unless from a recent spill given the volatile nature of the compounds. The LORs are considered not likely to influence the outcome of the investigation.

XRF Results

A total of nine surface soil locations were analysed from the vicinity of the bullet catcher using an XRF as a field indicator and to supplement the laboratory analytical data. Metals concentrations measured in soil samples using XRF were compared against the adopted investigation level in Table 19-2 (Appendix L).

The reported XRF results were obtained by averaging three readings collected from each sample point.

The following metals were detected above the LOR, but were below the applied guidelines at all locations:

- Arsenic (0 – 14 mg/kg)
- Cadmium (0 – 7 mg/kg)
- Lead (8 – 1471 mg/kg)
- Mercury (0 – 2 mg/kg)
- Nickel (2 – 16 mg/kg)
- Zinc (1 – 72 mg/kg)

Copper exceeded the adopted EIL at one sample location. A summary of the exceedance is provided in Table 82.

Results of XRF field sampling broadly support the laboratory analytical results in terms of ranges of concentrations of lead, copper and zinc reported.

Table 82 Summary of XRF exceedances – Former 25 m Small Arms Range (PCSR_0967_003)

Metal	Location impacted	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
Copper (by XRF)	0967_BH372_0.1	151	150	EIL

10.21.3 Sediment laboratory results

Two sediment sampling locations are located in drainage channels in close proximity to the former small arms range which are considered to be servicing the area. These sample locations include 0967_SD132 and 0967_SD133. Sediment analytical results from these locations are compared against the relevant assessment criteria in Table L19-3 (Appendix L). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC were all below LOR within the CSR:

- Metals (cadmium)
- BTEX-N
- VOCs
- Explosives residue

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines at a few locations:

- Metals (chromium, copper, lead, nickel)
- TRH (F2 (>C_{10}-C_{16} minus Naphthalene), F4 (>C_{34}-C_{40} Fraction))

Table 83 provides a summary of the sediment analytical results which exceeded the adopted sediment and soil investigation levels. A graphical representation of the distribution of metal exceedances in sediments in presented on Figure 13B and C.

Table 83 Sediment sample exceedances –Former 25 m Small Arms Range (PCSR_0967_003)

Group	Analyte	Locations IDs	Concentration range (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
Metals	Arsenic	0967_SD132 0967_SD133	21 - 26	20	ISQG - Low
	Mercury	0967_SD133	0.2	0.15	ISQG - Low
	Zinc	0967_SD133	551	410 370	ISQG – High EIL – Comm/Ind
TRH	>C_{10}-C_{16} Fraction	0967_SD133	1370	170	ESL – Comm/Ind
	F3 (>C_{16}-C_{34} Fraction)	0967_SD133	2220	1700	ESL – Comm/Ind

10.21.4 Groundwater laboratory results

Groundwater analytical results for the former small arms range were compared against the relevant assessment criteria in Table L19-4 (Appendix L). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (arsenic, cadmium, lead, mercury)
- BTEX-N
- TRH
- PAHs
- VOCs
- Explosives

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (nickel)

Table 84 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines.

Table 84 Groundwater sample exceedances – Former 25 m Small Arms Range (PCSR_0967_003)

Analyte	Monitoring Round	Location ID	Concentration (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium	April 2018	0967_MW241	0.002	0.001	ANZECC FW
Copper	April 2018	0967_MW241	0.012	0.0014	
Zinc	April 2018	0967_MW241	0.022	0.008	

A graphical representation of the distribution of groundwater impacts is presented on Figure 32C.

10.21.5 Surface water laboratory results

Of the two surface water sampling locations in drainage channels located in close proximity to the former small arms range, only one was found to have sufficient surface water for sampling (0967_SW132). Surface water analytical results from this location were compared against the relevant assessment criteria in Table L20-2 (Appendix L). Results confirm that the following CoPC were all below LOR:

- Metals (arsenic, cadmium, lead, mercury, nickel)
- BTEX-N
- TRH
- PAHs
- OC pesticides (excluding dieldrin)
- VOCs
- PCBs
- Explosives

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (iron)
- Dieldrin

Table 85 provides a summary of the surface water analytical results which exceeded the adopted screening guidelines.

Table 85 Surface water sample exceedances – Former Small Arms Range (PCSR_0967_003)

Analyte	Monitoring Round	Location ID	Concentration	Criteria limit	Criteria exceeded
Chromium	September 2018	0967_SW132	0.002	0.001	ANZECC FW
Copper	September 2018		0.002	0.0014	
Zinc	March 2018		0.01	0.008	
	September 2018		0.096		
E.coli	September 2018	0967_SW132	23 cfu/100 mL	10 cfu/100 mL	NPUG

10.21.6 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- Former small arms range activities at the site have impacted soils at the site. Although not exceeding ILs, lead concentrations in soils at the bullet catcher and the area between the firing platform and the bullet catchers are highly elevated above background concentrations and trace concentrations of nitroglycerine are also present.
- Laboratory analytical results generally correlated with the range of concentrations indicated during XRF sampling.
- All CoPC tested across the site were below the relevant human health ILs and therefore soils at the former small arms range do not pose a risk of impact to property users under the current land-use scenario.
- Copper concentrations in shallow soils (0.1 to 0.3 m bgl) at two locations within the former small arms range exceeded ecological investigation levels. Given the lack of credible terrestrial ecological receptors in contact with the soils of the former small arms range,

concentrations of copper in shallow and surface soils across the balance of the former small arms range do not indicate a contamination risk to ecological receptors.

Sediment

- Sediment sample 0967_SD133 reported concentrations of metals (arsenic, mercury and zinc) exceeding ISQG low criteria, ISQG high criteria (zinc), EIL criteria (zinc) and ESL criteria (TRH). These concentrations are also elevated above background levels.
- Given the lack of credible sensitive benthic communities in the drains of the site, it is considered unlikely they would experience adverse chronic biological effects from the elevated CoPC levels. A credible terrestrial ecological receptor is also not present on the site and therefore the elevated CoPC do not present a risk to terrestrial ecological receptors. Furthermore, the elevated CoPC concentrations are reduced or not present further down-stream (0967_SD132), indicating the impact in the drain is localised and also unlikely to migrate toward the Ellen Brook.

Surface water

- The majority of CoPC concentrations in surface water downstream of the small arms range were reported below LOR or the relevant ILs.
- Zinc concentrations exceeded the freshwater ILs and upstream surface water concentrations however were within background groundwater quality ranges. Zinc impacts at downstream locations were significantly reduced (0967_SW112) and at lower concentrations than upstream Ellen Brook concentrations.

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the former small arms range is likely to discharge to the Ellen Brook in the west. Groundwater at the property is not used for any purpose. Surrounding properties use the water for drinking, domestic/household uses including irrigation and showering.
- The majority of CoPC concentrations in groundwater tested in the south west corner of the former small arms range CSR boundary were below the relevant ILs. Given the groundwater flow direction is likely to be west, a comment cannot be provided regarding the impact to groundwater from the former small arms range footprint.
- Groundwater further down-gradient around the Sewage Treatment Plant however does not display distinct impacts from the former small arms range CoPC such as copper and lead which indicates if impacts are present beneath the small arms range, they are localised and not present at concentrations downgradient that would pose a risk to receptors.

10.21.7 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86, Section 10.22.

10.21.8 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- Concentrations of elevated CoPC detected in soil, sediment, surface water and groundwater do not pose a risk to property users under the current land-use scenario nor are they likely to migrate to the sensitive ecosystem of the Ellen Brook given the distance (greater than one kilometre).

- The soil, sediment, surface water and groundwater data does however indicate that the former small arms range activities had an impact, albeit minor, on the environment.
- Further investigation or monitoring of groundwater is considered not required.
- The primary source of metals (bullets and bullet fragments in the bullet catcher, an area of approximately 20 m by 10 m to a depth of 0.5 m bgl) should be removed/deleaded and validated to reduce ongoing contribution of metals impacts to soil and groundwater after which it can be archived from the CSR database.

10.22 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 86 and graphically in Figure 38

Table 86 Refined Conceptual Site Model – RAAF Base Pearce

Source		Pathway			Receptor							
					Human onsite		Human offsite	Ecological onsite			Ecological offsite	
CSR/PCSR	CoPC	Primary pathway	Secondary pathway	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Recreational users of Ellen and Ki-It Monger Brooks	Abstraction bore users	Groundwater dependent Remnant Native Vegetation (terrestrial) present in the south-western portion of the property.	Threatened terrestrial fauna species present in the south-western portion of the property.	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Residual data gaps/further action
CSR_WA_000024 – Fuel storage NE building 72 group of USTs and ASTs Four diesel USTs were removed in March 2018. Although stains were observed at the base of each excavation at approximately 3.2 m depth, further excavations were deemed impractical due to the proximity of the excavations to existing buildings. Excavations were backfilled following tank removal. Soil analytical results did not report any TRH impact, although this was inconsistent with field observations. Metals concentrations (copper and zinc) were reported above fresh water also exceed background groundwater quality ranges. Groundwater beneath the site does not indicate significant impact from historic and/or current fuel storage activities.	TRH Metals	Migration within groundwater	Abstracted groundwater (drinking water/irrigation) or Plant uptake	Direct contact with impacted groundwater or incidental ingestion of impacted groundwater	✗	✗	✗	✗	✗	✗	✗	Although residual soil impact is likely to be present, the sealing of the ground surface with hardstand following tank removal, and the presence of a confining clay layer may be preventing further migration of the soil impact to groundwater. Groundwater beneath the Fuel Storage NE of Building 72 indicates no significant impact from historic and/or current waste disposal activities however copper and zinc exceed background levels. Concentrations of elevated copper and zinc in groundwater are unlikely to impact property users under the current land-use scenario nor are they likely to migrate to the sensitive ecosystem of Ki-It Monger or the Ellen Brook given the distance (1.4 km). Groundwater monitoring at the Fuel Storage NE of building 72 area should be incorporated into future monitoring programs.
			Groundwater discharge to receiving surface water body to Ki-it Monger Brook	Direct or incidental ingestion of contact with surface water	✗	✗	✗	✗	✗	✗	✗	
		Direct contact with soils	Windblown dust	Incidental ingestion or inhalation of soil/dust	✓	✗	✗	✗	✗	✗	✗	
CSR_WA_000083 - Dog Compound - Buried Waste. Historical dumping/burial of waste within the northern extent of the compound: including asbestos, sand, bitumen, road base and concrete. Additional areas further south of the compound with historic landfilling of building waste. BaP in surface soils in north western portion of compound exceeding ESLs and dieldrin exceeding RSL. Soils at depth are not impacted. Groundwater beneath the site does not indicate impact from historic and/or current waste disposal activities.	PAH OCPs	Direct contact with soils	Windblown dust	Incidental ingestion or inhalation of soil/dust	✓	✗	✗	✗	✗	✗	✗	The soil impacts are considered to be minimal and isolated to the fenced Dog Compound area and do not present a significant exposure risk to the users of the fenced compound or downstream receptors. Impact to adjacent surface drain and surface water is unknown although immediately downstream no impacts were reported. No ongoing requirements for management. CSR can be archived.
		Surface water run-off	N/A	Direct or incidental ingestion of contact with surface water	✗	✗	✗	✗	✗	✗	✗	

Source		Pathway			Receptor							
					Human onsite		Human offsite	Ecological onsite			Ecological offsite	
CSR/PCSR	CoPC	Primary pathway	Secondary pathway	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Recreational users of Ellen and Ki-It Monger Brooks	Abstraction bore users	Groundwater dependent Remnant Native Vegetation (terrestrial) present in the south-western portion of the property.	Threatened terrestrial fauna species present in the south-western portion of the property.	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Residual data gaps/further action
CSR_WA_000084 - Sounness Road Landfill Uncontrolled landfilling for over 50 years including construction material, metal automotive, industrial and domestic waste. Landfill is capped with 0.5 m of sand. Impacts within landfill soils comprises heavy metals, TRH, SVOCs. Sediment and groundwater testing indicated no impacts from landfilling activities.	Metals TRH SVOCs	None identified	N/A	N/A	✘	✘	✘	✘	✘	✘	✘	No residual data gaps. A valid pathway for the contamination source to reach receptors has not been identified. Given the ongoing presence of the landfill as a potential contamination source, groundwater monitoring at the Sounness Landfill should continue and be incorporated into future monitoring programs however at a reduced frequency.
CSR_WA_000087 - Fuel Storage ILS 18 Glidepath AST bunding inadequate. Soil, surface water and sediment testing reported no CoPC exceeding LOR or criteria.	None identified	None identified	N/A	N/A	✘	✘	✘	✘	✘	✘	✘	No further investigation required however the bunding of the AST should be upgraded to meet current standards following which the CSR can be archived
CSR_WA_000088 - Fuel Storage ILS 18 AST bunding inadequate. Soil, surface water and sediment testing reported no CoPC exceeding LOR or criteria.	None identified	None identified	N/A	N/A	✘	✘	✘	✘	✘	✘	✘	No further investigation required however the bunding of the AST should be upgraded to meet current standards following which the CSR can be archived
CSR_WA_000104 - Former Hazardous Waste Store Footprint of Former Hazardous Waste Store, containing flammable liquids, chemicals, batteries and other materials. Soil, sediment and groundwater testing indicates no impact from historic waste storage activities.	None identified	None identified	N/A	N/A	✘	✘	✘	✘	✘	✘	✘	No residual data gaps. The hazardous waste store area should be archived from the CSR database.

Source		Pathway			Receptor							Residual data gaps/further action
					Human onsite		Human offsite	Ecological onsite			Ecological offsite	
CSR/PCSR	CoPC	Primary pathway	Secondary pathway	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Recreational users of Ellen and Ki-It Monger Brooks	Abstraction bore users	Groundwater dependent Remnant Native Vegetation (terrestrial) present in the south-western portion of the property.	Threatened terrestrial fauna species present in the south-western portion of the property.	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Residual data gaps/further action
CSR_WA_000106 - Sewage Treatment Plant Discharge Effluent Sewage Treatment Plant and discharge including two aerobic and two anaerobic ponds which have recently been upgraded (2018/2019). E.coli was detected above health criteria in groundwater immediately adjacent and downgradient to Pond 4 in 2018 but not in 2019. The E.coli in 2019 was detected further down-gradient at elevated concentrations (higher than in 2019)	Pathogens Nutrients Metals (copper)	Migration within groundwater	Abstracted groundwater (drinking water/irrigation) or Plant uptake	Direct contact with impacted groundwater or incidental ingestion of impacted groundwater	✗	✓	✓	✗	✗	✗	✗	The Sewage Treatment Plant area is suitable for ongoing use from a contamination risk perspective however the current groundwater monitoring network is considered insufficient to characterise the downgradient impact to groundwater from the Sewage Treatment Plant. Further groundwater investigation including installation of further monitoring wells should be carried out to confirm E.coli presence, establish the E.coli and copper plume extent and stability and potential for migration to the the Ellen Brook. Surface water in the Ellen Brook down gradient of 0967_MW223 should be sampled and tested for E.coli and copper to confirm concentrations at the receptor.
			Groundwater discharge to receiving surface water body to the Ellen Brook	Direct or incidental ingestion of contact with surface water	✗	✓	✓	✗	✗	✗	✗	
		Surface water run-off	N/A	Direct or incidental ingestion of contact with surface water	✓	✓	✗	✗	✗	✓	✓	
CSR_WA_000107 - Former Fire Training Area Sewage pit at northern extent of area, which was reported to have a history of overflowing. Soil, sediment and groundwater testing indicated no CoPCs exceeding human health criteria (except nickel) Groundwater metals (chromium, zinc, copper and nickel) exceed freshwater criteria with potential to migrate to Ki-it Monger Brook.	Metals	Migration within groundwater	Plant uptake	Direct contact with impacted groundwater	✗	✗	✗	✗	✗	✓	✓	Groundwater monitoring at the Former Fire Training area should be incorporated into future monitoring programs given the increased risk of metals impacted groundwater migration to Ki-it Monger Brook.
			Groundwater discharge to receiving surface water body (Ki-It Monger Brook and greater the Ellen Brook catchment)	Direct or incidental ingestion of contact with surface water	✗	✗	✗	✗	✗	✓	✓	
CSR_WA_000109 - Former USTs 240 – 245 It is understood contamination remains in situ beneath former bowsers. The four groundwater wells located down-hydraulic gradient of the Former USTs did not report any CoPCs above ILs and it is considered if residual impact is present, it is localised to the source area.	Metals BTEX TRH PAH	MigrationC within groundwater	Vapour migration	None identified	✗	✗	✗	✗	✗	✗	✗	Groundwater immediately down-gradient of the facility indicates no significant impact from fuel storage and handling activities. No identified exposure pathway for potential groundwater or soil impacts and therefore no subsequent risk to property users. A SMP should be developed to manage potential for localised residual soil and groundwater impacts in immediate vicinity of Former USTs and bowsers (unless area validated appropriately during civil works)
		Direct contact with soils	N/A	None identified	✓	✗	✗	✗	✗	✗	✗	

Source		Pathway			Receptor							
					Human onsite		Human offsite	Ecological onsite			Ecological offsite	
CSR/PCSR	CoPC	Primary pathway	Secondary pathway	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Recreational users of Ellen and Ki-It Monger Brooks	Abstraction bore users	Groundwater dependent Remnant Native Vegetation (terrestrial) present in the south-western portion of the property.	Threatened terrestrial fauna species present in the south-western portion of the property.	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Residual data gaps/further action
CSR_WA_000110 - Former Fuel Farm. Historical leakage/spills associated with former UST infrastructure. Soil and surface water impacts not identified. Groundwater TRH impacts identified in perched and superficial aquifer. Superficial aquifer plume is at negligible concentrations while the perched aquifer contains significant though stable concentrations. Occurrence of MNA is supported by the primary and secondary lines of evidence.	TRH, metals	Migration within groundwater	Abstracted groundwater (drinking water/irrigation) or Plant uptake	Direct contact with impacted groundwater or incidental ingestion of impacted groundwater	✗	✗	✗	✗	✗	✗	✗	The current groundwater monitoring network is considered adequate and impacts to groundwater are considered unlikely to impact sensitive receptors. Continue groundwater monitoring from the current well network to confirm plume reduction. The extent of soil impact has been adequately defined and there is no significant residual soil impact from fuel storage and historical leakage following the decommissioning phase. Clearing and appropriate disposal of impacted sediments in surface water drain at 0967_SD103 and 0967_SD104 where PAH (BaP) concentrations exceed health criteria should be undertaken.
			Groundwater discharge to receiving surface water body (Ki-It Monger Brook and greater Ellen Brook catchment)	Direct or incidental ingestion or contact with surface water	✗	✗	✗	✗	✗	✗	✗	
		Surface water run-off	N/A	Direct or incidental ingestion of contact with surface water	✗	✗	✗	✗	✗	✗	✗	
		Direct contact with soils/sediment	Windblown dust	Incidental ingestion or inhalation of soil/dust	✓	✗	✗	✗	✗	✗	✗	
CSR_WA_000117 - Former Service Station Potential spill/leakage associated with operation of former (decommissioned/removed 2009) underground fuel storage tanks and associated infrastructure. The extent of soil impact has been adequately defined to enable an assessment of risk to ongoing site users and indicate no contamination risk to property users and ecological receptors under the current land-use scenario. Elevated nickel, zinc, ethylbenzene, naphthalene, MTBE and a TRH plume were reported in groundwater in 2018. 2019 results did not report any PAHs or MTBE. The groundwater impacts can be considered delineated. TRH concentrations in the superficial aquifer are considered to be low. The TRH plume in the perched aquifer appears to be reducing.	Metals TRH PAH MTBE	Migration within groundwater	Abstracted groundwater (drinking water/irrigation) or Plant uptake	Direct contact with impacted groundwater or incidental ingestion of impacted groundwater	✗	✗	✗	✗	✗	✗	✗	Multiple lines of evidence support MNA has and is occurring at the Former Service Station. Given the Former Service Station has been decommissioned, no further primary sources of contamination are considered present and it is considered natural attenuation will continue in the perched and superficial aquifers, with monitoring for a two further annual events to clearly demonstrate this.
			Groundwater discharge to receiving surface water body (the Ellen Brook catchment)	Direct or incidental ingestion of contact with surface water	✗	✗	✗	✗	✗	✗	✗	

Source		Pathway			Receptor							
					Human onsite		Human offsite	Ecological onsite			Ecological offsite	
CSR/PCSR	CoPC	Primary pathway	Secondary pathway	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Recreational users of Ellen and Ki-It Monger Brooks	Abstraction bore users	Groundwater dependent Remnant Native Vegetation (terrestrial) present in the south-western portion of the property.	Threatened terrestrial fauna species present in the south-western portion of the property.	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Residual data gaps/further action
CSR_WA_000151 – Grounds Maintenance Area Storage of general equipment, plant, hazardous chemicals (pesticides/herbicides) and POL. Historic leaks/spills running off to surface water drain. ALL CoPC in soil are below human health criteria. TRH exceeds ESLs in surface soils adjacent to machinery storage bays and lay-down area. Lead and zinc in sediment of drain exceed ISQG low criteria. Metals (chromium, copper, nickel and zinc) exceed background levels and drinking water (health) levels (nickel only). Minor concentrations (not exceeding criteria) of VOCs and pesticides were detected in groundwater. TCE concentrations have fluctuated at 0967_MW112 since its detection by the PFASIMB in 2017 (section 4.1). The elevated concentrations are centred around 0967_MW112 and 0967_MW243 while minor concentrations were reported at downgradient monitoring wells 0967_MW244 and 0967_MW245. The upgradient reaches of the TCE plume are not adequately delineated.	Metals TRH Solvents (TCE) Pesticides	Migration within groundwater	Abstracted groundwater (drinking water/irrigation) or Plant uptake	Direct contact with impacted groundwater	✖	✖	✖	✖	✖	✖	✖	Concentrations of elevated CoPC detected in soil, sediment and groundwater are unlikely to impact property users under the current land-use scenario nor are they likely to migrate to the sensitive ecosystem of Ki-it Monger or The Ellen Brook given the distance (more than one kilometre). Chemical storage and handling practices including potential for engineering controls at the general maintenance area should be reviewed and improved to prevent further impact to the environment. Groundwater monitoring at the Grounds Maintenance area should be incorporated into future monitoring programs. Two further monitoring wells are recommended to be installed north of 0967_MW112 and 0967_MW243 to delineate the upgradient extent of the TCE plume. One additional well screened at base of superficial aquifer within source zone recommended to determine potential for DNAPL presence.
			Groundwater discharge to receiving surface water body (the Ellen Brook catchment)	Direct or incidental ingestion of contact with surface water	✖	✖	✖	✖	✖	✖	✖	
		Surface run-off	N/A	Direct or incidental ingestion of contact with impacted sediments	✖	✖	✖	✖	✖	✖	✖	
CSR_WA_000153 - Fire Training Area Fuel Storage Facilities One AST and one UST containing diesel and installed prior to 1975. Soil has been adequately investigated (ERM 2013) showing no impact. Sediment samples contain zinc and PAH exceeding ISQG Low criteria localised to the CSR. Tested CoPCs in sediment and groundwater did not exceed any human health ILs. Elevated metals (chromium, copper, lead, nickel, zinc) concentrations freshwater ILs and background concentrations.	Metals	Migration within groundwater	Plant uptake	Direct contact with impacted groundwater	✖	✖	✖	✖	✖	✖	✖	Concentrations of metals in discontinuous perched aquifer unlikely to migrate the distance (250 m) to the Ellen Brook.
			Groundwater discharge to receiving surface water body (the Ellen Brook catchment)	Direct or incidental ingestion of contact with surface water	✖	✖	✖	✖	✖	✖	✖	
		Surface run-off	N/A	Direct or incidental ingestion of contact with impacted sediments	✖	✖	✖	✖	✖	✖	✖	Receptor not identified. Impacts are localised, downstream sediments not impacted.

Source		Pathway			Receptor							Residual data gaps/further action
					Human onsite		Human offsite	Ecological onsite			Ecological offsite	
CSR/PCSR	CoPC	Primary pathway	Secondary pathway	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Recreational users of Ellen and Ki-It Monger Brooks	Abstraction bore users	Groundwater dependent Remnant Native Vegetation (terrestrial) present in the south-western portion of the property.	Threatened terrestrial fauna species present in the south-western portion of the property.	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	
CSR_WA_000155 - Power Station USTs One AST and two USTs. Historical 2000 L spill of diesel in 2004. Previous investigations indicate soil TRH impacts exceeded HSL-D. Current down-gradient groundwater testing indicates no down-gradient impact.	TRH	Migration within groundwater	Abstracted groundwater (drinking water/irrigation) or Plant uptake	Direct contact with impacted groundwater or incidental ingestion of impacted groundwater	✗	✗	✗	✗	✗	✗	✗	Though groundwater data is inconclusive at the source, impacts not migrating down-gradient from source area.
			Groundwater discharge to receiving surface water body to the Ellen Brook catchment	Direct or incidental ingestion of contact with surface water	✗	✗	✗	✗	✗	✗	✗	
			Vapour migration	Inhalation	✗	✗	✗	✗	✗	✗	✗	Based on multiple lines of evidence, i.e. the fact that the spill was diesel fuel and occurred in 2004, that the slab of the Power Station building was observed to be in good condition, and that personnel only work within the building on a temporary short term basis, if at all, it is considered unlikely that there is a vapour risk to users.
		Direct contact with soils	Windblown dust	Incidental ingestion or inhalation of soil/dust	✓	✗	✗	✗	✗	✗	✗	A SMP should be developed to manage potential exposure risk to property users and intrusive workers (if not already in place).
CSR_WA_000156 - Paint Shop Overflow of AST in 2011. Soil testing (GHD 2018 and ERM 2013) indicated no CoPC above relevant criteria. Sediment testing indicated PAH exceeding ISQG low criteria. Surface water sample did not report PAH concentrations above LOR and no risk of impact to property users or down-gradient water body. Groundwater testing indicates no CoPC above background levels.	PAH	Surface run-off	N/A	Direct or incidental ingestion of contact with impacted sediments	✗	✗	✗	✗	✗	✗	✗	The Paint shop area is suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management or monitoring and as such should be archived from the CSR database.

Source		Pathway			Receptor							Residual data gaps/further action
					Human onsite		Human offsite	Ecological onsite			Ecological offsite	
CSR/PCSR	CoPC	Primary pathway	Secondary pathway	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Recreational users of Ellen and Ki-It Monger Brooks	Abstraction bore users	Groundwater dependent Remnant Native Vegetation (terrestrial) present in the south-western portion of the property.	Threatened terrestrial fauna species present in the south-western portion of the property.	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	
CSR_WA_000160 – Hangar 95 Anecdotal evidence suggests the presence of hydrocarbon impact at each end of the building and inferences have also been made suggesting impact beneath the building. Chlorobenzene detected above human health (drinking water aesthetic and NPUG) in down-gradient well adjacent to Hangar in April 2018 was not detected in 2019 mobilisation. Toluene was detected above human health (drinking water aesthetic and NPUG) in April 2019 and is delineated down-gradient by monitoring wells at the Aircraft Shelters where it was reported at trace concentrations.	CHCs Toluene TRH	Migration within groundwater	Abstracted groundwater (drinking water/irrigation) or Plant uptake	Direct contact with impacted groundwater or incidental ingestion of impacted groundwater	✗	✗	✗	✗	✗	✗	✗	The extent of toluene in groundwater beneath the hangar is delineated by down-gradient monitoring wells at the Aircraft Shelters and given the distance (1.5 km) it is unlikely to migrate to the Ellen Brook. Although concentrations of volatile organic compounds have been detected in groundwater down-gradient of the hangars, it is considered the risk to on-site receptors is low and sufficiently managed by existing indoor air quality monitoring procedures. Groundwater monitoring from the existing network and incorporating new wells installed at the aircraft shelters (09687_MW249, 0967_MW250, 0967_MW251) should continue at this location (including toluene and chlorobenzene) to ensure the impact which fuel handling practices have on the environment is effectively monitored.
			Groundwater discharge to receiving surface water body to the Ellen Brook	Direct or incidental ingestion of contact with surface water	✗	✗	✗	✗	✗	✗	✗	
			Vapour migration	Inhalation	✓	✗	✗	✗	✗	✗	✗	
PCSR_0967_001 – Aircraft Shelters A former fitter from the Mechanical Equipment Operations and Maintenance Section reported that during the time the Macchi trainer jets were in use at RAAF Pearce up until 2000 there was significant venting of fuel from the rear of those aircraft onto the margin of the airfield (to the west of the current aircraft shelters). Reporting (Golder 2015) indicated strong hydrocarbon odours in this area from 0.3 m to 1.0 m in the vicinity of the shelters with no contamination analysis conducted. Soil sampling results indicate no impact from refuelling or venting activities. Groundwater monitoring data indicates that aircraft maintenance and fuelling practices at the aircraft shelters area has had an impact, albeit minor, on the environment and do not warrant any further investigation.	TRH, BTEX	Migration within groundwater	Abstracted groundwater (drinking water/irrigation) or Plant uptake	Direct contact with impacted groundwater or incidental ingestion of impacted groundwater	✗	✗	✗	✗	✗	✗	✗	No further investigation required however the wells installed in this area are to be incorporated into the network used for monitoring the Hanger 95 CSR area.
			Groundwater discharge to receiving surface water body to the Ellen Brook	Direct or incidental ingestion of contact with surface water	✗	✗	✗	✗	✗	✗	✗	
			Vapour migration	Inhalation	✗	✗	✗	✗	✗	✗	✗	

Source		Pathway			Receptor							
					Human onsite		Human offsite	Ecological onsite			Ecological offsite	
CSR/PCSR	CoPC	Primary pathway	Secondary pathway	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Recreational users of Ellen and Ki-It Monger Brooks	Abstraction bore users	Groundwater dependent Remnant Native Vegetation (terrestrial) present in the south-western portion of the property.	Threatened terrestrial fauna species present in the south-western portion of the property.	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Residual data gaps/further action
PCSR_0967_002 – New AVTUR Fuel Farm (DFI) Soil testing has not been conducted across the balance of the site as the fuel farm has only recently been commissioned (2014). Sediment samples directly downstream of the fuel farm were not impacted though further downstream sediment receiving run-off from Former Fuel Farm impacted with PAH and metals (not attributed to new AVTUR). Surface water testing across the airbase indicates no impacts to quality of surface water from the AVTUR fuel farm. Nickel in groundwater exceeds drinking water ILs. TRH plume present (TRH C_{10}-C_{34} up to 5.8 mg/L in 2018) and to the west of New AVTUR Fuel Farm beneath unsealed ground. Source of TRH plume (underground leak or overland spill) not established.	TRH Metals	Migration within groundwater	Abstracted groundwater (drinking water/irrigation) or Plant uptake	Direct contact with impacted groundwater or incidental ingestion of impacted groundwater	✗	✗	✗	✗	✗	✗	✗	A TRH plume is present on the western side of the CSR boundary south of the puraceptor and west of VST 1. Although delineated by the current well network, the source (subsurface leak or above ground spill) of the plume is not known. Installation of a monitoring well near to where the water from the puraceptor is discharged may be beneficial to assess if there are secondary sources in the area due to historical impacts. Further lines of evidence based assessment and trend analysis have indicated the potential for MNA to be occurring however the dataset is could be enhanced with further sampling. It is recommended monitoring at the AVTUR fuel farm continues into the future whilst the AVTUR fuel farm remains active and incorporates post winter sampling to reduce the impact that dry wells have on the value of the dataset.
			Groundwater discharge to receiving surface water body to Ki-it Monger Brook	Direct or incidental ingestion of contact with surface water	✗	✗	✗	✗	✗	✗	✗	
		Direct contact with soils	Windblown dust	Incidental ingestion or inhalation of soil/dust	✓	✗	✗	✗	✗	✗	✗	

Source		Pathway			Receptor							
					Human onsite		Human offsite	Ecological onsite			Ecological offsite	
CSR/PCSR	CoPC	Primary pathway	Secondary pathway	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Recreational users of Ellen and Ki-It Monger Brooks	Abstraction bore users	Groundwater dependent Remnant Native Vegetation (terrestrial) present in the south-western portion of the property.	Threatened terrestrial fauna species present in the south-western portion of the property.	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Ki-It Monger and the Ellen Brooks and associated aquatic flora and fauna ecosystems	Residual data gaps/further action
PCSR_0967_003 – Former 25 m Small Arms Range Former small arms range operable for small arms training. Significant volumes of spent bullets with various instances of staining at various small buildings. Although not exceeding ILs, lead concentrations in soils in the vicinity of the bullet catcher and between the firing platform and the bullet catcher are highly elevated above background concentrations and trace concentrations of nitroglycerine are also present. All CoPC tested across the site were below the relevant human health ILs. Copper concentrations in shallow soils (0.1 m to 0.3 m bgl) in two locations exceeded ecological investigation levels. Sediment sample 0967_SD133 reported concentrations of metals (arsenic, mercury and zinc) exceeding ISQG low criteria, ISQG high criteria (zinc), EIL criteria (zinc) and ESL criteria (TRH). Groundwater down-gradient of small arms range not impacted.	Metals Explosives TRH	Migration within groundwater	Abstracted groundwater (drinking water/irrigation) or Plant uptake	Direct contact with impacted groundwater or incidental ingestion of impacted groundwater	✖	✖	✖	✖	✖	✖	✖	No credible ecological receptors identified given the distance to the Ellen Brook (more than one kilometre). To reduce ongoing loading of metals to the environment it is recommended to remediate the top 0.5 m of the bullet catcher (estimated up to 100 m^3), observed to contain multiple weathered bullets and bullet fragments.
			Groundwater discharge to receiving surface water body to the Ellen Brook	Direct or incidental ingestion of contact with surface water	✖	✖	✖	✖	✖	✖	✖	
		Direct contact with soils	Windblown dust	Incidental ingestion or inhalation of soil/dust	✖	✖	✖	✖	✖	✖	✖	

11. Results and discussion – 3TU

All laboratory reports are provided in Appendix N and results summary tables in Appendix M.

11.1 Background groundwater quality

Background groundwater quality assessment is based upon data from monitoring wells 0965_MW101 (CSR_WA_000103) (Figure 34C) installed during the 2018 investigation and 0965_MW105 and 0965_MW107 (PCSR_0965_001) (Figure 34D), installed during the 2019 investigation. Monitoring well 0965_MW101 is located in the northern-west corner of the northern-most CSR and considered up hydraulic gradient of receiving surface water bodies. Monitoring wells 0965_MW105 and 0965_MW107 are located in the western-most CSR and are also considered to be up hydraulic gradient from identified source areas. The wells are located to the south of the Bulls Brook, a minor tributary associated with the Ellen Brook catchment. Salinity is noted to be fresh in each monitoring well. Results summary tables for all groundwater locations are presented in Table M1-1(metals and hydrocarbons), Table M1-2 (other CoPC) and Table M1-3 (PFAS) (Appendix M).

CoPCs TRH, PAHs and PFAS are generally not present or not exceeding adopted GILs at these locations. The majority of metals (arsenic, cadmium, lead, mercury, nickel) are also generally not present or not exceeding adopted GILs. Concentrations of chromium (III+IV) (0.002 mg/L), copper (0.018 mg/L) and zinc (0.028 mg/L) exceeding freshwater GILs were reported in 0965_MW101 (2018), reflecting the moderately disturbed land use setting. Elevated concentrations of PFOS (0.14 µg/L) exceeding freshwater GILs and sum of PFHxS and PFOS (0.19 µg/L) exceeding human health drinking water GILs were also reported in 0965_MW101 (2019) indicating the likely presence of an as yet unidentified up-gradient PFAS source.

Table 87 Background groundwater quality (detects only)

Analyte	Concentration
pH (pH units)	5.86 (acidic) (MW101) 5.00 (acidic) (MW105) 4.35 (acidic) (MW107)
Electrical conductivity (µS/cm)	190.2 (MW101) 137.8 (MW105) 173.3 (MW107)
Total dissolved solids	128.70 (fresh) (MW101) 89.70 (fresh) (MW105) 122.0 (fresh) (MW107)
Chromium (III+VI) (mg/L)	0.002 (MW101)
Copper (mg/L)	0.018 (MW101)
Zinc (mg/L)	0.028 (MW101)
PFHxS (µg/L)	0.05 (MW101)
PFOS (µg/L)	0.14 (MW101)
Sum of PFHxS and PFOS (µg/L)	0.19 (MW101)

11.2 Site wide - Surface water and sediment in on-site drainage channels

11.2.1 Summary of data gaps

No previous holistic assessment has been undertaken of potential contamination risk to surface water and sediment within the surface water drainage channel networks located on and immediately surrounding 3TU.

An assessment of the potential contamination status of the drainage channel network (within and immediately surrounding the 3TU property boundaries) was considered necessary given the range of CoPCs and existing contamination on the property and the potential to impact surface water which subsequently discharges to the Ellen Brook - Upper Swan catchment (ecologically sensitive surface water receiving body) located approximately 3.5 km east of the formerly built-up area of the property.

11.2.2 Sediment

Sediment samples were collected at locations up and downstream of the CSR locations at 3TU over three sampling events – six samples (0965_SD101 to 0965_SD106) in March 2018 (reflective of post-summer conditions), repeat sampling at two locations 0965_SD101 and 0965_SD102 in September 2018 (reflective of post winter conditions) and 17 samples across the property in March 2019. The sediment samples collected in 2019 were primarily analysed for PFAS only.

Sediment results from drainage channels considered to be receptors for individual CSRs are presented in the relevant CSR results sections below. As some sediment locations are located in areas generally considered up-stream or down-stream of the property as a whole, these results are summarised below and summary tables presented in Tables M 2-1, M2-2 and M2-3 (Appendix M).

Key observations and findings

Sediment samples collected across the property were generally collected from dry surface water drains or stagnant pools and therefore considered as not representative of conditions which would support an ephemeral benthic ecosystem. The results can however indicate presence or absence of CoPCs which have accumulated via surface run-off in these areas.

CoPCs comprising BTEX-N, phenols, phthalates, organophosphate pesticides, herbicides and fungicides, PCBs, explosives and the majority of organochlorine pesticides were not reported above the LOR in any of the sediment samples across 3TU.

- Analytical results for four samples collected from up and downstream locations in March 2018 reported a range of TRH fractions at concentrations exceeding ESLs for areas of ecological significance (at all four locations) and urban residential (including at upgradient location 0965_SD101). Repeat sampling undertaken in September 2018 included Silica Gel Clean Up (SGCU) of samples from 0965_SD101 and 0965_SD102. Results after SGCU were well over an order of magnitude lower indicating that the detections were likely related to presence of organic matter or polar (non-petrogenic) compounds and are considered unrelated to historical operations at the area.
- PFAS analytical results from 2019 indicated 15 of the 17 sediment samples reported PFAS (sum of total) at concentrations above LOR, however below adopted assessment criteria.

In 2018 and 2019 PFAS was detected above residential health guidelines in one sediment sample (0965_SD105) collected from the vicinity of the asphalt stockpile area, although concentrations decreased to below guideline criteria at the downstream sample location

(0965_SD106) delineating the extent of impact to the immediate vicinity of the PCSR. Analytical results for one sediment sample (0965_SD116) collected downstream of all 3TU CSRs in April 2019 reported PFAS (sum of total) at a concentration of 9.3 µg/kg, above the PFAS NEMP 2018 Human Health Residential guideline criteria for accessible soil.

- Although no sediment samples were collected down stream of 0965_SD116 during the current Stage 2 DSI, the recent PFAS OMP first flush surface water and sediment sampling assessment (GHD 2019) included results for a sediment sample (0965_SD058) collected approximately 2.3 km downstream from 0965_SD116 (the nearest down gradient sample location). Analytical results for SD058 reported PFAS (sum of total) below the LOR and ILs. The elevated PFAS concentrations detected in upstream sample 0965_SD116 are therefore considered to be adequately delineated in a down stream direction.

11.2.3 Surface water

As indicated in Figure 33A, surface water samples were collected at locations up and downstream of the CSR locations at 3TU over two sampling events reflective of post winter (6 samples in September 2018) and post summer (2 samples in March 2019) conditions. The surface water samples collected in 2019 were primarily analysed for PFAS only.

Surface water results from drainage channels considered to be receptors for individual CSRs are presented in the relevant CSR results sections below. As some surface water locations were located in areas generally considered up-stream or down-stream of the property as a whole, these results are summarised below and reported in more detail in Tables M3-1 and M3-2 (Appendix M).

Key observations and findings

- The majority of sample locations in both sampling events were observed to be dry. At locations where surface water was present it was noted that the water was generally stagnant and not representative of conditions which would support an ephemeral aquatic ecosystem. Therefore it is considered nutrients, biological and physicochemical parameter results are unlikely to provide valuable insight into the quality of surface water entering and exiting the property as these parameters are highly influenced by depleted oxygen in stagnant water.
- Analytical results for samples collected from up and downstream locations in September 2018 did not report any significant variation in CoPC concentrations for metals and only two locations (0965_SW104 upstream and 0965_SW103 downstream) reported minor TRH concentrations. Upstream location 0965_SW104 reported a trace toluene concentration (4 µg/L).
- Analytical results for one surface water sample (0965_SW115) collected from downstream in April 2019 reported PFAS (sum of total) at a concentration of 0.08 µg/L, with sum of PFHxS and PFOS above the PFAS NEMP 2018 Health Drinking Water guideline, and PFOS (0.03 µg/L) above the NEMP 99 % protection level (0.00023 µg/L) but below the 95 % protection level (0.13 µg/L).

  Although no surface water samples were collected down stream of 0965_SW115 during the current Stage 2 DSI, the recent PFASIMB first flush surface water and sediment sampling assessment (GHD 2019) included results for a surface water sample (SW058) collected approximately 2.3 km downstream from 0965_SW115 and approximately 600 m upstream of the point of discharge to the Ellen Brook. Analytical results for SW058 reported PFAS (sum of total) at a concentration of 0.01 µg/L, equal to the LOR, below the 95 % freshwater guideline, but above the 99 % freshwater guideline. The significantly lower PFAS concentration detected in down stream surface water sample SW058 indicates the potential risk of impact to the nearby sensitive ecological receptor is low, however further sampling between SW115 and SW058 during periods of flow would be required to further understand the distribution and flow of PFAS compounds in surface water. Ecological risk associated with PFAS impact to the Ellen Brook has also been extensively assessed by the PFASIMB.

11.2.4 Key outcomes

Whilst the results of surface water and sediment sampling undertaken across the property indicate localised impacts to drainage features, impacts are either delineated in a downstream direction or reported at concentrations which do not indicate chronic risk to human health or the aquatic ecosystem of the nearby ecologically sensitive surface water receiving bodies (the Ellen Brook – Upper Swan catchment). Results should be interpreted in conjunction with the Ecological Risk Assessment for RAAF Base Pearce (including the Ellen Brook) undertaken by PFASIMB.

Further assessment of surface water (site wide) is considered warranted to more accurately assess surface water impacts during periods of flow.

11.3 CSR_WA_000019 – Septic Tanks – Sewage Disposal

11.3.1 Summary of data gaps

Historical information suggests a septic tank was formerly located to the south of building 58.

Soil and groundwater investigation considered necessary to assess the current status of potential risk/presence of contamination associated with former septic tank use.

The findings of the 2018 investigation (mobilisation 1) identified hydrocarbon impacted sediments within nearby drainage channels. Further investigation into the source and type of hydrocarbon impact detected in sediments within nearby drainage features was warranted to enable an appropriate assessment of potential risk to ecological receptors.

All sampling locations within this CSR and sampling rationale are detailed in Section 6.2 and are presented in Figure 34A.

CoPC: Metals, nutrient, pathogens, asbestos, PFAS, dioxins.

11.3.2 Soil laboratory results

Soil samples were collected at three borehole locations and one monitoring well location. Soil analytical results for the septic tank area are compared against the relevant assessment criteria in Tables M4-1 and M4-2 (Appendix M). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (arsenic, cadmium, copper, lead, mercury, nickel)
- Nutrients (ammonia as N, nitrite as N)

The following CoPC were detected above the LOR but were below the applied guidelines:

- Metals (chromium, zinc)
- Nutrients (nitrate as N, total nitrogen, TKN, phosphorus (total))
- Faecal coliforms (no applicable guideline value)

Asbestos in soil

Soil samples were collected at three borehole locations and one monitoring well location at varying depths to assess for the presence or absence of asbestos in soil. Results indicate that no asbestos was identified in any of the soil samples analysed.

11.3.3 Groundwater laboratory results

Groundwater analytical results for the septic tank area were compared against the relevant assessment criteria in Tables M1-1, M1-2 and M1-3 (Appendix M). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (arsenic, cadmium, lead, mercury)
- Nutrients (nitrate as N, nitrite as N, nitrogen (total oxidised) as N)

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (nickel, zinc)
- Nutrients (ammonia as N, nitrogen, TKN)
- Faecal Coliforms
- PFAS (PFOS) was detected at 0965_MW104

Table 88 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines. A graphical representation of the distribution of groundwater impacts is presented on Figure 34C and 34D.

Table 88 Groundwater sample exceedances – Septic Tanks Sewage - Disposal (CSR_WA_000019)

Analyte	Monitoring Round	Location ID	Concentration (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Phosphorus	May 2018	0965_MW104	0.14	0.05	ANZECC 2000 Irrigation - Long-term Trigger Values
Chromium			0.005	0.001	ANZECC 2000 FW 95 %
Copper			0.002	0.0014	
PFAS (PFOS)	April 2019	0965_MW104	0.05 µg/L	0.00023 µg/L	PFAS NEMP 2018 Freshwater 99 %

11.3.4 Sediment laboratory results

Four sediment sampling locations are located in drainage channels in close proximity to the septic tank area as well as surrounding CSRs (CSR_WA_000080, CSR_WA_000103). The drainage channels are considered to be servicing these three areas. Sediment analytical results from these locations (0965_SD101, 0965_SD102, 0965_SD103 and 0965_SD104) were compared against the relevant assessment criteria in Tables M2-1, M2-2 and M2-3 (Appendix M). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in sediments were all below LOR:

- Metals (arsenic, cadmium, lead, mercury, nickel)
- BTEX-N
- PAHs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (chromium, copper, zinc)
- Dioxins and furans
- PFAS (Perfluorobutane Sulfonic Acid (PFBS) and Perfluorooctane Sulfonic Acid (PFOS)) were detected at sample locations 0965_SD101 and 0965_SD102

Table 89 provides a summary of the sediment analytical results which exceeded the adopted sediment and soil investigation levels. A graphical representation of the distribution of metal exceedances in sediments in presented on Figure 33B.

Table 89 Sediment sample exceedances – Septic tanks (CSR_WA_000019)

Analyte	Monitoring round	Location ID	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
TRH - F2 (>C_{10}–C_{16} Fraction)	March 2018	0965_SD101	510	25	ESLs – Ecological significance
				120	ESLs – Urban/ residential
				110	HSL - Residential
		0965_SD102 0965_SD103 0965_SD104	50 110 90	25	ESLs – Ecological significance
TRH - F3 (>C_{16}–C_{34} Fraction)	March 2018	0965_SD101 0965_SD104	1490 320	300	ESLs – Urban/ residential
TRH - F2 (>C_{10}–C_{16} Fraction)	September 2018	0965_SD101	28	25	ESLs – Ecological significance
		0965_SD102	842	25	ESLs – Ecological significance
				120	ESLs – Comm/ Ind
				170	ESLs – Urban/ residential
TRH – F3 (>C_{16}–C_{34} Fraction)		0965_SD102	2600	300	ESLs – Urban/ residential
				1700	ESLs – Comm/ Ind
TRH - F2 (>C_{10}–C_{16} Fraction) Silica Gel Clean Up		0965_SD102	28	25	ESLs – Ecological significance

11.3.5 Surface water laboratory results

Four surface water sampling locations are located in drainage channels in close proximity to the diesel UST area as well as surrounding CSRs (CSR_WA_000103, CSR_WA_000080). The drainage channels are considered to be servicing these three areas. Surface water analytical results from these locations (0965_SW101, 0965_SW102, 0965_SW103, 0965_SW104 and 0965_SW108) are compared against the relevant assessment criteria in Tables M3-1 and M3-2 (Appendix M). As surface water samples were generally collected from stagnant pools within the drainage channel/s they are not considered to be representative of conditions that may support ephemeral benthic ecosystems.

Results confirm that the following CoPC in surface water were all below LOR:

- Metals (arsenic, cadmium, mercury)
- PAHs
- Dioxins and furans
- OC Pesticides

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (lead and nickel)
- BTEX-N (0965_SW104)
- TRH (0965_SW103 and 0965_SW104)

Table 90 provides a summary of the surface water analytical results which exceeded the adopted surface water investigation levels. A graphical representation of the distribution of metal exceedances in surface water is presented on Figure 33C.

Table 90 Surface water sample exceedances – Septic tank (CSR_WA_000019)

Analyte	Monitoring round	Locations IDs	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium (III+IV)	September 2018	0965_SW101 0965_SW102 0965_SW103	0.002	0.001	ANZECC 2000 FW 95 %
Copper		0965_SW101 0965_SW102 0965_SW103 0965_SW104 0965_SW108	0.01 – 0.026	0.0014	
Zinc		0965_SW101 0965_SW102 0965_SW103 0965_SW104 0965_SW108	0.022 – 0.099	0.008	

11.3.6 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- Soil impacts were all reported below applicable guidelines.
- No asbestos was identified in any of the soil samples analysed.
- Faecal coliforms were detected in soils at MW104 to a depth of 6 m bgl, with no applicable guideline value.

Groundwater

- Based on the interpolated groundwater contours, groundwater beneath the septic tanks area flows in a south-easterly direction, and is likely to discharge to the Ellen Brook located approximately 3 km to the east/south-east. Groundwater at the property is not abstracted or used for any purpose. Surrounding properties (more than two kilometres east of area) may abstract the water for drinking water, domestic/household uses, irrigation and stock watering.
- Groundwater from 0965_MW104 (south-east/down gradient of the septic tank) reported PFOS at a concentration of 0.05 µg/L, above the Freshwater 99 % protection value (0.00023 µg/L), however below the established background concentration (0.14 µg/L).

- Excluding phosphorus, all concentrations of CoPC exceeding ecological investigation levels were reported below or marginally above the established background concentrations, and are therefore considered to be reflective of ambient conditions and not likely to pose significant impact or risk to ecological receptors.
- Phosphorus was detected in groundwater above the Irrigation - long-term (health) trigger values, indicating a risk to human health via use of groundwater for irrigation (incidental ingestion).
- Faecal coliforms were detected in groundwater above the drinking water (health) guideline, indicating a risk to human health in the case of consumption of groundwater. The extent of the impact is undelineated, although would be expected to be localised based on the length of time since the septic tank was in use and associated biodegradation processes in the subsurface environment.

Sediment

- A range of TRH fractions were reported in four sediment samples collected both upgradient and down-gradient of the CSR with concentrations exceeding ESLs for areas of ecological significance (at all four locations) and urban residential (at upgradient location SD101 only). SGCU indicated the source of the TRH impact is likely representative of organic matter present in the drainage channels.
- PFAS (Perfluorobutane sulfonic acid (PFBS) and Perfluorooctane sulfonic acid (PFOS)) were detected above LOR in sediment samples 0965_SD101 and 0965_SD102 collected from drainage channels located upgradient of the CSR area. The source of low level PFAS impact is not known, however is well below applicable guidelines.

Surface water

- Concentrations of chromium, copper and zinc were reported above freshwater ILs in in all four surface water samples collected from drainage channels located upgradient and down-gradient of the CSR area. Concentrations of chromium were reported marginally above IL criteria are therefore considered not to indicate significant impact or risk to the ecological environment.
- The source of heavy metals (copper and zinc) impact has not been identified.
- Low level TRH impacts were detected above LOR, but below applicable guideline criteria in surface water samples 0965_SW103 and 0965_SW104 collected from drainage channels located up (0965_SW104) and down hydraulic gradient (0965_SW103) of the CSR area. The minor detection is considered likely to indicate the presence of organic material or polar compounds within the drainage channel.

11.3.7 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 102.

11.3.8 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- No soil or groundwater impacts have been detected which would pose a risk human health receptors under the current land use scenario. However, faecal coliform impacts in soil and groundwater as well as phosphorus impacts in groundwater may potentially pose a risk to human health under direct contact, residential, and irrigation land use scenarios. Development of a site management plan including restriction on groundwater abstraction would be required to manage these risks to future users.

- No asbestos was detected in soil, however ACM fragments were identified on the soil surface at nearby CSR_WA_000080, therefore the potential presence of ACM fragments within the wider CSR area (CSR_WA_000080, CSR_WA_000019 and CSR_WA_000103) cannot be precluded.
- Minor detects of TRH in sediments within nearby drainage features is considered likely to indicate the presence of organic material or polar compounds within the drainage channel and is therefore not considered to pose risk to ecological receptors.
- Elevated concentrations of copper and zinc detected in surface water within nearby drainage features are not considered to pose significant impact or risk to the receiving ecological environment. Given the distance to the nearest sensitive ecological receptor (the Ellen Brook catchment) (approximately 3.5 km) concentrations are likely to be sufficiently diluted at the point of discharge.
- Any future civil works should be undertaken in accordance with an asbestos management plan.

11.4 CSR_WA_000080 – Incinerator (North of 3TU Workshop)

11.4.1 Summary of data gaps

A review of available historical information suggests the former presence of an incinerator in an area to the north of the former 3TU workshop. It is understood the incinerator was demolished in 2001.

Investigation of soil and groundwater was considered necessary to assess the current status of potential risk/presence of contamination associated with former incinerator operations.

The findings of the 2018 investigation (mobilisation 1) identified hydrocarbon-impacted sediments within nearby drainage channels.

Further investigation into the source and type of hydrocarbon impact detected in sediments within nearby drainage features was warranted to enable an appropriate assessment of potential risk to ecological receptors.

All sampling locations within this CSR and sampling rationale are detailed in Table 26 and are presented in Figure 34A.

CoPC: Metals, TRH, PAHs, dioxins, asbestos, PFAS.

11.4.2 Soil laboratory results

Soil samples were collected at three borehole locations and one monitoring well location. Soil analytical results for the incinerator area were compared against the relevant assessment criteria in Tables M5-1 and M5-2 (Appendix M). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (arsenic, cadmium, mercury, nickel)
- TRH
- PAHs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (chromium, copper, iron, lead)

Table 91 provides a summary of the soil analytical results which exceeded the adopted SILs. A graphical representation of the distribution of metal exceedances in soil is presented on Figure 34B.

Table 91 Soil sample exceedances – Incinerator (CSR_WA_000080)

Analyte	Monitoring Round	Location ID	Depth range (m bgl)	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
Zinc	March 2018	0965_BH105	0.1 – 0.5	67 - 120	55	EIL

Asbestos in soil

Soil samples were collected at three borehole locations and one monitoring well location at varying depths to assess for the presence or absence of asbestos in soil. Results indicate that no asbestos was identified in any of the soil samples analysed.

11.4.3 Groundwater laboratory results

Groundwater analytical results for the incinerator north of 3TU workshop area were compared against the relevant assessment criteria in Tables M1-1, M1-2 and M1-3 (Appendix M). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (arsenic, cadmium, mercury)
- TRH
- PAHs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (lead, nickel)
- PFAS (PFHxS, PFOS, PFHxA, PFOA) - detected at 0965_MW102
- PFAS (PFHxS) - detected at 0965_MW101

Table 92 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines. A graphical representation of the distribution of groundwater impacts is presented on Figure 34C and D.

Table 92 Groundwater sample exceedances – Incinerator (CSR_WA_000080)

Analyte	Monitoring Round	Location ID	Concentration (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium	May 2018	0965_MW102	0.002	0.001	ANZECC 2000 FW 95 %
Copper			0.012	0.0014	
Zinc			0.024	0.008	
PFAS (PFOS)	April 2019	0965_MW102	0.58 µg/L	0.13 µg/L	PFAS NEMP 2018 Freshwater 95 %
				0.00023 µg/L	PFAS NEMP 2018 Freshwater 99 %
PFAS (sum of PFHxS and PFOS)		0965_MW102	0.75 µg/L	0.07 µg/L	PFAS NEMP 2018 Health drinking water

11.4.4 Sediment laboratory results

Four sediment sampling locations are located in drainage channels in close proximity to the diesel UST area as well as surrounding CSRs (CSR_WA_000103, CSR_WA_000019). The drainage channels are considered to be servicing these three areas. Sediment analytical results from these locations (0965_SD101, 0965_SD102, 0965_SD103 and 0965_SD104) were compared against the relevant assessment criteria outlined in Tables M2-1, M2-2 and M2-3 (Appendix M). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in sediments were all below LOR:

- Metals (arsenic, cadmium, lead, mercury, nickel)
- BTEX-N

- PAHs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (chromium, copper, zinc)
- Dioxins and furans
- PFAS (PFBS and PFOS) were detected at sample locations 0965_SD101 and 0965_SD102.

Table 93 provides a summary of the sediment analytical results which exceeded the adopted sediment and soil investigation levels. A graphical representation of the distribution of sediment impacts is presented on Figure 33B.

Table 93 Sediment sample exceedances – Incinerator (CSR_WA_000080)

Analyte	Monitoring round	Location ID	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
TRH - F2 (>C_{10}–C_{16} Fraction)	March 2018	0965_SD101	510	25	ESLs – Ecological significance
				120	ESLs – Urban/ residential
				110	HSL - Residential
		0965_SD102 0965_SD103 0965_SD104	50 110 90	25	ESLs – Ecological significance
TRH - F3 (>C_{16}–C_{34} Fraction)	March 2018	0965_SD101 0965_SD104	1490 320	300	ESLs – Urban/ residential
TRH - F2 (>C_{10}–C_{16} Fraction)	September 2018	0965_SD101	28	25	ESLs – Ecological significance
		0965_SD102	842	25	ESLs – Ecological significance
				120	ESLs – Comm/ Ind
				170	ESLs – Urban/ residential
TRH – F3 (>C_{16}–C_{34} Fraction)		0965_SD102	2600	300	ESLs – Urban/ residential
				1700	ESLs – Comm/ Ind
TRH - F2 (>C_{10}–C_{16} Fraction) Silica Gel Clean Up		0965_SD102	28	25	ESLs – Ecological significance

11.4.5 Surface water laboratory results

Five surface water sampling locations are located in drainage channels in close proximity to the diesel UST area as well as surrounding CSRs (CSR_WA_000103, CSR_WA_000019). The drainage channels are considered to be servicing these three areas. Surface water analytical results from these locations (0965_SW101, 0965_SW102, 0965_SW103, 0965_SW104 and

0965_SW108) were compared against the relevant assessment criteria outlined in Tables M3-1 and M3-2 (Appendix M). As surface water samples were generally collected from stagnant pools within the drainage channel/s they are not considered to be representative of conditions which may support ephemeral benthic ecosystems.

