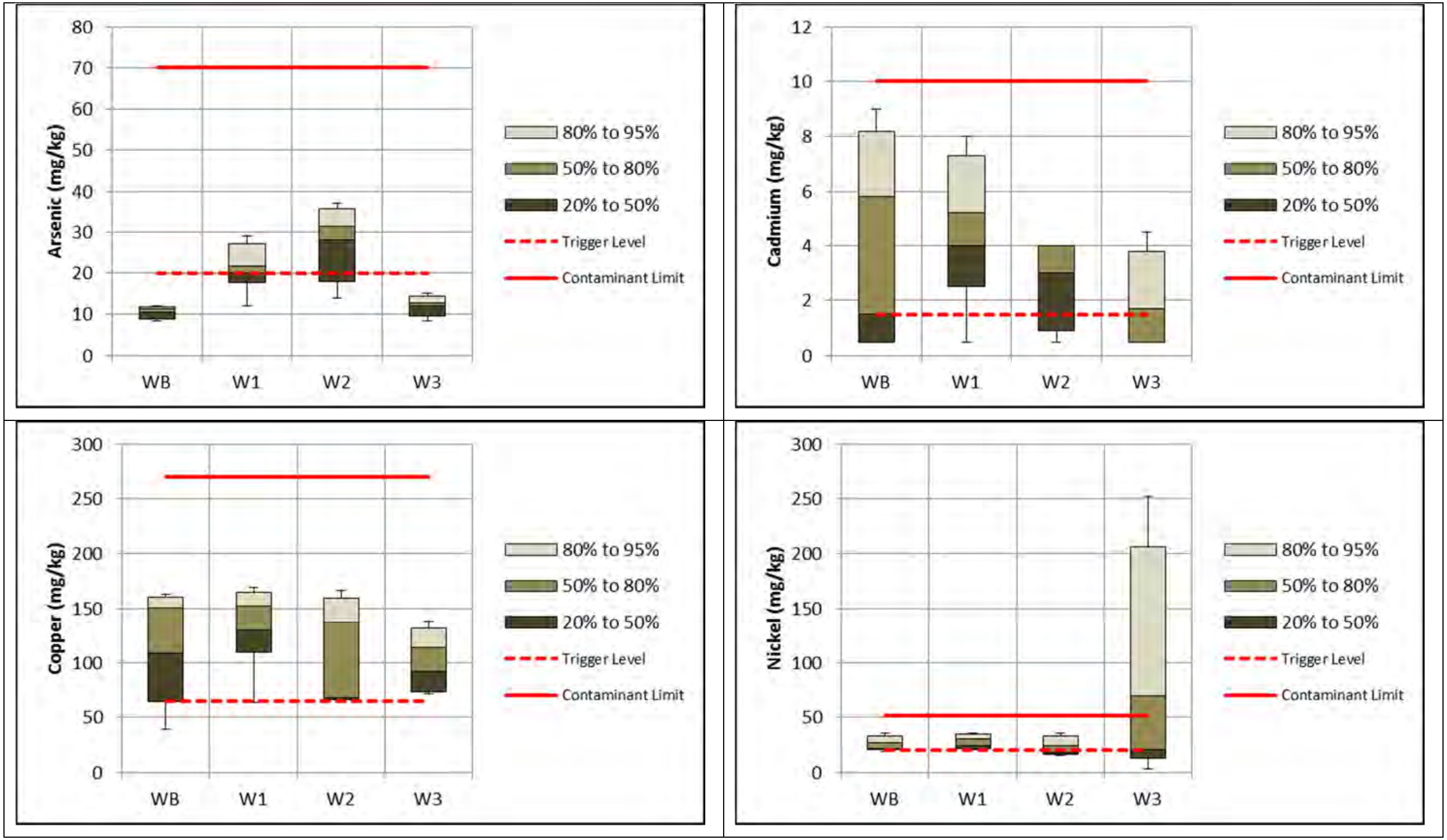

Figure 46 Stream sediment levels in samples analysed for <63μm fraction for arsenic, cadmium, copper and nickel

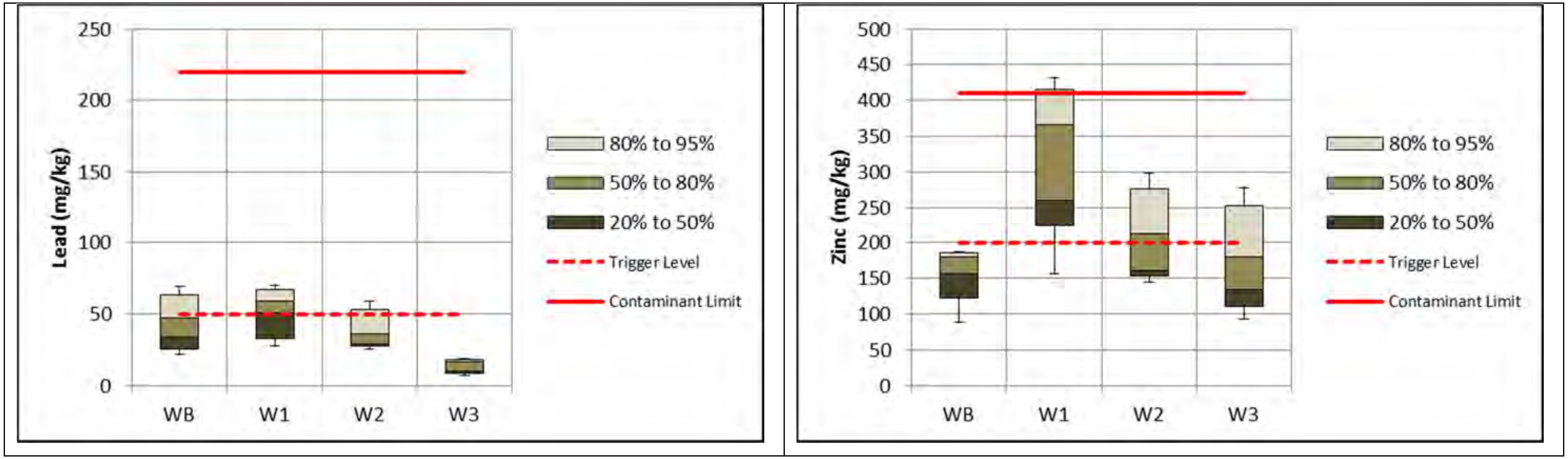

Figure 47 Stream sediment levels in samples analysed for <63µm fraction for lead and zinc

Table 48 All Sediment Results to Date for the Copperfield River

Site	Date	Arsenic		Cadmium		Copper		Nickel		Lead		Zinc		Chromium	WAD CN
		Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Total[1]
SQG		20		1.5		65		21		50		200		80	0.1
SQG-High		70		10		270		52		220		410		370	0.1
WB	19/03/2009	<5	--	<0.5	--	3	--	<3	--	3	--	9	--	--	<0.5
WB	19/09/2010	<5	--	<1	--	<5	--	<2	--	<5	--	<5	--	2	<1
WB	28/06/2011	<5	--	<1	--	<5	--	2	--	<5	--	6	--	2	<1
WB	7/05/2012	<5	--	<1	--	<5	--	<2	--	<5	--	<5	--	<2	<1
WB	23/05/2013	<5	11	<1	<3	<5	**109**	2	**22**	<5	42	10	178	4	<1
WB	19/11/2013	<5	*<21*	<1	**<10**	<5	**163**	<2	**25**	<5	34	5	156	2	<1
WB	26/05/2014	<5	9	<1	<1	<5	**71**	<2	21	<5	27	<5	130	<2	<1
WB	29/11/2014	<5	12	<1	<1	<5	40	3	**36**	<5	22	14	88	6	<1
WB	28/05/2015	<5	<17	<1	**9**	<5	**148**	<2	19	<5	**69**	8	188	2	<1
WB	26/04/2018	<5		<1		<5		3		<5		13		5	--
W1	19/03/2009	<5	--	<0.5	--	7	--	**16**	--	<5	--	50	--	--	<0.5
W1	19/09/2010	<5	--	<1	--	<5	--	<1	--	<5	--	8	--	3	<1
W1	28/06/2011	<5	--	<1	--	<5	--	3	--	5	--	22	--	6	<1
W1	7/05/2012	<5	--	<1	--	<5	--	<2	--	<5	--	5	--	3	<1
W1	23/05/2013	**10**	**20**	<1	<8	11	**121**	5	**22**	13	**51**	71	**350**	7	<1
W1	19/11/2013	<5	**29**	<1	**4**	5	**169**	3	**30**	7	**70**	32	***431***	4	<1
W1	26/05/2014	7	12	<1	**3**	<5	64	<2	21	<5	34	18	**242**	3	<1
W1	29/11/2014	<5	19	<1	<1	<5	**130**	3	**36**	<5	28	15	156	4	<1
W1	28/05/2015	<5	**20**	<1	**8**	<5	**148**	<2	**25**	<5	**56**	30	**260**	3	<1

Site	Date	Arsenic		Cadmium		Copper		Nickel		Lead		Zinc		Chromium	WAD CN
		Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Total[1]
SQG		20		1.5		65		21		50		200		80	0.1
SQG-High		70		10		270		52		220		410		370	0.1
W1	26/04/2018	<5		<1		<5		<2		<5		5		3	--
W2	19/03/2009	**15**	--	<0.5	--	5	--	8	--	<3	--	18	--	--	<0.5
W2	19/09/2010	<5	--	<1	--	<5	--	<2	--	<5	--	<5	--	2	<1
W2	28/06/2011	<5	--	<1	--	<5	--	<2	--	<5	--	10	--	2	<1
W2	7/05/2012	<5	--	<1	--	<5	--	<2	--	<5	--	7	--	4	<1
W2	23/05/2013	<5	**30**	<1	*<8*	<5	**68**	2	16	<5	29	12	191	4	<1
W2	19/11/2013	**15**	**37**	<1	**3**	<5	**167**	<2	18	<5	30	29	**298**	3	<1
W2	26/05/2014	<5	14	<1	1	<5	**67**	<2	**22**	<5	26	8	144	2	<1
W2	29/11/2014	<5	19	<1	<1	<5	**130**	3	**36**	<5	28	15	156	4	<1
W2	28/05/2015	<5	**28**	<1	*<8*	<5	64	<2	17	<5	**59**	10	161	4	<1
W2	26/04/2018	<5		<1		<5		<2		<5		9		3	--
W3	19/03/2009	<5	--	<0.5	--	<3	--	<3	--	3	--	10	--	--	<0.5
W3	19/09/2010	<5	--	<1	--	<5	--	<2	--	<5	--	6	--	4	<1
W3	28/06/2011	<5	--	<1	--	<5	--	<2	--	<5	--	7	--	3	<1
W3	7/05/2012	<5	--	<1	--	<5	--	2	--	<5	--	8	--	5	<1
W3	23/05/2013	<5	<17	<1	*<9*	<5	**138**	4	**21**	<5	19	19	156	8	<1
W3	19/11/2013	<5	12	<1	<1	<5	**108**	<2	15	<5	10	10	**277**	6	<1
W3	26/05/2014	<5	15	<1	<1	<5	**72**	2	**24**	<5	9	9	134	4	<1
W3	29/11/2014	<5	12	<1	<1	<5	**92**	4	3	<5	16	16	115	9	<1
W3	28/05/2015	<5	10	<1	*<2*	<5	**74**	<2	***252***	<5	7	7	92	3	<1

Site	Date	Arsenic		Cadmium		Copper		Nickel		Lead		Zinc		Chromium	WAD CN
		Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Fine[2]	Total[1]	Total[1]
SQG		20		1.5		65		21		50		200		80	0.1
SQG-High		70		10		270		52		220		410		370	0.1
W3	26/04/2018	<5		<1		<5		2		<5		9		4	--
E1	26/04/2018	<5		<1		<5		2		<5		6		6	--
E2	26/04/2018	<5		<1		<5		<2		<5		8		4	--

Legend

Exceeds SQG-High	[1] Total refers to the whole sediment sample [2] Fine references the <0.063mm fraction
Exceeds SQG	
LOR above SQG	

5.13 Aquatic Ecology

An aquatic ecology assessment was undertaken for the Project by C & R Consulting in April 2018. The purpose of this study was to determine aquatic ecological values present within the receiving environment to facilitate an impact assessment and propose mitigation strategies. The study involved a review of existing data from desktop sources and previous assessments and field surveys to identify the potential for conservation significant species as well as characterise habitat available for aquatic organisms and stream health.

The Copperfield River is a large ephemeral, braided watercourse which runs through the Eiansleigh Uplands bioregion in Far North Queensland, approximately 250km southwest of Cairns North. Access for sampling during the wet season is restricted from a safety perspective due to increased velocities of flows and inherent risks to the sampler. The high flow rates experienced in the Copperfield River over the wet season limits the establishment of aquatic flora and small bodied fauna communities. Successful recruitment in these systems can then occur once peak flows have subsided.

During the dry season the Copperfield River typically becomes a series of disconnected pools with reduced water quality. These pools experience large diurnal fluctuations which limit the diversity of remnant flora and fauna communities. The pools can be heavily impacted by cattle and feral pigs as they become the final refuges for these exotic species to water. Therefore aquatic ecology surveys in such systems often target the end of the wet season once significant flows have reduced as this is the period when the system will maintain its most diverse and healthy aquatic flora and fauna assemblages.

As such the aquatic ecology field survey was undertaken between 21 to 25 April 2018, approximately six weeks following significant flows in the receiving environment in accordance with AusRivAS methods. The provision of a late wet season aquatic ecology survey is considered suitable to provide an understanding of the condition of the receiving environment in the Copperfield River.

The following sections summarise the findings of the 2018 survey and previous data where available. For further details, refer to the Aquatic Ecology Survey Report in Appendix E.

5.13.1 Approach

The aquatic ecology survey assessed the values stated below. Full details of the methodology are outlined in Appendix E:

- Aquatic habitat characteristics and condition (using AusRivAS procedures)
- Water quality – physicochemical parameters and a suite of analytes
- Aquatic flora communities – including macrophytes and algae
- Fish communities (using backpack electrofishing, baited traps, seine nets, tangle nets, dip nets). Data analysis including:
  - Species richness
  - Total abundance
  - Abundance of listed aquatic species
  - Abundance of exotic species; and
  - Abundance of each life history stage present (e.g. juvenile, intermediate or adult)
- Turtles (visual surveys and baited cathedral traps)
- Other aquatic vertebrates (via database searches)
- Aquatic macroinvertebrate communities - using Queensland AusRivAS procedures and analysis of the following indices to categorise stream health:
  - **Taxonomic richness** – total number of macroinvertebrate taxa collected at each site. Typically healthier communities have a greater diversity

- **PET taxa richness** – indicates the number of families collected from three orders which are considered sensitive to environmental change (Plecoptera, Ephemeroptera and Trichoptera). A low diversity of families collected from these orders may suggest habitat degradation
- **SIGNAL 2 Index** – The Stream Invertebrate Grade Number Average Level (SIGNAL) is a measure of the sensitivity of freshwater macroinvertebrate families to pollutants and other physical and chemical stressors. The SIGNAL 2 score is a weighted score based on the community composition and scored against background assessments for the region or stream specific boundaries if sufficient data is available. This study has adopted interim boundaries based on the Central Queensland regional guidelines as a basis for comparison as these appear most relevant (QWQG, 2009)
- **Band Rating** – Band rating is determined by applying data to the AusRivAS modelling programme to provide an indication of the level of biological impairment experienced at the target sites. Sites are categorised into five potential bands based on this biological impairment as outlined below:
  - **Band X**: site is richer than reference sites within the region suggesting a potential biodiversity ‘hotspot’ or mild organic enrichment
  - **Band A**: site is in similar condition to reference sites i.e. in similar condition to the natural state of streams in the region
  - **Band B**: site is significantly impacted likely due to mild impact to water quality and/or habitat
  - **Band C**: site is severely impacted likely due to severely impacted water quality and/or habitat resulting in a loss of diversity
  - **Band D**: site is impoverished due to highly degraded water quality and/or habitat.

Surveys were undertaken at six locations which were co-located with historical water quality sampling sites (See Figure 47). Four of these sites were chosen based on historic monitoring locations (WB, W1, W2 and W3) to ensure historical trends in water quality and macroinvertebrate assemblages could be compared against the findings. Two additional sites were included (E1 and E2) to provide further information on the influence of East Creek.

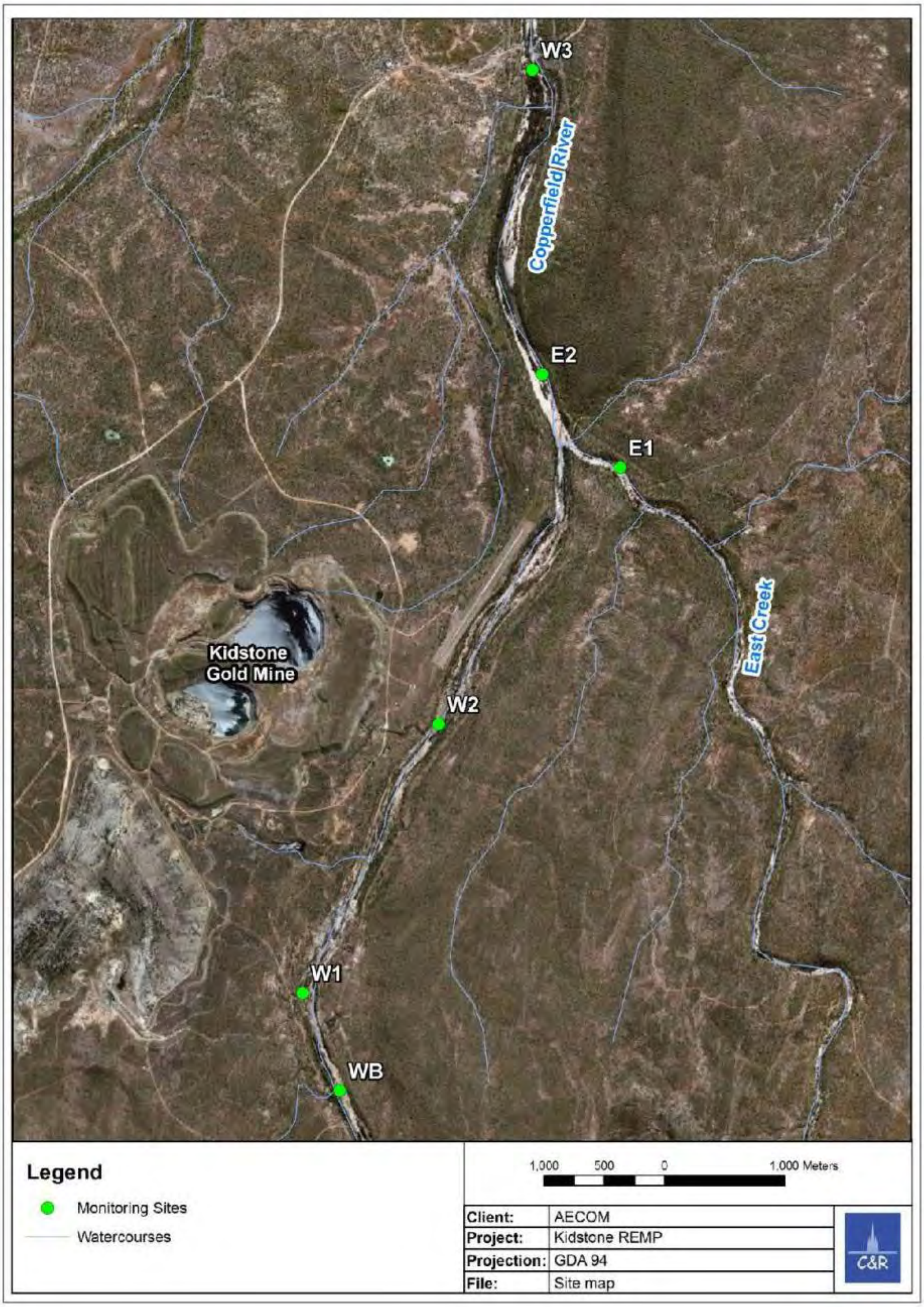

Figure 48 Aquatic ecology sample site locations

5.13.2 Riparian Vegetation

A desktop review found the following sub-dominant of concern Regional Ecosystems (RE) along banks of the Copperfield River in the vicinity of the Project.

