Vulcan Complex Project

Supporting information and responses to the Department of Environment and Science Information Request relating to surface water

Vitrinite Pty Ltd
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Contents

1 Introduction 5
2 Water management system 6
2.1 Water management system plans 6
2.2 Surface water management 11
2.3 Mine affected water management 12
2.4 Clean water management 12
2.5 Proposed surface water monitoring locations 13
3 Updated water balance assessment 15
3.1 Water balance model updates 15
3.2 Water balance model results 17
3.2.1 Jupiter pit inventory 18
3.2.2 Mine water dam inventories 18
3.2.3 Sediment dam discharges 19
4 Review of available baseline surface water quality data 21
4.1 Overview 21
4.2 Assessment methodology 21
4.3 Available data 21
4.4 Comparison of local data with the Project WQO and MMC default trigger values 23
4.5 Recommended receiving waters trigger values 23
4.6 Recommended interim sediment dam trigger values 24
5 References 26
Appendix A - WRM responses to DES information request 27
Appendix B - Baseline Water Quality Monitoring Data 30

List of Figures

Figure 2.1 - Stage 1 (Year 2022) conceptual drainage plan 8
Figure 2.2 - Stage 2 (Year 2024) conceptual drainage plan 9
Figure 2.3 - LOM (post-mining conditions) conceptual drainage plan 10
Figure 2.4 - Proposed surface water monitoring locations 14
Figure 3.1 - Jupiter forecast mine pit inventory 18
Figure 3.2 - Forecast mine affected water inventory 19
Figure 3.3 - Forecast annual sediment dam overflows to receiving waters 20
Figure 4.1 - Baseline surface water monitoring locations 22

List of Tables

Table 2.1 - Water storage catchment areas and landuses (Stage 1) 6
Table 2.2 - Water storage catchment areas and landuses (Stage 2) 7
Table 2.3 - Sediment dam details 11
Table 2.4 - Mine affected dam details 12
Table 2.5 - Proposed receiving water monitoring locations 13
Table 3.1 - Water balance model operational rules 15
Table 3.2 - Average annual water balance - all realisations 17
Table 4.1 - Receiving waters water quality laboratory analysis parameters 23
Table 4.2 - Proposed receiving waters trigger values for the VCP EA 25
Table A.1 - WRM responses to DES information request relating to Surface Water Management 28
Table B.1 - Recorded water quality at VCP baseline monitoring locations during the February 2020 event 31
Table B.2 - Recorded water quality at VCP baseline monitoring locations during the 5 March 2020 event 33
Table B.3 - Recorded water quality at VCP baseline monitoring locations during the 18-19 March 2020 event 35
Table B.4 - Recorded water quality at VCM baseline monitoring locations during the January 2021 event 37
Table B.5 - Summary of 80th percentile values for all baseline monitoring locations. 39
Table B.6 - 80th percentile values for the combined VSW1 and VSW2 data set compared with the receiving water WQO default trigger values and MMC Table F3 trigger values 41

1 Introduction

This report has been prepared in response to an information request by the Department of Environment and Science (DES) for the Vulcan Complex Project (VCP). The information request (dated 19 March 2021) was provided in response to the Notice of Change to an Environmental Authority Application (NoC) for the Vulcan Complex Project (METServe, 2021).

WRM previously completed the VCP Surface Water Assessment (SWA) (WRM, 2020), which included an operational water balance model, a flood model and the proposed surface water monitoring program. This report provides further details of the updates made to the VCP surface water assessment work as part of the NoC, including updates to the water management system, the water balance model and the surface water monitoring program.

WRM's responses to the DES comments are summarised in Appendix A.

2 Water management system

2.1 WATER MANAGEMENT SYSTEM PLANS

The water management system plans for the Project have been updated to reflect the revised mine plan. The revised mine stage layouts during operations and for the life of mine (post mining) are shown in Figure 2.1, Figure 2.2 and Figure 2.3.

Table 2.1 and Table 2.2 show the adopted catchment and landuse areas for each water storage during the operational Stage 1 and Stage 2 respectively, which have been updated in the water balance model to reflect the updated water management system plans shown in Figure 2.1 and Figure 2.2.

In addition to the dams proposed during the operational period of mining, SD10, SD11 and SD12 will be required during the closure period. Releases from SD10, SD11 and SD12 will drain into the proposed drainage corridor and discharge from the Project area at the Drainage Line 1 crossing of the railway culverts.

Table 2.1 – Water storage catchment areas and landuses (Stage 1)

Storage	Landuse area (ha)					
	Natural	Disturbed	In pit spoil	Out of pit spoil	Pit	Total Area
Sediment Dams						
SD1	0.0	0.0	0.0	19.5	0.0	19.5
SD2	0.0	0.0	0.0	8.3	0.0	8.3
SD3	0.0	11.8	0.0	0.0	0.0	11.8
SD4	0.0	5.0	0.0	0.0	0.0	5.0
SD5	0.0	2.2	6.3	0.0	0.0	8.5
SD6	0.0	1.9	0.0	0.0	0.0	2.0
SD7	0.0	5.2	8.8	0.0	0.0	14.0
SD8	0.0	1.7	7.0	0.0	0.0	8.8
Mine affected water dams						
MWD1	0.0	18.5	0.0	0.0	0.0	18.5
MWD3	0.0	2.5	0.0	0.0	0.0	2.5
Jupiter Pit	0.0	3.2	0.0	0.0	14.9	18.2

Table 2.2 – Water storage catchment areas and landuses (Stage 2)

Storage	Landuse area (ha)					
	Natural	Disturbed	In pit spoil	Out of pit spoil	Pit	Total Area
Sediment Dams						
SD1	0.0	0.0	0.0	19.5	0.0	19.5
SD2	0.0	0.0	0.0	8.3	0.0	8.3
SD3	0.0	12.7	0.0	0.0	0.0	12.7
SD4	0.0	5.0	0.0	0.0	0.0	5.0
SD5	0.0	1.3	4.3	0.0	0.0	5.6
SD6	0.0	1.7	38.3	0.0	0.0	39.9
SD7	0.0	4.5	10.4	0.0	0.0	14.9
SD8	0.0	2.0	3.7	0.0	0.0	5.7
SD9	0.0	0.8	4.9	0.0	0.0	5.7
Diverted water dams						
DD1	0.0	7.3	0.0	0.0	0.0	7.3
Mine affected water dams						
MWD1	0.0	16.7	0.0	0.0	0.0	16.7
MWD2	0.0	0.0	6.4	0.0	0.0	6.4
MWD3	0.0	2.5	0.0	0.0	0.0	2.5
Jupiter Pit	0.0	14.4	41.0	0.0	16.9	72.3