Results confirm that the following CoPC in surface water were all below LOR:

- Metals (arsenic, cadmium, mercury)
- PAHs
- Dioxins and furans
- OC Pesticides

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (lead and nickel)
- BTEX-N (0965_SW104)
- TRH (0965_SW103 and 0965_SW104)

Table 94 provides a summary of the analytical results which exceeded the adopted surface water investigation levels. A graphical representation of the distribution of surface water impacts is presented on Figure 33C.

Table 94 Surface water sample exceedances – Incinerator (CSR_WA_000080)

Analyte	Monitoring round	Locations IDs	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium (III+IV)	September 2018	0965_SW101 0965_SW102 0965_SW103	0.002	0.001	ANZECC 2000 FW 95 %
Copper		0965_SW101 0965_SW102 0965_SW103 0965_SW104 0965_SW108	0.01 – 0.026	0.0014	
Zinc		0965_SW101 0965_SW102 0965_SW103 0965_SW104 0965_SW108	0.022 – 0.099	0.008	

11.4.6 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- Concentrations of zinc were reported above EILs in soil samples 0965_BH105_0.1 and 0965_BH105_0.5 with concentrations decreasing at depth. Zinc was reported below EIL criteria in soil sample 0965_BH105_1.0 which indicates localised impact limited to shallow soil. The presence of localised zinc impact in soil is not considered to constitute unacceptable risk to ecological receptors given the CSR is considered a moderate to highly disturbed area with limited vegetation regrowth.

- Asbestos fragments were observed on the ground surface in the vicinity of the CSR (including adjacent area CSR_WA_000088). Confirmatory analysis of one fragment identified the presence of asbestos comprising Chrysotile and Amosite. Although asbestos was not reported in any of the soil samples analysed, the potential presence within soil across the CSR area cannot be precluded given the known presence of asbestos fragments on the ground surface.
- The results indicate there has not been any significant soil impact from current or historic activities and that there is no contamination risk to property users or the environment from soils within the CSR area under the current land-use scenario.

Groundwater

- Based on the interpolated groundwater contours, groundwater beneath the incinerator area flows in an easterly to south-easterly direction, and is likely to discharge to the Ellen Brook located approximately 3.5 km to the east/south-east. Groundwater at the property is not abstracted or used for any purpose. Surrounding properties (more than two kilometres east of area) may abstract the water for drinking water, domestic/household uses, irrigation and stock watering.
- Groundwater from well 0965_MW102 (south-east/down gradient of the former incinerator) reported PFOS at a concentration of 0.58 µg/L, exceeding the Freshwater 95 % protection value (0.13 µg/L) and established background concentration (0.14 µg/L), as well as PFHxS +PFOS at a concentration of 0.75 µg/L, exceeding the NEMP Drinking Water guideline value (0.07 µg/L) and established background concentration (19 µg/L). The impacts are currently undelineated in both an up-gradient and down-gradient direction.
- Although no groundwater samples were collected down gradient of 0965_MW102 during the current Stage 2 DSI, the PFASIMB DSI conducted by GHD in 2018 included results for groundwater sampled from down gradient private abstraction bores. The nearest private abstraction bores registered for domestic use are located approximately 3.0 km south-east (down gradient) of the CSR and approximately 300 m west (up gradient) of the West Bullsbrook residential area. Analytical results reported PFAS (sum of total) below the LOR of 0.01 µg/L. Based on these findings, the elevated concentrations of PFAS detected in groundwater at the Bullsbrook Training Area are not considered likely to represent a potential source of impact or exposure risk to down gradient abstraction bore users, however further groundwater assessment should be undertaken between the source area and receptors to improve understanding of PFAS distribution in the sub-surface.
- Excluding zinc, copper and PFAS, all concentrations of CoPC exceeding ecological investigation levels were reported below or marginally above the established background concentrations, and are therefore considered to be reflective of ambient conditions and not likely to pose significant impact or risk to ecological receptors.
- The detection of zinc, copper, PFAS above fresh water ILs indicates potential exposure risk to the ecological environment.

Sediment

- A range of TRH fractions were reported in four sediment samples collected both upgradient and down-gradient of the CSR with concentrations exceeding ESLs for areas of ecological significance (at all four locations) and urban residential (at upgradient location SD101 only). SGCU indicated the source of the TRH impact is likely representative of organic matter present in the drainage channels.
- PFAS (PFBS and PFOS) were detected above LOR in sediment samples 0965_SD101 and 0965_SD102 collected from drainage channels located upgradient of the CSR area.

The source of low level PFAS impact is not known, however is well below applicable guidelines

Surface water

- Concentrations of chromium, copper and zinc were reported above freshwater ILs in in all four surface water samples collected from drainage channels located upgradient and down-gradient of the CSR area. Concentrations of chromium were reported marginally above IL criteria are therefore considered not to indicate significant impact or risk to the ecological environment.
- The detection of zinc and copper above fresh water ILs indicates potential exposure risk to the ecological environment.
- Low level TRH impacts were detected above LOR, but below applicable guideline criteria in surface water samples 0965_SW103 and 0965_SW104 collected from drainage channels located up (0965_SW104) and down hydraulic gradient (0965_SW103) of the CSR area. The minor detection is considered likely to indicate the presence of organic material or polar compounds within the drainage channel.

11.4.7 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 102.

11.4.8 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- No soil or groundwater impacts have been detected which would pose a risk to human health receptors under the current land use scenario.
- Elevated concentrations of copper and zinc detected in groundwater beneath the CSR area are not considered to pose significant impact or risk to the receiving ecological environment. Given the distance to the nearest sensitive ecological receptor (the Ellen Brook catchment) (approximately 3.5 km) concentrations are likely to decrease to below guidance criteria prior to reaching the point of discharge.
- The detection of PFAS in groundwater exceeding PFAS NEMP 2018 Health Drinking Water criteria in 0965_MW102 is undelineated. The reported concentrations of PFAS are however considered to unlikely to currently pose an exposure risk to human health of registered abstraction bore users at down gradient properties (nearest 3.0 km down-gradient) based on sampling results from these abstraction bores indicating no reported PFAS above LOR. There is insufficient data to ascertain whether PFAS may post a risk to down-gradient bore users in the future.
- The detection of PFAS above fresh water ILs in groundwater indicates potential exposure risk to the ecological environment and sensitive receptors. Further groundwater assessment should be undertaken between the source area and receptors to improve understanding of PFAS distribution in the sub-surface.
- Minor detects of TRH in sediments within nearby drainage features is considered likely to indicate the presence of organic material or polar compounds within the drainage channel and is therefore not considered to pose risk to ecological receptors.

- Elevated concentrations of copper and zinc detected in surface water within nearby drainage features are not considered to pose significant impact or risk to the receiving ecological environment. Given the distance to the nearest sensitive ecological receptor (the Ellen Brook catchment) (Approximately 3.5 km) concentrations are likely to be sufficiently diluted at the point of discharge.
- Further assessment of surface water (site wide) is considered warranted to more accurately assess PFAS surface water impacts during periods of flow. Results should be interpreted in conjunction with ecological risk assessment undertaken by PFASIMB for Pearce (including the Ellen Brook).
- It is recommended that the groundwater well network be incorporated into an annual regional water quality monitoring programme.
- Any future civil works should be undertaken in accordance with an asbestos management plan.

11.5 CSR_WA_000081 – South of 3TU – Buried Waste Metals

11.5.1 Summary of data gaps

It is understood the area was formerly used for landfilling activities including burial of waste metals and concrete footings associated with former aerial farm infrastructure.

Sampling and assessment of the existing groundwater monitoring well network was considered necessary to determine the status of groundwater quality the status of potential risk associated with former use as a landfill.

The findings of the 2018 investigation (mobilisation 1) reported heavy metals impacts (namely zinc) within groundwater beneath the CSR area, however the extent of impact was reported as undelineated. Additional monitoring was undertaken during the subsequent 2019 investigation (mobilisation 2) to confirm the presence of elevated zinc impact in groundwater.

All sampling locations within this CSR and sampling rationale are detailed in Section 6.2 and presented in Figure 35A.

CoPC: Metals, TRH, PAHs, VOCs, PFAS

11.5.2 Groundwater laboratory results

Groundwater analytical results for the buried waste material CSR area were compared against the relevant assessment criteria in Tables M1-1, M1-2 and M1-3 (Appendix M) Results confirm that the following CoPC in groundwater were all below LOR:

- Metals (mercury)
- TRH
- PAHs
- VOCs
- PFAS

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (arsenic, cadmium, lead, nickel)

Table 95 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines. A graphical representation of the distribution of groundwater impacts is presented on Figure 35B and C.

Table 95 Groundwater sample exceedances – Buried waste metals

Analyte	Monitoring Round	Location ID	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium	April 2018	0965_MW001 0965_MW004	0.002 0.003	0.001	ANZECC 2000 FW 95 %
	April 2019	0965_MW001 0965_MW004	0.004 0.002		
Copper	April 2018	0965_MW004 0965_MW005	0.003 0.002	0.0014	ANZECC 2000 FW 95 %
	April 2019	0965_MW002 0965_MW004 0965_MW005	0.007 0.012 0.014		
Zinc	April 2018	0965_MW004 0965_MW005	0.982 0.025	0.008	ANZECC 2000 FW 95 %
	April 2019	0965_MW001 0965_MW002 0965_MW004 0965_MW005	0.016 0.048 0.356 0.058		

11.5.3 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Groundwater

- Based on the interpolated groundwater flow direction, groundwater beneath the former landfill is likely to discharge to the Ellen Brook located approximately 3.5 km to the south east. Groundwater at the property is not abstracted or used for any purpose. Surrounding properties (more than two kilometres east of area) may abstract the water for drinking water, domestic/household uses, irrigation and stock feed.
- Concentrations of copper and chromium exceed freshwater ILs in upgradient (0965_MW002) and downgradient (0965_MW004 and 0965_MW005) well locations. Concentrations of chromium were generally reported marginally above IL criteria and background levels and are therefore considered not to indicate significant impact or risk to the receiving ecological environment.
- Concentrations of zinc in groundwater exceed freshwater ILs and are up to three orders of magnitude higher on the downgradient (southeast) edge of the landfill compared to those upgradient. The concentrations reported in 2019 were marginally lower than concentrations reported in 2018, however the results confirm the presence of elevated zinc in groundwater beneath the CSR area. Considering the highest concentrations were reported in down gradient monitoring well locations, the potential for impact beyond the CSR boundary has not been assessed to date and therefore cannot be precluded.
- Analytical results for groundwater samples collected in 2019 did not detect PFAS in any of the groundwater samples.

11.5.4 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 102.

11.5.5 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- Groundwater beneath the landfill indicates a likely contribution to metals impacts (copper and zinc) from historic landfilling activities. The extent of impact is undelineated beyond the boundary of the CSR area.
- Further groundwater investigation including installation of additional monitoring wells down hydraulic gradient of the CSR area is considered warranted to adequately assess the extent of metals impact and potential for migration to the Ellen Brook.
- It is recommended that the groundwater well network be incorporated in to an annual regional water quality monitoring programme.

11.6 CSR_WA_000103 – South of Former Building 58 – 2 x Diesel A/USTs

11.6.1 Summary of data gaps

It is understood two former diesel A/USTs were formerly present within the CSR area to the south of former Building 58 (north-eastern corner of the area). It is further understood that the former 4500 L diesel UST (UST_001) was decommissioned, removed, and validated in 2007, however there is limited information available regarding the former diesel AST.

Data gaps were identified as soil and groundwater impact uncertainty, therefore the assessment of soil and groundwater was deemed necessary to determine groundwater status and confirm soil risk status remains low.

Following completion of the 2018 investigation (mobilisation 1), data gaps pertaining to surface water/sediment impact characterisation uncertainty were identified based on the detection of hydrocarbon impacts above ecological guidelines in sediment. Further investigation was considered warranted to enable an appropriate assessment of potential risk to identified ecological receptors.

All sampling locations within this CSR and sampling rationale are detailed in Section 6.2 and are presented in Figure 34A.

CoPC: Metals, TRH, PAHs, asbestos, PFAS

11.6.2 Soil laboratory results

Soil samples were collected at five soil bore locations and two monitoring well locations. Soil analytical results for the diesel A/UST area are compared against the relevant assessment criteria in Tables M6-1 and M6-2 (Appendix M). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (arsenic, cadmium, mercury)
- PAHs

The following CoPC were detected slightly above the LOR but were below the applied guidelines:

- Metals (chromium, copper, lead, nickel and zinc)
- Nutrients (nitrate as N, total nitrogen, TKN, phosphorus)
- TRH (F3(>C_{16}-C_{34} Fraction), >C_{10}-C_{40} (Sum of total))

Asbestos in soil

Soil samples were collected at three borehole locations and two monitoring well locations at varying depths to assess for the presence or absence of asbestos in soil. Asbestos was detected at one location, as summarised in Table 96.

Table 96 Summary of soil asbestos detects - Diesel A/USTs (CSR_WA_000103)

Location ID	Depth (m bgl)	Asbestos detected	Asbestos type
0965_MW103	0.5	Yes	Chrysotile + Amosite

11.6.3 Groundwater laboratory results

Groundwater analytical results for the former diesel A/UST area were compared against the relevant assessment criteria in Tables M1-1, M1-2 and M1-3 (Appendix M). Results confirm that the following CoPC in groundwater were all below LOR within the CSR:

- Metals (cadmium, mercury)
- PAHs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (arsenic, lead, nickel)
- TRH (F2 (>C_{10}-C_{16} minus Naphthalene), >C_{10}-C_{16} Fraction, F3 (>C_{16}-C_{34} Fraction), C_{10}-C_{40} (Sum of Total)) were detected at MW103
- PFAS (PFHxS) - detected at upgradient well 0965_MW101

Table 97 provides a summary of the groundwater analytical results which exceeded the adopted screening guidelines. A graphical representation of the distribution of groundwater impacts is presented on Figure 34C and D.

Table 97 Groundwater sample exceedances – Former Building 58 (CSR_WA_000103)

Analyte	Monitoring Round	Location ID	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium	May 2018	0965_MW101 0965_MW103	0.002	0.001	ANZECC 2000 FW 95 %
Copper			0.018	0.0014	
Zinc			0.028-0.038	0.008	
PFAS (PFOS)	April 2019	0965_MW103	0.01 µg/L	0.00023 µg/L	PFAS NEMP 2018 Freshwater 99 %

11.6.4 Sediment laboratory results

Four sediment sampling locations are located in drainage channels in close proximity to the diesel UST area as well as surrounding CSRs (CSR_WA_000080, CSR_WA_000019). The drainage channels are considered to be servicing these three areas. Sediment analytical results from these locations (0965_SD101, 0965_SD102, 0965_SD103 and 0965_SD104) are compared against the relevant assessment criteria in Tables M2-1, M2-2 and M2-3 (Appendix M). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in sediments were all below LOR:

- Metals (arsenic, cadmium, lead, mercury, nickel)
- BTEX-N
- PAHs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (chromium, copper, zinc)
- Dioxins and furans
- PFAS (PFBS and PFOS) were detected at sample locations 0965_SD101 and 0965_SD102.

Table 98 provides a summary of the sediment analytical results which exceeded the adopted sediment and soil investigation levels. A graphical representation of the distribution of metal exceedances in sediments in presented on Figure 33B.

Table 98 Sediment sample exceedances – Diesel USTs (CSR_WA_000103)

Analyte	Monitoring round	Location ID	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
TRH - F2 (>C_{10}–C_{16} Fraction)	March 2018	0965_SD101	510	25	ESLs – Ecological significance
				120	ESLs – Urban/ residential
				110	HSL - Residential
		0965_SD102 0965_SD103 0965_SD104	50 110 90	25	ESLs – Ecological significance
TRH - F3 (>C_{16}–C_{34} Fraction)	March 2018	0965_SD101 0965_SD104	1490 320	300	ESLs – Urban/ residential
TRH - F2 (>C_{10}–C_{16} Fraction)	September 2018	0965_SD101	28	25	ESLs – Ecological significance
		0965_SD102	842	25	ESLs – Ecological significance
				120	ESLs – Comm/ Ind
				170	ESLs – Urban/ residential
TRH – F3 (>C_{16}–C_{34} Fraction)		0965_SD102	2600	300	ESLs – Urban/ residential
				1700	ESLs – Comm/ Ind
TRH - F2 (>C_{10}–C_{16} Fraction) Silica Gel Clean Up		0965_SD102	28	25	ESLs – Ecological significance

11.6.5 Surface water laboratory results

Four surface water sampling locations are located in drainage channels in close proximity to the diesel UST area as well as surrounding CSRs (CSR_WA_000080, CSR_WA_000019). The drainage channels are considered to be servicing these three areas. Surface water analytical results from these locations (0965_SW101, 0965_SW102, 0965_SW103, 0965_SW104 and 0965_SW108) are compared against the relevant assessment criteria in Tables M3-1 and M3-2 (Appendix M). As surface water samples were generally collected from stagnant pools within the drainage channel/s they are not considered to be representative of conditions which may support ephemeral benthic ecosystems.

Results confirm that the following CoPC in surface water were all below LOR:

- Metals (arsenic, cadmium, mercury)
- PAHs

- Dioxins and furans
- OC Pesticides

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (lead and nickel)
- BTEX-N (0965_SW104)
- TRH (0965_SW103 and 0965_SW104)

Table 99 provides a summary of the sediment analytical results which exceeded the adopted surface water investigation levels. A graphical representation of the distribution of metal exceedances in surface water in presented on Figure 33B.

Table 99 Surface water sample exceedances – Diesel USTs (CSR_WA_000103)

Analyte	Monitoring round	Locations IDs	Concentration range (mg/L)	Criteria limit (mg/L)	Criteria exceeded
Chromium (III+IV)	September 2018	0965_SW101 0965_SW102 0965_SW103	0.002	0.001	ANZECC 2000 FW 95 %
Copper		0965_SW101 0965_SW102 0965_SW103 0965_SW104 0965_SW108	0.01 – 0.026	0.0014	
Zinc		0965_SW101 0965_SW102 0965_SW103 0965_SW104 0965_SW108	0.022 – 0.099	0.008	

11.6.6 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- Soil CoPC were all reported below applicable guidelines.
- Asbestos was detected in soils at one location. Based on the decommissioning history of the site, the potential presence at other locations across the CSR area cannot be precluded.

Groundwater

- Based on the interpolated groundwater contours, groundwater beneath the former diesel A/USTs area flows in a easterly to south-easterly direction, and is likely to discharge to the Ellen Brook located approximately 3.5 km to the east/south-east. Groundwater at the property is not abstracted or used for any purpose. Surrounding properties (more than two kilometres east of area) may abstract the water for drinking water, domestic/household uses, irrigation and stock watering.

- Groundwater from 0965_MW103 (south/down gradient of former building 58) reported PFOS at a concentration of 0.01 µg/L, above the Freshwater 99 % protection value (0.00023 µg/L), however below the upgradient/'background' concentration (0.14 µg/L).
- Excluding copper and zinc, all concentrations of CoPC exceeding ecological investigation levels were reported below or marginally above the established background concentrations, and are therefore considered to be reflective of ambient conditions and not likely to pose significant impact or risk to ecological receptors.
- The detection of copper and zinc above fresh water ILs in 0965_MW103 indicates potential exposure risk to the ecological environment.
- Low level TRH impacts were detected in groundwater below applicable guidelines at monitoring well 0965_MW103. The source may related to be the former U/ASTs, or may indicate the presence of organic material or polar compounds. The detection of low level TRH is not considered to pose a risk to current or future users and therefore further assessment is not considered warranted.

Sediment

- A range of TRH fractions were reported in four sediment samples collected both upgradient and down-gradient of the CSR with concentrations exceeding ESLs for areas of ecological significance (at all four locations) and urban residential (at upgradient location 0965_SD101 only). SGCU indicated the source of the TRH impact is likely representative of organic matter present in the drainage channels.
- PFAS (PFBS and PFOS) were detected above LOR in sediment samples 0965_SD101 and 0965_SD102 collected from drainage channels located upgradient of the CSR area. The source of low level PFAS impact is not known, however is well below applicable guidelines.

Surface water

- Concentrations of chromium, copper and zinc were reported above freshwater ILs in in all four surface water samples collected from drainage channels located upgradient and down-gradient of the CSR area. Concentrations of chromium were reported marginally above IL criteria are therefore considered not to indicate significant impact or risk to the ecological environment.
- The source of heavy metals (copper and zinc) impact has not been identified.
- Low level TRH impacts were detected above LOR, but below applicable guideline criteria in surface water samples 0965_SW103 and 0965_SW104 collected from drainage channels located up (0965_SW104) and down hydraulic gradient (0965_SW103) of the CSR area. The source may related to be the former USTs/ASTs, or may indicate the presence of organic material or polar compounds.

11.6.7 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 102.

11.6.8 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- With the exception of asbestos, no other soil or groundwater impacts have been detected which would pose a risk to human health receptors under the current land use scenario.
- Elevated concentrations of copper and zinc detected in groundwater beneath the CSR area are not considered to pose significant impact or risk to the receiving ecological environment. Given the distance to the nearest sensitive ecological receptor (the Ellen Brook catchment) (approximately 3.5 km) concentrations are likely to be sufficiently diluted at the point of discharge.
- Minor detects of TRH in sediments within nearby drainage features is considered likely to indicate the presence of organic material or polar compounds within the drainage channel and is therefore not considered to pose risk to ecological receptors.
- Elevated concentrations of copper and zinc detected in surface water within nearby drainage features are not considered to pose significant impact or risk to the receiving ecological environment. Given the distance to the nearest sensitive ecological receptor (the Ellen Brook catchment) (approximately 3.5 km) concentrations are likely to be sufficiently diluted at the point of discharge.
- It is recommended that the groundwater well network be incorporated in to an annual regional water quality monitoring programme.
- Any future civil works should be undertaken in accordance with an asbestos management plan.

11.7 PCSR_0965_001 – Potential Former Fire Extinguisher Training Area

11.7.1 Summary of data gaps

Anecdotal evidence suggests fire extinguishers were historically used in this area and inferences have also been made which indicate the AFFF may have been transported to the area by the Bush Fire Brigade. However, it is unknown whether this foam was discharged at 3TU.

Investigation of soil and groundwater was therefore considered necessary to determine the status of soil and groundwater quality and assess the status of potential risk associated potential former use as an AFFF discharge area.

All sampling locations within this CSR and sampling rationale are detailed in Section 6.2 and are presented in Figure 36A.

CoPC: PFAS

11.7.2 Soil laboratory results

Soil samples were collected at 11 soil bore locations. Soil analytical results were compared against the relevant assessment criteria in Table M7-1 (Appendix M). Results confirm that all CoPC in soils were below LOR and did not exceed any of the adopted SILs.

11.7.3 Groundwater laboratory results

Groundwater analytical results for the fire extinguisher training area were compared against the relevant assessment criteria in Tables M1-1, M1-2 and M1-3 (Appendix M). Results confirm that all CoPC in groundwater were below LOR and did not exceed any of the adopted guidelines.

11.7.4 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- All CoPC in soils were reported below LOR and did not exceed any of the adopted SILs in any of the soil samples analysed.

Groundwater

- All CoPC in groundwater were reported below LOR and did not exceed any of the adopted GILs in any of the groundwater samples analysed.

11.7.5 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 102.

11.7.6 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- No soil or groundwater impacts have been detected that are considered to pose a risk to ongoing or future land-uses under the current land use scenario.

- The potential fire extinguisher training area is considered suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management or monitoring and as such should be archived from the CSR database.

11.8 PCSR_0965_002 – Asphalt Stockpile Area

11.8.1 Summary of data gaps

Potential for contamination associated with leachable contaminants within the asphalt and the source of the stockpiled asphalt (from RAAF Base Pearce runway resurfacing works) and potential contaminants of concern associated with runway use. Additionally, due to the known use of AFFF on runways at RAAF Base Pearce, the potential exists for PFAS contamination of soil surrounding the stockpile via leaching contaminants from the asphalt material.

Investigation of soil was considered necessary to determine the current status of potential risk associated with leachable contaminants within the asphalt.

All sampling locations within this PCSR and sampling rationale are detailed in Section 6.2 and are presented in Figure 37A.

CoPC: Metals, TRH, PAHs, asbestos, PFAS

11.8.2 Soil laboratory results

Soil samples were collected at six soil bore locations. In addition, two asphalt samples were collected for PFAS analysis. Soil and asphalt analytical results for the asphalt stockpile area are compared against the relevant assessment criteria in Tables M8-1, M8-2 and M8-3 (Appendix M). Results confirm that the following CoPC in soils were all below LOR within the CSR:

- Metals (arsenic, cadmium, copper, mercury, nickel)
- TRH (excluding F3 (>C_{16}-C_{34} fraction), F4 (>C_{34}-C_{40} fraction), >C_{10}-C_{40} (sum of total))
- VOCs
- SVOCs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (chromium, lead)
- TRH (F3 (>C_{16}-C_{34} Fraction), F4 (>C_{34}-C_{40} Fraction), >C_{10}-C_{40} (Sum of Total))
- PAHs (excluding benzo(a)antracene, BaP, dibenz(a,h)anthracene, and indeno(1,2,3-c,d)pyrene)
- PFAS (PFHxS, PFOS)

Table 100 provides a summary of the soil analytical results which exceeded the adopted SILs.

Table 100 Soil sample exceedances - Asphalt Stockpile Area (PCSR_0965_002)

Analyte	Monitoring Round	Location ID	Depth (m bgl)	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
Zinc	March 2018	0965_BH115	0.1	86	55	NEPM EIL for Areas of Ecological Significance
Benzo(a) pyrene		0965_BH116	0.2	7.2	0.7	NEPM ESLs for Areas of Ecological Significance and Urban Res
					0.11	NEPM HIL A Residential
Benz(a) anthracene				6.8	1.1	
Dibenz(a,h) anthracene				1.5	0.1	
Indeno(1,2,3-c,d) pyrene				6.2	1.1	

Asbestos in soil

Soil samples were collected at six borehole locations at varying depths to assess for the presence or absence of asbestos in soil. Results confirm that no asbestos was identified in any of the soil samples analysed.

11.8.3 Sediment laboratory results

Two sediment sampling locations are located in drainage channels in close proximity to the asphalt stockpile area which are considered to be servicing the area. Sediment analytical results from these locations (0965_SD105 and 0965_SD106) were compared against the relevant assessment criteria in Tables M2-1, M2-2 and M2-3 (Appendix M). As sediment samples were generally collected from dry surface water drains or stagnant pools they are not considered to be representative of conditions which may support ephemeral benthic ecosystems. Therefore, sediment samples were compared against both sediment (ISQG) guidelines as well as soil guidelines considered relevant for this CSR.

Results confirm that the following CoPC in sediments were all below LOR:

- Metals (arsenic, cadmium)
- BTEX-N
- TRH
- PAHs
- Phenols
- VOCs
- SVOCs
- OCPs
- OPPs
- VOCs

The following CoPC were detected (typically slightly) above the LOR, but were below the applied guidelines:

- Metals (chromium, copper, lead, nickel)

Table 101 provides a summary of the sediment analytical results which exceeded the adopted sediment and soil investigation levels. A graphical representation of the distribution of metal exceedances in sediments in presented on Figure 37B.

Table 101 Sediment sample exceedances –Asphalt Stockpile Area (PCSR_0965_002)

Group	Analyte	Locations IDs	Concentration (mg/kg)	Criteria limit (mg/kg)	Criteria exceeded
PFAS	Sum of PFHxS and PFOS	0965_SD105	0.0098	0.009	PFAS NEMP 2018 Health Residential Accessible Soil
Metals	Mercury	0965_SD105	0.2	0.15	ISQG - Low
	Zinc	0965_SD105	84	55	EIL – Ecological Significance

11.8.4 Surface water laboratory results

No locations had sufficient surface water for sampling in the drainage channels located in close proximity to the asphalt stockpile area.

11.8.5 Discussion

The interpretation of the results with reference to the investigation objectives and identified data gaps is discussed below:

Soil

- Soil impacts were all reported below the human health guidelines with the exception of PAHs reported above HIL-A (residential) (and ESLs) in soil sample 0965_BH116_0.2.
- The detection of localised low level PAH impact limited to surface soil is not considered to pose a risk to future users of the area, provided the asphalt material and surface soil beneath and surrounding the asphalt stockpile is removed and underlying soil validated prior to any future residential redevelopment.

Asphalt

- Analytical results for PFAS within two stockpiled asphalt samples were all below ILs indicating the stockpiled material is not a source of PFAS. It should be noted that results are indicative as sampling density was not sufficient to satisfy waste classification sampling density requirements for the stockpiled volume.
- As indicated in the section above, it is recommended the asphalt material and surface soil beneath and surrounding the asphalt stockpile is removed and underlying soil validated prior to any future residential redevelopment.

Groundwater

- No groundwater investigation was undertaken within the CSR area. The findings of the soil investigation were sufficient to deem investigation of groundwater as not required at this time.

- There may however be a requirement for future monitoring pending results of soil validation subsequent to the validation testing of soil underlying the asphalt sockpile (recommended to be removed).

Sediment

- PFAS was detected above the NEMP Health Residential guidelines for accessible soil in sediment sample 0965_SD105 collected from a drainage channel located to the south west of the CSR area. Concentrations were reported below guideline criteria at downgradient location SD106 which indicates delineation of PFAS impact within the drainage channel and does not warrant further investigation.

Surface water

- No surface water samples were collected from the drainage channels located in close proximity to the asphalt stockpile area due to there being insufficient water volume available at the time of sampling.

11.8.6 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 102.

11.8.7 Key outcomes

The key outcomes of the investigation with regards to whether identified data gaps are considered to have been adequately addressed or require further investigation are outlined below:

- No contamination impacts have been detected which would pose a risk to ecological or human health receptors under the current land use scenario.
- The detection of PFAS and PAHs in surface soil poses a potential risk to future land users under more sensitive land use scenarios. The asphalt material and surface soil beneath and surrounding the asphalt stockpile should be removed and underlying soil validated. Groundwater monitoring may be required pending the results of the validation testing.

11.9 Refined conceptual site model

A tabulated refined CSM has been developed in light of the findings of the Stage 2 DSI, and is presented in Table 102 and graphically in Figure 38B.

Table 102 Refined Conceptual Site Model – 3TU

Source		Pathway			Receptor						
					Human onsite		Human offsite		Ecological offsite		
CSR/PCSR	CoPC	Primary	Secondary	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Future site users	Recreational users of the Ellen Brook	Users of down gradient bores (non potable/irrigation use) including higher order species (non potable/livestock use)	Groundwater dependant remnant native vegetation and associated threatened fauna species	The Ellen Brook and associated aquatic flora and fauna ecosystems	Residual data gaps/further action
CSR_WA_000019 – Septic Tanks – Sewage Disposal One septic tank observed to the south of former building 58. No soil or groundwater impacts have been detected which would pose a risk human health receptors under the current land use scenario. However, faecal coliform impacts in soil and groundwater may potentially pose a risk to human health under direct contact, residential, and irrigation land use scenario's. No asbestos detected in soil, however ACM fragments were identified on the soil surface at nearby CSR_WA_000080, therefore the potential presence of ACM fragments within the wider CSR area (CSR_WA_000080, CSR_WA_000019, and CSR_WA_000103) cannot be precluded. Sediment samples indicated TRH exceeding ESL criteria for ecological significance and urban/residential areas. Source considered likely attributed to the presence of organic matter within the drainage channel/s. Detection of PFAS in groundwater exceeding PFAS NEMP 2018 Fresh Water ILs, however below the established background concentration (Mobilisation 2).	Faecal coliforms Phosphorus	Direct contact with soil	Windblown dust	Incidental ingestion or inhalation of soil/dust	✗	✓	✗	✗	✗	✗	Faecal coliform impacts in soil and groundwater as well as phosphorus impacts in groundwater may potentially pose a risk to human health under direct contact, residential, and agricultural/irrigation land use scenarios. Development of a site management plan including restriction of groundwater abstraction is recommended to mitigate potential exposure risk to future land users. It is recommended that the groundwater well network be incorporated in to an annual regional water quality monitoring programme.
		Migration within groundwater	Abstracted groundwater (drinking water/ irrigation/stock watering)	Direct contact with impacted groundwater or incidental ingestion of impacted groundwater	✗	✓	✗	✗	✗	✗	
		Surface run-off	N/A	Direct contact or ingestion of impacted sediments.	✗	✓	✗	✗	✗	✗	
	TRH	Surface run-off	N/A	Direct contact or ingestion of impacted sediments.	✗	✗	✗	✗	✗	✗	Minor detects of TRH in sediments within nearby drainage features is considered likely to indicate the presence of organic material or polar compounds within the drainage channel and is therefore not considered to pose risk to ecological receptors. No further investigation or management measures necessary. Data gap considered adequately addressed.
	Asbestos	Windblown dust	N/A	Inhalation of fibres	✓	✓	✗	✗	✗	✗	No asbestos was detected in soil, however ACM fragments were identified on the soil surface at nearby CSR WA 000080, therefore the potential presence of ACM fragments within the wider CSR area (CSR_WA_000080, CSR_WA_000019 and CSR_WA_000103) cannot be precluded. Any future civil works should be undertaken in accordance with an asbestos management plan.

Source		Pathway			Receptor						
					Human onsite		Human offsite		Ecological offsite		
CSR/PCSR	CoPC	Primary	Secondary	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Future site users	Recreational users of the Ellen Brook	Users of down gradient bores (non potable/irrigation use) including higher order species (non potable/livestock use)	Groundwater dependant remnant native vegetation and associated threatened fauna species	The Ellen Brook and associated aquatic flora and fauna ecosystems	Residual data gaps/further action
CSR_WA_000080 – Incinerator (North of 3TU Workshop) Incinerator demolished in 2001. Soil CoPC all below human health guidelines. Zinc exceeding EIL in surface soil at one localised area. No ACM detected in soil at four investigation locations, however ACM fragments were identified on the soil surface in the vicinity of the CSR. Groundwater CoPC all below human health guidelines. Metals concentrations within background levels or marginally above ESL criteria for ecological significance and urban/residential areas. Sediment samples indicated TRH exceeding ESL criteria for ecological significance and urban/residential areas. Source considered likely attributed to the presence of organic matter within the drainage channel/s. Detection of PFAS in groundwater exceeding PFAS NEMP 2018 Health Drinking Water ILs and Fresh Water ILs (Mobilisation 2).	TRH	Surface run-off	N/A	Direct contact or ingestion of impacted sediments.	✗	✗	✗	✗	✗	✗	Minor detects of TRH in sediments within nearby drainage features is related to the presence of organic material or polar compounds within the drainage channel and is therefore not considered to pose risk to ecological receptors. No further investigation or management measures necessary. Data gap considered adequately addressed.
	Asbestos	Windblown dust	N/A	Inhalation of fibres	✓	✓	✗	✗	✗	✗	No asbestos was detected in soil, however ACM fragments were identified on the soil surface. The potential presence of ACM fragments in other areas within the CSR cannot be precluded. Any future civil works should be undertaken in accordance with an asbestos management plan.
	PFAS	Migration within groundwater	Abstracted groundwater (drinking water/ irrigation/stock watering) or Plant uptake	Direct contact with impacted groundwater or incidental ingestion of impacted groundwater	✗	✓	✗	✗	✗	✗	Due to localised impacts of CoPC detected in groundwater beneath the CSR area – restriction of groundwater abstraction is recommended to mitigate potential exposure risk to future land users. Further groundwater assessment should be undertaken between the source area and receptors to improve understanding of PFAS distribution in the sub-surface. Further assessment of surface water (site wide) is considered warranted to more accurately assess surface water impacts during periods of flow. Results to be interpreted in conjunction with ecological risk assessment undertaken by PFASIMB for Pearce (including the Ellen Brook). It is recommended that the groundwater well network be incorporated in to an annual regional water quality monitoring programme.
			Groundwater discharge to receiving surface water body (the Ellen Brook catchment)	Direct contact with and/or incidental ingestion of surface water	✗	✗	✗	✗	✗	✓	

Source		Pathway			Receptor						
					Human onsite		Human offsite		Ecological offsite		
CSR/PCSR	CoPC	Primary	Secondary	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Future site users	Recreational users of the Ellen Brook	Users of down gradient bores (non potable/irrigation use) including higher order species (non potable/livestock use)	Groundwater dependant remnant native vegetation and associated threatened fauna species	The Ellen Brook and associated aquatic flora and fauna ecosystems	Residual data gaps/further action
CSR_WA_000081 – South of 3TU – Buried Waste Metals Buried waste, including metals and concrete footings associated with old aerial farms. The 2018 investigation (mobilisation 1) reported elevated concentrations of copper and zinc exceeding freshwater ILs in groundwater beneath the CSR area. Concentrations of zinc were detected up to three orders of magnitude higher on the downgradient (southeast) edge of the landfill compared to those upgradient. Additional groundwater sampling and analysis undertaken during the subsequent 2019 investigation (mobilisation 2) confirmed the presence of elevated copper and zinc impact in groundwater, however the extent of impact is undelineated beyond the south eastern boundary of the CSR area.	Zinc	Migration within groundwater	Abstracted groundwater (drinking water/ irrigation/stock watering) or Plant uptake	Direct contact with impacted groundwater or incidental ingestion of impacted groundwater	✗	✓	✗	✓	✓	✗	Groundwater beneath the landfill indicates a contribution to metals impacts (namely zinc) from historic landfilling activities. The extent of impact is undelineated. Further groundwater investigation including installation of additional monitoring wells down hydraulic gradient of the CSR area is considered warranted to adequately assess the extent of metals impact and potential for migration to the Ellen Brook. It is recommended that the groundwater well network be incorporated into an annual regional water quality monitoring program.
			Groundwater discharge to receiving surface water body (the Ellen Brook catchment)	Direct contact with and/or incidental ingestion of surface water	✗	✗	✓	✗	✗	✓	
CSR_WA_000103 – South of Former Building 58 – 2 x Diesel ASTs/USTs Former UST (4,500 L diesel) which was decommissioned, removed and validated in 2007. Former ASTs (information limited). All soil CoPC below relevant human health and ecological ILs. Asbestos detected in one soil sample. All groundwater CoPC below human health criteria and metals within background concentrations for freshwaters. Low level TRH impacts were detected in groundwater below applicable guidelines at one monitoring well (MW103). The source may related to be the former USTs/ASTs, or may represent the presence of organic material or polar compounds. Sediment samples indicated TRH exceeding ESL criteria for ecological significance and urban/residential areas. Source considered likely attributed to the presence of organic matter within the drainage channel/s.	TRH	Surface run-off	N/A	Direct contact or ingestion of impacted sediments.	✗	✗	✗	✗	✗	✗	Minor detects of TRH in sediments within nearby drainage features is considered likely to indicate the presence of organic material or polar compounds within the drainage channel and is therefore not considered to pose risk to ecological receptors. No further investigation or management measures necessary. Data gap considered adequately addressed.
	Asbestos	Windblown dust	N/A	Inhalation of fibres	✗	✓	✗	✗	✗	✗	Due to minor localised impacts of CoPC detected in groundwater beneath the CSR area – restriction of groundwater abstraction is recommended to mitigate potential exposure risk to future land users. Results should be considered during any future redevelopment activities to inform appropriate land-use decisions. Any future civil works should be undertake in accordance with an asbestos management plan. CSR can be archived with consideration given to the above.

Source		Pathway			Receptor						Residual data gaps/further action
					Human onsite		Human offsite		Ecological offsite		
CSR/PCSR	CoPC	Primary	Secondary	Exposure route	Property users (Defence personnel), maintenance workers and contractors	Future site users	Recreational users of the Ellen Brook	Users of down gradient bores (non potable/irrigation use) including higher order species (non potable/livestock use)	Groundwater dependant remnant native vegetation and associated threatened fauna species	The Ellen Brook and associated aquatic flora and fauna ecosystems	
PCSR_0965_001 –Former Fire Extinguisher Training Area Anecdotal evidence suggests fire extinguishers were historically used in the vicinity of a former telecommunications building (known as 3TU), located approximately 5 km west of RAAF Base Pearce and inferences have also been made suggesting the Aqueous Film Forming Foam (AFFF) was transported to the area by the Bush Fire Brigade. However, it is unknown whether this foam was discharged at 3TU. Investigation of soil and groundwater undertaken during Mobilisation 2 did not identify PFAS in soil or groundwater.	PFAS	Surface run-off	N/A	Direct contact or ingestion of impacted sediment/soil/ surface water	✗	✗	✗	✗	✗	✗	No soil or groundwater impacts have been detected that are considered to pose a risk under the current land use scenario. The former fire extinguisher training area is considered suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management or monitoring and as such generation of a new CSR is not warranted.
		Direct contact with sediment/soil	Windblown dust	Incidental ingestion or inhalation of soil/dust	✗	✗	✗	✗	✗	✗	
PCSR_0965_002 – Asphalt Stockpile Material South of 3TU PAHs detected above HIL-A at one soil location. PFAS detected above NEMP residential guidelines for accessible soil at one sediment location (delineated down gradient).	PAHs PFAS	Surface run-off	N/A	Direct contact or ingestion of impacted sediment/soil/ surface water	✗	✓	✗	✗	✗	✗	The detection of PFAS and PAHs in surface soil poses a potential risk to future land users under more sensitive land use scenarios. Stockpiled material should be removed (under appropriate waste classification protocols) and the underlying soil validated. Groundwater monitoring may be required subsequent to results of validation testing.
		Direct contact with sediment/soil	Windblown dust	Incidental ingestion or inhalation of soil/sediment/ dust	✗	✓	✗	✗	✗	✗	

12. Defence CRAT risk assessment

The Defence risk management process is described in the Estate and Infrastructure Group Risk Management Framework. It follows the broad principles for environmental risk assessment under ISO 31000 Risk Management Standard. The Defence CRAT is aligned with the iterative site investigation process recommended in the National Environment Protection (Assessment of Site Contamination) Measure 1999 (as amended 2013).

Individual sources for each of the CSR locations have been considered in the risk assessment in the context of the Risk Dimensions as defined in Table 103 using CRAT version 4.

Table 103 Definitions risk definitions considered by the Defence CRAT

Risk Dimension	Description
Capability	Capacity of the facility to support the user unit in delivery of its primary outputs. Impact on the ability of the Australian Defence Force (ADF) to protect Australia and fulfil its national security obligations. Impact on the ADF's ability to train and equip for war and for the conduct of peacetime operations. Impact on the ability of Defence to develop its capability as detailed in the Defence White Paper. Impact on Civil (non-Defence) Capability as a consideration for shared facilities.
Occupational Health and Safety (Staff and Public)	Impact on the physical and psychological well-being of military and Defence employees, contractors, communities in Defence regions and the public in general.
Legislative Compliance	Compliance with regulatory requirements and the impact of failing to comply. Including but not limited to Federal, State, Territory, Local, foreign treaty, indigenous land use agreements, Defence Instructions or Defence Policy.
Environment and Heritage	Impact on the environment, including contamination, damage to flora and fauna, fire, noise, soil damage and erosion, greenhouse gas emission, bio-diversity, feral animals and water quality. Environmental management in the strategic context of Defence business. Impact on Heritage listed assets.
Financial Efficiency	An assessment of the potential for increased costs that would be incurred if the works were not performed in the preferred funding year. This includes costs directly related to the project itself and any flow on costs that may result if the works are not performed. Short-term cost of prevention vs. long-term cost of recovery. This would also cover reductions in costs and return on investment, i.e. shorter payback period if work performed now, costs now for long term savings. Cost estimates should be inclusive of GST.
Personnel	Impact on Military and Defence employees, in the context of staff morale, staff retention and productivity.
Reputation	Impact on Defence's reputation in managing the estate, political and media attention to Defence estate matters, community concerns or actions over activities. Impact on compliance with Government commitments as opposed to specific government policy/legislation.

The consequences and likelihood ratings have been mapped to determine the Risk Level for each Risk Dimension using the CRAT risk assessment matrix. Ratings for consequence and likelihood have been assigned on the basis on the definitions provided by the Defence CRAT.

A Risk Banding has been subsequently determined for each CSR/PCSR location based on the highest Risk Level of the Risk Levels of the Risk Dimensions. Details of the CRAT inputs and outputs is provided in Appendix Q, with a summary of the outcomes provided below. Following Defence endorsement, the outcomes of the risk assessment will be finalised.

Comparison of the CRAT risks rankings allocated to each CSR/PCSR pre- and post- Stage 2 investigations undertaken during Mobilisation 1 (2018) and Mobilisation 2 (2019) are outlined in Table 104.

Table 104 Summary of CRAT Environment risk ranking pre- and post- Stage 2 DSI

CSR/PCSR	Initial CRAT risk	CRAT risk - post Stage 2 Mob 1	CRAT risk - post Stage 2 Mob 2	Comment (if applicable)
CSR_WA_000024 Fuel Storage NE of Building 72 (ASTs and USTs)	Medium	Not assessed	Low[19]	Risk is considered low however continued monitoring recommended.
CSR_WA_000083 Dog Compound - Buried Waste	Medium	Medium	Low	CSR can be archived.
CSR_WA_000084 Sounness Road Landfill	Medium	Medium	Low[19]	Potential contamination source is still present and it is recommended groundwater monitoring continues albeit at reduced frequency. Risk rating has lowered due to a lower risk likelihood evaluation.
CSR_WA_000085 Waste Oil Storage East of Building 134 (AST_039)	Low	Low	Low	CSR can be archived. No identified data gaps.
CSR_WA_000086 Fuel storage – 2 x ASTs 026 and 027	Medium	Low	Low	Bunding should be upgraded to meet current standards, after which CSR can be archived. No identified data gaps.
CSR_WA_000087 Fuel Storage ILS 18 Glide Path	Medium	Low	Low	Bunding should be upgraded to meet current standards, after which CSR can be archived. No identified data gaps.
CSR_WA_000088 Fuel Storage ILS 18	Medium	Low	Low	Bunding should be upgraded to meet current standards, after which CSR can be archived. No identified data gaps.
CSR_WA_000104 Former Hazardous Waste Store	Medium	Low	Low	CSR can be archived. No identified data gaps, CSR considered low risk.
CSR_WA_000105 Former Ammunition Bunker - Toxic Waste	Low	Low	Low	CSR can be archived. No identified data gaps, CSR considered low risk.
CSR_WA_000106 Sewage Treatment Plant Discharge Effluent	Medium	High	Medium	Medium risk is attributed to magnitude of exceedance of E.coli in groundwater which is not delineated. Further groundwater and surface water investigations recommended.
CSR_WA_000107 Former Fire Training Area (1960s)	High	Medium	Low[19]	Although low risk, groundwater impacted by metals to be monitored given proximity to receptor. Magnitude of exceedance in groundwater reduced to reflect likely concentration at receptor.
CSR_WA_000108 Former Fire Training Area – AFFF	Low	Low	Low	CSR can be archived. No identified data gaps, CSR considered low risk.
CSR_WA_000109 Former USTs 240 – 245 near Building 329	Medium	Medium	Low	No identified data gaps. Conservative risk evaluation from Mob 1 reduced in Mob 2 with the provision of an SMP.

[19]Note that the Medium CRAT risk pre-DSI was based on compliance risk not environmental risk

CSR/PCSR	Initial CRAT risk	CRAT risk - post Stage 2 Mob 1	CRAT risk - post Stage 2 Mob 2	Comment (if applicable)
CSR_WA_000110 Former Fuel Farm	Medium	Medium	Low[19]	Plume is delineated. MNA is demonstrated to be occurring and should be monitored for a further two years (subject to outcomes of future monitoring) to confirm plume reduction, together with clearing and disposal of impacted sediment in adjacent drain.
CSR_WA_000111 Aircraft Wash Down (Bird bath)	Medium	Low	Low	CSR can be archived. No identified data gaps, CSR considered low risk.[20]
CSR_WA_000112 Radioactive Aircraft Former Jet Wash Down Area	Low	Low	Low	CSR can be archived. No identified data gaps, CSR considered low risk.
CSR_WA_000117 Former Service Station	High	Medium	Low[19]	Plume is delineated. MNA is demonstrated to be occurring and should be monitored for a further two years.
CSR_WA_000151 Grounds Maintenance Area	High	Medium	Low[19]	Surface water uncertainty producing medium risk is closed out. Although low risk and below applicable GILs, TCE plume is not delineated in an upgradient direction and forms a data gap for further intrusive works (installation of wells and further monitoring). One additional well screened at base of superficial aquifer within source zone recommended to determine potential for DNAPL presence.
CSR_WA_000153 Fire Training Area – Fuel Storage Facilities	High	Medium	Low	CSR can be archived pending results of PFASIMB ongoing works. No identified data gaps. Reduced risk likelihood evaluation.
CSR_WA_000154 Fuel Storage – South of Building 13 (UST_030 and AST_031)	Low	Low	Low	CSR can be archived. No identified data gaps.
CSR_WA_000155 Power Station USTs	Medium	Low	Low	CSR considered low risk with the provision of an SMP.
CSR_WA_000156 Paint Shop	Medium	Low	Low	CSR can be archived. No identified data gaps, CSR considered low risk.
CSR_WA_000157 Waste Oil Storage East of Building 134 (UST_038)	Low	Low	Low	CSR can be archived. No identified data gaps.
CSR_WA_000158 Waste Oil Sumps between Building A78 and A125	Low	Low	Low	CSR can be archived. No identified data gaps.
CSR_WA_000159 Waste Oil Sumps between Building A116 and Hangar 95	Low	Low	Low	CSR can be archived. No identified data gaps.
CSR_WA_000160 Hangar 95	High	Medium	Low[19]	Plume is delineated. VOCs present in groundwater and further monitoring is recommended.

[20] Note that the medium CRAT risk pre-DSI was based on compliance risk not environmental risk

CSR/PCSR	Initial CRAT risk	CRAT risk - post Stage 2 Mob 1	CRAT risk - post Stage 2 Mob 2	Comment (if applicable)
PCSR_0967_001 Aircraft Shelters	Not assessed	Not Assessed	Low	No generation of new CSR ID required. No identified data gaps.
PCSR_0967_002 New AVTUR Fuel Farm (DFI)	Not assessed	Medium	Low[21]	Groundwater impacts are delineated, therefore magnitude of exceedance at the receptor has been reduced. New CSR ID to be generated for this PCSR with recommendations included for additional investigation work.
PCSR_0967_003 Former 25 m Small Arms Range	Not assessed	Medium	Low[21]	New CSR ID to be generated for this PCSR. Surface water post winter results have closed data gap and reduced uncertainty in Mob 2 assessment. Remediation of shallow soils within bullet catcher recommended.
0965 3TU				
CSR_WA_000019 Septic Tanks – Sewage Disposal	Medium	Medium	Low	Magnitude of exceedance in groundwater reduced to reflect likely concentration at receptor resulting in low risk rating. Ongoing monitoring warranted.
CSR_WA_000080 Incinerator (North of 3TU Workshop)	Medium	Low	High	PFAS concentrations in groundwater and surface water considerably exceed 99% freshwater GILs at property boundary.
CSR_WA_000081 South of 3TU (0.75 km) – Buried Waste Metals	Medium	Medium	Medium	Undelineated zinc concentrations considerably exceed 95 % freshwater GILs. Further groundwater investigation warranted.
CSR_WA_000101 Former 3TU Workshop – Buried Waste	Low	Low	Low	CSR can be archived. No identified data gaps.
CSR_WA_000103 South of Former Building 58 – 2 x Diesel A/USTs	Low	Low	Low	CSR can be archived. No identified data gaps.
PCSR_0965_001 Former Fire Extinguisher Training Area	Not assessed	Not assessed	Low	No identified data gaps. Creation of new CSR not warranted.
PCSR_0965_002 Asphalt Stockpile Area	Medium	Medium	Medium	Risk ranking due to BaP concentration in surface soils exceeding HIL-A. The detection of PFAS and PAHs in surface soil poses a potential risk to future land users under more sensitive land use scenarios. New CSR ID to be generated. Stockpiled material to be removed and the underlying soil validated.

21 Although environmental CRAT risk is low, the estimated financial costs associated with management and/or remediation of the identified contamination hazard drives the overall CRAT risk to a 'medium'

13. Conclusions

13.1 RAAF Base Pearce

This Stage 2 DSI has resolved the majority of the data gaps that existed in the CSM understanding. The collective soil and groundwater interpretation and property-wide risk evaluation outcomes indicate that the property is suitable for the ongoing current use subject to the considerations provided below and the recommendations provided in Section 14.

Conclusions associated with each CSR investigated including recommended updates to the CSR records are summarised in Table 105.

Table 105 CSR updates – 0967 RAAF Base Pearce

CSR ID # CSR Name	Environment Risk Ranking	Key findings
CSR_WA_000024 Fuel Storage NE Building 72 - Group of USTs and ASTs	Low[22]	Residual soil impact (hydrocarbon) is likely to be present, however has not been identified in groundwater Concentrations of elevated copper and zinc in groundwater are unlikely to impact property users under the current land-use scenario nor are they likely to migrate to the sensitive ecosystem of the Ki-It Monger or the Ellen Brook given the distance (1.4 km). Data gaps considered adequately addressed with no further investigation or management measures required beyond incorporation into future monitoring programs.
CSR_WA_000083 Dog Compound - Buried Waste	Low	The presence of elevated BaP and dieldrin in surface soils at the north-western portion of the CSR are considered to be minimal and isolated to the fenced Dog Compound area and do not present a significant exposure risk. Elevated concentration of copper and nickel reported in groundwater beneath the Dog Compound is likely associated with historic waste burial activities. Impacts were not observed at the receiving surface water body 100 m to the south. There are no residual data gaps regarding the current contamination risk (low). The Dog Compound is suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management or monitoring and as such should be archived from the CSR database.
CSR_WA_000084 Sounness Road Landfill	11.7	Groundwater beneath the landfill indicates no significant impact from historic landfilling activities. There are no residual data gaps regarding the current contamination risk (low) associated with the landfill. Given the ongoing presence of the landfill as a potential contamination source, groundwater monitoring at the Sounness Landfill should continue and be incorporated into future monitoring programs. Given the findings of the DSI, monitoring frequency may be reduced to two to five yearly.
CSR_WA_000085 Waste Oil Storage East of Building 134 (AST_039)	Low	This CSR was considered low risk with no risk driver for inclusion in the Stage 2 DSI. It is recommended that this CSR can be archived from CSR Database.
CSR_WA_000086 Two ASTs 026 and 027	Low	This CSR was considered low risk with no risk driver for inclusion in the Stage 2 DSI. To ensure contamination risk remains low, the bunding of the ASTs should be upgraded to meet current standards, following which the CSR can be archived.

22 Although environmental CRAT risk is low, the estimated financial costs associated with management and/or remediation of the identified contamination hazard drives the overall CRAT risk to a 'medium'.

CSR ID # CSR Name	Environment Risk Ranking	Key findings
CSR_WA_000087 Fuel Storage ILS 18 Glide Path (AST_032)	Low	Soil, sediment and surface water testing has indicated no impact from the AST at the ILS 18 glidepath. There is no contamination risk to property users or the down-stream ecosystem of the Ellen Brook under the current land-use scenario. There are no residual data gaps regarding the current contamination risk (low) and no further investigations are required. To ensure contamination risk remains low, the bunding of the AST should be upgraded to meet current standards, following which the CSR can be archived.
CSR_WA_000088 Fuel Storage ILS 18 Localiser (AST_033)	Low	There is no contamination risk to property users or ecological receptors under the current land-use scenario. There are no residual data gaps regarding the current contamination risk (low) and no further investigations are required. To ensure contamination risk remains low, the bunding of the AST should be upgraded to meet current standards, following which the CSR can be archived.
CSR_WA_000104 Former Hazardous Waste Store	Low	There is no contamination risk to property users or ecological receptors under the current land-use scenario. The hazardous waste store area is suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management or monitoring and as such should be archived from the CSR database.
CSR_WA_000105 Hazardous Material Storage - Former Ammunition Bunker	Low	This CSR was considered low risk with no risk driver for inclusion in the Stage 2 DSI. It is recommended that this CSR can be archived from CSR Database.
CSR_WA_000106 Sewage Treatment Plant and Effluent Discharge	Medium	The Sewage Treatment Plant area is suitable for ongoing use from a contamination risk perspective however the current groundwater monitoring network is considered insufficient to characterise the potential impact to groundwater down gradient from the Sewage Treatment Plant. Further groundwater investigation including installation of further monitoring wells should be carried out to establish the E.coli and copper extent and potential for migration to the Ellen Brook. Surface water samples should be collected from the Ellen Brook down gradient of 0967 MW223 and tested for E.coli and metals to confirm concentrations at the receptor.
CSR_WA_000107 Former Fire Training Area (1960s)	Low[22]	Groundwater monitoring identified heavy metal impacts (copper and nickel) in groundwater exceeding freshwater ILs and background concentrations with the potential to migrate to the Ki-It Monger Brook, therefore presenting an increased risk to this ecosystem. Groundwater monitoring at the Former Fire Training area should be incorporated into future monitoring programs.
CSR_WA_000108 Former Fire Training Area - AFFF (1980s)	Low	This CSR was considered low risk with no risk driver for inclusion in the Stage 2 DSI. It is recommended that this CSR can be archived from CSR Database.

