Richmond River Floodplain Prioritisation Study: Appendix A – L

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Appendix A Floodplain drainage

A1 Preamble

Up to date mapping of floodplain waterways within the study area was required to inform the prioritisation assessment and can also be used to inform the implementation of management options. The following section summarises the available existing data which maps present day waterways across the Richmond River floodplain (below 5 m AHD) and also presents an updated spatial waterways data layer, created using existing data, which provides a consistent and uniform dataset across the floodplain. This updated spatial layer incorporates the results of a detailed multi criteria analysis for categorising a waterway as a natural waterbody watercourse, an artificial waterbody, a watercourse or connector watercourse. Details on the development of the updated spatial layer and the multi criteria analysis can be found in Section 12 of the Methods report (Rayner et al., 2023). The updated waterways layer was used to calculate subcatchment drainage density during the subcatchment prioritisation assessment and will also be a valuable tool for informing management option implementation.

A2 Existing waterway data

Available information for the floodplain waterway network across the Richmond River floodplain was from multiple data sources as summarised in Table A-1.

Table A-1: Summary of available waterway data

Dataset	Data format	Provides waterway naming information?	Distinguishes between artificial and natural waterways?	Local or state wide dataset?
Geoscience Australia surface hydrology lines	Geodatabase	Yes	Yes	State wide
NSW Spatial Services hydrology lines	Shapefile	Yes	No	State wide
NSW Spatial Services hydrology lines	WMS layer	Yes	Yes	State wide
NSW DPI Fisheries manmade drains	Shapefile	No	Yes	State wide
Rous County Council flood lines	TAB	Yes	Yes	Local
Lismore City Council drainage lines	TAB	Yes	Yes	Local

A3 Waterway classification

For this study, an updated waterways spatial dataset was developed for the Richmond River floodplain to incorporate the most recent changes to the waterway network and ensure a consistent level of detail across the floodplain. The alignments and configurations of floodplain waterways are continuously changing due to varying management requirements of waterway owners across the floodplain. Inspection of the existing waterway data showed varying degrees of accuracy and detail for the different

datasets in Table A-1 reflecting the different purposes for which the individual spatial layers had been created.

To ensure an up-to-date waterways dataset across all areas in the Coastal Floodplain Prioritisation Study, a multi criteria analysis was completed to categorise waterways into the following:

- Natural waterbody watercourses –a natural waterway that pre-dates European settlement. Natural waterbody watercourses are typically sinuous and follow geological features;
- Artificial waterbodies – a constructed waterway that was purpose built to enhance drainage of backswamps or redirect water. Artificial waterways are typically straight, and deep;
- Watercourses – typically a waterway that follows a natural drainage system, but has been heavily modified or disconnected from the upstream catchment; and
- Connector watercourses – a waterway with either natural or artificial sections that provides a connection between two natural waterbody watercourses. Typically connector watercourses flow through a drainage network which was once a backswamp connecting the upper catchment to the river.

Further details on the approach taken to update the waterways spatial layer and the multi criteria analysis can be found in Section 12 of the Methods report (Rayner et al., 2023). The updated spatial dataset and results of the multi criteria analysis are presented in Figure A-1. Note, update and classification of waterways was completed for elevations below 5 m Australian Height Datum (AHD) as is consistent with catchment delineation used for the subcatchment prioritisation.

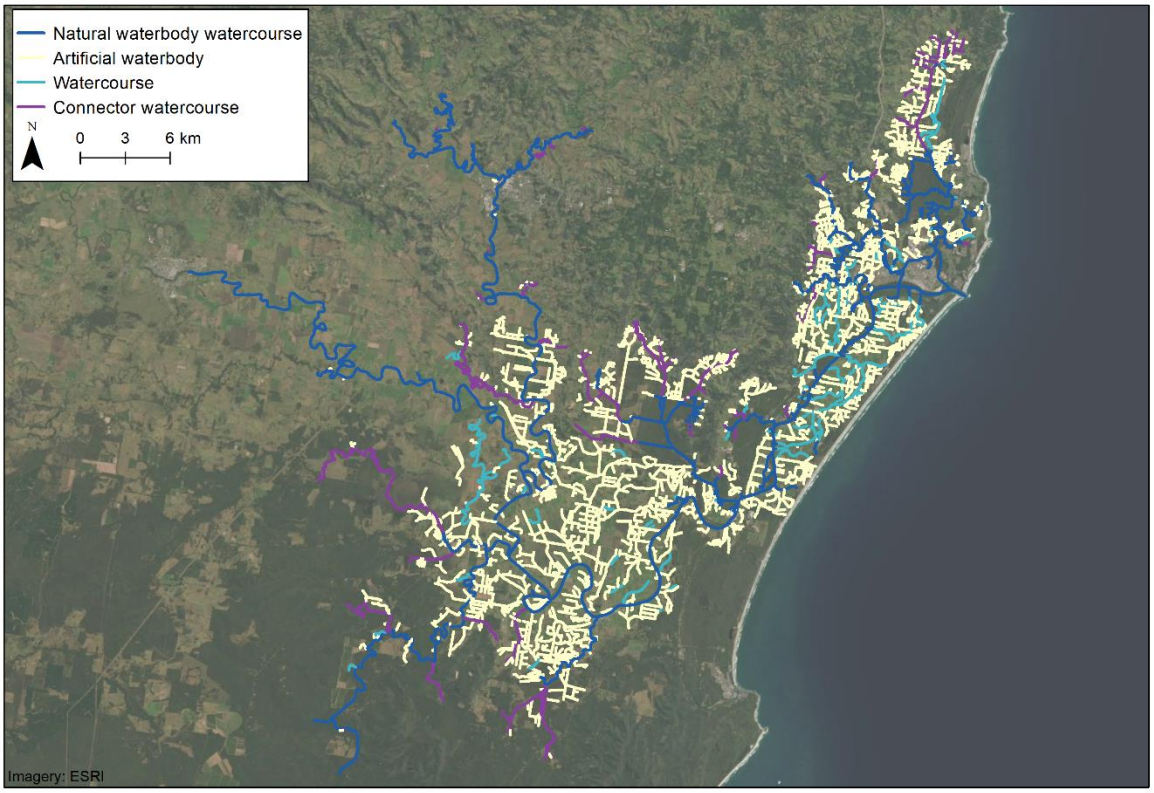


Figure A-1: Richmond River floodplain waterways

A4 Drainage density

The drainage density of each subcatchment is determined by the total waterway length across the subcatchment relative to the subcatchment area affected by acid sulfate soils (see Section 4.3.1 of the Methods report (Rayner et al., 2023)). When assessing the length of waterways that contribute to the drainage of an acid sulfate soil affected landscape, all waterways within the subcatchment boundaries were included in the priority assessment to provide a total waterway length for each subcatchment, as all waterways have the potential to impact acid sulfate soil oxidation and acid mobilisation. A summary of the floodplain drainage density analysis is provided in Table A-2 and the ranking of the drainage density factors for each subcatchment of the Richmond River floodplain is presented in Figure A-2.

Table A-2: Floodplain drainage density

Subcatchment	Total waterway length (m)	Floodplain area* (km^2)	Drainage density (m/km^2)	Drainage density rank**
Back Channel	32,838	10.4	3,143	6
Bungawalbin Creek/Sandy Creek	114,837	96.3	1,193	13
East Coraki	80,361	36.0	2,235	10
Emigrant Creek/Maguires Creek	224,853	46.5	4,840	1
Empire Vale	103,416	32.2	3,207	4
Kilgin/Buckendoon	66,796	31.8	2,103	11
North Creek	170,113	43.8	3,887	3
Rileys Hill	36,078	20.7	1,742	12
Rocky Mouth Creek	84,993	34.2	2,482	7
South Ballina	49,786	12.7	3,921	2
Swan Bay	49,318	15.5	3,181	5
Tuckean Swamp	175,671	77.6	2,263	9
Upper Richmond/Wilsons River	128,546	54.7	2,352	8

* Floodplain area is calculated as the area below 5 m AHD that is high or low risk in the acid sulfate soil risk mapping.

** Ranking is from highest drainage density to lowest drainage density.

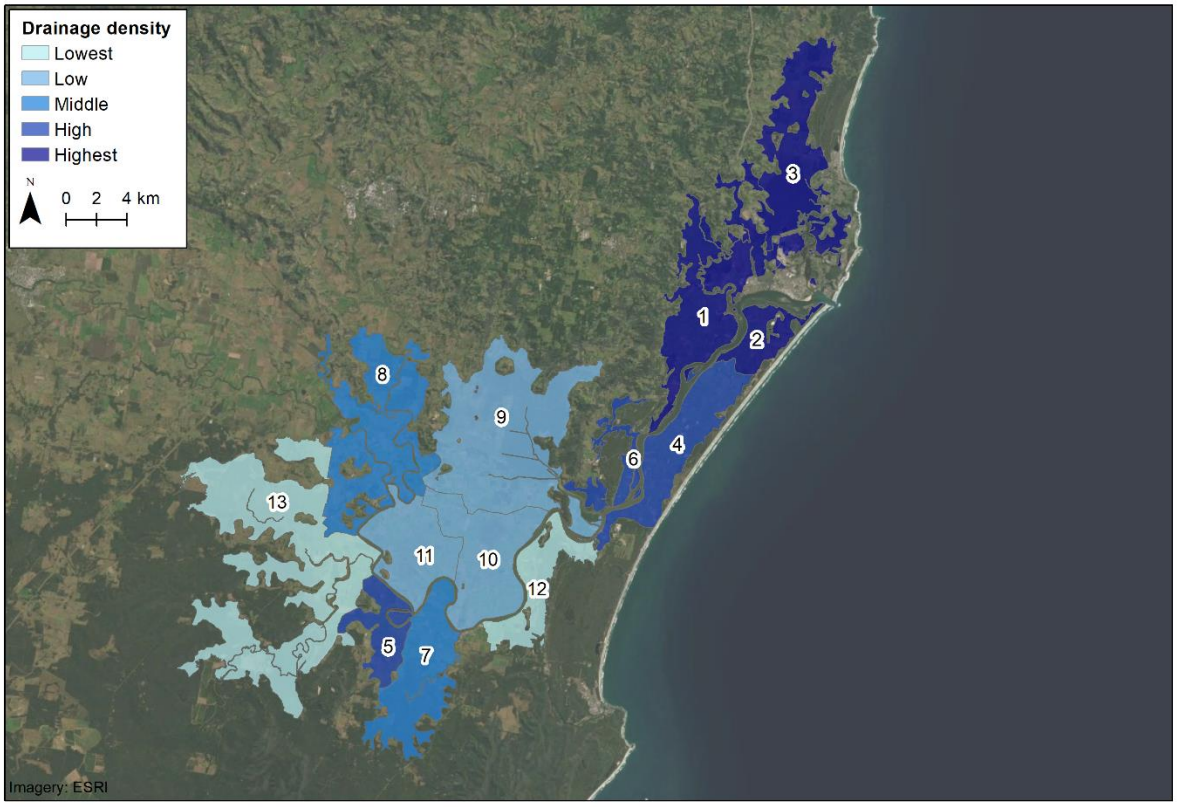


Figure A-2: Floodplain drainage density ranking

Appendix B Catchment hydrology

B1 Preamble

The following appendix details the catchment hydrology which is included in the normalised inflow factor in the acid sulfate soil prioritisation assessment, described in detail in Section 4.3.2 in the Methods report (Rayner et al., 2023). This includes the calculation of a runoff coefficient (Section B2) and a catchment size factor (Section B3), to determine an inflow factor (Section B4).

B2 Runoff coefficient

The catchment runoff assessment for the Richmond River floodplain was undertaken by comparing the volume of runoff generated by precipitation from incident rainfall with the observed subsequent streamflow data. Details of the methods used to calculate the runoff coefficient can be found in Section 4.3.2 in the Methods report (Rayner et al., 2023). The WaterNSW network of river flow gauges and the available daily rainfall data from the Bureau of Meteorology (BOM) for the Richmond River floodplain are shown in Figure B-1.

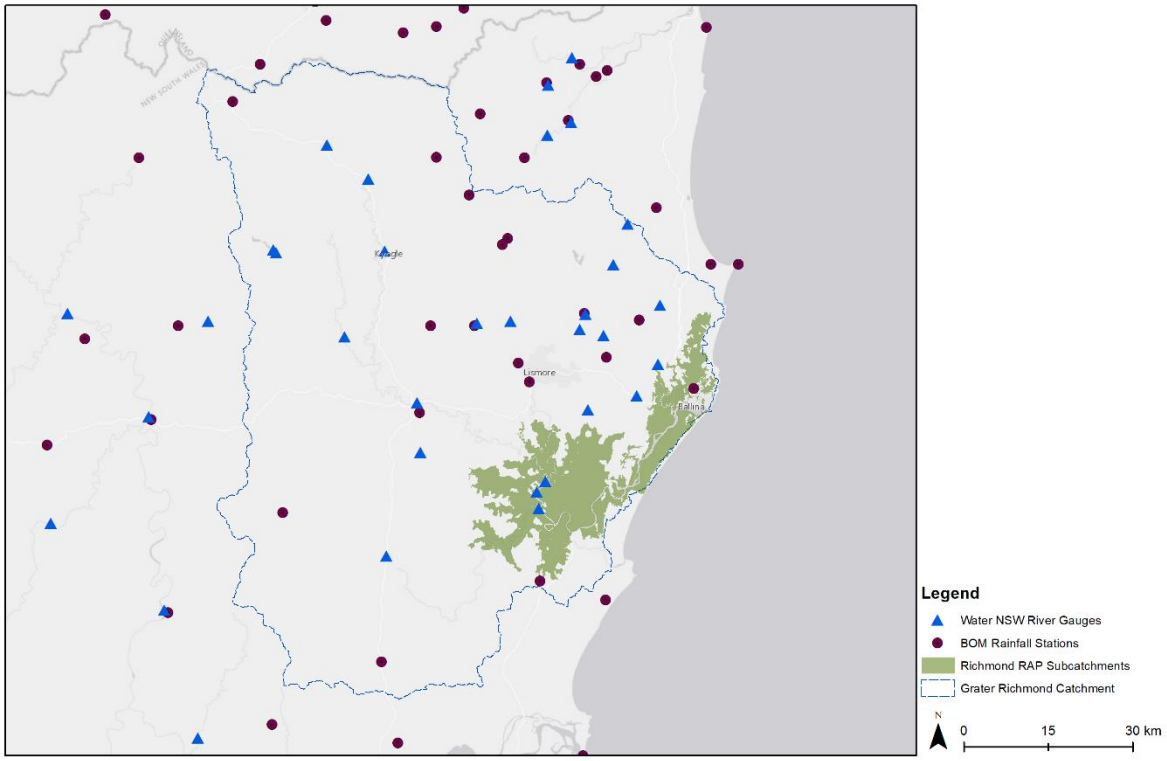


Figure B-1: Richmond River floodplain location of rainfall and runoff stations

Stream flow gauges upstream of the tidal confluence that are most representative of the lower catchment rainfall-runoff conditions were selected for the catchment hydrology analysis. WaterNSW gauging stations 203057 and 203059 were selected for the Richmond River floodplain assessment. The upstream contributing areas for these sites were delineated using standard GIS techniques based on a digital elevation model (DEM) of the catchment. Daily rainfall data relative to each river gauging station

was sourced from the BOM database and a Thiessen polygon approach was applied to weight the total rainfall to upstream areas. The location of the gauging sites, upstream catchment area of the gauging sites, and the BOM rainfall contributions (shown in parenthesis) used in the analysis are summarised in Figure B-2.

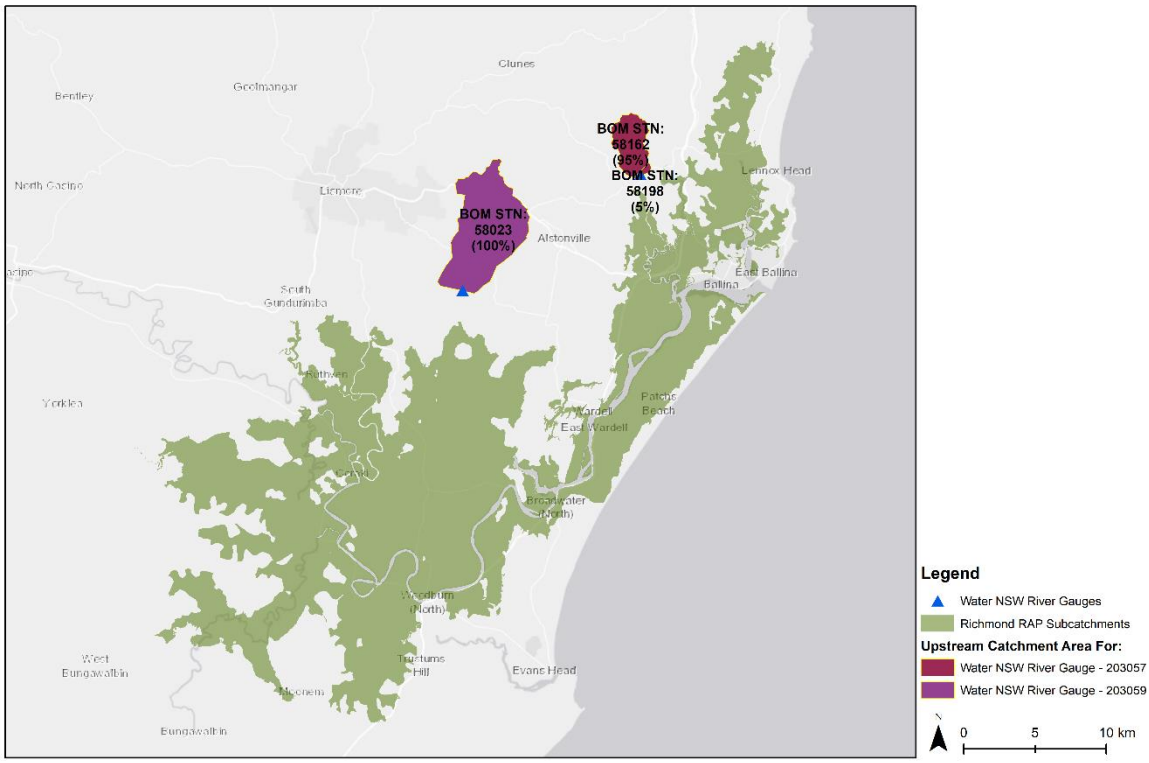


Figure B-2: Upstream catchments of selected flow sites

The runoff coefficient provides a relationship between rainfall-runoff volumes and allows for varying amounts of pervious and impervious surfaces across a catchment. It follows that if the predicted runoff volume from incident rainfall is known, and is compared to the available observed streamflow data, then the volume difference would be equivalent to the runoff coefficient (assuming the catchment was 100% impervious). For consistency, in this study, it was also assumed that land-use type, vegetation, and the proportion of pervious and impervious surfaces, was the same for each subcatchment in the floodplain (i.e. the runoff coefficient for this study represents an amalgamated factor taking into account catchment variables such as soil type, land use etc. for each subcatchment).

The runoff co-efficient was selected by comparing the annual time-series of streamflow data for the predicted runoff volume calculated for the selected gauging stations. Figure B-3 shows an example time-series of predicted and observed runoff for 2012. This analysis yielded an estimated runoff coefficient of 0.55 and 0.60, which was applied to Richmond Floodplain subcatchments for the acid prioritisation assessment.

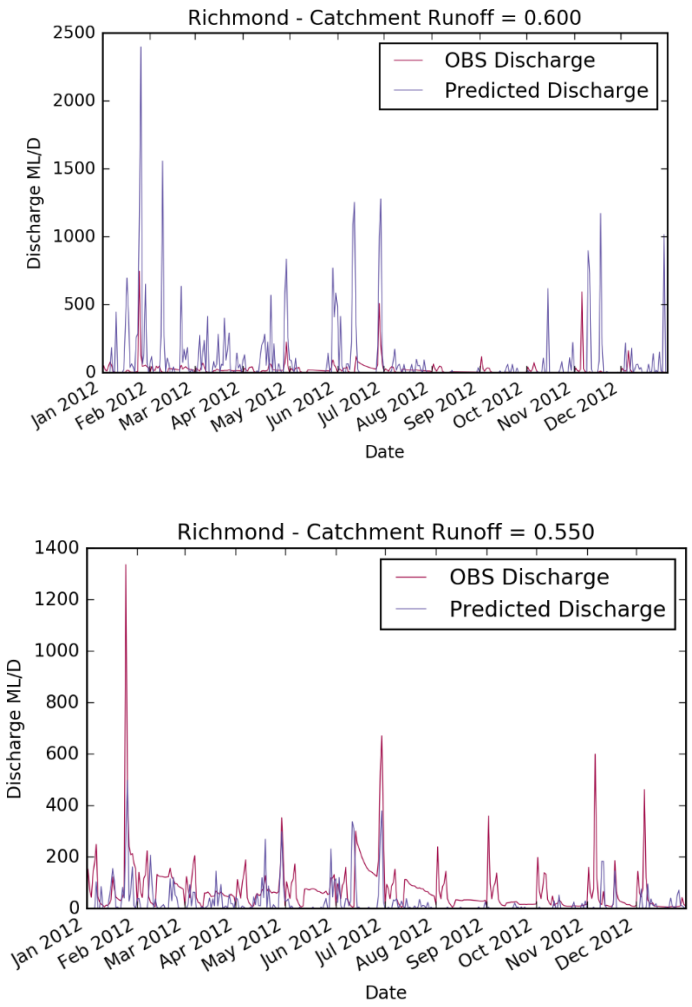


Figure B-3: Predicted and observed runoff for the catchment area upstream of river gauging Station 203057 (top) and Station 203059 (bottom)

B3 Catchment size factor

The size of the subcatchment influences the hydrological response of the site during a rainfall event. When comparing drainage areas of similar acidity, a large catchment will have a greater potential to discharge more acid than a small catchment. That is, an ASS affected drainage unit with high-risk ASS and a large catchment area contributing to acid drainage has a greater potential to produce higher potential acid flux during a post-flood recession period. Subsequently, accurate estimates of subcatchment areas and the potential discharge from those areas is critical to assessing subcatchments that are of a high-risk for acid drainage.

For the purpose of this study, the floodplain subcatchments have been defined as areas that are below 5 m AHD and classified as at risk for ASS. The whole floodplain area is considered to contribute to acid drainage risk. Upland catchments (above 5 m AHD) were divided into areas that discharge to the estuary via an end-of-system floodgate structure, or discharge uninhibited to the estuary. In this study, only upland catchments that are upstream of floodgates have been considered to contribute to acid drainage potential. These areas were identified using information on floodgate infrastructure and the NSW hydrography layer. Contributing catchments were then delineated using standard GIS techniques as shown in Figure B-4.

The total areas of each subcatchment were then normalised against the subcatchment with the largest total area (i.e. catchment size factor = 1.0) for comparison.

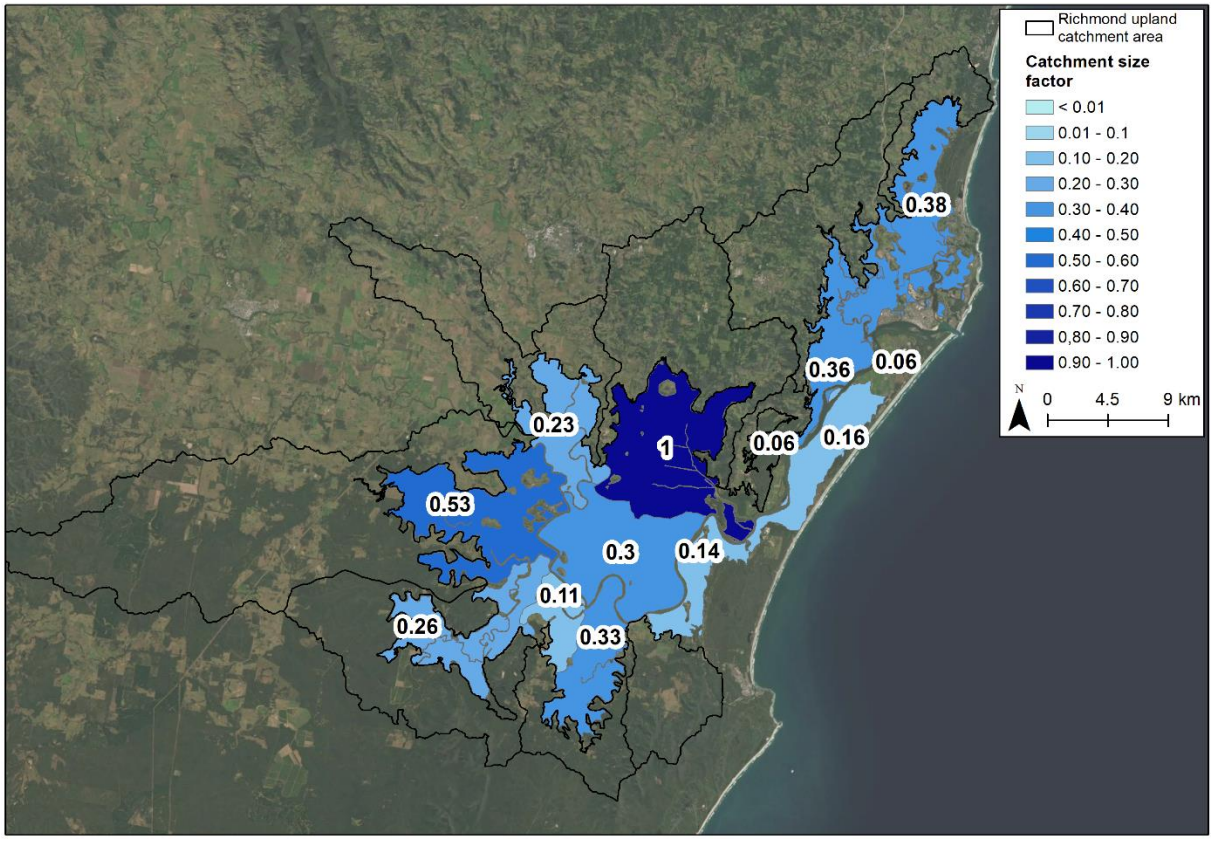


Figure B-4: Catchment size factor for each subcatchment in the Richmond River Estuary

B4 Normalised inflow factor

The combination of a runoff coefficient and a normalised catchment size factor is used to provide an estimation of the relative water yield of each floodplain subcatchment. The inflow factor is calculated as per Equation B-1.

$$\boldsymbol{Normalised\ inflow\ factor} = \boldsymbol{Runoff\ coefficient} \times \boldsymbol{Catchment\ Size\ Factor}$$

Equation B-1

The inflow factors for each Richmond River floodplain subcatchment are detailed in Table B-1 and shown in Figure B-5.

Table B-1: Catchment hydrology analysis summary table

Subcatchment	Runoff Coefficient	Upland Catchment Area (m^2)	Total Catchment Area (m^2)	Catchment Size Factor	Inflow Factor
Back Channel	0.55	2,869,110	13,315,604	0.06	0.03
Bungawalbin Creek/Sandy Creek	0.55	60,023,900	156,300,819	0.69	0.38
East Coraki	0.55	444,407	36,408,063	0.16	0.09
Emigrant Creek/Maguires Creek	0.6	33,733,400	80,190,610	0.36	0.21
Empire Vale	0.6	4,440,040	36,685,713	0.16	0.10
Kilgin/Buckendoon	0.55	44,969	31,813,971	0.14	0.08
North Creek	0.6	40,294,600	84,061,015	0.37	0.22
Rileys Hill	0.55	11,748,000	32,456,431	0.14	0.08
Rocky Mouth Creek	0.55	40,403,100	74,651,159	0.33	0.18
South Ballina	0.6	709,696	13,405,492	0.06	0.04
Swan Bay	0.55	8,432,810	23,936,996	0.11	0.06
Tuckean Swamp	0.55	147,736,000	225,377,021	1.00	0.55
Upper Richmond/Wilsons River	0.55	19,836,300	74,494,325	0.33	0.18

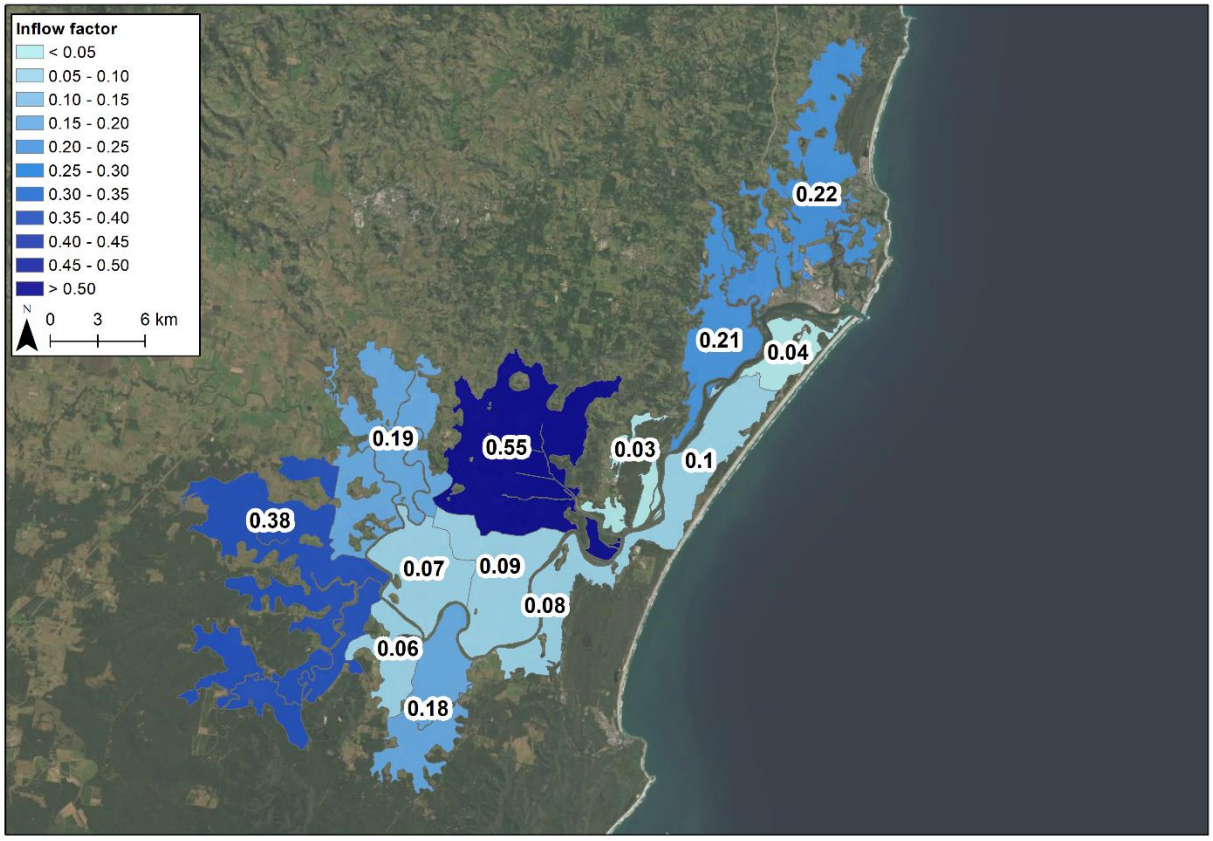


Figure B-5: Subcatchment inflow factors

Appendix C Groundwater saturated hydraulic conductivity data

C1 Preamble

The following section outlines the saturated hydraulic conductivity data (hereafter referred to as hydraulic conductivity) used in the prioritisation method (Section 4 of the Methods report (Rayner et al., 2023)) for determining the groundwater factor for the Richmond River floodplain. A detailed discussion of the principles relating to hydraulic conductivity and data collection can be found in Appendix B of Methods report (Rayner et al., 2023)). Details on the techniques and methods used to collect the field data presented in this section can be found in Appendix A of Methods report (Rayner et al., 2023)).

C2 Existing saturated hydraulic conductivity data

A data gaps analysis was completed to identify existing hydraulic conductivity data within the Richmond River floodplain. The data identified was limited to certain areas of the floodplain as listed in Table C-1 and spatially presented in Figure C-1. Data was available from the following sources:

- Brodie (2007) completed slug tests on shallow piezometers at Tuckean Swamp. The hydraulic conductivity was determined from the recovery water level data using the Hvorslev (1951) and Bouwer and Rice (1976) methods.

- Johnston (2004) presented previously unpublished hydraulic conductivity data for the Tuckean Swamp subcatchment collected using the auger hole slug test method. No specific location information was provided with this data to determine exact location within the subcatchment. For these reasons this data has not been included in the analysis.

- Hirst et al. (2009) collected hydraulic conductivity data for ASS across six different NSW North Coast floodplains (Tweed, Richmond, Clarence, Hastings, Macleay, and Manning), using the pit bailing method. On the Richmond River floodplain, data was collected in the Bulgawalbin Creek, Kingin/Buckendoon, North Creek, Rock Mouth Creek, Sandy Creek and Swan Bay subcatchments. The hydraulic conductivity values were calculated using the Bouwer and Rice (1983) and Boast and Langebartel (1984) methods.

- Johnston et al. (2009) presented hydraulic conductivity data collected using the pit bailing method for the Bungawalbin Creek, Kingin/Buckendoon, North Creek, Rock Mouth Creek, Sandy Creek, Swan Bay and Tuckean Swamp subcatchments as well as in the Woodburn area. Close inspection indicated that the majority of this data is the same as was presented by Hirst et al. (2009). Furthermore, there was no specific location information provided with this data to determine its exact location within subcatchments. For these reasons this data has not been included in the analysis.

- Bioregional Assessment Programme (2014) computed hydraulic conductivity values across the Richmond River floodplain using the method outlined by Bradbury and Rothschild (1985) which used pumping test data to determine hydraulic conductivity. Inspection of the dataset found that pumping tests often pumped wells reducing the water depth to levels greater than 5 m

below the ground surface. Hydraulic conductivity data including inflows from deeper depths would not be representative of the acidified layer at the surface (approximately <2 m depth) which is required for the prioritisation method. Subsequently, this data has not been used in the analysis.

- WRL (2019) completed pit bailing tests at two (2) different locations within South Ballina subcatchment. The hydraulic conductivity values were quantitatively analysed using the Boast and Langebartel (1984) method.

- Tucker et al. (2021) completed pit bailing tests at two (2) different locations within South Ballina subcatchment in October 2020. The hydraulic conductivity values were quantitatively analysed using the Boast and Langebartel (1984) method.

Table C-1: Summary of existing hydraulic conductivity data in the Richmond River floodplain

Point ID	Saturated hydraulic conductivity (m/day)			Risk classification	Reference	Method
	Bouwer and Rice (1983) method	Boast and Langebartel (1984) method	Other method			
1	36.9	58.8		High	Hirst et al. (2009)	Pit bailing
2	133.9	160.7		Extremely high	Hirst et al. (2009)	Pit bailing
3	75.7	98.4		High	Hirst et al. (2009)	Pit bailing
4	110.0	148.9		Extremely high	Hirst et al. (2009)	Pit bailing
5	1.1	1.5		Low - Moderate	Hirst et al. (2009)	Pit bailing
6	18.0	20.5		High	Hirst et al. (2009)	Pit bailing
7	174.3	231.2		Extremely high	Hirst et al. (2009)	Pit bailing
8	11.3	12.7		Moderate	Hirst et al. (2009)	Pit bailing
9	4.9	7.7		Moderate	Hirst et al. (2009)	Pit bailing
10	3.4	4.5		Moderate	Hirst et al. (2009)	Pit bailing
11	1.8	2.7		Moderate	Hirst et al. (2009)	Pit bailing
12	13.8	15.7		Moderate - High	Hirst et al. (2009)	Pit bailing
13	29.3	30.8		High	Hirst et al. (2009)	Pit bailing
14			3.00	Moderate	Brodie (2007)	Auger hole
15			0.20	Low	Brodie (2007)	Auger hole
16			0.07	Low	Brodie (2007)	Auger hole
17			0.40	Low	Brodie (2007)	Auger hole
18			0.00	Low	Brodie (2007)	Auger hole
19			0.60	Low	Brodie (2007)	Auger hole
20			0.50	Low	Brodie (2007)	Auger hole
21			0.80	Low	Brodie (2007)	Auger hole
22			0.01	Low	Brodie (2007)	Auger hole
23			0.20	Low	Brodie (2007)	Auger hole
24			0.06	Low	Brodie (2007)	Auger hole
25			0.00	Low	Brodie (2007)	Auger hole
26			0.70	Low	Brodie (2007)	Auger hole
27			0.70	Low	Brodie (2007)	Auger hole
28			6.00	Moderate	Brodie (2007)	Auger hole
29			0.10	Low	Brodie (2007)	Auger hole
30			0.00	Extremely low	Brodie (2007)	Auger hole
31			0.20	Low	Brodie (2007)	Auger hole

Point ID	Saturated hydraulic conductivity (m/day)			Risk classification	Reference	Method
	Bouwer and Rice (1983) method	Boast and Langebartel (1984) method	Other method			
32			0.30	Low	Brodie (2007)	Auger hole
33		10.0		Moderate	WRL (2019)	Pit bailing
34		10.8		Moderate	WRL (2019)	Pit bailing
35		3.1		Moderate	Tucker et al. (2021)	Pit bailing
36		4.0		Moderate	Tucker et al. (2021)	Pit bailing

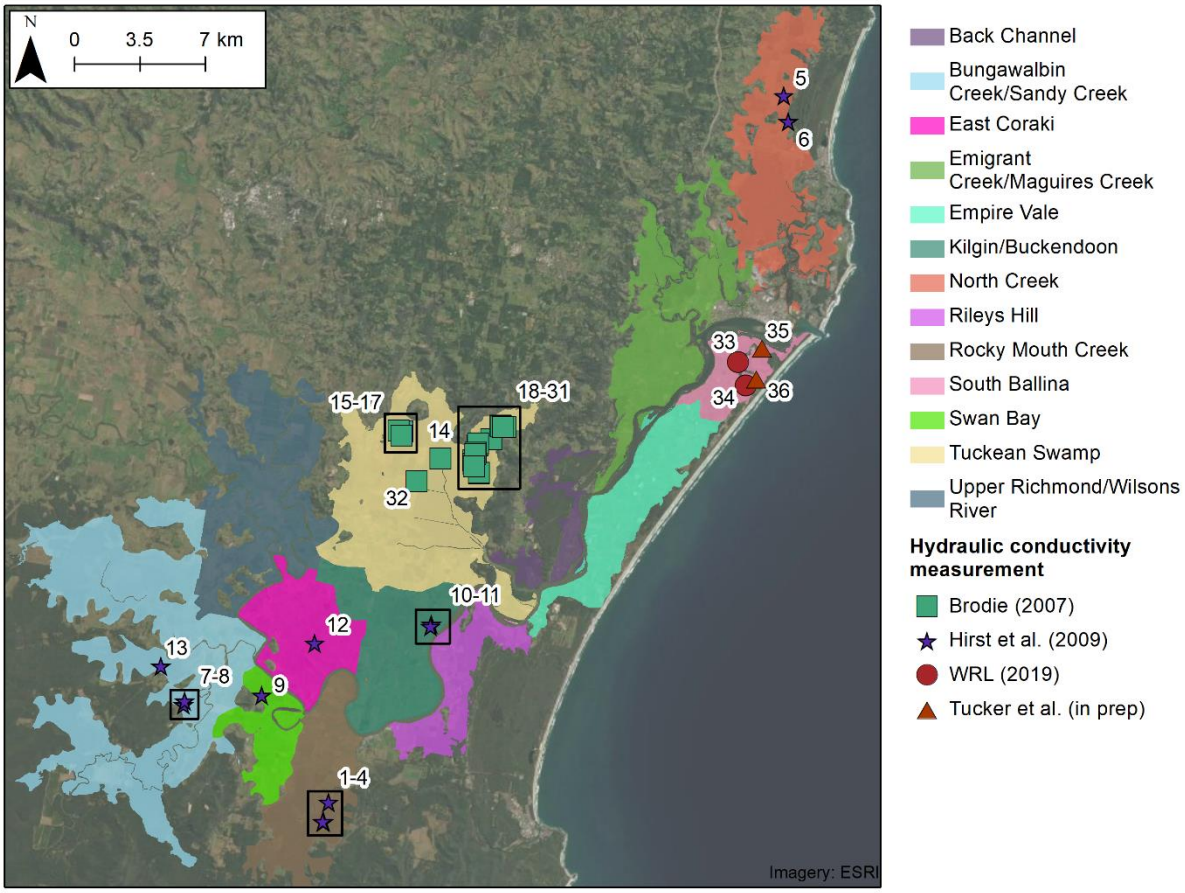


Figure C-1: Existing saturated hydraulic conductivity data available on the Richmond River floodplain

C3 Data collection

Following the data gaps analysis, a data collection program was completed to further supplement existing data. The auger hole slug test method was used as the primary way to determine the hydraulic conductivity across the coastal floodplains. This method was chosen:

- Due to drought conditions occurring at the time of field investigations, and the water table depth was too low to determine hydraulic conductivity using the standard pit bailing method at many sites;

- As it was easily implemented using the existing soil sampling equipment and did not require additional large machinery to be transported on-site; and
- As it allowed for hydraulic conductivity measurements to be taken at most soil sample locations.

In addition to the auger hole slug test method, the pit bailing and inverse auger methods were also used. Wherever the water table was high enough, a pit bailing test was completed as well as an auger hole slug test allowing for comparison of the two (2) methodologies. In some circumstances, the water table was sufficiently deep below the ground surface that the auger hole created by the soil sampling equipment could not reach the water table. In these instances, the inverse auger method was used to obtain a hydraulic conductivity measurement. A detailed description of the sampling procedure and data analysis techniques used to calculate the hydraulic conductivity can be found in Appendix A of Methods report (Rayner et al., 2023).

During the data collection field campaign, it was observed that the water table within the sample hole used to measure hydraulic conductivity was below the mean low water spring (MLWS) tide level of nearby waterways. This was due to the ongoing drought conditions that were prevalent at the time of data collection (August 2019 – March 2020). The result of this was that the hydraulic conductivity measured using the slug test method is of a soil layer that is unlikely to contribute to the export of acid via horizontal water movement. This meant that only a selection of measurements are representative of groundwater flow potential within acidic soil layers and are therefore applicable in the prioritisation methodology. For this reason, it was decided that only hydraulic conductivity measurements where the water table was above the MLWS tide level would be used during the subcatchment prioritisation. Hydraulic conductivity data that has been collected by WRL and used for the Richmond River floodplain to supplement existing data for the calculation of the groundwater factor and subsequently the risk ratings of the subcatchments within the floodplain, are identified in Table C-2 and shown in Figure C-2.

Table C-2: Summary of saturated hydraulic conductivity data collected by WRL and used for the subcatchment prioritisation

Location ID	Easting (m) GDA94	Northing (m) GDA94	Hydraulic Conductivity (m/day)	Risk Classification	Measurement method	Data used for prioritisation?*
RA_03	525373.1	6799552.4	0.2	Low	Auger hole	Below MLWS
RA_07_S	539650.3	6791011.9	0.3	Low	Auger hole	Below MLWS
RA_11	551077.9	6804096.2	0.1	Low	Auger hole	Below MLWS
RA_21	553136.0	6813260.2	0.1	Low	Inverse auger	Yes
RA_34	548069.4	6797008.0	0.1	Low	Auger hole	Yes
RA_40	530320.0	6790643.8	1.9	Moderate	Auger hole	Yes
RA_43_S	531274.5	6784330.8	0.2	Low	Auger hole	Yes
RA_47	529187.1	6777709.0	31.9	High	Auger hole	Below MLWS
RA_47	529187.1	6777709.0	24.5	High	Pit bailing	Yes
RA_51	524728.3	6783910.6	200.0	Extremely high	Auger hole	Below MLWS
RA_55	554165.3	6815025.4	0.1	Low	Auger hole	Yes
RP_02	529790.6	6799736.9	0.4	Low	Auger hole	Yes
RP_03	527592.9	6798484.8	0.1	Low	Auger hole	Yes
RP_10_S	544567.7	6796005.9	0.3	Low	Auger hole	Yes
RP_20	556043.1	6820193.9	0.0	Low	Auger hole	Yes
RP_22	553588.8	6813609.8	0.8	Low	Auger hole	Yes
RP_22	553588.8	6813609.8	24.4	High	Pit bailing	Yes

Location ID	Easting (m) GDA94	Northing (m) GDA94	Hydraulic Conductivity (m/day)	Risk Classification	Measurement method	Data used for prioritisation?*
RP_30	556855.6	6809936.3	2.5	Moderate	Pit bailing	Yes
RP_33	545512.0	6792076.2	9.5	Moderate	Pit bailing	Yes
RP_37	543455.8	6791988.1	0.1	Low	Auger hole	Yes
RP_40	535519.1	6789270.0	0.1	Low	Auger hole	Below MLWS
RP_45	527974.0	6786658.0	0.1	Low	Auger hole	Below MLWS
RP_47	531595.2	6779447.2	39.9	High	Auger hole	Yes
RP_47	531595.2	6779447.2	5.6	Low	Pit bailing	Yes
RP_50	527664.1	6783228.0	0.2	Low	Auger hole	Below MLWS
RP_58	521501.7	6791605.3	0.03	Low	Inverse auger	Yes

*Note: Only hydraulic conductivity values where the water table was above the MLWS level were used for subcatchment prioritisation.

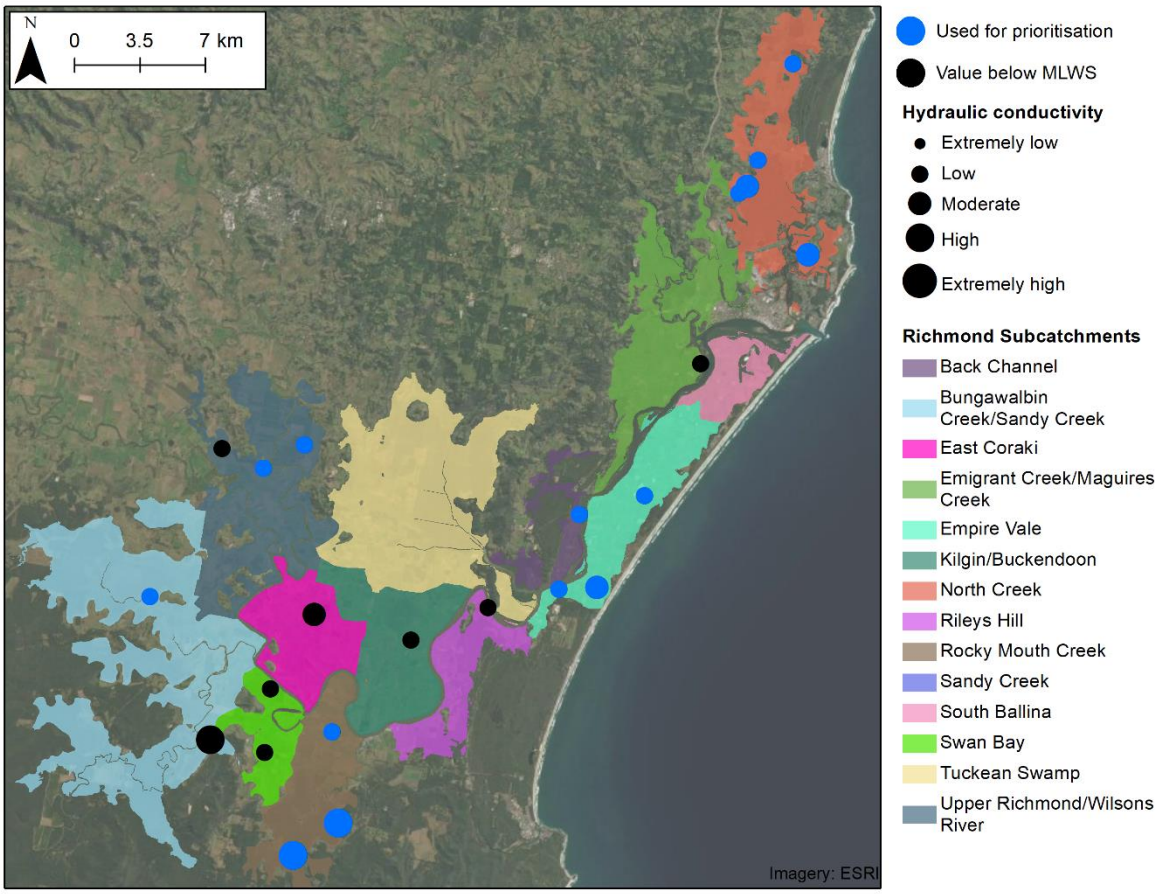


Figure C-2: Spatial variability of saturated hydraulic conductivity data collected by WRL and data used during the subcatchment prioritisation

C4 Summary of saturated hydraulic conductivity risk ratings

Hydraulic conductivity measurements have been used to determine a risk rating which forms part of the groundwater factor during the subcatchment prioritisation (see Section 4 of Methods report (Rayner et al., 2023). The risk rating applies on a scale of one (1) to five (5) corresponding to the risk classifications with extremely low equating to a risk rating of one and extremely high equating to a risk rating or five. This results in subcatchments with larger hydraulic conductivities having an increased risk as they are able to transport larger volumes of acidic groundwater to the estuary.

Note that the spatial coverage of hydraulic conductivity data across certain subcatchments of the Richmond River floodplain is poor. This is due to limitations experienced in the field investigations including situations whereby the groundwater table was sufficiently deep that no hydraulic conductivity measurements within contributing acidic soil layers could be taken. For subcatchments where there was no available data, it has been interpolated from adjacent subcatchments:

- Emigrant Creek/Maguires Creek has been assumed to have the same hydraulic conductivity as North Creek; and
- Rileys Hill has been assumed to have the same hydraulic conductivity as Empire Vale.

Since hydraulic conductivity measurements across ASS affected floodplains can be highly variable, further hydraulic conductivity investigations may be required to add further detail to the management options. An overall summary of the risk associated with hydraulic conductivity for each subcatchment is provided in Table C-3 and Figure C-3.

Table C-3: Summary of saturated hydraulic conductivity for each subcatchment in the Richmond River floodplain

Subcatchment	Hydraulic conductivity classification	Hydraulic conductivity risk rating	Number of data points per area*
Back Channel	Low	2	1
Bungawalbin Creek/Sandy Creek	High	4	4
Emigrant Creek/Maguires Creek*	Moderate	3	0
East Coraki	Moderate	3	2
Empire Vale	Moderate	3	3
Kilgin/Buckendoon	Moderate	3	2
North Creek	Moderate	3	8
Rileys Hill*	Moderate	3	0
Rocky Mouth Creek	High	4	9
South Ballina	Moderate	3	2
Swan Bay	Moderate	3	1
Tuckean Swamp	Low	2	19
Upper Richmond/Wilsons River	Low	2	2

* Where no data was available risk classifications were interpolated from adjacent subcatchments.

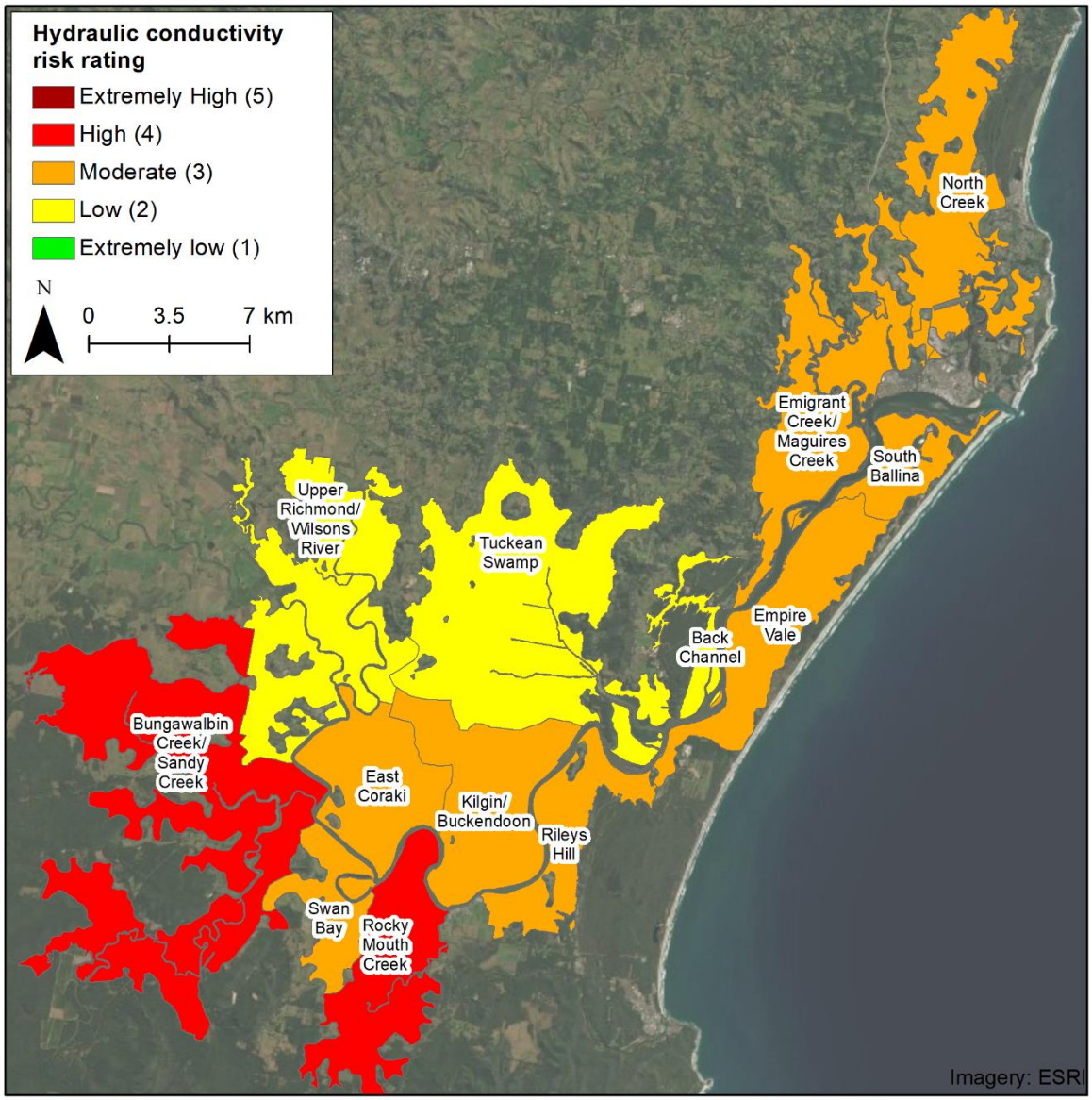


Figure C-3: Risk ratings for saturated hydraulic conductivity for each subcatchment in the Richmond River floodplain

Appendix D Acid Sulfate Soil distribution

D1 Preamble

This section provides an overview of the soil profile data, such as surface elevation, profile depths and minimum pH available within the Richmond River floodplain. This includes existing data available on the NSW Government eSPADE database and data in published literature where applicable (Section D2). In areas with limited existing soil profile information, a targeted field campaign was undertaken to address data gaps. Information on the data collected is summarised in Section D3.

D2 Existing soil profile data

Soil profile data on the Richmond River floodplain that was available prior to the commencement of this study was sourced from:

- eSPADE Database (DPIE, 2020);
- Lin et al. (2004);
- Maher (2013);
- Sammut et al. (1996a);
- WRL (2019);
- Tucker et al. (2021); and
- Wong et al. (2016).

D2.1 eSPADE database

eSPADE provides a database of information collected by earth scientists and other technical experts. eSPADE contains descriptions of soils, landscapes and other geographic features, and is used by the NSW Government, other organisations, and individuals, to improve planning and decision-making for land management. eSPADE contains extensive soil profile data for the Richmond area.

eSPADE data has been filtered to remove any profiles that do not contain acidity (pH) data for each of the layers. Elevation data has been extracted from a 1 m DEM of the Richmond floodplain. Where data is available on the floodplain, it has been included in estimating acid export in the region. Note that a low pH often indicates oxidised acidic soils, particularly in conjunction with the presence of yellow/orange mottling (jarosite). A near neutral pH (pH 7 to 8) below an acidic layer indicates a potential acidic layer, often in conjunction with a soil description of dark grey estuarine muds and clays. The presence of potential acid sulfate soils can be confirmed via a field oxidation test, with high stored acidity confirmed by a violent oxidation reaction, although this is not typically provided in the eSPADE database. The location of all relevant eSPADE soil profiles within the study area is presented in Figure D-1, and a summary of the soil profile data, including approximate surface elevation and minimum profile pH (within the tidal range), is provided in Table D-1.

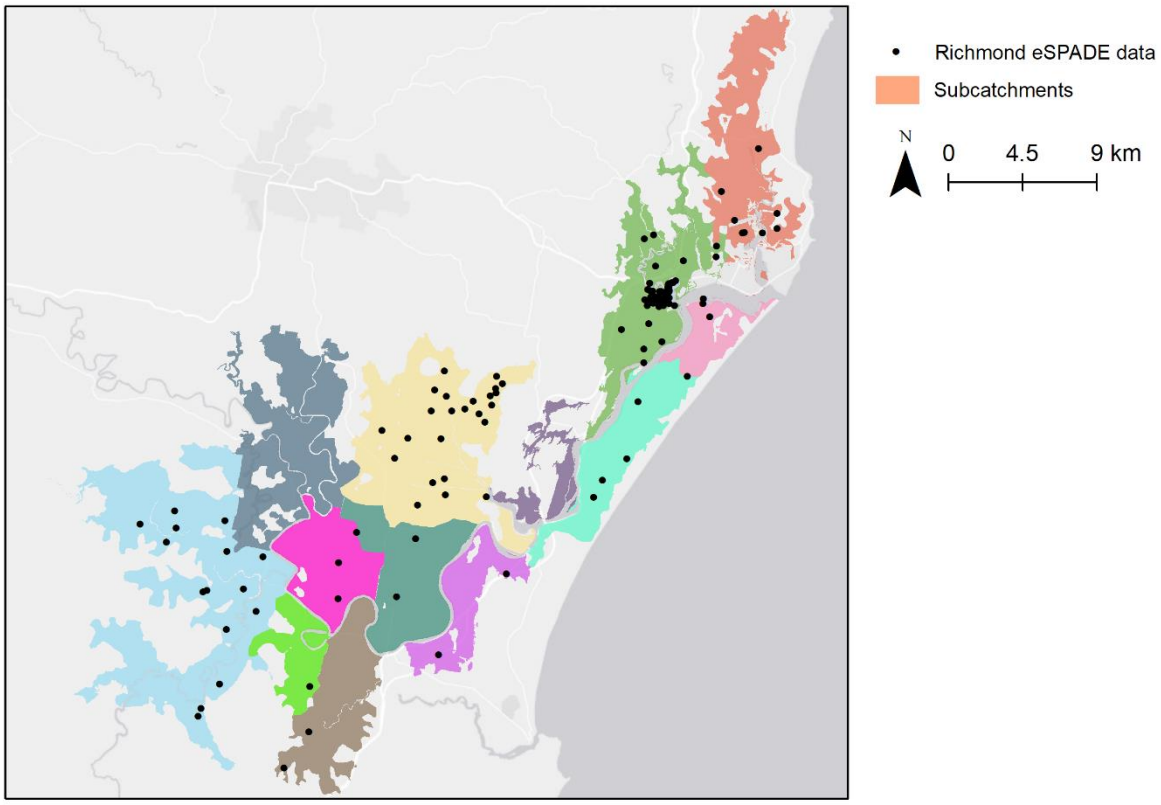


Figure D-1: Location of applicable eSPADE soil profiles in the study region

Table D-1: Summary of relevant eSPADE profiles (DPIE, 2020)

*Surface elevation extract from 1 m LiDAR

** Minimum pH in this table is within the range of MLWS to 1 m AHD. Lower pH may have been observed elsewhere in the profile

eSPADE Profile ID	Subcatchment	Easting	Northing	Surface Elevation (m AHD)*	Total Profile Depth (m)	Minimum pH**
17000	Bungawalbin Creek/Sandy Creek	523518	6785601	1.1	2.9	3
17007	Bungawalbin Creek/Sandy Creek	525338	6786705	1.3	3.1	5
17008	Bungawalbin Creek/Sandy Creek	524557	6788056	1.7	3.1	4.5
17011	Bungawalbin Creek/Sandy Creek	523124	6782280	1.2	2.5	4
17055	Bungawalbin Creek/Sandy Creek	521980	6780787	1.8	2.2	4.5
19166	Bungawalbin Creek/Sandy Creek	521805	6780337	1.4	1.5	4.5
16649	Emigrant Creek/ Maguires Creek	549266	6806633	1.6	2.9	6

eSPADE Profile ID	Subcatchment	Easting	Northing	Surface Elevation (m AHD)*	Total Profile Depth (m)	Minimum pH**
16650	Emigrant Creek/ Maguires Creek	551318	6807995	0.4	3	3.5
16651	Emigrant Creek/ Maguires Creek	553310	6808893	1.6	2.1	4
16652	Emigrant Creek/ Maguires Creek	553276	6808232	1.6	2.1	3.5
16653	Emigrant Creek/ Maguires Creek	548899	6802650	2.8	3	6
16654	Emigrant Creek/ Maguires Creek	547526	6803842	0.8	3.1	6
16661	Emigrant Creek/ Maguires Creek	548936	6809352	0.9	3.1	5
23451	Emigrant Creek/ Maguires Creek	549455	6805887	0.9	9.99	4.5
23452	Emigrant Creek/ Maguires Creek	549555	6805737	0.5	1	4.5
23453	Emigrant Creek/ Maguires Creek	549705	6805612	0.9	1	5.5
23454	Emigrant Creek/ Maguires Creek	549755	6805612	1.4	1	6
23455	Emigrant Creek/ Maguires Creek	549805	6805837	1.5	9.99	7
23456	Emigrant Creek/ Maguires Creek	549955	6806137	1.6	1	7
23457	Emigrant Creek/ Maguires Creek	549855	6806137	0.9	0.95	6
23458	Emigrant Creek/ Maguires Creek	550105	6806087	0.8	1	5.5
23459	Emigrant Creek/ Maguires Creek	550230	6806112	1.0	0.7	5.5
23460	Emigrant Creek/ Maguires Creek	550380	6806062	0.8	0.65	5.5
23461	Emigrant Creek/ Maguires Creek	550455	6805412	1.2	0.95	6
23462	Emigrant Creek/ Maguires Creek	549780	6805487	1.2	9.99	6
23463	Emigrant Creek/ Maguires Creek	549830	6805237	1.3	1.1	8
23465	Emigrant Creek/ Maguires Creek	549904	6805362	0.6	1	5.5
23466	Emigrant Creek/ Maguires Creek	549905	6805487	1.0	1	6
23467	Emigrant Creek/ Maguires Creek	550055	6805487	0.9	0.9	5.5
23468	Emigrant Creek/ Maguires Creek	550280	6805637	0.5	0.9	4.5
23471	Emigrant Creek/ Maguires Creek	550455	6805762	1.0	0.9	5
23473	Emigrant Creek/ Maguires Creek	550455	6806147	1.6	9.99	7
23474	Emigrant Creek/ Maguires Creek	550455	6806217	1.1	0.8	6
23475	Emigrant Creek/ Maguires Creek	550365	6806417	1.0	0.9	6

eSPADE Profile ID	Subcatchment	Easting	Northing	Surface Elevation (m AHD)*	Total Profile Depth (m)	Minimum pH**
23476	Emigrant Creek/ Maguires Creek	550455	6806497	0.5	0.9	6
23477	Emigrant Creek/ Maguires Creek	550380	6806547	0.7	9.99	5.5
23478	Emigrant Creek/ Maguires Creek	550415	6806612	0.4	0.2	6
23479	Emigrant Creek/ Maguires Creek	550530	6806637	0.6	0.8	6.5
23480	Emigrant Creek/ Maguires Creek	550585	6806687	0.8	1	5
23481	Emigrant Creek/ Maguires Creek	550685	6806687	1.1	0.9	5.5
23482	Emigrant Creek/ Maguires Creek	550835	6806787	0.8	9.99	4
23483	Emigrant Creek/ Maguires Creek	549480	6805417	1.0	9.99	5
23484	Emigrant Creek/ Maguires Creek	549325	6805697	1.2	9.99	5.5
23485	Emigrant Creek/ Maguires Creek	549805	6805507	1.4	0.9	5.5
23486	Emigrant Creek/ Maguires Creek	549415	6806012	1.1	0.9	5.5
23487	Emigrant Creek/ Maguires Creek	549130	6806247	1.4	0.9	5
23488	Emigrant Creek/ Maguires Creek	549245	6806192	0.9	0.6	6
23489	Emigrant Creek/ Maguires Creek	549330	6805782	1.0	0.7	6
23490	Emigrant Creek/ Maguires Creek	549435	6806182	1.0	0.7	6
23493	Emigrant Creek/ Maguires Creek	549685	6805427	1.0	0.85	5.5
23495	Emigrant Creek/ Maguires Creek	549430	6805587	1.0	0.9	4
23496	Emigrant Creek/ Maguires Creek	549410	6805447	1.1	0.9	5
23498	Emigrant Creek/ Maguires Creek	549315	6805467	1.7	9.99	7.5
23499	Emigrant Creek/ Maguires Creek	549844	6805537	1.3	0.9	6
23500	Emigrant Creek/ Maguires Creek	550025	6805657	0.8	0.9	5
23501	Emigrant Creek/ Maguires Creek	550115	6805692	0.5	0.9	5
23502	Emigrant Creek/ Maguires Creek	550165	6805737	0.5	0.9	4
23503	Emigrant Creek/ Maguires Creek	550080	6805277	0.5	1	4.5
23505	Emigrant Creek/ Maguires Creek	550365	6805812	0.5	0.9	4
23506	Emigrant Creek/ Maguires Creek	548955	6805647	0.8	0.9	4.5
23507	Emigrant Creek/ Maguires Creek	550785	6805297	0.0	0.85	4.5

eSPADE Profile ID	Subcatchment	Easting	Northing	Surface Elevation (m AHD)*	Total Profile Depth (m)	Minimum pH**
4090	Emigrant Creek/ Maguires Creek	548895	6801823	1.6	1.6	5
4091	Emigrant Creek/ Maguires Creek	550005	6803087	1.6	1.6	6
4092	Emigrant Creek/ Maguires Creek	549205	6804187	0.7	1.3	5.5
4093	Emigrant Creek/ Maguires Creek	549105	6805287	1.6	1.3	6
4094	Emigrant Creek/ Maguires Creek	549505	6809587	0.6	1.25	5.5
4114	Emigrant Creek/ Maguires Creek	549605	6807687	0.9	1	5.5
16647	Empire Vale	546381	6794666	1.5	1.2	7
16648	Empire Vale	548556	6799454	1.3	2.1	5
4087	Empire Vale	551554	6800987	0.7	0.9	6
4332	Empire Vale	545855	6793637	1.5	1	6
4333	Empire Vale	547855	6795987	1.3	1	5.5
17005	Kilgin/ Buckendoon	533887	6787587	0.9	3.05	4.5
17013	Kilgin/ Buckendoon	535046	6791115	0.5	2.5	4
17014	East Coraki	531455	6791503	2.2	2.4	5.5
17018	East Coraki	530325	6787469	1.2	3.1	4
25163	East Coraki	530345	6789662	1.3	1.1	4.5
16655	North Creek	553631	6812224	0.7	2.6	3.5
16656	North Creek	555021	6809722	1.1	2	4
16657	North Creek	557003	6809966	0.4	3.1	3
16658	North Creek	555859	6814836	0.5	2.1	4.5
4095	North Creek	554905	6809687	1.5	1.6	6
4123	North Creek	557005	6810887	0.9	1	7
4225	North Creek	556096	6809701	1.0	1	6.5
82072	North Creek	554403	6810468	-1.3	4	
17017	Rileys Hill	536437	6784068	2.2	1.9	6
13700	Rileys Hill	540555	6788987	1.9	1.17	5.5
17012	Rocky Mouth Creek	528554	6779386	0.9	3.1	3.5
14923	Rocky Mouth Creek	527036	6777175	1.7	0.9	5
16635	Bungawalbin Creek/Sandy Creek	520401	6792814	1.4	2.4	3.5
16646	Bungawalbin Creek/Sandy Creek	523435	6792220	2.0	2.1	5
17001	Bungawalbin Creek/Sandy Creek	522111	6787881	1.1	3	3.5
17002	Bungawalbin Creek/Sandy Creek	519872	6790906	1.2	2.7	3.5

eSPADE Profile ID	Subcatchment	Easting	Northing	Surface Elevation (m AHD)*	Total Profile Depth (m)	Minimum pH**
17003	Bungawalbin Creek/Sandy Creek	518279	6792018	1.4	2.8	4.5
17004	Bungawalbin Creek/Sandy Creek	525749	6790029	1.7	2.6	3.5
17009	Bungawalbin Creek/Sandy Creek	523566	6790354	1.7	2.4	5
17010	Bungawalbin Creek/Sandy Creek	520481	6791777	1.4	2.8	4
4442	Bungawalbin Creek/Sandy Creek	522355	6787987	1.1	1	4.5
4075	South Ballina	552905	6804587	1.6	1.1	6
4077	South Ballina	552498	6805390	1.3	1	5
4083	South Ballina	552505	6805687	1.0	0.5	6
17006	Swan Bay	528603	6782132	1.1	3.1	4.5
16626	Tuckean Swamp	533755	6796012	1.2	2.1	4.5
16627	Tuckean Swamp	535146	6793174	2.5	2.1	5.5
16628	Tuckean Swamp	536841	6793793	1.4	1.4	4.5
16629	Tuckean Swamp	536774	6794766	1.1	2.11	5
16630	Tuckean Swamp	534551	6797232	1.2	2.1	4.5
16631	Tuckean Swamp	532981	6797693	0.9	3.1	4.5
16633	Tuckean Swamp	535974	6798879	2.4	1.8	4.5
16634	Tuckean Swamp	536911	6799777	1.1	1.7	4.5
16641	Tuckean Swamp	539951	6800987	1.5	3.1	4
16642	Tuckean Swamp	538534	6799474	0.5	3.1	4
16643	Tuckean Swamp	538019	6798988	0.4	3.1	4
16644	Tuckean Swamp	536771	6801325	1.1	3.1	4
16645	Tuckean Swamp	536192	6800141	1.0	2.6	3.5
73411	Tuckean Swamp	536569	6797191	0.6	0.8	4
73412	Tuckean Swamp	539576	6799789	0.9	1.1	4.5
21344	Tuckean Swamp	539645	6799222	0.9	0.8	3.5
21345	Tuckean Swamp	539255	6798197	1.0	1	2.9
21347	Tuckean Swamp	539895	6800247	1.0	0.9	3
21348	Tuckean Swamp	540320	6800537	1.5	1.15	2.8
79827	Tuckean Swamp	537233	6798873	0.7	43.5	4
79828	Tuckean Swamp	536079	6794520	1.3	6.5	5
79829	Tuckean Swamp	539340	6793653	0.9	6.5	4.5
79830	Tuckean Swamp	539923	6799986	1.0	6	3.5
79831	Tuckean Swamp	538886	6798700	0.7	9.5	3

D2.2 Other literature

Published and grey literature was investigated for other soil profiles within the Richmond River floodplain, which included data from journal papers (Lin et al. (2004), Maher (2013), Sammut et al. (1996a) and Wong et al. (2016)) and WRL investigations undertaken on behalf of Rous County Council (WRL (2019) and Tucker et al. (2021)). Locations of the profiles are shown in Figure D-2. Only literature that provided information on pH at depth and suitable location information was included. Where no surface elevation data was provided, it was extracted from a 1 m DEM of the Richmond floodplain. The location of all relevant soil profiles from the literature within the study area is presented in Figure D-2, and a summary of the soil profile data, including approximate surface elevation and minimum profile pH (within the tidal range), is provided in Table D-2.

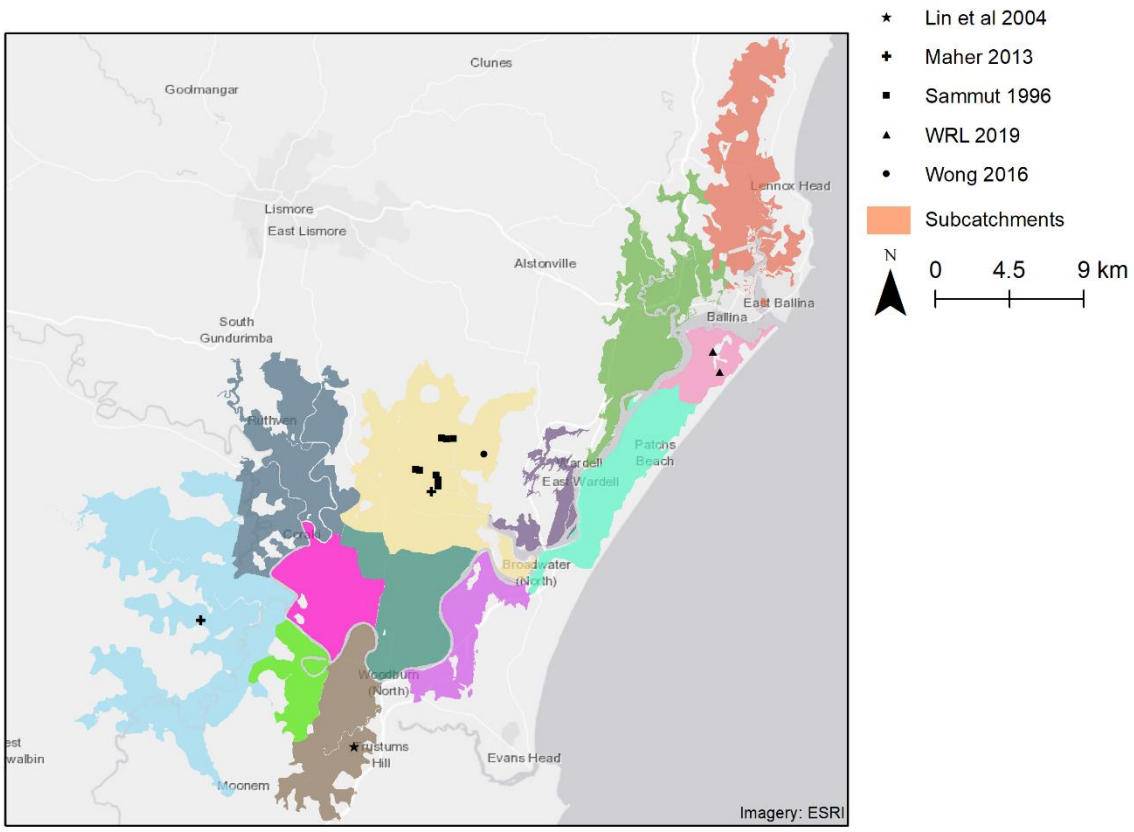


Figure D-2: Location of applicable soil profiles from literature in the study region

Table D-2: Summary of relevant soil profiles from literature

Profile	Subcatchment	Easting	Northing	Surface Elevation (m AHD)	Total Profile Depth (m)	Minimum pH
Lin_2004	Rocky Mouth Creek	531256	6780087	0.65	1.15	3.4
Maher_2013_3	Sandy Creek	521945	6787793	1.00	1.8	3.4
WRL_2019_KH1	South Ballina	553093	6804127	1.36	1.15	3.5
WRL_2019_KH2	South Ballina	553505	6802885	0.08	3	3
Tucker_P1	South Ballina	554388	6804859	0.4	1.7	3.9
Tucker_P2	South Ballina	554036	6803201	0.4	1.8	5.0
Tucker_P3	South Ballina	552521	6802037	0.6	1.4	5.6

Profile	Subcatchment	Easting	Northing	Surface Elevation (m AHD)	Total Profile Depth (m)	Minimum pH
Tucker_P4	South Ballina	552268	6803075	1.2	1.4	5.9
Tucker_P5	South Ballina	551349	6802237	0.9	1.6	5.1
Maher_2013_2	Tuckean Swamp	535972	6795614	0.45	1.8	3.4
Sammut_1996_J1	Tuckean Swamp	535045	6796981	0.65	2	3.6
Sammut_1996_J2	Tuckean Swamp	535259	6796914	1.15	2.8	2.6
Sammut_1996_H1	Tuckean Swamp	536599	6798884	1.05	1.8	3.3
Sammut_1996_H2	Tuckean Swamp	536893	6798815	0.85	1.8	3.1
Sammut_1996_H3	Tuckean Swamp	537307	6798840	0.9	2.5	3.4
Sammut_1996_T2	Tuckean Swamp	536394	6795930	0.45	1.9	3
Sammut_1996_T4	Tuckean Swamp	536383	6796338	0.55	2.5	3.2
Sammut_1996_T5	Tuckean Swamp	536283	6796632	0.6	2.2	3
Wong_2016_C	Tuckean Swamp	539171	6797886	0.8	1.6	2.9

D3 Field campaign

Following a data collation and data gaps analysis, a targeted field campaign was undertaken to collect data in areas with limited information. Information on field data collection methods can be found in Appendix A of the Methods report (Rayner et al., 2023). The location of an additional 34 soil profiles collected for this study is shown in Figure D-3, and a summary of the soil profile data, including approximate surface elevation and minimum profile pH (within the tidal range), is provided in Table D-2.