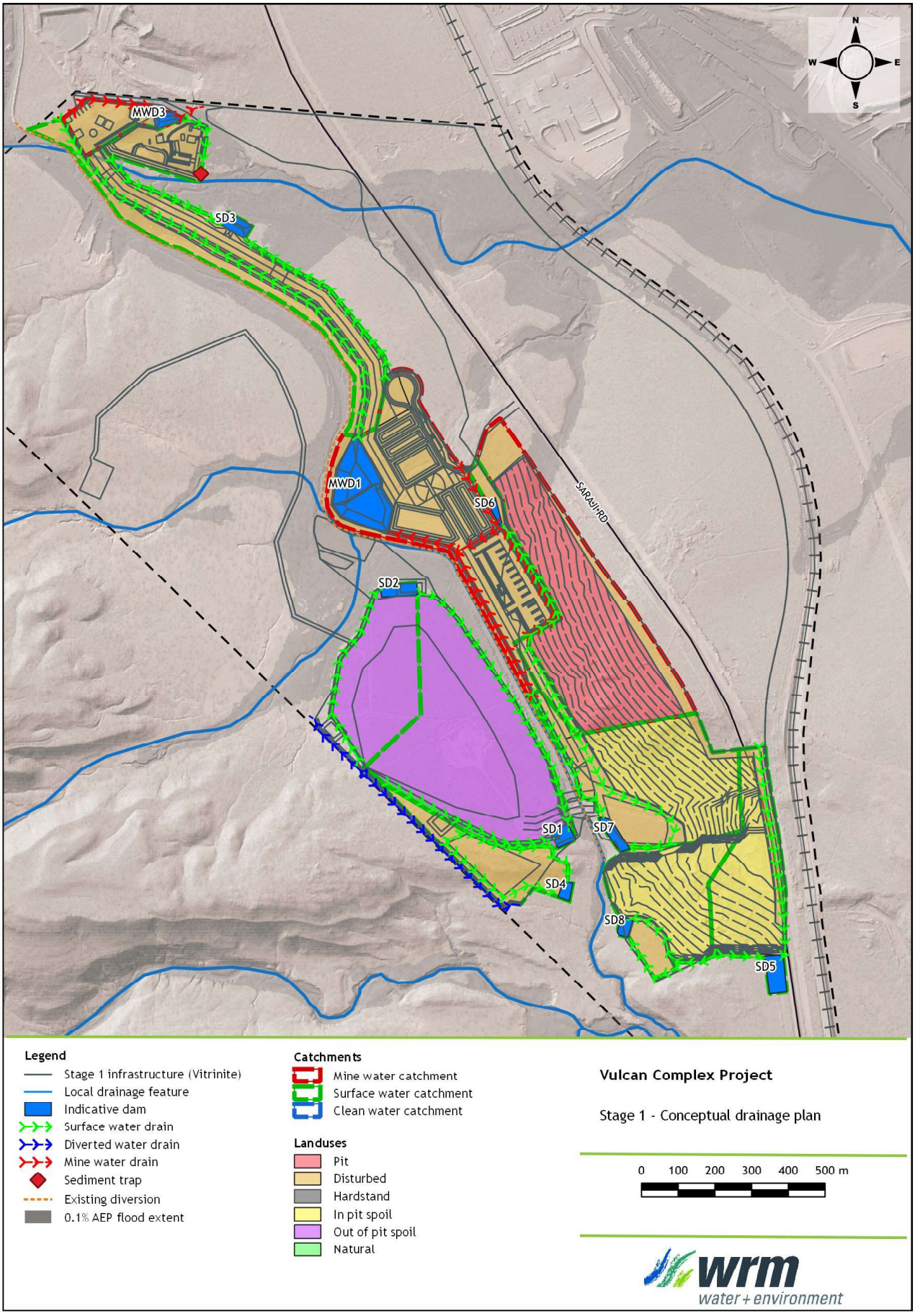


Figure 2.1 - Stage 1 (Year 2022) conceptual drainage plan

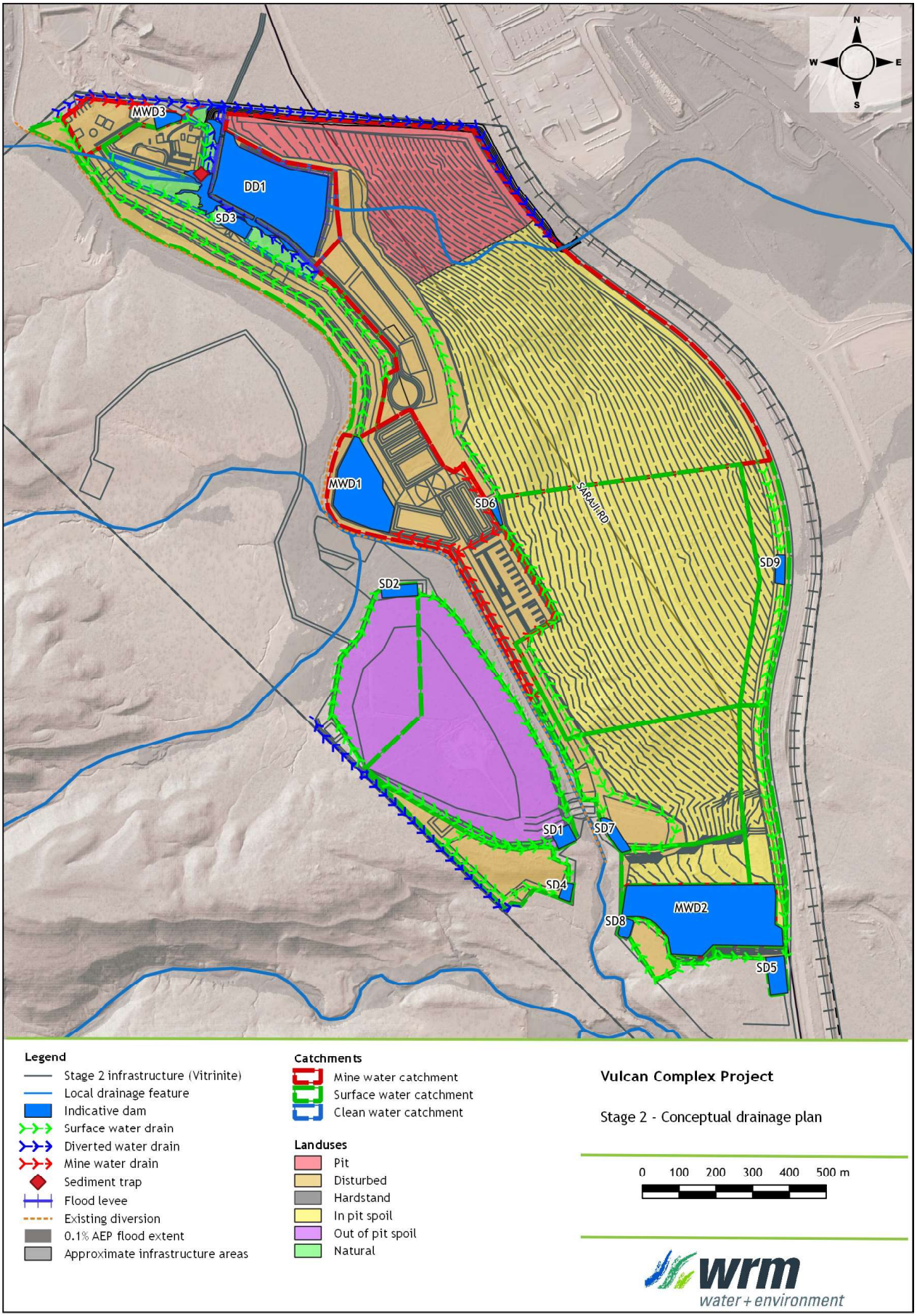


Figure 2.2 - Stage 2 (Year 2024) conceptual drainage plan

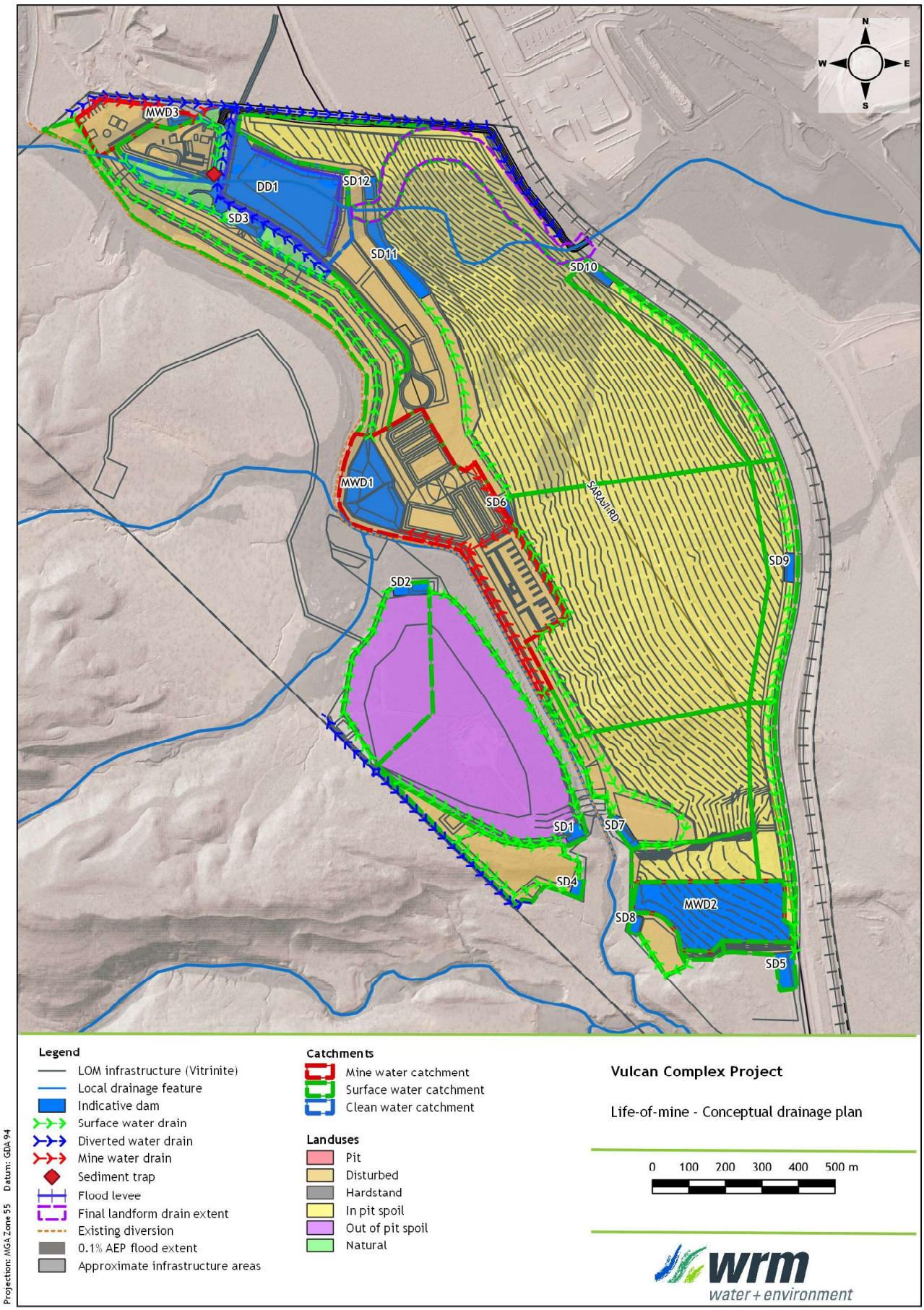


Figure 2.3 – LOM (post-mining conditions) conceptual drainage plan

2.2 SURFACE WATER MANAGEMENT

The following areas of the site have been defined as surface water catchments, consistent with the Guideline Model Mining Conditions (DES, 2017) definitions (see Figure 2.1, Figure 2.2 and Figure 2.3):

- the in pit and out of pit spoil dumps - the runoff from these dumps is not expected to come into contact with coal or other carbonaceous materials. This runoff may contain high sediment loads but is not expected to contain elevated levels of other water quality parameters (e.g. electrical conductivity, pH, metals, metalloids, non-metals). This runoff will be managed to ensure adequate sediment removal prior to release to receiving waters. Consistent with DES (2017), this runoff is classified as surface water as it will drain to sediment dams installed in accordance with an Erosion and Sediment Control Plan and it will not be mixed with pit water, tailings water, processing plant or workshop water.
- topsoil stockpiles - this runoff will have a high sediment load but will not come into contact with coal or other carbonaceous material.
- the southeastern portion of the northern mine infrastructure area (reporting to the sediment trap) - this area includes a warehouse, carpark and site offices. The runoff from this area is therefore expected to be relatively benign and will not come into contact with coal.
- northern mine access road (reporting to SD3) - this road will link the northern mine infrastructure area with the ROM Pad. This road is not expected to have trucks carrying ROM coal as the main internal haulage for the site will be undertaken on haul roads between the pit and southern infrastructure area (to transport coal from the pits to the stockpiles).

The above areas all drain to sediment dams (via overland flow and surface water drains) which will be installed in accordance with an Erosion and Sediment Control Plan. Table 2.3 provides details for the proposed sediment dams for the Project.

Table 2.3 – Sediment dam details

Storage name	Latitude	Longitude	Sediment dam water source	Receiving waters description
SD1	-22.29316	148.18773	Out of pit spoil dump	Drainage line 2 via the existing drainage diversion
SD2	-22.28714	148.18329	Out of pit spoil dump	
SD3	-22.27815	148.17893	Northern mine access road	Drainage line 1
SD4	-22.29451	148.18781	Topsoil stockpile south of the out of pit spoil dump	Drainage line 2 via the existing drainage diversion
SD5	-22.29651	148.19342	In pit spoil dump	Drainage line 2
SD6	-22.28512	148.18586	In pit spoil dump	Drainage line 2 via the existing drainage diversion
SD7	-22.29309	148.18911	In pit spoil dump and topsoil stockpile	
SD8	-22.29542	148.18936	In pit spoil dump and topsoil stockpile	
SD9	-22.28652	148.19337	In pit spoil dump	Drainage line 1
SD10	-22.27929	148.18825	In pit spoil dump	
SD11	-22.27914	148.18291	In pit spoil dump, topsoil stockpiles and mine access road	Drainage line 1 via the final landform drain
SD12	-22.27728	148.18213	In pit spoil dump	

2.3 MINE AFFECTED WATER MANAGEMENT

Table 2.4 shows the mine affected dam details for the Project, including the full supply volume (FSV) of each dam and the operating rules for each dam which are applied if the operating volume (OV) is exceeded.

The following areas of the site have been defined as mine water catchments, consistent with the definitions provided in the Guideline Model Mining Conditions (DES, 2017) (see Figure 2.1, Figure 2.2 and Figure 2.3):

- the pit.
- the southern mine infrastructure area - this area contains a number of coal stockpiles and the sorter/crusher and therefore will come into contact with coal.
- the northwestern section of the northern mine area (reporting to MWD3) - this area will contain a maintenance workshop, tyre fitting bay and wash bay.

The above areas all drain to mine water dams (via overland flow and mine water drains) or to the pit itself.

Table 2.4 – Mine affected dam details

Storage name	OV (ML)	FSV (ML)	Operating rules
MWD1	73.0	107.4	Above the OV, pit dewatering and MWD3 dewatering to MWD1 ceases. In addition, during Stage 2, MWD1 commences dewatering to MWD2
MWD2	300.0	321.2	Above the OV, pit dewatering to MWD2 ceases
MWD3	1.1	5.4	Above the OV, MWD3 commences dewatering to MWD1

In the event that transfer capacity is not available between the Mine Water Dams, excess mine affected water will be pumped to the pit to prevent releases to the receiving environment.

2.4 CLEAN WATER MANAGEMENT

The key features of the site clean water management are (see Figure 2.1, Figure 2.2 and Figure 2.3):

- DD1 (operational in Stage 2) – a clean water dam, located adjacent to the pit, which has been designed to provide the pit with flood immunity during heavy rainfall. DD1 has a spillway at 247.0 mAHD which drains to the north of the dam. A pump transfers water which collects in DD1 to the existing drainage diversion. The dam will only collect direct rainfall and flood runoff which overtops the existing drainage diversion during flood events.
- Northern diverted water bund (operational in Stages 1 and 2) – a clean water bund located around the northern side of the northern workshop area. This bund diverts runoff from the catchment area to the north of the workshop to the east.
- Northern diverted water drain (operational in Stage 2) - a diversion drain which has been designed to divert water around the northern side of the pit. This drain collects the undisturbed catchment to the north of the pit, as well as any overflows from DD1.
- Southern diversion drains (introduced in Stage 1) – two drains on the western side of the out of pit emplacement which will drain the undisturbed catchment to the west of the mining area around the out of pit spoil dump and toward the existing drainage diversion.

2.5 PROPOSED SURFACE WATER MONITORING LOCATIONS

Table 2.5 and Figure 2.4 show the proposed receiving water monitoring locations for the Project. The following is of note:

- VSW1 and VSW11 are upstream monitoring points;
- VSW2 and VSW8 are downstream monitoring points; and
- VSW3 to VSW7, VSW9 and VSW10 are not used nor are relevant for the VCP monitoring program. They are used for receiving waters baseline monitoring to the south of the VCP and should not be referenced or included in the Environmental Authority for the VCP.

Table 2.5 – Proposed receiving water monitoring locations

Station ID	Catchment Area	Latitude	Longitude	Description
Upstream sites				
VSW1	Boomerang Ck	-22.27659	148.17436	Diversion bund approximately 3.1km upstream of Drainage lIne 2. Used as an upstream monitoring site for all site dams
VSW11	Boomerang Ck	-22.29796	148.18932	Minor drainage line, upstream of confluence of Drainage line 2.
Downstream sites				
VSW2	Boomerang Ck	-22.3011	148.19507	Drainage Line 2 upstream of the railway. Used as a downstream monitoring site for SD1, SD2, SD4, SD5, SD7, SD8, MWD2.
VSW8	Boomerang Ck	-22.27859	148.18782	Drainage Line 1 upstream of the railway. Used as a downstream site for SD10, SD11, SD12, DD1, MWD3, SD3.

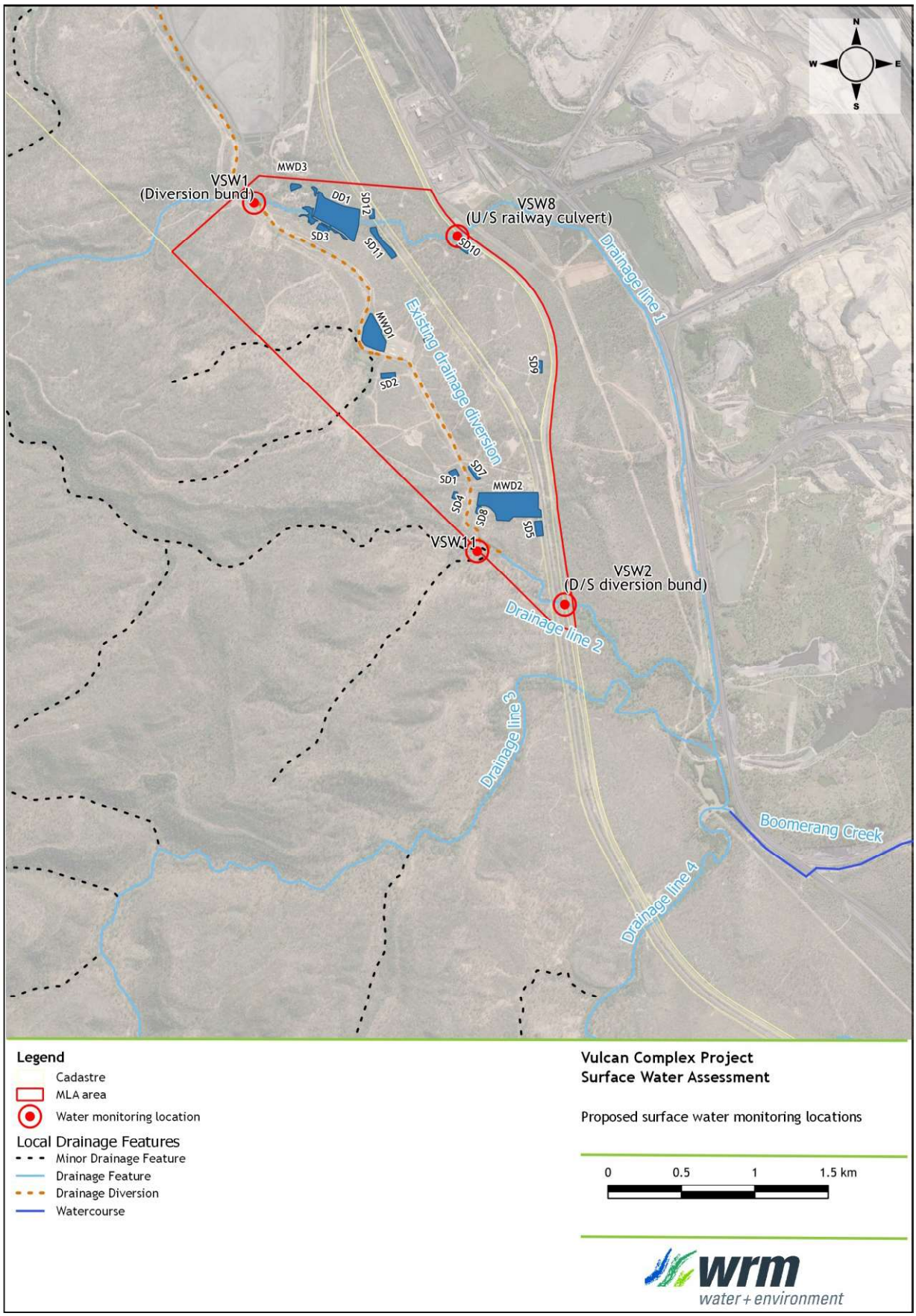


Figure 2.4 – Proposed surface water monitoring locations

3 Updated water balance assessment

3.1 WATER BALANCE MODEL UPDATES

The mine life remains unaltered from the NoC updates and therefore the updated water balance was configured with the following schedule:

- Stage 1 (2 year duration): 1/1/2021 - 31/12/2022; and
- Stage 2 (2 year duration): 1/1/2023 - 31/12/2024.

Other key parts of the model (such as AWBM parameters, site water demands and predicted groundwater inflows) have remained unchanged from the previous SWA (WRM, 2020).

The water balance model was updated to reflect the water management system described in the sections above, including the revised storages and catchment areas.

The updated operational rules which have been applied in the model are outlined in Table 3.1.

Table 3.1 – Water balance model operational rules

Item	Node Name	Operating Rules
1	***External water supply***	
1.1	External water	• Mine affected water can be imported (assumed to be from Peak Downs) to supplement mine water demands. • Supplies haul road dust suppression demands (3rd priority).
1.2	Trucked water	• Supplies the potable water demand.
2	***Supply to demands***	
2.1	Haul road dust suppression	• Sourced from the following: - 1st priority: MWD1/MWD2/MWD3. - 2nd priority: Sediment dams. - 3rd priority: External water. • 100% loss assumed; and • Demand values as per WRM (2020).
2.2	Potable water demand	• Sourced from trucked water delivered to site; • 100% loss assumed; and • Assumed constant rate of 50 ML/yr (as outlined in WRM [2020]).
3	***Pit water***	
3.1	Jupiter pit	• Proposed mining pit active during all stages. • Dewaters to MWD1/MWD2 at 100 L/s (8.64 ML/d), provided there is available storage. • Receives negligible groundwater inflows as outlined in WRM (2020).
4	***Operation of mine affected dams***	
4.1	MWD1	• Proposed primary mine affected water storage; • Receives pumped inflows from the Jupiter pit at 100 L/s (8.64 ML/d) until MWD1 reaches its OV, at which point dewatering ceases. Pumped inflows recommence once the inventory drops below its OV. • Receives pumped inflows from MWD3 at 11 L/s (1 ML/d), until it reaches its OV.

4.2	MWD2	• Active in Stage 2. • Receives pumped inflows from the Jupiter pit at 100 L/s (8.64 ML/d) until MWD2 reaches its OV, at which point dewatering ceases. Pumped inflows recommence once the inventory drops below its OV. • Supplies water to haul road dust suppression (1st priority).
4.3	MWD3	• Collects mine affected (potential) runoff from the mine workshop and laydown area. • Pumps to MWD1 at 11 L/s (1 ML/d) if MWD3 is above its OV and MWD1 is below its OV.
5	***Operation of sediment dams***	
5.1	Primary sediment dams (SD1, SD2, SD3, SD4, SD5, SD7, SD8, SD9)	• SD1 & SD2 collect water from the out of pit spoil dump. • SD5, SD7, SD8, SD9 collect runoff primarily from the in pit spoil dump. • SD3 and SD4 collect runoff primarily from topsoil stockpiles and mine access roads. • Supply water to the haul road dust suppression as 2nd priority. • Overflow to Boomerang Creek via Drainage Line 1/Drainage Line 2/existing drainage diversion.
5.2	SD6	• Collects runoff from the in pit spoil dump. • Pumps to the existing drainage diversion at 2.7 ML/d once it exceeds its sediment storage volume; and • Overflows to the pit.
6	***Clean water storages***	
6.1	DD1	• Active in Stage 2. • Diverted water dam used as flood protection for the Jupiter pit. • Transfers water to the existing drainage diversion at 100 L/s (8.64 ML/d) from empty. • Overflows to Drainage Line 1 via a diverted water drain which runs around the northern edge of the pit.

3.2 WATER BALANCE MODEL RESULTS

The annual average water balance for the Project based on the 125 model realisations are presented in Table 3.2. The results presented in Table 3.2 are the average of all realisations and will include wet and dry periods distributed throughout the mine life. Rainfall yield and evaporation for each stage is affected by the variation in climatic conditions within the adopted climate sequence.

Table 3.2 provides an indication of the long-term average annual inflows and outflows. Key outcomes from the overall water balance are as follows:

- Average annual inflows from rainfall runoff into mine affected and surface water dams increase from Stage 1 to Stage 2, as the pit progresses, and more catchment runoff is collected in mine affected water dams and sediment dams.
- The proposed water management system is in negative balance under 'average' climate conditions. This indicates that the Project will likely require significant volumes of external water to meet mine water demands in drier years.
- External water requirements are greater in Stage 1 compared to Stage 2.

Table 3.2 – Average annual water balance – all realisations

Description	Stage 1	Stage 2
Inflows (ML/year)		
Rainfall Runoff		
Mine affected water	78.1	134.6
Surface water	91.8	117.6
Diverted water	0.0	16.0
Groundwater inflow	1.6	9.6
BMA Pipeline	113.5	75.4
Trucked potable water	50.0	50.0
Total Inflows	334.9	403.2
Outflows (ML/year)		
Evaporation	13.7	32.5
Dam overflows		
Mine affected water	0.0	0.0
Surface water	49.8	78.6
Diverted water	0.0	0.0
Haul road dust suppression	216.1	216.1
Potable water demand	50.0	50.0
Total Outflows	329.7	393.2
Change in stored volume (ML/year)		
Change in stored volume	5.2	9.9

3.2.1 Jupiter pit inventory

Figure 3.1 shows the forecast inventory of the Jupiter mine pit for the 1%ile (wettest climatic conditions), 5%ile, 10%ile, 25%ile and 50%ile percentile traces. The pit is continuously dewatered into MWD1 and MWD2, as long as the mine dams are maintained below their OV. MWD1 and MWD2 have been sized to keep the pit dewatered as long as practical given sizing constraints.

The model results show the following:

- Under very wet (1%ile) conditions, the Jupiter pit will have a forecast inventory of approximately:
  - up to 40 ML during Stage 1; and
  - up to 60 ML during Stage 2.
- Under wet (10%ile conditions), the Jupiter pit will have an inventory under 1 ML during both Stages 1 and 2.

The results suggest that pit dewatering may be constrained under very wet (between 1%ile and 10%ile) conditions in Stages 1 and 2, with accumulating (on average) up to 60 ML. The addition of MWD2 in Stage 2 allows the pit to be dewatered under the majority of climate conditions for Stage 2 and is therefore expected to accumulate water under only the wettest (1%ile - 5%ile) conditions.

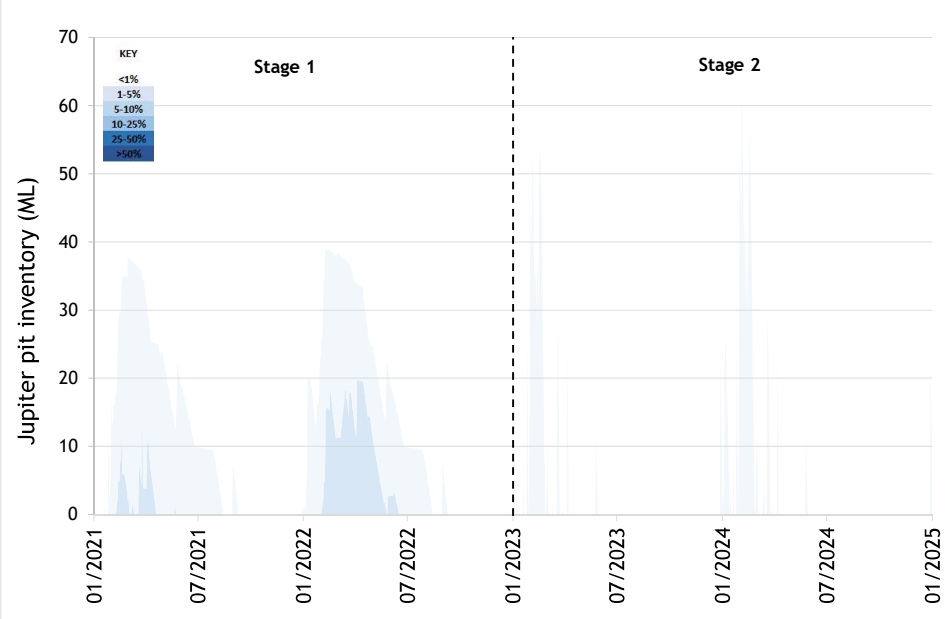


Figure 3.1 - Jupiter forecast mine pit inventory

3.2.2 Mine water dam inventories

MWD1, MWD2 and MWD3 are the mine affected water dams on site. MWD1 and MWD2 dewater the pit following rainfall events. MWD3 collects runoff from the northern mine workshop area and dewaters to MWD1 when it rises above its OV. The OVs of these dams have been designed to keep the pit as dry as possible while also limiting the requirement to transfer water back to the pit.

The mine affected water dams are not predicted to spill under any of the 125 modelled realisations.

The forecast combined maximum inventory of the mine affected dams is shown in Figure 3.2. Figure 3.2 also shows the combined OVs and FSVs of the mine affected dams.

The model results show that:

- the combined water inventories in MWD1, MWD2 and MWD3 remain below the combined FSV under all climatic conditions assessed and therefore are not predicted to spill under any modelled climate sequence;
- under 25%ile and drier conditions, the maximum mine water inventory is maintained below the combined OV for all years; and
- under 10%ile conditions, the maximum mine water inventory is above the combined OVs for Stage 1, but under the combined OV for Stage 2.

The results indicate that the mine water dams are utilised, to some extent, under the majority of conditions, but are not at risk of surpassing their FSVs, even under extremely wet (<1%ile) conditions.

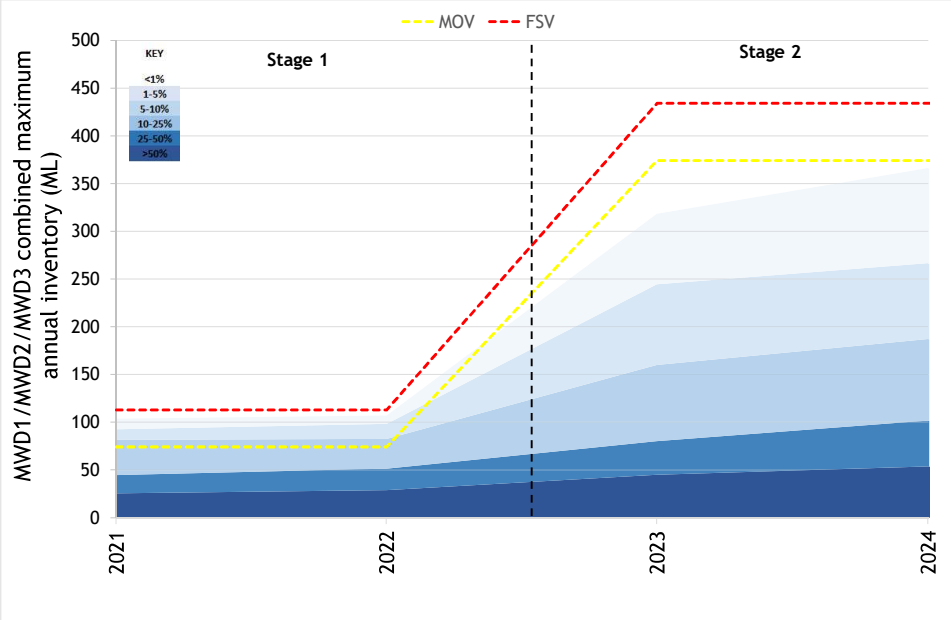


Figure 3.2 - Forecast mine affected water inventory

3.2.3 Sediment dam discharges

Consistent with the IECA guidelines (2008), the sediment dams are not designed to provide 100% containment of captured runoff. Hence overflows will occur from the sediment dams when rainfall exceeds the design capacity.