RE	Full Description
RE 9.3.20 Least Concern Eucalyptus microneura +/- Corymbia spp. +/- E leptophleba woodland on alluvial plains	• Woodland to low open woodland of *Eucalyptus microneura (Georgetown box) +/- Corymbia pocillum +/- E. leptophleba (Molloy red box) +/- Terminalia spp.* • There is an absent to sparse mixed shrub layer which can include juvenile canopy species, *Gardenia vilhelmii (breadfruit), Dolichandrone alternifolia (lemonwood), Atalaya hemiglauca (whitewood), Melaleuca spp. and Carissa lanceolata (currantbush)*, with some of these species sometimes forming an open sub-canopy layer. • The grassy ground layer is generally dominated by *Heteropogon contortus (black speargrass), Eragrostis spp. and Aristida spp*. • Occur on alluvial plains. (BVG1M: 18d)
RE 9.3.3a Of Concern Corymbia spp. and Eucalyptus spp. dominated mixed woodland on alluvial flats, levees and plains	**RE 9.3.3** • Mixed woodland to open woodland often dominated by *Eucalyptus leptophleba* (Molloy red box) but also including combinations of the species *E. platyphylla* (poplar gum), *Corymbia clarksoniana* (Clarkson's bloodwood), *E. crebra* (narrow-leaved ironbark), *C. tessellaris* (Moreton Bay ash), and *Erythrophleum chlorostachys* (Cooktown ironwood) +/- *C. grandifolia subsp. grandifolia and C. polycarpa* (long-fruited bloodwood). • An open sub-canopy dominated by canopy species often occurs. • An absent to a mid-dense shrub layer of *Melaleuca spp., Planchonia careya* (cocky apple), *Carissa lanceolata (currantbush)* and juveniles of canopy species can occur. • The mid-dense to dense ground layer is dominated by *Heteropogon spp., Themeda triandra* (kangaroo grass) and *Sarga plumosum* (plume sorghum). • Occurs on alluvial plains, terraces and levees. Soils are generally sandy alluvium. (BVG1M: 16b) **RE9.3.3a** • Woodland to low open woodland of *Eucalyptus leptophleba* (Molloy red box) +/- *E. platyphylla* (poplar gum) +/- *Corymbia confertiflora* (broad-leaved carbeen) +/- *E. crebra* (narrow-leaved ironbark) or *E. cullenii* (Cullen's ironbark) +/- *C. clarksoniana* (Clarkson's bloodwood). • The subdominant species may be codominant in this community. • An open sub-canopy of canopy species can occur. • The shrub layer is absent to sparse and contain juvenile canopy species, *Carissa lanceolata* (currantbush) and *Atalaya hemiglauca* (whitewood). • The dense grassy ground layer is dominated by *Heteropogon contortus* (black speargrass) and *Bothriochloa spp.* (bluegrasses). • Occurs on alluvial plains and terraces. Floodplain (other than floodplain wetlands). (BVG1M: 16b)

5.13.3 Aquatic Habitat Characteristics and Condition

During the survey period the Copperfield River was still experiencing flow conditions, while East Creek retained water in a series of pools connected by subsurface flows. The following aquatic habitat factors were identified within the Project site;

- Run
- Riffle
- Deep pool
- Shallow pool
- Undercut/eroded bank
- Bedrock; and
- Complex woody debris.

Details of aquatic habitat within each site can be found in Table 3 of Appendix E.

An AusRivAS habitat condition assessment was completed for each sample location which included assessing the following habitat factors to provide a rating of habitat quality:

- Bottom substrate and available cover
- Embeddedness
- Velocity / depth of cover
- Channel alteration
- Bottom scouring and deposition
- Pool/riffle, run/bend ratio
- Bank stability
- Bank vegetative stability; and
- Streamside cover.

The results of these assessments determined that five of the six sites were in ‘good’ condition, with one site (E1) observed in a ‘Moderate’ condition. The similarity of condition observed at the majority of sites is likely due to the relative uniformity of flowing habitats comprised of riffle and run units during the assessment. Lack of flows and subsequent reduced diversity of habitats in E1 is likely to have reduced the score at this reach.

Only two species of macrophytes were encountered at the monitoring sites. These included rice sedge (*Cyperus difformis*) and *Cyperus sp.*. Prolonged flows immediately prior to the survey is a probable cause of the low diversity of macrophyte species encountered.

5.13.4 Physico-chemical Water Quality Parameters

In-situ water quality analysis results were relatively stable across the majority of parameters (Table 49) with the exception of temperature. Stability of the majority of parameters is expected due to consistent flow mixing water in the system and variability in observed temperatures is largely due to time of sampling during each day.

Table 49 In-situ physico-chemcial water quality results

Site	Temperature (°C)	Electrical Conductivity (µS/cm)	pH (pH units)	Dissolved oxygen (% saturation)
WB	23.23	107	7.75	N/A
W1	20.99	113	7.75	91.7
W2	25.67	108	7.81	100.9
E1	22.50	116	7.78	105.9
E2	22.20	112	7.9	100.9
W3	25.00	115	7.63	99.2

5.13.5 Macroinvertebrates

5.13.5.1 Historical Survey Results

Macroinvertebrate assessments were previously conducted at four of the six sites between 2009 and 2013. A number of indicators have been derived from macroinvertebrate surveys undertaken during this period including (Barrick Australia, 2013):

- Diversity of taxa
- Shannon Diversity Index / Shannon Equitability Index
- SIGNAL 2 Index; and
- AusRivAS Band Scores.

A summary of previous macroinvertebrate sampling from the REMP (Genex Power, 2015) indicates that there is little to no impact resulting from historic mining activities at Kidston as:

- All sites fell into "Band A", indicating no significant deviation of species and families from what would be expected at reference sites.
- SIGNAL 2 values are equivalent at the upstream, intermediate and downstream sites, indicating that the receiving environment did not vary from what is expected within the other areas in the system.
- Cluster analysis suggests a larger difference in macroinvertebrate assemblage between years rather than between sites.
- Results suggest slightly higher overall environmental health at WB and W1 than sites further downstream. The differences between sites are very minor and may be attributable to differences in habitat structure rather than contaminant release from the site.

5.13.5.2 Survey Results 2018

The 2018 macroinvertebrate assessment (Appendix E) compared values and indices from the data collected against guidelines from Central Queensland as there are no guidelines specifically developed for the region. Due to natural spatial variation in water quality, guidelines need to be interpreted in a local context or against site-specific predictions. The Central Queensland guidelines are considered most appropriate because of several watercourse characteristics, including:

- Highly seasonal flow regime
- Substrates typically dominated by sand and interspersed with bedrock barrages and intermittent riffle zones
- High amount of sediment movement within the channel during flow events; and
- Turbid waters.

Although similarities in watercourse characteristics do exist between the regions, no specific guidelines have been developed for the region. As such the Central Queensland guidelines are used as a reference, but conclusions drawn from the results are not definitive. More value is derived from the macroinvertebrate data from comparison of upstream sites to downstream sites.

The earlier studies (2009-2013) do not state which set of guidelines data were compared against. Therefore comparison of the AusRivAS modelling and resultant classification from the 2009-2013 dataset to the 2018 dataset could be misleading.

Taxonomic Richness

Fifty one macroinvertebrate taxa were recorded during the field survey, a higher diversity than were recorded for each sampling event between 2009 and 2013.

For bed habitat, five of the six sampling locations achieved the 20^{th} percentile value stipulated by the QWQG for the Central Coast region. Where this criteria was not met (site E2) the bed substrate was dominated by sand. The reduced richness at this location is likely attributable to the lack of structural complexity.

Only two sites (W1 and E1) were compliant with the QWQG 20^{th} value for the Central Coast region with no sites exceeding the 80^{th} percentile. Edge habitat is typically more diverse than bed habitat leading to greater rates of primary production and in turn higher diversity of macroinvertebrate taxa. This was true of the edge habitat observed during the survey which consisted primarily of exposed roots with scouring from recent flows evident. However, lack of diversity of habitat units, with almost all sites being within riffle habitat, may have limited macroinvertebrate diversity. Further, as no guidelines are available for this area, this may be consistent with regional trends.

PET Richness

Both bed and edge habitats recorded PET richness scores significantly above the 20^{th} percentile guideline value and often equal or above the 80^{th} percentile guideline value for the Central Queensland region. These results suggest that the macroinvertebrate communities are in excellent condition. However, the possibility that these guidelines are not relevant to the region must still be considered.

SIGNAL 2

SIGNAL 2 / Family bi-plots is a simple biotic index for freshwater macroinvertebrates which provides an indication of how pollutants and other anthropogenic and environmental stressors are impacting the structure of macroinvertebrate assemblages. Results from the bed and edge habitat were compared against the Central Queensland guidelines.

Only one SIGNAL 2 score fell outside of quadrant 1. Site E2 fell into quadrant 3 suggesting that this location was experiencing toxic pollution or harsh environmental conditions. An analysis of a suite of analytes determined that at this location all of these parameters were compliant with the default ANZECC and ARMCANZ (2000) water quality objectives for 95% Species Protection level, with the exception of dissolved aluminium. However these levels of dissolved aluminium are not outside of the range experienced in the system naturally, with higher recordings at upstream sites. It is likely that the quadrant positon of E2 was a result of harsh environmental conditions experienced naturally in the region and the lack of habitat diversity at the site.

For edge habitat, both upstream and downstream sites fall into quadrant three, suggesting that all sites were experiencing harsh conditions, either naturally or from anthropogenic impacts. This result may have been influenced by high flow rates in the previous month, limiting the ability of some families to recolonise and reducing the diversity of available habitat. These results are consistent with both upstream and downstream sites and as such they are unlikely a result of activities associated with the Kidston Gold Mine.

AusRivAS Modelling

Macroinvertebrate data was interpreted using AusRivAS modelling which categorises bed and edge habitat for each site into a ‘Band’ which provides an indication of the degree of biological impairment. Bed and edge habitat fell within either Band A or Band B for all sites. Brief descriptions of the Bands are below:

- Band A classed as *similar to reference sites*; and
- Band B classed as *significantly impaired.*

The results of this modelling indicated that bed habitat was more biologically impaired than edge habitat. Bed habitat at all sites was evaluated to be within Band B, while at four of the six sites (W1, W2, E1 and E2) the edge habitat was within Band A.

These results were consistent with PET richness and taxonomic richness which suggested that bed habitat was not as favourable for establishment or persistence of macroinvertebrate assemblages.

Other Macroinvertebrates

Other macroinvertebrates observed during the survey consisted of three larger-bodied decapod species. These included redclaw (*Cherax quadricarinatus*), freshwater prawn (*Macrobrachium australiense*) and inland freshwater crab (*Austrothelphus transversa*). None of these species are listed as threatened under the *Nature Conservation Act 1992* (NC Act) or the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

5.13.6 Fish Communities

Seven species of freshwater fish were identified during the field survey. These included:

- Checkered rainbowfish (*Melanotaenia mogurnda*)
- Northern trout gudgeon (*Mogurnda mogurnda*)
- Hyrtl's tandan (*Neosuluris hyrtlii*)
- Spangled perch (*Leiopotherapon unicolor*)
- Sooty grunter (*Hepthaestus fuliginosus*)
- Bony bream (*Nematolosa erebi*); and
- Barred grunter (*Amniataba percoides*).

Site W3 had the highest species richness identified during the survey (six species) and also the highest abundance (approximately 90 individuals). Site W2 recorded the lowest abundance (approx. 30) and species richness (3) out of all monitoring sites (Appendix E). Comparatively the East Creek upstream site (E1) had a similar species richness as W2 (3 species) but a much higher abundance (approximately 65).

5.13.7 Turtles

No turtles were encountered during the assessment using visual surveys and baited cathedral traps. Shallow water at the majority of sites prevented the use of cathedral traps except at site W1, where the cathedral trap was deployed for a total of 15 hours. Electrofishing surveys for fish also did not find any turtles (Appendix E, Section 2.2.8). Anecdotal evidence suggests that the common Krefft's turtle (*Emydura macquari krefftii*) can be found in waterholes and farm supply dams throughout the area (Appendix E, Section 3.6.1).

5.13.8 Macroinvertebrate Findings

The macroinvertebrate assessment determined that communities inhabiting the Copperfield River both upstream and within the receiving environment are in good condition. AusRivAS modelling did determine that assemblages at some locations were considered to be significantly impacted. However these scores may be typical of the region and PET scores and taxa richness determined sensitive taxa were well represented. This is consistent with the findings of previous macroinvertebrate assessments (Genex, 2015).

5.14 Dry Season Copperfield River Field Survey

5.14.1 Sample Sites

The locations of semi-permanent waterholes within the floodplain of the Copperfield River were identified through flyover with a drone in September 2018. Six locations were identified, and water quality was sampled at each waterhole between 22 and 23 September 2018. Standing water was present at long term monitoring points W1 and W3, and these two sites were also sampled as part of the dry season Copperfield River field survey. The location of the dry season sampling points is provided in Table 50 and Figure 49.

Rainfall records at Georgetown Airport (BOM station 030124) indicate that the most recent rainfall prior to this sampling event was 2mm on 17 April 2018. However, 429.8mm was recorded during March 2018 and is likely to be the most recent period of flow in the Copperfield River.

The majority of waterholes found were minor remnant pools occurring in-channel. Only two substantial pools were noted downstream of the Project site (Pond 5 near W3 and the Sandy Creek site). These two pools have the potential to persist year round, providing refuge to aquatic fauna. The longevity of these pools would be highly correlated with the hydrology of the system on a yearly basis.

Table 50 Dry Season Sample Locations

Monitoring Location	Proximity to Proposed Release Location	Easting	Northing	Description
Pond 1	2km upstream			Copperfield River upstream of the TSF Dam Spillway
Pond 2	1.7km upstream			Copperfield River upstream of the TSF Dam Spillway
Pond 3	1.4km upstream			Copperfield River upstream of the TSF Dam Spillway
W1	1.2km upstream	200799	7908133	Copperfield River below the TSF Dam Spillway
Pond 4	5.4km downstream			Copperfield River downstream
Pond 5	5.8km downstream			Copperfield River downstream
W3	6.2km downstream	202667	7915973	Downstream monitoring site at the Causeway
Sandy Creek	20km downstream			Copperfield River immediately upstream of the confluence with Sandy River

AECOM
www.aecom.com

N

DATUM GDA 1994, PROJECTION MGA ZONE 56

0 250 500 1,000
metres

1:30,000 (when printed at A3)

LEGEND

- Monitoring Point
- Ponding Identified
- Existing Release Points
- Key Project Infrastructure Footprint
- Spillway Options Corridor
- Major Watercourse
- Minor Watercourse

Data sources:

KIDSTON PUMPED STORAGE HYDRO PROJECT
IMPACT ASSESSMENT REPORT

Dry Season Copperfield River Survey

PROJECT ID	60544566
CREATED BY	RF
LAST MODIFIED	RF - 11 Jan 2019
VERSION:	1

Figure
49

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A3 size

Plate 1 Pond 1 drone snapshot

Plate 2 Pond 2 drone snapshot

Plate 3 Pond 3 drone snapshot

Plate 4 W1 drone snapshot

Plate 5 Pond 4 drone snapshot

Plate 6 Pond 5 drone snapshot

Plate 7 W3 drone snapshot

Plate 8 Sandy Creek drone snapshot

5.14.2 Dry Season Water Quality Results

The results of the semi-permanent waterhole water quality samples are presented in Table 52. Many of the parameters returned a result below the LOR.

Table 52 also presents the applicable WQO for each parameter, including recommended site-specific objectives, as outlined in sections 3.5.2 and 3.6.12. Exceedances of these WQOs are highlighted in the table below. Total manganese, total iron, total nitrogen and total phosphorus recorded results above their respective WQOs both upstream and downstream of the proposed release point.