Detailed data logs of each of soil profile is provided in Appendix L.

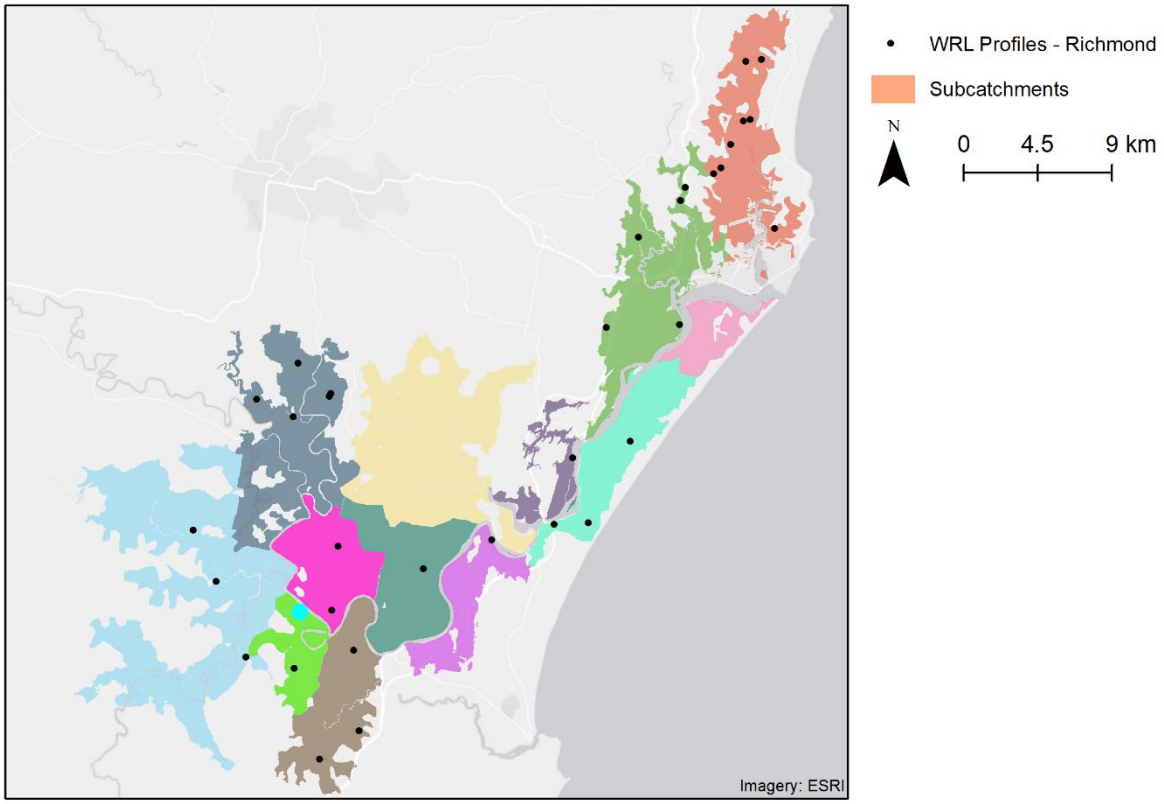


Figure D-3: Location of soil profiles from WRL field investigations

Table D-3: Summary of relevant soil profiles from WRL field investigations

Profile	Subcatchment	Easting	Northing	Surface Elevation (m AHD)	Total Profile Depth (m)	Minimum pH
RA_02	Upper Richmond/ Wilsons River	529878	6799915	2.22	3.35	5
RA_03	Upper Richmond/ Wilsons River	525373	6799552	0.67	2.1	5.2
RA_07_S	Rileys Hill	539650	6791012	0.80	2.7	5.1
RA_11	Emigrant Creek/ Maguires Creek	551078	6804096	0.68	1.9	5.4
RA_19	North Creek	555089	6820076	1.66	1.85	5.6
RA_20	North Creek	554949	6816471	1.13	1.35	4.2
RA_21	North Creek	553136	6813260	0.62	1.8	5
RA_28	Emigrant Creek/ Maguires Creek	548578	6809403	0.58	2.2	4
RA_34	Empire Vale	548069	6797008	0.94	1.9	6.4
RA_43_S	Rocky Mouth Creek	531274	6784331	0.98	1.5	4
RA_47	Rocky Mouth Creek	529187	6777709	0.50	1.55	3.9
RA_51	Bungawalbin Creek/Sandy Creek	524728	6783911	0.98	2.3	4.1
RA_55	North Creek	554165	6815025	0.57	1.9	5.4
RP_02	Upper Richmond/ Wilsons River	529791	6799737	1.99	3.2	5.7
RP_10_S	Back Channel	544568	6796006	1.07	1.5	4.9
RP_17	Emigrant Creek/ Maguires Creek	546633	6803917	0.22	2.6	4.5
RP_20	North Creek	556043	6820194	1.38	2.8	4.2
RP_21	North Creek	555369	6816545	0.09	1.85	4.5
RP_22	North Creek	553589	6813610	0.76	1.1	4.4
RP_23	Emigrant Creek/ Maguires Creek	551416	6812418	0.58	2	7.2
RP_24	Emigrant Creek/ Maguires Creek	551121	6811612	0.35	2.4	3.1
RP_30	North Creek	556855	6809936	0.51	1.5	4.1
RP_33	Empire Vale	545512	6792076	0.53	2.1	4.3
RP_37	Empire Vale	543456	6791988	0.69	2.1	4
RP_40	Kilgin/ Buckendoon	535519	6789270	0.32	2.8	3.7
RA_40	East Coraki	530320	6790644	0.88	2.4	4
RP_44	East Coraki	529949	6786749	0.47	1.8	4.4
RP_45	Swan Bay	527974	6786658	0.21	1.6	4.1
RP_47	Rocky Mouth Creek	531595	6779447	0.74	1.52	3.5
RP_50	Rocky Mouth Creek	527664	6783228	0.83	2.6	3.5
RP_57_C	Bungawalbin Creek/Sandy Creek	522902	6788503	1.15	1.55	4.9
RP_58	Bungawalbin Creek/Sandy Creek	521502	6791605	1.21	2.1	3.9

D4 Summary of soil acidity for prioritisation

Section 4 of Methods report (Rayner et al., 2023) summarises the method for prioritising subcatchments for acid generation. There are two key pieces of information that are used to determine the pH factor used in the priority assessment that can be derived from the ASS data:

- Depth averaged hydrogen ion concentration (related to soil pH); and
- The contributing depth.

All else being equal, a higher hydrogen concentration (i.e. more acidic) and larger contributing depth is an indicator of a greater potential for acid generation and export. More information on how these are calculated can be found in Section 4 of Methods report (Rayner et al., 2023). These are multiplied together to get the pH factor which forms part of the final prioritisation. Table D-4 summarises the information per subcatchment in the Richmond River floodplain.

Table D-4: Summary of information from soil acidity information

Subcatchment	Depth averaged H+ concentration (µmol/L)	Contributing depth (m)	pH factor	Number of soil profiles available
Back Channel	4.7	1.4	6.6	1
Bungawalbin Creek/Sandy Creek	94.2	1.2	113.0	19
East Coraki	40.3	1.2	48.3	5
Emigrant Creek/Maguires Creek	18.0	1.4	25.2	66
Empire Vale	14.9	1.4	20.9	8
Kilgin/Buckendoon	50.8	1.0	50.8	3
North Creek	38.3	1.6	61.3	16
Rileys Hill	4.7	1.2	5.6	3
Rocky Mouth Creek	138.0	1.2	165.6	6
South Ballina	60.4	1.4	84.5	10
Swan Bay	74.4	1.2	89.3	3
Tuckean Swamp	212.0	1.4	296.8	34

D5 Data confidence

As shown in Table D-4, the number of profiles in each catchment varies quite significantly. There are three (3) catchments in particular that only have five (5) profiles or less in the area:

- Back Channel (1 profile);
- Swan Bay (3 profiles);
- Rileys Hill (3 profiles); and
- Upper Richmond/Wilsons River (5 profiles).

Confidence in this data is therefore limited, so information in literature on ASS or water quality has been consulted to provide greater certainty in the pH factor. Of the catchments with five (5) profiles or less, Back Channel, Rileys Hill and Upper Richmond/Wilsons River all have comparatively low pH factors (6.6, 5.6 and 4.7 respectively). Swan Bay, on the other hand, has a moderate pH factor of around 90.

However, this subcatchment is relative small, so the soil profile density is considered sufficient in this area.

None of the catchments with limited data were identified as ASS hotspots on the Richmond River by Tulau (1999a). Similarly, all three (3) areas were stated to be low risk for water quality problems from acid sulfate soils by Moore (2007). Based on this, there is no evidence to the contrary that Back Channel, Rileys Hill and Upper Richmond/Wilsons River should have a low pH factor, and no adjustments have been made to account for lower confidence at these three (3) sites. However, care should be exercised when interpreting the data from these catchments.

Appendix E Blackwater elevation thresholds

E1 Preamble

This section provides an overview of the data used to develop the elevation thresholds for the prioritisation of blackwater generation potential for floodplain subcatchments in the Richmond River. The water level analysis undertaken is described in detail in Section 5 of Methods report (Rayner et al., 2023).

E2 Water level gauges

There are seven (7) water level gauges operated by NSW DPIE Manly Hydraulics Laboratory (MHL) in the Richmond River estuary that have been used for the analysis of critical thresholds for blackwater generation. The location of the gauges is shown in Figure E-1 and detailed in Table E-1. Water level data has been provided on a 15 minute time step throughout each monitoring period, although intermittent data gaps do occur.

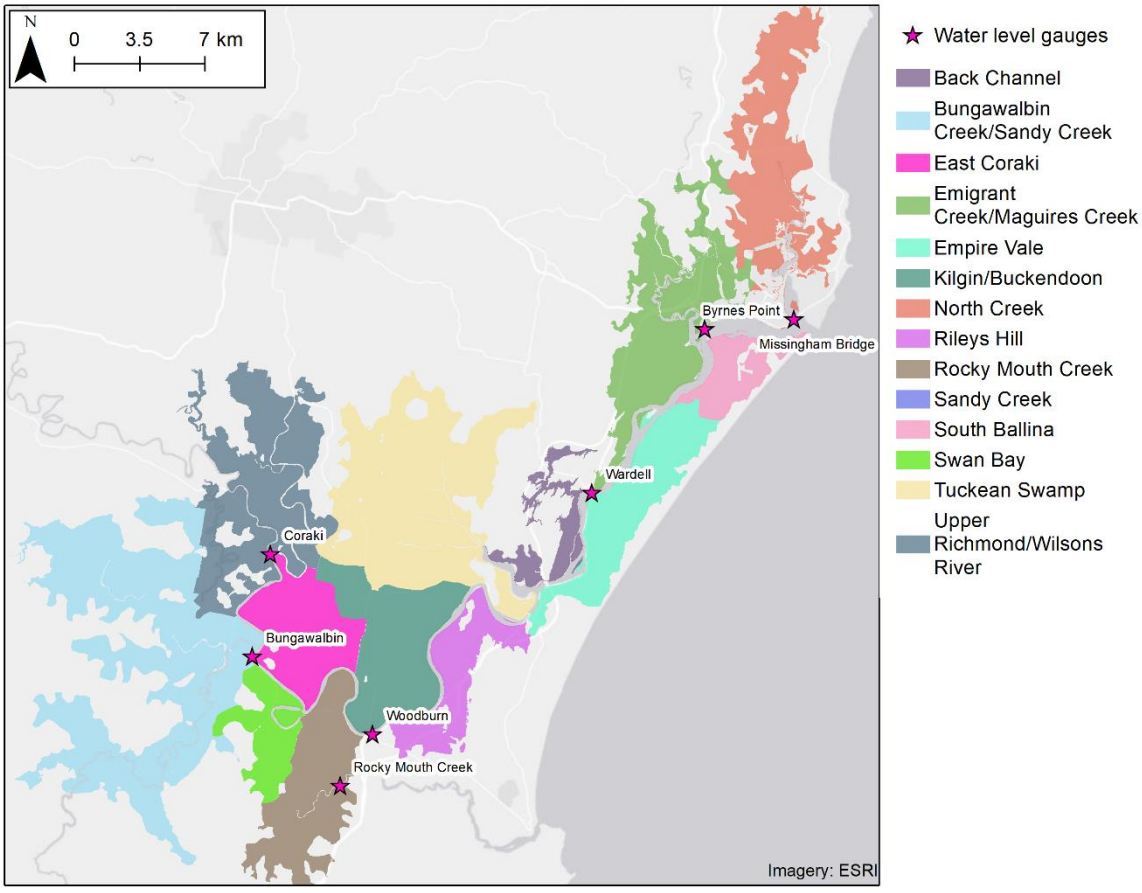


Figure E-1: Locations of water level gauges used for blackwater elevation thresholds

Table E-1: Details of water level gauges

Station	Chainage (km from entrance)	Length of Record (years)*	Mean High Water (MHW) (m AHD)
Missingham Bridge	1.4	16.3	0.5
Byrnes Point	6.3	29.3	0.4
Wardell	18	17.3	0.5
Woodburn	42	33.75	0.4
Bungawalbin	55	17.5	0.4
Coraki	63	32.25	0.4
Rocky Mouth Creek	Not on main river	25.5	0.4

* Excluding data gaps of greater than 6 hours.

Water level time series data at each gauge was analysed to establish a range of levels which can be applied to each floodplain subcatchment whereby the potential for prolonged inundation can be assessed. This is then related to floodplain topography and land use to prioritise blackwater generation across the floodplain. The analysis of the water level time series data is undertaken 25 times, to account for events that happen on average every 1, 2, 3, 4 and 5 years as well as events that result in inundation for 1, 2, 3, 4 and 5 days at a time. As a result, there can be up to 25 unique elevations at each gauge (noting that the minimum allowable level is mean high water (MHW). The range of levels from this analysis, as well as the median and mean levels are shown in Table E-2.

Table E-2: Representative water level elevations at each water level gauge

Station	Minimum Level (m AHD)	Median Level (m AHD)	Mean Level (m AHD)	Maximum Level (m AHD)
Missingham Bridge	0.5	0.5	0.5	0.5
Byrnes Point	0.4	0.4	0.4	0.4
Wardell	0.5	0.5	0.6	1.1
Woodburn	0.4	2.1	1.9	3.0
Bungawalbin	0.4	2.9	2.6	4.1
Coraki	0.4	2.1	2.3	4.1
Rocky Mouth Creek	0.4	1.5	1.9	2.0

E3 Subcatchment elevation thresholds

The subcatchments of the Richmond River floodplain are shown in Figure E-1. For some of these catchments, the primary discharge point at the main river is sufficiently close to one of the water level gauges that the gauge well represents the downstream boundary condition. The subcatchments that discharge near water level stations are summarised in Table E-3.

For other subcatchments, the main discharge points are located away from the available water level gauges. In these cases, the chainage along the river of the major discharge point has been measured, and the critical elevations have been interpolated between gauges, using the relationships summarised in Table E-3.

The range of levels, as well as the median and mean levels, at each subcatchment is shown in Table E-4. Figure E-2 shows spatially the area covered by the median elevation thresholds in each subcatchment.

Table E-3: Relationship between subcatchments and water level gauges

Subcatchment	Interpolation of levels (as required)
North Creek	Missingham Bridge
South Ballina	Missingham Bridge
Emigrant Creek/ Maguires Creek	Brynes Point
Empire Vale	0.18 x Brynes Point + 0.82 x Wardell
Back Channel	Wardell
Tuckean Swamp	0.82 x Wardell + 0.28 x Woodburn
Rocky Mouth Creek	Rocky Mouth Creek
Rileys Hill	0.41 x Wardell + 0.59 x Woodburn
Kilgin/Buckendoon	0.32 x Wardell + 0.68 x Woodburn
East Coraki	0.38 x Bungawalbin + 0.62 x Woodburn
Swan Bay	Bungawalbin
Bungawalbin Creek/Sandy Creek	Bungawalbin
Upper Richmond/ Wilsons River	Coraki

Table E-4: Representative elevations at each subcatchment in the Richmond River floodplain

Subcatchment	Minimum Level (m AHD)	Median Level (m AHD)	Mean Level (m AHD)	Maximum Level (m AHD)
Back Channel	0.5	0.5	0.6	1.1
Bungawalbin Creek/Sandy Creek	0.6	2.9	2.7	4.1
East Coraki	0.5	2.5	2.2	3.4
Emigrant Creek/Maguires Creek	0.4	0.4	0.4	0.4
Empire Vale	0.5	0.5	0.6	1
Kilgin/Buckendoon	0.4	1.5	1.4	2.2
North Creek	0.5	0.5	0.5	0.5
Rileys Hill	0.4	1.5	1.4	2.2
Rocky Mouth Creek	0.5	1.5	1.5	2
South Ballina	0.5	0.5	0.5	0.5
Swan Bay	0.6	2.9	2.7	4.1
Tuckean Swamp	0.5	1	1.0	1.6
Upper Richmond/Wilsons River	0.5	2.3	2.4	4.1

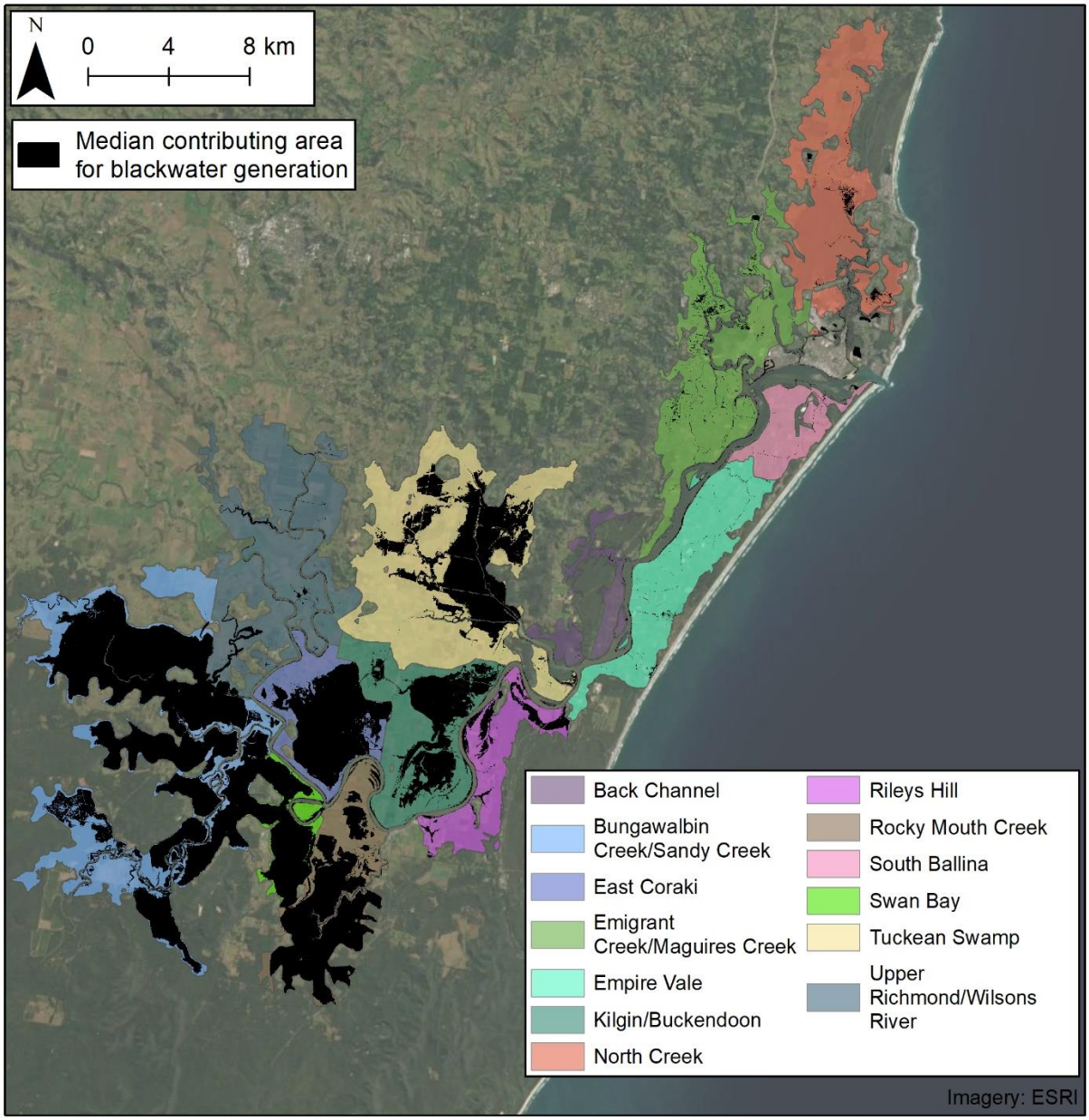


Figure E-2: Areas in the Richmond River floodplain below the median elevation threshold

Appendix F Floodplain infrastructure

F1 Preamble

A range of floodplain infrastructure exists across the Richmond River floodplain for the purpose of drainage and inundation protection (tidal and flooding). Included within this infrastructure is a number of structures that have been modified to improve water quality and aquatic connectivity across the floodplain. Floodplain infrastructure includes:

- Floodgates;
- Culverts or pipes;
- Weirs; and
- Levees.

The following section provides information on floodplain infrastructure for the Richmond River floodplain. This includes results of a data gaps analysis, an assessment of data for critical floodplain infrastructure and details of infrastructure condition and maintenance programs. Data tables containing information on floodplain infrastructure are provided.

F2 Data gaps analysis

F2.1 Existing infrastructure data

Prior to the data collection program undertaken as part of this study, the existing data available for floodplain infrastructure was collated. Floodplain infrastructure data was reviewed from the following sources and has been summarised in Table F-1.

- Floodgate and levee GIS data provided by Rous County Council (RCC);
- Floodgate and levee GIS data provided by Lismore City Council (LCC);
- Evans River flood study (Rodgers et al., 2014);
- Keith Hall drainage survey (WRL, 2019); and
- Tuckean Swamp hydrological options study (Rayner et al., 2020a).

Across the Richmond River floodplain existing data for floodplain infrastructure is generally limited to dimension information with negligible data being available for invert or crest elevation measurements. The exception to this is for levees whereby LiDAR observations means that crest elevation data is well represented (information specific to levees is addressed in Section F3.2).

During the data gaps analysis, aerial imagery and waterways spatial datasets were used to determine possible locations for end of system infrastructure that was not included in the existing infrastructure data sources. Verification of the existence of these structures was undertaken, where possible, during the data collection campaign. Where inspection of these structures was not possible due to access restrictions, the structure has been marked as “unknown”. In these circumstances the existence of the structure and structure geometry requires confirmation.

Table F-1: Description of existing data sources

Source	Description
RCC – GIS	GIS shapefiles containing location, dimension, condition, maintenance and access information for floodgates and levees managed by RCC.
LCC – GIS	GIS shapefiles containing location information for floodgates and levees managed by LCC.
Rodgers et al. (2014)	A study investigating flooding on the Evans River which includes the crest elevation of the Tuckombil Canal weir.
WRL (2019)	A study addressing drainage in the Keith Hall area that contains survey measurements of the main floodgates for the drainage system.
Rayner et al. (2020a)	An investigation which developed a detailed numerical model to assess options for remediating acid sulfate soils in Tuckean Swamp. During model development field investigations were completed which included survey measurements of the Bagotville Barrage.

A summary table of existing structure data is provided in Section F5. Note that during the gaps analysis only data for end of system structures such as floodgates that discharge directly to the Richmond River estuary were assessed. Subsequently, there may be existing data available for structures that are located upstream of end of system infrastructure which do not directly discharge to the Richmond River estuary.

F2.2 Data collection

Field investigations were completed to obtain invert and dimension data for floodplain infrastructure within the Richmond River floodplain. Initially WRL completed opportunistic surveys of easily accessible end of system structures. Northern Rivers Land Solutions (NRLS) and Abbott and Macro Land and Engineering Surveyors (Abbott and Macro LES) then collected further end of system structure data. Focus of the investigations was on collecting data for primary end of system floodgate structures, however, data was also collected opportunistically for other floodplain infrastructure. Figure F-1 summarises the data available for floodplain structures. A summary table of all structure data measured during the field investigations is provided in Section F6.

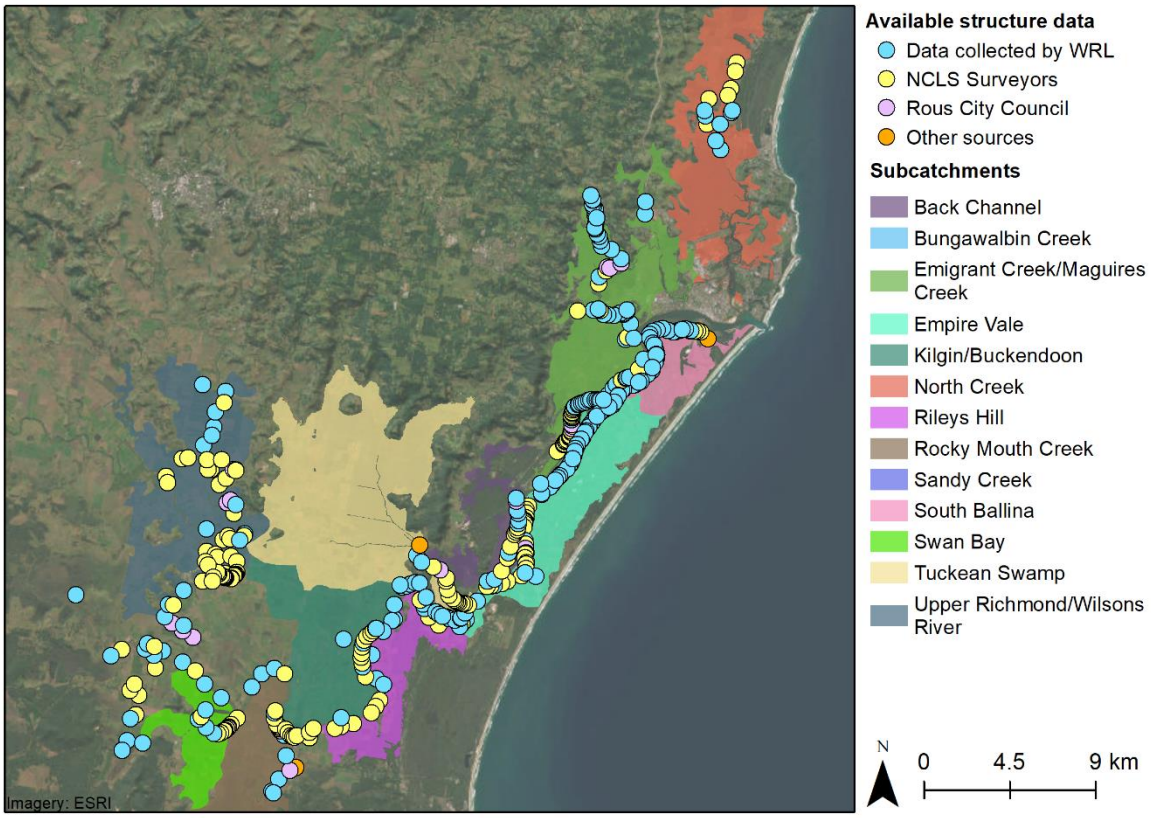


Figure F-1: Summary of structures with data available for the Richmond River floodplain

F3 Assessment of critical floodplain infrastructure

F3.1 End of system structures

A floodplain infrastructure assessment was completed with particular focus given to end of system (EOS) structures which act as barriers to prevent the upstream flow of tidal waters and limit the risk of backwater flooding from the river. Examples of EOS structures include weirs or one-way floodgates which work alongside levee banks to facilitate drainage while preventing inundation of the floodplain, often where agricultural land use practices are undertaken. These EOS structures have been separated into two categories:

1. Primary EOS structures: floodplain infrastructure that plays a significant role in draining the upstream catchment. An example of a primary EOS structure is the Bagotville Barrage on the Tuckean Broadwater.
2. Secondary EOS structures: floodplain infrastructure that provides drainage for small floodplain areas which are insignificant when compared to the total catchment drainage. An example of a secondary EOS structure would be a 300 mm diameter floodgate draining local catchment runoff on a paddock scale.

The location and condition of individual EOS structures have management implications due to their operation as drainage and flood mitigation devices. For this reason, EOS structures have been carefully considered during the development of the management options. Furthermore, EOS structures are vulnerable to sea level rise as a result of climate change, resulting in reduced drainage potential. A

detailed vulnerability assessment has been completed for EOS floodgate structures (See Section 7). Figure F-2 provides the locations, category and survey status for the 487 EOS structures which have been identified within the Richmond River floodplain.

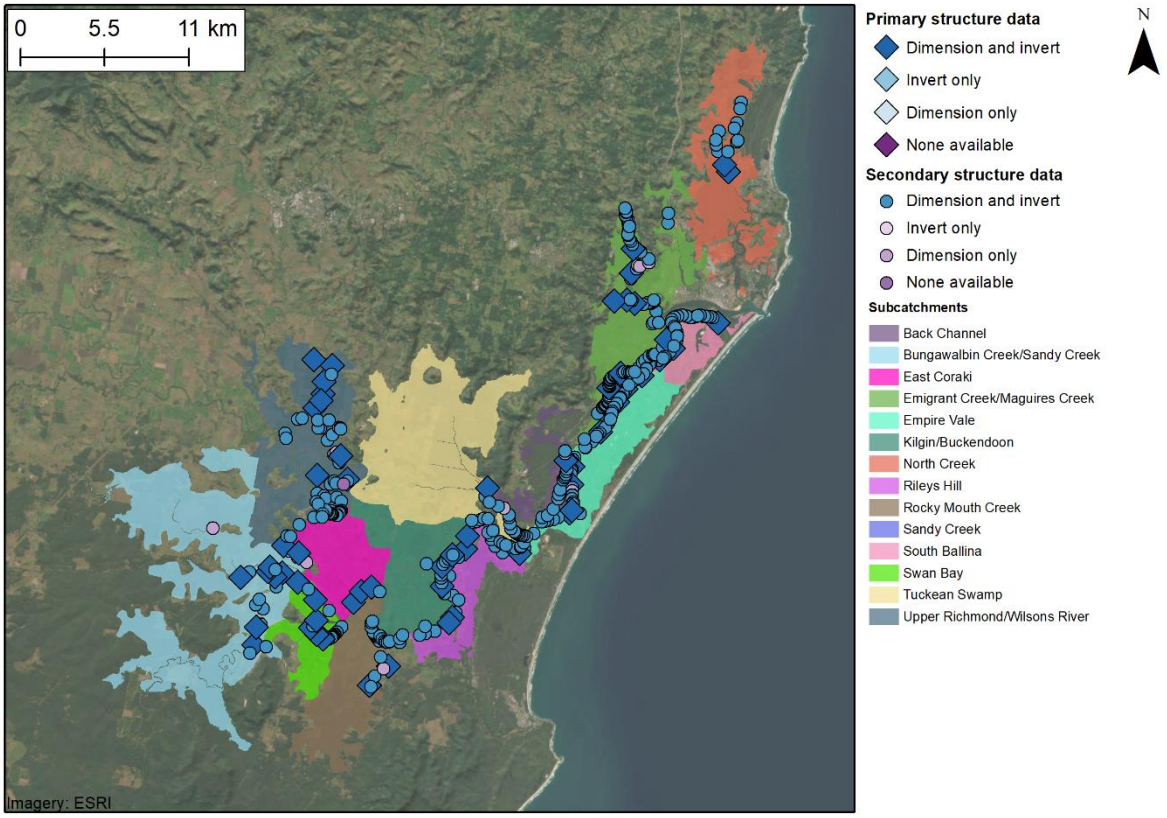


Figure F-2: Summary of data available for end of system structures of the Richmond River floodplain

F3.2 Levees

Levee structures are generally constructed to protect the floodplain from extreme flood events. They can also protect the floodplain from inundation due to high tidal levels. Within the Richmond River floodplain there are a large number of levees that have been constructed in both rural and urban areas. Data provided by Rous County Council indicates that the majority of levees across the floodplain were built in the 1920s. Little information is available about the protection level provided by individual levee structures. Flood mapping for the sections of the river upstream of Broadwater and in the Evans River show that the levees are completely inundated during a 1% annual exceedance probability (AEP) event (Caddis and Dearnley, 2011; Rodgers et al., 2014). Figure F-3 shows the locations of flood mitigation levees across the Richmond River floodplain. All levees are actively managed by Rous County Council and Lismore City Council with priority given to levees offering protection for urban areas.

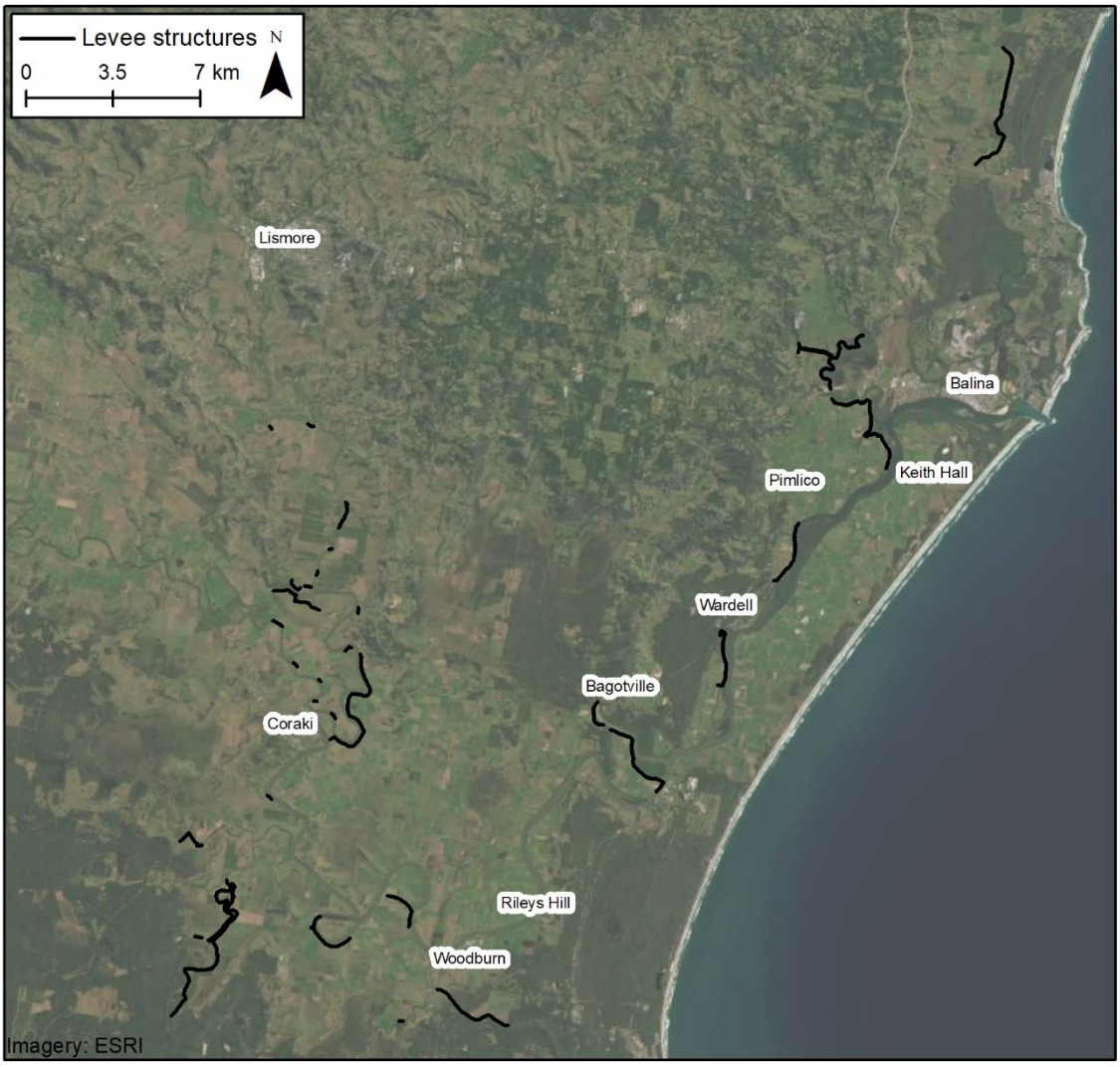


Figure F-3: Locations of flood mitigation levee structures on the Richmond River floodplain managed by Rous County Council

F4 Infrastructure tenure and maintenance

F4.1 Infrastructure tenure

Information on the tenure of EOS structures across the Richmond River floodplain is presented in Figure F-4.

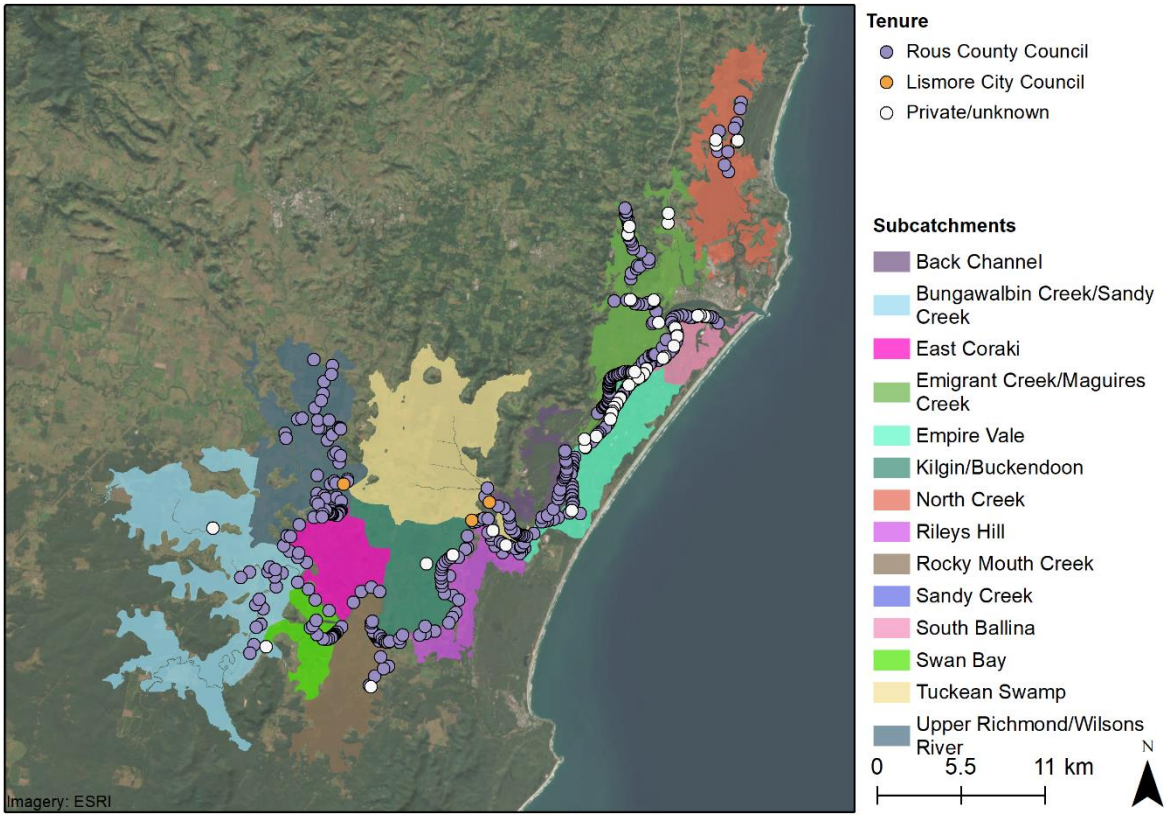


Figure F-4: Tenure of end of system structures on the Richmond River floodplain

F4.2 Maintenance schedule

Rous County Council has developed floodgate and drain management guidelines for the Richmond River floodplain (Richmond River County Council, 2015). These guidelines provide information for Councils and individual landholders on requirements for managing both floodgate and drainage infrastructure. The guidelines also include management considerations for acid sulfate soils.

In addition to the general floodgate and drainage management guidelines, Rous County Council has developed specific active floodgate management plans for end of system infrastructure on the following waterways:

- Boggy Creek (Rous County Council, 2019a);
- Bora Creek (Rous County Council, 2019b);
- Campbells Drain (Rous County Council, 2020a);
- Haughwood Canal (Rous County Council, 2019c);
- Keith Hall (Rous County Council, 2020b);

- Reardon's Drain (Rous County Council, 2020c);
- Rocky Mouth Creek (Rous County Council, 2018);
- Sandy Creek No. 1 (Rous County Council, 2020d);
- Wades Canal (Rous County Council, 2019e); and
- West Coraki Canal (Rous County Council, 2020e).

In addition to the management plans and guidelines for floodgate and drainage infrastructure, Rous County Council has a maintenance schedule for all floodplain infrastructure detailed within a GIS data register (Rous County Council, 2019d). This stipulates the condition and risk inspection frequency required for each asset. Inspection frequency generally varies from once every six months to once every five years depending on the asset.

Ongoing maintenance of floodplain infrastructure is important in ensuring that the way structures affect water quality and connectivity across the floodplain remains as per their design specifications. The level of maintenance floodplain infrastructure receives directly impacts the management option recommendations for the subcatchment where the structures are located. It has been assumed that for structures where the tenure was identified as private or unknown that routine maintenance is completed on an as required basis by the landholder.

F4.3 Condition assessment

During the fieldwork program, structures which were inspected were also assessed for condition. Floodgate structures were only assessed when access to the downstream (gated) side of the structure was available and the structure was above the water level. The condition assessment was completed using an approach similar to Walsh et al. (2012) as outlined in Table F-2. Where data was available, the structure condition has been considered during the development of remediation actions plans.

Table F-2: Condition assessment criteria

Condition	Description
Good	The structure is in good working order. For floodgates, the seals work well. The structure does not require any maintenance in the near future.
Fair	The structure is functioning well however it is starting to become damaged. Issues such as rust or broken seals (for floodgates) are starting to become evident and affect the structures performance. For floodgates some vegetation, oysters or debris may be partially blocking the gate or preventing it from closing. The structure will require some maintenance in the near future.
Poor	The structure is no longer functioning well. For floodgates, the flaps no longer close properly or have holes. There may be extensive rust or concrete cancer in the structure. Sections of the culvert may have collapsed. For floodgates, the flap may be blocked or obstructed from opening. The structure requires maintenance to allow it to function correctly.
Other	The structure is broken and irreparable or has been removed.

F5 Infrastructure terminology

The following section provides a number of figures which describe common types of floodplain infrastructure used to control water movement across the floodplain. These figures include descriptions for common terminology used to describe infrastructure.

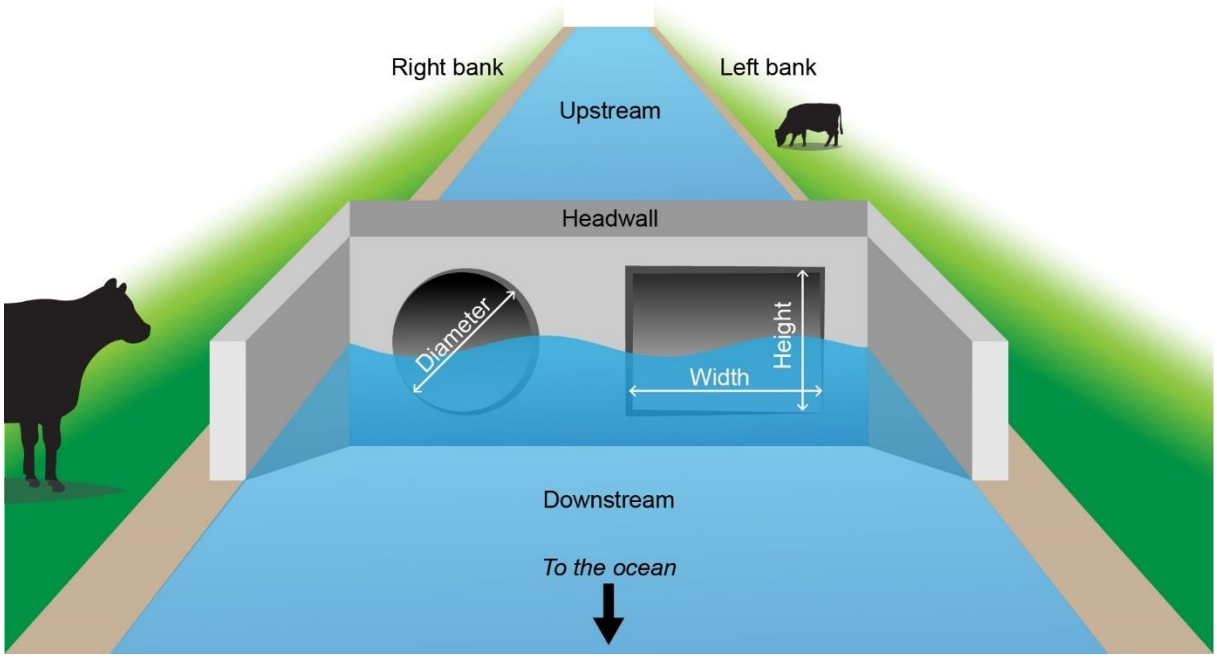


Figure F-5: Example of culverts controlling water in an agricultural drain

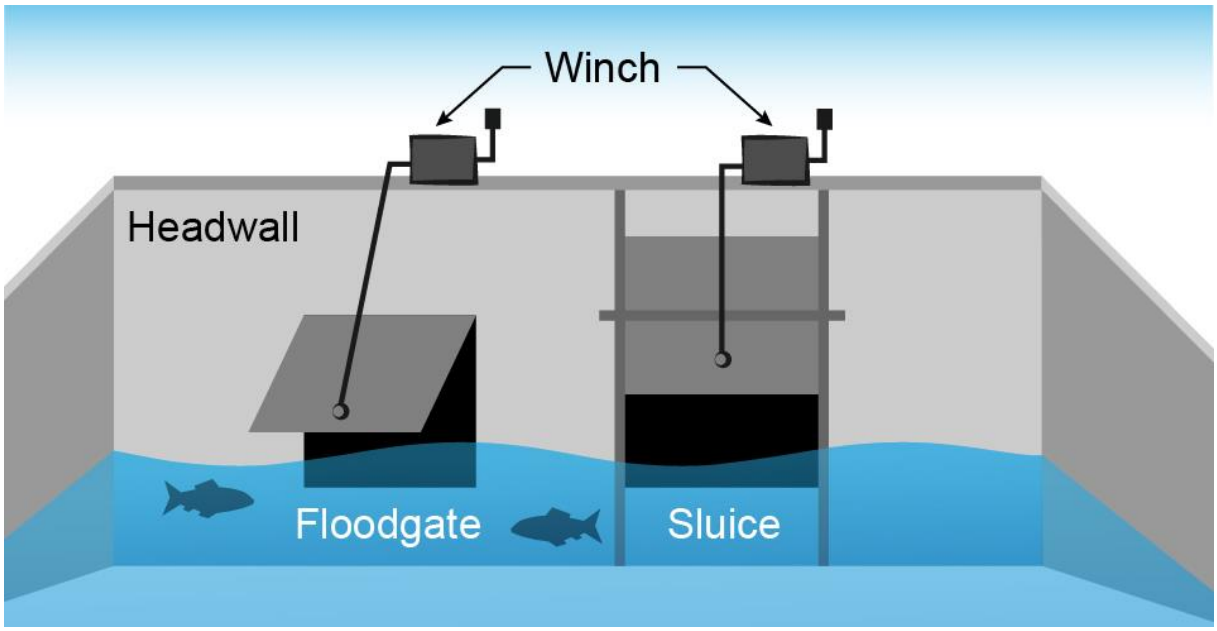


Figure F-6: Example of floodgate and sluice structures which can be fitted to culverts to control flow using a winch

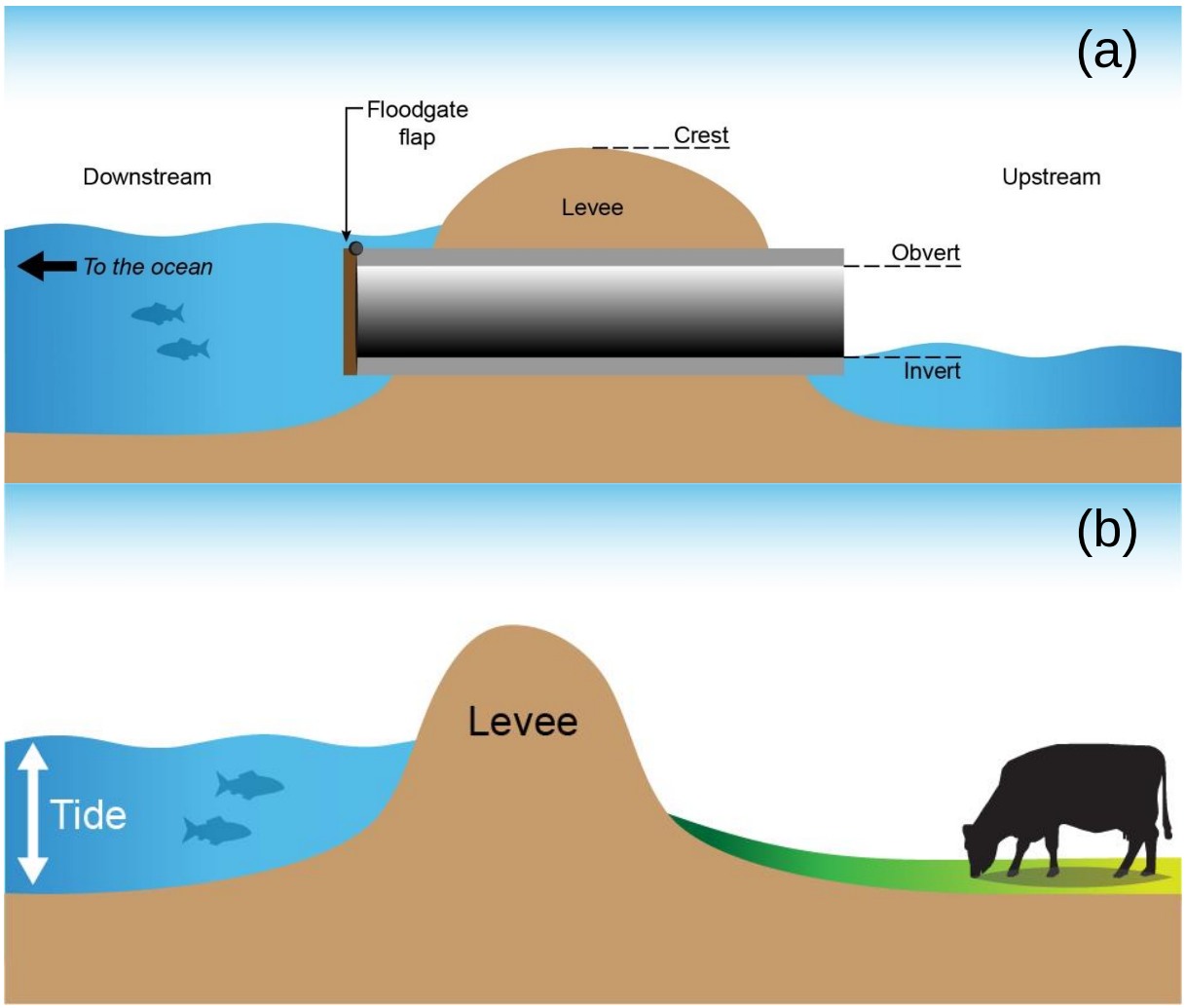


Figure F-7: Example of (a) a floodgate structure ensuring water levels upstream of a levee remain at the low tide level and (b) a levee preventing tidal inundation of the floodplain

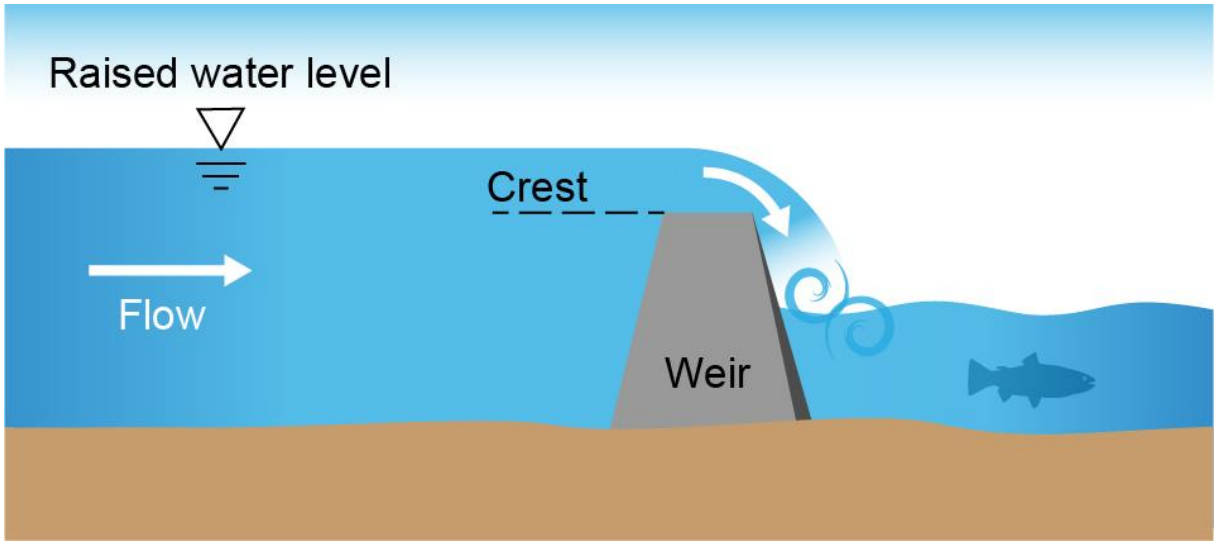


Figure F-8: Example of a weir ensuring a raised water level on the upstream side

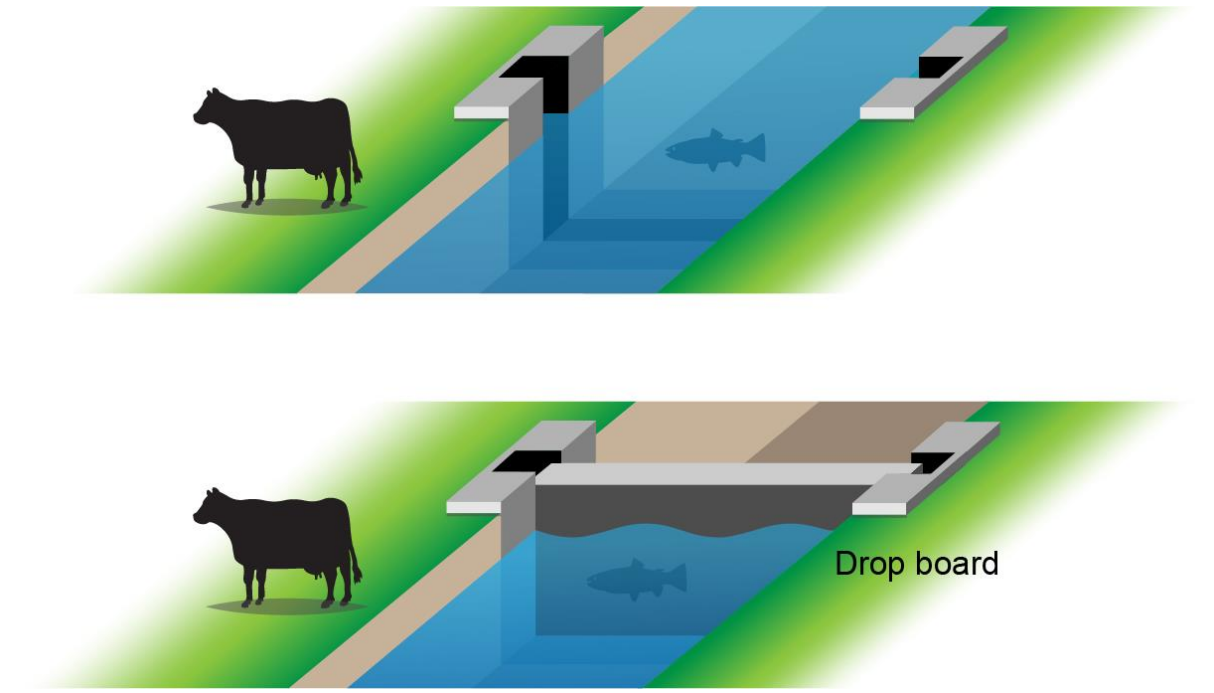


Figure F-9: Example of a drop board structure which can be used to control water levels and prevent inundation

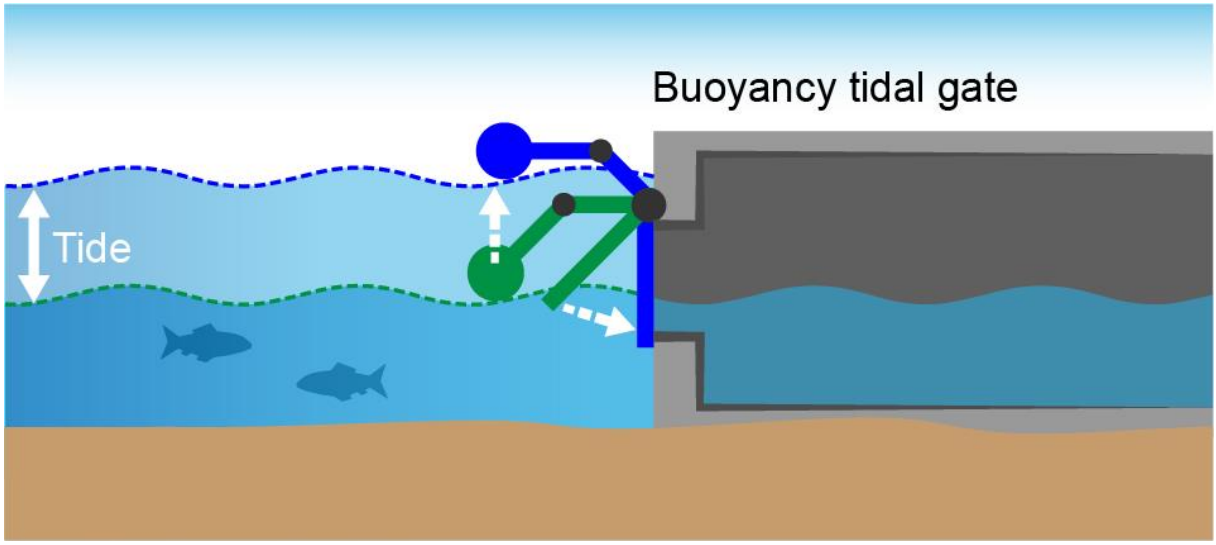


Figure F-10: Example of a buoyancy tidal gate that lets a controlled level of tidal water upstream of the structure (green) before closing due to a buoyancy mechanism and preventing further water ingress (blue)

F6 Floodplain infrastructure data tables

The following section includes:

1. A summary table for structures surveyed by WRL for this current project (Table F-3); and
2. A summary table for structures data obtained from other sources (Table F-4); and
3. A summary table for structures that were not surveyed or have incomplete data (Table F-5).

Table F-3: Summary of structures where data was collected during this current project

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
														Culvert is under the road. The floodgate flap does not fully open. There was poor GPS accuracy due to powerlines above.
150	20/08/2019	Floodgate	1	0.4			552839	6805368	0.63	0.235	Good	Secondary	Rous County Council	Culvert is under the road. It drains the floodplain. Good condition.
160	20/08/2019	Floodgate	1	0.95			552755	6805369	-0.543	-0.838	Fair	Secondary	Rous County Council	Culvert is under the road. Large floodgates.
170	20/08/2019	Floodgate	1	0.385			552475	6805446	0.356	0.336	Poor	Secondary	Rous County Council	Upstream side of the culvert is blocked.
180	20/08/2019	Floodgate	1	0.3			552204	6805539	0.356	0.166	Fair	Secondary	Rous County Council	Culvert is under the road. The upstream side was underwater. Red water on the downstream side. Culvert diameter on downstream side was 0.45m - larger than on the upstream side.
190	20/08/2019	Floodgate	1	0.45			551901	6805470	0.712	0.65	Fair	Secondary	Rous County Council	Upstream side of the culvert is blocked by 0.15m of sediment.
200	20/08/2019	Floodgate	1	0.29			551685	6805393	0.881	0.916	Fair	Secondary	Rous County Council	0.1m of sediment in the base of the culvert. Originally a 0.4m diameter culvert. A 0.29m culvert has been retrofitted on the downstream side.
210	20/08/2019	Floodgate	1	0.65			551529	6805247	-0.705	-0.904	Good	Secondary	Rous County Council	Culvert is under the road. Culvert was underwater. Thickness of pipe was estimated to be 0.05m.
220	20/08/2019	Floodgate	1	0.9			551540	6805060	-0.714	-0.862	Fair	Secondary	Rous County Council	Culvert is under the road.
230	20/08/2019	Floodgate	1	0.345			551674	6804786		0.061	Other	Secondary	Rous County Council	Upstream side was blocked with concrete.
240	20/08/2019	Floodgate	1	0.345			551751	6804660	0.804	0.431	Poor	Secondary	Rous County Council	New smaller culvert retrofitted on the downstream side. Original diameter was

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
														0.375m. Floodgate is blocked and cannot open.
250	20/08/2019	Culvert	1	0.75			551843	6804403	-0.461	-0.421	Poor	Secondary	Rous County Council	Culvert in poor condition. Mangroves growing inside the culvert on downstream side. 0.1m of freeboard between sediment and obvert.
260	20/08/2019	Floodgate	1	1.2			551890	6804174	-0.756	-0.745	Good	Secondary	Rous County Council	One of two culverts. Culvert wall is 0.08m thick.
260	20/08/2019	Floodgate	1	1.2			551890	6804174	-0.763	-0.721	Good	Secondary	Rous County Council	One of two culverts. 0.3m wide by 0.25m high buoyancy gate on the downstream side. Culvert wall is 0.08m thick.
270	21/08/2019	Floodgate	1	0.3			551856	6803995	0.604	0.521	Fair	Secondary	Rous County Council	There is mud at the bottom on the upstream side.
280	21/08/2019	Floodgate	2	1.25			551803	6803780	-0.596	-0.845	Good	Secondary	Rous County Council	Culvert is under a road. Good condition.
290	21/08/2019	Floodgate	1	0.75			551628	6803343	-0.536	-0.659	Good	Secondary	Rous County Council	One of four culverts. Downstream side was almost completely underwater at the time of survey.
290	21/08/2019	Floodgate	1	0.75			551628	6803343	-0.544	-0.636	Good	Secondary	Rous County Council	One of four culverts. Downstream side was almost completely underwater at the time of survey.
290	21/08/2019	Floodgate	1	0.75			551628	6803343	-0.531	-0.63	Good	Secondary	Rous County Council	One of four culverts. Downstream side was almost completely underwater at the time of survey.
290	21/08/2019	Floodgate	1	0.75			551628	6803343	-0.528	-0.616	Good	Secondary	Rous County Council	One of four culverts. Downstream side was almost completely underwater at the time of survey.
300	21/08/2019	Floodgate	1	0.9			551412	6803140	-0.323	-0.426	Good	Secondary	Rous County Council	Culvert is under the road.
310	21/08/2019	Floodgate	1	0.875			551072	6802785	-0.462	-0.542	Good	Secondary	Rous County Council	One of three culverts. Culvert is under private property.
310	21/08/2019	Floodgate	1	0.875			551072	6802785	-0.423	-0.547	Good	Secondary	Rous County Council	One of three culverts. Culvert is under private property.
310	21/08/2019	Floodgate	1	0.875			551072	6802785	-0.448	-0.549	Good	Secondary	Rous County Council	One of three culverts. Culvert is under private property.
320	21/08/2019	Floodgate	1	0.375			550953	6802725	0.159	0.264	Fair	Secondary	Rous County Council	Culvert under private property.
330	21/08/2019	Floodgate	1	1.2			550737	6802610	-0.674	-0.701	Good	Secondary	Rous County Council	One of three culverts. Culverts under private property. Old structure with flaps removed downstream.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
330	21/08/2019	Floodgate	1	1.2			550737	6802610	-0.713	-0.711	Good	Secondary	Rous County Council	One of three culverts. Culverts under private property. Old structure with flaps removed downstream.
330	21/08/2019	Floodgate	1	1.2			550737	6802610	-0.668	-0.698	Good	Secondary	Rous County Council	One of three culverts. Culverts under private property. Old structure with flaps removed downstream.
340	21/08/2019	Floodgate	1	0.6			550654	6802588	0.277	0.333	Good	Secondary	Rous County Council	Culvert is under a road.
350	21/08/2019	Floodgate	1	0.45*			550160	6802383	0.166	-0.279	Good	Secondary	Rous County Council	
360	21/08/2019	Floodgate	1	1.05			550051	6802306	-0.26	-0.426	Good	Secondary	Rous County Council	Culvert is under a road.
370	21/08/2019	Floodgate	1	0.6			549874	6802024	-0.054	0.039	Good	Secondary	Rous County Council	Culvert is under private property.
380	21/08/2019	Floodgate	1	0.75			549738	6801798	0.088	0.113	Good	Secondary	Rous County Council	Culvert under a road.
390	21/08/2019	Floodgate	4		1.5	1.54	549582	6801555	-1.028		Fair	Primary	Rous County Council	Upstream invert taken from average of two elevation measurements. Sluice gate (closed) on the gate second from the right. Two smaller floodgate flaps (winched open) on far right gate. Loggers on upstream side of the gate.
540	22/08/2019	Floodgate	1		1.54	1.54	546882	6797911	-1.072		Poor	Primary	Rous County Council	One of four culverts. Flaps were leaking letting river water upstream.
540	22/08/2019	Floodgate	1		1.54	1.54	546882	6797911	-1.069		Poor	Primary	Rous County Council	One of four culverts. Flaps were leaking letting river water upstream.
540	22/08/2019	Floodgate	1		1.54	1.54	546882	6797911	-1.053		Poor	Primary	Rous County Council	One of four culverts. Flaps were leaking letting river water upstream.
540	22/08/2019	Floodgate	1		1.54	1.54	546882	6797911	-1.046		Poor	Primary	Rous County Council	One of four culverts. Flaps were leaking letting river water upstream.
560	21/08/2019	Floodgate	1	0.375			549218	6801363		-0.01	Fair	Secondary	Rous County Council	Culvert under a road. Upstream side is overflow for a stormwater grate.
570	21/08/2019	Floodgate	1	0.45			549160	6801306	1.103	1.049	Good	Secondary	Rous County Council	Culvert is under a road.
580	21/08/2019	Floodgate	1	0.45			548986	6801216	0.009	0.985	Fair	Secondary	Rous County Council	Culvert is under a road. Upstream side of culvert has a concrete curb.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
590	21/08/2019	Floodgate	1	0.65			548895	6801125	0.009	-0.048	Fair	Secondary	Rous County Council	Culvert is beside a road.
600	21/08/2019	Floodgate	1	0.385			548743	6800954	0.385	0.396	Good	Secondary	Rous County Council	Culvert is beside a road.
610	21/08/2019	Floodgate	1	0.385			548647	6800855	0.476	0.31	Good	Secondary	Rous County Council	0.085m of sediment in the base of the culvert on the upstream side.
620	21/08/2019	Floodgate	1	1.4			548530	6800700		-0.607	Good	Secondary	Rous County Council	Culvert is under a road.
630	21/08/2019	Floodgate	1	0.375			548487	6800612	0.876	0.675	Good	Secondary	Rous County Council	
640	21/08/2019	Floodgate	1	0.75			548373	6800465	-0.322	-0.409	Good	Secondary	Rous County Council	
650	21/08/2019	Floodgate	1	0.75			548324	6800392	-0.061	0.45	Good	Secondary	Rous County Council	
660	21/08/2019	Floodgate	1	1.2			548188	6800176	-0.732	-0.706	Good	Secondary	Rous County Council	
670	21/08/2019	Floodgate	1	0.375			548143	6800107	0.718	0.638	Fair	Secondary	Rous County Council	Culvert is under a road.
690	22/08/2019	Floodgate	1		1.52	1.5	547995	6799836	-0.694		Good	Primary	Rous County Council	One of four culverts. Under a road.
690	22/08/2019	Floodgate	1		1.52	1.5	547995	6799836	-0.674		Good	Primary	Rous County Council	One of four culverts. Under a road.
690	22/08/2019	Floodgate	1		1.52	1.5	547995	6799836	-0.688		Good	Primary	Rous County Council	One of four culverts. Under a road.
690	22/08/2019	Floodgate	1		1.52	1.5	547995	6799836	-0.67		Good	Primary	Rous County Council	One of four culverts. Under a road.
695	22/08/2019	Floodgate	1	0.6			547943	6799752	0.237	0.235	Fair	Secondary	Rous County Council	Upstream side of the culvert is broken however flow through it is unaffected.
750	22/08/2019	Floodgate	1	0.375			547850	6799669	0.959	0.794	Good	Secondary	Rous County Council	Culvert is under a road. The upstream side of the culvert has 0.1m of sediment in the bottom.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
760	22/08/2019	Floodgate	1	0.6			547741	6799474	0.064	0.093	Poor	Secondary	Rous County Council	The upstream side of the culvert is broken however flow is not inhibited.
770	22/08/2019	Floodgate	1	0.6			547641	6799249	0.077	0.087	Fair	Secondary	Rous County Council	
780	22/08/2019	Floodgate	1	0.3			547613	6799191	0.669	0.412	Fair	Secondary	Rous County Council	Culvert has broken edges
790	22/08/2019	Floodgate	1	0.8			547598	6799106	0.068	0.773	Fair	Secondary	Rous County Council	Culvert has broken edges
800	22/08/2019	Floodgate	1	0.375			547564	6799002	0.303	0.097	Fair	Secondary	Rous County Council	Originally a 0.375m diameter culvert, a 0.315m diameter PVC pipe has been retrofitted on the downstream side.
810	22/08/2019	Floodgate	1	0.375			547548	6798879	0.742	-0.123	Good	Secondary	Rous County Council	Culvert is under a road. Originally a 0.375m diameter culvert, a 0.295m diameter pvc pipe has been retrofitted on the downstream side.
820	22/08/2019	Floodgate	1	0.9			547451	6798600	-0.31	-0.238	Fair	Secondary	Rous County Council	The downstream culvert presents some cracks
830	22/08/2019	Floodgate	1	1.2			547385	6798476	-0.788	-0.882	Good	Secondary	Rous County Council	There is a tidal gate on the downstream side.
840	22/08/2019	Floodgate	1	0.45			547316	6798389	-0.188	-0.369	Good	Secondary	Rous County Council	Culvert is under a road. The downstream side was under water at the time of inspections. Invert taken from water level.
850	22/08/2019	Floodgate	1	0.375			547180	6798186	0.255	0.047	Good	Secondary	Rous County Council	One of two culverts.
850	22/08/2019	Floodgate	1	0.6			547180	6798186	-0.104	-0.017	Good	Secondary	Rous County Council	One of two culverts.
870	22/08/2019	Floodgate	1	0.75			546797	6797831	0.334	0.177	Fair	Secondary	Rous County Council	Culvert is under a road.
880	22/08/2019	Floodgate	1	0.375			546693	6797726	0.61	0.537	Good	Secondary	Rous County Council	Culvert is under a road.
900	22/08/2019	Floodgate	1	0.3			546585	6797599	0.404	0.323	Not available	Secondary	Rous County Council	Culvert is under private property.
920	22/08/2019	Culvert	1	0.6			546449	6797438	0.284	0.286	Other	Secondary	Rous County Council	Culvert is under a road. Originally a 0.6m diameter culvert, a 0.375m diameter culvert has been retrofitted on the downstream side. The flap on the downstream side has fallen off.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
940	22/08/2019	Floodgate	1	0.75			546289	6797245	0.655	-0.613	Good	Secondary	Rous County Council	One of two culverts. Culvert is under a road.
940	22/08/2019	Floodgate	1	1.2			546289	6797245	-0.437	-0.728	Good	Secondary	Rous County Council	One of two culverts. Culvert is under a road.
990	22/08/2019	Floodgate	1	0.9			545864	6796875	-0.253	-0.219	Good	Secondary	Rous County Council	Culvert is under private property (beside a road).
1080	26/02/2020	Floodgate	3	1.5			544980	6794448		-0.523	Good	Primary	Rous County Council	Good condition, all gates have winches with middle winch not attached. Looks like there has been a tidal flushing program - signs indicate.
1180	29/08/2019	Floodgate	1	1.5			545540	6792569	-0.652		Good	Primary	Rous County Council	One of two culverts. Sluice gate on 1180_left.
1180	29/08/2019	Floodgate	1	1.5			545540	6792569	-0.843		Good	Primary	Rous County Council	One of two culverts. Sluice gate on 1180_left.
1180	29/08/2019	Sluice	1		0.4	0.45	545528	6792585		-1.539	Good		Rous County Council	Sluice gate on 1180_left.
1180	29/08/2019	Floodgate	1	0.9			545526	6792583		0.747	Good	Primary	Rous County Council	Culvert with higher invert connected to a pump on the upstream side.
1230	30/01/2020	Floodgate	4	1.5			543378	6792095	-0.8	-0.641*	Not available	Secondary	Rous County Council	Approximate invert measurement from water level.
1260	29/08/2019	Floodgate	3		1.23	2.15	542487	6791274	0.045		Not available	Secondary	Rous County Council	
1265	29/08/2019	Floodgate	1	1.5			541893	6790301		0.164*	Good	Secondary	Rous County Council	Discharge of stormwater. Invert measured as the base of the upstream stormwater pit.
1280	29/08/2019	Floodgate	4	1.8			541571	6789937	-0.159	-0.159*	Good	Secondary	Rous County Council	Buoyancy gate on right flap.
1280	29/08/2019	Buoyancy gate	1		0.4	0.4	541571	6789937			Good		Rous County Council	Could not measure invert due to poor GPS reception.
1300	30/01/2020	Floodgate	1	0.9			539729	6790881	0.004		Good	Secondary	Rous County Council	Good conditions. Near RA_07_S.
1305	30/01/2020	Floodgate	1	0.3			539663	6791117		0.096	Good	Secondary	Rous County Council	Near soil profile RA_07_S.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
1320	29/08/2019	Floodgate	1	0.9			538158	6790324	0.021		Not available	Secondary	Rous County Council	One of two culverts.
1320	29/08/2019	Floodgate	1	0.9			538158	6790324	0.04		Not available	Secondary	Rous County Council	One of two culverts.
1330	29/08/2019	Floodgate	2		2.1*	2.1*	538017	6790251	-0.779	-1.053*	Good	Primary	Rous County Council	
1360	29/08/2019	Floodgate	1	0.9			537558	6789682		-0.081	Good	Secondary	Rous County Council	
1370	29/08/2019	Floodgate	1	0.6			536967	6788469		1.181	Fair	Secondary	Rous County Council	
1380	29/08/2019	Floodgate	1	0.375			537215	6787209		1.047	Fair	Secondary	Rous County Council	Very weedy upstream.
1390	29/08/2019	Floodgate	1	0.75			537582	6786906	1.025		Good	Secondary	Rous County Council	One of three culverts.
1390	29/08/2019	Floodgate	1	0.6			537582	6786906	0.767		Good	Secondary	Rous County Council	One of three culverts.
1390	29/08/2019	Floodgate	1	0.6			537582	6786906	0.819		Good	Secondary	Rous County Council	One of three culverts.
1530	28/08/2019	Floodgate	1		3	3	531750	6781327	-2.3		Good	Primary	Rous County Council	Rocky Mouth Creek floodgates. One of six floodgates. Floodgates winched fully open.
1530	28/08/2019	Floodgate	1		3	3	531750	6781327	-2.341		Good	Primary	Rous County Council	Rocky Mouth Creek floodgates. One of six floodgates. Floodgates winched fully open.
1530	28/08/2019	Floodgate	1		3	3	531750	6781327	-2.344		Good	Primary	Rous County Council	Rocky Mouth Creek floodgates. One of six floodgates. Floodgates winched fully open.
1530	28/08/2019	Floodgate	1		3	3	531750	6781327	-2.355		Good	Primary	Rous County Council	Rocky Mouth Creek floodgates. One of six floodgates. Floodgates winched fully open.
1530	28/08/2019	Floodgate	1		3	3	531750	6781327	-2.338		Good	Primary	Rous County Council	Rocky Mouth Creek floodgates. One of six floodgates. Floodgates winched fully open.
1530	28/08/2019	Floodgate	1		3	3	531750	6781327	-2.347		Good	Primary	Rous County Council	Rocky Mouth Creek floodgates. One of six floodgates. Floodgates winched fully open.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
1560	28/08/2019	Floodgate	1	1.2			532102	6781954	-0.062		Good	Secondary	Rous County Council	
1570	29/08/2019	Floodgate	1	1.2			532489	6783183	-0.079		Good	Primary	Rous County Council	One of three culverts. Right hand culvert has been retrofitted with a 1.6m culvert on the downstream side.
1570	29/08/2019	Floodgate	1	1.2			532489	6783185	-0.099		Good	Primary	Rous County Council	One of three culverts. Right hand culvert has been retrofitted with a 1.6m culvert on the downstream side.
1570	29/08/2019	Floodgate	1	1.2			532489	6783187	-0.177		Good	Primary	Rous County Council	One of three culverts. Right hand culvert has been retrofitted with a 1.6m culvert on the downstream side.
1580	28/08/2019	Floodgate	2		1.5*	1.2	532367	6784239	0.065	-0.033*	Fair	Secondary	Rous County Council	
1650	28/08/2019	Floodgate	1		1.5	1.5	531881	6785417	-0.285		Good	Primary	Rous County Council	Buoyancy gate on flap.
1650	28/08/2019	Buoyancy gate	1		0.5	0.55	531889	6785416		-0.198	Good		Rous County Council	Buoyancy gate for 1650. Width approximate.
1780	28/08/2019	Sluice	1		0.5	0.65	528703	6784367		-0.455	Good		Rous County Council	Sluice gate located on box culvert flap for 1780.
1780	28/08/2019	Floodgate	1		2.6*	2.6	528703	6784367		-0.992	Good	Primary	Rous County Council	One of two culverts. Circular culvert on top of a box culvert. Box culvert height approximate.
1780	28/08/2019	Floodgate	1	0.6			528703	6784364		1.556	Good	Primary	Rous County Council	One of two culverts. Circular culvert on top of a box culvert. Box culvert height approximate.
1790	28/02/2020	Floodgate	3		2.1	2.1	528288	6784654	-0.809	-0.831*	Good	Primary	Rous County Council	Good condition. Sluice on centre culvert. Pump on drainage system - see 1790_pump.
1790	28/02/2020	Floodgate	1	0.9			528296	6784668		0.944	Good	Primary	Rous County Council	Good condition. Flap blocked. Pump on upstream side.
1820	28/08/2019	Floodgate	2	1.8			527896	6785101	-0.356		Good	Primary	Rous County Council	Sluice gate on left flap.
1820	28/08/2019	Sluice	1		0.8	0.8	527928	6785102		-0.673	Good		Rous County Council	Located on left flap of 1620.
1860	28/08/2019	Floodgate	2	1.8			528274	6785572	-0.105		Good	Primary	Rous County Council	Sluice gate on left flap with no opening mechanism.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
1860	28/08/2019	Sluice	1		0.5	0.6	528278	6785558	0.142		Good		Rous County Council	Located on the left flap of 1860.
1870	28/02/2020	Floodgate	1		3.1	2.1	529082	6786208	0.081		Good	Primary	Rous County Council	Good condition.
1880	28/08/2019	Floodgate	4		2.2	2.15	528211	6786925	-0.249	-0.267*	Good	Primary	Rous County Council	Tidal buoyancy gate on left culvert. Width is approximate.
1880	28/08/2019	Buoyancy gate			0.4	0.4	528217	6786937		-0.069	Good		Rous County Council	Dimensions are approximate.
1890	28/08/2019	Floodgate	1	1.2			527060	6788071	-0.485		Fair	Primary	Rous County Council	
1900	28/02/2020	Floodgate	2	1.5			526030	6788672		0.156	Good	Primary	Rous County Council	Good condition. Smaller culvert raised at higher invert - see 1900-high.
1900	28/02/2020	Floodgate	1	0.6			526031	6788670		2.92	Good	Primary	Rous County Council	Good condition.
1940	28/08/2019	Floodgate	1	0.6			524165	6783978	-0.158		Not available	Primary	Rous County Council	One of two culverts. Could only access upstream side. Appeared to be a winch of some form on downstream side.
1940	28/08/2019	Floodgate	1		2.1	1.5	524164	6783976	-0.677		Not available	Primary	Rous County Council	One of two culverts. Could only access upstream side. Appeared to be a winch of some form on downstream side.
1950	28/08/2019	Sluice	1		0.6	0.75	523909	6783458		-0.245	Good		Rous County Council	Sluice gate for 1950. Open at time of inspection.
1950	28/08/2019	Floodgate	2	1.8			523910	6783457		-0.647	Fair	Secondary	Rous County Council	Open sluice gate on left culvert. Note GPS measured obvert not invert. Evidence of broken seal in the right floodgate
1960	28/02/2020	Floodgate	4		2.1	2.1	524349	6785120	-0.325	-0.358*	Good	Primary	Rous County Council	Good condition. Loggers upstream and downstream.
1990	28/02/2020	Floodgate	2		2.1	2.1	525557	6788427		0.14	Good	Primary	Rous County Council	Good condition.
2010	28/02/2020	Floodgate	2		2.1	2.1	525113	6788776		-0.779	Good	Primary	Rous County Council	Good condition.
2030	28/08/2019	Sluice	1		0.75	2.8	523322	6788414		-0.834	Fair		Rous County Council	Sluice for 2030.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
2030	28/08/2019	Floodgate	1		0.2	2.15	523319	6788401	-1.048		Fair	Primary	Rous County Council	Width is approximate. Sluice on culvert. Rusted pulley sytem
2050	28/08/2019	Floodgate	2		2.2	2.15	525219	6789063	-0.935		Fair	Primary	Rous County Council	Tidal buoyancy gate on left culvert.
2100	28/08/2019	Floodgate	5		2.1*	2.1*	526112	6790462	-0.185	-0.091*	Good	Primary	Rous County Council	Sluice gate located on the flap second from the left.
2100	28/08/2019	Sluice	1		0.7	0.9	526128	6790467		-0.03	Good		Rous County Council	Sluice gate for 2100.
2120	28/08/2019	Floodgate	1	1.2			526338	6791087		1.023	Good	Secondary	Rous County Council	
2130	28/08/2019	Floodgate	1	1.2*			527132	6791846	0.755	0.26*	Fair	Secondary	Rous County Council	
2190	28/08/2019	Floodgate	3		2.1	2.15	528320	6795051	0.542		Good	Primary	Rous County Council	An open sluice gate was on the right floodgate flap.
2190	28/08/2019	Sluice	3		0.2	0.5	528320	6795051	0.542		Good		Rous County Council	Sluice for 2190.
2380	26/02/2020	Floodgate	4		2.1*	2.1*	528170	6799450		0.046*	Good	Primary	Rous County Council	Good condition.
2390	26/02/2020	Floodgate	1	1.05*			528701	6800388		2.978	Good	Primary	Rous County Council	Good condition. Set back from river. Higher elevation.
2400	26/02/2020	Floodgate	4		2.1*	2.1*	528790	6801178		0.04*	Good	Primary	Rous County Council	Good condition.
2410	5/11/2019 1:50:41 PM, 28/08/2019	Floodgate	2		2.1	1.8	528111	6802619	1.31		Good	Primary	Rous County Council	There were rocks in the dowstream channel.
2540	28/08/2019	Floodgate	3	1.5			529323	6802240		0.088	Good	Primary	Rous County Council	Downstream side was weedy with trees in the drain.
2580	28/08/2019	Floodgate	4		2.1*	2.1*	528591	6799948		1.748*	Good	Primary	Rous County Council	Very large. Couldn't measure dimensions accurately. Gate second from the right was slightly open. Invert approximate.
2640	26/02/2020	Floodgate	3	1.2			529854	6796329		1.741	Good	Primary	Rous County Council	Good condition.

