Goldenfields Water

Vegetation Page 5

NANGUS, NSW

Legend

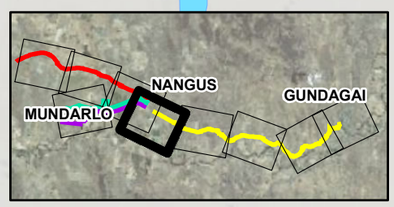
- Indicative River Intake and Pump Station Option 5
- Indicative Bore Location Option 6
- Major Road (NSW SS)
- Local Road (NSW SS)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- Proposed Reticulation
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

PCTs Riverina E4469 (OEH)

- 0: Not Native / Other
- 5: River Red Gum herbaceous-grassy very tall open forest wetland
- 79: River Red Gum shrub/grass riparian tall woodland or open forest wetland
- 266: White Box grassy woodland
- 276: Yellow Box grassy tall woodland
- 277: Blakelys Red Gum - Yellow Box grassy tall woodland

1:15,000 Scale at A3

m
0 150 300 450 600



Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2020-02-14 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-015-VegetationDDP.mxd 03
Aerial Imagery supplied by DFSI (2017)
PCT names have been shortened to fit legend

Goldenfields Water

Vegetation Page 6

NANGUS, NSW

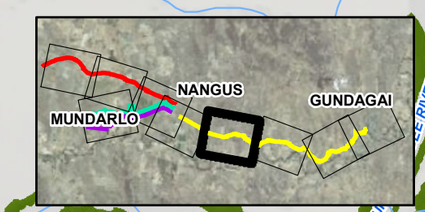
Legend

- Reservoir Option 1
- Major Road (NSW SS)
- Local Road (NSW SS)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

18km
17km
16km
15km
14km
13km
NANGUS ROAD
OAK CREEK

PCTs Riverina E4469 (OEH)

- 0: Not Native / Other
- 5: River Red Gum herbaceous-grassy very tall open forest wetland
- 266: White Box grassy woodland
- 277: Blakelys Red Gum - Yellow Box grassy tall woodland
- 289: Mugga Ironbark - Inland Scribbly Gum - Red Box shrub/grass open forest
- 347: White Box - Blakelys Red Gum shrub/grass woodland



1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
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Aerial Imagery supplied by DFSI (2017)
PCT names have been shortened to fit legend

Goldenfields Water

Vegetation Page 7

NANGUS, NSW

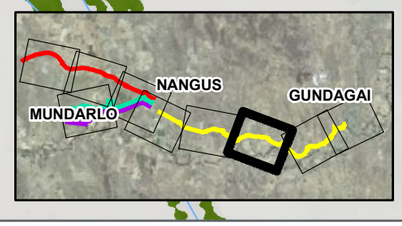
Legend

- Major Road (NSW SS)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

PCTs Riverina E4469 (OEH)

- 0: Not Native / Other
- 5: River Red Gum herbaceous-grassy very tall open forest wetland
- 266: White Box grassy woodland
- 277: Blakelys Red Gum - Yellow Box grassy tall woodland
- 278: Riparian Blakelys Red Gum - box - shrub - sedge - grass tall open forest
- 289: Mugga Ironbark - Inland Scribbly Gum - Red Box shrub/grass open forest
- 347: White Box - Blakelys Red Gum shrub/grass woodland
- 796: Derived grassland

12km
11km
10km
9km
8km
NANGUS ROAD
MURRUMBIDGEE RIVER
LONG TUNNEL CREEK



1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Aerial Imagery supplied by DFSI (2017)
PCT names have been shortened to fit legend

Goldenfields Water

Vegetation Page 8

NANGUS, NSW

Legend

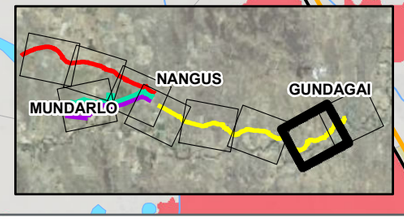
- Booster Pump Station (Option 1)
- Major Road (NSW SS)
- Local Road (NSW SS)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- CGRC Existing Water Mains
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

PCTs Riverina E4469 (OEH)

- 0: Not Native / Other
- 5: River Red Gum herbaceous-grassy very tall open forest wetland
- 79: River Red Gum shrub/grass riparian tall woodland or open forest wetland
- 266: White Box grassy woodland
- 277: Blakelys Red Gum - Yellow Box grassy tall woodland
- 283: Apple Box - Blakelys Red Gum moist valley and footslopes grass-forb open forest
- 347: White Box - Blakelys Red Gum shrub/grass woodland
- 796: Derived grassland

1:15,000 Scale at A3

m 0 150 300 450 600



Cardno

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PCT names have been shortened to fit legend

Goldenfields Water

Vegetation Page 9

NANGUS, NSW

Legend

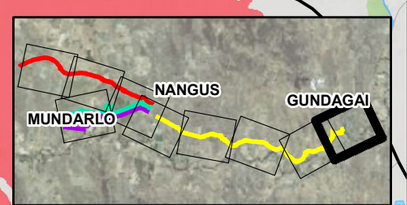
- Major Road (NSW SS)
- Local Road (NSW SS)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- CGRC Existing Water Mains
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

PCTs Riverina E4469 (OEH)

- 0: Not Native / Other
- 5: River Red Gum herbaceous-grassy very tall open forest wetland
- 79: River Red Gum shrub/grass riparian tall woodland or open forest wetland
- 266: White Box grassy woodland
- 277: Blakelys Red Gum - Yellow Box grassy tall woodland
- 278: Riparian Blakelys Red Gum - box - shrub - sedge - grass tall open forest
- 796: Derived grassland

1:15,000 Scale at A3

m
0 150 300 450 600



Cardno

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Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-015-VegetationDDP.mxd 03
Aerial Imagery supplied by DFSI (2017)
PCT names have been shortened to fit legend

Goldenfields Water

Hydrology and Groundwater

NANGUS, NSW

Legend

- Indicative River Intake and Pump Station Option 5
- Indicative Bore Location Option 6
- Groundwater Bore (BoM)
- Booster Pump Station (Option 1)
- Reservoir Option 1
- Reservoir Option 2
- Reservoir Options 3 and 4
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- GWCC Existing Water Mains
- CGRC Existing Water Mains
- Major Road (LPI)
- Local Road (LPI)
- 100m Contours (LPI)
- Waterbodies (LPI)

Stream Order (DPI Water, 2017)

- 3
- 4
- 5
- 6
- >8

1:100,000 Scale at A3

km 0 1 2 3 4

N

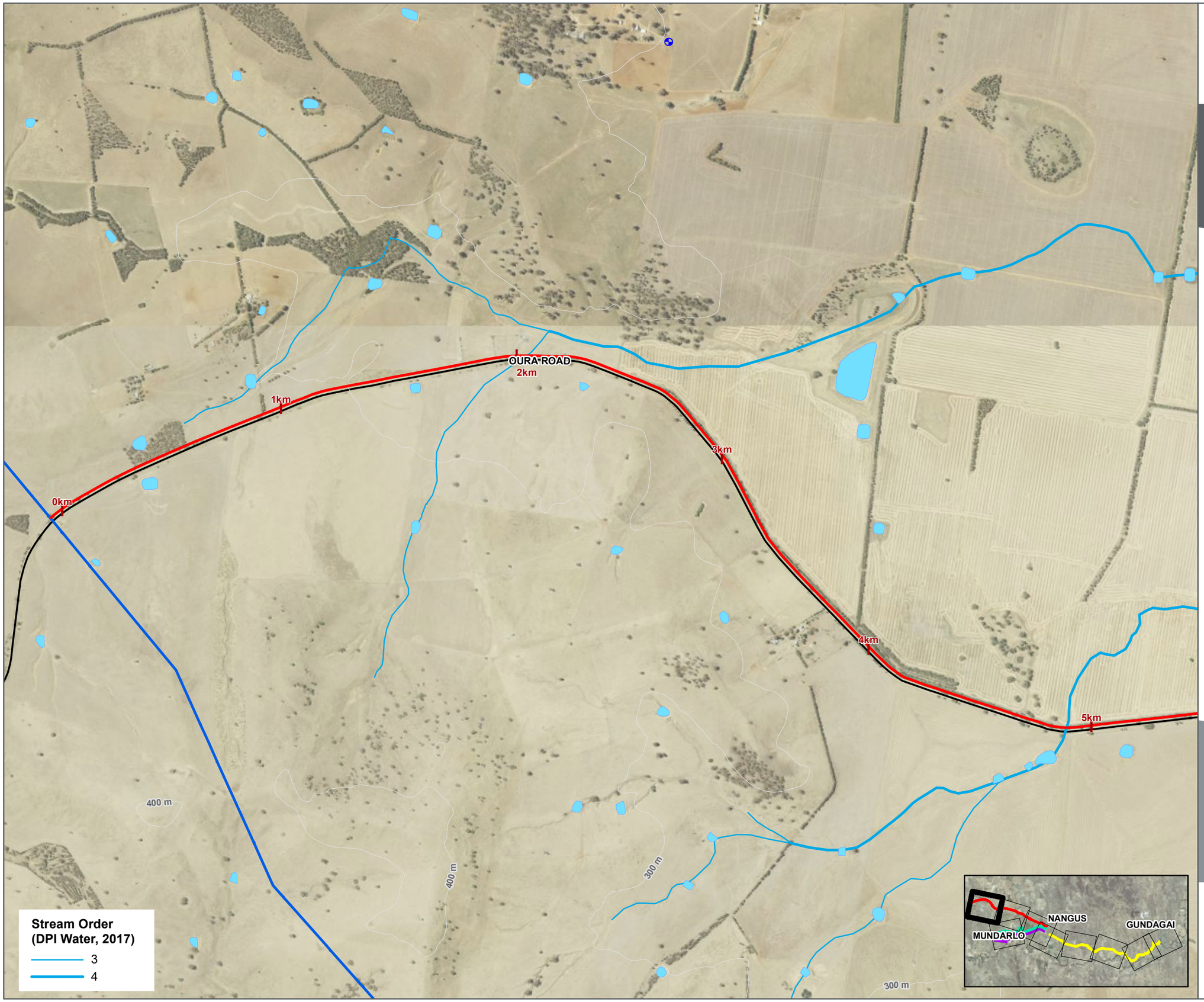
Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-009-Hydrology1.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Hydrology and Groundwater Page 1

NANGUS, NSW



Legend

- Groundwater Bore (BoM)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- GWCC Existing Water Mains
- 100m Contours (LPI)
- Major Road (LPI)
- Waterbodies (LPI)

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-016-HydrologyDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Hydrology and Groundwater Page 2

NANGUS, NSW

BILLABONG CREEK

NANGUS ROAD

OURA ROAD

RIVER ROAD

5km

6km

7km

8km

9km

10km

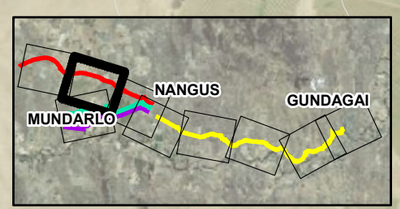
300 m

Legend

- Reservoir Option 2
- Groundwater Bore (BoM)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Waterbodies (LPI)

Stream Order (DPI Water, 2017)

- 3
- 4
- 6



1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
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Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-016-HydrologyDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Hydrology and Groundwater Page 3

NANGUS, NSW

Legend

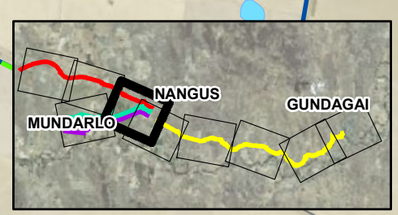
- Reservoir Option 2
- Groundwater Bore (BoM)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- Proposed Reticulation
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Waterbodies (LPI)

Stream Order (DPI Water, 2017)

- 3
- 5
- >8

1:15,000 Scale at A3

m
0 150 300 450 600



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Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-016-HydrologyDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Hydrology and Groundwater Page 4

NANGUS, NSW

Legend

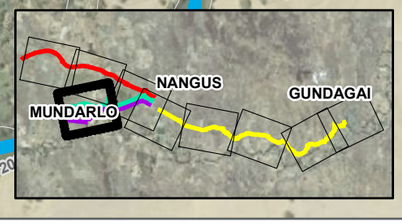
- Reservoir Options 3 and 4
- Groundwater Bore (BoM)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- GWCC Existing Water Mains
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Waterbodies (LPI)

Stream Order (DPI Water, 2017)

- 3
- 4
- 6
- >8

1:15,000 Scale at A3

m
0 150 300 450 600



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Cardno

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Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-016-HydrologyDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Hydrology and Groundwater Page 5

NANGUS, NSW

Legend

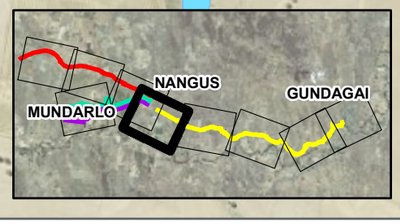
- Indicative River Intake and Pump Station Option 5
- Indicative Bore Location Option 6
- Groundwater Bore (BoM)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- Proposed Reticulation
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Waterbodies (LPI)

Stream Order (DPI Water, 2017)

- 3
- 5
- >8

1:15,000 Scale at A3

m
0 150 300 450 600



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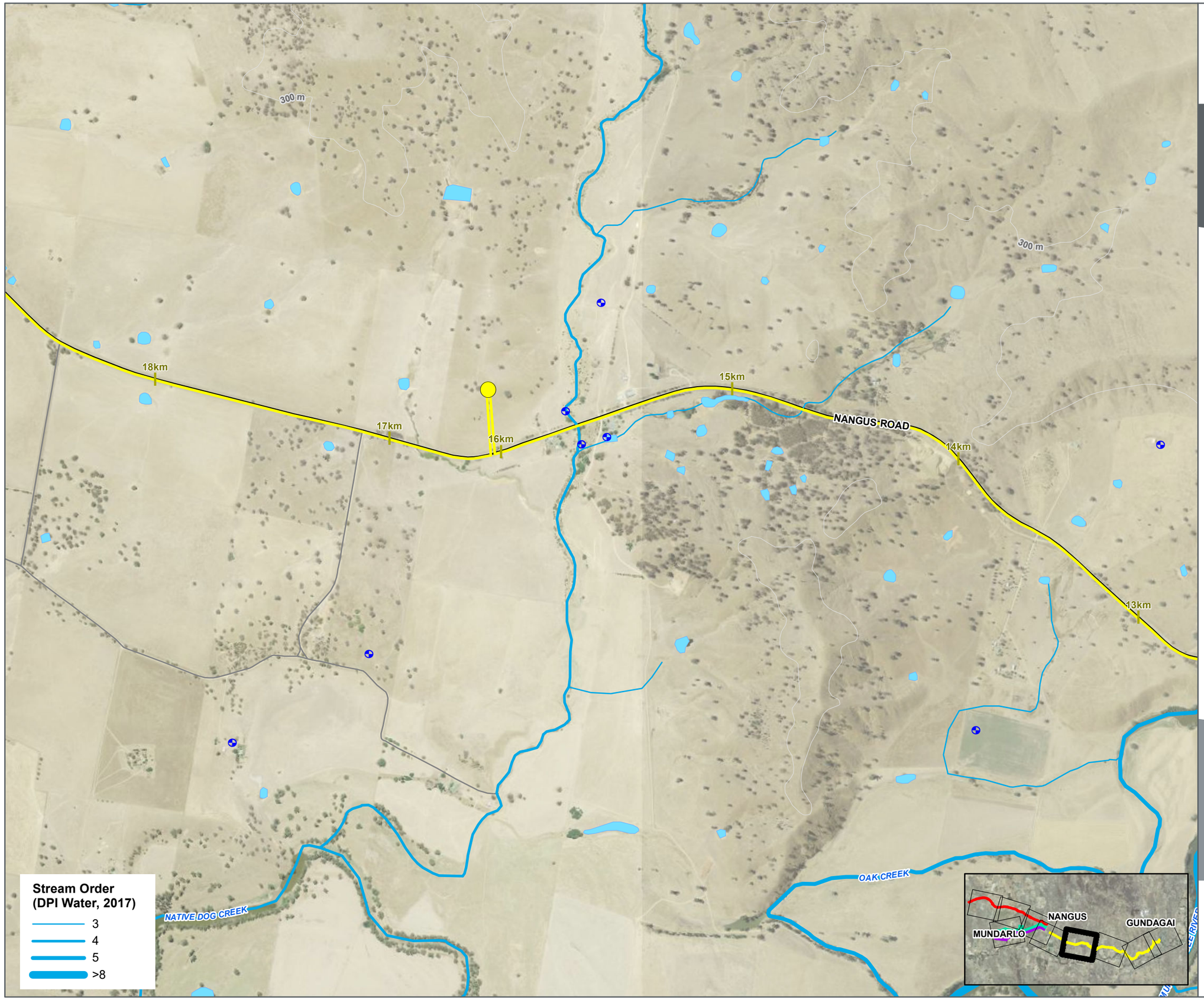
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-016-HydrologyDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Hydrology and Groundwater Page 6

NANGUS, NSW



Legend

- Reservoir Option 1
- Groundwater Bore (BoM)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Waterbodies (LPI)

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-016-HydrologyDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Hydrology and Groundwater Page 7

NANGUS, NSW

Legend

- Groundwater Bore (BoM)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- 100m Contours (LPI)
- Major Road (LPI)
- Waterbodies (LPI)

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-016-HydrologyDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Hydrology and Groundwater Page 8

NANGUS, NSW

Legend

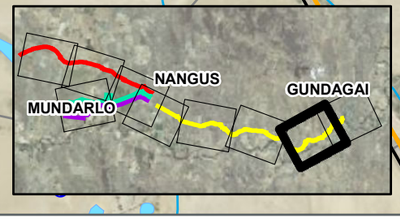
- Booster Pump Station (Option 1)
- Groundwater Bore (BoM)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- CGRC Existing Water Mains
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Waterbodies (LPI)

Stream Order (DPI Water, 2017)

- 3
- 5
- >8

1:15,000 Scale at A3

m
0 150 300 450 600



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Cardno

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Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-016-HydrologyDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Hydrology and Groundwater Page 9

NANGUS, NSW

Legend

- Groundwater Bore (BoM)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- CGRC Existing Water Mains
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Waterbodies (LPI)

Stream Order (DPI Water, 2017)

- 3
- 4
- 5
- >8

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-016-HydrologyDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Zoning and Land Use

NANGUS, NSW

Legend

- Indicative River Intake and Pump Station Option 5
- Indicative Bore Location Option 6
- Booster Pump Station (Option 1)
- Reservoir Option 1
- Reservoir Option 2
- Reservoir Options 3 and 4
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- GWCC Existing Water Mains
- CGRC Existing Water Mains
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)

Zoning (DPE, July 2019)

- B2 - Local Centre
- B4 - Mixed Use
- IN1 - General Industrial
- R1 - General Residential
- R3 - Medium Density Residential
- R5 - Large Lot Residential
- RE1 - Public Recreation
- RE2 - Private Recreation
- RU1 - Primary Production
- RU4 - Primary Production Small Lots
- RU5 - Village
- SP1 - Special Activities
- SP3 - Tourist
- W1 - Natural Waterways

1:100,000 Scale at A3

km 0 1 2 3 4

N

Cardno

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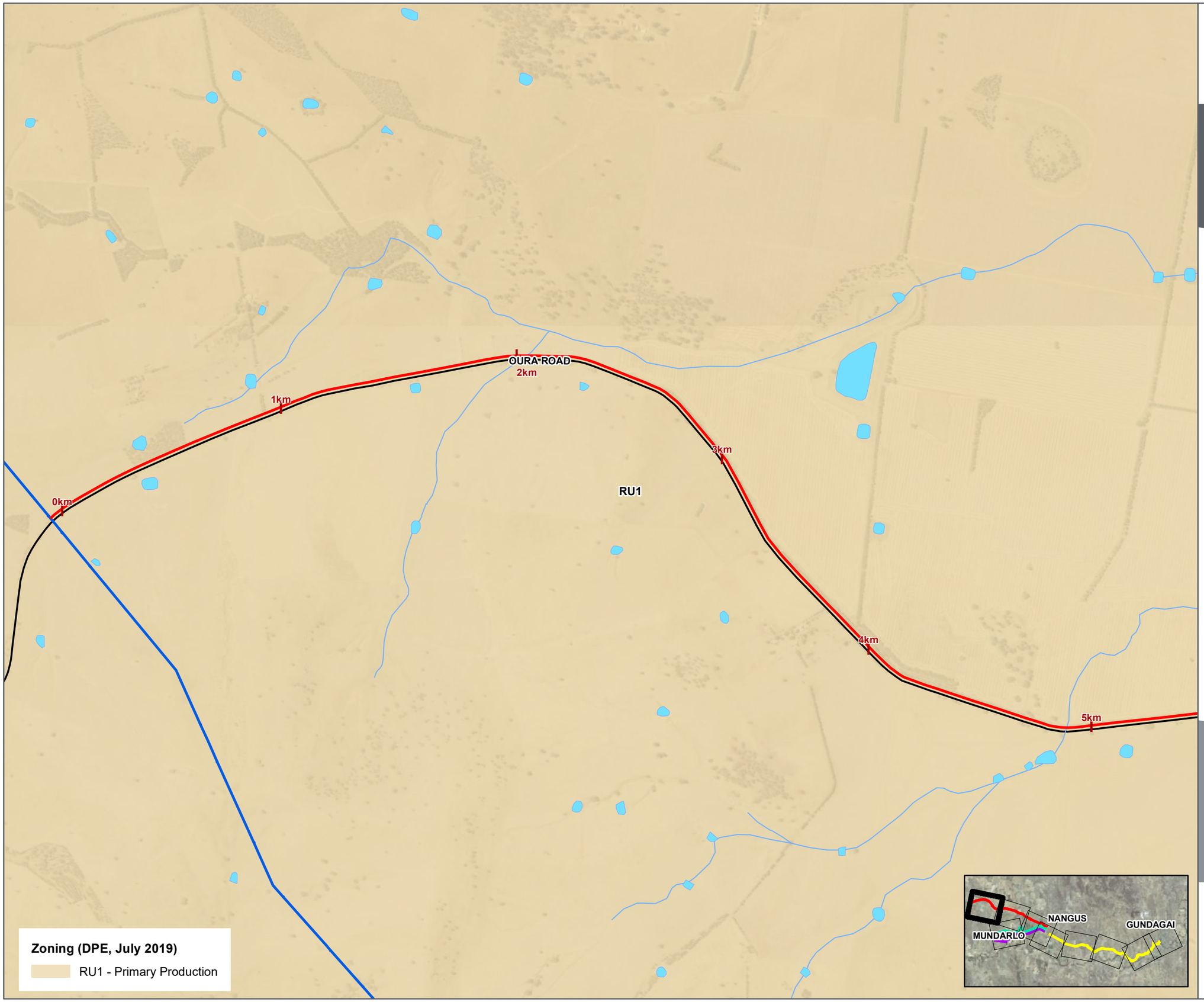
Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-010-Zoning1.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Zoning and Land Use Page 1

NANGUS, NSW



Legend

- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- GWCC Existing Water Mains
- Major Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-019-ZoningDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Zoning and Land Use Page 2

NANGUS, NSW

Legend

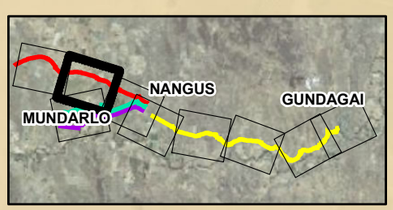
- Reservoir Option 2
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Zoning (DPE, July 2019)

- RU1 - Primary Production

1:15,000 Scale at A3

m 0 150 300 450 600



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Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-019-ZoningDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Zoning and Land Use Page 3

NANGUS, NSW

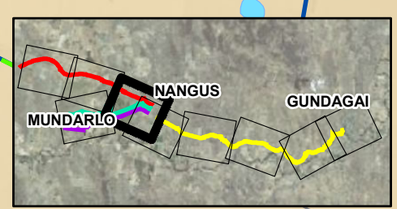
Legend

- Reservoir Option 2
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- Proposed Reticulation
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

NANGUS ROAD
BETHUNGRA ROAD
OURA ROAD
KIMO STREET
ISLAND CREEK
NANGUS CREEK
10km
11km
12km
13km
10km
9km
9km
8km
8km
7km
7km
21km
RU1
RU5
NANGUS

Zoning (DPE, July 2019)

- RU1 - Primary Production
- RU5 - Village
- SP1 - Special Activities
- W1 - Natural Waterways



1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
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Goldenfields Water

Zoning and Land Use Page 4

NANGUS, NSW

Legend

- Reservoir Options 3 and 4
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- GWCC Existing Water Mains
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

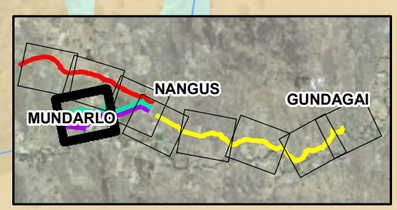
RU1

0km
1km
2km
3km
4km
5km
6km

BILLABONG CREEK
ISLAND CREEK
TENANDRA RESERVOIR
RIVER ROAD
W1
MURRUMBIDGEE RIVER

Zoning (DPE, July 2019)

- RU1 - Primary Production
- W1 - Natural Waterways



1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Goldenfields Water

Zoning and Land Use Page 5

NANGUS, NSW

Legend

- Indicative River Intake and Pump Station Option 5
- Indicative Bore Location Option 6
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- Proposed Reticulation
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Zoning (DPE, July 2019)

- RU1 - Primary Production
- RU5 - Village
- SP1 - Special Activities
- W1 - Natural Waterways

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Goldenfields Water

Zoning and Land Use Page 6

NANGUS, NSW

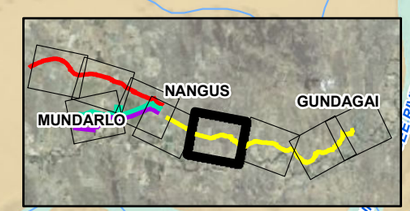
Legend

- Reservoir Option 1
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

18km
17km
16km
15km
14km
13km
NANGUS ROAD
RU1
W1
OAK CREEK

Zoning (DPE, July 2019)