Table 51 Dry Season Copperfield River Field Survey Water Quality Results

Parameter	Unit	LOR	Upstream					Downstream			Applicable WQO
			Pond 1	Pond 2	Pond 3	W1	Sandy Creek	Pond 4	Pond 5	W3	
pH value	pH unit	0.01	7.56	7.74	7.90	7.94	7.75	7.88	7.67	8.79	6.0 – 8.4*
Electrical Conductivity	(µS/cm)	1	189	669	194	289	192	245	170	217	500
Sulfate as SO_4^{2-}	mg/L	1	2	<1	2	20	<1	11	<1	1	250
Aluminium (total)	mg/L	0.01	0.01	<0.01	0.06	0.02	<0.01	0.02	0.03	0.02	1.52*
Aluminium (dissolved)	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.57*
Arsenic (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.01
Arsenic (dissolved)	mg/L	0.001	0.002	<0.001	<0.001	<0.001	0.002	0.001	0.002	0.001	0.013
Cadmium (total)	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.002
Cadmium (dissolved)	mg/L	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0003*
Cobalt (total)	mg/L	0.001	0.001	0.009	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05
Cobalt (dissolved)	mg/L	0.001	0.002	0.012	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0028
Chromium (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.05
Chromium (dissolved)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0017*
Copper (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.2
Copper (dissolved)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003*
Manganese (total)	mg/L	0.001	1.26	6.88	0.056	0.079	0.487	0.192	0.117	0.038	0.1
Manganese (dissolved)	mg/L	0.001	0.881	5.81	0.004	0.012	0.286	0.076	0.095	0.004	1.9
Molybdenum (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	0.01
Nickel (total)	mg/L	0.001	0.001	0.002	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.02
Nickel (dissolved)	mg/L	0.001	0.001	0.003	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	0.019*

Parameter	Unit	LOR	Upstream					Downstream			Applicable WQO
			Pond 1	Pond 2	Pond 3	W1	Sandy Creek	Pond 4	Pond 5	W3	
Lead (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01
Lead (dissolved)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0075*
Zinc (total)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	2*
Zinc (dissolved)	mg/L	0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	<0.005	0.014
Total Cyanide	mg/L	0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	<0.004	0.08
Iron (total)	mg/L	0.05	1.10	1.64	0.11	<0.05	0.79	0.26	0.61	0.10	0.43*
Iron (dissolved)	mg/L	0.05	0.22	1.95	<0.05	<0.05	0.19	0.09	0.15	<0.05	0.3
Chloride	mg/L	1	7	8	8	26	8	21	7	7	175*
Sodium	mg/L	1	12	11	18	26	13	27	13	21	115
Boron (total)	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.5
Boron (dissolved)	mg/L	0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.37
Barium (total)	mg/L	0.001	0.084	0.153	0.042	0.037	0.076	0.046	0.045	0.039	1.0
Beryllium (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.06
Beryllium (dissolved)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.00013
Mercury (total)	mg/L	0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	0.001
Mercury (dissolved)	mg/L	0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	<0.00004	0.00005
Selenium (total)	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01
Selenium (dissolved)	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.011
Uranium (total)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01
Uranium (dissolved)	mg/L	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.0005
Vanadium (total)	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.1

Parameter	Unit	LOR	Upstream					Downstream			Applicable WQO
			Pond 1	Pond 2	Pond 3	W1	Sandy Creek	Pond 4	Pond 5	W3	
Vanadium (dissolved)	mg/L	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.006
Fluoride	mg/L	0.1	<0.1	<0.1	<0.1	<0.1	<0.1	<0.1	0.1	0.1	1
Ammonia as N	mg/L	0.005	0.08	0.23	0.04	0.13	0.02	0.05	0.07	0.08	0.5
Nitrate as N	mg/L	0.002	0.006	0.018	0.008	0.022	0.004	0.024	0.023	0.006	0.7
Nitrite as N	mg/L	0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	<0.002	1
Total N	mg/L	0.01	0.77	0.61	0.48	0.91	0.23	0.30	0.62	0.36	0.15
Total P	mg/L	0.005	0.079	0.036	0.026	0.042	0.020	0.014	0.039	0.016	0.01

* Site-specific WQO (refer Section 3.6.1.2)

5.14.3 Comparison against Post-2011 surface water quality dataset

Long term water quality data is available for monitoring points W1 and W3 (Section 3.3.1). Table 52 presents the median post-2011 water quality and the dry season results at these sites for comparison. Exceedances against the WQOs for these datasets are also highlighted in the table below. The following comparisons were noted:

- pH, electrical conductivity, chloride and sodium were recorded to be higher at both sites during the dry season than the long term post-2011 median dataset. pH at W3 during the dry season exceeded the WQO.
- Sulfate and total manganese were recorded to be higher at W1 during the dry season than the long term post-2011 median dataset. The parameters were both lower at W3 during the dry season.
- Total aluminium was recorded to be lower at both sites during the dry season than the long term post-2011 median dataset.
- Total iron was recorded to be below the WQO during the dry season, but exceeded the WQO in the post-2011 median dataset.

Table 52 Dry Season and Post-2011 comparison of W1 and W3

Parameter	Unit	W1		W3		Applicable WQO
		Post-2011 Median	Dry Season	Post-2011 Median	Dry Season	
pH value	pH unit	7.75	7.94	7.8	8.79	6.0 – 8.4*
Electrical Conductivity	(µS/cm)	135	289	150	217	500
Sulfate as SO_4^{2-}	mg/L	4	20	4	1	250
Aluminium (total)	mg/L	0.55	0.02	0.52	0.02	1.52*
Aluminium (dissolved)	mg/L	0.19	<0.01	0.22	<0.01	0.57*
Arsenic (total)	mg/L	0.0005	<0.001	0.001	<0.001	0.01
Arsenic (dissolved)	mg/L	0.0005	<0.001	0.0005	0.001	0.013
Cadmium (total)	mg/L	0.00005	<0.0001	0.00005	<0.0001	0.002
Cadmium (dissolved)	mg/L	0.00005	<0.0001	0.00005	<0.0001	0.0003*
Cobalt (total)	mg/L	0.0005	<0.001	0.0005	<0.001	0.05
Cobalt (dissolved)	mg/L	0.0005	<0.001	0.0005	<0.001	0.0028
Chromium (total)	mg/L	0.0005	<0.001	0.0005	<0.001	0.05
Chromium (dissolved)	mg/L	0.0005	<0.001	0.0005	<0.001	0.0017*
Copper (total)	mg/L	0.002	<0.001	0.002	<0.001	0.2
Copper (dissolved)	mg/L	0.002	<0.001	0.002	<0.001	0.003*
Manganese (total)	mg/L	0.046	0.079	0.064	0.038	0.1
Manganese (dissolved)	mg/L	0.017	0.012	0.023	0.004	1.9
Molybdenum (total)	mg/L	0.0005	<0.001	0.0005	<0.001	0.01
Nickel (total)	mg/L	0.0005	0.001	0.0005	<0.001	0.02
Nickel (dissolved)	mg/L	0.0005	0.001	0.0005	<0.001	0.019*
Lead (total)	mg/L	0.0005	<0.001	0.0005	<0.001	0.01
Lead (dissolved)	mg/L	0.0005	<0.001	0.0005	<0.001	0.0075*

Parameter	Unit	W1		W3		Applicable WQO
		Post-2011 Median	Dry Season	Post-2011 Median	Dry Season	
Zinc (total)	mg/L	0.0025	<0.005	0.0025	<0.005	2*
Zinc (dissolved)	mg/L	0.0025	<0.005	0.0025	<0.005	0.014
Total Cyanide	mg/L	0.002	<0.004	0.002	<0.004	0.08
Iron (total)	mg/L	0.71	<0.05	3.32	0.10	0.43*
Iron (dissolved)	mg/L	0.23	<0.05	0.19	<0.05	0.3
Chloride	mg/L	5	26	4	7	175*
Sodium	mg/L	11	26	4	21	115
Boron (total)	mg/L	-	<0.05	0.025	<0.05	0.5
Boron (dissolved)	mg/L	-	<0.05	0.025	<0.05	0.37
Barium (total)	mg/L	-	0.037	0.032	0.039	1.0
Beryllium (total)	mg/L	-	<0.001	0.0005	<0.001	0.06
Beryllium (dissolved)	mg/L	-	<0.001	0.0005	<0.001	0.00013
Mercury (total)	mg/L	-	<0.00004	-	<0.00004	0.001
Mercury (dissolved)	mg/L	-	<0.00004	-	<0.00004	0.00005
Selenium (total)	mg/L	0.005	<0.01	0.005	<0.01	0.01
Selenium (dissolved)	mg/L	0.005	<0.01	0.005	<0.01	0.011
Uranium (total)	mg/L	-	<0.001	-	<0.001	0.01
Uranium (dissolved)	mg/L	-	<0.001	-	<0.001	0.0005
Vanadium (total)	mg/L	-	<0.01	0.005	<0.01	0.1
Vanadium (dissolved)	mg/L	-	<0.01	0.005	<0.01	0.006
Fluoride	mg/L	-	<0.1	0.05	0.1	1
Ammonia as N	mg/L	-	0.13	-	0.08	0.5
Nitrate as N	mg/L	-	0.022	-	0.006	0.7
Nitrite as N	mg/L	-	<0.002	-	<0.002	1
Total N	mg/L	-	0.91	-	0.36	0.15
Total P	mg/L	-	0.042	-	0.016	0.01

* Site-specific WQO (refer Section 3.6.1.2)

5.15 Summary

The main outcomes of the investigation of the baseline receiving environment are summarised below:

Surface Water Quality

- EVs for the Gilbert River basin have not been defined under the EPP Water. In this instance, the EPP Water prescribes the application of all default EVs. EVs have been described for the Copperfield River over a 44km stretch downstream from the former Kidston mine site to the confluence of the Einasleigh River.
- Macroinvertebrate data supports the distinction of a 'Slightly Disturbed' aquatic ecosystem condition under the EPP Water. The management intent for this water type is to gradually improve water quality and to aim to achieve a HEV waterway classification, however HEV WQOs may not be achievable in the Copperfield River as there are a number of regionally based negative influences on water quality.
- The QWQG and EPP Water do not specify WQOs for the Gulf Rivers region or the Gilbert Basin. Instead they recommend the use of the ANZECC (2000) guidelines, cautioning that these values may not be appropriate for intermittent and ephemeral inland streams. In cases where more than one WQO is available for a particular parameter, the most stringent value from all EVs is applicable. Where applicable, site-specific trigger values were derived based on the upstream dataset for monitoring location WB. HMTVs were developed for the area in the immediate vicinity of the release point, using the median baseline hardness values at monitoring location W2.
- Some anomalies in the receiving environment water quality datasets were noted and led to the exclusion of samples collected prior to 2012 (providing an adequate dataset size for analysis of 40 to 60 samples). Ongoing monitoring is recommended for parameters with limited dataset sizes.
- The baseline assessment indicated that a number of parameters are elevated above WQOs in the receiving environment. Monitoring site W2 has indicated potential impacts from seepage.

Hydrology

- In the absence of stream gauging, hydrological modelling was used to undertake a flow spells analysis which showed a definite seasonal distribution with a distinct high flow season occurring from December through April.
- Cease to flow conditions (less than 1 ML/d) are present on approximately 55% of all days for any day and reduce to approximately 32% during the wet season (November through April).

Hydrogeology

- The groundwater flow regime of the Project has been modified by the construction of the tailings dam, interception drains, and by dewatering of the two pits. In their current state, Wises Pit and Eldridge Pit are both understood to function as groundwater 'sinks', as groundwater levels in the surrounds of both pits are higher than the surface water level in the pits.
- One confirmed wetland spring, Middle Spring, lies within the vicinity of the mine area. This spring is located west-northwest of the former mine; although it is not considered to be hydraulically connected to the groundwater regime of the proposed release area, it is recommended that this is further assessed/monitored as part of water modelling refinement and design phase work.

Sediment Quality

- The braided nature of the Copperfield River results in sediment transport that is limited to a few months per year during the wet season when discharge is high enough. Very little fine sediment is stored in the channel bed in the upper to mid catchments.
- Sediment samples have been collected annually between 2009 and 2013. No whole-sediment samples exceeded the SQG, indicating that sediment within the Copperfield River is considered to be unaffected by the historical mining processes. Although the <0.063 mm samples reported a number of SQG exceedances, this fraction is considered less useful for comparison to guideline values.

- For toxicants in the <0.063 mm fractions, exceedances reported around the potential release sites (e.g., W1 and W2) are also reported in the upstream and downstream monitoring sites (e.g., WB and W3, respectively) suggesting that there are no widespread impacts from historical mining activities evident within the Copperfield River and that the concentrations of metals found are a result of the overall catchment drainage. Additional sampling and monitoring is recommended in accordance with the REMP.

Aquatic Ecology

- The macroinvertebrate assessment determined that communities inhabiting the Copperfield River both upstream and within the receiving environment are in good condition. AusRivAS modelling determined that assemblages at some locations were considered to be significantly impacted. However these scores may be typical of the region and PET scores and taxa richness determined sensitive taxa were well represented.

Dry Season Survey

- Six semi-permanent waterholes were identified within the floodplain of the Copperfield River through a drone flyover in September 2018. These waterholes were sampled in late September 2018, along with monitoring locations W1 and W3.
- Previous significant rainfall in the catchment occurred in March 2018, therefore the water in the pools is assumed to have been standing for a long duration and were likely subjected to evapo-concentration.
- Total manganese, total iron, total nitrogen and total phosphorus recorded results above their respective WQOs both upstream and downstream of the proposed release point.
- A comparison against the long-term (post 2011) dataset for W1 and W3 did not indicate any clear trends with regards to water quality.

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Step 3 – Impact Assessment

"Predict Outcomes of Impacts of the Proposed Wastewater Release"

6.0 Impact Assessment – Operational Releases

6.1 Approach

A comprehensive assessment has been undertaken to develop an understanding of the potential impacts of the Project on the EVs of the receiving environment. The assessment included an impact assessment of both the construction and operational phases of the Project. This section addresses the potential impacts relating to operational releases on water quality, ecology, hydrology, geomorphology and hydrogeology of the receiving environment.

The operational impacts will endure throughout the life of the Project and the development of appropriate discharge limits has been used as a primary mitigation measure to ensure that environmental impacts are appropriately minimised. To achieve this, applicable EVs were used to set WQOs with consideration of practical discharge requirements. Where WQOs were available for more than one EV, the lowest, more stringent value was applied (in most cases, this was associated with the protection of aquatic ecosystems). This approach ensures that relevant EVs are protected, including downstream users of the Copperfield River.

6.1.1 Assessment of Dilution Ratio and Assimilative Capacity

The assimilative capacity of the receiving environment is its capacity to receive some anthropogenic input of contaminants or alteration without causing the water quality to deteriorate so that the WQOs are no longer met. Since the assimilative capacity can be related to the dilution ratio achieved in the mixed water (downstream of the release point), it provides a constraint on the rate at which water may be released from the Project. Dilution ratio is therefore an important aspect of this impact assessment. As stated in ESR/2015/1654, it should be demonstrated "that the assimilative capacity of the receiving waters is not exceeded and that some assimilative capacity is preserved for future ecologically sustainable development – the proportion proposed to be consumed should be determined".

The assimilative capacity for any given parameter is defined as the difference between the WQO and the median baseline water quality (refer to Equation 1).

Equation 1 Assimilative Capacity:

$$\text{Assimilative Capacity} = [\text{WQO}] - [\text{Median baseline concentration}]$$

This section evaluates release water quality effects on the receiving environment water quality in order to assess which of the water quality parameters have the lowest assimilative capacity once release water is added to the receiving environment.

6.1.1.1 Dilution Ratio and Constituents of Concern

The dilution ratio applied to each parameter is calculated using Equation 2. This function represents a ratio between the concentration of the release water and the available assimilative capacity of the receiving environment. Dilution rates between the release water and Copperfield River baseline (at monitoring location W2) were calculated for each parameter.

Equation 2 Dilution ratios incorporating background water quality:

$$\text{Dilution ratio} = \frac{[\text{Release water concentration}]}{[\text{WQO}] - [\text{Median baseline concentration}]}$$

Target water quality was calculated using Equation 3. Information sources used to estimate dilution ratios and constituents of most concern are outlined in Table 53.

Equation 3 Target water quality:

Target Water Quality = [Assimilative Capacity Utilisation %]* ([WQO]-[Median baseline conc.])+[Median baseline conc.]

Table 53 Information sources used to estimate dilution ratios and constituents of most concern

Description	Information Source/s	Justification/Detail
Release water concentration	Historical maximum of both pits mixed at 9 parts Eldridge to 1 part Wises.	Use of the historical maximum considered as a highly conservative estimate (unlikely to be observed in reality) of release water concentration. As discussed in Section 4.8.2, a sensitivity analysis has been undertaken for a variety of release scenarios. As a result of the sensitivity analysis, it was determined that the 'worst case scenario' (i.e. highest overall parameter concentrations) for a mixed pit water release was achieved by using the maximum concentrations observed over the full dataset, mixed at a ratio of nine parts Eldridge Pit to one part Wises Pit.
Baseline receiving environment concentration	The median baseline concentration was taken to be the 50th percentile of water quality at the W2 monitoring site.	W2 was chosen as it is closest to the proposed release location and most representative of baseline water quality in this section of the Copperfield River (refer section 5.5.3.2 and Appendix A). Use of W2 is considered a conservative estimate.
WQOs	Default WQOs are set out in Section 5.5.1. For the dilution ratio calculations the SSTV has been adopted as the WQO. Where applicable, HMTVs have been applied (refer to Section 5.6.1 above).	Modifications to WQOs based on data at the upstream site (WB) are recommended for dissolved aluminium, total aluminium dissolved copper and total iron. HMTVs have been adopted for dissolved cadmium, chromium, lead, nickel and zinc. Further detail regarding HMTVs is presented in Section 5.6.1 above.

Table 54 summarises the dilution ratios from the worst case release scenario (historical maximum value for both pits, mixed at nine parts Eldridge Pit to one part Wises Pit), noting that all dilution ratios presented in the table represent use of 100% of the assimilative capacity of the receiving environment. As can be seen in Table 54, dissolved zinc is the constituent of most concern in the releases, requiring a dilution ratio of 138:1.

There are a number of parameters where there is limited historical information. These parameters include selenium, vanadium, mercury, beryllium, uranium, ammonia, nitrite, nitrate, total N, total P and fluoride. Historic data is lacking in either the Pit water samples or for the receiving environment. In most cases for many parameters there is only one sample available from each. Dilution ratios have been calculated based on these individual samples. The dilution ratios required to ensure that the WQOs are met by these parameters are an order of magnitude lower than that required for other Constituent of Potential Concerns (COPCs) and would need to be presented in concentrations that are an order of magnitude larger than current measured values in order to have an impact on dilution ratio calculations. Ongoing monitoring recommended in the Project REMP will ensure that these parameters are monitored on a regular basis and that these thresholds are incorporated.

