Appendix H – Mine Subsidence Assessment

29 June 2020

Hunter Water Corporation
PO Box 5171
HRMC NSW 2310

Our ref: 2219573-18541
Your ref:

Drought Response Desalination Plant
Mine Subsidence Desktop Assessment - Desalination Plant Site, Seawater Pump Station and Direct Ocean Intake

1 Introduction

This letter report provides the findings of a mine subsidence desktop assessment for the drought response desalination plant site, seawater pump station and direct ocean intake alignment. Discussion relating to subsidence associated risk and possible mitigation measures are also provided.

The above site is not within a declared mine subsidence district, despite being undermined by abandoned workings in the Borehole and Victoria Tunnel coal seams. Subsidence Advisory NSW (SA NSW) is not an integrated approval authority for development in this area. The related project for the construction of the northern water pipeline alignment is within a mine subsidence district and will be addressed separately through the approval process for that project.

The purpose of this letter is to identify the anticipated risks posed by underground mine workings to the proposed water treatment process plant, seawater pump station and direct ocean intake structures and provide a recommendation for mitigation measures based on the desktop review. The letter will be used to support the EIS Amendment Report for the project.

1.1 Limitations

This report has been prepared by GHD for Hunter Water Corporation and may only be used and relied on by Hunter Water Corporation for the purpose agreed between GHD and the Hunter Water Corporation as set out in Section 1 of this report.

GHD otherwise disclaims responsibility to any person other than Hunter Water Corporation arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

GHD has prepared this report on the basis of information provided by Hunter Water Corporation and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

2 Methodology

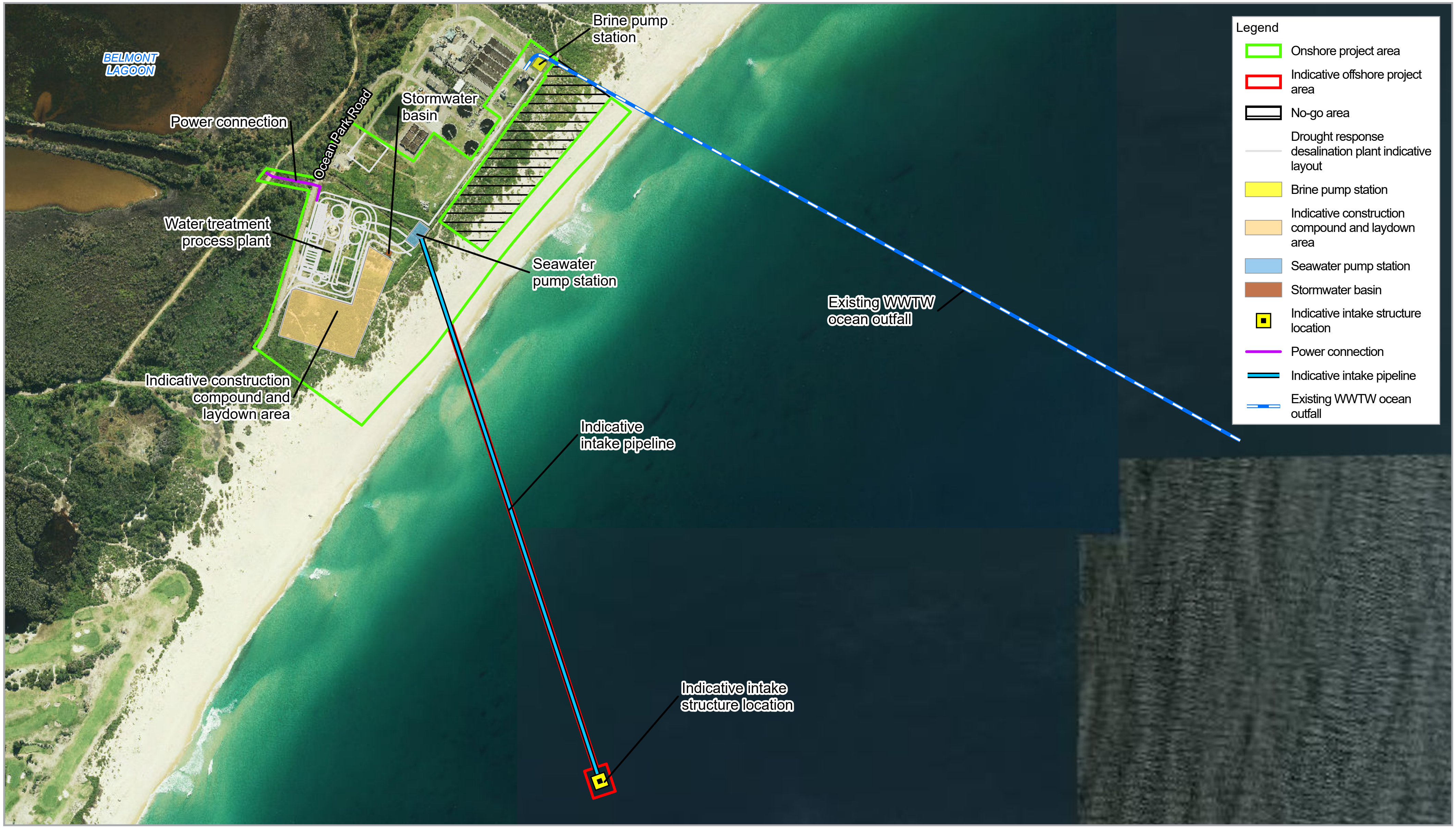
The desktop review was completed with reference to record tracings (mine plans) and a PhD thesis of subsidence relating to pillar extraction and longwall mining (Kapp, William Arthur 1984[1]).