- RU1 - Primary Production
- W1 - Natural Waterways



1:15,000 Scale at A3

m
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N

Cardno

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Date: 2019-11-29 | Project: 82020043-01
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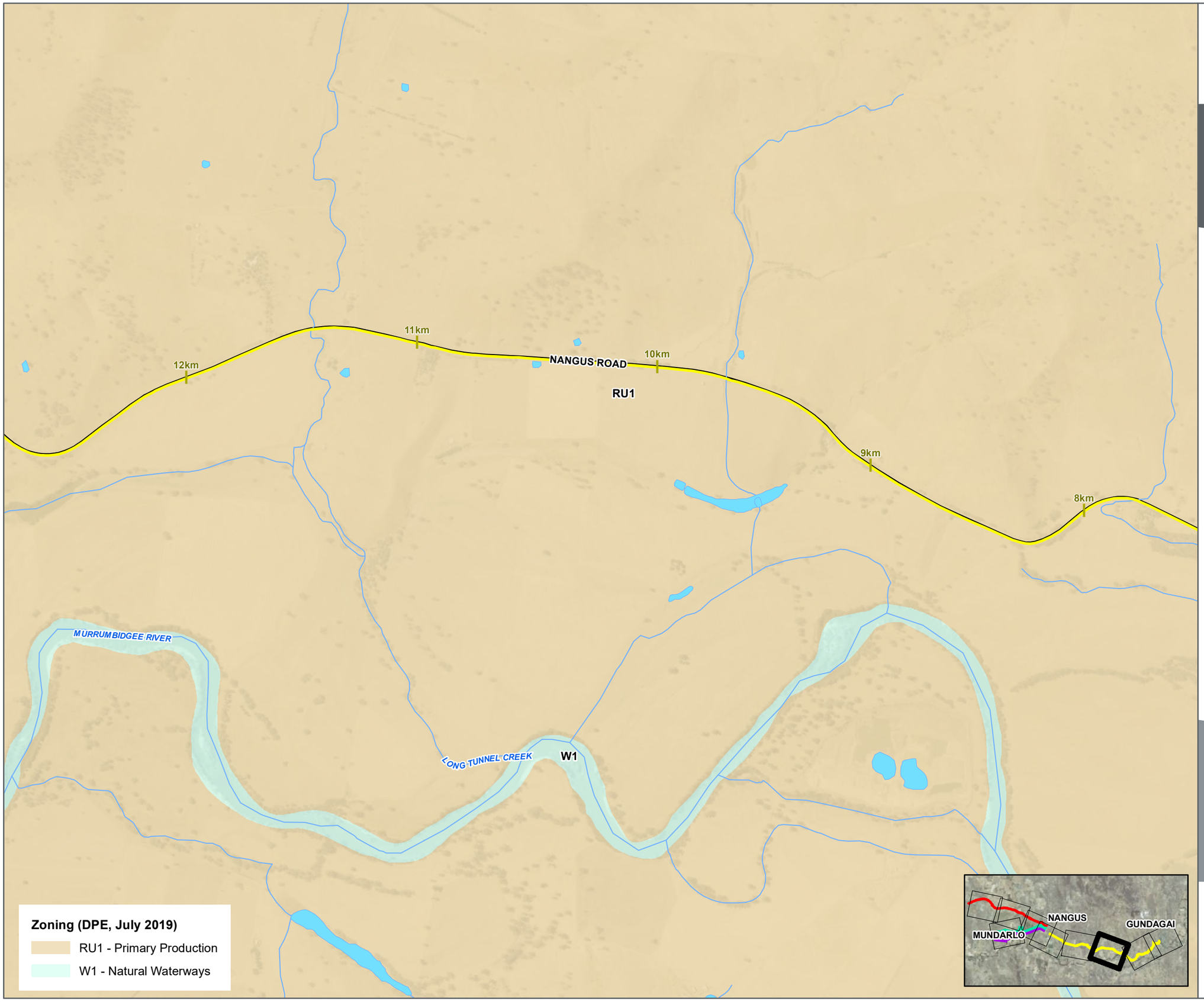
Map: 8202004301-01-GS-019-ZoningDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Zoning and Land Use Page 7

NANGUS, NSW



Legend

- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Major Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Goldenfields Water

Zoning and Land Use Page 8

NANGUS, NSW

Legend

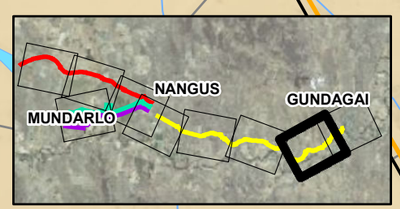
- Booster Pump Station (Option 1)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- CGRC Existing Water Mains
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Zoning (DPE, July 2019)

- B4 - Mixed Use
- R1 - General Residential
- RU1 - Primary Production
- SP1 - Special Activities
- W1 - Natural Waterways

1:15,000 Scale at A3

m
0 150 300 450 600



N

Cardno

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Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-019-ZoningDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Zoning and Land Use Page 9

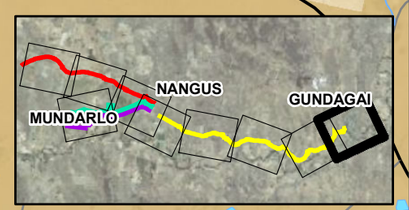
NANGUS, NSW

Legend

- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- CGRC Existing Water Mains
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Zoning (DPE, July 2019)

- B2 - Local Centre
- B4 - Mixed Use
- IN1 - General Industrial
- R1 - General Residential
- R3 - Medium Density Residential
- R5 - Large Lot Residential
- RE2 - Private Recreation
- RU1 - Primary Production
- RU4 - Primary Production Small Lots
- SP1 - Special Activities
- SP3 - Tourist
- W1 - Natural Waterways



1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-019-ZoningDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Contamination and Soils

NANGUS, NSW

Legend

- Indicative River Intake and Pump Station Option 5
- Indicative Bore Location Option 6
- Booster Pump Station (Option 1)
- Reservoir Option 1
- Reservoir Option 2
- Reservoir Options 3 and 4
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- GWCC Existing Water Mains
- CGRC Existing Water Mains
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Dryland Salinity / Saline Land

Soil Classifications (OEH, 2019)

- Chromosols
- Dermosols
- Ferrosols
- Kandosols
- Kurosols
- Kurosols, Natric
- Rudosols (Alluvial)
- Rudosols and Tenosols
- Sodosols
- Vertosols

1:100,000 Scale at A3

km 0 1 2 3 4

N

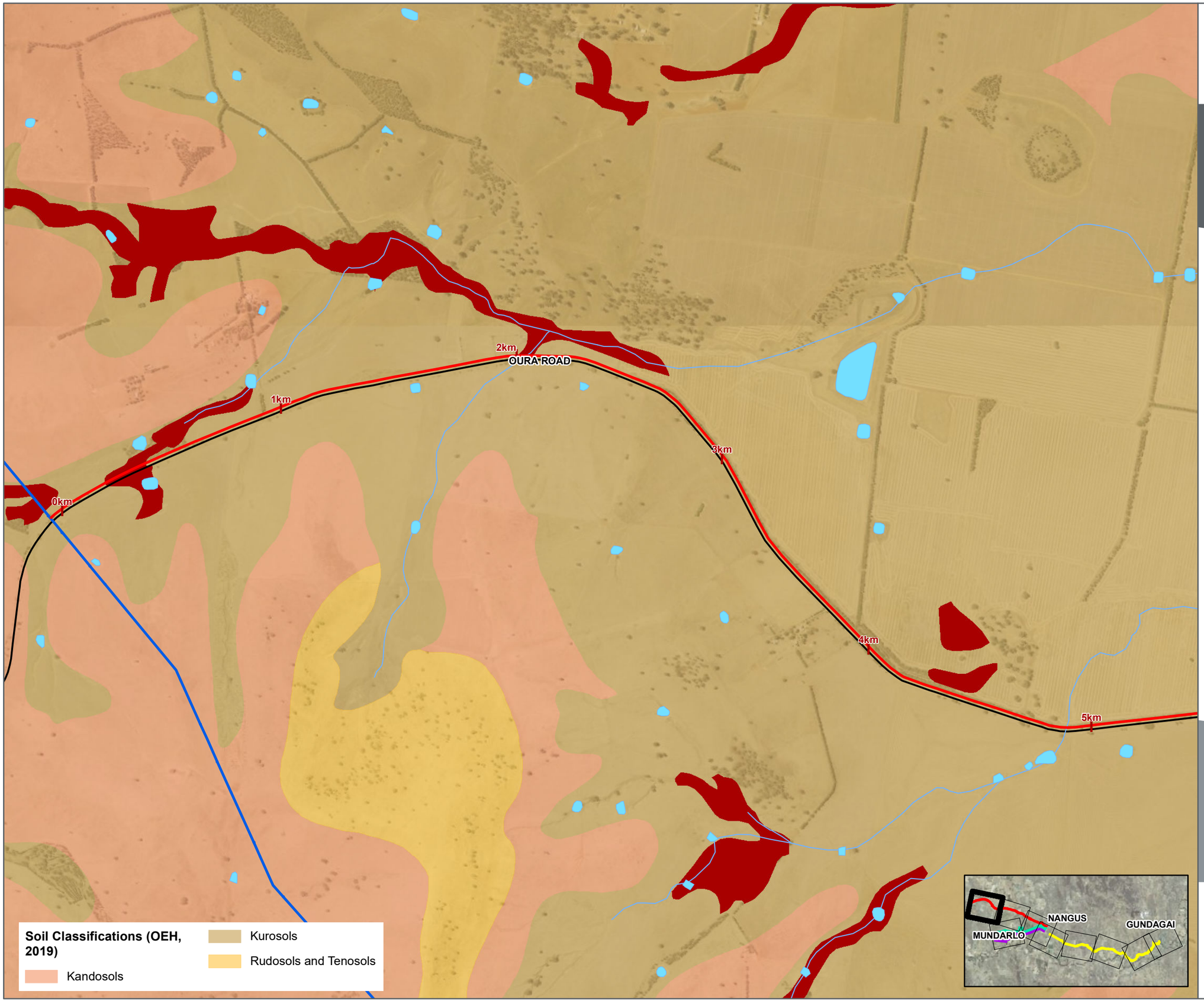
Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-011-SoilsContamination1.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Contamination and Soils Page 1

NANGUS, NSW



Legend

- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- GWCC Existing Water Mains
- Major Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)
- Dryland Salinity / Saline Land

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-017-SoilsContaminationDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Contamination and Soils Page 2

NANGUS, NSW

BILLABONG CREEK

NANGUS ROAD

OURA ROAD

RIVER ROAD

5km

6km

7km

8km

9km

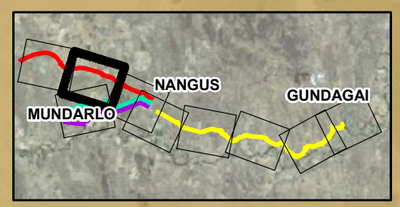
10km

Legend

- Reservoir Option 2
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Soil Classifications (OEH, 2019)

- Kandosols
- Kurosols



1:15,000 Scale at A3

m

0 150 300 450 600

N

Cardno

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Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
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Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Contamination and Soils Page 3

NANGUS, NSW

Legend

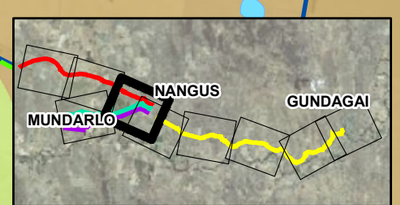
- Reservoir Option 2
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- Proposed Reticulation
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Soil Classifications (OEH, 2019)

- Kandosols
- Kurosols
- Rudosols (Alluvial)

1:15,000 Scale at A3

m
0 150 300 450 600



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Cardno

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Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-017-SoilsContaminationDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Contamination and Soils Page 4

NANGUS, NSW

Legend

- Reservoir Options 3 and 4
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- GWCC Existing Water Mains
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Soil Classifications (OEH, 2019)

- Dermosols
- Kandosols
- Kurosols
- Rudosols (Alluvial)
- Rudosols and Tenosols

1:15,000 Scale at A3

m
0 150 300 450 600

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
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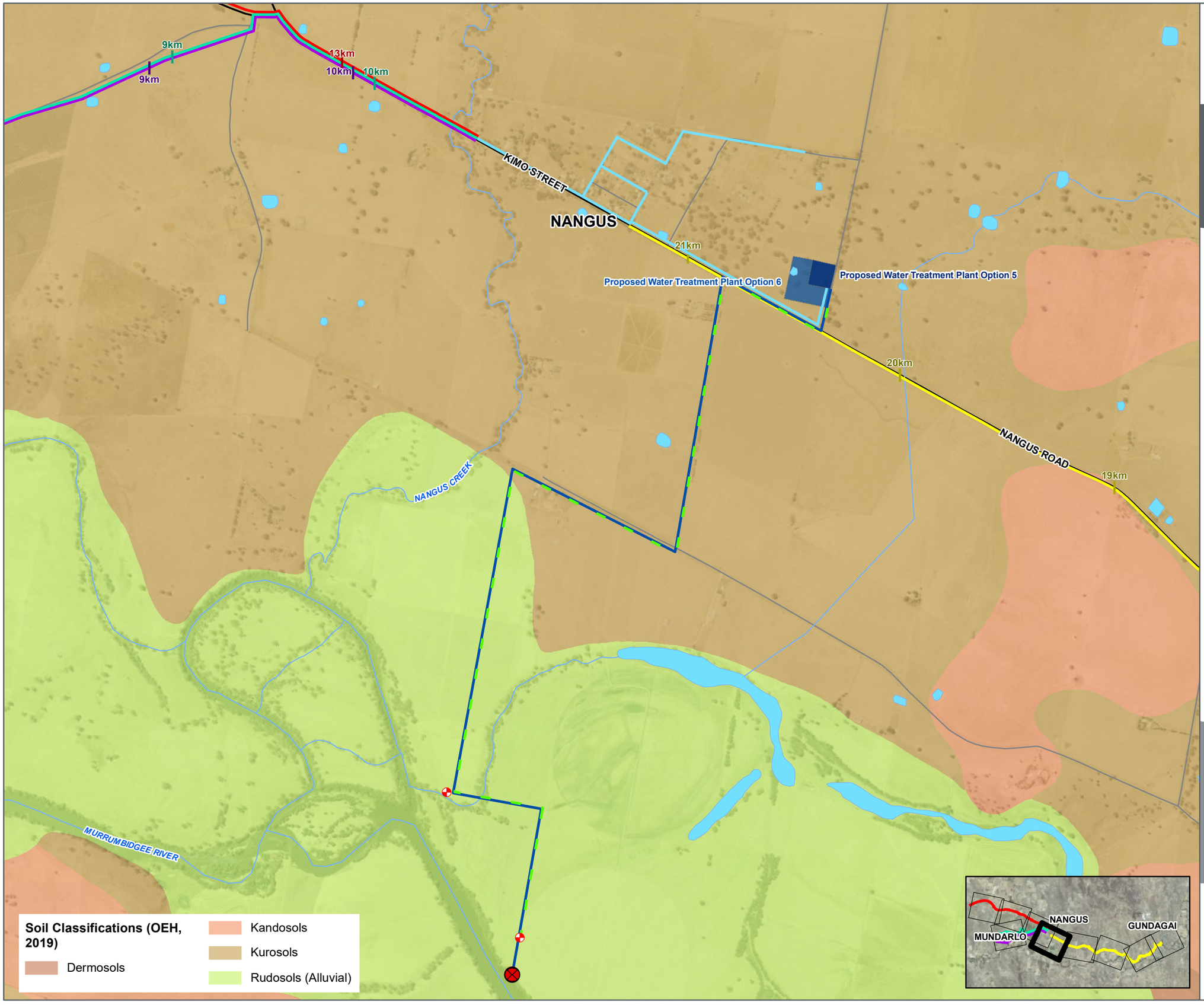
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-017-SoilsContaminationDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Contamination and Soils Page 5

NANGUS, NSW



Legend

- Indicative River Intake and Pump Station Option 5
- Indicative Bore Location Option 6
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- Proposed Reticulation
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-017-SoilsContaminationDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Contamination and Soils Page 6

NANGUS, NSW

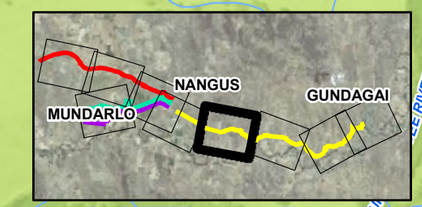
Legend

- Reservoir Option 1
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

18km
17km
16km
15km
14km
13km
NANGUS ROAD
OAK CREEK

Soil Classifications (OEH, 2019)

- Dermosols
- Kandosols
- Kurosols
- Rudosols (Alluvial)



1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-017-SoilsContaminationDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Contamination and Soils Page 7

NANGUS, NSW

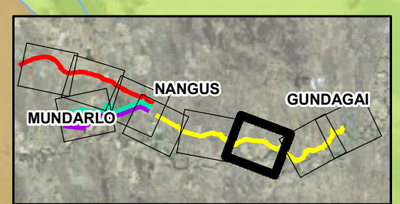
Legend

- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Major Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

NANGUS ROAD
12km
11km
10km
9km
8km
MURRUMBIDGEE RIVER
LONG TUNNEL CREEK

Soil Classifications (OEH, 2019)

- Ferrosols
- Kurosols
- Rudosols (Alluvial)



1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-017-SoilsContaminationDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Contamination and Soils Page 8

NANGUS, NSW

Legend

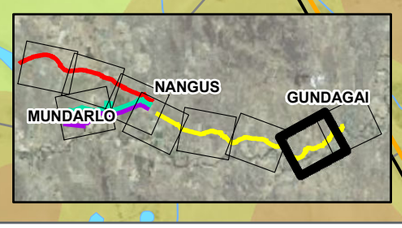
- Booster Pump Station (Option 1)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- CGRC Existing Water Mains
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Soil Classifications (OEH, 2019)

- Ferrosols
- Kurosols
- Kurosols, Natric
- Rudosols (Alluvial)
- Sodosols

1:15,000 Scale at A3

m
0 150 300 450 600



Cardno

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Map: 8202004301-01-GS-017-SoilsContaminationDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Contamination and Soils Page 9

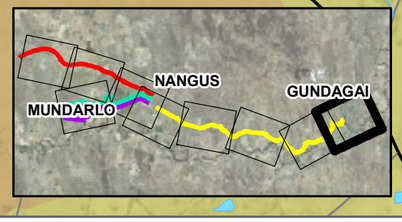
NANGUS, NSW

Legend

- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- CGRC Existing Water Mains
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Soil Classifications (OEH, 2019)

- Ferrosols
- Kurosols
- Rudosols (Alluvial)
- Rudosols and Tenosols
- Sodosols



1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-017-SoilsContaminationDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Heritage

NANGUS, NSW

Legend

- Indicative River Intake and Pump Station Option 5
- Indicative Bore Location Option 6
- Booster Pump Station (Option 1)
- Reservoir Option 1
- Reservoir Option 2
- Reservoir Options 3 and 4
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- GWCC Existing Water Mains
- CGRC Existing Water Mains
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Local Heritage (DPE, July 2019)
- Conservation Area - General (DPE, July 2019)
- State Heritage Register (OEH, 2019)
- Waterbodies (LPI)

1:100,000 Scale at A3

km 0 1 2 3 4

N

Cardno

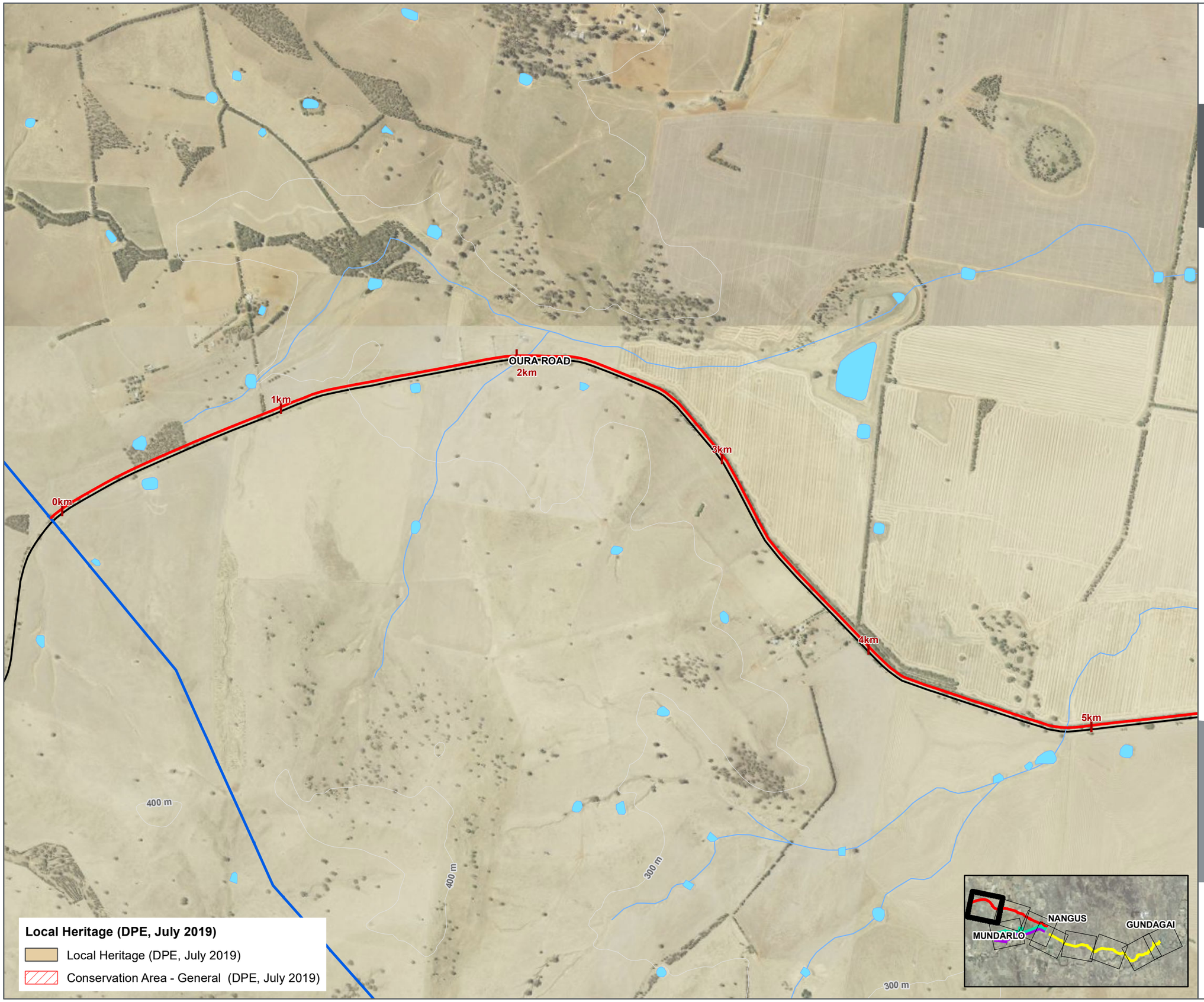
Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-012-Heritage1.mxd 02
Aerial Imagery supplied by DFSI (2017)

EURONGILLY CREEK
DOLLAR VALE ROAD
BETHUNGRA ROAD
DRY CREEK
COOBA CREEK
GUNDAGAI ROAD
LEFT ARM CREEK
ROCKY GULLY CREEK
OAK HILL CREEK
WATERFALL CREEK
JERUSALEM CREEK
BONGONGALONG CREEK
JOHNSONS CREEK
FIVE MILE CREEK
BURRA ROAD
I3: Dog on the Tuckerbox Memorial
OURA ROAD
BILLABONG CREEK
WANTABADGERY
NANGUS CREEK
NATIVE DOG CREEK
JONES CREEK
TARGET CREEK
SPRILBRY CREEK
I5: Gundagai District Hospital
GUNDAGAI
NANGUS VILLAGE
I20: War Memorial Nangus
ISLAND CREEK
TENANDRA RESERVOIR
LONG TUNNEL CREEK
BACK STATION CREEK
I11: Lanigan Abbey
I1: Anzac Grove & Other Memorials
C2: Old Gundagai Town Site
NANGUS ROAD
I9: Gundagai Rail Bridge Over Murrumbidgee River
RIVER ROAD
I14: Nangus Station Group
OAK CREEK
OLD HUME HIGHWAY
I22: Hillas Hut and other buildings
MURRUMBIDGEE RIVER
JELLINGRO CREEK
COOKOOMOOROO CREEK
SANDY CREEK
MUNDARLO
STONY CREEK
BIG BEN CREEK
ADELONG CREEK
GOCUP ROAD
TUMBLONG
HUME HIGHWAY
I21: War Memorial Tumblong
SNOWBALL CREEK
DIGGERS CREEK
OAKY CREEK
ADELONG ROAD
HILLAS CREEK
I10: Hillas Creek Bridge

Goldenfields Water

Heritage Page 1

NANGUS, NSW



Legend

- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- GWCC Existing Water Mains
- 100m Contours (LPI)
- Major Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Local Heritage (DPE, July 2019)

- Local Heritage (DPE, July 2019)
- Conservation Area - General (DPE, July 2019)

1:15,000 Scale at A3

m
0 150 300 450 600

N

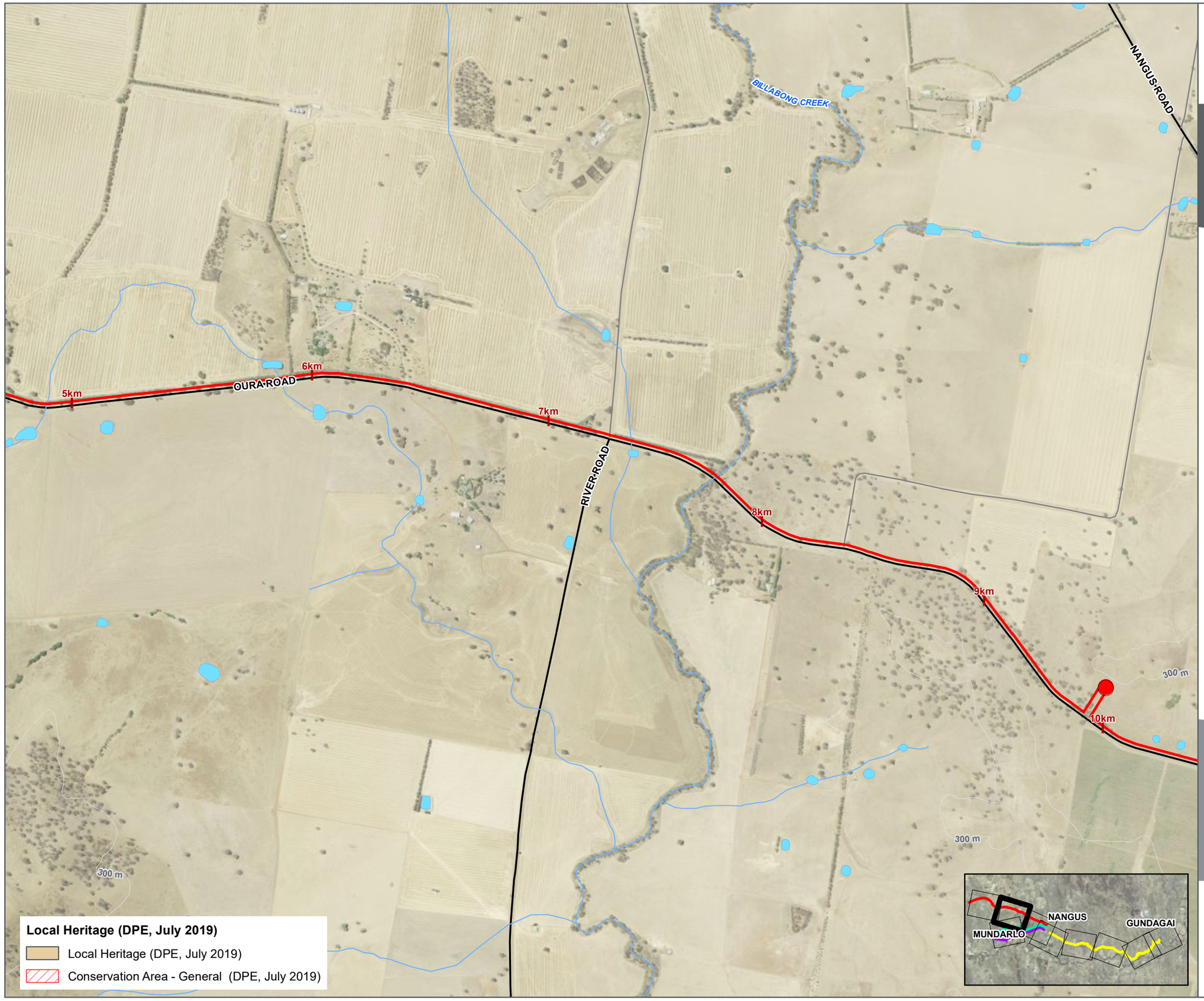
Cardno

Map Produced by Cardno NSW/ACT Pty Ltd (WOL)
Date: 2019-11-29 | Project: 82020043-01
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-01-GS-018-HeritageDDP.mxd 02
Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Heritage Page 2