The potential for overflows from the proposed sediment dams have been modelled using a passive overflow rather than active release (to regain storage capacity within 5 days). SD6 is pumped to the existing drainage diversion at 2.7 ML/d following rainfall events.

Figure 3.3 shows the forecast annual sediment dam releases to the receiving waters (including the pumped flows from SD6) which indicate that:

- Under wet (10%ile) conditions, the annual volume of sediment dam releases to the receiving waters are approximately:
  - up to 150 ML/yr during Stage 1; and
  - up to 220 ML/yr during Stage 2.
- Under 50%ile conditions, the annual volume of sediment dam releases to the receiving waters are approximately:
  - up to 30 ML/yr during Stage 1; and
  - up to 50 ML/yr during Stage 2.

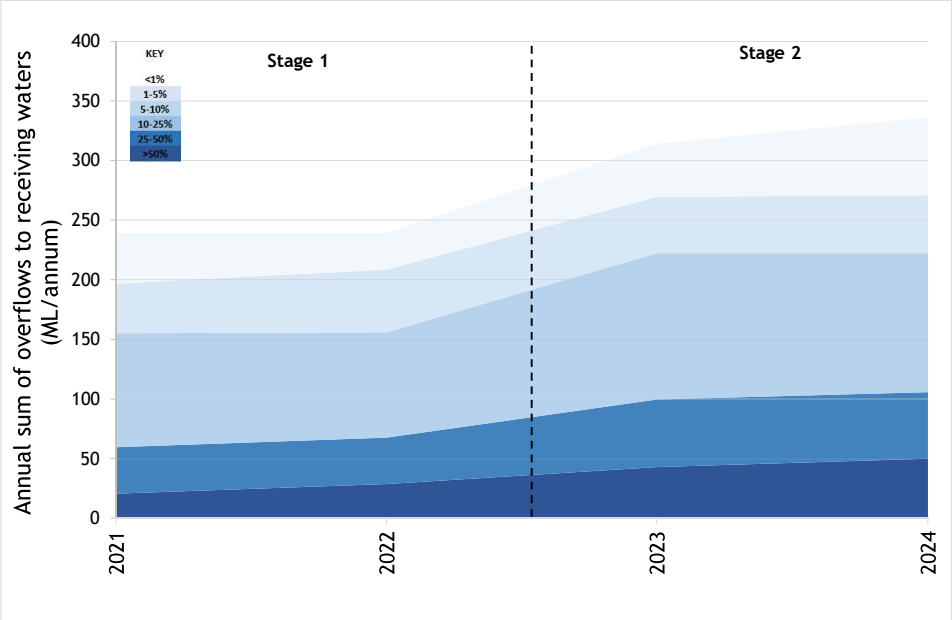


Figure 3.3 – Forecast annual sediment dam overflows to receiving waters

4 Review of available baseline surface water quality data

4.1 OVERVIEW

Vitrinite has implemented a routine baseline water quality monitoring network since February 2020 within and in the vicinity of the Project to collect baseline (reference) surface water quality along natural drainage lines. A preliminary review of the available baseline (reference) surface water quality data has been undertaken to develop interim locally derived receiving waters trigger values for the VCP Environmental Authority (EA).

The review has been undertaken using natural surface water quality measurements at the two relevant baseline (reference) monitoring sites on the following drainage lines (see Figure 4.1):

- The existing drainage diversion (VSW1); and
- Drainage Line 2 (VSW2).

This assessment was undertaken in accordance with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality guidelines (ANZG, 2018) for deriving site specific guideline value (SSGVs) for aquatic ecosystems protection from local reference data.

4.2 ASSESSMENT METHODOLOGY

To address DES's comments, interim locally derived receiving waters trigger values have been proposed for the Project using the 80th percentile of recorded reference site data in accordance with ANZG (2018). The 80th percentile values were compared against the Project Water Quality Objective (WQO) default trigger values given in Table 3.1 of WRM (2020) and the DES Model Mine Conditions (MMC) guidelines (DES, 2017). ANZG (2018) states that reference data can be used to derive SSGVs for water quality when natural background concentrations of a toxicant exceed the Project WQO default trigger value.

Note that ANZG (2018) also states that data collected over 2 years of monthly sampling (18 to 24 samples) is regarded as sufficient to indicate ecosystem variability to derive guideline values based on reference site data. It is noted that the recommended number of samples at each location have not yet been collected and therefore the proposed interim receiving water SSGVs should be reviewed once sufficient monitoring data has been collected.

4.3 AVAILABLE DATA

Vitrinite provided site water quality data collected from February 2020 to January 2021 for this review. Based on available water quality data, samples were taken at the monitoring sites during four natural flow events. One event occurred in February 2020, two events in March 2020 and one event in January 2021. Table 4.1 shows the water quality laboratory analysis parameters that are measured for each water sample.

Vitrinite monitor baseline water quality at 11 monitoring sites in the vicinity of the Project. The two relevant baseline monitoring locations for the Project are VSW1 and VSW2. The locations of Vitrinite's receiving waters baseline monitoring locations are shown in Figure 4.1.

The recorded water quality data at all 11 monitoring sites are shown in Table B.1 to Table B.4, Appendix B. The shaded values are recorded values that exceeded the WQO default trigger values given in Table 3.1 of WRM (2020) and/or the MMC guideline values. The available data indicates that a number of parameters exceeded the Project WQO default trigger values and MMC guidelines values at numerous monitoring locations for all four flow events that were monitored.

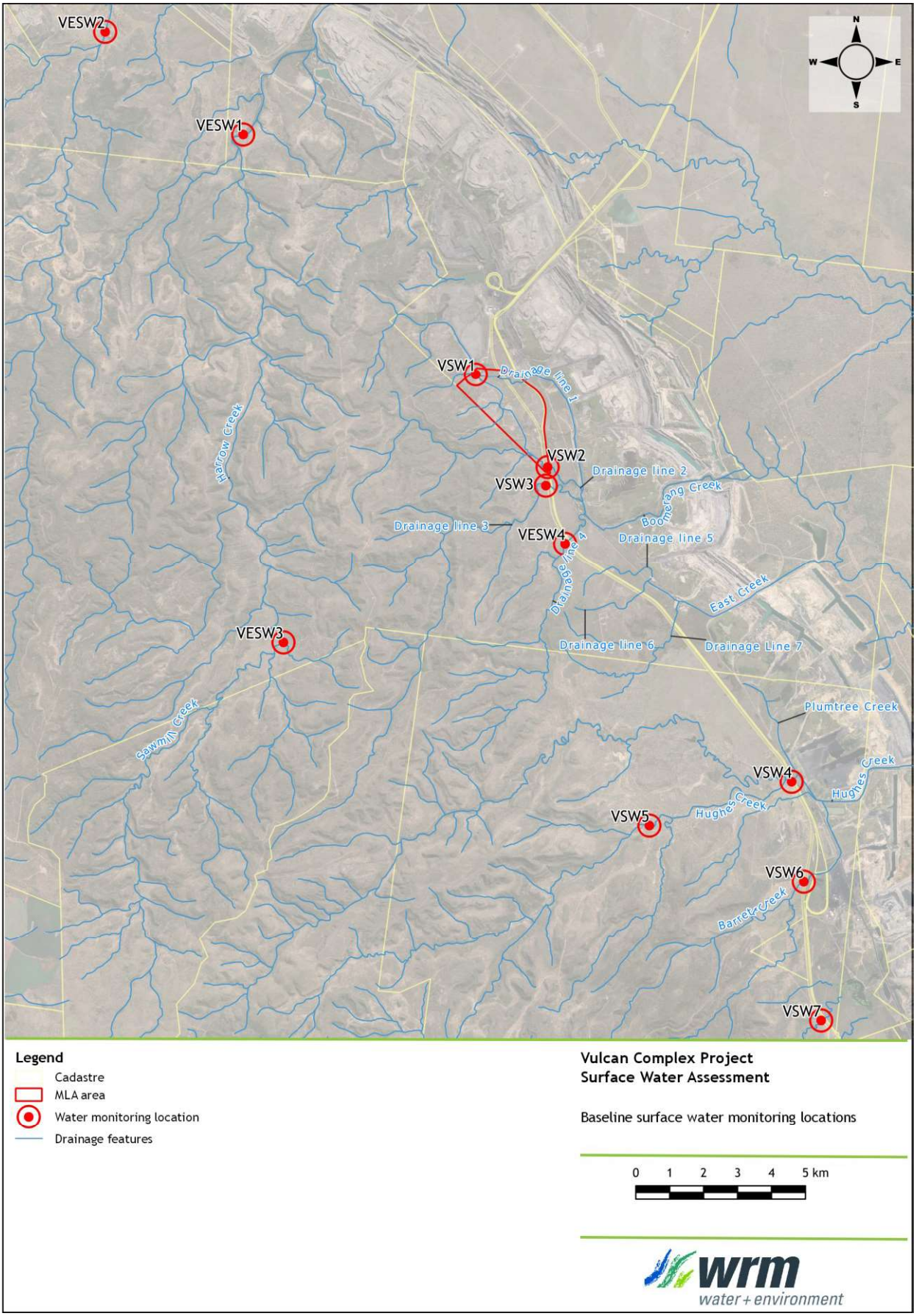


Figure 4.1 – Baseline surface water monitoring locations

Table 4.1 – Receiving waters water quality laboratory analysis parameters

	Analyte		Analyte
Physio-chemical		*Metals and metalloids (total and filtered)*	
1	Electrical conductivity	17	Aluminium
2	pH	18	Arsenic
3	Turbidity	19	Cadmium
4	Total Suspended Solids	20	Chromium
5	Dissolved Oxygen	21	Copper
Major cations and anions		22	Iron
6	Sulfate	23	Lead
7	Calcium	24	Mercury
8	Fluoride	25	Nickel
9	Chloride	26	Zinc
10	Sodium	27	Boron
Nutrients		28	Cobalt
11	Total Phosphorus	29	Manganese
12	Filterable Reactive Phosphorus	30	Molybdenum
13	Total Nitrogen	31	Selenium
14	Oxidised Nitrogen	32	Silver
15	Total Kjeldahl Nitrogen	33	Uranium
16	Ammonium	34	Vanadium
		Hydrocarbons	
		35	Total Petroleum Hydrocarbon (C6-C36)
		Biological	
		36	Chlorophyll-a

4.4 COMPARISON OF LOCAL DATA WITH THE PROJECT WQO AND MMC DEFAULT TRIGGER VALUES

Site monitoring data to date has measured 3 events at VSW1 and 4 events at VSW2. Hence, the dataset is insufficient to determine an 80th percentile value. To increase the number of samples the VSW1 and VSW2 data set was combined so that a preliminary comparison of the 80th percentile value against the ANZG (2018) and MMC (DES, 2017) guideline values could be undertaken.

Table B.6, Appendix B shows the 80th percentile values for all parameters measured for the VSW1 and VSW2 combined data set as well as the Project WQO default trigger values and MMC (DES, 2017) default trigger values. The reference site 80th percentile values that exceed the default trigger values have been shaded.

4.5 RECOMMENDED RECEIVING WATERS TRIGGER VALUES

Table 4.2 shows the recommended receiving waters trigger values for the water quality parameters requested by DES. The parameters for which the combined VSW1 and VSW2 dataset 80th percentile value exceeded the Project WQO and MMC default trigger values have been proposed as interim locally derived trigger values. The recommended receiving waters trigger values for all other parameters are based either on the Project WQO, MMC default guideline value or the Vulcan Bulk Sample Project EA value. The recommended locally derived receiving waters trigger values based on available reference data include:

- Electrical Conductivity - 1,328 µS/cm;
- Filtered Iron - 0.81 mg/L;
- Filtered Aluminium - 0.302 mg/L;
- Bicarbonate as $CaCO_3$ - 97 mg/L;
- Sodium - 208 mg/L;

- Carbonate as $CaCO_3$ - 97 mg/L;
- Calcium - 26 mg/L;
- Chloride - 262 mg/L;
- Potassium - 10 mg/L; and
- Magnesium - 30 mg/L.

The receiving water quality trigger levels proposed for the VCP EA will help reduce the risk of exceeding release trigger levels. The summary of the recommended receiving water trigger levels to be adopted for the VCP EA include:

- Initially adopt the 80th percentile values given in Table 4.2 as interim locally derived trigger values for Electrical Conductivity, Filtered Iron, Filtered Aluminium, major cations and anions. Note that further monitoring of receiving waters is required to obtain a sufficient data set to confirm these values;
- Adopt the WQO default trigger values in WRM (2020) for pH, Filtered Arsenic and total metals given in Table 4.2;
- Adopt the MMC (DES, 2017) default trigger values for Filtered Lead, Filtered Mercury, Filtered Molybdenum, Selenium and hydrocarbons given in Table 4.2; and
- Adopt the Sulfate trigger value of 770 mg/L from Table F4 of the Vulcan Bulk Sample Project EA.

4.6 RECOMMENDED INTERIM SEDIMENT DAM TRIGGER VALUES

The DES information request had requested sediment dam release water trigger values for the Project to confirm that surface water runoff is of a suitable water quality to be managed by sediment control structures in accordance with an Erosion and Sediment Control Plan.

It is recommended that the VCP EA initially adopt a value (say) 20% higher than the adopted receiving waters trigger values. It is noted that for most cases, these values would be below the maximum value recorded at VSW1 and VSW2. This would allow for some dilution with receiving waters upstream of the receiving waters monitoring location.