Record tracings (RTs) for John Darling Colliery (RT270 and RT270A) were obtained from the NSW Department of Planning, Industry and Environment and overlayed (approximately) on geospatial imagery. The RTs include depictions of the extent and method of mining, location of shafts, surface boreholes and survey stations, and geological commentary (i.e. dykes, areas of 'want' in the coal seam and geological faults). RTs often include a coordinate grid and seam structural contours in various formats, depending on the age of the plan. Limited surface features are also often included with roads, portion boundaries and water bodies shown.

The proposed design layout of the desalination plant, seawater pump station and direct ocean intake (Figure 1) as well as construction methods detailed in the memo "Belmont Desalination plant – Intake construction options" (WSP, 25 Nov 2019) were used to inform the review and subsequent discussion.

The geotechnical investigation report (GHD, 2018, Belmont Temporary Desalination Design - Geotechnical Investigation Report, Doc. 50411) provided information about subsurface conditions.

[1] Mine subsidence and strata control in the Newcastle district of the northern coalfield New South Wales, Doctor of Philosophy thesis, Department of Civil and Mining Engineering, University of Wollongong, 1984, Appendix B, Study 9.



Paper Size ISO A4

0 60 120 180 240

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 56

N

Hunter Water Corporation
Belmont Drought Response Desalination Plant
Mine Subsidence Desktop Assessment

The Amended Project

Project No. **22-19573**
Revision No. **0**
Date **29/06/2020**

Figure 1

G:\22\19573\Design\04 Deliverables\02 Other\2219573_AR_MSDA_0.aprx\2219573_MSDA001_TheProject_0
Print date: 29 Jun 2020 - 10:10

Data source: HWC: Aerial Imagery, Existing outfall: 2019; LPI: DTDB / DCDB, 2017; public_NSW_Imagery: © Department of Customer Service 2020. Created by: fmackay

3 Subsurface profile

A generalised subsurface profile of the desalination plant and direct ocean intake site is presented in Table 1. This is based on the 2018 geotechnical investigation report by GHD, geological sections from Kapp (1984) and typical strata shown on the RTs.