NANGUS, NSW



Legend

- Reservoir Option 2
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Local Heritage (DPE, July 2019)

- Local Heritage (DPE, July 2019)
- Conservation Area - General (DPE, July 2019)

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Aerial Imagery supplied by DFSI (2017)

Goldenfields Water

Heritage Page 3

NANGUS, NSW

Legend

- Reservoir Option 2
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- Proposed Reticulation
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Local Heritage (DPE, July 2019)

- Local Heritage (DPE, July 2019)
- Conservation Area - General (DPE, July 2019)

1:15,000 Scale at A3

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NANGUS ROAD
BETHUNGRA ROAD
OURA ROAD
KIMO STREET
ISLAND CREEK
MURRUMBIDGEE RIVER
NANGUS CREEK
NANGUS
MUNDARLO
GUNDAGAI
I20: War Memorial Nangus
300 m
200 m
10km
11km
12km
13km
9km
8km
7km
21km

Goldenfields Water

Heritage Page 4

NANGUS, NSW

Legend

- Reservoir Options 3 and 4
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- GWCC Existing Water Mains
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Local Heritage (DPE, July 2019)

- Local Heritage (DPE, July 2019)
- Conservation Area - General (DPE, July 2019)

1:15,000 Scale at A3

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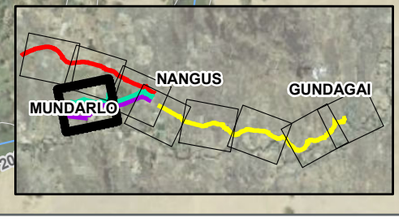

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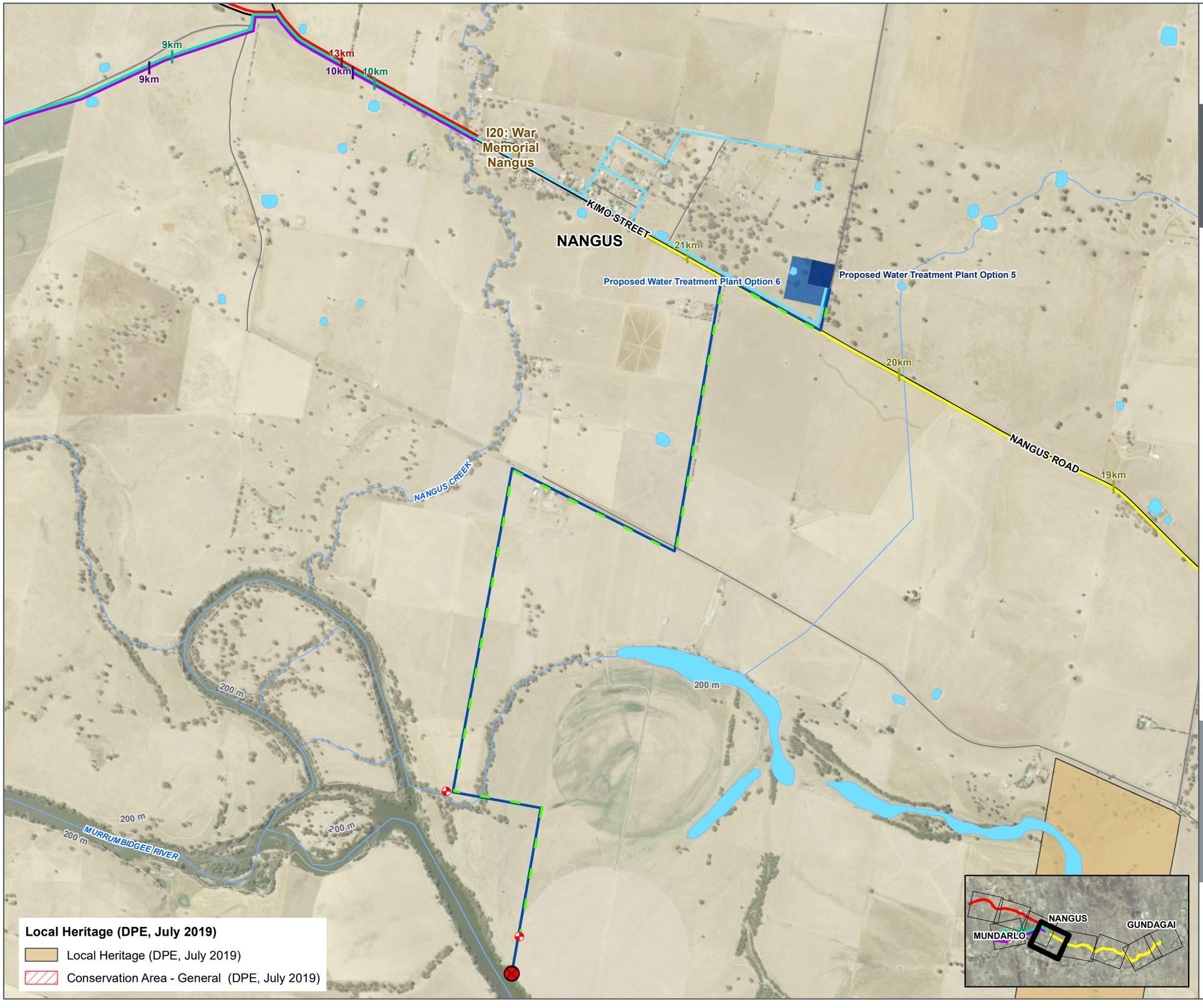
Goldenfields Water

Heritage Page 5

NANGUS, NSW



Legend

- Indicative River Intake and Pump Station Option 5
- Indicative Bore Location Option 6
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- Proposed Raw Water Pipeline Option 5
- Proposed Raw Water Pipeline Option 6
- Proposed Reticulation
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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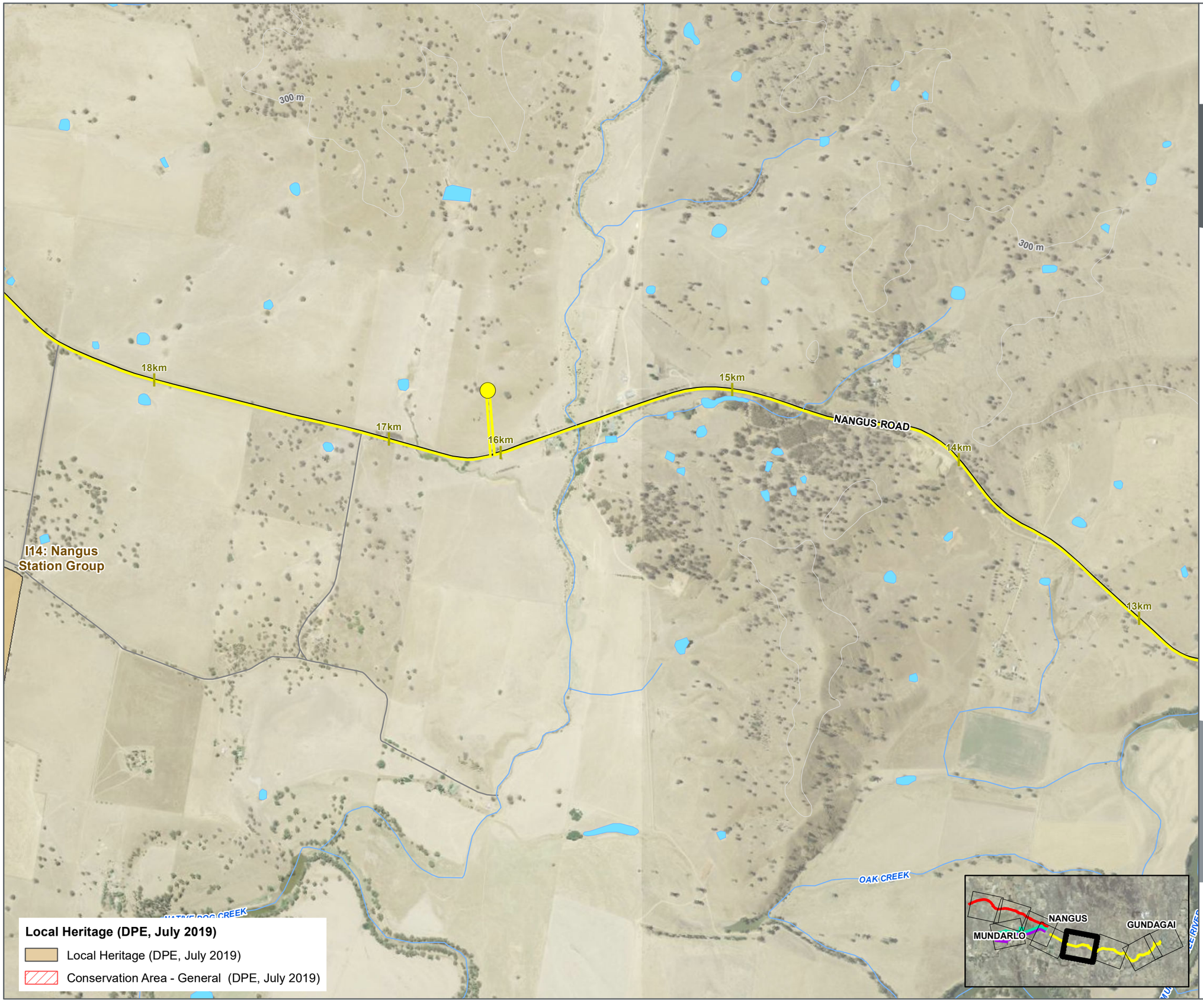
Goldenfields Water

Heritage Page 6

NANGUS, NSW



Legend

- Reservoir Option 1
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Local Heritage (DPE, July 2019)

- Local Heritage (DPE, July 2019)
- Conservation Area - General (DPE, July 2019)

1:15,000 Scale at A3

m
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N

Cardno

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Goldenfields Water

Heritage Page 7

NANGUS, NSW

Legend

- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- 100m Contours (LPI)
- Major Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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Goldenfields Water

Heritage Page 8

NANGUS, NSW

Legend

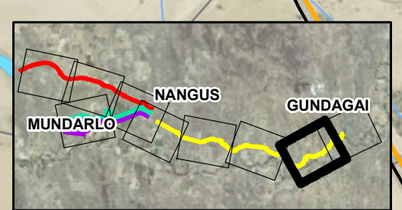
- Booster Pump Station (Option 1)
- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- CGRC Existing Water Mains
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)

Local Heritage (DPE, July 2019)

- Local Heritage (DPE, July 2019)
- Conservation Area - General (DPE, July 2019)

1:15,000 Scale at A3

m
0 150 300 450 600



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Goldenfields Water

Heritage Page 9

NANGUS, NSW

Legend

- Pipeline Option 1 (21.5km)
- Pipeline Option 2 (13.7km)
- Pipeline Option 3 (10.5km)
- Pipeline Option 4 (10.6km)
- CGRC Existing Water Mains
- 100m Contours (LPI)
- Major Road (LPI)
- Local Road (LPI)
- Major Watercourses (DPI Water, 2017)
- Waterbodies (LPI)
- State Heritage Register (OEH, 2019)

Local Heritage (DPE, July 2019)

- Local Heritage (DPE, July 2019)
- Conservation Area - General (DPE, July 2019)

1:15,000 Scale at A3

m
0 150 300 450 600

N

Cardno

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BURRA ROAD
HUME HIGHWAY
WEST STREET
TARGET CREEK
MORLEYS CREEK
JONES CREEK
PUNCH STREET
GUNDAGAI
I5: Gundagai District Hospital
I16: Rusconi's Marble Masterpiece
I8: Gundagai Police Station
I11: Lanigan Abbey
I19: War Memorial Gundagai
I1: Anzac Grove & Other Memorials
I6: Gundagai Flour Mill (Former)
Gundagai Railway Station & Yard Group
C1: Gundagai Railway Station & Yard Group
I9: Gundagai Rail Bridge Over Murrumbidgee River
Gundagai Rail Bridge over Murrumbidgee River
C2: Old Gundagai Town Site
I2: Murrumbidgee Inn
I17: Sturt's Cairn Memorial
I15: Prince Alfred Bridge
MIDDLETON DRIVE
MOUNT STREET
BRUNGLE ROAD
SLATE QUARRY CREEK
NANGUS ROAD
MURRUMBIDGEE RIVER
COOKOOMOOROO CREEK
MIDDLE STREET
0km
1km
2km
300 m
400 m
NANGUS
MUNDARLO
GUNDAGAI

APPENDIX C

WATER TREATMENT OPTIONS

Surface and Groundwater Treatment Options

Nangus Water Supply Feasibility Study

8202004301-R02-V01

Prepared for

Goldenfields Water County Council

29 November 2019

Cardno

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Date Approved 27/11/2019

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Table of Contents

Appendices

Tables

Figures

1 Introduction

Cardno has evaluated two standalone water source and treatment options as part of the Nangus Water Supply Feasibility Study.

Option 5 proposes a treatment plant designed to extract water from the Murrumbidgee River and treat it to provide potable water to Nangus that meets the Australian Drinking Water Guidelines and the draft Heath-based Targets (NHRMC, 2018).

Option 6 proposes a treatment plant designed to take water from local groundwater bores and treat it to provide potable water to Nangus that meets the Australian Drinking Water Guidelines and the draft Heath-based Targets (NHMRC, 2018). It is noted that further hydrogeological investigation will be needed to confirm the viability of extraction from local groundwater sources.

2 Source Water Demand Assumptions

The average annual produced water demand is estimated at 80kL/day (29.2ML/yr). The peak daily demand is estimated at 400kL/day.

Process losses in a treatment plant can range from 2% to 30% depending on the type of treatment processes that are employed to achieve the target water quality. This means that there will be greater demand on the source in terms of total and instantaneous flows. The estimated source demands for each of the options is included with each specific source assessment.

3 Source Water Quality Assumptions

3.1 Microbiological Risks– Health Based Treatment Targets

The microbiological risks of drinking water sources and the treatment requirements to mitigate those risks are described in the draft Chapter 5 of the Australian Drinking Water Guidelines (NHMRC, 2018) and the Water Services Association of Australia (WSAA) – Manual for the Application of Health Based Targets for Drinking-Water Safety (September 2015).

Table 3-1 is reproduced from the ‘draft Chapter 5 Microbial Quality of Drinking Water’ of the ADWGs (NHMRC, 2018), and provides descriptions of the Category classifications and treatment requirements for various types of raw water sources.

Table 3-1 Treatment targets for protozoa, bacteria and viruses given the source water type and *E. coli* results (NHMRC, 2018)

Source water category classification	Source water type	Maximum *E. coli* results from raw water monitoring (number/100mL)	LRV target to achieve 10^{-6} DALYs per person per year (1)			Indicative specified treatment technologies (Assuming well designed, highly controlled, managed and monitored system)
			Protozoa	Virus	Bacteria	
Category 1	Fully protected surface water or groundwater	<20 (*E. coli* band 1)	0	0	4	Chlorination
Category 2	Groundwater or surface water with moderate levels of protection	20 to 2000 (2) (*E. coli* band 2)	3	4	4	Direct filtration and chlorination
Category 3	Groundwater or surface water with poor levels of protection		4	5	5	Conventional filtration and chlorination
Category 4	Unprotected surface water	2001 to 20,000 (*E. coli* band 3)	5	6	6	Conventional filtration and UV and chlorination

(1) Note that these values are based on estimation from first principles using QMRA

(2) Maximum E. coli results for raw water monitoring for source water Categories 2 and 3 are within the same range and distinguishing between these two categories is confirmed based on the results of a vulnerability assessment.

3.1.2 Murrumbidgee River Surface Water Source

The Murrumbidgee River would be the most suitable source in the locality to provide a reliable surface water supply to Nangus.

While a formal source categorisation has not been carried out, we have assumed the Murrumbidgee River is an unprotected surface water source with a microbiological risk assessment of Category 4. Within the catchment upstream of the river from Nangus there is a significant level of human habitation, including the presence of sewered and unsewered areas, along with discharge of treated sewage and the potential for sewer overflows. The catchment also includes the potential for intensive animal husbandry. These are noted as features of a Category 4 catchment in Table 5.2 of the draft Chapter 5 of the Australian Drinking Water Guidelines (NHMRC, 2018).

3.1.3 Nangus Groundwater Source

The Desktop Hydrogeological Review (Cardno, 2019) has investigated the viability of groundwater resources within a 5km radius around Nangus. Ground water is expected to be found in alluvial aquifers at depths ranging from 5m to 19m.

The Draft Chapter 5 Microbial Quality of Drinking Water (NHMRC, 2018) states that for groundwater a starting point for classification of the source is to “assume a groundwater resource is unprotected until objective, credible scientific evidence can conclusively demonstrate otherwise”. In the worst case, if information is not available, the aquifer should be considered to be the same category as the surface water that recharges the aquifer.

Based on evidence that existing bores in the locality are shallow, the recharge source is likely to be the Murrumbidgee River and surface rainfall/runoff. There is not yet any water quality monitoring of the particular source therefore a conservative approach needs to be taken. For these reasons and for the purposes of this feasibility study the groundwater sources within the study area have been given a preliminary microbiological risk assessment of Category 4. With further assessment of an actual source it is possible that the result could be a Category 3 classification.

3.2 Chemical Risks

3.2.1 Murrumbidgee River – Surface Water Source

GWCC has provided Cardno with operational data from the Jugiong Water Treatment Plant which sources water from further upstream on the Murrumbidgee River. Raw water quality for 2018/19 collected by on-line instrumentation is presented in Appendix A. The results are summarised in Table 3-2.

Table 3-2 Raw Water Quality in the Murrumbidgee River at Jugiong 2018/19

Parameter	Units	Number of Samples	Minimum	Maximum	Median
Turbidity	NTU	365	1.8	2500	6
Colour	Hazen	365	15	303	40
pH	pH Units	365	7.32	8.20	7.72
Temperature	deg C	365	7	29	19
Fluoride	mg/L	365	0.08	0.33	0.20

The raw water, as is typical of a surface water, has variable, and elevated levels of turbidity and colour. A suitable water treatment process will need to address these issues.

From separate single samples taken at the Jugiong WTP hardness is typically around 100-120mg/L as $CaCO_3$ and therefore is within the acceptable range of the ADWG. Iron and Manganese can be elevated at times above the aesthetic guideline values therefore an oxidation process to address these parameters will be required.

Raw water quality from the specific location would need to be assessed to determine if any other water quality issues also need to be addressed.

3.2.2 Nangus Groundwater Source

The Desktop Hydrogeological Review (Cardno, 2019) has investigated existing bores in the vicinity of Nangus. Recent data on groundwater quality is very limited. From historic data that is available from when the bores were developed it appears that total dissolved solids are elevated ranging from 800-4200mg/L (based on converting electrical conductivity measurements to TDS). According to the ADWG this degree of salinity would be poor to unacceptable quality, with TDS required to be below 600mg/L to be aesthetically acceptable. It is also common that groundwater in the regional aquifers have elevated iron and manganese. Therefore, it is highly likely that a suitable groundwater treatment process will have to address iron, manganese and TDS.

4 Option 5 – Murrumbidgee River Extraction and Treatment

4.1 Option 5 Description

A schematic of Option 5 is shown in Figure 4-1. Option 5 has the following proposed components:

- A surface water intake, taking water from the Murrumbidgee River
- Powdered activated carbon dosing
- pH control dosing
- Coagulant dosing and rapid mixing
- Polymer dosing and slow mixing
- Solids settling
- Clarified water storage
- Filtration using ultrafiltration membranes
- Ultraviolet disinfection
- pH Correction
- Chlorine dosing for disinfection
- Fluoridation
- Treated water reservoir (250 kL) and Booster Pumping
- Backwash settling and evaporation

Each of these processes is described in more detail in the following sections.

4.2 Surface Water Intake and Pumping

Raw water would be sourced from the Murrumbidgee River with a river intake and transfer pumps to the treatment plant site.

A produced flow of 400 kL/d has been proposed for the water supply. Given that surface water treatment plants typically have 5%-10% of losses, the treatment plant will need to be capable of processing up to 420 kL/d of raw water. Assuming that this can be achieved over a period of approximately 20 hours the plant will need to be sized for approximately 500 kL/d (6 L/s).

A typical surface water intake would comprise a wedgewire screen – e.g. a Johnson type screen, to prevent course solids and to ensure that fish are protected. This would be surrounded by a reinforced concrete structure to protect the screen and channel floor. A pumping station on the shore would transfer the raw water to the treatment plant. It is noted that the actual configuration would need to be determined based on a detailed investigation of the river conditions and adjacent flood plain.

The Murrumbidgee River is approximately 5,000m from the proposed WTP location. Assuming a velocity of 1.0m/s in the pipeline an estimated pipe diameter of 100mm diameter would be required.

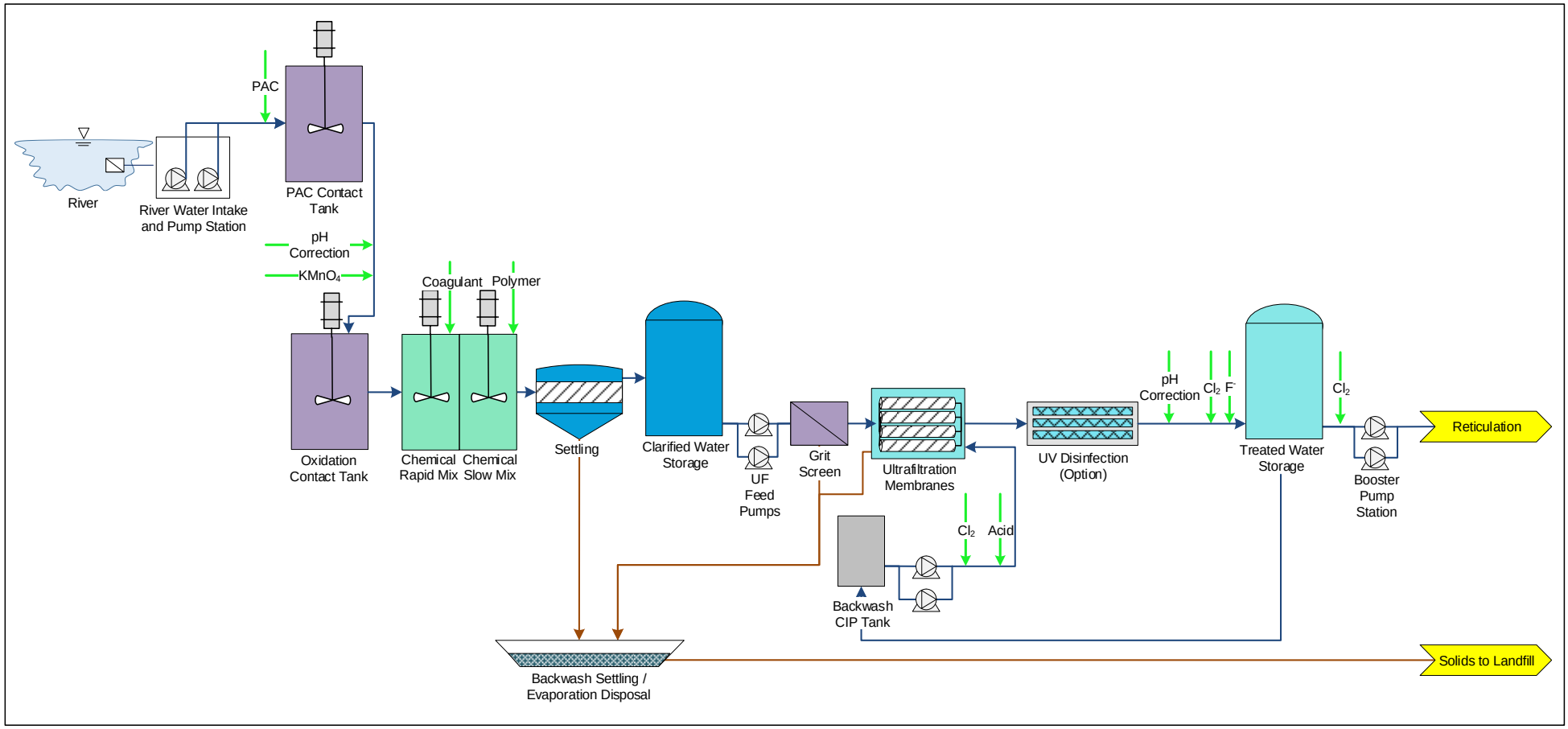


Figure 4-1 Option 5 – Process Schematic

4.3 Microbiological Barriers (Viral, Protozoal, and Bacteriological)

Both the draft Chapter 5 of the ADWG and the WSAA HBT Manual recommend similar treatment technologies to achieve the log reduction value (LRV) targets. Cardno has undertaken an assessment of Option 5 and the results are shown in Table 4-1.

For this assessment Cardno has used the HBTs manual as it is more explicit in assigning specific and measurable Process Critical Limits to each LRV.

Based on the source risk, the minimum required health-based targets for pathogen LRVs are: Virus 6.0, Protozoa 5.0, and Bacteria 6.0.The sum of process unit LRVs are greater than the risks therefore the proposed treatment process will provide sufficient barriers under the multi-barrier approach.

Table 4-1 Recommended LRVs for the Option 1 Water Treatment Process

Treatment Process	Log reduction value			Process Critical Limits
	Virus	Protozoa	Bacteria	
Coagulation, Flocculation, and Sedimentation	1.0	0.5	1.0	Under-float or settled water turbidity < 2 NTU for 95% of month. Alternate target is 70% reduction in turbidity on average over the month where raw water turbidity is very high, the key being consistent quality pre filtration
Ultra-Filtration (UF)	2.5	3.0	3.0	Individual filter turbidity <0.1 NTU for 95% of month and not > 0.15 NTU for > 15 consecutive minutes.
Ultraviolet Disinfection	0.5	4.0	4.0	UV dose > 40mJ/cm^2 Feedwater Turbidity <1.0 NTU UVT% > Manufacturers specifications
Chlorine (Cl_2) Disinfection	4	0	4.0	Ct > 15 mg- min/L with pH < 8.5 at all water temperatures Feed water turbidity < 1.0 NTU
Total achievable	**8.0**	**7.5**	**12.0**	
Log reduction required	**6.0**	**5.0**	**6.0**	
Gap	**0.0**	**0.0**	**0.0**	

4.4 Taste and Odour Control

Powdered activated carbon (PAC) is added for adsorption of taste and odour causing compounds. PAC will be dosed directly to the raw water. The earlier the PAC can be dosed the more effective it will be. A separate PAC contact tank may be required. To achieve a contact time of 15mins the contact tank will have an estimated volume of 6m^3.