The adopted values can then be progressively refined as water quality testing is undertaken to better define the surface runoff characteristics from the Project. It is recommended that water samples be taken at the spillway or pipe outlet during sediment dam release events. Is also recommended that any conditioning of sediment dam water quality be related to the receiving waters water quality sample results.

If it is found that sediment dam releases consistently (say 3 times in a row) exceed the sediment dam release water trigger values at the same time that the receiving waters water trigger values are exceeded, it is recommended that an investigation into the exceedances be trigger by EA conditions. Conditions should also require the results of the investigation and associated mitigation and management measures to be reported to the administering authority.

The mitigation measures that are implemented should be undertaken with the aim of preventing these exceedances from reoccurring. This may include investigating the potential source of poorer quality water and/or dewatering runoff from the affected catchment area to the mine water system until the contamination source can be identified and remediated.

Exceedance of sediment dam triggers should not trigger the requirement for a sediment dam to be converted to a mine affected water dam.

Table 4.2 – Proposed receiving waters trigger values for the VCP EA

Parameter	Unit	Proposed receiving waters trigger values	Source
pH		<6.5 and >8.5	WQO (aquatic ecosystem)
Electrical Conductivity*	µS/cm	1,328	Locally derived
Sulfate	mg/L	770	Vulcan Bulk Sample Project EA^
Filtered Metals			
Iron*	mg/L	0.81	Locally derived
Lead	mg/L	0.004	MMC (aquatic ecosystem)
Mercury	mg/L	0.0002	MMC (aquatic ecosystem)
Arsenic	mg/L	0.024	WQO (aquatic ecosystem)
Aluminium*	mg/L	0.302	Locally derived
Molybdenum	mg/L	0.034	MMC (aquatic ecosystem)
Selenium	mg/L	0.01	MMC (aquatic ecosystem)
Total Metals			
Iron	mg/L	10	WQO (irrigation)
Lead	mg/L	0.1	WQO (stock)
Mercury	mg/L	0.002	WQO (aquatic ecosystem)
Arsenic	mg/L	0.5	WQO (stock)
Aluminium	mg/L	5.0	WQO (stock)
Molybdenum	mg/L	0.05	WQO (irrigation)
Selenium	mg/L	0.02	WQO (stock)
Hydrocarbons			
C6 - C10 Fraction	mg/L	20	MMC (aquatic ecosystem)
C10 - C40 Fraction	mg/L	100	MMC (aquatic ecosystem)
Major Cations and Anions			
Bicarbonate as $CaCO_3$*	mg/L	97	Locally derived
Sodium*	mg/L	208	Locally derived
Carbonate as $CaC0_3$*	mg/L	97	Locally derived
Calcium*	mg/L	26	Locally derived
Chloride*	mg/L	262	Locally derived
Potassium*	mg/L	10	Locally derived
Magnesium*	mg/L	30	Locally derived

* Interim locally derived trigger value based on limited data set
^ From Table F4 of the Vulcan Bulk Sample Project EA based on 95% species protection from Dunlop et al. (2016).
Notes:
Vulcan Bulk Sample EA: EA0002054 granted 30 October 2020
MMC: Model Mine Conditions ESR/2016/1936 (DES, 2017)
WQO: Relevant Water Quality Objective from Table 3.1 of WRM (2020)
Locally Derived: Interim value based on the 80th percentile of combined VSW1 and VSW2 data set

5 References

ANZG, 2018	*'Australian and New Zealand Guidelines for Fresh and Marine Water Quality'*, New Zealand Governments and Australian state and territory governments (ANZG), Canberra ACT, Australia, 2018.
DES, 2017	*'Mining Guideline: Model mining conditions'*. ESR/2016/1936. Effective 07 March 2017.
Dunlop et al., 2016	'*Toxicity guideline values for sulfate in hard waters. Australasian Bulletin of Ecotoxicology & Environmental Chemistry*', Vol. 3, 2016, pp. 1-10.
IECA (2008)	International Erosion Control Association (Australasia), November 2008. *'Best Practice Erosion and Sediment Control'*.
METServe, 2021	*'Notice of Change to an Environmental Authority Application'*, Vulcan Complex Project, *Prepared by METServe* for Vitrinite Pty Ltd, March 2021.
WRM, 2020	*'Vulcan Complex project Surface water assessment'*, Prepared by WRM Water & Environment Pty Ltd for Vitrinite Pty Ltd, 17 September 2020.

Appendix A - WRM responses to DES information request

Table A.1 - WRM responses to DES information request relating to Surface Water Management

Section	Comment	Requirement	Suggested response
Section 2.3 Surface Water Management	The change application proposed an increase in the size of MWD5, re-alignment of MDW1 and re-location of MWD4. Further information is required on the management of the mine water dams and the management of potential uncontrolled releases.	Further clarification is required on the management of the mine water dams. Provide justification on the ability of MDW5 and MWD1 to contain mine affected water in high rainfall events; and ensure contingency planning is included if all MAW cannot be reused on-site i.e. during long periods of wet weather when use for dust suppression is not appropriate.	The mine water management is described in Section 2.3 of this report including the management of MWD1, MWD2 and MWD3. The water balance model has been updated to include the mine affected water dams. Updated water balance model results indicate that the proposed mine water storage system has a low risk of the mine affected water system reaching capacity. The updated results indicate the mine affected water dams will reach capacity and cause short periods of inundation of the pit under only the wettest (5%ile) conditions.
Section 3.1 Surface Water	The change application proposes five (5) additional water storage dams that have been categorised as sediment dams. The department requires further clarification on the management of sediment dams.	Review the site water balance model relating specifically to site discharge and MAW. Provide the below as a minimum: • An updated Site Water Balance Model. Clarification on which areas are reporting to which dams—this is to confirm those classified as sediment dams and those classified MAW dams. • Detail how clean water is diverted around site. • Clarify if the water management is reliant on geography of land to manage the direction of water runoff or other management practices. • Provide further details and justification on how the waste rock dump run off water can be classified as 'surface water runoff'. If no evidence is available for this classification, then including the waste rock dump area within the MAW footprint area is recommended.	The site water balance model has been updated to reflect the revised water management system and the updated results are presented in Section 3 of this report. Details regarding which areas report to which dams are described in Section 2 of this report. Further detail is also provided in this section regarding clean water, surface water and mine affected water management. The areas which have been classified as 'surface water' and 'mine water' are also described as per the definitions provided in DES (2017). Water management at the Project is reliant on geography, as well as constructed surface water, diverted water and mine water drains as shown in Figure 2.1, Figure 2.2 and Figure 2.3 of this report. The waste rock dump has been classified as 'surface water runoff' as it will be managed by sediment control structures in accordance with an Erosion and Sediment Control Plan and will not be mixed with tailings, pit or processing water. This is consistent with the definitions provided by DES (2017).
	Limited discussion has been provided on changes proposed to clean water storage and diversions on site.	Provide details of DD1 with the new design and how DD1 will not collect runoff from mine affected activities. Clarify the movement and storage of undisturbed water onsite and how this associates with DD1.	The function of DD1 has been described in Section 2.4 of this report. DD1 collects runoff from peripheral areas of the Project such as areas that are undisturbed by mining and surface water catchments that are first managed through erosion and sediment control measures. DD1 will also prevent diverted water from entering the pit in the event that flood waters overtop the existing drainage diversion. DD1 will be dewatered to the existing drainage diversion.
Figure 2-1	The sediment dam numbering jumps from SD4 to SD6.	Confirm whether there is an SD5.	Sediment dam numbering is shown in Figure 2.1, Figure 2.2 and Figure 2.3.
	MWD4 points to an area not mapped.	Confirm location of MWD4 and include in figure 2-1 of the supporting documentation.	MWD4 has been removed due to the updated mine plan. Runoff from the workshop area in the northern infrastructure area is managed by MWD3. Runoff from the office area to the southeast of the workshop will pass through a sediment trap.
Surface water	It is acknowledged that the proposed project has no authorised release of MAW, however the application is proposing to release water from onsite sediment dams through water	Review and provide interim release (runoff) limits and receiving water trigger limits included in the following table for water releases from sediment dams.	Section 4 of this report presents a review of the available reference receiving waters data used to develop interim locally derived receiving waters trigger limits. The proposed receiving waters trigger limits are based on locally derived values, as well as WQOs default trigger values from ANZG

runoff. It was also proposed in the original application that all MAW and sediment dams are proposed to be monitored. The information provided provides minimal justification that water from sediment dams will not be mine affected water. As such, the department would advise the inclusion of conditions to monitoring water quality of sediment dams. It was interpreted that if sediment dam water quality were to exceed certain limits of parameters, then the dam would be classified as a mine affected water dam. Interim values are required for surface water trigger and limits - due to limited data to establish site specific data - in order to ensure that the quality of water runoff during high rainfall events will not cause impacts to environmental values in the receiving waterways.		(2018) and MMC (DES, 2017) default trigger values. These trigger values are provided in Table 4.2 of this report. Note that due to the limited availability of water quality data, further monitoring of receiving waters is required to obtain a sufficient data set to confirm the interim locally derived trigger values. Recommended measures to manage sediment dam release water quality and sediment dam trigger limits are discussed in Section 4.6 of this report.
Upstream and downstream monitoring locations have not been provided for conditioning in the EA.	Provide the following details: - Differentiate which monitoring sites will be monitoring upstream and which will be utilised for downstream monitoring - monitoring locations (lat/long) in the following table to be conditioned in the environmental authority:	Proposed upstream and downstream receiving waters monitoring locations have been listed in Table 2.5 and Figure 2.4 of this report.
Surface water runoff locations have not been updated to reflect the proposed changes to the water management onsite.	Provide location points and other values in the table below to be conditioned in the EA:	Sediment dam locations have been tabulated in Table 2.3 of this report.

Appendix B - Baseline Water Quality Monitoring Data

Table B.1 - Recorded water quality at VCP baseline monitoring locations during the February 2020 event

Parameter	Unit	VSW-1 10/02/20	VSW-2 9/02/20	VSW-3 9/02/20	VSW-4 9/02/20	VSW-5 9/02/20	VSW-6 9/02/20	VSW-7 10/02/20	VESW-2 10/02/20	VESW-4 9/02/20	WQO (see Table 3.1 of WRM [2020])	MMC (see Table F3 of MMC)
Physico-chemical parameters												
pH Value	-	7.42	6.74	6.54	6.82	7.46	6.9	7.24	8.01	6.64	6.5 - 8.5	
Sodium Adsorption Ratio	-	6.64	2.92	1.69	1.3	0.7	1.29	0.73	0.67	1.47	-	
Electrical Conductivity	µS/cm	1400	310	184	73	136	152	113	354	150	> 720 (baseflow) > 250 (high flow)	
Total Dissolved Solids (Calc.)	mg/L	910	202	120	47	88	99	73	230	98	> 2,000	
Suspended Solids (SS)	mg/L	10	55	20	637	57	93	572	54	49	> 55	
Turbidity	NTU	42.9	221	90.8	2660	650	748	1520	49.1	244	> 50	
Dissolved Oxygen	mg/L	6.7	7.3	7.3	6.2	6.7	7.4	5.5	6.8	7.2	< 4	
Dissolved Metals												
Aluminium	mg/L	0.11	0.45	0.39	2.22	0.72	1.25	1.1	0.02	0.51	> 0.055	>0.055
Arsenic	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	> 0.024	> 0.013
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.0002	> 0.0002
Chromium	mg/L	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.001	> 0.001
Cobalt	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	> 0.090
Copper	mg/L	0.003	0.001	0.002	0.003	0.002	0.002	0.002	<0.001	0.001	> 0.0014	> 0.002
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.0034	> 0.004
Manganese	mg/L	0.039	0.019	0.015	0.01	0.006	0.005	0.028	0.048	0.005	> 1.9	> 1.9
Molybdenum	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	> 0.034
Nickel	mg/L	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.003	0.003	> 0.011	>0.010
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.005	>0.001
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	> 0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.1	>0.001
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.5	> 0.010
Zinc	mg/L	0.024	<0.005	0.024	0.008	0.007	<0.005	0.006	0.012	0.013	> 0.008	> 0.008
Boron	mg/L	0.09	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	> 0.37	> 0.37
Iron	mg/L	0.2	0.35	0.35	0.84	0.58	0.68	0.55	<0.05	0.37	-	> 0.3
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.00006	> 0.0002
Total Metals												
Aluminium	mg/L	0.89	3.38	1.56	32.4	12.1	13.7	23.8	1.58	4.46	> 5	
Arsenic	mg/L	0.001	0.002	0.001	0.003	0.002	0.003	0.002	0.002	0.001	> 0.5	
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.01	
Chromium	mg/L	<0.001	0.002	0.001	0.028	0.01	0.01	0.026	0.002	0.003	> 1	
Cobalt	mg/L	<0.001	0.001	<0.001	0.016	0.004	0.005	0.012	0.001	0.002	> 0.1	
Copper	mg/L	0.004	0.004	0.002	0.029	0.01	0.01	0.017	0.002	0.004	> 1	
Lead	mg/L	<0.001	0.004	0.002	0.041	0.014	0.014	0.024	0.001	0.005	> 0.1	
Manganese	mg/L	0.042	0.034	0.024	0.3	0.081	0.058	0.209	0.085	0.024	> 10	
Molybdenum	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.05	
Nickel	mg/L	0.002	0.004	0.003	0.029	0.011	0.011	0.02	0.005	0.004	> 1	
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.02	

Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	
Uranium	mg/L	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	0.001	<0.001	<0.001	-	
Vanadium	mg/L	<0.01	<0.01	<0.01	0.03	0.02	0.02	0.03	<0.01	<0.01	-	
Zinc	mg/L	0.031	0.017	0.029	0.078	0.035	0.031	0.088	0.033	0.039	> 5	
Boron	mg/L	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	> 5	
Iron	mg/L	0.79	3.26	1.62	31.5	13.6	13.7	21	1.41	4.71	> 10	
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	> 0.002	
Major cations and anions												
Total Hardness as CaCO3	mg/L	191	37	26	9	38	29	29	136	22	> 150	> 150
Hydroxide Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	
Carbonate Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	
Bicarbonate Alkalinity as CaCO3	mg/L	63	12	4	16	33	10	34	130	8	-	
Total Alkalinity as CaCO3	mg/L	63	12	4	16	33	10	34	130	8	-	
Sulfate as SO4 - Turbidimetric	mg/L	212	40	19	5	8	18	3	5	10	> 25	
Chloride	mg/L	275	54	34	10	13	24	13	25	27	-	
Calcium	mg/L	27	5	4	2	7	5	5	38	4	-	
Magnesium	mg/L	30	6	4	1	5	4	4	10	3	-	
Sodium	mg/L	211	41	20	9	10	16	9	18	16	> 30	
Potassium	mg/L	8	7	7	4	6	7	3	7	7	-	
Fluoride	mg/L	<1.0	0.1	<0.1	0.1	0.2	0.1	0.2	0.2	0.1	> 2	> 2
Total Anions	meq/L	13.4	2.6	1.43	0.7	1.19	1.25	1.11	3.41	1.13	-	
Total Cations	meq/L	13.2	2.7	1.58	0.68	1.35	1.45	1.05	3.68	1.32	-	
Ionic Balance	%	0.87	----	----	----	----	----	----	3.87	----	-	
Nutrients												
Ammonia as N	mg/L	0.05	0.1	<0.01	0.02	<0.01	0.03	0.08	0.01	0.04	> 0.02	> 0.74
Nitrite as N	mg/L	0.03	0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	-	
Nitrate as N	mg/L	1.7	1.57	1.19	0.22	0.7	1.09	0.26	<0.01	2.29	-	> 0.248
Nitrite + Nitrate as N	mg/L	1.73	1.58	1.19	0.23	0.7	1.09	0.26	<0.01	2.29	-	
Total Kjeldahl Nitrogen as N	mg/L	1.6	1.3	0.9	3.2	0.6	1.8	2.1	0.6	1.3	-	
Total Nitrogen as N	mg/L	3.3	2.9	2.1	3.4	1.3	2.9	2.4	0.6	3.6	> 0.5	
Total Phosphorus as P	mg/L	0.04	0.09	0.05	0.52	0.07	0.25	0.25	0.05	0.07	> 0.05	
Reactive Phosphorus as P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.02	
Hydrocarbons												
C6 - C10 Fraction	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	-	
C10 - C40 Fraction	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	-	
Biological												
Chlorophyll a	mg/m³	<4	<4	<4	<20	<4	<4	<17	4	<4	-	

Note: Recorded exceedances of the WQOs or MMC trigger values have been shaded in grey.

Table B.2 – Recorded water quality at VCP baseline monitoring locations during the 5 March 2020 event

Parameter	Unit	VSW-2 5/03/20	VSW-3 5/03/20	VSW-4 4/03/20	VSW-6 4/03/20	VSW-7 4/03/20	VESW-1 5/03/20	VESW-2 5/03/20	WQO (see Table 3.1 of WRM [2020])	MMC (see Table F3 of MMC)
Physico-chemical parameters										
pH Value	-	7.38	6.92	7.16	7.12	7.57	7.79	8.41	6.5 - 8.5	
Sodium Adsorption Ratio	-	3.86	0.55	0.61	0.26	0.34	0.82	0.93	-	
Electrical Conductivity	µS/cm	442	66	81	46	106	219	395	> 720 (baseflow) > 250 (high flow)	
Total Dissolved Solids (Calc.)	mg/L	287	43	53	30	69	142	257	> 2,000	
Suspended Solids (SS)	mg/L	100	293	296	379	1200	62	33	> 55	
Turbidity	NTU	116	751	1590	503	1240	320	41	> 50	
Dissolved Oxygen	mg/L	7	6.8	6.4	6.8	7.6	6.7	7.5	< 4	
Dissolved Metals										
Aluminium	mg/L	<0.01	0.28	0.26	0.2	0.07	<0.01	<0.01	> 0.055	>0.055
Arsenic	mg/L	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	> 0.024	> 0.013
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.0002	>0.0002
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.001	> 0.001
Cobalt	mg/L	0.002	0.004	0.001	<0.001	<0.001	<0.001	<0.001	-	> 0.090
Copper	mg/L	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	> 0.0014	> 0.002
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.0034	> 0.004
Manganese	mg/L	0.141	0.278	0.125	0.04	0.066	0.089	0.102	> 1.9	> 1.9
Molybdenum	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	> 0.034
Nickel	mg/L	0.003	0.003	0.001	<0.001	0.001	0.002	0.002	> 0.011	>0.010
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.005	>0.001
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	> 0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.1	>0.001
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.5	> 0.010
Zinc	mg/L	<0.005	0.014	<0.005	<0.005	<0.005	<0.005	<0.005	> 0.008	> 0.008
Boron	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	> 0.37	> 0.37
Iron	mg/L	<0.05	0.38	0.18	0.13	0.15	<0.05	<0.05	-	> 0.3
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.00006	> 0.0002
Total Metals										
Aluminium	mg/L	1.71	12.8	22.8	6.62	21.8	5.42	0.72	> 5	
Arsenic	mg/L	0.001	0.003	0.005	0.003	0.003	0.002	0.001	> 0.5	
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.01	
Chromium	mg/L	0.001	0.008	0.02	0.006	0.026	0.004	<0.001	> 1	
Cobalt	mg/L	0.003	0.013	0.014	0.003	0.013	0.003	0.001	> 0.1	
Copper	mg/L	0.004	0.014	0.023	0.008	0.016	0.004	<0.001	> 1	
Lead	mg/L	0.003	0.016	0.032	0.009	0.022	0.007	<0.001	> 0.1	
Manganese	mg/L	0.195	0.586	0.477	0.112	0.334	0.174	0.156	> 10	
Molybdenum	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.05	
Nickel	mg/L	0.006	0.016	0.028	0.006	0.022	0.008	0.004	> 1	
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.02	

Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	
Uranium	mg/L	<0.001	0.001	0.001	<0.001	0.001	<0.001	<0.001	-	
Vanadium	mg/L	<0.01	0.01	0.03	<0.01	0.03	<0.01	<0.01	-	
Zinc	mg/L	0.014	0.1	0.058	0.022	0.037	0.018	<0.005	> 5	
Boron	mg/L	0.05	0.38	<0.05	<0.05	<0.05	<0.05	0.06	> 5	
Iron	mg/L	2.35	11.7	27.7	8.42	25.7	7.15	0.83	> 10	
Mercury	mg/L	<0.0001	<0.0001	<0.0005	<0.0001	<0.0001	<0.0001	<0.0001	> 0.002	
Major cations and anions										
Total Hardness as CaCO3	mg/L	50	16	18	12	40	64	125	> 150	> 150
Hydroxide Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	-	
Carbonate Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	8.00	-	
Bicarbonate Alkalinity as CaCO3	mg/L	27	9	33	6	49	62	120	-	
Total Alkalinity as CaCO3	mg/L	27	9	33	6	49	62	129	-	
Sulfate as SO4 - Turbidimetric	mg/L	58	2	4	2	<1	7	13	> 25	
Chloride	mg/L	80	10	6	3	6	25	40	-	
Calcium	mg/L	7	3	4	3	8	14	32	-	
Magnesium	mg/L	8	2	2	1	5	7	11	-	
Sodium	mg/L	63	5	6	2	5	15	24	> 30	
Potassium	mg/L	7	4	3	3	2	6	6	-	
Fluoride	mg/L	0.1	<0.1	0.2	<0.1	0.2	0.1	0.2	> 2	> 2
Total Anions	meq/L	4	0.5	0.91	0.25	1.15	2.09	3.98	-	
Total Cations	meq/L	3.93	0.63	0.7	0.4	1.08	2.08	3.7	-	
Ionic Balance	%	0.97	-	-	-	-	-	3.61	-	
Nutrients										
Ammonia as N	mg/L	0.1	0.99	0.11	0.07	0.11	0.1	0.02	> 0.02	> 0.74
Nitrite as N	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	0.03	<0.01	-	
Nitrate as N	mg/L	0.08	<0.01	0.02	0.02	0.04	0.14	<0.01	-	> 0.248
Nitrite + Nitrate as N	mg/L	0.09	<0.01	0.02	0.02	0.04	0.17	<0.01	-	
Total Kjeldahl Nitrogen as N	mg/L	2.7	1	1.8	0.8	0.6	0.7	0.9	-	
Total Nitrogen as N	mg/L	2.8	1	1.8	0.8	0.6	0.9	0.9	> 0.5	
Total Phosphorus as P	mg/L	0.18	0.2	0.43	0.19	0.18	0.17	0.21	> 0.05	
Reactive Phosphorus as P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.02	
Hydrocarbons										
C6 - C10 Fraction	µg/L	<20	<20	<20	<20	<20	<20	<20	-	
C10 - C40 Fraction	µg/L	<100	<100	<100	110	<100	<100	<100	-	
Biological										
Chlorophyll a	mg/m³	<2	-	<12	<4	<10	4	<2	-	

Note: Recorded exceedances of the WQOs or MMC trigger values have been shaded in grey.

Table B.3 – Recorded water quality at VCP baseline monitoring locations during the 18-19 March 2020 event

Parameter	Unit	VSW-5 18/03/20	VSW-1 19/03/20	VSW-2 19/03/20	VSW-3 19/03/20	VSW-4 19/03/20	VSW-6 19/03/20	VSW-7 19/03/20	VESW-1 19/03/20	VESW-2 19/03/20	VESW-3 19/03/20	VESW-4 19/03/20	WQO (see Table 3.1 of WRM [2020])	MMC (see Table F3 of MMC)
Physico-chemical parameters														
pH Value	-	6.78	7.53	7.04	6.57	7.11	6.89	7.57	7.89	7.74	7.00	7.13	6.5 - 8.5	
Sodium Adsorption Ratio	-	0.68	9.17	1.86	1.10	0.37	0.77	0.42	0.87	0.58	0.37	0.51	-	
Electrical Conductivity	µS/cm	44	2440	346	104	74	80	124	306	280	70	129	> 720 (baseflow) > 250 (high flow)	
Total Dissolved Solids (Calc.)	mg/L	29	1590	225	68	48	52	81	199	182	46	84	> 2,000	
Suspended Solids (SS)	mg/L	77	168	10	92	2050	386	51	<5	33	155	168	> 55	
Turbidity	NTU	339	221	37	209	850	701	346	9	143	324	419	> 50	
Dissolved Oxygen	mg/L	7.5	6.2	6.8	5.6	7.1	5.9	6.7	7.3	5.5	6.3	4.9	< 4	
Dissolved Metals														
Aluminium	mg/L	1.11	0.01	<0.01	0.07	0.35	0.22	0.02	<0.01	<0.01	0.09	0.09	> 0.055	>0.055
Arsenic	mg/L	<0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	0.001	0.002	0.004	> 0.024	> 0.013
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.0002	> 0.0002
Chromium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.001	> 0.001
Cobalt	mg/L	<0.001	0.004	0.002	<0.001	0.001	<0.001	<0.001	<0.001	0.001	0.005	0.006	-	> 0.090
Copper	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	> 0.0014	> 0.002
Lead	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.0034	> 0.004
Manganese	mg/L	0.011	0.443	0.201	0.028	0.192	0.026	0.002	0.012	0.362	0.309	0.295	> 1.9	> 1.9
Molybdenum	mg/L	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	> 0.034
Nickel	mg/L	<0.001	0.003	0.003	0.002	0.002	0.001	0.001	0.003	0.002	0.003	0.003	> 0.011	>0.010
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.005	>0.001
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	> 0.001
Uranium	mg/L	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.1	>0.001
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.5	> 0.010
Zinc	mg/L	<0.005	0.006	0.006	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	> 0.008	> 0.008
Boron	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	> 0.37	> 0.37
Iron	mg/L	0.63	1.83	<0.05	0.24	0.33	0.21	0.11	<0.05	<0.05	1.6	3.02	-	> 0.3
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.00006	> 0.0002
Total Metals														
Aluminium	mg/L	7.97	3.61	0.94	3.76	16.5	10.3	9.22	0.38	3.94	6.56	6.36	> 5	
Arsenic	mg/L	0.002	0.002	0.001	0.003	0.005	0.005	0.002	<0.001	0.002	0.003	0.005	> 0.5	
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.01	
Chromium	mg/L	0.005	0.003	<0.001	0.002	0.017	0.008	0.011	<0.001	0.004	0.006	0.004	> 1	
Cobalt	mg/L	0.003	0.006	0.003	0.003	0.018	0.005	0.004	<0.001	0.003	0.008	0.01	> 0.1	
Copper	mg/L	0.006	0.003	0.002	0.003	0.02	0.009	0.005	0.001	0.003	0.006	0.012	> 1	
Lead	mg/L	0.007	0.005	<0.001	0.004	0.028	0.011	0.006	<0.001	0.003	0.007	0.01	> 0.1	
Manganese	mg/L	0.077	0.431	0.214	0.106	0.804	0.13	0.108	0.046	0.444	0.389	0.383	> 10	