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2670	28/08/2019	Floodgate	1	1.2			530316	6794790	1.581	0.985*	Good	Primary	Rous County Council	Floodgate looks new. Upstream is dry.
2940	28/08/2019	Floodgate	4		2.1*	2.1*	527109	6789994	-0.443	-0.541*	Good	Primary	Rous County Council	East Coraki canal - drains low land.
2960	28/08/2019	Floodgate	4		2.1	2.15	530699	6786773	-0.835		Good	Primary	Rous County Council	Approximate width. sluice gate is on the second gate from the right.
2970	28/08/2019	Buoyancy gate	1		0.4	0.36	531213	6787469		0.188	Good		Rous County Council	Approximate width.
2970	28/08/2019	Floodgate	1	1.2			531207	6787481	-0.055		Good	Primary	Rous County Council	One of two culverts. Buoyancy tidal gate on right culvert.
2970	28/08/2019	Floodgate	1	1.2			531206	6787480	-0.151		Good	Primary	Rous County Council	One of two culverts. Buoyancy tidal gate on right culvert.
2980	28/08/2019	Floodgate	4		2.1	2.15	531864	6787756	-0.37	-0.415*	Good	Primary	Rous County Council	sluice on right culvert.
2980	28/08/2019	Sluice	1		0.8	0.9	531860	6787749		-0.347	Good		Rous County Council	Size approximate only.
3110	28/08/2019	Floodgate	1	1.5			535371	6785181	-0.311		Good	Secondary	Rous County Council	
3120	28/08/2019	Floodgate	3		2.1*	2.1*	536493	6787823	-0.885	-0.825*	Good	Primary	Rous County Council	Approximate width.
3170	28/08/2019	Floodgate	4		2.4	2.12	536504	6789084	-0.649		Fair	Primary	Rous County Council	Large fish observed upstream. one sluice on left culvert. Rusted pulley system
3170	28/08/2019	Sluice	1		0.8	0.9	536510	6789083		-0.534	Fair		Rous County Council	Sizes approximate. Rusted pulley system
3370	26/08/2019	Floodgate	1	1.2			537166	6789847	-0.878		Fair	Primary	Rous County Council	One of two culverts. Approximately 20m upstream of WRL_Rich_40.
3370	26/08/2019	Floodgate	1	1.2			537166	6789847	-0.949		Fair	Primary	Rous County Council	One of two culverts. Approximately 20m upstream of WRL_Rich_40.
3390	26/08/2019	Floodgate	1		2.28	2.15	538152	6791102	-0.853		Good	Primary	Rous County Council	One of five gates. Major drain. Measured invert from headwall.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
3390	26/08/2019	Floodgate	1		2.28	2.15	538152	6791102	-0.862		Good	Primary	Rous County Council	One of five gates. Major drain. Measured invert from headwall.
3390	26/08/2019	Floodgate	1		2.28	2.15	538152	6791102	-0.868		Good	Primary	Rous County Council	One of five gates. Major drain. Measured invert from headwall.
3390	26/08/2019	Floodgate	1		2.28	2.15	538152	6791102	-0.879		Good	Primary	Rous County Council	One of five gates. Major drain. Measured invert from headwall.
3390	26/08/2019	Floodgate	1		2.28	2.15	538152	6791102	-0.881		Good	Primary	Rous County Council	One of five gates. Major drain. Measured invert from headwall. Sluice gate approximately 0.73m wide.
3510	26/08/2019	Floodgate	1	1.54			538548	6792009	-0.536	-0.47	Good	Secondary	Rous County Council	One of two culverts. Sluice gate letting tidal flows upstream.
3510	26/08/2019	Floodgate	1	1.54			538579	6792003	-0.747	-0.389	Good	Secondary	Rous County Council	One of two culverts.
3510	26/08/2019	Sluice	1		0.53	0.5	538580	6792003		-0.117	Good		Rous County Council	Sluice gate on left pipe. Open at time of inspection.
3540	26/08/2019	Floodgate	1	1.2			538777	6792063	-0.017		Good	Secondary	Rous County Council	Deep drain upstream. Downstream was in water. Note snake lives on downstream side.
3550	26/08/2019	Floodgate	1	0.45			539004	6792158		0.439	Good	Secondary	Rous County Council	Upstream very weedy . Downstream dry.
3560	26/08/2019	Floodgate	2	0.45			539246	6792244	0.529	-0.088*	Good	Secondary	Rous County Council	Culverts extend into the river on the downstream side. The upstream side of the culvert has the two culverts meeting in a pit. The culverts then form one and extend under a road to the drain behind. Invert was measured as the base of the pit.
3570	26/08/2019	Floodgate	1	0.6			539488	6792221	1.01	0.68*	Fair	Secondary	Rous County Council	Upstream is very weedy and partially blocked with rocks.
3580	26/08/2019	Floodgate	1	0.45			540308	6790710	1.712		Good	Secondary	Rous County Council	Dry drain upstream along a road. Dry and lots of weeds downstream.
3590	26/08/2019	Floodgate	1	0.45			540495	6790591	1.334*		Good	Secondary	Rous County Council	The downstream side was weedy and there was a poor drainage pathway to the river.
3600	26/08/2019	Floodgate	1	0.45			540830	6790452	1.477		Good	Secondary	Rous County Council	Larger upstream drain through cane. Downstream was dry and discharged through mangroves.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
3610	26/08/2019	Floodgate	1	0.45			540901	6790429	1.913		Good	Secondary	Rous County Council	Dry on the downstream side which has in mangroves. Upstream had lots of weeds and sugar cane.
3620	26/08/2019	Floodgate	1	0.45			540987	6790376		1.464	Good	Secondary	Rous County Council	Dry and lots of weeds on both ends of the culvert.
3630	26/08/2019	Floodgate	1	0.45			541045	6790360	1.15*	0.91	Good	Secondary	Rous County Council	Dry on the downstream side before leading to a winding drain.
3640	26/08/2019	Floodgate	2	0.3			541314	6790286		2.164	Good	Secondary	Rous County Council	One of two culverts. Two culverts on top of each other on the downstream side. Could only find the higher culvert on the upstream side.
3640	26/08/2019	Floodgate	2	0.45			541314	6790286		1.107	Good	Secondary	Rous County Council	One of two culverts. Two culverts on top of each other on the downstream side. Could only find the higher culvert on the upstream side.
3650	26/08/2019	Floodgate	1	0.6			541623	6790373	0.87		Good	Secondary	Rous County Council	Dry downstream, paddock drain.
3660	26/08/2019	Floodgate	1	0.6			541654	6790416	1.097		Good	Secondary	Rous County Council	Dry downstream, paddock drain.
3670	26/08/2019	Floodgate	1	1.2			541863	6790653	-0.11		Good	Secondary	Rous County Council	
3820	26/08/2019	Floodgate	1	1.23			539319	6793671	-0.133		Good	Secondary	Rous County Council	A smaller culvert was immediately upstream passing under a paddock.
3990	26/08/2019	Floodgate	1	0.6			543026	6792313	0.093		Fair	Secondary	Rous County Council	Upstream drain was very weedy.
4000	26/08/2019	Floodgate	1	0.45			543391	6792425	0.625		Good	Secondary	Rous County Council	Paddock drainage. Upstream had lots of weeds and was dry.
4030	26/08/2019	Floodgate	1	0.6			544129	6793799	0.013		Fair	Secondary	Rous County Council	
4090	25/02/2020	Floodgate	1	0.75			544646	6795322		-0.351	Poor	Secondary	Rous County Council	All measurements approximate. Downstream floodgates wedged open slightly, poor condition. Could not access the upstream side.
4100	25/02/2020	Floodgate	1	0.45			544656	6795486	0.331		Poor	Secondary	Rous County Council	Downstream wedged open slightly. Poor condition.
4110	25/02/2020	Floodgate	1	0.75			544644	6795872		-0.601	Poor	Secondary	Rous County Council	Water too high to observe culvert. Invert and size are based on Rous County Council dimensions. Downstream appears to be in poor conditional and the headwall has been repaired.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
4120	25/02/2020	Floodgate	2	1.5			544593	6796016	-0.683		Fair	Primary	Rous County Council	Looks in fair condition. Old disused pump upstream.
4140	25/02/2020	Floodgate	1	0.45			544532	6796648	0.515		Poor	Secondary	Rous County Council	Poor condition. Mangroves located upstream. Flap wedged open.
4280	26/02/2020	Floodgate	3		1.5*	1.5	547415	6800780	-0.993		Good	Primary	Rous County Council	Good condition.
4360	22/08/2019	Floodgate	1	0.63			547595	6801459	0.073	-0.015	Good	Secondary	Rous County Council	
4370	22/08/2019	Floodgate	1	1.2			547770	6801568	-0.015	-0.154	Good	Secondary	Rous County Council	
4380	22/08/2019	Floodgate	1	0.375			547834	6801599	0.743	0.742	Poor	Secondary	Rous County Council	Culvert is under a road. Upstream side of the culvert was blocked with sediments and rocks
4390	22/08/2019	Floodgate	1	0.6			547949	6801635	-0.207	-0.297	Good	Secondary	Rous County Council	
4400	22/08/2019	Floodgate	1	0.6			548061	6801672	0.193	-0.097	Good	Secondary	Rous County Council	Culvert is under a road.
4410	22/08/2019	Floodgate	1	1.2			548181	6801724	-0.874	-1.047	Good	Primary	Rous County Council	One of two culverts. Culvert is under a road.
4410	22/08/2019	Floodgate	1	1.2			548181	6801724	-0.909	-0.975	Good	Primary	Rous County Council	One of two culverts. Culvert is under a road.
4440	23/08/2019	Floodgate	1	0.375			548331	6801784	0.142	0.01	Fair	Secondary	Rous County Council	Culvert is under a road. Upstream side of the culvert was blocked (there was 0.3 m freeboard). A 0.3m diameter PVC pipe has been retrofitted on the downstream side.
4450	23/08/2019	Floodgate	1	0.375			548434	6801814	0.787	0.803	Good	Secondary	Rous County Council	Culvert is under a road. Good condition.
4460	23/08/2019	Floodgate	1	0.615			548657	6801822	0.151	-0.104	Good	Secondary	Rous County Council	Culvert is under a road.
4470	23/08/2019	Floodgate	1	0.6			548772	6801804	-0.357	-0.392	Poor	Secondary	Rous County Council	Culvert is under a road. There is 0.2m of sediment in the base of the culvert on the upstream side. The gate is blocked by sediments on the downstream side and cannot open.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
4480	23/08/2019	Floodgate	1	0.375			548883	6801785	0.568	0.531	Good	Secondary	Rous County Council	Culvert is under a road. A 0.3m diameter culvert has been retrofitted on the downstream side.
4490	23/08/2019	Floodgate	1	1			548957	6801787	-0.572	-0.583	Good	Secondary	Rous County Council	Culvert is under a road. There is an old structure further upstream (has not been surveyed - see photos).
4500	23/08/2019	Floodgate	1	0.375			549111	6801826	0.395	0.229	Good	Secondary	Rous County Council	There is a garden on the upstream side.
4510	23/08/2019	Floodgate	1	0.45*			549335	6802039	0.297	-0.541*	Fair	Secondary	Rous County Council	
4520	23/08/2019	Floodgate	1	0.9			549603	6802419	-0.653	-0.656	Good	Primary	Rous County Council	One of two culverts. Under a road. Good condition, underwater at time of second inspection.
4520	23/08/2019 , 26/02/2020 12:58:00 PM	Floodgate	1	0.9			549603	6802419	-0.632	-0.656	Good	Primary	Rous County Council	One of two culverts. Under a road. Good condition, underwater at time of second inspection.
4540	23/08/2019	Floodgate	1	0.65			549777	6802604		0.04	Good	Secondary	Rous County Council	Culvert is under a road. Could not locate the upstream side. May be below a concrete box.
4550	23/08/2019	Floodgate	1	0.3			550283	6802946	0.515	0.374	Poor	Secondary	Rous County Council	dowstream culvert has extensive concrete cracks
4560	23/08/2019	Floodgate	1	0.3			550339	6802960	0.053	-0.083	Good	Secondary	Rous County Council	
4570	23/08/2019	Floodgate	1	0.3			550450	6802987	0.351	0.19	Fair	Secondary	Rous County Council	floodgate is in good condition, however, upstream culvert has broken edges
4590	23/08/2019 , 31/01/20	Floodgate	1		1.5	1.5	551190	6803933	-0.835	-0.75	Good	Primary	Rous County Council	One of four culverts. Headwall is 1.7m above the obvert. Near soil profile RA_11.
4590	23/08/2019 , 31/01/20	Floodgate	1		1.5	1.5	551190	6803933	-0.831	-0.753	Good	Primary	Rous County Council	One of four culverts. Headwall is 1.7m above the obvert. Near soil profile RA_11.
4590	23/08/2019 , 31/01/20	Floodgate	1		1.5	1.5	551190	6803933	-0.834	-0.746	Good	Primary	Rous County Council	One of four culverts. Headwall is 1.7m above the obvert. Near soil profile RA_11.
4590	23/08/2019 , 31/01/20	Floodgate	1		1.5	1.5	551190	6803933	-0.827	-0.748	Good	Primary	Rous County Council	One of four culverts. Headwall is 1.7m above the obvert. Near soil profile RA_11.
4700	31/01/2020	Floodgate	1	1.2			550667	6805039	-1.247		Good	Secondary	Rous County Council	Within private property (near RA_11). Downstream side was underwater at time of survey.

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4710	31/01/2020	Floodgate	2	0.9			550245	6804989	-0.716		Good	Secondary	Rous County Council	Within private property (near RA_11). Downstream side was underwater at time of survey.
4730	31/01/2020	Floodgate	1	1.5			550494	6805794	-0.471		Good	Secondary	Rous County Council	Within private property. Updated invert during QA with correct staff height.
4740	31/01/2020	Floodgate	1	0.6			550332	6806425	0.035		Fair	Secondary	Rous County Council	Within private property. The drain was dry on the upstream side of the culvert.
4750	31/01/2020	Floodgate	1	0.6			550135	6806297	-0.86		Not available	Secondary	Rous County Council	Both sides of culvert were underwater at the time of the survey.
4760	31/01/2020	Floodgate	3	0.75			550070	6806314	-0.601		Good	Secondary	Rous County Council	One of three culverts. Within private property. Downstream side was underwater at time of survey.
4760	31/01/2020	Floodgate	3	0.75			550070	6806314	-0.651		Good	Secondary	Rous County Council	One of three culverts. Within private property. Downstream side was underwater at time of survey. Middle culvert is 0.05m lower than the left culvert.
4760	31/01/2020	Floodgate	3	0.75			550070	6806314	-0.671		Good	Secondary	Rous County Council	One of three culverts. Within private property. Downstream side was underwater at time of survey. Right culvert is 0.07m lower than the left culvert.
4770	31/01/2020	Floodgate	1	0.6			549985	6806369	-0.433		Good	Secondary	Rous County Council	Within private property. Downstream side was underwater at time of survey.
4780	31/01/2020	Floodgate	1	0.9			549632	6806233	-0.664		Fair	Secondary	Rous County Council	Within private property. Culvert is in fair condition. Downstream side was underwater at the time of survey.
4790	31/01/2020	Floodgate	1	0.6			549341	6806247	-0.141		Good	Secondary	Rous County Council	Within private property. Downstream side was almost completely underwater at the time of survey.
4800	31/01/2020	Floodgate	2	1.5			549107	6806289	-0.852		Fair	Primary	Rous County Council	Within private property. Seal on floodgate flap is not perfect
4820	23/08/2019	Floodgate	1	0.85			548809	6806536	-0.269		Fair	Secondary	Rous County Council	Culvert is under a road.
4830	23/08/2019	Floodgate	1	1.5			548578	6806502	-1.153	-1.006	Good	Primary	Rous County Council	One of three culverts.
4830	23/08/2019	Floodgate	1	1.5			548578	6806502	-1.098	-1.022	Good	Primary	Rous County Council	One of three culverts.
4830	23/08/2019	Floodgate	1	1.5			548578	6806502	-1.022	-1.041	Good	Primary	Rous County Council	One of three culverts.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
5500	26/02/2020	Floodgate	2		2.4	2.2	548882	6808255	-1.714		Good	Primary	Rous County Council	Good condition. Fish kill observed on downstream side.
5550	23/08/2019	Floodgate	1	0.95			550034	6809203	-1.043	-1.037	Good	Secondary	Rous County Council	One of three culverts.
5550	23/08/2019	Floodgate	1	0.6			550034	6809203	-0.966	-1.006	Good	Secondary	Rous County Council	One of three culverts.
5550	23/08/2019	Floodgate	1	0.95			550034	6809203	-0.953	-1.041	Good	Secondary	Rous County Council	One of three culverts. Upstream invert from water level measurement.
5560	23/08/2019	Floodgate	1	0.9			549502	6809686	-0.575	-0.554	Fair	Secondary	Rous County Council	One of three culverts.
5560	23/08/2019	Floodgate	1	0.6			549502	6809686	-0.635	-0.603	Fair	Secondary	Rous County Council	One of three culverts.
5560	23/08/2019	Floodgate	1	0.9			549502	6809686	-0.606	-0.574	Fair	Secondary	Rous County Council	One of three culverts.
5570	23/08/2019	Floodgate	1		2.1*	2.1*	548996	6809867		-0.867*	Good	Secondary	Rous County Council	RTK unreliable for upstream measurements. Obvert measurerd on downstream.
5580	26/08/2019	Floodgate	1	0.9			548936	6810140	-0.715	-1.099*	Fair	Secondary	Rous County Council	One of three culverts.
5580	26/08/2019	Floodgate	1	0.9			548936	6810140	-0.736	-1.046*	Fair	Secondary	Rous County Council	One of three culverts.
5580	26/08/2019	Floodgate	1	0.9			548936	6810140	-0.674	-0.993*	Fair	Secondary	Rous County Council	One of three culverts.
5590	26/08/2019	Floodgate	1	0.9			548859	6810371		-0.411	Good	Secondary	Rous County Council	One of two culverts.
5590	26/08/2019	Floodgate	1	0.9			548859	6810371		-0.426	Good	Secondary	Rous County Council	One of two culverts.
5600	26/08/2019	Floodgate	1	0.9			548759	6810504	-0.693		Good	Secondary	Rous County Council	One of two culverts.
5600	26/08/2019	Floodgate	1	0.9			548759	6810504	-0.724		Good	Secondary	Rous County Council	One of two culverts.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
5610	26/08/2019	Floodgate	2	0.9			548663	6810750	-0.655		Good	Secondary	Rous County Council	
5620	26/08/2019	Floodgate	1	0.9			548657	6810816		0.438	Poor	Secondary	Rous County Council	Very blocked - does not appear to drain significant area.
5680	26/08/2019	Floodgate	1	0.375			548655	6810853		0.351	Poor	Secondary	Rous County Council	Very blocked. Drains paddock only.
5690	26/08/2019	Floodgate	1		1.8	1.25	548691	6811024	-0.611		Good	Secondary	Rous County Council	One of two culverts.
5690	26/08/2019	Floodgate	1		1.8	1.25	548691	6811024	-0.615		Good	Secondary	Rous County Council	One of two culverts.
5700	26/08/2019	Floodgate	1	0.9			548731	6811186	-0.116		Good	Secondary	Rous County Council	Services a narrow drain.
5710	26/08/2019	Floodgate	1	1			548680	6811473	-0.316		Good	Secondary	Rous County Council	
5720	26/08/2019	Floodgate	1	0.45*			548657	6811647	1.19	0.981*	Poor	Secondary	Rous County Council	Quiet blocked, paddock drainage.
5730	26/08/2019	Floodgate	1	0.375			548667	6811793		1.294	Good	Secondary	Rous County Council	Paddock drainage. Upstream had lots of weeds and was dry.
5740	26/08/2019	Floodgate	1	1.15			548565	6811933	-0.307		Good	Secondary	Rous County Council	Deep drain.
5750	26/08/2019	Floodgate	1	0.9			548508	6812062	0.076		Good	Secondary	Rous County Council	Short deep drain.
5760	26/08/2019	Floodgate	1	0.45			548541	6812258	0.985		Good	Secondary	Rous County Council	Downstream channel blocked, paddock drainage.
5770	26/08/2019	Floodgate	1	0.9			548549	6812297	-0.178		Good	Secondary	Rous County Council	Couldn't inspect downstream side.
5780	26/08/2019	Culvert	1	0.45			548449	6812506	1.726		Good	Secondary	Rous County Council	Much higher than nearer culverts - paddock drainage only.
5800	25/02/2020	Floodgate	2		1	2	555240	6814908	-1.073		Poor	Primary	Rous County Council	Left bank gate is a buoyancy gate. Right gate appears to have been opened or is broken.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
5810	29/08/2019	Floodgate	2		1	2	554978	6815361	-0.891	-1.196*	Good	Secondary	Rous County Council	
7030	28/10/2019	Floodgate	1	1.5			555206	6816230		0.054	Poor	Secondary	Rous County Council	Floodgate is leaking.
Lismore_29	26/08/2019	Floodgate	1	0.45			538456	6792111	-0.004		Good	Secondary	Lismore City Council	One of three culverts.
Lismore_29	26/08/2019	Floodgate	1	0.45			538456	6792111	0.036		Good	Secondary	Lismore City Council	One of three culverts.
Lismore_29	26/08/2019	Floodgate	1	0.45			538456	6792111	0.04		Good	Secondary	Lismore City Council	One of three culverts.
Lismore_41	26/08/2019	Floodgate	1	0.6			539590	6793315	1.528		Other	Secondary	Lismore City Council	Flap fallen off, upstream very blocked. No downstream channel . Poor RTK accuracy.
WRL_Rich_01	20/08/2019	Culvert	1	0.4			553648	6805426	0.828	0.648	Good	Secondary	Private/unknown	Under the road.
WRL_Rich_02	20/08/2019	Culvert	1	0.3			553671	6805450	0.783	0.827	Fair	Secondary	Private/unknown	20m from road. Drains to mangroves.
WRL_Rich_03	20/08/2019	Culvert	1	0.4			553380	6805526	0.558	0.561	Good	Secondary	Private/unknown	Culvert is under a road. There are trees on the downstream side. There is 0.15m of sediment in the bottom of the culvert.
WRL_Rich_04	20/08/2019	Culvert	1	0.38			553220	6805502	0.938	0.773	Good	Secondary	Private/unknown	Culvert is under a road. There are trees on the downstream side. Good condition.
WRL_Rich_05	20/08/2019	Floodgate	1	0.15			551747	6804681	0.682		Not available	Secondary	Private/unknown	Could not find the downstream side of the culvert. Possibly under rock protection.
WRL_Rich_06	20/08/2019	Culvert	4	0.92			551867	6804171	-0.2	-0.136	Good	Secondary	Private/unknown	Detailed survey available for individual invert levels for each culvert.
WRL_Rich_07	20/08/2019	Floodgate	1	0.22			551870	6804180	0.887	0.913	Fair	Secondary	Private/unknown	Side drain. Upstream side is half blocked.
WRL_Rich_08	20/08/2019	Floodgate	1	0.22			551869	6804164	0.628	0.637	Fair	Secondary	Private/unknown	Side drain. Upstream side is half blocked.
WRL_Rich_09	21/08/2019	Floodgate	1	0.23			551667	6803508	0.709	0.233	Other	Secondary	Private/unknown	Culvert is under private property. The flap is partially destroyed.
WRL_Rich_10	21/08/2019	Culvert	3	0.75			551061	6802799	-0.368	-1.053	Good	Secondary	Private/unknown	Culverts are under the road. No flaps.
WRL_Rich_11	21/08/2019	Culvert	1	0.5			550951	6802727	0.248	0.065	Poor	Secondary	Private/unknown	Culvert is under a road. Downstream culvert is blocked with a 0.05m gap at the top.
WRL_Rich_12	21/08/2019	Culvert	1	0.6			549861	6802027	0.117	0.009	Fair	Secondary	Private/unknown	The floodgate is in good condition, however, upstream culvert has extensive concrete cracks
WRL_Rich_13	21/08/2019	Floodgate	1	0.29			549866	6802034	0.921	0.503	Fair	Secondary	Private/unknown	

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
WRL_Rich_14	21/08/2019	Floodgate	1	0.35			549857	6802020	0.448	0.277	Fair	Secondary	Private/unknown	
WRL_Rich_15	21/08/2019	Culvert	1	0.39			549664	6801683	1.24	1.115	Fair	Secondary	Private/unknown	Culvert beside a road. Dowstream concrete culvert has broken edges.
WRL_Rich_16	21/08/2019	Culvert	1	0.39			549665	6801682	1.115	1.389	Fair	Secondary	Private/unknown	Culvert under a road. Dowstream concrete culvert has broken edges.
WRL_Rich_17	21/08/2019	Culvert	1	0.76			548889	6801132	0.069	-0.231	Good	Secondary	Private/unknown	
WRL_Rich_18	21/08/2019	Floodgate	1	0.29			548885	6801127	0.664	0.518	Good	Secondary	Private/unknown	Culvert is parallel to the road.
WRL_Rich_19	21/08/2019	Floodgate	1	0.375			548732	6800958	0.29	0.179	Other	Secondary	Private/unknown	Located downstream of 0600. The flap is concrete and has been infilled with sediment so is permanently closed. There is some leakage around its edges.
WRL_Rich_20	21/08/2019	Culvert	1	0.375			548132	6800112	0.619	0.401	Poor	Secondary	Private/unknown	Downstream of structure 0670-031-01. There is a 0.2 m gap at the top of culvert on the downstream side due to sediment build-up.
WRL_Rich_21	22/08/2019	Culvert	1	0.375			549370	6801435	0.389	0.873	Poor	Secondary	Private/unknown	On the upstream side half of the culvert was blocked with mud.
WRL_Rich_22	22/08/2019	Culvert	1	0.6			547931	6799754	0.199	0.007	Fair	Secondary	Private/unknown	Culvert is under a road. Culvert is located downstream of structure 0695. Originally a 0.6m diameter culvert, however a 0.35m diameter culvert has been retrofitted on the downstream side.
WRL_Rich_23	22/08/2019	Culvert	1	0.6			547727	6799479	0.08	0.139	Good	Secondary	Private/unknown	Culvert is located under a road downstream of structure 0760. There is 0.2m of sediment in the bottom of the culvert.
WRL_Rich_24	22/08/2019	Culvert	1	0.9			547629	6799251	0.196	0.107	Good	Secondary	Private/unknown	There is 0.4 m of sediment in the bottom of the culvert. Culvert is located downstream of structure 0770.
WRL_Rich_25	22/08/2019	Culvert	1	0.85			547586	6799110	0.071	0.076	Good	Secondary	Private/unknown	
WRL_Rich_26	22/08/2019	Floodgate	1	0.23			547586	6799108		0.938	Poor	Secondary	Private/unknown	Floodgate flap has been partially destroyed.
WRL_Rich_27	22/08/2019	Floodgate	1	0.23			547588	6799112		0.961	Fair	Secondary	Private/unknown	Flap is corroded at the base.
WRL_Rich_28	22/08/2019	Culvert	1	0.6			547503	6798730	0.433	0.355	Poor	Secondary	Private/unknown	Dowstream culvert has many broken edges
WRL_Rich_29	22/08/2019	Floodgate	1	0.6			546579	6797604	0.141	-0.44	Good	Secondary	Private/unknown	Culvert is under a road.
WRL_Rich_30	22/08/2019	Floodgate	1	0.25			546581	6797605	0.478		Not available	Secondary	Private/unknown	Culvert is next to a road.
WRL_Rich_31	23/08/2019	Culvert	1	0.9			545857	6796894	-0.242	-0.316	Poor	Secondary	Private/unknown	Culvert is under a road. Downstream structure 0990. Top section of culvert has started to fall off.
WRL_Rich_32	24/08/2019	Culvert	1	0.75			545870	6796903	0.686	0.536	Good	Secondary	Private/unknown	Culvert is under a road.

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
WRL_Rich_33	22/08/2019	Floodgate	1	0.325			545861	6796916	0.465		Poor	Secondary	Private/unknown	Culvert is parallel to the road. Approximate size due to sediments at base of the culvert. The downstream side of the culvert was not found - appears to be covered in rocks. Could not determine if it had a flap on it.
WRL_Rich_34	22/08/2019	Culvert	1	0.9			545806	6797427	-0.148	-0.259	Good	Secondary	Private/unknown	One of two culverts.
WRL_Rich_34	22/08/2019	Culvert	1	0.9			545806	6797427	-0.136	-0.257	Good	Secondary	Private/unknown	One of two culverts.
WRL_Rich_35	23/08/2019	Floodgate	1	0.6			549113	6801816	-0.51		Poor	Secondary	Private/unknown	Culvert is under a road. Pipe is buried on the downstream side - the outlet could not be located.
WRL_Rich_36	23/08/2019	Floodgate	1	0.15			549112	6801816		0.558	Good	Secondary	Private/unknown	Small pipe.
WRL_Rich_37	23/08/2019	Culvert	1	0.6			548813	6806556	-0.499	-0.519	Poor	Secondary	Private/unknown	Crest of weir over the top of the culvert is at 0.974m AHD.
WRL_Rich_38	26/08/2019	Culvert	2		3.4	2.8	548654	6810830		-1.121	Good	Secondary	Private/unknown	
WRL_Rich_38	26/08/2019	Culvert	2		3.4	2.8	548654	6810830		-1.053	Good	Secondary	Private/unknown	
WRL_Rich_39	27/08/2019	Floodgate	1	0.375			548738	6811346		0.838	Good	Secondary	Private/unknown	Dry and quite weedy.
WRL_Rich_40	26/08/2019	Culvert	4	0.9			537208	6789843		-0.485	Poor	Secondary	Private/unknown	Immediately D/S of 3370. Flaps either removed or open. Floodgates in poor conditions.
WRL_Rich_41	26/08/2019	Culvert	1	0.6			539811	6791464	1.844		Good	Secondary	Private/unknown	Dry upstream and downstream.
WRL_Rich_42	26/08/2019	Floodgate	1	0.45			540685	6790486		1.475	Good	Secondary	Private/unknown	Upstream side has a T section which allows flow into the culvert perpendicular to the direction it travels. The downstream side was dry with lots of weeds.
WRL_Rich_43	29/08/2019	Culvert	3	0.9			544982	6792755	-0.274		Fair	Primary	Private/unknown	Invert level set as 0.1m below water level measurement. Observed water flowing upstream through culvert. Observed from downstream side that there were no floodgate flaps. Bush too dense to access cuvert for survey from downstream side. Appears that new 0.9m culverts have been retrofitted inside of larger culverts (possibly 1.5m diameter).
WRL_Rich_44	28/10/2019	Floodgate	1	0.45			555787	6816849	-0.421		Good	Secondary	Private/unknown	
WRL_Rich_45	28/10/2019	Floodgate	2	1.5			555839	6816946	1.281		Good	Secondary	Private/unknown	
WRL_Rich_46	28/10/2019	Floodgate	1	0.6			554430	6816673	-0.423		Good	Secondary	Private/unknown	Only invert measured (no dimensions). Diameter estimated from photo.
WRL_Rich_47	28/10/2019	Floodgate	2	0.45			554388	6816966		0.107	Good	Secondary	Private/unknown	

Structure ID*	Date/time surveyed	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m) GDA94	Northing (m) GDA94	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Condition	Category	Tenure	Comment
WRL_Rich_48	30/10/2019	Floodgate	1	0.9			551271	6811545	-0.671		Poor	Secondary	Private/unknown	Floodgate was leaking. Number of culverts assessed from Nearmap as not specified.
WRL_Rich_49	30/10/2019	Floodgate	1	0.75			551302	6812192	-0.735		Not available	Secondary	Private/unknown	Dimensions, invert and number of culverts are approximate due to difficult access.
WRL_Rich_50	4/11/2019	Floodgate	1	0.75			524965	6783841	-0.187		Good	Secondary	Private/unknown	Sluice gate is blocking the culvert. Appears to be for managing acid sulfate soil. Number of culverts taken from photo - not in log sheet.
WRL_Rich_51	29/01/2020	Floodgate	2	0.9			535488	6789270	-0.698		Good	Secondary	Private/unknown	Good condition. There is a separate pump which can be used to pump water from the drain when the downstream water level is high.
WRL_Rich_52	30/01/2020	Weir	1		1.2		521488	6791612			Good	Secondary	Private/unknown	Drop board weir structure with crest elevation of 1.606m AHD. Installed to hold water in the swamp area.
WRL_Rich_53	31/01/2020	Floodgate	1	0.9			550677	6805035	-0.686		Good	Secondary	Private/unknown	Within private property (near RA_11). Upstream of structure 4700.
WRL_Rich_54	31/01/2020	Floodgate	1	0.6			550336	6806508	-0.554		Other	Secondary	Private/unknown	Downstream side was underwater at time of survey.
WRL_Rich_55	28/02/2020	Floodgate	1	1.2			531825	6781246	-0.393		Good	Primary	Private/unknown	Good condition. Winched open.
WRL_Rich_56	23/08/2019	Culvert	1	0.6			548814	6806559	-0.431		Poor	Secondary	Private/unknown	

Note: Structure IDs have been provided by Rous County Council or Lismore City Council. If a structure was identified that did not have a local council ID it has been given a WRL ID (WRL_Rich_##).

* Dimension or invert measurement has been cross-checked with other survey data by NCLS or Abbott and Marco and the alternate value has been selected over the value measured by WRL.

Table F-4: Summary of existing data

Structure ID	Date	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Category	Tenure	Dimension data source	Invert data source	Comment
10	29/04/2022	Floodgate	6		1.23	1.22	554565	6805017	-0.40 to -0.43	-0.56 to -0.57	Primary	Rous County Council	WRL (2019)	WRL (2019)	
90	29/04/2022	Floodgate	1	0.3			554195	6805353		0.643	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, pipe cracked, no headwall
100	29/04/2022	Floodgate	1	0.3			554037	6805424		0.41	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate partly open, fair condition, no headwall
110	29/04/2022	Floodgate	1	1.2			553868	6805429		-1.023	Primary	Rous County Council	NCLS Surveyors	NCLS Surveyors	No gate, no headwall
1010	6/05/2022	Floodgate	2	0.825			545163	6796243		-0.258	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, fair condition, no headwall
1010	6/05/2022	Floodgate		1.6			545164	6796245		-0.72	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, fair condition, no headwall
1020	6/05/2022	Tidal Flushing Gate	1	0.675			545050	6796069		0.05	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, fair condition, has headwall
1030	6/05/2022	Floodgate	1	0.3			545042	6795902		0.246	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate open and blocked, no headwall
1040	6/05/2022	Tidal Flushing Gate	3	1.6			545045	6795638		-1.098	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
1040	6/05/2022	Tidal Flushing Gate		1.8			545044	6795640		-1.116	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
1040	6/05/2022	Tidal Flushing Gate		0.55			545045	6795636		-0.403	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
1050	6/05/2022	Floodgate	1	0.825			544992	6795486		0.377	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, fair condition, has headwall
1060	6/05/2022	Tidal Flushing Gate	1	0.45			544972	6795426		0.57	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Outlet only, no gate
1070	25/05/2022	Floodgate	1	0.9			544954	6795330		-0.332	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate blocked with debris, fair condition, has headwall
1075	25/05/2022	Floodgate	1	0.6			544930	6795144		1.27	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, has headwall
1100	6/05/2022	Floodgate	1	1.05			545022	6794248		-0.307	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Broken gate, pipe average, no headwall
1110	25/05/2022	Floodgate		0.75			545029	6794027			Secondary	Rous County Council	Rous County Council		Not found
1120	6/05/2022	Floodgate	1	0.9			545031	6793795		0.254	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, fair condition, no headwall
1130	6/05/2022	Floodgate	1	0.9			545006	6793750		1.062	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Underwater, gate broken, has headwall
1140	6/05/2022	Floodgate	1	0.75			545000	6793533		-0.302	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, has headwall

Structure ID	Date	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Category	Tenure	Dimension data source	Invert data source	Comment
1150	25/05/2022	Floodgate	2	1.2			545069	6793295		-0.714	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Underwater, only top of gate visible
1150	25/05/2022	Floodgate		1.2			545069	6793297		-0.688	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Underwater, only top of gate visible
1160	25/05/2022	Floodgate	1	0.6			545049	6793212		0.099	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate and pipe in fair condition, has headwall
1170	25/05/2022	Floodgate	1	0.45			545030	6792982		0.309	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate in good condition
1200	6/05/2022	Floodgate	3	1.8			544815	6792601		-0.82	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
1200	6/05/2022	Floodgate		1.8			544817	6792604		-0.738	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
1200	6/05/2022	Floodgate		1.8			544818	6792606		-0.751	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
1210	6/05/2022	Floodgate	1	0.45			544083	6792310		-0.353	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, hole in pipe, no headwall
1220	6/05/2022	Floodgate	1	0.975			543773	6792190		-0.063	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate part open with hinge rusted, has headwall
1230	6/05/2022	Floodgate	4	1.2			543371	6792094	-0.8	-0.598	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate part open, pipe cracked
1230	6/05/2022	Floodgate		1.2			543373	6792094	-0.8	-0.641	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate part open, pipe cracked
1230	6/05/2022	Floodgate		1.2			543376	6792095	-0.8	-0.607	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate part open, pipe cracked
1230	6/05/2022	Floodgate		1.2			543378	6792095	-0.8	-0.614	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate part open, pipe cracked
1240	6/05/2022	Floodgate	2	0.825			543204	6792063		-0.357	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, has headwall
1240	6/05/2022	Floodgate		0.825			543205	6792063		-0.324	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, has headwall
1250	6/05/2022	Floodgate	1	0.9			543007	6792037		0.019	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Fair condition, has headwall
1270	6/05/2022	Floodgate	1	0.375			541697	6790094		0.794	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate open and blocked, has headwall
1290	11/05/2022	Floodgate	2	2			540467	6790026		-0.509	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate part open, good condition, no headwall
1290	11/05/2022	Floodgate		2			540465	6790027		-0.573	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate part open, good condition, no headwall
1295	26/05/2022	Floodgate	1	0.6			539974	6790431		0.029	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate partly open underwater and in fair condition, no headwall
1310	11/05/2022	Floodgate	2	0.9			539497	6791316		-0.357	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate part open, good condition, no headwall

Structure ID	Date	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Category	Tenure	Dimension data source	Invert data source	Comment
1310	11/05/2022	Floodgate		0.9			539498	6791315		-0.327	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate part open, good condition, no headwall
1397	11/05/2022	Floodgate	1	0.6			537381	6786091		0.813	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
1400	11/05/2022	Tidal Flushing Gate	2		2.1	2.4	537172	6785759		-1.192	Secondary	Rous County Council	Rous County Council & NCLS Surveyors	NCLS Surveyors	Gate closed, good condition
1400	11/05/2022	Tidal Flushing Gate			2.1	2.4	537174	6785761		-1.2	Secondary	Rous County Council	Rous County Council & NCLS Surveyors	NCLS Surveyors	Gate closed, good condition
1410	11/05/2022	Floodgate	3	2.1			536948	6785420		-0.52	Primary	Rous County Council	NCLS Surveyors	NCLS Surveyors	
1410	11/05/2022	Floodgate		2.1			536950	6785422		-0.499	Primary	Rous County Council	NCLS Surveyors	NCLS Surveyors	
1410	11/05/2022	Floodgate		2.1			536952	6785424		-0.492	Primary	Rous County Council	NCLS Surveyors	NCLS Surveyors	
1420	11/05/2022	Floodgate	1	1.2			536011	6784866		0.541	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
1430	12/05/2022	Floodgate	3	1.2			535365	6784707		0.023	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
1430	12/05/2022	Floodgate		1.2			535368	6784708		-0.237	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
1430	12/05/2022	Floodgate		1.2			535370	6784708		-0.053	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
1440	26/05/2022	Floodgate	2		1.5	1.5	535038	6784621		0.095	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Fair condition, has headwall
1450	10/05/2022	Floodgate	1	0.6			533711	6784131		0.422	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate part open,fair condition, has headwall
1460	7/06/2022	Weir					532996	6782567	0.94	0.94	Primary	Rous County Council		BMT (2014)	
1565	26/05/2022	Floodgate		0.75			532674	6782409			Secondary	Rous County Council	Rous County Council		Not found
1590	26/05/2022	Floodgate		0.375			532192	6784481			Secondary	Rous County Council	Rous County Council		Not found, gone/burried
1600	12/05/2022	Floodgate	1	0.375			532134	6784592		2.364	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	No gate, pipe in good condition, has headwall
1610	12/05/2022	Floodgate	1	0.375			532105	6784651		2.377	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	No gate, pipe in good condition, has headwall
1620	12/05/2022	Floodgate	1	0.375			532071	6784737		1.747	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
1630	26/05/2022	Tidal Flushing Gate	1		2.4	2.4	532009	6784808		-0.142	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate partly open and in working condition
1640	12/05/2022	Floodgate	1	0.75			531867	6785144		1.387	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	No gate, pipe in good condition, has headwall

Structure ID	Date	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Category	Tenure	Dimension data source	Invert data source	Comment
1660	26/05/2022	Floodgate	1	1.2			531921	6785526		-1.394	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate partly blocked, pipe in fair condition
1670	12/05/2022	Floodgate	1	0.375			529926	6785155		2.309	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, blocked and overgrown, no headwall
1680	2/06/2022	Floodgate	1	0.45			529595	6784813		2.009	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Metal gate closed, good condition, no headwall
1690	2/06/2022	Floodgate	1	0.45			529477	6784686		2.034	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate blocked, fair condition, no headwall
1700	2/06/2022	Floodgate		0.375			529435	6784640			Secondary	Rous County Council	Rous County Council		Not found
1710	2/06/2022	Floodgate	1	0.45			529368	6784585		2.35	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate broken and open, pipe in fair condition, no headwall
1720	2/06/2022	Floodgate	1	0.3			529354	6784574		2.619	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate blocked and open, fair condition, no headwall
1730	2/06/2022	Floodgate	1	0.3			529284	6784518		2.495	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, fair condition, no headwall
1740	2/06/2022	Floodgate	1	0.375			529259	6784501		1.939	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
1750	2/06/2022	Floodgate	1	0.375			529242	6784477		1.934	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
1760	2/06/2022	Floodgate	1	0.375			529052	6784381		1.93	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Metal gate open and blocked by mud and debris, no headwall
1770	2/06/2022	Floodgate	1	0.6			528897	6784341		1.524	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, pipe blocked but in fair condition, no headwall
1850	3/06/2022	Floodgate	1	0.45			528031	6785224		0.957	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Metal gate and conc headwall in good condition
1910	3/06/2022	Floodgate	1	0.75			525638	6787788		0.402	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Metal gate in fair condition, no headwall
1920	3/06/2022	Floodgate	1	1.8			524770	6786353		0.246	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Metal gate in fair condition, no headwall
1930	3/06/2022	Floodgate	1	1.5			524630	6785328		0.152	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Metal gate in fair condition, no headwall
1970	8/06/2022	Floodgate	1	0.6			524311	6786594		1.363	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, fair condition, no headwall
1980	7/06/2022	Tidal Flushing Gate	1	1.8			524530	6786942		-0.905	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
2020	7/06/2022	Floodgate	1	0.6			523889	6788753		0.757	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed and in working order
2020	7/06/2022	box culvert	1		1.8	2.2	523887	6788753		-0.655	Secondary	Rous County Council	Rous County Council & NCLS Surveyors	NCLS Surveyors	Gate closed and in working order
2060	7/06/2022	Floodgate	1	0.6			525599	6788893		0.331	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Concrete gate open and partly blocked, has headwall

Structure ID	Date	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Category	Tenure	Dimension data source	Invert data source	Comment
2070	7/06/2022	Floodgate		1.2			527614	6789391			Secondary	Rous County Council	Rous County Council		Not found
2080	8/06/2022	Floodgate		0.3			527059	6789710			Secondary	Rous County Council	Rous County Council		Not found
2090	7/06/2022	Floodgate		0.6			526511	6790119			Secondary	Rous County Council	Rous County Council		INV not measured, gate closed and in good condition
2140	8/06/2022	Floodgate	1	0.825			528116	6792322		0.45	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, has headwall
2170	31/05/2022	Floodgate	1	0.375			526213	6797797		5.717	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate broken off and blocked pipe
2180	31/05/2022	Floodgate	1	0.6			526276	6797480		3.518	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
2210	17/05/2022	Floodgate	1	0.375			528318	6793879		4.071	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate blocked open, pipe in fair condition, no headwall
2220	17/05/2022	Floodgate	1	0.375			528773	6793716		1.937	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
2230	17/05/2022	Floodgate	1	1.2			528880	6793572		0.659	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
2240	9/06/2022	Floodgate	1	1.2			529266	6792723		0.852	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
2250	17/05/2022	Floodgate	1	0.225			529188	6794498		4.813	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Pipe smashed and broken, gate gone
2260	17/05/2022	Floodgate	3		1.8	1.5	529452	6794687		-0.173	Secondary	Rous County Council	Rous County Council & NCLS Surveyors	NCLS Surveyors	Gates closed and in working condition
2270	31/05/2022	Floodgate	1	1.2			529755	6795877		2.653	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gates part open fair condition, no headwall
2280	31/05/2022	Floodgate		0.6			529404	6796437			Secondary	Rous County Council	NCLS Surveyors		INV not surveyed, good condition, gate closed no headwall
2290	31/05/2022	Floodgate	1	0.525			528990	6797369		3.922	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate blocked open, pipe in fair condition, no headwall
2300	31/05/2022	Floodgate	1	1.05			529332	6797716		2.427	Primary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate partly open, good condition, has headwall
2310	31/05/2022	Floodgate		0.45			529727	6798179			Secondary	Rous County Council	Rous County Council		Not surveyed
2320	31/05/2022	Floodgate	1	0.375			528558	6798158		3.244	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, part of pipe detached, no headwall
2330	31/05/2022	Floodgate	1	0.75			527042	6798729		4.647	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Plastic pipe, gate closed, no headwall
2340	31/05/2022	Floodgate	1	0.375			527347	6798780		5.311	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headeall
2360	8/06/2022	Floodgate	1	0.45			528399	6798157		1.292	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headeall

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2570	1/06/2022	Floodgate	1	0.3			529243	6801660		4.011	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate in fair condition, no headwall
2590	1/06/2022	Floodgate	1	1.2			528350	6798676		3.156	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Concrete gate in poor condition, no headwall
2600	1/06/2022	Floodgate	1	1.8			529100	6798678		-0.015	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate in poor condition, no headwall
2610	1/06/2022	Floodgate		0.6			529840	6798152			Secondary	Rous County Council	Rous County Council	NCLS Surveyors	INV not surveyed, concrete gate blocked, no headwall
2620	1/06/2022	Floodgate	1	1.8			529852	6798104		0.916	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	metal gate, fair condition, no headwall
2630	1/06/2022	Floodgate	1	0.375			529575	6796565			Secondary	Rous County Council	NCLS Surveyors		No invert recorded, pvc pipe and metal gate, no headwall
2680	2/06/2022	Floodgate	1	0.9			530292	6794684		2.256	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Very old concrete gate, no headwall
2710	20/05/2022	Floodgate	1	0.6			529546	6794544		3.248	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
2720	2/06/2022	Floodgate	1	0.375			529593	6793609		3.452	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate in good condition, PVC pipe, no headwall
2725	2/06/2022	Floodgate	1	0.375			529904	6793351		3.907	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	metal gate in good condition, drain blocked, no headwall
2730	20/05/2022	Floodgate	1	0.3			529896	6792774		3.819	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
2740	20/05/2022	Floodgate	1	0.3			529840	6792683		3.933	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, has headwall
2750	20/05/2022	Floodgate	1	0.3			529803	6792641		4.285	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, has headwall
2760	20/05/2022	Floodgate	1	0.3			529776	6792617		4.223	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, has headwall
2770	20/05/2022	Floodgate	1	0.375			529755	6792588		3.203	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, partly blocked, no headwall
2780	20/05/2022	Floodgate	1	0.3			529631	6792477		4.494	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, has headwall
2790	20/05/2022	Floodgate	1	0.375			529599	6792456		2.384	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed and blocked by fallen tree, no headwall
2800	20/05/2022	Floodgate		0.375			529303	6792504			Secondary	Rous County Council	Rous County Council		Not found
2810	20/05/2022	Floodgate		0.375			529282	6792517			Secondary	Rous County Council	Rous County Council		Not found
2820	20/05/2022	Floodgate	1	0.375			529250	6792535		4.448	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
2830	20/05/2022	Floodgate	1	0.375			529210	6792559		3.735	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed and rusted, area overgrown, no headwall

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2840	20/05/2022	Floodgate		0.45			529183	6792573			Secondary	Rous County Council	Rous County Council		Not found
2850	20/05/2022	Floodgate	1	0.375			529102	6792610		2.331	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
2860	20/05/2022	Floodgate	1	0.375			528969	6792697		3.898	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
2870	20/05/2022	Floodgate	1	0.375			528938	6792720		3.82	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
2880	20/05/2022	Floodgate	1	0.375			528875	6792783		3.548	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
2890	17/05/2022	Floodgate	1	1.8			528280	6793347		0.586	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
2900	17/05/2022	Floodgate	1	0.3			528395	6793171		4.079	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
2910	17/05/2022	Floodgate	1	0.3			528684	6792532		1.821	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
2920	17/05/2022	Floodgate	1	0.375			528632	6792331		3.624	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, fair condition but blocked, no headwall
2930	6/06/2022	Floodgate	1	0.6			526576	6791080		-0.102	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Metal gate in fair condition, no headwall
2950	17/05/2022	Floodgate	1	0.825			527744	6787628		3.304	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, has headwall
3020	17/05/2022	Floodgate	1	0.45			532413	6787460		2.281	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate rusted, poor condition, no headwall
3030	10/05/2022	Floodgate	1	0.3			532453	6784554		0.985	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, has headwall
3040	10/05/2022	Floodgate	1	0.225			532588	6784372		2.598	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
3050	10/05/2022	Floodgate	1	0.375			532730	6784238		2.14	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate open, good condition, no headwall
3060	10/05/2022	Floodgate	1	0.6			532836	6784179		2.014	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, area overgrown, no headwall
3070	10/05/2022	Tidal Flushing Gate	1	0.6			532921	6784149		0.174	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, fair condition but blocked, has headwall
3080	10/05/2022	Floodgate	1	0.45			533052	6784217		1.578	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, has headwall
3090	10/05/2022	Floodgate	1	0.375			533717	6784397		1.615	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate open and blocked, no headwall
3100	10/05/2022	Floodgate	2	0.6			533923	6784620		0.358	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
3100	10/05/2022	Floodgate		0.6			533923	6784619		0.471	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall

Structure ID	Date	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Category	Tenure	Dimension data source	Invert data source	Comment
3118	10/05/2022	Floodgate	1	1.2			536653	6787326		-0.56	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate blocked and open, no headwall
3130	10/05/2022	Floodgate	1	0.45			536454	6788032		1.149	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate broken off, poor condition, no headwall
3140	10/05/2022	Floodgate	1	0.45			536420	6788347		1.063	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate blocked and open, no headwall
3150	10/05/2022	Floodgate	1	0.45			536427	6788548		0.906	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate blocked and open, no headwall
3160	10/05/2022	Floodgate	2	0.45			536464	6788885		0.342	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Conc gate in poor condition, headwall damaged
3160	10/05/2022	Floodgate		0.45			536464	6788885		0.349	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Conc gate in poor condition, headwall damaged
3330	10/05/2022	Floodgate	1	0.375			536576	6789239		1.259	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
3340	10/05/2022	Floodgate	1	0.375			536728	6789435		1.127	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
3350	10/05/2022	Floodgate	1	0.6			536915	6789597		0.385	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
3360	10/05/2022	Floodgate	1	0.375			537059	6789712		1.154	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
3680	12/05/2022	Floodgate	1	0.45			542032	6791060		0.203	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Good condition, gate closed, no headwall
3690	12/05/2022	Floodgate	1	0.45			541836	6791140		-0.05	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Good condition, gate closed, no headwall
3700	12/05/2022	Floodgate	1	0.375			541703	6791136		0.299	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Good condition, gate closed, no headwall
3710	12/05/2022	Floodgate	1	0.6			541527	6791168		0.251	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, fair condition, no headwall
3720	12/05/2022	Floodgate	1	0.6			541454	6791212		0.029	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, underwater and not visible
3730	12/05/2022	Floodgate	1	0.375			541357	6791276		0.405	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Good condition, gate closed, no headwall
3740	12/05/2022	Floodgate	1	0.6			541295	6791326		0.269	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Good condition, gate closed, no headwall
3750	12/05/2022	Floodgate	1	0.6			541216	6791401		-0.107	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, underwater and not visible
3760	6/06/2022	Floodgate	1	1.5			541010	6791588		-0.505	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Metal gate in fair condition with no headwall
3770	6/06/2022	Floodgate	1	1.2			540921	6791885		-0.055	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Metal gate in fair condition with no headwall
3780	6/06/2022	Floodgate	1	0.9			540855	6792318		-0.412	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	PVC gate in fair condition, no headwall

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3790	6/06/2022	Floodgate	1	0.9			540869	6792467		-0.319	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Metal gate in fair condition, no headwall
3800	25/05/2022	Floodgate		0.45			540538	6792912			Secondary	Rous County Council	Rous County Council		Not found
3810	25/05/2022	Floodgate	1	1.2			540181	6793050		-0.295	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, fair condition, no headwall
3830	6/06/2022	Floodgate	8		3.05	3.05	539479	6794217	-1.76	-1.73	Primary	Rous County Council	Rayner et al. (2020a)	Rayner et al. (2020a)	
4010	19/05/2022	Floodgate	1	1.2			543774	6792848		-0.033	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
4020	19/05/2022	Floodgate	1	0.825			544081	6793522		-0.487	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
4040	19/05/2022	Floodgate	1	0.825			544217	6794122		-0.475	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
4048	19/05/2022	Floodgate	1	1.05			544427	6794766		-0.42	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Part open, fair condition, has headwall
4060	19/05/2022	Tidal Flushing Gate	1	0.6			544510	6794887		0.785	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, fair condition, no headwall
4070	19/05/2022	Floodgate	1	0.6			544573	6795004		0.197	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, pipe has minor cracks, no headwall
4080	19/05/2022	Floodgate	1	0.6			544618	6795123		0.01	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, pipe has minor cracks, no headwall
4130	19/05/2022	Floodgate		0.6			544526	6796507			Secondary	Rous County Council	Rous County Council		Not found
4150	29/04/2022	Floodgate	2	0.9			546666	6799122		0.133	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gates closed and in good condition
4150	29/04/2022	Floodgate		0.9			546668	6799122		0.078	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gates closed and in good condition
4160	29/04/2022	Floodgate	1	0.6			547000	6799480		-1.86	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gates closed and in good condition, has headwall
4170	29/04/2022	Floodgate	1	0.3			547033	6799523		0.779	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate partly open, poor condition, no headwall
4180	29/04/2022	Floodgate	1	0.3			547112	6799611		0.744	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate partly open, average condition, no headwall
4190	29/04/2022	Floodgate	1	0.15			547160	6799658		1.297	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	PVC pipe blocked, gate closed and in fair condition
4200	29/04/2022	Floodgate	1	0.3			547221	6799700		0.697	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, fair condition, no headwall
4210	2/05/2022	Floodgate	1	0.45			547309	6799845		0.336	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed and part blocked, no headwall
4220	2/05/2022	Floodgate	1	0.225			547352	6799902		1.161	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate part open, good condition, no headwall

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4230	2/05/2022	Floodgate	1	0.225			547377	6799940		0.964	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate part open, good condition, no headwall
4240	2/05/2022	Floodgate	1	0.825			547410	6800119		0.039	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate part open, good condition, no headwall
4250	2/05/2022	Floodgate	1	0.15			547423	6800189		0.589	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate partly open, blocked, no headwall
4260	2/05/2022	Floodgate		0.225			547440	6800301			Secondary	Rous County Council	Rous County Council		Not found
4270	2/05/2022	Floodgate	1	0.375			547460	6800426		0.097	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate partly open and in fair condition, no headwall
4272	2/05/2022	Floodgate		0.225			547451	6800503			Secondary	Rous County Council	Rous County Council		Not found
4300	2/05/2022	Floodgate		0.225			547437	6800879			Secondary	Rous County Council	Rous County Council		Not found
4310	2/05/2022	Floodgate	1	0.3			547432	6800914		0.401	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, fair condition, no headwall
4320	2/05/2022	Floodgate	1	1.2			547425	6800998		-0.046	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate partly open, good condition, no headwall
4330	2/05/2022	Floodgate	1	0.6			547460	6801100		0.111	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
4340	2/05/2022	Floodgate	1	0.45			547465	6801147		0.299	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, pipe cracked and broken, no headwall
4344	2/05/2022	Floodgate	1	0.225			547490	6801285		0.708	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
4346	2/05/2022	Floodgate	1	0.225			547523	6801354		1.011	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate closed, good condition, no headwall
4350	2/05/2022	Floodgate	1	0.15			547580	6801425		1.189	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, good condition, no headwall
4545	2/05/2022	Floodgate		0.225			550049	6802837		0.477	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate open, pipe blocked, no headwall
4580	2/05/2022	Floodgate	1	1.2			550937	6803422		-0.949	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate part open, good condition, no headwall
4720	2/05/2022	Floodgate	1	0.25			550348	6805092		-0.308	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Condition unknown, underwater, no headwall
4810	31/05/2022	Floodgate	1	0.225			548922	6806497		0.031	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate blocked and in poor condition, has headwall
5410	6/06/2022	Tidal Flushing Gate	4		1.5	1.5	547750	6806454		-1.102	Primary	Rous County Council	Rous County Council	NCLS Surveyors	Metal gates in fair condition, has headwall
5480	15/06/2022	Floodgate	1	0.825			548842	6807905		-0.824	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed, underwater, condition fair, no headwall
5510	15/06/2022	Floodgate	1	0.6			549240	6808562		-0.505	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Underwater, gate closed, fair condition, no headwall

Structure ID	Date	Type	Number of Culverts	Diameter (m)	Width (m)	Height (m)	Easting (m)	Northing (m)	Upstream Invert (m AHD)	Downstream Invert (m AHD)	Category	Tenure	Dimension data source	Invert data source	Comment
5520	15/06/2022	Floodgate		0.6			549303	6808767			Secondary	Rous County Council	Rous County Council		Not found
5530	15/06/2022	Floodgate	1	0.6			549438	6808707			Secondary	Rous County Council	Rous County Council		Could not record measurements
5540	15/06/2022	Floodgate		0.6			550018	6808974			Secondary	Rous County Council	Rous County Council		Not found
5820	6/05/2022	Tidal Flushing Gate	1	0.9			554515	6816231		-0.504	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Fair condition, gate closed, no headwall
5830	6/05/2022	Floodgate	2	1.2			554615	6817564		-0.218	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Gate closed and blocked, no headwall
6990	30/05/2022	Floodgate	1	0.9			556069	6819454		-0.417	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Blocked gate, has headwall
7000	30/05/2022	Tidal Flushing Gate	1	1.2			555999	6819008		-0.576	Secondary	Rous County Council	NCLS Surveyors	NCLS Surveyors	Fair condition, no headwall
7010	30/05/2022	Floodgate	1	0.9			555770	6818111		0.167	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Fair condition, no headwall
7020	30/05/2022	Floodgate	1	1.8			555613	6817740		-0.441	Secondary	Rous County Council	Rous County Council	NCLS Surveyors	Gate ajar, average condition, no headwall

Table F-5 Summary table for structures that were not surveyed or have incomplete data

Structure ID	Easting	Northing	Sub-catchment	Comment
1110	545029	6794027	Empire Vale	Inspected, invert not surveyed
1565	532674	6782409	Rocky Mouth Creek	Inspected, invert not surveyed
1590	532192	6784481	Rocky Mouth Creek	Inspected, invert not surveyed
1700	529435	6784640	Swan Bay	Inspected, invert not surveyed
2070	527614	6789391	Bungawalbin Creek/Sandy Creek	Inspected, invert not surveyed
2080	527059	6789710	Bungawalbin Creek/Sandy Creek	Inspected, invert not surveyed
2090	526511	6790119	Bungawalbin Creek/Sandy Creek	Inspected, invert not surveyed
2280	529404	6796437	Upper Richmond/Wilsons River	Inspected, invert not surveyed
2310	529727	6798179	Upper Richmond/Wilsons River	Inspected, invert not surveyed
2610	529840	6798152	Upper Richmond/Wilsons River	Inspected, invert not surveyed
2630	529575	6796565	Upper Richmond/Wilsons River	Inspected, invert not surveyed
2800	529303	6792504	East Coraki	Inspected, invert not surveyed
2810	529282	6792517	East Coraki	Inspected, invert not surveyed
2840	529183	6792573	East Coraki	Inspected, invert not surveyed
3800	540538	6792912	Tuckean Swamp	Inspected, invert not surveyed
4130	544526	6796507	Back Channel	Inspected, invert not surveyed
4260	547440	6800301	Emigrant Creek/Maguires Creek	Inspected, invert not surveyed
4272	547451	6800503	Emigrant Creek/Maguires Creek	Inspected, invert not surveyed
4300	547437	6800879	Emigrant Creek/Maguires Creek	Inspected, invert not surveyed
5520	549303	6808767	Emigrant Creek/Maguires Creek	Inspected, invert not surveyed
5530	549438	6808707	Emigrant Creek/Maguires Creek	Inspected, invert not surveyed

Structure ID	Easting	Northing	Sub-catchment	Comment
5540	550018	6808974	Emigrant Creek/Maguires Creek	Inspected, invert not surveyed
Lismore_95	530045	6794470	Upper Richmond/Wilsons River	Not inspected
WRL_Rich_52	521488	6791612	Bungawalbin Creek/Sandy Creek	Inspected, invert not surveyed

Appendix G Cross-sections

During field investigations, floodplain drainage channels and waterways were surveyed opportunistically. Measurements were taken using Trimble GNSS RTK survey equipment as specified in Appendix A of Methods report (Rayner et al., 2023). Locations of cross-sectional measurements surveyed across the Richmond River floodplain are shown in Figure G-1. All sections were surveyed from left bank to right bank (when looking downstream). Table G-1 provides the start and end coordinates for each cross-section, and individual cross-section profiles are shown from Figure G-2 to Figure G-33.