4.5 Oxidation for Iron and Manganese Removal

Pre-oxidation with potassium permanganate is recommended to achieve iron and manganese removal. Permanganate will oxidise both iron and manganese as long as adequate contact time, typically 15mins, for the oxidation reaction is provided. The contact tank will have an estimated volume of 6m^3.

4.6 pH Control

pH control is undertaken to ensure that the coagulation pH conditions are consistent and optimal for the coagulant. Because coagulants are typically weak acids, pH correction for this size of plant typically takes the form of caustic soda or soda ash dosing.

4.7 Coagulation, Flocculation and Sedimentation

Coagulation, flocculation, and sedimentation is required to reduce the turbidity load from the raw water prior to filtration. To claim the 1-log microbiological credits associated with the sedimentation process it must be supported by coagulation and flocculation to achieve the turbidity reduction target.

The coagulant chemical could be Alum, ACH or PACl depending on the treatability, handling and cost. Rapid mixing is required to ensure the coagulant is effectively mixed. The volume of the coagulation zone should allow for at least 5 minutes of flash mixing time.

Dosing of polyelectrolyte and associated slow mixing would occur after the rapid mixing to ensure floc development. Although floc size development is often not as critical where clarification is followed by membrane filtration, it is still important if the microbiological barrier is to be claimed. Modern chemical mixing systems usually incorporate structured floc growth tanks prior to the settling process. A 2 or 3-stage floc growth system with 20 minutes flocculation time at peak flow is recommended. The first and second stage would have contact time of approximately 7.5 minutes. The third stage would have a contact time of approximately 5.0 minutes. Mixing would become progressively less intense at each stage.

This will require new coagulant and polymer make-up, storage and dosing facilities. Settling could be achieved by conventional sedimentation (or alternatively by dissolved air flotation [DAF]). A variety of clarifiers are able to be designed or are available from suppliers with either rectangular or circular configuration and in some instances with proprietary technologies, for example ballasting (e.g. Veolia Actiflo), lamella plates or tube settlers which can reduce the footprint by achieving a much higher loading rate. Conventional rectangular hopper clarifiers are capable of maximum rise rates in the order of 2 m/hr.

4.8 Clarified Water Storage and Transfer Pumping

Clarified water storage and transfer pumping provides flexibility to provide flow and pressure balancing to the downstream filtration process. An automatically backwashing strainer would provide additional protection to the filtration process against grit.

4.9 Membrane Ultrafiltration

Ultrafiltration membranes following clarification will provide a high quality of treated water with a low turbidity.

Regular backwashing includes water and air scouring. The treated water recovery rate is typically 90-98% depending on the feed water quality and UF configuration.

A clean in place (CIP) system is used to routinely clean the membranes with chemicals to control fouling. The cleaning chemicals are typically acids, alkalis and hypochlorite.

Package UF systems at this size (skid mounted) are available from a number of suppliers.

An alternative to membrane filtration would be multi-media filtration. However, the LRV's attributable to a conventional filtration process are lower and the treated water quality can be more inconsistent.

4.10 UV Disinfection

Ultraviolet disinfection will be required to provide 4-log reduction of protozoa and bacteria and 0.5-log reduction of viruses. This requires a validated unit, installed and monitored as per its validation requirements and providing an ultraviolet dose of >40 mJ/cm^2. At the same time the feed water turbidity must be <1.0NTU and the ultraviolet transmissivity greater than the manufacture's validation specifications.

There are a number of different suppliers who can meet these ultraviolet disinfection requirements relying on the pre-treatment process to achieve the requirements for turbidity and ultraviolet transmissivity.

4.11 pH Correction

pH Correction of the final water controls the aggressiveness of the water distributed to the consumers and ensures that chlorine disinfection is maintained within an optimal range. Typically treated water pH correction at this scale requires a slight increase in the pH using either caustic soda or soda ash dosing.

4.12 Chlorine Dosing

Chlorine dosing and a chlorine contact tank can provide 4-log each of virus and bacteria reduction. This requires a C.t >15mg/L. C.t values are calculated based on the chlorine residual at the outlet, multiplied by the tank volume and the baffling factor and divided by the treated water flow rate.

4.13 Fluoridation

The NHMRC strongly recommends community water fluoridation as a safe, effective and ethical way to help reduce tooth decay across the population. NHMRC supports Australian states and territories fluoridating their

drinking water supplies within the range of 0.6 to 1.1 mg/L. For these reasons fluoridation has been included as a treatment step after filtration.

4.14 Treated-Water Storage and Reticulation Booster Pumping

Treated water storage and pumping provides flexibility to provide flow and pressure control to meet instantaneous demand in the reticulation. The proposed reservoir storage volume is 250 kL, in line with GWCC's requirements for three days storage at average day flow.

4.15 Residual Solids Management

Liquid and solid waste streams will be produced from the grit strainer, clarifier wasting, and filter backwashing processes. The clarifier sludge stream will be much more concentrated than the filter waste stream.

The primary option for waste handling is to construct sludge lagoons. Downstream of the filters it is proposed that there would be a waste water balance tank to buffer the high backwash flows received off the filters to avoid scouring within the lagoons which would be counterproductive to the lagoon settlement process. A decant tank or thickener could be used at this stage of the process to return waste water supernatant to the head of the plant.

Evaporation or environmental discharge would be the best disposal route for the sludge lagoon supernatant and underdrainage from the perspective of managing public health risks and operational costs. It is estimated that there would need to be two lagoons each with a size of 25m long x 15m wide x 1.5m deep. The total volume of these lagoons would be approximately 1125 kL. We have assumed that excess sludge lagoon supernatant or underdrainage could be discharged to Nangus Creek.

If no environmental disposal route is available, then it may be necessary to return the lagoon supernatant to the head of the plant. If this is the case, then the return stream would need to be filtered and disinfected with UV and chlorine to avoid concentrating the microbiological risk through this waste stream.

4.16 Capital Cost Estimate

A rough order capital cost estimate for this option is $5.43M. A more detailed breakdown of this estimate is included in Appendix B.

4.17 Indicative Layout

Indicative layouts for this option are included in Appendix C.

5 Option 6 - Groundwater Extraction and Treatment

5.1 Option 6 Description

A schematic of Option 6 is shown in Figure 5.1. Option 6 has the following proposed components:

- Groundwater bores and pumping
- Groundwater storage and transfer pumping
- Iron and Manganese oxidation and filtration
- Chlorine neutralisation
- Reverse Osmosis
- Recarbonation / pH Correction
- Chlorine dosing for disinfection
- Fluoridation
- Treated water reservoir (250 kL) and Booster Pumping
- Backwash settling and evaporation
- Brine storage and evaporation

Each of these processes is described in more detail in the following sections.

5.2 Groundwater Bores and Pumping

Raw water would be sourced from local groundwater bores. To achieve the design flow and to manage risk it is anticipated that a minimum of two bores would be required. Each bore would require a bore pump, surface well head to prevent contamination and backflow, and an electrical supply.

A peak produced flow of 400kL/d has been proposed for the water supply. Given that groundwater treatment plants that include reverse osmosis typically have up to 20% of losses (range 15-35%) through solids and brine management requirements, the treatment plant will need to be capable of processing up to 480kL/d of raw water. Assuming that this can be processed over a period of approximately 20 hours the plant will need to be sized for approximately 600 kL/d (7 L/s).

5.3 Microbiological Barriers (Viral, Protozoal, and Bacteriological)

Both the draft chapter 5 of the ADWG and the WSAA HBT Manual recommend similar treatment technologies to achieve the microbiological log reduction value (LRV) targets. Cardno has undertaken an assessment of Option 6 and the results are shown in Table 5-1.

For this assessment Cardno has used the HBTs manual as it is more explicit in assigning specific and measurable Process Critical Limits to each LRV, with guidance from the ADWG draft HBTs on the application of reverse osmosis.

Based on the source risk, the minimum required health-based targets for pathogen LRVs are: Virus 6.0, Protozoa 5.0, and Bacteria 6.0. The sum of process unit LRVs are greater than the risks therefore the proposed treatment process will provide sufficient barriers under the multi-barrier approach.

Table 5-1 Recommended LRVs for the Option 2 Water Treatment Process

Treatment Process	Log reduction value			Process Critical Limits
	Virus	Protozoa	Bacteria	
Reverse Osmosis (TDS reduction)	2.5	3.0	3.0	Note 1.
Ultraviolet Disinfection	0.5	4.0	4.0	UV dose > 40mJ/cm^2 Feedwater Turbidity <1.0 NTU UVT% > Manufacturers specifications
Chlorine (Cl_2) Disinfection	4	0	4.0	Ct > 15 mg- min/L with pH < 8.5 at all water temperatures Feed water turbidity < 1.0 NTU
Total achievable	**7.0**	**7.0**	**11.0**	
Log reduction required	**6.0**	**5.0**	**6.0**	
Gap	**0.0**	**0.0**	**0.0**	

(1) Reverse osmosis systems would routinely achieve greater log reduction values in practice than those that can be routinely and readily validated. As a result, LRVs of the order 1 to 2 log are all that can be routinely validated where on-line operational monitoring of Electrical Conductivity or Total Organic Carbon forms the critical parameter. LRVs of 2.5-4.0 can be achieve where on-line or off-line operational monitoring of sulphate or fluorescent dyes forms the critical limit parameter. For this purposes of this assessment it is assumed that the LVRs for reverse osmosis are similar to those for ultrafiltration.

5.4 Groundwater Storage and Transfer Pumping

Bore water storage and transfer pumping provides flexibility to provide flow and pressure balancing to the downstream processes. An automatically backwashing strainer would provide additional protection to the downstream processes against grit.

5.5 Oxidation and Removal of Iron and Manganese

The removal of iron and manganese requires oxidation and then filtration of the oxidised solids. Manganese is more difficult to oxidise than iron therefore the use of chlorine and a catalytic media filter (e.g. greensands or similar) is an effective way to achieve this. For the size of plant proposed, this can be achieved using pressure media filters with automatic flow and backwashing control valves. It is assumed that coagulant and flocculent dosing is not required.

Oxidation by aeration has been disregarded as it has the potential to introduce air-borne pathogens into the water. Additionally, the effectiveness of oxidation by aeration is limited to iron and has no performance controls. It is assumed that the raw water does not have elevated levels of carbon dioxide or hydrogen sulphide which may require gas stripping. If it does, then aeration may still be necessary.

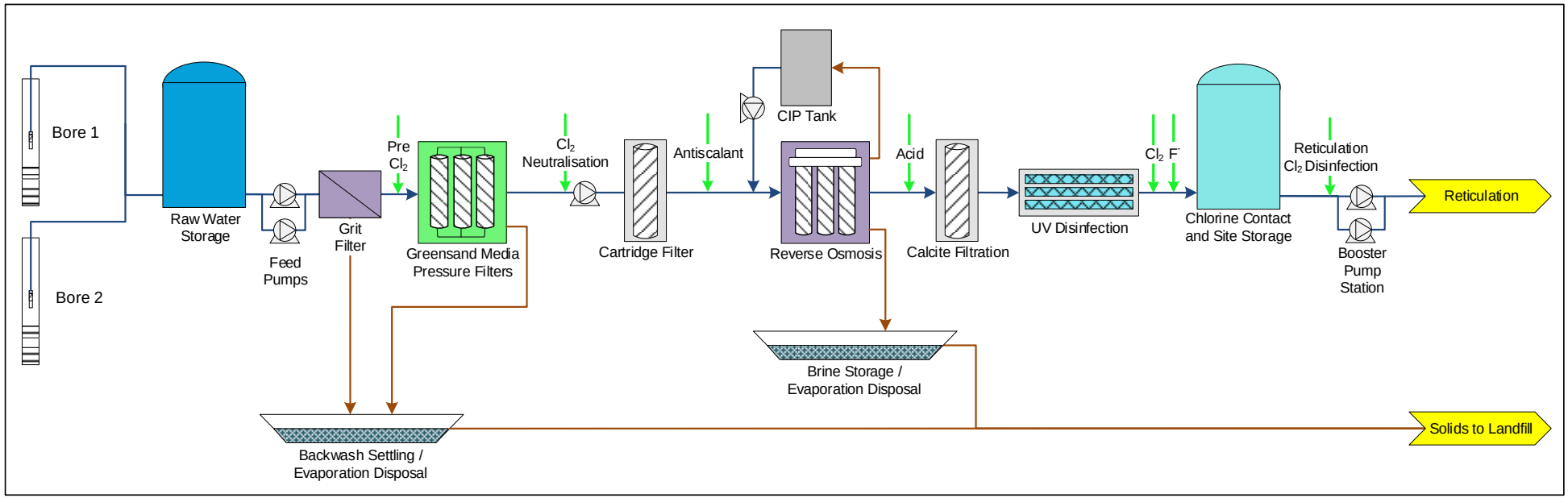


Figure 5-1 Option 6 – Process Schematic

5.6 Reverse Osmosis

Reverse osmosis (RO) would be required to reduce the total dissolved solids (TDS) content from up to 5,000mg/L to potable quality. It is assumed that the TDS will be mostly due to sodium and chloride ions. Reverse osmosis will also provide a pathogen barrier, as noted in Table 5-1.

Prior to reverse osmosis, neutralisation of excess chlorine from the prior oxidation process would be required with the objective of protecting the membranes chemically, and the flow would need to pass through cartridge filtration (5 and 1 micron) to protect the membranes physically. Antiscalant is dosed to inhibit the formation of scale on the RO membranes.

A high pressure pump is required to pump through the membranes and overcome the osmotic pressure of the membranes. The treated water out of the membranes with reduced total dissolved solids is referred to as permeate. The waste stream from the membranes with an elevated salt content is the reject or brine. For a RO system designed to treat a brackish water quality the recovery rate of permeate typically ranges from 60-85% depending on the water quality and RO configuration. As noted in Section 5.2, we have assumed 80% recovery.

A clean in place (CIP) system is used to routinely clean the membranes with chemicals to further control fouling. The cleaning chemicals are typically acids and alkalis.

Skid mounted RO systems are available from a number of suppliers.

5.7 Recarbonation / pH Correction

Reverse osmosis permeate can be aggressive because calcium and magnesium ions are removed through the membranes. The pH needs to be neutralised and hardness increased. One way to do this is by passing the permeate through a calcite filter which provides remineralisation and neutralises the pH. The lower the pH of the permeate the more hardness is added by the filter therefore by adding acid upstream of the filter the dissolution of calcite can be controlled.

5.8 Ultraviolet Disinfection

Ultraviolet disinfection will be required to provide 4-log reduction of protozoa and bacteria and 0.5-log reduction of viruses. This requires a validated unit, installed and monitored as per its validation requirements and providing an ultraviolet dose of >40 mJ/cm^2. At the same time the feed water turbidly must be <1.0NTU and the ultraviolet transmissivity greater than the manufacture's validation specifications.

There are a number of different suppliers who can meet these ultraviolet disinfection requirements relying on the pre-treatment process to achieve the requirements for turbidity and ultraviolet transmissivity.

5.9 Chlorine Disinfection

Chlorine dosing and a chlorine contact tank can provide 4-log each of virus and bacteria reduction. This requires a C.t >15mg/L. C.t values are calculated based on the chlorine residual at the outlet, multiplied by the tank volume and the baffling factor and divided by the treated water flow rate.

5.10 Fluoridation

The NHMRC strongly recommends community water fluoridation as a safe, effective and ethical way to help reduce tooth decay across the population. NHMRC supports Australian states and territories fluoridating their drinking water supplies within the range of 0.6 to 1.1 mg/L. For these reasons fluoridation has been included as a treatment step after filtration.

5.11 Treated-Water Storage and Reticulation Booster Pumping

Treated water storage and pumping provides flexibility to provide flow and pressure control to meet instantaneous demand in the reticulation. The proposed reservoir storage volume is 250 kL, in line with GWCC's requirements for three days storage at average day flow.

5.12 Residual Solids Management

Liquid and solid waste streams will be produced by the grit strainer and filter backwashing processes.

The primary option for waste handling is to construct sludge lagoons. Downstream of the filters it is proposed that there would be a waste water balance tank to buffer the high backwash flows received off the filters to

avoid scouring within the lagoons which would be counterproductive to the lagoon settlement process. A decant tank or thickener could be used at this stage of the process to return waste water supernatant to the head of the plant.

Evaporation or environmental discharge would be the best disposal route for the sludge lagoon supernatant and underdrainage from the perspective of managing public health risks and operational costs. It is estimated that there would need to be two lagoons each with a size of 15m long x 10m wide x 1.5m deep. The total volume of these lagoons would be approximately 450 kL. We have assumed that excess sludge lagoon supernatant or underdrainage could be discharged to Nangus Creek.

If no environmental disposal route is available, then it may be necessary to return the lagoon supernatant to the head of the plant. If this is the case, then the return stream would need to be filtered and disinfected with UV and chlorine to avoid concentrating the microbiological risk through this waste stream.

5.13 Brine Management

The reject stream from the RO membranes contains a high total dissolved solids content. The primary option for brine management is to construct evaporation lagoons. Based on an annual average flow of 80 kL/d and a reject ratio of 20% approximately 16-20 kL/day (5,840 kL/yr – 7,300 kL/yr) of brine will be produced. Brine cannot be returned to the plant.

Based on the closest available historical climate data for rainfall (Bureau of Meteorology station 'GUNDAGAI (NANGUS RD)' - 073141) and evaporation (Bureau of Meteorology station 'WAGGA WAGGA AMO' - 072150) a water balance has been prepared to estimate the required size of the brine evaporation ponds.

A total evaporation surface area of approximately 0.8 ha is required to provide sufficient evaporation to balance the inflows (rainfall and brine) during a 90 percentile rainfall year (i.e. a year wetter than 90% of years on record). This would require 2 x 100m long x 40m wide evaporation lagoons.

5.14 Capital Cost Estimate

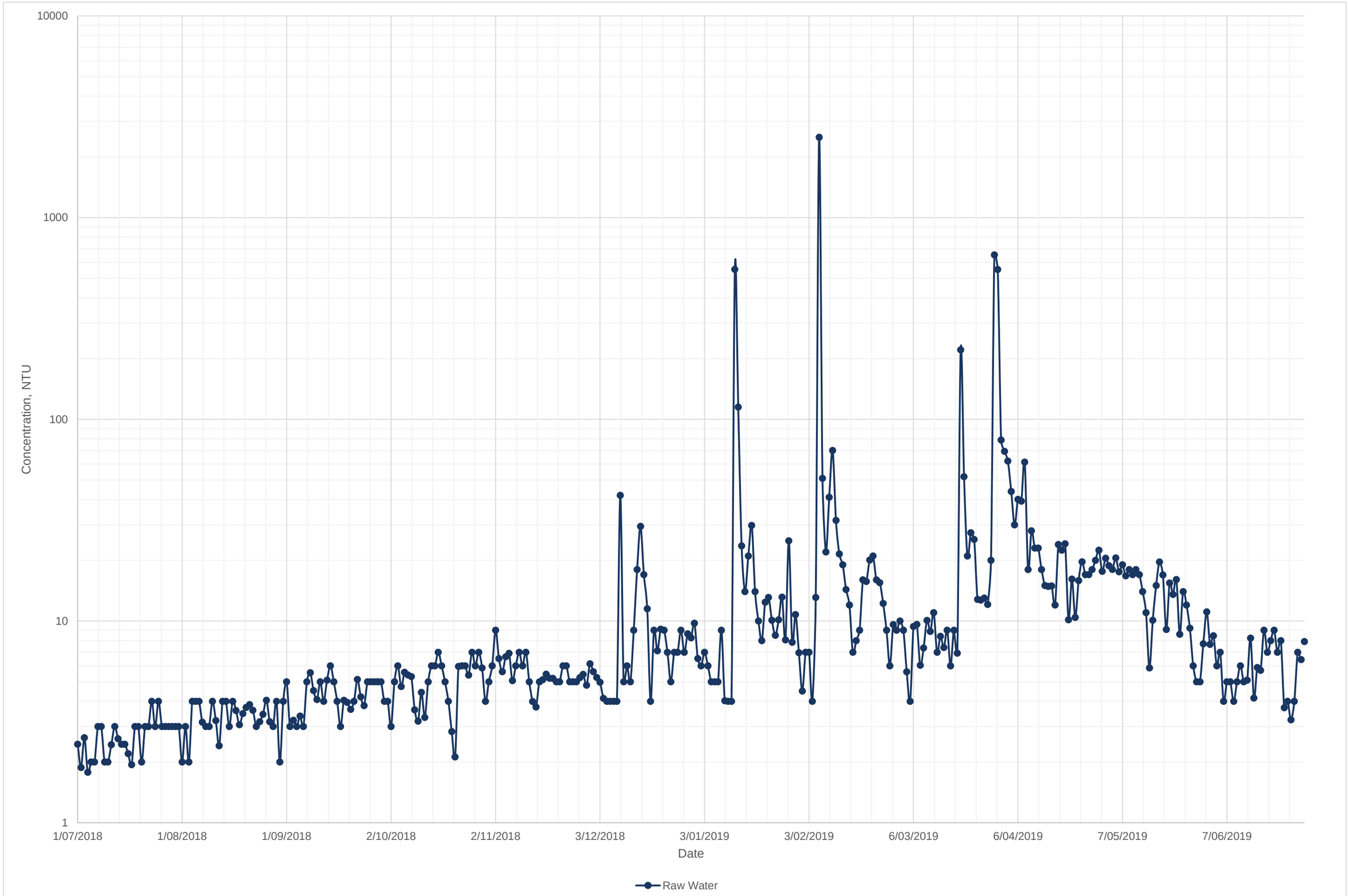
A rough order capital cost estimate for this option is $5.26M. A more detailed breakdown of this estimate is included in Appendix B.

5.15 Indicative Layout

An indicative layout for this option is included in Appendix C.