Molybdenum	mg/L	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.05	
Nickel	mg/L	0.006	0.005	0.004	0.004	0.025	0.012	0.008	0.003	0.007	0.009	0.009	> 1	
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.02	
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	
Uranium	mg/L	<0.001	0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	0.02	0.01	0.01	<0.01	<0.01	<0.01	<0.01	-	
Zinc	mg/L	0.024	0.021	0.015	0.018	0.059	0.031	0.022	<0.005	0.01	0.019	0.031	> 5	
Boron	mg/L	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	> 5	
Iron	mg/L	7.88	5.57	1.62	6.96	21.8	12.9	7.86	0.66	4.26	8.88	12.5	> 10	
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.002	
Major cations and anions														
Total Hardness as CaCO3	mg/L	7	362	78	16	22	16	51	99	108	22	18	> 150	> 150
Hydroxide Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	
Carbonate Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	
Bicarbonate Alkalinity as CaCO3	mg/L	11	174	70	15	26	21	65	94	103	29	45	-	
Total Alkalinity as CaCO3	mg/L	11	174	70	15	26	21	65	94	103	29	45	-	
Sulfate as SO4 - Turbidimetric	mg/L	2	340	33	6	6	4	1	11	6	3	2	> 25	
Chloride	mg/L	5	528	40	17	5	9	6	30	19	6	7	-	
Calcium	mg/L	1	46	10	3	4	3	9	20	27	4	4	-	
Magnesium	mg/L	1	60	13	2	3	2	7	12	10	3	2	-	
Sodium	mg/L	4	401	38	10	4	7	7	20	14	4	5	> 30	
Potassium	mg/L	3	11	7	5	4	4	2	8	6	4	5	-	
Fluoride	mg/L	<0.1	0.2	<0.1	<0.1	0.1	0.1	0.2	0.1	0.2	<0.1	0.1	> 2	> 2
Total Anions	meq/L	0.4	25.4	3.21	0.9	0.78	0.76	1.49	2.95	2.72	0.81	1.14	-	
Total Cations	meq/L	0.38	25	3.4	0.88	0.72	0.72	1.38	3.06	2.92	0.72	1.33	-	
Ionic Balance	%	-	0.98	2.82	-	-	-	-	-	-	-	-	-	
Nutrients														
Ammonia as N	mg/L	0.1	0.17	0.13	0.21	0.09	0.21	0.12	0.16	0.55	0.22	6.95	> 0.02	> 0.74
Nitrite as N	mg/L	<0.01	0.02	<0.01	<0.01	<0.01	0.01	0.04	<0.01	0.62	<0.01	0.21	-	
Nitrate as N	mg/L	0.14	0.07	0.05	<0.01	<0.01	0.08	0.03	<0.01	0.16	<0.01	0.1	-	> 0.248
Nitrite + Nitrate as N	mg/L	0.14	0.09	0.05	<0.01	<0.01	0.09	0.07	<0.01	0.78	<0.01	0.31	-	
Total Kjeldahl Nitrogen as N	mg/L	1.3	2.1	0.7	0.9	2.6	2	1.1	0.7	1.3	1.2	9.9	-	
Total Nitrogen as N	mg/L	1.4	2.2	0.8	0.9	2.6	2.1	1.2	0.7	2.1	1.2	10.2	> 0.5	
Total Phosphorus as P	mg/L	0.12	0.09	0.02	0.08	0.58	0.37	0.1	0.02	0.09	0.12	0.41	> 0.05	
Reactive Phosphorus as P	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.02	
Hydrocarbons														
C6 - C10 Fraction	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	-	
C10 - C40 Fraction	µg/L	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	<100	-	
Biological														
Chlorophyll a	mg/m³	-	<3	<1	<4	-	<8	<3	2	<2	<4	-	-	

Note: Recorded exceedances of the WQOs or MMC trigger values have been shaded in grey.

Table B.4 – Recorded water quality at VCM baseline monitoring locations during the January 2021 event

Parameter	Unit	VSW-1 20/01/21	VSW-2 20/01/21	VSW-3 20/01/21	VSW-4 19/01/21	VSW-6 19/01/21	VSW-7 20/01/21	VESW-1 21/01/21	VESW-2 21/01/21	VESW-4 20/01/21	VESW-1 22/02/20	VESW-3 22/02/20	WQO (see Table 3.1 of WRM [2020])	MMC (see Table F3 of MMC)
Physico-chemical parameters														
pH Value	-	7.97	7.38	7.33	6.88	6.6	7.58	7.79	8.1	6.65	7.17	6.79	6.5 - 8.5	
Sodium Adsorption Ratio	-	6.46	2.88	0.77	0.78	0.84	0.54	4.74	2.02	0.72	0.88	0.64	-	
Electrical Conductivity	µS/cm	1040	306	114	116	65	117	1590	482	48	218	90	> 720 (baseflow) > 250 (high flow)	
Total Dissolved Solids (Calc.)	mg/L	676	199	74	75	42	76	1030	313	31	142	58	> 2,000	
Suspended Solids (SS)	mg/L	10	19	92	3040	262	220	14	40	236	63	76	> 55	
Turbidity	NTU	62.8	131	160	6340	508	499	19.4	39.7	441	738	352	> 50	
Dissolved Oxygen	mg/L	7.7	7.6	6.2	2.8	5.6	7.4	8	8.4	7	5.4	3.8	< 4	
Dissolved Metals														
Aluminium	mg/L	0.35	0.06	0.36	0.12	0.94	0.17	0.02	0.04	1.38	<0.01	0.14	> 0.055	>0.055
Arsenic	mg/L	0.002	0.001	0.006	0.005	0.002	<0.001	0.001	<0.001	<0.001	0.001	0.001	> 0.024	> 0.013
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.0002	> 0.0002
Chromium	mg/L	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.001	> 0.001
Cobalt	mg/L	<0.001	0.002	0.005	0.008	0.001	<0.001	0.008	<0.001	0.002	0.002	0.003	-	> 0.090
Copper	mg/L	0.002	0.002	0.003	<0.001	0.004	0.001	<0.001	0.001	0.002	<0.001	0.004	> 0.0014	> 0.002
Lead	mg/L	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.0034	> 0.004
Manganese	mg/L	0.052	0.124	0.247	0.717	0.046	0.025	1.36	0.013	0.07	0.272	0.197	> 1.9	> 1.9
Molybdenum	mg/L	0.002	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	-	> 0.034
Nickel	mg/L	0.002	0.005	0.007	0.005	0.004	0.002	0.009	0.002	0.003	0.003	0.004	> 0.011	>0.010
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.005	>0.001
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	> 0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.1	>0.001
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.5	> 0.010
Zinc	mg/L	<0.005	0.009	0.006	<0.005	0.006	<0.005	0.006	<0.005	0.006	<0.005	0.007	> 0.008	> 0.008
Boron	mg/L	0.08	0.06	<0.05	0.06	<0.05	<0.05	0.12	0.11	<0.05	<0.05	<0.05	> 0.37	> 0.37
Iron	mg/L	0.86	0.61	3.05	1.69	0.64	0.43	0.16	0.06	0.86	<0.05	0.22	-	> 0.3
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.00006	> 0.0002
Total Metals														
Aluminium	mg/L	1.29	2.54	2.76	26.3	8.37	11.8	0.3	1.11	6.85	9.27	7.21	> 5	
Arsenic	mg/L	0.002	0.002	0.006	0.009	0.003	0.002	0.001	0.001	0.002	0.003	0.003	> 0.5	
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.01	
Chromium	mg/L	0.002	0.002	0.003	0.022	0.007	0.011	0.001	0.002	0.005	0.008	0.007	> 1	
Cobalt	mg/L	0.001	0.003	0.007	0.038	0.005	0.005	0.007	0.001	0.005	0.006	0.006	> 0.1	
Copper	mg/L	0.003	0.004	0.01	0.055	0.012	0.008	<0.001	0.002	0.008	0.007	0.018	> 1	
Lead	mg/L	0.002	0.004	0.005	0.072	0.01	0.011	<0.001	0.001	0.011	0.015	0.008	> 0.1	
Manganese	mg/L	0.065	0.129	0.278	1.58	0.138	0.136	1.18	0.052	0.15	0.464	0.284	> 10	

Molybdenum	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.05	
Nickel	mg/L	0.002	0.006	0.01	0.036	0.011	0.01	0.008	0.004	0.009	0.013	0.01	> 1	
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.02	
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	
Uranium	mg/L	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	
Vanadium	mg/L	<0.01	<0.01	<0.01	0.04	<0.01	0.01	<0.01	<0.01	<0.01	0.01	<0.01	-	
Zinc	mg/L	0.006	0.014	0.022	0.082	0.03	0.03	0.007	0.008	0.028	0.026	0.032	> 5	
Boron	mg/L	0.07	0.06	<0.05	0.07	<0.05	<0.05	0.1	0.1	<0.05	<0.05	<0.05	> 5	
Iron	mg/L	2.19	4.42	7.23	40.5	9.6	11.1	2.33	1.34	7.51	13.4	8.99	> 10	
Mercury	mg/L	<0.0001	<0.0001	0.0001	0.0001	0.0002	0.0002	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	> 0.002	
Major cations and anions														
Total Hardness as CaCO3	mg/L	174	57	16	38	13	53	437	141	9	63	22	> 150	> 150
Hydroxide Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	
Carbonate Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	
Bicarbonate Alkalinity as CaCO3	mg/L	104	35	34	43	8	45	122	73	8	56	24	-	
Total Alkalinity as CaCO3	mg/L	104	35	34	43	8	45	122	73	8	56	24	-	
Sulfate as SO4 - Turbidimetric	mg/L	124	30	4	2	4	2	150	27	3	10	3	> 25	
Chloride	mg/L	209	50	8	8	6	8	384	93	5	25	8	-	
Calcium	mg/L	22	8	3	7	2	8	76	30	2	12	4	-	
Magnesium	mg/L	29	9	2	5	2	8	60	16	1	8	3	-	
Sodium	mg/L	196	50	7	11	7	9	228	55	5	16	7	> 30	
Potassium	mg/L	8	10	8	6	5	3	20	11	4	8	5	-	
Fluoride	mg/L	0.1	0.1	<0.1	0.2	<0.1	0.2	<0.1	0.1	<0.1	0.1	0.2	> 2	> 2
Total Anions	meq/L	10.6	2.73	0.99	1.13	0.5	1.21	16.4	4.64	0.36	2.03	0.77	-	
Total Cations	meq/L	12.2	3.57	0.82	1.39	0.7	1.52	19.2	5.49	0.5	2.16	0.88	-	
Ionic Balance	%	7.29	----	----	----	----	----	7.78	8.32	----			-	
Nutrients														
Ammonia as N	mg/L	0.5	0.33	4.73	1.1	0.26	0.14	0.16	<0.01	0.58	0.18	0.39	> 0.02	> 0.74
Nitrite as N	mg/L	0.02	0.06	<0.01	0.3	1.21	0.04	0.05	<0.01	0.34	<0.01	<0.01	-	
Nitrate as N	mg/L	<0.01	0.57	0.03	<0.01	0.02	0.53	4.09	0.15	0.16	0.02	<0.01	-	> 0.248
Nitrite + Nitrate as N	mg/L	0.02	0.63	0.03	0.11	1.23	0.57	4.14	0.15	0.5	0.02	<0.01	-	
Total Kjeldahl Nitrogen as N	mg/L	1.6	1.1	7.2	12.1	3.4	1.8	1.5	0.6	2.3	1.8	1.7	-	
Total Nitrogen as N	mg/L	1.6	1.7	7.2	12.2	4.6	2.4	5.6	0.8	2.8	1.8	1.7	> 0.5	
Total Phosphorus as P	mg/L	0.16	0.06	1.44	2.48	1.13	0.21	0.02	0.03	0.29	0.28	0.12	> 0.05	
Reactive Phosphorus as P	mg/L	0.07	<0.01	0.71	<0.01	0.58	0.01	<0.01	<0.01	0.13	<0.01	<0.01	> 0.02	
Hydrocarbons														
C6 - C10 Fraction	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	-	
C10 - C40 Fraction	µg/L	<100	<100	<100	370	<100	130	<100	<100	130	<100	130	-	
Biological														
Chlorophyll a	mg/m³	3	<2	----	<10	<8	----	3	2	----	<5	<5	-	

Note: Recorded exceedances of the WQOs or MMC trigger values have been shaded in grey.

Table B.5 – Summary of 80th percentile values for all baseline monitoring locations.