Table 1 Subsurface profile for the direct ocean intake and desalination plant site

Approximate depth below ground	Unit
Surface to 50 m	Alluvium, comprising sand to around 20-30 m, over estuarine clay.
50 m to 130 m	Charlestown Conglomerate.
130 m to > 280 m	Undifferentiated Sedimentary Bedrock, comprising sandstone, shale, claystone and coal seam
210 m *280 m*	*Victoria Tunnel coal seam* *Borehole coal seam*

4 Mining at the site

Abandoned coal mine workings from John Darling Colliery in the Victoria Tunnel Seam and Borehole Seam are present under the desalination plant site, seawater pump station and direct ocean intake alignment as shown in Figures A and B (attached).

Excavation of the first shaft at the colliery commenced in 1925 and operations ceased in 1987.

Bord and pillar (first workings) and pillar extraction (second workings) methods of mining were employed throughout the mine. Mini longwall methods were used in some areas between 1969 and 1975, and longwall methods used from 1981.

Table 2 summarises the mining methods employed within the angle of draw (defined here by where a projected line from the edge of mining at 26.5° to the vertical) of the desalination plant site, seawater pump station and direct ocean intake alignment.

The angle of draw is a key consideration in subsidence prediction and defines the typical zone of practical influence (i.e. 20 mm subsidence contour) at the ground surface should collapse of mine workings occur (as shown in Figure 2 as angle β). While the actual angle of draw varies considerably and does not include far field subsidence effects, the value of 26.5° (1H:2V) is commonly adopted in the Newcastle area as a “rule of thumb”.

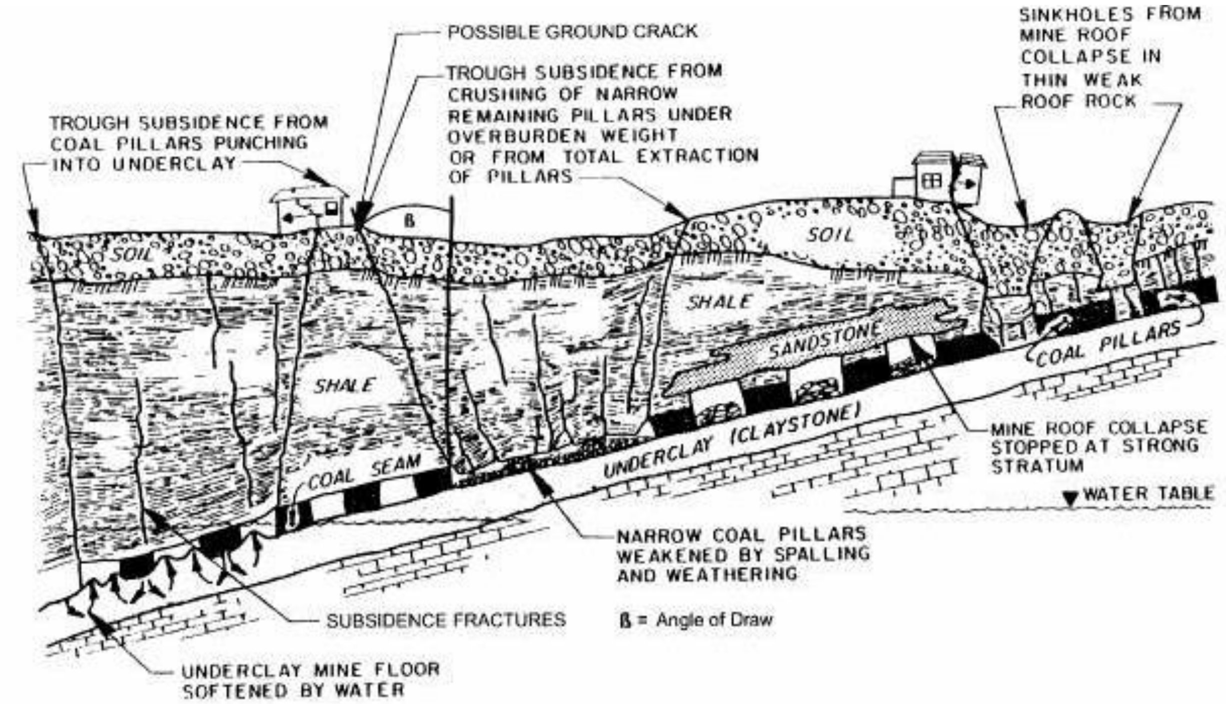


Figure 2 **Types of mine subsidence (Knott and Bruyn)**

Table 2 **Mining methods within angle of draw of plant, seawater pump station and intake alignment**