Table 54 Dilution ratios required to achieve WQOs

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)[2]	Baseline Receiving Water Concentration (mg/L)[3]	Dilution Ratio Required[4]
Zinc (F)	0.014	1.5874	0.0025	138.0
Manganese (T)	0.1	3.622	0.073	134.1
Cadmium (F)	0.00030	0.02901	0.00005	116.0
Cobalt (T)	0.05	3.5151	0.0005	71.0
Arsenic (T)	0.01	0.368	0.001	40.9
Cobalt (F)	0.0028	0.0283	0.0005	31.4
Nickel (F)	0.00190	0.0352	0.0005	25.1
Cadmium (T)	0.002	0.04186	0.00005	21.5
Lead (T)	0.01	0.1723	0.0005	18.1
Electrical Conductivity @ 25°C	500	5311	167	15.9
Arsenic (F)	0.013	0.1694	0.0005	13.6
Molybdenum (T)	0.01	0.122	0.0005	12.8
Sulfate as SO4 - Turbidimetric	250	2690	10	11.2
Nitrate as N	0.7	4.935	0.0325	7.4
Total Phosphorus as P	0.01	0.0315	0.005	6.3
Mercury (F)	0.00006	0.00005	0.00005	5.0
Vanadium (F)	0.006	0.005	0.005	5.0
Fluoride	1	3.03	0.2	3.8
Sodium	115	318.4	10	3.0
Nickel (T)	0.02	0.0505	0.0005	2.6
Copper (F)	0.003	0.0047	0.001	2.4
Molybdenum (F)	0.034	0.0623	0.0005	1.9
Iron (T)	0.43	0.3065	0.22	1.5
Manganese (F)	1.9	2.5868	0.035	1.4
Zinc (T)	2	2.352	0.0025	1.2
Selenium (F)	0.011	0.005	0.005	<1
Chloride	175	100	7	<1
Ammonia as N	0.5	0.211	0.02	<1

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)[2]	Baseline Receiving Water Concentration (mg/L)[3]	Dilution Ratio Required[4]
Chromium (F)	0.00170	0.0005	0.0005	<1
Copper (T)	0.2	0.061	0.002	<1
Aluminium (T)	1.52	0.234	0.45	<1
Iron (F)	0.3	0.025	0.113	<1
Boron (F)	0.37	0.0285	0.025	<1
Lead (F)	0.00750	0.0005	0.0005	<1
Mercury (T)	0.001	0.00005	0.00005	<1
Aluminium (F)	0.57	0.0185	0.16	<1
Barium (T)	1	0.0422	0.027	<1
Chromium (T)	0.05	0.00055	0.0005	<1
Beryllium (T)	0.06	0.0005	0.0005	<1
Nitrite as N	1	0.005	0.005	<1
Beryllium (F)	0.00013	0.0005	0.0005	NA[5]
Total Hardness as CaCO3		1809.8	56.2	NA[5]
Total Nitrogen as N	0.15	6.39	0.25	NA[5]

[1] Including site-specific WQOs and HMTVs as presented in Section 5.6.12.

[2] Maximum value for Eldridge Pit and Wises Pit, mixed at 9 parts Eldridge to 1 part Wises

[3] Median value for W2 (based on data collected since 2012)

[4] Assuming use of 100% assimilative capacity

[5] Baseline receiving environment concentration (or LOR) above WQO.

6.1.1.2 Dilution Ratio for Adoption

As stated in ESR/2015/1654, it should be demonstrated "*that the assimilative capacity of the receiving waters is not exceeded and that some assimilative capacity is preserved for future ecologically sustainable development – the proportion proposed to be consumed should be determined*".

As outlined in Section 6.1.1.1, a maximum dilution ratio of 1 to 138 was found for dissolved zinc, based on use of 100% of assimilative capacity. This is to account for a 'worst case scenario', representing the maximum historical water quality for any parameter in the Wises Pit mixed together with the maximum historical water quality for any parameter in the Eldridge Pit at a proportion of 1 part Wises to 9 parts Eldridge.

If 69% of the assimilative capacity of the receiving environment is used, this results in an effective dilution ratio of 200:1. This equates to an effective release ratio of 0.5% (refer to Equation [2], Section 6.1.1.1) and is proposed to be adopted for the operational phase of the Project. By limiting the use of assimilative capacity to 69%, this allows for preservation of a portion of the capacity for future development. The assumptions behind calculating effective dilution ratios are highly conservative (based on maximum pit water qualities). In reality the actual assimilative capacity usage will be lower than 69% in most cases.

6.1.1.3 Constituents of Most Concern

Applying the adopted operations period dilution ratio of 200:1 for the operations phase, a simple mass balance has been undertaken to determine the likely concentration in the receiving environment post mixing of a release. This has been undertaken by applying the maximum concentration of each parameter observed in both pits and mixing at a ratio of nine parts Eldridge Pit to one part Wises Pit and is considered to be a conservative, worst-case assessment. Results are presented in Table 55.

The assessment indicates that only total nitrogen will exceed the WQO post-mixing. It should be noted that the baseline concentration of total nitrogen at W2 already exceeds the WQO, and there were only limited data points available for the pits. Additional monitoring of the Eldridge Pit subsequently confirmed these samples to be reported. Further monitoring of total nitrogen will continue to be undertaken as part of the REMP (refer to Appendix I).

At the lower dilution rates proposed for the construction phase of the Project (refer to Section 7.2.2), the following parameters are predicted to exceed the WQO in the receiving environment post-mixing and are therefore considered to be constituents of most concern (COPCs) (in order of importance):

- Dissolved zinc
- Dissolved cadmium
- Total cobalt
- Total manganese
- Total arsenic
- Dissolved cobalt
- Total nitrogen
- Electrical conductivity (no guideline exceedance, but included at the request of DES)
- Sulfate (no guideline exceedance, but included at the request of DES).

The downstream (far-field) dilution of these parameters is therefore also assessed further in Section 6.2.2 for the operational phase.

Whilst a number of parameters were present at concentrations above the WQO in the release water (assuming use of maximum historical values), the high dilution rate being applied during the operations phase (200:1) means that concentrations in the receiving environment post-release will be diluted sufficiently below WQOs.

The DTA results (refer to Section 4.9.4) indicated a minimum dilution ratio of nine parts receiving environment water to one part release water (using the worst case construction phase mix for release water), required to meet 95% species protection. During the operations phase, the simulated releases are well in excess (200:1) of this minimum dilution ratio, thereby indicating that the proposed releases will not result in toxicity-related impacts to aquatic ecosystems, even in the near-field mixing zone where WQOs might not necessarily be met immediately (refer to Section 6.2.1 below).

Table 55 Worst-Case Final Concentrations of Constituents in Receiving Environment (Operations Phase)

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)[2]	Baseline Receiving Water Concentration (mg/L)[3]	Final Concentration in Receiving Environment for Operational Period Releases (mg/L)
Electrical Conductivity @ 25°C	500	*5311*	167	194
Total Dissolved Solids (Calc.)		NA	NA	NA
Total Hardness as CaCO3		1809.8	56.2	65
Hydroxide Alkalinity as CaCO3		NA	NA	NA
Carbonate Alkalinity as CaCO3		NA	NA	NA
Bicarbonate Alkalinity as CaCO3		NA	NA	NA
Total Alkalinity as CaCO3		162.1	51.5	52.3
Sulfate as SO4 - Turbidimetric	250	*2690*	10	23.45
Chloride	175	100	7	7.5
Calcium		506.8	12	14.5
Magnesium		132.4	7	7.7
Sodium	115	*318.4*	10	11.6
Potassium		51.3	2	2.3
Aluminium (F)	0.57	0.0185	0.16	0.1601
Arsenic (F)	0.013	*0.1694*	0.0005	0.0013
Beryllium (F)[4]	0.00013	0.0005	0.0005	0.0005
Barium (F)		0.0362	0.023	0.0232
Cadmium (F)	0.0003	*0.02901*	0.00005	0.0002
Chromium (F)	0.0017	0.0005	0.0005	0.0005
Cobalt (F)	0.0028	*0.0283*	0.0005	0.0006
Copper (F)	0.0024	*0.0047*	0.001	0.0010
Lead (F)	0.0075	0.0005	0.0005	0.0005

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)[2]	Baseline Receiving Water Concentration (mg/L)[3]	Final Concentration in Receiving Environment for Operational Period Releases (mg/L)
Manganese (F)	1.9	*2.5868*	0.035	0.0479
Molybdenum (F)	0.034	*0.0623*	0.0005	0.0008
Nickel (F)	0.019	*0.0352*	0.0005	0.0007
Selenium (F)	0.011	0.005	0.005	0.0050
Uranium (F)	0.01			
Vanadium (F)	0.006	0.005	0.005	0.0050
Zinc (F)	0.0136	*1.5874*	0.0025	0.0104
Boron (F)	0.37	0.0285	0.025	0.0251
Iron (F)	0.3	0.025	0.113	0.1131
Mercury (F)	0.00006	0.00005	0.00005	0.0001
Aluminium (T)	1.52	0.234	0.45	0.4512
Arsenic (T)	0.01	*0.368*	0.001	0.0028
Beryllium (T)	0.06	0.0005	0.0005	0.0005
Barium (T)	1	0.0422	0.027	0.0272
Cadmium (T)	0.002	0.04186	0.00005	0.0003
Chromium (T)	0.05	0.00055	0.0005	0.0005
Cobalt (T)	0.05	*3.5151*	0.0005	0.0181
Copper (T)	0.2	0.061	0.002	0.0023
Lead (T)	0.01	*0.1723*	0.0005	0.0014
Manganese (T)	0.1	*3.622*	0.073	0.0911
Molybdenum (T)	0.01	*0.122*	0.0005	0.0011
Nickel (T)	0.02	*0.0505*	0.0005	0.0008
Selenium (T)	0.01	NA	NA	NA
Uranium (T)	0.01	NA	NA	NA
Vanadium (T)	0.1	NA	NA	NA
Zinc (T)	2	*2.352*	0.0025	0.0143
Boron (T)	0.5	NA	NA	NA
Iron (T)	0.43	0.3065	0.22	0.2215
Mercury (T)	0.001	0.00005	0.00005	0.0001

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)[2]	Baseline Receiving Water Concentration (mg/L)[3]	Final Concentration in Receiving Environment for Operational Period Releases (mg/L)
Free Cyanide	0.08	NA	NA	NA
Total Cyanide		NA	NA	NA
Weak Acid Dissociable Cyanide		NA	NA	NA
Fluoride	1	*3.03*	0.2	0.2152
Ammonia as N	0.5	0.211	0.02	0.0211
Nitrite as N	1	0.005	0.005	0.0050
Nitrate as N	0.7	*4.935*	0.0325	0.0572
Nitrite + Nitrate as N		NA	NA	NA
Total Kjeldahl Nitrogen as N		NA	NA	NA
Total Nitrogen as N[4]	0.15	*6.39*	**0.25**	**0.2820**
Total Phosphorus as P	0.01	*0.0315*	0.005	0.0052
Reactive Phosphorus as P		NA	NA	NA

[1] Including site-specific WQOs and HMTVs as presented in Section 5.6.12.
[2] Maximum value for Eldridge Pit and Wises Pit, mixed at 9 parts Eldridge to 1 part Wises
[3] Median value for W2 (based on data collected since 2012)
[4] Baseline receiving environment concentration (or LOR) above WQO.
NA = No data available
Red italicised values denote an exceedance of the WQO in the release water (i.e. prior to release). This does not necessarily indicate that concentrations in the receiving environment will also be above the WQO.
Grey shaded values denote an exceedance of the WQO post-release.

6.2 Water Quality Impact Assessment

Potential impacts to water quality associated with operational releases are as follows:

1. Increased water temperature and reducing natural thermal variability.
2. Increased toxicant loads in Copperfield River resulting in adverse impacts to aquatic ecosystems.
3. Impacts to drinking water quality.
4. Visual impact at Einasleigh Gorge, through precipitation of dissolved contaminants.
5. Residual water quality changes following discharge events, pooling in Copperfield River.
6. Accumulation of contaminants in sediment.
7. Water quality changes in Pit water as level in Eldridge Pit rises and falls and exposes pit walls.

In order to assess whether these impacts are likely to occur the following key tasks were undertaken:

- In order to assess the rate of near field dilution and mixing downstream from the proposed release point, the mixing zone model CORMIX was used. The model predicts estimated mixing zone length based on the distance downstream at which the relevant WQO is reached. Design of the modelled scenarios has considered releases into a number of different receiving flows and potential release rates based on the constituent of most concern, dissolved zinc at a dilution ratio of 200:1. Detail is presented in Section 6.2.1.
- A mass balance analysis has been undertaken in order to develop an understanding of the mass loading at various locations from the release point down to Einasleigh. Mass balance modelling was undertaken for selected key constituents. Detail is presented in Section 6.2.2.
- Results of the near-field (CORMIX modelling) and far-field (mass balance) assessments described above were used to assess the water quality-related impacts to each EV, as presented in Section 6.2.3.

6.2.1 Near Field Mixing Zone Assessment (CORMIX)

The capacity of the receiving environment to accept releases in terms of mass carried and flow rate is a crucial aspect of the Project. This was investigated by assessing the load potential of the receiving environment at the proposed release location.

As the zone in which the release water meets the receiving water, the mixing zone is expected to experience the largest initial changes in water quality and potential impacts may be greatest here. Modelling of the mixing zone was therefore undertaken to provide constraints on the mixing dynamics.

The mixing zone model CORMIX was used to assess the rate of near field dilution and mixing downstream from the proposed release point. CORMIX is a United States Environmental Protection Authority (US EPA) supported, Windows-based software system for the analysis, prediction and design of continuous, steady-state point source releases into water bodies. CORMIX is also recommended as a mixing zone model by the DES (EHP, 2016). The model focuses on the geometry and dilution characteristics of the initial (near-field) mixing zone as well as predicting the behaviour of the release plume at larger distances (far-field).

The results of CORMIX's hydrodynamic simulations have been extensively validated and generally agree with available field and laboratory data. In particular, CORMIX predicts highly complex release situations involving boundary interactions, internal layer formation, buoyant intrusions, and large-scale induced currents in shallow environments.

6.2.1.1 CORMIX Model Limitations

Modelling of releases into a water body should be regarded as a tool for the identification and prediction of potential impacts to the water quality of the receiving environment within the study area. When reviewing release modelling outputs, it is important to interpret the results in the context of the model limitations. The most significant limitations of the CORMIX system are related to the use of idealised representations of ambient geometry, currents and stratification (and assumptions around diffuser configuration, as discussed below). This is however considered conservative for the purpose of this assessment.

Mixing processes in the near-field region are noted to be sensitive to the release design conditions and this is particularly notable when applied to the current assessment where release and ambient conditions are subject to a significant range of variability. Actual process changes can result in variations of one or more of three parameters associated with the release: flow rate, density, or release concentration as well as the release geometry. These changes can result in different mixing rates in the near-field. In contrast, mixing conditions at large distances (far-field) often show little sensitivity unless the ambient conditions change substantially or drastic process variations are introduced.

6.2.1.2 CORMIX Model Scenario Inputs and Assumptions

A total of four scenarios have been assessed for the proposed releases. Design of the scenarios has considered releases into a number of different receiving flows and potential release rates based on a dissolved zinc dilution ratio of 200:1 as outlined in Section 6.1.1. Receiving flow rates have been selected to result in as broad a range of release flow rates as possible within the limitation of the proposed discharge capacity of 1 m^3/s (86.4 ML/d). Table 56 below summarises key assumptions adopted for the modelling.

Table 56 Key CORMIX Assumptions

Aspect	Assumption	Comment
Release concentration	1.5874 mg/L	• Dissolved zinc • Equivalent to 1.585 mg/L excess over the receiving environment background concentration • Based on the maximum values from Wises and Eldridge Pits mixed at a 1:9 ratio. Refer to Section 6.0.
Release water density	998.65 kg/m^3	• Total dissolved solids (TDS) of 2,090 mg/L assuming Wises and Eldridge Pits mixed at a 1:9 ratio • Assumed temperature of 25ºC (assumes releases predominantly occurring during summer)
Receiving concentration	0.0025 mg/L	W2 median concentration (Zinc (F))
Receiving water density	997.16 kg/m^3	• TDS of 108 mg/L (W2 median value) • Assumed temperature of 25ºC (assumes releases predominantly occurring during summer)
Water quality objective	0.014 mg/L	• Hardness modified trigger value (HMTV) • Equivalent to 0.0115 mg/L excess over the receiving environment concentration
Assimilative capacity utilisation	69%	Refer to Section 6.1.1
Effective dilution ratio	200:1	Refer to Section 6.1.1
Effective release ratio	0.5%	Refer to Appendix L for detailed discussion on the use and application of release ratios.
Ambient conditions	Bounded Highly irregular Mannings of 0.035	For all scenarios

Aspect	Assumption	Comment
• Ambient geometry conditions Average depth • Depth at release • Channel width	Dependant on scenario – refer to	• Values taken from HEC-RAS model (Section 5.10.1 cross sections. • Mean values derived over 500m up and downstream of proposed release point
CORMIX model	• Preliminary multiport assessment using CORMIX2 • CORMIX1 single port assessment as recommended by CORMIX	• Initial model runs were conducted using CORMIX2, multiport assessment however the conceptual configurations assessed are more suited to a single port assessment which resulted in a better representation of near field mixing. • To complete the CORMIX1 single port assessment the discharge flowrate was simply divided by the number of ports.
Adopted diffuser type	Co-flowing	
Diffuser length	Dependant on scenario – refer to Table 57	
No. of ports		
Diameter of ports		

6.2.1.3 Conceptual Diffuser Configurations Used

Two different conceptual diffuser configurations have been adopted for the purpose of the near field mixing zone assessment (refer to Table 57) as proof of concept assessment. Both conceptual configurations utilise a unidirectional, multiport diffuser with a perpendicular alignment known as a co-flowing diffuser (Figure 50).

Each conceptual configuration has been selected to demonstrate that, under the adopted conditions and assumptions detailed in Table 56 and for the ambient and discharge conditions simulated, potential releases of water from the Project are able to be mixed to meet proposed water quality and mixing zone objectives. It is noted however that the final outlet structure and diffuser design will be subject to ongoing design refinement as the Project progresses through to detailed design and will need to consider a number of additional criteria that were not considered as part of this high level assessment.

The relatively wide range of potential discharge capacity (up to 1 m^3/s (86.4 ML/d) and potential receiving flow rates (from 4.6 m^3/s (400 ML/d) at the release trigger to 198.8 m^3/s (17,176 ML/d) at the maximum discharge capacity) necessitates that releases will need to be made via multiple diffuser configurations in order to realise water quality and mixing zone objectives i.e. a single diffuser arrangement can only be optimised for a relatively narrow range of discharge and receiving flow conditions.