CSR ID # CSR Name	Environment Risk Ranking	Key findings
CSR_WA_000109 Near Building 239 - Former Group of USTs	Low	Groundwater immediately down-gradient of the facility indicates no significant impact from fuel storage and handling activities. Although the possibility remains that localised residual soil and groundwater impacts remain in the immediate vicinity of the former USTs/bowsers, there is no identified exposure pathway or subsequent risk to commercial/industrial users via direct contact or inhalation. A site management plan should be developed to manage potential risks to intrusive/maintenance workers within the immediate vicinity of the USTs and bowsers from potential residual localised soil and groundwater impacts, unless these can be confirmed to have been removed during 2018 upgrade works.
CSR_WA_000110 Former Fuel Farm	Low[22]	It is considered the extent of soil impact has been adequately delineated and there is no significant residual soil impact from fuel storage and historical leakage following the decommissioning works. Clearing and appropriate disposal of impacted sediments in the surface water drain at 0967_SD103 and 0967_SD104 (an area of up to 150 m x 1 m x 0.5 m) where PAH (BaP) concentrations exceed health criteria should be undertaken. Multiple lines of evidence support that MNA is occurring at the Former Fuel Farm. Given the Former Fuel farm has been decommissioned, no further sources of contamination are considered present and it is considered natural attenuation will continue. Two further groundwater monitoring events are considered warranted (subject to outcomes of future monitoring events) to clearly demonstrate MNA progression and close out data gaps.
CSR_WA_000111 Aircraft Wash Down	Low	This CSR was considered low risk with no risk driver for inclusion in the Stage 2 DSI. It is recommended that this CSR can be archived from CSR Database.
CSR_WA_000112 Radioactive Aircraft Former Wash Down Area	Low	This CSR was considered low risk with no risk driver for inclusion in the Stage 2 DSI. It is recommended that this CSR can be archived from CSR Database.
CSR_WA_000117 Former Service Station	Low[22]	It is considered the extent of soil impact has been adequately defined and indicates no contamination risk to property users and ecological receptors under the current land-use scenario. The groundwater impacts (benzene, ethylbenzene, MTBE and naphthalene) exceeding health and ecological ILs are limited to the area beneath the source zone, are not migrating from the boundary of the CSR, and is naturally attenuating. The risk to human health and ecological receptors from the hydrocarbon plume is therefore considered low. Given no further primary sources of contamination are considered present and it is considered natural attenuation will continue in the perched and superficial aquifers, two further groundwater monitoring events are considered warranted to clearly demonstrate MNA progression and close out data gaps.

CSR ID # CSR Name	Environment Risk Ranking	Key findings
CSR_WA_000151 Grounds Maintenance Area	Low[22]	Concentrations of elevated CoPC detected in soil, sediment and groundwater are unlikely to impact property users or ecological receptors under the current land-use scenario. The soil, sediment and groundwater data does however indicate that chemical storage and handling practices at the Grounds Maintenance Area has had an impact, albeit minor, on the environment. Storage and handling practices including potential for engineering controls should be reviewed and improved. Two additional monitoring wells are recommended to be installed north of 0967 MW112 and 0967 MW243 to delineate the upgradient reaches of the TCE plume. One additional well screened at base of superficial aquifer within source zone is recommended to determine potential for DNAPL presence. Groundwater monitoring should be incorporated into future monitoring programs.
CSR_WA_000153 Fire Training Area - Fire Station Centre of Base	Low	With the exception of PFAS, no contamination risk has been identified to property users or ecological receptors under the current land-use scenario. Elevated metals concentrations detected in groundwater above ecological ILs and background concentrations have not been fully delineated. However, given the concentrations were reported in the discontinuous perched aquifer, it is unlikely impacts could migrate from the Fire Training Area to the Ellen Brook and are therefore the groundwater impacts are considered unlikely to pose a risk to this ecosystem. Further conventional contamination investigation of the Fire Training Area is considered not required although PFAS investigation/management activities are ongoing. CSR can be archived pending outcomes of PFASIMB activities.
CSR_WA_000154 Fuel Storage South of Building 13 (UST_030 and AST_031)	Low	This CSR was considered low risk with no risk driver for inclusion in the Stage 2 DSI. It is recommended that this CSR can be archived from CSR Database.
CSR_WA_000155 Fuel Storage Power Station	Low	Soil and groundwater testing is inconclusive with regards to the risk posed to property users from impacted soil, groundwater and vapours in the vicinity of the historic spill area as access was limited. Soil and groundwater investigations carried out to date indicate the following: –No impacts in groundwater further down-gradient of the impact area since 2013 –No risk is posed to down-gradient ecosystem of the Ellen Brook as contamination (if present) is not migrating from the CSR and –No impacts in soil adjacent to the historic spill area. –Based on multiple lines of evidence, it is considered unlikely that there is a vapour risk to users. A SMP should be developed to manage potential exposure risk to intrusive workers (if not already in place).

CSR ID # CSR Name	Environment Risk Ranking	Key findings
CSR_WA_000156 Paint Shop	Low	There is no contamination risk to property users or ecological receptors under the current land-use scenario. The Paint Shop area is suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management or monitoring and as such should be archived from the CSR database.
CSR_WA_000157 Waste Oil Storage East of Building 134 (UST_038)	Low	This CSR was considered low risk with no risk driver for inclusion in the Stage 2 DSI. It is recommended that this CSR can be archived from CSR Database.
CSR_WA_000158 Waste Oil Sumps - Between Building A78 and A125	Low	This CSR was considered low risk with no risk driver for inclusion in the Stage 2 DSI. It is recommended that this CSR can be archived from CSR Database.
CSR_WA_000159 Waste Oil Sumps - Building A116 and Hanger 95	Low	This CSR was considered low risk with no risk driver for inclusion in the Stage 2 DSI. It is recommended that this CSR can be archived from CSR Database.
CSR_WA_000160 Hangar 95	Low[22]	The extent of toluene detected in groundwater beneath Hangar 95 is delineated by down-gradient monitoring wells at the Aircraft Shelters and given the distance (1.5 km) it is considered unlikely to migrate to ecological receptors. Vapour risk to on-site receptors is considered low and sufficiently managed by existing indoor air quality monitoring procedures. Groundwater monitoring from the existing network (including for toluene and chlorobenzene) and incorporation of new wells installed at the aircraft shelters (0967_MW249, 0967_MW250, 0967_MW251) should continue at this location to ensure the impact which fuel handling practices have on the environment is effectively monitored.
PCSR_0967_001 Aircraft Shelters	Low	There is no contamination risk to property users or ecological receptors under the current land-use scenario. Groundwater monitoring data indicates that aircraft maintenance and fuelling practices at the aircraft shelters area has had an impact, albeit minor, on the environment and do not warrant any further investigation. The Aircraft Shelters area is suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management or monitoring and generation of a new CSR in the CSR database is not recommended. Monitoring wells installed at this location are to be incorporated into the monitoring network targeting the Hangar 95 CSR.

CSR ID # CSR Name	Environment Risk Ranking	Key findings
PCSR_0967_002 New AVTUR Fuel Farm (RAAF Base Pearce)	Low[22]	Soils are not considered to pose a contamination risk to receptors under current site usage. Provided the land-use scenario is retained and groundwater is not abstracted for any purpose, the groundwater quality - including where human health ILs are exceeded (nickel exceeding drinking water ILs) - does not pose a risk of impact to property users. A TRH plume is present beneath unsealed ground on the western side of the CSR boundary south of the separator system and west of VST 1. Although delineated by the current well network, the source of the plume (subsurface leak or aboveground spill) is not known. Information regarding a possible source of the TRH plume should be sought and if deemed required, further soil and groundwater investigations in this area. Consideration may be given to installation of a further monitoring well near to the puraceptor discharge point. Further lines of evidence based assessment and trend analysis have indicated the potential for MNA to be occurring however the dataset is could be enhanced with further sampling. It is recommended that a CSR be generated and that monitoring at the AVTUR fuel farm continues into the future whilst the AVTUR fuel farm remains active and incorporates post winter sampling to reduce the impact that dry wells have on the value of the dataset.
PCSR_0967_003 Former 25 m Small Arms Range (RAAF Base Pearce)	Low[22]	Concentrations of elevated CoPC detected in soil, sediment, surface water and groundwater do not pose a risk to property users under the current land-use scenario nor are they likely to migrate to the sensitive ecosystem of the Ellen Brook given the distance (more than one kilometre). The soil, sediment, surface water and groundwater data does however indicate that former small arms range activities had an impact, albeit minor, on the environment. Further investigations or monitoring of groundwater is considered not required. It is recommended that a CSR be generated and the primary source of metals (bullets and bullet fragments in the bullet catcher, an area of approximately 20 m x 10 m to a depth of 0.5 m bgl) be removed/deleaded and validated to reduce ongoing contribution of metals impacts to soil and groundwater, following which it can be archived from the CSR database.

13.2 3TU

This Stage 2 DSI has resolved the majority of the data gaps that existed in the CSM understanding. The collective soil, groundwater, surface water, and sediment interpretation and property-wide risk evaluation outcomes indicate that the property is suitable for the ongoing current use and for potential future mixed land-use including residential development subject to the considerations provided below and the recommendations provided in Section 14.

Conclusions associated with each CSR/PCSR investigated including recommended updates to the CSR records are summarised in Table 106.

Our interpretation of the results - and those obtained by PFASIMB (GHD 2018b) - suggests that the PFAS contamination detected at 3TU is unlikely to be the source of PFAS detected in groundwater at the West Bullsbrook residential area and the Ellen Brook due to the following considerations:

- The groundwater and surface water level data obtained during the PFASIMB investigations suggests that the Ellen Brook is both receiving from and discharging to groundwater.
- The most likely mechanisms by which the PFAS has migrated to the private bores in the West Bullsbrook residential area was reported to be primarily from the discharge of impacted surface water from the Ellen Brook to the underlying groundwater, particularly following flood events or sustained rainfall and secondarily, groundwater migration from RAAF Base Pearce.
- Further, anecdotal evidence in relation to flooding and drainage within the area suggests that surface water levels within the Ellen Brook and nearby backwater flooding may be significant factors in contributing to changes of PFAS concentrations in groundwater at West Bullsbrook over time.

Table 106 CSR update summary - 0965 3TU

CSR	Environment Risk Ranking	Stage 2 DSI Conclusions
CSR_WA_000019 Septic Tanks – Sewage Disposal	Low	Faecal coliform impacts in soil and groundwater may potentially pose a risk to human health under a direct contact or residential land-use scenario. Ongoing groundwater monitoring recommended. Development of a site management plan including restriction of groundwater abstraction is recommended to mitigate potential exposure risk to future land users. ACM fragments were identified on the soil surface at nearby CSR_WA_000080, therefore the potential presence of ACM fragments cannot be precluded. Any future civil works should be undertaken in accordance with an asbestos management plan.
CSR_WA_000080 Incinerator (North of 3TU Workshop)	High	No soil risk identified with the exception of ACM fragments identified in surface soils in the vicinity of the CSR. Any future civil works should be undertaken in accordance with an asbestos management plan. Minor detects of TRH in sediments within nearby drainage features is related to the presence of organic material or polar compounds within the drainage channel and is therefore not considered to pose risk to ecological receptors. Due to localised impacts of PFAS detected in groundwater beneath the CSR area, restriction of groundwater abstraction is recommended to mitigate potential exposure risk to future land users. Further groundwater assessment should be undertaken between the source area and receptors to improve understanding of PFAS distribution in the sub-surface. Further assessment of surface water (site wide) is considered warranted to more accurately assess surface water impacts during periods of flow. Results to be interpreted in conjunction with ecological risk assessment undertaken by PFASIMB for Pearce (including the Ellen Brook).
CSR_WA_000081 South of 3TU (0.75 km) – buried waste Metals	Medium	The extent of zinc impacts to groundwater is undelineated. Further groundwater investigation including installation of additional monitoring wells down hydraulic gradient of the CSR area is considered warranted to adequately assess the extent of metals impact and potential for migration to the Ellen Brook.
CSR_WA_000101 Former 3TU Workshop – Buried Waste	Low	This CSR was considered low risk with no risk driver for inclusion in the Stage 2 DSI. It is recommended that this CSR can be archived from CSR Database.
CSR_WA_000103 South of Former Building 58 – 2 x Diesel A/USTs	Low	Any future civil works should be undertake in accordance with an asbestos management plan. Restriction on groundwater abstraction recommended. No further investigation measures necessary. Data gaps considered adequately addressed and CSR can be archived with consideration to above.

CSR	Environment Risk Ranking	Stage 2 DSI Conclusions
PCSR_0965_001 Former Fire Extinguisher Training Area	Low	No soil or groundwater impacts have been detected that are considered to pose a risk under the current land use scenario. The former fire extinguisher training area is considered suitable for ongoing use from a contamination risk perspective with no ongoing requirements for management or monitoring and as such generation of a new CSR is not recommended.
PCSR_0965_002 Asphalt Stockpile Area	Medium	New CSR ID to be generated for this PCSR. The detection of PFAS and PAHs in surface soils of the stockpile poses a potential risk to future land users under more sensitive land use scenarios. Stockpiled material should be removed (under appropriate waste classification protocols) and underlying soil validated. Groundwater monitoring may be required subsequent to results of validation testing.

14. Recommendations

14.1 Further groundwater and surface water assessment

Based on the outcomes of the Stage 2 DSI, the following recommendations for further groundwater and surface water assessment have been made.

14.1.1 Installation of additional groundwater monitoring wells

Installation of additional groundwater monitoring wells is considered warranted to assess the extent of undelineated impacts and associated exposure risk identified at the following CSRs:

RAAF Base Pearce

- CSR_WA_000151 (Grounds Maintenance Area) – installation of two additional monitoring wells to the north of 0967_MW112 and 0967_MW243 to adequately delineate the upgradient reaches of the TCE plume and one additional well screened at base of superficial aquifer within source zone to determine potential for DNAPL presence..
- CSR_WA_000106 (Sewage Treatment Plant) - installation of additional monitoring wells down gradient of the STP adequately assess the extent of E.coli and copper impacts and potential for migration to the Ellen Brook.
- PCSR_0967_002 - Further investigation is warranted into the source (subsurface leak or aboveground spill) of TRH impacts to groundwater at the AVTUR fuel facility including the installation of an additional well at the puraceptor discharge point.

3TU

- CSR_WA_000081 (Buried Waste Metals – 0.75 km south of 3TU) - installation of additional monitoring wells down hydraulic gradient of the CSR area to adequately assess the extent of metals impact and potential exposure risk to ecological receptors.
- Former workshop area - Further groundwater assessment should be undertaken between the former workshop area and down-gradient receptors to improve understanding of PFAS distribution in the sub-surface.

14.1.2 Ongoing groundwater monitoring program

Development of an ongoing groundwater monitoring program of select groundwater wells at RAAF Base Pearce and 3TU is recommended to monitor existing impacts and risks to receptors. Groundwater monitoring wells at the following CSRs are recommended for inclusion in ongoing monitoring programs:

RAAF Base Pearce

- CSR_WA_000110 (Former Fuel Farm)
- CSR_WA_000117 (Former Service Station)
- CSR_WA_000106 (Sewage Treatment Plant)
- CSR_WA_000084 (Sounness Rd landfill)
- CSR_WA_000107 (Former Fire Training Area 1960s)
- CSR_WA_000151 (Grounds Maintenance Area)
- CSR_WA_000160 (Hangar 95)
- PCSR_0967_002 (New AVTUR Fuel Farm)

3TU

- CSR_WA_000080 (Incinerator – North of 3TU Workshop)
- CSR_WA_000081 (Buried Waste Metals – 0.75 km south of 3TU)

It should be noted that groundwater monitoring may be required pending results of validation of underlying soil at the Asphalt Stockpile Area (PCSR_0965_002).

14.1.3 Surface water sampling

Further assessment of surface water is considered warranted to more accurately assess surface water impacts during periods of flow at the following CSRs:

RAAF Base Pearce

- CSR_WA_000106 (Sewage treatment plant) – Collection of surface water samples from within the Ellen Brook (down gradient of 0967_MW223) to assess the potential concentrations of E.coli and metals at the point of discharge to the receiving ecological receptor.

3TU

- Site wide assessment of surface water in drainage channels within and surrounding 3TU to adequately characterise surface water quality during periods of flow.

14.2 Contamination management/risk mitigation activities

Based on the outcomes of the Stage 2 DSI, the following recommendations for remediation works and contamination risk mitigation and management controls have been made:

14.2.1 Remediation works

RAAF Base Pearce

- Remediation/validation of impacted sediment in the drainage channel adjacent to CSR_WA_000110 (Former Fuel Farm), estimated to be a volume of up to 75 m^3 (150 m by 1 m wide by 0.5 m deep).
- Removal/deleading of the bullet catcher at PCSR_0967_003 (Former 25 m Small Arms Range), estimated to comprise a volume of up to 100 m^3 (10 m by 20 m by 0.5 m deep).

3TU

- The asphalt stockpile should be removed and underlying soil validated in accordance with waste classification protocols.
- Any redevelopment works in the vicinity of the former workshop area should be undertaken in accordance with an asbestos management plan and an unexpected finds procedure.

14.2.2 Contamination risk mitigation and management

RAAF Base Pearce

- Bund upgrades should be undertaken at ASTs at the ILS 18 and associated Glide Path CSR_WA_000087 and CSR_WA_000088) and at fuel storage ASTs CSR_WA_000086.
- Development of SMPs for CSR_WA_000109 (Former USTs 240 – 245) and CSR_WA_000155 (Power Station) to manage residual risks to intrusive workers.

- Review and improve engineering controls (such as bunding) at the Grounds Maintenance Area to prevent further impact to the environment.
- Sewage treatment and disposal processes and infrastructure at Pearce should be reviewed to establish the cause of the E.coli presence in groundwater.

3TU

- Development of SMPs for CSR_WA_000080 (Incinerator – north of 3TU workshop) and CSR_WA_000019 (Septic tanks – Sewage treatment) to manage residual risks during future redevelopment works (if proposed).

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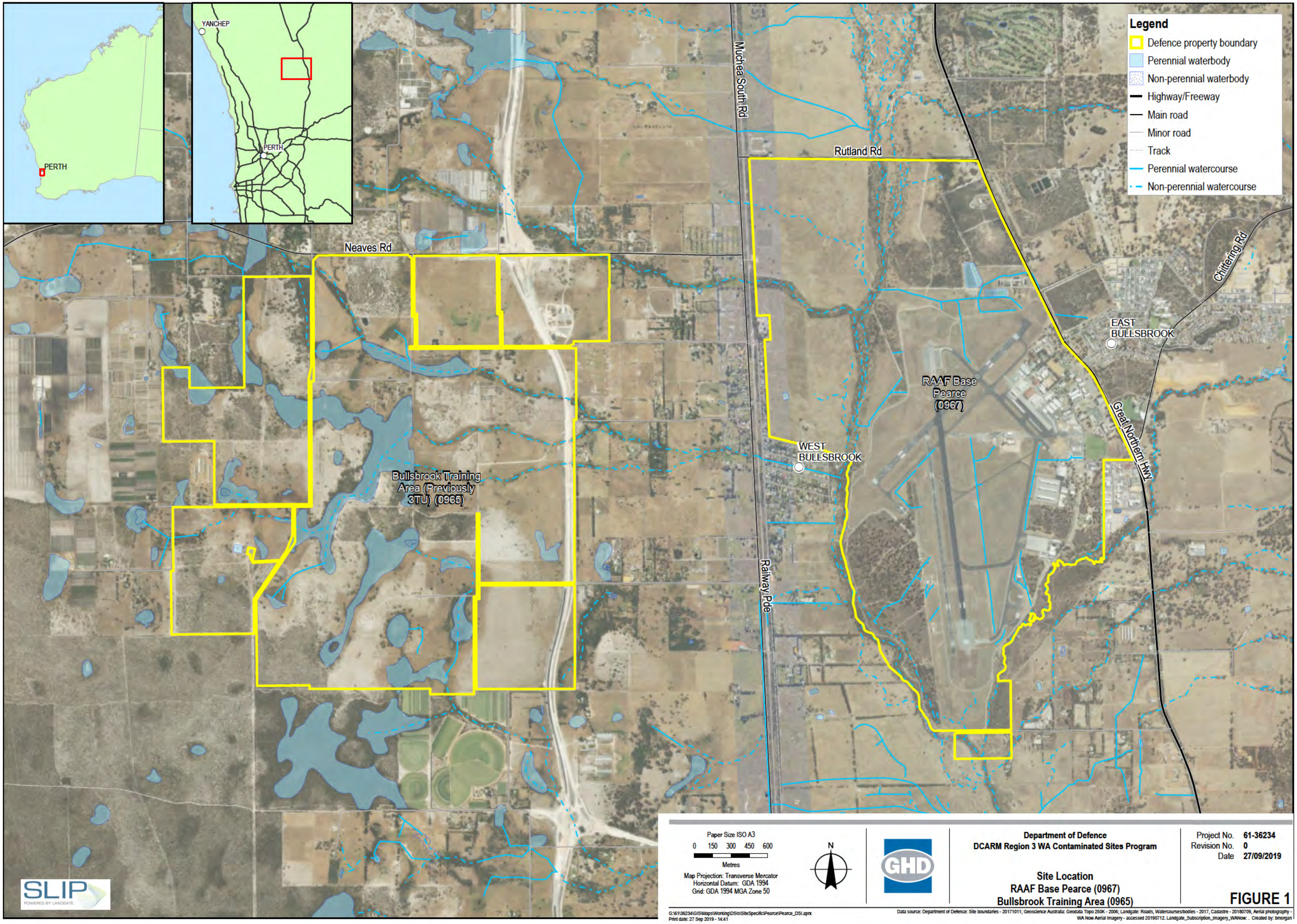
Figures

Defence FOI 536/21/22
Document 1



Paper Size ISO A3

0 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Deparment of Defence
DCARM Region 3 WA Contaminated Sites Program

Property Layout
RAAF Base Pearce (0967)

Project No. **61-36234**
Revision No. **0**
Date **18/07/2019**

FIGURE 2A

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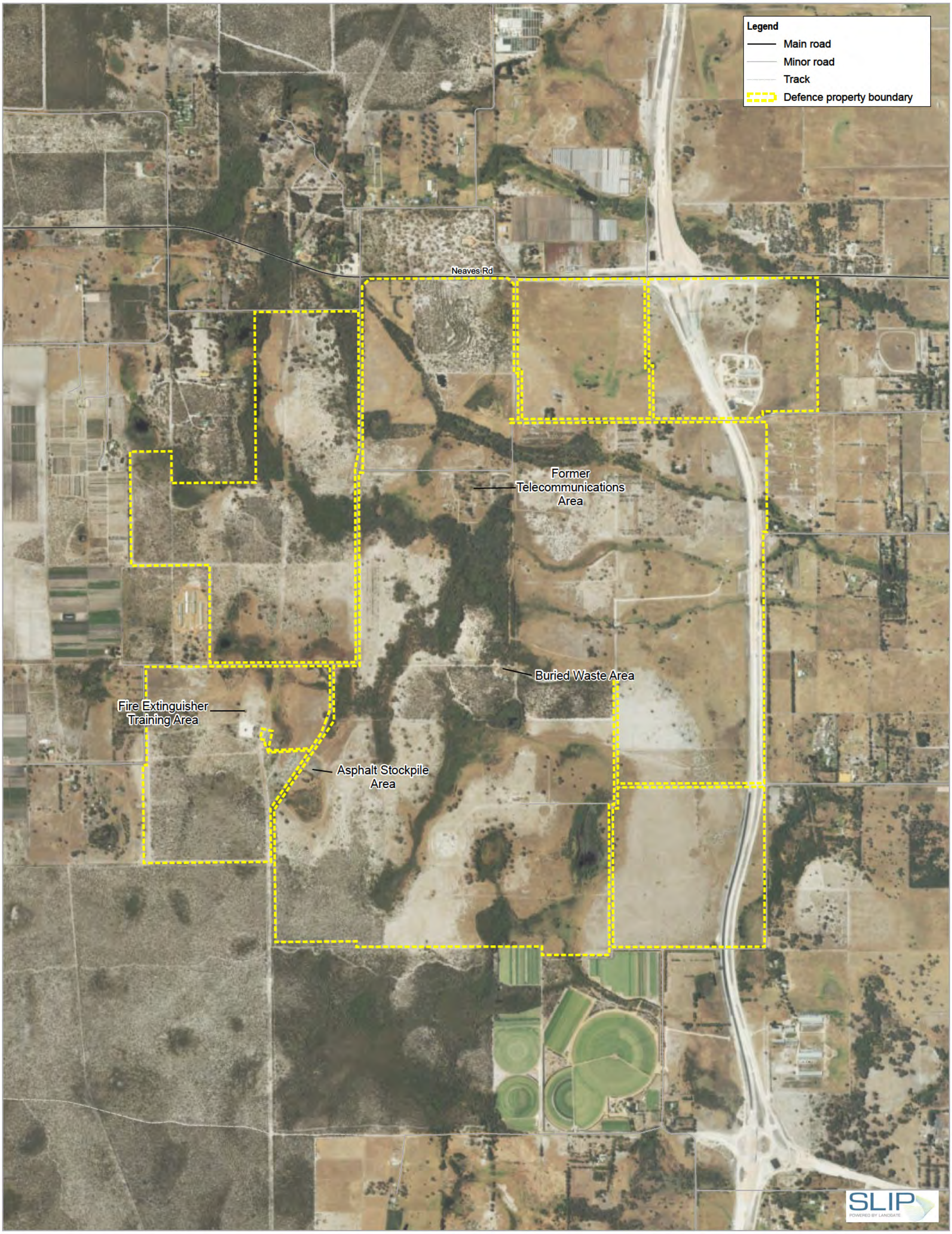
Data source Department of Defence Site boundaries CSR boundaries - 20171011 Landgate Roads - 2017 Watercourses/bodies - 2017 WA Now Aerial Mosaic - accessed 20180727 Medium scale topo contours - 20171007 Landgate_Subscription_Imagery_WANow . Created by rjwalker



Paper Size ISO A3

0 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Deparment of Defence
DCARM Region 3 WA Contaminated Sites Program

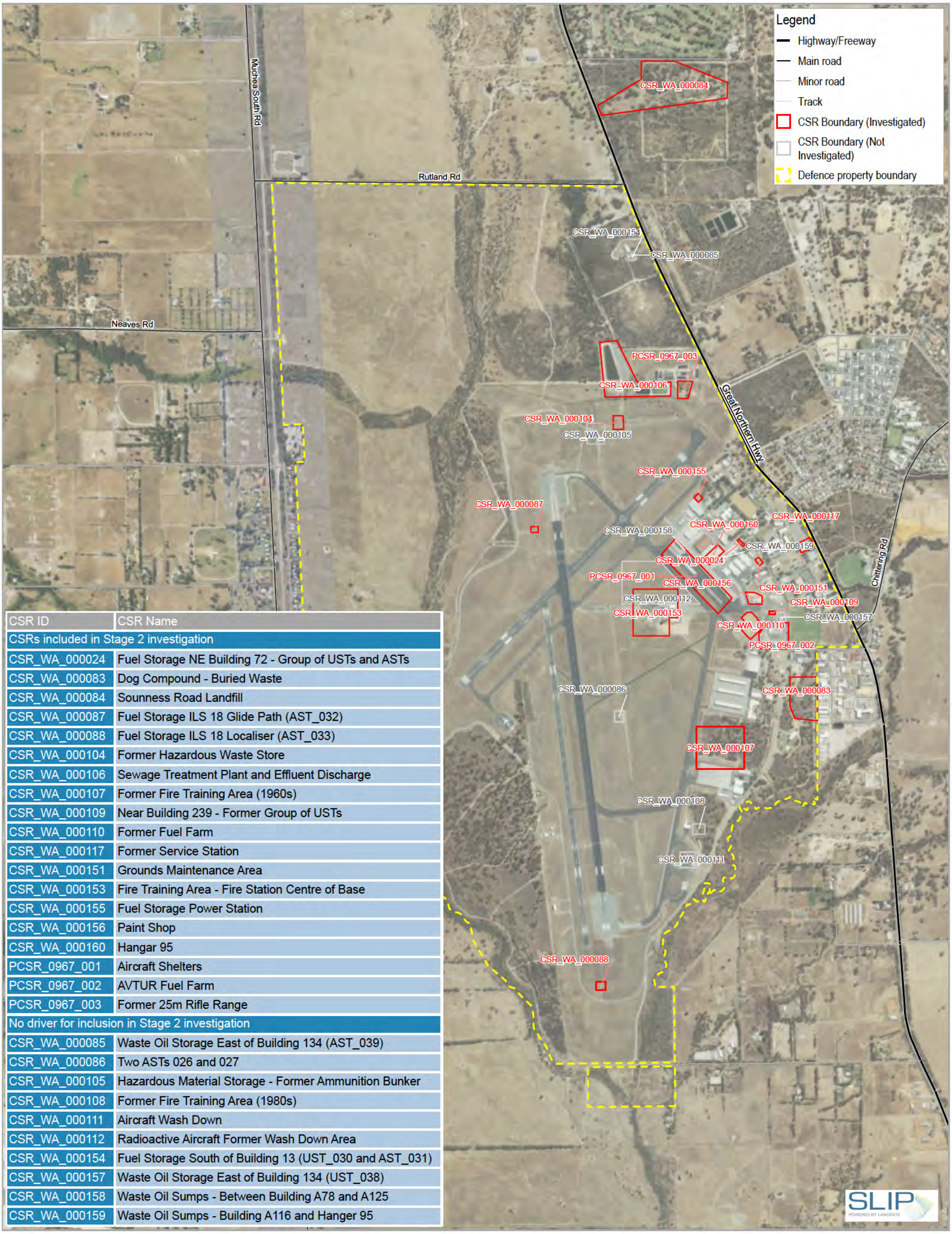
Property Layout
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 18/07/2019

FIGURE 2B

Data source Department of Defence Site boundaries CSR boundaries - 20171011 Landgate Roads - 2017 Watercourses/bodies - 2017 WA Now Aerial Mosaic - accessed 20180727. Landgate_Subscription_Imagery_WANow . Created by rjwalker

Defence FOI 536/21/22
Document 1



CSR ID	CSR Name
CSRs included in Stage 2 investigation	
CSR_WA_000024	Fuel Storage NE Building 72 - Group of USTs and ASTs
CSR_WA_000083	Dog Compound - Buried Waste
CSR_WA_000084	Sounness Road Landfill
CSR_WA_000087	Fuel Storage ILS 18 Glide Path (AST_032)
CSR_WA_000088	Fuel Storage ILS 18 Localiser (AST_033)
CSR_WA_000104	Former Hazardous Waste Store
CSR_WA_000106	Sewage Treatment Plant and Effluent Discharge
CSR_WA_000107	Former Fire Training Area (1960s)
CSR_WA_000109	Near Building 239 - Former Group of USTs
CSR_WA_000110	Former Fuel Farm
CSR_WA_000117	Former Service Station
CSR_WA_000151	Grounds Maintenance Area
CSR_WA_000153	Fire Training Area - Fire Station Centre of Base
CSR_WA_000155	Fuel Storage Power Station
CSR_WA_000156	Paint Shop
CSR_WA_000160	Hangar 95
PCSR_0967_001	Aircraft Shelters
PCSR_0967_002	AVTUR Fuel Farm
PCSR_0967_003	Former 25m Rifle Range
No driver for inclusion in Stage 2 investigation	
CSR_WA_000085	Waste Oil Storage East of Building 134 (AST_039)
CSR_WA_000086	Two ASTs 026 and 027
CSR_WA_000105	Hazardous Material Storage - Former Ammunition Bunker
CSR_WA_000108	Former Fire Training Area (1980s)
CSR_WA_000111	Aircraft Wash Down
CSR_WA_000112	Radioactive Aircraft Former Wash Down Area
CSR_WA_000154	Fuel Storage South of Building 13 (UST_030 and AST_031)
CSR_WA_000157	Waste Oil Storage East of Building 134 (UST_038)
CSR_WA_000158	Waste Oil Sumps - Between Building A78 and A125
CSR_WA_000159	Waste Oil Sumps - Building A116 and Hanger 95

Paper Size ISO A3
0 100 200 300 400
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

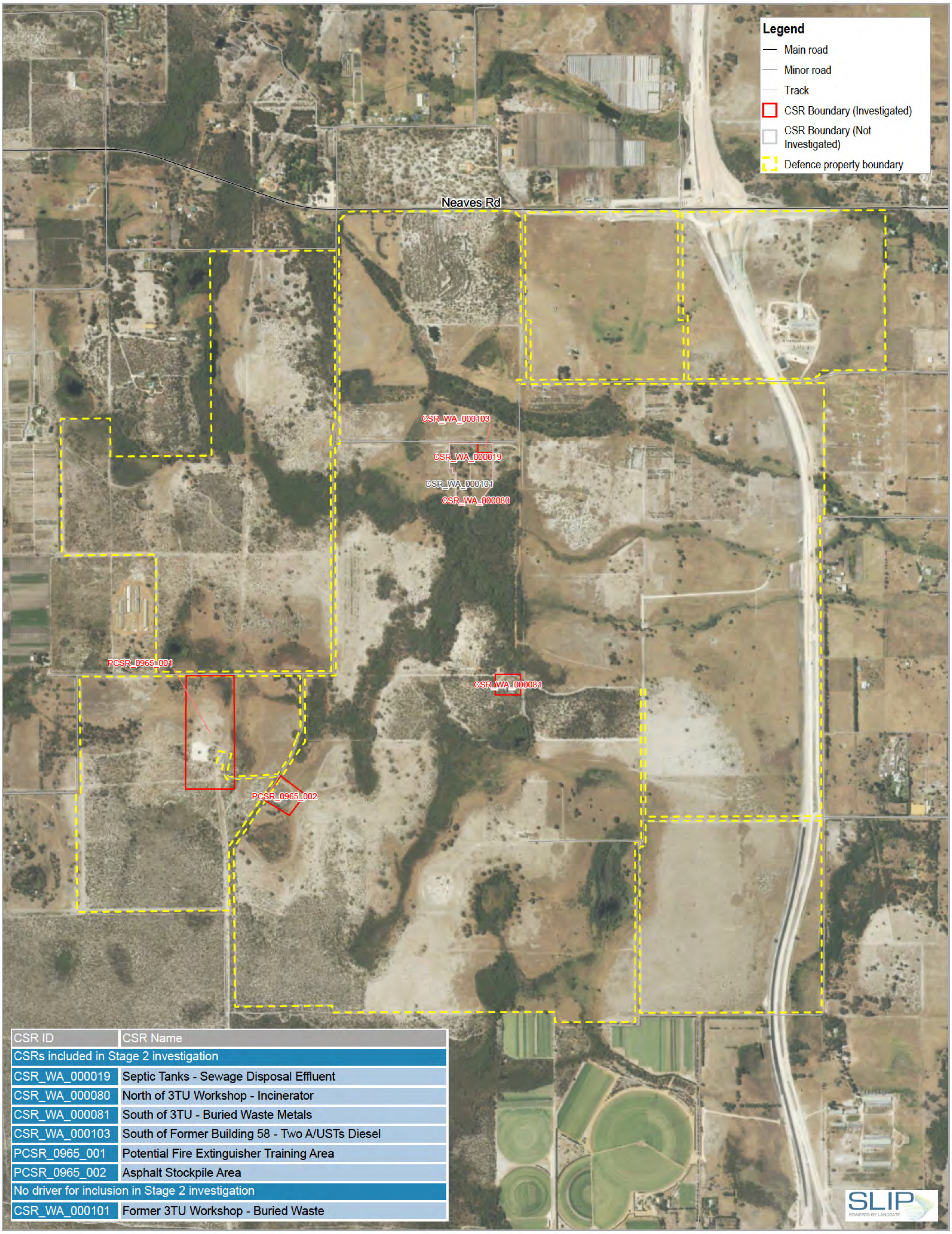
CSR Locations
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 27/09/2019

FIGURE 3A

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\Pearce_DSI.aprx
Print date: 27 Sep 2019 - 14:45

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20190712. Created by: bmorgan



CSR ID	CSR Name
CSRs included in Stage 2 investigation	
CSR_WA_000019	Septic Tanks - Sewage Disposal Effluent
CSR_WA_000080	North of 3TU Workshop - Incinerator
CSR_WA_000081	South of 3TU - Buried Waste Metals
CSR_WA_000103	South of Former Building 58 - Two A/USTs Diesel
PCSR_0965_001	Potential Fire Extinguisher Training Area
PCSR_0965_002	Asphalt Stockpile Area
No driver for inclusion in Stage 2 investigation	
CSR_WA_000101	Former 3TU Workshop - Buried Waste

Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

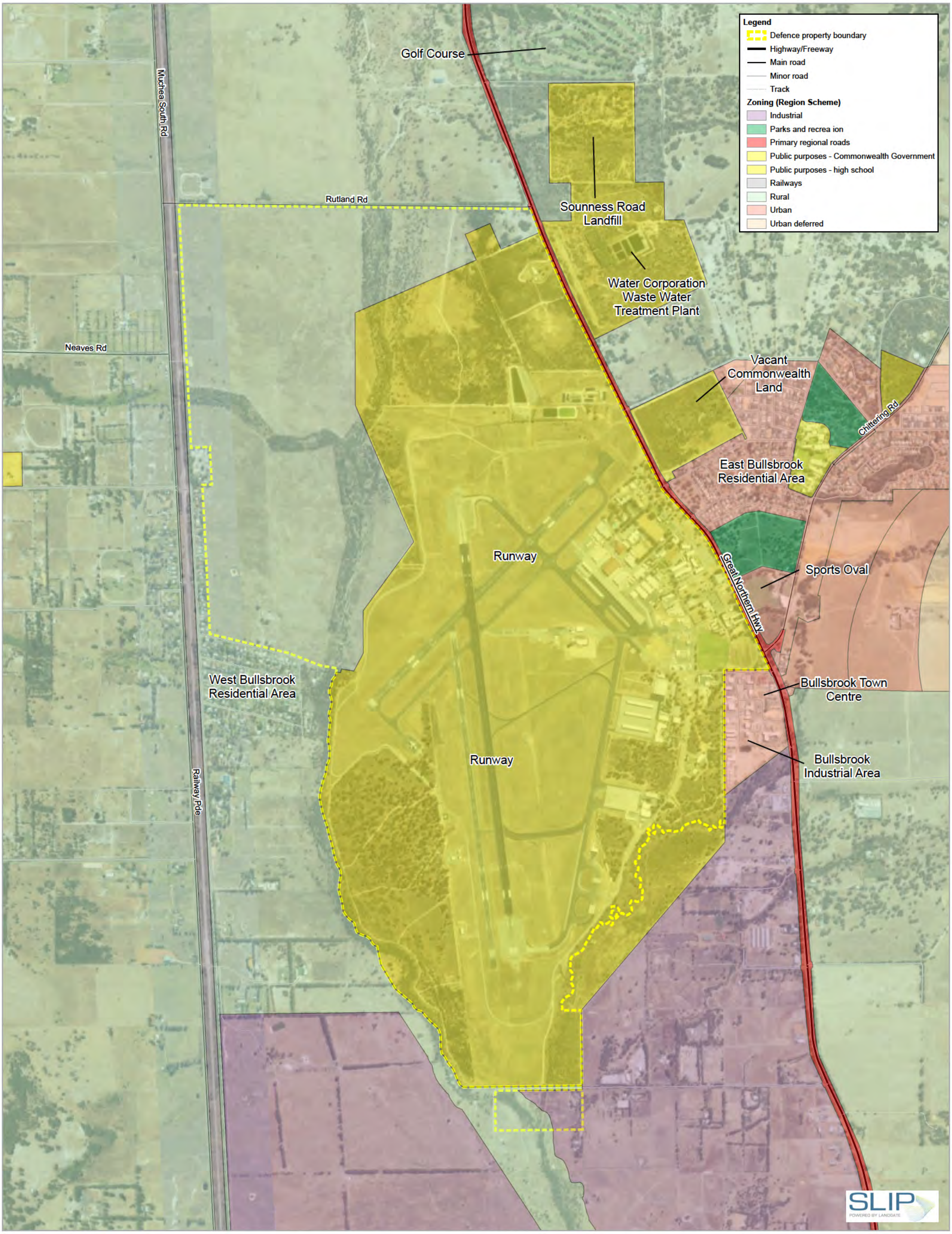
CSR Locations
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 27/09/2019

FIGURE 3B

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\Pearce_DSI.aprx
Print date: 27 Sep 2019 - 14:46

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20190712. Landgate_Subscription_Imagery_WANow: . Created by: bmorgan



Paper Size ISO A3

0 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Deparment of Defence
DCARM Region 3 WA Contaminated Sites Program

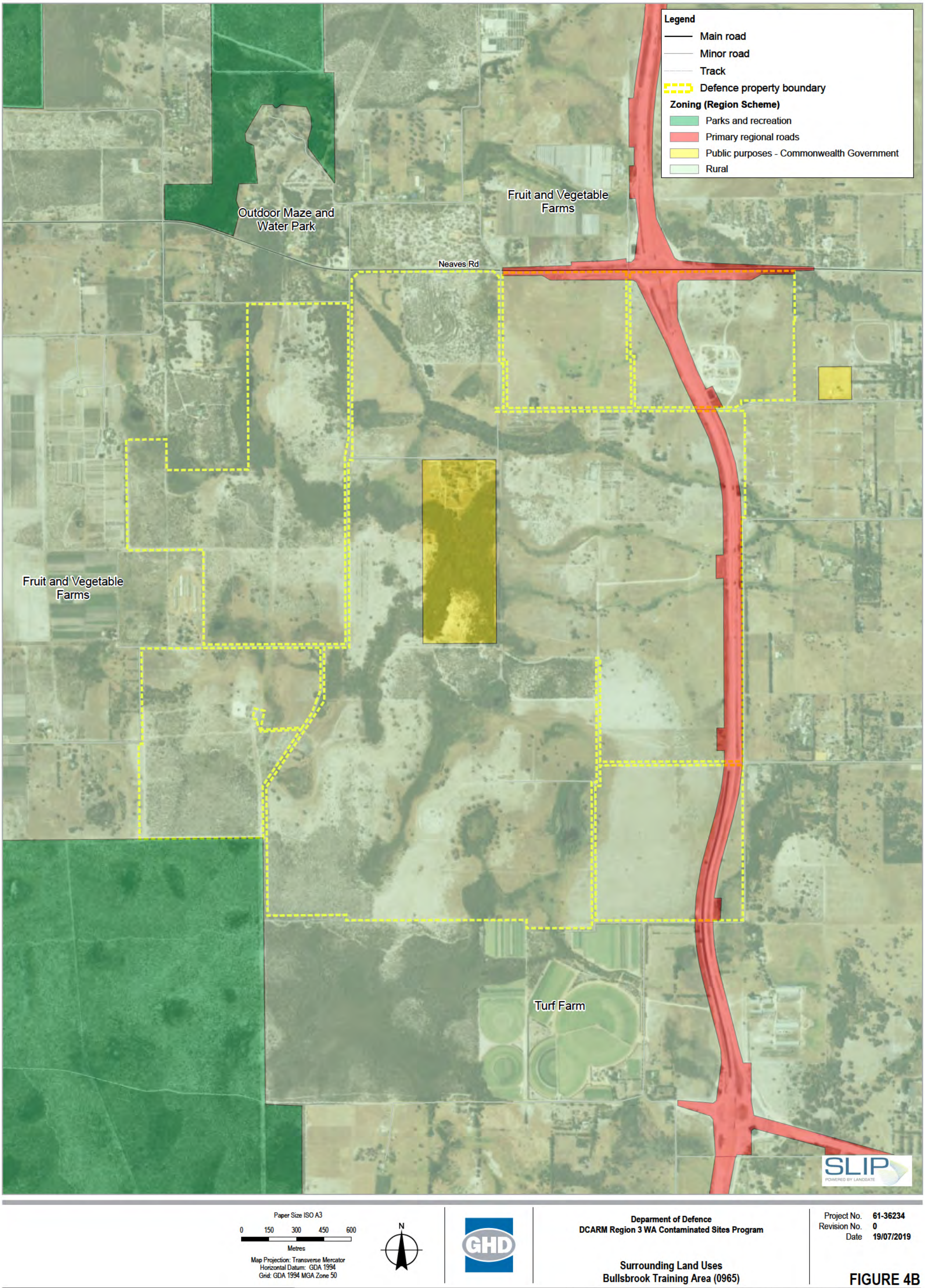
Surrounding Land Uses
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 19/07/2019

FIGURE 4A

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\4_DSI 2019\6136234_Figs2-4-RW.aprx
Print date 19 Jul 2019 - 17:02

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011. Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20180727, Medium scale topo contours - 20171007. Landgate_Subscription_Imagery_WANow . Created by: rjwalker



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

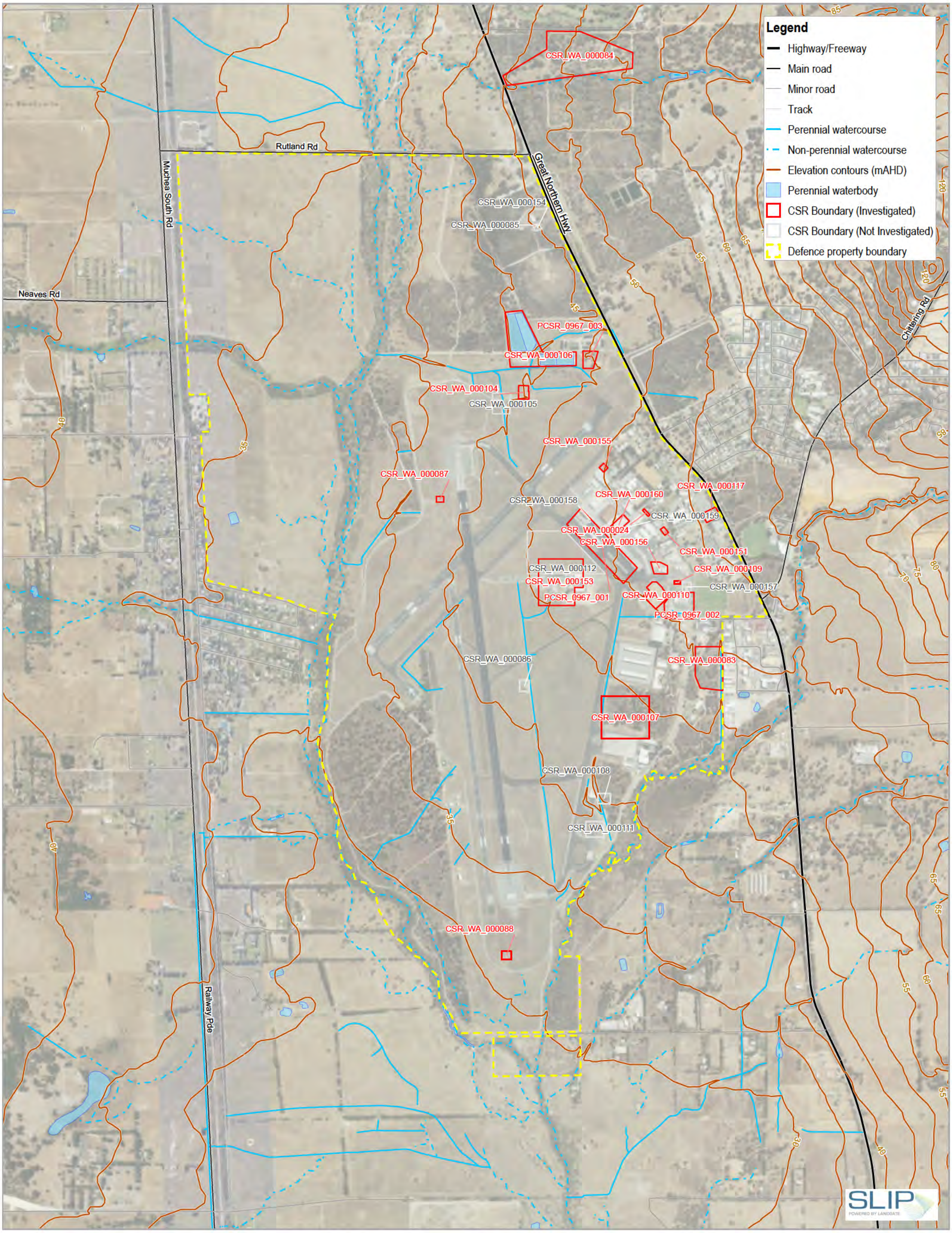
Deparment of Defence
DCARM Region 3 WA Contaminated Sites Program

Surrounding Land Uses
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 19/07/2019

FIGURE 4B

Data source Department of Defence Site boundaries CSR boundaries - 20171011 Landgate Roads - 2017 Watercourses/bodies - 2017 WA Now Aerial Mosaic - accessed 20180727. Landgate_Subscription_Imagery_WANow . Created by rjwalker



Paper Size ISO A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

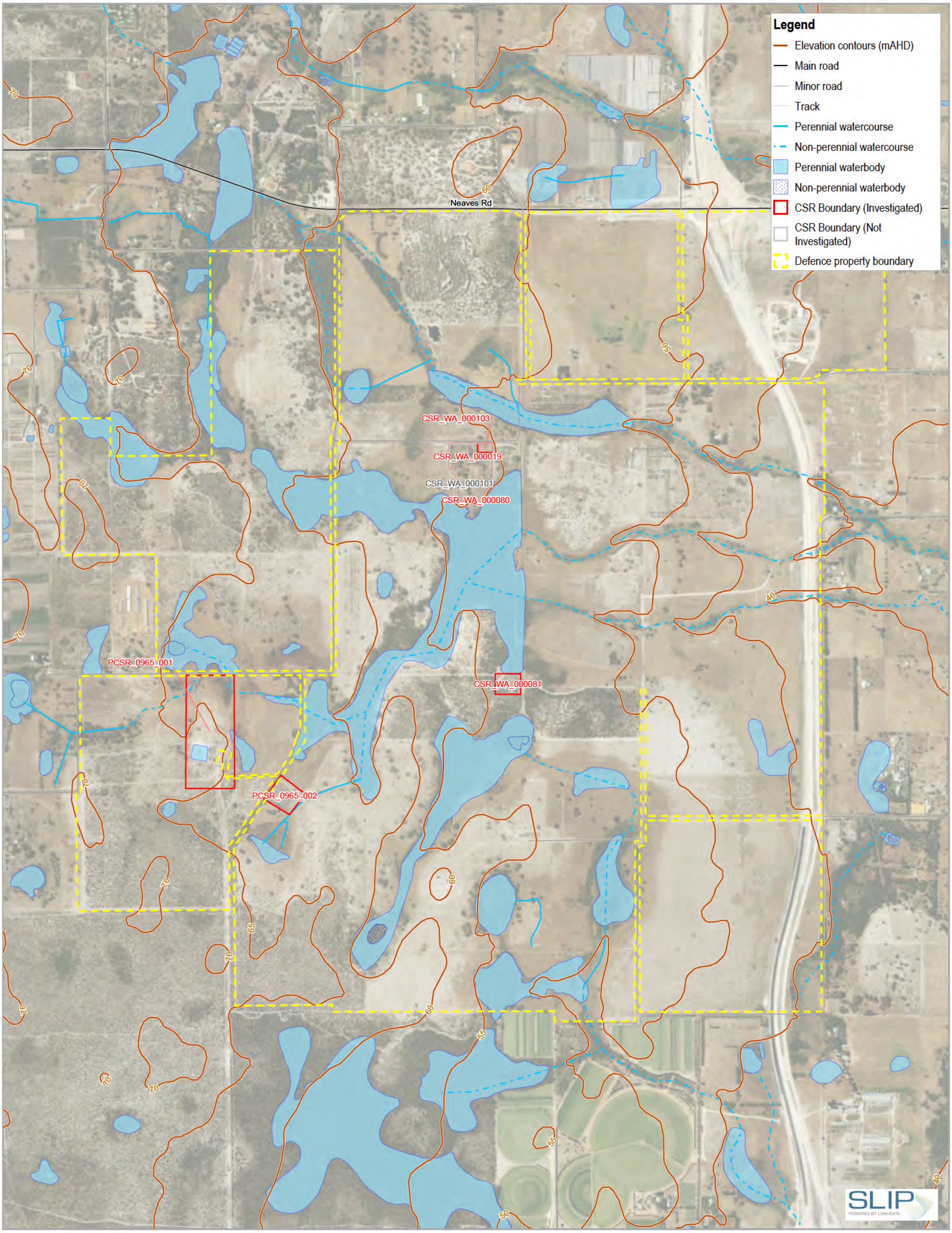
Site Topography
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 27/09/2019

FIGURE 5A

G:\61\36234\GIS\Maps\Working\DSI\SiteSpecific\Pearce\Pearce_DSI.aprx
Print date: 27 Sep 2019 - 14:48

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20190712, Medium scale topo contours - 20171007 Landgate_Subscription_Imagery_WANow: . Created by: bmorgan



Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

Site Topography
Bullsbrook Training Area (0965)

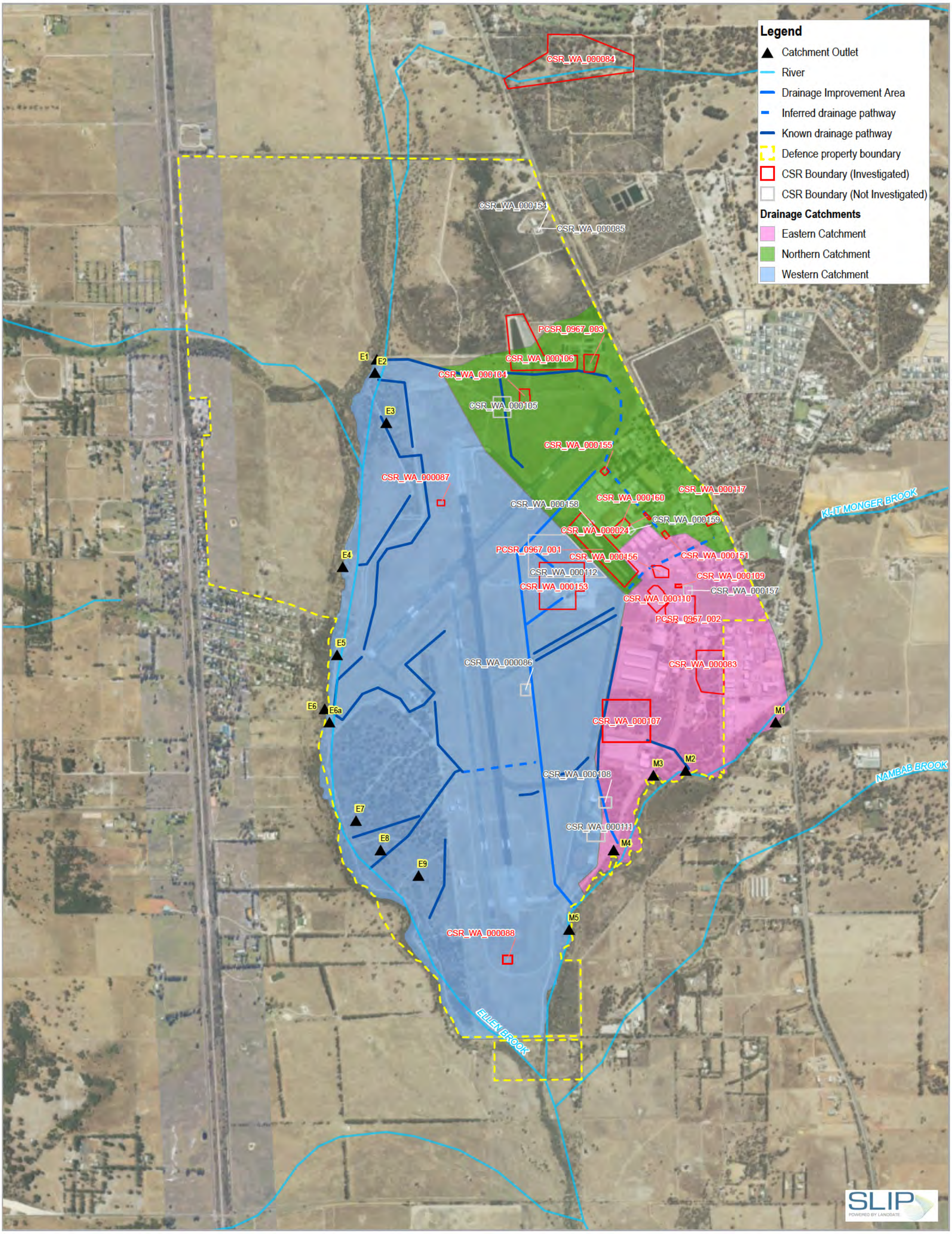
Project No. **61-36234**
Revision No. **0**
Date **27/09/2019**

FIGURE 5B

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\Pearce_DSI.aprx
Print date: 27 Sep 2019 - 14:49

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20190712, Medium scale topo contours - 20171007 Landgate_Subscription_Imagery_WANow: . Created by: bmorgan

Defence FOI 536/21/22
Document 1



Paper Size ISO A3
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Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