Approximate depth below ground	Coal seam	Mining method	Location
210 m	Victoria Tunnel	Second workings c. 1973 to 1975	Within the angle of draw (50 – 105 m) from plant, seawater pump station and first 60 m of intake alignment.
		Longwall c. 1981 to 1987	Underlying and within the angle of draw of plant, seawater pump station and intake alignment.
280 m	Borehole	Longwall c. 1982 to 1987	Underlying and within the angle of draw of plant, seawater pump station and intake alignment.

The Victoria Tunnel longwall panel shown on Figure A (Appendix A) overlies two Borehole Seam longwall panels, all of which underlie and are within the angle of draw of the plant, seawater pump station and intake alignment.

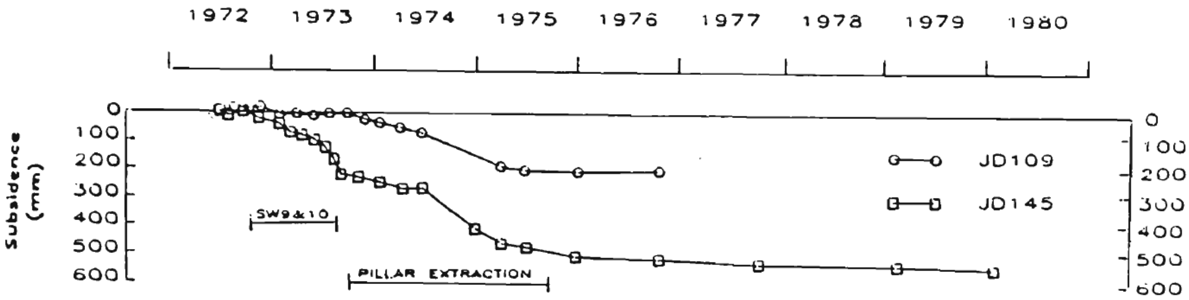
5 Discussion

For longwall panels, we anticipate that goafing (collapse of the roof above the longwall panels) occurred progressively during mining as the support chocks and face advanced. A lack of progressive roof collapse is a very dangerous situation for underground mining personnel as air blasts result when collapse finally does occur. Given the characteristics of the strata above the mined seam, such progressive collapse is likely to have occurred reliably and the resulting surface subsidence completed within a few months following mining.

Goafing above the mined panel and subsidence of the overburden strata results in disturbance to the strata in the form of cracking, bedding separations and sagging around the collapsed “goaf” zone. The characteristics of this disturbance depend largely on the nature of the overburden strata. In the case of longwall mining in the Borehole Seam, it is almost certain that pre-existing workings in the Victoria Tunnel Seam were effected. The effects are likely to include shearing through remaining coal pillars, reducing their strength and hence increasing their likelihood of failure.

Large areas of second workings (pillar extraction) also usually collapse and are marked on record tracings as “goafed”. They are sealed off (to maintain ventilation in operational areas of the mine) and usually not re-entered. However, in many cases, small areas of secondary workings with short spans of more competent strata between supporting pillars or unmined coal will remain standing for several decades. This is particularly so where remnant pillars “stooks” exist. Such stooks are often not depicted on record tracings. As such, complete collapse (“goafing”) of areas of secondary pillar extraction, particularly with short roof spans, is not reliably known despite such areas being shown as “goafed” on record tracings. Consequently the potential for future collapse and subsidence cannot be discounted without further knowledge of the mine, subsidence survey data or borehole investigations post-mining.