The effect of reducing discharge rates through a specific arrangement is to gradually reduce the outlet velocity relative to the receiving environment ambient velocity. This reduces the ability of the discharge to mix in the near field zone around the outlet. Eventually a low pressure zone may form at the diffuser outlet causing a ‘wake’ effect downstream of the diffuser outlet and preventing effective mixing.

- Alternatively, as discharge through a specific diffuser arrangement increases, continuity necessitates that the outlet velocity must increase. High discharge outlet velocities are undesirable for a number of reasons including harm to aquatic fauna, erosion risk and increasingly poor mixing due to the high discharge to receiving velocity ratio.
- The current assessment has demonstrated that a single configuration is capable of meeting mixing objectives for a range of release flow rates (two configurations were each assessed against two different discharge flow rates). However, assessment of discharge potential (6.3.1) has considered a continuously variable rate of release (based on a daily timestep simulation) up to the proposed release capacity of $1m^3/s$. Ongoing detailed design and practical considerations of providing optimised outlet configurations for such a wide discharge capacity will likely need to consider a ‘stepped’ or incremental rate of release such that each configuration operates at or approximates a fixed discharge rate. The number of potential release rates or ‘steps’ and potential diffuser configurations is again, subject to ongoing assessment through detailed design.
- The following additional criteria have not been considered for this assessment but will need to inform the final design of the proposed outlet structure:
  - Fish passage requirements (refer to Section 2.4)
  - Geomorphic stability – The potential for the lateral migration of braided channels evident at the proposed release location will need to addressed through possible solutions including training, armouring, etc. of the channel in the vicinity of the release structure
  - Constructability
  - Erosion and sedimentation
  - Maintenance, etc
- Final selection of the proposed release location has yet to be determined however site assessment will include (but is not limited to) key selection criteria such as accessibility, geomorphic suitability, presence of riparian and aquatic vegetation, etc.

In summary, the proposed diffuser configurations simulated in this mixing zone assessment represent a conceptual level of design that is considered appropriate for the current level of design progression. The results of the assessment indicate that the low adopted use of available assimilative capacity and resultant high effective dilution ratio combined with the adopted diffuser configurations provide for a rapid mixing of potential releases and compliance with the relevant WQOs.

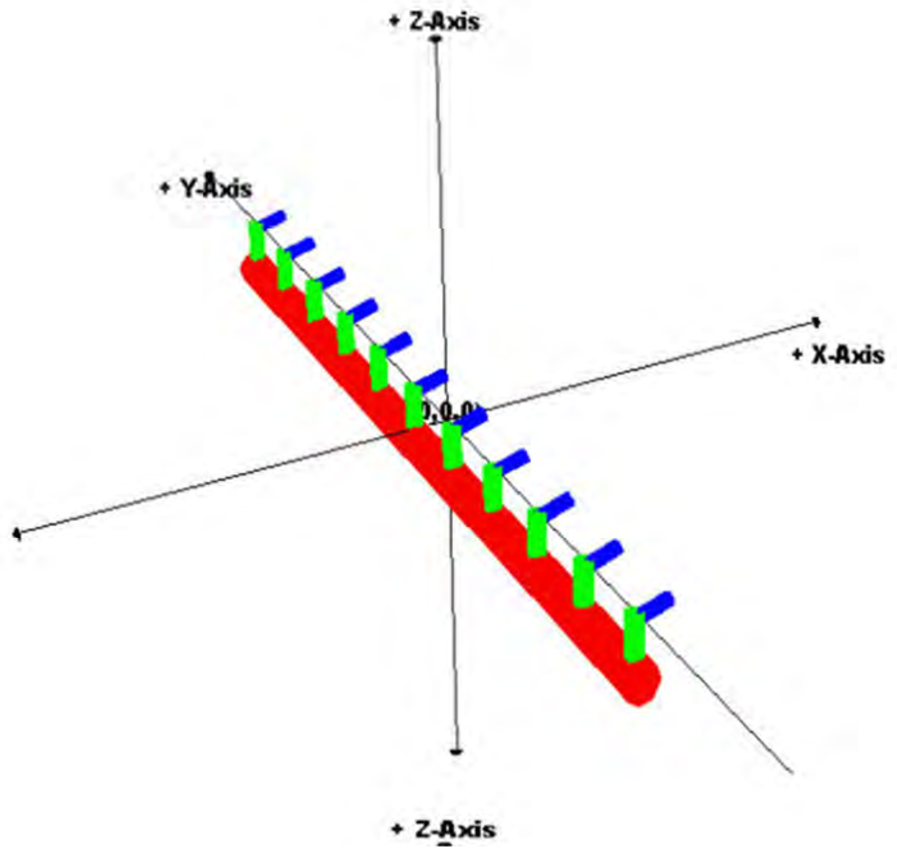


Figure 50 Typical Co-Flowing Diffuser Arrangement (Doneker & Jirka, 2017)

6.2.1.4 CORMIX Scenarios

Table 57 details the four modelled scenarios assessed. Ambient environment data was obtained from the HEC-RAS hydraulic model (refer to Section 5.10.1). For the purpose of the assessment the proposed release location was assumed to be at model chainage 7846km and average channel dimensions were based on the average of all cross sections 500m up and downstream of the proposed release point. The diffuser was assumed to be located in the channel centre for the purpose of the assessment however due to large expansion in flow width associated with each incremental increase in the ambient flow rate the distance from the bank to the diffuser also increases.

Table 57 CORMIX Scenarios Assessed

Scenario	Description	Receiving Flow	Release Flow	Ambient Assumptions			Adopted Conceptual Diffuser Configuration				
				Depth at Discharge (m)	Average Width (m)	Average Depth (m)	Length (m)	Distance to Banks (m)	Port Height[12] (m)	Port Diameter (m)	No. of Ports
1	Minimum rate of release – receiving flow at the release trigger	400 ML/d (4.63 m^3/s)	2.0 ML/d (0.023 m^3/s)	0.38	31.8	0.31	18	3.5	0.1	0.11	4
2	Release into the 2% daily flow	3,790 ML/d (43.87 m^3/s)	19.1 ML/d (0.221 m^3/d)	0.43	82.8	0.63	18	18	0.1	0.11	4
3	Release into the 1% daily flow	11,098 ML/d (128.45 m^3/s)	55.9 ML/d (0.646 m^3/s)	0.87	124.5	0.94	25	49.5	0.1	0.125	10
4	Release at maximum discharge capacity	17,176 ML/d (198.8 m^3/s)	86.4 ML/d (1.00 m^3/s)	1.16	134.0	1.17	25	54	0.1	0.125	10

[12] Height of the release port centres above the channel bed

6.2.1.5 Scenario Results

Initial results from multi-port modelling using CORMIX2 were compared to a single port assessment using CORMIX1 as recommended by CORMIX based on the adopted configurations assessed. For all scenarios use of a CORMIX1 single port assessment resulted in a longer mixing zone and therefore only these results have been presented.

Figure 51 to Figure 54 show CORMIX1 mixing zone results for each of the four modelled scenarios assessed. The estimated mixing zone length is summarised in Table 58 along with the mixing zone to channel width. From the results it can be seen that the proposed releases are subject to initial mixing within the near field and that predicted water quality within the mixing zone reaches the WQO for dissolved zinc, being the contaminant of most concern, within a maximum distance of 623m. Other modelled scenarios indicate a much smaller mixing zone of between 50 and 70 m downstream. The difficulty in optimising diffuser performance across a wide of range of discharge and ambient conditions (as discussed in Section 6.2.1.3) is highlighted by the estimated mixing zone length for scenario 2. While both scenarios 1 and 2 utilise the same configuration, the changes in discharge and flow rate and ambient flow rate result in a significant difference in the estimated mixing zone length.

Table 58 CORMIX Scenario Results for Estimated Mixing Zones (CORMIX1 Single Port Assessment)

Scenario	Estimated Mixing Zone Length (m)	Estimated Scenario Channel Width (m)
1	51.3	31.8
2	622.7	82.8
3	66.9	124.5
4	62.5	134.0

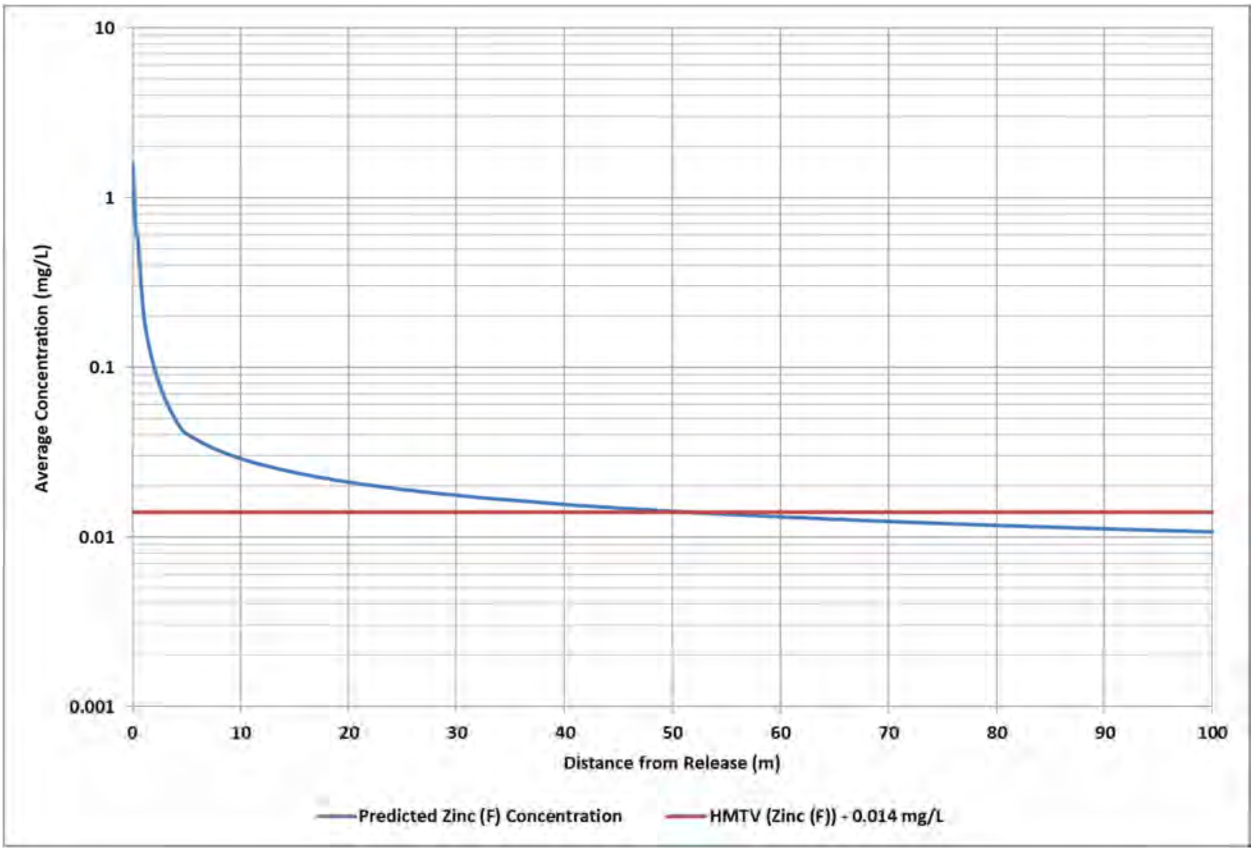


Figure 51 Scenario 1 – Mixing Zone (CORMIX1 Single Port Assessment)

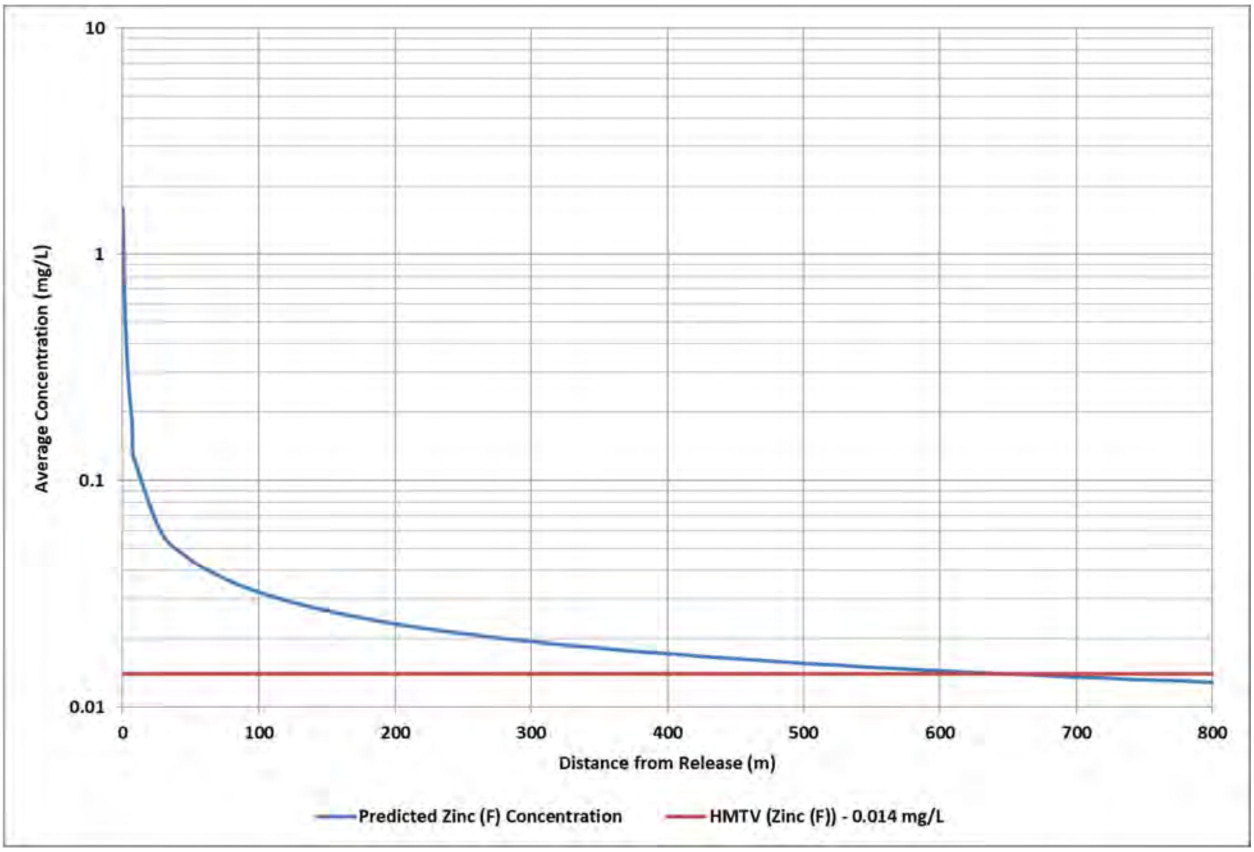


Figure 52 Scenario 2 – Mixing Zone (CORMIX1 Single Port Assessment)

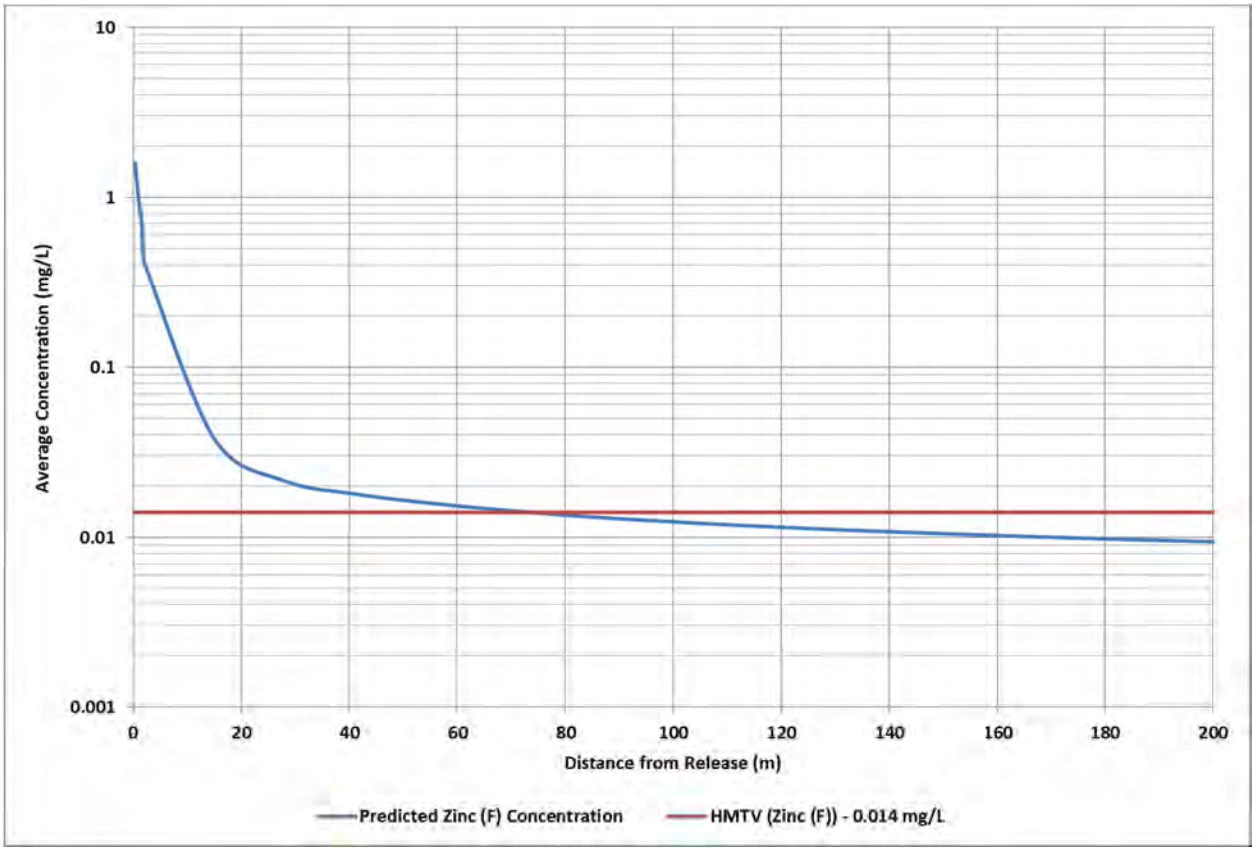


Figure 53 Scenario 3 – Mixing Zone (CORMIX1 Single Port Assessment)