APPENDIX A

MURRUMBIDGEE RIVER WQ DATA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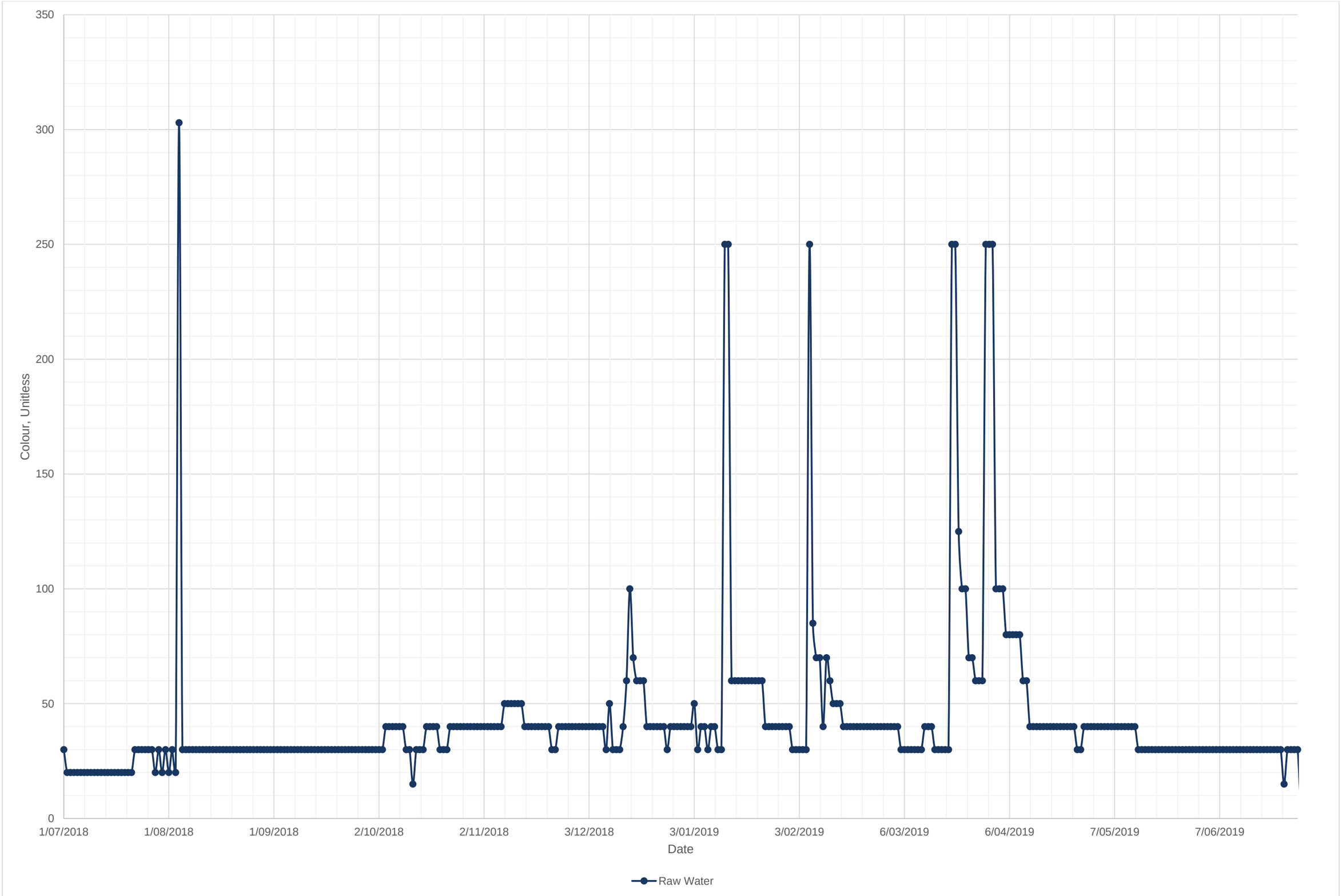
Date
Raw Water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250
200
150
100
50
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1/08/2018
1/09/2018
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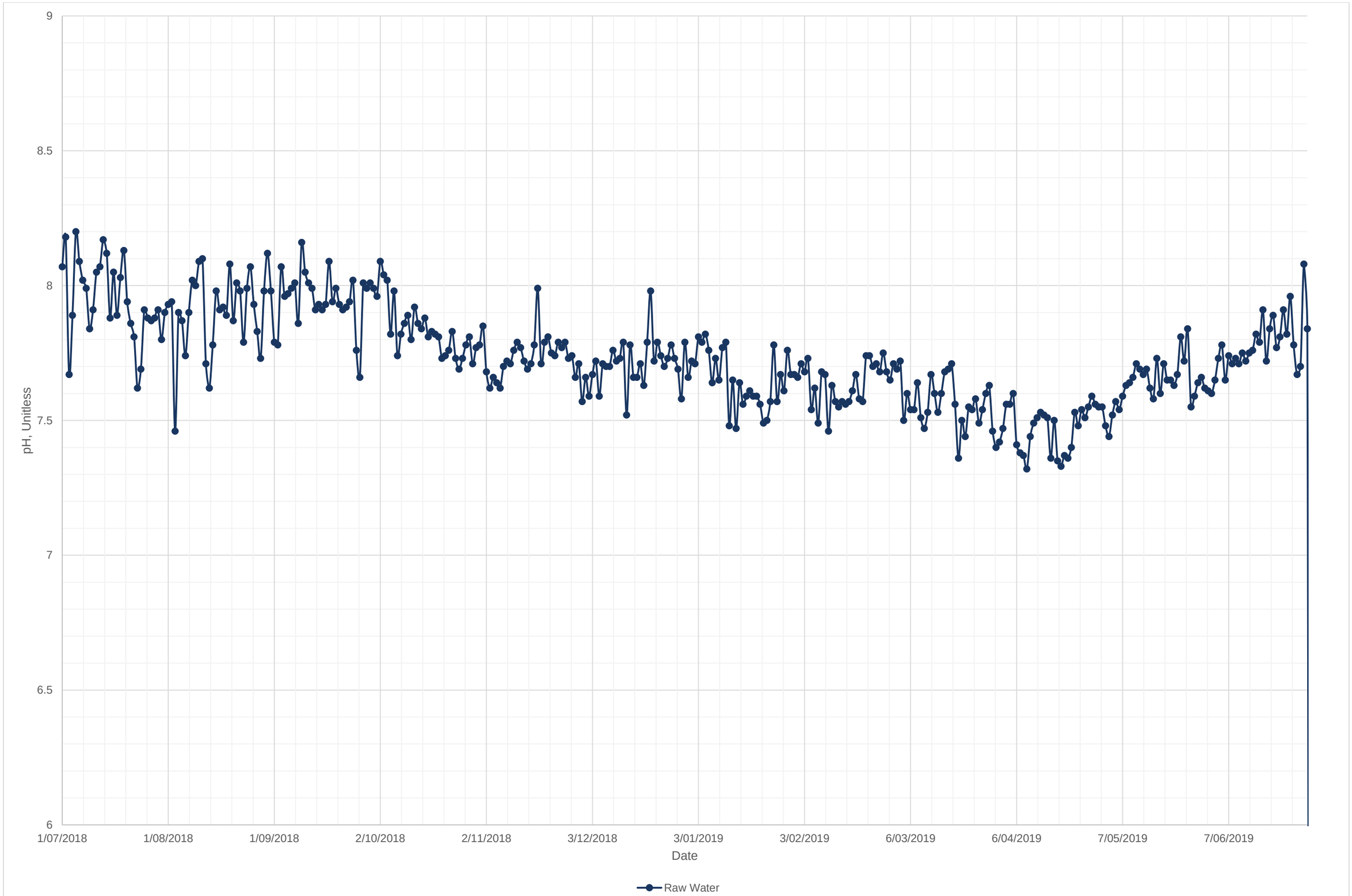
9
8.5
8
7.5
7
6.5
6
pH, Unitless
1/07/2018
1/08/2018
1/09/2018
2/10/2018
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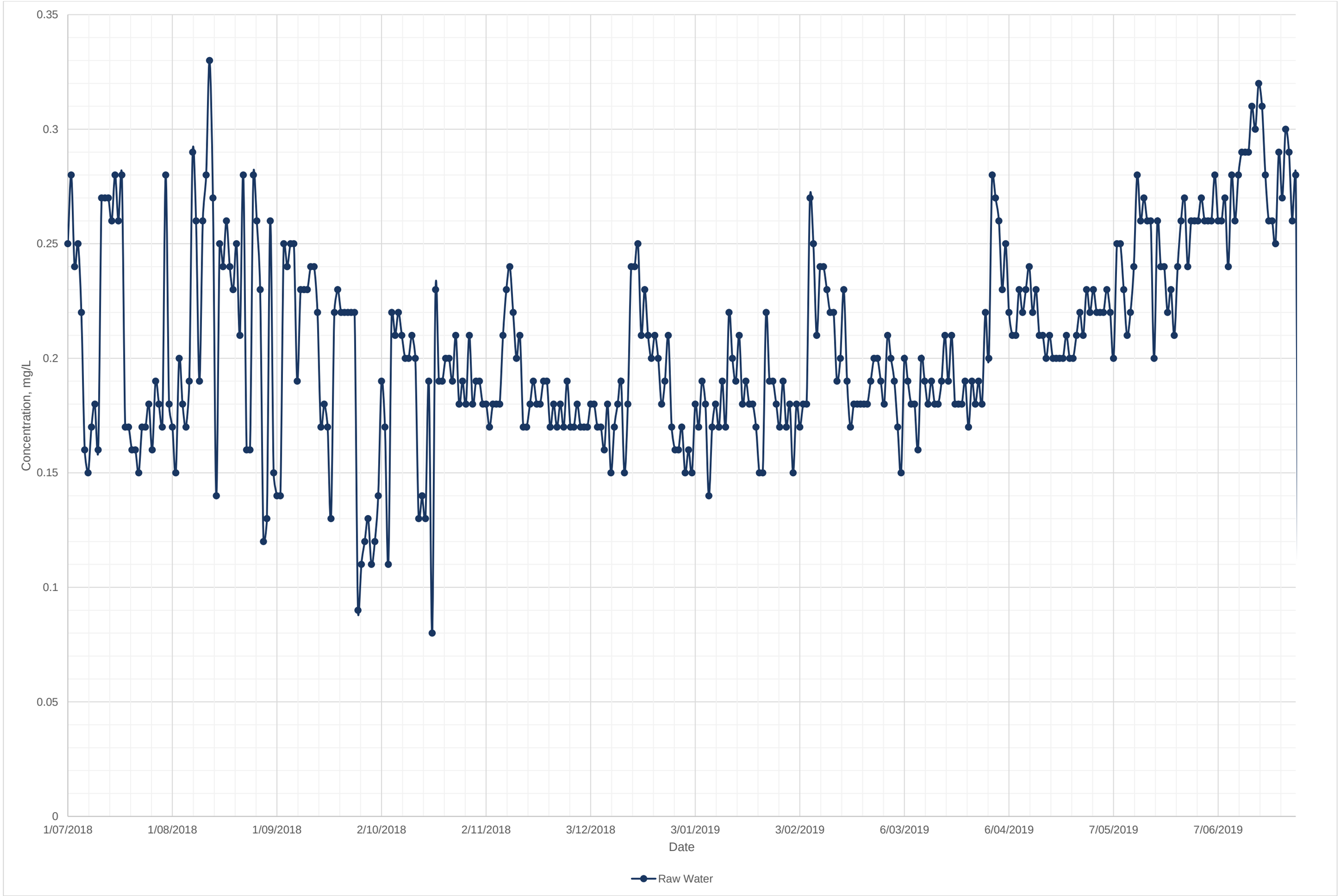
6/04/2019
7/05/2019
7/06/2019
Date
Raw Water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0.25
0.2
0.15
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Concentration, mg/L
1/07/2018
1/08/2018
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2/10/2018
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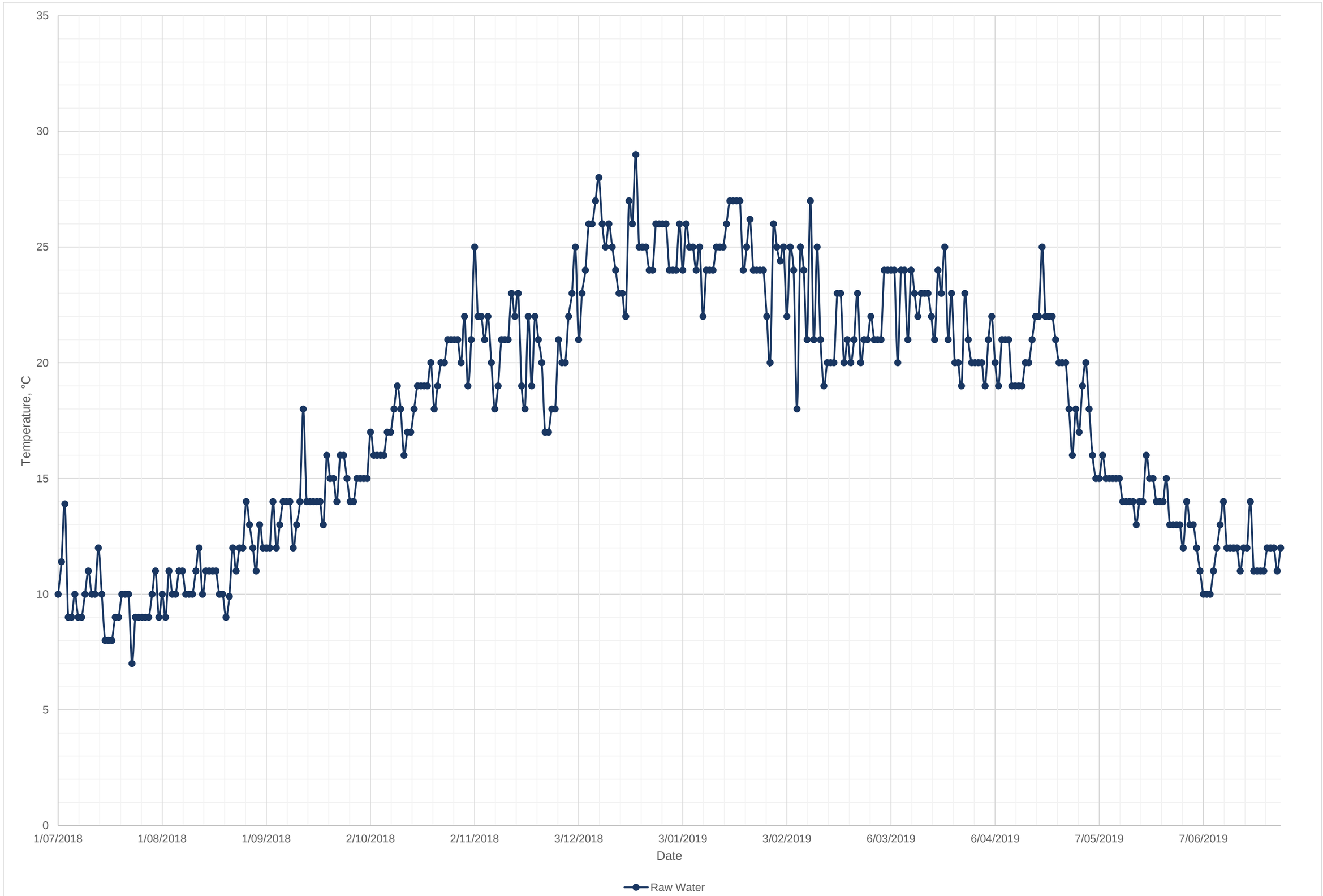
6/04/2019
7/05/2019
7/06/2019
Date
Raw Water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Temperature, °C
1/07/2018
1/08/2018
1/09/2018
2/10/2018
2/11/2018
3/12/2018
3/01/2019
3/02/2019
6/03/2019
6/04/2019
7/05/2019
7/06/2019
Date
Raw Water

APPENDIX

B

CAPITAL COST ESTIMATES

Rough Order Cost Estimate

Nangus 400kL Surface Water Source and Treatment Plant

Cardno

Date 27/11/2019
Job No. 8202004301
Prepared By P Garrity
Checked By J Knudsen

Area	Description	Unit	Quantity	Unit Cost	Total
Siteworks	Site Clearance / Earthworks	LS	1	$ 20,000	$ 20,000
	Roading / Access	LS	1	$ 30,000	$ 30,000
	Fencing	LS	1	$ 30,000	$ 30,000
	Landscaping	LS	1	$ 20,000	$ 20,000
	Stormwater	LS	1	$ 15,000	$ 15,000
	Sewer	LS	1	$ 25,000	$ 25,000
	Telecoms	LS	1	$ 10,000	$ 10,000
					$ 150,000
Taste, Odour, Iron and Manganese	PAC contact tank	LS	1	$ 12,000	$ 12,000
	PAC contact tank equipment	LS	1	$ 6,000	$ 6,000
	PAC contact tank pipework	LS	1	$ 10,000	$ 10,000
	Oxidation contact tank	LS	1	$ 12,000	$ 12,000
	Oxidation contact tank equipment	LS	1	$ 6,000	$ 6,000
	Oxidation contact tank pipework	LS	1	$ 10,000	$ 10,000
	Electrical (local) and instrumentation (minor)	LS	1	$ 6,000	$ 6,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 67,000
Coagulation. Flocculation,and Sedimentation	Clarification civil and structural	LS	1	$ 40,000	$ 40,000
	Coagulation tank, equipment and pipework	LS	1	$ 80,000	$ 80,000
	Flocculation tank equipment and pipework	LS	1	$ 140,000	$ 140,000
	Settling tank, equipment and pipework	LS	1	$ 360,000	$ 360,000
	Electrical (local) and instrumentation (minor)	LS	1	$ 30,000	$ 30,000
	Commissioning	LS	1	$ 25,000	$ 25,000
					$ 675,000
Clarified Water Storage	New water storage tank - structural and civil	LS	1	$ 120,000	$ 120,000
	New water storage tank - equipment	LS	1	$ 10,000	$ 10,000
	New storage tank - pipework	LS	1	$ 30,000	$ 30,000
	Electrical and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 175,000
Ultrafiltration	New transfer pumps (UF feed pumps)	ea	2	$ 10,000	$ 20,000
	Automatic grit screen	LS	1	$ 10,000	$ 10,000
	Ultrafiltration Membrane Filtration - structure and civil	LS	1	$ 20,000	$ 20,000
	Ultrafiltration Membrane Filtration - equipment	LS	1	$ 150,000	$ 150,000
	Ultrafiltration Membrane Filtration - pipework	LS	1	$ 100,000	$ 100,000
	Air-scour blowers	LS	1	$ 15,000	$ 15,000
	Backwash water tank	LS	1	$ 10,000	$ 10,000
	Backwash water pump	LS	1	$ 5,000	$ 5,000
	Backwash water pipework	LS	1	$ 10,000	$ 10,000
	CIP Tank	LS	1	$ 5,000	$ 5,000
	Electrical and instrumentation	LS	1	$ 80,000	$ 80,000
	Commissioning	LS	1	$ 30,000	$ 30,000
					$ 455,000
UV Disinfection (Bacteria and Protozoa)	UV disinfection - equipment	ea	2	$ 25,000	$ 50,000
	UV disinfection - pipework	LS	1	$ 15,000	$ 15,000
	Electrical and instrumentation	LS	1	$ 20,000	$ 20,000
	Commissioning	LS	1	$ 10,000	$ 10,000
					$ 95,000
Powdered Activated Carbon Storage, Make-Up and Dosing (Tastes and Odours)	PAC dosing - structural and civil	LS	1	$ 5,000	$ 5,000
	PAC dosing - equipment	LS	1	$ 80,000	$ 80,000
	PAC - pipework	LS	1	$ 15,000	$ 15,000
	Electrical and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 115,000
Permanganate Dosing (Iron and Manganese)	Permanganate dosing - structural and civil	LS	1	$ 5,000	$ 5,000
	Permanganate dosing - equipment	LS	1	$ 80,000	$ 80,000
	Permanganate dosigin - pipework	LS	1	$ 15,000	$ 15,000
	Electrical and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 115,000
Coagulant Storage and Dosing (Turbidity)	Coagulant dosing - structural and civil	LS	1	$ 5,000	$ 5,000
	Coagulant dosing - equipment	LS	1	$ 60,000	$ 60,000
	Coagulant dosing - pipework	LS	1	$ 20,000	$ 20,000
	Electrical and instrumentation	LS	1	$ 5,000	$ 5,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 95,000
Polymer Storage Make-Up and Dosing (Turbidity)	Polymer dosing - structural and civil	LS	1	$ 5,000	$ 5,000
	Polymer dosing - equipment	LS	1	$ 80,000	$ 80,000
	Polymer dosing - pipework	LS	1	$ 20,000	$ 20,000
	Electrical and instrumentation	LS	1	$ 5,000	$ 5,000
	Commissioning	LS	1	$ 5,000	$ 5,000

Rough Order Cost Estimate

Nangus 400kL Surface Water Source and Treatment Plant

Cardno

Date 27/11/2019
Job No. 8202004301
Prepared By P Garrity
Checked By J Knudsen

Area	Description	Unit	Quantity	Unit Cost	Total
					$ 115,000
Caustic Soda Storage and Dosing (pH Correction)	Caustic soda dosing - structural and civil	LS	1	$ 5,000	$ 5,000
	Caustic soda dosing - equipment	LS	1	$ 60,000	$ 60,000
	Caustic soda dosing - pipework	LS	1	$ 30,000	$ 30,000
	Electrical and instrumentation	LS	1	$ 5,000	$ 5,000
	Commissioning	LS	1	$ 10,000	$ 10,000
					$ 110,000
Citric Acid Storage and Dosing (CIP)	Citric acid dosing - structural and civil	LS	1	$ 5,000	$ 5,000
	Citric acid dosing - equipment	LS	1	$ 40,000	$ 40,000
	Citric acid dosing - pipework	LS	1	$ 10,000	$ 10,000
	Electrical and instrumentation	LS	1	$ 5,000	$ 5,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 65,000
Chlorine Storage and Dosing (Bacteria and Virus)	Chlorine dosing - structural and civil	LS	1	$ 20,000	$ 20,000
	Chlorine dosing - equipment	LS	1	$ 150,000	$ 150,000
	Chlorine dosing - pipework	LS	1	$ 20,000	$ 20,000
	Electrical and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 205,000
Fluoride Storage, Make-Up and Dosing	Fluoride dosing - structural and civil	LS	1	$ 30,000	$ 30,000
	Fluoride dosing - equipment	LS	1	$ 120,000	$ 120,000
	Fluoride - pipework	LS	1	$ 20,000	$ 20,000
	Electrical and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 185,000
Polymer Dosing (for Sludge Settling)	Polymer dosing - structural and civil	LS	1	$ 5,000	$ 5,000
	Polymer dosing - equipment	LS	1	$ 80,000	$ 80,000
	Polymer dosing - pipework	LS	1	$ 20,000	$ 20,000
	Electrical and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 120,000
Backwash Settling / Evaporation Disposal	Washwater Buffer Tank	LS	1	$ 30,000	$ 30,000
	Sludge settling pond - civil works, earthworks	LS	1	$ 90,000	$ 90,000
	Sludge settling pond - pipework	LS	1	$ 10,000	$ 10,000
	Electrical (local) and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 145,000
Plant Electrical & Controls	Electrical and Controls	LS	1	$ 350,000	$ 350,000
	VSDs				
	Soft Starters				
	Cable Containment				
	DB`s				
	Cable VSD				
	Cable Mains (AL)				
	Cable (other CU)				
	SCADA and Software				
	Standby generator				
	Installation				
	Testing and Commissioning				
					$ 350,000
Treatment Plant Building	Treatment Plant Building	LS	1	$ 600,000	$ 600,000
	Electrical room				
	Control Room				
	Lunch/ meeting room				
	Office space				
	Operator and ablutions areas				
	Laboratory area				
	Building services				
	Fire protection				
					$ 600,000
Process Services	Plant process water system	LS	1	$ 60,000	$ 60,000
	Plant process air	LS	1	$ 30,000	$ 30,000
	Information network	LS	1	$ 20,000	$ 20,000
					$ 110,000
SUB-TOTAL					**$ 3,947,000**
Preliminary and General	Contractors Preliminary and General	%	7.5%	$ 3,947,000	$ 296,025
Works Contingency	Allowances for changes to scope of works	%	15.0%	$ 3,947,000	$ 592,050

Rough Order Cost Estimate

Nangus 400kL Surface Water Source and Treatment Plant

Cardno

Date 27/11/2019
Job No. 8202004301
Prepared By P Garrity
Checked By J Knudsen

Area	Description	Unit	Quantity	Unit Cost	Total
Design & Management Fees	Professional Services	%	15.0%	$ 3,947,000	$ 592,050
TOTAL					**$ 5,427,125**

Excludes
Land Purchase
Consents and Easements
Mains Power Supply
Surface Water Intake and Transfer Pumping and Pipelines
Treated Water Storage and Pumping and Reticulation

Rough Order Cost Estimate

Nangus WTP 400kL Ground Water Source and Treatment Plant

Cardno

Date 27/11/2019
Job No. 8202004301
Prepared By P Garrity
Checked By J Knudsen

Area	Description	Unit	Quantity	Unit Cost	Total
Siteworks	Site Clearance / Earthworks	LS	1	$ 20,000	$ 20,000
	Roading / Access	LS	1	$ 30,000	$ 30,000
	Fencing	LS	1	$ 30,000	$ 30,000
	Landscaping	LS	1	$ 20,000	$ 20,000
	Stomwater	LS	1	$ 15,000	$ 15,000
	Sewer	LS	1	$ 25,000	$ 25,000
	Telecoms	LS	1	$ 10,000	$ 10,000
					$ 150,000
Bore Water Storage	Bore water storage tank - structural and civil	LS	1	$ 120,000	$ 120,000
	Water storage tank - equipment	LS	1	$ 10,000	$ 10,000
	Storage tank - pipework	LS	1	$ 30,000	$ 30,000
	Electrical and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 175,000
Media Pressure Filters	Media pressure filters - structure and civil	LS	1	$ 30,000	$ 30,000
	Feed pumps	ea	2	$ 10,000	$ 20,000
	Automatic Grit Screen	LS	1	$ 10,000	$ 10,000
	Greensand media pressure filters - equipment (filter and media)	ea	3	$ 30,000	$ 90,000
	Greensand media pressure filters - pipework	LS	1	$ 60,000	$ 60,000
	Electrical and instrumentation	LS	1	$ 45,000	$ 45,000
	Commissioning	LS	1	$ 20,000	$ 20,000
					$ 275,000
Cartridge Filters	Cartridge filter - structure and civil	LS	1	$ 5,000	$ 5,000
	Cartridge filter housing	ea	2	$ 25,000	$ 50,000
	Cartridge filter - pipework	LS	1	$ 40,000	$ 40,000
	Electrical and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 110,000
Reverse Osmosis	RO system - structural and civil	LS	1	$ 30,000	$ 30,000
	RO system - equipment	LS	1	$ 450,000	$ 450,000
	RO system - pipework	LS	1	$ 100,000	$ 100,000
	Clean in place system (CIP tank)	LS	1	$ 10,000	$ 10,000
	Clean in place system (CIP transfer pump)	LS	1	$ 5,000	$ 5,000
	Electrical and instrumentation	LS	1	$ 80,000	$ 80,000
	Commissioning	LS	1	$ 30,000	$ 30,000
					$ 705,000
Calcite Filtration	Calcite filtration system - structural and civil	LS	1	$ 5,000	$ 5,000
	Calcite filtration system - equipment (filter and media)	ea	2	$ 30,000	$ 60,000
	New calcite filtration system - pipework	LS	1	$ 40,000	$ 40,000
	Electrical and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 120,000
UV Disinfection	UV disinfection - equipment	ea	2	$ 25,000	$ 50,000
(Bacteria and Protozoa)	UV disinfection - pipework	LS	1	$ 15,000	$ 15,000
	Electrical and instrumentation	LS	1	$ 20,000	$ 20,000
	Commissioning	LS	1	$ 10,000	$ 10,000
					$ 95,000
Chlorine Storage and Dosing	Chlorine dosing - structural and civil	LS	1	$ 20,000	$ 20,000
(Bacteria and Virus)	Chlorine dosing - equipment	LS	1	$ 150,000	$ 150,000
	Chlorine dosing - pipework	LS	1	$ 20,000	$ 20,000
	Electrical and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 205,000
Chlorine Neutralisation Storage and Dosing	SMBS dosing - structural and civil	LS	1	$ 5,000	$ 5,000
	SMBS chemical dosing - equipment	LS	1	$ 40,000	$ 40,000
	SMBS chemical dosing - pipework	LS	1	$ 10,000	$ 10,000
	Electrical and instrumentation	LS	1	$ 5,000	$ 5,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 65,000
Membrane Antiscalant Storage and Dosing	Antiscalant dosing - structural and civil	LS	1	$ 5,000	$ 5,000
	Antiscalant dosing - equipment	LS	1	$ 40,000	$ 40,000
	Antiscalant dosing - pipework	LS	1	$ 10,000	$ 10,000
	Electrical and instrumentation	LS	1	$ 5,000	$ 5,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 65,000
Citric Acid Storage and Dosing	Citric acid dosing - structural and civil	LS	1	$ 5,000	$ 5,000
(pH Correction)	Citric acid dosing - equipment	LS	1	$ 40,000	$ 40,000
	Citric acid dosing - pipework	LS	1	$ 10,000	$ 10,000
	Electrical and instrumentation	LS	1	$ 5,000	$ 5,000
	Commissioning	LS	1	$ 5,000	$ 5,000

Rough Order Cost Estimate

Nangus WTP 400kL Ground Water Source and Treatment Plant

Cardno

Date 27/11/2019
Job No. 8202004301
Prepared By P Garrity
Checked By J Knudsen

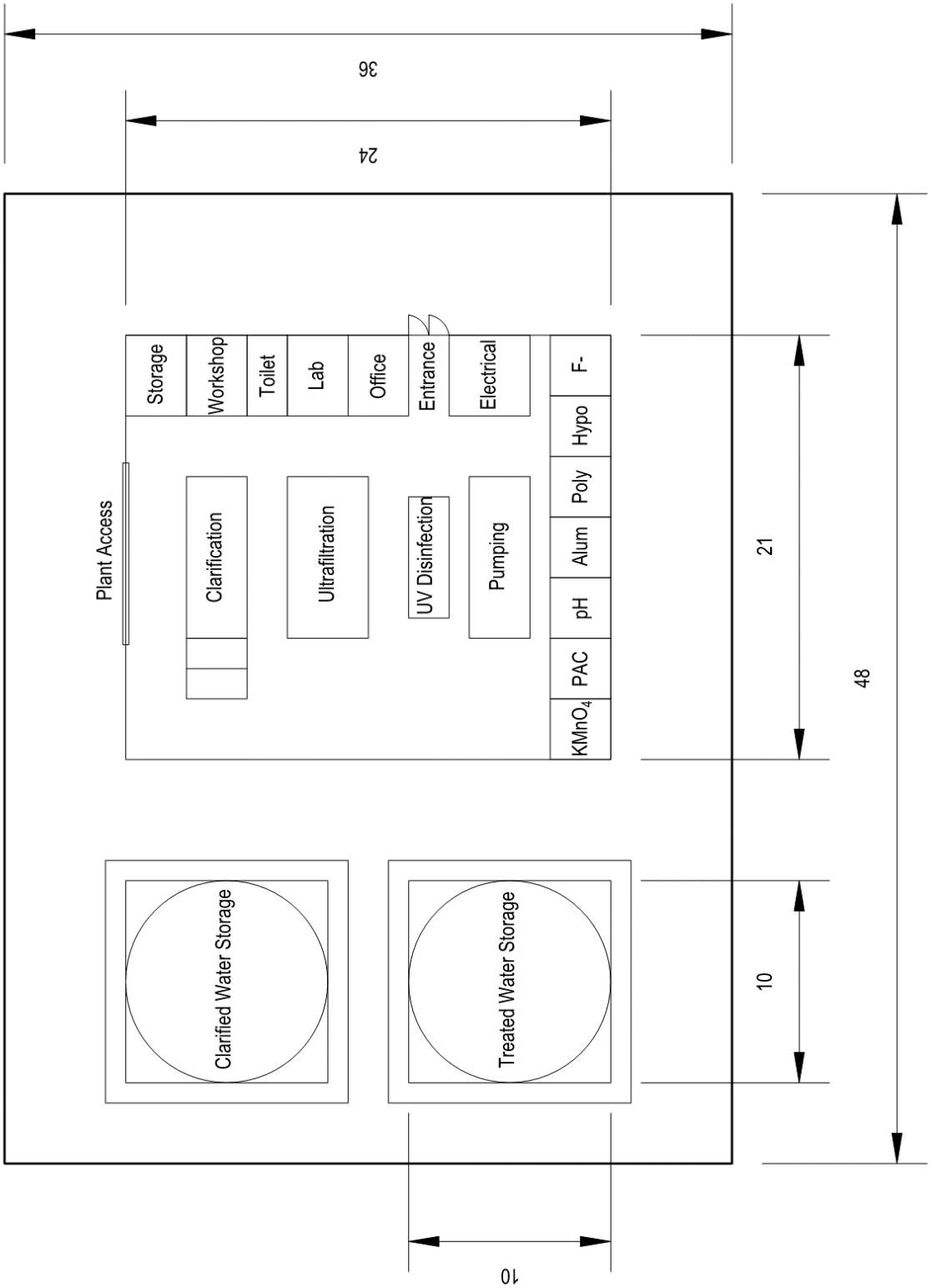
Area	Description	Unit	Quantity	Unit Cost	Total
					$ 65,000
Fluoride Storage, Make-Up and Dosing	Fluoride dosing - structural and civil	LS	1	$ 30,000	$ 30,000
	Fluoride dosing - equipment	LS	1	$ 120,000	$ 120,000
	Fluoride - pipework	LS	1	$ 20,000	$ 20,000
	Electrical and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 185,000
Polymer Dosing	Polymer dosing - structural and civil	LS	1	$ 5,000	$ 5,000
(for Sludge Settling)	Polymer dosing - equipment	LS	1	$ 80,000	$ 80,000
	Polymer dosing - pipework	LS	1	$ 20,000	$ 20,000
	Electrical and instrumentation	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 5,000	$ 5,000
					$ 120,000
Backwash Settling / Evaporation Disposal	Washwater Buffer Tank	LS	1	$ 30,000	$ 30,000
	Sludge Settling Pond	LS	1	$ 90,000	$ 90,000
	Sludge settling pond - pipework	LS	1	$ 10,000	$ 10,000
	Brine Evaporation Pond	LS	1	$ 240,000	$ 240,000
	Brine Evaporation Pond - pipework	LS	1	$ 10,000	$ 10,000
	Electrical (local) and instrumentation (minor)	LS	1	$ 10,000	$ 10,000
	Commissioning	LS	1	$ 10,000	$ 10,000
					$ 400,000
Plant Electrical & Controls	Electrical and Controls	LS	1	$ 380,000	$ 380,000
	VSDs				
	Soft Starters				
	Cable Containment				
	DB`s				
	Cable VSD				
	Cable Mains (AL)				
	Cable (other CU)				
	SCADA and Software				
	Standby generator				
	Installation				
	Testing and Commissioning				
					$ 380,000
Treatment Plant Building	Treatment Plant Building (Upgrade Existing)	LS	1	$ 600,000	$ 600,000
	Electrical room				
	Control Room				
	Lunch/ meeting room				
	Office space				
	Operator and ablutions areas				
	Laboratory area				
	Building services				
	Fire protection				
					$ 600,000
Plant Services	Plant process water system	LS	1	$ 60,000	$ 60,000
	Plant process air	LS	1	$ 30,000	$ 30,000
	Information network	LS	1	$ 20,000	$ 20,000
					$ 110,000
SUB-TOTAL					**$ 3,825,000**
Preliminary and General	Contractors Preliminary and General	%	7.5%	$ 3,825,000	$ 286,875
Works Contingency	Allowances for changes to scope of works	%	15.0%	$ 3,825,000	$ 573,750
Design & Management Fees	Professional Services	%	15.0%	$ 3,825,000	$ 573,750
TOTAL					**$ 5,259,375**