Fortunately the ground surface above the area of second workings noted in Table 2 was monitored and subsidence recorded in the PhD thesis (Kapp, 1984). A surface survey line was monitored between 1972 and 1975 to record subsidence due to extraction of a number of mini wall panels as well as the area of pillar extraction in the VT Seam. Maximum subsidence (S_{max}) of 600 mm was recorded (compared to a predicted S_{max} of 690 mm). Subsidence monitoring continued until 1980 and showed no further notable movement. After 1980, longwall mining in the Victoria Tunnel Seam and underlying Borehole Seam was undertaken and additional subsidence would have occurred.



Note: JD109 located above short wall, JD145 located near southern edge of pillar extraction

Figure 3 Subsidence monitoring (Kapp, 1984)

Kapp (1984) noted the subsidence profile was smooth with no unaccounted irregularities, indicating full roof convergence (collapse) occurred over the area of secondary workings. Calculation of the geometric relationship (size, depth and height) of the pillars indicated that surrounding smaller pillars would have been crushed and larger pillars would not have remained stable (Kapp, 1983, pp B-86). Based on the above, we anticipate that goafing of the second workings did occur and further roof convergence (crushing of pillars due to abutment loading) surrounding the area of secondary workings also occurred.

While considered very unlikely based on the information reviewed, there is the possibility of future residual subsidence due to crushing of chain and development pillars between panels (abutment loading and pillar degradation). More likely is that stress redistribution through goaf areas and stress reduction due to mine inundation (flooding) has occurred reducing stresses on pillars to achieve a “long term stable” situation.

The magnitude and profile of subsidence at the ground surface and near surface would be mitigated by a thick conglomerate unit (Charlestown Conglomerate) and approximately 50 m thick alluvial soil unit which would both act to reduce and distribute (‘smooth out’) any ground surface subsidence. It is unlikely the effects of such residual subsidence would be noticeable without the aid of high accuracy ground surveys before and during subsidence.

Multi-bean sonar bathymetry and sub-bottom profiling (sparker) over a 1 km x 2 km area was collected in October 2019 (GHD letter dated 19 December 2019). Bathymetry showed no patterns that could be attributed to longwall mine subsidence troughs and we expect any such troughs would have been infilled with sand. Bedrock level isopachs show lower areas that could be attributed to subsidence however, their relief relative to areas of bedrock high are in the order of up to 10 to 25 m. These are natural erosional features. A clear pattern representing the longwall panels beneath is not evident. This is primarily expected to be due to the degree of natural bedrock relief that obscures shallower trough subsidence depressions.

6 Risk and mitigation measures

Based on the proposed layout of the desalination plant, seawater pump station and direct ocean intake alignment, the construction methods for the intake structure, as well as the above desktop review, we anticipate the likelihood is:

1) Very low that future mine subsidence would occur

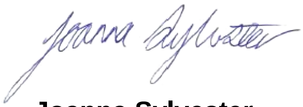
2) Very low that should subsidence occur, it would adversely impact the proposed development

A conceivable worst-case consequence of subsidence is differential movement of foundations or pipes in the plant or rotation of the seawater pump station, putting it slightly out of vertical alignment and resulting in rotation at the well/pipework connection. A very rigid connection would see such rotation result in additional stress at the connection.

We recommend HWC consider the assessed very low likelihood of residual subsidence occurring combined with the very low likelihood that such subsidence would be of a magnitude to adversely impact the proposed development. If the associated risk is acceptable to HWC, no further assessment or design consideration would be recommended.

Alternatively, if the risk is considered unacceptable, detailed design could consider options to provide a less rigid connection (given that this is understood to be common practice for the use of flexible pipe connections in such designs). If required, the magnitude of seawater pump station tilt to accommodate in the design could be estimated from a hypothetical subsidence profile approximated by an exponential function that is derived in part from the subsidence data provided in Kapp 1984.