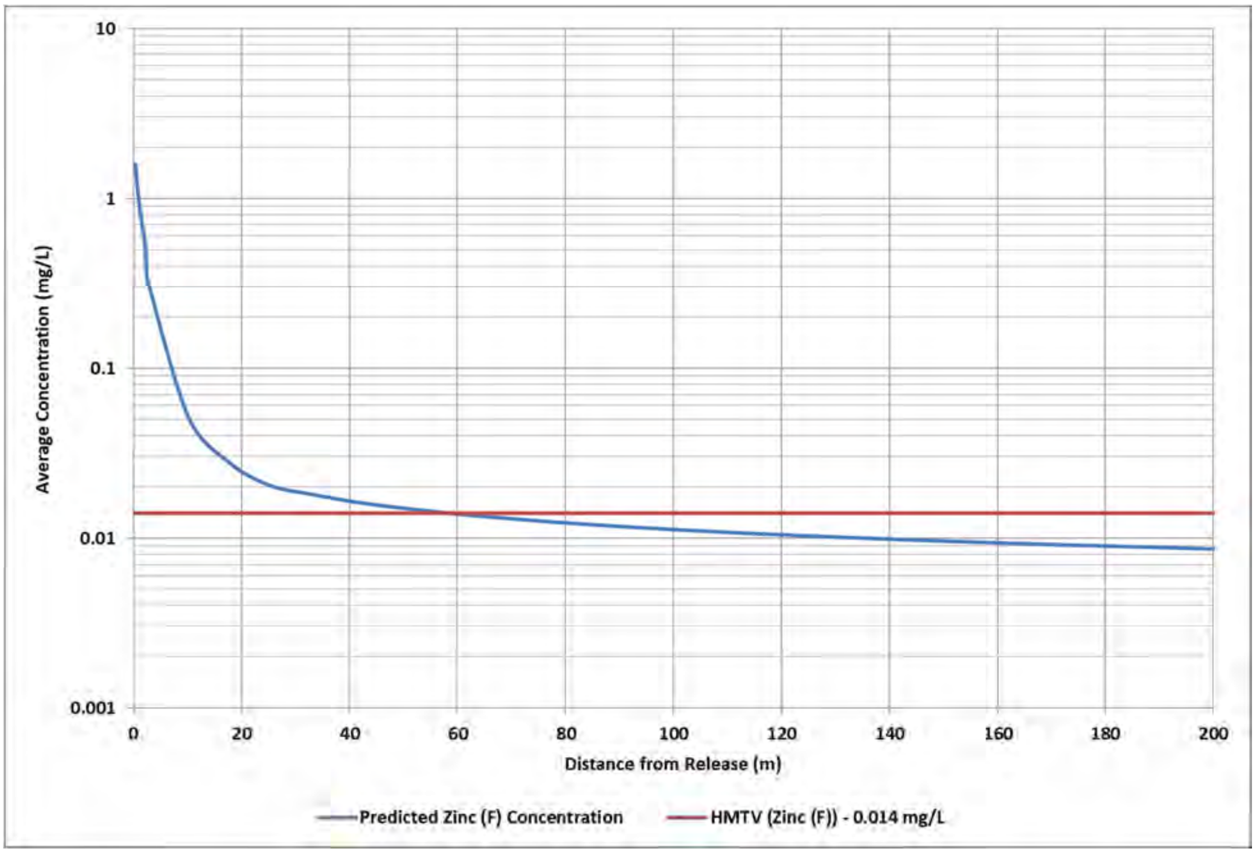


Figure 54 Scenario 4 – Mixing Zone (CORMIX1 Single Port Assessment)

6.2.2 Far Field Assessment of Sustainable Load (Downstream Mass Balance)

A mass balance analysis has been undertaken in order to develop an understanding of the release potential of water from the Project and to assess the sustainable load in terms of frequency, volumes, mass loading and downstream cumulative impact. The analysis has been conducted using water balance assessment as per the model described in Appendix L. Detailed discussion of the model development, assumptions and limitations is also provided in Appendix L.

The following release water quality assumptions were modelled:

1. Assumed release water quality based on the median value of parameters in both pits, mixed at a ratio of nine parts Eldridge to one part Wises, using a receiving environment dilution ratio of 200 parts receiving environment water to one part release water.
2. Assumed release water quality based on the maximum value of parameters in both pits, mixed at a ratio of nine parts Eldridge to one part Wises, using a receiving environment dilution ratio of 200 parts receiving environment water to one part release water.

In terms of other potential catchment pollutant sources, Section 5.4 indicates that 95% of the Gilbert Catchment is comprised of cattle grazing land uses. The only identified potential industrial use of water (apart from Kidston itself) is adjacent to Einasleigh township. Loads associated with these sources have not been accounted for in the mass balance assessment, except where they form part of inflows to the Copperfield River (i.e. water quality monitoring data for tributaries such as East Creek)

In-stream concentrations for each downstream location have only been estimated on those days when releases occurred and have been calculated assuming mass-conserved advective transport only. Concentrations have been estimated for the contaminant of most concern (dissolved zinc) (refer to Section 6.1.1) as well as a number of additional contaminants that are either expected to potentially exceed WQOs during the construction phase or are considered common stressors in the receiving environment.

A number of scenarios were assessed for the assessment as outlined in Table 59 below. Key assumptions are shown in Table 60 with all release parameters based on the contaminant of most concern, dissolved zinc.

For dissolved cadmium and dissolved zinc, the HMTV has been applied up to approximately 7 km downstream of the release location (junction with East Creek) due to the elevated baseline in the receiving environment (median hardness of 56 mg/L at Copperfield River monitoring location W2).

Table 59 Operational Phase Downstream Mass Balance Scenarios Assessed

Scenario	Release Water Quality Assumption	Description	Comment
1a	Median	Annual simulation	Detailed downstream mass balance assessment focused on contaminant of most concern, Dissolved zinc
1b	Maximum		
2a	Median	Life of Project (50 year) simulation	Detailed downstream mass balance assessment focused on contaminant of most concern, dissolved zinc
2b	Maximum		
3a	Median	Annual simulation	Comparative downstream mass balance assessment for: • EC and sulfate, • Cadmium (F), cobalt (F), dissolved zinc, arsenic (T), cobalt (T), manganese (T) and total nitrogen (as N)
3b	Maximum		

Table 60 Operational Phase Downstream Mass Balance – Key Assumptions

Scenario	Release Parameters Derived for Contaminant of Most Concern (Dissolved Zinc)			Assumed Concentration for Contaminant of Most Concern (Dissolved Zinc)
	Dilution Ratio (1 in xx)	Release Ratio	Assimilative Capacity Utilisation	
1a	200	0.5%	27.4%	Median: 0.6298 mg/L
1b	200	0.5%	69.0%	Maximum: 1.5874 mg/L
2a	200	0.5%	27.4%	Median: 0.6298 mg/L
2b	200	0.5%	69.0%	Maximum: 1.5874 mg/L
3a	200	0.5%	27.4%	Median: 0.6298 mg/L plus median concentrations for 8 additional contaminants as detailed in Table 59.
3b	200	0.5%	69.0%	Maximum: 1.5874 mg/L plus maximum concentrations for 8 additional contaminants as detailed in Table 59.

6.2.2.1 Dissolved Zinc Mass Balance Results

The following is a high-level summary of the dissolved zinc mass balance assessment set out in Sections . to 6.2.2.4.

- Scenario 1a: All mass balance calculations for dissolved zinc are below the relevant WQO for 95% species protection (HMTV down to East Creek, and default WQO from Charles Creek to Einasleigh).
- Scenario 2a: All mass balance calculations for dissolved zinc are below the relevant WQO for 95% species protection (HMTV down to East Creek, and default WQO from Charles Creek to Einasleigh).
- Scenario 2b: Under a life of Project maximum (worst-case) scenario, dissolved zinc is below the HMTV for 95% species protection down to East Creek. At Charles Creek, results are slightly above the default WQO for 95% species protection, but well below the WQO for 90% species protection. From Oak Creek to Einasleigh, all results are below the default WQO for 95% species protection.

- Scenario 1a - Annual Mass Balance Simulation for Contaminant of Most Concern - Dissolved Zinc, Median Release Concentration

Table 61 and Figure 55 below show estimated downstream concentrations for dissolved zinc based on releases at the assumed median concentration of 0.6298 mg/L. Results are shown at key tributary inflows on the Copperfield River downstream of the proposed release point with the final point at the confluence with the Einasleigh River at Einasleigh. Estimated concentrations at each location are based on a fully conserved mass balance and assumed 27.4% usage of the available assimilative capacity (as per Table 60).

The mass balance results in Table 61 and Figure 55 show that additional dilution occurs between the proposed release point and Einasleigh. The conservative utilisation of 27.4% of the available assimilative capacity ensures that the mass-balanced concentration is significantly below the WQO at the proposed release point and continues to reduce with increasing downstream distance.

Table 61 Scenario 1a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Annual Simulation, Median Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0055	0.0050	0.0048	0.0044	0.0043	0.0042	0.0032
P5	0.0049	0.0045	0.0042	0.0038	0.0037	0.0036	0.0029
P10	0.0053	0.0048	0.0045	0.0040	0.0038	0.0037	0.0029
P20	0.0055	0.0049	0.0046	0.0042	0.0040	0.0039	0.0030
P50	0.0056	0.0051	0.0049	0.0044	0.0042	0.0041	0.0032
P80	0.0056	0.0053	0.0051	0.0047	0.0046	0.0045	0.0034
P90	0.0056	0.0054	0.0053	0.0050	0.0049	0.0048	0.0037
P95	0.0056	0.0055	0.0054	0.0051	0.0051	0.0050	0.0040
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

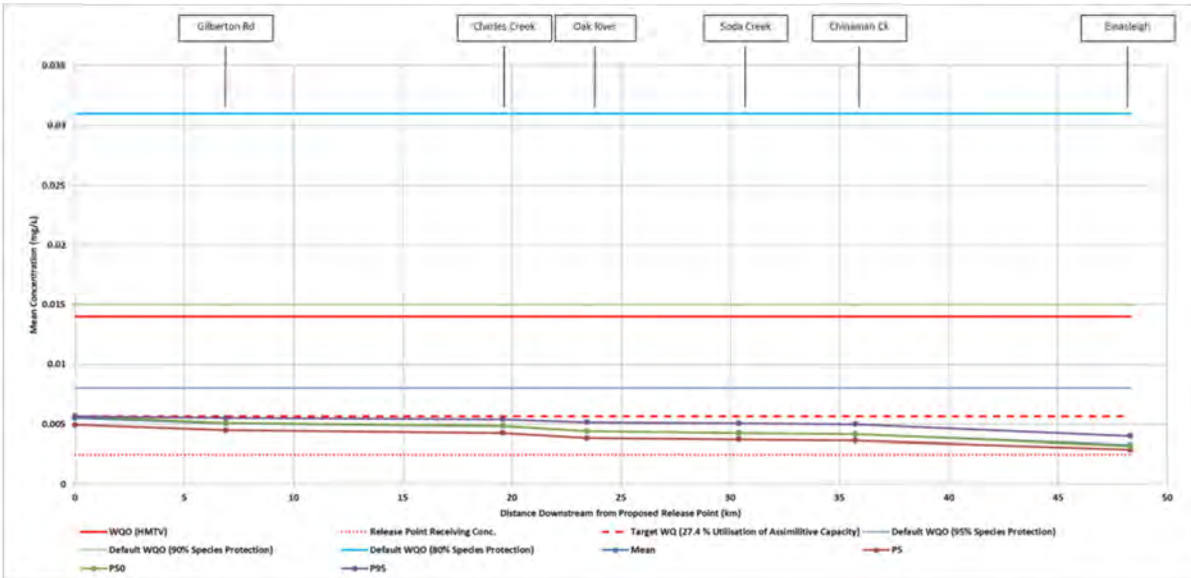


Figure 55 Scenario 1a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Annual Simulation, Median Release Concentration)

6.2.2.2 Scenario 1b - Annual Mass Balance Simulation for Contaminant of Most Concern - Dissolved Zinc, Maximum Release Concentration

Table 62 and Figure 56 below show estimated downstream concentrations for based on releases at the maximum assumed concentration of 1.5874 mg/L. Although the higher release concentration (and utilisation of assimilative capacity (69.0%)) results in a higher concentration at the proposed release point, significant additional dilution occurs between the proposed release point and Einasleigh as a result of tributary inflows.

Table 62 Scenario 1b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Annual Simulation, maximum Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0101	0.0089	0.0084	0.0073	0.0070	0.0068	0.0044
P5	0.0086	0.0075	0.0069	0.0059	0.0056	0.0054	0.0035
P10	0.0097	0.0083	0.0076	0.0062	0.0058	0.0056	0.0036
P20	0.0100	0.0086	0.0079	0.0067	0.0063	0.0061	0.0038
P50	0.0104	0.0091	0.0085	0.0073	0.0069	0.0067	0.0042
P80	0.0104	0.0095	0.0090	0.0080	0.0077	0.0075	0.0049
P90	0.0104	0.0098	0.0095	0.0087	0.0085	0.0083	0.0055
P95	0.0104	0.0100	0.0098	0.0092	0.0089	0.0088	0.0063
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

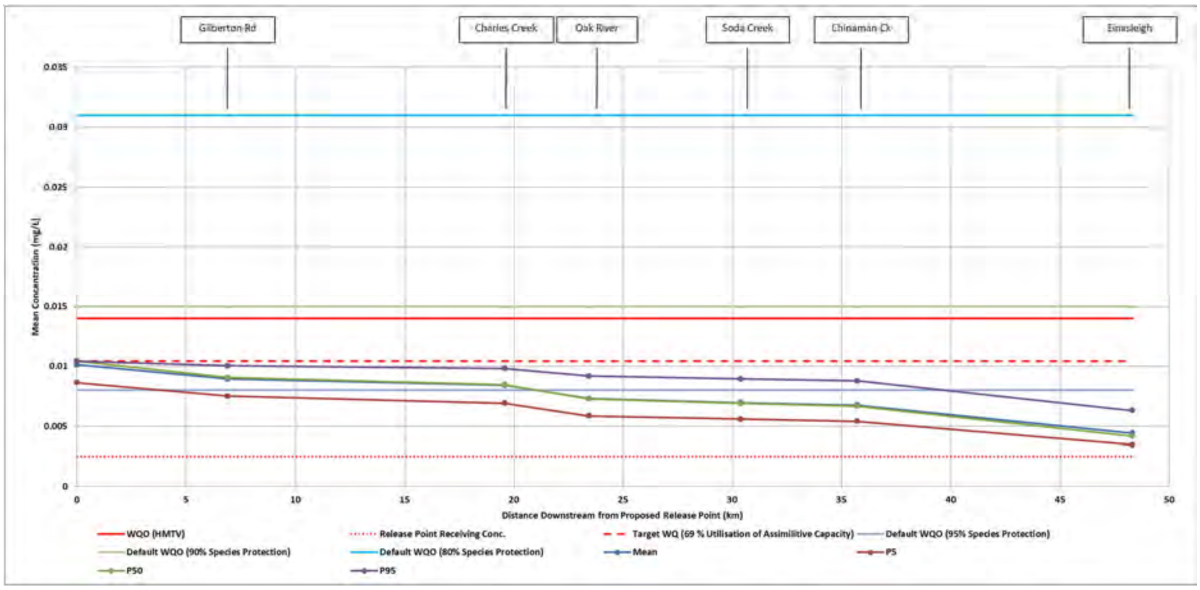


Figure 56 Scenario 1b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Annual Simulation, Maximum Release Concentration)

6.2.2.3 Scenario 2a – Life of Project Mass Balance Simulation (50 Year) for Contaminant of Most Concern - Dissolved Zinc, Median Release Concentration

Table 63 and Figure 57 below again show that significant additional dilution occurs between the proposed release point and Einasleigh although the moderating effect of averaging results over the 50 year life of Project means that results show significantly less variation than Scenario 1a and 1b (annual simulations). Estimated concentrations at each location are based on a fully conserved mass balance and assumed 27.4% usage of the available assimilative capacity (as per Table 60).

Table 63 Scenario 2a - Downstream Mass Balanced Concentrations for Dissolved Zinc (Life of Project (50 yr) Simulation)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0055	0.0050	0.0048	0.0043	0.0042	0.0041	0.0032
P5	0.0054	0.0049	0.0047	0.0043	0.0041	0.0040	0.0031
P10	0.0054	0.0049	0.0047	0.0043	0.0041	0.0041	0.0031
P20	0.0055	0.0050	0.0048	0.0043	0.0042	0.0041	0.0031
P50	0.0055	0.0050	0.0048	0.0043	0.0042	0.0041	0.0032
P80	0.0055	0.0051	0.0048	0.0044	0.0042	0.0042	0.0032
P90	0.0056	0.0051	0.0049	0.0044	0.0042	0.0042	0.0032
P95	0.0056	0.0051	0.0049	0.0044	0.0043	0.0042	0.0032
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

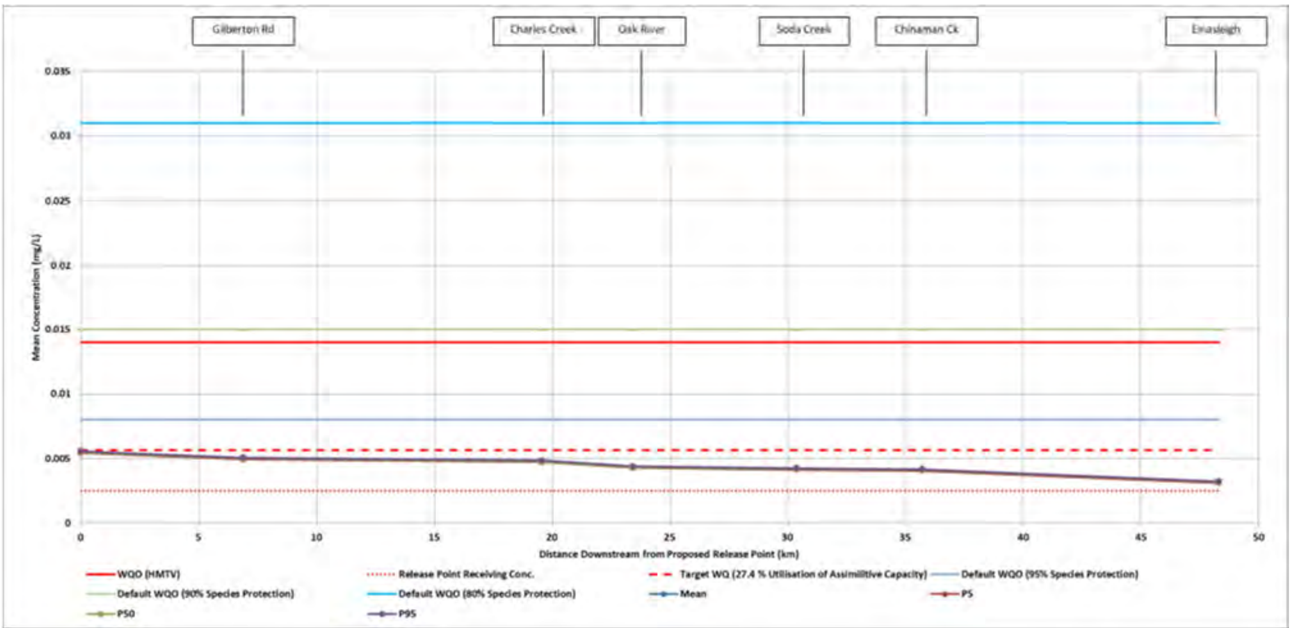


Figure 57 Scenario 2a - Downstream Mass Balanced Concentrations for Dissolved Zinc (Life of Project (50yr) Simulation, Median Release Concentration)

6.2.2.4 Scenario 2b – Life of Project Mass Balance Simulation (50 Year) for Contaminant of Most Concern - Dissolved Zinc, Maximum Release Concentration

Table 64 and Figure 58 below again show that significant additional dilution occurs between the proposed release point and Einasleigh. Estimated concentrations at each location are based on a fully conserved mass balance and assumed 69.0% usage of the available assimilative capacity.