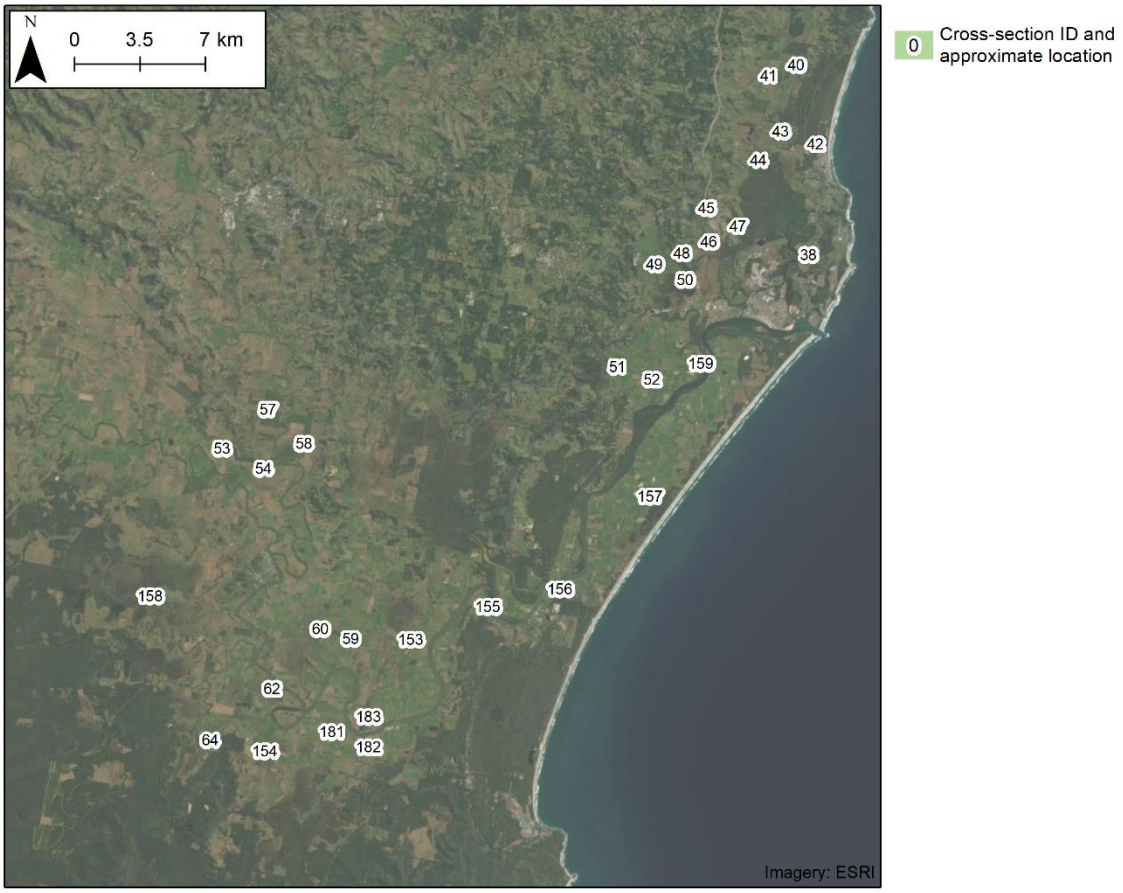


Figure G-1: General location of cross-sections surveyed on the Richmond River floodplain

Table G-1: Coordinates for the start and end of each cross-sections profile

Cross-section ID	Coordinates (GDA 1994 MGA 56)			
	Start easting (m)	Start northing (m)	End easting (m)	End northing (m)
38	556872.6	6809938.8	556856.3	6809926.4
40	556230.8	6820111.6	556202.2	6820115.8
41	555088.2	6820093.7	555087.1	6820082.2
42	555478.3	6816598.6	555469.4	6816599.4
43	555381.2	6816537.4	555363.9	6816551.6
44	554175.3	6815059.3	554173.0	6814978.9
45	551402.4	6812436.1	551384.8	6812415.6
46	551176.3	6812432.6	551154.7	6812429.6
47	551313.5	6812184.7	551293.7	6812201.8
48	551119.0	6811581.2	551116.9	6811571.6
49	548591.9	6809426.6	548584.4	6809408.3
50	548466.9	6809319.7	548450.6	6809313.4
51	546610.0	6803916.1	546626.9	6803912.7
52	546676.2	6803981.3	546674.5	6803965.6
53	525353.3	6799540.3	525408.1	6799533.8
54	527607.3	6798460.8	527593.6	6798475.7
57	527849.0	6801641.6	527843.1	6801604.1
58	529782.2	6799778.9	529781.9	6799814.0
59	530508.9	6790049.1	530499.5	6790044.9
60	530659.5	6789843.2	530641.6	6789850.5
62	528038.7	6786641.1	528078.8	6786624.4
64	524729.6	6783871.8	524732.1	6783890.5
153	535494.1	6789284.0	535485.1	6789284.7
154	527649.3	6783289.0	527666.0	6783294.4
155	539631.8	6791037.0	539638.6	6791039.6
156	543502.0	6791977.0	543503.1	6791987.9
157	548338.8	6796970.4	548349.9	6796971.3
158	521498.3	6791607.3	521486.4	6791600.9
159	551068.4	6804098.5	551076.6	6804097.1
181	531278.9	6784313.5	531280.3	6784325.4
182	531256.6	6784329.7	531255.7	6784317.8
183	531260.6	6784339.0	531272.2	6784336.7

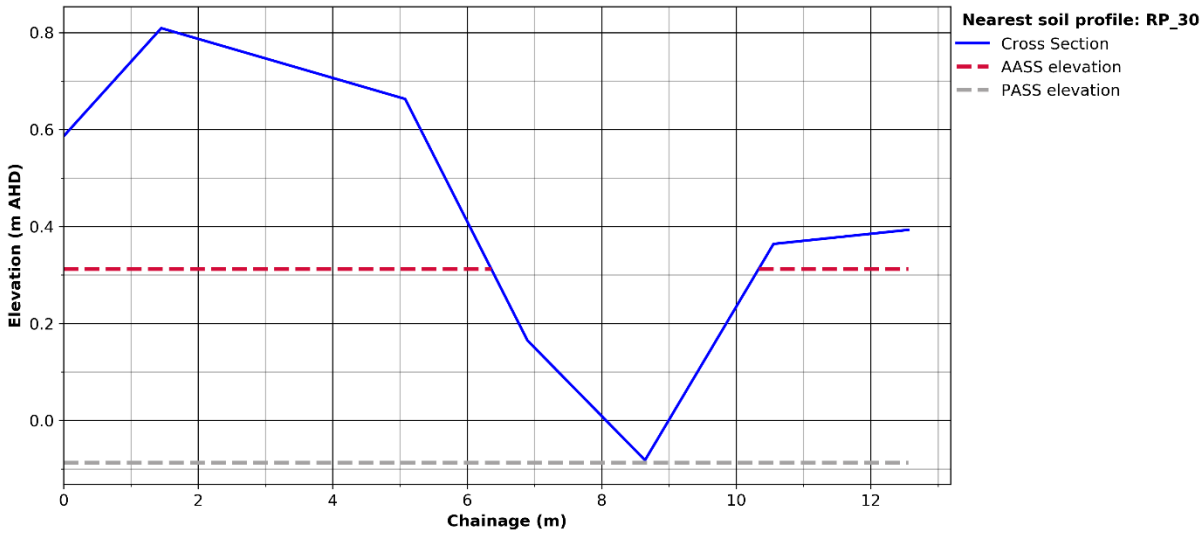


Figure G-2: Richmond cross-section 38

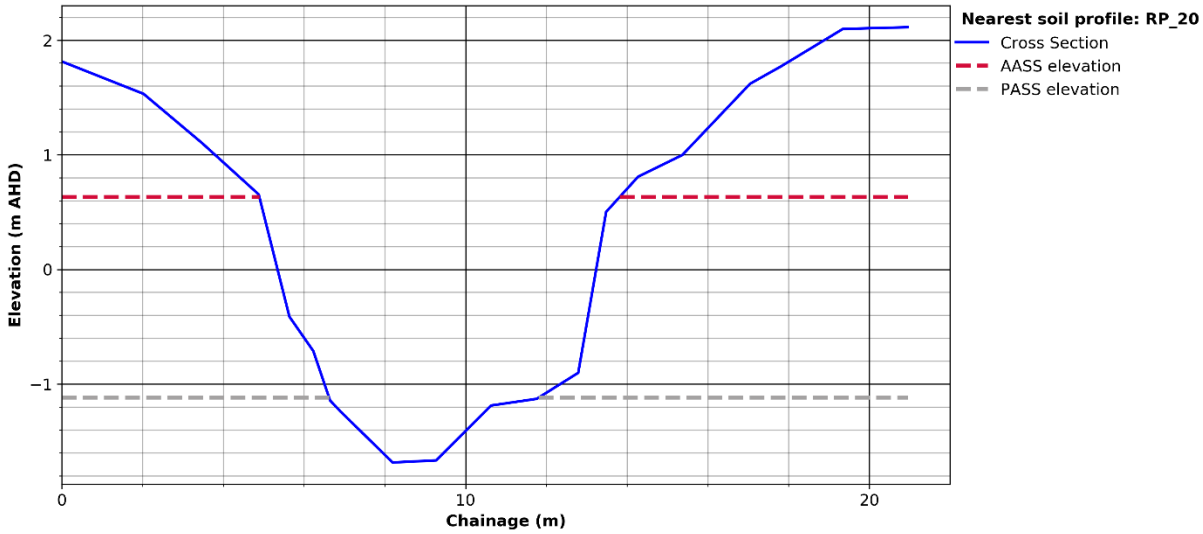


Figure G-3: Richmond cross-section 40

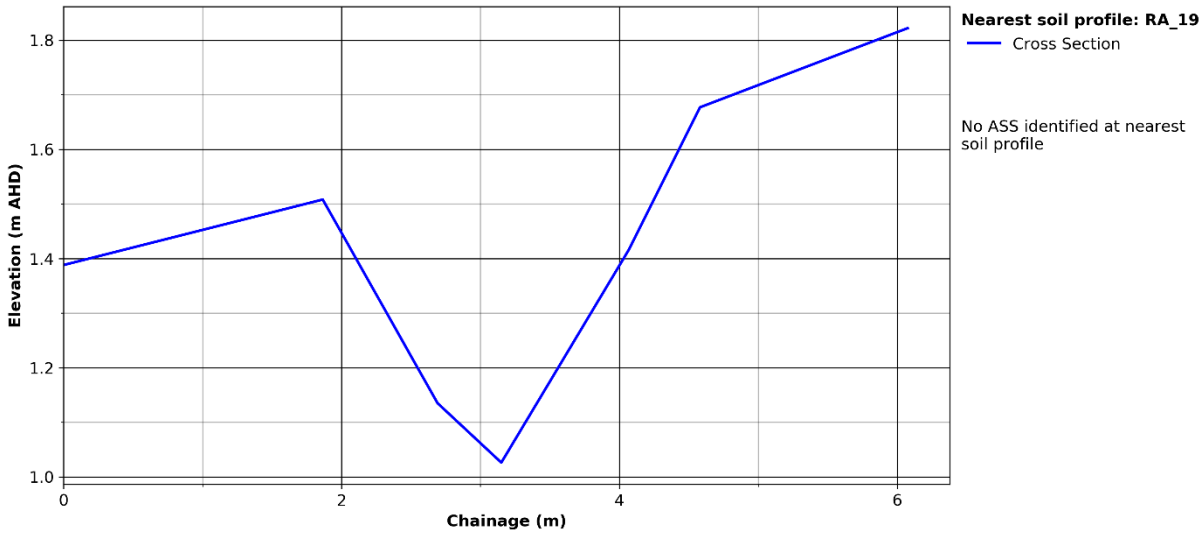


Figure G-4: Richmond cross-section 41

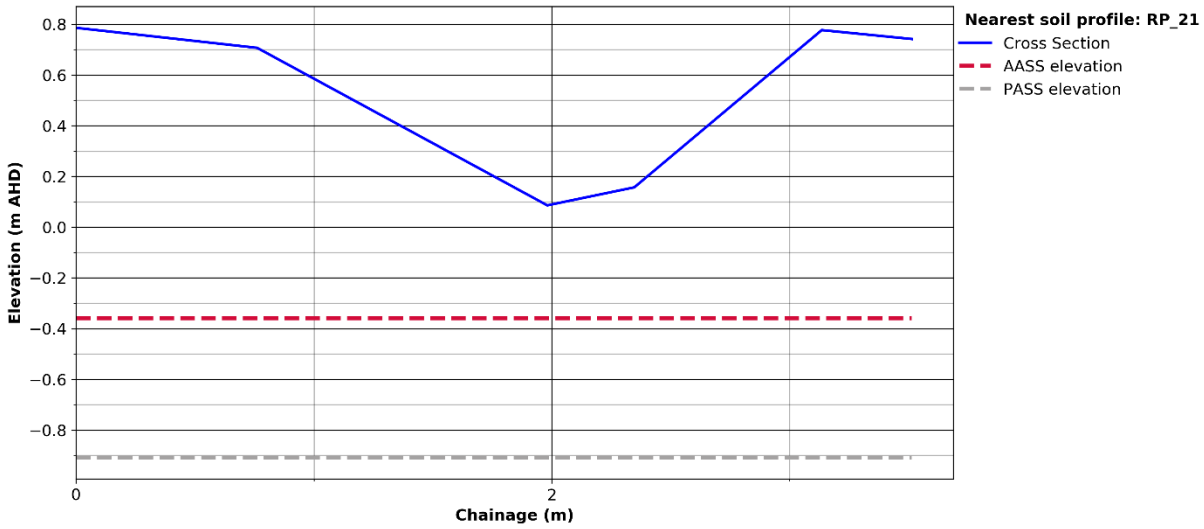


Figure G-5: Richmond cross-section 42

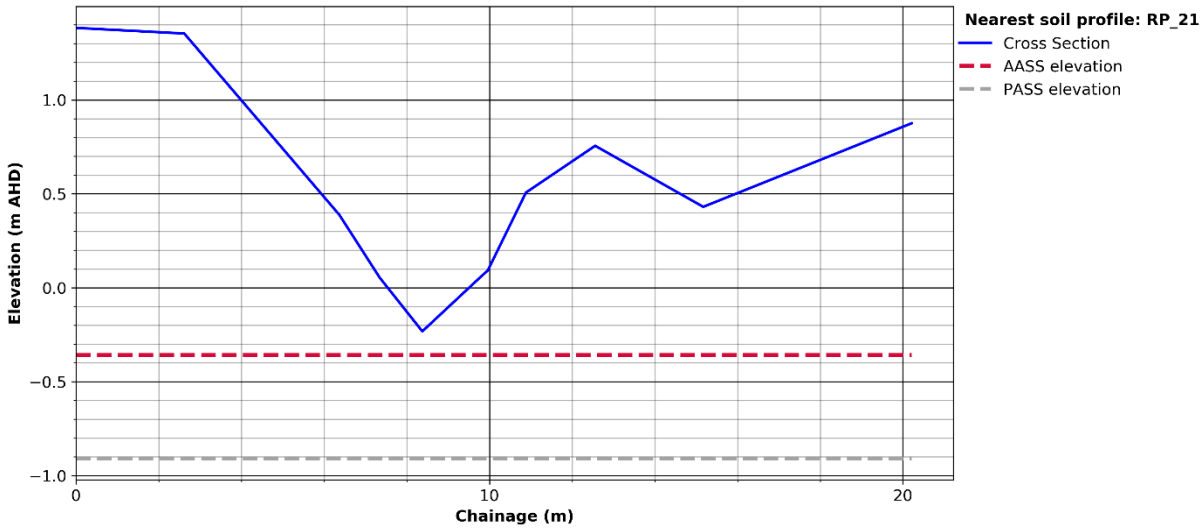


Figure G-6: Richmond cross-section 43

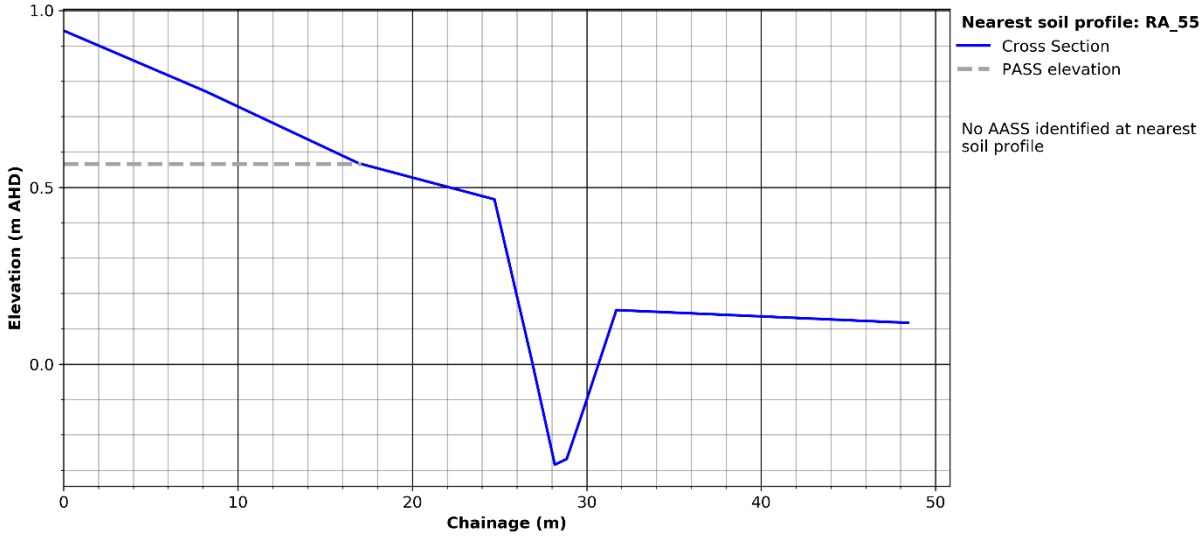


Figure G-7: Richmond cross-section 44

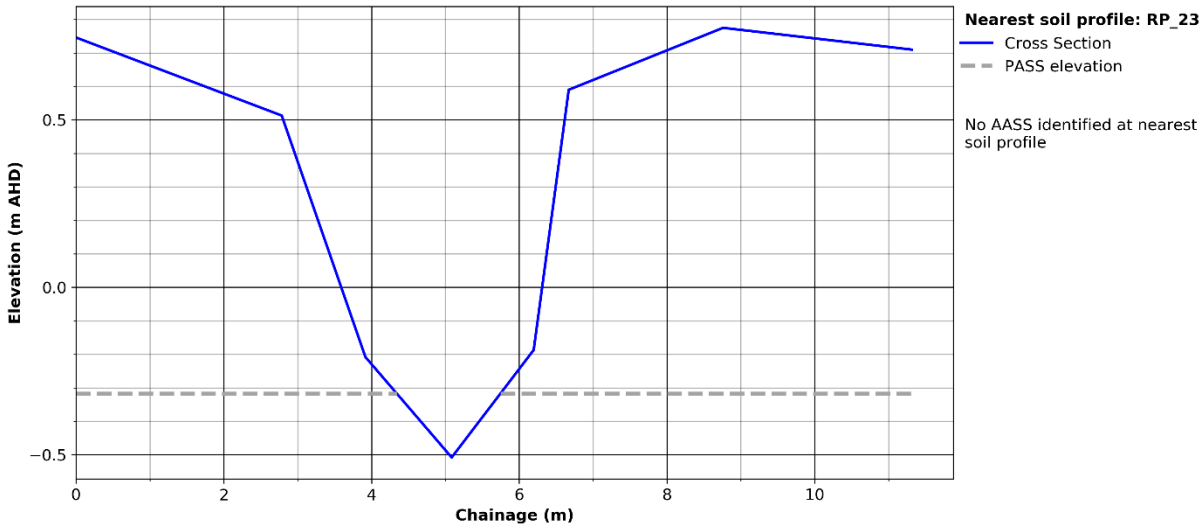


Figure G-8: Richmond cross-section 45

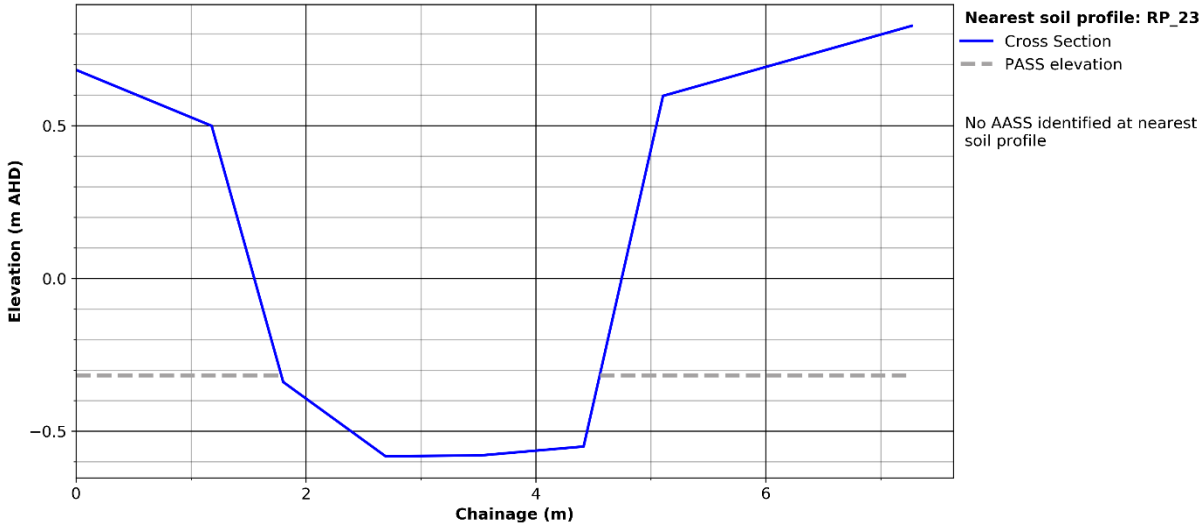


Figure G-9: Richmond cross-section 46

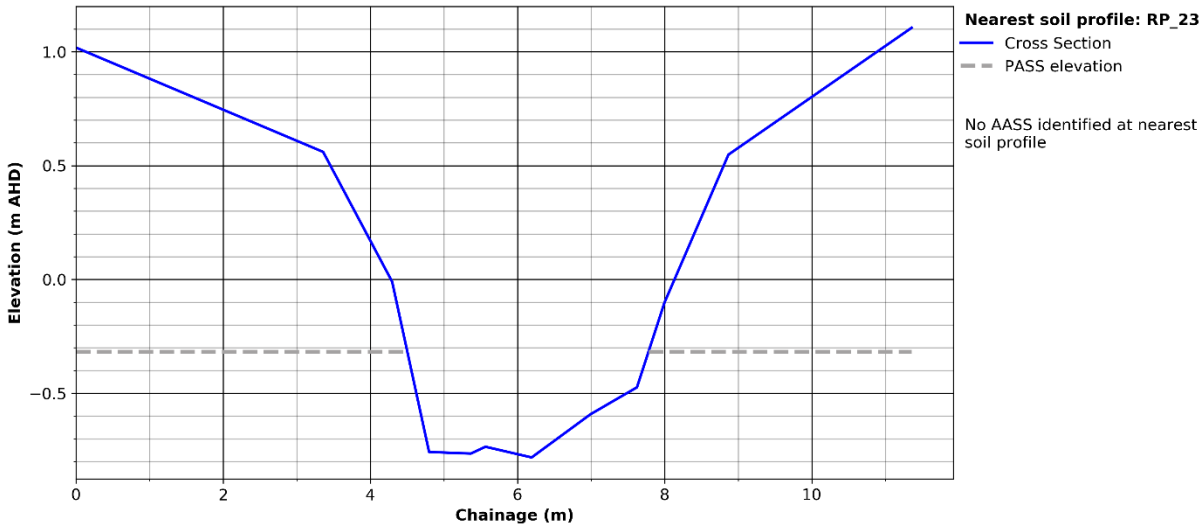


Figure G-10: Richmond cross-section 47

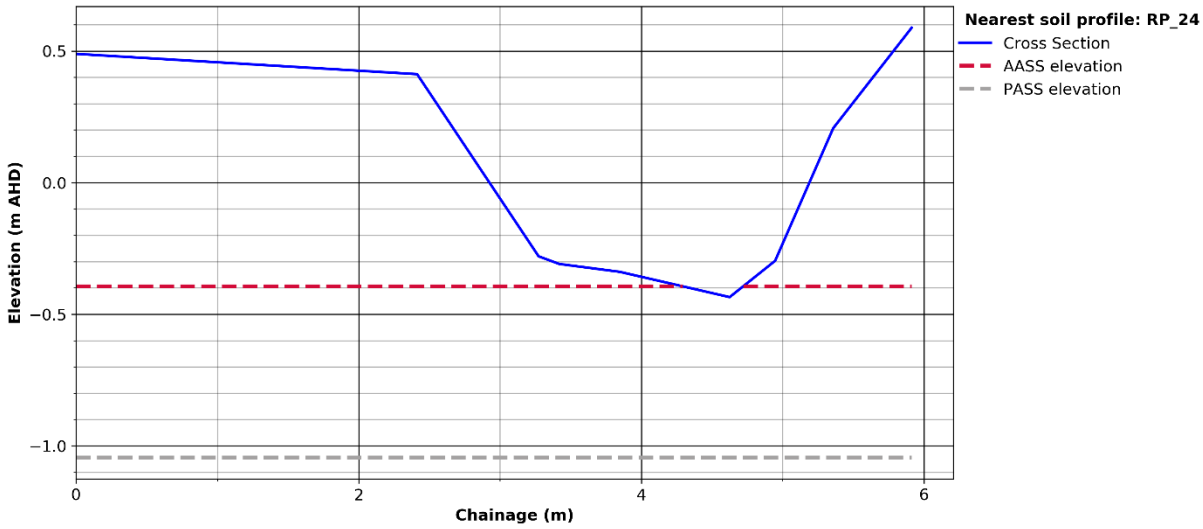


Figure G-11: Richmond cross-section 48

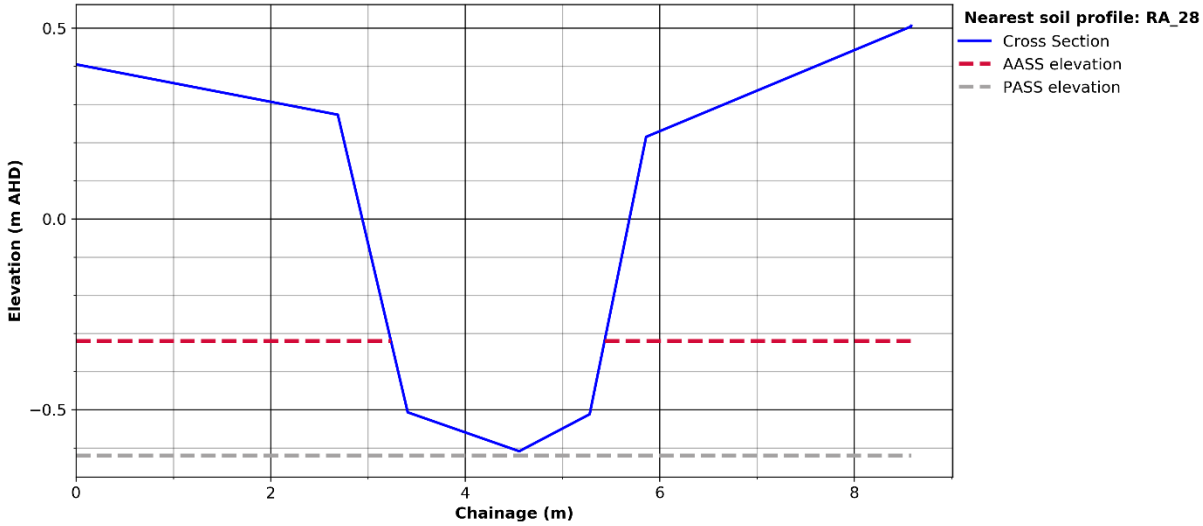


Figure G-12: Richmond cross-section 49

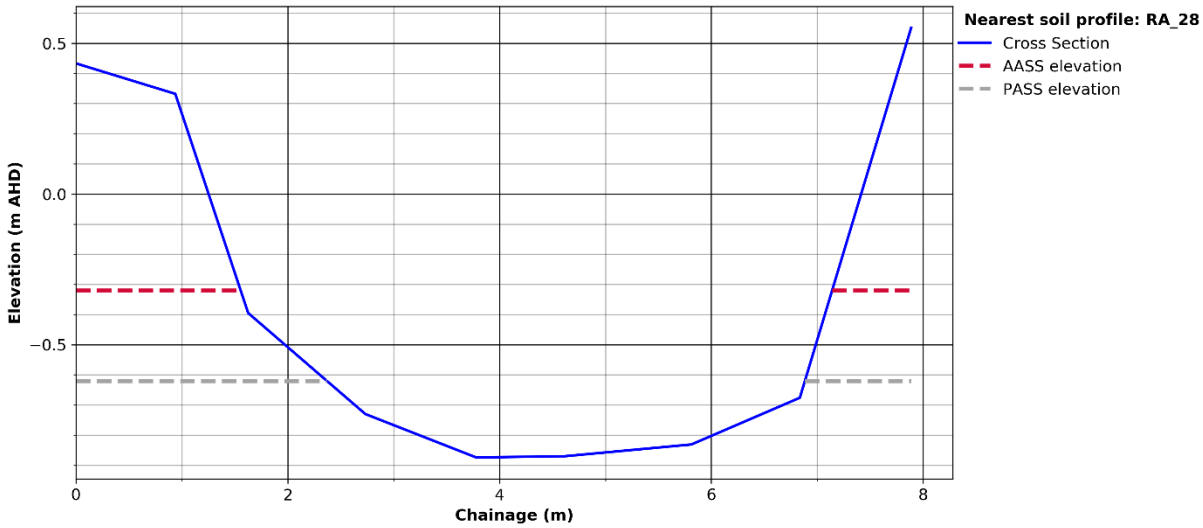


Figure G-13: Richmond cross-section 50

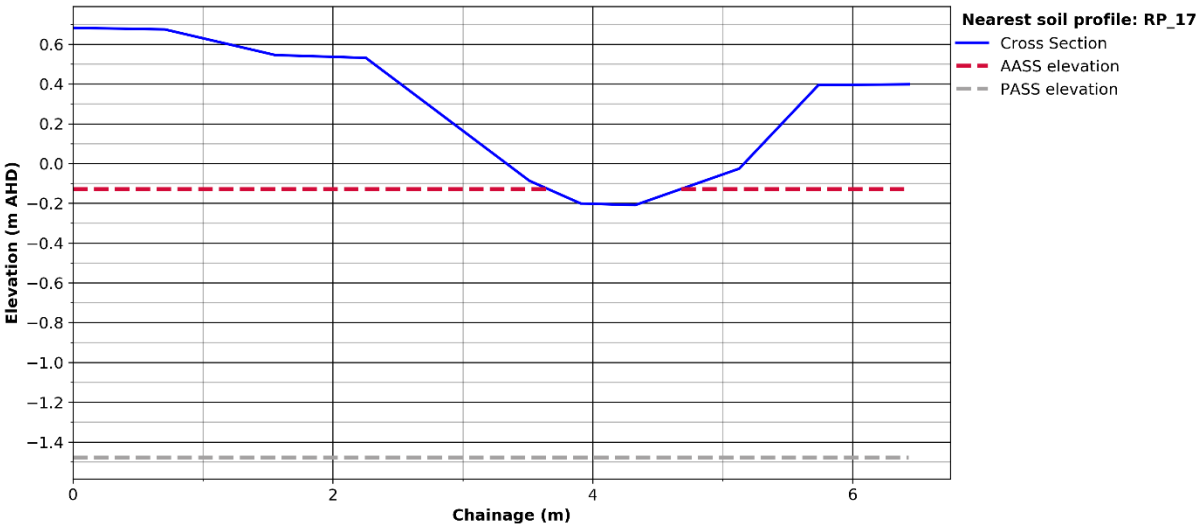


Figure G-14: Richmond cross-section 51

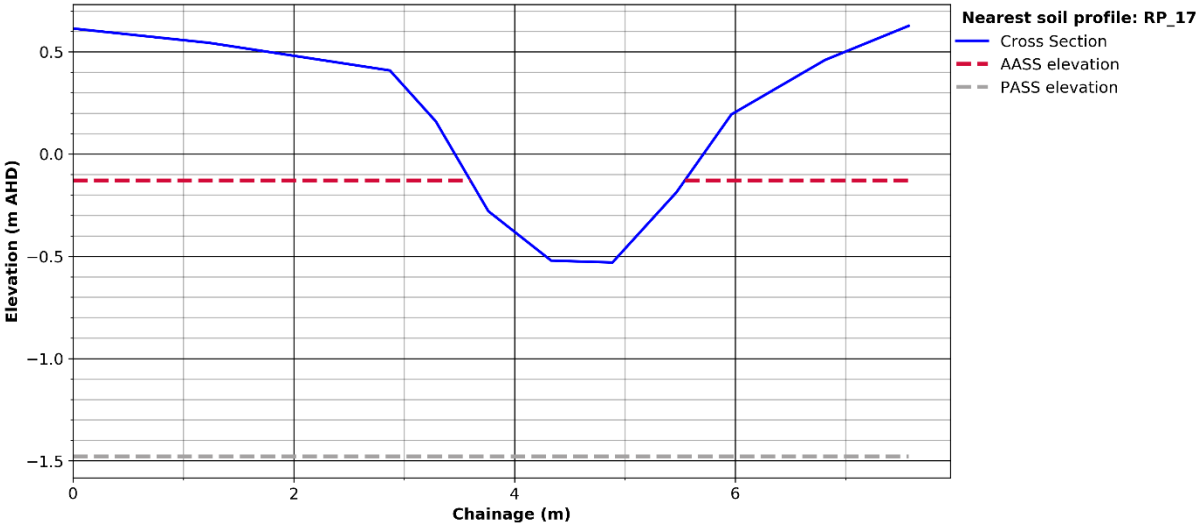


Figure G-15: Richmond cross-section 52

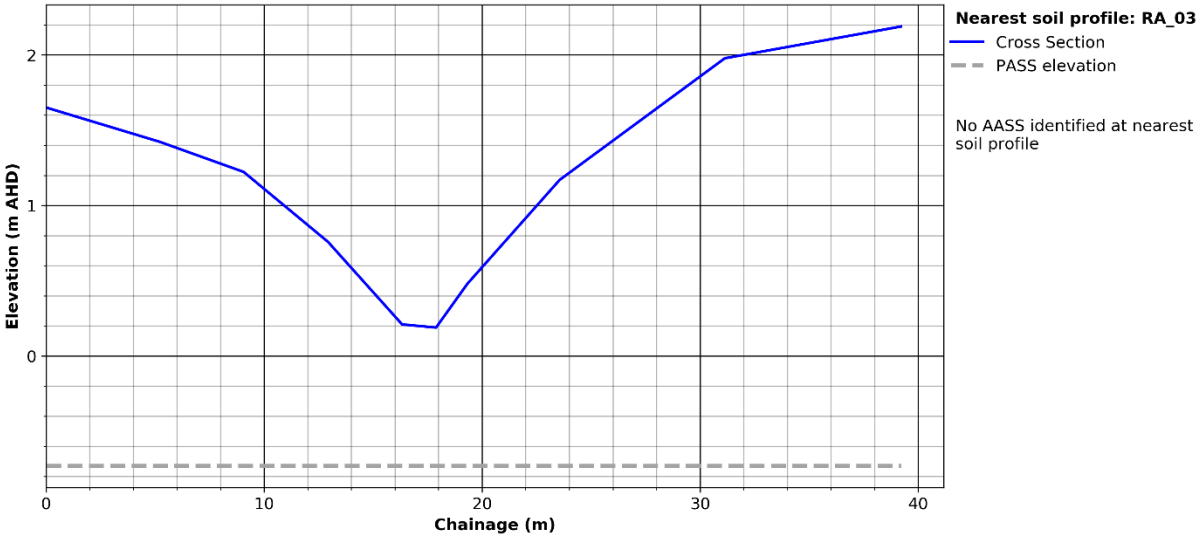


Figure G-16: Richmond cross-section 53

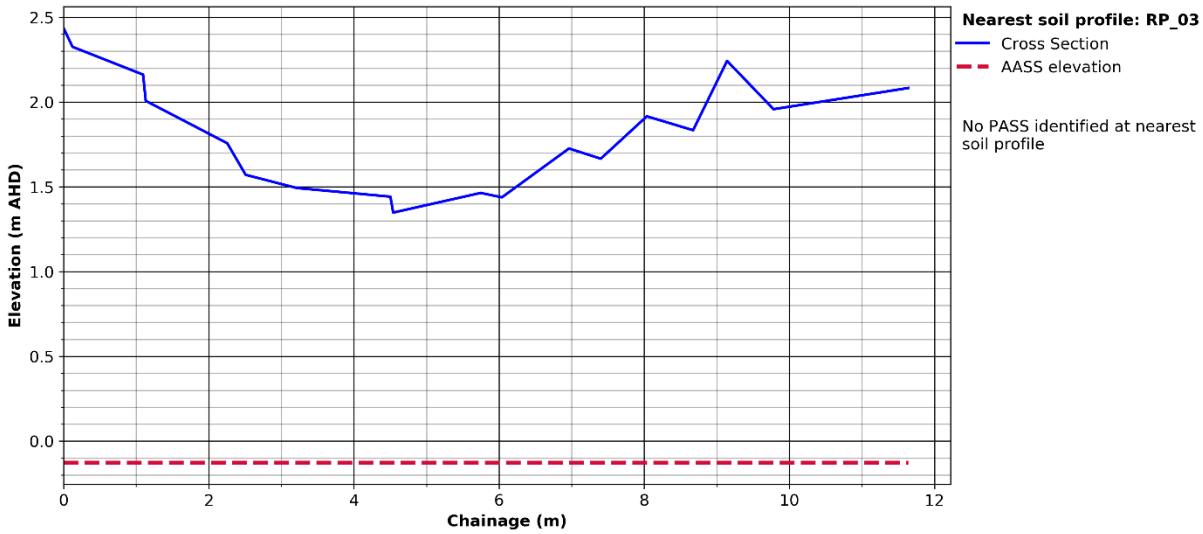


Figure G-17: Richmond cross-section 54

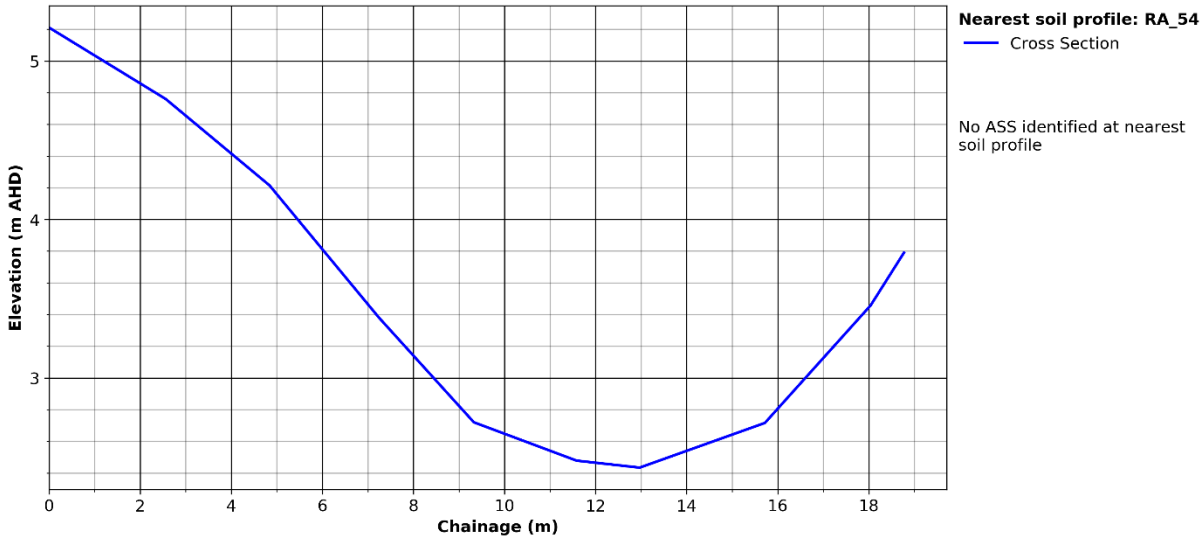


Figure G-18: Richmond cross-section 57

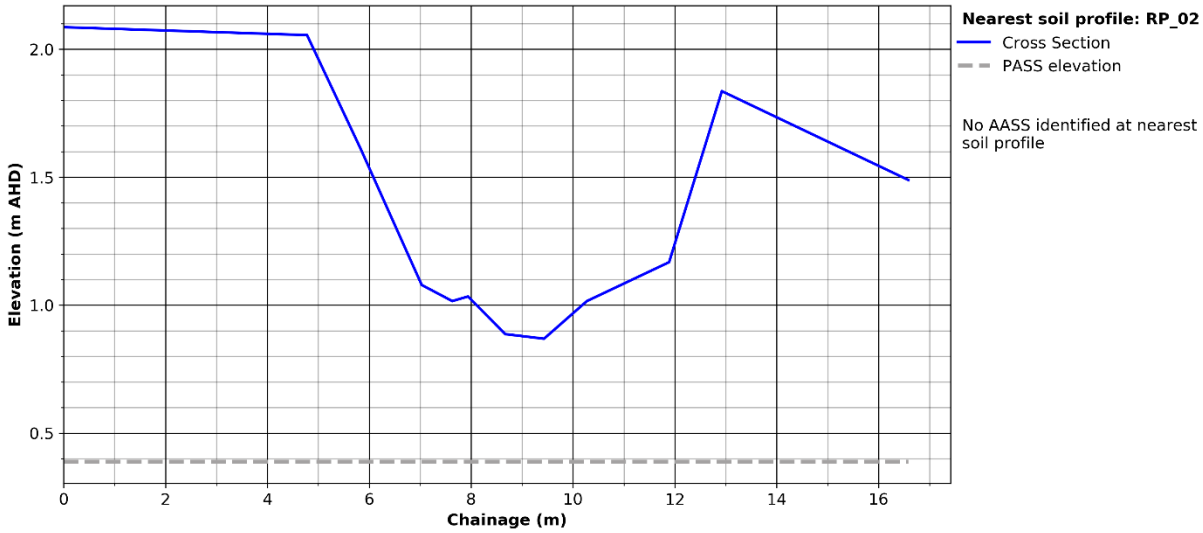


Figure G-19: Richmond cross-section 58

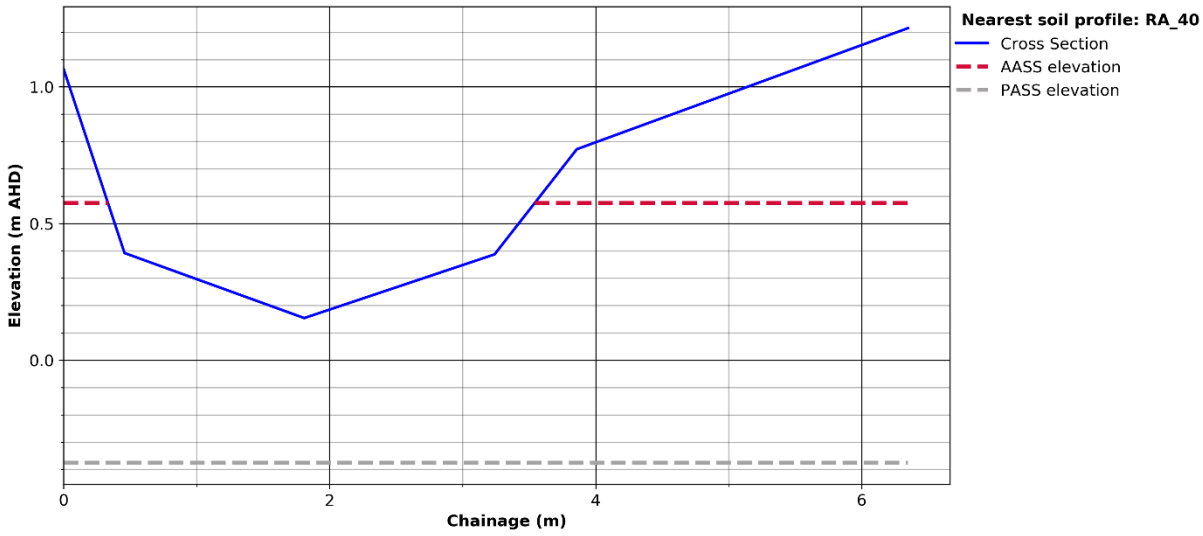


Figure G-20: Richmond cross-section 59

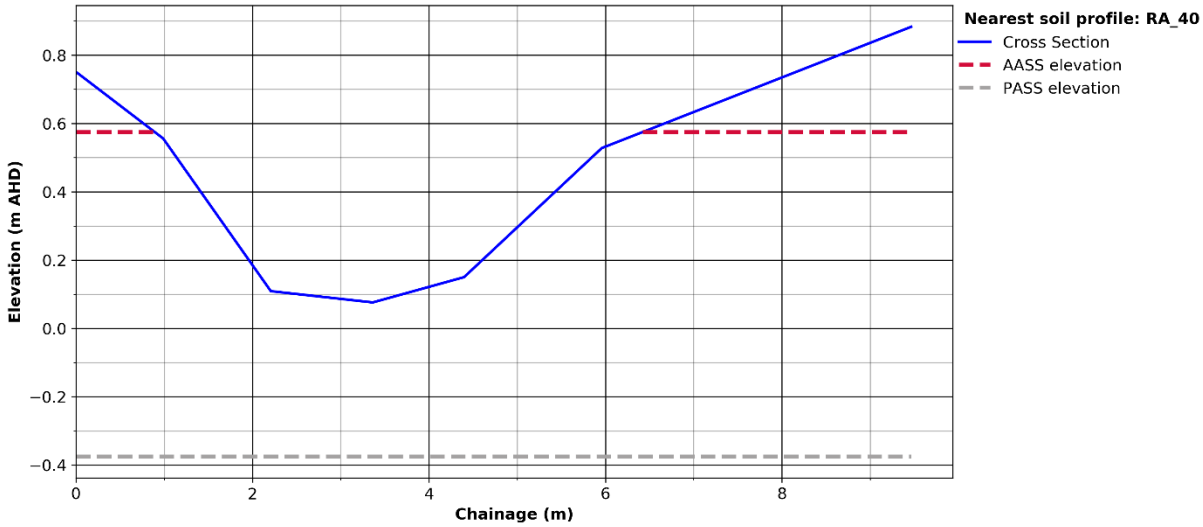


Figure G-21: Richmond cross-section 60

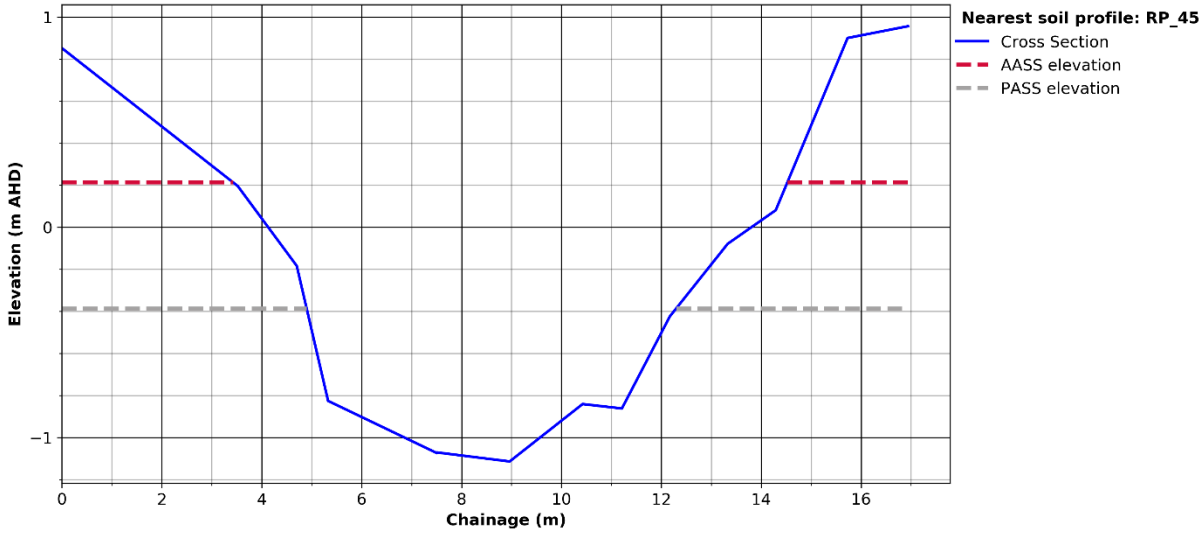


Figure G-22: Richmond cross-section 62

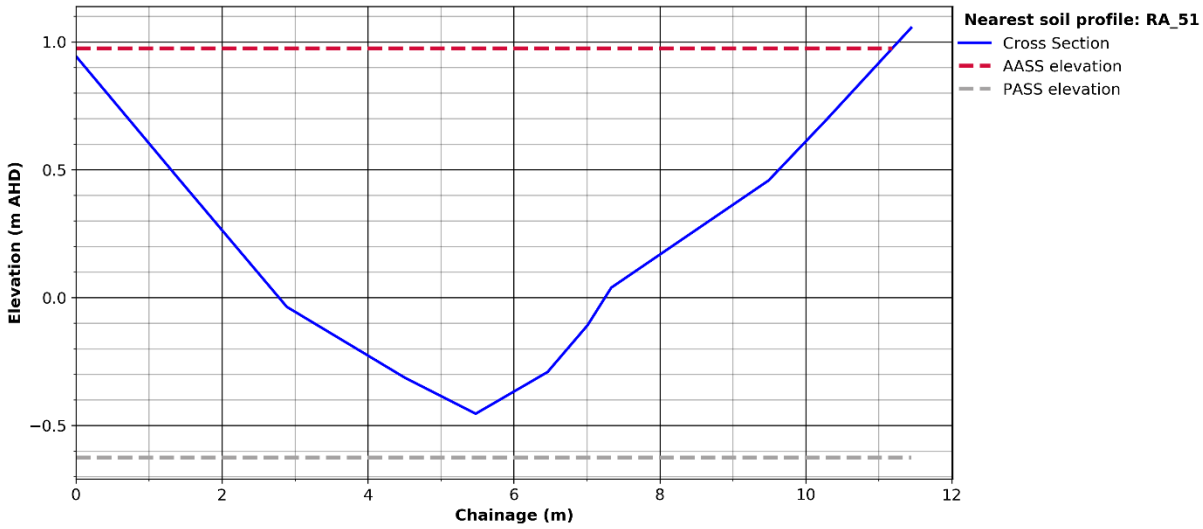


Figure G-23: Richmond cross-section 64

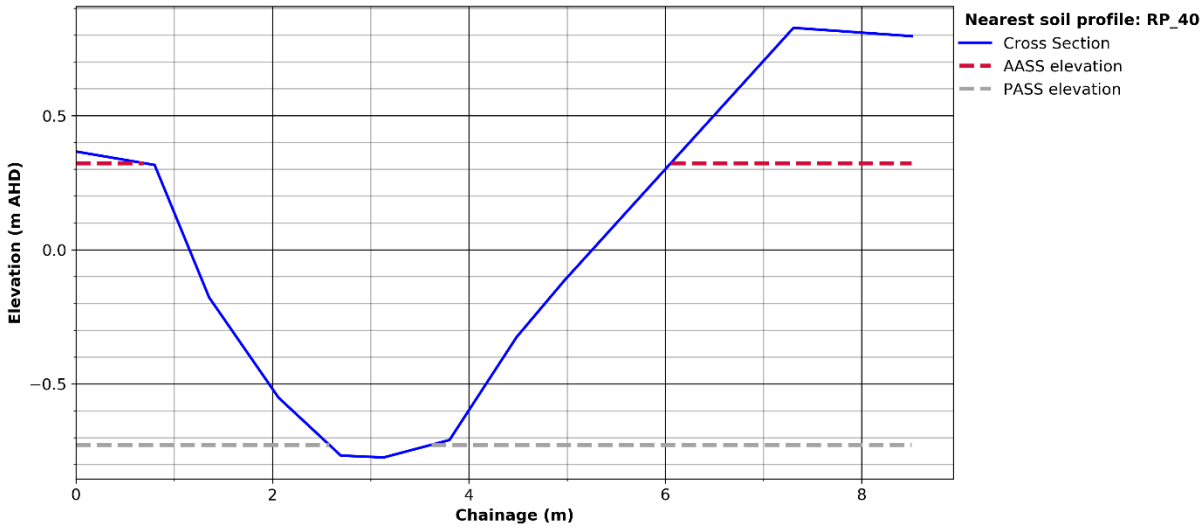


Figure G-24: Richmond cross-section 153

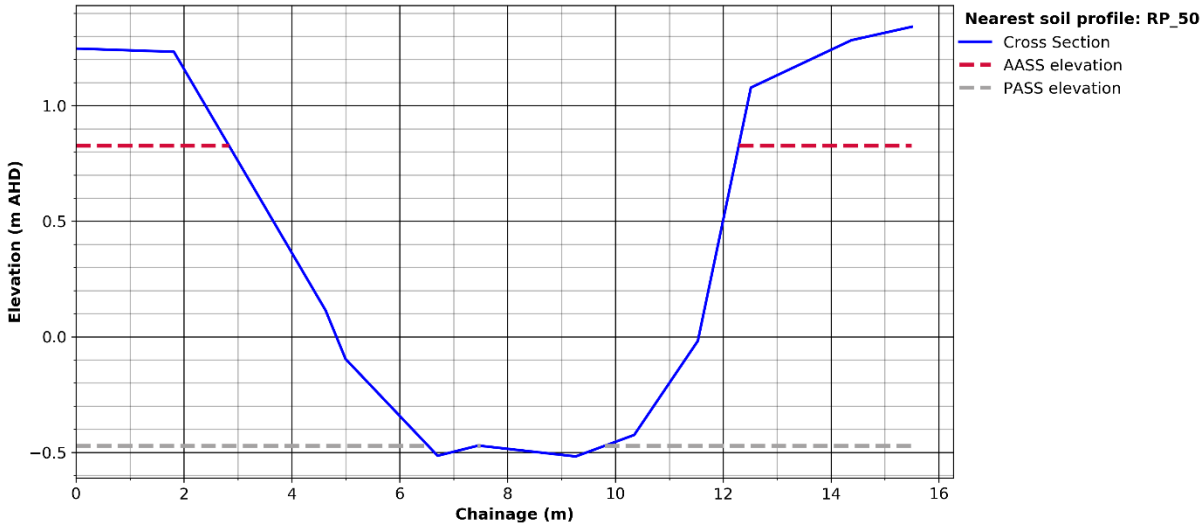


Figure G-25: Richmond cross-section 154

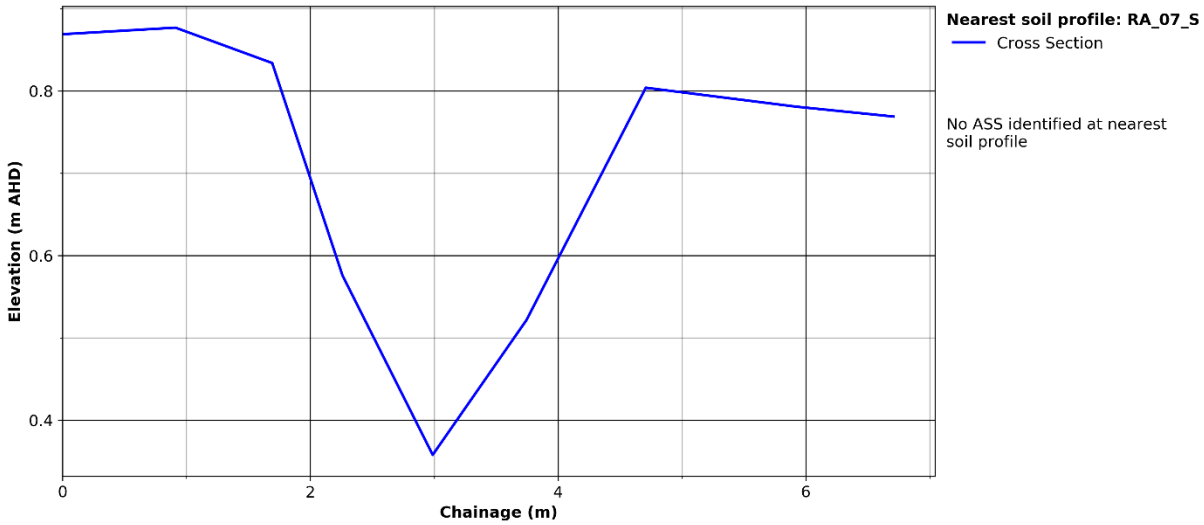


Figure G-26: Richmond cross-section 155

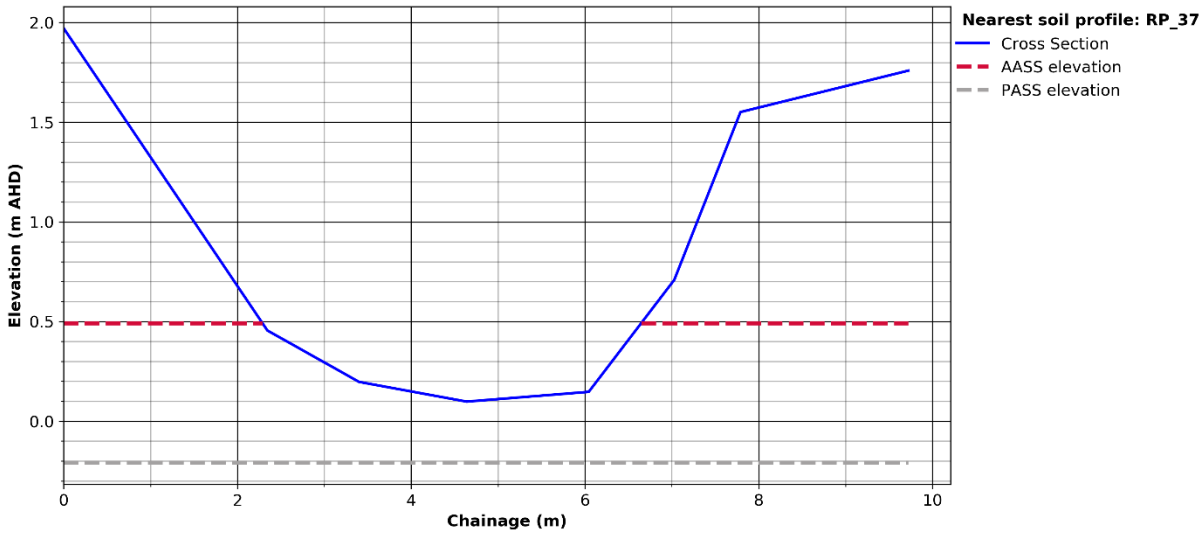


Figure G-27: Richmond cross-section 156

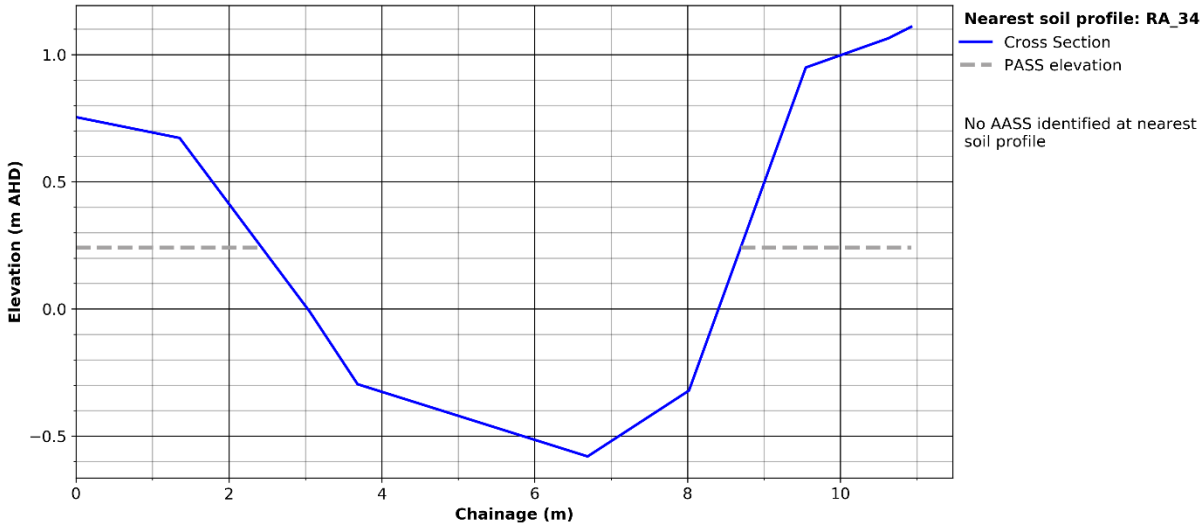


Figure G-28: Richmond cross-section 157

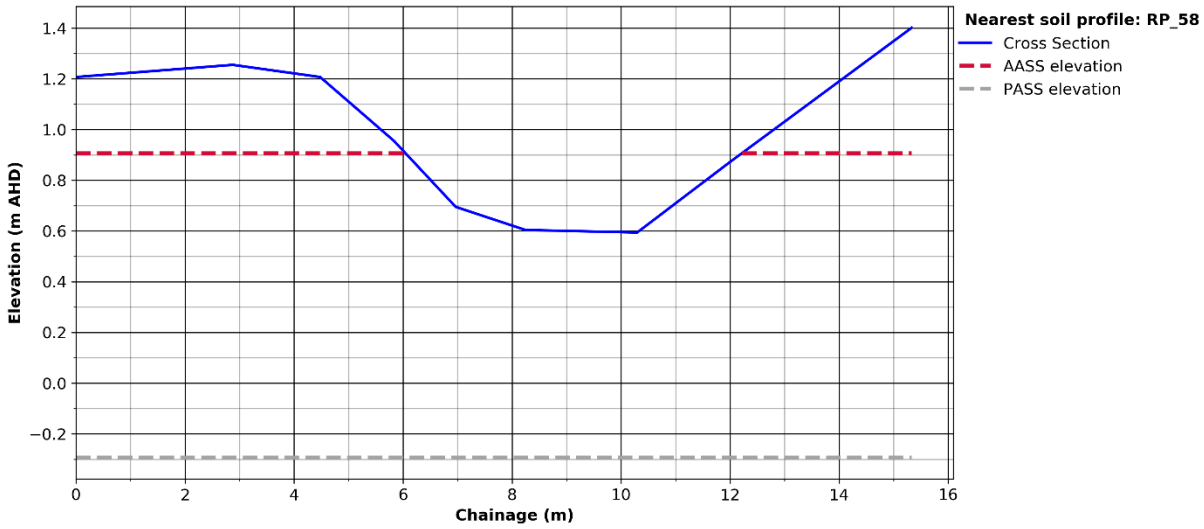


Figure G-29: Richmond cross-section 158

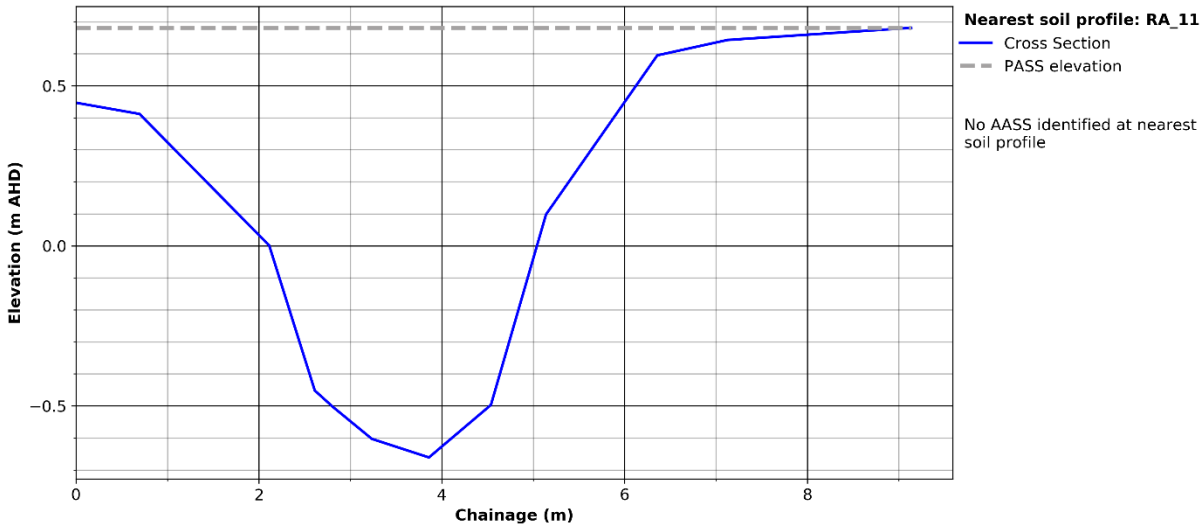


Figure G-30: Richmond cross-section 159

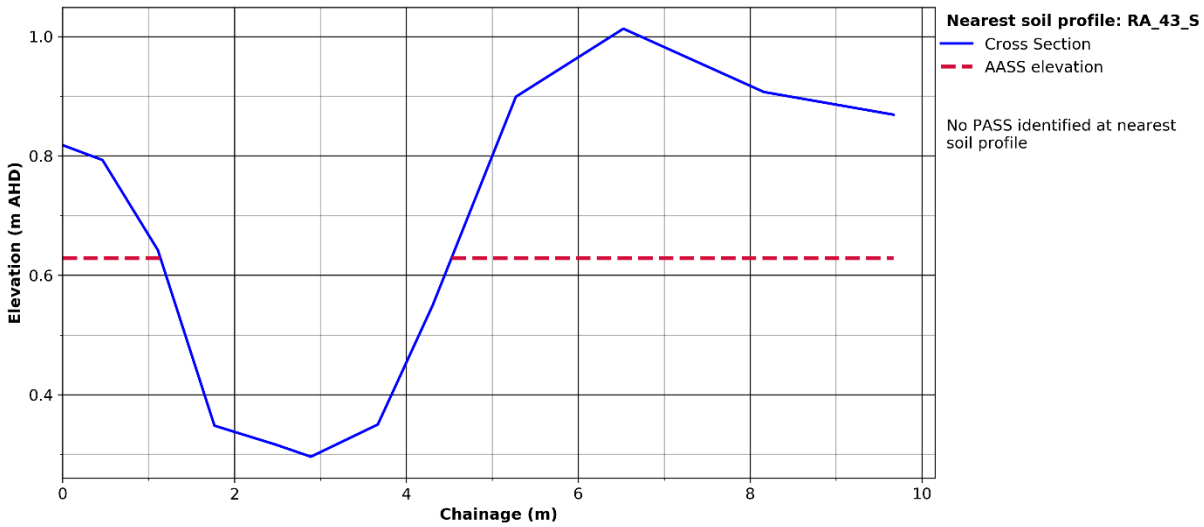


Figure G-31: Richmond cross-section 181

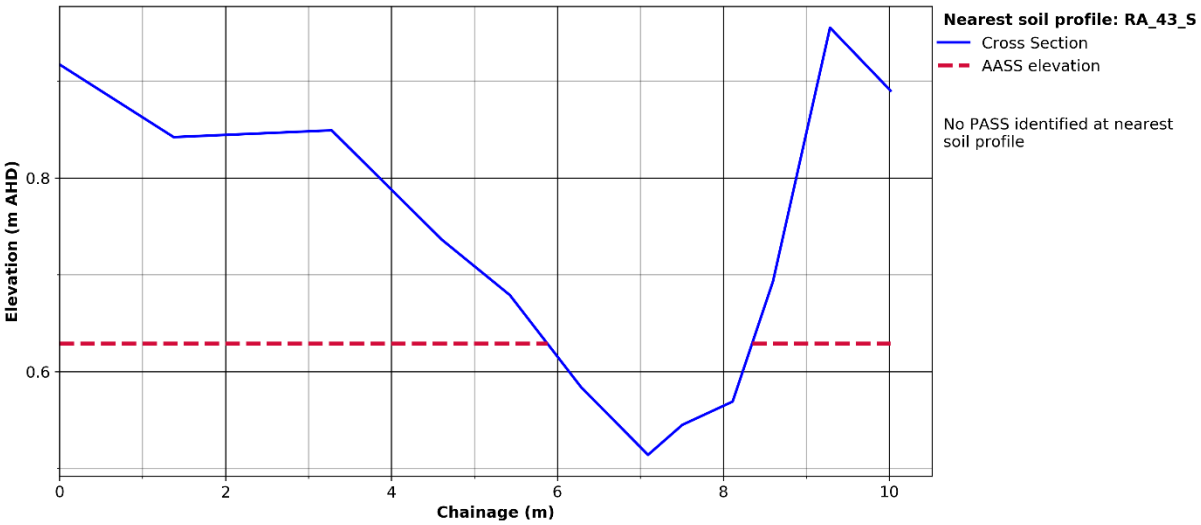


Figure G-32: Richmond cross-section 182

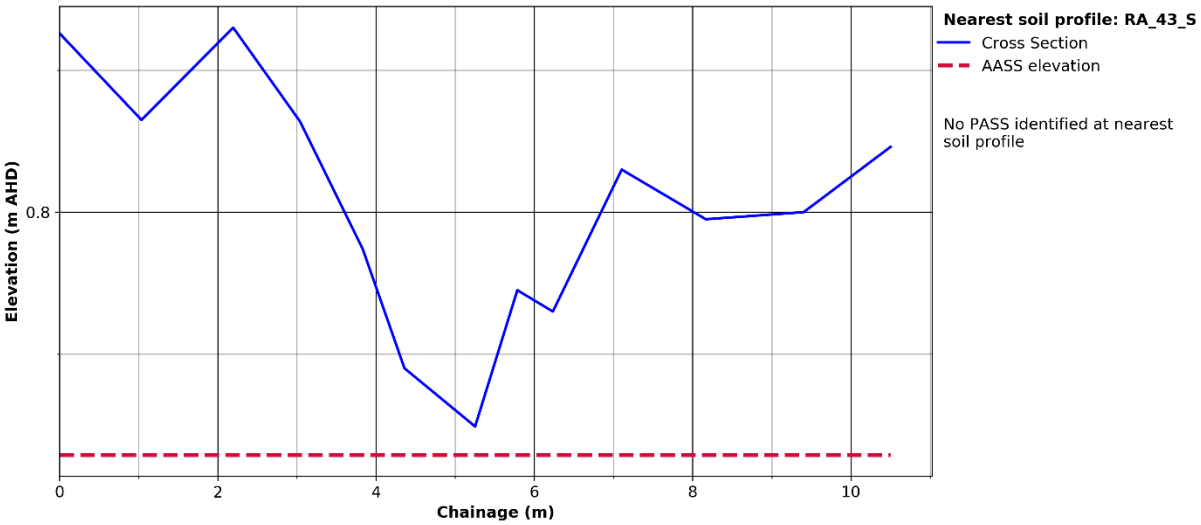


Figure G-33: Richmond cross-section 183

Appendix H Water quality

H1 Preamble

Water quality information provides an indication of the overall health of the marine estate. The following section outlines:

- The water quality objectives for the Richmond River Estuary which are used to assess estuarine health;
- A literature review compiling and summarising historic water quality measurement data; and
- Water quality collected during this study.

Historic monitoring of the Richmond River Estuary has resulted in an extensive dataset that can be used to assess a multitude of water quality related matters. For the purpose of this study, a focus has been given to surface and groundwater physical-chemical parameters associated with the disturbance of acid sulfate soils (ASS) and low dissolved oxygen blackwater. Key water quality parameters that relate to these processes are pH, electric conductivity (EC), nutrients (e.g. nitrogen and phosphorus), dissolved oxygen (DO) and metals (e.g. aluminium and iron).

H2 Richmond River water quality objectives

In 2006, water quality objectives (WQOs) were developed for the Richmond River catchment by the NSW Department of Planning, Industry and Environment (DPIE, formerly the Department of Environment, Climate Change and Water). The goal of the WQOs is to set out community values and uses for waterways and to provide a range of water quality indicators to assess the condition of these values and uses (DPIE, 2006). Trigger levels for the water quality indicators within the WQOs are based on the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG, 2018) (formerly the ANZECC guidelines) and the Australian Drinking Water Guidelines (NHMRC, 2011). WQOs have been identified for uncontrolled streams, national parks, nature reserves, state forests, estuaries and waterways affected by urban development within the study area for the Richmond River Estuary and include objectives for the protection of:

- Aquatic ecosystems;
- Visual amenity;
- Primary and secondary contact recreation;
- Aquatic foods (cooked);
- Livestock, irrigation and homestead water supply; and
- Drinking water at point of supply (disinfection only, clarification and disinfection, and groundwater).

Table H-1 outlines key trigger levels for stressors applicable to the Richmond River Estuary for each of the WQOs. Trigger levels (and their associated WQOs) have only been presented for dissolved oxygen, pH, electrical conductivity and nutrients due to their relevance to this study. Trigger levels for metals (e.g. iron and aluminium) are dependent upon different ecosystem conditions and could vary throughout the estuary. For a complete list of trigger values consult the Australian and New Zealand Guidelines for

Fresh and Marine Water Quality (ANZG, 2018) and the Australian Drinking Water Guidelines (NHMRC, 2011).

Protection of aquatic ecosystems is governed by the trigger levels for dissolved oxygen, pH and nutrients. For estuaries and waterways affected by urban development no guidance is provided for electrical conductivity values as it is expected that high values will occur due to the continuous flushing of these waters with sea water. Trigger levels for electrical conductivity were provided for uncontrolled streams which are freshwater and upstream of the estuary.

Table H-1: Water quality objective trigger levels (DPIE, 2006)

WQOs	Dissolved oxygen (% saturation)	pH	Electrical conductivity (µS/cm)	Total nitrogen (µg/L)	Total phosphorus (µg/L)
Aquatic ecosystems	80 - 110	7.0 - 8.5	Not applicable	300	30
Primary contact recreation	Not specified	5.0 - 9	Not applicable	Not specified	Not specified
Livestock water supply	Not specified	Not specified	0 – 3,350 (varies for different livestock)	Not specified	Not specified
Irrigation water supply	Not specified	Not specified	< 950 - >12,200 (varies for different crop)	Not specified	Not specified
Homestead water supply	Not specified	6.5 - 8.5	<1,000	Not specified	Not specified
Drinking water (treated)	> 80	6.5 – 8.5	<1,500	Not specified	Not specified

H3 Existing floodplain water quality data

H3.1 Summary

This study has focused on identifying water quality information that provided information on sources and impacts of blackwater (caused through deoxygenation) and acid sulfate soils within the Richmond River Estuary floodplain. Table H-2 provides a more detailed summary of historic water quality investigations including monitoring dates, parameters measured and a brief summary of the study findings. Note, in addition to this summary, reviews of existing water quality data have been completed by Tulau (1999b) and Hydrosphere Consulting (2011).

Water quality monitoring is continually being undertaken across the Richmond River estuary with new data being collected on an ongoing basis. Rous County Council are currently monitoring water quality (pH, EC, DO and turbidity) at seven (7) sites, including Tuckean Swamp (upstream and downstream of the Bagotville Barrage), Rocky Mouth Creek, North Creek at Ross Lane, Bungawalbin Creek, Woodburn and Wardell. This program has been funded through the Coasts and Estuary Grants program, and has been implemented using loggers designed and services by South Cross University.

H3.2 Blackwater

Water quality measurements for nutrients (usually nitrogen and phosphorus) and dissolved oxygen can be used as an indicator for blackwater which results when oxygen is stripped from the water column. This usually occurs via biological means (which can occur as a result of the breakdown of organic matter caused by eutrophication or prolonged inundation of water intolerant vegetation) or chemical means (as occurs when monosulfidic black ooze (MBO) is mobilised or acid sulfate soils are oxidised). Note, the blackwater prioritisation has focused on the biological cause of blackwater specifically through prolonged inundation of water on floodplains resulting in the die off and decomposition of organic matter. This causes water to become 'hypoxic' whereby dissolved oxygen is consumed from a water body at a greater rate than it can be replenished. Alternative causes for blackwater have been assessed in literature and are discussed in this section. These include nutrient loading of waterways which causes eutrophication, which can lead to blackwater (in a mechanism similar to prolonged inundation) as biological matter breaks down, and also chemical causes of blackwater whereby minerals oxidise during chemical reactions stripping oxygen from the water column.

Blackwater has been a re-occurring issue on the Richmond River and a number of studies have investigated the cause and impacts of deoxygenated water on the estuary. An early study by the State Pollution Control Commission (1987) found that low oxygen levels occurred towards the upper estuary specifically at Woodburn and Bungawalbin Creek. In the 1990s Manly Hydraulics Laboratory established a number of water monitoring sites across the estuary (Manly Hydraulics Laboratory, 1995; Manly Hydraulics Laboratory, 1996; Manly Hydraulics Laboratory, 1997). Notably, monitoring at Rocky Mouth Creek, which flows into the Richmond River at Woodburn, recorded extremely low dissolved oxygen levels. Low levels were also recorded at Coraki further upstream that corresponded with runoff events. More studies in the 2000s linked blackwater generation to backswamps and agricultural practises (Brodie, 2007; Eyre et al., 2006). Wong et al. (2010) found that backswamps in the mid to upper estuary caused blackwater events with the greatest impact and linked these events to the decomposition of water intolerant vegetation. It was also observed that during summer months, which have a higher temperature, there is a greater likelihood of blackwater events occurring. Recent studies have continued to find that blackwater is a prevalent issue across the Richmond River Estuary with low readings of dissolved oxygen being observed, most likely caused due to the inundation of water intolerant vegetation (NSW DPIE, 2019; Rayner et al., 2020b; Roads and Maritime Services, 2016). During the field investigation of this current study a blackwater event was observed in Sandy Creek (a tributary of Bungawalbin creek) where dissolved oxygen levels were measured to be zero on 28 February 2020 following a flood event.