Sincerely
GHD



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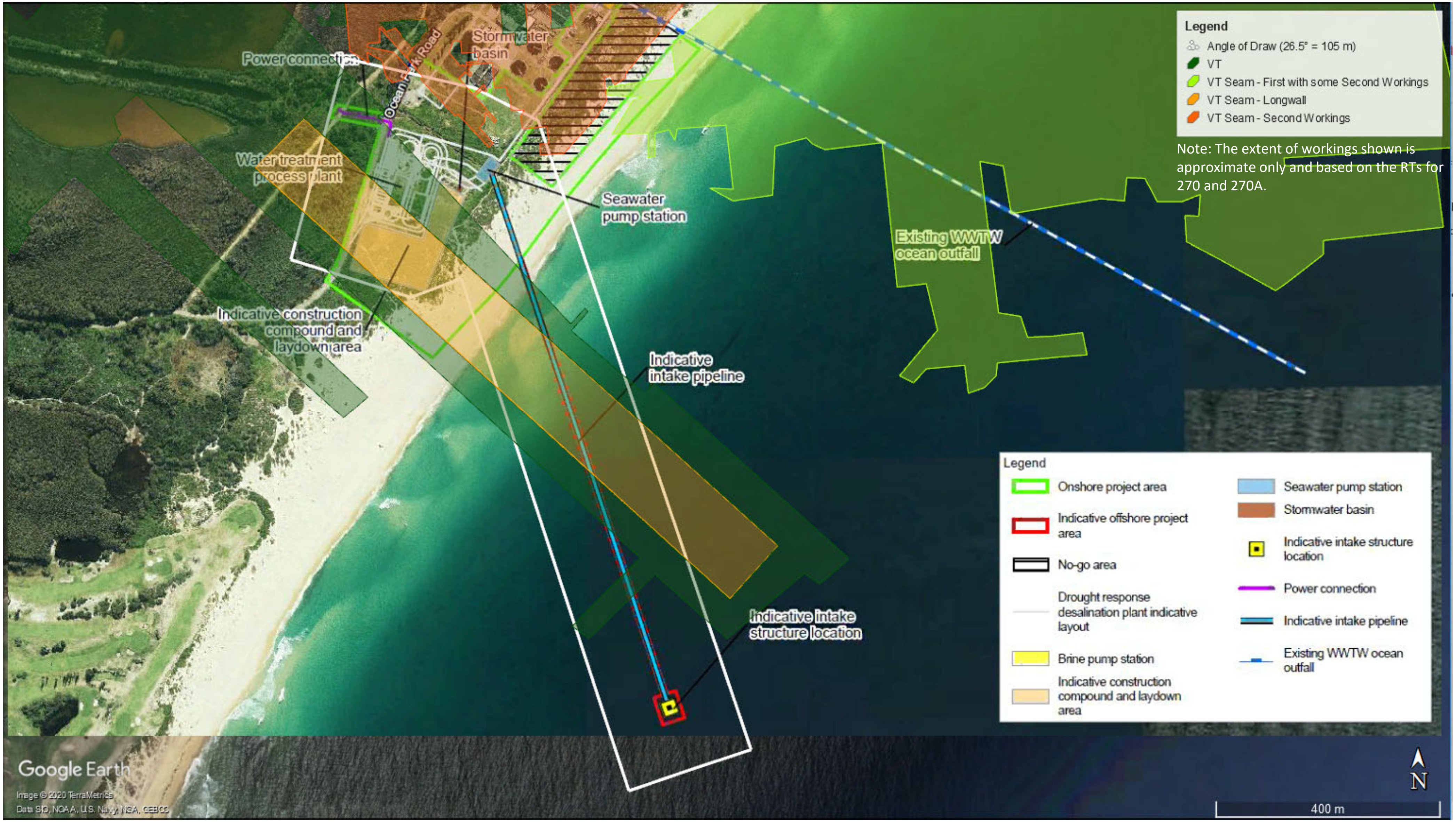
Attachment: A – Figures

Appendix A

Figures



Hunter Water Corporation
Belmont Desalination Plant
Historic Underground Mining – Victoria Tunnel Seam workings (approx.)