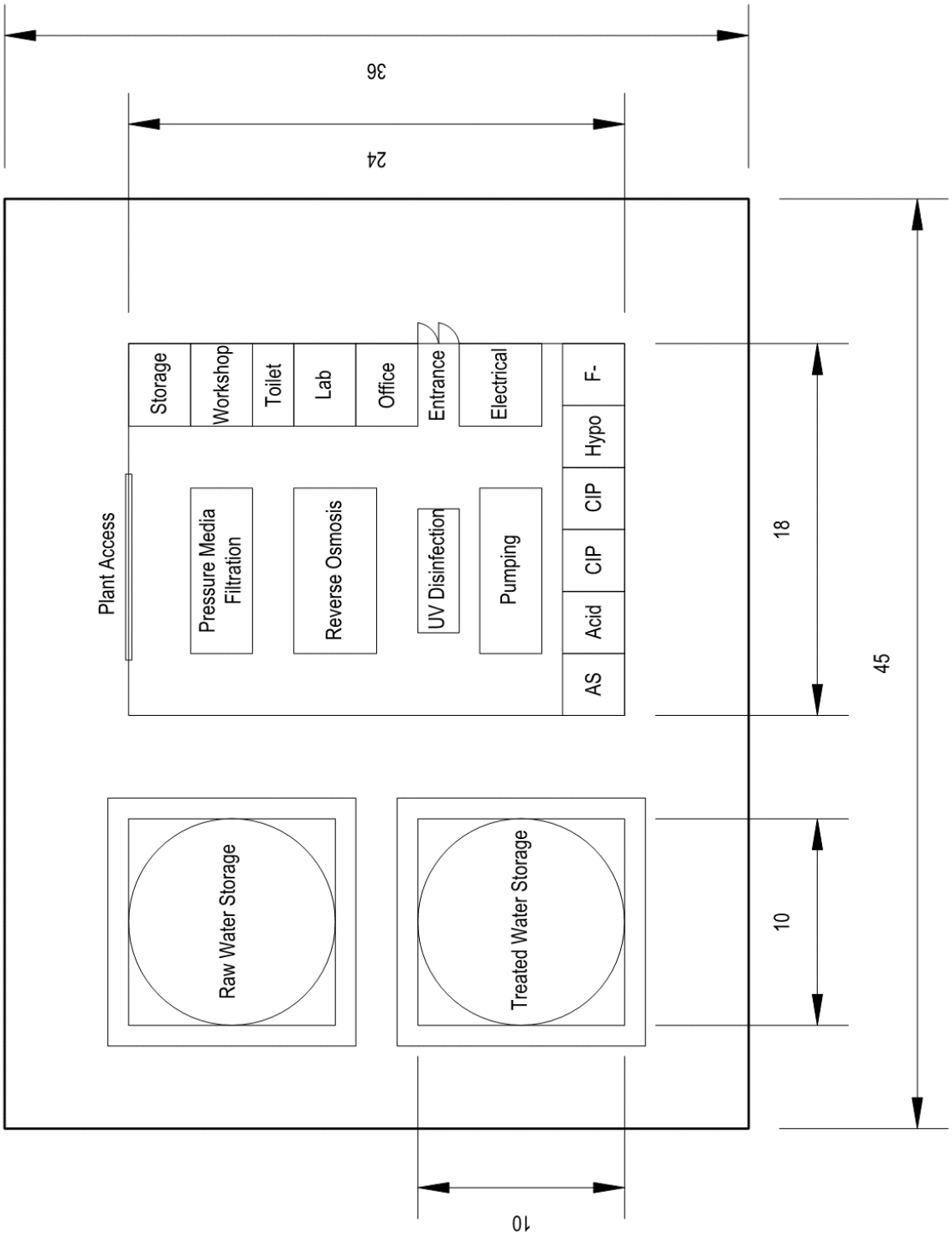
Excludes

Land Purchase
Consents and Easements
Mains Power Supply
Groundwater Bores
Groundwater Pumping and Pipelines
Treated Water Storage and Pumping and Reticulation

APPENDIX C

INDICATIVE LAYOUTS


36
24
Storage
Workshop
Toilet
Lab
Office
Entrance
Electrical
F-
Hypo
Poly
Alum
pH
PAC
$KMnO_4$
Plant Access
Clarification
Ultrafiltration
UV Disinfection
Pumping
21
48
Clarified Water Storage
Treated Water Storage
10
10
NANGUS WATER SUPPLY FEASIBILITY
SURFACE WATER TREATMENT PLANT
CONCEPT FOOTPRINT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Storage
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Entrance
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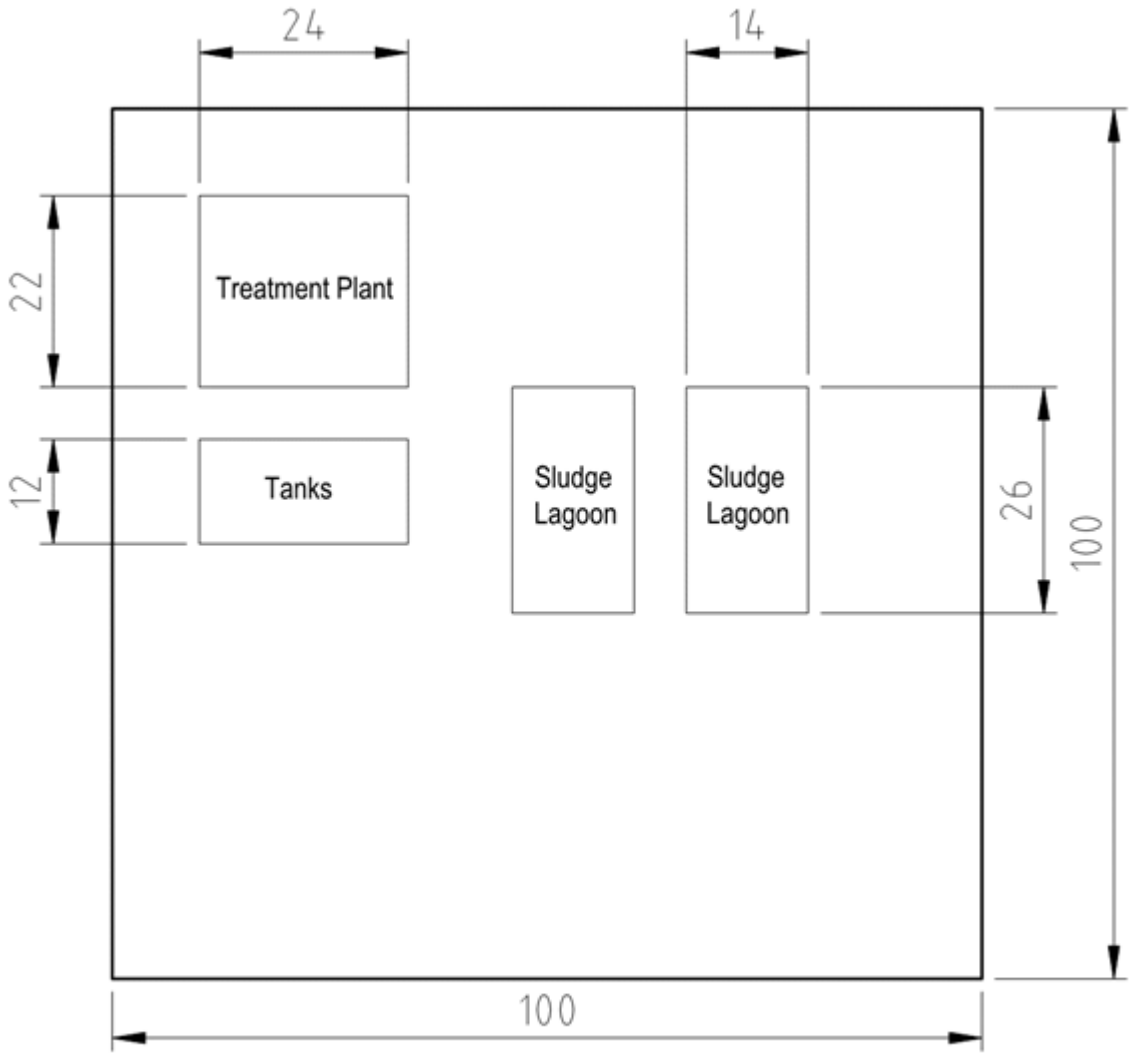
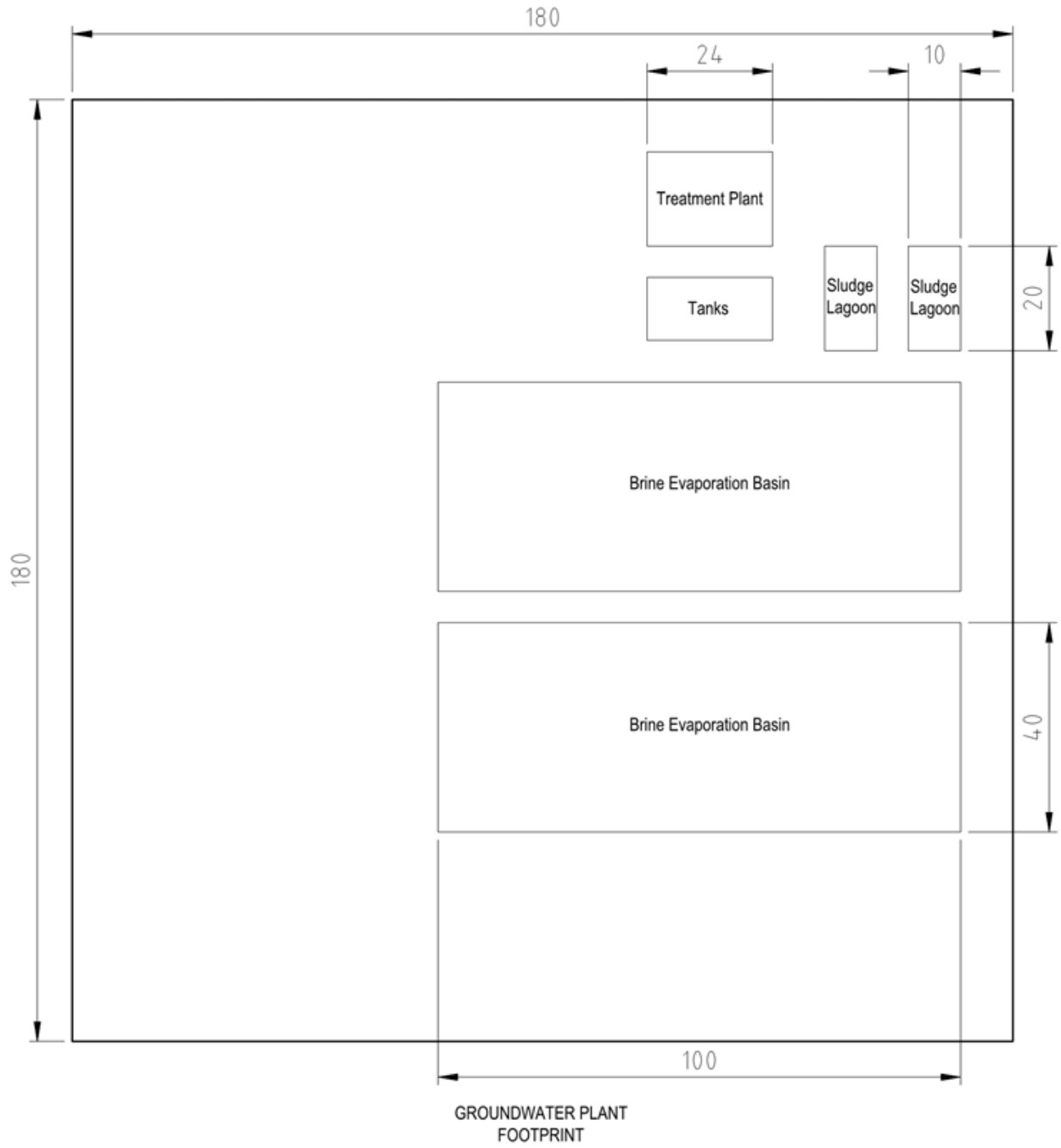
F-
Hypo
CIP
CIP
Acid
AS
Plant Access
Pressure Media Filtration
Reverse Osmosis
UV Disinfection
Pumping
Raw Water Storage
Treated Water Storage
18
10
45
10
NANGUS WATER SUPPLY FEASIBILITY
GROUNDWATER TREATMENT PLANT
CONCEPT FOOTPRINT



SURFACE WATER PLANT
FOOTPRINT


180
24
10
Treatment Plant
Tanks
Sludge Lagoon
Sludge Lagoon
20
Brine Evaporation Basin
Brine Evaporation Basin
40
180
100
GROUNDWATER PLANT FOOTPRINT

APPENDIX

D

HYDROGEOLOGICAL REVIEW

Cardno Victoria Pty Ltd
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Australia

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www.cardno.com

Our Ref: NangusReport01.1

31 October 2019

Goldenfields Water
84 Parkes Street
Temora NSW 2666

Attention: Nigel Marion

Dear Nigel,

Desktop Hydrogeological Review
Nangus Study Area, NSW

1 Introduction

1.1 Background

Cardno was engaged by Goldenfields Water to carry out the Nangus Feasibility Study ("the feasibility study") with the aim of assisting with the provision of a potable water supply system for the town. Nangus is located in the Riverina area of New South Wales, approximately 18 km west of the town of Gundagai and about 2 km north of the Murrumbidgee River. It is understood that the Nangus water supply currently relies on private bores, water carting and roof water, and that the associated quality and security issues are potentially restricting residential and commercial growth in the area.

This Desktop Hydrogeological Review ("the review") forms an integral part of the feasibility study, investigating the viability of groundwater resources in the Nangus Study Area ("the study area"). The study area covers an approximate 5 km radius around Nangus.

1.2 Purpose & Objectives

The aim of the review is to investigate the viability of groundwater resources in the study area, with the objective of providing a water supply to the town of Nangus.

The specific objectives of the review are:

- Assess the hydrogeology of the study area with respect to groundwater occurrence and quality.
- Assess the potential of groundwater resources in the vicinity of the study area.

1.3 Scope of Review

Cardno carried out the following tasks in order to satisfy the purpose and objectives of this review.

- Reviewed publicly available geological and hydrogeological maps, reports and groundwater database records to evaluate local groundwater occurrence and quality.
- Prepared a Conceptual Hydrogeological Model based on available data and information.
- Evaluated the potential for groundwater resources to exist in the vicinity of Nangus.

- Recommended further investigations required to assess the suitability of potential groundwater resources identified.

Cardno notes that this is a desktop study and there have not been any visits to the site or its surrounds, or other site activities. An overview of environmental site assessments is included in Appendix C.

1.4 Data and Information Sources

Data and information contained in the following reports and documentation has been used by Cardno in the preparation of this report:

- NSW Department of Water and Energy (DWE), 2009, Mid Murrumbidgee Alluvium Groundwater Management Area 013: Groundwater Resources Status Report
- NSW Department of Primary Industries Water, May 2016, Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources – Background document for amended plan 2016
- Wagga Wagga Geological Map Series Sheet (S1 55-15)
- Bureau of Meteorology (BOM), accessed October 2019
- Water NSW database, accessed October 2019

2 Site Description and Setting

Table 2-1 summarises key details defining the study area for this review. Nangus is located on the north side of the Murrumbidgee River, approximately 18 km west of Gundagai and 50 km east of Wagga Wagga.

2.1 Site Definition and Description

Aspect	Findings
Study Area	5 km radius from Nangus town centre Area of approximately 80 km^2
Local Government	Cootamundra Gundagai Regional Council (CGRC)
Land uses	Urban residential and commercial (Nangus) Farming (grazing / agricultural use) and rural residential located to the north, east, south and west
Topography	The town area itself is relatively flat at an elevation of approximately 220 m above mean sea level (amsl). The surrounding land consists of gently undulating plains and hills. Land elevations within the study area range from approximately 200 m amsl near the Murrumbidgee River to the south of Nangus to approximately 350 m amsl in the hills to the east of Nangus (Nearmap, October 2019).
Vegetation	Grassy paddocks with generally sparse trees that mainly occur along rivers and creeks, as well on hills and rises beyond the town.

The study area, with a radius of approximately 5 km, is presented in Figure 2-1.

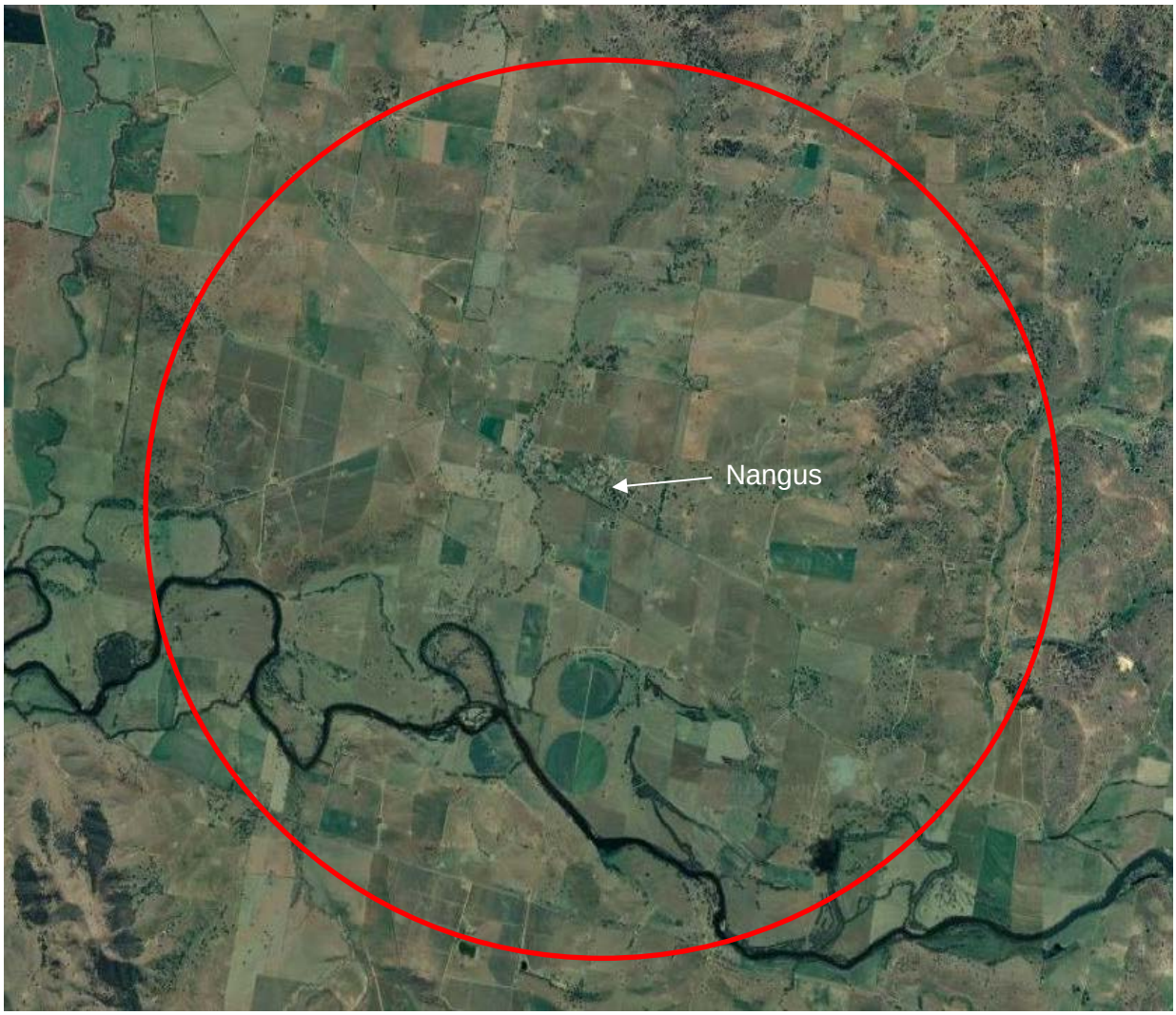


Figure 2-1: Nangus Study Area

3 Conceptual Hydrogeological Model

3.1 Introduction

This section presents Cardno's interpretation of the Conceptual Hydrogeological Model for the site in its regional context.

3.2 Climate Setting

The study area is located in a temperate area with hot, dry conditions in the summer months and cool, wet conditions during the winter months. Average annual rainfall is in the order of 550 mm (Bureau of Meteorology, October 2019). Rainfall statistics were obtained from the nearest weather station (Gundagai Station No. 073141).

Rainfall distribution during the year is relatively uniform with highest rainfall totals likely to occur from June to December, as shown in Figure 3-1.

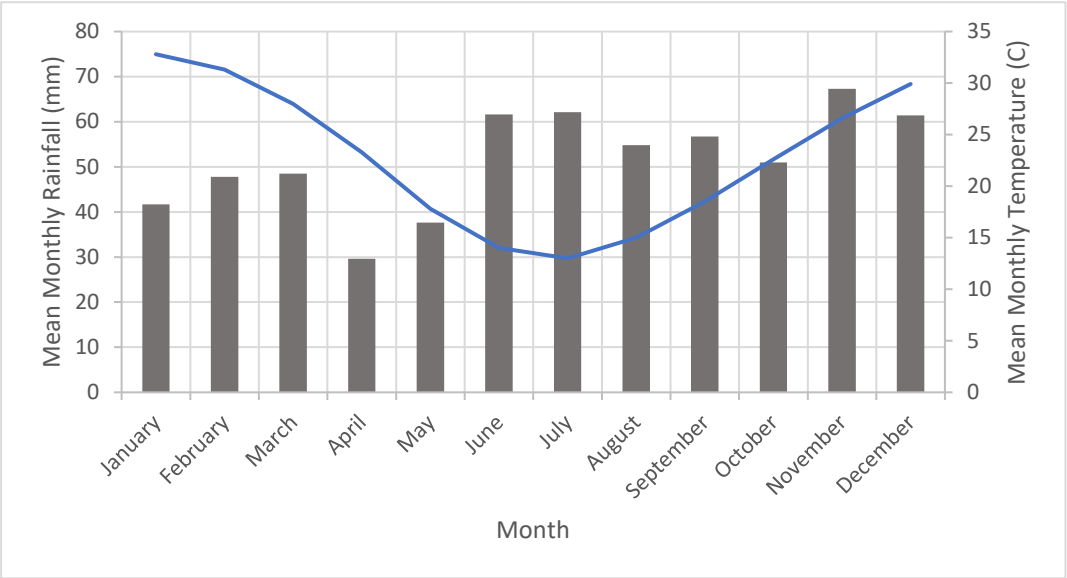


Figure 3-1: Mean Monthly Rainfall and Temperature 1995-2019

Figure 3-2 shows the total monthly rainfall from 1995 to 2019. High rainfall totals are noted during 2010, late 2011 to early 2012, and during 2016.