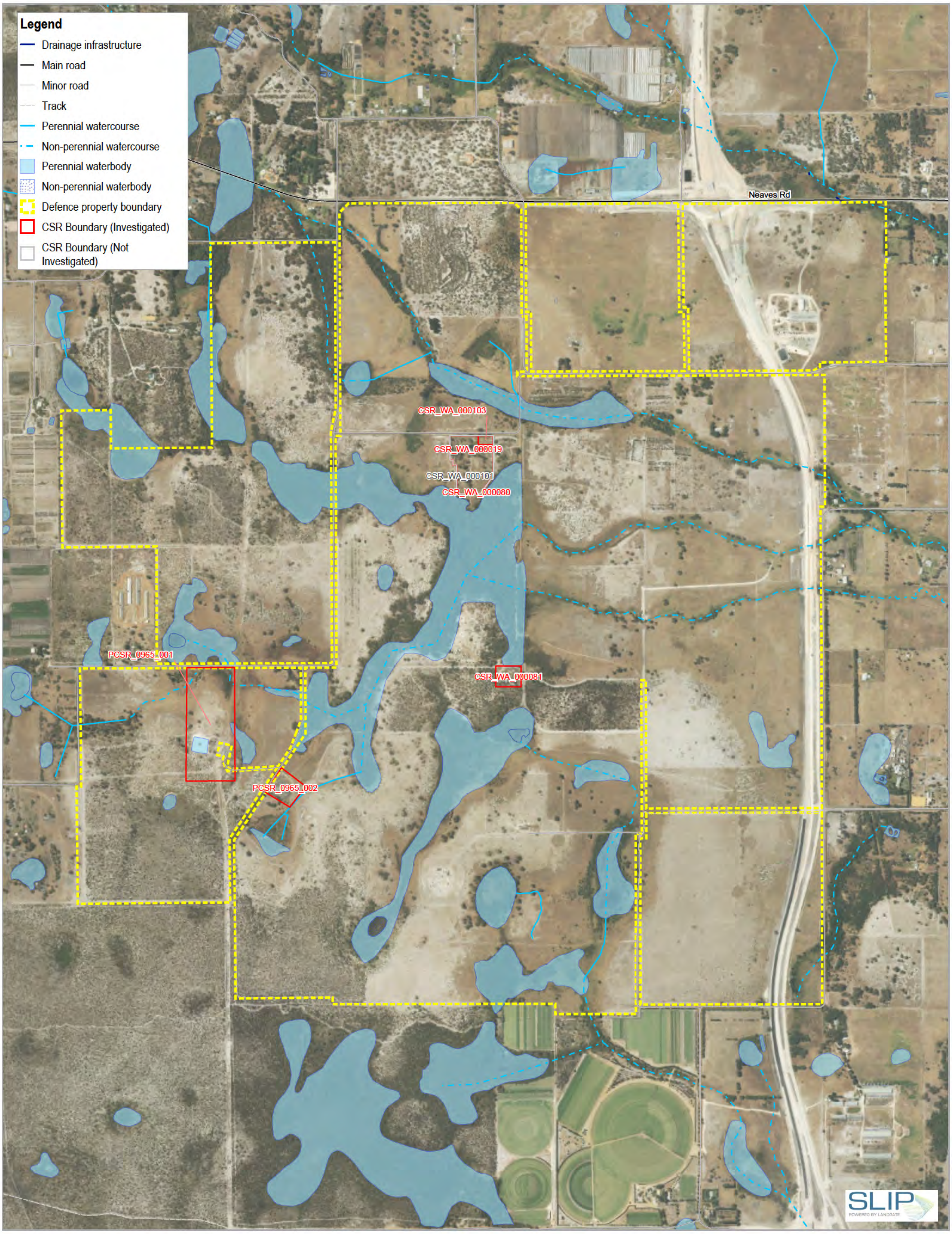
Surface Water Drainage Lines and Water Bodies
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 27/09/2019

FIGURE 6A

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\Pearce_DSI.aprx
Print date: 27 Sep 2019 - 14:52

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20180727; GHD: Drainage lines
CAD drawings Landgate_Subscription_Imagery_WANow: . Created by: bmorgan



Paper Size ISO A3

0 130 260 390 520

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

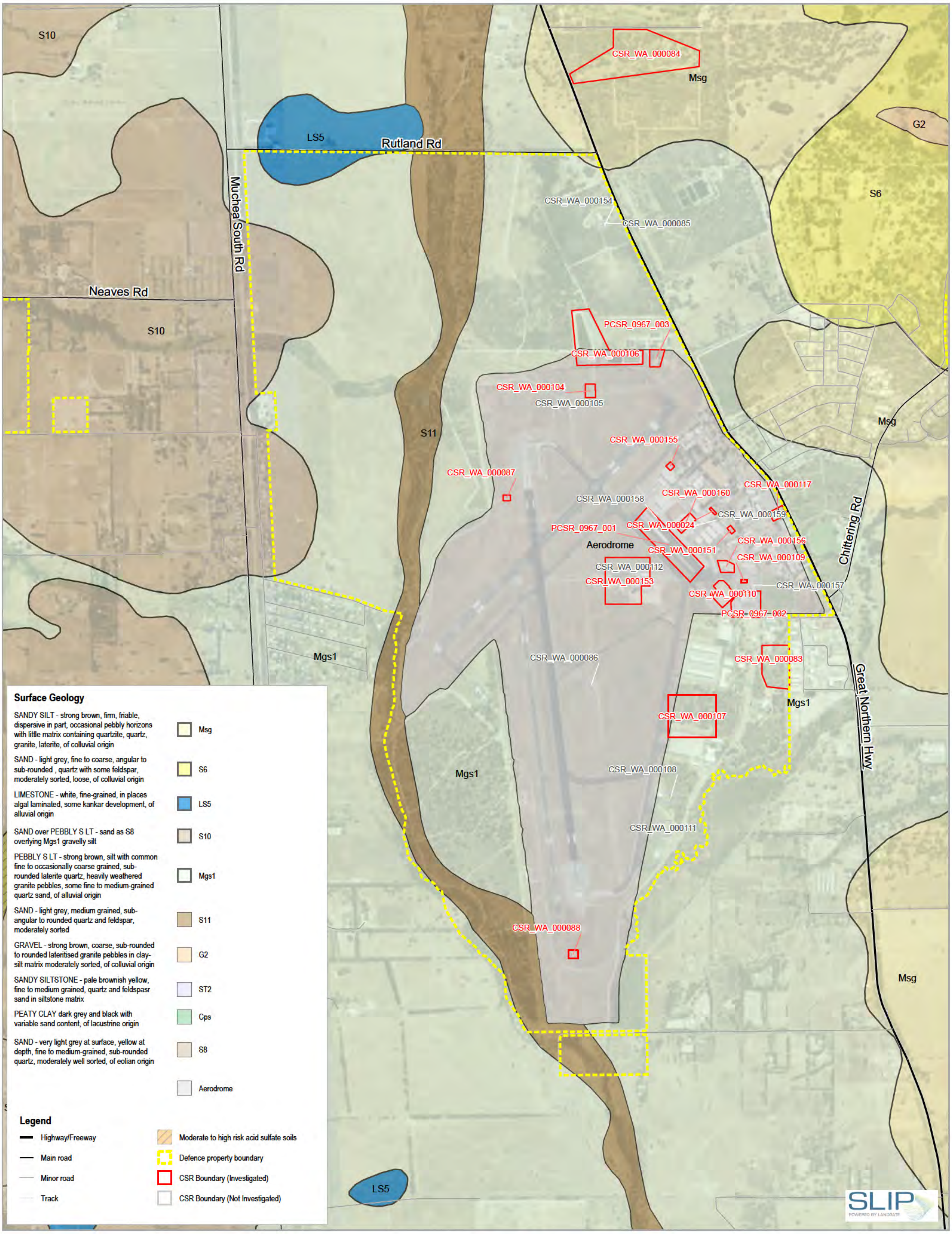
Surface Water Drainage Lines and Water Bodies
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 27/09/2019

FIGURE 6B

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\Pearce_DSI.aprx
Print date: 27 Sep 2019 - 15:30

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20180727; GHD: Drainage ines
CAD drawings Landgate_Subscription_Imagery_WANow: . Created by: bmorgan



Paper Size ISO A3

0 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

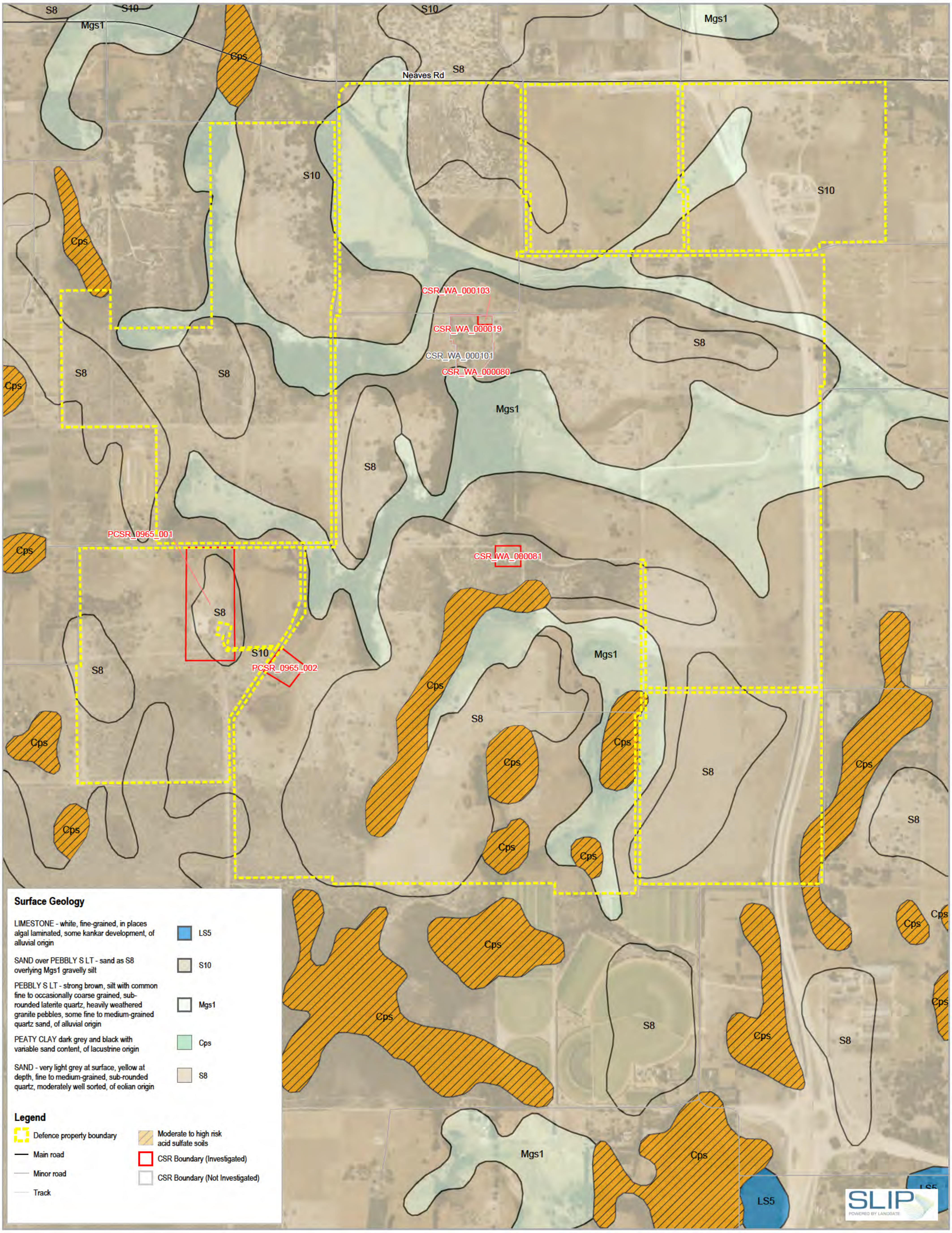
Regional Geology
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 27/09/2019

FIGURE 7A

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\Pearce_DSI.aprx
Print date: 27 Sep 2019 - 14:58

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20190712, DWER: Acid sulfate risk areas - 20140922; Geoscience Australia: Surface Geology - 2012Landgate_Subscription_Imagery_WANow: . Created by: bmorgan



Paper Size ISO A3

0 130 260 390 520

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

Regional Geology
Bullsbrook Training Area (0965)

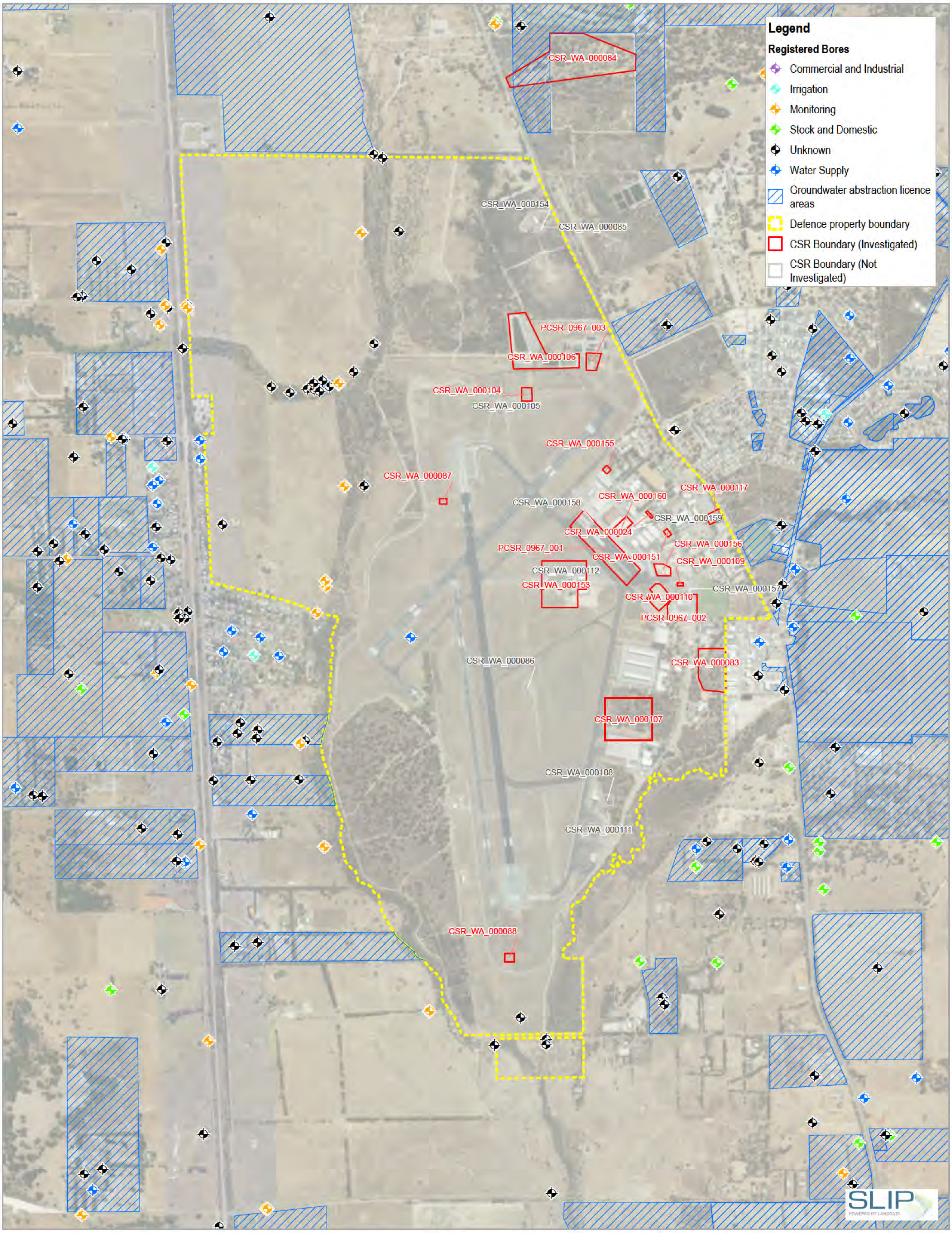
Project No. 61-36234
Revision No. 0
Date 27/09/2019

FIGURE 7B

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\Pearce_DSI.aprx
Print date: 27 Sep 2019 - 15:00

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20190712, DWER: Acid sulfate risk areas - 20140922; Geoscience Australia: Surface Geology - 2012Landgate_Subscription_Imagery_WANow: . Created by: bmorgan

Defence FOI 536/21/22
Document 1



Paper Size ISO A3
0 150 300 450 600
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

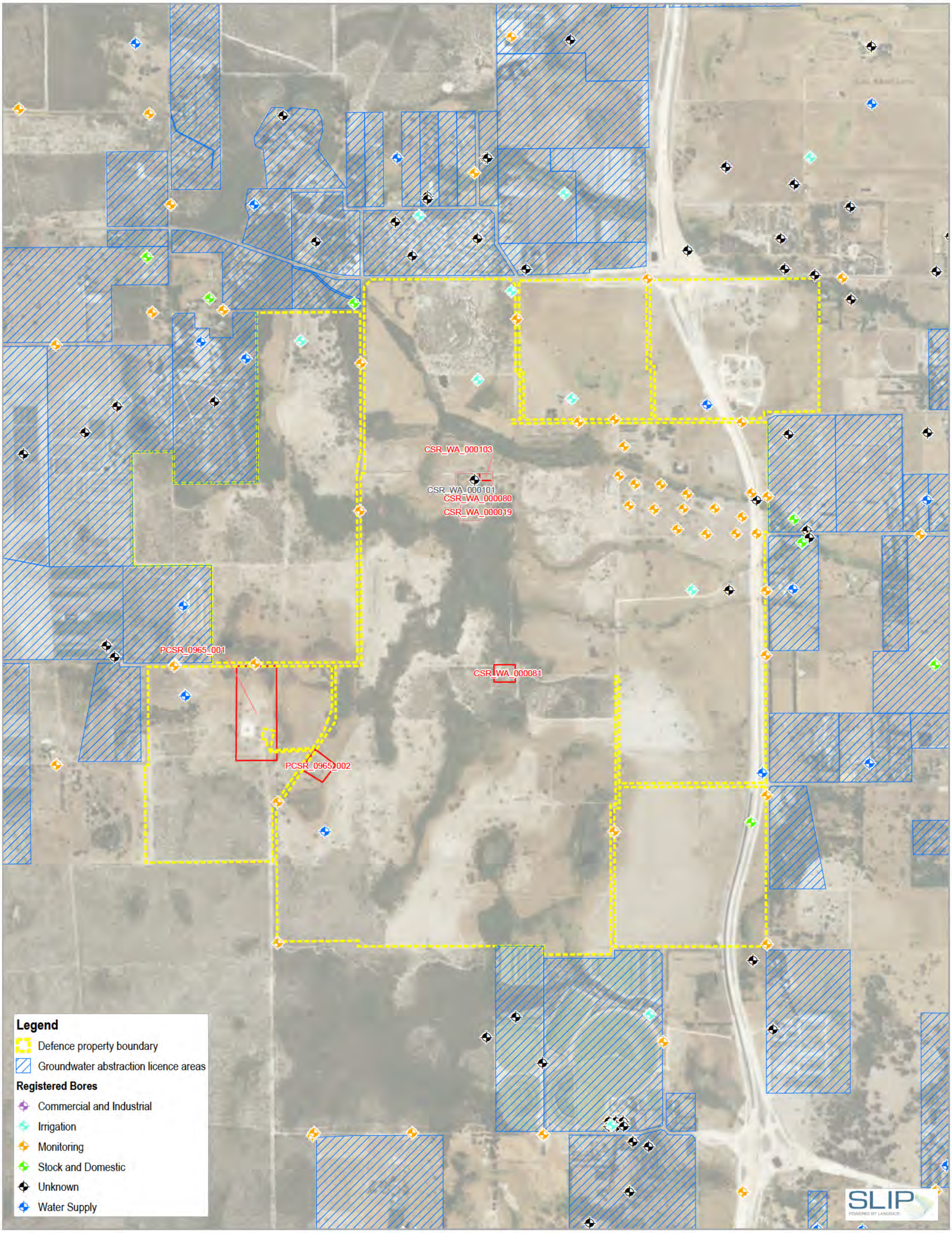
Registered Groundwater Bores
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 27/09/2019

FIGURE 8A

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\Pearce_DSI.aprx
Print date: 27 Sep 2019 - 15:01

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20190712; DWER: Registered bores - 20190712. Created by: bmorgan



Paper Size ISO A3

0 150 300 450 600

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

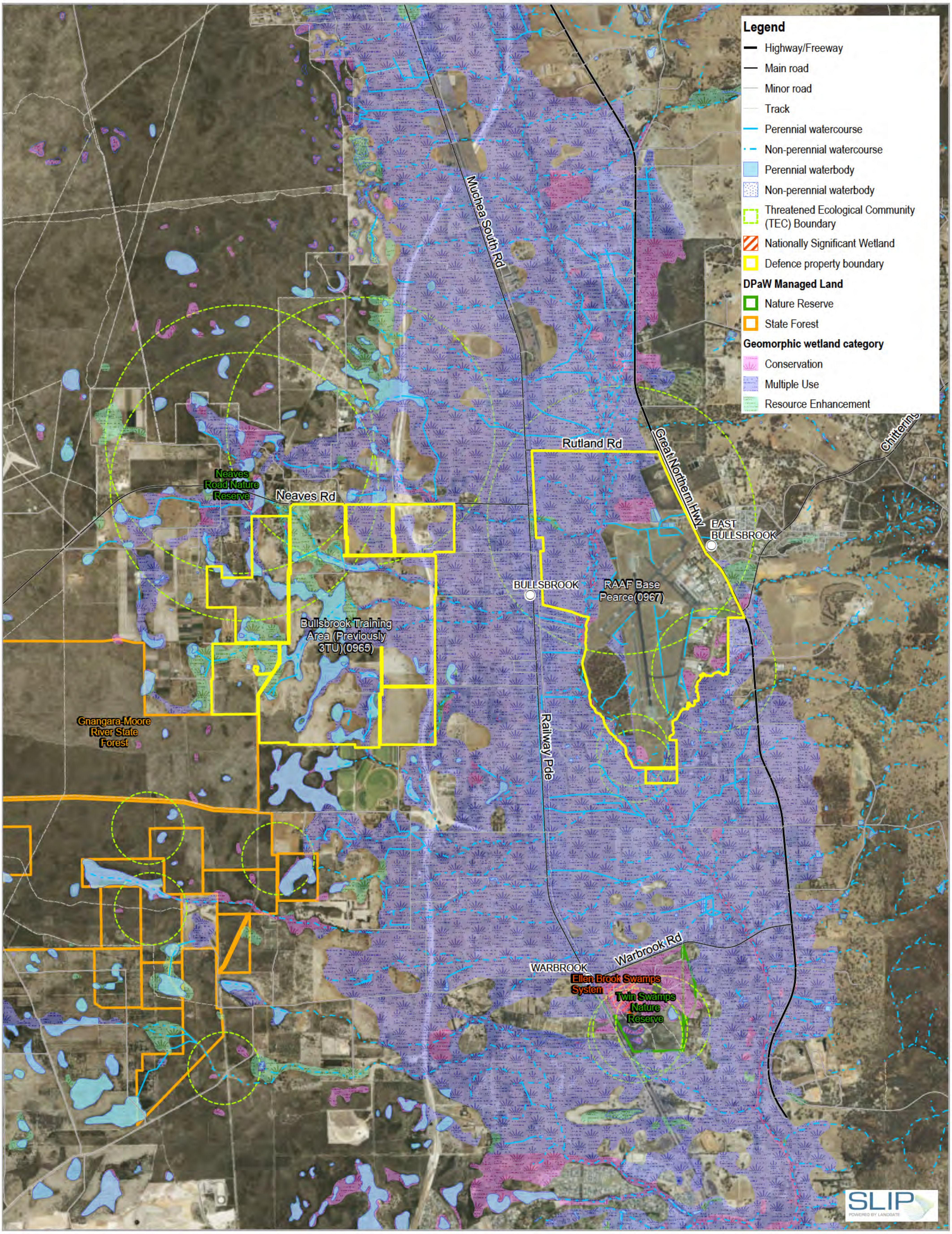
Registered Groundwater Bores
Bullsbrook Training Area (0965)

Project No.	61-36234
Revision No.	0
Date	27/09/2019

FIGURE 8B

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\Pearce_DSI.aprx
Print date: 27 Sep 2019 - 15:03

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20190712; GHD: Drainage ines
CAD drawings Landgate_Subscription_Imagery_WANow: . Created by: bmorgan



Paper Size ISO A3

0 425 850 1,275 1,700

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

Areas of Ecological Significance
RAAF Base Pearce (0967)
Bullsbrook Training Area (0965)

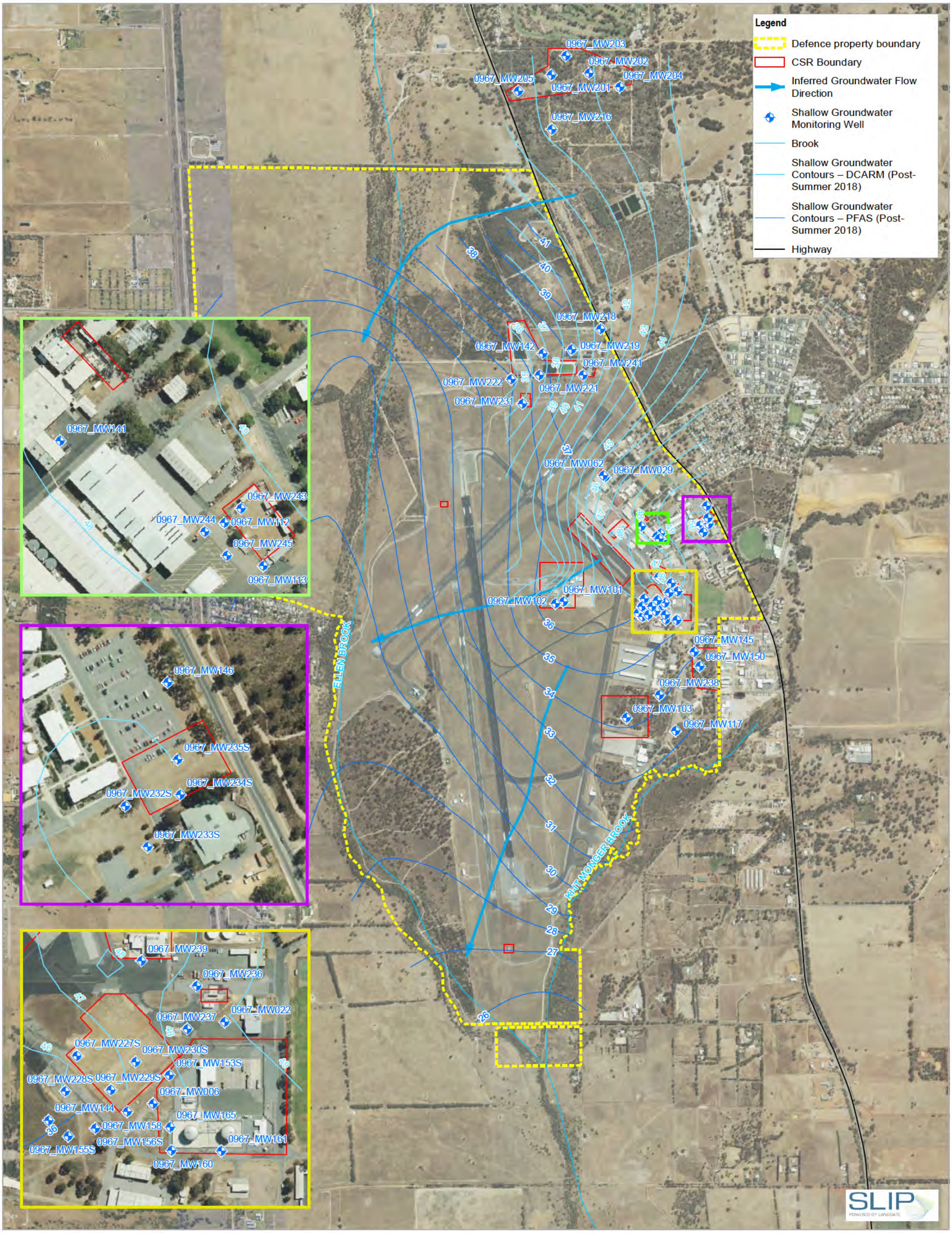
Project No. **61-36234**
Revision No. **0**
Date **27/09/2019**

FIGURE 9

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\Pearce_DSI.aprx
Print date: 27 Sep 2019 - 15:04

Data source: Department of Defence: Site boundaries - 20171011; Geoscience Australia: Geodata Topo 250K - 2006; Landgate: Roads, Watercourses/bodies - 2017, Cadastre - 20180709, Aerial photography - WA Now Aerial Imagery - accessed 20190712; DBCA: DBCA legislated land, Geomorphic wetlands - 201710; DWER: Environmentally sensitive areas - 201710. Landgate_Subscription_Imagery_WANow: .
Created by: bmorgan

Defence FOI 536/21/22
Document 1



Paper Size ISO A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

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Department of Defence
DCARM Region 3 WA Contaminated Sites Program

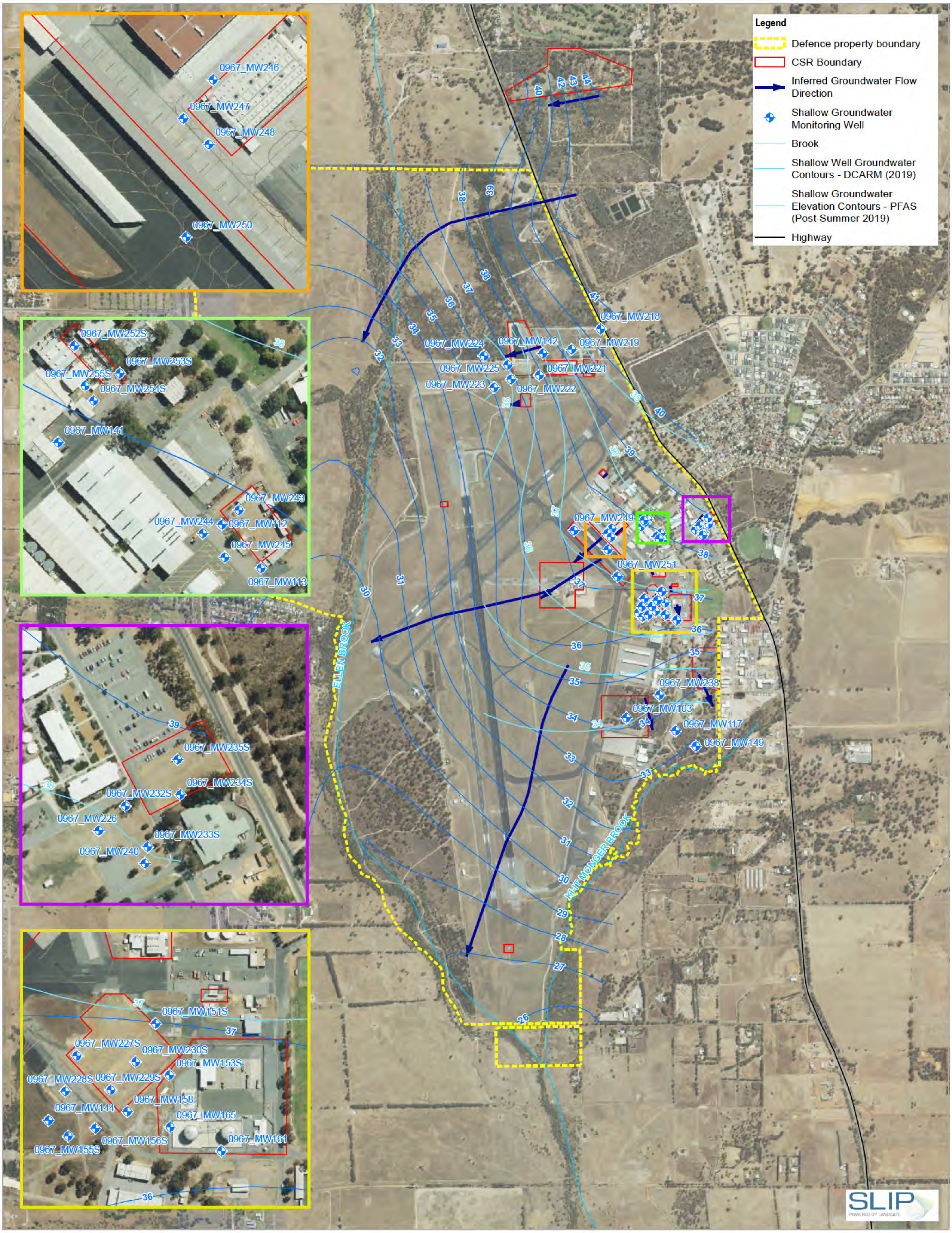
Shallow Regional Aquifer
Groundwater Contours (March-May 2018)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 10A

G:\61\36234\GIS\Maps\Working\DSI\SiteSpecific Pearce\DCARM 2019\6136234_06_010a_0967_GWContours2018_A3P_Rev0.mxd
Print date 27 Sep 2019 - 14:44

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20180727; GHD: Regional Aquifer Contours - PFAS 20171201, DSI - 20180802. Created by: kaadams



Paper Size ISO A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

Shallow Regional Aquifer
Groundwater Contours (April 2019)
RAAF Base Pearce (0967)

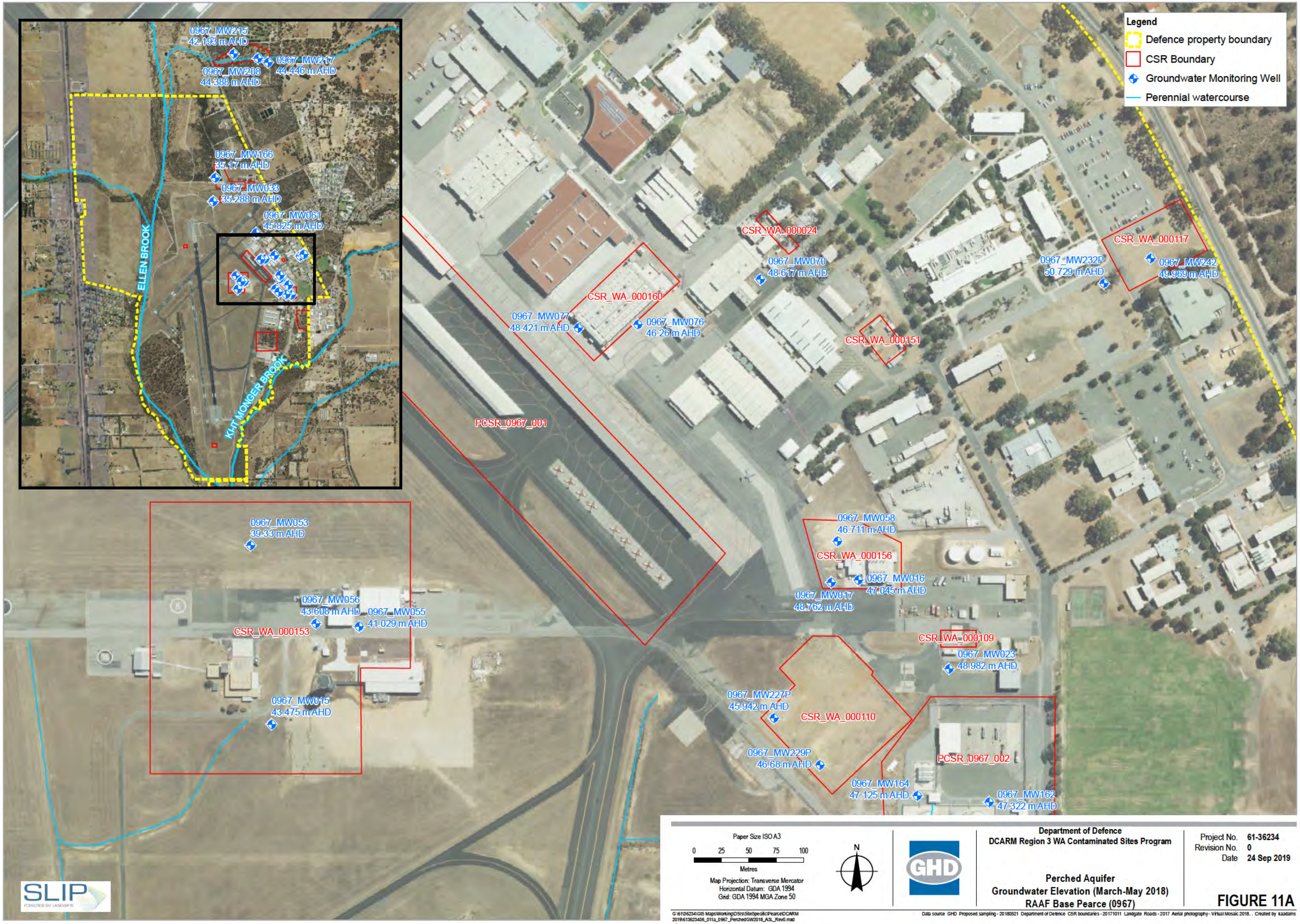
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 10B

G:\61\36234\GIS\Maps\Working\DSI\SiteSpecific Pearce\DCARM 2019\6136234 06_010b_0967_GWContours2019_A3P_Rev0.mxd
Print date: 27 Sep 2019 - 14:43

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017; WA Now Aerial Mosaic - accessed 20180727; GHD: Regional Aquifer Contours - PFAS 20171201, DSI - 20180802. Created by: kaadams

Defence FOI 536/21/22
Document 1



Department of Defence
DCARM Region 3 WA Contaminated Sites Program

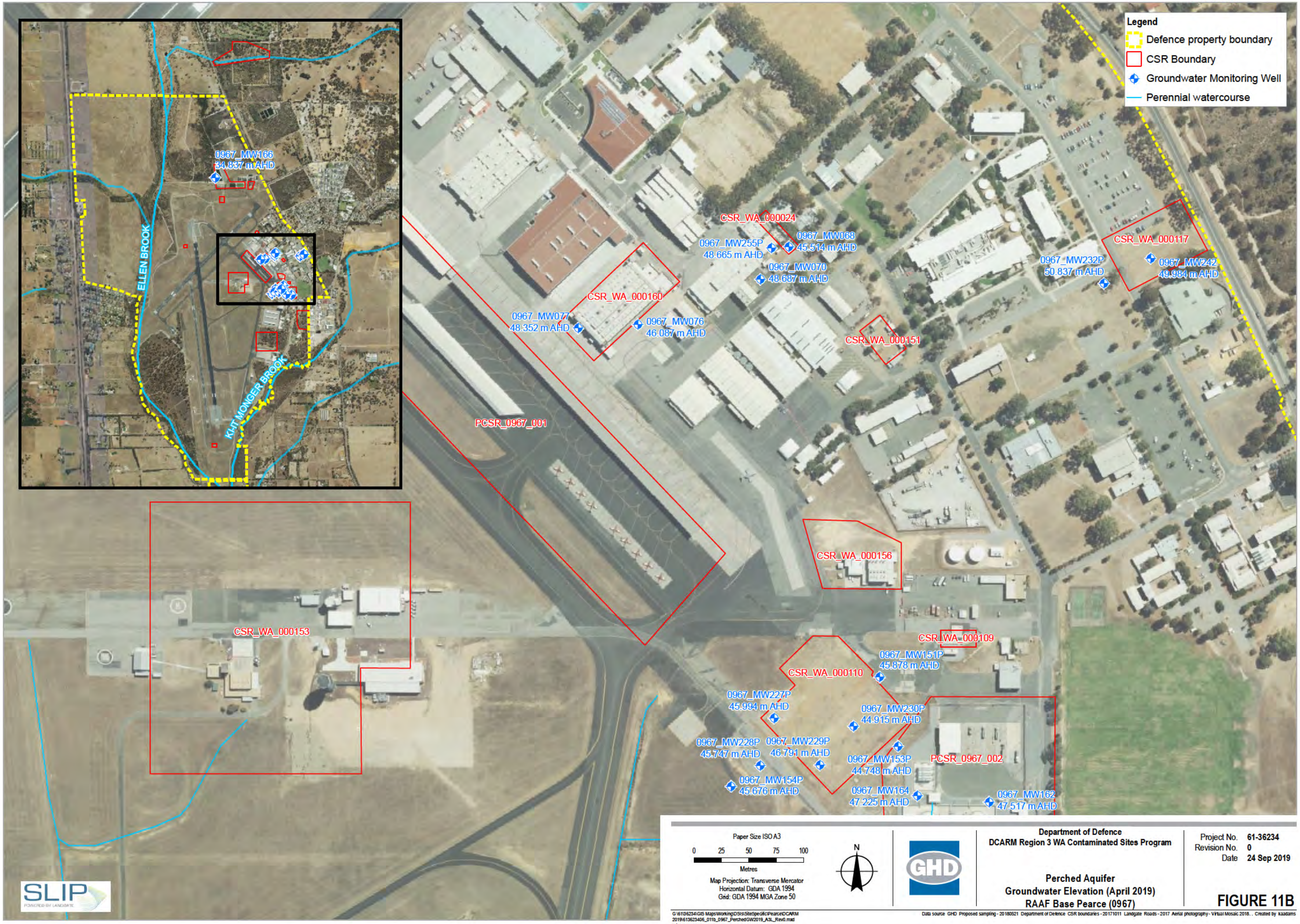
Perched Aquifer
Groundwater Elevation (March-May 2018)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 11A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_011a_0967_PerchedGW2018_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:49

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams



Paper Size ISO A3

0 25 50 75 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

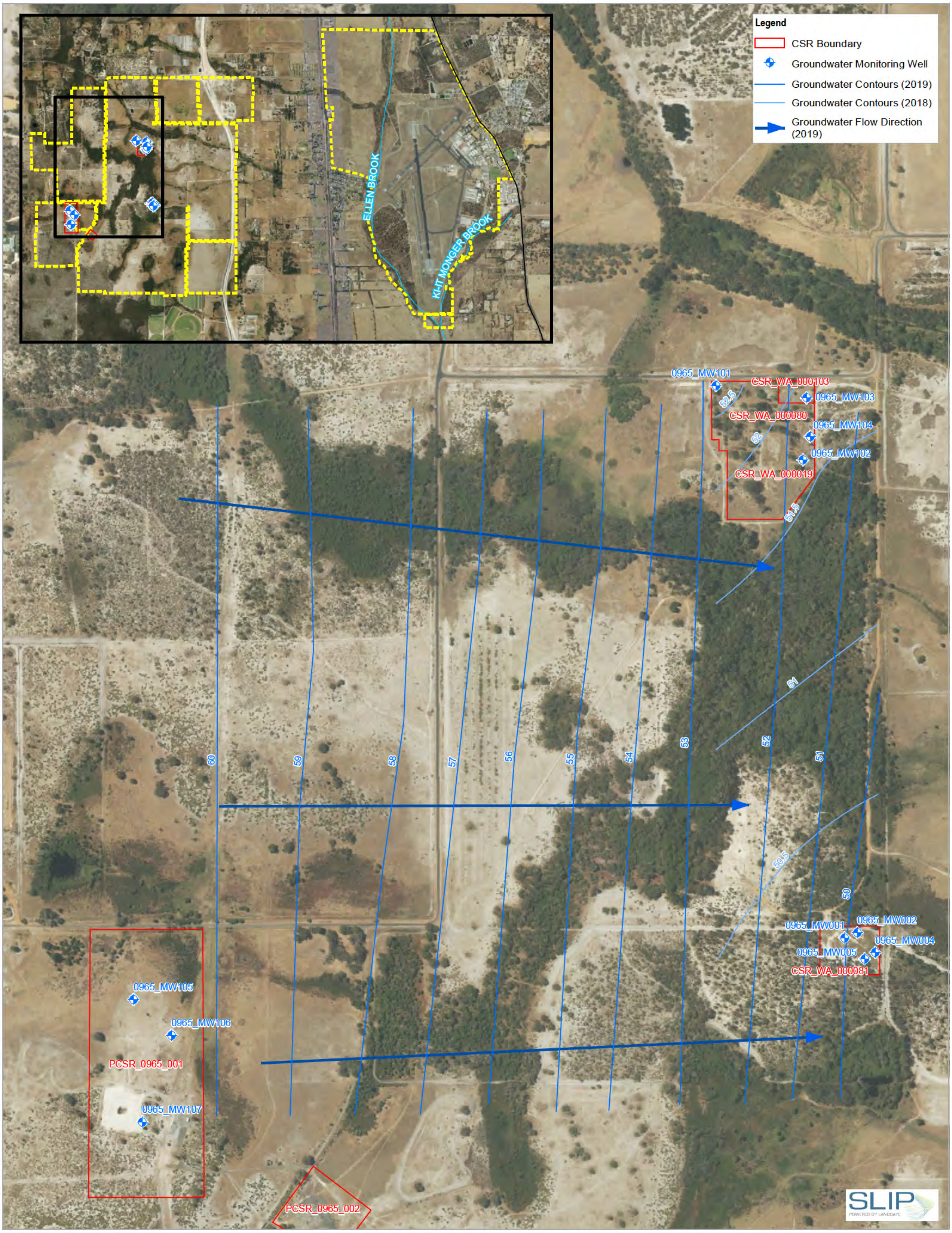
Perched Aquifer
Groundwater Elevation (April 2019)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 11B

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_011b_0967_PerchedGW2019_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:49

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams



Paper Size ISO A3

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

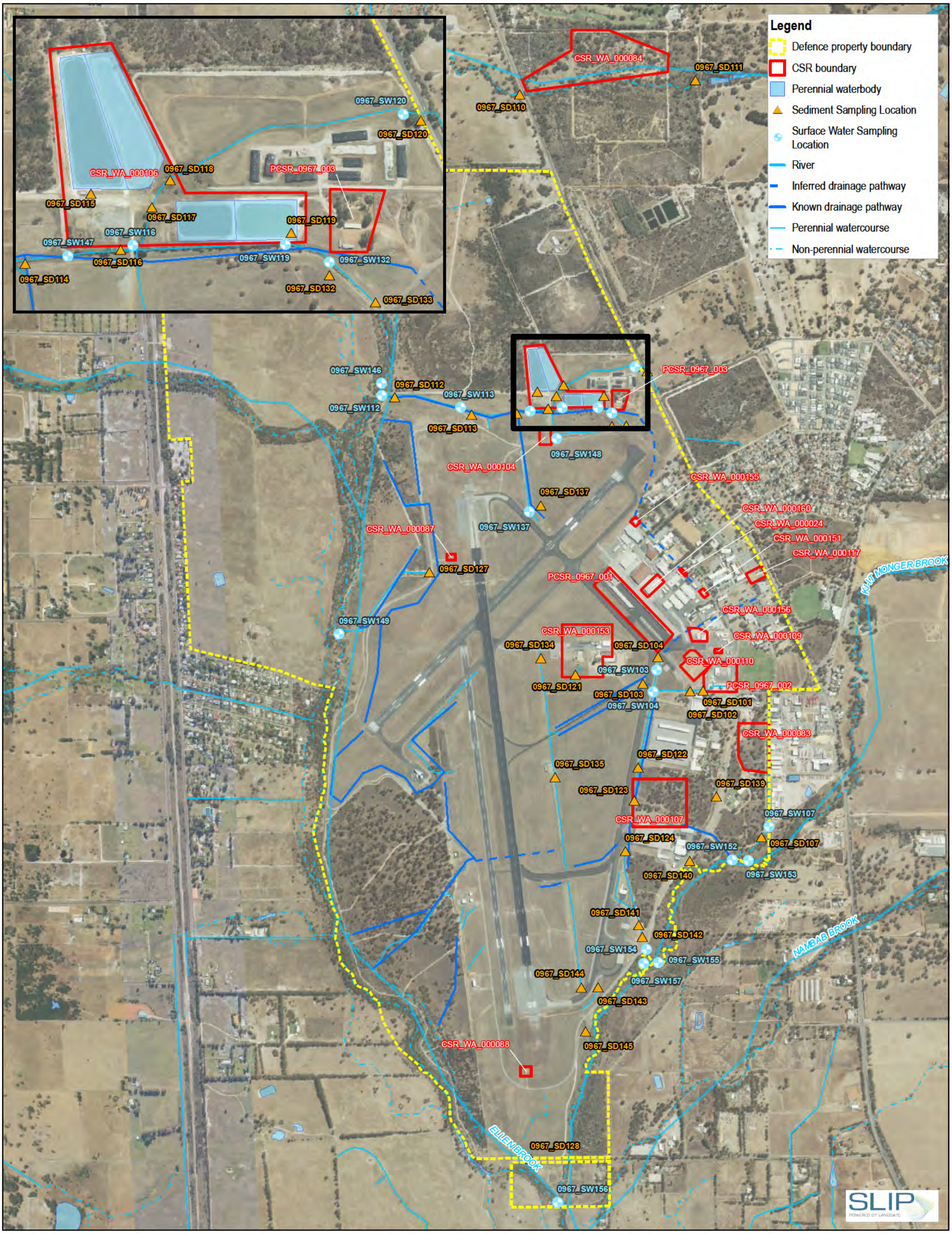
Groundwater Contours
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 12

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific Pearce\DCARM 2019\613623406_012_0965_3TUGWContours2019_A3P_Rev0.mxd
Print date 27 Sep 2019 - 14:44

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20180727; GHD: Regional Aquifer Contours - PFAS 20171201, DSI - 20180802. Created by: kaadams



Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

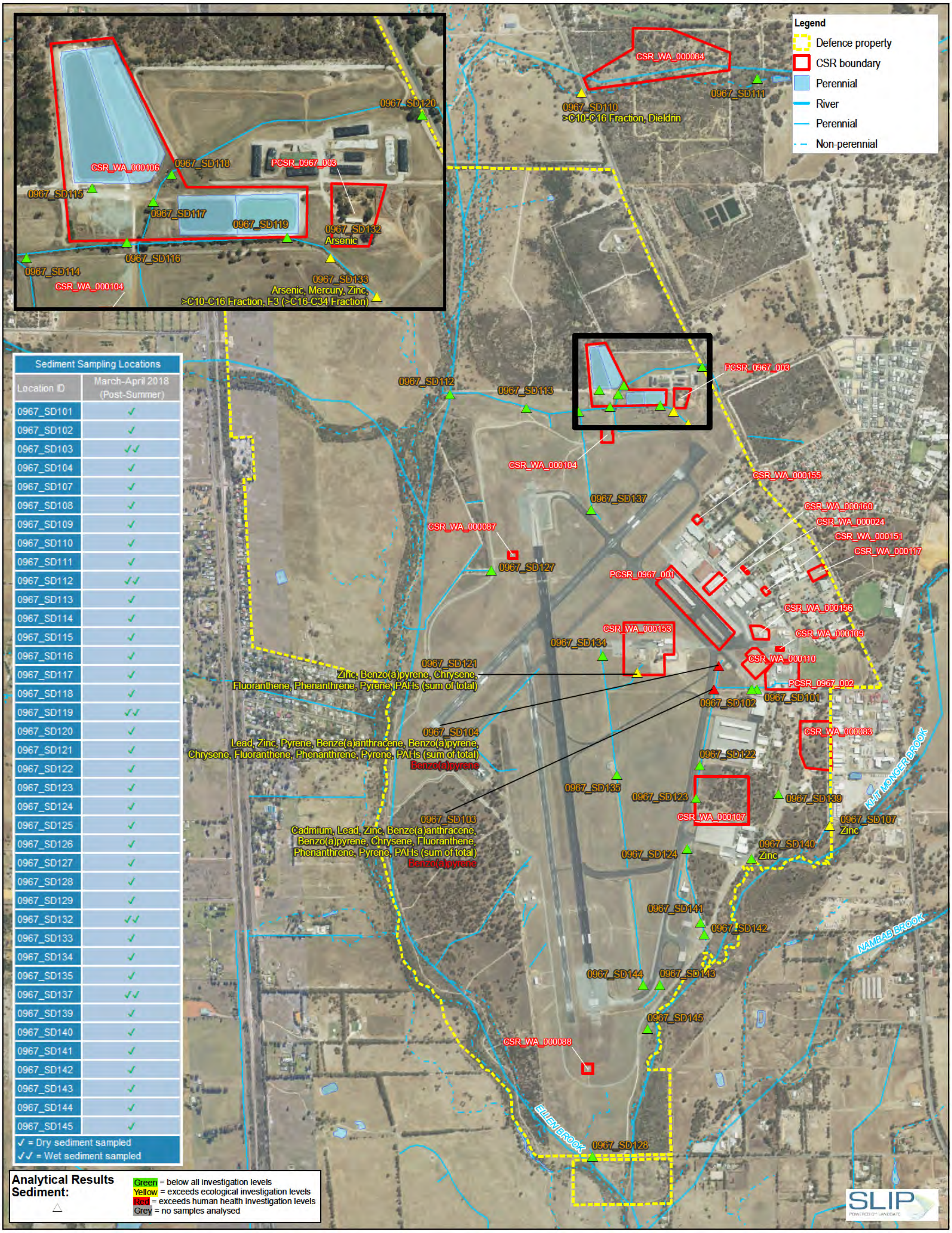
Site-Wide Surface Water and Sediment Sampling Locations
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 13A

G:\61\36234\GIS\Maps\Working\DSI\SiteSpecific Pearce\DCARM 2019\6136234 06_013a_Surface_Water_Sediment_0967_ASP_Rev0.mxd
Print date 27 Sep 2019 - 14:45

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011. Landgate: Roads - 2017. Watercourses/bodies - 2017. WA Now Aerial Mosaic - accessed 20180727. DWER: Acid sulfate risk areas - 20140922. Geoscience Australia: Surface Geology - 2012. Created by: kaadams



Sediment Sampling Locations	
Location ID	March-April 2018 (Post-Summer)
0967_SD101	✓
0967_SD102	✓
0967_SD103	✓✓
0967_SD104	✓
0967_SD107	✓
0967_SD108	✓
0967_SD109	✓
0967_SD110	✓
0967_SD111	✓
0967_SD112	✓✓
0967_SD113	✓
0967_SD114	✓
0967_SD115	✓
0967_SD116	✓
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0967_SD119	✓✓
0967_SD120	✓
0967_SD121	✓
0967_SD122	✓
0967_SD123	✓
0967_SD124	✓
0967_SD125	✓
0967_SD126	✓
0967_SD127	✓
0967_SD128	✓
0967_SD129	✓
0967_SD132	✓✓
0967_SD133	✓
0967_SD134	✓
0967_SD135	✓
0967_SD137	✓✓
0967_SD139	✓
0967_SD140	✓
0967_SD141	✓
0967_SD142	✓
0967_SD143	✓
0967_SD144	✓
0967_SD145	✓

✓ = Dry sediment sampled
✓✓ = Wet sediment sampled

Analytical Results Sediment:
Green = below all investigation levels
Yellow = exceeds ecological investigation levels
Red = exceeds human health investigation levels
Grey = no samples analysed

Paper Size ISO A3
0 100 200 300 400
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

Site-Wide Sediment Analytical Results (March-April 2018) RAAF Base Pearce (0967)

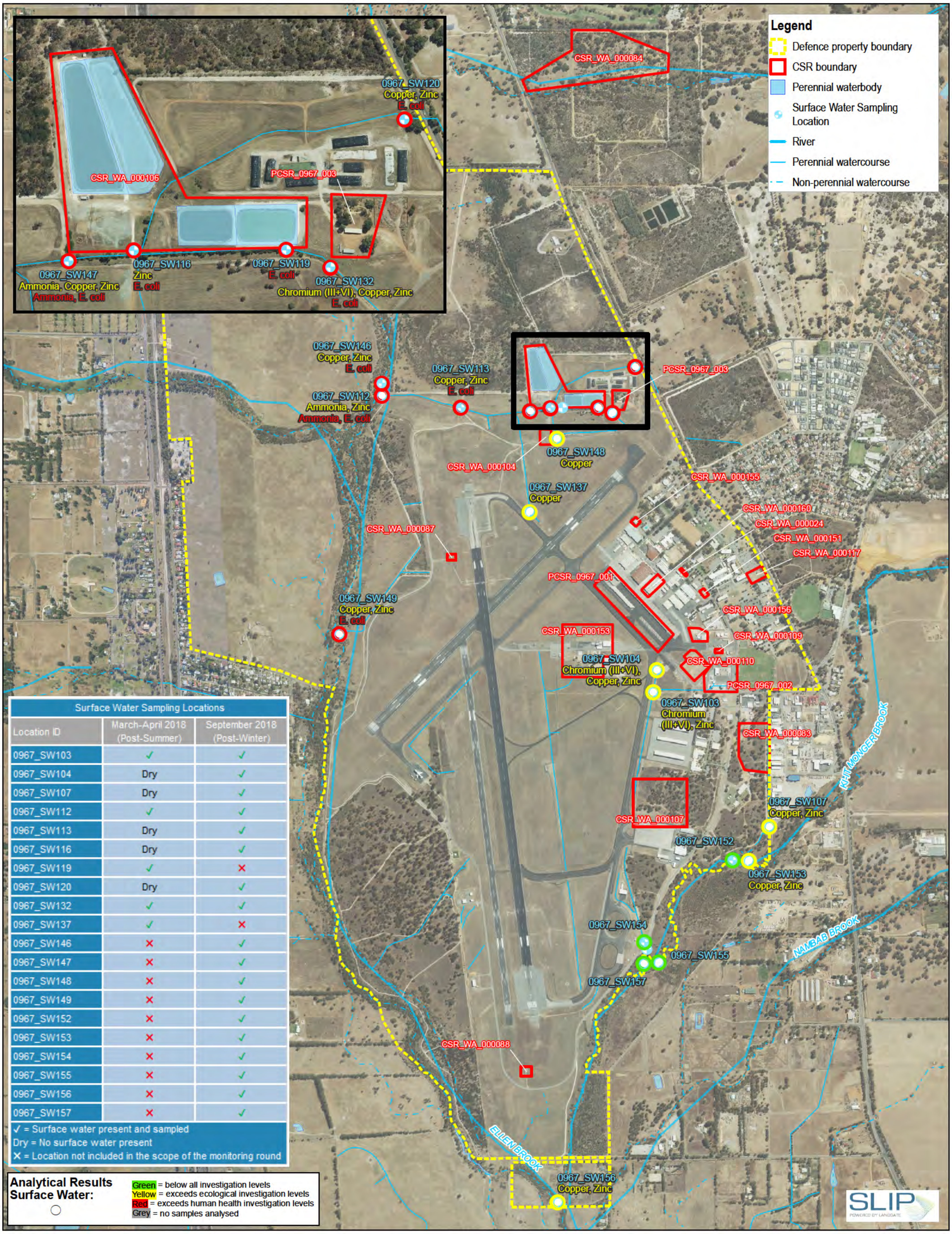
Project No. 61-36234
Revision No. 0
Date 27/09/2019