H3.3 Acid sulfate soils

The oxidisation of acid sulfate soils (ASS) results in the development of acid which can be transported via groundwater to nearby waterways resulting in acidic water with a low pH. In the Richmond River estuary, the acidification of waterways due to export from ASS has been extensively studied. The State Pollution Control Commission (1987) investigated pH levels in the estuary and found very low levels of pH in the Tuckean Broadwater. Sammut et al. (1995) completed a detailed investigation at Tuckean Swamp and found that the oxidisation of ASS had resulted in the release of acidic water impacting the wider Richmond River Estuary. Additionally, they found that the low pH levels corresponded with the release of iron and aluminium further impacting the aquatic ecosystem. Numerous other studies have looked at Tuckean Swamp and the impact of ASS developed there (Brodie, 2007; Bush et al., 2004; Ferguson and Eyre, 1999; Manly Hydraulics Laboratory, 1997; Rayner et al., 2020a; Sammut, 1998; Santos et al., 2013; Santos and Eyre, 2011; Weys et al., 2011). One study found that there is enough

pyrite (the material that oxidises to form acid) in the soil at Tuckean Swamp that it would take 1000 years before it is completely released (Sammut, 1996). In addition to the Tuckean Swamp, Tulau (1999b) named Rocky Mouth Creek, Sandy Creek/Bungawalbin Creek, Maguires Creek/Emigrant Creek and Newrybar/North Creek as priority areas that are significantly impacting the estuarine water quality due to ASS. The impact of ASS and the broader water quality issues in the Richmond River estuary has resulted in continued monitoring at permanent water quality stations (Manly Hydraulics Laboratory, 1995; Manly Hydraulics Laboratory, 1996; Manly Hydraulics Laboratory, 1997; NSW DPIE, 2019; Rayner et al., 2020b; Roper et al., 2011), as well as ad-hoc monitoring (Roads and Maritime Services, 2016; WRL, 2019). Review of this data shows that acidification of the waterways by ASS is an ongoing issue for the estuary and is impacting the aquatic ecosystem.

Table H-2: Existing water quality data for the Richmond River floodplain

Study	Sampling dates	Location	Parameters	Findings
State Pollution Control Commission (1987)	November 1983 to March 1985	Richmond River Estuary	Temperature, electrical conductivity/salinity, dissolved oxygen, nitrogen, phosphorus, pH, chlorophyll a, volatile suspended solids, turbidity, Secchi depth, light penetration	Generally dissolved oxygen concentrations across the estuary were normal; low concentrations were recorded near Woodburn (72%) and in Bungawalbin Creek (56%); high concentrations were recorded in the Wilsons River near Lismore (115%). Salinity measurements showed a steady gradient between the ocean and Woodburn which was the furthest location upstream oceanic water had an influence. pH measurements within the estuary ranged between 6.5 to 8.5; with the exception of the Tuckean Broadwater where a pH of 4.1 was observed during high flows. Poor water quality was observed in flood mitigation drains however it did not affect the main estuary. Nutrient concentrations were observed near Lismore, Coraki and Woodburn above threshold limits due to wastewater discharge and resulted in nuisance aquatic plant growth creating an increased risk of eutrophication.
Sammut et al. (1995)	9/03/1991 to 19/03/1991, 9/06/1993 to 20/8/1993	Tuckean Swamp, Tuckean Broadwater, Richmond River Estuary	pH, aluminium	Measurements of pH in Tuckean Swamp showed acidification of water resulted due to runoff. Brackish water from the estuary had the ability to neutralise acidic water. Plumes of low pH water can have a lasting impact on the estuary, particularly following large rainfall events that decrease the salinity concentration in the estuary. Flocculation of aluminium occurred when the pH levels dropped below 5.4.
Manly Hydraulics Laboratory (1995)	6/09/1994 to 29/09/1995	Rocky Mouth Creek	Temperature, electrical conductivity/salinity, pH, dissolved oxygen, turbidity	Levels of pH below 4 were recorded for extended periods following significant rainfall. Extremely low dissolved oxygen levels were observed following major rainfall events.
Manly Hydraulics Laboratory (1996)	Sep 1994 to Sept 1995	Coraki	Temperature, electrical conductivity/salinity, pH, dissolved oxygen, turbidity	Measurements of pH showed a diurnal fluctuation. pH measurements only showed a small response to rainfall events indicating that acid sulfate soils are not prevalent in the vicinity of Coraki. Saline intrusion of ocean waters does not extend upstream to Coraki to any significant degree. Low dissolved oxygen periods occurred sometimes and only for short periods following flooding.
Sammut et al. (1996a); Sammut et al. (1996b)	January 1993 to June 1994	Tuckean Swamp	pH, electrical conductivity, temperature, aluminium, major cations, chloride, sulfate, dissolved organic carbon, nitrogen , phosphorus	Tidal floodgates were observed to moderate acidic discharge to the estuary at a rates that are readily neutralised by tidal water in the estuary. It was observed that floods caused major acidification of the Tuckean Swamp. Measurements of pyrite concentration in acid sulfate soils indicated it would take 1000 years for complete oxidisation at its current rate. Rainfall both caused and diluted acidification of waterways.
Sammut (1998)	Feb1993 to April 1995	Tuckean Swamp	pH, electrical conductivity, dissolved oxygen, temperature, turbidity, aluminium, chloride, sulfate, nitrogen, fluoride, sodium, potassium, magnesium, calcium, silicon, zinc, copper, boron, manganese	Tidal water was able to buffer acid, however, during high rainfalls this ability was lost as water became less saline. Oxidisation of pyrite was determined to be the key contributor of acid to waterways. Quantities of acid discharged from Tuckean Swamp are 1000 times greater than an industrial spill of sulfuric acid. Acidic discharge affects 240 km of river and includes massive iron flocculation events.
Manly Hydraulics Laboratory (1997)	30/10/1995 to 29/10/1996	Tuckean Broadwater	pH, electrical conductivity/salinity, temperature, dissolved oxygen, turbidity	Very acidic waters during wet periods with a minimum pH: 2.91 recorded during the study period; Observations of low dissolved oxygen occurred at the same time as low pH events with levels dropping close to zero on a number of occasions.
Ferguson and Eyre (1999)	September 1995	Sandy Creek, Bungawalbyn Creek, Rocky Mouth Creek, Tuckean Swamp, North Creek	pH, reduction potential, temperature, aluminium, iron, salinity, dissolved oxygen, turbidity	Metal solubility was observed to increase as pH levels decreased. Iron concentrations were observed to decrease as salinity levels increased. Above a pH of 4 (and also corresponding with salinity increase) metal concentrations tended to decrease and as flocculation increased.
Tulau (1999b)	Not applicable	Richmond River Estuary	Not applicable	Contains a literature review including multiple datasets that are not publicly available. Rainfall was shown to be a key factor influencing to acidity levels. Presence of acid-volatile sulphide was found in deeper drains (~2 m deep) but not in shallow swale drains. It was observed that the saline estuarine water has the ability to buffer acidic water. It was found excessive drainage of wetlands caused acid discharge to the waterways. The Tuckombil Canal prevents salinity from reaching Rocky Mouth Creek from the Evens River. Sandy Creek was observed to be severely impacted by acid sulfate soils and subsequently affect Bungawalbyn Creek.
Kennelly and McVea (2002)	February 2001 to March 2002	Richmond River Estuary	Dissolved oxygen, pH, electrical conductivity/salinity, turbidity, temperature	A low dissolved oxygen event was observed in the estuary for the first two months of observations. During this period no low pH measurements were recorded.
Bush et al. (2004)	Not specified	Tuckean Swamp, Rock Mouth Creek, Sandy Creek	Acid volatile sulfur, pyritic sulfur, organic carbon, pH	It was found that the development of monosulfidic black ooze (MBO) is linked to acid sulfate soil landscapes.

Study	Sampling dates	Location	Parameters	Findings
Eyre et al. (2006)	9/03/2004, 18/3/2004	Richmond River Estuary	Dissolved oxygen	Slashed pasture was found to be the biggest contributor to oxygen demand. Oxygen consumption rates correlated with each materials nitrogen content. The lower Richmond River floodplain has the potential to deoxygenate the entire stored volume of the floodplain in 3 to 4 days. Mobilisation of iron from acid sulfate soils contributes to deoxygenation.
ABER (2007)	Not specified	Richmond River Estuary	Turbidity, dissolved oxygen, pH, nitrogen, phosphorus, chlorophyll a, faecal coliforms	Acidification due to acid sulfate soils and blackwater due to inundation of water intolerant vegetation were highlighted as key drivers of poor water quality in the estuary.
Brodie (2007)	September 2004, December 2004	Tuckean Swamp	pH, electrical conductivity, redox potential, dissolved oxygen, major ions and cations	Meerschaum Drain was found to be a hot spot for development of acid. Additional research was needed to determine why some drains mapped in acid sulfate soil landscape did not have high acid levels. Blackwater was found to occur in Marom and Tucki Drains. A summary of water quality dates and locations in the Richmond river was also provided.
Roper et al. (2011)	1971 to 2007	Richmond River Estuary	Salinity, temperature, dissolved oxygen, pH, Secchi depth, turbidity, chlorophyll a, total suspended solids, nitrogen, phosphorus, silicon	Out of 101 NSW estuaries assessed for condition the Richmond River was given a 'very good' rating (along with 27% of estuaries, the best rating given to estuaries). Out of 184 NSW estuaries assessed for susceptibility to environmental pressures the Richmond River was given a 'high' rating (along with 6% of all estuaries, no estuaries were 'very high').
Wong et al. (2010)	January 2008	Richmond River	Dissolved oxygen temperature, electrical conductivity, pH, chemical oxygen demand, dichromate oxidisation, cations, metals, nutrients, chloride, sulfate, dissolved organic carbon, total carbon, total organic carbon	Sources of poor water quality were located in backswamps of the mid to upper estuary. Timing of flood events is critical for occurrence of deoxygenation events with higher temperature summer months more likely to cause an event. Decomposition of water intolerant vegetation was the main driver of deoxygenation events. Extensive drainage of backswamps has led to the export of deoxygenated water to the main estuary.
Hydrosphere Consulting (2011)	Not applicable	Richmond River Estuary	Not applicable	A literature review is provided identifying sources of poor water quality and blackwater and includes discussion of some literature that is not publicly available. Pasture (NSW Food Authority, 2019) management will help reduce blackwater events. Blackwater can occur in the mid and upper estuary.
Santos and Eyre (2011)	September 2009, November 2009	Richmond River Estuary	pH, dissolved oxygen, electrical conductivity, temperature	Deepening and straightening of drainage channels enhances groundwater-surface water interaction and subsequently acid discharge. There was no evidence of a relationship between groundwater and acid export in the upper estuary.
Weys et al. (2011)	6/01/2010 to 1/06/2010	Tuckean Swamp	pH, electrical conductivity	80% of acid export from acid sulfate soils occurs post-flood when there is limited ability for the receiving waters to dilute the acid.
Santos et al. (2013)	November 2009, April 2010, June 2011	Tuckean Swamp	Nutrients, pH, dissolved oxygen, electrical conductivity, temperature	Groundwater is a key driver for catchment exports of nutrients including being nearly 100% responsible for ammonium exports.
Ryder et al. (2015)	December 2013 to November 2014	Richmond River Estuary	Chlorophyll a, total suspended solids, inorganic nutrients, pH, temperature, electrical conductivity/salinity, dissolved oxygen, turbidity	Nutrient and chlorophyll a levels measured were above ANZECC (2000) guideline values. Nutrient loads increased travelling in a downstream direction. Low flow levels contributed to low dissolved oxygen levels. No low pH events were recorded during sampling.
Roads and Maritime Services (2016)	Aug 2016 to Feb 2020 (monthly)	Along the Pacific highway Woolgoolga to Ballina	pH, electrical conductivity, temperature, dissolved oxygen, turbidity	Water quality monitoring indicated that across the Richmond River Estuary there was low dissolved oxygen, low pH, and high turbidity levels. Water quality within Tuckean Swamp and Rocky Mouth creek failed to meet the water quality objectives.
NSW Food Authority (2019)	2000 to 2019	Richmond River near Ballina	Temperature, salinity	Average salinity was recorded as 30.2ppt with a 10th percentile of 21ppt and 90th percentile of 35.2ppt.
WRL (2019)	26/02/2019 to 28/02/2019	Keith Hall	pH. electrical conductivity	High salinity levels in the tidally flushed lower sections of the drainage network appeared to be buffering pH. At upstream locations that were not well connected lower levels of pH were measured.
NSW DPIE (2019)	2012 to 2019	Richmond River Estuary	Secchi depth, temperature, electrical conductivity (salinity), turbidity, chlorophyll a, colour, nitrogen, phosphorus, pH, CDOM, fDOM, dissolved oxygen, blue green algae, silicon	Salinity measured across the estuary varied from 0.05ppt to 24ppt. pH measurements varied from 6.8 to 8.4 (only measured in 2015, 2018 and 2019). Dissolved oxygen varied from 58.1% to 124.0% (only measured in 2015, 2018 and 2019).
Rayner et al. (2020b)	2004 to 2019	Richmond River Estuary	Electrical conductivity, dissolved oxygen, pH, temperature, turbidity	An assessment of long term water quality data collect by Rous County Council. Due to the proximity of North Creek to the ocean it was observed that regular flushing results in a quick recovery from acid and blackwater events. At Tuckean Swamp there was a trend that blackwater issues were worse during higher temperature summer periods. At the site there are also prolonged impacts on water quality cause by acidic discharges. Prolonged low dissolved oxygen events were observed to occur at Rocky Mouth creek where less catchment and tidal flushing occurs.
Rayner et al. (2020a)	March 2018, June 2018, October 2018 to February 2019	Tuckean Swamp	pH, electrical conductivity	Measurements indicated that the north east section of the swamp and the Tuckean Nature reserve are major sources of acid. Salinity levels in the Broadwater reached ~30,000µS/cm during a prolonged dry period between October 2018 and February 2019.

H4 Field investigation

During field investigations, surface water and groundwater water quality measurements were opportunistically collected at various locations across the Richmond River floodplain. Water quality parameters measured included pH, electrical conductivity (EC) and rugged dissolved oxygen (RDO). Details on the instrumentation used to measure water quality parameters can be found in Appendix A of Methods report (Rayner et al., 2023).

Water quality data was collected during structure surveys (surface water quality upstream and downstream of the structures) and soil profile sampling (surface water quality of nearby waterways and groundwater quality within the soil sample holes). Water quality measurements taken during structure surveys upstream and downstream of the structures are summarised in Table H-3. Surface water quality measurements taken from nearby water bodies during soil profile sampling are summarised in Table H-4. Groundwater quality measurements taken during soil profile sampling are summarised in Table H-5. This data has also been spatially represented to show the variability of pH and electrical conductivity across the Richmond River floodplain. Surface water quality measurements for the Richmond River floodplain are presented in Figure H-1 and Figure H-2 for pH and electrical conductivity, respectively. Groundwater quality measurements for the Richmond River floodplain are presented in Figure H-3 and Figure H-4 for pH and electrical conductivity, respectively.

Table H-3 Summary of surface water quality measurements taken upstream and downstream of structures

Nearby structure ID	Date	Easting (m)	Northing (m)	Upstream of the structure		Downstream of the structure		
				pH	Electrical Conductivity (µS/cm)	pH	Electrical Conductivity (µS/cm)	Rugged Dissolved Oxygen (%)
1080	26/02/2020	544980	6794448			5.8	364	12%
1230	30/01/2020	543378	6792095	6.9	12,178			
1305	30/01/2020	539663	6791117	6.7	15,200			
1900	28/02/2020	526030	6788672				224	37%
1960	28/02/2020	524349	6785120			5.9	205	51%
2010	28/02/2020	525113	6788776			5.4	230	23%
4730	31/01/2020	550494	6805794	7.5	37,124	7.4	33,120	
4750	31/01/2020	550135	6806297	7.0	35,537	7.4	33,120	
4770	31/01/2020	549985	6806369	7.5	35,228	7.4	33,120	
4780	31/01/2020	549632	6806233	6.9	32,242	7.4	33,120	
4790	31/01/2020	549341	6806247	7.2	34,507	7.4	33,120	
4800	31/01/2020	549107	6806289	7.2	31,380	7.4	33,120	
5500	26/02/2020	548882	6808255			5.6	1,086	
5800	25/02/2020	555240	6814908	4.9	3,895	5.2	121	
4760	31/01/2020	550070	6806314	7.6	36,500	7.4	33,120	
WRL_Rich_44	28/10/2019	555787	6816849	6.8	25,600	6.8	25,700	
WRL_Rich_54	31/01/2020	550336	6806508	7.1	38,760			

Table H-4: Summary of surface water quality measurements taken in waterbodies near soil profile sample holes

Nearby soil profile ID	Date	Easting (m)	Northing (m)	pH	Electrical Conductivity (µS/cm)	Notes
RP_21	28/10/2019	555369	6816545	6.9	35,900	
RP_22	29/10/2019	553589	6813610	3.8	15,300	
RA_55	29/10/2019	554165	6815025	5.9	24,600	
RA_19	29/10/2019	555089	6820076	6.3	4,500	
RP_20	29/10/2019	556043	6820194	6.4	6,500	
RP_24	30/10/2019	551122	6811612	4.1	20,700	
RP_23	30/10/2019	551416	6812418	6.8	4,200	
RA_28	30/10/2019	548578	6809403	6.7	25,100	
RA_02	31/10/2019	529878	6799915	6.7	200	
RP_02	31/10/2019	529791	6799737	6.8	200	
RP_45	31/10/2019	527974	6786658	4.5	3,100	Measured in dam approx. 150 m away
RP_44	31/10/2019	529949	6786749	7.3	4,300	
RA_51	1/11/2019	524728	6783911	5.8	500	
RP_33	4/11/2019	545512	6792076	7.2	20,460	
RP_03	5/11/2019	527634	6798501	7.0	34	Measured in nearby perched swamp
RP_03	5/11/2019	527631	6798429	6.9	300	Measured in Pelican Creek
RA_21	6/11/2019	553136	6813260	8.5	22,800	
RP_30	6/11/2019	556856	6809936	6.9	56,200	
RA_11	31/01/2020	551078	6804096	7.4	40,060	
RA_34	30/01/2020	548069	6797008	7.8	1,740	
RP_40	29/01/2020	535519	6789270	6.1	7,500	
RP_50	29/01/2020	527664	6783228	2.6	2,750	
RA_43_S	26/02/2020	531275	6784331	3.9	2	
RP_10_S	25/02/2020	544568	6796006	6.4	651	

Table H-5: Summary of groundwater quality measurements taken from soil sample holes

Soil profile ID	Date	Easting (m)	Northing (m)	pH	Electrical Conductivity (µS/cm)
RP_22	29/10/2019	553589	6813610	5.6	8,400
RA_55	29/10/2019	554165	6815025	5.9	15,000
RA_19	29/10/2019	555089	6820076	6.0	1,950
RP_20	29/10/2019	556043	6820194	4.5	2,200
RP_02	31/10/2019	529791	6799737	6.0	650
RP_45	31/10/2019	527974	6786658	4.7	1,675
RP_44	31/10/2019	529949	6786749	4.8	880
RA_40	1/11/2019	530320	6790644	3.8	970
RA_51	1/11/2019	524728	6783911	3.6	560
RP_33	4/11/2019	545512	6792076	6.0	10,200
RA_03	5/11/2019	525373	6799552	5.0	28,800
RP_03	5/11/2019	527593	6798485	5.1	7,850

Soil profile ID	Date	Easting (m)	Northing (m)	pH	Electrical Conductivity (µS/cm)
RA_21	6/11/2019	553136	6813260	6.0	8,700
RP_30	6/11/2019	556856	6809936	6.5	35,200
RA_11	31/01/2020	551078	6804096	6.6	10,603
RP_37	30/01/2020	543456	6791988	6.2	6,700
RA_07_S	30/01/2020	539650	6791012	4.9	9,200
RP_40	29/01/2020	535519	6789270	5.9	3,200
RP_50	29/01/2020	527664	6783228	3.5	5,000
RA_47	29/01/2020	529187	6777709	3.5	1,714
RA_43_S	26/02/2020	531275	6784331	3.8	5
RP_57_C	25/02/2020	522902	6788503	4.2	384
RP_10_S	25/02/2020	544568	6796006	4.1	4,300
RP_47	26/02/2020	531595	6779447	3.4	1,950

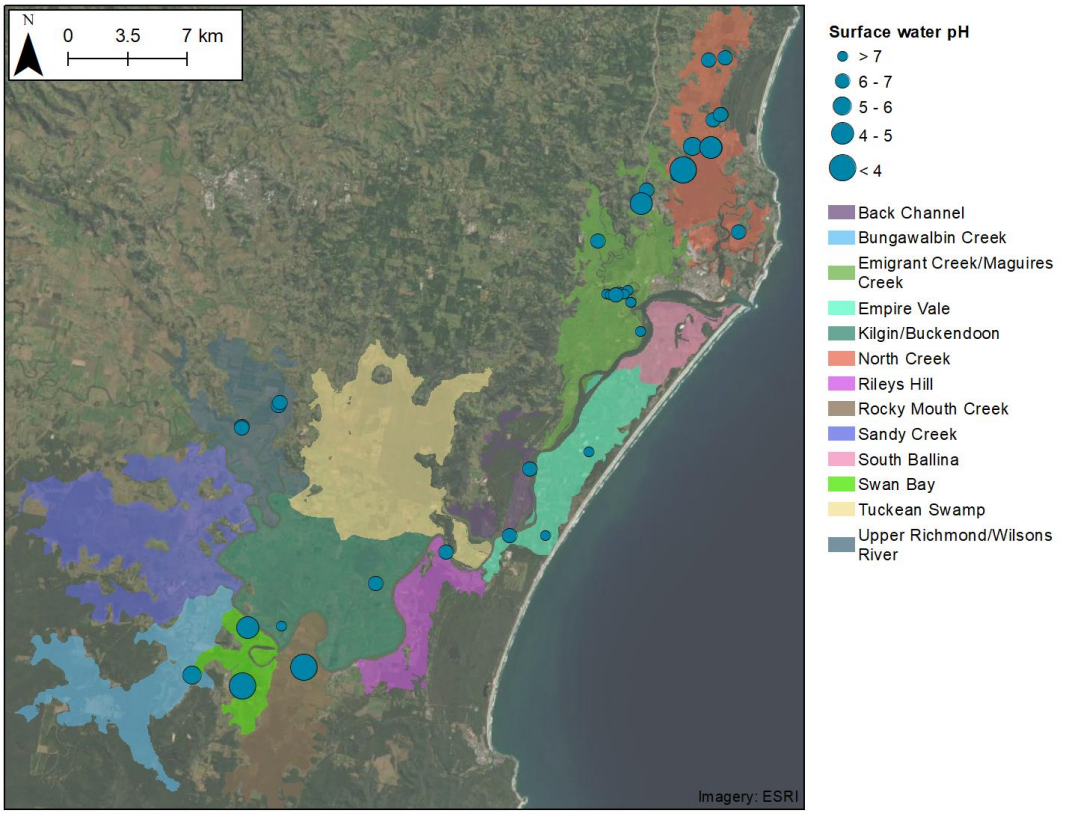


Figure H-1: Surface water pH measurements taken across the Richmond River floodplain

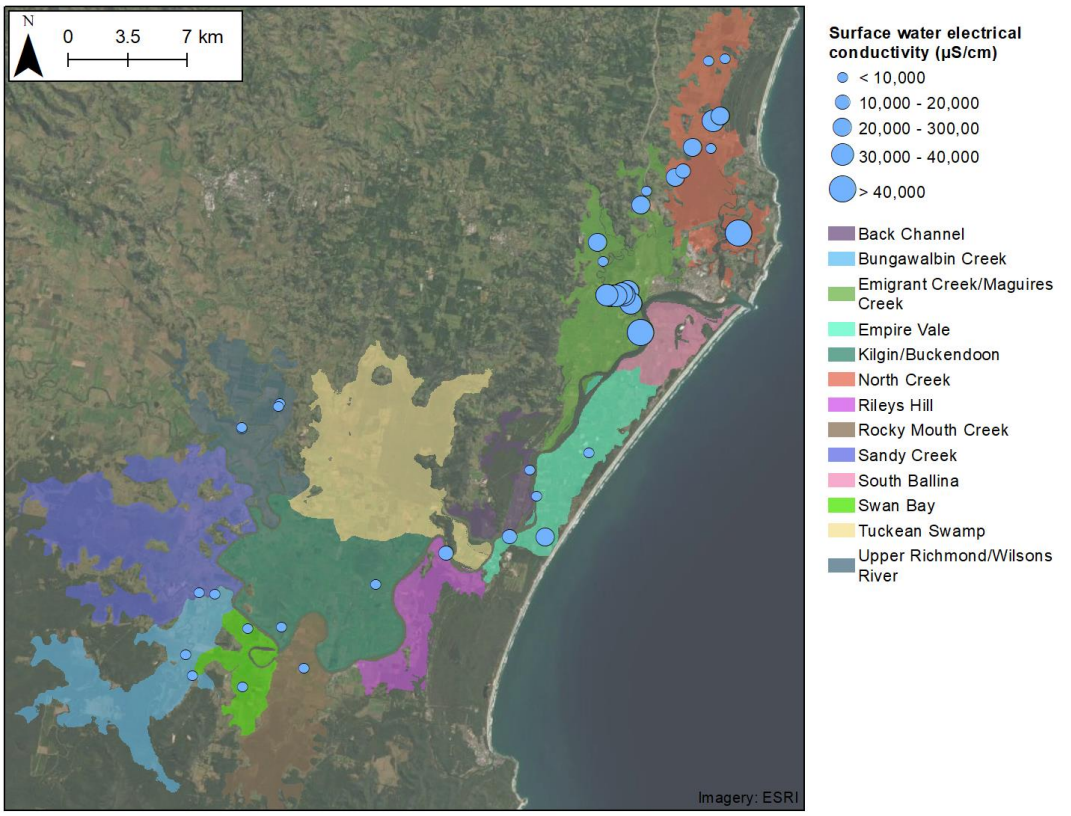


Figure H-2: Surface water electrical conductivity measurements taken across the Richmond River floodplain

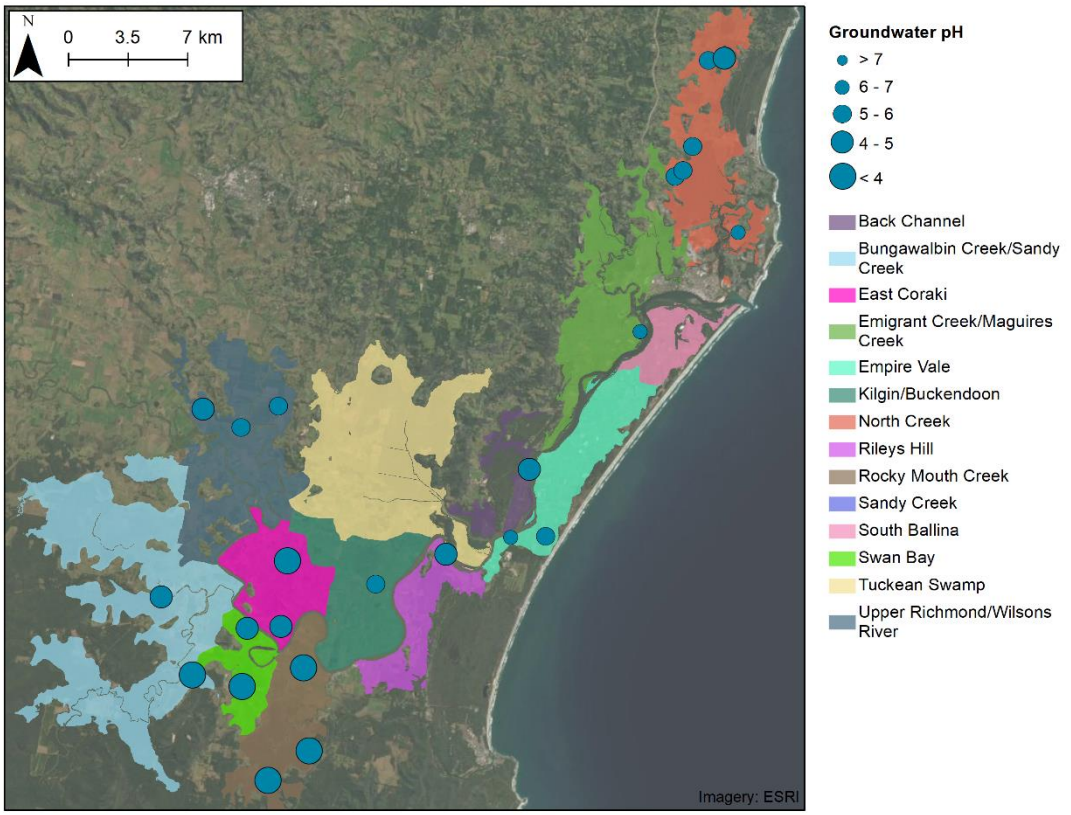


Figure H-3: Groundwater pH measurements taken across the Richmond River floodplain

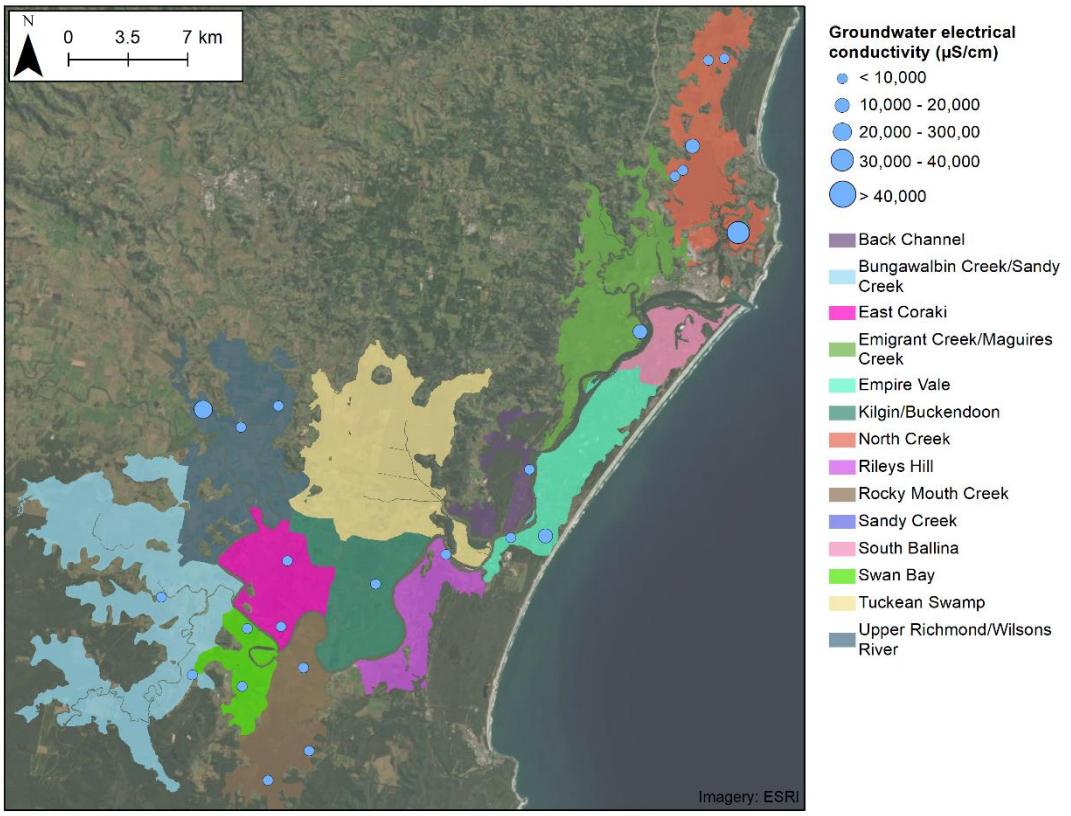


Figure H-4: Groundwater electrical conductivity measurements taken across the Richmond River floodplain

Appendix I Hydrodynamic modelling

I1 Preamble

The following section provides a summary of the hydrodynamic numerical model developed for the Richmond River estuary. Results of the hydrodynamic modelling were used for the floodplain vulnerability assessments, detailed in Section 11 of the Methods report (Rayner et al., 2023).

I2 Hydrodynamic model

Hydrodynamics is the study of water movement. In an estuary, three main elements control the movement of water (tidal hydrodynamics). This includes, estuary geometry, upstream catchment inflows and downstream ocean tides. The geometry of an estuary is defined by its width, length, depth or the shape and storage of sidearms. Upstream catchment inflows are based on rainfall and runoff and downstream tidal inflows are based on the water levels in the ocean.

I2.1 Numerical model

Numerical modelling of the Richmond River estuary tidal hydrodynamics was undertaken using the RMA modelling suite (King, 2015). The RMA-2 hydrodynamic model solves the shallow water wave equations and is suitable for the simulation of flow in vertically, well-mixed water bodies such as, estuaries. RMA-2 uses the principles of conservation of mass and momentum, and represents typical processes of bed and bank friction, turbulence and wind stress.

RMA-2 calculates a finite element solution of the Reynolds-form of the Navier-Stokes equations for turbulent flows. The main internal model parameters applied to the model are eddy viscosity, bed friction and turbulent mixing. The horizontal eddy viscosity (ε) is specified in terms of a scaled velocity and element size as presented in Equation I-2.

$$\varepsilon_{xy} = \alpha(x,y,t) \cdot V(x,y,t) \cdot \Delta_{elt}(x,y) \qquad \textbf{Equation I-2}$$

Where:

- ε = horizontal eddy viscosity (m^2/s)
- V = velocity (m/s)
- α = non-dimensional scaling factor
- Δ_{elt} = is a length representative of the element size (m)

The RMA-2 model utilises a finite element mesh consisting of an irregular connection of nodes and elements to represent the model domain. Finite elements are suitable to model complex estuaries as the elements can vary in size and shape to represent the geometry of the waterbody. Accurate representation of the waterway geometry is important as it is a major factor in replicating and predicting tidal hydrodynamics.

Water levels and flow velocities are predicted at every node within the finite element mesh of the model. One dimensional (1-D) elements are used to represent channel flow velocities in one horizontal

direction (i.e. upstream to downstream and where flow occurs perpendicular to the channel cross section), whereas two (2) dimensional (2-D) elements represent depth-averaged flow velocities in two-horizontal directions (i.e. x-y plane). RMA-2 simulates the process of bank wetting and drying as the water level changes through the use of marshing elements. Marshing simulates drying by approximating elements with a smaller width and higher friction for water transfer thereby effectively preventing flow in those elements while conserving mass.

I2.2 Model domain

A 1-D/2-D hydrodynamic model of the Richmond River estuary was developed to simulate the typical tidal water level variations within the estuary. The hydrodynamic model extends to the tidal limits of major rivers, tributaries and creeks in the estuary, including the Richmond River, Wilsons River, Bungawalbin Creek and North Creek. The model also includes smaller tributaries and creeks in the lower estuary that contained important floodgate structures. A model grid representing the study area provided increased resolution in areas around the lower estuary where complex 2-D flows were expected and lower resolution in the upper reaches of the estuary where flows were modelled using 1-D elements. The model area is shown in Figure I-1.



Figure I-1: Richmond River estuary – tidal hydrodynamic model extent

I2.3 Model inputs

The hydrodynamic model comprised of three (3) main inputs, including channel geometry, downstream ocean tidal water levels and upstream catchment inflows.

Channel geometry below 2 m AHD was based on previously calibrated models of the Richmond River estuary and digitised using standard GIS methods. Upstream channel bathymetry was based on the previous modelling of the Richmond River (Peirson et al., 1999) which had previously been calibrated against the tidal discharge measurements recorded on 3 November 1994 (MHL, 1995). The downstream areas of the model were updated with more recent bathymetry sourced from the flood model developed for the Richmond River floodplain (BMTWBM, 2010).

Catchment inflows were based on observed river flow data from WaterNSW gauging stations in the upper Richmond River catchment as shown in Figure I-2. The flow gauging stations are located upstream of the numerical model boundary, and therefore required adjustment to account for the additional catchment area and runoff that could occur in between the flow gauging location and the model inflow boundary. To account for this, catchment runoff data was scaled by the additional contributing catchment areas that were missed between the gauges and the model boundary. This was achieved using standard GIS methods to compare the upstream area of the gauging sites to the upstream area of the model domain. A summary table of the upstream inflow boundaries and scaling factors are provided in

Table I-1. Localised floodplain subcatchment runoff inflows were excluded from the model as sensitivity testing indicated that day-to-day water levels in the lower reaches of the estuary were found to be dominated by tidal fluctuations. The downstream ocean tidal boundary of the model was based on the observed water levels from the MHL station at Ballina Breakwell (Station Number 203452).

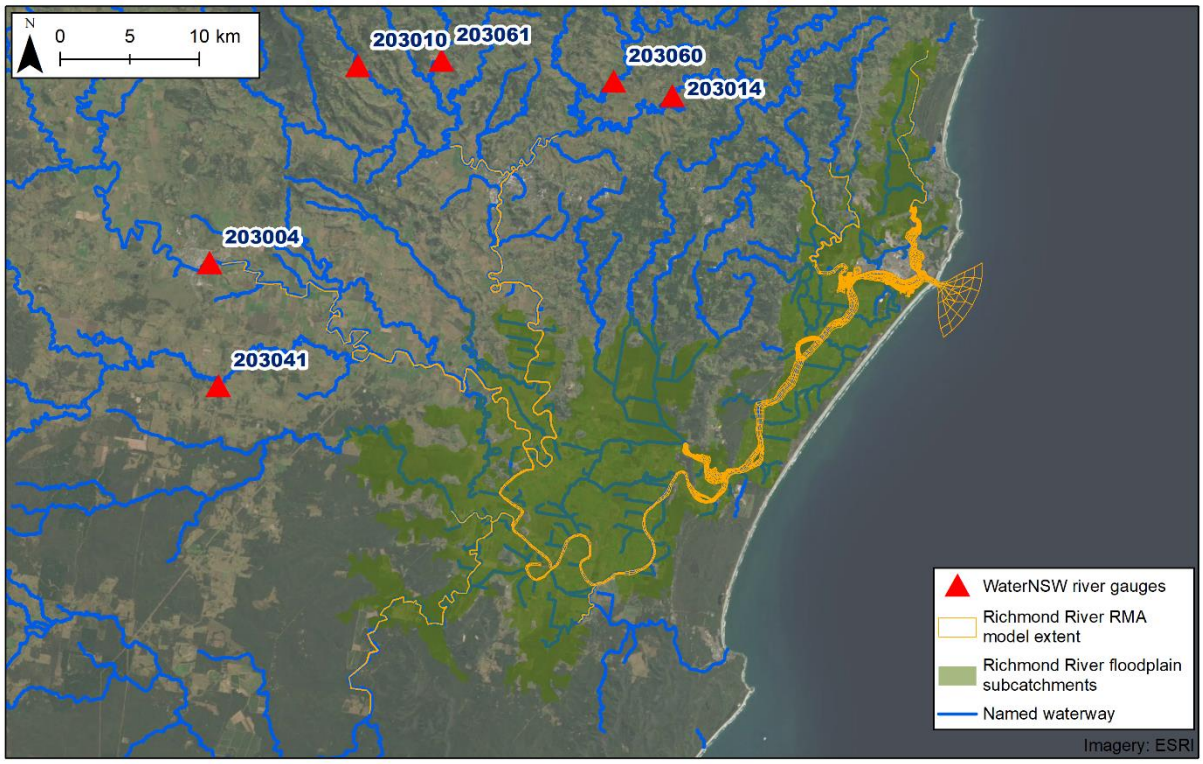


Figure I-2: Location of WaterNSW river flow gauges with relation to the hydrodynamic model extent

Table I-1: Summary of model boundary conditions

Gauging Station Name	Data Source	Station Number	Scale Factor
Richmond River at Casino	WaterNSW	203004	1.00
Shannon Brook at Yorklea	WaterNSW	203041	1.00
Coopers Creek at Fairmeadow	WaterNSW	203060	1.18
Wilsons River at Eltham	WaterNSW	203014	1.18
Leycester River at Rock Valley	WaterNSW	203010	2.62
Goolmangar Creek at McNamara Bridge Weir	WaterNSW	203061	2.62
Ballina Breakwell	MHL	203452	N/A

I2.4 Model calibration

The hydrodynamic model for the Richmond River estuary was calibrated to selected water level gauging stations along the main river channel for 2017. The year 2017 was selected based on BOM rainfall records for the northern parts of NSW closely representing the long-term annual average rainfall for this region. The locations of the water level stations used for the water level calibrations are shown in Figure I-3. Water level data was sourced from NSW DPIE Manly Hydraulics Laboratory (MHL)

The main internal model parameters in the RMA-2 hydrodynamic model are eddy viscosity and friction (applied as Manning's n). The model was calibrated by adjusting the Manning's n value to match the observed tidal ranges and phasings throughout the estuary. A Manning's n value of 0.020 was adopted offshore near the estuary entrance and a value of 0.023 was adopted for the main channel up to the tidal limit to achieve final calibrations.

The calibration results for a selected 20-day window during 2017 are provided Figure I-4 to Figure I-11. The model was calibrated (for dry weather periods) to within 0.05 m in the lower estuary and to within 0.15 m in the upper estuary, where the channel geometry incorporated into the model was less reliable.

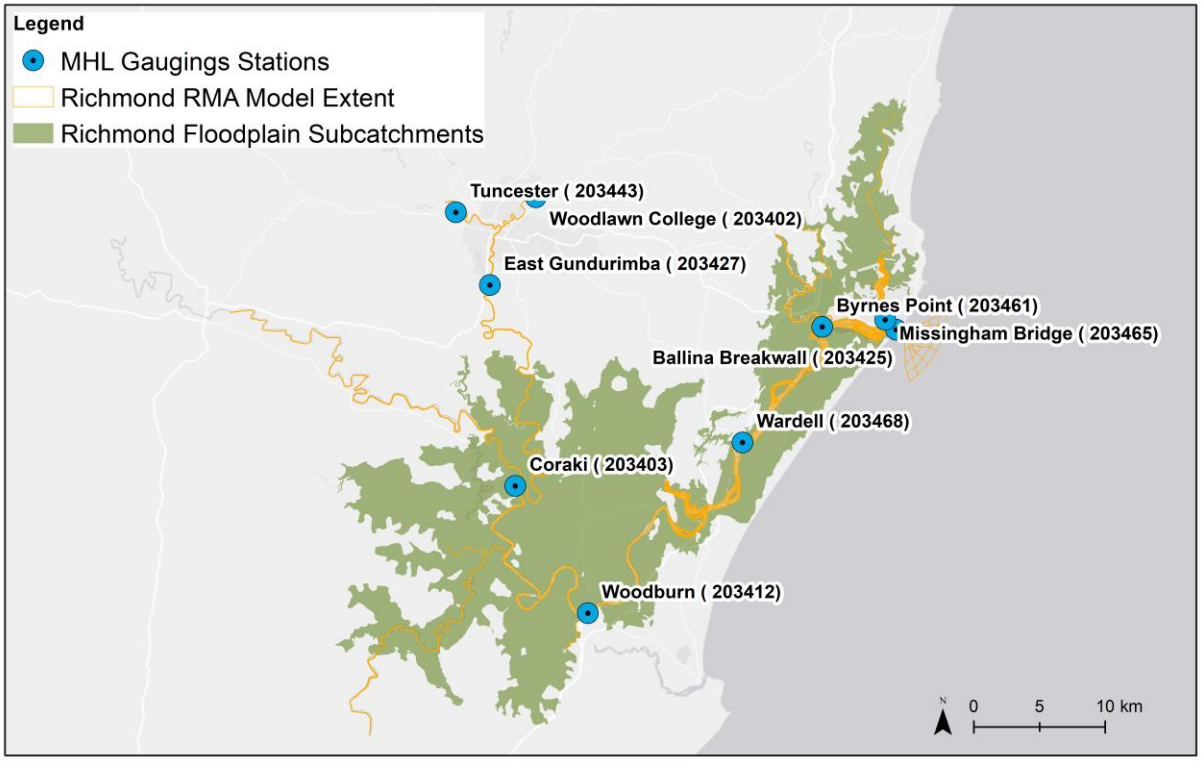


Figure I-3: Location of selected[1] water level stations used for calibration of the Richmond River estuary hydrodynamic model

I2.5 Model verification

The calibrated model was then used to simulate a representative 'wet' year (i.e. more rain than average across the catchment) and a representative 'dry' year (i.e. less rain than average across the catchment) based on analysis of BOM rainfall records in Northern NSW. For this study, 2013 and 2019[2] were selected as the wet and dry years respectively. The model results from these simulations were then used to verify the tidal water calibrations throughout the estuary. Tidal water level verification plots for the Richmond River estuary for 2013 and 2019 are provided in Figure I-12 to Figure I-27.

[1] Note that MHL water level data at Bungawalbin Creek showed a smaller tidal amplitude compared to the upstream and downstream gauges and was therefore excluded from the overall model calibrations. This is likely to be a function of a local shoal which would require more detail bathymetry survey to be well represented in the numerical model.

[2] Note that for 2019, there was data gaps in water level records at the Ballina Breakwall MHL Station (203452). To compensate for this data water level data from MHL gauge at Missingham Bridge (203456) was used in lieu. The water levels from these two sites were compared to be less than 0.05 m of each other with a phase lag of less than 5 minutes (this was considered to be within the calibration limits of the Richmond hydrodynamic model).

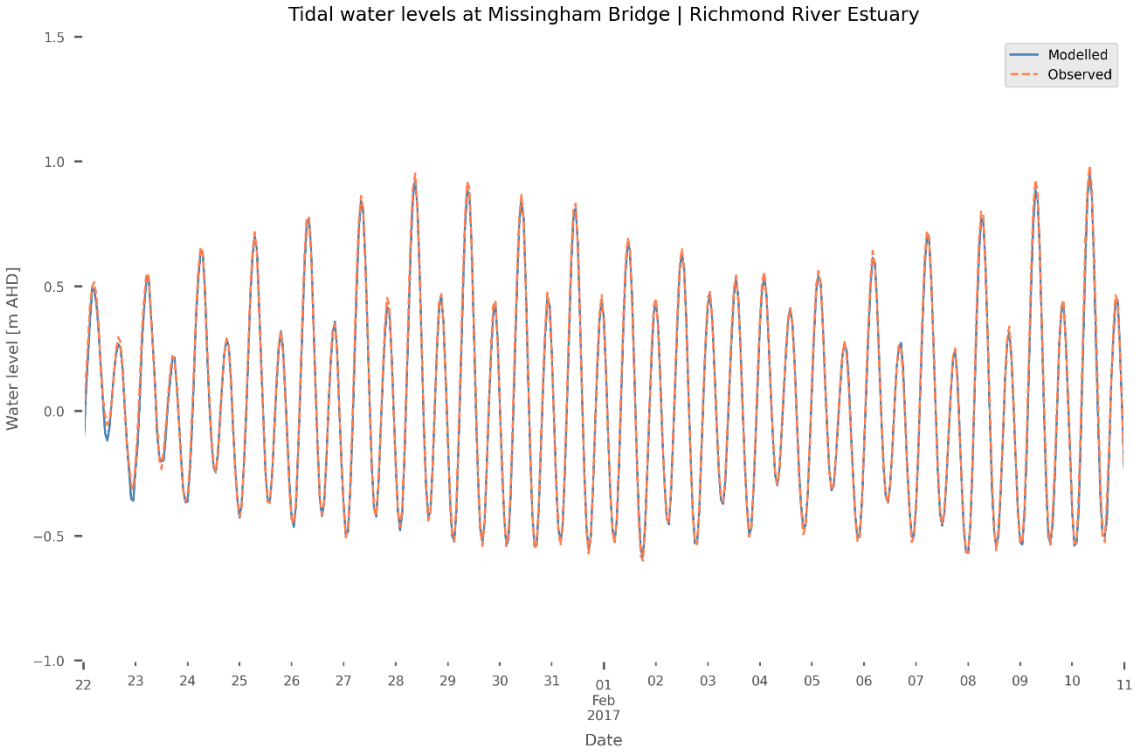


Figure I-4: Richmond hydrodynamic model calibration results (2017) at Missingham Bridge (203456)

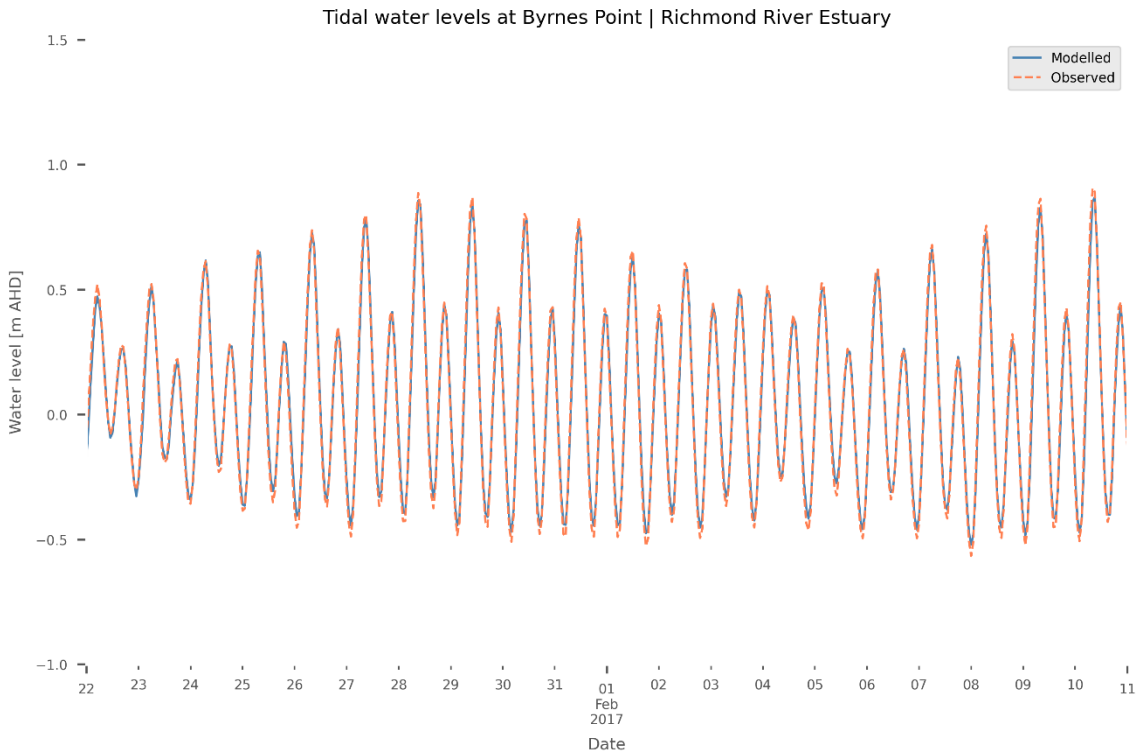


Figure I-5: Richmond hydrodynamic model calibration results (2017) at Byrnes Point (203461)

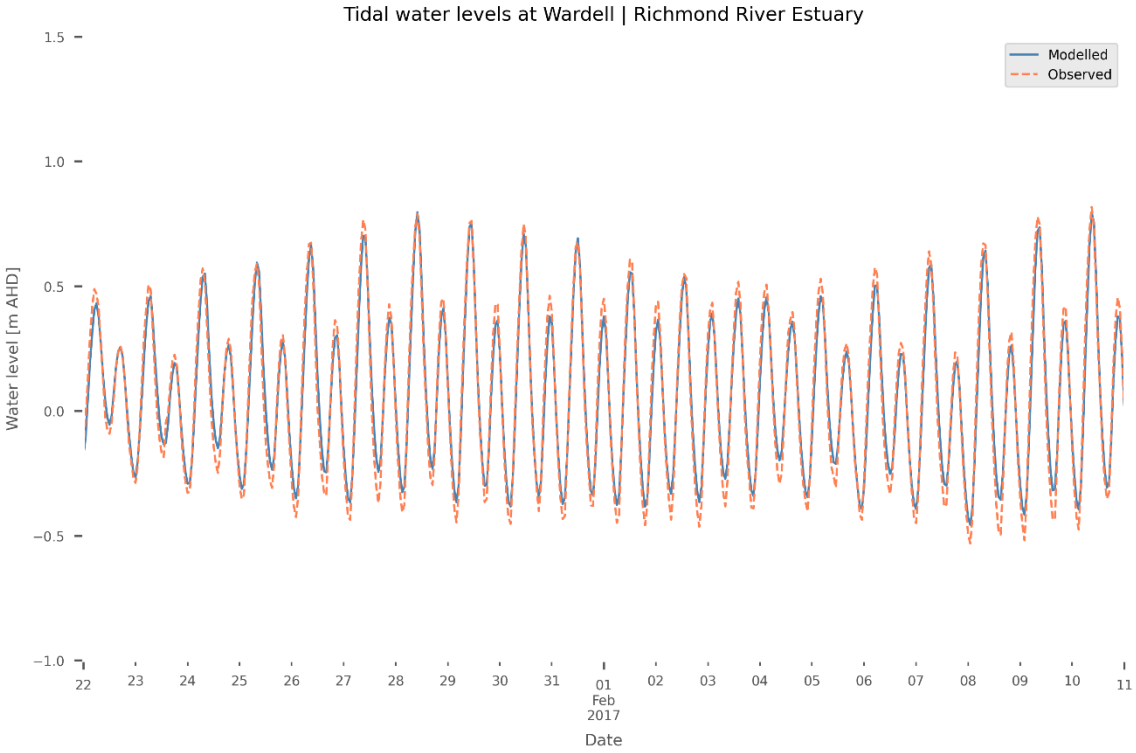


Figure I-6: Richmond hydrodynamic model calibration results (2017) at Wardell (203468)

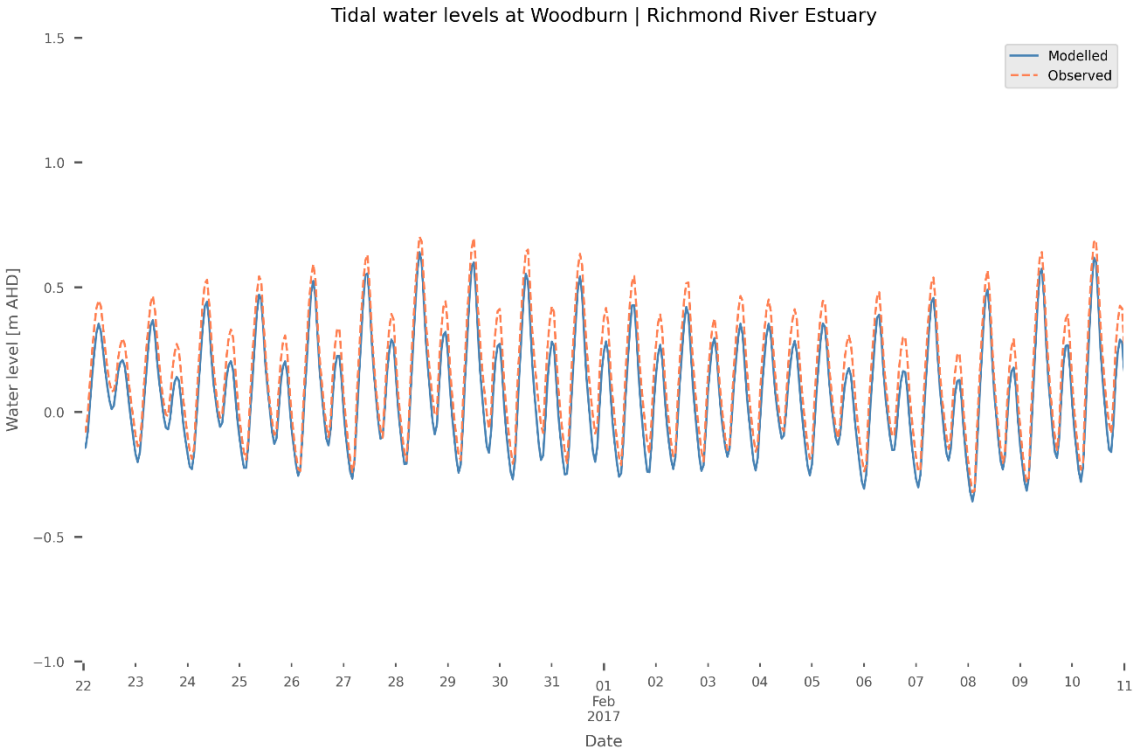


Figure I-7: Richmond hydrodynamic model calibration results (2017) at Woodburn (203412)

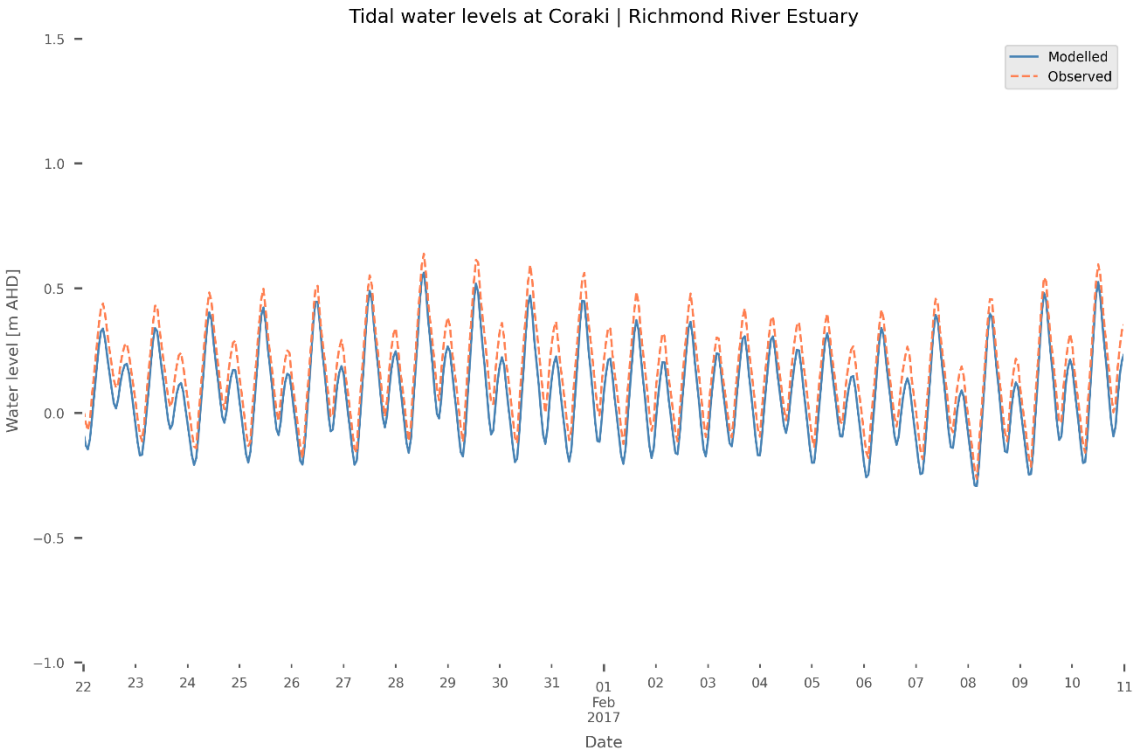


Figure I-8: Richmond hydrodynamic model calibration results (2017) at Coraki (203403)

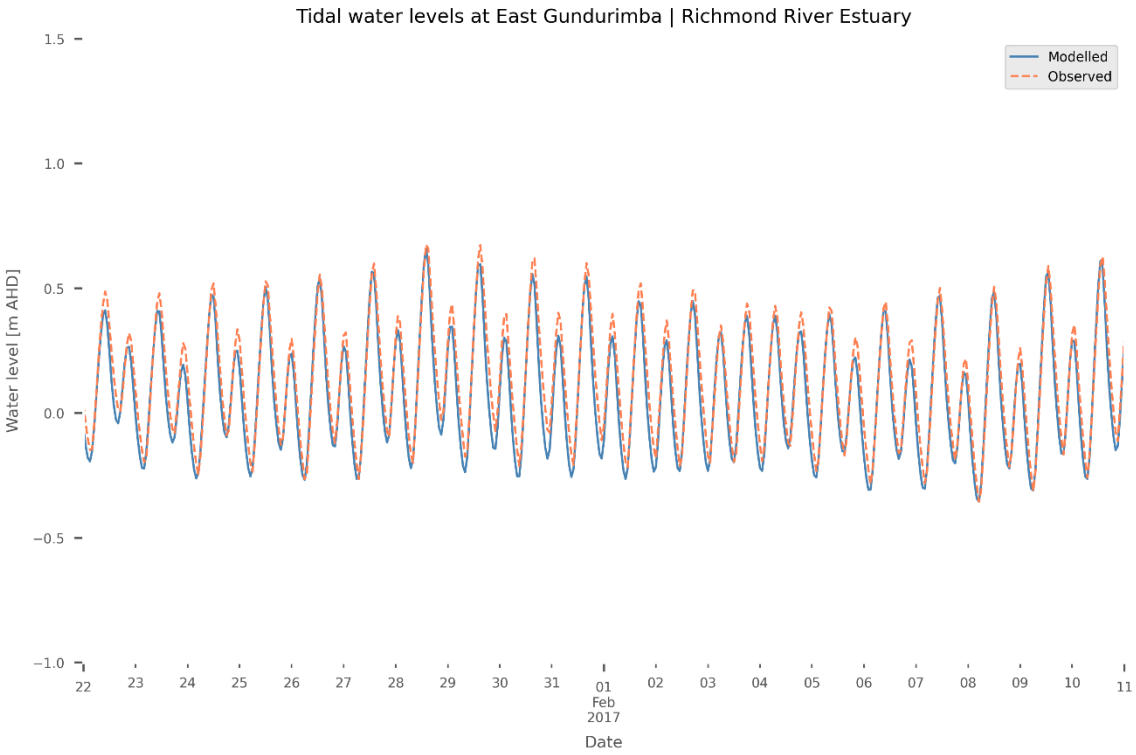


Figure I-9: Richmond hydrodynamic model calibration results (2017) at East Gundurimba (203427)

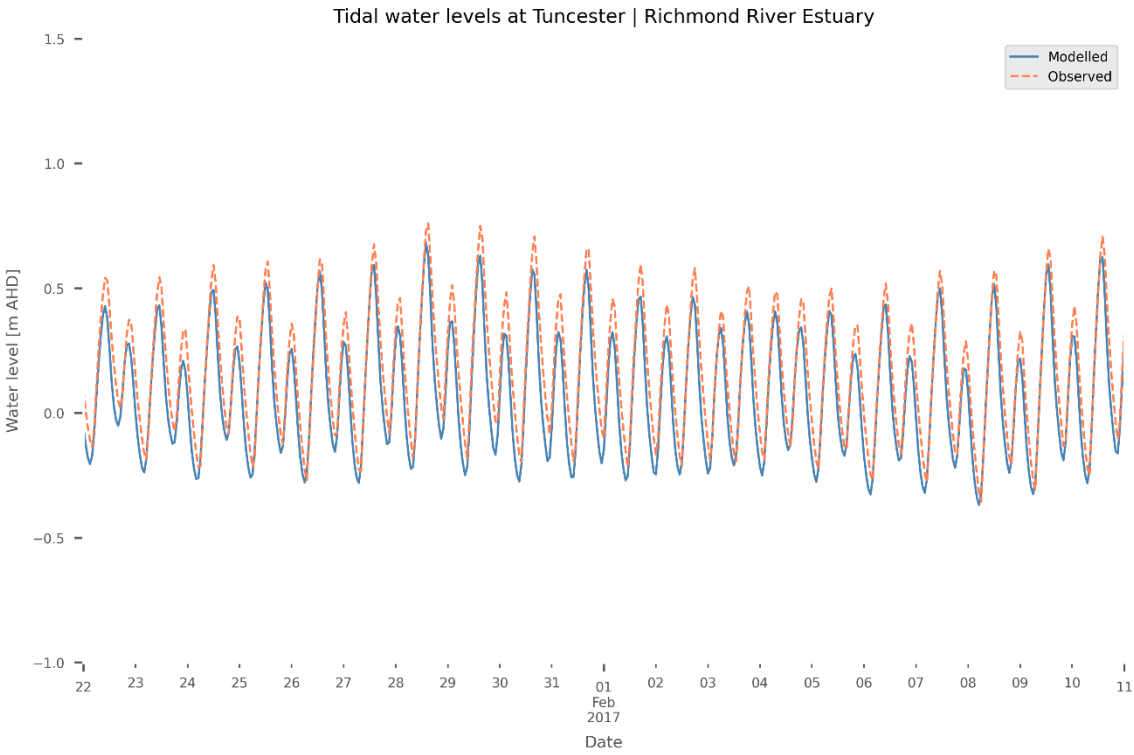


Figure I-10: Richmond hydrodynamic model calibration results (2017) at Tuncester (203443)

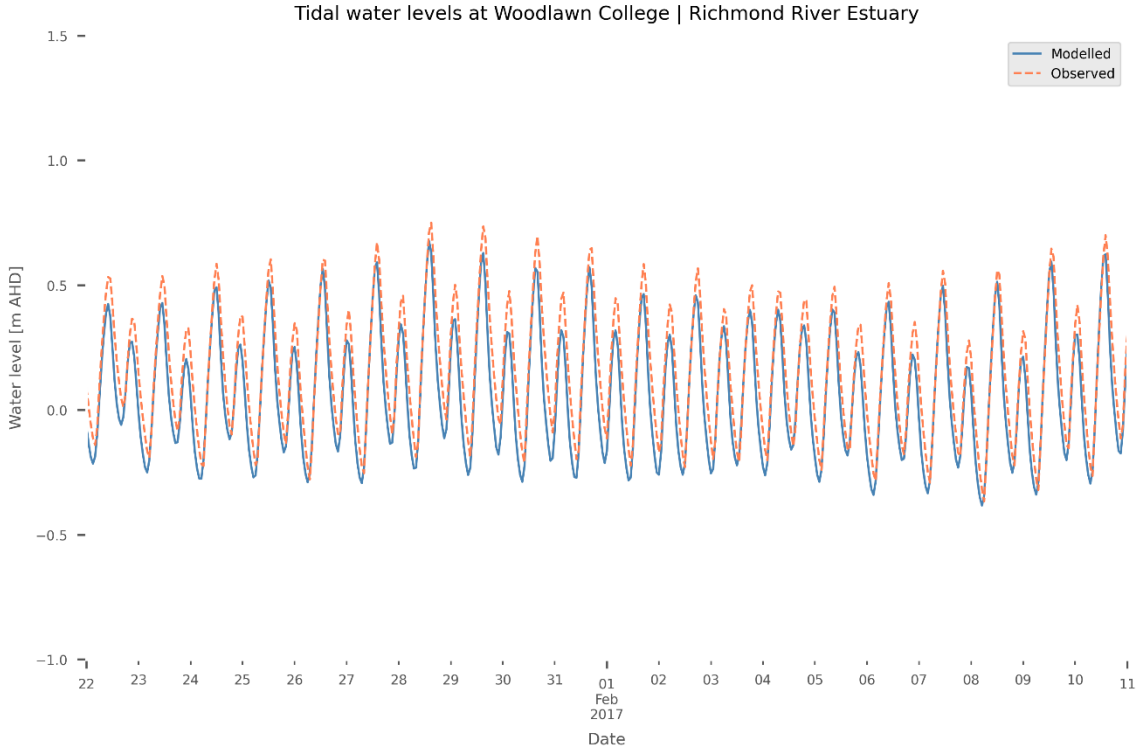


Figure I-11: Richmond hydrodynamic model calibration results (2017) at Woodlawn College (203402)

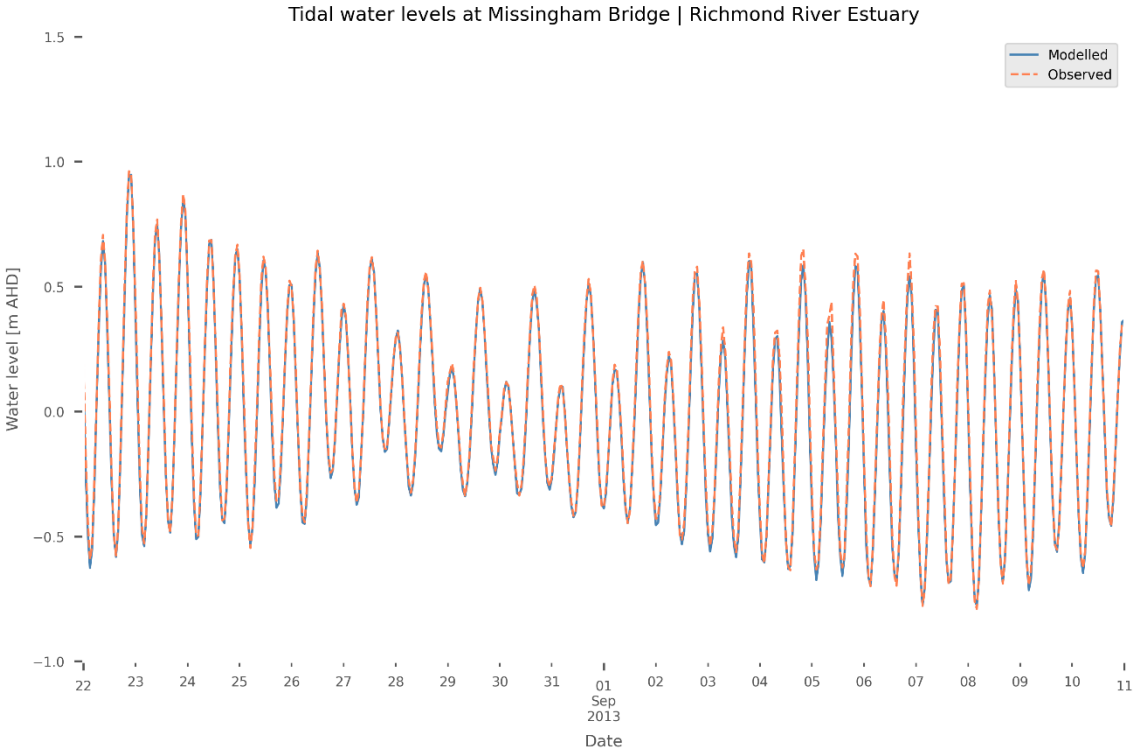


Figure I-12: Richmond hydrodynamic model verification results (2013) at Missingham Bridge (203456)

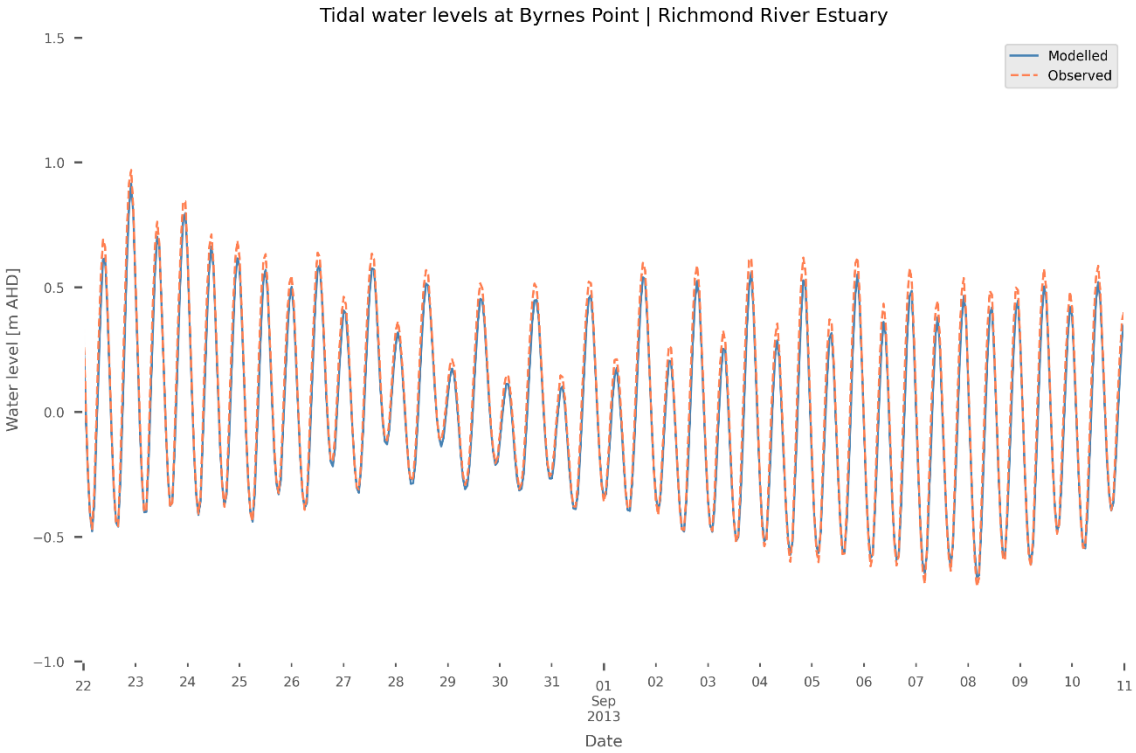


Figure I-13: Richmond hydrodynamic model verification results (2013) at Byrnes Point (203461)

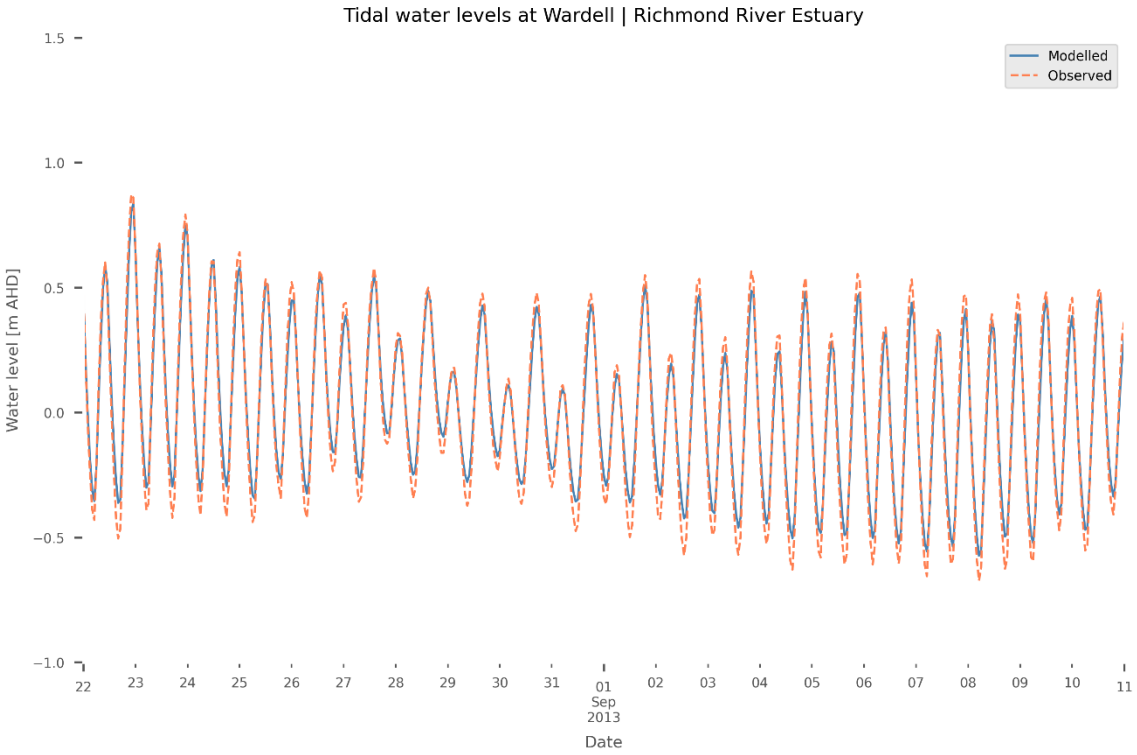


Figure I-14: Richmond hydrodynamic model verification results (2013) at Wardell (203468)