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Figure A

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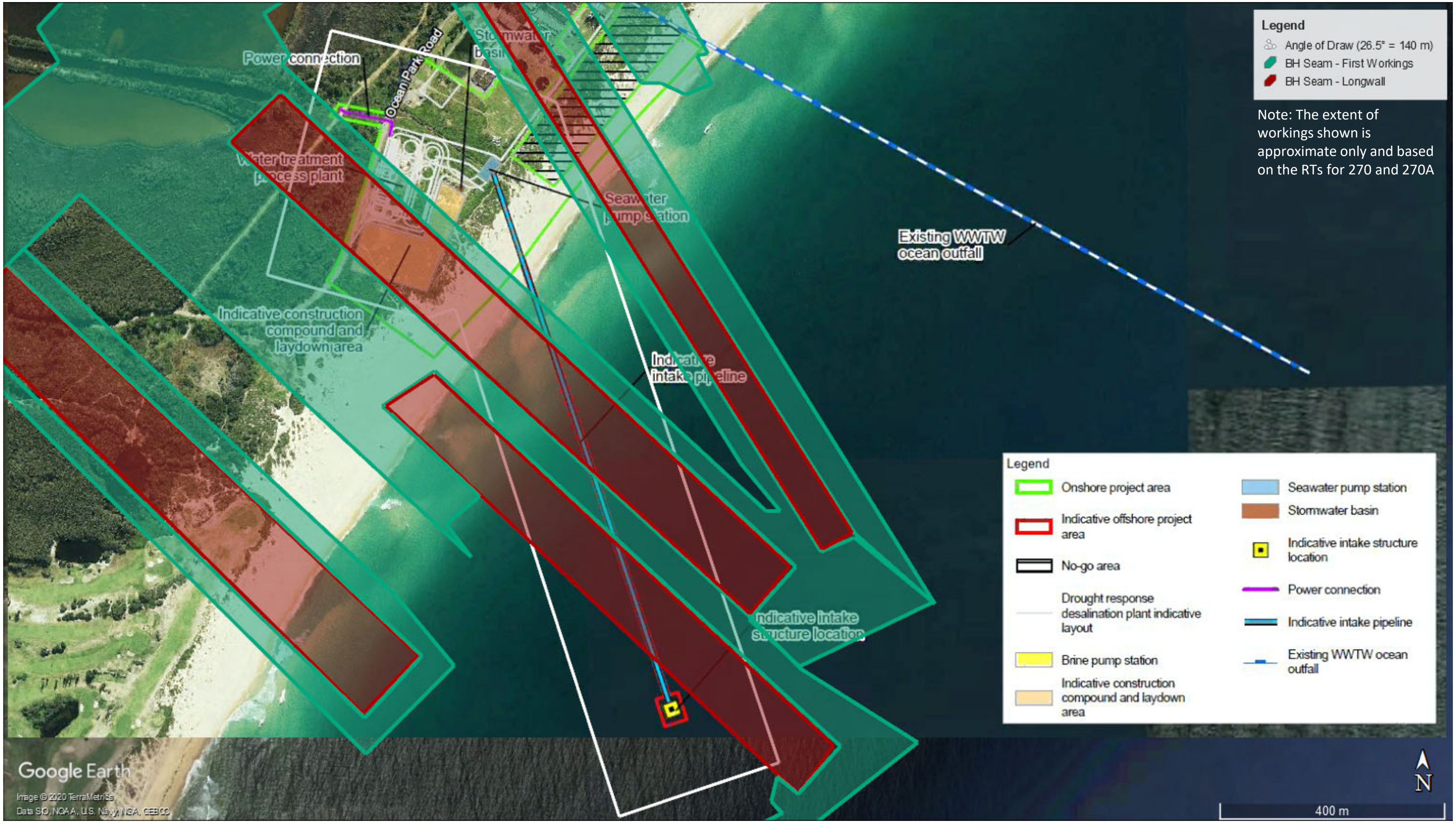

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Belmont Desalination Plant

Historic Underground Mining – Borehole Seam workings (approx.)

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Figure B

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