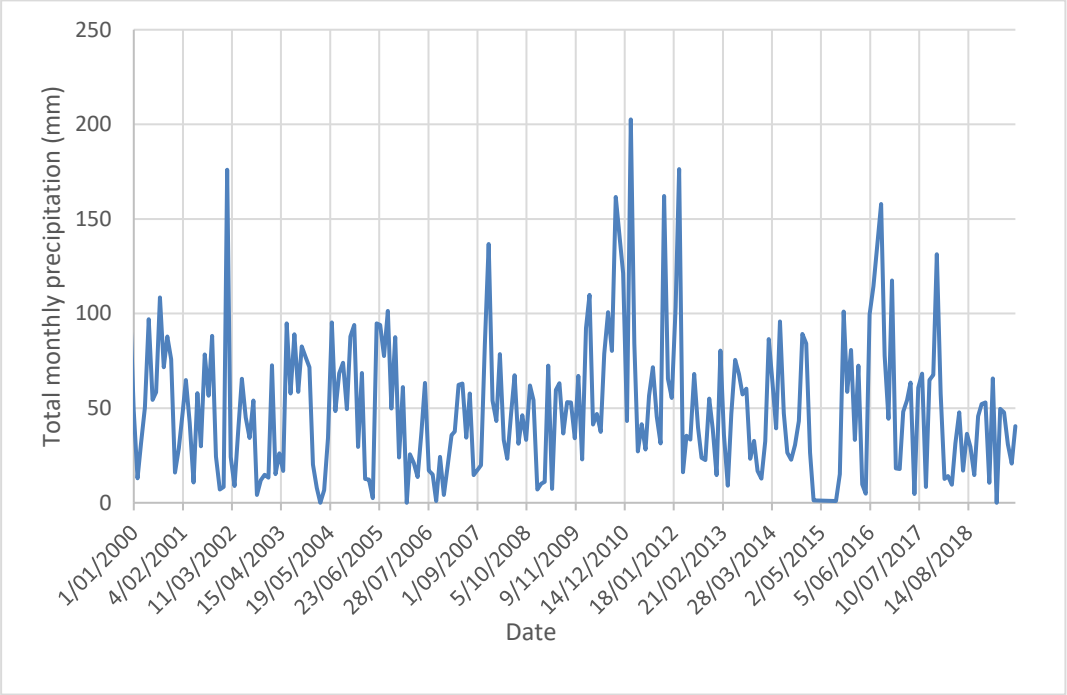


Figure 3-2: Total Monthly Rainfall 2000-2019

3.3 Geology and Aquifers

3.3.1 Regional Geology

The geology of the site in its regional setting has been ascertained from the following references:

- Wagga Wagga 1:250,000 Metallogenic Series Sheet (SI/55-15) - First Edition 1977
- Geological Survey of New South Wales - Geology Project Online Map - accessed 16 October 2019

The online Geological Survey plan (2019) was the main source used to reference geological units within and surrounding the study area. The regional geology is presented in Figure 3, Appendix A, and in Figure 3-3 below. Key geological units in the study area include the following:

- Quaternary aged sediments (Q), including alluvial and colluvial gravels, sands silts and clays.
- Silurian aged Bumbolee Creek Formation (Sufu), mainly comprising shale/ slate and sandstone, and also including conglomerate.
- Silurian aged Frampton Volcanics (Suff_m), including rhyolite, rhyodacite, dacite, as well as sandstone, siltstone and conglomerate.
- Ordovician aged Junawarra Volcanics (Olcj), mainly comprising andesite, but also including pyroclastics, latite, minor dacite and sedimentary rocks.

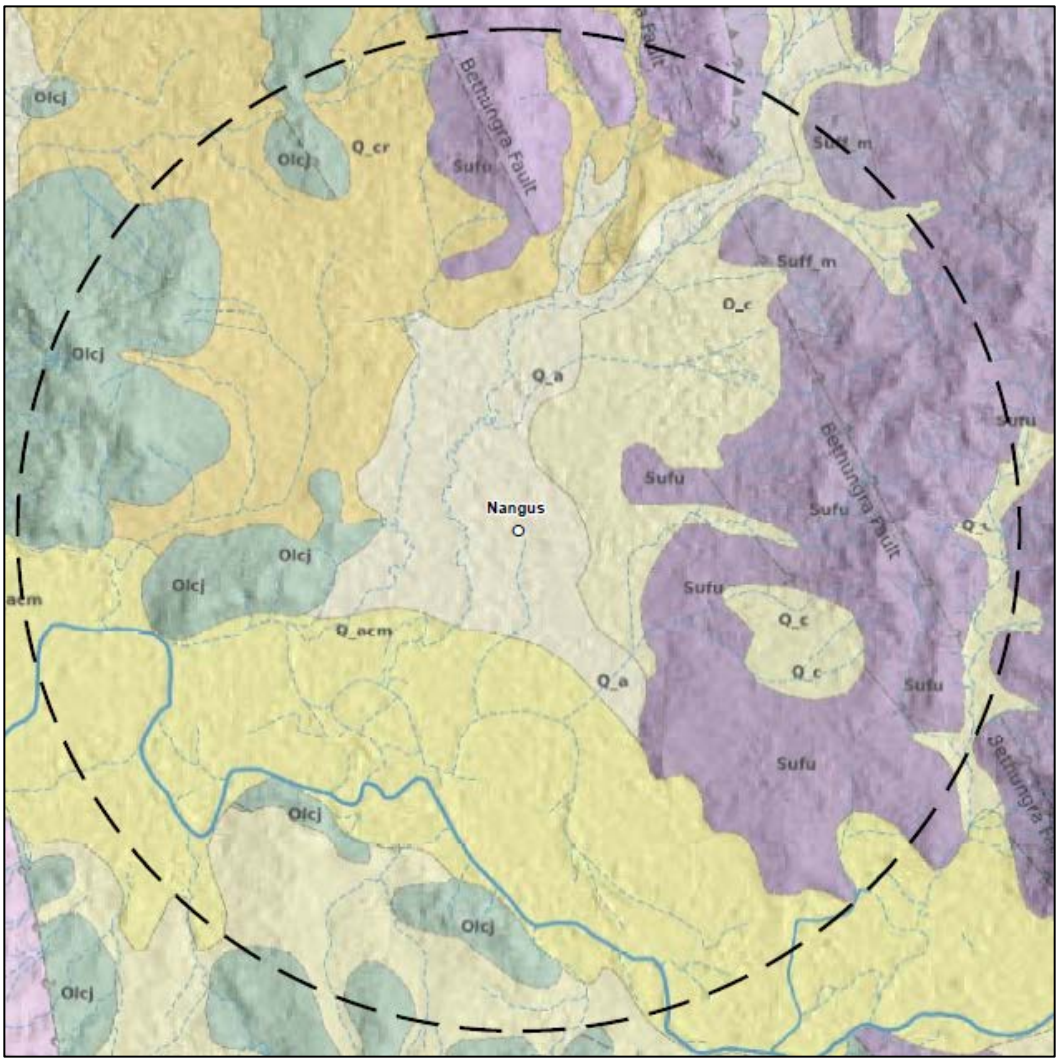


Figure 3-3: Geology - Nangus Study Area

3.3.2 Regional Aquifers

The study area is dominated by alluvial aquifers in the south and central parts, and by bedrock aquifers to the north-east and north-west. The alluvial aquifers include "channel" deposits of the Murrumbidgee River and fluvial deposits from a smaller drainage system to the north, as shown in Figure 3-3 above. The characteristics of the regional aquifer types are presented in Table 3-1. The "channel" alluvial deposits in the study area are understood to be part of the Cowra Formation which are reported to extend to depths of 25 m to 30 m. Regionally, the Cowra Formation overlies the Lachlan Formation, the latter occurring 'downstream', from near the town of Oura and extending to Narrandera. Groundwater quality and yield in the Cowra Formation are reportedly lower than in the Lachlan Formation.

Table 3-1: Aquifer Units

Aquifer	Occurrence	Geology	Yield	Water Quality
Porous Media	Southern to central parts of the study area, proximal to Murrumbidgee River (particularly on the northern bank) and extending north along a smaller drainage feature.	Sands, silts and gravels, with layers of clay.	High	High
Fractured Rock	Approximate north-east quadrant of study area.	Shales and sandstones of the Silurian aged Bumbolee Creek Formation.	Variable	Low to Moderate
	Approximate north-west quadrant of study area.	Andesites and pyroclastics of the Ordovician aged Junawarra Volcanics.	Variable	Low to Moderate

The regional extent of the aquifer types is shown in Figure 3-4 below. The figure represents a 'broad scale', simplified plan of the main aquifer types of the area.

Figure 3-4: Principal Aquifer Types (after Bureau of Meteorology, October 2019)

3.4 Groundwater Resources

A search of the Bureau of Meteorology and Water NSW databases identified 51 registered bores within the study area. The locations of the bores are presented in Figure 2, Appendix A, and tabulated bore information is provided in Appendix B. Where geology is reported, the lithologies indicate that the bores were installed and screened in Quaternary alluvial and/or colluvial deposits. These include silty to sandy clays and gravels in bores that typically range in depth, from 13 m to 20 m below ground surface.

The following groundwater uses were identified:

- Water Supply (26)
- Irrigation (12)
- Stock and Domestic (3)
- Monitoring (1)
- Other (1)
- Unknown (8)

3.5 Groundwater Occurrence and Flow Systems

3.5.1 Groundwater Levels and Flow Direction

Depth to groundwater is expected to vary considerably across the study area. A review of groundwater bores in the study area indicate that standing water levels occur at depths ranging from 5 m to 19 m below ground surface (Bureau of Meteorology, October 2019). Available standing water levels that have been reported are presented in Appendix B. They are all close to the town of Nangus, and are mainly for the bore use that is listed as “water supply”. The deepest groundwater (19 m) was reported to be for “irrigation” use.

The Groundwater Resources Status Report for this area (NSW DWE, 2009) noted that declines in groundwater levels in the region have been observed since the early 1980s due to the use of groundwater for irrigation and lower rainfall.

Groundwater across the majority of the study area is expected to flow from north to south towards the Murrumbidgee River.

3.5.2 Groundwater Yields

The Bureau of Meteorology database reported groundwater yields for seven bores in the study area, with yields ranging from 0.76 L/s to 13 L/s, and an average of approximately 3 L/s. It noted that these yields are typically obtained from airlift tests during bore development and may not be accurate.

3.5.3 Groundwater Quality

A search of the BOM bore database provided salinity results for three of the bores in the study area, reporting Electrical Conductivity (EC) ranging from 1,200 µs/cm to 6,354 µs/cm. Using a factor of 0.65 to convert from EC to Total Dissolved Solids (TDS), the TDS concentration is estimated to range from 780 mg/L to 4,130 mg/L (refer to Appendix B). Table 3-2 below categorises this as fair to unacceptable quality drinking water. One other bore reported salinity as “good”, but did not record a TDS concentration.

It is understood that the salinity of groundwater in the alluvial deposits along the Murrumbidgee River between Wagga Wagga and Gundagai in the Cowra formation is commonly less than 1,000 mg/L TDS, and that the salinity increases with distance from the river (NSW DWE, 2009).

The *Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources – Background document for amended plan 2016* reports that iron levels in the Cowra formation are generally quite high. No data for iron were available within the study area.

3.5.4 Australian Drinking Water Guidelines

The NSW government has endorsed the *Australian Drinking Water Guidelines* (ADWG) 2011 which provide a framework for good management of drinking supplies. Groundwater quality based on TDS (mg/L) is outlined in Table 3-2.

Based on the available data, the groundwater in the alluvial aquifer around Nangus would be classified as between fair quality and unacceptable quality in terms of TDS.

Table 3-2: Australian Drinking Water Guideline Values TDS (mg/L)

TDS Aesthetic Guideline Value (mg/L)	Quality of drinking water
< 600	Good quality
600 - 900	Fair quality
900 – 1,200	Poor quality
> 1,200	Unacceptable drinking quality

4 Licensing Assessment

The assessment reviewed policy, regulation and legislation applied from the following sources:

- *Water Management (General) Regulation 2018* (NSW).
- *Water Management Act 2000* (NSW).

The licensing summary details are outlined in Table 4-1, and water sharing plan areas are shown in Figure 4, Appendix A.

Table 4-1: Licensing Details Summary

Aspect	Findings
Water Sharing Plan Area [1]	Murrumbidgee Unregulated and Alluvial Water Sources
Groundwater Management Area (GWMA) (NSW DWE, 2009)	013 Gundagai to Narrandera: Zone 1
Water Sources within Plan Area [1]	- Murrumbidgee Central (Burrinjuck to Gogeldrie) Water Source - Gundagai Alluvial Groundwater Source
Water Access Licence Exemptions	Yes (discussed in Section 6.2)
Proposed Water Use	Town Water Supply
Notes: 1. Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources (2012)	

4.1 Water Sharing Plans

Following the establishment of the *Water Management Act 2000* (NSW), water sharing plan areas have been progressively introduced across the state. The Nangus Study Area falls within the following water sharing plans:

- *Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources 2012*
- *Water Sharing Plan for the NSW Murray-Darling Basin Fractured Rock Groundwater Sources 2011*

Water sharing requirements applicable to groundwater extracted from alluvial aquifers are covered in *Water Sharing Plan for the Murrumbidgee Unregulated and Alluvial Water Sources 2012*, as shown in Figure 4, Appendix A. Under this plan, the study area falls within the following areas:

- Murrumbidgee Central (Burrinjuck to Gogeldrie) Water Source
- Gundagai Alluvial Groundwater Source

As part of the Water Sharing Plan (NSW DSE, 2009), the yield estimates calculated for Zone 1 are presented in Table 4-2.

Table 4-2: Sustainable Yield Estimates in GWMA 013 (NSW DWE, 2009)

Zone	Area (Ha)	Sustainable Yield Limit per annum (ML)	Total Entitlement per annum for 16 licences (ML)	No. Licences	No. Constructed Bores	2006/7 Usage per year (ML)	% Allocated	Intensity of Entitlement (ML/Ha)
1	22,767	19,038	1,684	16	16	51	8.6	0.07

Sustainable yield limit is how much can sustainably be extracted per year in Zone 1. **Total entitlement** refers to the annual volume of water entitled under the 16 existing licences, of which only 51 ML was extracted in 2006/07. The total existing entitlement represents 8.6% of the sustainable yield limit (**% allocated**). The existing total entitlement divided over the total area of Zone 1 represents an **intensity of entitlement** of 0.07ML/ha per year. This is well below the average sustainable intensity over the Groundwater Management Area (GMWA), calculated to be 0.7 ML/ha per year (NSW DWE, 2009).

Sustainable yield calculations provided in NSW DWE (2009) are established as a percentage of average annual recharge. The annual recharge to the Mid Murrumbidgee alluvial aquifer system is estimated to be about 127,000 ML/yr, incorporating Murrumbidgee River leakage and rainfall recharge over the GWMA. The long term average extraction limit of the groundwater system is approximately 70% of the average annual recharge, and is therefore estimated to be about 89,000 ML/yr. This correlates to an average entitlement of about 0.7 ML/ha over the main body of the GWMA 013 (Ross 1999).

4.2 Licensing Summary

Responsibilities for granting and managing water access licences are shared between the following administrations:

- NSW Department of Planning, Industry, and Environment (DPIE)
- Water NSW

DPIE handles licence applications from water utilities.

5 Conclusions and Recommendations

As part of the Nangus Feasibility Study, Cardno has completed a Desktop Hydrogeological Review to investigate the viability of using groundwater to augment the town water supply. Based on the information gathered for this review, the following conclusions are made:

- Groundwater in the study area is likely be present in porous media alluvial aquifers or in fractured bedrock aquifers.
- Groundwater in alluvial aquifers may occur at depths ranging from approximately 5 m to 19 m below ground surface, based on existing bores near the town of Nangus. Depth of groundwater in bedrock aquifers is not known at this stage.
- Groundwater yields are reported to range from approximately 1 to 13 L/s in the alluvial aquifer in the study area, with an average yield of about 3 L/s. Bore yields are expected to be relatively high in the alluvial aquifers, but may not be sufficient for the peak daily requirement which is understood to be 4.6 L/s. Bore yields in the bedrock aquifers is expected to be variable, though generally lower.
- Groundwater quality, with respect to salinity, is expected to be fair to unacceptable in alluvial aquifers (based on available data) and poor to unacceptable in bedrock aquifers (based on our experience of bedrock aquifers).
- A total 51 registered groundwater bores have been identified within the study area. Groundwater uses mostly include water supply and irrigation, with minor stock/ domestic and monitoring uses. Potential impacts on existing registered bores would need to be considered if town supply bores were to be installed in the study area.
- Goldenfields Water may apply for a water access licence through the DPIE. The application is subject to the Minister's approval.

In summary, it is considered that there is potential for suitable groundwater resources to exist in the study area. However, further testing of bore yields and salinity is required to confirm this. Low yields may be addressed by using more than one bore for the groundwater supply. Poor groundwater quality can be addressed through the treatment of the groundwater prior to use as drinking water. Further, it is likely that groundwater salinity may be lower closer to the Murrumbidgee River, and groundwater investigations could target areas closer to the river.

Should Goldenfields Water wish to further assess potential groundwater resources in the study area, the following investigations are recommended:

- Exploratory drilling of one or more groundwater bores should be undertaken in selected locations in the alluvial aquifer(s) in the study area. This will provide an initial indication of bore yield and groundwater quality.
- Should water bearing units with indications of favourable groundwater quality and yield be identified in the alluvial aquifer(s), then more detailed investigations (including pumping tests) are recommended to assess the suitability of groundwater with respect to long-term bore production.
- If testing of bedrock aquifers is required, target locations (including fault and/or fracture zones) may be identified through detailed assessment of geological maps. As with the testing of alluvial aquifers, exploratory drilling should be undertaken to assess bore yield and groundwater quality. Should favourable results be achieved, more detailed investigations, such as pumping tests, would be required to assess the potential of the bedrock aquifer for long-term bore production.

With respect to budget estimates, exploratory drilling to assess bore yield and groundwater quality may be in the order $15,000.00 per location. This would include the installation of a groundwater monitoring bore, screening the target aquifer. For more detailed investigations, including the installation of a

pumping bore and an observation bore (for the purpose of conducting pumping tests) the cost would be in the vicinity of $80,000.00 per location.

The budget estimate costs stated above are approximate, based on available information.

Yours faithfully
Cardno

Michelle Agnew
Environmental Geoscientist

Approved:

David Louwrens
Senior Associate Hydrogeologist

Appendices

Appendix A

4 Pages

Figures

FIGURE 1

1:50,000 Scale at A3

Metres

0 1,000 2,000

Nangus Study Area

DESKTOP HYDROGEOLOGICAL REVIEW

N

Cardno

Map Produced by Cardno
Date: 2019-10-15 | Project: 8202040301
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-GS-001-SiteLocalityPlan.mxd 01
Aerial Imagery Supplied by ESRI

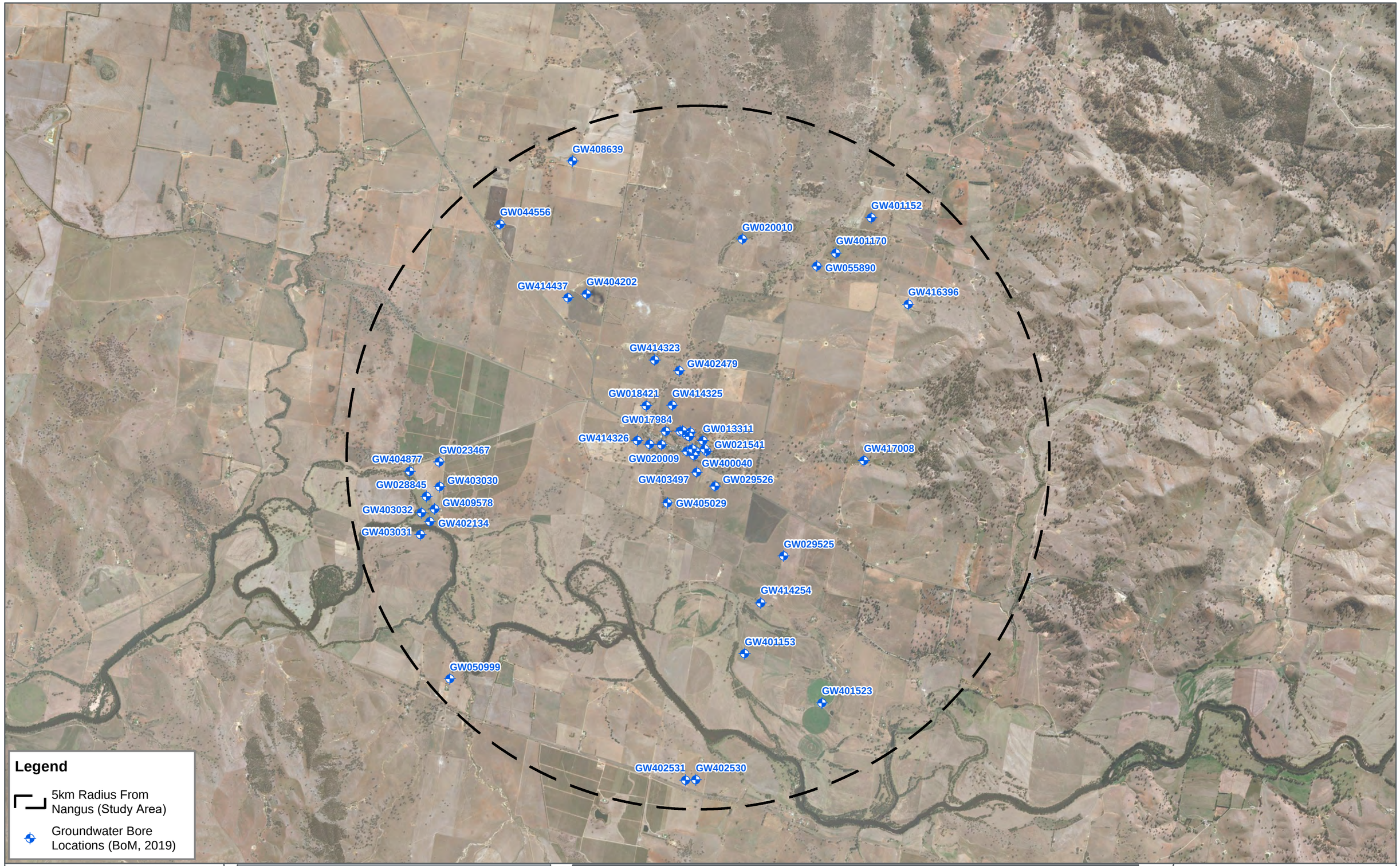


FIGURE 2

1:50,000 Scale at A3

Metres

0 1,000 2,000

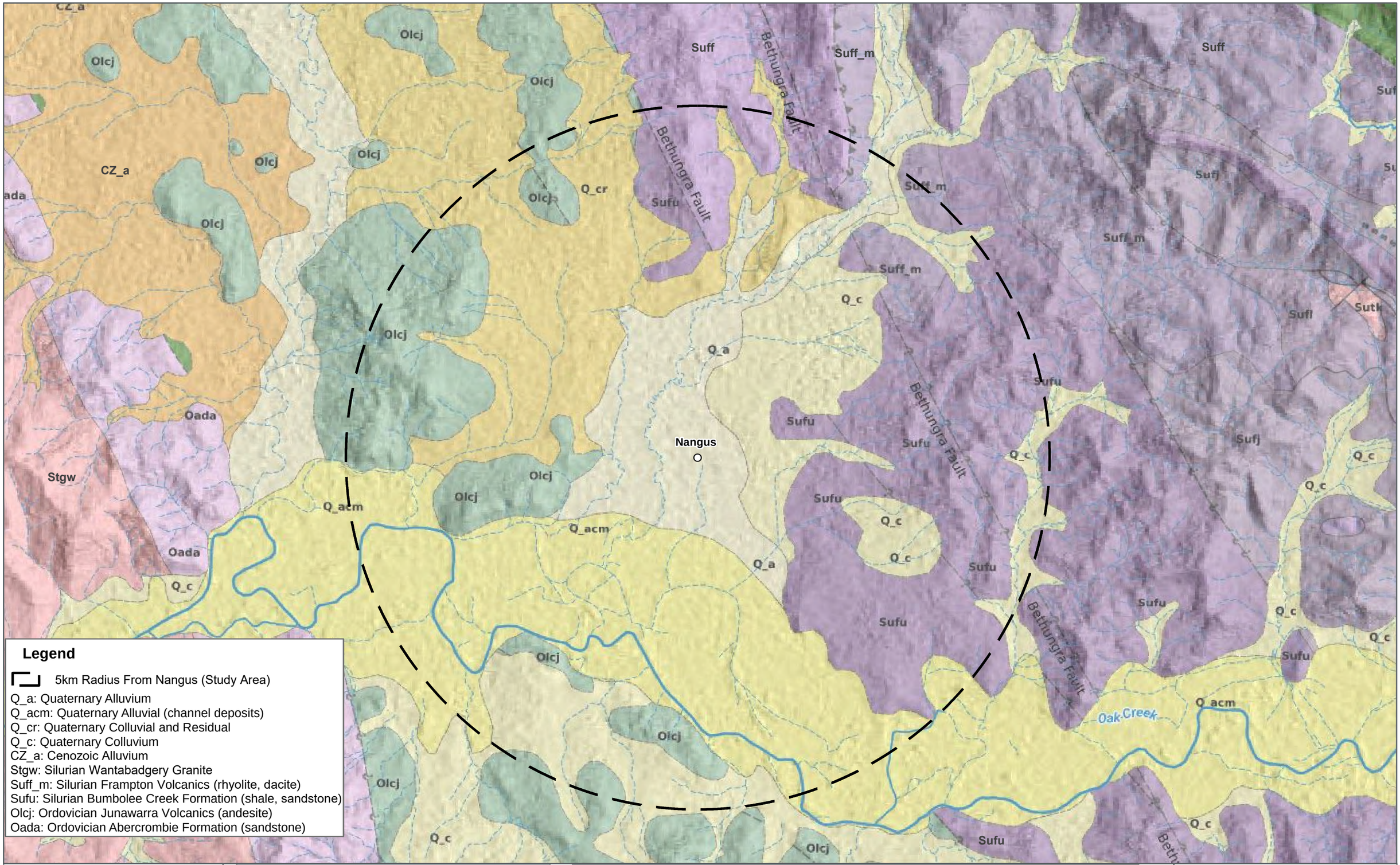
Registered Groundwater Bore Search

DESKTOP HYDROGEOLOGICAL REVIEW

N

Cardno

Map Produced by Cardno
Date: 2019-10-15 | Project: 82020040301
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-GS-002-RegBoreSearch.mxd 01
Aerial Imagery Supplied by ESRI



Data Source: Geological Survey of NSW (2019) Seamless Geology Map Layer: https://minview.geoscience.nsw.gov.au