FIGURE 13B

G:\61\36234\GIS\Maps\Working\DSt\SiteSpecific Pearce\DCARM 2019\613623406_013b_Surface_Water_Sediment_0967_ASP_Rev0.mxd
Print date 27 Sep 2019 - 15:03

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017; Watercourses/bodies - 2017; WA Now Aerial Mosaic - accessed 20180727; DWER: Acid sulfate risk areas - 20140922; Geoscience Australia: Surface Geology - 2012. Created by: kaadams

Defence FOI 536/21/22
Document 1



Surface Water Sampling Locations

Location ID	March-April 2018 (Post-Summer)	September 2018 (Post-Winter)
0967_SW103	✓	✓
0967_SW104	Dry	✓
0967_SW107	Dry	✓
0967_SW112	✓	✓
0967_SW113	Dry	✓
0967_SW116	Dry	✓
0967_SW119	✓	✕
0967_SW120	Dry	✓
0967_SW132	✓	✓
0967_SW137	✓	✕
0967_SW146	✕	✓
0967_SW147	✕	✓
0967_SW148	✕	✓
0967_SW149	✕	✓
0967_SW152	✕	✓
0967_SW153	✕	✓
0967_SW154	✕	✓
0967_SW155	✕	✓
0967_SW156	✕	✓
0967_SW157	✕	✓

✓ = Surface water present and sampled
Dry = No surface water present
✕ = Location not included in the scope of the monitoring round

Analytical Results Surface Water:
Green = below all investigation levels
Yellow = exceeds ecological investigation levels
Red = exceeds human health investigation levels
Grey = no samples analysed

Paper Size ISO A3
0 100 200 300 400
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

Site-Wide Surface Water
Analytical Results (March-April 2018 & September 2018)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 13C

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific Pearce\DCARM 2019\613623406_013c_Surface_Water_Sediment_0967_A3P_Rev0.mxd
Print date 27 Sep 2019 - 15:12

Data source Department of Defence Site boundaries CSR boundaries - 20171011 Landgate Roads - 2017 Watercourses/bodies - 2017 WA Now Aerial Mosaic - accessed 20180727 DWER Acid sulfate risk areas - 20140922 Geoscience Australia Surface Geology - 2012. Created by kaadams

Paper Size ISO A3

0 2.5 5 7.5 10

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

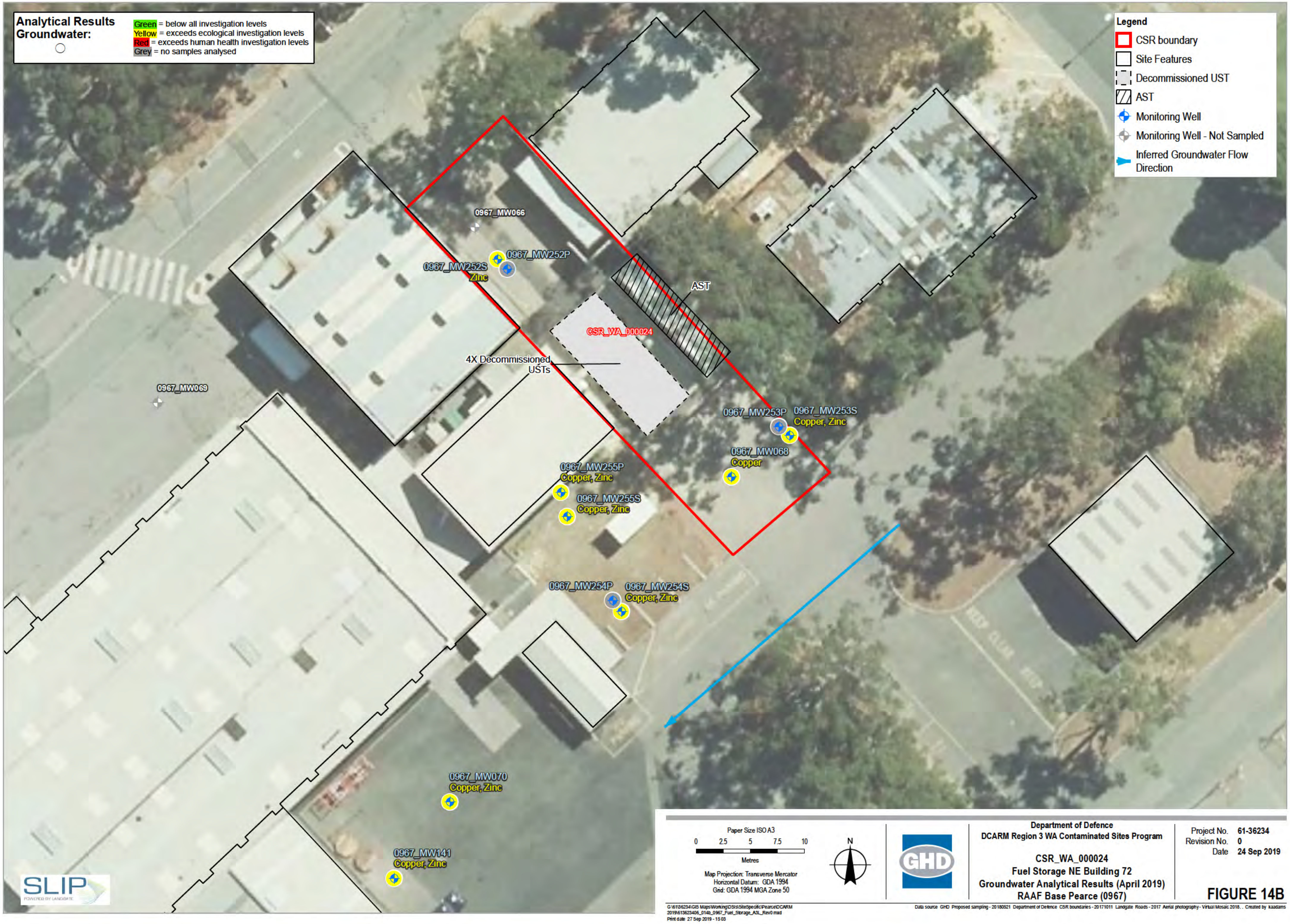
CSR_WA_000024
Fuel Storage NE Building 72
Sampling Locations
RAAF Base Pearce (0967)

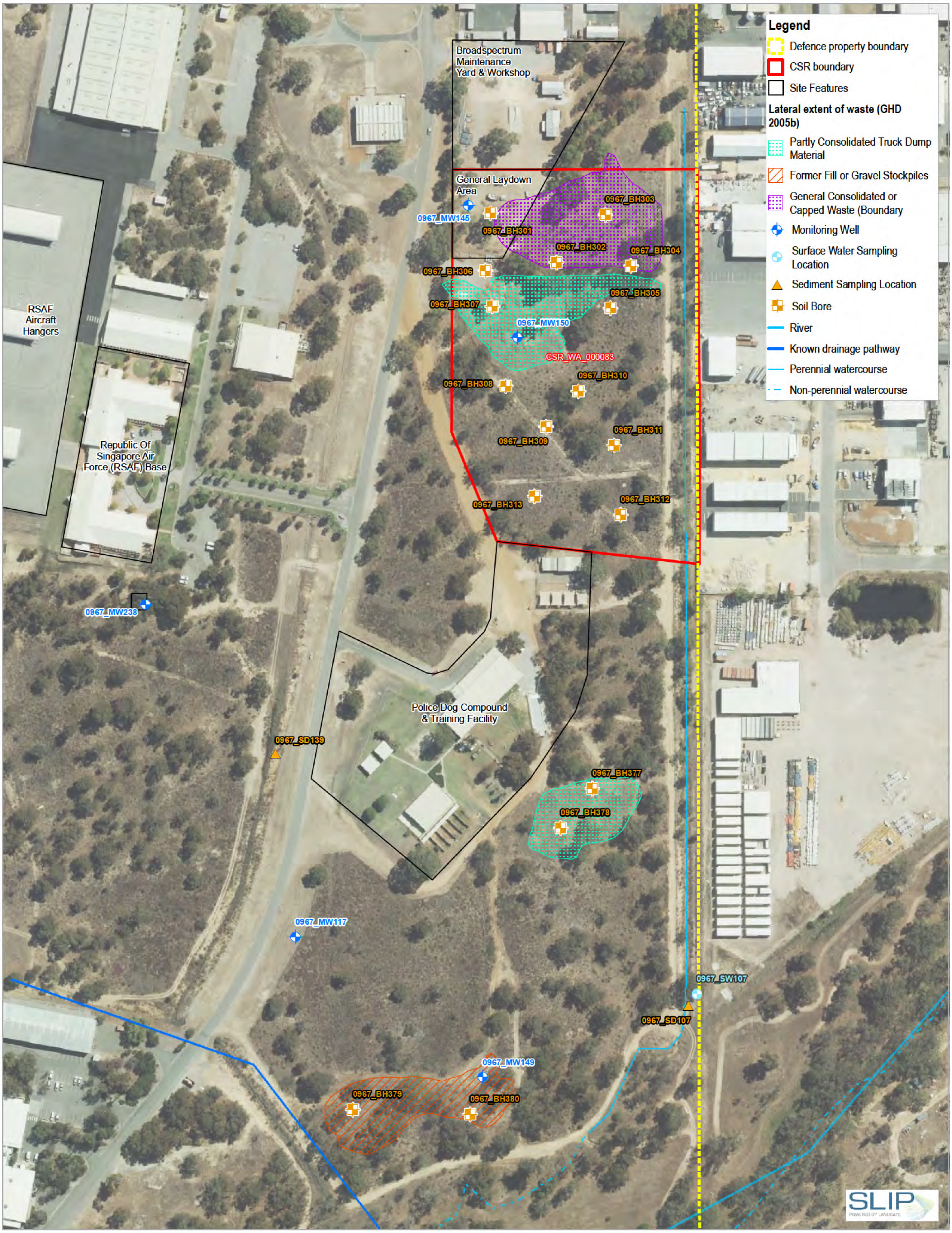
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 14A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_014a_0967_Fuel_Storage_A3L_Rev0.mxd
Print date: 27 Sep 2019 - 14:49

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams


Analytical Results Groundwater:
Green = below all investigation levels
Yellow = exceeds ecological investigation levels
Red = exceeds human health investigation levels
Grey = no samples analysed
Legend
CSR boundary
Site Features
Decommissioned UST
AST
Monitoring Well
Monitoring Well - Not Sampled
Inferred Groundwater Flow Direction
0967_MW066
0967_MW252P
0967_MW252S
Zinc
AST
CSR_WA_000024
4X Decommissioned USTs
0967_MW069
0967_MW253P
0967_MW253S
Copper, Zinc
0967_MW068
Copper
0967_MW255P
Copper, Zinc
0967_MW255S
Copper, Zinc
0967_MW254P
0967_MW254S
Copper, Zinc
0967_MW070
Copper, Zinc
0967_MW141
Copper, Zinc
SLIP
Paper Size ISO A3
0 2.5 5 7.5 10
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50
N
GHD
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000024
Fuel Storage NE Building 72
Groundwater Analytical Results (April 2019)
RAAF Base Pearce (0967)
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019
FIGURE 14B



Paper Size ISO A3
0 10 20 30 40
Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000083
Dog Compound - Buried Waste
Sampling Locations
RAAF Base Pearce (0967)

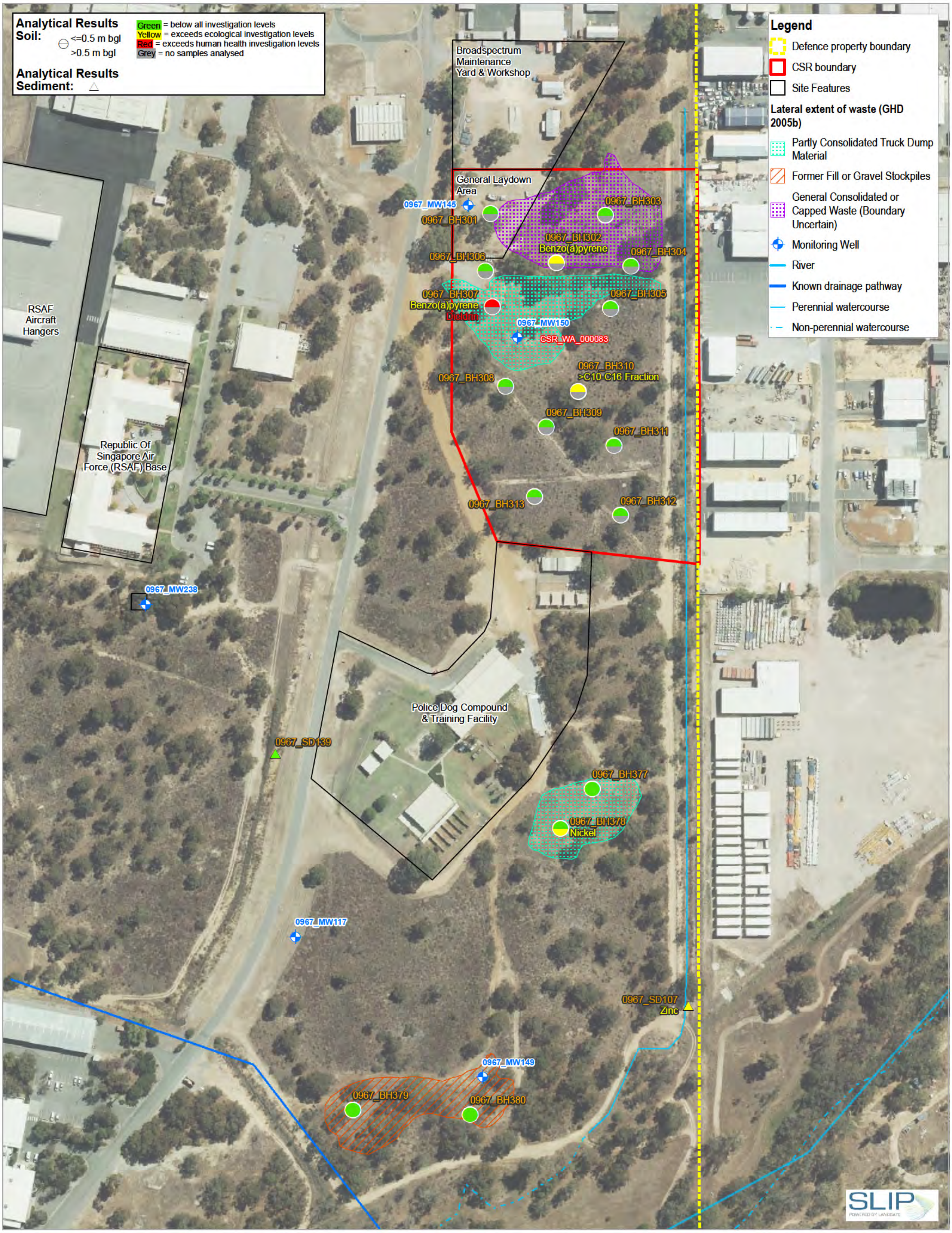
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 15A

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_015a_0967_Dog_Compound_CSR_WA_000083_A3P_Rev0.mxd
Print date 27 Sep 2019 - 15:01

Data source GHD Proposed sampling - 20181126 AOC boundaries - 20171214 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 20180314. . Created by kaadams

Defence FOI 536/21/22
Document 1



Paper Size ISO A3

0 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

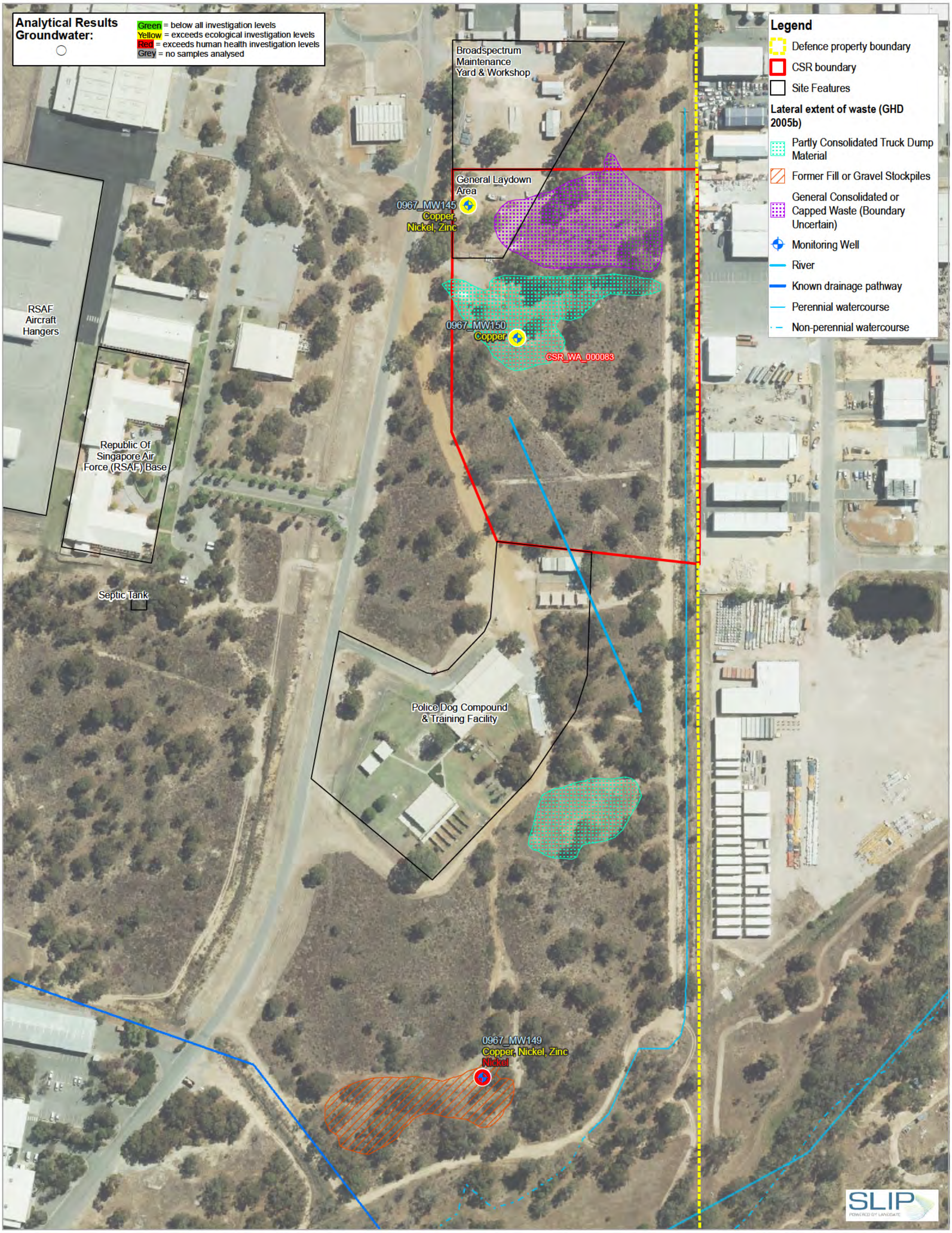
CSR_WA_000083
Dog Compound - Buried Waste
Soil Analytical Results
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 15B

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_015b_0967_Dog_Compound_CSR_WA_000083_A3P_Rev0.mxd
Print date 27 Sep 2019 - 15:03

Data source GHD Proposed sampling - 20181126 AOC boundaries - 20171214 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 20180314.. Created by kaadams



Paper Size ISO A3
0 10 20 30 40
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000083
Dog Compound - Buried Waste
Groundwater Analytical Results
(March-May 2018 & April 2019)
RAAF Base Pearce (0967)

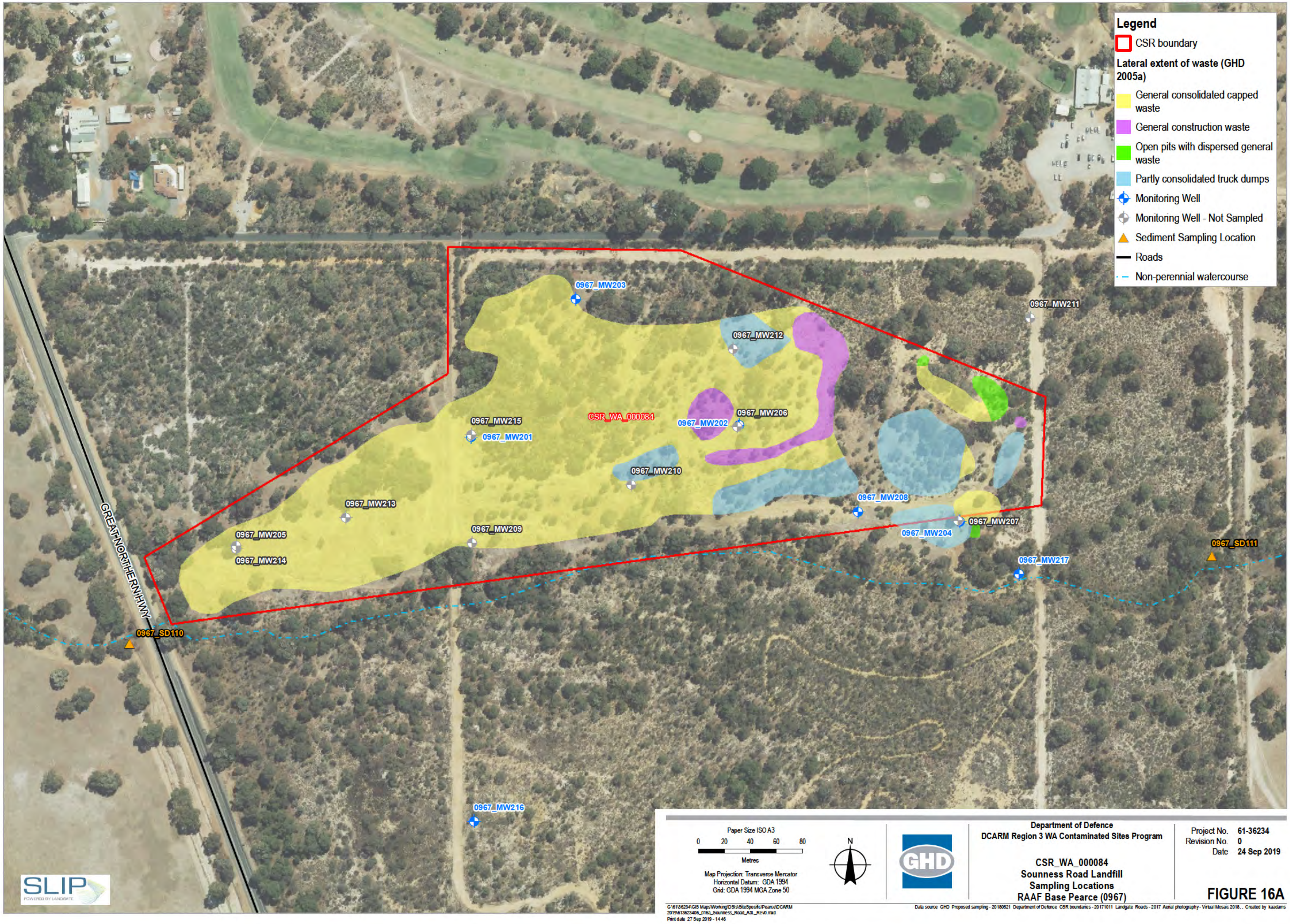
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

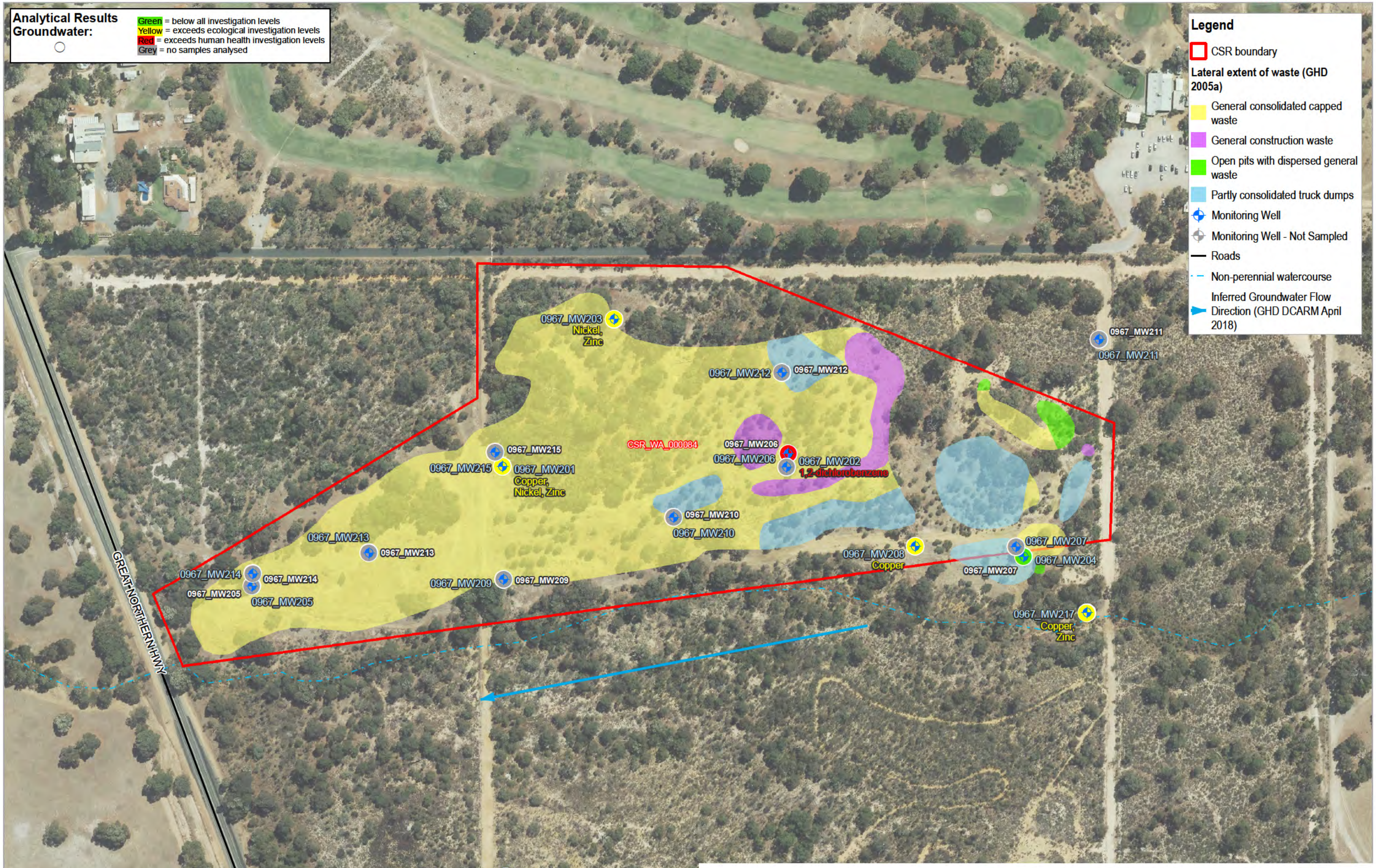
FIGURE 15C

G:\61\36234\GIS\Maps\Working\DSI\SiteSpecific\Pearce\DCARM 2019\613623406_015c_0967_Dog_Compound_CSR_WA_000083_A3P_Rev0.mxd
Print date: 27 Sep 2019 - 15:05

Data source: GHD: Proposed sampling - 20181126; AOC boundaries - 20171214; Department of Defence: CSR boundaries - 20171011; Landgate: Roads - 2017; Aerial photography - Virtual Mosaic 20180314. . Created by: kaadams

Defence FOI 536/21/22
Document 1





Paper Size ISO A3

0 20 40 60 80

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

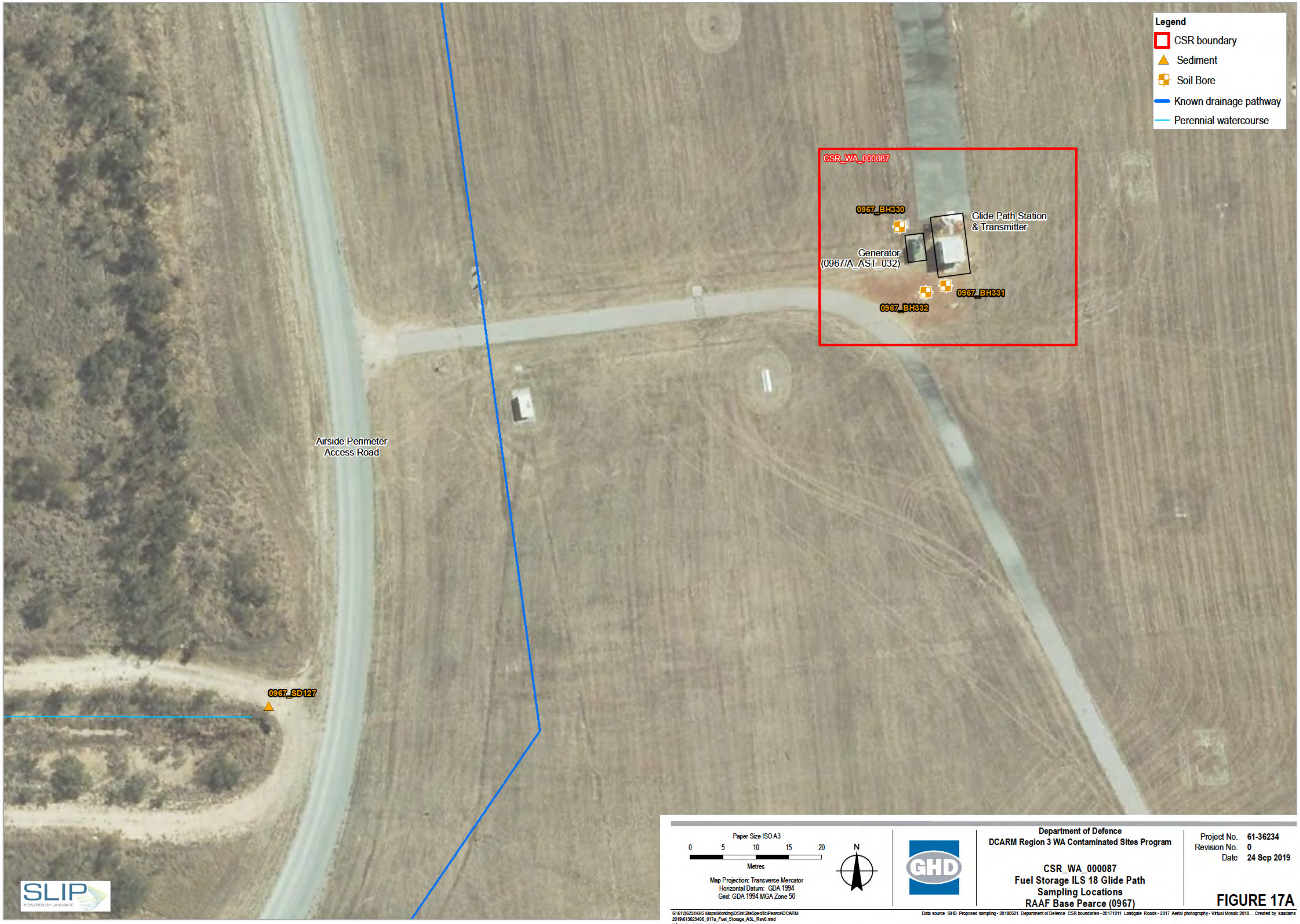
CSR_WA_000084
Sounness Road Landfill
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 16B

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_016b_Sounness_Road_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:14

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams



Department of Defence
DCARM Region 3 WA Contaminated Sites Program

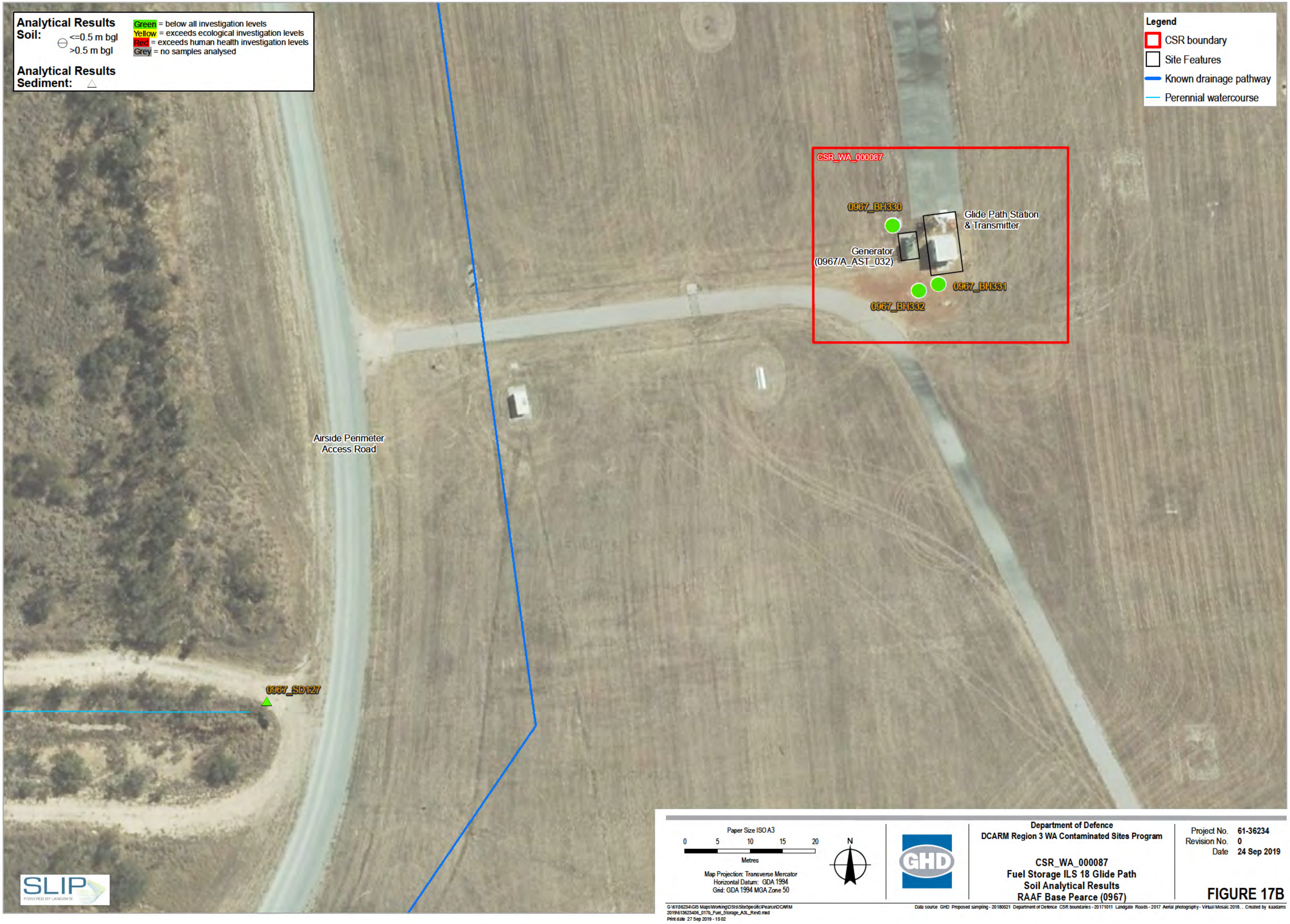
CSR_WA_000087
Fuel Storage ILS 18 Glide Path
Sampling Locations
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 17A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_017a_Fuel_Storage_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:47

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams


Analytical Results Soil:
<=0.5 m bgl
>0.5 m bgl
Green = below all investigation levels
Yellow = exceeds ecological investigation levels
Red = exceeds human health investigation levels
Grey = no samples analysed
Analytical Results Sediment:
Legend
CSR boundary
Site Features
Known drainage pathway
Perennial watercourse
CSR_WA_000087
0967_BH330
Glide Path Station & Transmitter
Generator (0967/A_AST_032)
0967_BH331
0967_BH332
Airside Perimeter Access Road
0967_SD127
SLIP
Paper Size ISO A3
0 5 10 15 20
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50
N
GHD
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000087
Fuel Storage ILS 18 Glide Path
Soil Analytical Results
RAAF Base Pearce (0967)
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019
FIGURE 17B

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000088
Fuel Storage ILS 18 Localiser
Sampling Locations
RAAF Base Pearce (0967)

Project No. **61-36234**
Revision No. **0**
Date **24 Sep 2019**

FIGURE 18A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_018a_Fuel_Storage_A3L_Rev0.mxd
Print date: 27 Sep 2019 - 14:46

Data source: GHD: Proposed sampling - 20180521; Department of Defence: CSR boundaries - 20171011; Landgate: Roads - 2017; Aerial photography - Virtual Mosaic 2018. . Created by: kaadams

Paper Size ISO A3

0 5 10 15 20

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

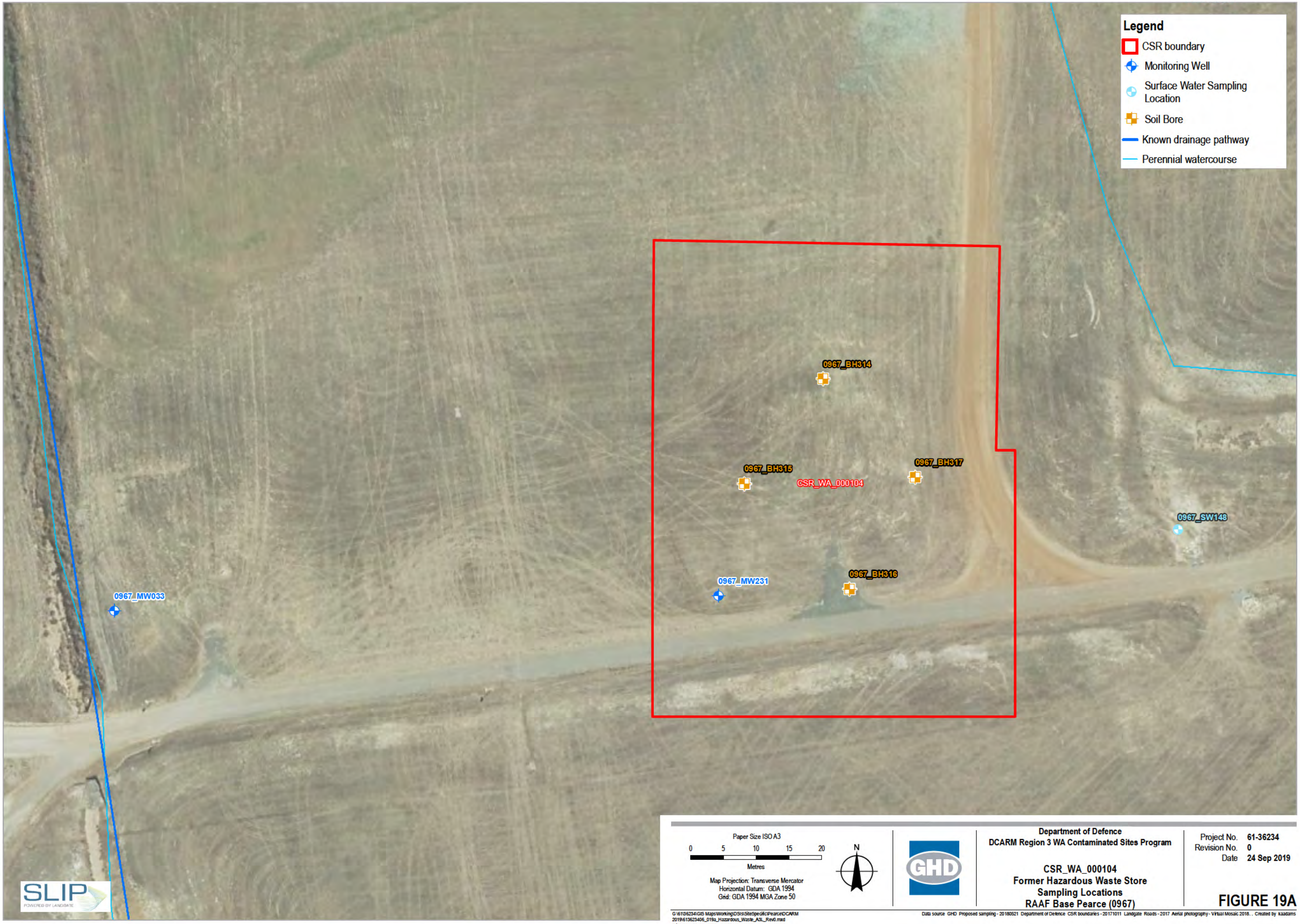
CSR_WA_000088
Fuel Storage ILS 18 Localiser
Soil Analytical Results
RAAF Base Pearce (0967)

Project No. **61-36234**
Revision No. **0**
Date **24 Sep 2019**

FIGURE 18B

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_018b_Fuel_Storage_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:02

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018.. Created by kaadams



Department of Defence
DCARM Region 3 WA Contaminated Sites Program

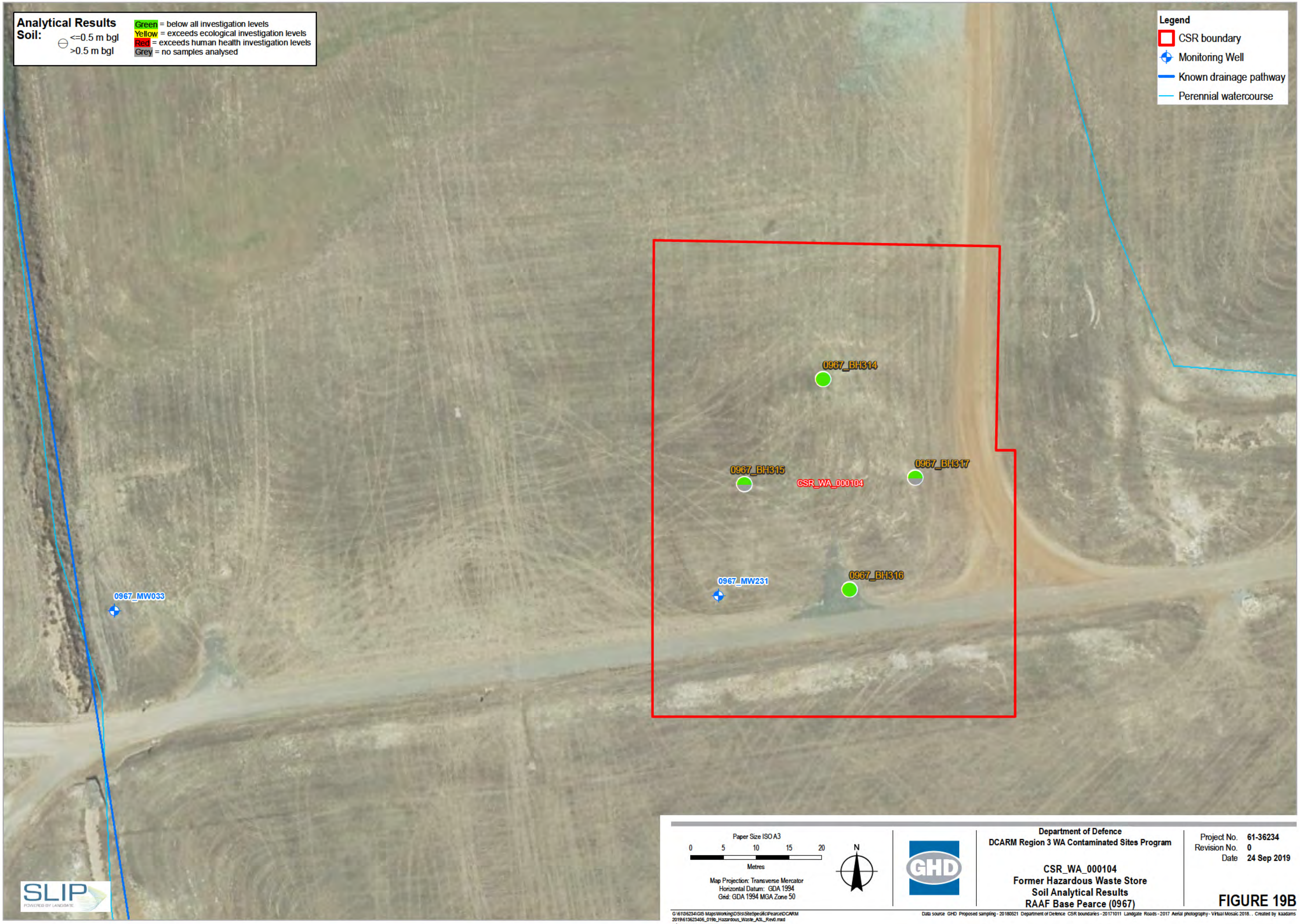
CSR_WA_000104
Former Hazardous Waste Store
Sampling Locations
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 19A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_019a_Hazardous_Waste_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:47

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams



Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000104
Former Hazardous Waste Store
Soil Analytical Results
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 19B

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_019b_Hazardous_Waste_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:02

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018.. Created by kaadams

Paper Size ISO A3
0 5 10 15 20
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000104
Former Hazardous Waste Store
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)

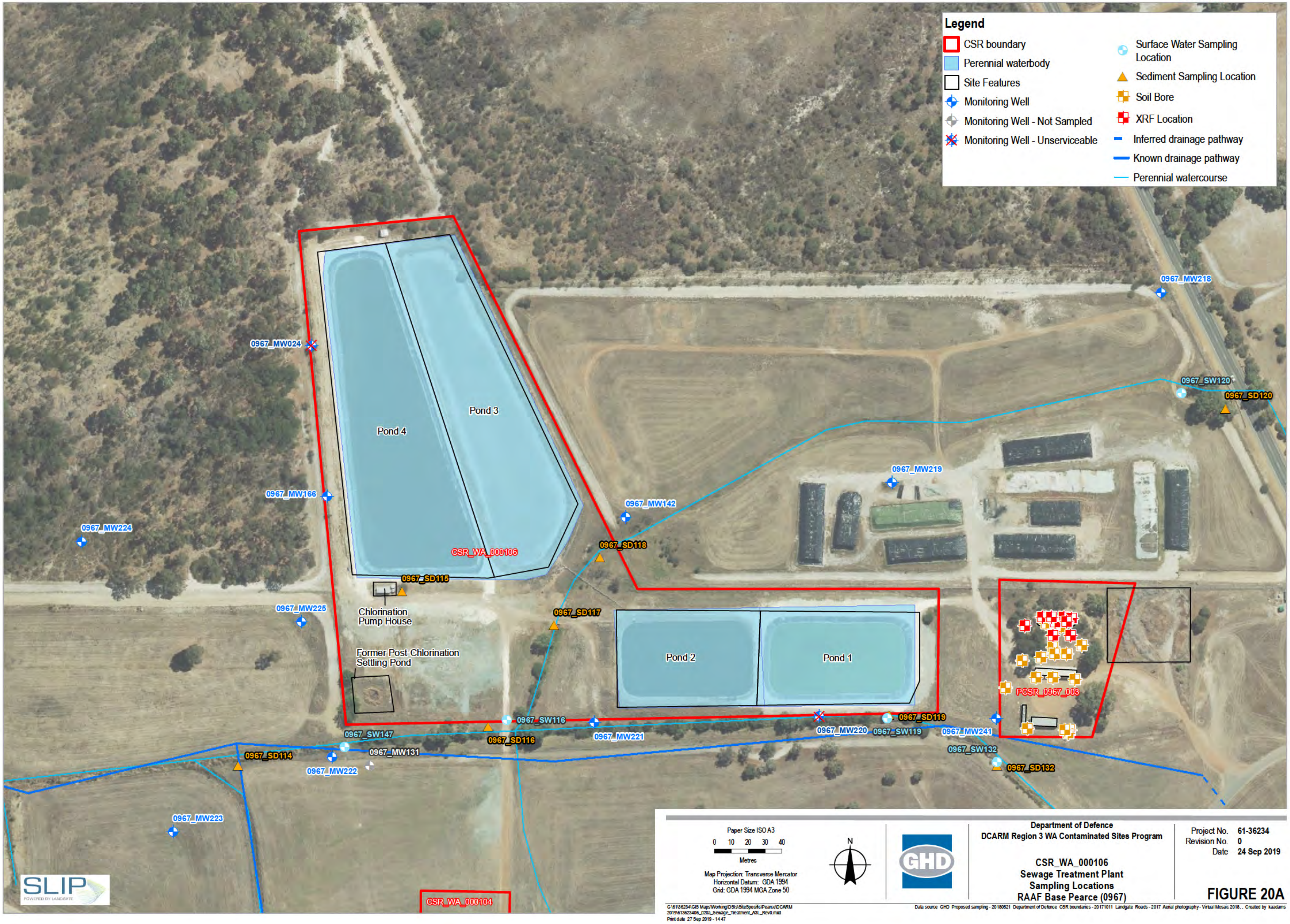
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

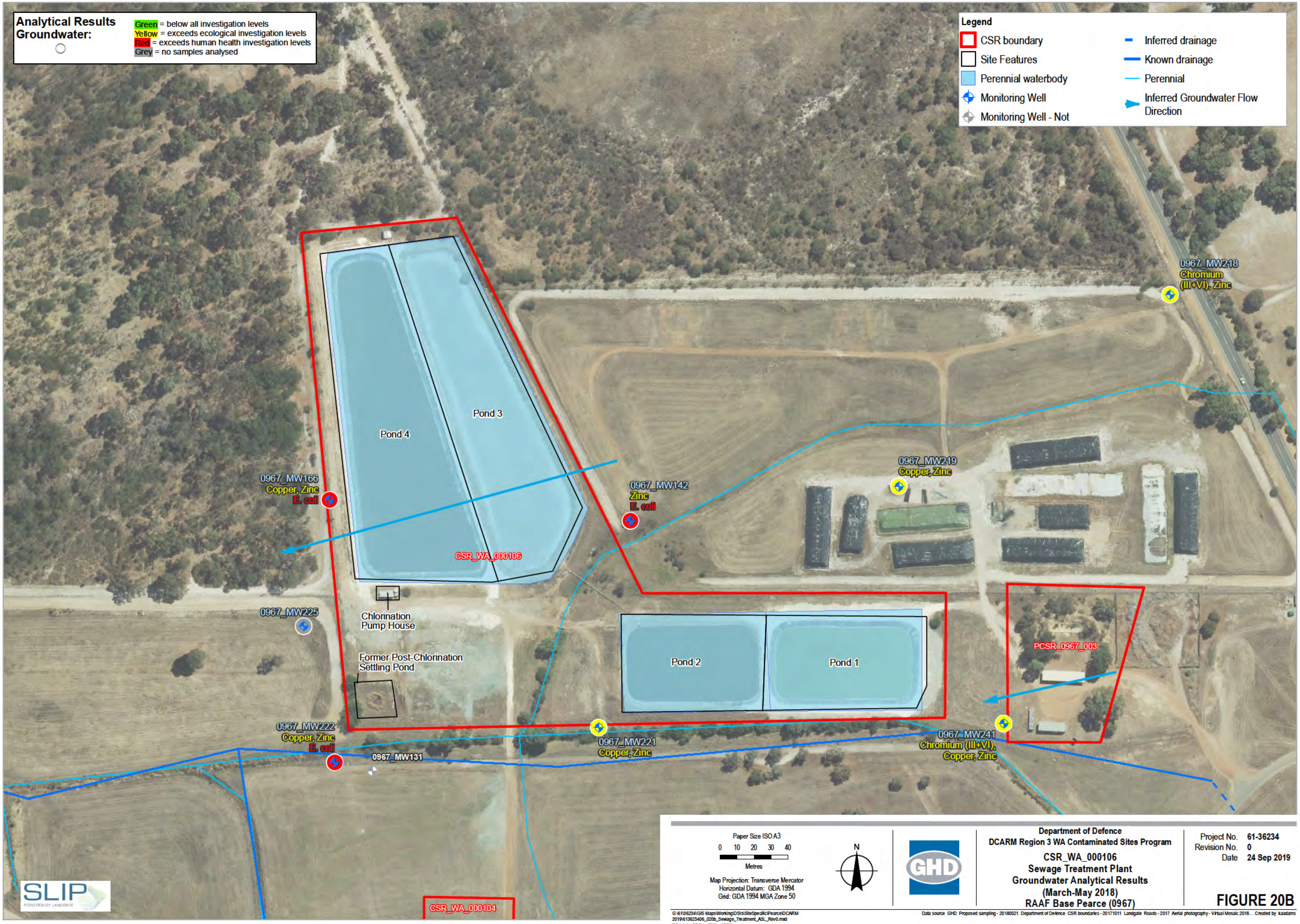
FIGURE 19C

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_019c_Hazardous_Waste_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:02

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams

Defence FOI 536/21/22
Document 1





Paper Size ISO A3
0 10 20 30 40
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

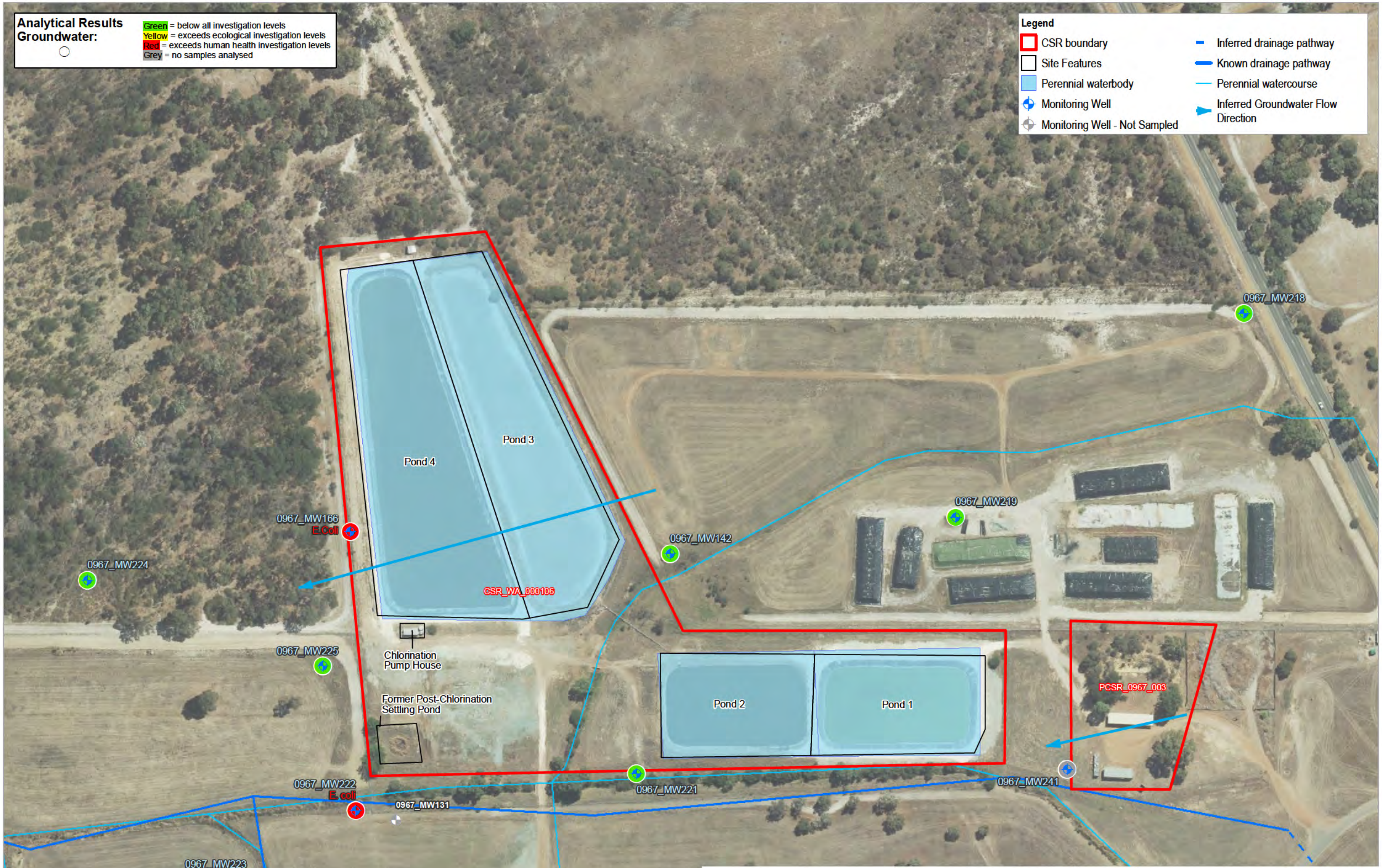
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000106
Sewage Treatment Plant
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 20B

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\6136234 06_020b_Sewage_Treatment_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:02

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams



Paper Size ISO A3
0 10 20 30 40
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