Table 64 Scenario 2b - Downstream Mass Balanced Concentrations for Dissolved Zinc (Life of Project (50 yr) Simulation, Maximum Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0100	0.0088	0.0083	0.0071	0.0068	0.0066	0.0042
P5	0.0098	0.0086	0.0081	0.0070	0.0066	0.0064	0.0041
P10	0.0099	0.0087	0.0081	0.0070	0.0066	0.0064	0.0041
P20	0.0099	0.0087	0.0082	0.0070	0.0067	0.0065	0.0041
P50	0.0100	0.0088	0.0083	0.0072	0.0068	0.0066	0.0042
P80	0.0102	0.0090	0.0084	0.0073	0.0069	0.0067	0.0043
P90	0.0102	0.0090	0.0084	0.0073	0.0069	0.0067	0.0043
P95	0.0102	0.0090	0.0084	0.0073	0.0069	0.0067	0.0044
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

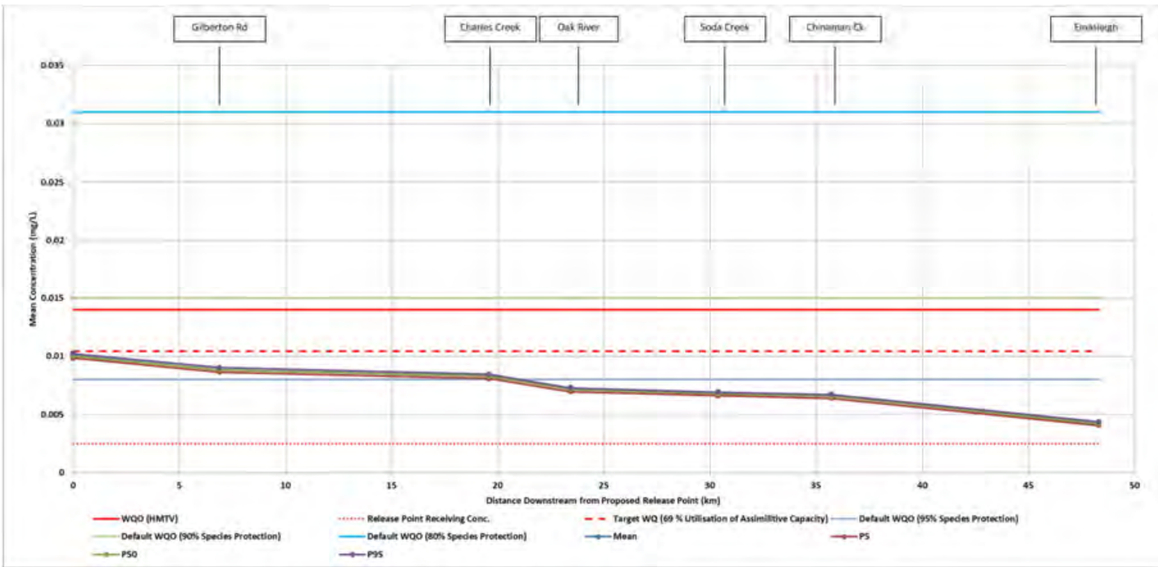


Figure 58 Scenario 2b - Downstream Mass Balanced Concentrations for Dissolved Zinc (Life of Project (50yr) Simulation, Maximum Release Concentration)

6.2.2.5 Scenario 3 – Annual Mass Balance Simulation for Comparative Assessment of Nine Constituents of Most Concern

Results of the annual mass balance simulation for the operations phase are presented in Table 65.

The assessment indicates that parameters relevant to the aquatic ecosystem EV are below the WQO at all locations, with the exception of total nitrogen and dissolved zinc. The concentration of total nitrogen is above the WQO at all modelled locations. It should be noted however that the baseline concentration of total nitrogen at W2 already exceeds the WQO, and there are only two data points available for the pits, therefore this is a low-reliability indication. Further monitoring of total nitrogen will be undertaken as part of the REMP.

Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek (modelled P95 concentrations of 0.009 or 0.010 mg/L compared with the default WQO of 0.008 mg/L). For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment.

Table 65 Operations Phase Mass Balance Results

Description		Median Concentration for Releases (Scenario 3b)									Worst Case Maximum Concentrations for Releases (Scenario 3a)								
Contaminant		Electrical Conductivity @ 25°C	Sulfate as SO_4 - Turbidimetric	Cadmium (F)	Cobalt (F)	Zinc (F)	Arsenic (T)	Cobalt (T)	Manganese (T)	Total Nitrogen as N	Electrical Conductivity @ 25°C	Sulfate as SO_4 - Turbidimetric	Cadmium (F)	Cobalt (F)	Zinc (F)	Arsenic (T)	Cobalt (T)	Manganese (T)	Total Nitrogen as N
Relevant Environmental Value		Aquatic Ecosystems (physico-chemical stressor)	Drinking Water - Aesthetic	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Drinking Water - Health	Long Term Irrigation	Recreation	Aquatic Ecosystems (physico-chemical stressor)	Aquatic Ecosystems (physico-chemical stressor)	Drinking Water - Aesthetic	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Drinking Water - Health	Long Term Irrigation	Recreation	Aquatic Ecosystems (physico-chemical stressor)
Units		µS/cm	mg/L	mg/L*	mg/L	mg/L*	mg/L	mg/L	mg/L	mg/L	µS/cm	mg/L	mg/L*	mg/L	mg/L*	mg/L	mg/L	mg/L	mg/L
Baseline Median at W2		167	10	0.00005	0.0005	0.0025	0.001	0.0005	0.073	0.25	167	10	0.00005	0.0005	0.0025	0.001	0.0005	0.073	0.25
WQO (80% species protection for aquatic ecosystems)		**N/A**	**N/A**	**HMTV 0.0014 [0.0008]**	**N/A**	**HMTV 0.0527 [0.031]**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**HMTV 0.0014 [0.0008]**	**N/A**	**HMTV 0.0527 [0.031]**	**N/A**	**N/A**	**N/A**	**N/A**
WQO (90% species protection for aquatic ecosystems)		**N/A**	**N/A**	**HMTV 0.0007 [0.0004]**	**N/A**	**HMTV 0.0255 [0.015]**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**HMTV 0.0007 [0.0004]**	**N/A**	**HMTV 0.0255 [0.015]**	**N/A**	**N/A**	**N/A**	**N/A**
WQO (95% species protection for aquatic ecosystems)		**500**	**250**	**HMTV 0.0003 [0.0002]**	**0.0028**	**HMTV 0.0140 [0.008]**	**0.0100**	**0.0500**	**0.1000**	**0.1500**	**500**	**250**	**HMTV 0.0003 [0.0002]**	**0.0028**	**HMTV 0.0140 [0.008]**	**0.0100**	**0.0500**	**0.1000**	**0.1500**
Proposed Release Point (0 km)	Mean	180.191	17.921	0.00014	0.001	0.006	0.001	0.001	0.078	0.279	190.5	22.8	0.0002	0.0006	0.010	0.003	0.017	0.090	0.279
	Median	182.075	18.313	0.00014	0.001	0.006	0.001	0.001	0.079	0.280	192.7	23.4	0.0002	0.0006	0.010	0.003	0.018	0.091	0.280
	P95	182.075	18.313	0.00014	0.001	0.006	0.001	0.001	0.079	0.281	192.7	23.4	0.0002	0.0006	0.010	0.003	0.018	0.091	0.281
East Creek (Gilberton Rd) (6.9 km)	Mean	169.345	15.483	0.00012	0.001	0.005	0.001	0.001	0.072	0.273	178.0	19.6	0.0002	0.0006	0.009	0.002	0.015	0.081	0.273
	Median	170.236	15.583	0.00013	0.001	0.005	0.001	0.001	0.072	0.273	179.0	19.8	0.0002	0.0006	0.009	0.002	0.015	0.082	0.273
	P95	178.539	17.513	0.00014	0.001	0.005	0.001	0.001	0.077	0.275	188.7	22.4	0.0002	0.0006	0.010	0.003	0.017	0.088	0.275
Charles Creek (19.6 km)	Mean	164.336	14.358	0.00012	0.001	0.005	0.001	0.001	0.069	0.270	172.3	18.2	0.0002	0.0006	0.008	0.002	0.014	0.078	0.270
	Median	164.878	14.353	0.00012	0.001	0.005	0.001	0.001	0.069	0.270	172.8	18.2	0.0002	0.0006	0.008	0.002	0.014	0.078	0.270
	P95	176.379	17.024	0.00013	0.001	0.005	0.001	0.001	0.075	0.273	186.2	21.7	0.0002	0.0006	0.010	0.003	0.017	0.086	0.273
Oak River (23.4 km)	Mean	154.146	12.073	0.00011	0.001	0.004	0.001	0.001	0.063	0.264	160.6	15.2	0.0001	0.0006	0.007	0.002	0.011	0.070	0.264
	Median	154.197	11.831	0.00011	0.001	0.004	0.001	0.001	0.062	0.264	160.6	14.9	0.0001	0.0006	0.007	0.002	0.011	0.070	0.264
	P95	170.641	15.725	0.00013	0.001	0.005	0.001	0.001	0.072	0.268	179.6	20.0	0.0002	0.0006	0.009	0.002	0.015	0.082	0.268
Soda Creek (30.4 km)	Mean	150.888	11.342	0.00010	0.001	0.004	0.001	0.001	0.061	0.262	156.9	14.2	0.0001	0.0006	0.007	0.002	0.010	0.068	0.262
	Median	150.497	11.035	0.00010	0.001	0.004	0.001	0.001	0.060	0.262	156.3	13.8	0.0001	0.0006	0.007	0.002	0.010	0.067	0.262
	P95	168.375	15.212	0.00012	0.001	0.005	0.001	0.001	0.071	0.266	177.0	19.3	0.0002	0.0006	0.009	0.002	0.015	0.080	0.266
Chinaman Creek (35.7km)	Mean	149.005	10.920	0.00010	0.001	0.004	0.001	0.001	0.060	0.261	154.8	13.7	0.0001	0.0006	0.007	0.002	0.010	0.066	0.261
	Median	148.352	10.587	0.00010	0.001	0.004	0.001	0.001	0.059	0.261	153.9	13.2	0.0001	0.0006	0.007	0.002	0.010	0.065	0.261
	P95	166.950	14.890	0.00012	0.001	0.005	0.001	0.001	0.070	0.265	175.4	18.9	0.0002	0.0006	0.009	0.002	0.014	0.079	0.265
Einasleigh (48.3 km)	Mean	127.152	6.025	0.00007	0.001	0.003	0.001	0.001	0.047	0.249	129.8	7.3	0.0001	0.0005	0.004	0.001	0.005	0.050	0.249
	Median	125.583	5.527	0.00007	0.001	0.003	0.001	0.001	0.046	0.248	127.9	6.5	0.0001	0.0005	0.004	0.001	0.004	0.048	0.248
	P95	144.483	9.805	0.00009	0.001	0.004	0.001	0.001	0.057	0.252	149.6	12.2	0.0001	0.0006	0.006	0.002	0.009	0.062	0.252

*Indicates HMTV. Default WQO presented in brackets.

Red values denote exceedance of WQO (for 95% species protection where multiple levels of protection are available). The HMTV has been applied up to ~7km downstream due to the elevated baseline in the receiving environment (median hardness of 56 mg/L at Copperfield River monitoring location W2).

6.2.3 Assessment of Water Quality Impacts to Environmental Values

Results of the DTA, near-field (CORMIX modelling) and far-field (mass balance) assessments were used to assess the water quality-related impacts to each EV as a result of operational releases. Results are presented in Table 66.

Table 66 Potential Operations Phase Water Quality Impacts to Relevant Environmental Values

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
Aquatic ecosystems (incorporating Habitat value)	From the CORMIX modelling results it can be seen that the proposed releases are subject to initial mixing within the near field and that predicted water quality within the mixing zone reaches the HMTV for dissolved zinc (the constituent of most concern), within 625 m under the worst-case scenario. Other modelled scenarios indicate a much smaller mixing zone of between 50 and 70 m downstream. Mass balance assessment indicates that parameters relevant to the aquatic ecosystem EV are below the WQO at all locations, with the exception of total nitrogen and dissolved zinc. The concentration of total nitrogen is above the WQO at all modelled locations, partly due to the elevated baseline concentrations (also above the WQO). Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek (modelled P95 concentrations of 0.009 or 0.010 mg/L compared with the default WQO of 0.008 mg/L). For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment. The exceedances are within the likely margin of error of the various methods used in the assessment. Whist concentrations of nitrate are elevated in release waters,	Baseline total nitrogen is already elevated in the receiving environment and is thereby contributing to the exceedance of the WQO. Elevated nitrogen concentrations in waterways may under certain circumstances lead to algal blooms, which can impact aquatic ecosystems. Whilst the levels of nitrogen exceed the WQO, the exceedance is not likely to cause such impacts given the nature of the receiving environment and composition of the discharge water, namely the limited availability of phosphorus. Monitoring undertaken as part of the REMP (refer to Section 8.2) will ensure that any impacts are appropriately managed, and if necessary that additional mitigation measures are implemented (see Section 9.3). Nitrate concentrations are expected to be well below the WQO post-release and therefore impacts associated with nitrate are considered negligible. Although there may be rare and very minor exceedances of the 95% level of protection for dissolved zinc from Charles Creek to Einasleigh, the DTA results (refer to Section 4.9) indicate that the proposed releases will not result in toxicity-related impacts to aquatic ecosystems. Under the DTA, a minimum dilution ratio of nine parts receiving environment water to one part release water is required to meet 95% species protection. In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. During the operations and construction phases, the simulated releases are well in excess (200:1) of this minimum dilution ratio. With regards to scour at the outfall contributing to sedimentation, modelling suggests that the increased flow from the releases will not have any significant effect on the hydraulics of the natural system (refer to Section 6.5 below for detail). Detailed design and construction will need to take into consideration the potential for erosion, and ensure that engineering solutions appropriately mitigate this impact to avoid downstream impacts.

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
	concentrations post-release are expected to be well below the WQO for aquatic ecosystem protection post-release during the operations and construction phases (refer to Table 55). It was therefore considered unnecessary to include nitrate in the mass balance assessment.	The potential impacts to the downstream environment from increased erosion and sedimentation associated with the release point are expected to be minimal as construction of this component will be strictly limited to the dry season. During operation, impacts are anticipated to be restricted to the immediate area surrounding and downstream of the release point. Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values. Further, photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point.
Irrigation (Short Term < 20 years)	As set out in Section 5.4, WQOs for short term irrigation do not apply as the lowest applicable WQO for any parameter.	Modelling has shown that more stringent WQOs for other EVs will not be exceeded as a result of Project releases. It therefore concluded that the Project is unlikely to result in impacts to the short term irrigation EV during the operations period when dilution rates are high (200:1).
Irrigation (Long Term ~100 years)	The WQO for total cobalt is specific to the protection of the long term irrigation EV. Modelling has shown that the WQO for total cobalt will not be exceeded post-mixing in the receiving environment.	Impacts to long term irrigation during the operations phase are not anticipated, as concentrations of total cobalt post releases are modelled to be below the relevant WQO for long term irrigation at all downstream locations.
Farm supply (e.g. fruit washing, milking sheds, intensive livestock yards)	As set out in Section 5.4, WQOs for farm supply do not apply as the lowest applicable WQO for any parameter.	The high dilution rate for the operations phase of the Project (200:1) means that all relevant WQOs will be met post-release in the receiving environment. The ANZECC/ARMCANZ 2000 guidelines includes trigger values for assessing the corrosiveness and fouling potential of water. pH and hardness in the releases post-mixing indicates limited potential for both corrosion and fouling potential. Impacts to the farm supply EV in the receiving environment are therefore considered highly unlikely.
Stock watering (e.g. grazing cattle)	As set out in Section 5.4, WQOs for stock watering do not apply as the lowest applicable WQO for any parameter.	ANZECC/ARMCANZ 2000 WQOs for stock watering are presented in Table 29. The worst case concentrations in the receiving environment based on maximum concentrations (Table 55) indicates that WQOs for stock watering will not be exceeded. It therefore concluded that the Project is unlikely to result in impacts to the stock watering EV during the operations period.