Parameter	Unit	VSW-1	VSW-2	VSW-3	VSW-4	VSW-5	VSW-6	VSW-7	VESW-1	VESW-2	VESW-3	VESW-4	WQO (see Table 3.1 of WRM [2020])	MMC (see Table F3 of MMC)
No. of Samples		3	4	4	4	2	4	4	4	4	2	3		
Physico-chemical parameters														
pH Value	-	7.464	6.92	6.558	6.856	6.916	6.774	7.438	7.542	7.902	6.832	6.644	6.5 - 8.5	
Sodium Adsorption Ratio	-	8.158	3.296	1.336	0.988	0.696	1.02	0.616	2.424	1.366	0.586	1.17	-	
Electrical Conductivity	µS/cm	2024	384.4	142	95	117.6	108.8	119.8	819.6	429.8	86	141.6	> 720 (baseflow) > 250 (high flow)	
Total Dissolved Solids (Calc.)	mg/L	1318	249.8	92.4	61.8	76.2	70.8	78	531.4	279.4	55.6	92.4	> 2,000	
Suspended Solids (SS)	mg/L	104.8	73	172.4	2446	73	381.8	823.2	62.4	45.6	139.2	208.8	> 55	
Turbidity	NTU	157.72	167	425.8	4132	587.8	719.8	1352	487.2	86.66	346.4	432.2	> 50	
Dissolved Oxygen	mg/L	7.3	7.42	7	6.68	7.34	7.04	7.48	7.58	7.86	5.8	7.12	< 4	
Dissolved Metals														
Aluminium	mg/L	0.254	0.372	0.372	1.098	1.032	1.064	0.542	0.014	0.028	0.13	1.032	> 0.055	>0.055
Arsenic	mg/L	0.0016	0.001	0.005	0.0034	<0.001	0.0014	<0.001	0.001	0.001	0.0018	0.0028	> 0.024	> 0.013
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.0002	> 0.0002
Chromium	mg/L	<0.001	<0.001	0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.001	> 0.001
Cobalt	mg/L	0.004	0.002	0.0048	0.0038	<0.001	0.001	<0.001	0.0044	0.001	0.0046	0.0044	-	> 0.090
Copper	mg/L	0.0026	0.0016	0.0028	0.0018	0.0018	0.0028	0.0014	<0.001	0.001	0.0034	0.002	> 0.0014	> 0.002
Lead	mg/L	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.0034	> 0.004
Manganese	mg/L	0.2866	0.165	0.2594	0.402	0.01	0.0424	0.0432	0.7072	0.206	0.2866	0.205	> 1.9	> 1.9
Molybdenum	mg/L	0.0016	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.0018	<0.001	<0.001	<0.001	-	> 0.034
Nickel	mg/L	0.0026	0.0038	0.0046	0.0032	0.002	0.0032	0.0024	0.0054	0.0024	0.0038	0.003	> 0.011	>0.010
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.005	>0.001
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	> 0.001
Uranium	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.1	>0.001
Vanadium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.5	> 0.010
Zinc	mg/L	0.0168	0.0084	0.02	0.0062	0.0066	0.0054	0.0054	0.0054	0.0078	0.0066	0.0102	> 0.008	> 0.008
Boron	mg/L	0.086	0.06	<0.05	0.054	<0.05	<0.05	<0.05	0.078	0.074	<0.05	<0.05	> 0.37	> 0.37
Iron	mg/L	1.442	0.558	1.448	1.18	0.62	0.656	0.478	0.094	0.054	1.324	2.156	-	> 0.3
Mercury	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.00006	> 0.0002
Total Metals														
Aluminium	mg/L	2.682	2.876	7.376	28.74	11.274	11.66	22.6	6.96	2.524	7.08	6.654	> 5	
Arsenic	mg/L	0.002	0.002	0.0042	0.0066	0.002	0.0038	0.0024	0.0024	0.002	0.003	0.0038	> 0.5	
Cadmium	mg/L	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	> 0.01	
Chromium	mg/L	0.0026	0.002	0.005	0.0244	0.009	0.0088	0.026	0.0056	0.0028	0.0068	0.0046	> 1	
Cobalt	mg/L	0.004	0.003	0.0106	0.026	0.0038	0.005	0.0124	0.0064	0.0018	0.0076	0.008	> 0.1	
Copper	mg/L	0.0036	0.004	0.0116	0.0394	0.0092	0.0108	0.0164	0.0052	0.0024	0.0156	0.0104	> 1	
Lead	mg/L	0.0038	0.004	0.0094	0.0534	0.0126	0.0122	0.0228	0.0102	0.0018	0.0078	0.0106	> 0.1	

Manganese	mg/L	0.2846	0.2026	0.4012	1.1144	0.0802	0.1332	0.259	0.7504	0.2712	0.368	0.2898	> 10	
Molybdenum	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	> 0.05	
Nickel	mg/L	0.0038	0.006	0.0124	0.0318	0.01	0.0114	0.0208	0.01	0.0058	0.0098	0.009	> 1	
Selenium	mg/L	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	> 0.02	
Silver	mg/L	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	-	
Uranium	mg/L	<0.001	<0.001	0.001	0.0024	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	-	
Vanadium	mg/L	<0.01	<0.01	0.01	0.034	0.018	0.014	0.03	0.01	<0.01	<0.01	<0.01	-	
Zinc	mg/L	0.027	0.0158	0.0574	0.0796	0.0328	0.031	0.0574	0.0212	0.0192	0.0294	0.0358	> 5	
Boron	mg/L	0.066	0.058	0.38	0.058	<0.05	<0.05	<0.05	0.07	0.076	<0.05	<0.05	> 5	
Iron	mg/L	4.218	3.724	9.018	35.1	12.456	13.22	22.88	9.65	2.55	8.968	10.504	> 10	
Mercury	mg/L	<0.0001	<0.0001	0.0001	0.0001	<0.0001	0.0002	0.00014	<0.0001	<0.0001	<0.0001	0.00016	> 0.002	
Major cations and anions														
Total Hardness as CaCO3	mg/L	293.6	65.4	20	28.4	31.8	21.2	51.8	234.2	138	22	20.4	> 150	> 150
Hydroxide Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	-	
Carbonate Alkalinity as CaCO3	mg/L	<1	<1	<1	<1	<1	<1	<1	<1	3.8	<1	<1	-	
Bicarbonate Alkalinity as CaCO3	mg/L	146	49	22.6	37	28.6	14.4	55.4	105.2	124	28	30.2	-	
Total Alkalinity as CaCO3	mg/L	146	49	22.6	37	28.6	14.4	55.4	105.2	129.4	28	30.2	-	
Sulfate as SO4 - Turbidimetric	mg/L	288.8	47.2	11.2	5.4	6.8	9.6	2.4	66.6	18.6	3	7.2	> 25	
Chloride	mg/L	426.8	64.4	23.8	8.8	11.4	15	10	171.6	61.2	7.6	19	-	
Calcium	mg/L	38.4	8.8	3.4	5.2	5.8	3.8	8.4	42.4	34.4	4	4	-	
Magnesium	mg/L	48	10.6	2.8	3.8	4.2	2.8	7.4	31.2	13	3	2.6	-	
Sodium	mg/L	325	55.2	14	9.8	8.8	10.6	9	103.2	36.4	6.4	11.6	> 30	
Potassium	mg/L	9.8	8.2	7.4	4.8	5.4	5.8	3	12.8	8.6	4.8	6.2	-	
Fluoride	mg/L	0.68	0.1	<0.1	0.2	0.18	0.1	0.2	0.1	0.2	0.2	0.1	> 2	> 2
Total Anions	meq/L	20.6	3.526	1.166	0.998	1.032	0.956	1.322	8.33	4.244	0.802	1.136	-	
Total Cations	meq/L	20.28	3.714	1.16	0.988	1.156	1.012	1.436	9.516	4.416	0.848	1.326	-	
Ionic Balance	%	4.766	2.45	-	----	-	----	----	7.78	6.54	-	----	-	
Nutrients														
Ammonia as N	mg/L	0.368	0.21	3.234	0.506	0.1	0.23	0.128	0.168	0.232	0.356	4.402	> 0.02	> 0.74
Nitrite as N	mg/L	0.026	0.04	<0.01	0.126	<0.01	0.49	0.04	0.038	0.254	<0.01	0.288	-	
Nitrate as N	mg/L	1.374	0.97	0.958	0.1	0.588	0.484	0.368	1.72	0.154	<0.01	1.438	-	> 0.248
Nitrite + Nitrate as N	mg/L	1.074	1.01	0.958	0.158	0.588	1.146	0.384	1.758	0.402	<0.01	1.574	-	
Total Kjeldahl Nitrogen as N	mg/L	1.9	1.86	3.48	6.76	1.16	2.56	1.92	1.62	1.06	1.6	6.86	-	
Total Nitrogen as N	mg/L	2.86	2.84	4.14	6.92	1.38	3.58	2.4	3.32	1.38	1.6	7.56	> 0.5	
Total Phosphorus as P	mg/L	0.132	0.126	0.696	1.34	0.11	0.674	0.226	0.214	0.138	0.12	0.362	> 0.05	
Reactive Phosphorus as P	mg/L	<0.01	<0.01	0.71	<0.01	<0.01	0.238	0.01	<0.01	<0.01	<0.01	0.082	> 0.02	
Hydrocarbons														
C6 - C10 Fraction	µg/L	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	<20	-	
>C10 - C40 Fraction (sum)	µg/L	<100	<100	<100	208	<100	104	112	<100	<100	124	124	-	
Biological														
Chlorophyll a	mg/m^3	<4	<4	<4	<16.8	<4	<8	<14.2	4.4	2.8	<4.8	<4	-	

Note: Recorded exceedances of the WQOs or MMC trigger values have been shaded in grey.

Table B.6 – 80th percentile values for the combined VSW1 and VSW2 data set compared with the receiving water WQO default trigger values and MMC Table F3 trigger values

Parameter	Unit	VSW1 + VSW2	WQO default trigger values (see Table 3.1 of WRM [2020])	MMC trigger value (see Table F3 of MMCs)
No. of Samples		7	-	
Physico-chemical parameters				
pH Value	-	7.11	< 6.5 or > 8.5	
Sodium Adsorption Ratio	-	6.60	-	
Electrical Conductivity	µS/cm	1328	> 720 (baseflow) > 250 (high flow)	
Total Dissolved Solids (Calc.)	mg/L	863	> 2,000	
Total Suspended Solids (TSS)	mg/L	91	> 55	
Turbidity	NTU	203	> 50	
Dissolved Oxygen	mg/L	7.54	< 4	
Dissolved Metals				
Aluminium	mg/L	0.302	> 0.055	>0.055
Arsenic	mg/L	0.001	> 0.024	> 0.013
Cadmium	mg/L	<0.0001	> 0.0002	> 0.0002
Chromium	mg/L	<0.001	> 0.001	> 0.001
Cobalt	mg/L	0.002	-	> 0.090
Copper	mg/L	0.002	> 0.0014	> 0.002
Lead	mg/L	<0.001	> 0.0034	> 0.004
Manganese	mg/L	0.189	> 1.9	> 1.9
Molybdenum	mg/L	0.001	-	> 0.034
Nickel	mg/L	0.003	> 0.011	>0.010
Selenium	mg/L	<0.01	> 0.005	>0.001
Silver	mg/L	<0.001	-	> 0.001
Uranium	mg/L	0.001	> 0.1	>0.001
Vanadium	mg/L	<0.01	> 0.5	> 0.010
Zinc	mg/L	0.0084	> 0.008	> 0.008
Boron	mg/L	0.076	> 0.37	> 0.37
Iron	mg/L	0.81	-	> 0.3
Mercury	mg/L	<0.0001	> 0.00006	> 0.0002
Total Metals				
Aluminium	mg/L	3.212	> 5	
Arsenic	mg/L	0.002	> 0.5	
Cadmium	mg/L	<0.0001	> 0.01	
Chromium	mg/L	0.002	> 1	
Cobalt	mg/L	0.003	> 0.1	
Copper	mg/L	0.004	> 1	
Lead	mg/L	0.004	> 0.1	
Manganese	mg/L	0.2102	> 10	
Molybdenum	mg/L	0.001	> 0.05	

Nickel	**mg/L**	0.0058	> 1	
Selenium	**mg/L**	<0.01	> 0.02	
Silver	**mg/L**	<0.001	-	
Uranium	**mg/L**	0.001	-	
Vanadium	**mg/L**	<0.01	-	
Zinc	**mg/L**	0.0202	> 5	
Boron	**mg/L**	0.064	> 5	
Iron	**mg/L**	4.19	> 10	
Mercury	**mg/L**	<0.0001	> 0.002	
Major cations and anions				
Total Hardness as $CaCO_3$	**mg/L**	188	> 150	> 150
Hydroxide Alkalinity as $CaCO_3$	**mg/L**	<1	-	
Carbonate Alkalinity as $CaCO_3$	**mg/L**	<1	-	
Bicarbonate Alkalinity as $CaCO_3$	**mg/L**	97.2	-	
Total Alkalinity as $CaCO_3$	**mg/L**	97.2	-	
Sulfate as SO_4 - Turbidimetric	**mg/L**	194	> 770	
Chloride	**mg/L**	262	-	
Calcium	**mg/L**	26	-	
Magnesium	**mg/L**	29.8	-	
Sodium	**mg/L**	208	> 30	
Potassium	**mg/L**	9.6	-	
Fluoride	**mg/L**	0.18	> 2	> 2
Total Anions	**meq/L**	12.84	-	
Total Cations	**meq/L**	13	-	
Ionic Balance	**%**	3.71	-	
Nutrients				
Ammonia as N	**mg/L**	0.30	> 0.02	> 0.74
Nitrite as N	**mg/L**	0.028	-	
Nitrate as N	**mg/L**	1.37	-	> 0.248
Nitrite + Nitrate as N	**mg/L**	1.39	-	
Total Kjeldahl Nitrogen as N	**mg/L**	2	-	
Total Nitrogen as N	**mg/L**	2.88	> 0.5	
Total Phosphorus as P	**mg/L**	0.15	> 0.05	
Reactive Phosphorus as P	**mg/L**	0.01	> 0.02	
Hydrocarbons				
C6 - C10 Fraction	**µg/L**	<20	-	
C10 - C40 Fraction	**µg/L**	<100	-	
Biological				
Chlorophyll a	**mg/m³**	<4	-	