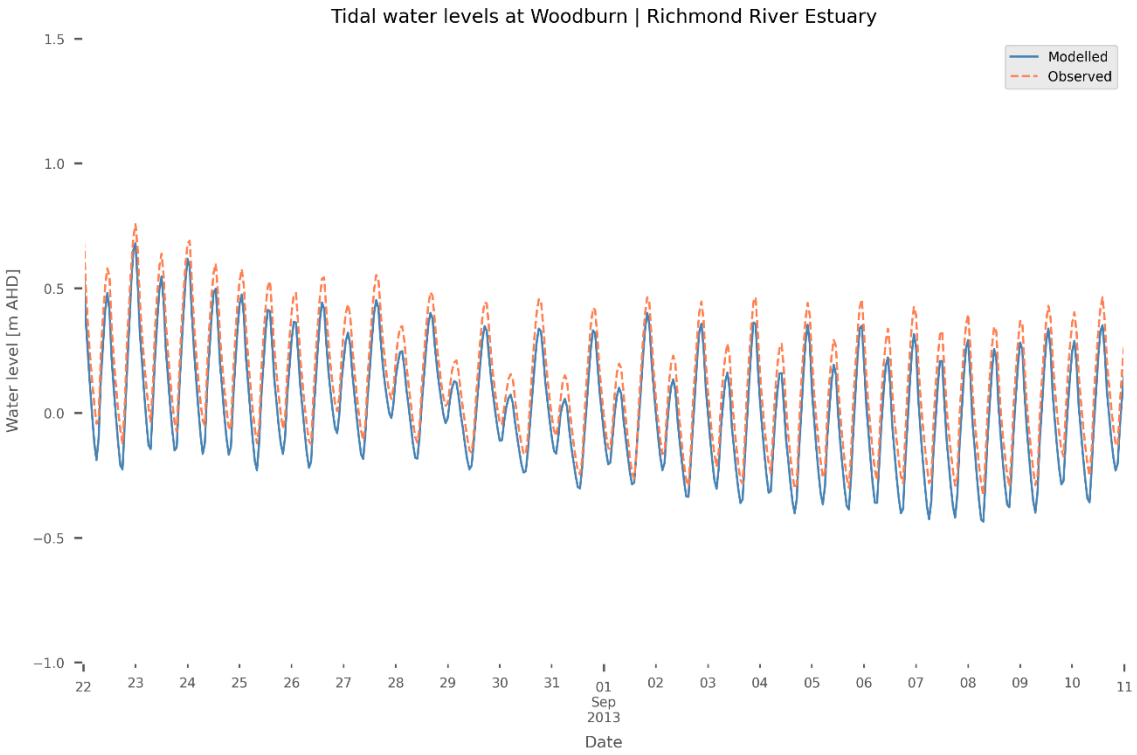


Figure I-15: Richmond hydrodynamic model verification results (2013) at Woodburn (203412)

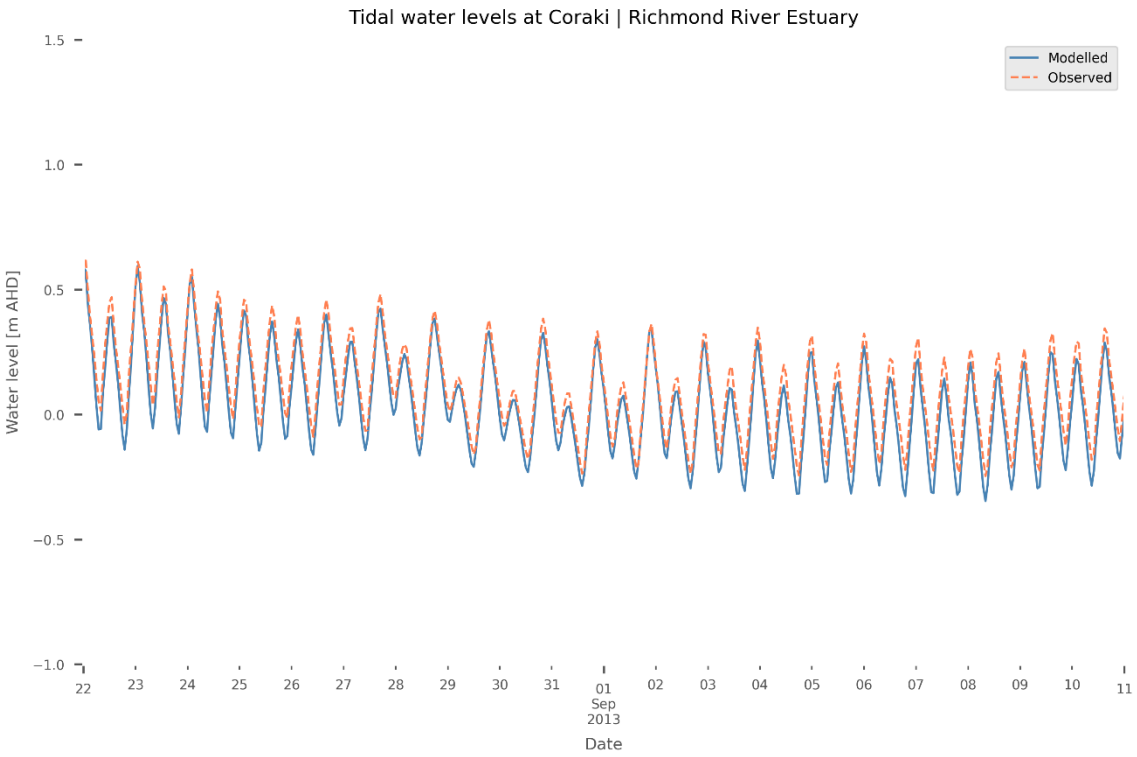


Figure I-16: Richmond hydrodynamic model verification results (2013) at Coraki (203403)

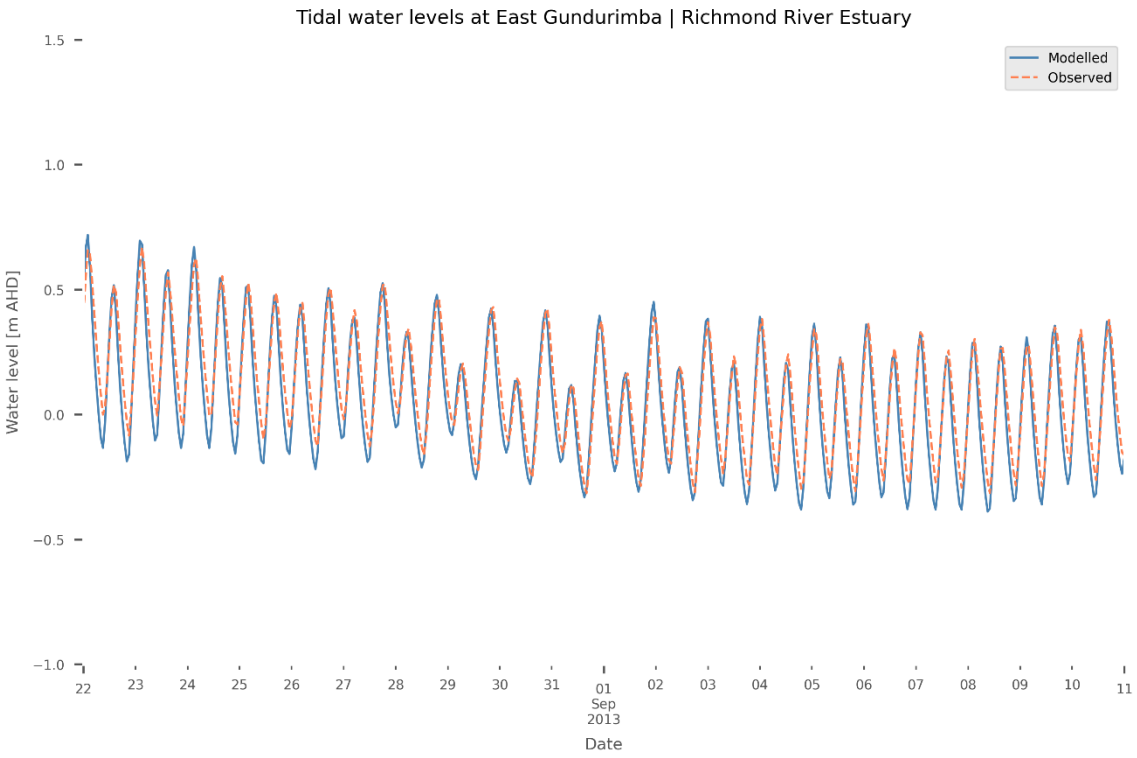


Figure I-17: Richmond hydrodynamic model verification results (2013) at East Gundurimba (203427)

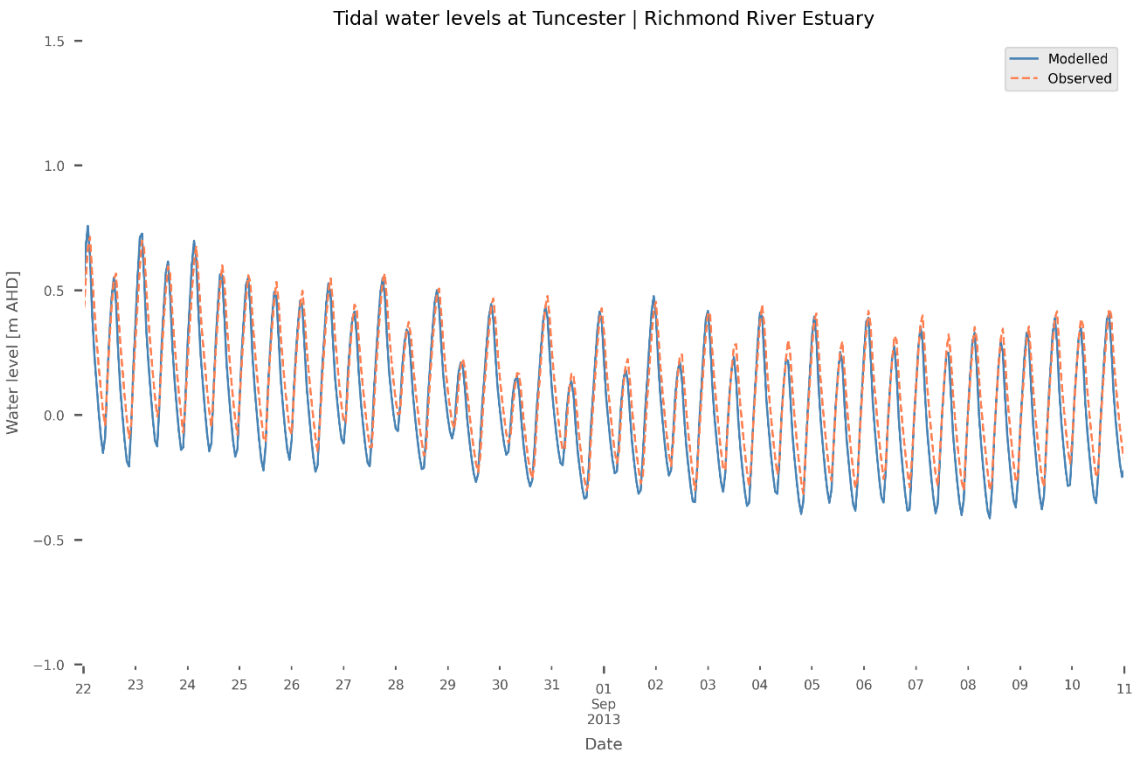


Figure I-18: Richmond hydrodynamic model verification results (2013) at Tuncester (203443)

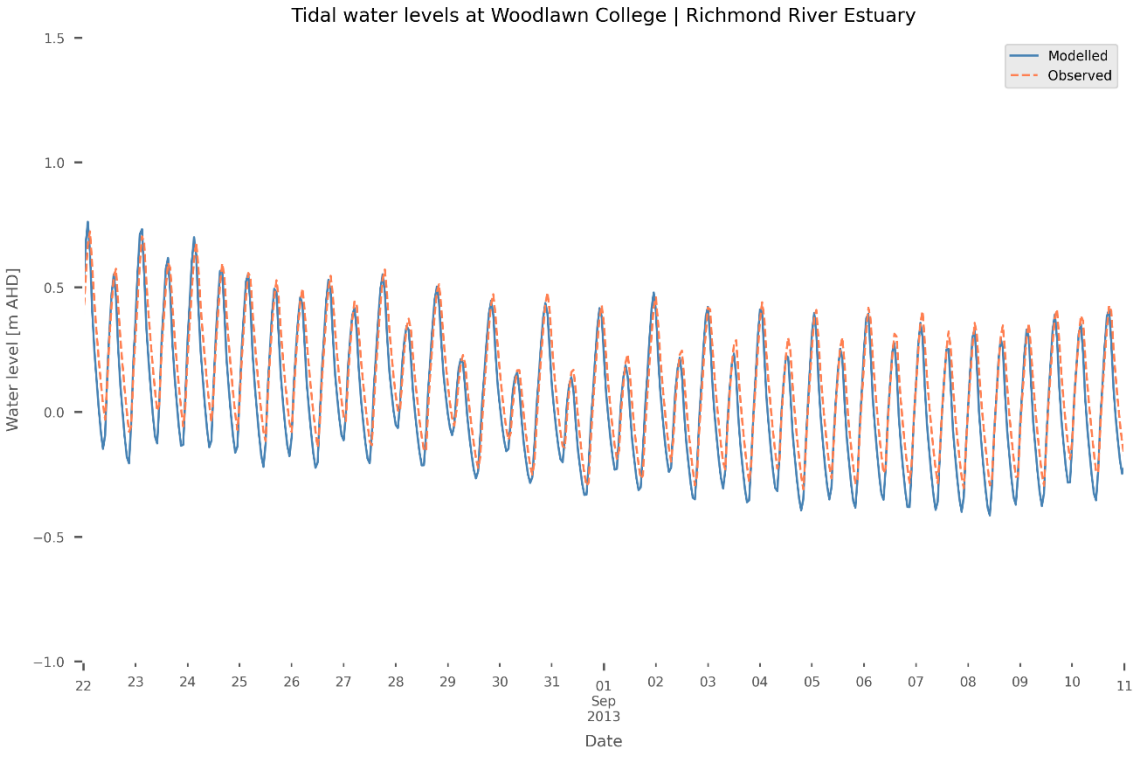


Figure I-19: Richmond hydrodynamic model verification results (2013) at Woodlawn College (203402)

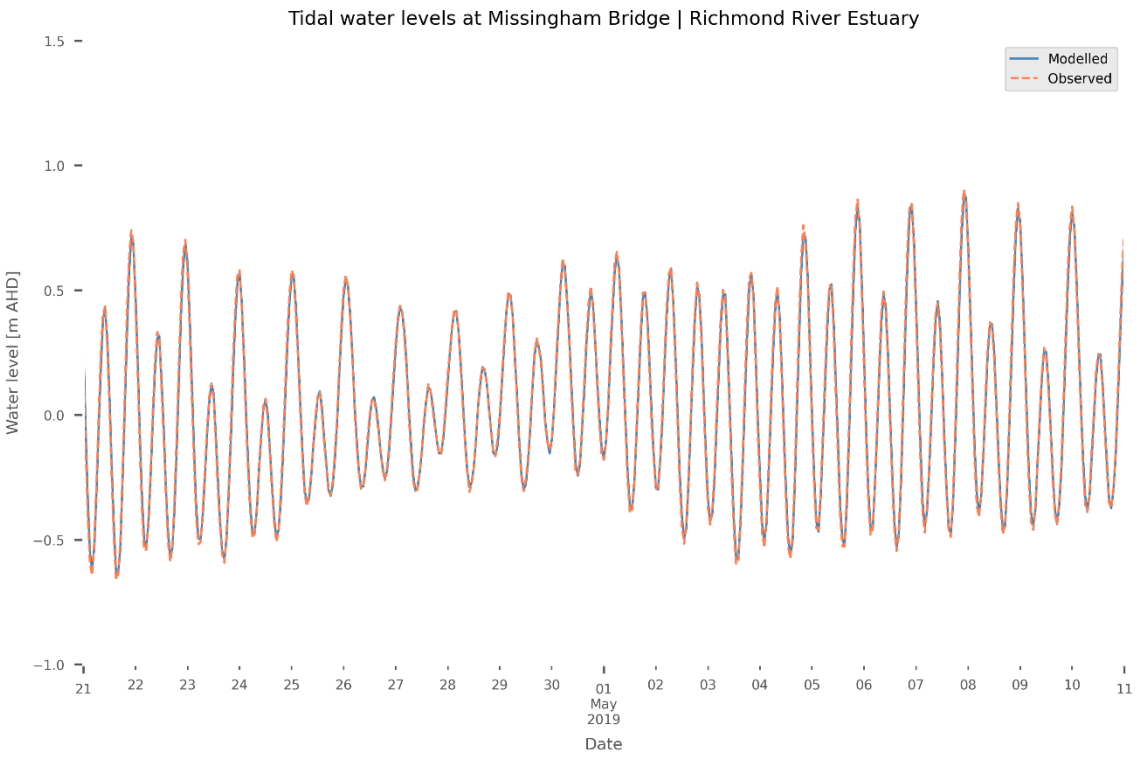


Figure I-20: Richmond hydrodynamic model verification results (2019) at Missingham Bridge (203456)

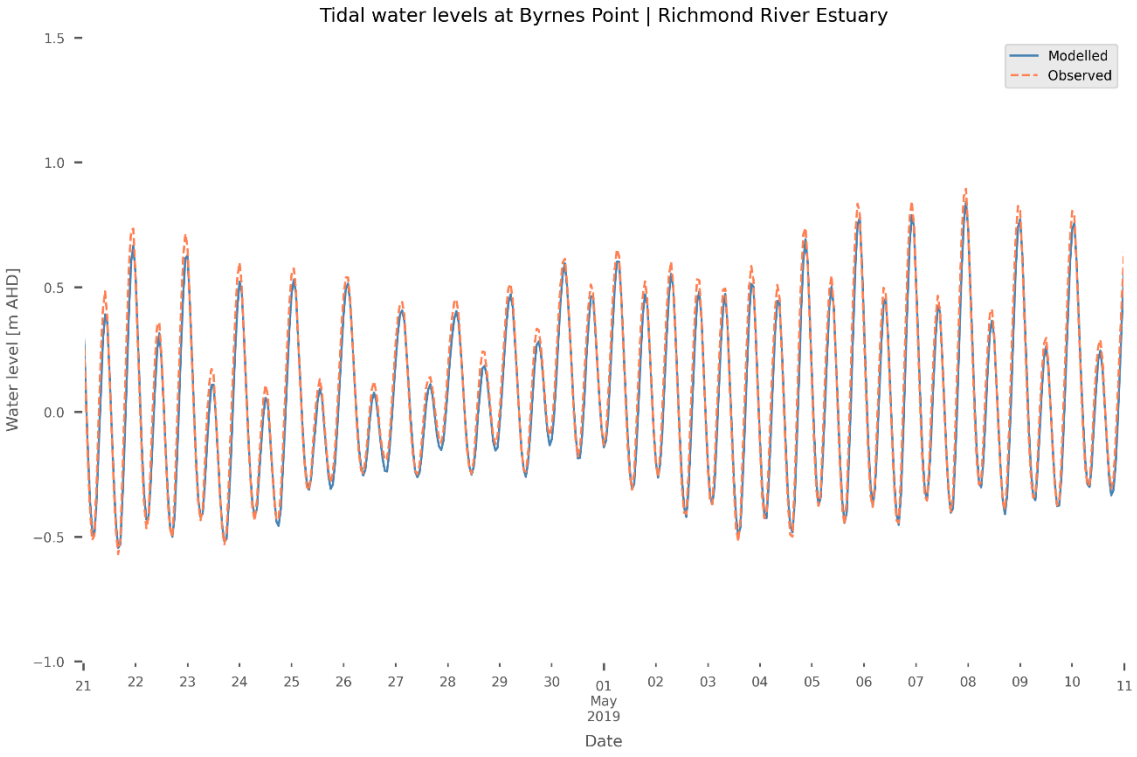


Figure I-21: Richmond hydrodynamic model verification results (2019) at Byrnes Point (203461)

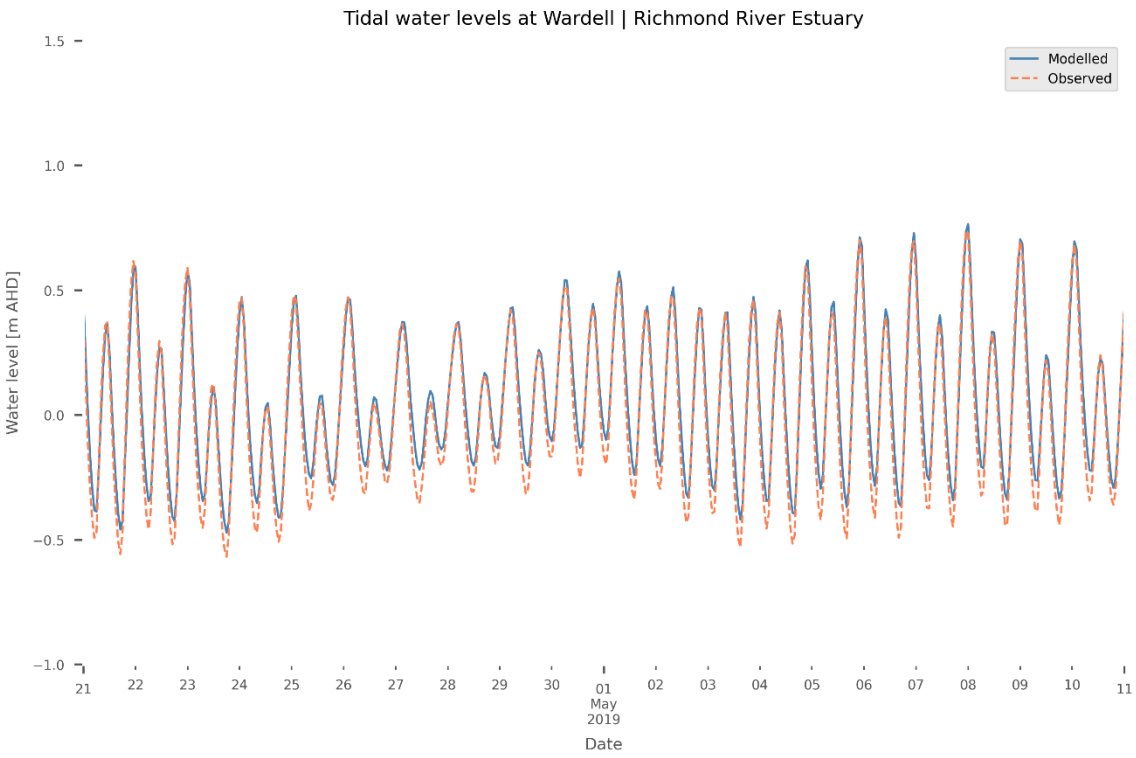


Figure I-22: Richmond hydrodynamic model verification results (2019) at Wardell (203468)

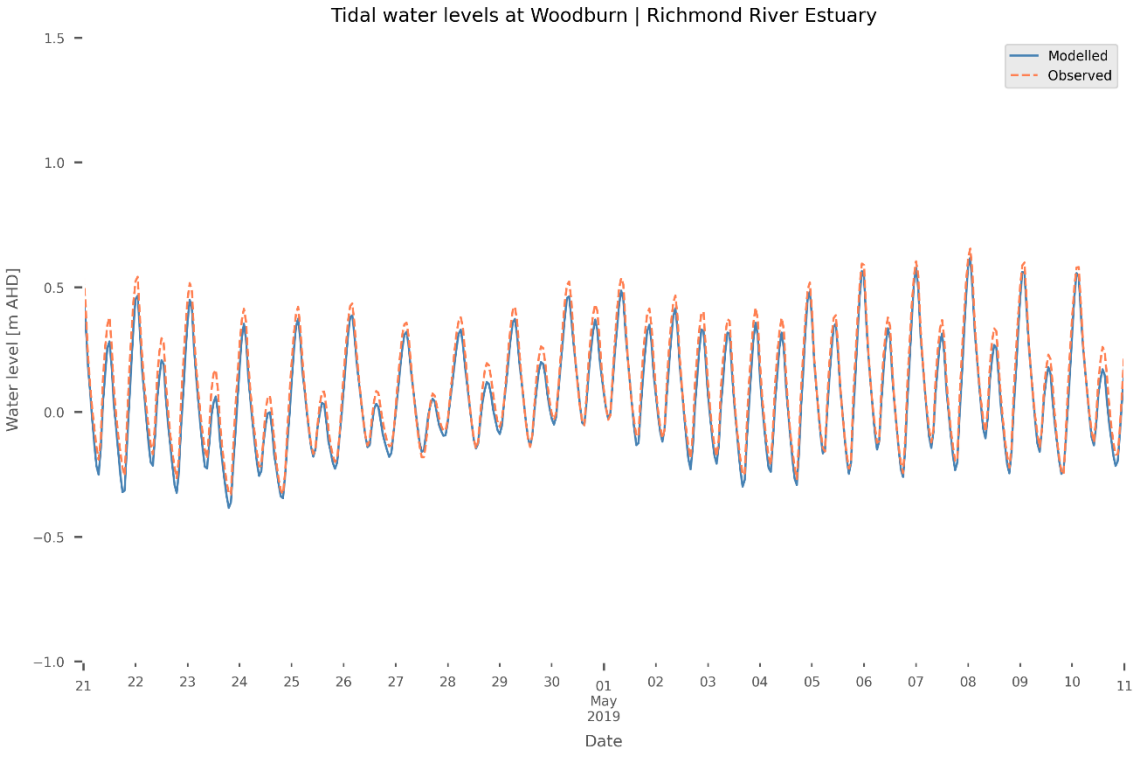


Figure I-23: Richmond hydrodynamic model verification results (2019) at Woodburn (203412)

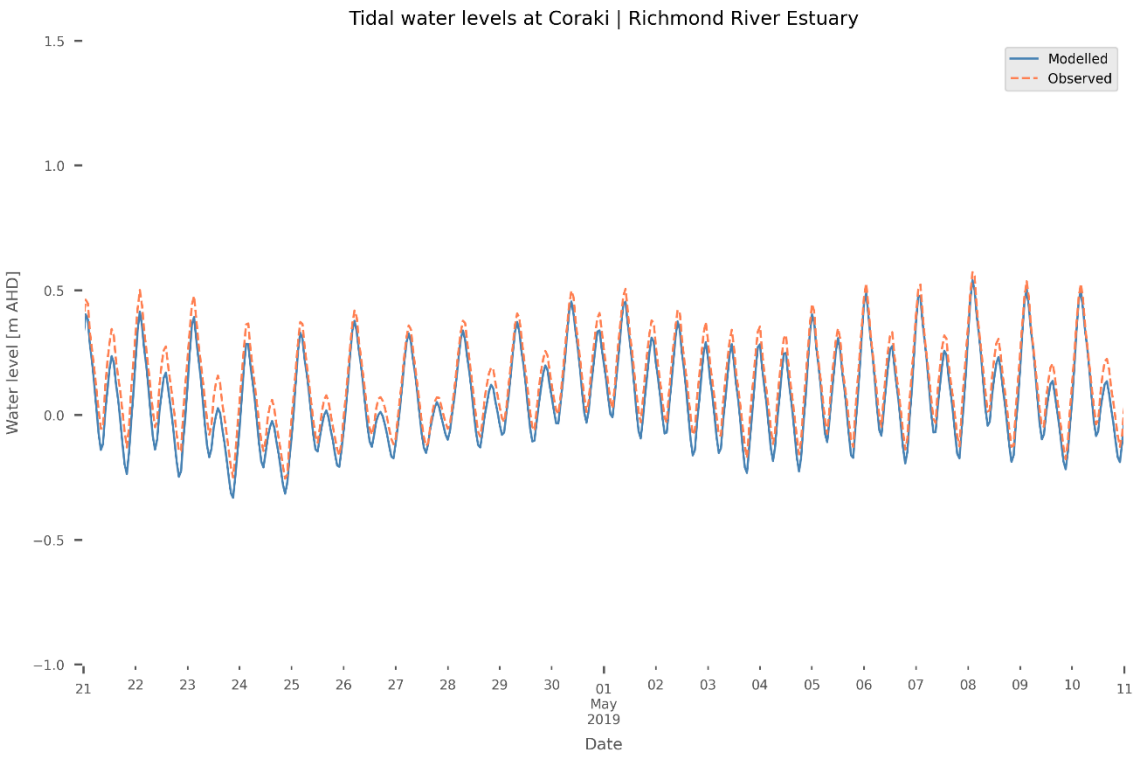


Figure I-24: Richmond hydrodynamic model verification results (2019) at Coraki (203403)

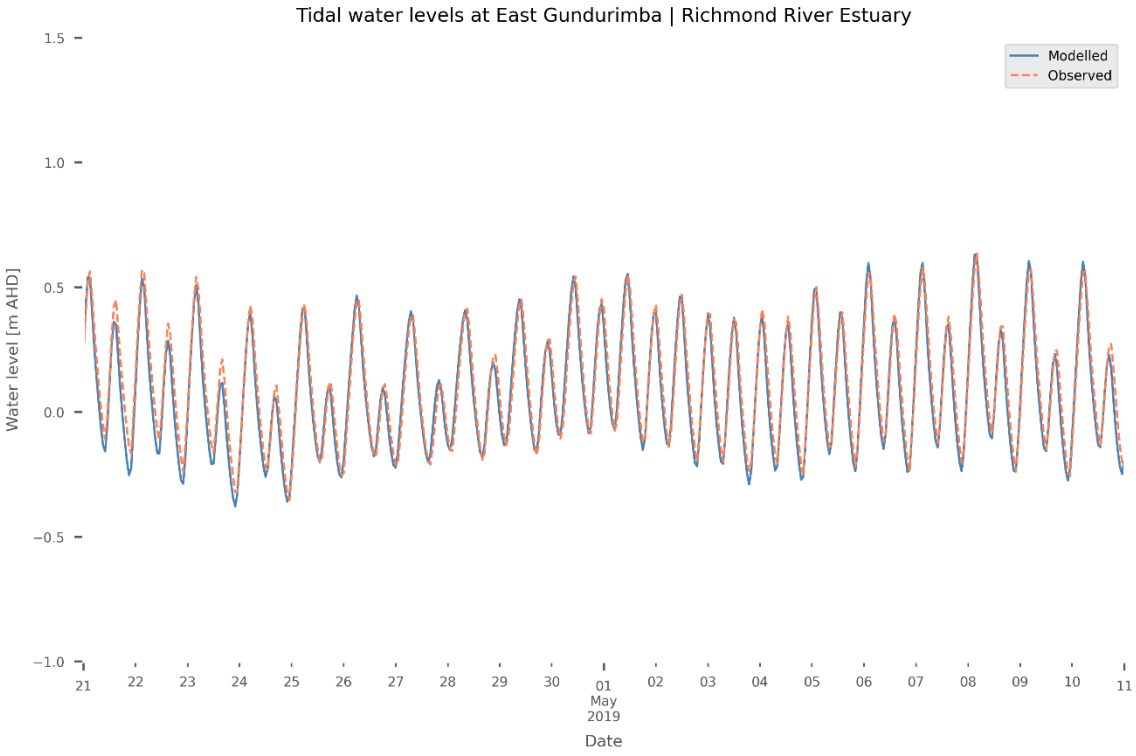


Figure I-25: Richmond hydrodynamic model verification results (2019) at East Gundurimba (203427)

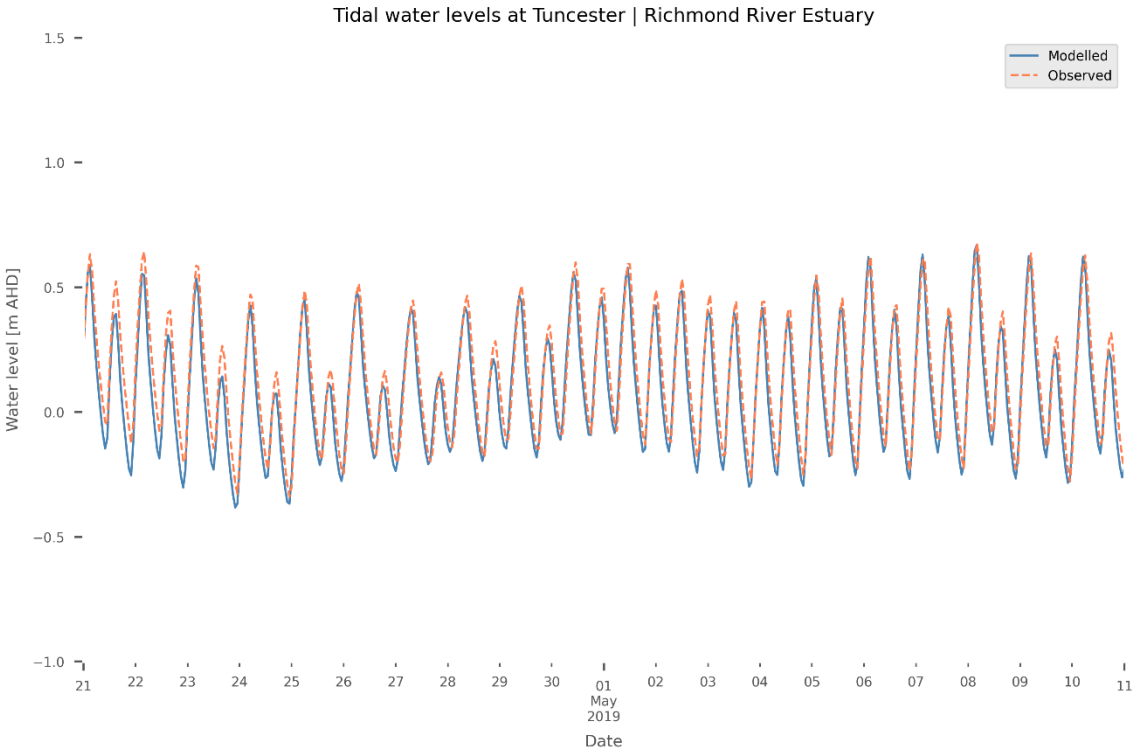


Figure I-26: Richmond hydrodynamic model verification results (2019) at Tuncester (203443)

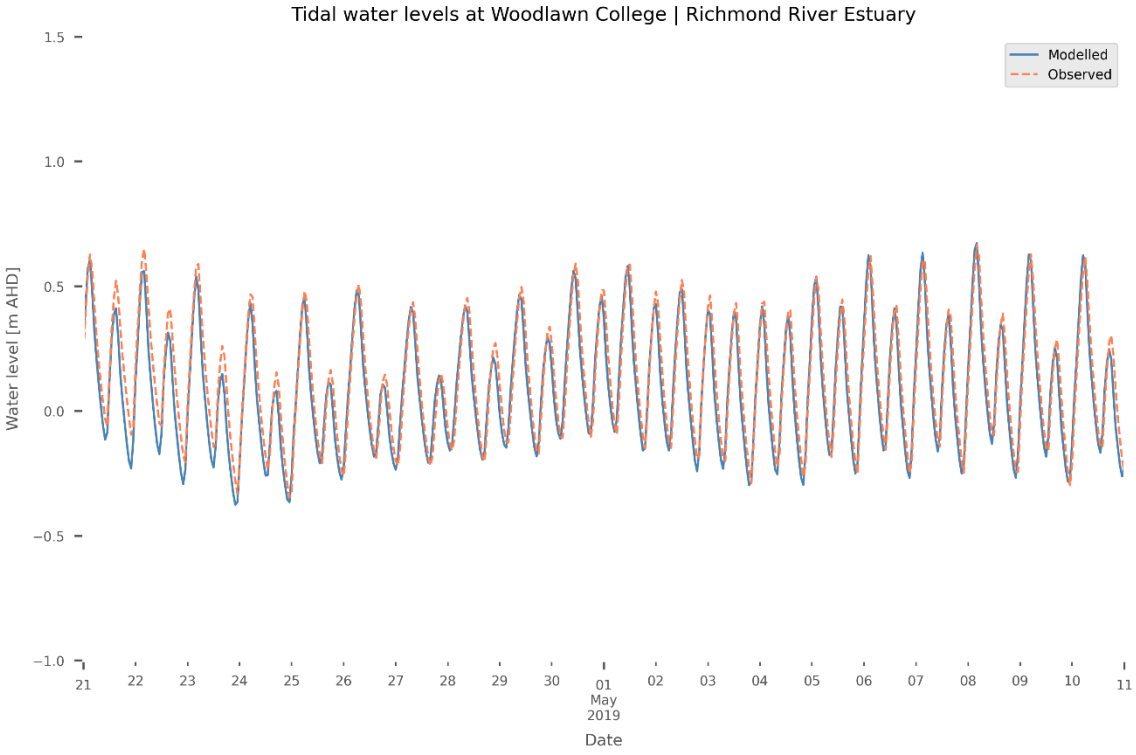


Figure I-27: Richmond hydrodynamic model verification results (2019) at Woodlawn College (203402)

Appendix J Sensitive environmental receivers

J1 Preamble

Acid discharges from ASS-affected floodplains are well reported to cause stress to sensitive environmental receivers (Glamore, 2003; Rayner, 2010; Sammut et al., 1996a; Winberg and Heath, 2010). Furthermore, water control structures associated with ASS-affected drains, such as one-way floodgates, prohibit the passage of aquatic species and limit the overall primary production of estuaries (Winberg and Heath, 2010). Sensitive environmental receivers are widespread throughout the Richmond River estuary. This section provides an overview of the proximity of sensitive environmental receivers to acidic drainage areas within the study area, and the information provided in this section was used to inform the prioritisation of each subcatchment.

J2 Sensitive environmental receivers of the Richmond River Estuary

Several sensitive environmental receivers were identified during the course of this investigation. Both aquatic and terrestrial ecological communities and sensitive locations were identified and mapped as provided in Figure J-1to Figure J-4 including:

- Key fish habitat relating to the Fisheries Management Act (1994);
- Oyster leases;
- Estuarine macrophytes; and
- Coastal wetlands as defined by the State Environmental Planning Policy (Coastal Management) 2018.

The proximity of each subcatchment in the study area to downstream stationary sensitive receivers was calculated as provided in Table J-1.

Table J-1: Summary of approximate proximity (in metres) of sensitive environmental receivers (SER) to each subcatchment within the study area

Subcatchment	Oyster leases	Estuarine Macrophytes			Coastal Management SEPP coastal wetlands	SER within subcatchment*
		Saltmarsh	Seagrass	Mangroves		
Back Channel	7,800	3,900	11,600	0	0	Mangroves, coastal wetland, key fish habitat
Bungawalbin Creek	39,000	35,000	42,700	13,500	16,500	Key fish habitat
Emigrant Creek/ Maguires Creek	600	0	0	0	0	Saltmarsh, mangroves, coastal wetland, key fish habitat
Empire Vale	1,100	0	4,900	0	0	Saltmarsh, mangroves, coastal wetland, key fish habitat
Kilgin/ Buckendoon	20,700	16,700	24,400	0	200	None
North Creek	0	0	0	0	0	Saltmarsh, mangroves, coastal wetland, key fish habitat
Rileys Hill	16,500	12,500	20,200	0	0	Key fish habitat
Rocky Mouth Creek	31,900	28,000	35,700	200	9,500	Key fish habitat
Sandy Creek	39,500	35,500	43,200	14,000	17,000	Key fish habitat
Swan Bay	35,300	31,300	39,000	5,500	12,800	Key fish habitat
South Ballina	0	0	0	0	0	Saltmarsh, mangroves, coastal wetland, key fish habitat
Tuckean Swamp	15,000	11,000	18,700	0	0	Mangroves, coastal wetland, key fish habitat
Upper Richmond/ Wilsons River	47,400	43,400	51,100	22,000	25,000	Key fish habitat

*Note: Within subcatchment does not include SER that may be found on the outside boundary (i.e. downstream of floodgates) of the subcatchment.

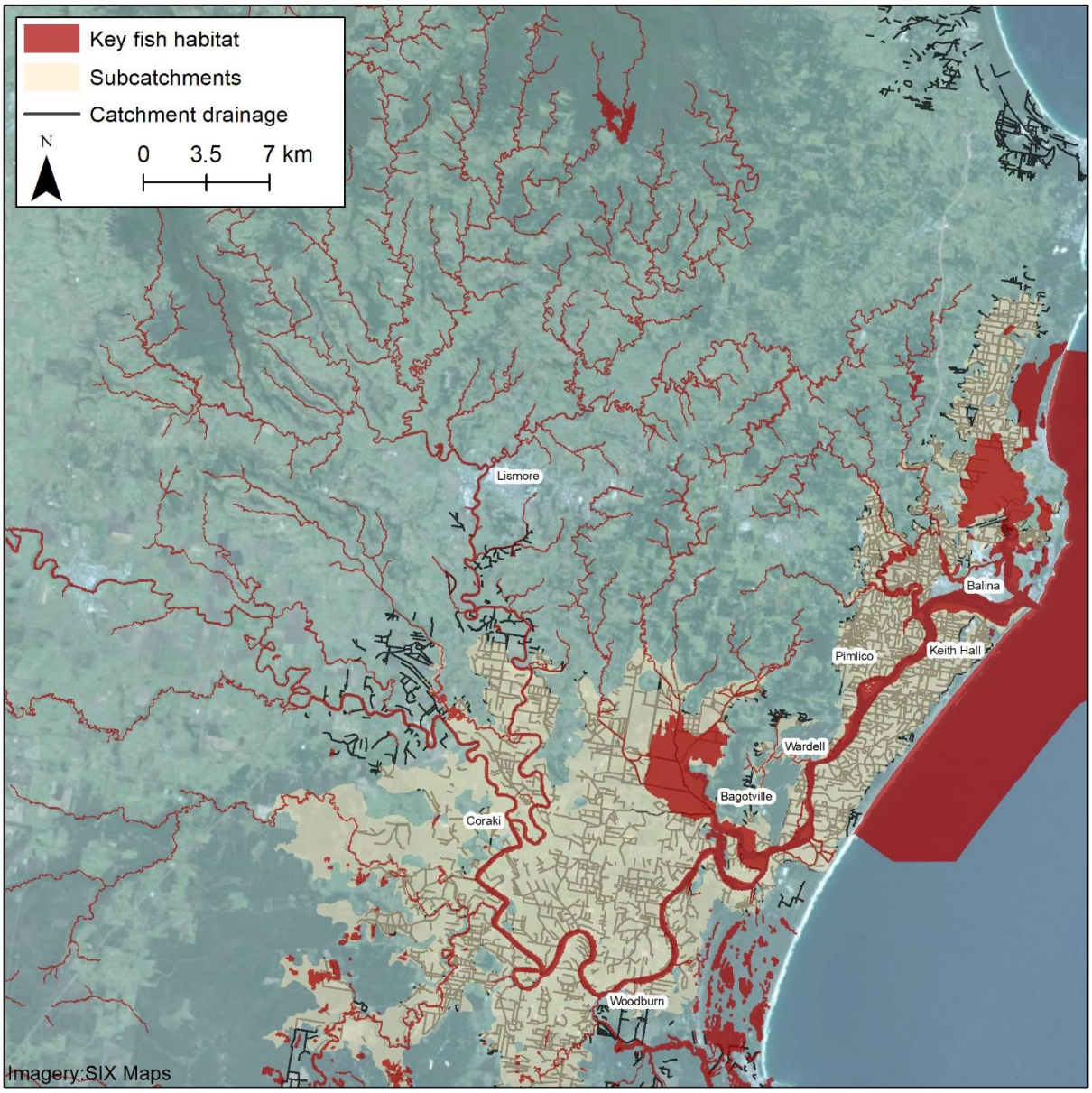


Figure J-1: Key fisheries habitat (Source: NSW DPI Fisheries)

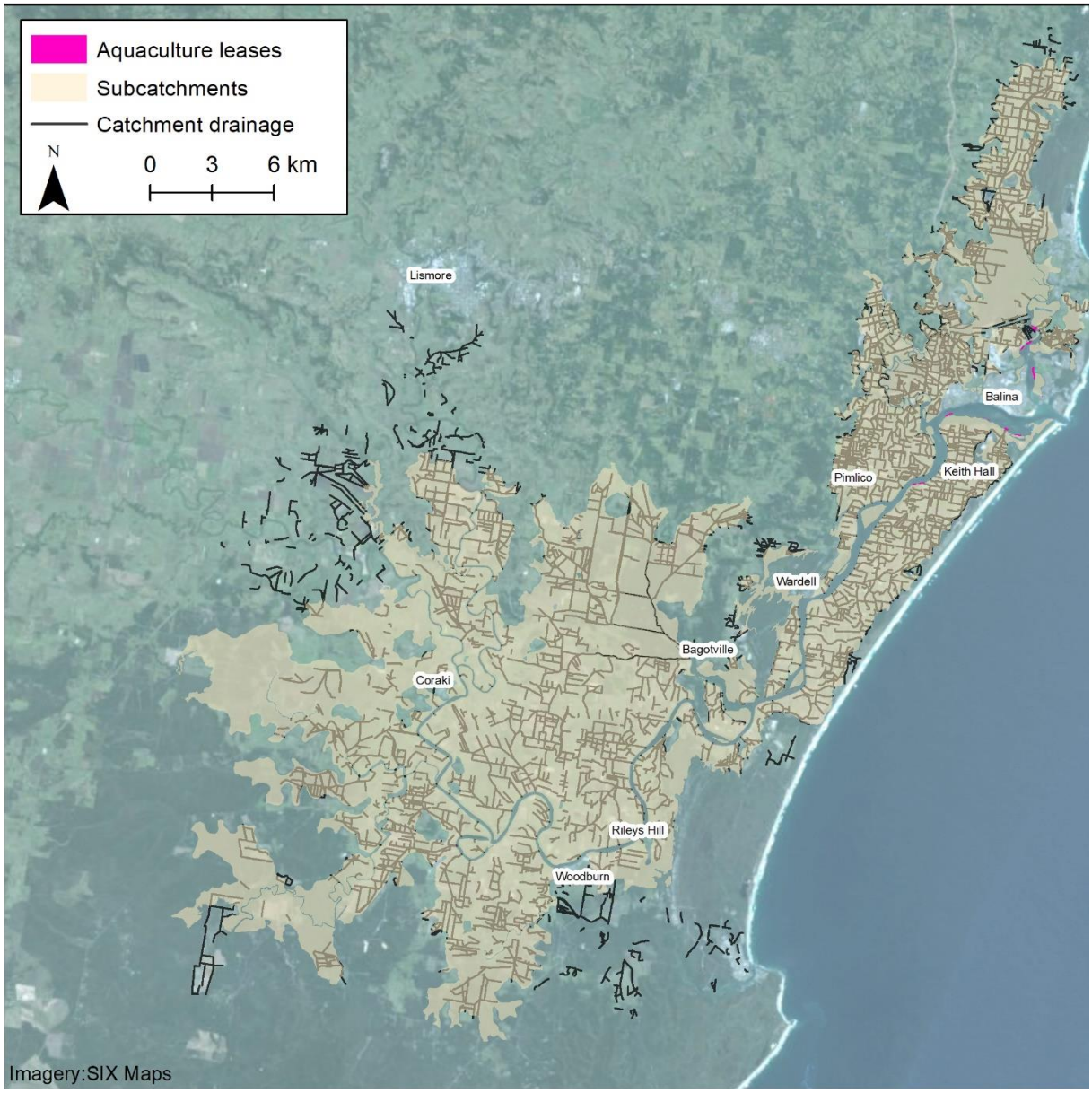


Figure J-2: Priority oyster leases (Source: NSW DPI Fisheries)

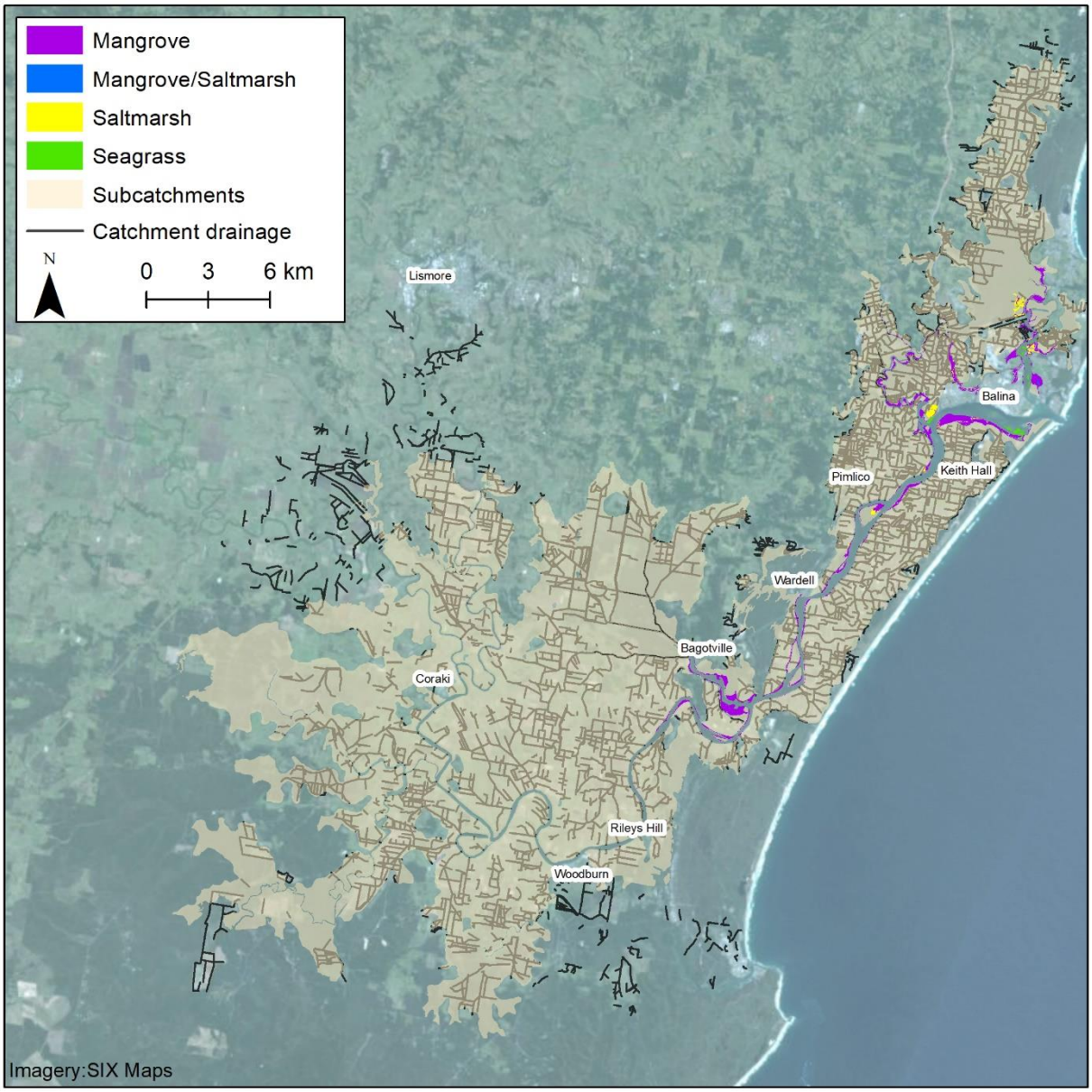


Figure J-3: Estuarine macrophytes (Source: NSW DPI Fisheries)

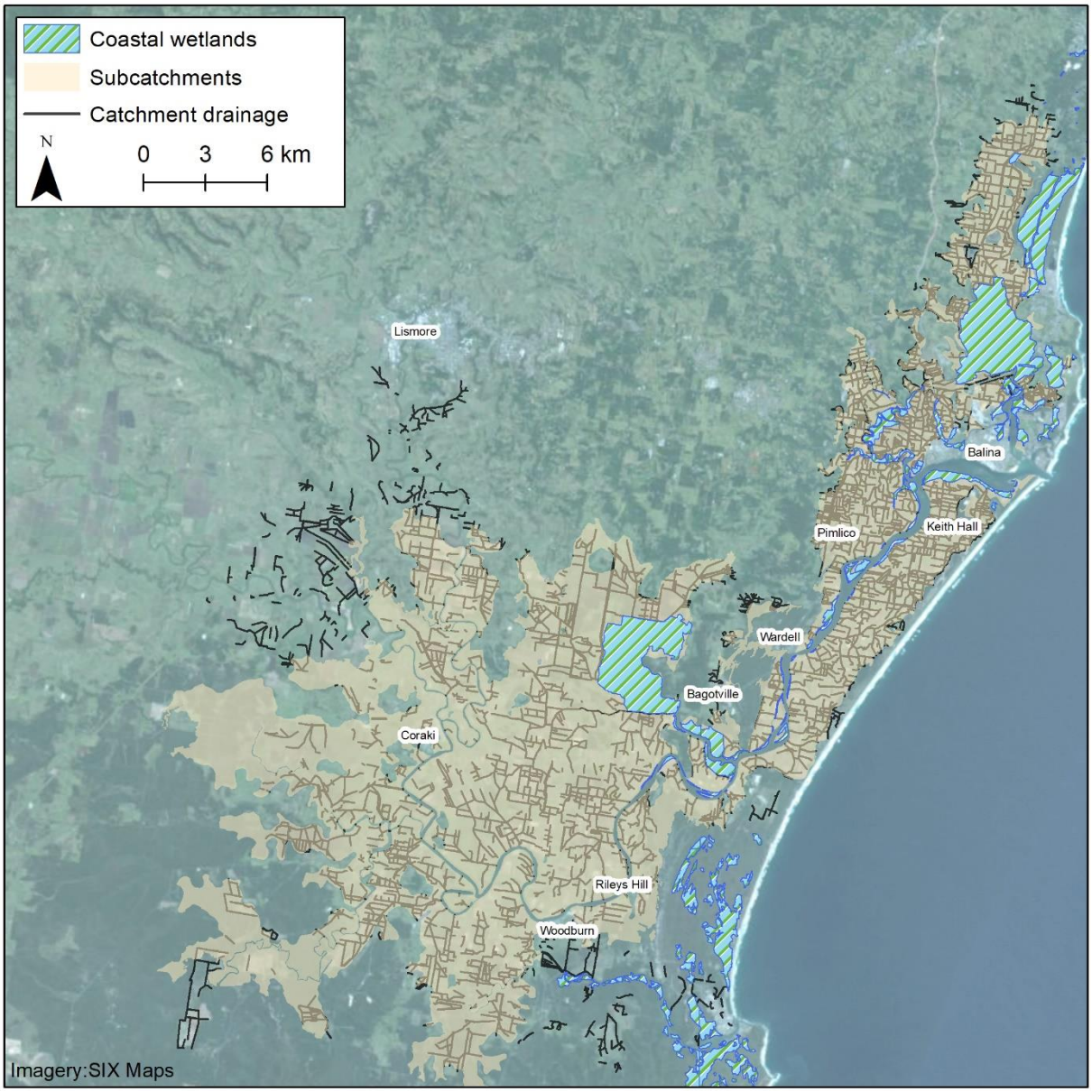


Figure J-4: Coastal Management SEPP coastal wetlands (Source: SEED NSW data portal)[1]

[1] Note that the State Environmental Planning Policy No. 14 (SEPP14) for Coastal Wetlands was repealed by cl 9 (a) of State Environmental Planning Policy (Coastal Management) 2018 (106) with effect from 3.4.2018. This policy aims to promote an integrated and co-ordinated approach to land use planning in the coastal zone to ensure that these areas, including coastal wetlands are preserved and protected in the environmental and economic interests of the State.

Appendix K Heritage

K1 Preamble

Heritage listings in NSW are protected by law under the Heritage Act, 1977 (amended 1998) and the Environmental Planning and Assessment Act 1979. National heritage items are protected under the Environment Protection and Biodiversity Conservation Act 1999. Heritage items protected include:

- Items listed in local councils Local Environmental Plan (LEP) or Regional Environmental Plan (REP);
- Items listed on the State Heritage Register;
- Items listed on State Agency Heritage Registers (under Section 170 of the Heritage Act, 1977);
- Items listed on Interim Heritage Orders;
- Items listed on the Aboriginal Heritage Information Management System (AHIMS);
- Items listed on the Maritime Heritage Database;
- Items listed on the Commonwealth Heritage List; and
- Items listed on the National Heritage List.

Implementation of management options needs to consider any heritage listed items that may be affected during on-ground works. Heritage items fall under the category of implementation constraints in the prioritisation methodology (see Section 2 of the Methods report (Rayner et al., 2023)). Note that new heritage items are continuously being registered. Subsequently, items identified and presented in this section should only be used as a guide and it is encouraged that anyone seeking to identify the most recent information on heritage listed items will need to consult the relevant registers which contain current information.

K2 Aboriginal heritage

Aboriginal sites across the Richmond River floodplain listed within the Aboriginal Heritage Information Management System (AHIMS) have been identified to determine if they affect the implementation of management options. Due to the sensitive nature of this information no data can be presented here, however, some aboriginal heritage items are presented within the NSW State Heritage Inventory where there is no restriction (see Section K3).

Note that for any works that will alter the landscape due diligence may need to be carried out as per the National Parks and Wildlife Act 1974. Searching AHIMS is only part of this due diligence process. Furthermore, AHIMS data sourced for this study is only up to date as of October 2019. Prior to any activities being undertaken such as actions outlined in the management options, a renewed search of AHIMS will need to be undertaken to ensure the most current information is being used.

K3 European heritage

Heritage listed items, including items of European origin, have been identified from the Commonwealth Heritage List, National Heritage List and the NSW State Heritage Inventory, which includes:

- Items listed on the State Heritage Register

- Listed Interim Heritage Orders;
- Items listed on State Agency Heritage Registers;
- Items listed on the Ballina Shire Council LEP;
- Items listed on the Lismore City Council LEP; and
- Items listed on the Richmond Valley Council LEP.

Figure K-1 outlines items that have been identified on the National Heritage List, the NSW State Heritage Register and the NSW Office of Environment and Heritage (OEH) Agency Register, the Historic Heritage Information Management System (HHIMS). Items listed on the Commonwealth Heritage Register overlap with the NSW State Heritage Register in the study region so only the NSW State Register items have been displayed. As of June 2020, no Interim Heritage Order items were identified within the study area. Note, prior to any activities being undertaken such as actions outlined in the management options, a renewed search of registers will need to be undertaken to ensure the most current information is being used.

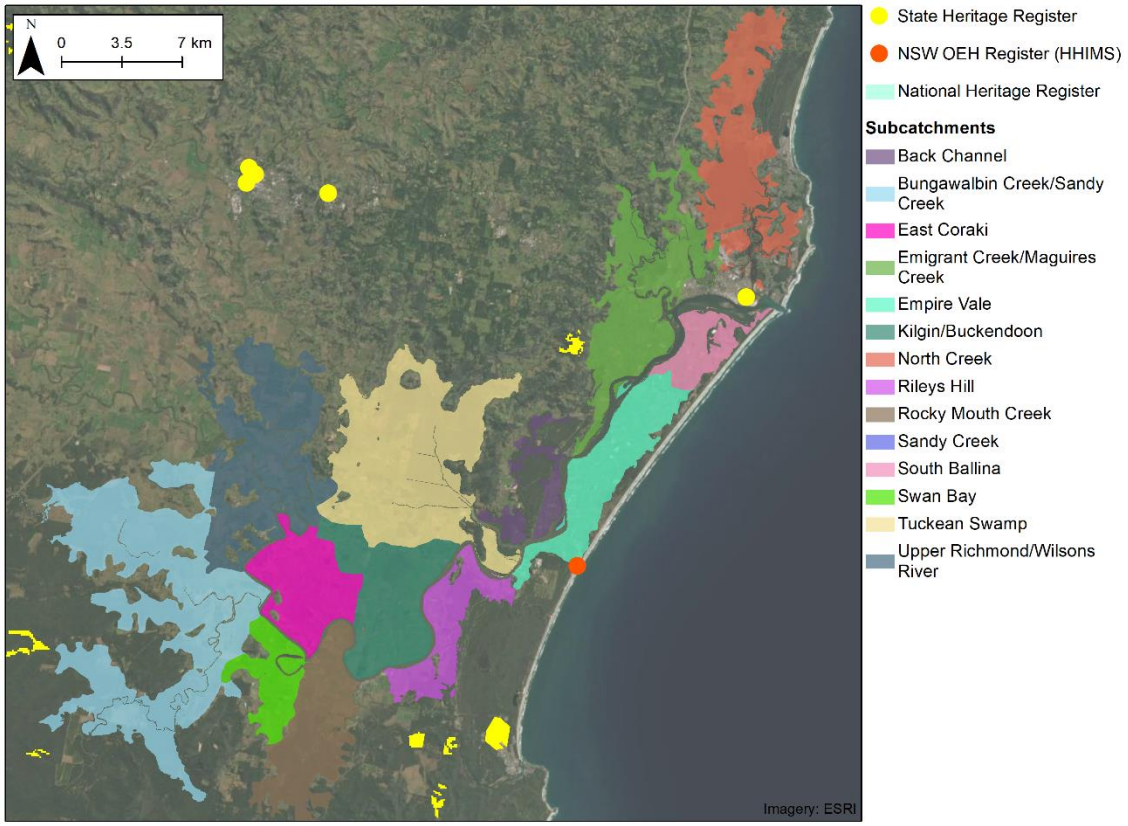


Figure K-1: Heritage items listed on Australian and NSW registers with location information

A total of 582 items were identified as listed on State Agency Registers and the Ballina Shire Council, Lismore City Council and Richmond Valley Council LEPs. For an up to date list of these items consult the NSW State Heritage Inventory.

K4 Maritime heritage

In addition to provisions outlined under the NSW Heritage Act 1977, items of maritime heritage are protected by the Commonwealth Underwater Cultural Heritage Act 2018. Maritime heritage items can be found on the following registers:

- The Australian Underwater Cultural Heritage Database (AUCHD); and
- The NSW Maritime Heritage Database.

Items of maritime heritage listed in the aforementioned registers are displayed in Figure K-2. Note that items added after June 2020 are not included in this list and prior to any activities being undertaken, such as actions outlined in the management options, a renewed search of registers will need to be undertaken to ensure the most current information is being used. Furthermore, the Maritime Heritage specialist services team should be contacted to determine if there are any items of importance that have not been listed.

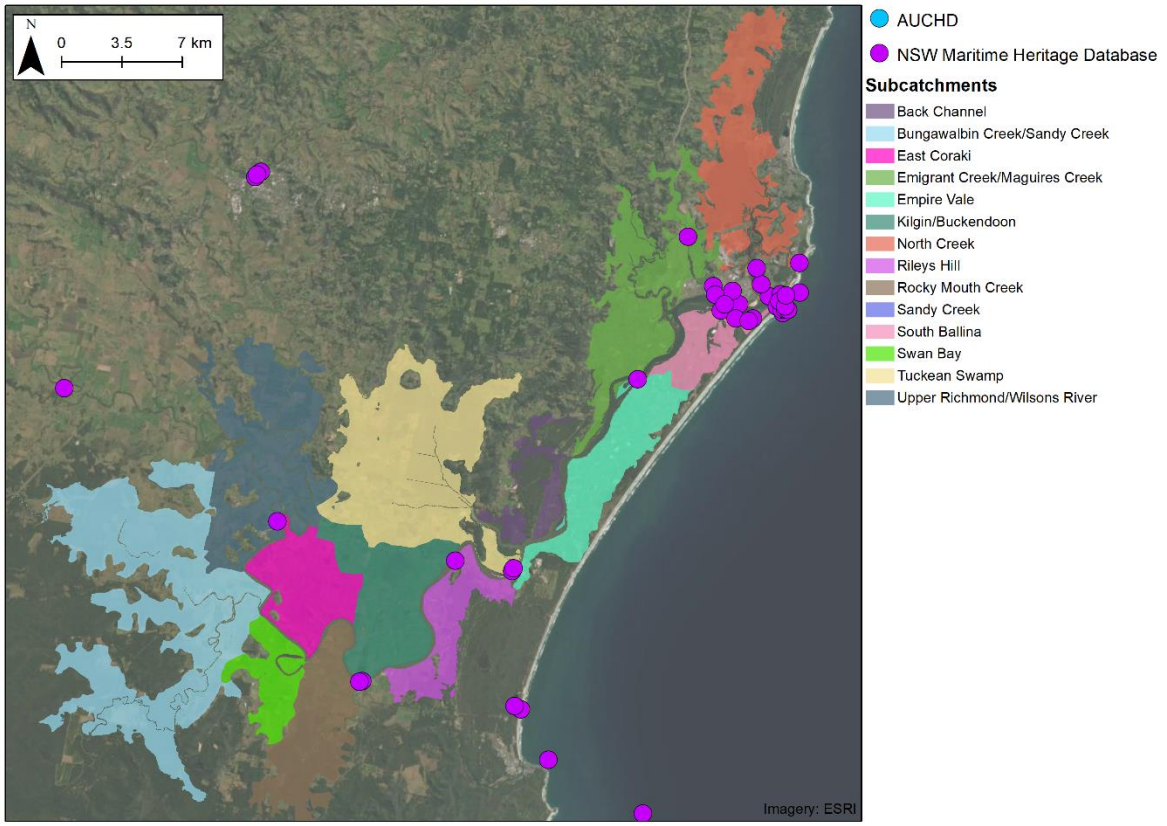


Figure K-2: Maritime heritage items listed on Australian and NSW registers

Appendix L Soil profile data sheets

Soil profile details:

Project Number:	2018064	Profile ID:	RA_02
River/estuary:	Richmond	Sample date:	31/10/19
Easting:	529877.7	Sampled by:	AJH GL KW
Northing:	6799914.7		

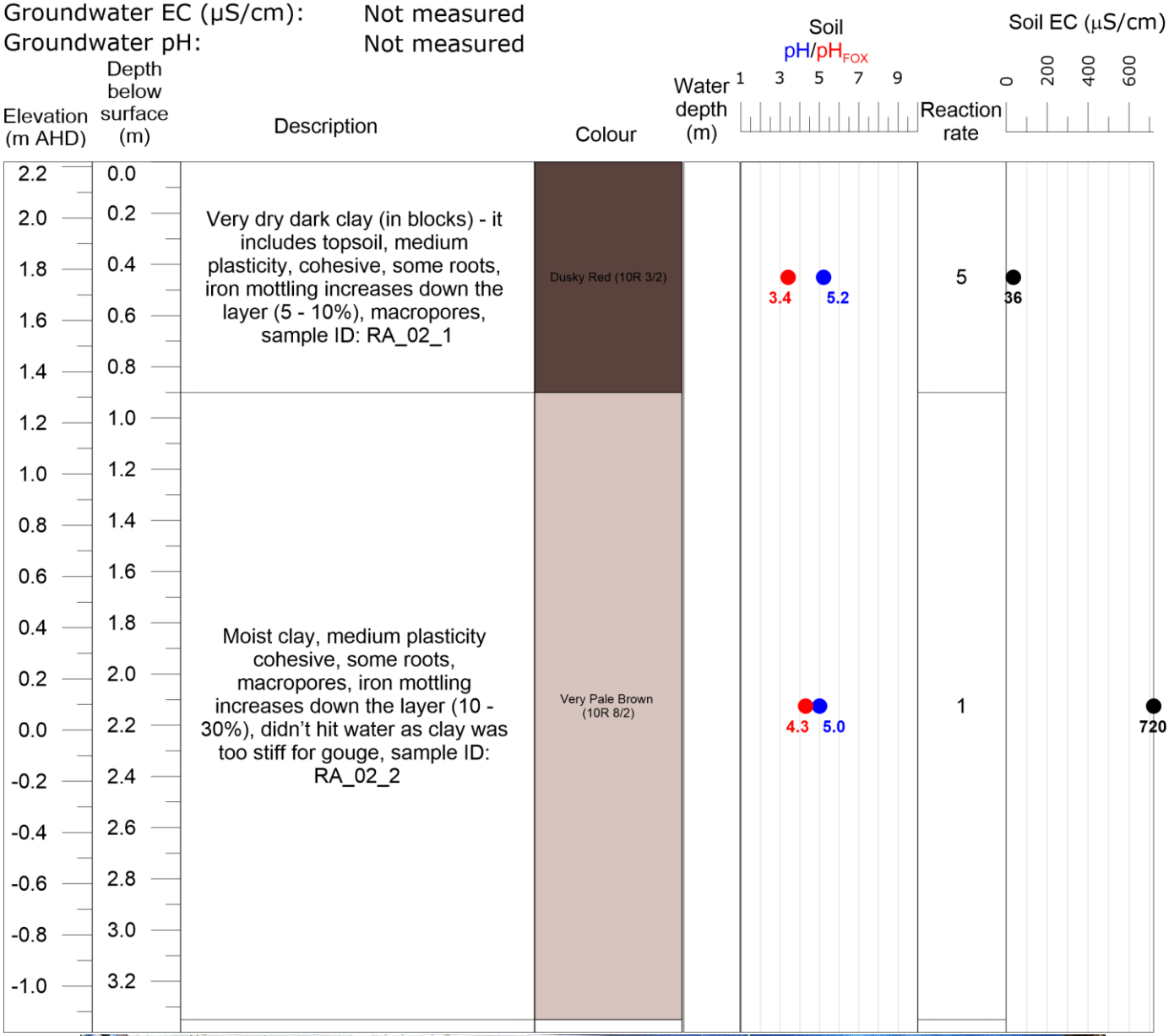
Ground elevation (m AHD): 2.22
Hydraulic conductivity (m/d): Not measured

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Water quality:

Surface water EC (µS/cm): 200
Surface water pH: 6.7
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured





Soil profile details:

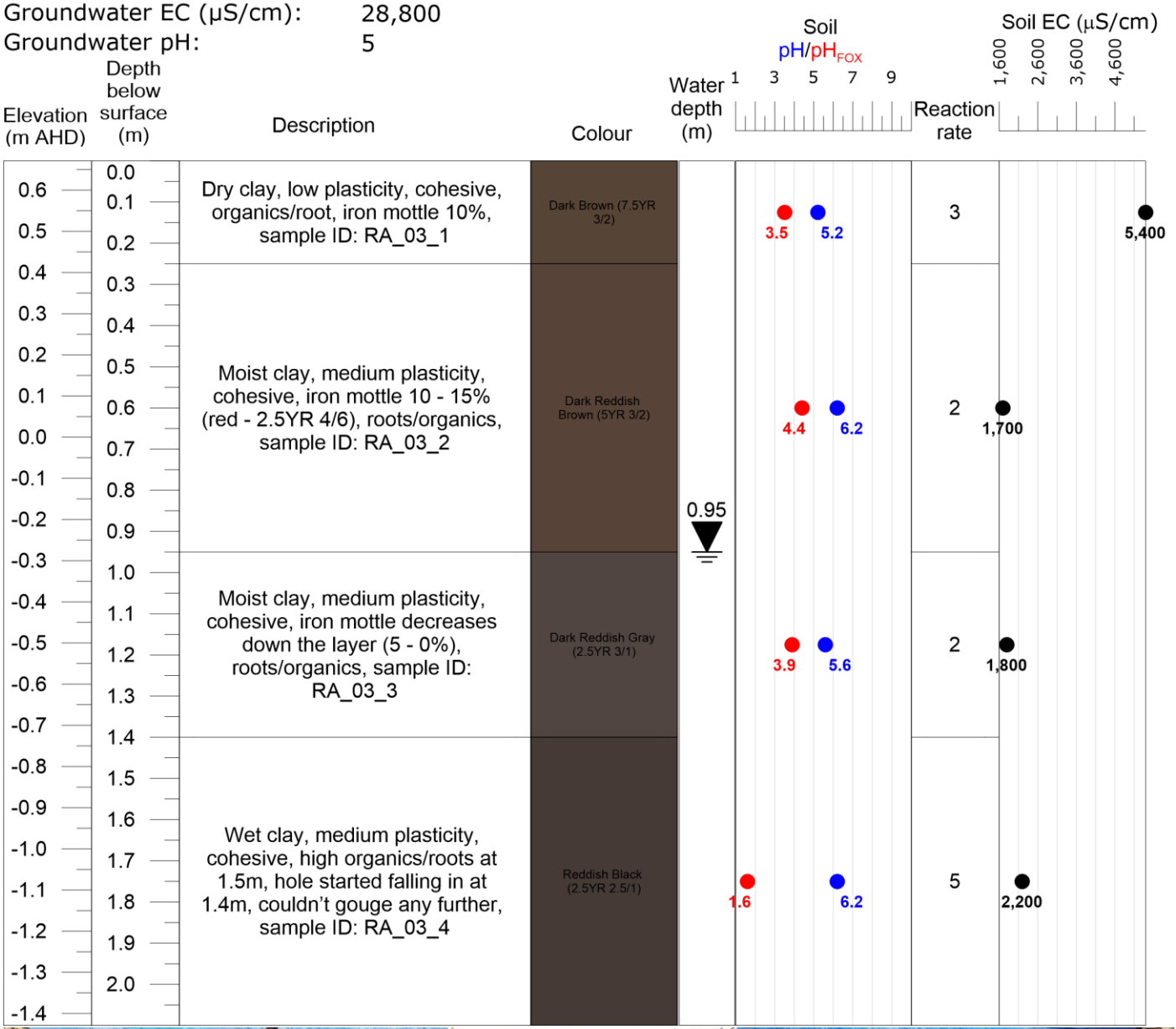
Project Number:	2018064	Profile ID:	RA_03
River/estuary:	Richmond	Sample date:	05/11/19
Easting:	525373.1	Sampled by:	AJH GL
Northing:	6799552.4		

Ground elevation (m AHD): 0.67
Hydraulic conductivity (m/d): 0.23

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Water quality:

Surface water EC (µS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (µS/cm): 28,800
Groundwater pH: 5





Soil profile details:

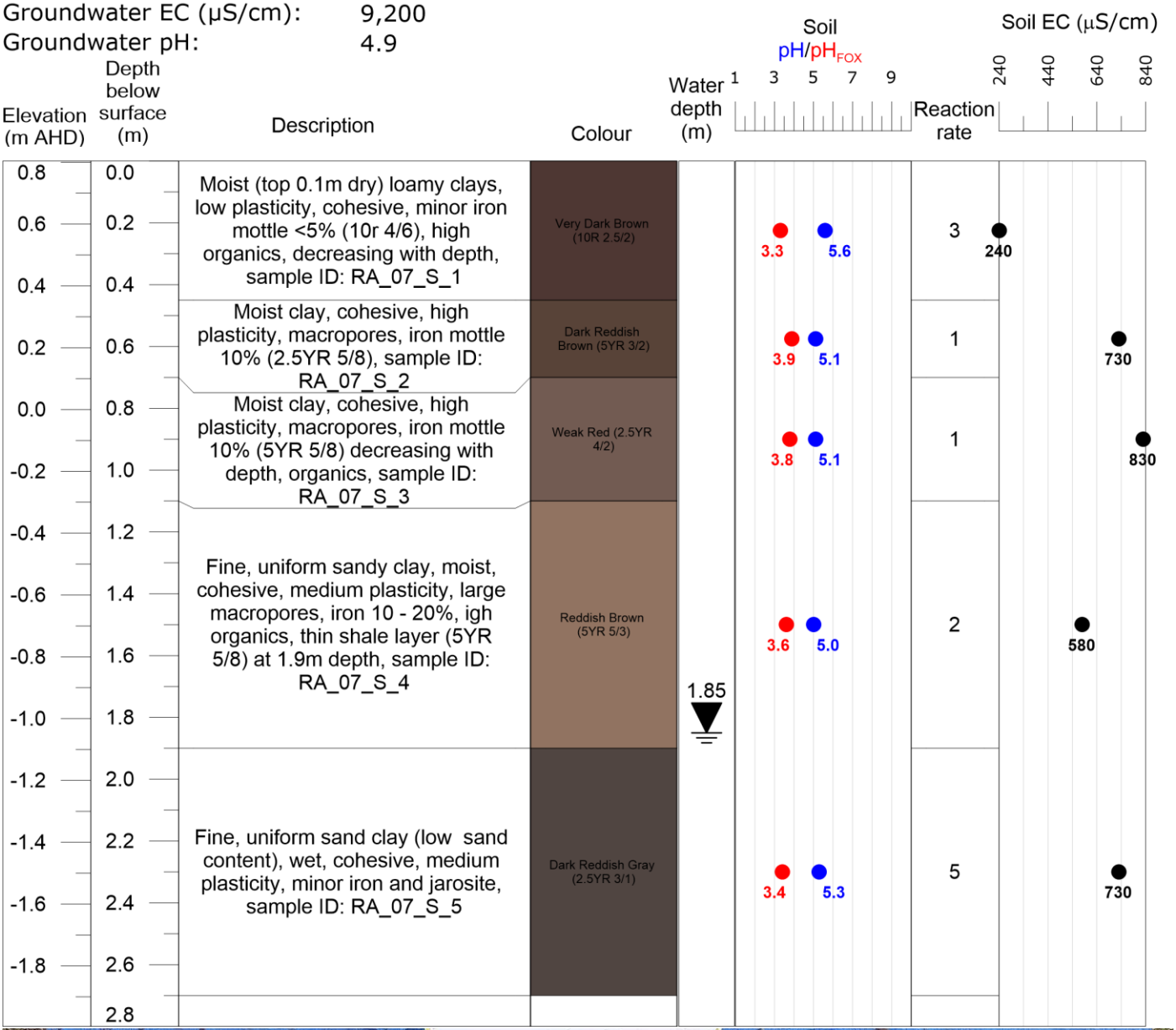
Project Number:	2018064	Profile ID:	RA_07_S
River/estuary:	Richmond	Sample date:	30/01/20
Easting:	539650.3	Sampled by:	AJH GL
Northing:	6791011.9		

Ground elevation (m AHD): 0.80
Hydraulic conductivity (m/d): 0.30

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Water quality:

Surface water EC (µS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (µS/cm): 9,200
Groundwater pH: 4.9





Soil profile details:

Project Number:	2018064	Profile ID:	RA_11
River/estuary:	Richmond	Sample date:	31/01/20
Easting:	551077.9	Sampled by:	AJH GL
Northing:	6804096.2		

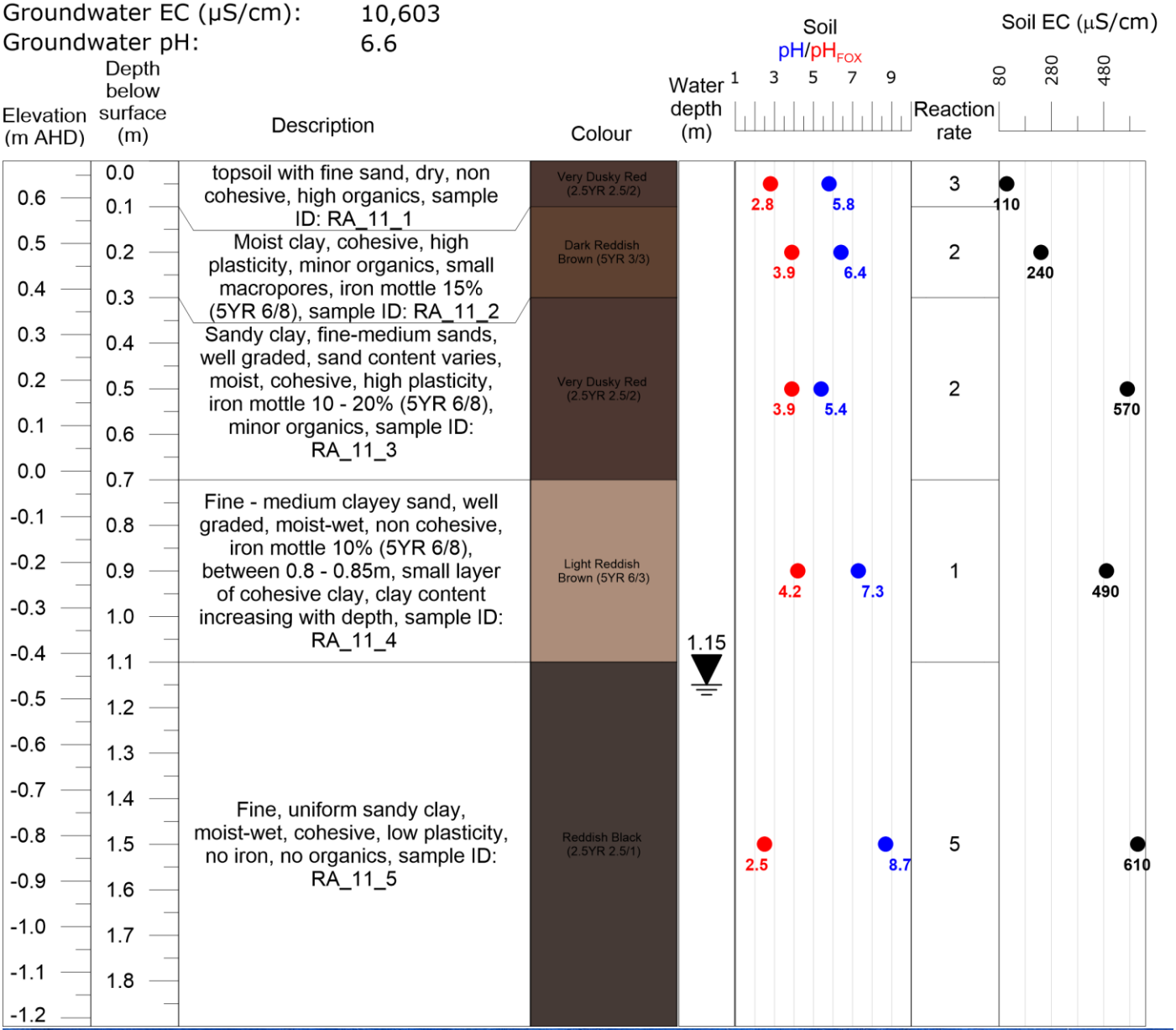
Ground elevation (m AHD): 0.68
Hydraulic conductivity (m/d): 0.12

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Water quality:

Surface water EC (µS/cm): 40,060
Surface water pH: 7.4
Groundwater EC (µS/cm): 10,603
Groundwater pH: 6.6





Soil profile details:

Project Number:	2018064	Profile ID:	RA_19
River/estuary:	Richmond	Sample date:	29/10/19
Easting:	555088.5	Sampled by:	AJH GL KW
Northing:	6820076.2		

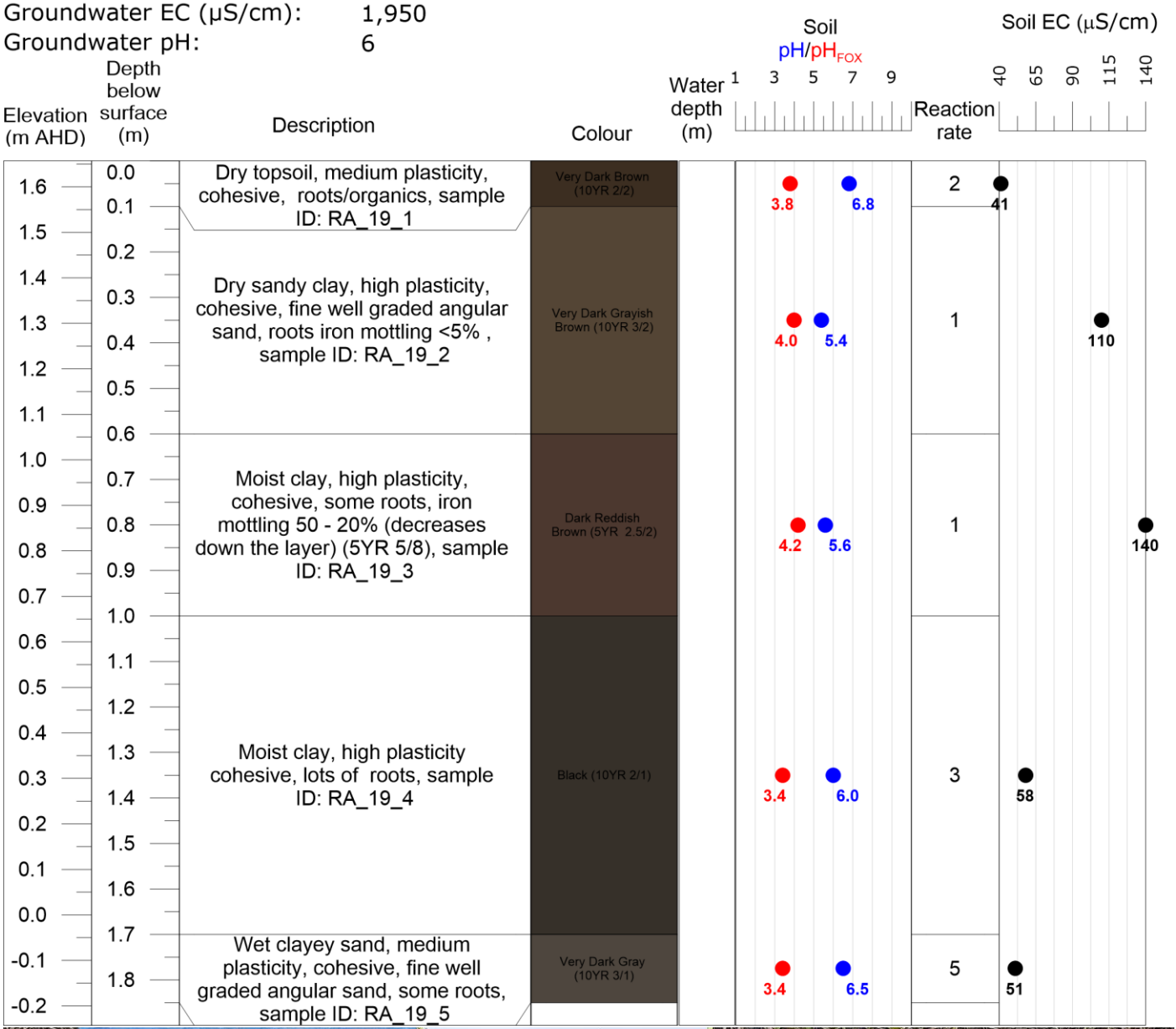
Ground elevation (m AHD): 1.66
Hydraulic conductivity (m/d): Not measured

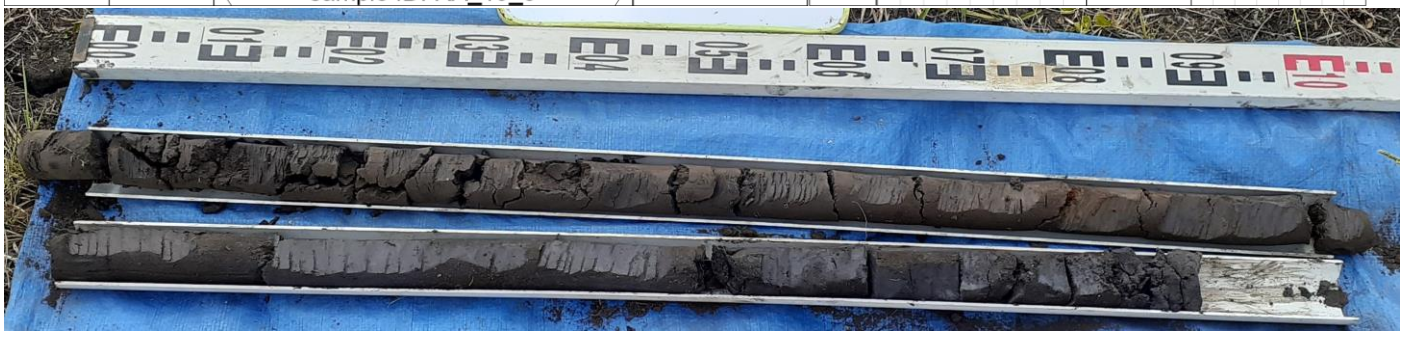
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Water quality:

Surface water EC (µS/cm): 4,500
Surface water pH: 6.3
Groundwater EC (µS/cm): 1,950
Groundwater pH: 6





Soil profile details:

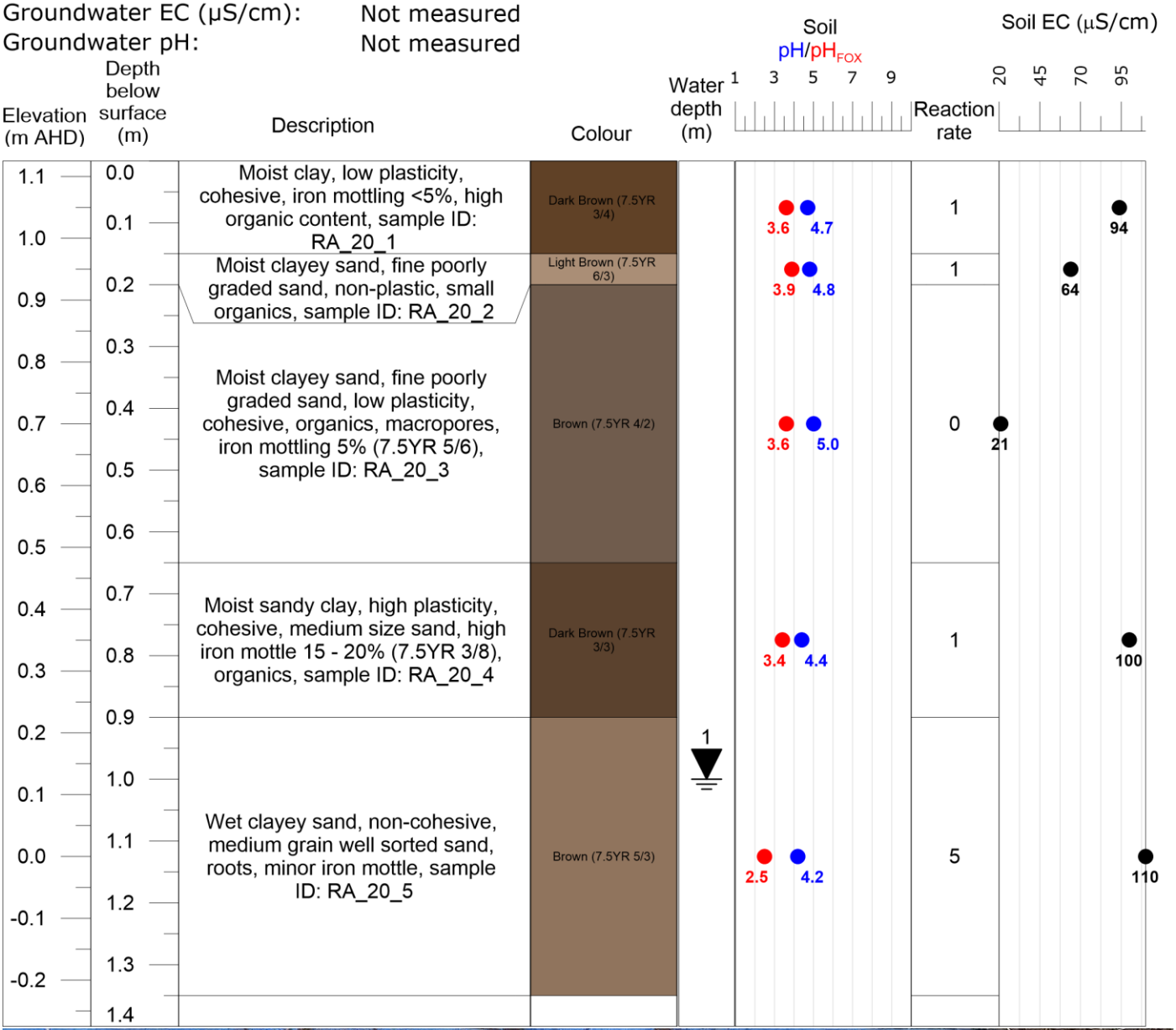
Project Number:	2018064	Profile ID:	RA_20
River/estuary:	Richmond	Sample date:	28/10/19
Easting:	554949.3	Sampled by:	AJH GL
Northing:	6816470.9		

Ground elevation (m AHD): 1.13
Hydraulic conductivity (m/d): Not measured

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Water quality:

Surface water EC (µS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured





Soil profile details:

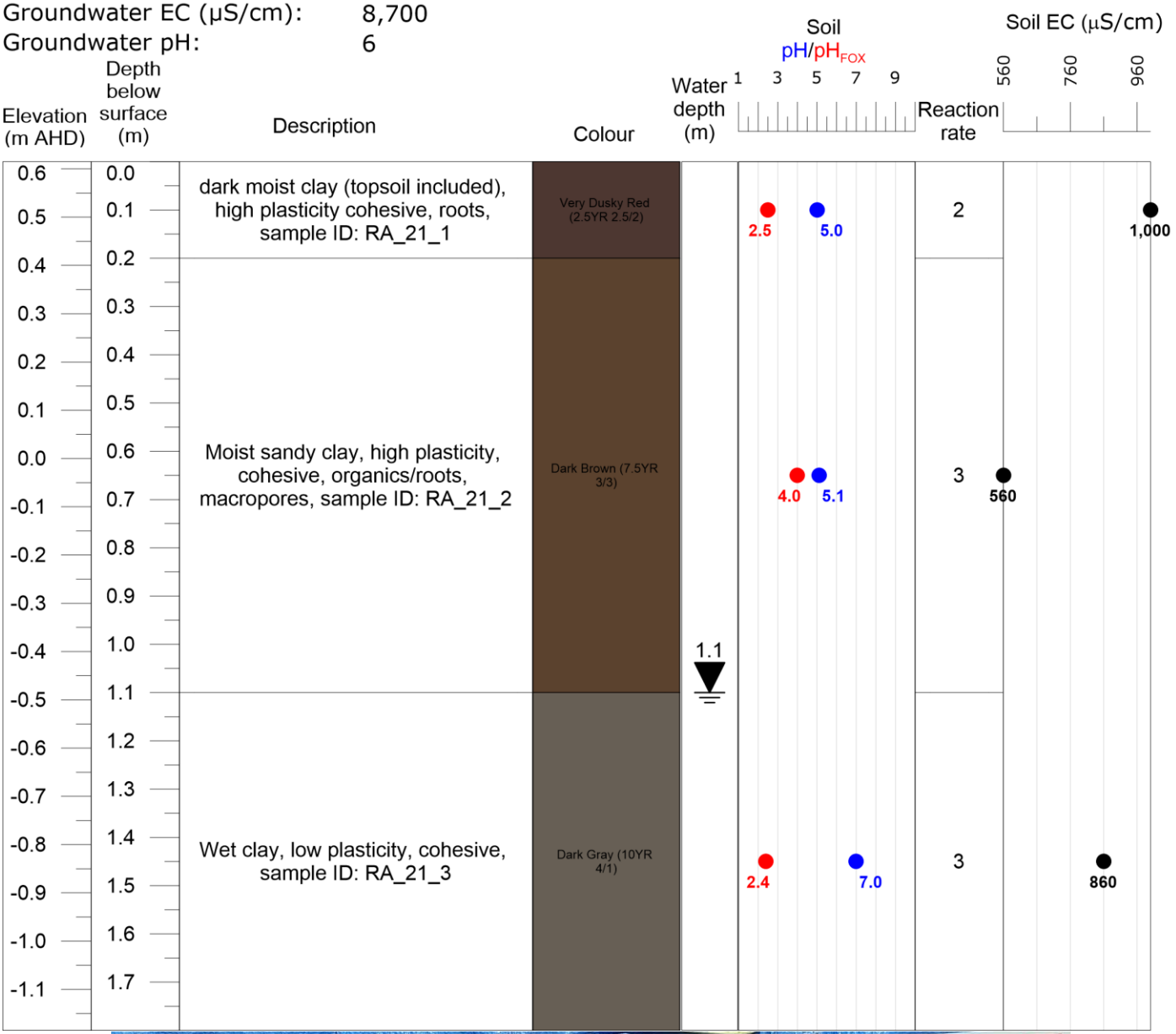
Project Number:	2018064	Profile ID:	RA_21
River/estuary:	Richmond	Sample date:	06/11/19
Easting:	553136	Sampled by:	AJH GL
Northing:	6813260.2		

Ground elevation (m AHD): 0.61
Hydraulic conductivity (m/d): 0.10

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Water quality:

Surface water EC (µS/cm): 22,800
Surface water pH: 8.5
Groundwater EC (µS/cm): 8,700
Groundwater pH: 6





Soil profile details:

Project Number:	2018064	Profile ID:	RA_28
River/estuary:	Richmond	Sample date:	30/10/19
Easting:	548578	Sampled by:	AJH GL KW
Northing:	6809402.8		

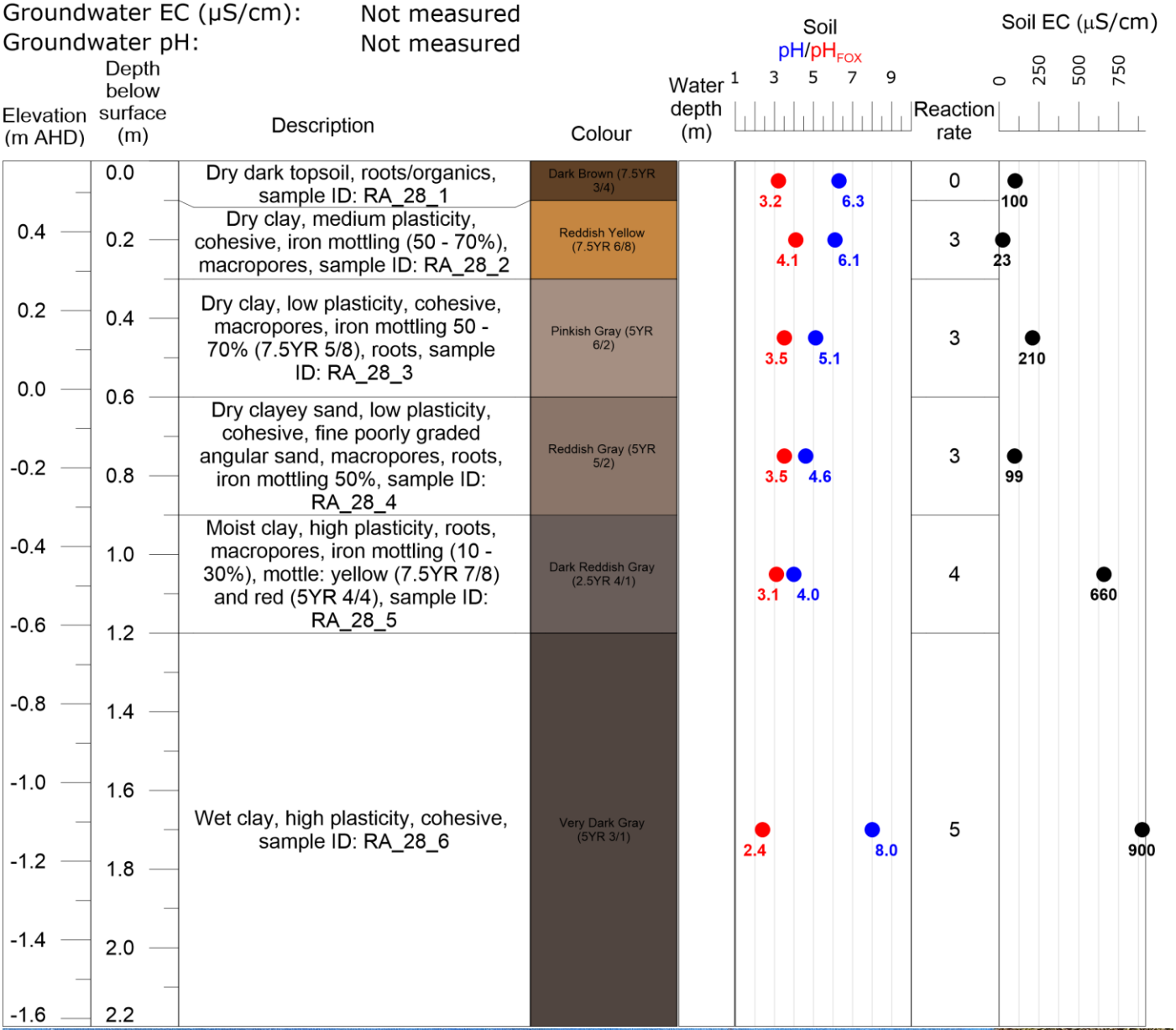
Ground elevation (m AHD): 0.58
Hydraulic conductivity (m/d): Not measured

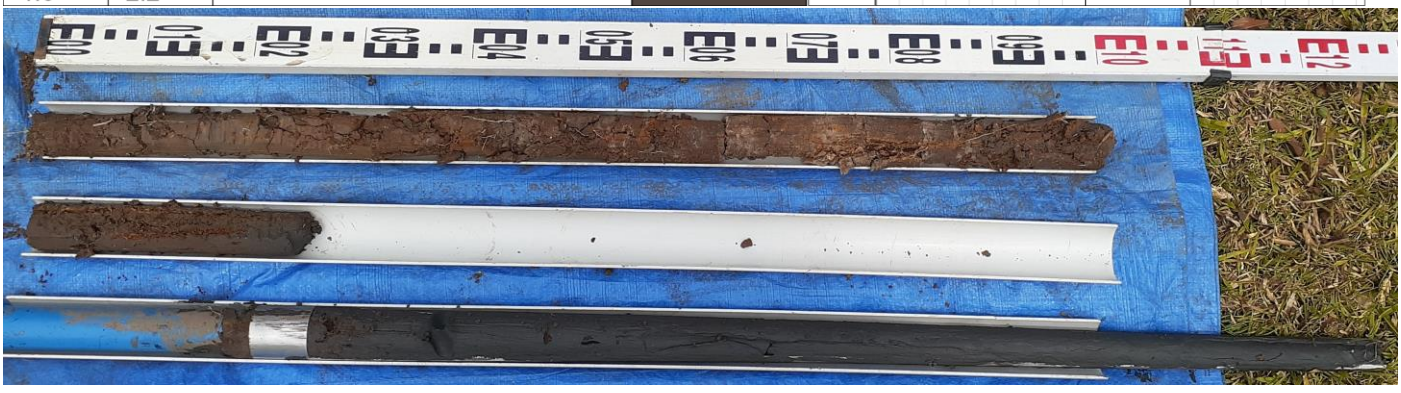
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Water quality:

Surface water EC (µS/cm): 25,100
Surface water pH: 6.7
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured





Soil profile details:

Project Number:	2018064	Profile ID:	RA_34
River/estuary:	Richmond	Sample date:	30/01/20
Easting:	548069.4	Sampled by:	AJH GL
Northing:	6797008.0		

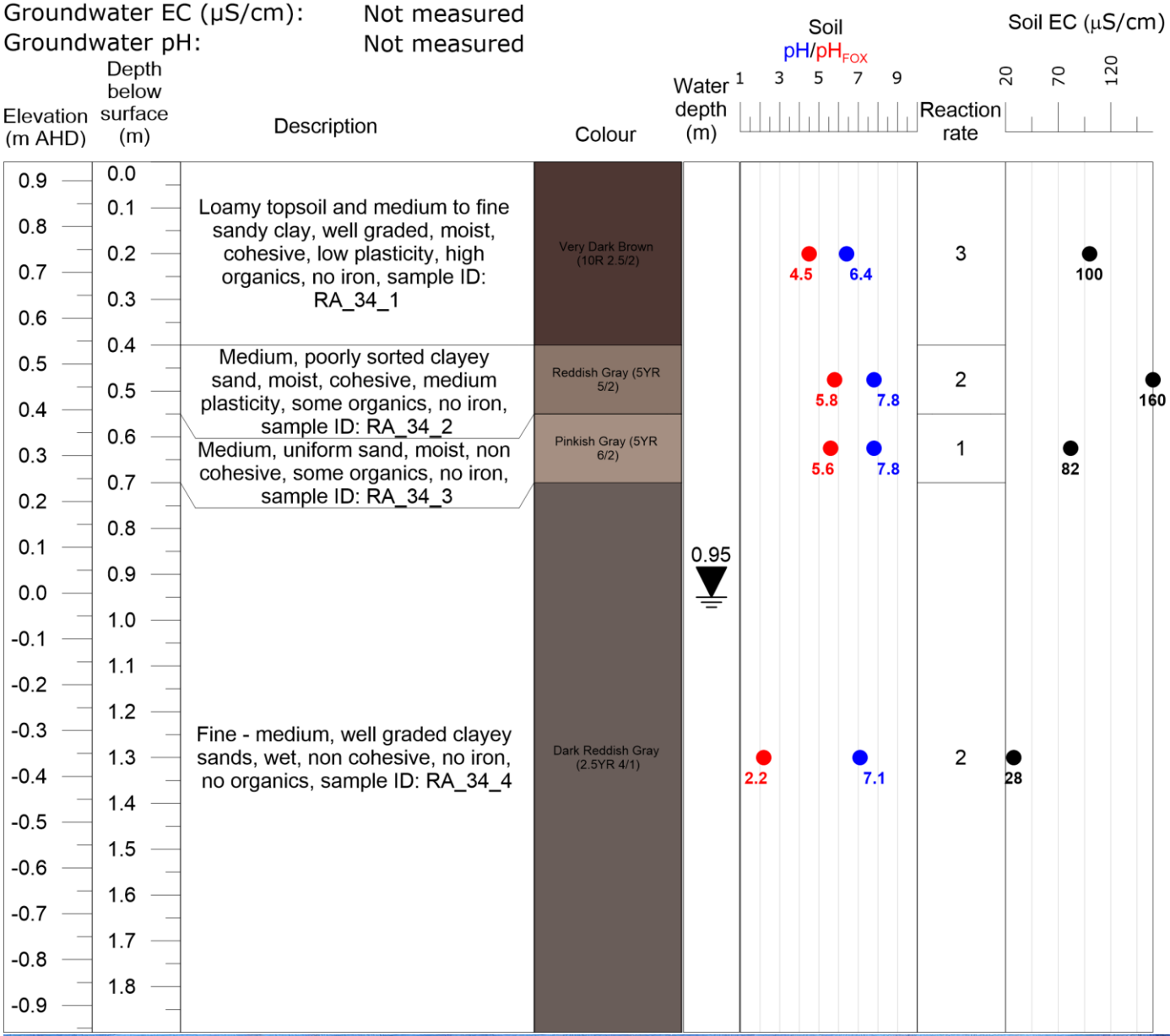
Ground elevation (m AHD): 0.94
Hydraulic conductivity (m/d): 0.13

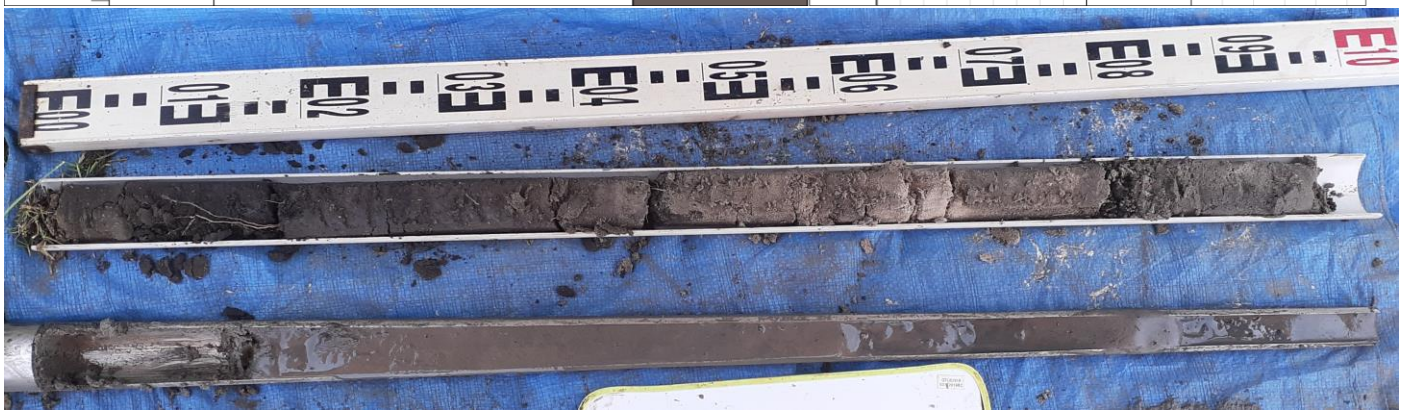
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Water quality:

Surface water EC (µS/cm): 1,740
Surface water pH: 7.8
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured





Soil profile details:

Project Number:	2018064	Profile ID:	RA_40
River/estuary:	Richmond	Sample date:	01/11/19
Easting:	530320	Sampled by:	AJH GL KW
Northing:	6790643.8		

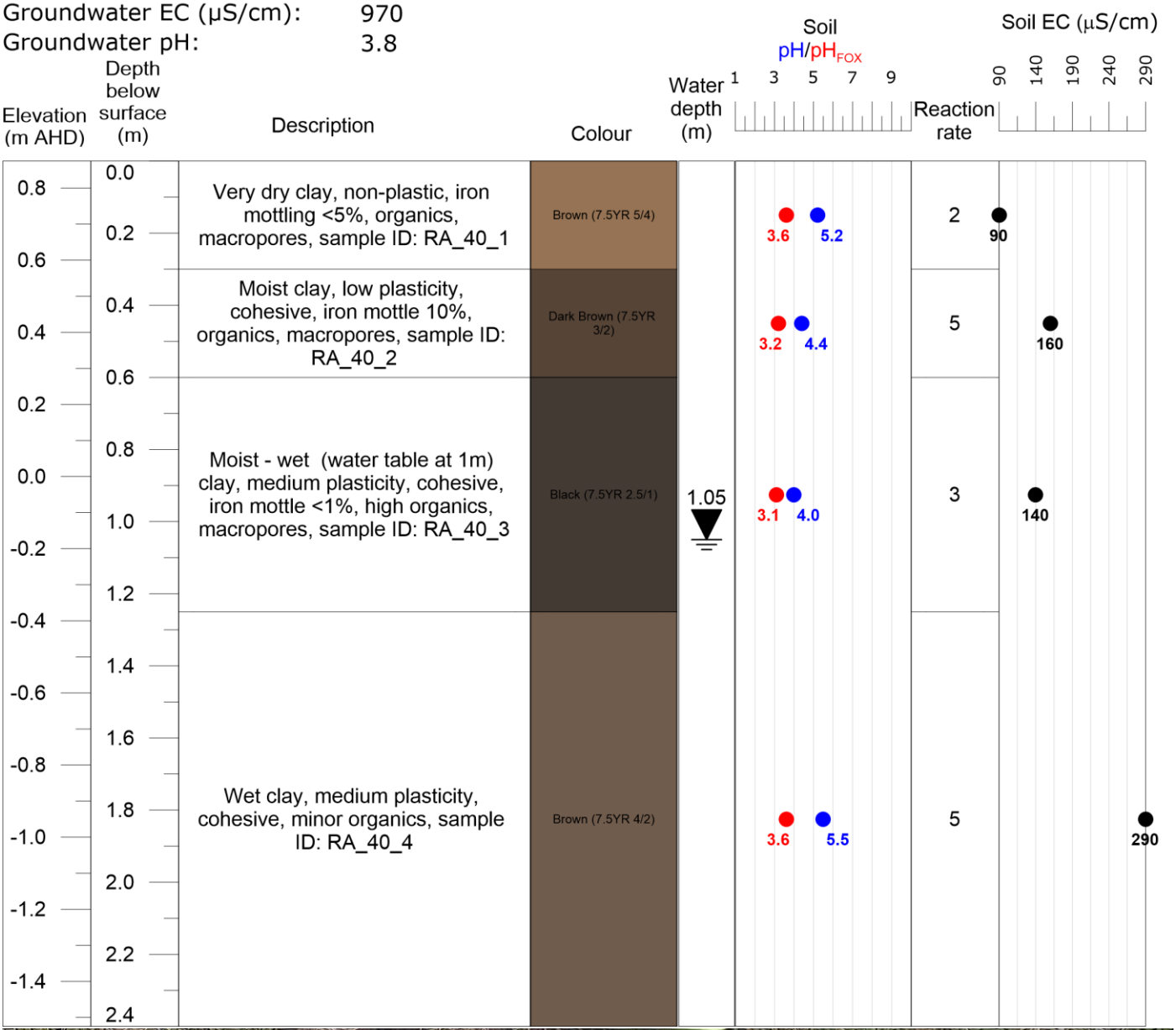
Ground elevation (m AHD): 0.88
Hydraulic conductivity (m/d): 1.87

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Water quality:

Surface water EC (µS/cm):
Surface water pH:
Groundwater EC (µS/cm): 970
Groundwater pH: 3.8





Soil profile details:

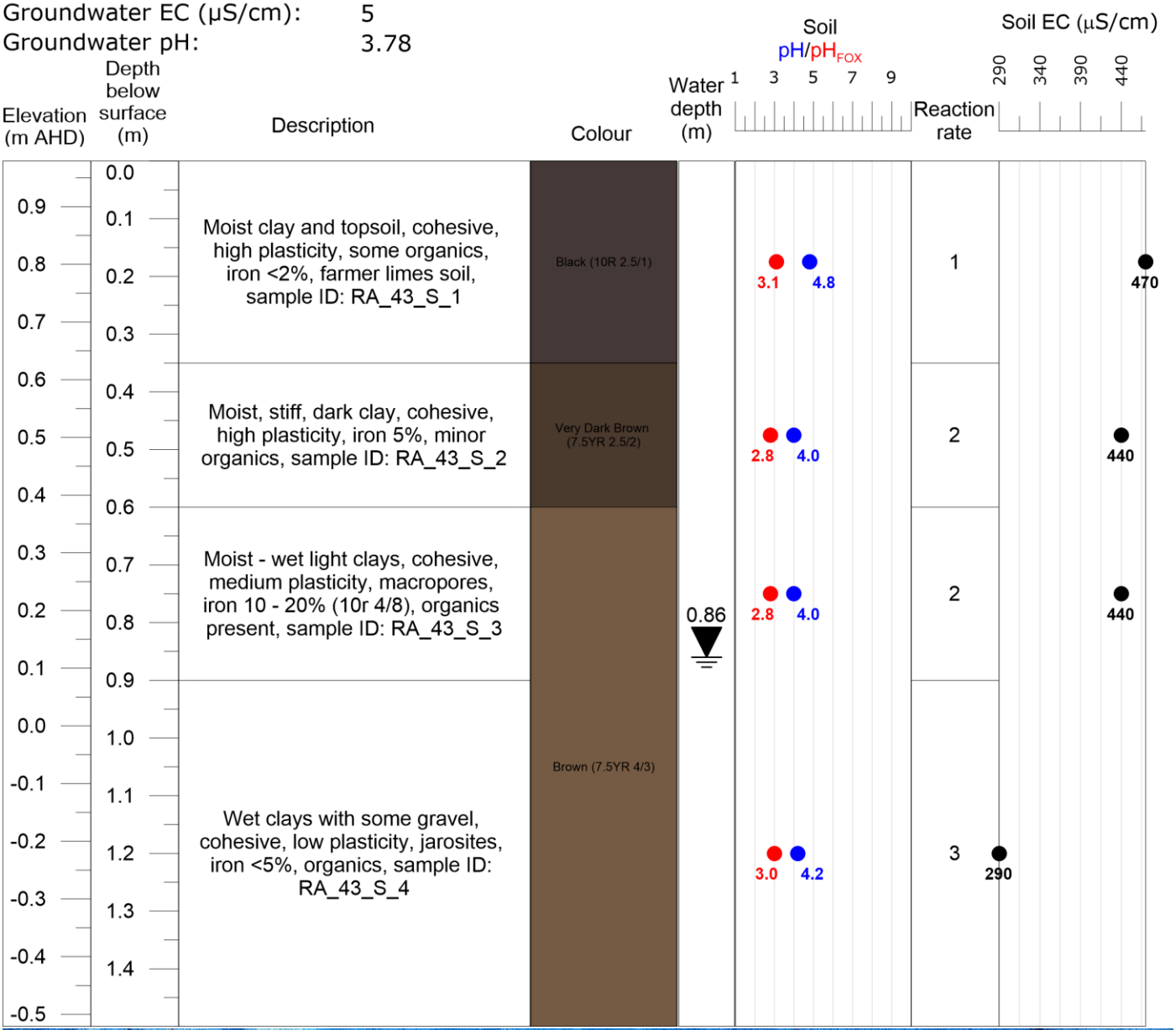
Project Number:	2018064	Profile ID:	RA_43_S
River/estuary:	Richmond	Sample date:	26/02/20
Easting:	531274.5	Sampled by:	AJH DWJ
Northing:	6784330.8		

Ground elevation (m AHD): 0.98
Hydraulic conductivity (m/d): Not measured

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Water quality:

Surface water EC (µS/cm): 2
Surface water pH: 3.9
Groundwater EC (µS/cm): 5
Groundwater pH: 3.78





Soil profile details:

Project Number:	2018064	Profile ID:	RA_47
River/estuary:	Richmond	Sample date:	29/01/20
Easting:	529187.1	Sampled by:	AJH GL
Northing:	6777709.0		

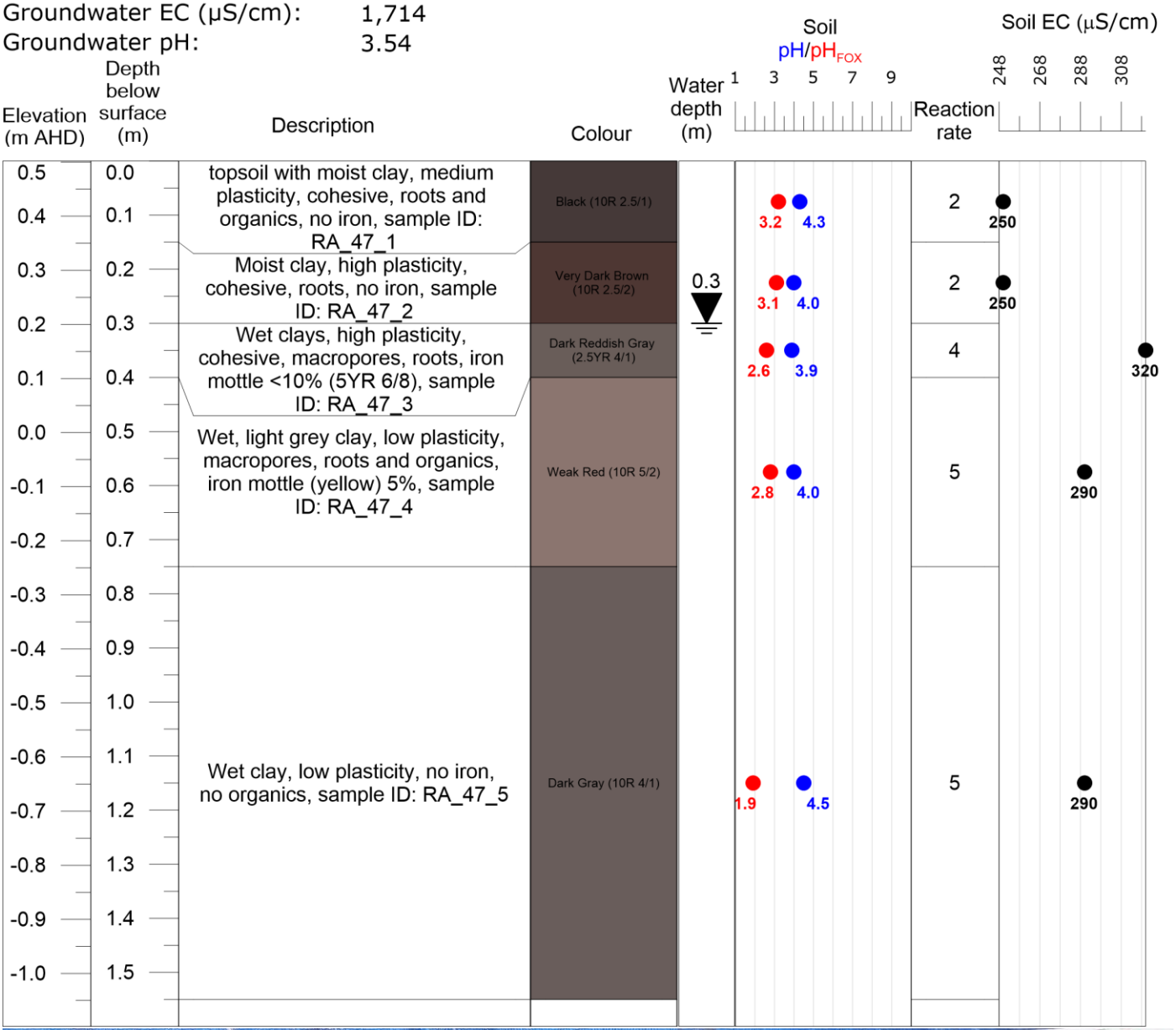
Ground elevation (m AHD): 0.50
Hydraulic conductivity (m/d): 28.18

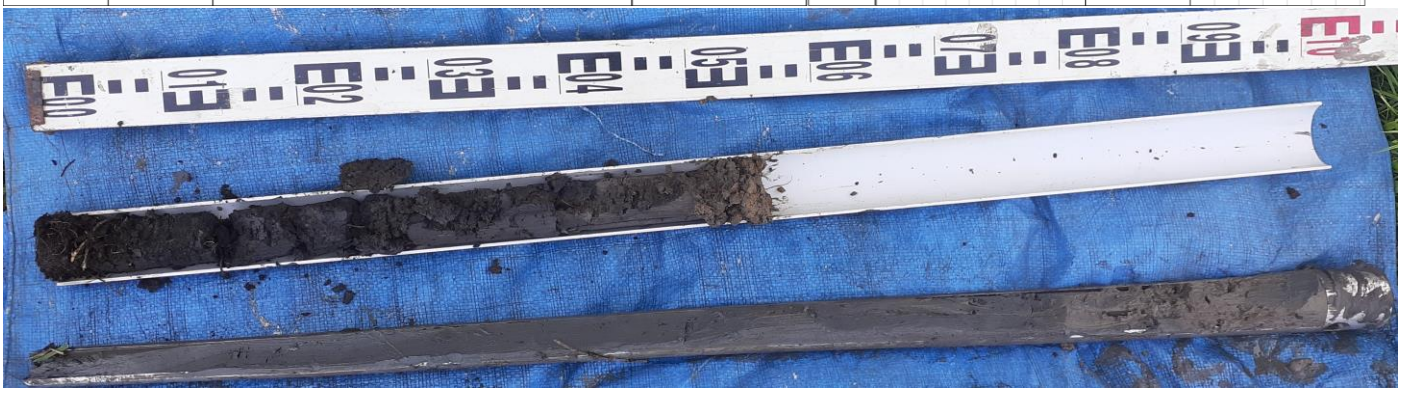
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Water quality:

Surface water EC (µS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (µS/cm): 1,714
Groundwater pH: 3.54





Soil profile details:

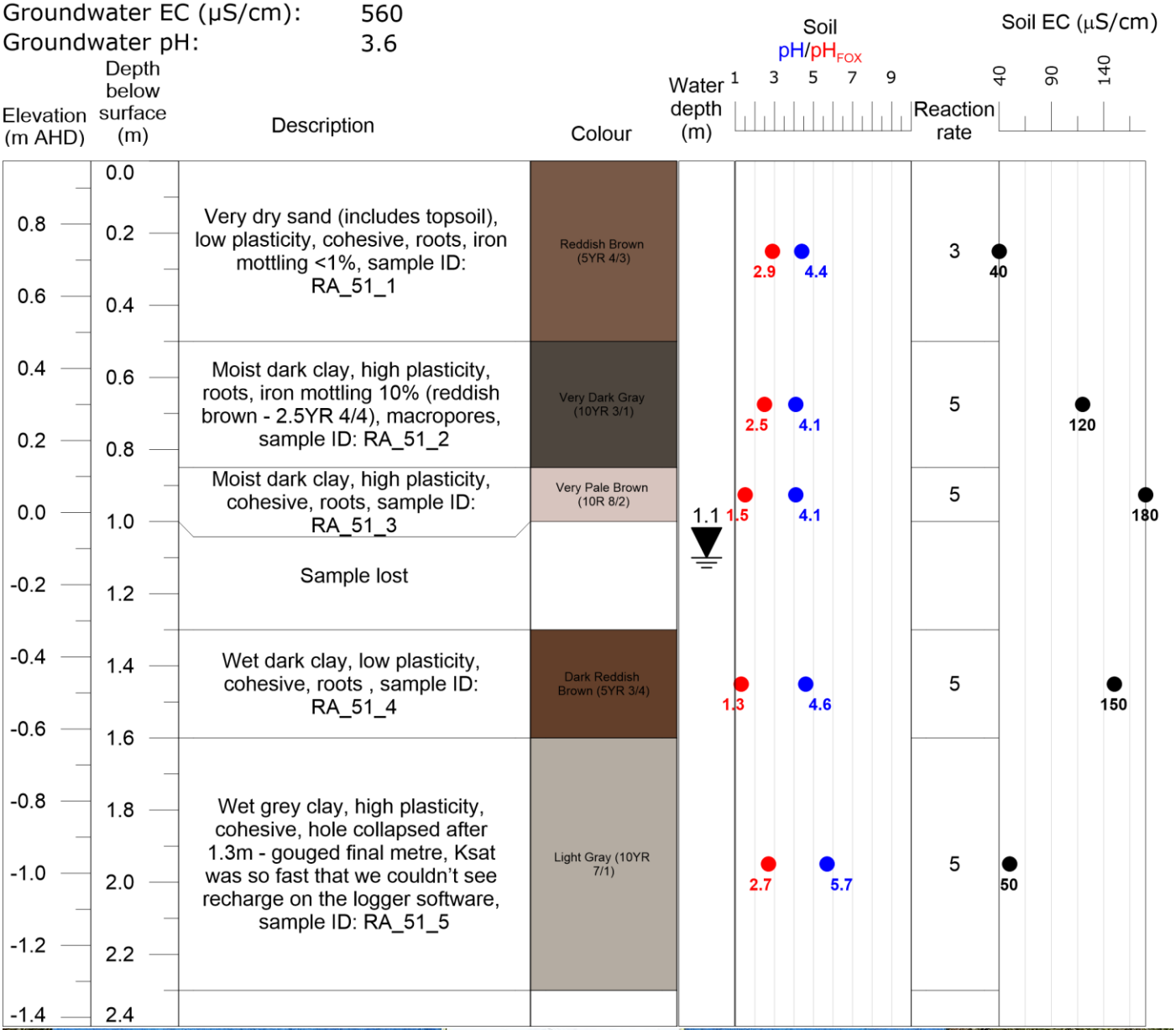
Project Number:	2018064	Profile ID:	RA_51
River/estuary:	Richmond	Sample date:	01/11/19
Easting:	524728.3	Sampled by:	AJH GL
Northing:	6783910.6		

Ground elevation (m AHD): 0.97
Hydraulic conductivity (m/d): 16.94

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Water quality:

Surface water EC (µS/cm): 500
Surface water pH: 5.8
Groundwater EC (µS/cm): 560
Groundwater pH: 3.6





Soil profile details:

Project Number:	2018064	Profile ID:	RA_54
River/estuary:	Richmond	Sample date:	05/11/19
Easting:	527874.6	Sampled by:	AJH GL
Northing:	6801757.1		

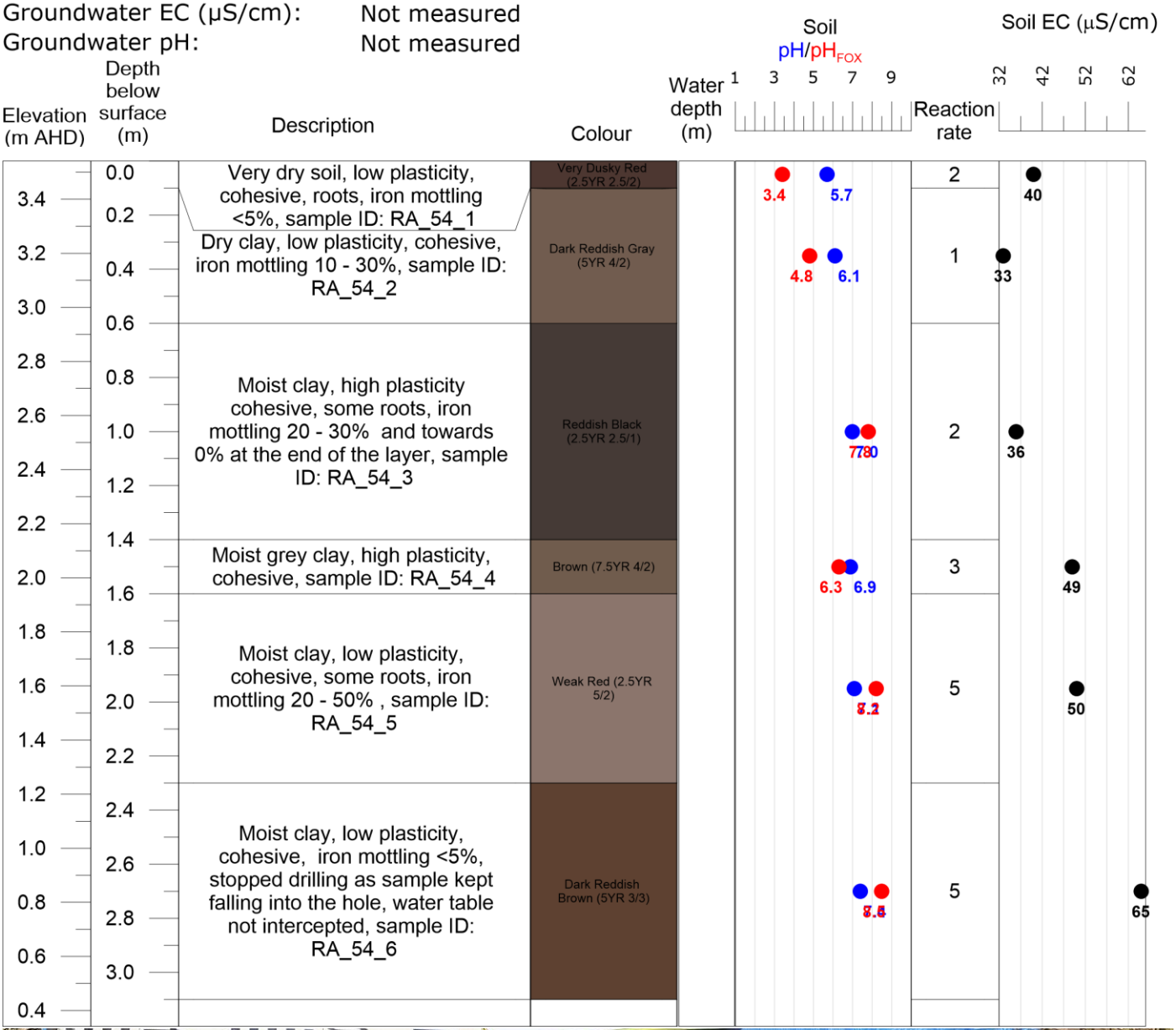
Ground elevation (m AHD): 3.54
Hydraulic conductivity (m/d): Not measured

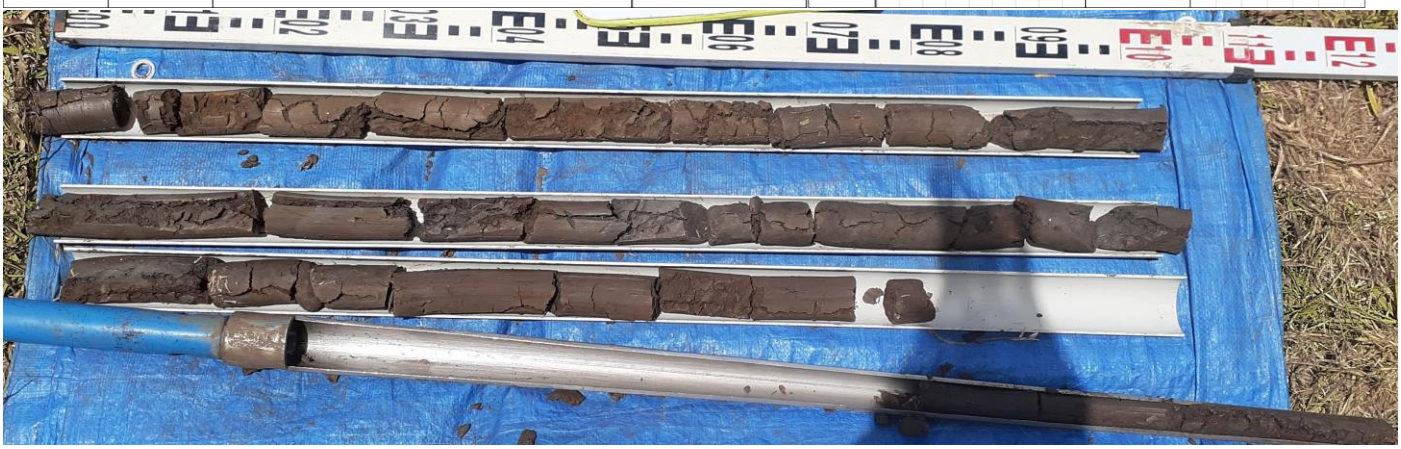
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Water quality:

Surface water EC (µS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured





Soil profile details:

Project Number:	2018064	Profile ID:	RA_55
River/estuary:	Richmond	Sample date:	29/10/19
Easting:	554165.3	Sampled by:	AJH GL KW
Northing:	6815025.4		

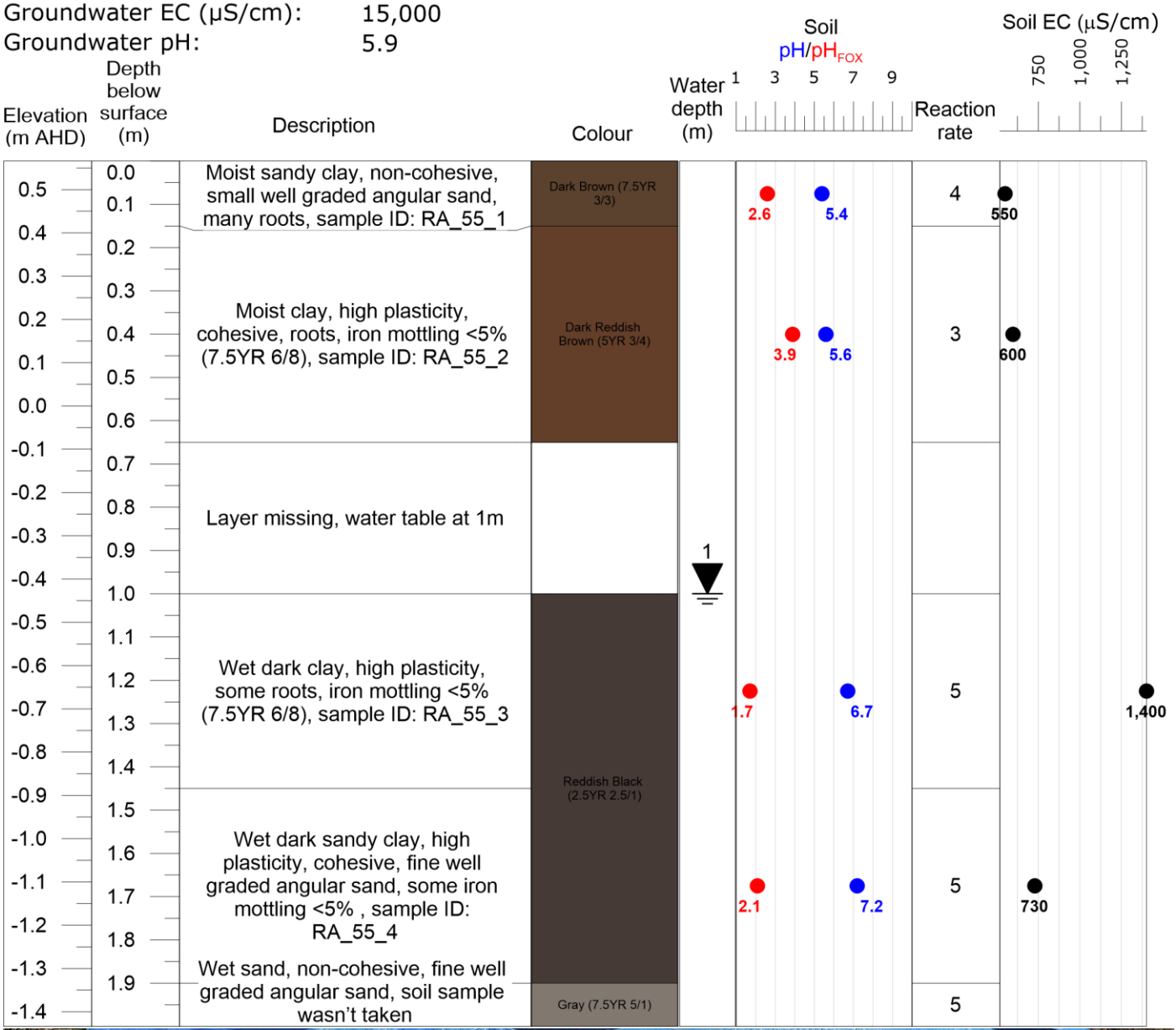
Ground elevation (m AHD): 0.57
Hydraulic conductivity (m/d): 0.10

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Water quality:

Surface water EC (µS/cm): 24,600
Surface water pH: 5.9
Groundwater EC (µS/cm): 15,000
Groundwater pH: 5.9





Soil profile details:

Project Number:	2018064	Profile ID:	RP_02
River/estuary:	Richmond	Sample date:	31/10/19
Easting:	529790.6	Sampled by:	AJH GL KW
Northing:	6799736.9		

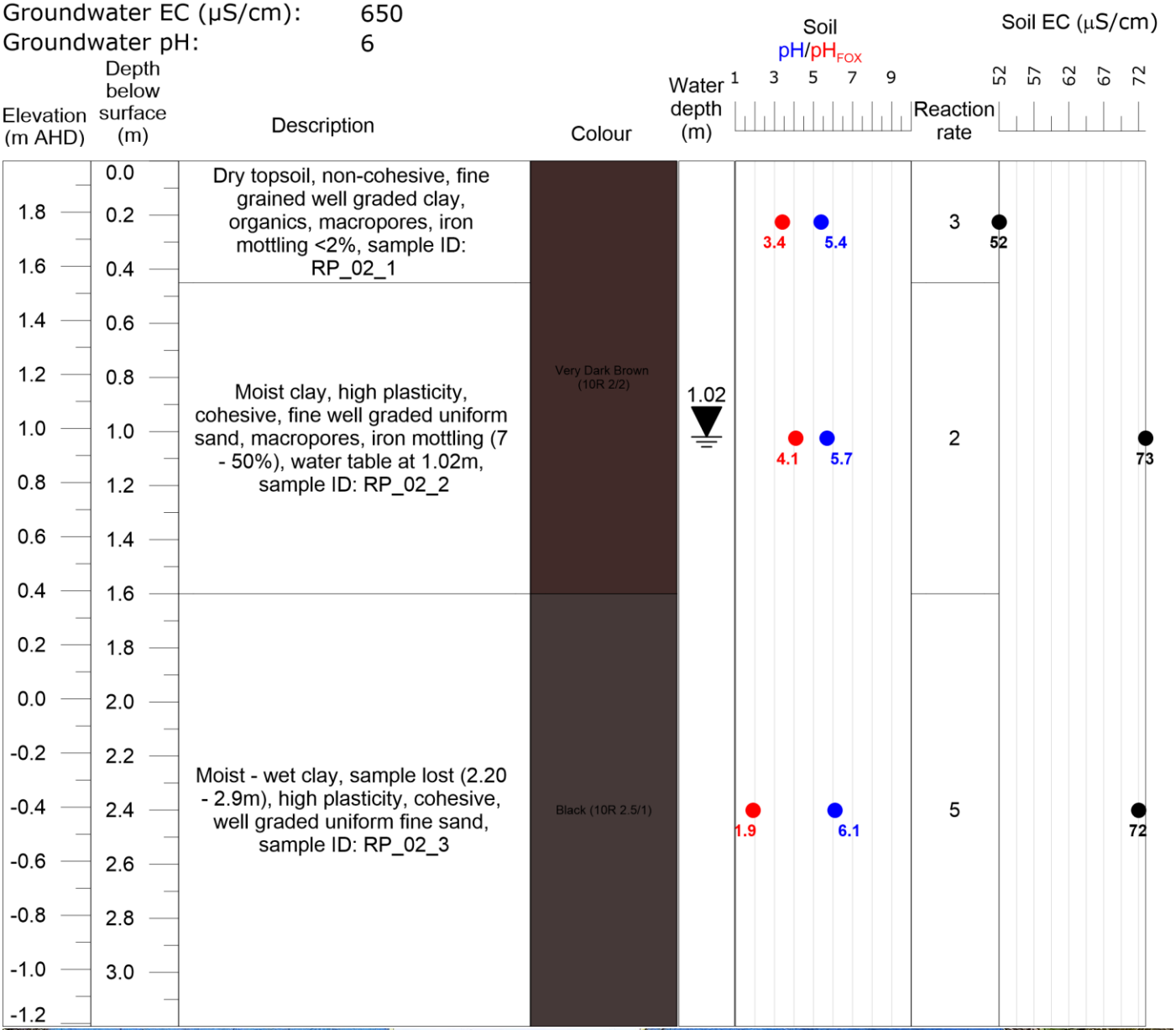
Ground elevation (m AHD): 1.99
Hydraulic conductivity (m/d): 0.43

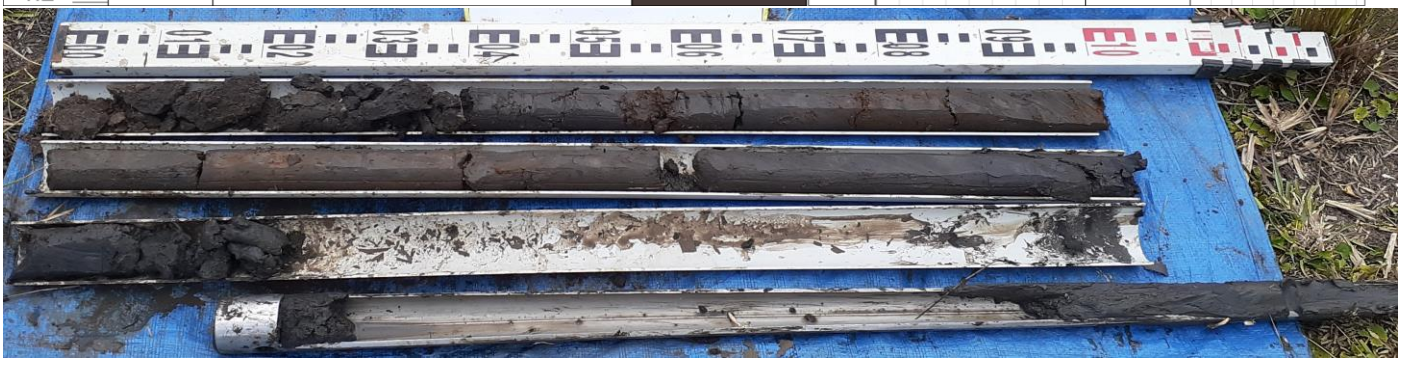
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Water quality:

Surface water EC (µS/cm): 200
Surface water pH: 6.8
Groundwater EC (µS/cm): 650
Groundwater pH: 6





Soil profile details:

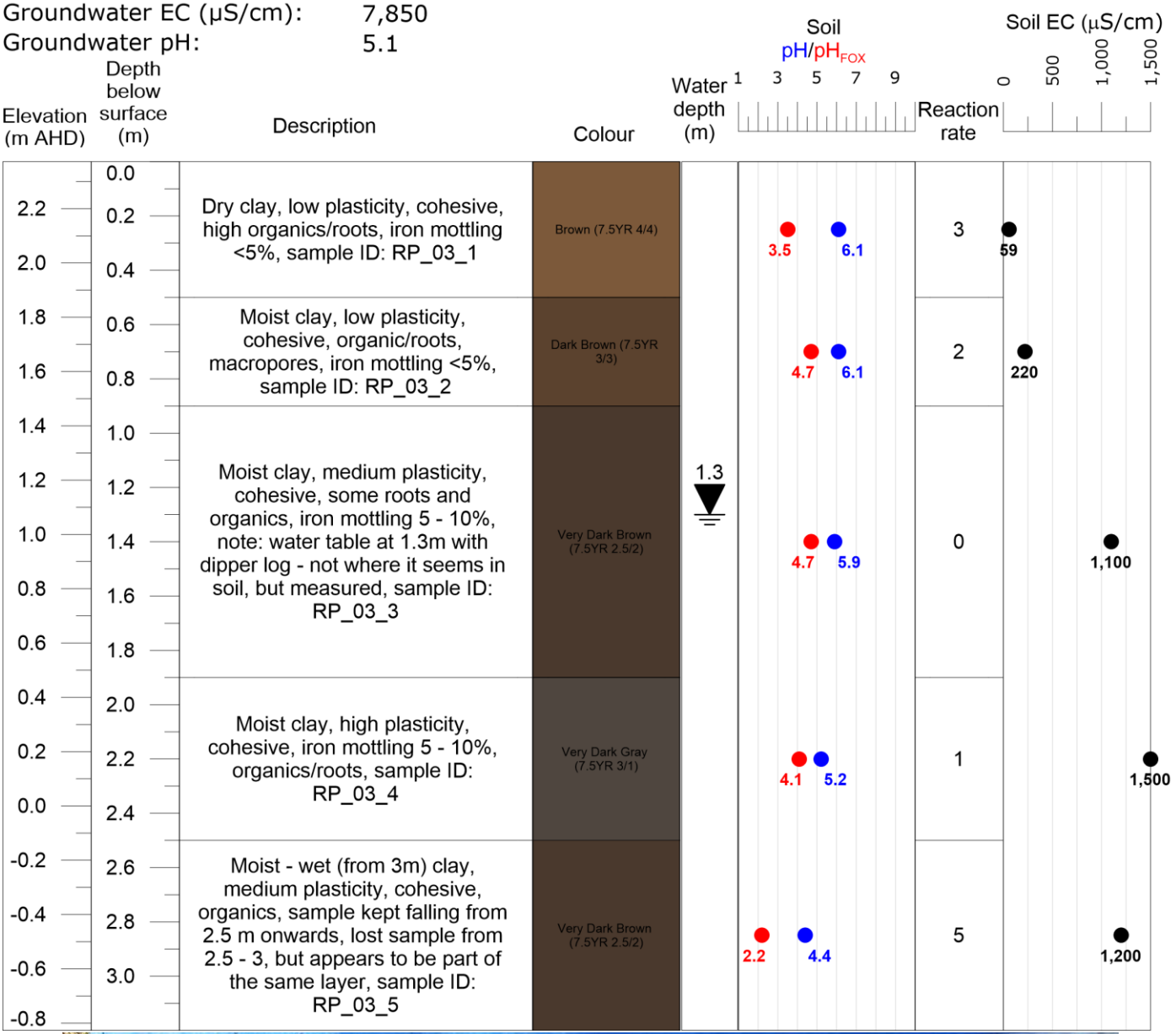
Project Number:	2018064	Profile ID:	RP_03
River/estuary:	Richmond	Sample date:	05/11/19
Easting:	527592.9	Sampled by:	AJH GL
Northing:	6798484.8		

Ground elevation (m AHD): 2.37
Hydraulic conductivity (m/d): 0.09

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Water quality:

Surface water EC (µS/cm): 34.39 (in perched swamp), 300 (in Pelican Creek)
Surface water pH: 6.96 (in perched swamp), 6.9 (in Pelican Creek)
Groundwater EC (µS/cm): 7,850
Groundwater pH: 5.1





Soil profile details:

Project Number:	2018064	Profile ID:	RP_10_S
River/estuary:	Richmond	Sample date:	25/02/20
Easting:	544567.7	Sampled by:	AJH DWJ
Northing:	6796005.9		

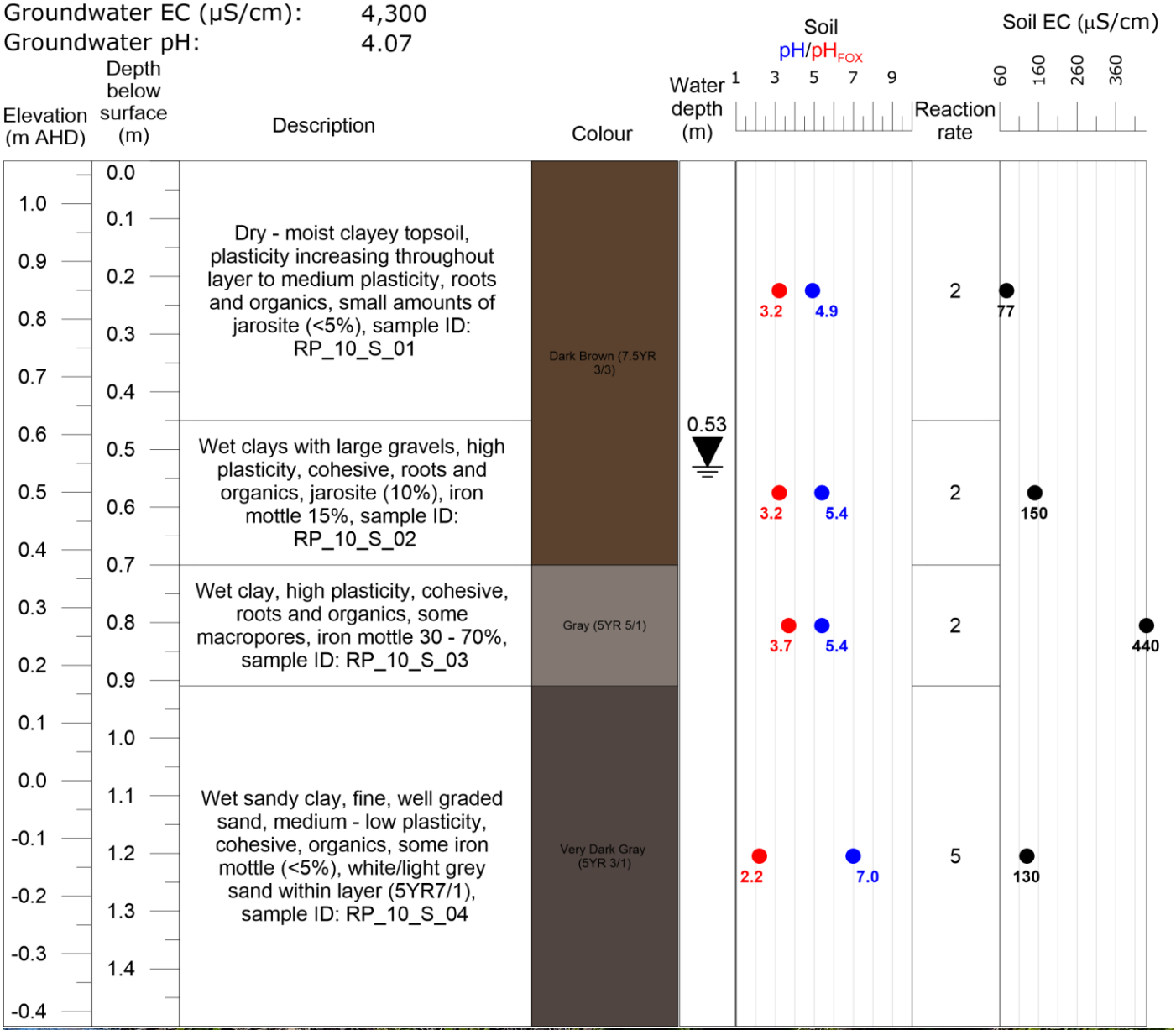
Ground elevation (m AHD): 1.07
Hydraulic conductivity (m/d): 0.35