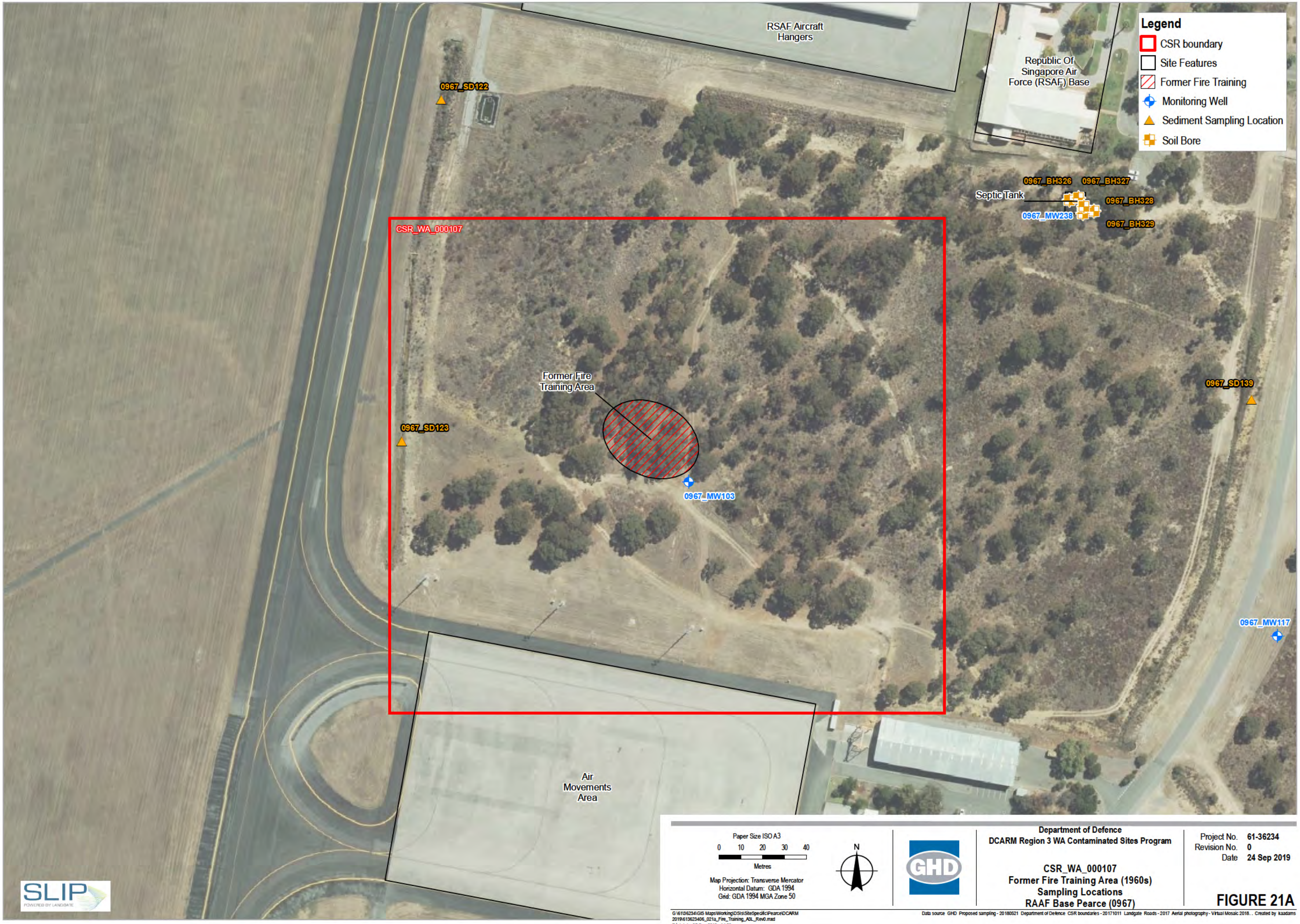
CSR_WA_000106
Sewage Treatment Plant
Groundwater Analytical Results (April 2019)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 20C

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_020c_Sewage_Treatment_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:02

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

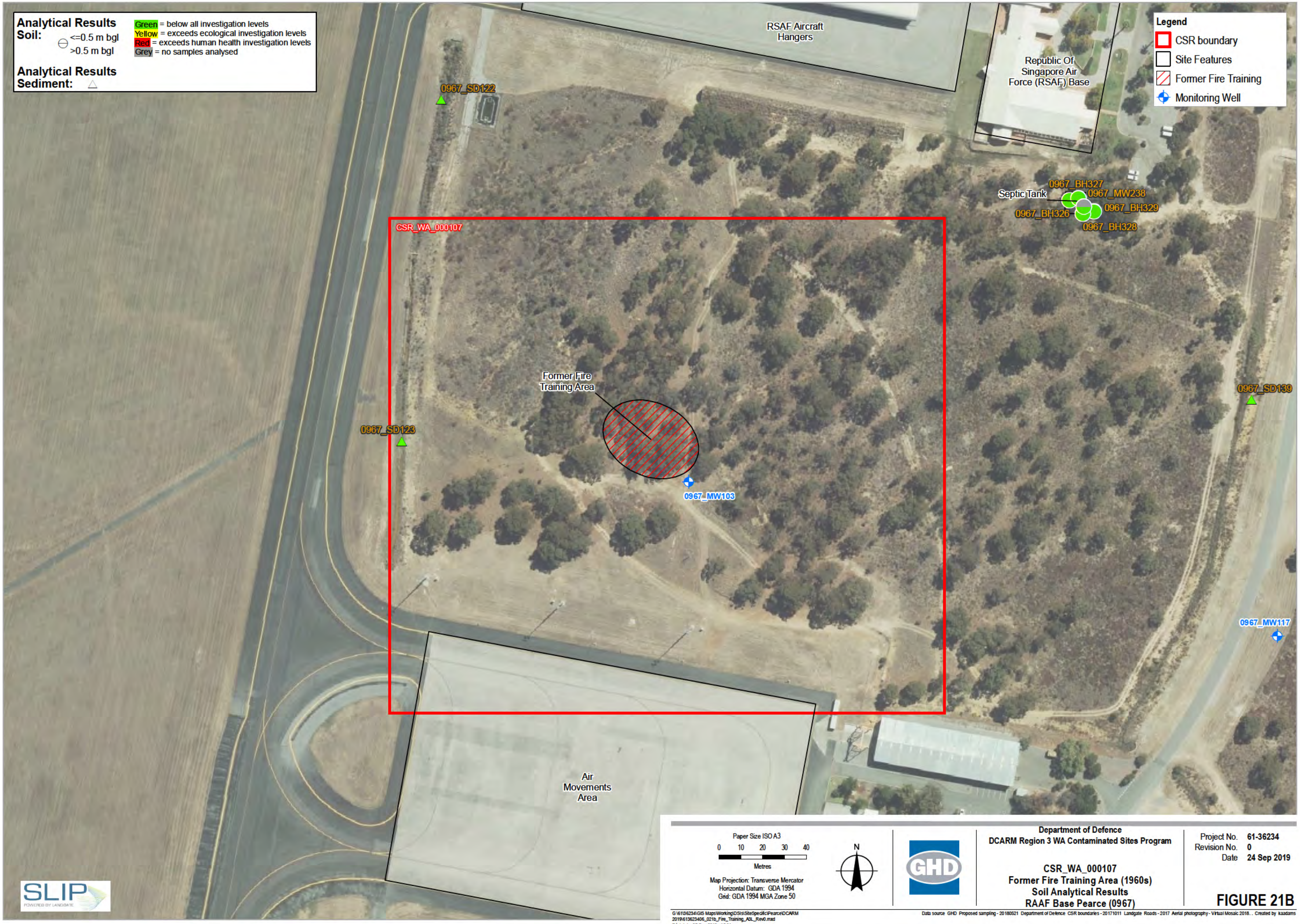
CSR_WA_000107
Former Fire Training Area (1960s)
Sampling Locations
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 21A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_021a_Fire_Training_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:50

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018.. Created by kaadams



Paper Size ISO A3

0 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000107
Former Fire Training Area (1960s)
Soil Analytical Results
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 21B

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_021b_Fire_Training_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:01

Data source: GHD Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams

Paper Size ISO A3

0 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

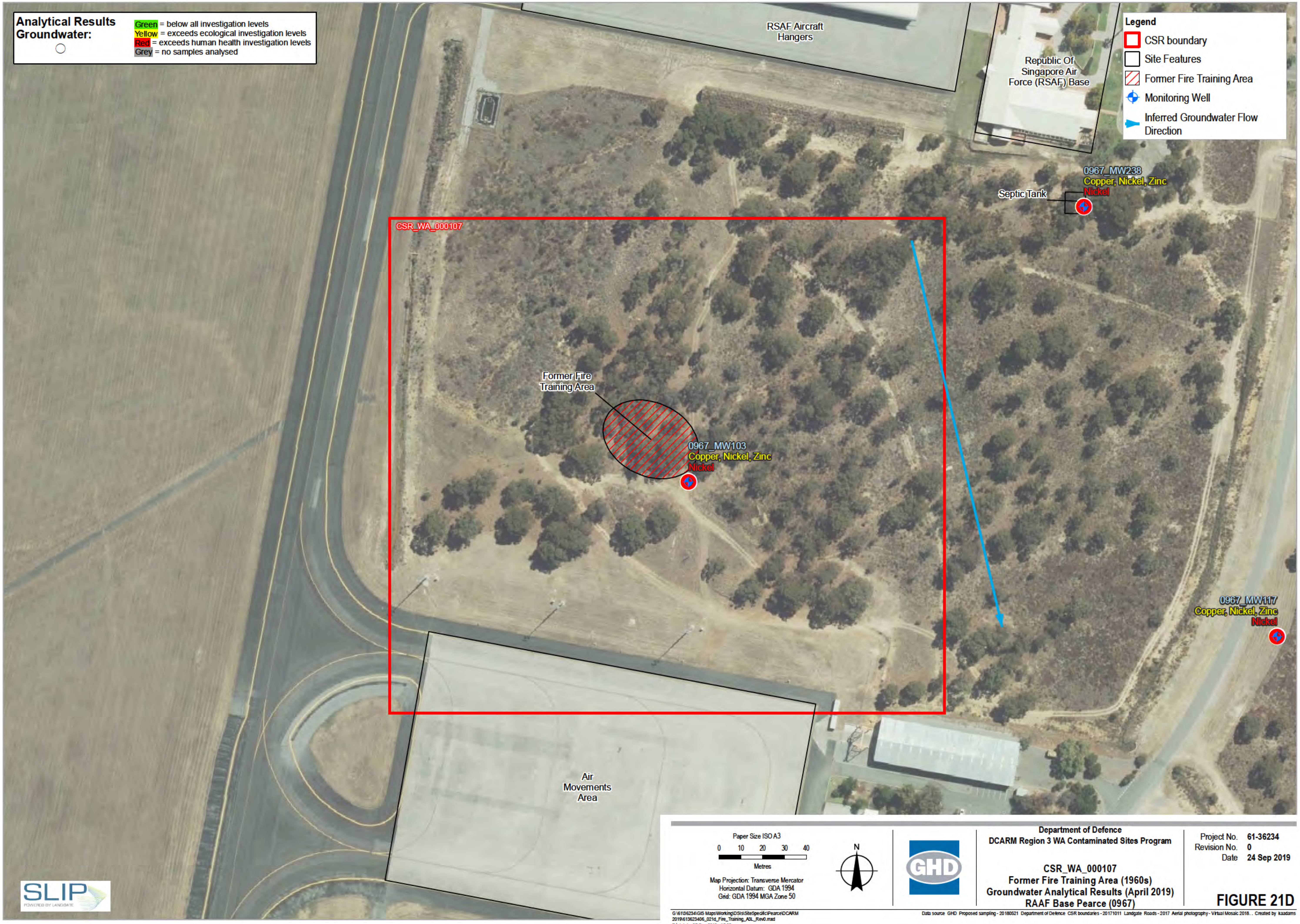
CSR_WA_000107
Former Fire Training Area (1960s)
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 21C

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_021c_Fire_Training_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:02

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018.. Created by kaadams



Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000107
Former Fire Training Area (1960s)
Groundwater Analytical Results (April 2019)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 21D

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_021d_Fire_Training_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:02

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018.. Created by kaadams

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000109
Near Building 239 - Former Group of USTs
Sampling Locations
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 22A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_022a_Former_USTs_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:18

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018.. Created by: kaadams

Paper Size ISO A3
0 2 4 6 8
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

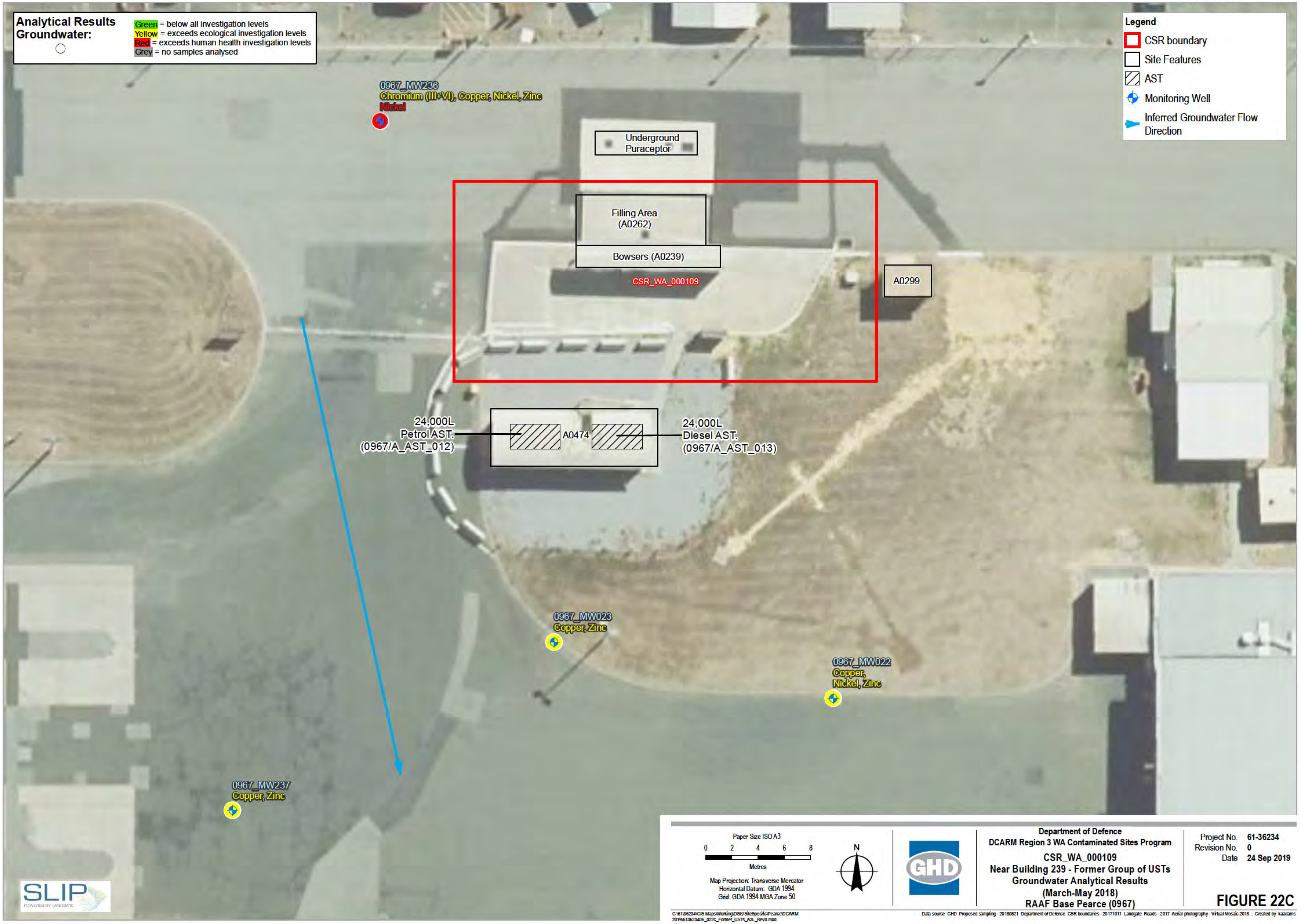
GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000109
Near Building 239 - Former Group of USTs
Soil Analytical Results
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 22B



Paper Size ISO A3

0 2 4 6 8

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000109
Near Building 239 - Former Group of USTs
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)

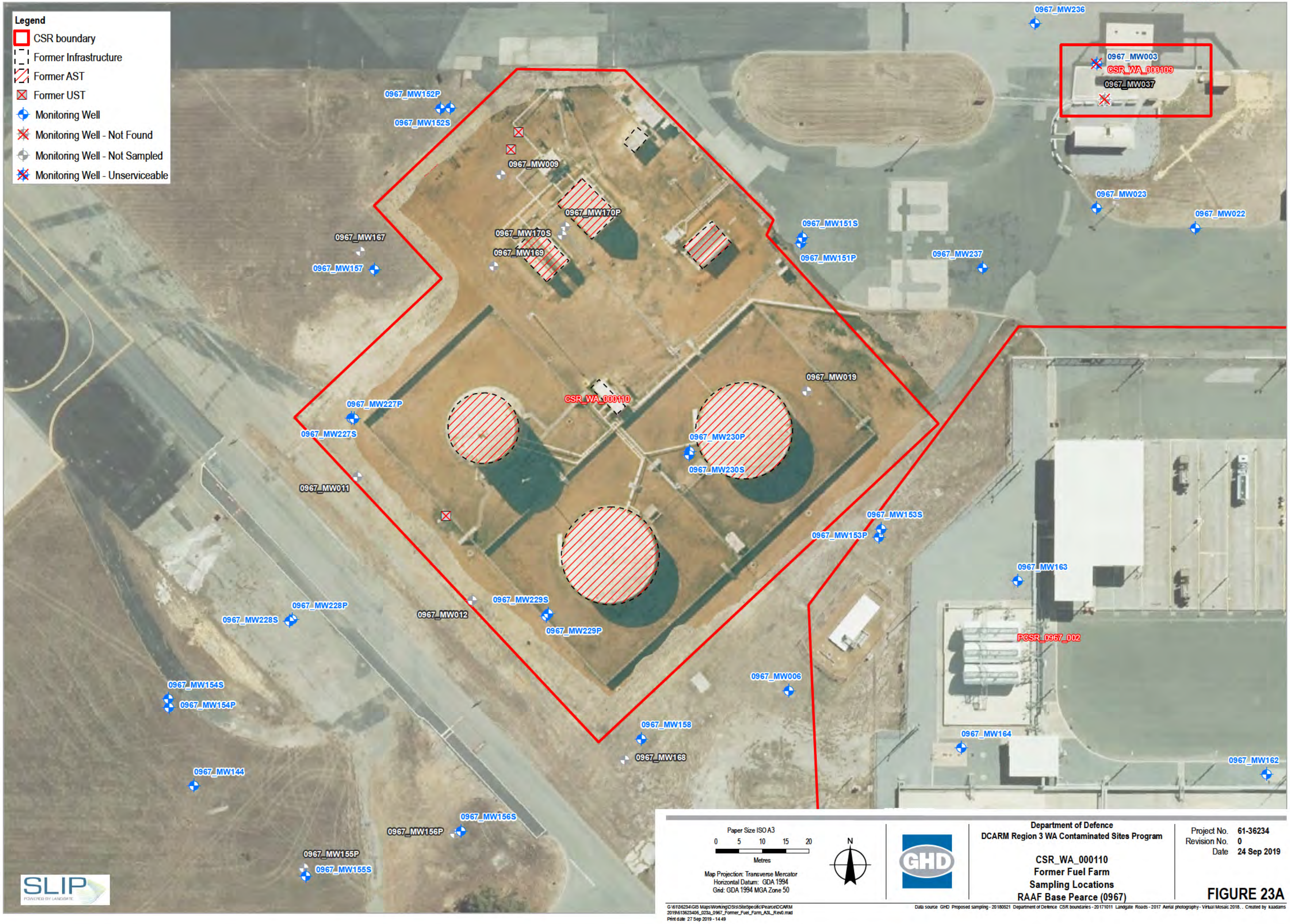
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

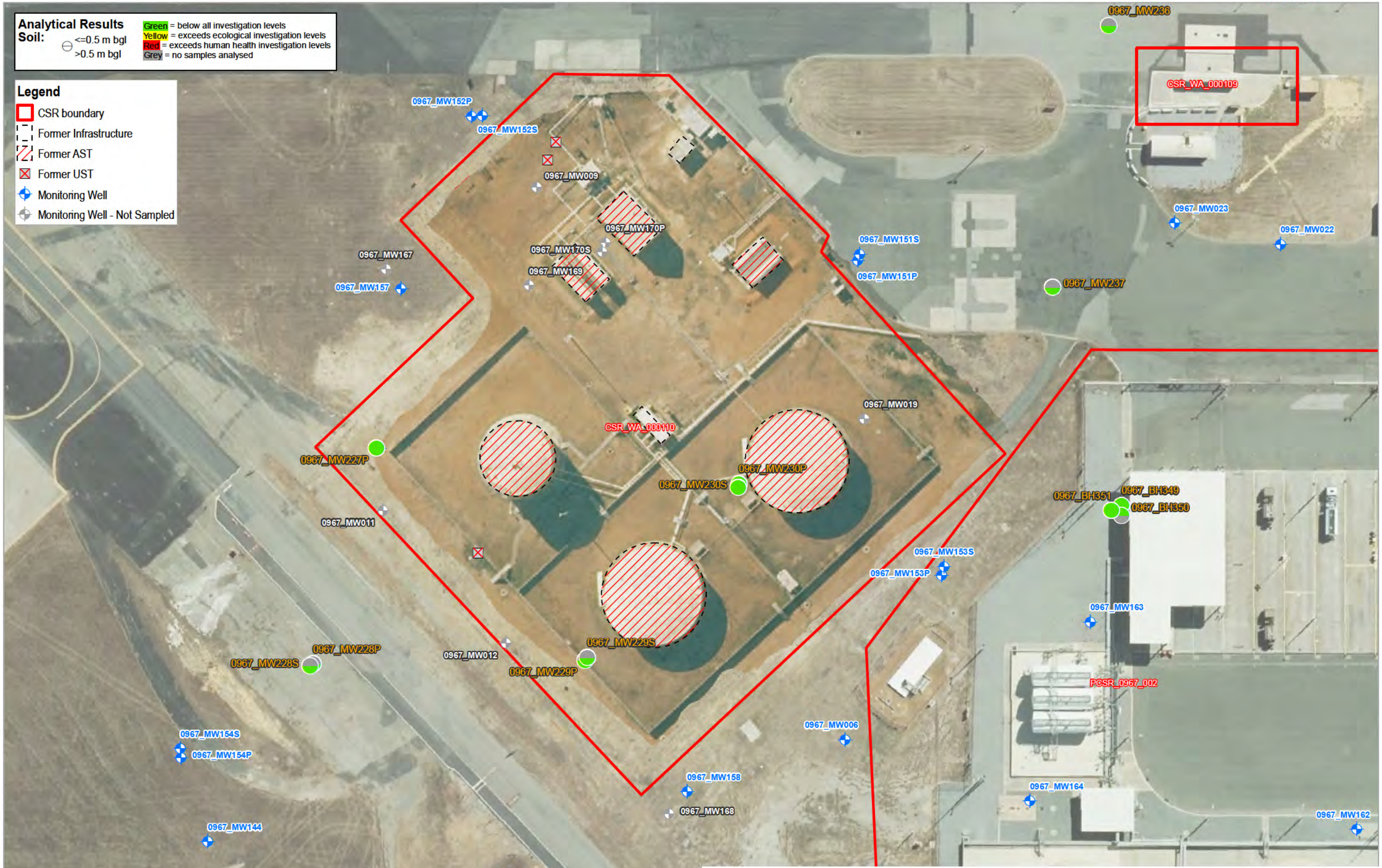
FIGURE 22C

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_022c_Former_USTs_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:43

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams

Defence FOI 536/21/22
Document 1





Paper Size ISO A3

0 5 10 15 20

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

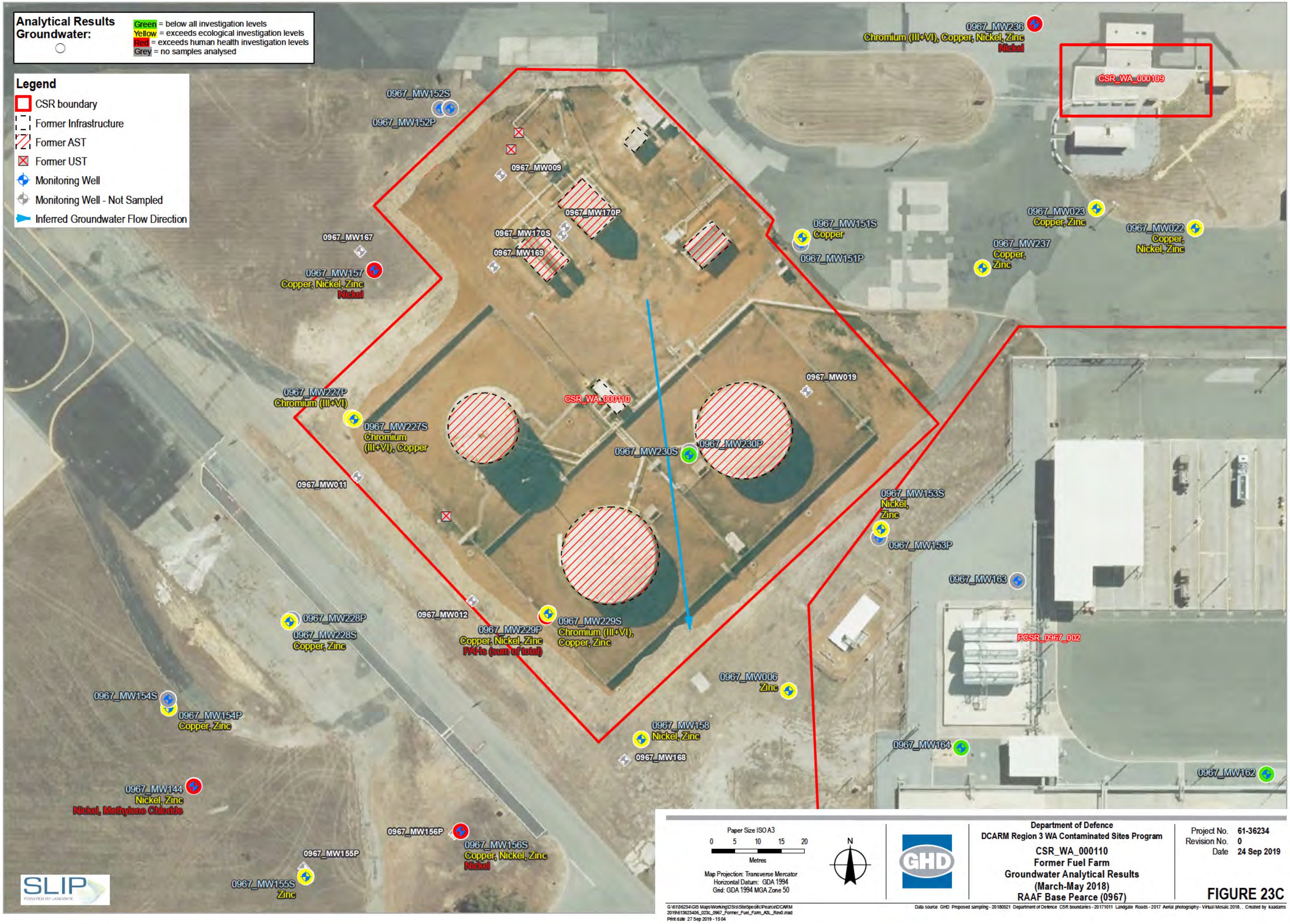
CSR_WA_000110
Former Fuel Farm
Soil Analytical Results
RAAF Base Pearce (0967)

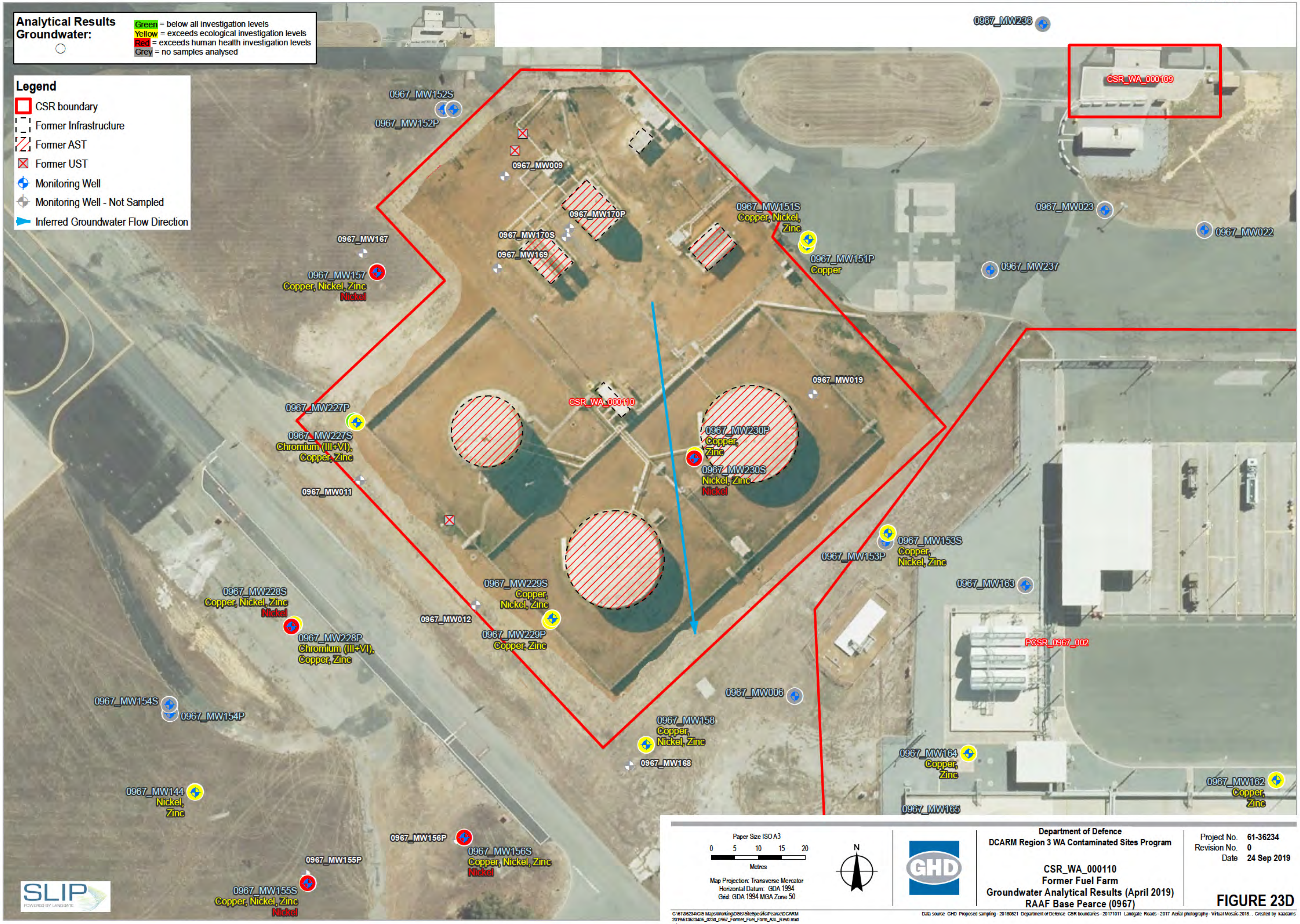
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 23B

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_023b_0967_Former_Fuel_Farm_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:03

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams


Analytical Results Groundwater:
Green = below all investigation levels
Yellow = exceeds ecological investigation levels
Red = exceeds human health investigation levels
Grey = no samples analysed
Legend
CSR boundary
Former Infrastructure
Former AST
Former UST
Monitoring Well
Monitoring Well - Not Sampled
Inferred Groundwater Flow Direction
0967_MW236
Chromium (III+VI), Copper, Nickel, Zinc
Nickel
CSR_WA_000109
0967_MW152S
0967_MW152P
0967_MW009
0967_MW170P
0967_MW170S
0967_MW169
0967_MW167
0967_MW157
Copper, Nickel, Zinc
Nickel
0967_MW151S
Copper
0967_MW151P
0967_MW023
Copper, Zinc
0967_MW022
Copper, Nickel, Zinc
0967_MW237
Copper, Zinc
0967_MW019
0967_MW227P
Chromium (III+VI)
0967_MW227S
Chromium (III+VI), Copper
CSR_WA_000110
0967_MW230S
0967_MW230P
0967_MW011
0967_MW153S
Nickel, Zinc
0967_MW153P
0967_MW163
0967_MW228P
0967_MW228S
Copper, Zinc
0967_MW012
0967_MW229P
Copper, Nickel, Zinc
PAHs (sum of total)
0967_MW229S
Chromium (III+VI), Copper, Zinc
PCSR_0967_002
0967_MW006
Zinc
0967_MW154S
0967_MW154P
Copper, Zinc
0967_MW158
Nickel, Zinc
0967_MW168
0967_MW164
0967_MW162
0967_MW144
Nickel, Zinc
Nickel, Methylene Chloride
0967_MW156P
0967_MW156S
Copper, Nickel, Zinc
Nickel
0967_MW155P
0967_MW155S
Zinc
SLIP
Paper Size ISO A3
0 5 10 15 20
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50
N
GHD
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000110
Former Fuel Farm
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019
FIGURE 23C



Paper Size ISO A3
0 5 10 15 20
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000110
Former Fuel Farm
Groundwater Analytical Results (April 2019)
RAAF Base Pearce (0967)

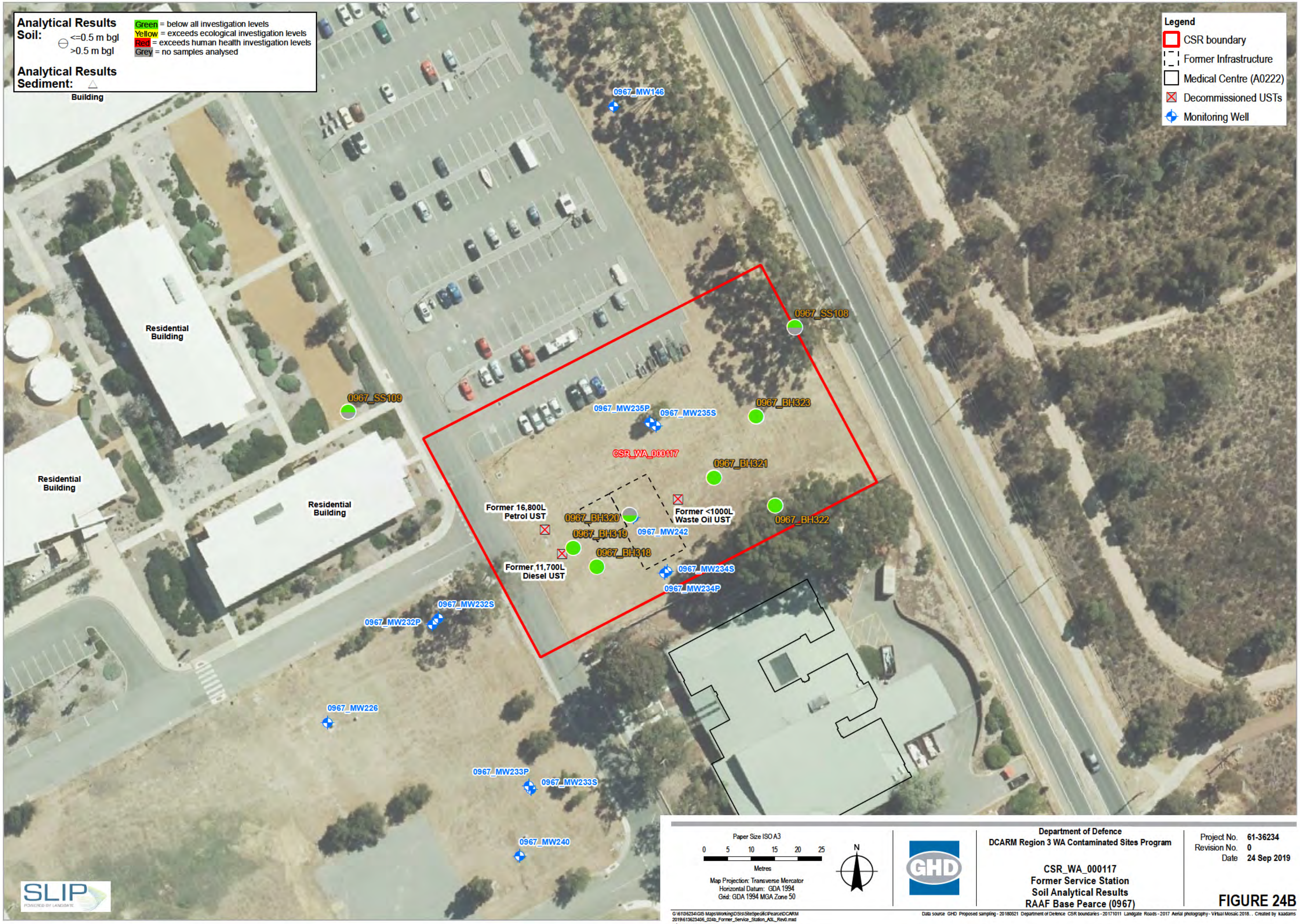
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 23D

G:\61\36234\GIS\Maps\Working\DSI\SiteSpecific\Pearce\DCARM 2019\613623406_023d_0967_Former_Fuel_Farm_ASL_Rev0.mxd
Print date: 27 Sep 2019 - 15:21

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams

Defence FOI 536/21/22
Document 1



Paper Size ISO A3
0 5 10 15 20 25
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000117
Former Service Station
Soil Analytical Results
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 24B

G:\61\36234\GIS\Maps\Working\DSI\SiteSpecific\Pearce\DCARM 2019\6136234_024b_Former_Service_Station_ASL_Rev0.mxd
Print date: 27 Sep 2019 - 15:01

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams

Paper Size ISO A3

0 5 10 15 20 25

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000117
Former Service Station
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 24C

G:\61\36234\GIS Maps\Working\DSI\SiteSpecific\Pearce\DCARM 2019\613623406_024c_Former_Service_Station_A3L_Rev0.mxd
Print date: 27 Sep 2019 - 15:05

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams

Paper Size ISO A3

0 5 10 15 20 25

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

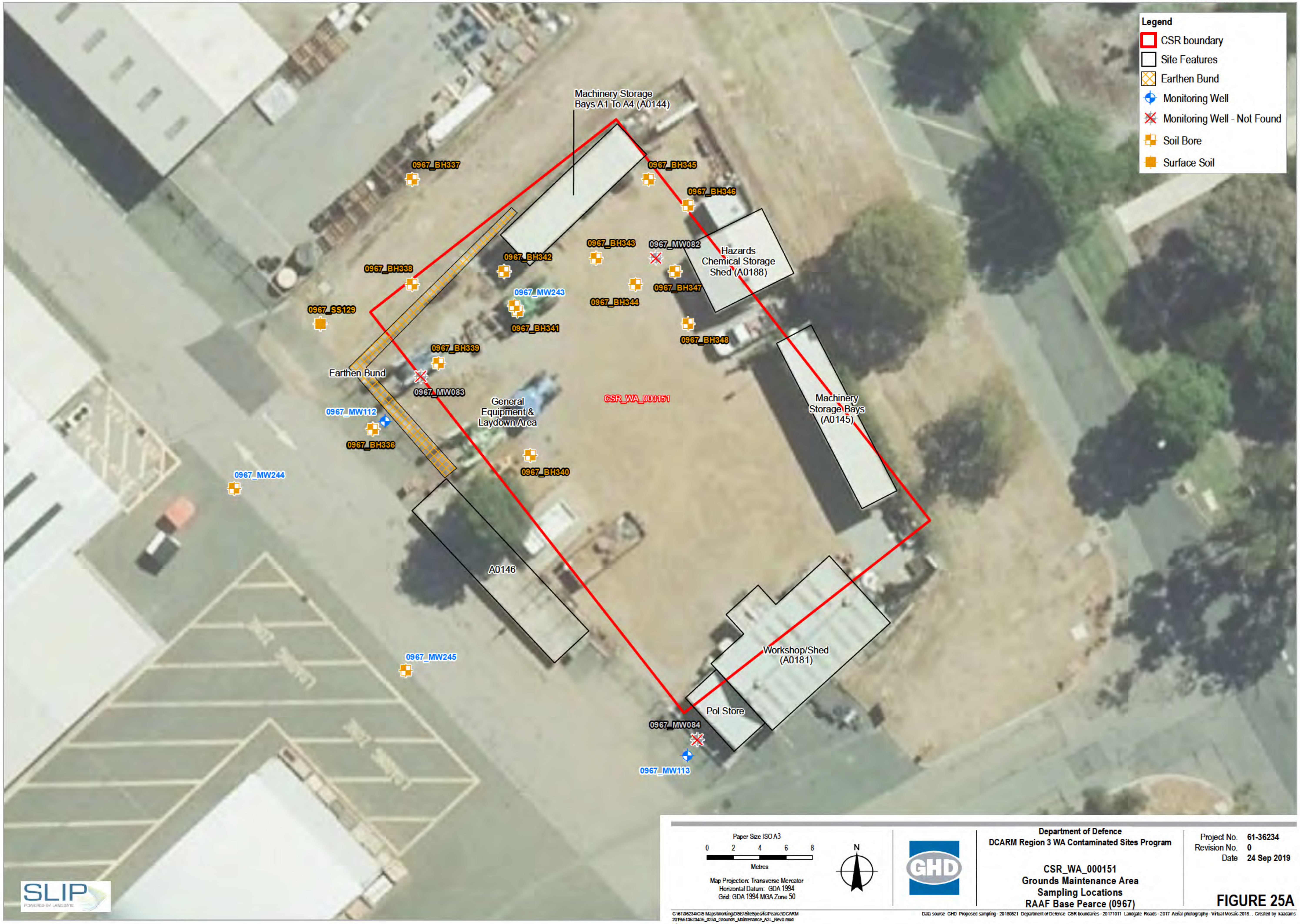
CSR_WA_000117
Former Service Station
Groundwater Analytical Results (April 2019)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 24D

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_024d_Former_Service_Station_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:05

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018.. Created by kaadams



Paper Size ISO A3

0 2 4 6 8

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000151
Grounds Maintenance Area
Sampling Locations
RAAF Base Pearce (0967)

Project No. **61-36234**
Revision No. **0**
Date **24 Sep 2019**

FIGURE 25A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_025a_Grounds_Maintenance_A3L_Rev0.mxd
Print date: 27 Sep 2019 - 14:49

Data source: GHD: Proposed sampling - 20180521; Department of Defence: CSR boundaries - 20171011; Landgate: Roads - 2017; Aerial photography - Virtual Mosaic 2018. . Created by: kaadams

Paper Size ISO A3

0 2 4 6 8

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

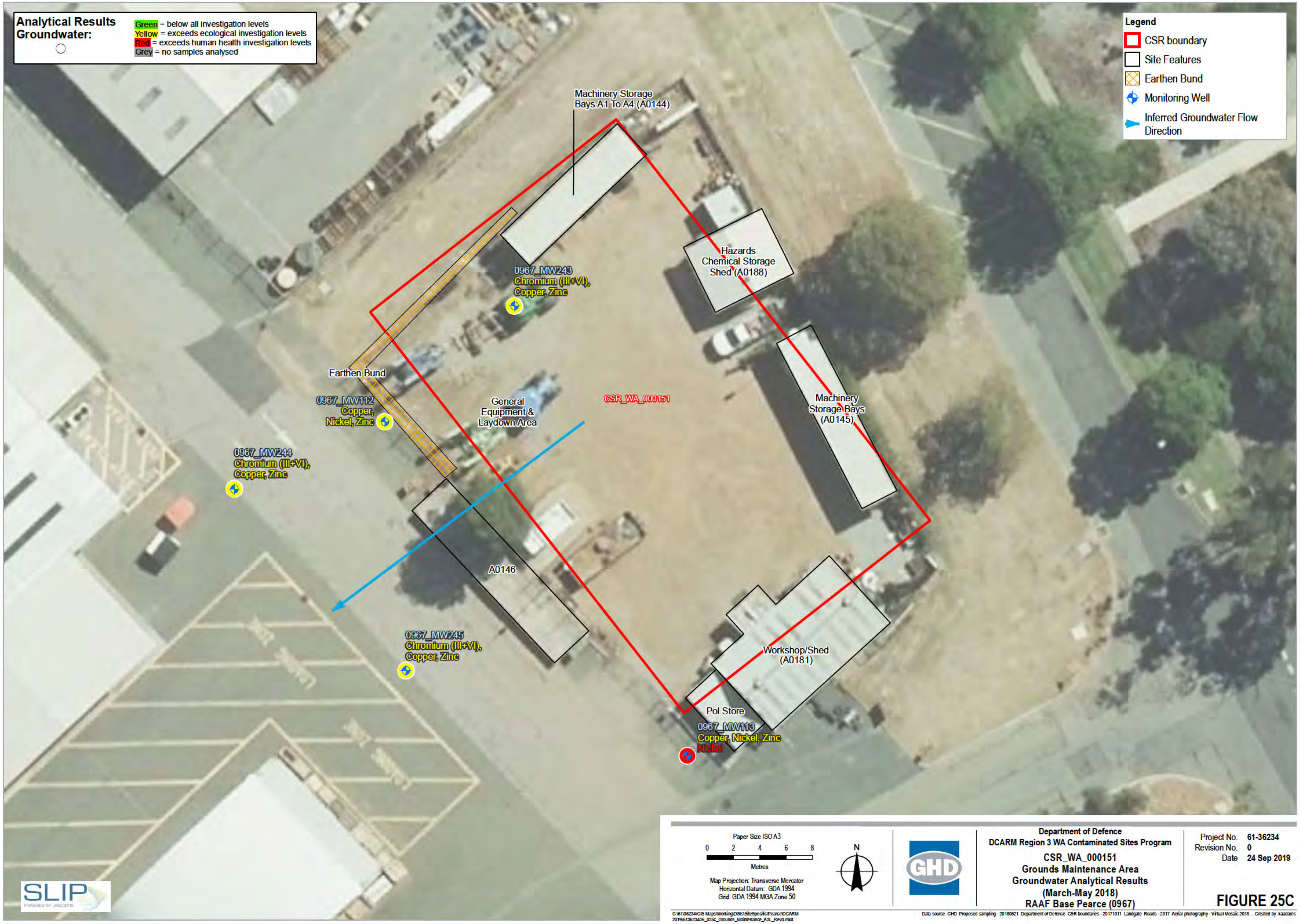
CSR_WA_000151
Grounds Maintenance Area
Soil Analytical Results
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 25B

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_025b_Grounds_Maintenance_A3L_Rev0.mxd
Print date: 27 Sep 2019 - 15:00

Data source: GHD: Proposed sampling - 20180521; Department of Defence: CSR boundaries - 20171011; Landgate: Roads - 2017; Aerial photography - Virtual Mosaic 2018. . Created by: kaadams



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000151
Grounds Maintenance Area
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)

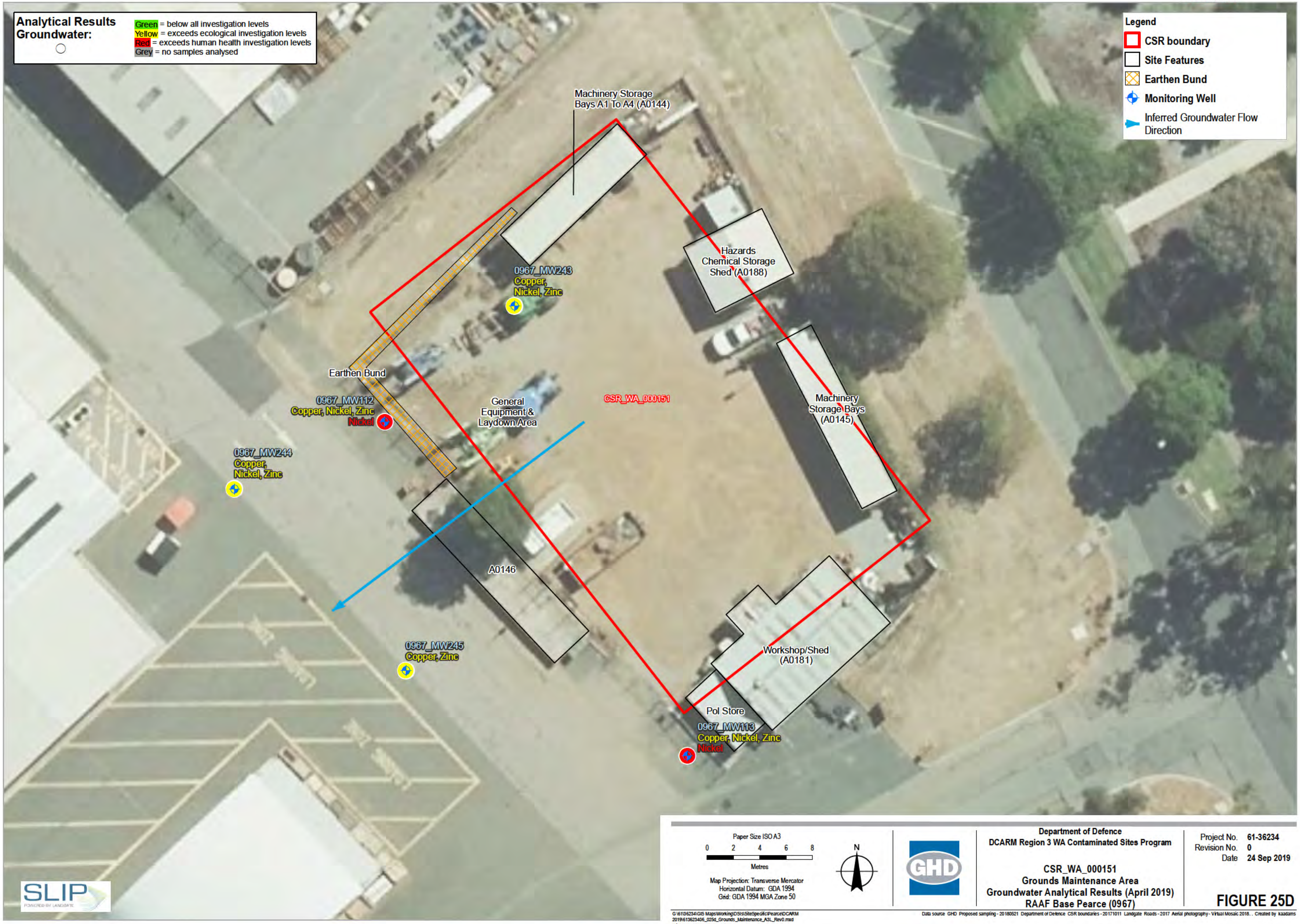
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 25C

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_025c_Grounds_Maintenance_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:00

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018.. Created by kaadams

Defence FOI 536/21/22
Document 1



Paper Size ISO A3
0 2 4 6 8
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

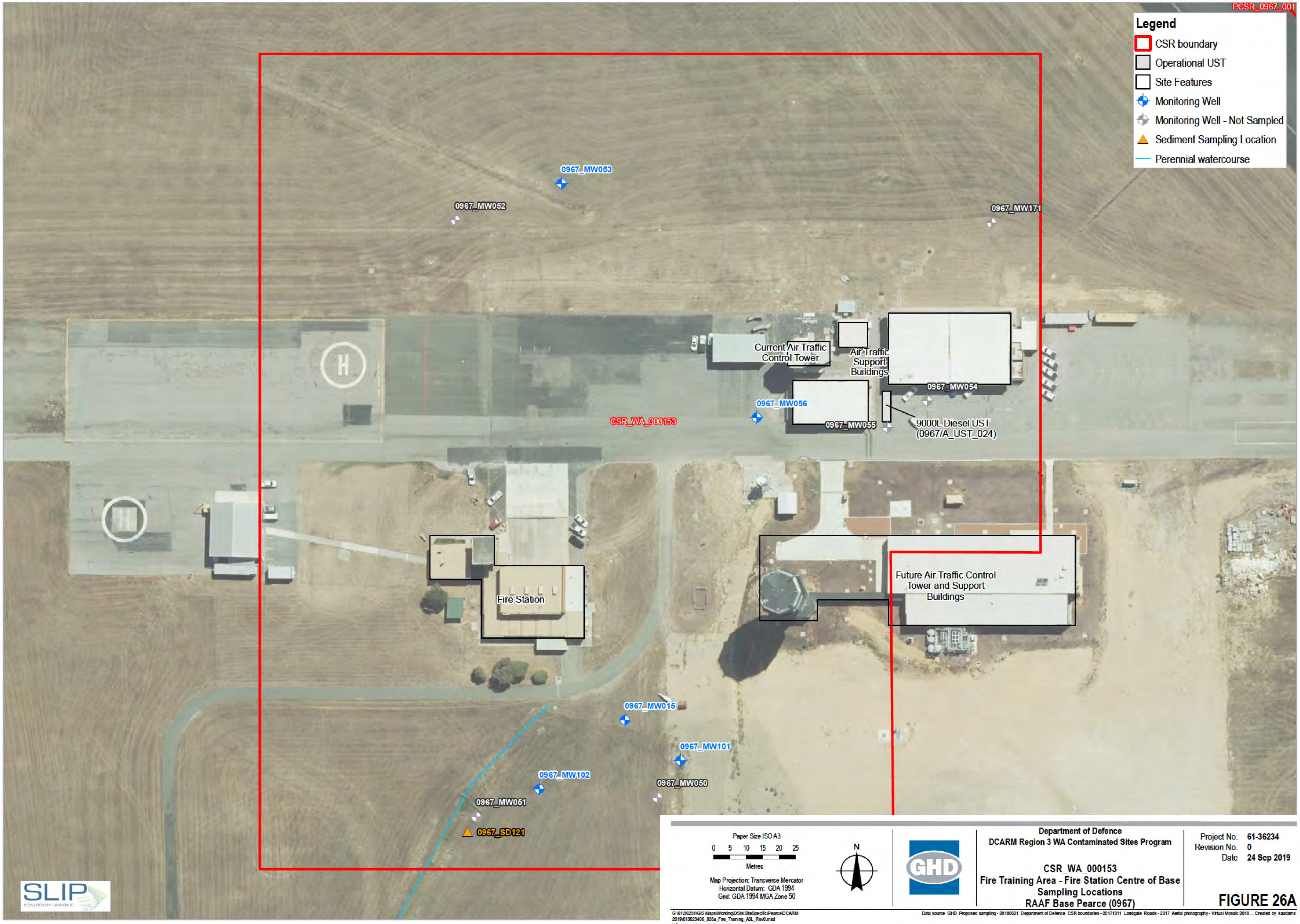
CSR_WA_000151
Grounds Maintenance Area
Groundwater Analytical Results (April 2019)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 25D

G:\61\36234\GIS Maps\Working\DSI\SiteSpecific\Pearce\DCARM 2019\613623406_025d_Grounds_Maintenance_A3L_Rev0.mxd
Print date: 27 Sep 2019 - 15:00

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams



Paper Size ISO A3
0 5 10 15 20 25
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

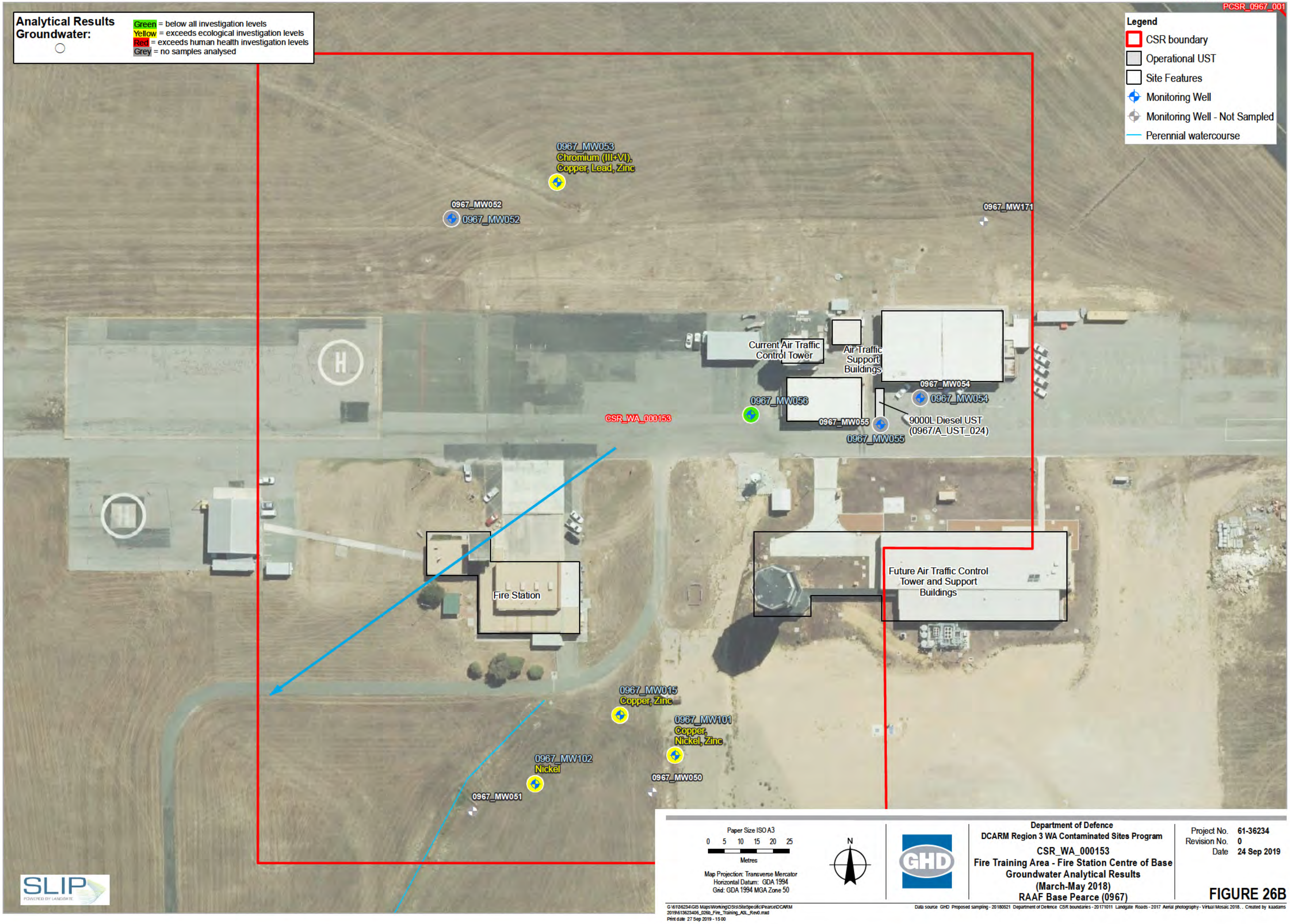
CSR_WA_000153
Fire Training Area - Fire Station Centre of Base
Sampling Locations
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 26A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_026a_Fire_Training_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:52