FIGURE 3

1:50,000 Scale at A3

Metres

0 1,000 2,000

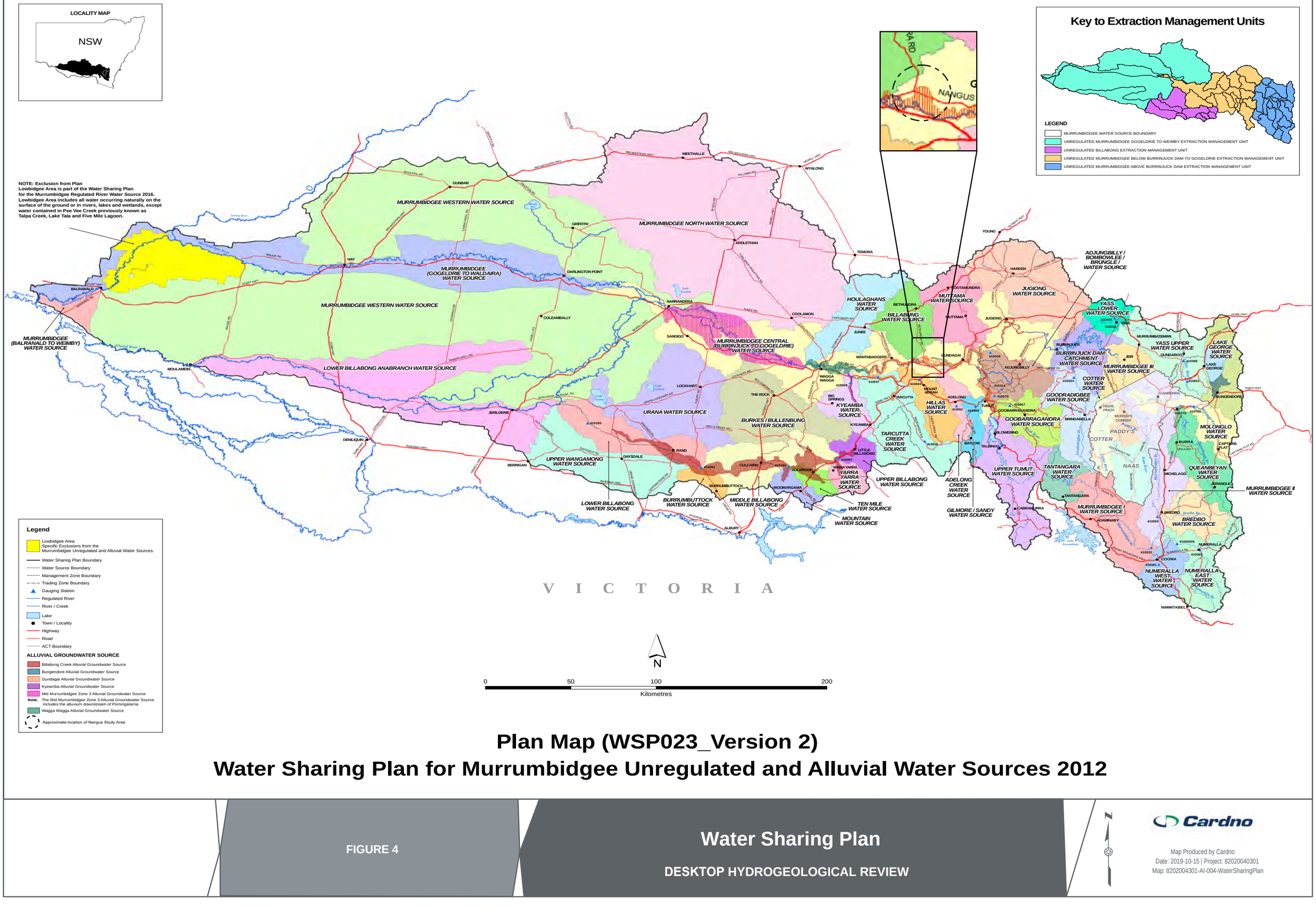
Regional Geology

DESKTOP HYDROGEOLOGICAL REVIEW

N

Cardno

Map Produced by Cardno
Date: 2019-10-16 | Project: 82020040301
Coordinate System: GDA 1994 MGA Zone 55
Map: 8202004301-GS-003-Geology.mxd 01



Plan Map (WSP023_Version 2)

Water Sharing Plan for Murrumbidgee Unregulated and Alluvial Water Sources 2012

FIGURE 4

Water Sharing Plan

DESKTOP HYDROGEOLOGICAL REVIEW

Cardno

Map Produced by Cardno
Date: 2019-10-15 | Project: 82020040301
Map: 8202004301-AI-004-WaterSharingPlan

Appendix B

2 Pages

Summary of Registered Bores

Bore ID	Bore Depth (m)	Drilled Date	Purpose	Status	Geology	Water Level (mbgl)	Yield	Salinity Description
GW409578	60	2004-10-01	Irrigation	Functioning	NR	NR	NR	NR
GW403030	23	2004-10-01	Irrigation	Unknown	NR	NR	NR	NR
GW028845	10.4	1968-03-01	Irrigation	Unknown	NR	NR	NR	NR
GW414323	27	2008-11-25	Irrigation	Functioning	NR	NR	NR	NR
GW414325	26	2008-11-25	Irrigation	Functioning	NR	NR	NR	NR
GW402134	14	2001-02-21	Irrigation	Unknown	NR	NR	NR	NR
GW414326	21	1990-01-01	Irrigation	Functioning	NR	19	6	NR
GW403031	29	2004-10-01	Irrigation	Unknown	NR	NR	NR	NR
GW404877	11.2	2008-12-23	Irrigation	Functioning	NR	NR	NR	NR
GW403032	14	2004-09-01	Irrigation	Unknown	NR	NR	NR	NR
GW402530	84	2003-09-06	Irrigation	Unknown	NR	NR	NR	NR
GW404202	36	2007-07-12	Irrigation	Functioning	NR	NR	NR	NR
GW402531	111	2003-09-04	Monitoring	Unknown	NR	NR	NR	NR
GW017984	18.9	1959-09-01	Other	Unknown	Unknown (0-6.4m) Rock (6.4-7.01) Unknown (7.01-1067m) Gravel (10.67-18.9m)	6.2	0.76	NR
GW417008	42	2018-08-07	Stock and Domestic	Functioning	NR	NR	NR	NR
GW050999	16.2	1980-02-01	Stock and Domestic	Unknown	NR	NR	NR	NR
GW020010	9.1	1962-03-01	Stock and Domestic	Functioning	NR	NR	NR	NR
GW029526	11.9	1948-01-01	Unknown	Non-functional	NR	NR	NR	3,490-4,130 mg/L
GW055890	4.3	1936-01-01	Unknown	Functioning	NR	NR	NR	NR
GW020009	13.4	1962-03-01	Unknown	Functioning	Unknown (0-9.14m), Clay (12.19-13.41m)	11	NR	NR
GW023467	13.4	1966-01-01	Unknown	Unknown	NR	NR	NR	NR
GW013311	21.3	1953-01-01	Unknown	Unknown	NR	NR	NR	NR
GW403625	20	2006-09-22	Unknown	Unknown	Clay (0-18.8m) Silty gravel (18.8-19.7, Sandy clay (19.7-20.3m)	11.5	NR	NR
GW013312	16.5	1928-02-01	Unknown	Non-functional	Unknown (0-13.72m) Gravel (13.72-16-46m)	NR	NR	NR
GW029525	11.4	1948-01-01	Unknown	Non-functional	NR	NR	NR	780-840 mg/L
GW408639	132	2006-01-24	Water Supply	Functioning	NR	NR	NR	NR
GW403701	19.4	2006-09-24	Water Supply	Unknown	Clay (0.3-3m), Gravel (3-3.6m), Clay (3.6-19m), Gravel (19-19.4m)	12.7	NR	NR
GW400040		1995-09-14	Water Supply	Unknown	Alluvial	5.48	NR	NR
GW405029	18	2009-08-27	Water Supply	Functioning	NR	NR	NR	NR
GW403942	20.6	2007-04-15	Water Supply	Unknown	Clay (0.3-6m), Gravel (6-6.6m), Clay (6.6-19.4m), Gravel (19.4-21.2m)	12.8	NR	NR
GW402479	28	2003-05-26	Water Supply	Unknown	NR	NR	NR	NR
GW060696	21.6	1984-11-01	Water Supply	Functioning	Clay (0-18.29m), Sandy Gravel (18.29-21.64m)	NR	0	NR
GW414437	35	2010-05-16	Water Supply	Functioning	NR	NR	NR	NR
GW400047	21.33	1996-01-09	Water Supply	Unknown	Alluvial	9.14	2.53	Good
GW403724	78	2007-01-12	Water Supply	Unknown	NR	NR	NR	NR
GW416108	20	2009-10-30	Water Supply	Functioning	NR	NR	1.5	NR
GW401523	7		Water Supply	Unknown	NR	NR	NR	NR
GW401152	15.24	2000-03-14	Water Supply	Unknown	NR	NR	NR	NR
GW401153	12.19	2000-03-29	Water Supply	Unknown	NR	NR	NR	NR
GW403497	21	2006-03-12	Water Supply	Unknown	Clay (1-6m), Shale (6-7m), Clay (7-12m), Shale (12-13m),Clay (13-17m), Shale (17-18m), Sandy Gravel (18-20m)	13	11	NR
GW416396	140	2014-01-08	Water Supply	Unknown	NR	NR	NR	NR

Bore ID	Bore Depth (m)	Drilled Date	Purpose	Status	Geology	Water Level (mbgl)	Yield	Salinity Description
GW403663	22	2006-05-15	Water Supply	Unknown	Hard red to brown (2-15m) sand and gravel (15-22m)	12	1.25	NR
GW021541	26.8	1964-02-01	Water Supply	Unknown	Clay (0-3.66m), Unknown (3.66-4.88m), Clay (4.88-19.2m), Gravel (19.2-26.82m), Clay (26.82-26.84m)	12.2	1.21	2,065-2,140 mg/L
GW416378	20.5	2009-01-20	Water Supply	Unknown	Clay (0.3-19.3m), Gravel (19.3-20.3m)	13	NR	NR
GW414254	18	2010-02-27	Water Supply	Functioning	NR	NR	NR	NR
GW403943	19.4	2007-11-26	Water Supply	Unknown	Clay (0.3-9m), Gravel (9-10.6m), Clay (10.6-18.8m), Gravel (18.8-19.4m)	12.2	NR	NR
GW401170	68.58	2000-03-24	Water Supply	Unknown	NR	NR	NR	NR
GW416146	128	2009-12-08	Water Supply	Functioning	NR	NR	NR	NR
GW018421	22.6	1960-01-01	Water Supply	Unknown	NR	NR	NR	NR
GW403700	18.5	2006-09-23	Water Supply	Unknown	Clay (0-18.1m), Sand (18.1-19m)	12	NR	NR
GW044556	97.5	1975-10-01	Water Supply	Functioning	NR	NR	NR	NR
AVERAGE						11.6	3.0	
MEDIAN						12.1	1.4	

NR- Not Recorded
Data Source: Bureau of Meteorology, Accessed October 2019

Appendix C
3 Pages

About ESA Reports

About Site Environmental Assessment Reports

1. Introduction

This document explains the Environmental Site Assessment (ESA) process and the context that applies to the use of Environmental Reports issued by Cardno.

2. What is an ESA?

Environmental Site Assessments (ESA) are undertaken for a range of purposes, specific to the brief issued by the client in each case. The scope may include one or a combination of any of the following:

- A factual report of the condition of a portion of the site or one aspect of an entire site.
- Assessment of the contamination levels in soil to be removed from a site – a waste classification assessment.
- Validation of the success of remediation of a site or a portion of a site.
- Provision of a professional opinion about the suitability of a site for one or more uses, in terms of its contamination status.

The scope of any ESA needs to be defined at the outset.

An ESA is not an Environmental Audit. Such audits are undertaken in accordance with the provisions of regulations enacted in various states of Australia, and are referred to as Site Audits in some jurisdictions. Statutory audits provide certification by EPA accredited auditors that a site is suitable for one or more uses. An ESA may provide similar advice but cannot be used in place of an audit if the latter is required by regulation in any instance. However in some circumstances and jurisdictions an ESA is sufficient to provide "environmental sign-off" of a site.

An ESA may be undertaken for due diligence purposes, to establish whether the site has been impacted to the extent that some beneficial uses of the site may be precluded. Due diligence audits in many cases may be completed as non-statutory Audits, although in some jurisdictions they can also be statutory audits, if defined as such at the outset.

3. The ESA Process

The Client generally initiates the ESA process by specifying a brief which identifies the specific objectives of the assessment. If not, it is the consultants' duty to so specify the ESA

In the case of an ESA to provide an opinion about the suitability of the site for use, it would be conducted in accordance with NEPM (Site Assessment). Such ESA would not commence until a thorough site history assessment (Phase 1 Assessment: to identify the potential for significant contamination at a site) is conducted. However, where the history is unclear, a broad screening of chemical parameters can be used to test environmental media. This normally includes a broad range of organic and inorganic compounds and elements, often referred to as an Environmental Screen.

(In the case of an ESA for a purpose other than to provide an opinion about the suitability of the site for use, it is not always necessary to undertake a Phase 1 assessment.)

The ESA requires sampling of soil at representative locations across the site. A NATA accredited laboratory performs the analysis of soil. It is impractical for all of the soil to be assessed. The ESA is often based on a statistical method of grid or random sampling, augmented by targeted sampling at locations known or suspected to be contaminated. Guidance on sampling strategy and density is provided in Australian Standard AS4482.1–2005. However, some considerable degree of judgement is still required in the application of any sampling and testing strategy. For example the blanket application of the "hot spot" method presented in this standard is often inappropriate given its limitations.

The field program also investigates the likelihood of contamination below the site surface. Field investigations must sample and test fill as well as the natural soils. If contamination is found then it is common for further work to be undertaken to characterise, to the extent practical, its vertical and horizontal extent. However, where fill is encountered and testing shows it to be uncontaminated, it must be realised that the heterogeneous nature of the material might mean that not all pockets of contaminated material can be detected using normal sampling regimes.

EPA guidelines for auditors, that may be relevant for an ESA, indicate the need in all cases to consider the potential for groundwater contamination in any site. This does not mean all sites need to be drilled to sample groundwater, but it is most often the case. Most hydrogeological settings and groundwater conditions are complex and vary in space and time. The condition of groundwater is investigated to identify if any beneficial use or environmental value of groundwater is precluded due to contamination.

As previously stated for soil, all groundwater at the site cannot be tested. The environmental investigations are conducted in accordance with industry standards and guidelines (e.g. EPA Vic Pub 668). This provides a level of confidence that a sufficiently comprehensive assessment of the groundwater at the site is achieved.

Where an investigation shows that groundwater is polluted, consideration should be given to assessing the risks and the need for and practicality of any clean up.

4. Environmental Assessment Report

The ESA Report details the findings of the ESA. It provides summary information on the site definition, the reasons for the assessment and other relevant facts. It reviews the scope and quality of the site investigations, laboratory testing and data analyses undertaken. These reports also present a review of the contamination status of the site, the need for any further clean up, and an opinion on the suitability of the site for a range of beneficial uses and land uses such as “residential – low density”, “commercial” etc, as appropriate.

However, as noted above, some ESA have a narrow scope such as for classification of waste soil for removal from site, and do not make conclusions on suitability of site for use.

The ESA Report generally includes copies of other documents and reports, necessary to support the assessment findings, presented as appendices. These can contain more detailed information than the body of the ESA Report. Care should be taken to also read the appended documents and the ESA report in full.

Cardno generally issues reports in electronic form (e-Report) on CD ROM. ESA Reports are issued in this format as Adobe Acrobat™ PDF files. However, a paper copy of the executive summary of the ESA Report is generally issued to the client, and others as required by the brief or by regulation.

5. Limitations of Environmental Assessment Report

The ESA Report is prepared in a manner that can be easily read by a lay person with a legitimate interest in the contamination status of the site, such as the site owner or occupier, EPA and Local Planning Authority. The ESA report is not intended for use by other parties or for other purposes. Anyone who uses the assessment report for purposes other than specified in the report, does so at their own risk.

The site should only be used for one or more of the beneficial uses and land uses identified in the ESA as suitable.

The conditions and qualifications may apply to the suitability of the site for use, and it is the responsibility of the Client to be cognizant of and accept these in accepting the report. Cardno are only responsible for the issuing of the ESA report but accepts no liability for the costs incurred in the implementation of ESA findings.

The ESA provides a “snapshot” of the site conditions at the time of the site investigation. Consequently, the report may not be valid at a later time if there has been any change to the contamination status of the site in that time. Verification of the status of the site may be required in cases where a significant time has elapsed, or site conditions have changed since the assessment and audit.

The ESA is necessarily limited by constraints such as time, cost and available information; although normal professional practice at the time has been applied with all due care to prepare the report. A necessary requirement of this process is the horizontal and vertical interpolation of data from discrete locations. However, site conditions are generally not homogenous and some discrepancies will occur between the actual and predicted results at locations not directly sampled. There is a risk that contamination may occur at the site and not be identified by a competent investigation and assessment. The approach adopted in sampling (a combination of statistically based grid and judgmental sampling) seeks to reduce, but cannot eliminate, this risk.

Where unexpected occurrences of contamination arise, subsequent to the issue of the ESA Report, Cardno should be permitted to make an interpretation of these facts in relation to the ESA Report findings. Consequently, the Client should inform Cardno and seek their opinion. Cardno accepts no liability for costs incurred due to such

unexpected occurrences, given the inherent uncertainties in the assessment process.

Cardno uses information provided by other parties as the basis for the ESA, and reliance on this information is at the discretion of Cardno. However, however Cardno cannot guarantee any of the facts, findings or conclusions presented by other parties. Cardno will not be liable for the use of information, provided by others that is subsequently found to be intentionally misleading.

The ESA Report is not and does not purport to be anything other than a contaminated land ESA. It is not a geotechnical report and bore logs reproduced are for interpretation of the likely distribution of contamination. They are not intended for geotechnical interpretations and may not be adequate for this purpose.

The ESA Report is not intended to be a comprehensive analysis of the presence and associated risk of asbestos in buildings and services. Where asbestos in buildings and services is known or likely, the report may only caution that an appropriately qualified person be engaged to undertake demolition to avoid contamination of the site.

Cardno

13 August 2015

APPENDIX

E

COST ESTIMATES

Nangus Water Supply Feasibility Study
Goldenfields Water County Council
Construction Costs
Option 1: Pipeline from CGRC Water Supply at Gundagai
Date: 5/12/2019

Item	Description	Units	No.	Rate	Cost
1	**General**				
1.1	Preliminaries and General	LS	1	$300,000	$300,000
2	**Pipelines**				
2.1	PVC-O DN100 Trunk Main	m	16300	$82	$1,336,600
2.2	PVC-O DN150 Trunk Main	m	5200	$111	$577,200
2.3	PVC-O DN100 Reticulation	m	2500	$82	$205,000
2.4	Service connections (existing developments)	ea	30	$1,000	$30,000
2.5	Easements for trunk main	ha	17.2	$3,900	$67,080
2.6	Bridge creek crossings	ea	3	$15,000	$45,000
2.7	Open trench creek crossings	ea	7	$3,000	$21,000
3	**Reservoirs**				
3.1	Nangus Reservoir - Steel standpipe	LS	1	$445,480	$445,480
3.2	Land purchase	LS	1	$10,975	$10,975
3.3	Access road	LS	1	$22,500	$22,500
3.4	Fencing	m	120	$55	$6,600
4	**Booster Pump Station**				
4.1	Booster Pump Station	LS	1	$119,140	$119,140
4.2	Pump station building	LS	1	$15,000	$15,000
4.3	Land purchase	LS	1	$10,975	$10,975
4.4	Fencing	m	120	$55	$6,600
5	**Chlorine Booster**				
5.1	Chlorine Booster	LS	1	$59,050	$59,050
Sub Total					$3,278,200
Contingency - Inherent Risk				30%	$983,460
Contingency - Contingent Risk				10%	$327,820
Total (rounded)					$4,590,000

Nangus Water Supply Feasibility Study
Goldenfields Water County Council
Construction Costs
Option 2: Pipeline from GWCC Water Supply – from Oura Road
Date: 5/12/2019

Item	Description	Units	No.	Rate	Cost
1	**General**				
1.1	Preliminaries and General	LS	1	$300,000	$300,000
2	**Pipelines**				
2.1	DICL DN100 Trunk Main	m	9800	$104	$1,019,200
2.2	PVC-O DN150 Trunk Main	m	3900	$111	$432,900
2.3	PVC-O DN100 Reticulation	m	2500	$82	$205,000
2.4	Service connections (existing developments)	ea	30	$1,000	$30,000
2.5	Easements for trunk main	ha	11.0	$3,900	$42,744
2.6	Bridge creek crossings	ea	2	$15,000	$30,000
2.7	Open trench creek crossings	ea	4	$3,000	$12,000
3	**Reservoirs**				
3.1	Concrete reservoir - 250kL	LS	1	$141,000	$141,000
3.2	Land purchase	LS	1	$10,975	$10,975
3.3	Access road	LS	1	$6,300	$6,300
3.4	Fencing	m	120	$55	$6,600
4	**Pressure Reducing Valve**				
4.1	DN150 PRV and valve chamber	LS	1	$30,000	$30,000
5	**Chlorine Booster**				
5.1	Chlorine Booster	LS	1	$59,050	$59,050
Sub Total					$2,325,769
Contingency - Inherent Risk				30%	$697,731
Contingency - Contingent Risk				10%	$232,577
Total (rounded)					$3,260,000

Nangus Water Supply Feasibility Study
Goldenfields Water County Council
Construction Costs

Option 3: Pipeline from GWCC water supply – from Tenandra Reservoirs following new route
Date: 11/12/2019

Item	Description	Units	No.	Rate	Cost
1	**General**				
1.1	Preliminaries and General	LS	1	$300,000	$300,000
2	**Pipelines**				
2.1	DICL DN100 Trunk Main	m	5420	$104	$563,680
2.2	PVC-O DN150 Trunk Main	m	5000	$111	$555,000
2.3	Extra over for DN100 in steep, rocky terrain	m	2675	$38	$101,650
2.4	Extra over for DN150 in steep, rocky terrain	m	675	$41	$27,675
2.5	PVC-O DN100 Reticulation	m	2500	$82	$205,000
2.6	Service connections (existing developments)	ea	30	$1,000	$30,000
2.7	Easements for trunk main	ha	9.4	$3,900	$36,574
2.8	Bridge creek crossings	ea	1	$15,000	$15,000
2.9	Directional drilling of creek DN125 PE	ea	80	$445	$35,600
3	**Reservoirs**				
3.1	Concrete reservoir - 250kL	LS	1	$141,000	$141,000
3.2	Land purchase	LS	1	$10,975	$10,975
3.3	Access road	LS	1	$72,000	$72,000
3.4	Fencing	m	120	$55	$6,600
4	**Pressure Reducing Valve**				
4.1	DN150 PRV and valve chamber	LS	1	$30,000	$30,000
5	**Chlorine Booster**				
5.1	Chlorine Booster	LS	1	$59,050	$59,050
Sub Total					$2,189,804
Contingency - Inherent Risk				30%	$656,941
Contingency - Contingent Risk				10%	$218,980
Total (rounded)					$3,070,000

Nangus Water Supply Feasibility Study
Goldenfields Water County Council
Construction Costs

Option 4: Pipeline from GWCC water supply – from Tenandra Reservoirs following existing easement
Date: 11/12/2019

Item	Description	Units	No.	Rate	Cost
1	**General**				
1.1	Preliminaries and General	LS	1	$300,000	$300,000
2	**Pipelines**				
2.1	DICL DN100 Trunk Main	m	5600	$104	$582,400
2.2	PVC-O DN150 Trunk Main	m	5000	$111	$555,000
2.3	Extra over for DN100 in steep, rocky terrain	m	1650	$38	$62,700
2.4	Extra over for DN150 in steep, rocky terrain	m	675	$41	$27,675
2.5	PVC-O DN100 Reticulation	m	2500	$82	$205,000
2.6	Service connections (existing developments)	ea	30	$1,000	$30,000
2.7	Easements for trunk main	ha	9.5	$3,900	$37,206
2.8	Bridge creek crossings	ea	1	$15,000	$15,000
2.9	Directional drilling of creek DN125 PE	ea	80	$445	$35,600
2.10	Open trench creek crossing	ea	1	$3,000	$3,000
3	**Reservoirs**				
3.1	Concrete reservoir - 250kL	LS	1	$141,000	$141,000
3.2	Land purchase	LS	1	$10,975	$10,975
3.3	Access road	LS	1	$72,000	$72,000
3.4	Fencing	m	120	$55	$6,600
4	**Pressure Reducing Valve**				
4.1	DN150 PRV and valve chamber	LS	1	$30,000	$30,000
5	**Chlorine Booster**				
5.1	Chlorine Booster	LS	1	$59,050	$59,050
Sub Total					$2,173,206
Contingency - Inherent Risk				30%	$651,962
Contingency - Contingent Risk				10%	$217,321
Total (rounded)					$3,040,000

Nangus Water Supply Feasibility Study
Goldenfields Water County Council
Construction Costs
Option 5: Murrumbidgee River extraction and treatment
Date: 5/12/2019

Item	Description	Units	No.	Rate	Cost
1	**General**				
1.1	Preliminaries and General	LS	1	$300,000	$300,000
2	**Pipelines**				
2.1	PVC-O DN100 Raw Water Main	m	5000	$82	$410,000
2.2	Easements for raw water main	ha	4.0	$3,900	$15,600
2.3	PVC-O DN100 Reticulation	m	3640	$82	$298,480
2.4	Service connections (existing developments)	ea	30	$1,000	$30,000
2.5	Directional drilling of creek DN125 PE	ea	80	$445	$35,600
3	**Water Treatment Plant and Reservoir**				
3.1	Water Treatment Plant (refer to Surface and Groundwater Treatment Option report)	LS	1	$4,539,050	$4,539,050
3.2	Land purchase	ha	3.24	$9,750	$31,590
3.3	Fencing	m	720	$55	$39,600
3.4	Power supply	LS	1	$30,000	$30,000
3.5	Concrete reservoir - 250kL	LS	1	$141,000	$141,000
3.6	Water supply pump station	LS	1	$119,140	$119,140
3.7	Pump station building	LS	1	$15,000	$15,000
3	**Surface Water Intake**				
3.1	River intake pumping system - structural and civil	LS	1	$150,000	$150,000
3.2	River intake pumping system - screens	ea	1	$20,000	$20,000
3.3	River intake pumping system - pumps	ea	2	$20,000	$40,000
3.4	River intake pumping system - pipework	LS	1	$30,000	$30,000
3.5	Electrical and instrumentation	LS	1	$20,000	$20,000
3.6	SCADA/RTU	LS	1	$10,000	$10,000
3.7	Land purchase	LS	1	$10,975	$10,975
3.8	Access road	LS	1	$120,000	$120,000
3.9	Fencing	m	120	$55	$6,600
3.10	Power supply	LS	1	$100,000	$100,000
Sub Total					$6,512,635
Contingency - Inherent Risk				30%	$1,953,791
Contingency - Contingent Risk				10%	$651,264
Total (rounded)					$9,120,000

Nangus Water Supply Feasibility Study
Goldenfields Water County Council
Construction Costs
Option 6: Groundwater extraction and treatment
Date: 5/12/2019

Item	Description	Units	No.	Rate	Cost
1	**General**				
1.1	Preliminaries and General	LS	1	$300,000	$300,000
2	**Pipelines**				
2.1	PVC-O DN100 Raw Water Main	m	4900	$82	$401,800
2.2	Easements for raw water main	ha	3.9	$3,900	$15,288
2.3	PVC-O DN100 Reticulation	m	3640	$82	$298,480
2.4	Service connections (existing developments)	ea	30	$1,000	$30,000
2.5	Directional drilling of creek DN125 PE	ea	80	$445	$35,600
3	**Water Treatment Plant and Reservoir**				
3.1	Water Treatment Plant (refer to Surface and Groundwater Treatment Option report)	LS	1	$4,398,750	$4,398,750
3.2	Land purchase	ha	3.24	$9,750	$31,590
3.3	Fencing	m	720	$55	$39,600
3.4	Power supply	LS	1	$30,000	$30,000
3.5	Concrete reservoir - 250kL	LS	1	$141,000	$141,000
3.6	Water supply pump station	LS	1	$119,140	$119,140
3.7	Pump station building	LS	1	$15,000	$15,000
3	**Bores**				
3.1	Bores	ea	2	$51,800	$103,600
3.2	Wellhead protection	ea	2	$10,000	$20,000
3.3	Electrical and instrumentation	LS	2	$15,000	$30,000
3.4	SCADA/RTU	LS	2	$10,000	$20,000
3.5	Land purchase	LS	1	$20,975	$20,975
3.6	Access road	LS	1	$120,000	$120,000
3.7	Fencing	m	120	$55	$6,600
3.8	Power supply	LS	1	$100,000	$100,000
Sub Total					$6,277,423
Contingency - Inherent Risk				30%	$1,883,227
Contingency - Contingent Risk				10%	$627,742
Total (rounded)					$8,790,000