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Water quality:

Surface water EC (µS/cm): 651
Surface water pH: 6.35
Groundwater EC (µS/cm): 4,300
Groundwater pH: 4.07





Soil profile details:

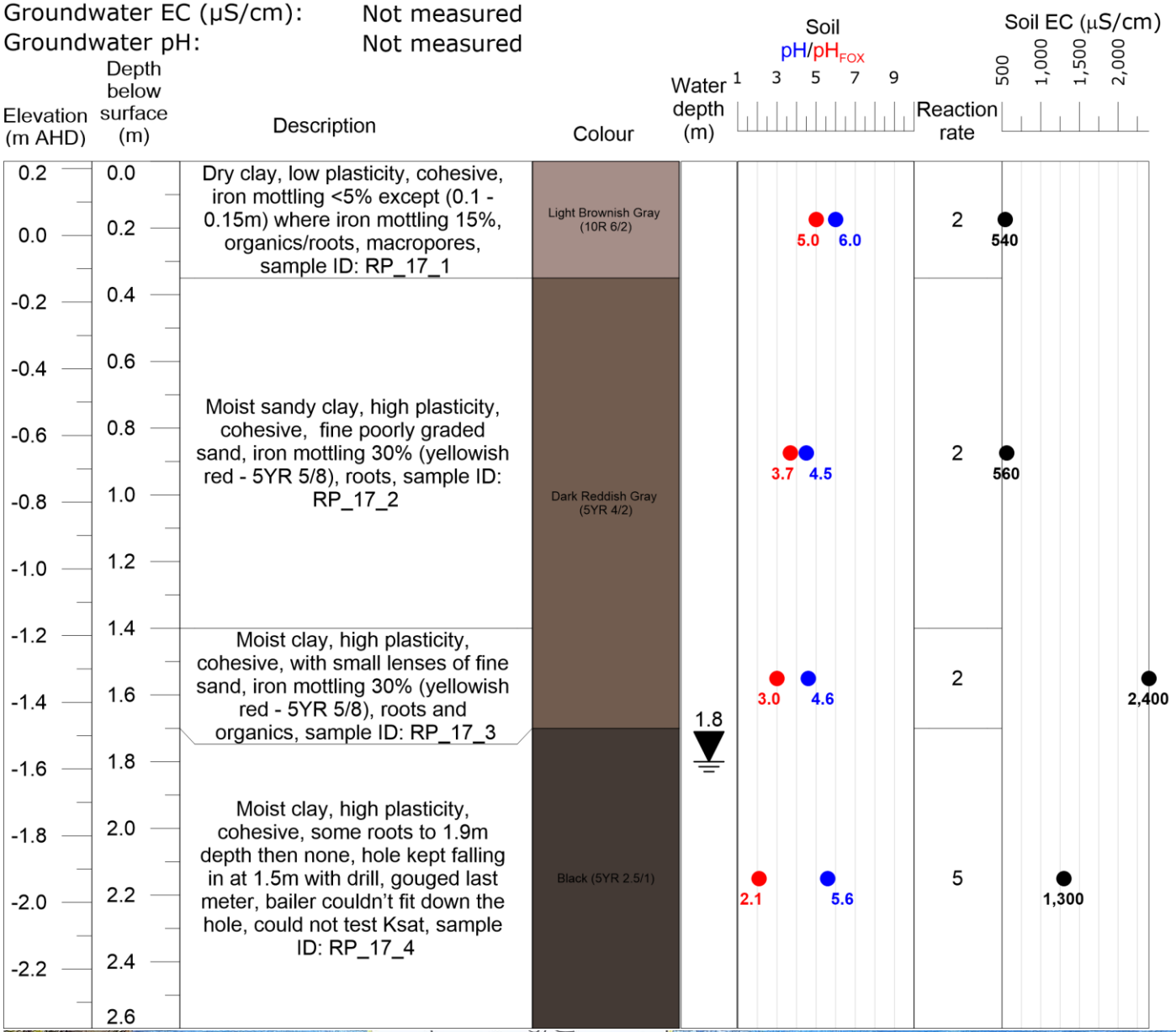
Project Number:	2018064	Profile ID:	RP_17
River/estuary:	Richmond	Sample date:	06/11/19
Easting:	546633.5	Sampled by:	AJH GL
Northing:	6803917.3		

Ground elevation (m AHD): 0.22
Hydraulic conductivity (m/d): Not measured

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Water quality:

Surface water EC (µS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured





Soil profile details:

Project Number:	2018064	Profile ID:	RP_20
River/estuary:	Richmond	Sample date:	29/10/19
Easting:	556043.1	Sampled by:	AJH GL KW
Northing:	6820193.9		

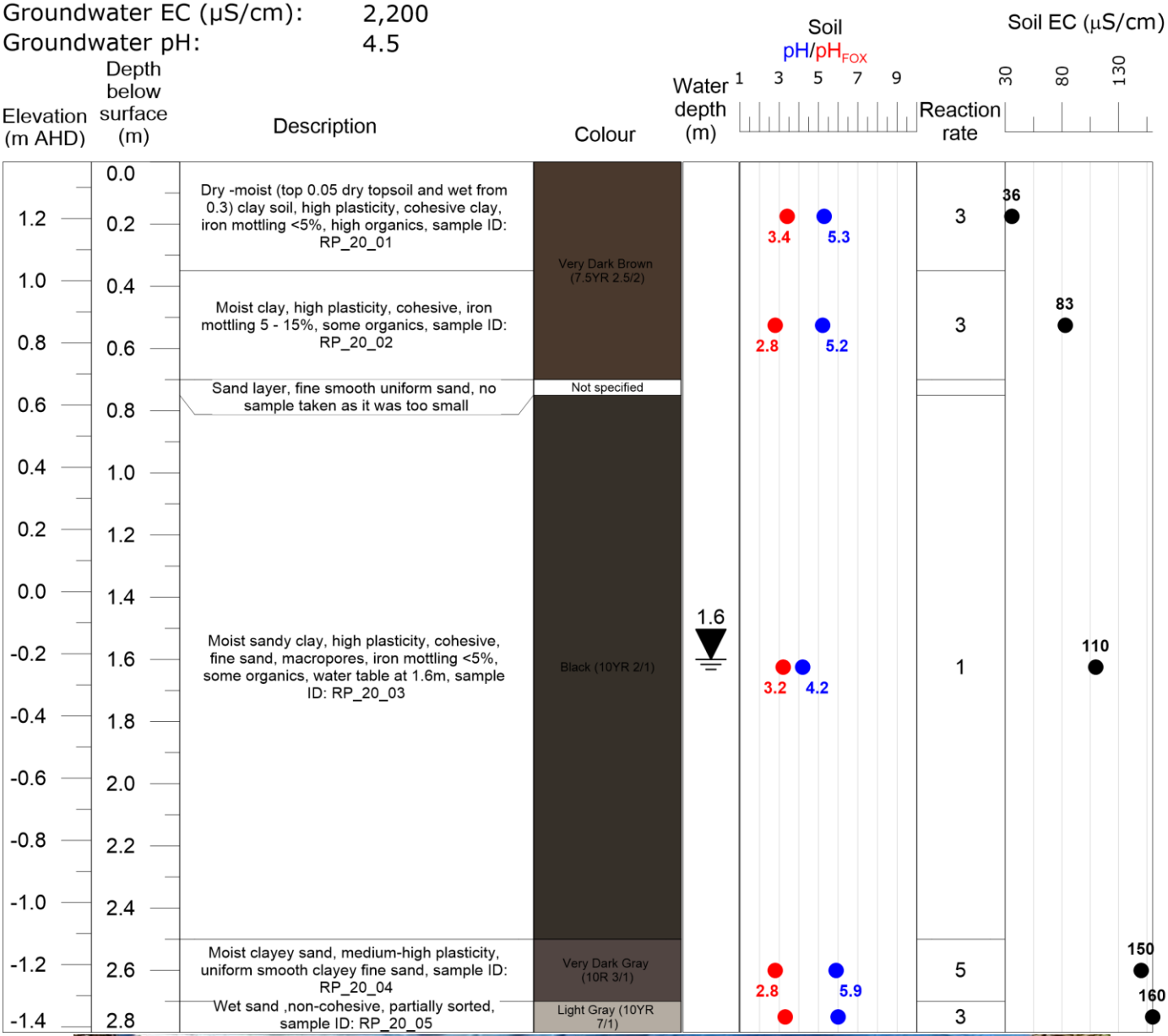
Ground elevation (m AHD): 1.38
Hydraulic conductivity (m/d): 0.02

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Water quality:

Surface water EC (µS/cm): 6,500
Surface water pH: 6.4
Groundwater EC (µS/cm): 2,200
Groundwater pH: 4.5





Soil profile details:

Project Number:	2018064	Profile ID:	RP_21
River/estuary:	Richmond	Sample date:	28/10/19
Easting:	555369.2	Sampled by:	AJH GL
Northing:	6816545.0		

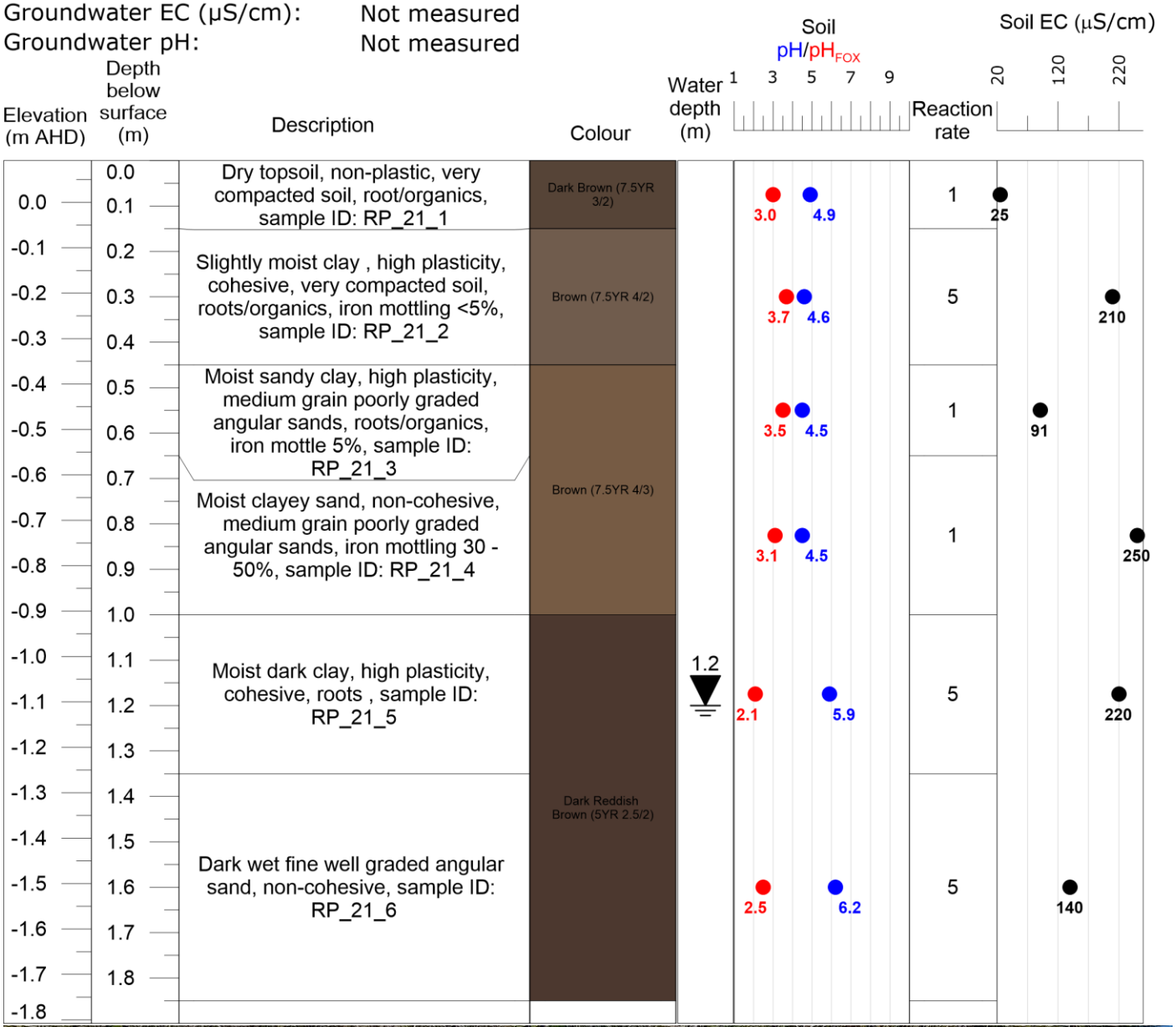
Ground elevation (m AHD): 0.09
Hydraulic conductivity (m/d): Not measured

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Water quality:

Surface water EC (µS/cm): 35,900
Surface water pH: 6.9
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured





Soil profile details:

Project Number:	2018064	Profile ID:	RP_22
River/estuary:	Richmond	Sample date:	29/10/19
Easting:	553588.8	Sampled by:	AJH GL KW
Northing:	6813609.8		

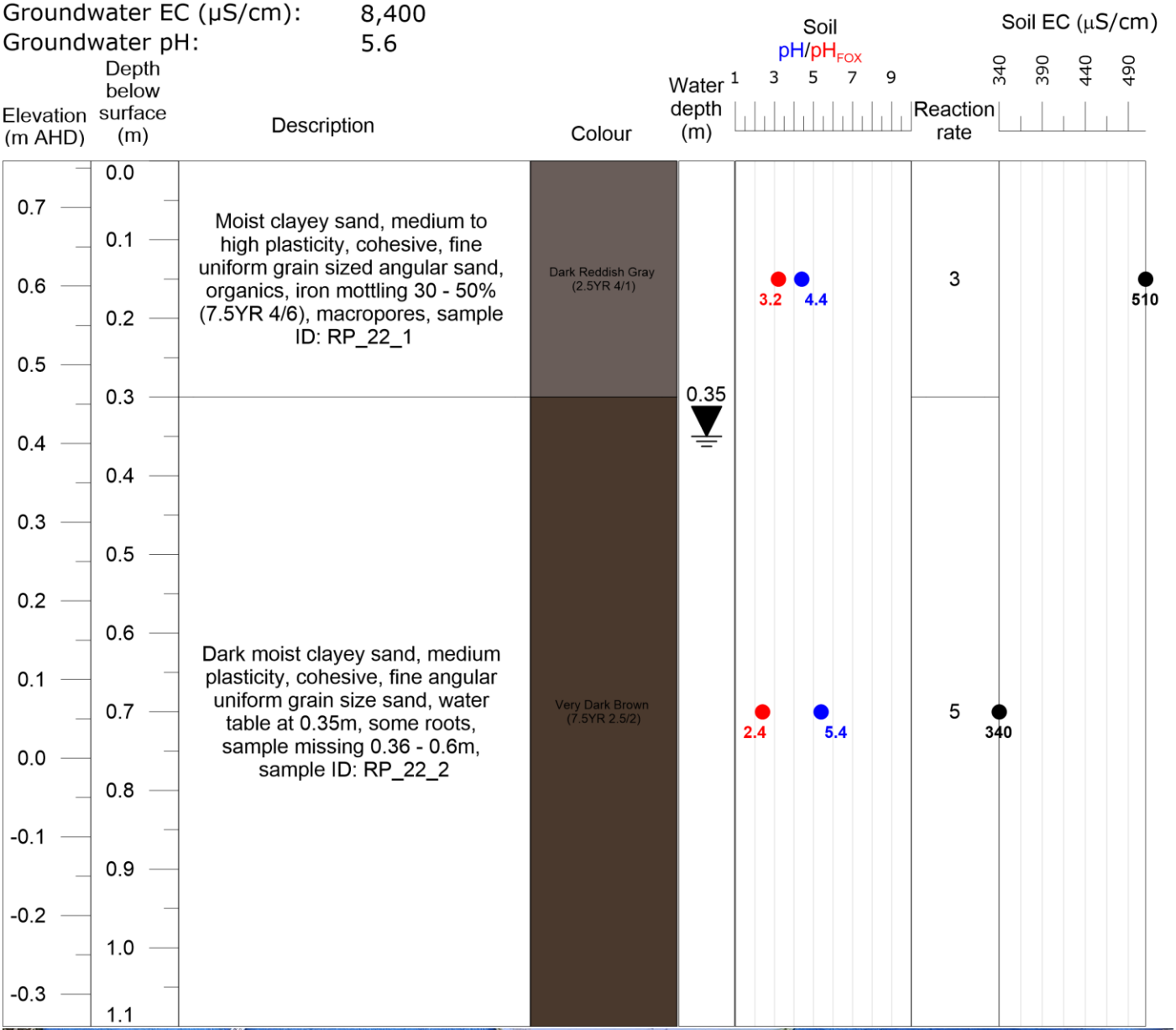
Ground elevation (m AHD): 0.76
Hydraulic conductivity (m/d): 12.59

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Water quality:

Surface water EC (µS/cm): 15,300
Surface water pH: 3.8
Groundwater EC (µS/cm): 8,400
Groundwater pH: 5.6





Soil profile details:

Project Number:	2018064	Profile ID:	RP_23
River/estuary:	Richmond	Sample date:	30/10/19
Easting:	551416.2	Sampled by:	AJH GL KW
Northing:	6812418.2		

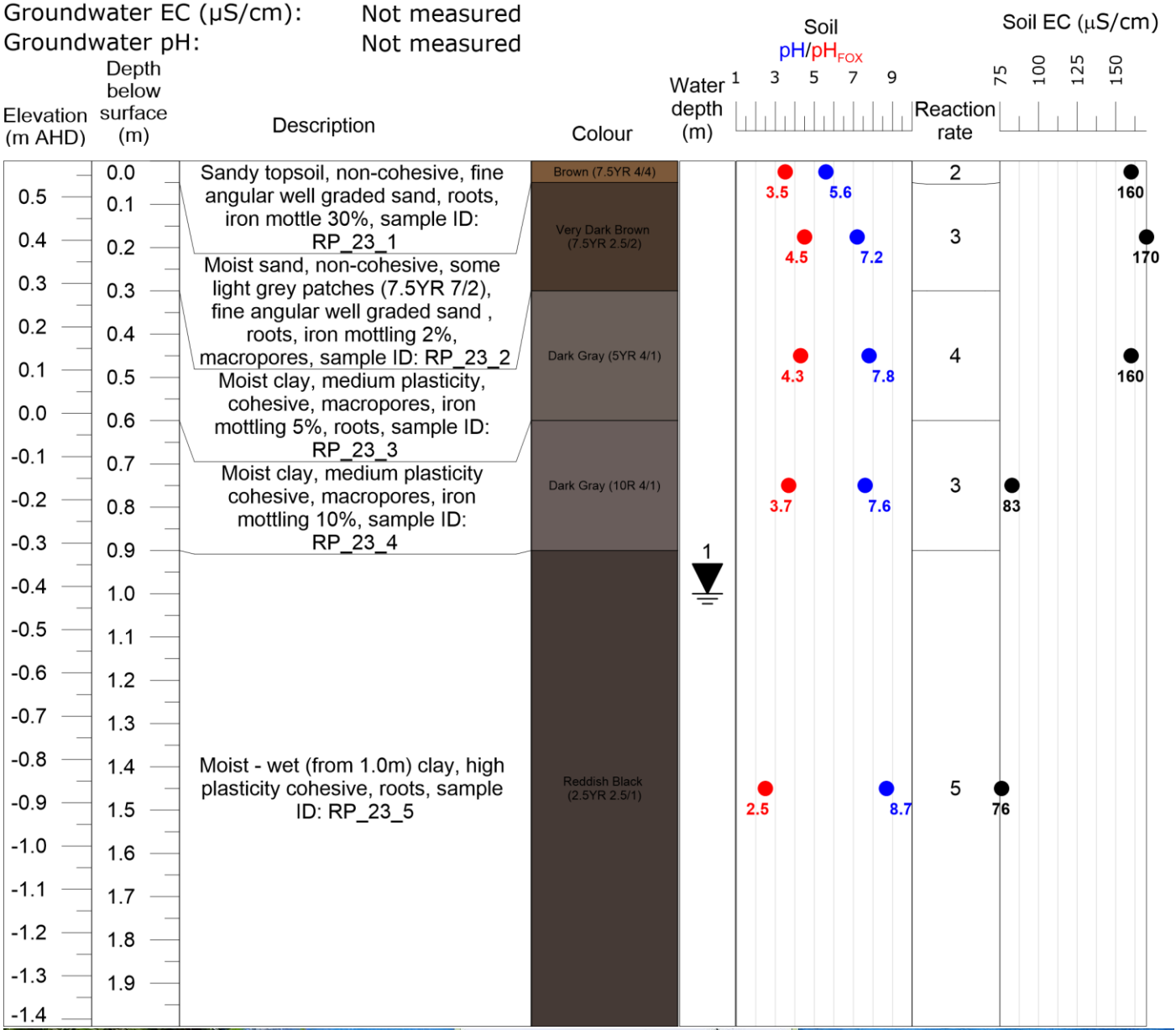
Ground elevation (m AHD): 0.58
Hydraulic conductivity (m/d): Not measured

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Water quality:

Surface water EC (µS/cm): 4,200
Surface water pH: 6.8
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured





Soil profile details:

Project Number:	2018064	Profile ID:	RP_24
River/estuary:	Richmond	Sample date:	30/10/19
Easting:	551121.7	Sampled by:	AJH GL KW
Northing:	6811612.2		

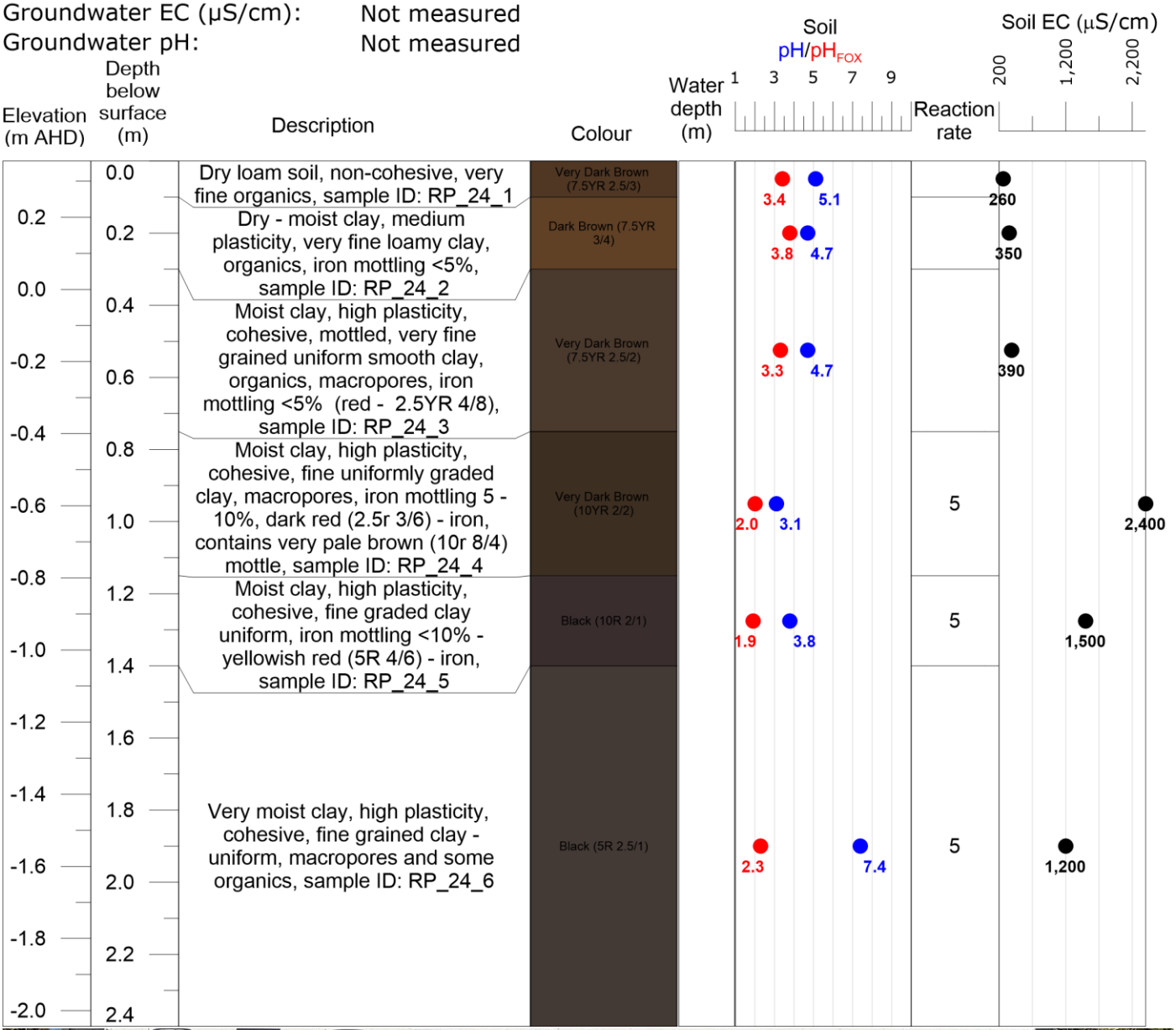
Ground elevation (m AHD): 0.36
Hydraulic conductivity (m/d): Not measured

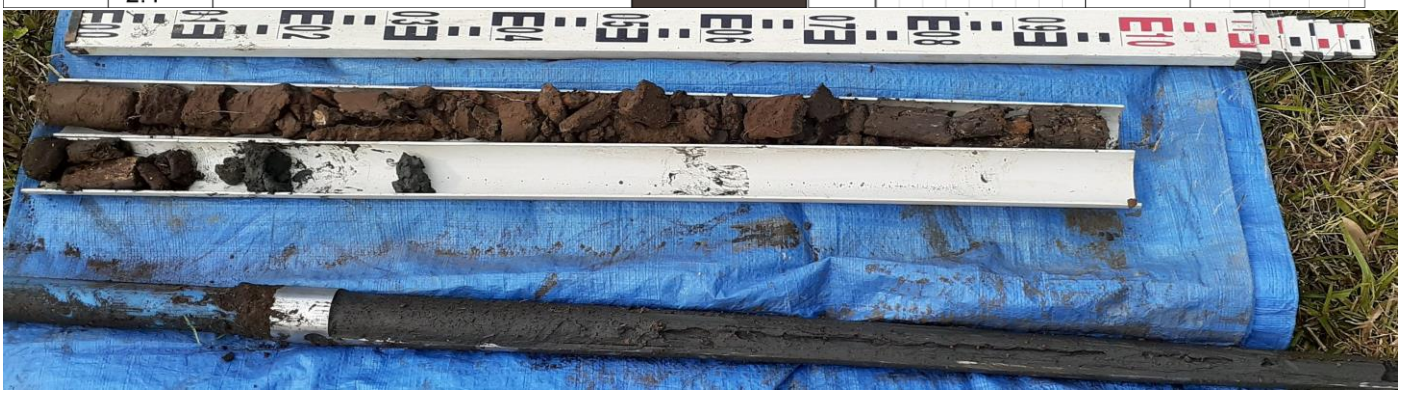
Water quality:

Surface water EC (µS/cm): 20,700
Surface water pH: 4.1
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured

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Soil profile details:

Project Number:	2018064	Profile ID:	RP_30
River/estuary:	Richmond	Sample date:	06/11/19
Easting:	556855.6	Sampled by:	AJH GL
Northing:	6809936.3		

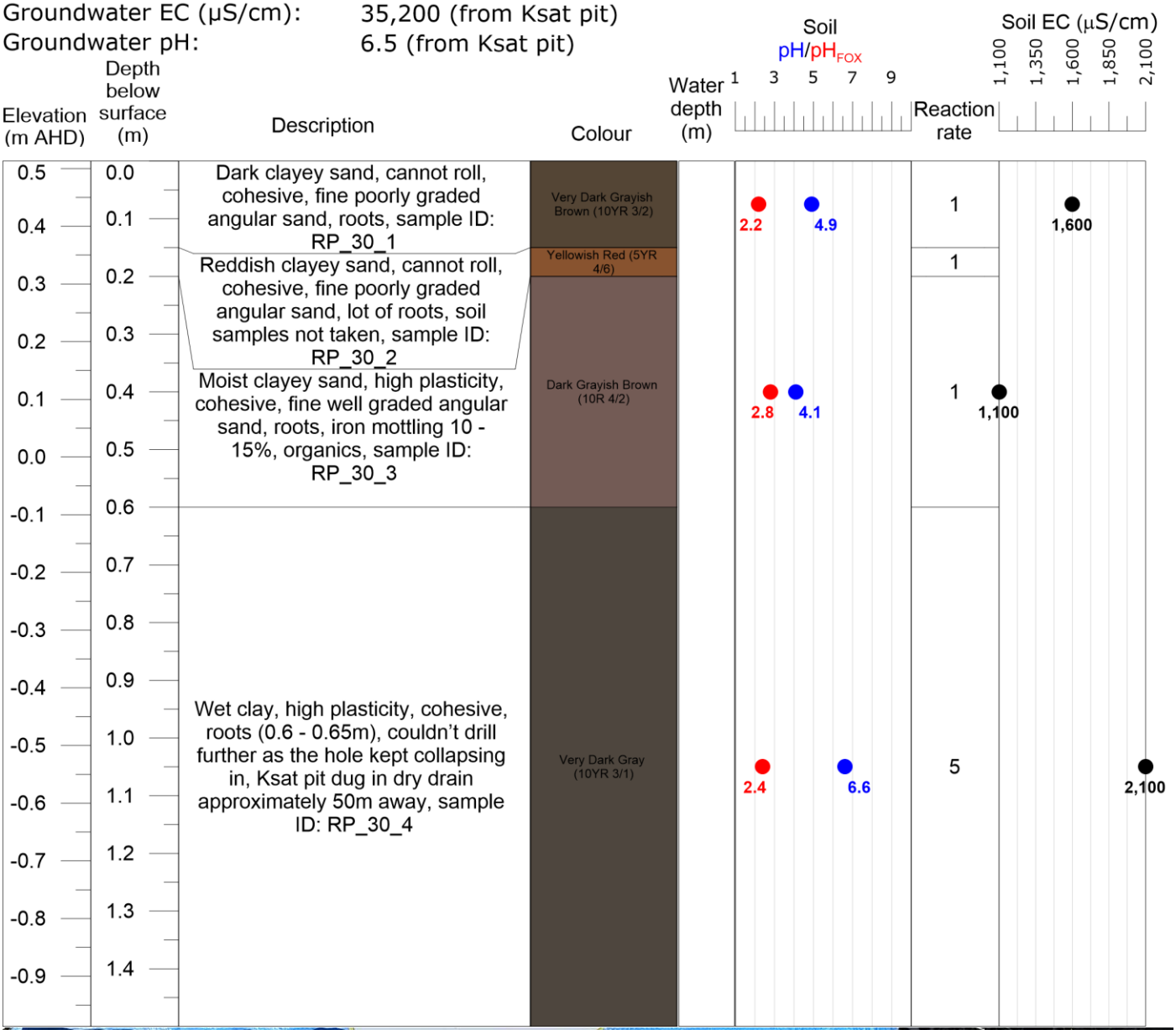
Ground elevation (m AHD): 0.51
Hydraulic conductivity (m/d): 2.53

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Water quality:

Surface water EC (µS/cm): 56,200
Surface water pH: 6.9
Groundwater EC (µS/cm): 35,200 (from Ksat pit)
Groundwater pH: 6.5 (from Ksat pit)





Soil profile details:

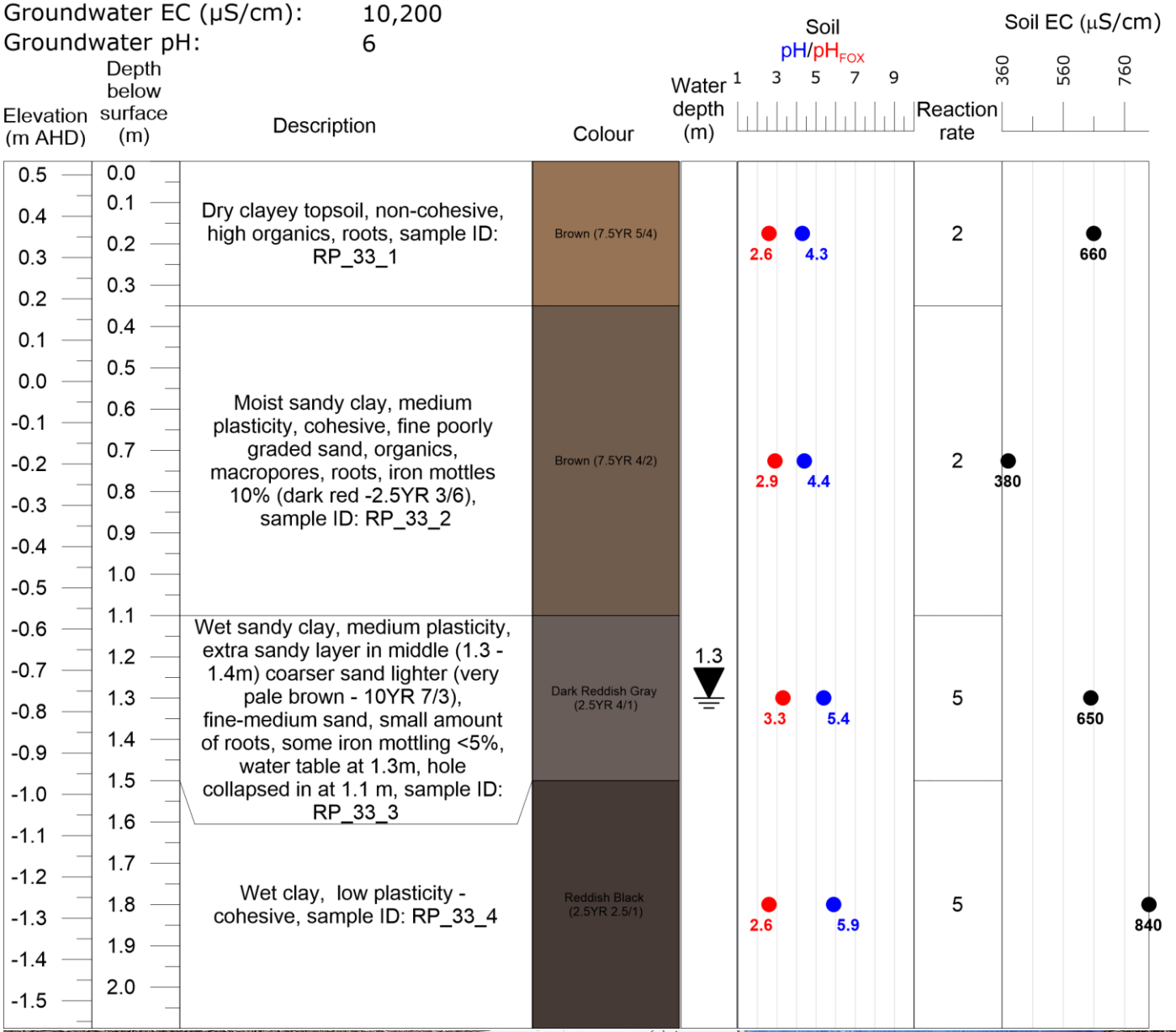
Project Number:	2018064	Profile ID:	RP_33
River/estuary:	Richmond	Sample date:	04/11/19
Easting:	545512	Sampled by:	AJH GL
Northing:	6792076.2		

Ground elevation (m AHD): 0.53
Hydraulic conductivity (m/d): 9.50

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Water quality:

Surface water EC (µS/cm): 20,460
Surface water pH: 7.17
Groundwater EC (µS/cm): 10,200
Groundwater pH: 6





Soil profile details:

Project Number:	2018064	Profile ID:	RP_37
River/estuary:	Richmond	Sample date:	30/01/20
Easting:	543455.8	Sampled by:	AJH GL
Northing:	6791988.1		

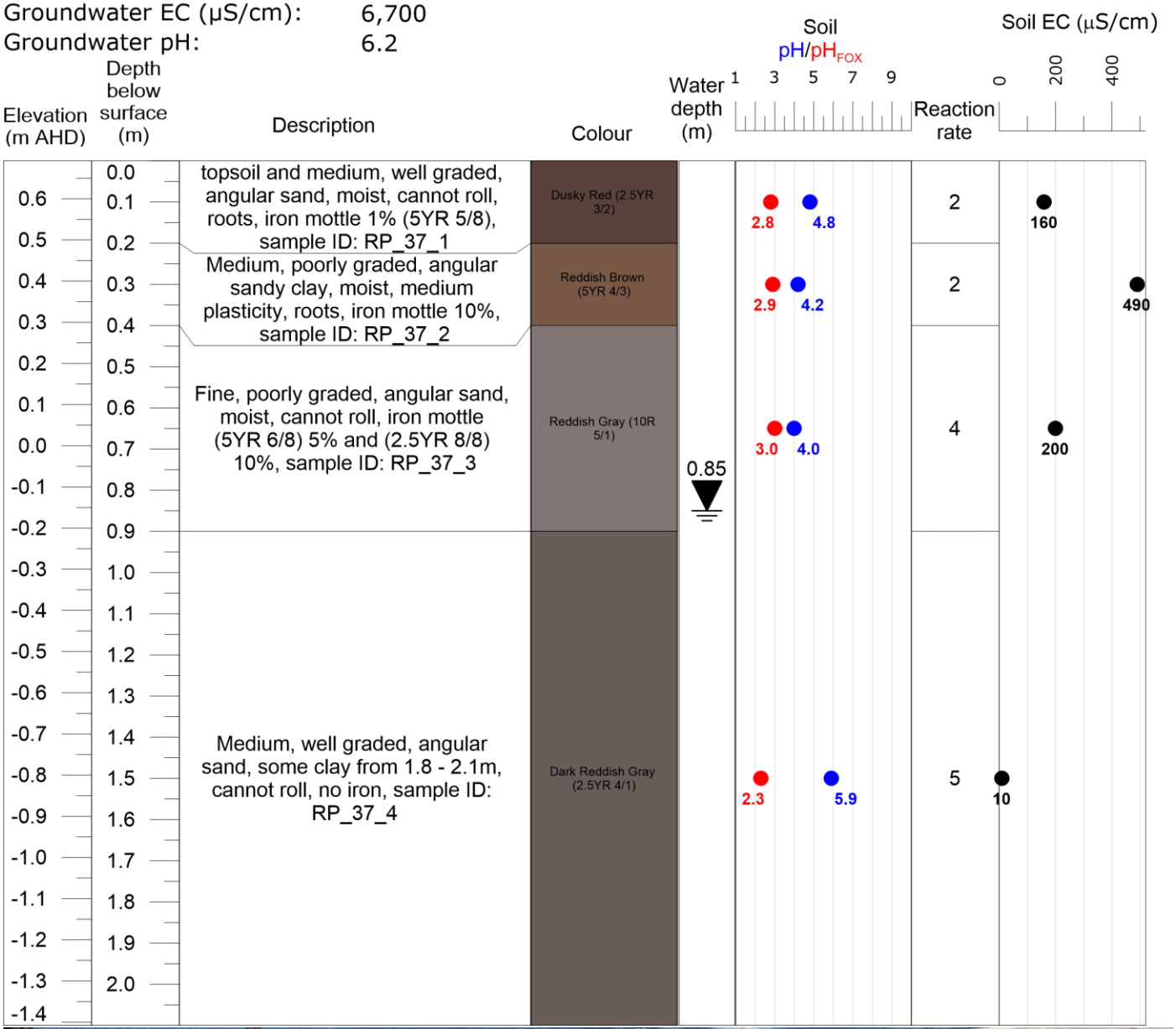
Ground elevation (m AHD): 0.69
Hydraulic conductivity (m/d): 0.05

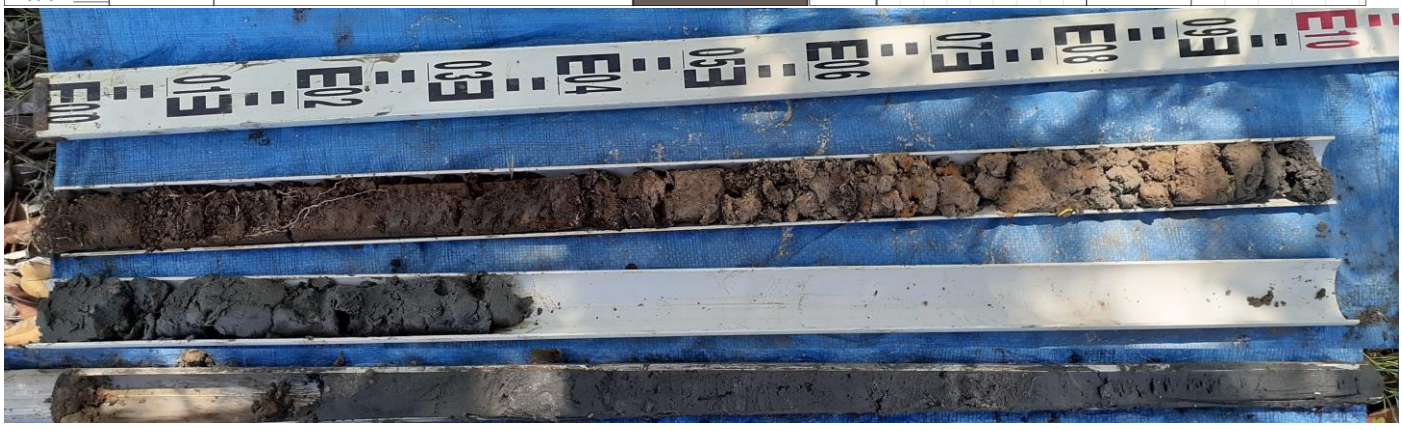
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Water quality:

Surface water EC (µS/cm): 12,178
Surface water pH: 6.87
Groundwater EC (µS/cm): 6,700
Groundwater pH: 6.2





Soil profile details:

Project Number:	2018064	Profile ID:	RP_40
River/estuary:	Richmond	Sample date:	29/01/20
Easting:	535519.1	Sampled by:	AJH GL
Northing:	6789270.0		

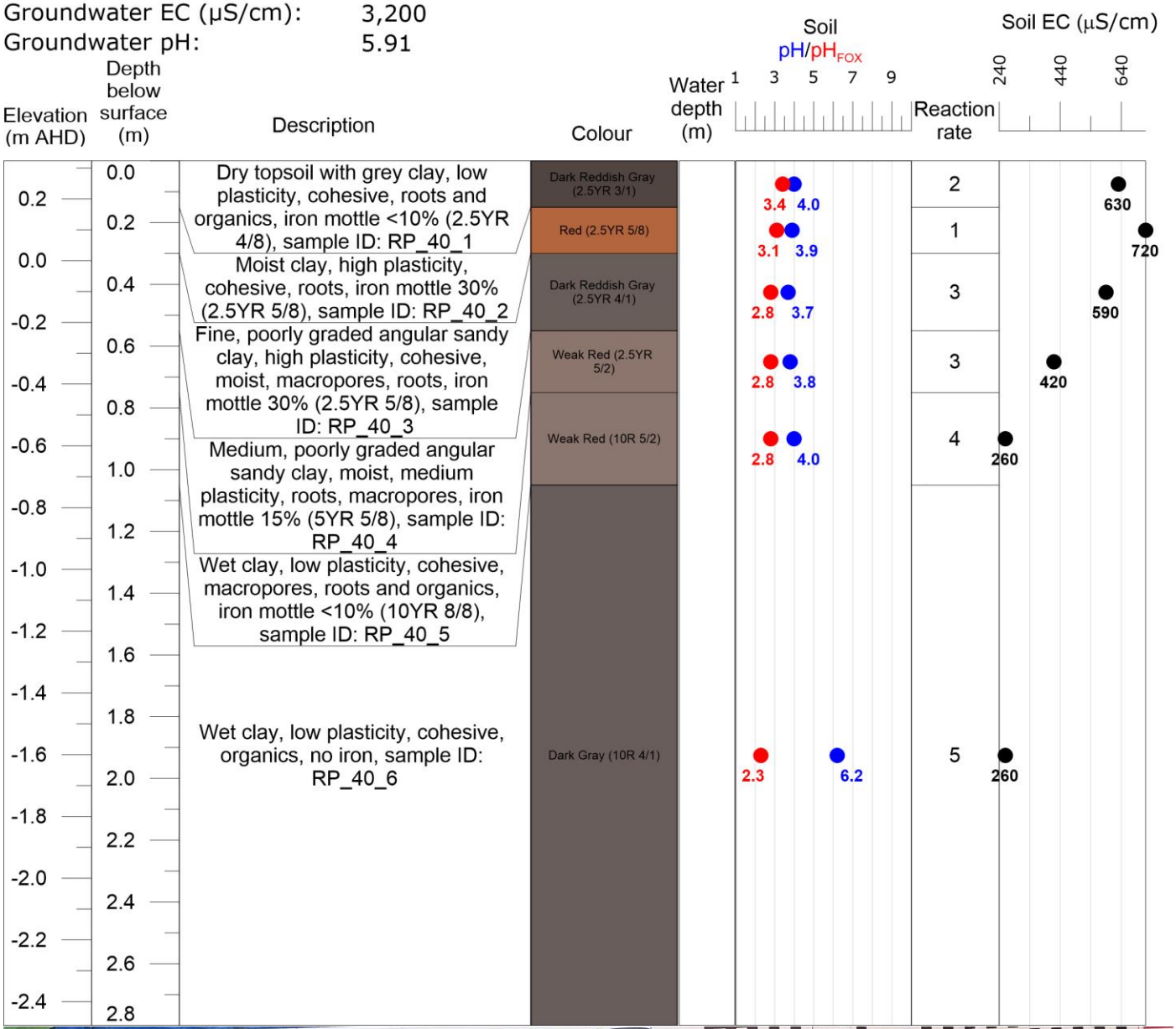
Ground elevation (m AHD): 0.32
Hydraulic conductivity (m/d): 0.10

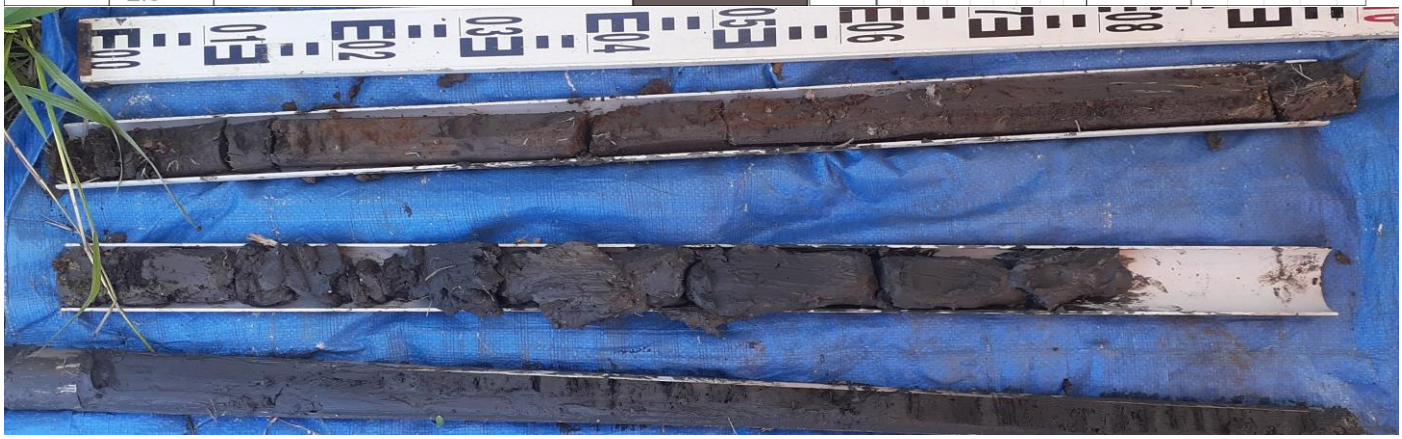
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Water quality:

Surface water EC (µS/cm): 7,500
Surface water pH: 6.1
Groundwater EC (µS/cm): 3,200
Groundwater pH: 5.91





Soil profile details:

Project Number:	2018064	Profile ID:	RP_44
River/estuary:	Richmond	Sample date:	31/10/19
Easting:	529948.8	Sampled by:	AJH GL KW
Northing:	6786749.5		

Ground elevation (m AHD): 0.47
Hydraulic conductivity (m/d): Not measured

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Water quality:

Surface water EC (µS/cm): 4,300
Surface water pH: 7.31
Groundwater EC (µS/cm): 880
Groundwater pH: 4.84

Elevation (m AHD)	Depth below surface (m)	Description	Colour	Water depth (m)	Soil pH/pH_{FOX}	Reaction rate	Soil EC (µS/cm)
0.4 to 0.0	0.0 to 0.3	Dry (includes topsoil) clay, high plasticity, cohesive, organics, macropores, iron mottling <5% (red - 2.5YR 4/8), sample ID: RP_44_1	Very Dark Grayish Brown (10YR 3/2)		3.2, 4.6	3	130
0.1 to -0.1	0.4 to 0.6	Moist clay, high plasticity, cohesive, mottled - burnt residue, fine poorly graded clay, organics, macropores, iron mottling <10% 2.5YR 4/8, has black (10YR 2.5/1) mottling, sample ID: RP_44_2	Dark Reddish Gray (5YR 4/2)		2.6, 4.4	3	130
-0.2 to -1.0	0.7 to 1.5	Moist clay, high plasticity, cohesive, fine poorly graded clay with layers of organics, high organics, macropores, water table at 1m, sample ID: RP_44_3	Black (10R 2.5/1)	1	2.1, 5.5	5	97
-1.1 to -1.3	1.6 to 1.7	Moist clay, high plasticity, cohesive, very fine poorly graded clay - uniform, transitions to green 5YR 4/3, reached water table, but too shallow to test Ksat, sample ID: RP_44_4	Black (7.5YR 2.5/1)		1.8, 6.2	5	150



Soil profile details:

Project Number:	2018064	Profile ID:	RP_45
River/estuary:	Richmond	Sample date:	31/10/19
Easting:	527974	Sampled by:	AJH GL KW
Northing:	6786658.0		

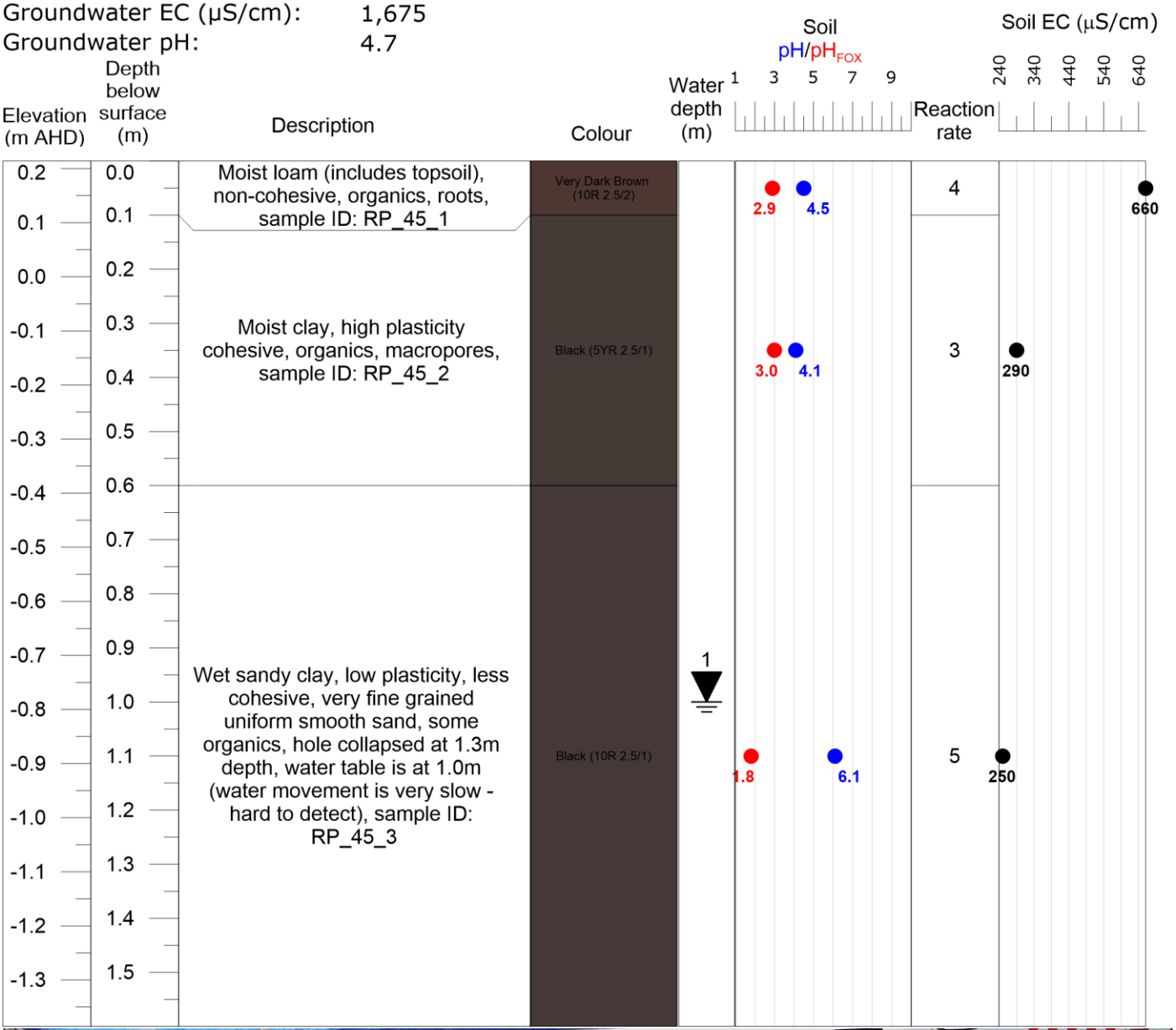
Ground elevation (m AHD): 0.21
Hydraulic conductivity (m/d): 0.06

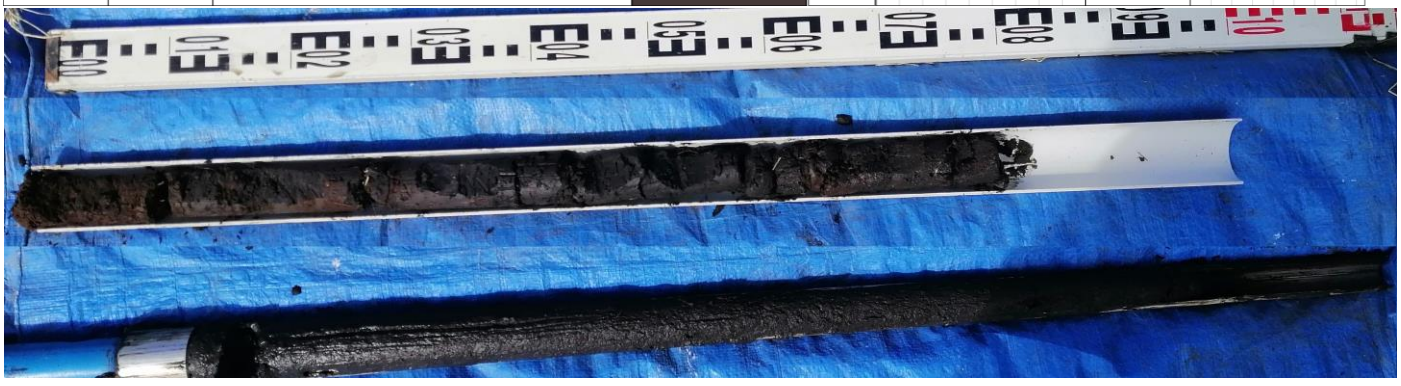
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Water quality:

Surface water EC (µS/cm): 3,100 (dam ~150m away)
Surface water pH: 4.5 (dam ~150m away)
Groundwater EC (µS/cm): 1,675
Groundwater pH: 4.7





Soil profile details:

Project Number:	2018064	Profile ID:	RP_47
River/estuary:	Richmond	Sample date:	26/02/20
Easting:	531595.2	Sampled by:	AJH DWJ
Northing:	6779447.2		

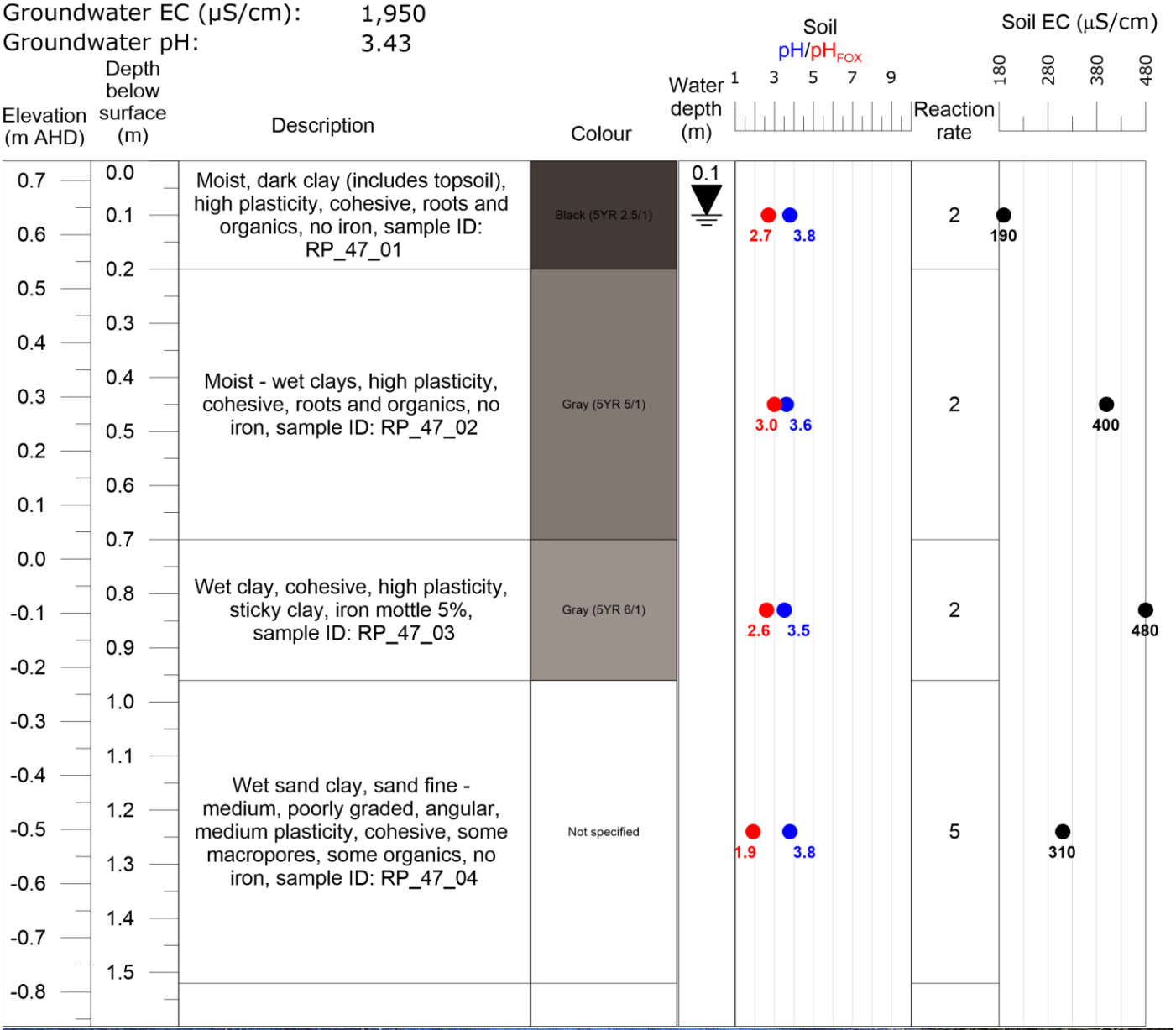
Ground elevation (m AHD): 0.74
Hydraulic conductivity (m/d): 22.76

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Water quality:

Surface water EC (µS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (µS/cm): 1,950
Groundwater pH: 3.43





Soil profile details:

Project Number:	2018064	Profile ID:	RP_50
River/estuary:	Richmond	Sample date:	29/01/20
Easting:	527664.1	Sampled by:	AJH GL
Northing:	6783228.0		

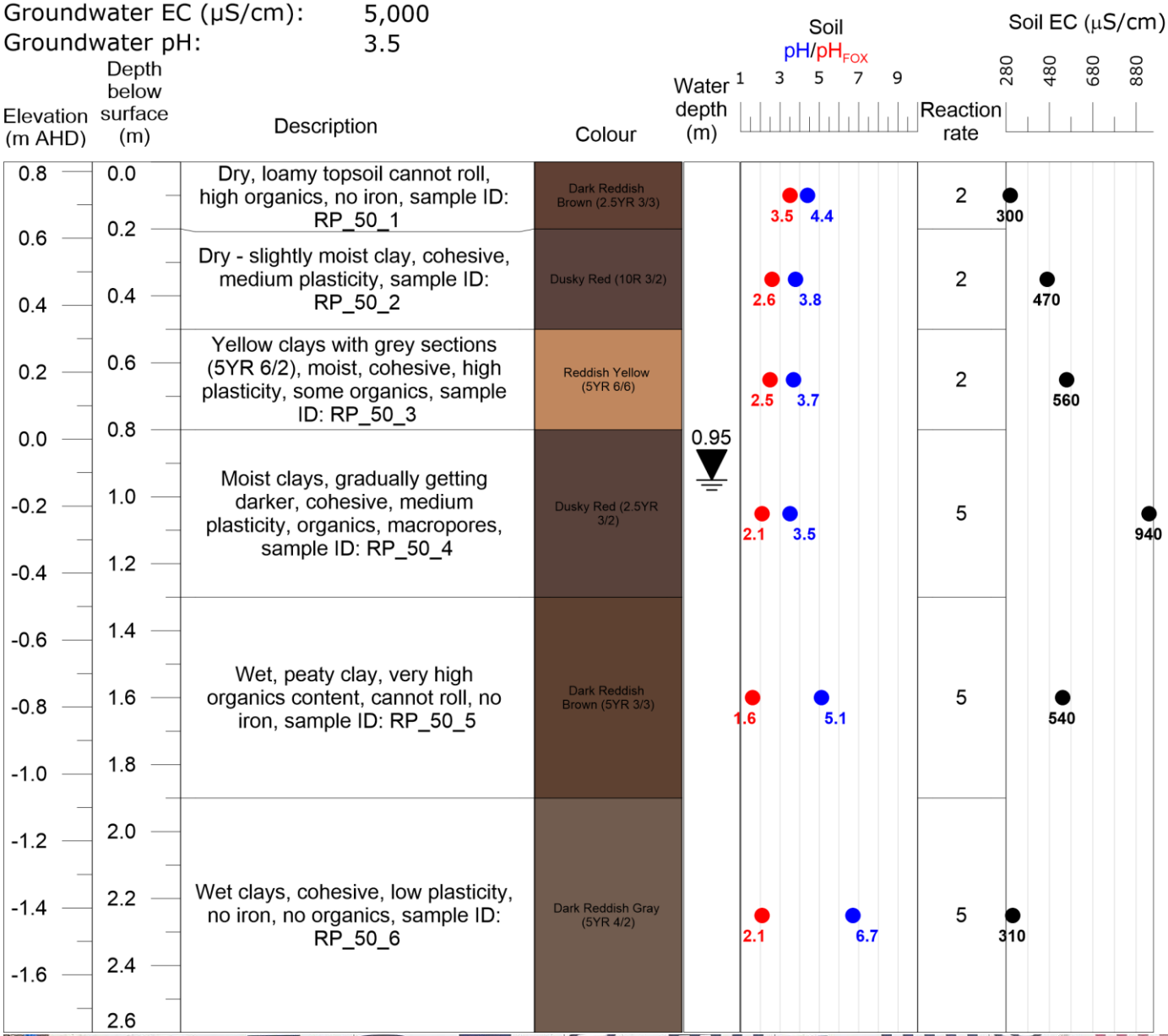
Ground elevation (m AHD): 0.83
Hydraulic conductivity (m/d): 0.24

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Water quality:

Surface water EC (µS/cm): 2,750
Surface water pH: 2.6
Groundwater EC (µS/cm): 5,000
Groundwater pH: 3.5





Soil profile details:

Project Number:	2018064	Profile ID:	RP_57_C
River/estuary:	Richmond	Sample date:	25/02/20
Easting:	522901.6	Sampled by:	AJH DWJ
Northing:	6788503.4		

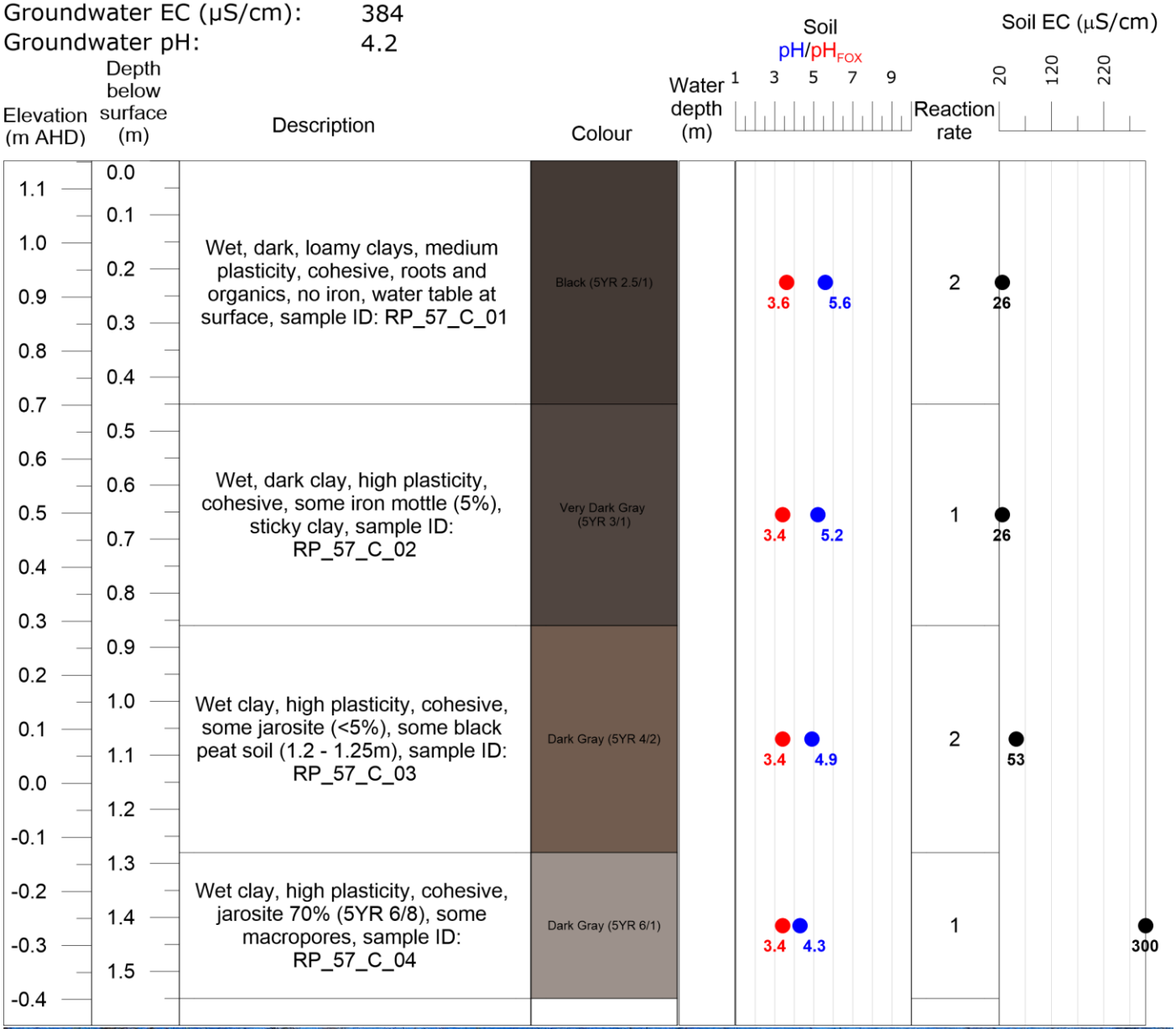
Ground elevation (m AHD): 1.15
Hydraulic conductivity (m/d): Not measured

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Water quality:

Surface water EC (µS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (µS/cm): 384
Groundwater pH: 4.2





Soil profile details:

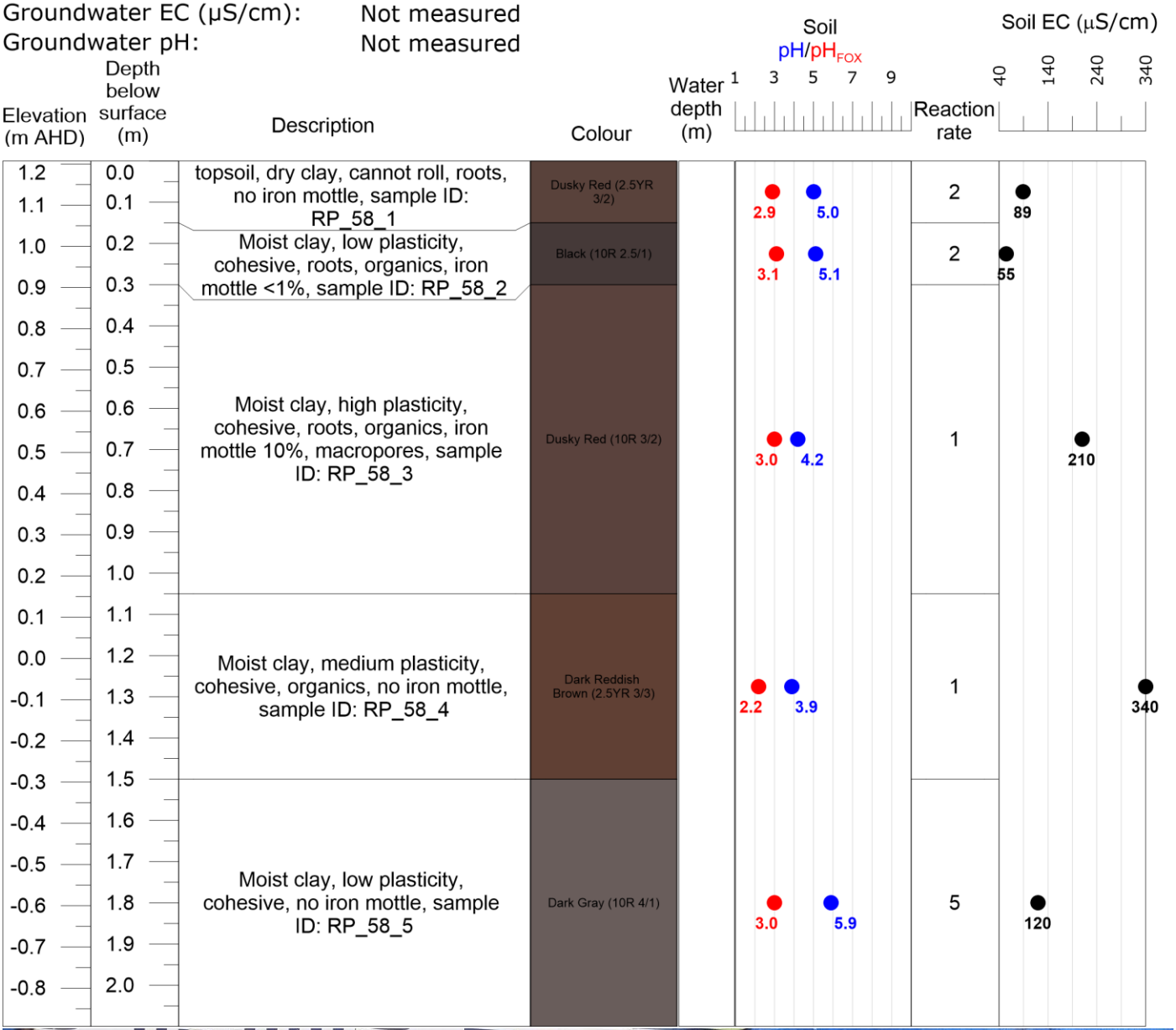
Project Number:	2018064	Profile ID:	RP_58
River/estuary:	Richmond	Sample date:	30/01/20
Easting:	521501.7	Sampled by:	AJH GL
Northing:	6791605.3		

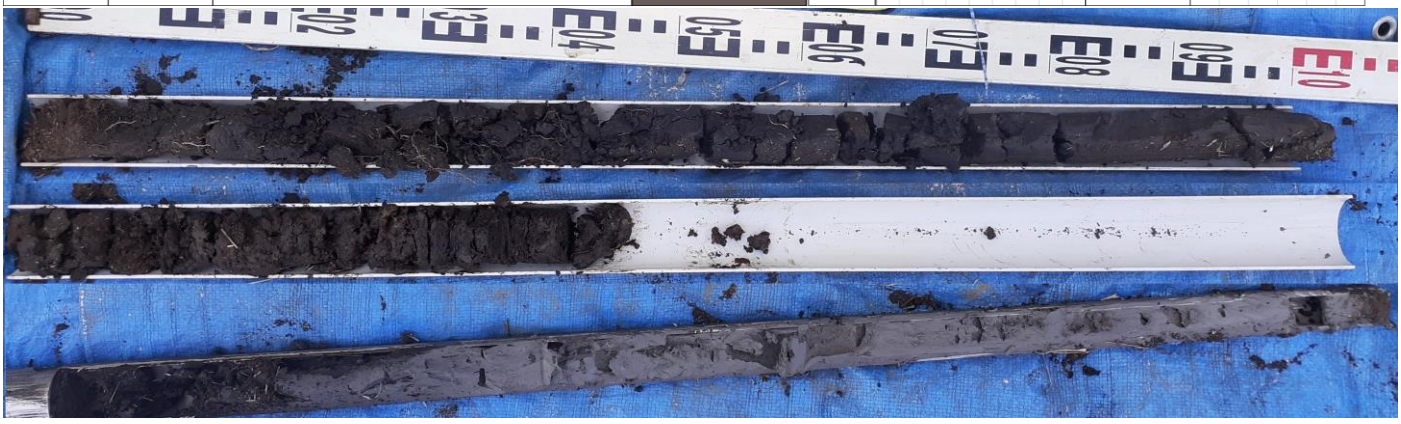
Ground elevation (m AHD): 1.21
Hydraulic conductivity (m/d): 0.03

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Water quality:

Surface water EC (µS/cm): Not measured
Surface water pH: Not measured
Groundwater EC (µS/cm): Not measured
Groundwater pH: Not measured





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