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams


PCSR_0967_001
Analytical Results Groundwater:
Green = below all investigation levels
Yellow = exceeds ecological investigation levels
Red = exceeds human health investigation levels
Grey = no samples analysed
Legend
CSR boundary
Operational UST
Site Features
Monitoring Well
Monitoring Well - Not Sampled
Perennial watercourse
0967_MW053
Chromium (III+VI), Copper, Lead, Zinc
0967_MW052
0967_MW052
0967_MW171
Current Air Traffic Control Tower
Air Traffic Support Buildings
0967_MW054
0967_MW054
0967_MW056
CSR_WA_000153
0967_MW055
0967_MW055
9000L Diesel UST (0967/A_UST_024)
Fire Station
Future Air Traffic Control Tower and Support Buildings
0967_MW015
Copper, Zinc
0967_MW101
Copper, Nickel, Zinc
0967_MW102
Nickel
0967_MW050
0967_MW051
SLIP
Paper Size ISO A3
0 5 10 15 20 25
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50
N
GHD
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000153
Fire Training Area - Fire Station Centre of Base
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019
FIGURE 26B

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000155
Fuel Storage Power Station
Sampling Locations
RAAF Base Pearce (0967)

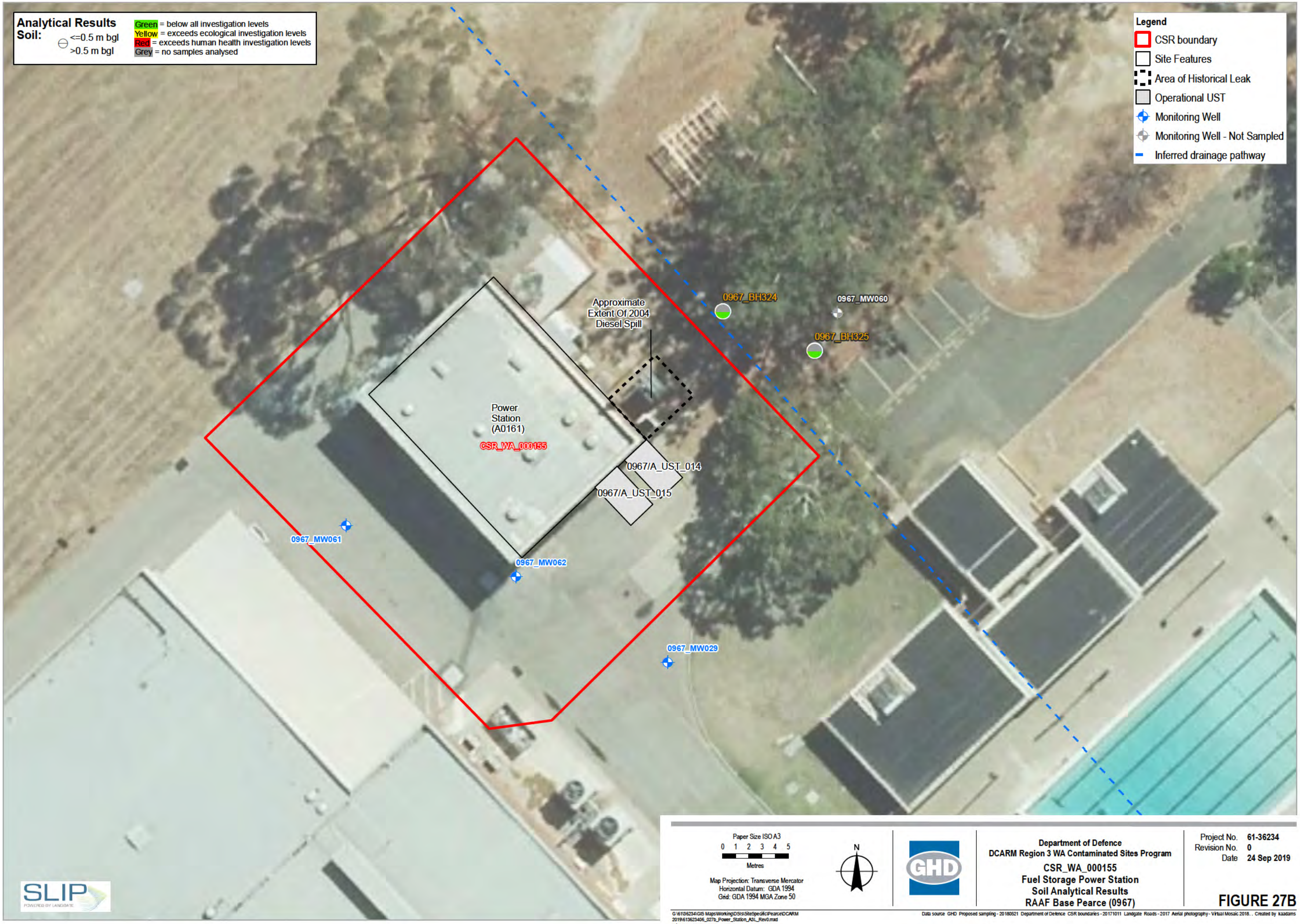
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 27A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_027a_Power_Station_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:50

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams

Defence FOI 536/21/22
Document 1



Paper Size ISO A3
0 1 2 3 4 5
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

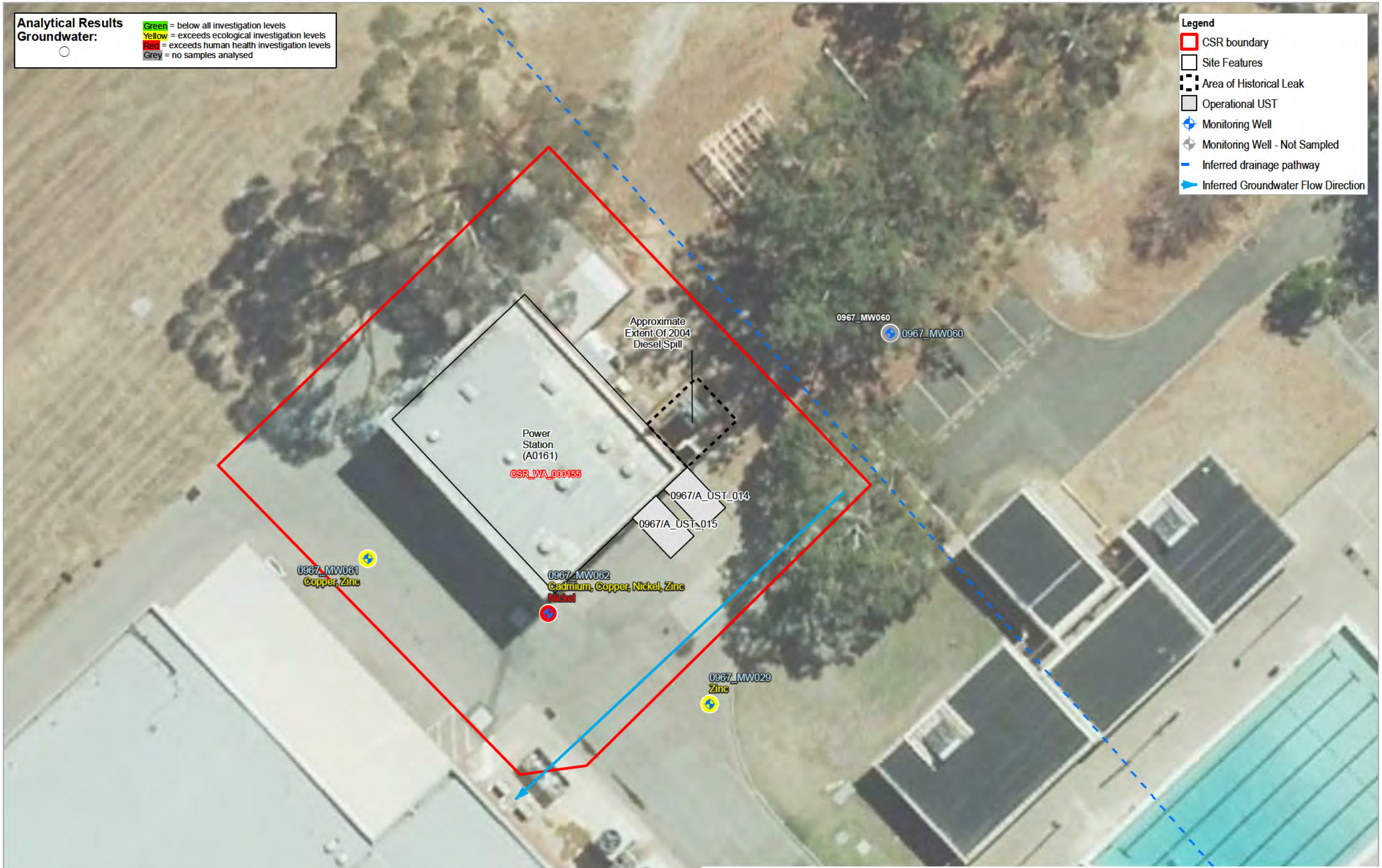
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000155
Fuel Storage Power Station
Soil Analytical Results
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 27B

G:\61\36234\GIS Maps\Working\DSI\SiteSpecific\Pearce\DCARM 2019\6136234_027b_Power_Station_A3L_Rev0.mxd
Print date: 27 Sep 2019 - 14:59

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams



Paper Size ISO A3

0 1 2 3 4 5

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000155
Fuel Storage Power Station
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)

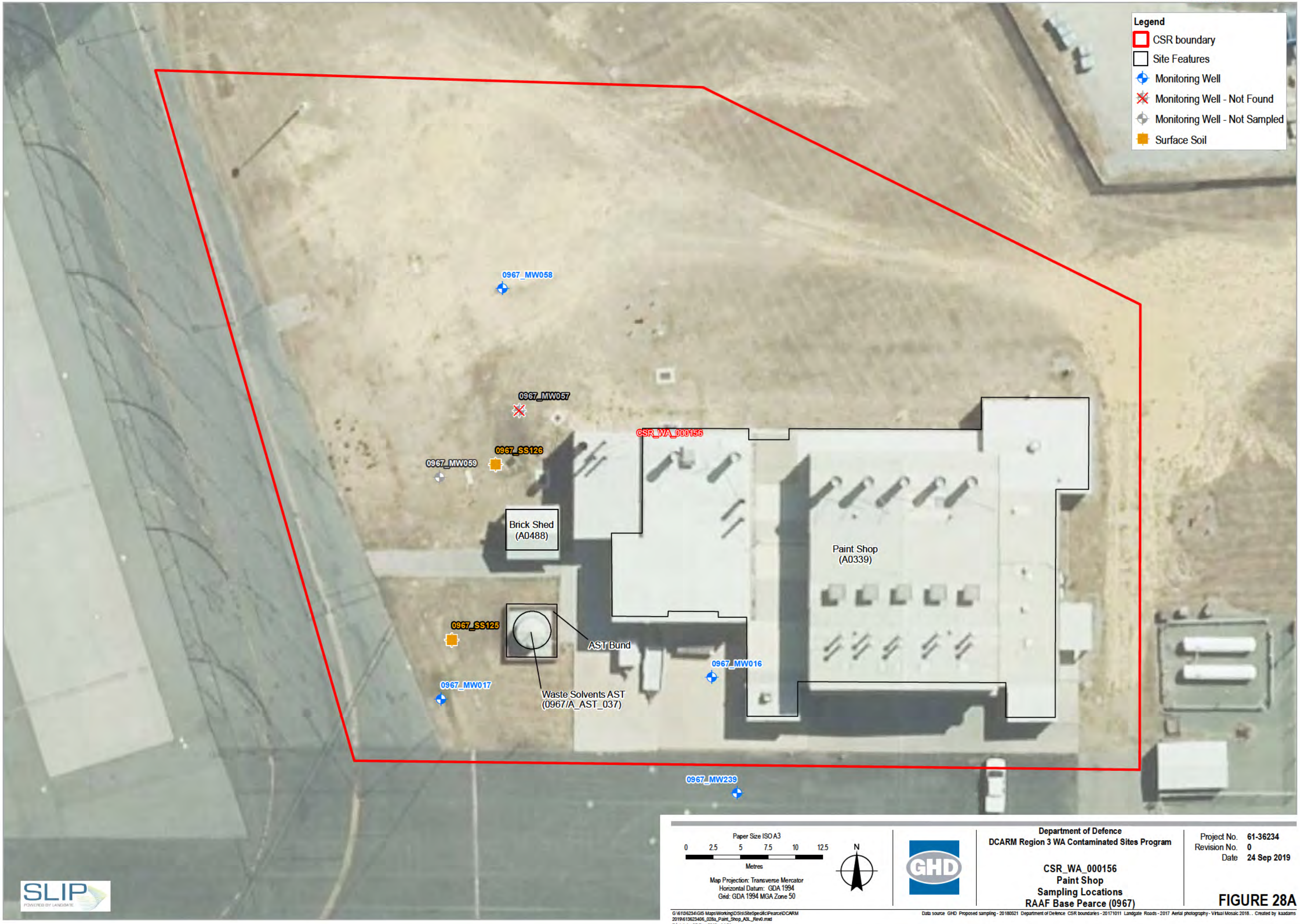
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 27C

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_027c_Power_Station_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:00

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018.. Created by kaadams

Defence FOI 536/21/22
Document 1



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

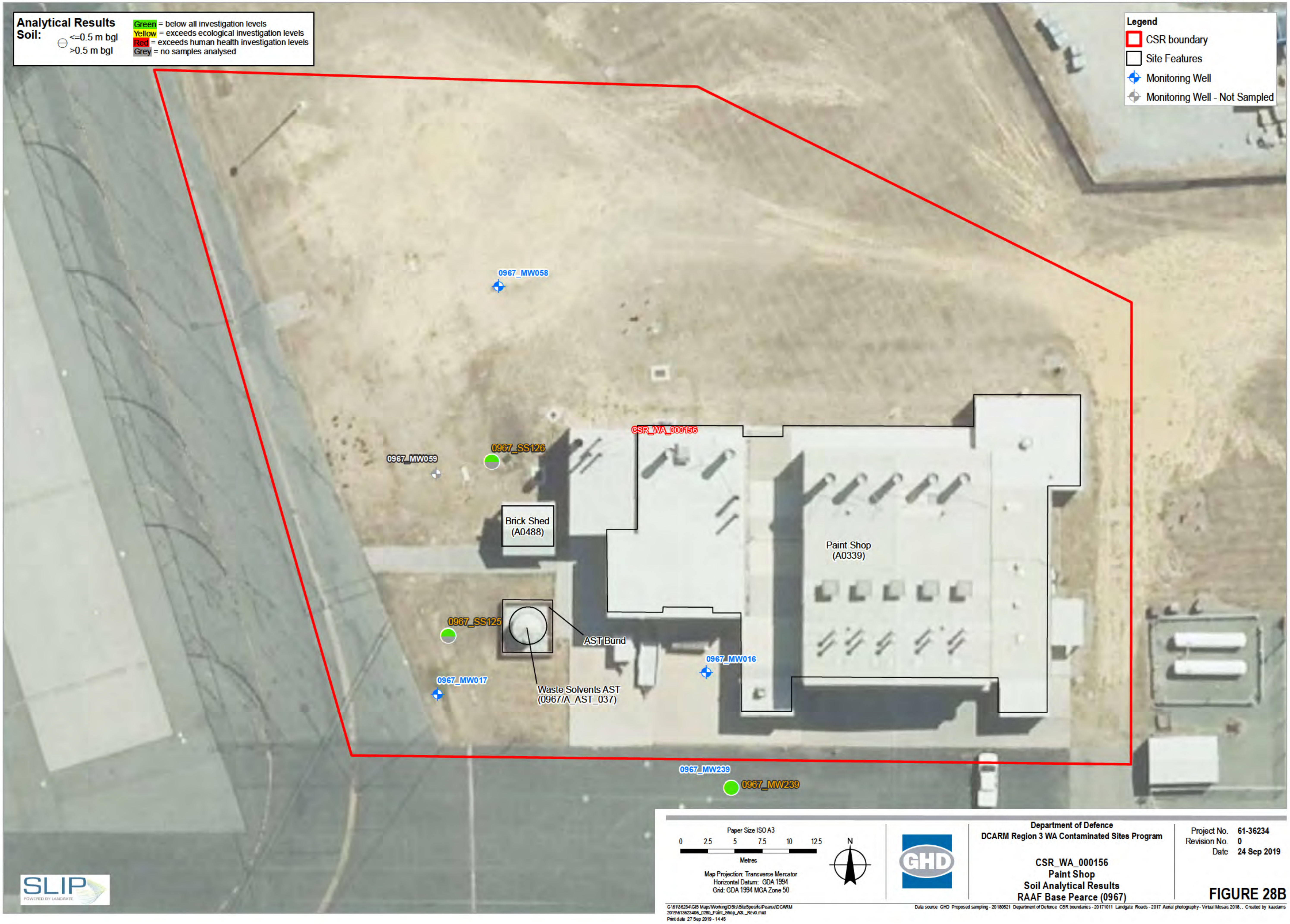
CSR_WA_000156
Paint Shop
Sampling Locations
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

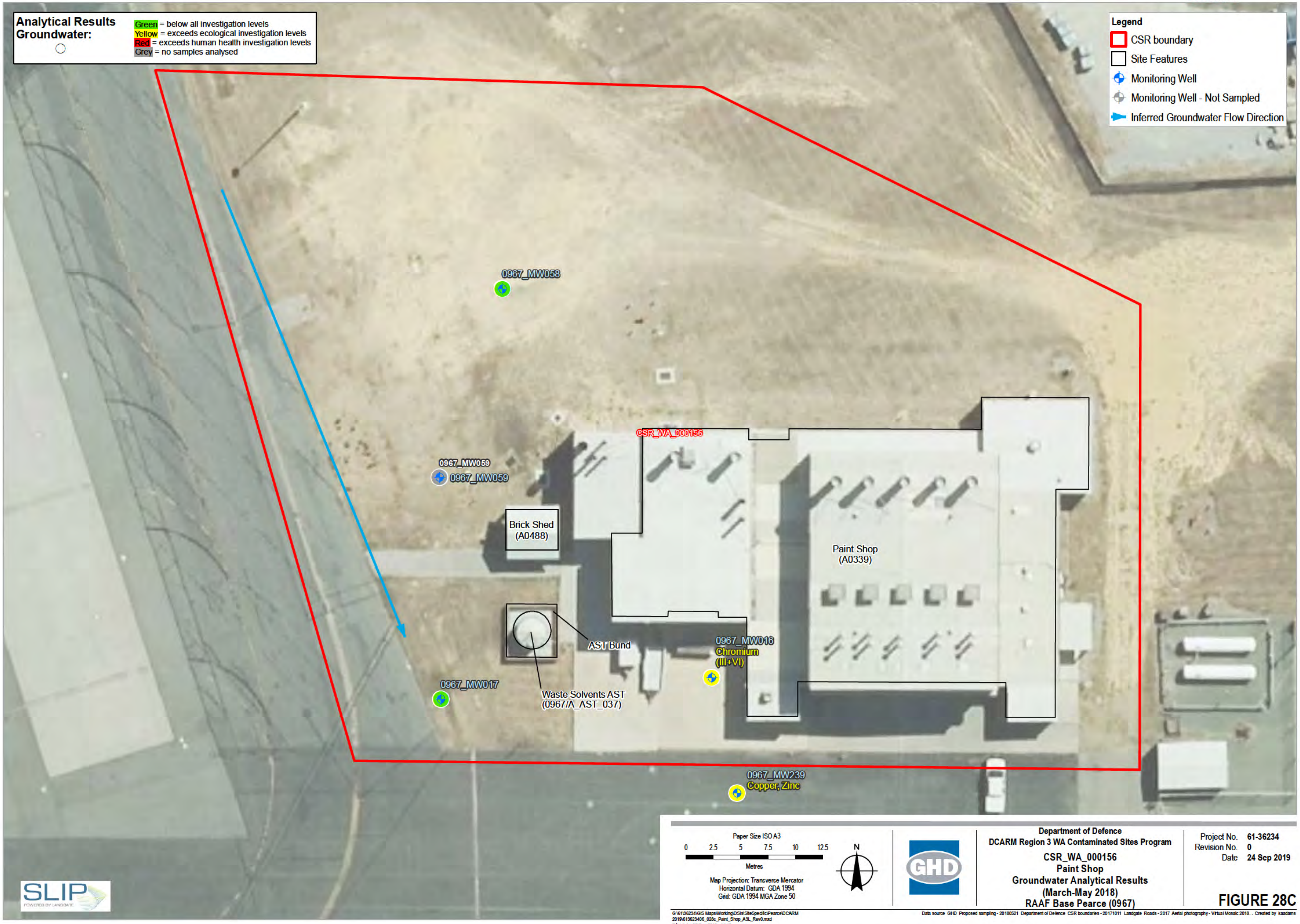
FIGURE 28A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_028a_Paint_Shop_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:51

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams


Analytical Results
Soil:
<=0.5 m bgl
>0.5 m bgl
Green = below all investigation levels
Yellow = exceeds ecological investigation levels
Red = exceeds human health investigation levels
Grey = no samples analysed
Legend
CSR boundary
Site Features
Monitoring Well
Monitoring Well - Not Sampled
0967_MW058
CSR_WA_000156
0967_SS126
0967_MW059
Brick Shed
(A0488)
Paint Shop
(A0339)
0967_SS125
AST Bund
0967_MW016
0967_MW017
Waste Solvents AST
(0967/A_AST_037)
0967_MW239
0967_MW239
SLIP
Paper Size ISO A3
0 2.5 5 7.5 10 12.5
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50
N
GHD
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000156
Paint Shop
Soil Analytical Results
RAAF Base Pearce (0967)
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019
FIGURE 28B

Defence FOI 536/21/22
Document 1



Paper Size ISO A3
0 2.5 5 7.5 10 12.5
Metres
N
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

GHD

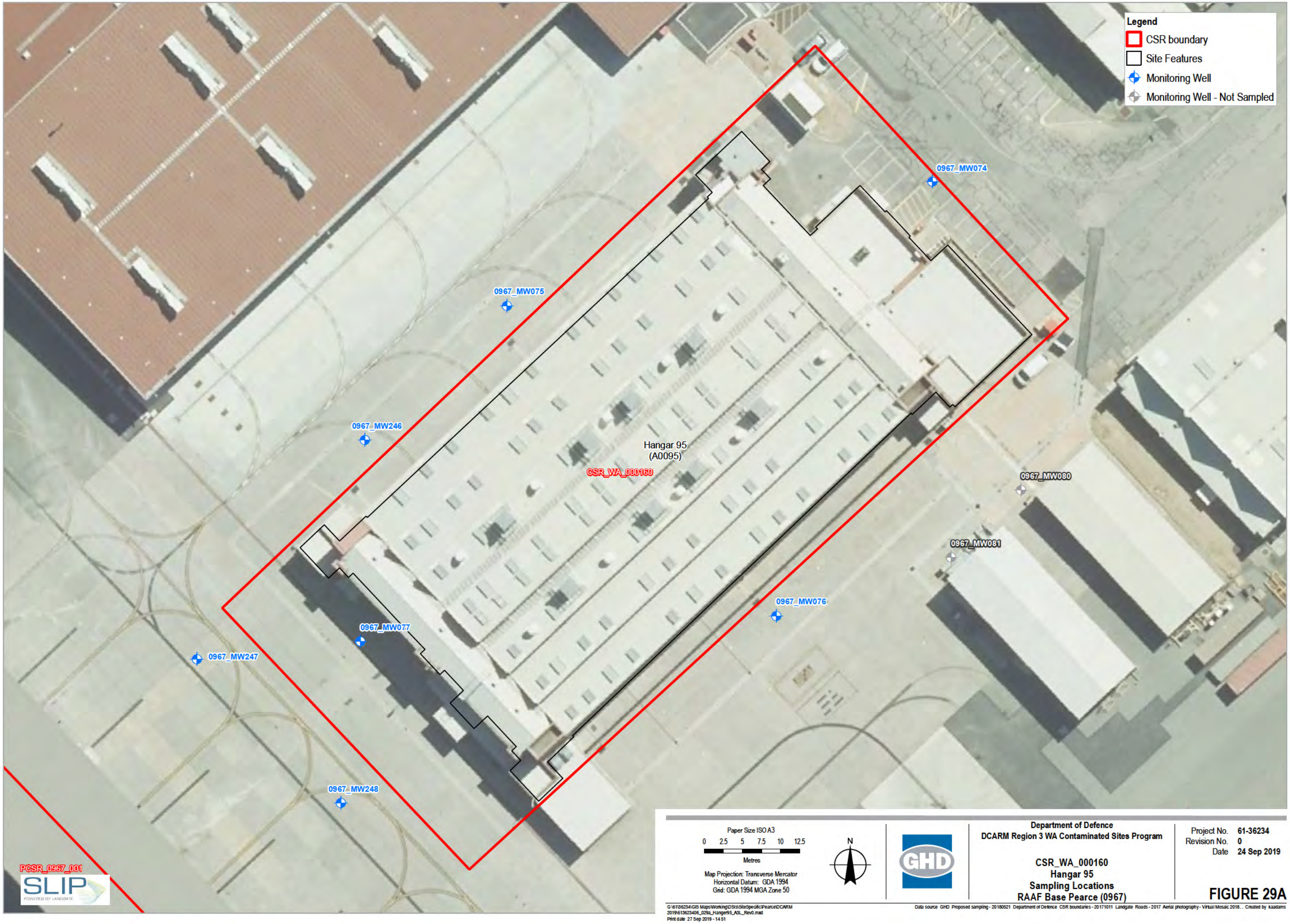
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000156
Paint Shop
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 28C

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_028c_Paint_Shop_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:43

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams


Legend
CSR boundary
Site Features
Monitoring Well
Monitoring Well - Not Sampled
0967_MW074
0967_MW075
0967_MW246
0967_MW080
0967_MW081
0967_MW076
0967_MW077
0967_MW247
0967_MW248
Hangar 95
(A0095)
CSR_WA_000160
PCSR_0967_001
SLIP
Paper Size ISO A3
0 2.5 5 7.5 10 12.5
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50
N
GHD
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000160
Hangar 95
Sampling Locations
RAAF Base Pearce (0967)
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019
FIGURE 29A

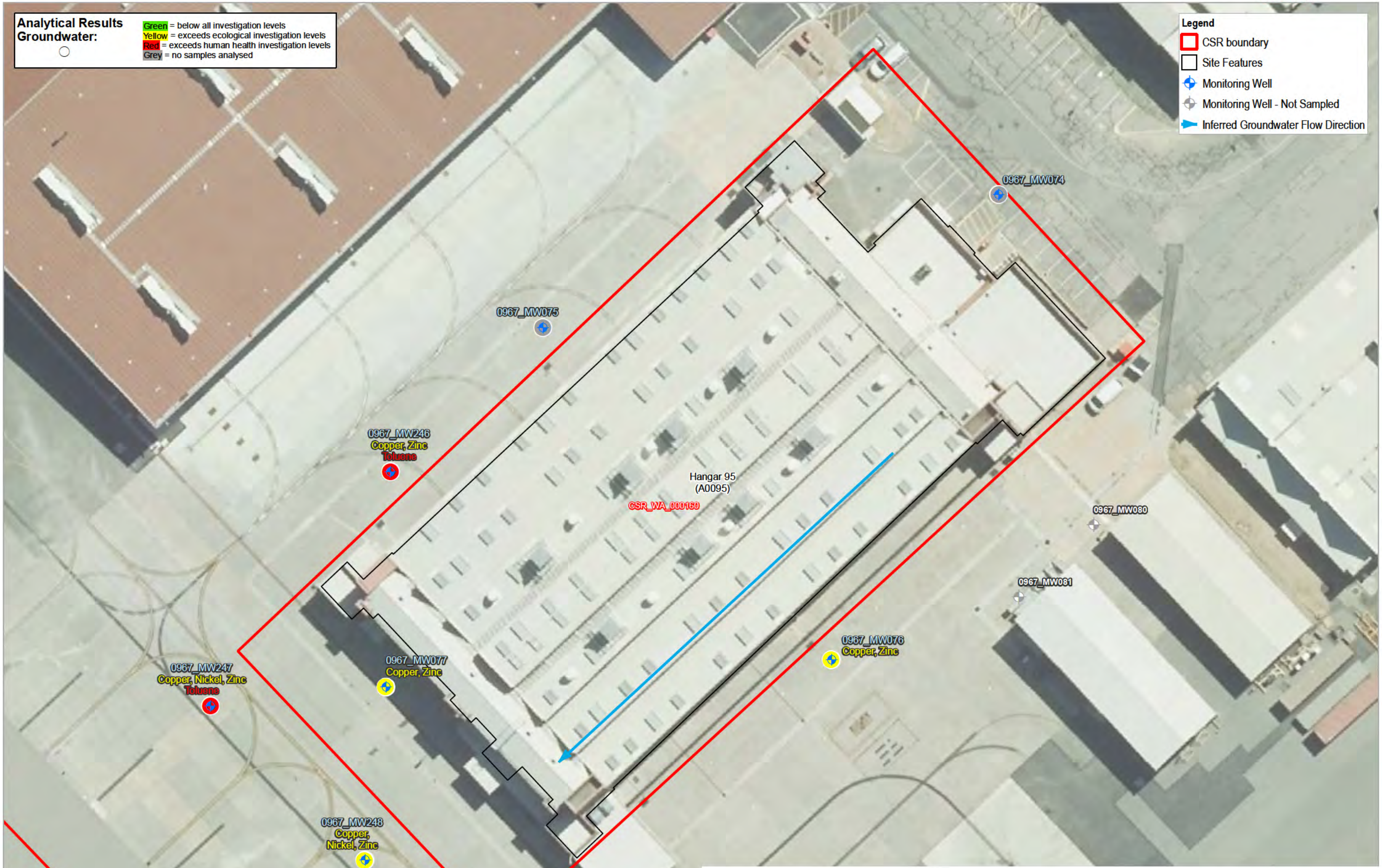
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000160
Hangar 95
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 29B

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_029b_Hanger95_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:59

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams



Paper Size ISO A3

0 2.5 5 7.5 10 12.5

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000160
Hangar 95
Groundwater Analytical Results (April 2019)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 29C

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_029c_Hanger95_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:59

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams

Paper Size ISO A3

0 10 20 30 40 50

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

PCSR_0967_001
Aircraft Shelters
Sampling Locations
RAAF Base Pearce (0967)

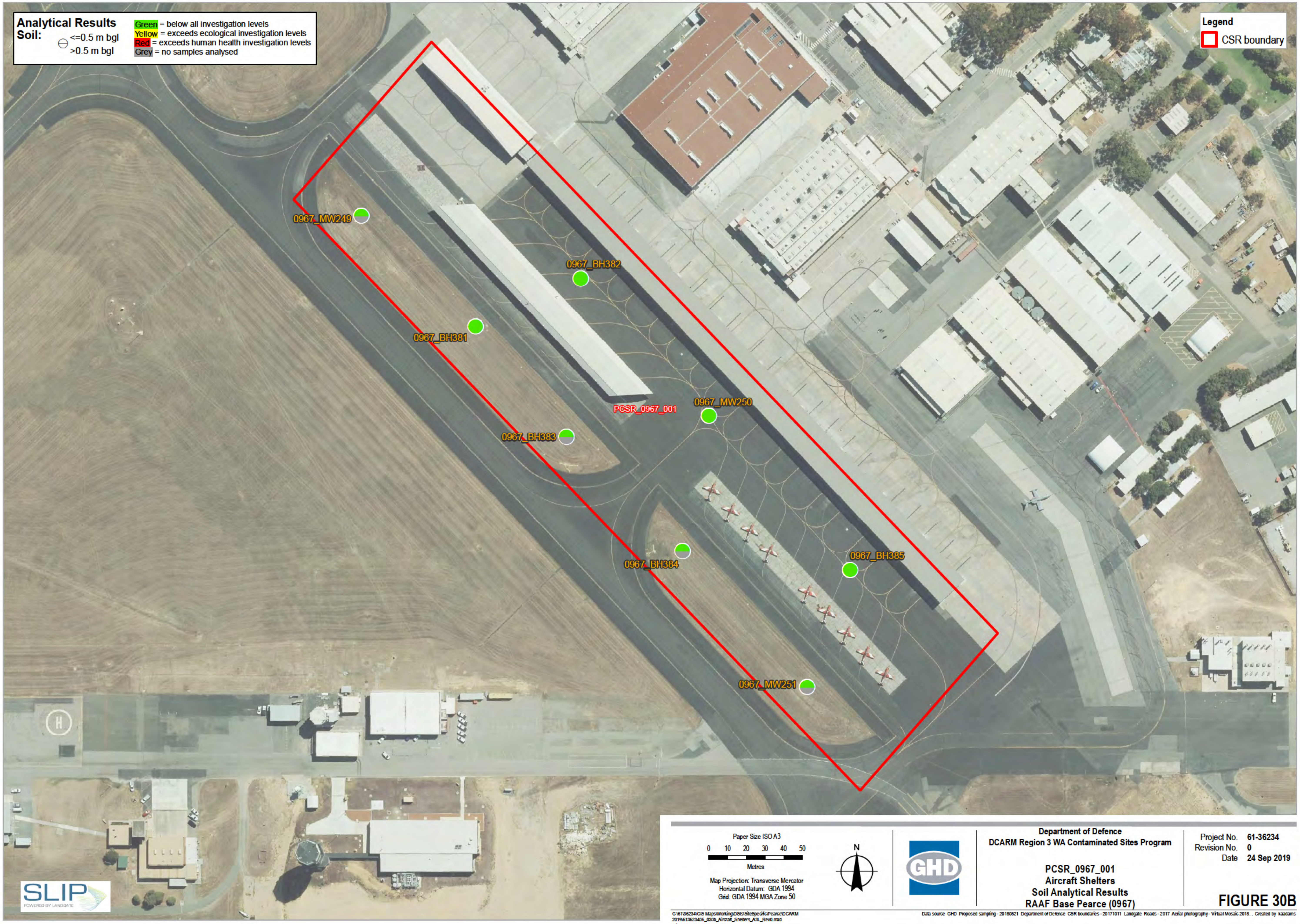
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 30A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_030a_Aircraft_Shelters_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:52

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams

Defence FOI 536/21/22
Document 1



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

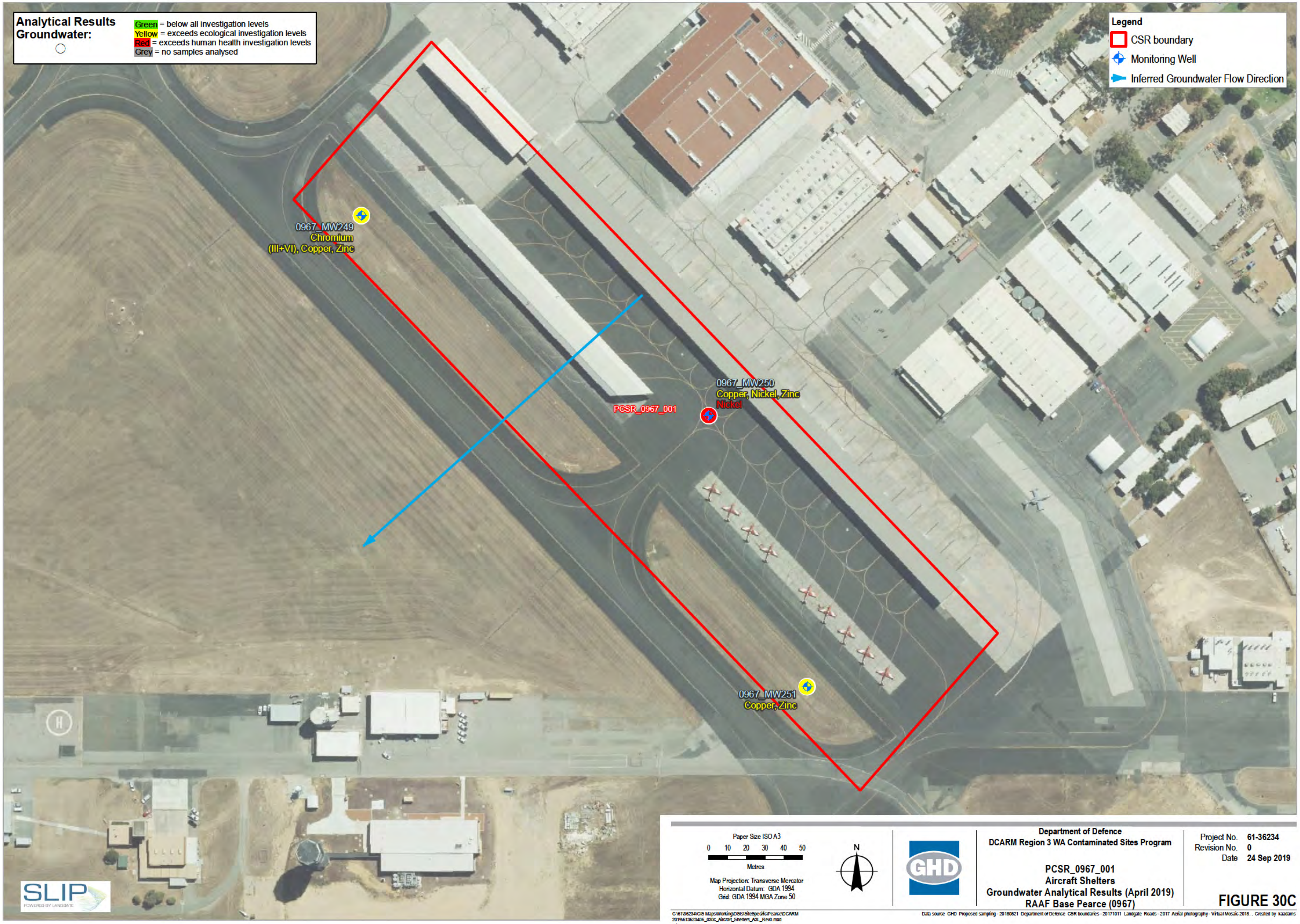
PCSR_0967_001
Aircraft Shelters
Soil Analytical Results
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 30B

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_030b_Aircraft_Shelters_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:22

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams



Paper Size ISO A3

0 10 20 30 40 50

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

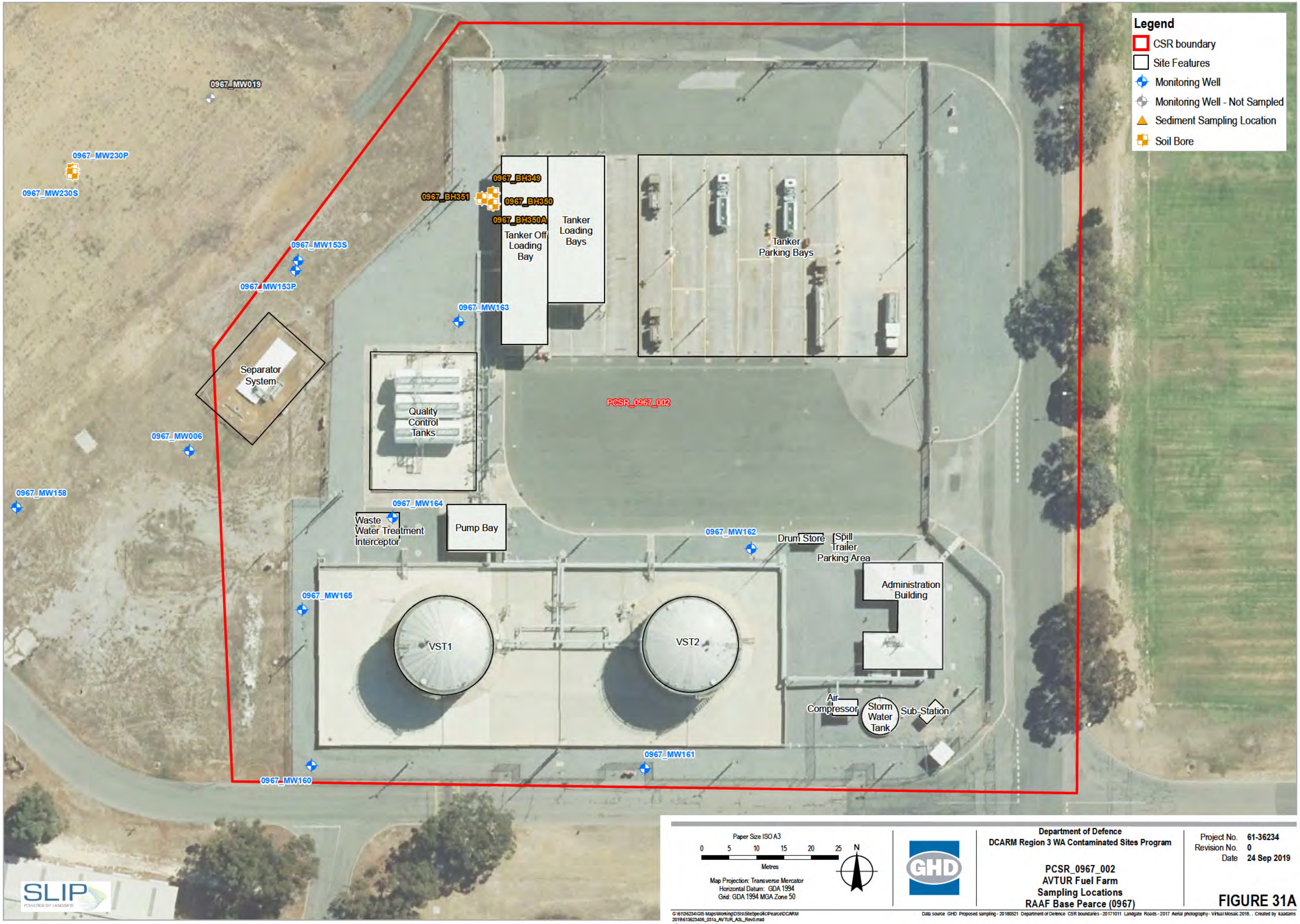
PCSR_0967_001
Aircraft Shelters
Groundwater Analytical Results (April 2019)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 30C

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_030c_Aircraft_Shelters_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:59

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams



Paper Size ISO A3

0 5 10 15 20 25

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

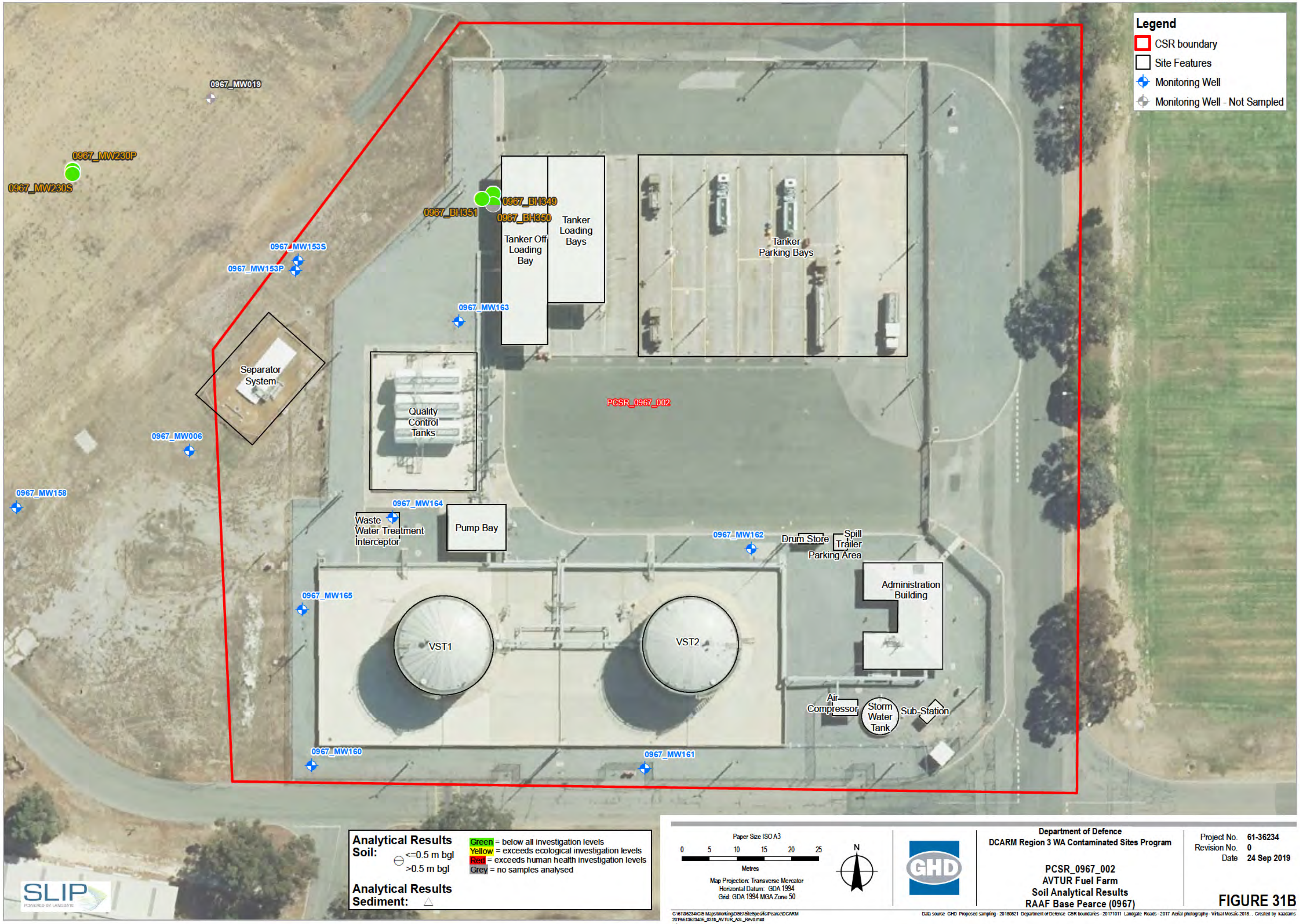
PCSR_0967_002
AVTUR Fuel Farm
Sampling Locations
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

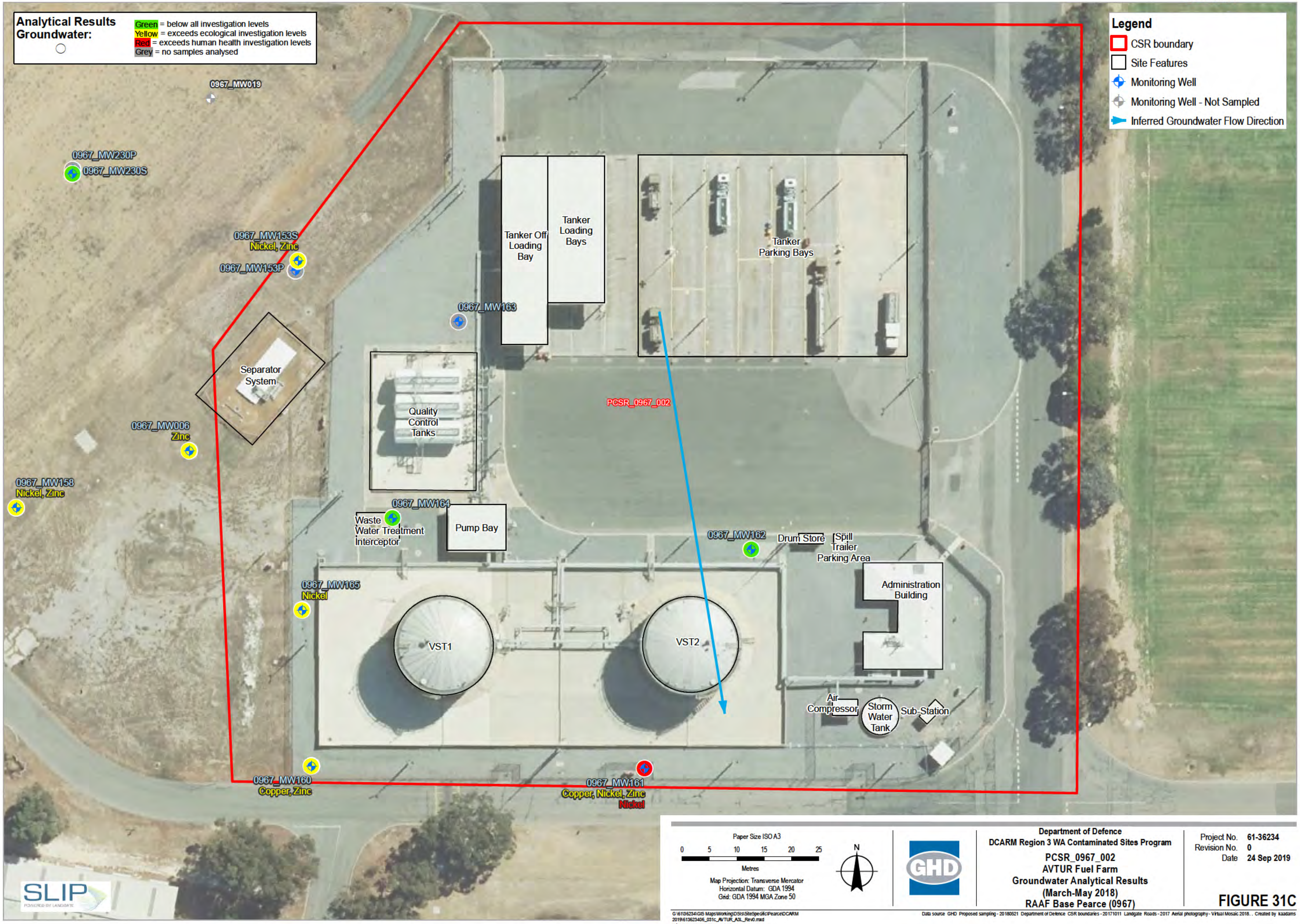
FIGURE 31A

G:\61\36234\GIS Maps\Working\DSI\SiteSpecific\Pearce\DCARM 2019\6136234O6_031a_AVTUR_ASL_Rev0.mxd
Print date 27 Sep 2019 - 14:52

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams


Legend
CSR boundary
Site Features
Monitoring Well
Monitoring Well - Not Sampled
0967_MW019
0967_MW230P
0967_MW230S
0967_BH349
0967_BH351
0967_BH350
0967_MW153S
0967_MW153P
0967_MW163
0967_MW006
0967_MW158
0967_MW164
0967_MW162
0967_MW165
0967_MW160
0967_MW161
Tanker Off Loading Bay
Tanker Loading Bays
Tanker Parking Bays
Separator System
Quality Control Tanks
PCSR_0967_002
Waste Water Treatment Interceptor
Pump Bay
Drum Store
Spill Trailer Parking Area
Administration Building
VST1
VST2
Air Compressor
Storm Water Tank
Sub-Station
Analytical Results
Soil:
<=0.5 m bgl
>0.5 m bgl
Green = below all investigation levels
Yellow = exceeds ecological investigation levels
Red = exceeds human health investigation levels
Grey = no samples analysed
Analytical Results
Sediment:
SLIP
Paper Size ISO A3
0 5 10 15 20 25
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50
N
GHD
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
PCSR_0967_002
AVTUR Fuel Farm
Soil Analytical Results
RAAF Base Pearce (0967)
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019
FIGURE 31B

Defence FOI 536/21/22
Document 1



Paper Size ISO A3

0 5 10 15 20 25

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

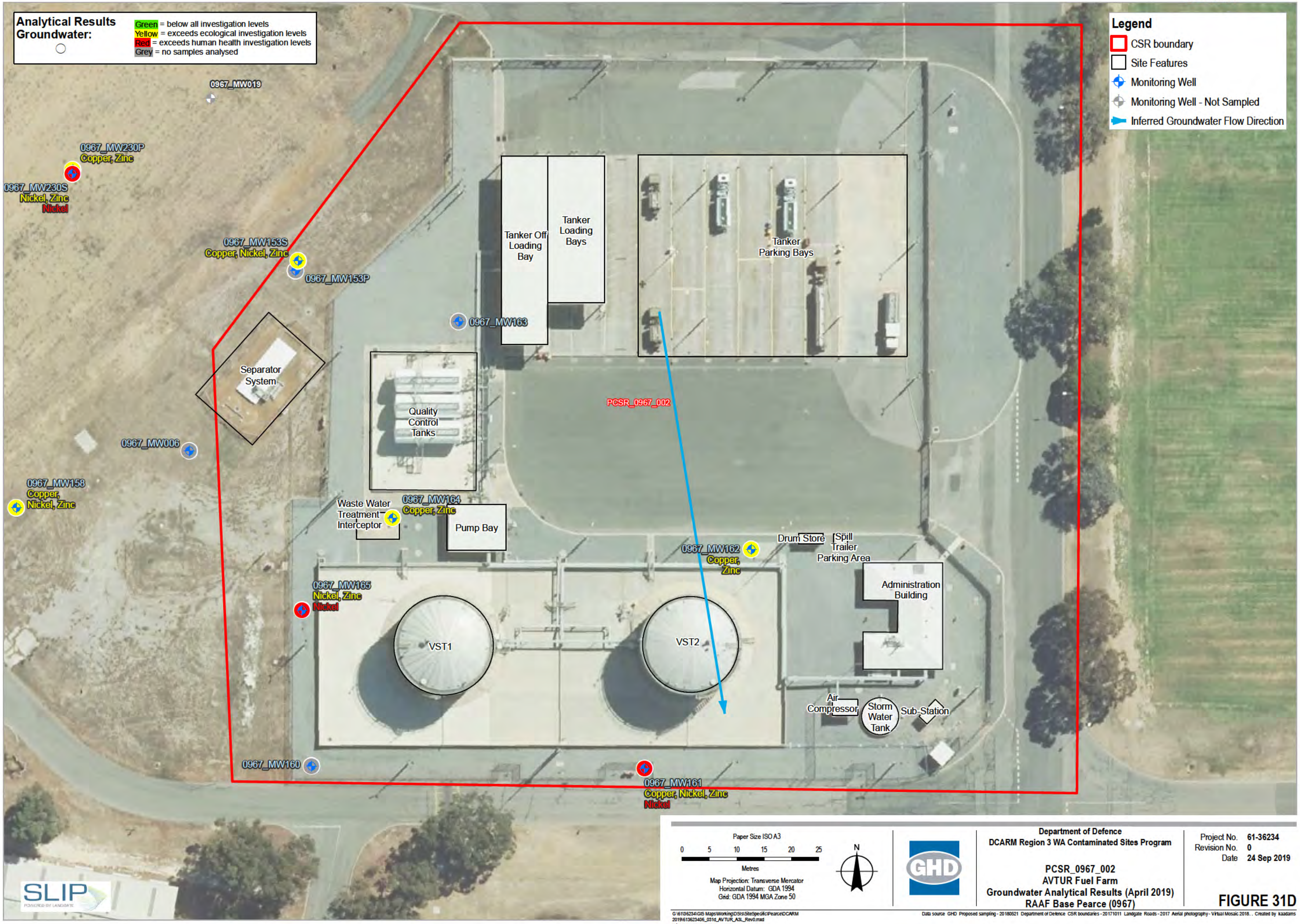
PCSR_0967_002
AVTUR Fuel Farm
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 31C

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_031c_AVTUR_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:05

Data source: GHD: Proposed sampling - 20180521. Department of Defence: CSR boundaries - 20171011. Landgate: Roads - 2017. Aerial photography - Virtual Mosaic 2018. . Created by: kaadams



Paper Size ISO A3

0 5 10 15 20 25
Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

PCSR_0967_002
AVTUR Fuel Farm
Groundwater Analytical Results (April 2019)
RAAF Base Pearce (0967)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 31D

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_031d_AVTUR_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:58

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018.. Created by kaadams

Defence FOI 536/21/22
Document 1

Paper Size ISO A3
0 2.5 5 7.5 10 12.5
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

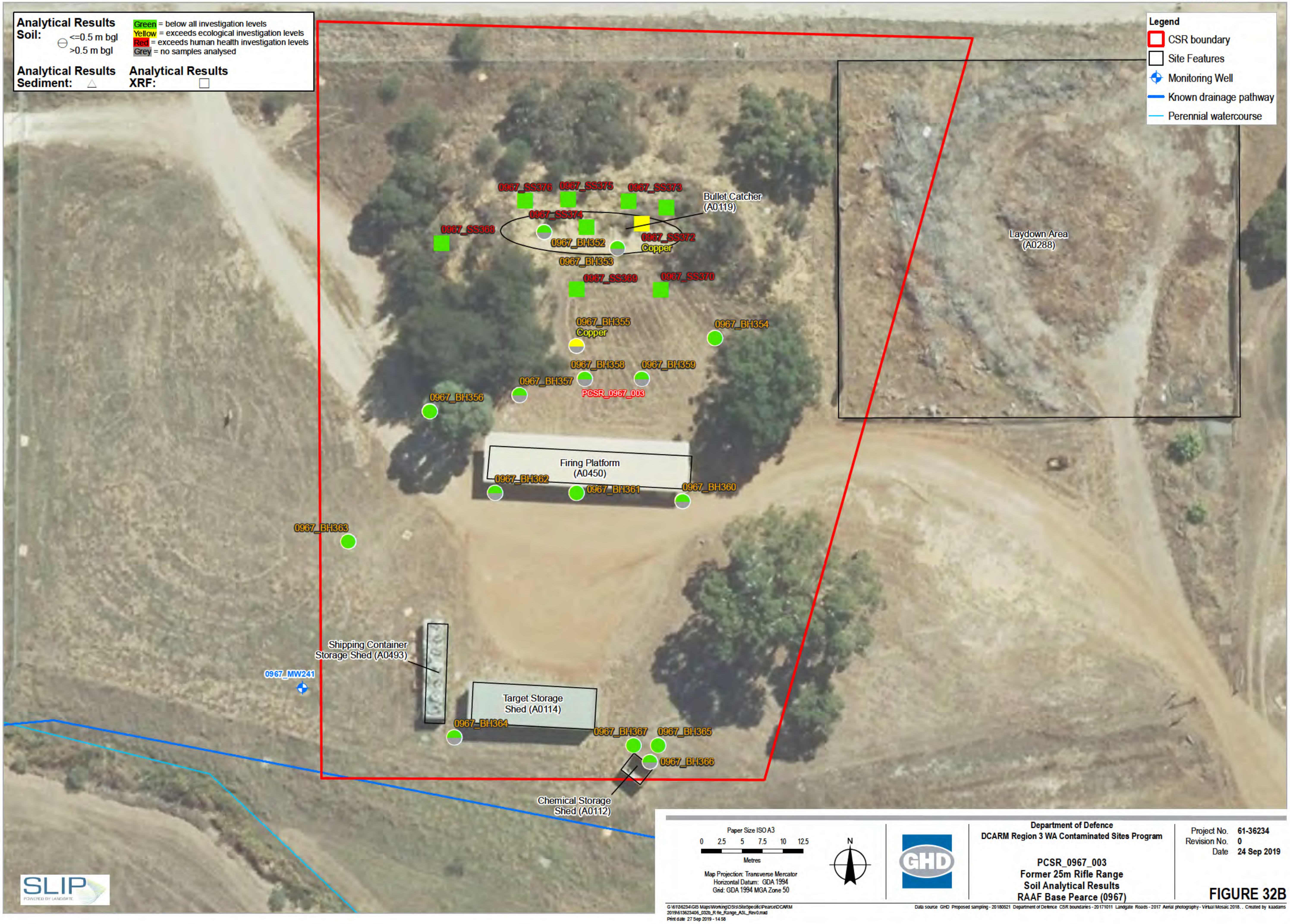
PCSR_0967_003
Former 25m Rifle Range
Sampling Locations
RAAF Base Pearce (0967)

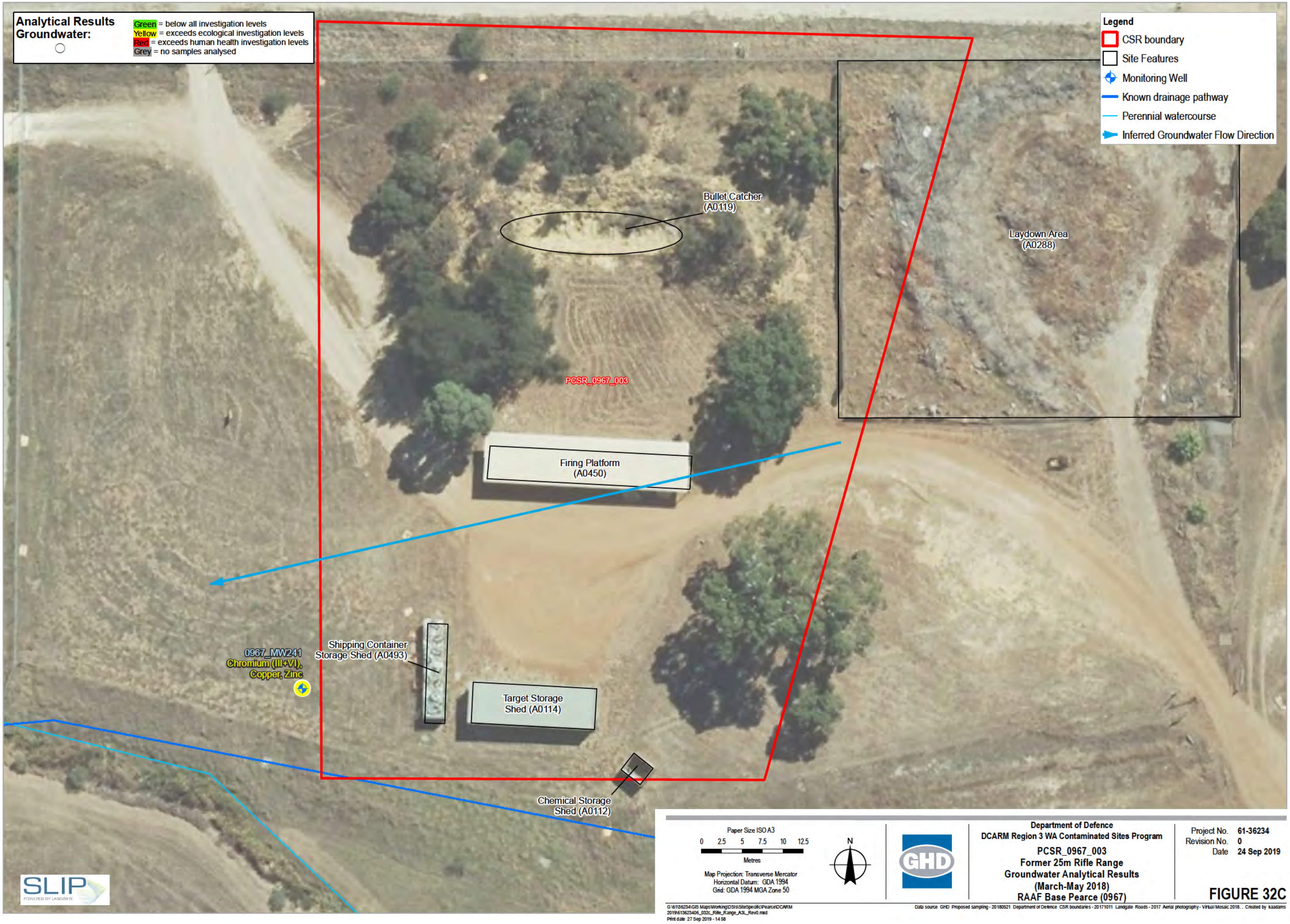
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

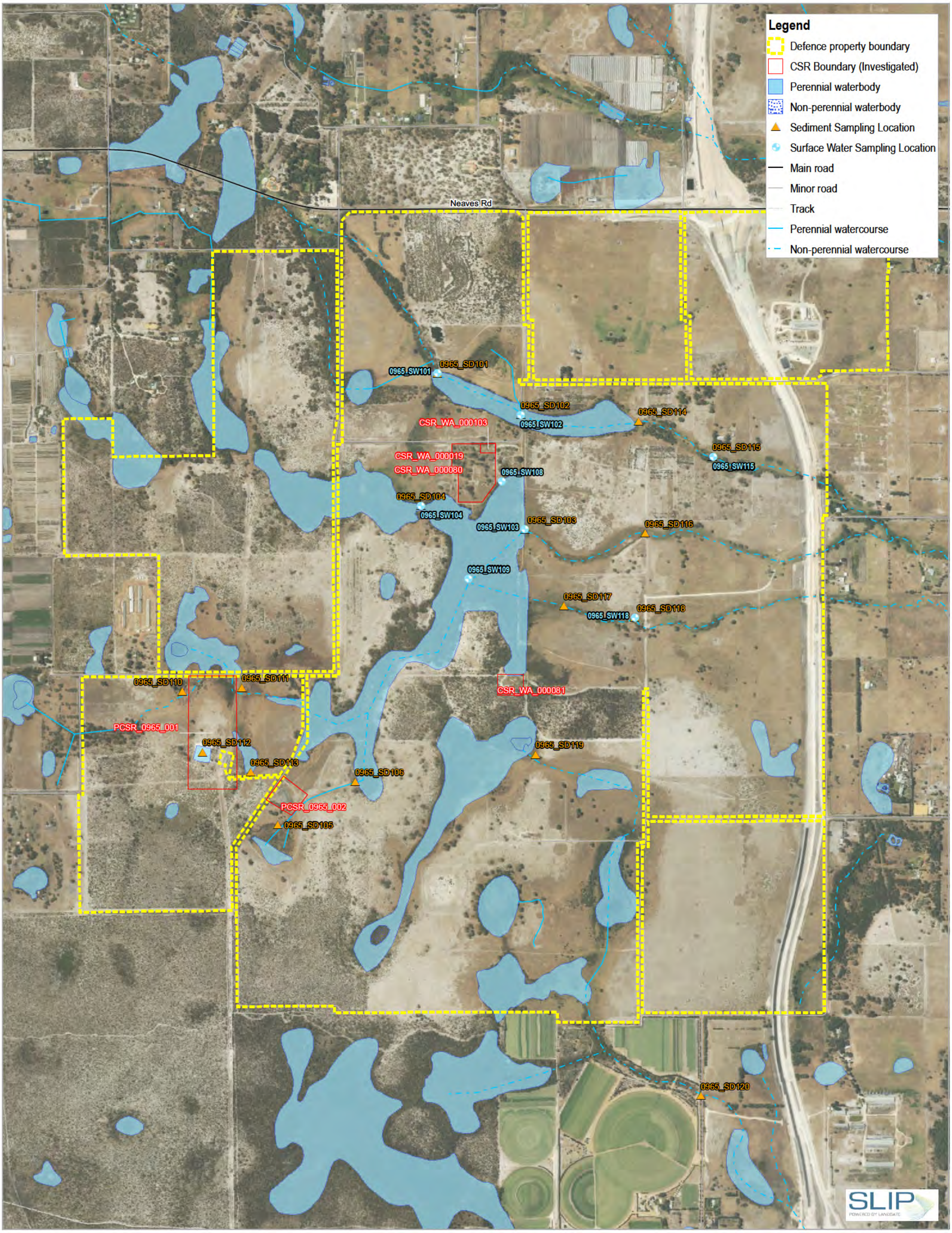
FIGURE 32A

Data source: GHD: Proposed sampling - 20180521; Department of Defence: CSR boundaries - 20171011; Landgate: Roads - 2017; Aerial photography - Virtual Mosaic 2018. Created by: kaadams

Defence FOI 536/21/22
Document 1




Analytical Results
Groundwater:
Green = below all investigation levels
Yellow = exceeds ecological investigation levels
Red = exceeds human health investigation levels
Grey = no samples analysed
Legend
CSR boundary
Site Features
Monitoring Well
Known drainage pathway
Perennial watercourse
Inferred Groundwater Flow Direction
Bullet Catcher
(A0119)
Laydown Area
(A0288)
PCSR_0967_003
Firing Platform
(A0450)
Shipping Container
Storage Shed (A0493)
0967_MW241
Chromium (III+VI),
Copper, Zinc
Target Storage
Shed (A0114)
Chemical Storage
Shed (A0112)
SLIP
Paper Size ISO A3
0 2.5 5 7.5 10 12.5
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50
N
GHD
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
PCSR_0967_003
Former 25m Rifle Range
Groundwater Analytical Results
(March-May 2018)
RAAF Base Pearce (0967)
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019
FIGURE 32C
G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_032c_Rifle_Range_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:58
Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams



Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

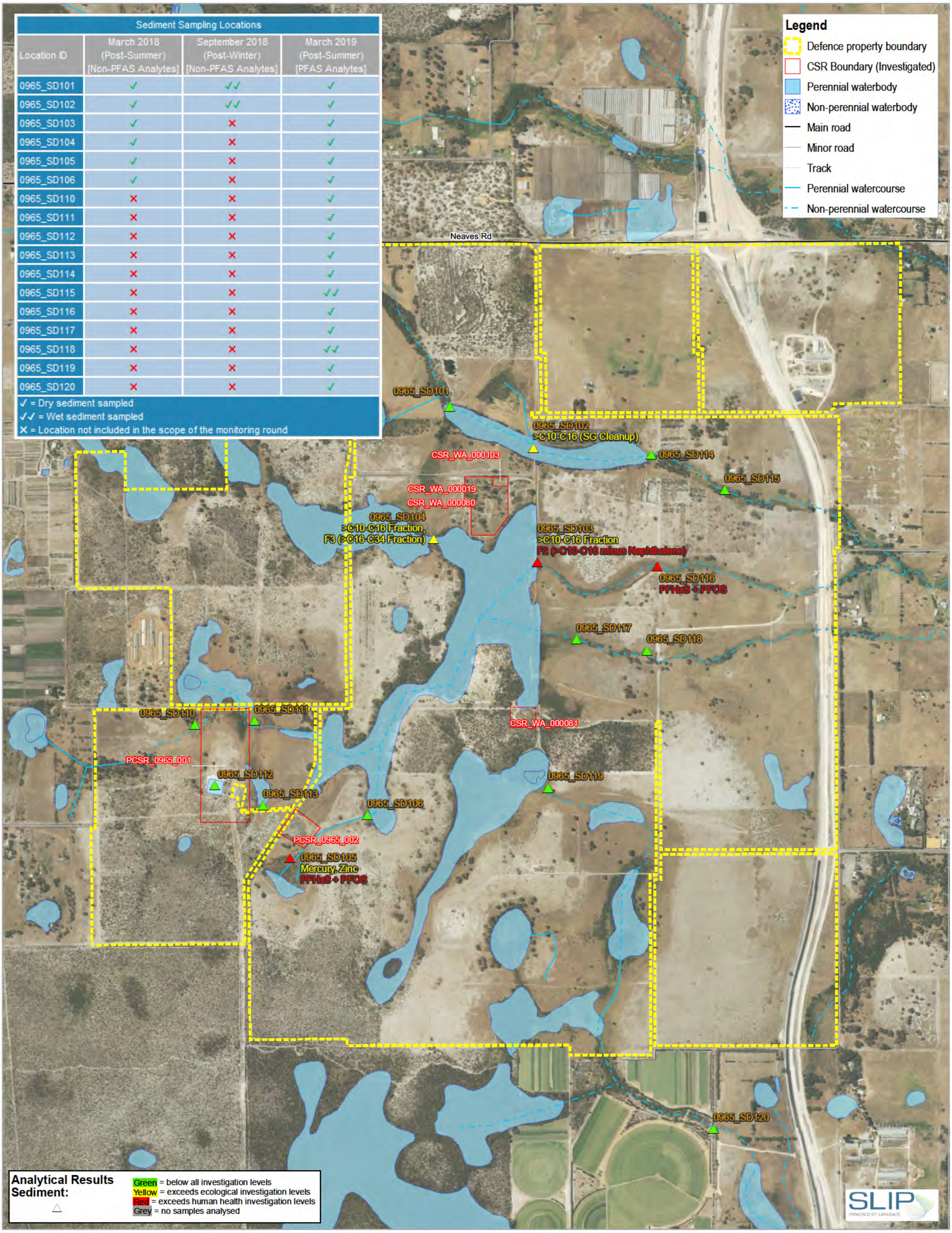
Site-Wide Surface Water and Sediment Sampling Locations
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 33A

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific Pearce\DCARM 2019\613623406_033a_0967_Surface_Water_A3P_Rev0.mxd
Print date 27 Sep 2019 - 14:59

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011. Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20180727.. Created by: kaadams



Sediment Sampling Locations

Location ID	March 2018 (Post-Summer) [Non-PFAS Analytes]	September 2018 (Post-Winter) [Non-PFAS Analytes]	March 2019 (Post-Summer) [PFAS Analytes]
0965_SD101	✓	✓✓	✓
0965_SD102	✓	✓✓	✓
0965_SD103	✓	✗	✓
0965_SD104	✓	✗	✓
0965_SD105	✓	✗	✓
0965_SD106	✓	✗	✓
0965_SD110	✗	✗	✓
0965_SD111	✗	✗	✓
0965_SD112	✗	✗	✓
0965_SD113	✗	✗	✓
0965_SD114	✗	✗	✓
0965_SD115	✗	✗	✓✓
0965_SD116	✗	✗	✓
0965_SD117	✗	✗	✓
0965_SD118	✗	✗	✓✓
0965_SD119	✗	✗	✓
0965_SD120	✗	✗	✓

✓ = Dry sediment sampled
✓✓ = Wet sediment sampled
✗ = Location not included in the scope of the monitoring round

Paper Size ISO A3

0 100 200 300 400

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

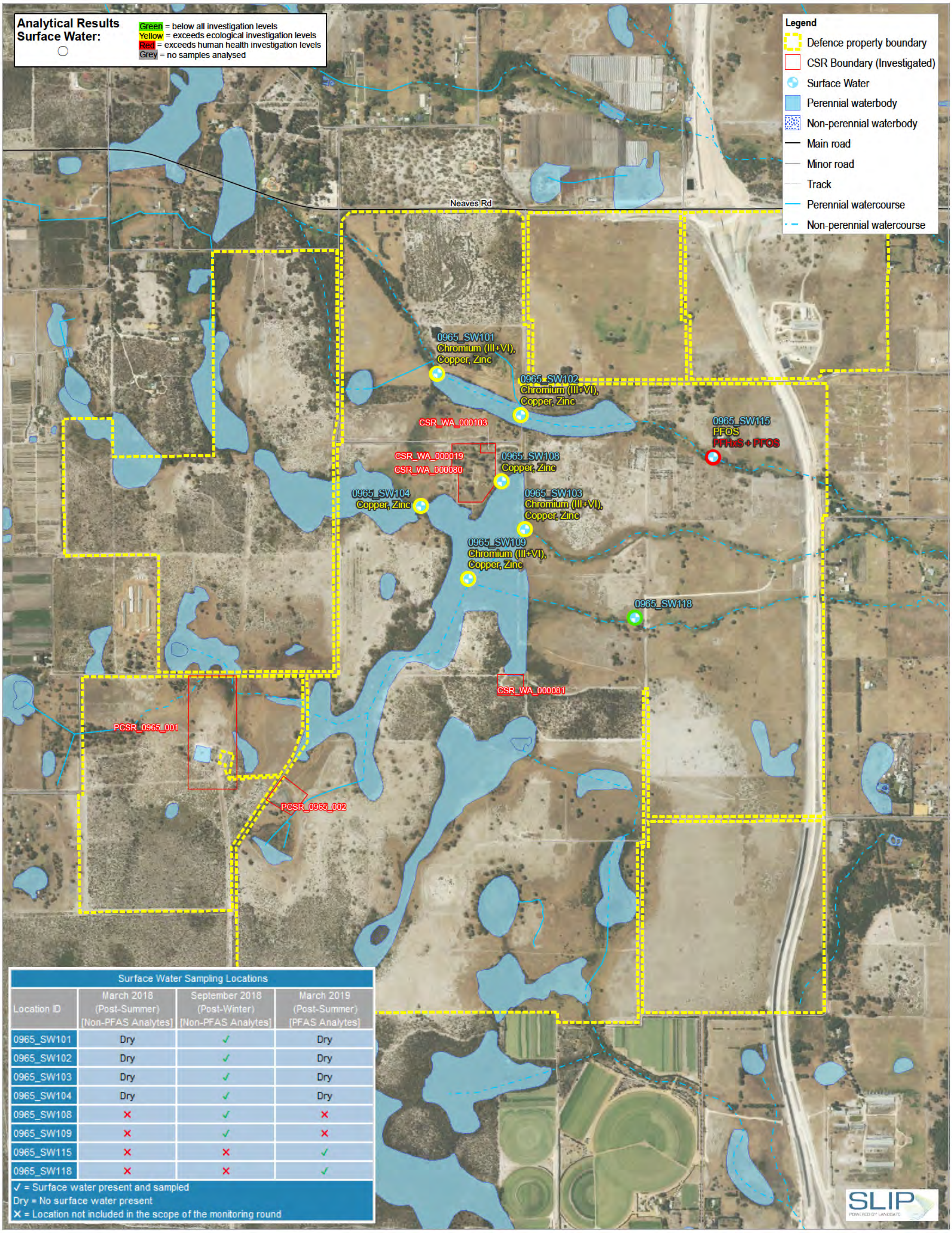
Site-Wide Sediment
Analytical Results (2018 & 2019)
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 33B

G:\61\36234\GIS\Maps\Working\DSts\SteSpecific Pearce\DCARM 2019\6136234_0965_Surface_Water_A3P_Rev0.mxd
Print date 27 Sep 2019 - 14:59

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017; Watercourses/bodies - 2017; WA Now Aerial Mosaic - accessed 20180727. Created by: kaadams



Surface Water Sampling Locations

Location ID	March 2018 (Post-Summer) [Non-PFAS Analytes]	September 2018 (Post-Winter) [Non-PFAS Analytes]	March 2019 (Post-Summer) [PFAS Analytes]
0965_SW101	Dry	✓	Dry
0965_SW102	Dry	✓	Dry
0965_SW103	Dry	✓	Dry
0965_SW104	Dry	✓	Dry
0965_SW108	✗	✓	✗
0965_SW109	✗	✓	✗
0965_SW115	✗	✗	✓
0965_SW118	✗	✗	✓

✓ = Surface water present and sampled
Dry = No surface water present
✗ = Location not included in the scope of the monitoring round

Paper Size ISO A3
0 100 200 300 400
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

Site-Wide Surface Water
Analytical Results (2018 & 2019)
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 33C

G:\61\36234\GIS\Maps\Working\DSI\SiteSpecific Pearce\DCARM 2019\613623406_033c_0967_Surface_Water_A3P_Rev0.mxd
Print date: 27 Sep 2019 - 14:58

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017; Watercourses/bodies - 2017; WA Now Aerial Mosaic - accessed 20180727. Created by: kaadams

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000019 & CSR_WA_000080 & CSR_WA_000103
Former Telecommunications Area
Sampling Locations
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 34A

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific Pearce\DCARM 2019\613623406_034a_0967_Former_Telcoms_A3P_Rev0.mxd
Print date 27 Sep 2019 - 15:00

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20180727. . Created by: kaadams

Defence FOI 536/21/22
Document 1

Paper Size ISO A3

0 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

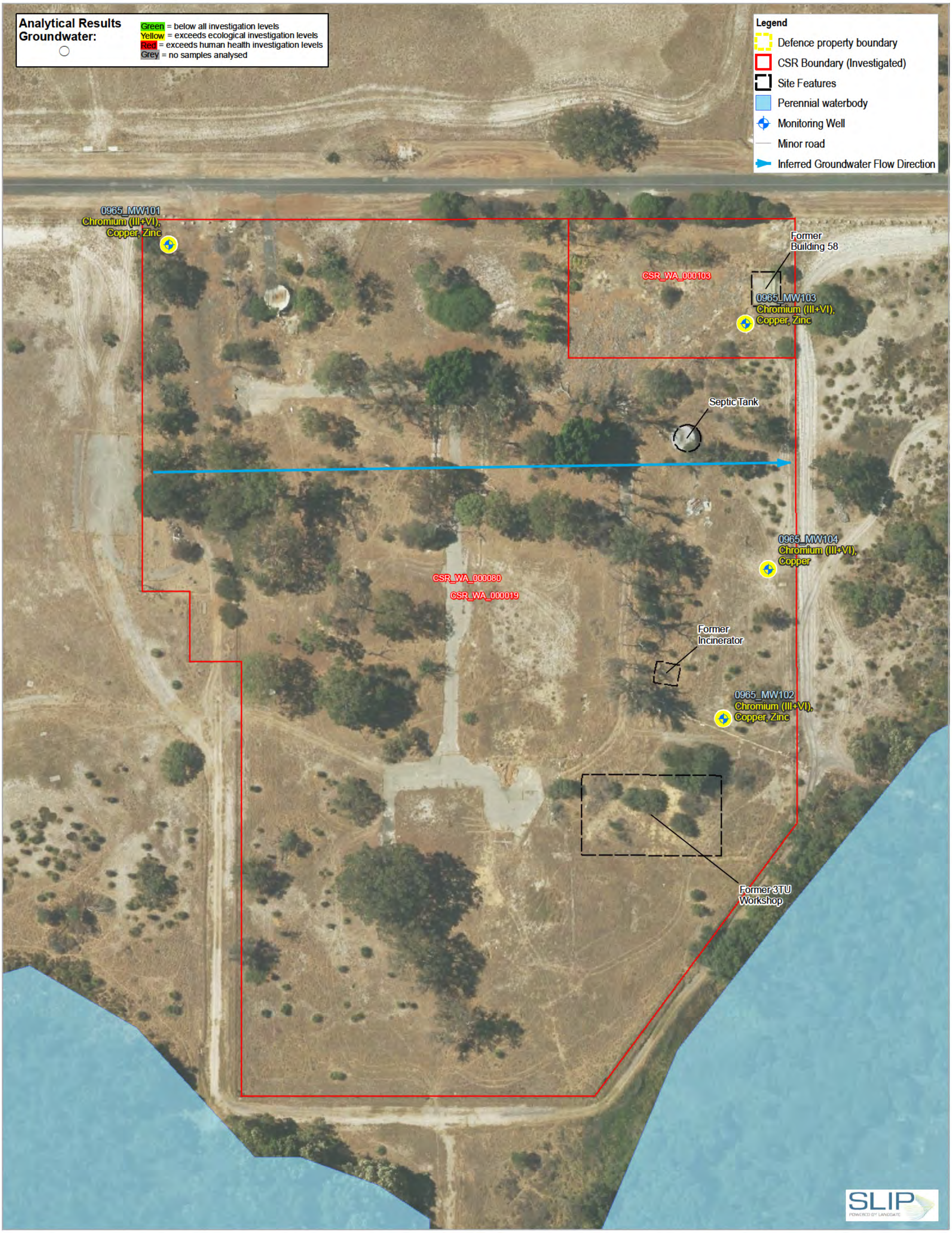
CSR_WA_000019 & CSR_WA_000080 & CSR_WA_000103
Former Telecommunications Area
Soil Analytical Results
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 34B

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific Pearce\DCARM 2019\6136234_034b_0967_Former_Telcoms_ASP_Rev0.mxd
Print date 27 Sep 2019 - 14:58

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011; Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20180727. Created by: kaadams



Paper Size ISO A3

0 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

CSR_WA_000019 & CSR_WA_000080 & CSR_WA_000103
Former Telecommunications Area
Groundwater Analytical Results (May 2018)
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 34C

G:\61\36234\GIS\Maps\Working\DSts\SiteSpecific Pearce\DCARM 2019\6136234 06_034c_0967_Former_Telcoms_A3P_Rev0.mxd
Print date 27 Sep 2019 - 15:04

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011. Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20180727. Created by: kaadams

Paper Size ISO A3

0 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

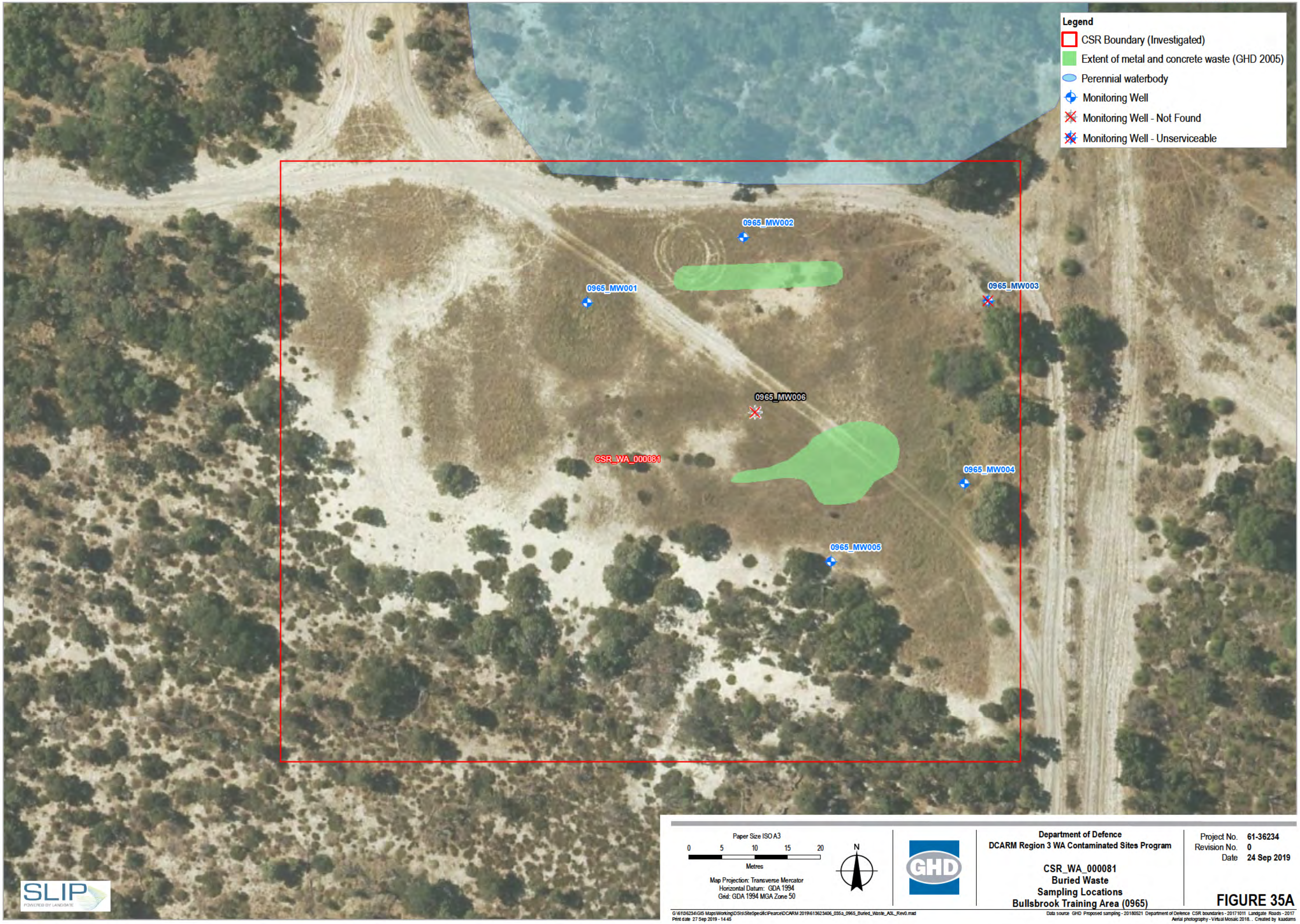
CSR_WA_000019 & CSR_WA_000080 & CSR_WA_000103
Former Telecommunications Area
Groundwater Analytical Results (May 2019)
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 34D

G:\61\36234\GIS\Maps\Working\DSIs\SiteSpecific Pearce\DCARM 2019\613623406_034d_0967_Former_Telcoms_A3P_Rev0.mxd
Print date 27 Sep 2019 - 15:04

Data source: Department of Defence: Site boundaries, CSR boundaries - 20171011. Landgate: Roads - 2017, Watercourses/bodies - 2017, WA Now Aerial Mosaic - accessed 20180727.. Created by: kaadams



Paper Size ISO A3

0 5 10 15 20

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

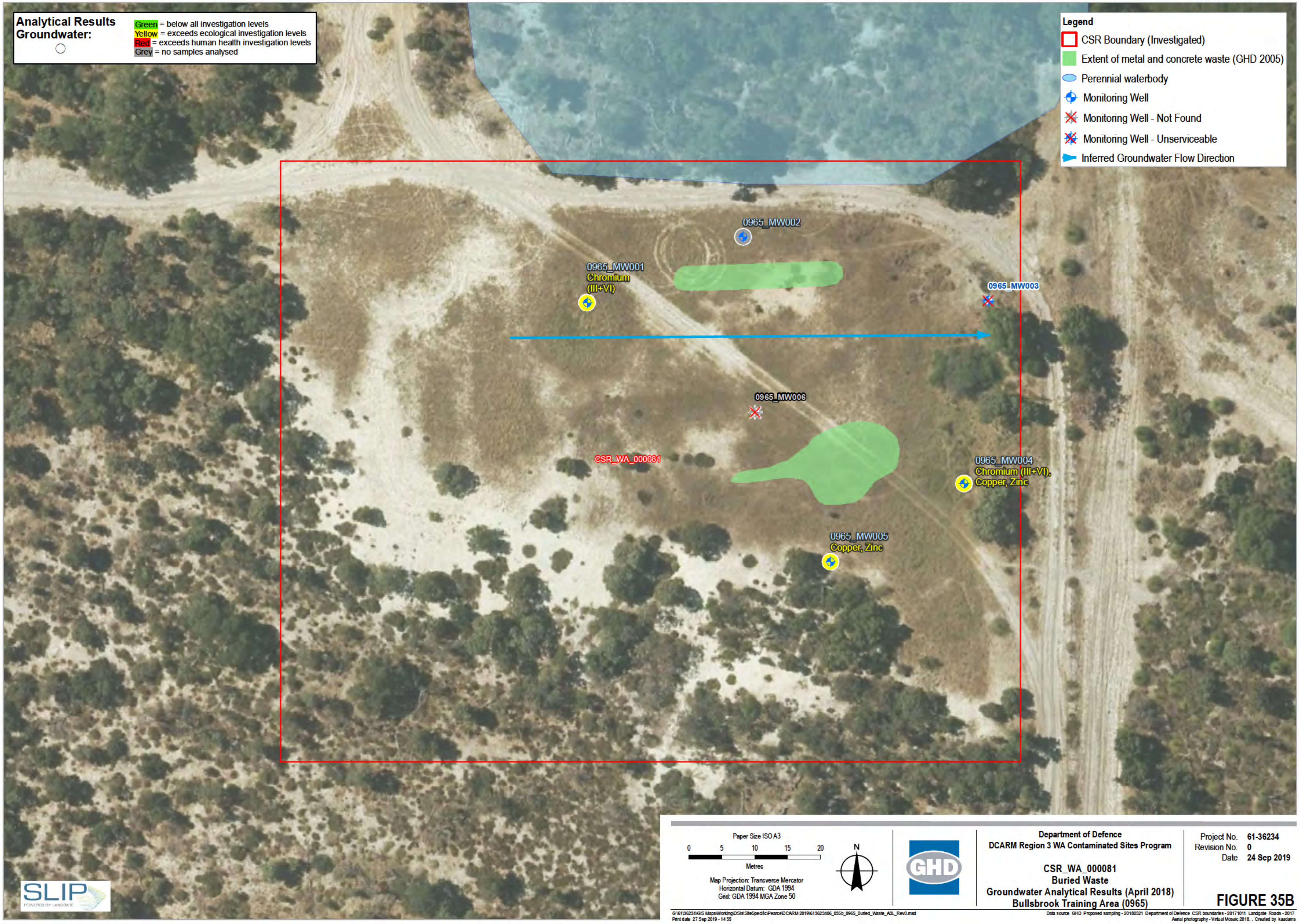
CSR_WA_000081
Buried Waste
Sampling Locations
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 35A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_035a_0965_Buried_Waste_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:45

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017
Aerial photography - Virtual Mosaic 2018. . Created by kaadams


Analytical Results
Groundwater:
Green = below all investigation levels
Yellow = exceeds ecological investigation levels
Red = exceeds human health investigation levels
Grey = no samples analysed
Legend
CSR Boundary (Investigated)
Extent of metal and concrete waste (GHD 2005)
Perennial waterbody
Monitoring Well
Monitoring Well - Not Found
Monitoring Well - Unserviceable
Inferred Groundwater Flow Direction
0965_MW002
0965_MW001
Chromium
(III+VI)
0965_MW003
0965_MW006
CSR_WA_000081
0965_MW004
Chromium (III+VI),
Copper, Zinc
0965_MW005
Copper, Zinc
Paper Size ISO A3
0 5 10 15 20
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50
N
GHD
Department of Defence
DCARM Region 3 WA Contaminated Sites Program
CSR_WA_000081
Buried Waste
Groundwater Analytical Results (April 2018)
Bullsbrook Training Area (0965)
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019
FIGURE 35B
SLIP

Paper Size ISO A3

0 5 10 15 20

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

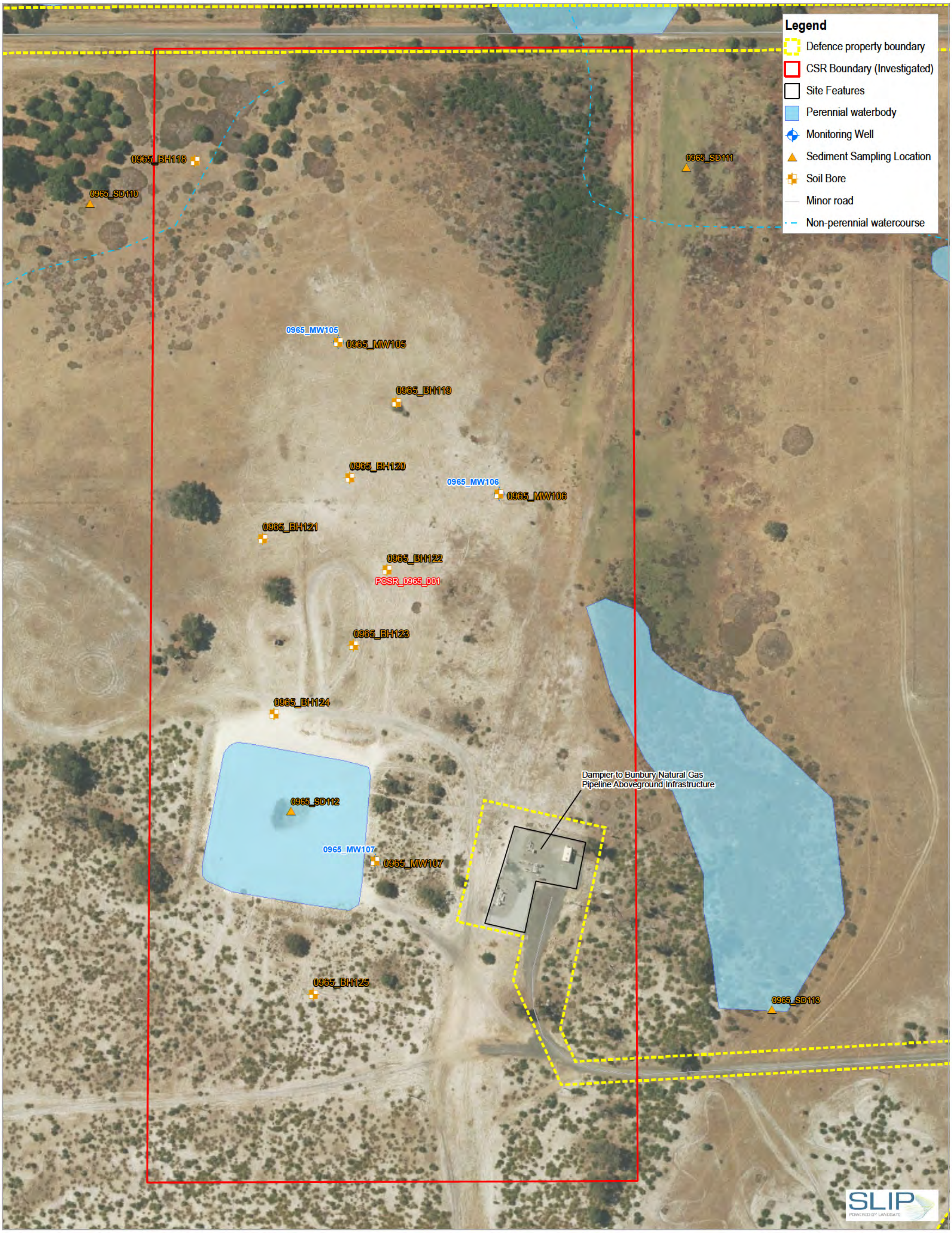
CSR_WA_000081
Buried Waste
Groundwater Analytical Results (April 2019)
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 35C

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_035c_0965_Buried_Waste_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:28

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017
Aerial photography - Virtual Mosaic 2018. . Created by kaadams



Paper Size ISO A3

0 10 20 30 40

Metres

N

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

PCSR_0965_001
Fire Extinguisher Training Area
Sampling Locations
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 36A

G:\61 36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_036a_Fire_Ext_TA_0965_001_A3P_Rev0.mxd
Print date 27 Sep 2019 - 15:01

Data source GHD Proposed sampling - 20181126 AOC boundaries - 20171214 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 20180314. . Created by kaadams

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

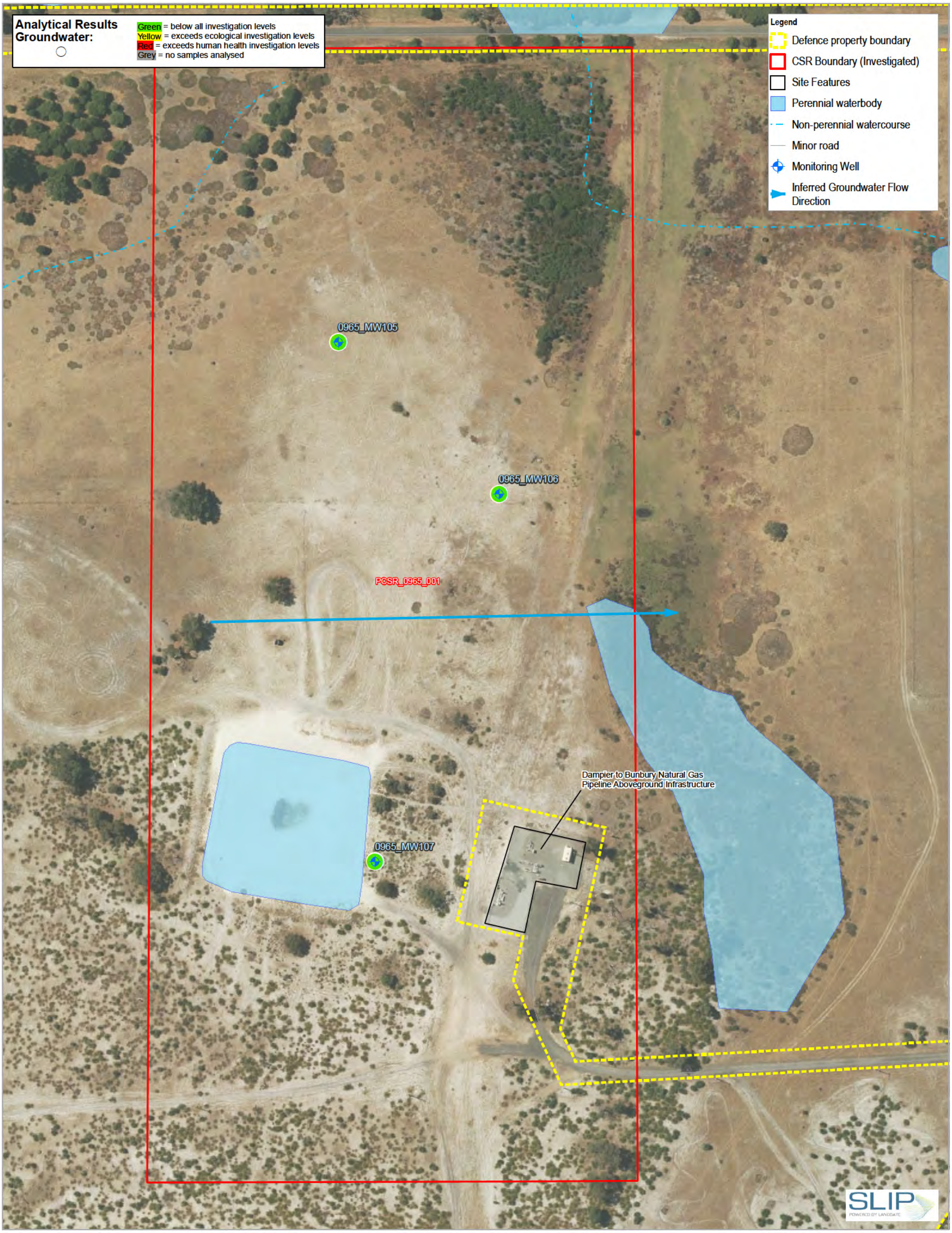
PCSR_0965_001
Fire Extinguisher Training Area
Soil Analytical Results
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 36B

G:\61 36234\GIS\Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_036b_Fire_Ext_TA_0965_001_A3P_Rev0.mxd
Print date 27 Sep 2019 - 14:52

Data source GHD Proposed sampling - 20181126 AOC boundaries - 20171214 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 20180314.. Created by kaadams



Paper Size ISO A3
0 10 20 30 40
Metres
Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

PCSR_0965_001
Fire Extinguisher Training Area
Groundwater Analytical Results (April 2019)
Bullsbrook Training Area (0965)

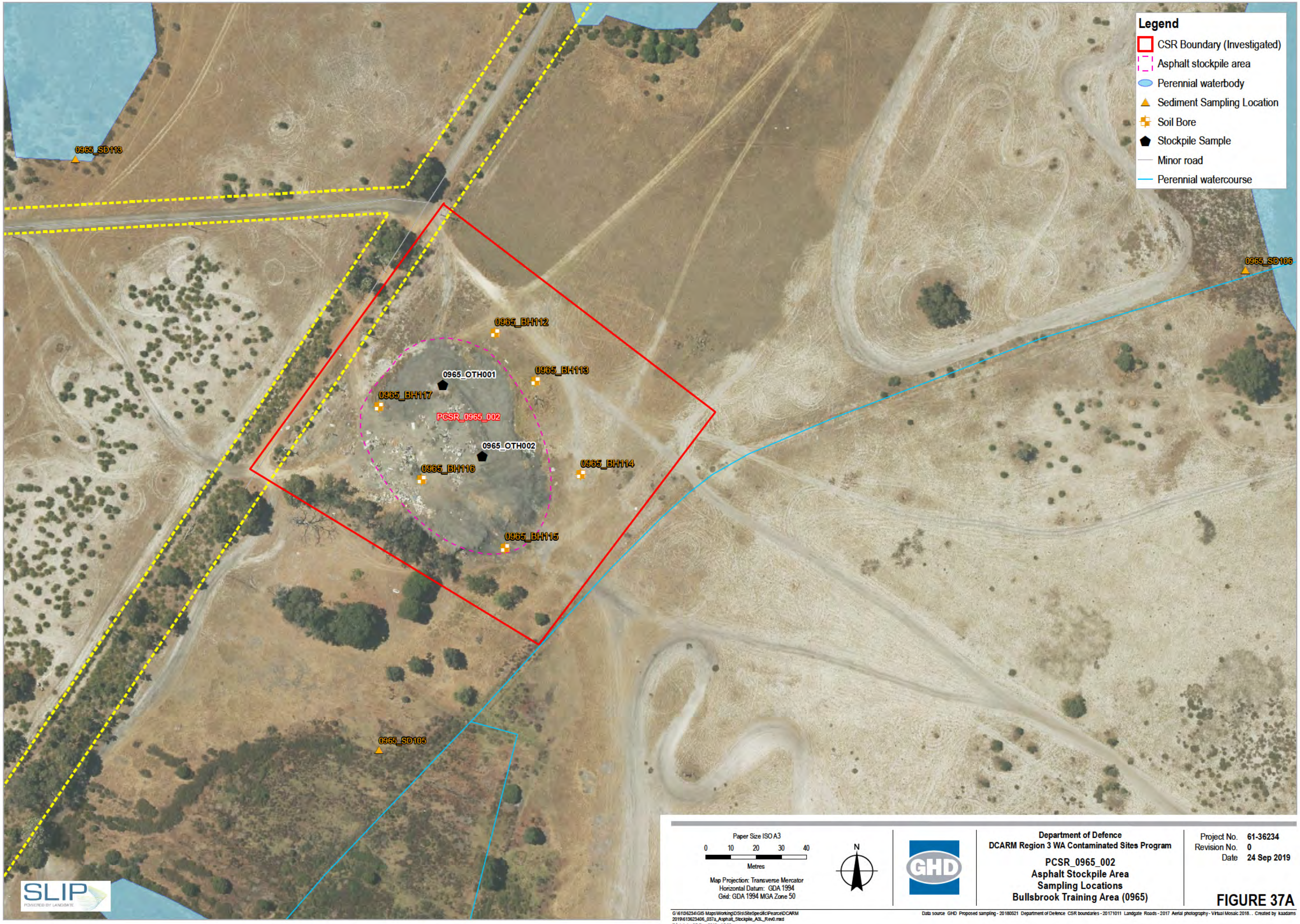
Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 36C

G:\61\36234\GIS\Maps\Working\DSI\SiteSpecific\Pearce\DCARM 2019\6136234_036c_Fire_Ext_TA_0965_001_A3P_Rev0.mxd
Print date: 27 Sep 2019 - 14:53

Data source: GHD: Proposed sampling - 20181126; AOC boundaries - 20171214; Department of Defence: CSR boundaries - 20171011; Landgate: Roads - 2017; Aerial photography - Virtual Mosaic 20180314.. Created by: kaadams

Defence FOI 536/21/22
Document 1



Department of Defence
DCARM Region 3 WA Contaminated Sites Program

PCSR_0965_002
Asphalt Stockpile Area
Sampling Locations
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 37A

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_037a_Asphalt_Stockpile_A3L_Rev0.mxd
Print date 27 Sep 2019 - 15:03

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018.. Created by kaadams

Defence FOI 536/21/22
Document 1

Paper Size ISO A3

0 10 20 30 40

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 50

N

GHD

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

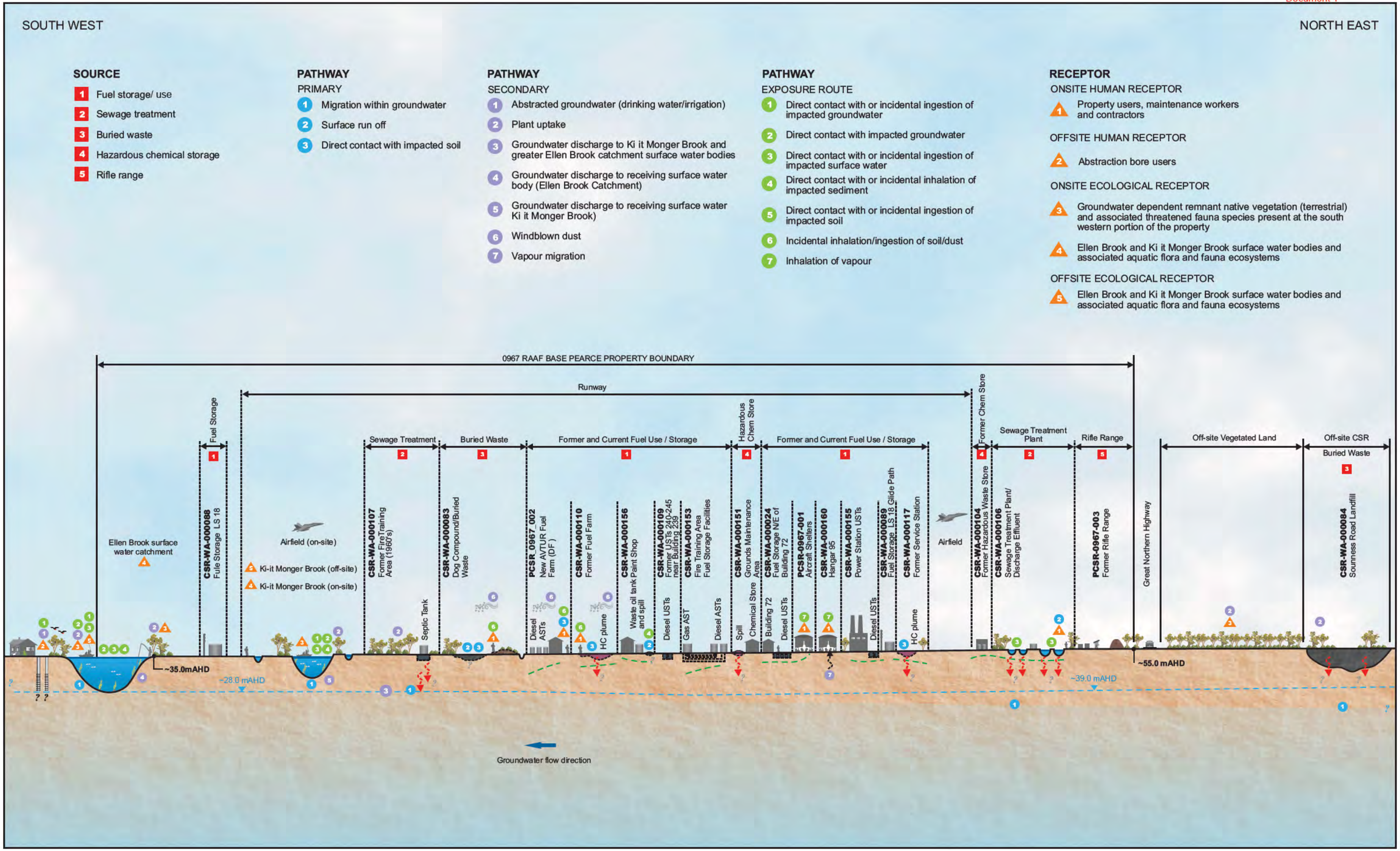
PCSR_0965_002
Asphalt Stockpile Area
Soil Analytical Results
Bullsbrook Training Area (0965)

Project No. 61-36234
Revision No. 0
Date 24 Sep 2019

FIGURE 37B

G:\61\36234\GIS Maps\Working\DSIs\SiteSpecific\Pearce\DCARM 2019\613623406_037b_Asphalt_Stockpile_A3L_Rev0.mxd
Print date 27 Sep 2019 - 14:44

Data source GHD Proposed sampling - 20180521 Department of Defence CSR boundaries - 20171011 Landgate Roads - 2017 Aerial photography - Virtual Mosaic 2018. . Created by kaadams



Schematic diagram only not to scale

LEGEND

- Geology: Guildford Formation sediments, predominantly comprising brown silty and slightly sandy clays or clayey sands with subordinate sands and gravels
- Topography (35mAHD N/E 55mAHD S/W) sloping S/W
- Buried waste
- Stockpiled material
- Subsurface contamination plume
- Surface water body
- Underground storage tank
- Vertical migration
- Regional groundwater aquifer/continuous superficial aquifer
- Perched groundwater aquifer/localised areas (34.48 50.73mAHD)
- Building/ structure
- Communications antenna
- Abstraction groundwater well
- Regional groundwater flow direction (S/W towards Ellen Brook)

Department of Defence
DCARM Region 3 WA Contaminated Sites Program

0967 - RAAF Base Pearce Conceptual Site Model

Job Number	61 36234
Revision	0
Date	19 Jul 2019

Figure 38A

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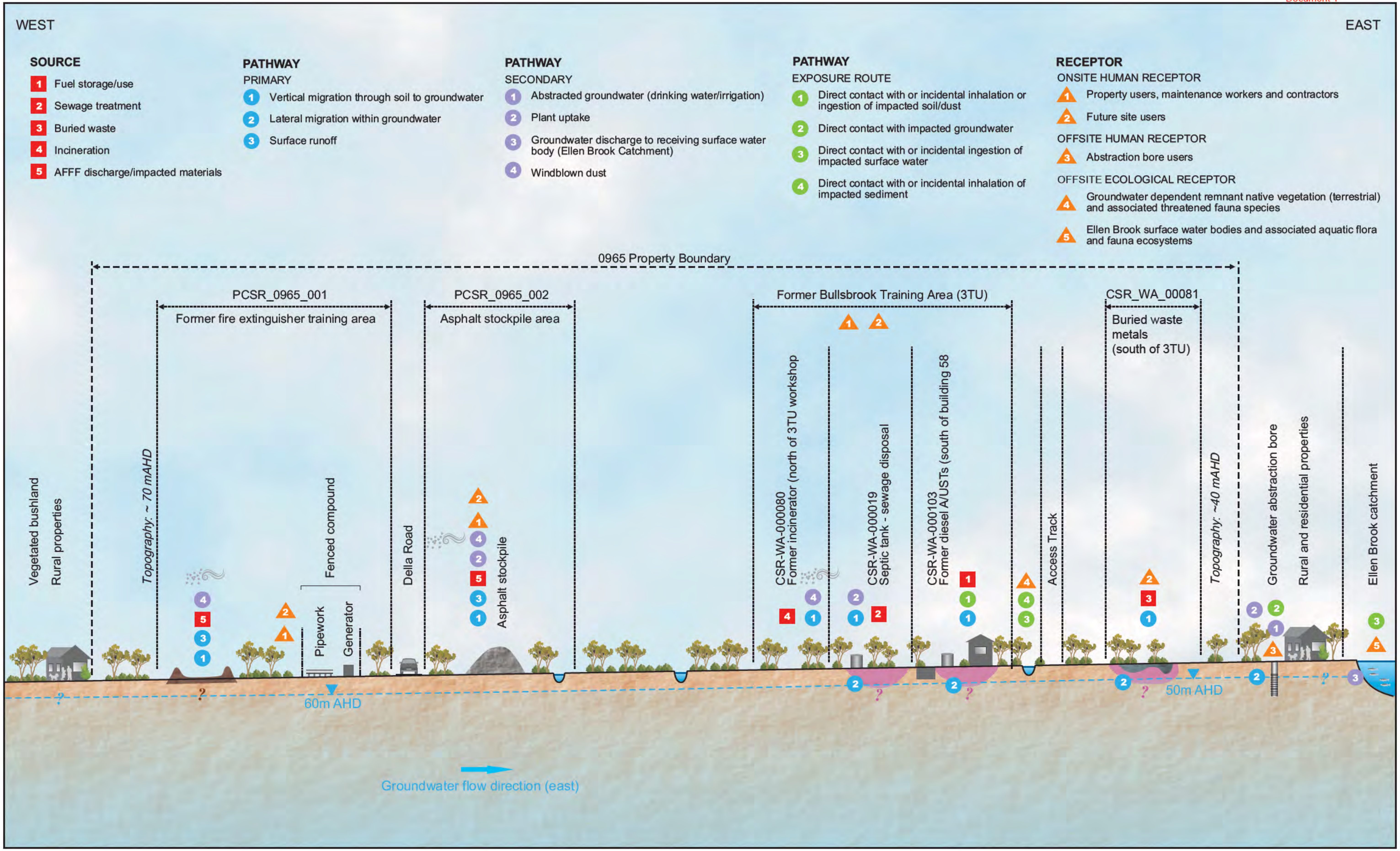

Schematic diagram only
not to scale

LEGEND

- Geology: Variable surficial deposits of Bassendean Sands & Muchea Limestone overlying Guildford Formation. Swamp deposits in low lying wetland areas.
- Topography ~70m AHD (west) to ~40m AHD (east)
- Contamination plume
- Buried waste/ stockpiled material
- Groundwater aquifer
- Surface water body/ drainage channel
- Groundwater flow direction (east)
- Groundwater abstrac ion bore

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Department of Defence
DCARM Region 3 WA Contaminated Sites Program

0965 - Bullsbrook Training Area (3TU)
Conceptual Site Model

Job Number	61 36234
Revision	0
Date	24 Jul 2019

Figure 38B

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613623406-52112/https://projects.ghd.com/oc/WesternAustralia/derpwapackage2pearce/Delivery/Documents/613623406-REP-A_0967_0965_Pearce_Bullsbrook_PDSI.docx

Document Status

Revision	Author	Reviewer		Approved for Issue		
		Name	Signature	Name	Signature	Date
0	s47F [redacted]		s22 [redacted]	s47F [redacted]	s22 [redacted]	09/10/2019
1						25/10/2019
2						01/05/2019

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