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
Aquaculture	This EV was considered and is not applicable to downstream receiving environment	This EV was considered and is not applicable to downstream receiving environment
Human consumption (e.g. of wild or stocked fish)	As set out in Section 5.4, WQOs for human consumption do not apply as the lowest applicable WQO for any parameter.	ANZECC/ARMCANZ 2000 WQOs for human consumption are presented in Table 29. The worst case concentrations in the receiving environment based on maximum concentrations (Table 55) indicates that WQOs for human consumption will not be exceeded. It therefore concluded that the Project is unlikely to result in impacts to the human consumption EV during the operations period.
Primary recreation (fully immersed in water e.g. swimming)	The WQO for total manganese is specific to the protection of the recreation EV. Modelling has shown that the WQO for total manganese will not be exceeded post-mixing in the receiving environment.	Impacts to recreation during the operations phase are not anticipated, as concentrations of total manganese post releases are modelled to be below the relevant WQO for recreation at all downstream locations.
Secondary recreation (possibly splashed with water, e.g. sailing)		
Visual appreciation (no contact with water, e.g. picnics)	No specific WQOs associated with the protection of visual appreciation. See above for recreation.	Modelling has shown that more stringent WQOs for other EVs will not be exceeded as a result of Project releases. It therefore concluded that the Project is unlikely to result in impacts to the visual appreciation EV during the operations period when dilution rates are high (200:1).
Drinking water (raw water supplies taken for drinking)	The WQOs for sulfate and total arsenic are specific to the protection of the drinking water EV (sulfate for aesthetics and arsenic for health). Modelling has shown that the WQO for these parameters will not be exceeded post-mixing in the receiving environment.	Impacts to drinking water during the operations phase are not anticipated, as concentrations of sulfate and total arsenic post releases are modelled to be below the relevant WQO for drinking water at all downstream locations.
Industrial use (e.g. power generation, manufacturing, road maintenance)	As set out in Section 5.4, WQOs for industrial use do not apply as the lowest applicable WQO for any parameter.	Modelling has shown that more stringent WQOs for other EVs will not be exceeded as a result of Project releases. It is therefore concluded that the Project is unlikely to result in impacts to the industrial use EV during the operations period when dilution rates are high (200:1).
Cultural and spiritual values	No specific WQOs associated with the protection of cultural and spiritual values.	It is assumed that by protecting other EVs relevant to the receiving environment, cultural and spiritual values will also be protected.

6.2.4 Conclusions of Water Quality Impact Assessment

An assessment of near-field and far-field water quality modelling and DTA results indicates no significant adverse impacts to EVs relevant to the Project area resulting from operational releases. This is evidenced by the following:

- For operational releases, it is proposed that a maximum of 69% of the assimilative capacity of the receiving environment be utilised (this equates to an effective dilution ratio of 200 parts receiving environment to one part release water). The assumptions behind calculating effective dilution ratios are highly conservative (based on maximum pit water qualities). In reality the actual assimilative capacity usage will be lower than 69% in most cases.
- Parameters relevant to the aquatic ecosystem EV are below WQOs at all locations, with the exception of total nitrogen and dissolved zinc.
- Proposed releases are subject to initial mixing within the near field and predicted water quality within the mixing zone reaches the HMTV for dissolved zinc (the constituent of most concern), within a maximum (worst-case) distance of 625 m. Other modelled scenarios indicate a much smaller mixing zone of between 50 and 70 m downstream.
- Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek (95^{th} percentile concentrations). In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment.
- The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible.
- During the operations phase, the simulated releases are well in excess (200:1) of the minimum dilution ratio for toxicity-related impacts in the receiving environment (9:1).
- Concentrations of parameters relevant to other EVs are all modelled to be below the specified WQO.

Further information regarding potential water quality impacts and mitigation measures is presented in the risk assessment (Section 8.0).

6.3 Hydrology Impact Assessment

The event-based nature of the proposed release of water from the Project is unlikely to alter the existing hydrologic regime as potential releases only will take place when the receiving flow exceeds the flow trigger of 400 ML/d. (McGregor, Marshall, & Takahashi, 2011) suggest assessing changes to the flow regime through the following flow parameters:

- Timing of flows
- Frequency of flows
- Duration of flows
- Magnitude of flows; and
- Rate of rise and fall of flows.

Streamflow data from the GoldSim model (Appendix L) for the Copperfield River at the proposed release point inclusive of potential releases based on the proposed release criteria presented in Section 1.0 has been subjected to a number of different analysis as described below and summarised in Table 67:

1. Analysis of releases and flushes (Section 6.3.1) – assessment of the timing, duration and volume of potential releases as well as the timing, duration and volume of naturally occurring streamflow after cessation of any releases i.e. post-release flushing.
2. Assessment of potential changes to streamflow discharge and flow duration (Section 6.3.2) – deterministic assessment using RAP (v3.08, eWater) to assess potential changes to key environmental flow performance indicators of the Water Plan (Gulf) 2007.
3. Assessment of potential changes to the existing flow regime (Section 6.3.3) – deterministic flow spells analysis using RAP (v3.08, eWater) to assess potential changes to key flow parameters including timing, frequency and duration of flows as well as rates of rise and fall.

Table 67 Hydrology Impact Assessment Summary

Aspect	Scenarios Assessed	Reference
Analysis of releases and flushes	Scenario 1 - annual assessment	Section 6.3.1.1
	Scenario 2 – life of project (50 yr.) assessment	Section 6.3.1.2
Assessment of potential changes to streamflow discharge and flow duration	Single deterministic (1890 to 2017) simulation	Section 6.3.2
Assessment of potential changes to the existing flow regime	Single deterministic (1890 to 2017) simulation	Section 6.3.3

6.3.1 Estimated Releases and Post-Release Flushes

Confirming that sufficient streamflow continues in the Copperfield River after cessation of any potential releases is required to ensure that potential releases continue to move downstream, are subject to ongoing dilutionary inflows and do not become stranded due to natural streamflow recession.

Estimated releases and post-release flushes have been assessed on both an annual basis (Scenario 1) as well as on a life of Project (50 years) basis (Scenario 2). Estimated releases for Scenario 1 and 2 are provided below in Sections 6.3.1.1 and 6.3.1.2 respectively.

6.3.1.1 Scenario 1 - Annual (1 Year) Simulation

Annual controlled release statistics are shown in Table 68:

- There is a large variation in the volume, timing and associated loading of potential releases which is a function of the significant variability in both rainfall and streamflow as described in Sections 5.2.1 and 5.9 respectively. Periods of heavy, frequent and prolonged rainfall are likely to result in significant generation of excess water within the Project and a commensurate requirement to release. This would however predominately be expected to be accompanied by a corresponding increase in receiving flow in the Copperfield River.
- While the median mean annual release volume is estimated to be 294 ML, the P95 and P5 results range from 1,737 ML to 10 ML respectively.
- The median volume released per event is 68 ML and varies from 6 ML (P5 result) to 537 ML (P95 result).
- The mean annual number of release days, events and duration are similarly broadly distributed:
  - The median mean number of release days is estimated to be 33.6 per year and the median number of release events is 4.2 per year with an estimated duration of 7.0 days
  - The P95 number of release days and events is 74.4 and 8.0 respectively with an estimated duration of 19.5 days; and
  - P5 results indicate 3.0 release days and 1.0 release event per year with a duration of 2.1 days.
- Median mean annual loading for the contaminant of most concern (dissolved zinc) is 467 kg and ranges from 16 kg to 2,757 kg (P5 and P95 respectively).

Table 68 Scenario 1 - Annual Controlled Release Statistics (Annual Simulation)

Statistic	Annual Volume Releases	Mean Volume Released per Event	Annual Number of Release Days	Annual Number of Release Events[13]	Mean Release Event Duration	Annual Mass Loading
	ML	ML	days	1/ 1yr	d	kg
Mean	530	152	33.6	4.2	8.9	841
P5	10	6	3.0	1.0	2.1	16
P10	33	14	8.0	1.8	3.0	53
P20	70	22	12.0	2.0	4.1	111
P50	294	68	32.0	4.0	7.0	467
P80	920	207	51.8	6.0	11.9	1,460
P90	1,483	359	64.0	7.0	15.0	2,354
P95	1,737	537	74.4	8.0	19.5	2,757

Confirming that sufficient streamflow continues in the Copperfield River after cessation of any potential releases is required to ensure that potential releases continue to move downstream, are subject to ongoing dilutionary inflows and don't become stranded due to natural streamflow recession.

The post-release flush is the period of continued streamflow in the Copperfield River after a controlled release has ceased. The flush duration is taken from the time of release cessation to commencement of the next release or when flow in the Copperfield reaches zero; whichever is sooner (refer to Figure 59 for an example of how this occurs).

[13] A release event is the occurrence of controlled releases occurring for one or more consecutive days

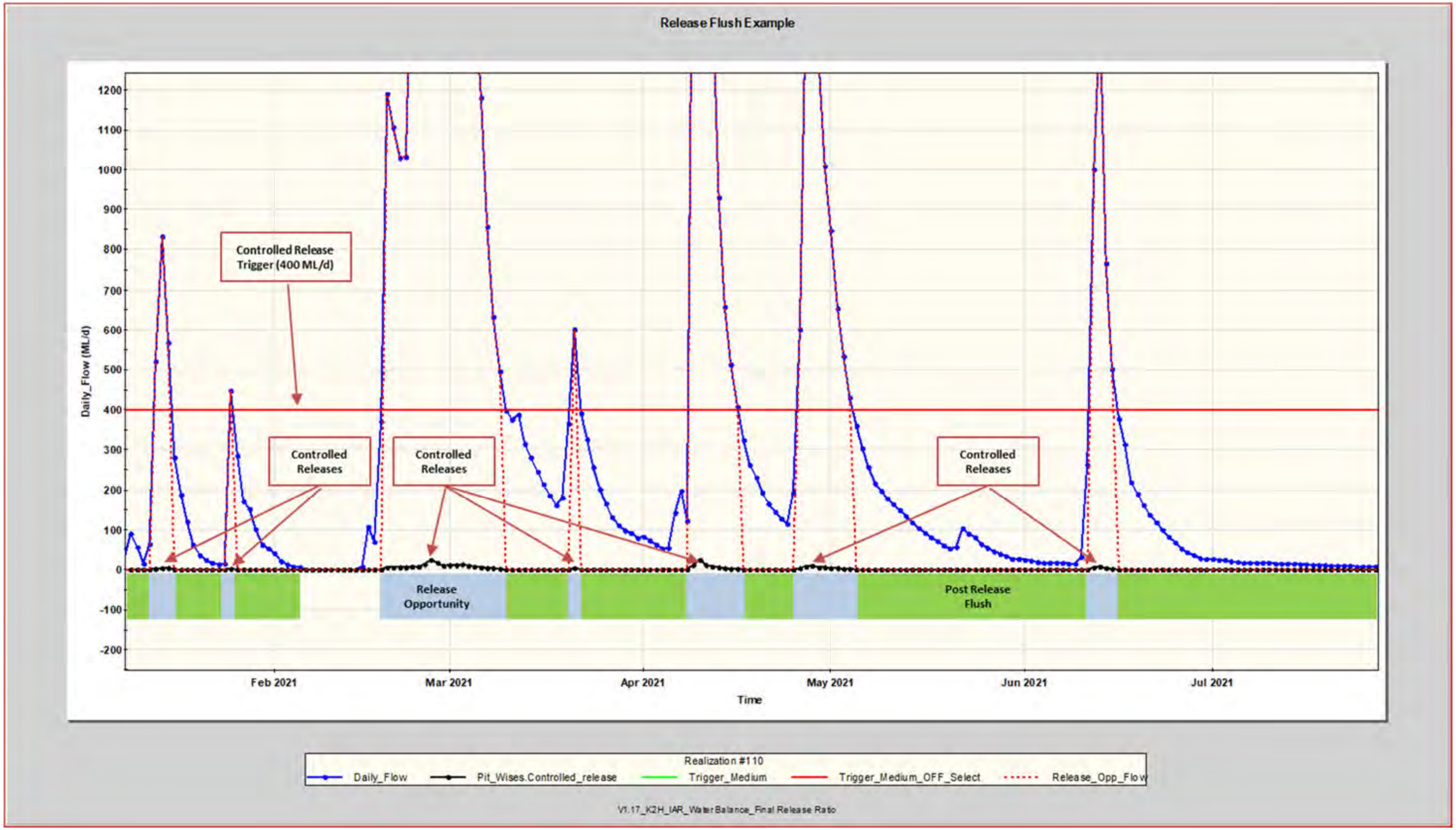


Figure 59 Example of Controlled Releases and Post-Release Flushes

Table 69 provides details of the estimated annual post-release flush afforded by the Copperfield River at the potential release point while Table 70 and Figure 60 show the flush ratio (mean release volume divided by the mean flush volume) from the proposed release point to Einasleigh:

- The median duration of each post release flush at the proposed release point is 32 days with a volume of 1,758 ML (Table 69).
- Reflective of the wide variation in streamflow described in Section 5.9.3, there is a large variation in the duration and volume associated with post-release flushes at the proposed release point which range from 13.6 days/704 ML (P5 result) to 78.0 days/9,895 ML (P95 result) (Table 69).
- The median release to flush ratio at the proposed release point is estimated to be 3.5% with P5 and P95 ratios estimated to be 0.5% and 14.1% (Table 69) respectively i.e. the results show that for 95% of releases, the post release flush at the proposed release point is estimated to exceed 7 times the release volume.
- At increasing distance from the proposed release point, the additional contribution of tributary inflows adds to the post-release flush volume. This provides a continual reduction in the post release flush ratio as shown in Table 70 and Figure 60:
  - The median post-release flush ratio shows continual reduction as distance from the proposed release point increases such that by Einasleigh, the flush ratio has reduced from 3.5% at the proposed release point to 0.6% (Table 70). This indicates that at Einasleigh, for 95% of releases, the post release flush at the proposed release point is estimated to exceed 41 times the release volume.
  - It should be noted that due to the manner in which the post release flush duration is calculated (refer to Section 6.3.1.1), no changes in the mean post release duration are incurred as distance downstream from the proposed release point increases.

Table 69 Scenario 1 - Post-Release Flush Statistics (Annual Simulation, Proposed Release Point)

Statistic	Mean Post Release Flush[14] Duration	Mean Post Release Flush Volume (per Release)	Mean Volume Released per Event	Release to Flush Ratio[15]
	days	ML	ML	%
Mean	35.9	2,709	152	4.8
P5	13.6	704	6	0.5
P10	17.5	830	14	1.1
P20	20.9	1,194	22	1.6
P50	32.0	1,758	68	3.5
P80	43.6	2,916	207	7.4
P90	59.7	4,546	359	9.4
P95	78.0	9,895	537	14.1

[14] The post-release flush is the period of continued streamflow in the Copperfield River after a controlled release has ceased. The flush duration is taken from the time of release cessation to commencement of the next release or when flow in the Copperfield reaches zero; whichever is sooner.
[15] The release to flush ratio is the mean volume per release event divided by the mean flush volume following each release event. The result is expressed as a percentage.

Table 70 Scenario 1 – Post-Release Flush Ratios (Annual Simulation, Proposed Release Point to Einasleigh)

Statistic	Proposed Release Point	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	%	%	%	%	%	%	%
Mean	4.8	3.9	3.5	2.7	2.4	2.3	0.8
P5	0.5	0.5	0.5	0.4	0.4	0.4	0.1
P10	1.1	0.9	0.8	0.6	0.6	0.5	0.2
P20	1.6	1.4	1.2	1.0	0.9	0.8	0.3
P50	3.5	2.9	2.6	2.0	1.8	1.7	0.6
P80	7.4	6.1	5.6	4.1	3.7	3.5	1.3
P90	9.4	8.1	7.4	5.9	5.5	5.2	1.9
P95	14.1	11.0	9.6	7.2	6.3	5.9	2.4
Distance downstream (km)	0.0	6.9	19.6	23.4	30.4	35.7	48.3

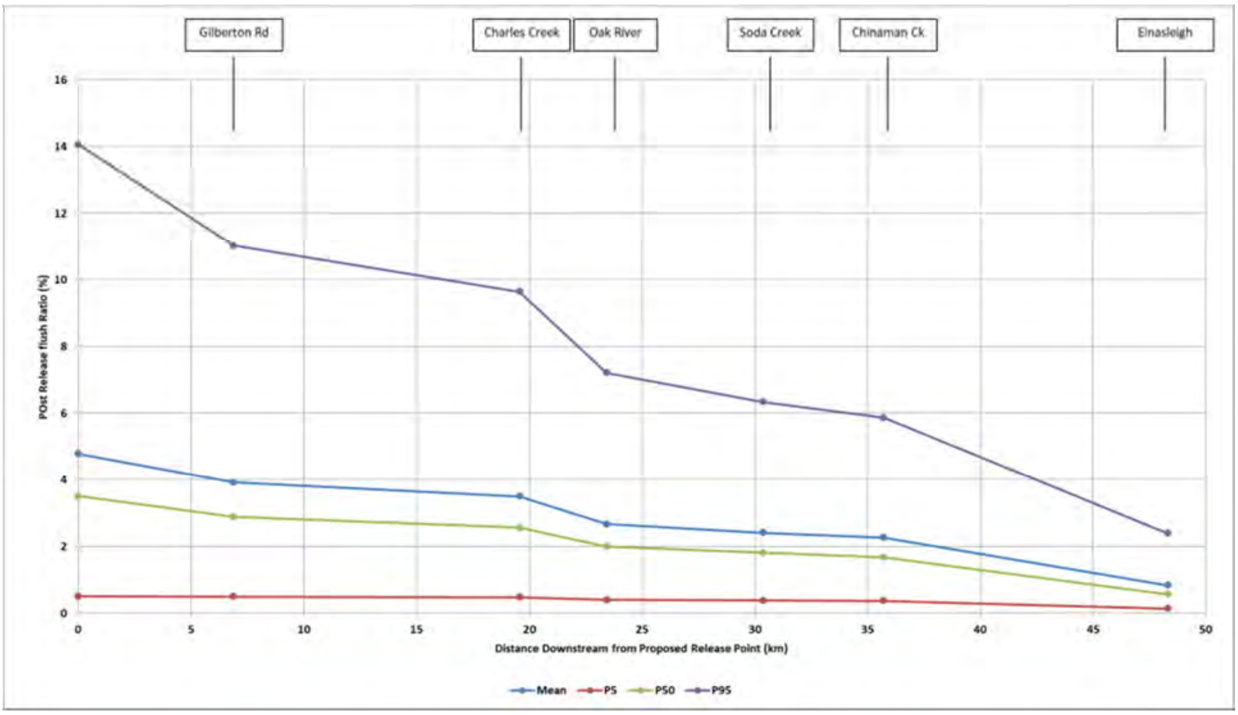


Figure 60 Scenario 1 – Post-Release Flush Ratios (Annual Simulation, Proposed Release Point to Einasleigh)

6.3.1.2 Scenario 2 – Life of Project (50 Year) Simulation

Mean annual controlled release statistics for the 50-year life of Project are shown in Table 71:

- The mean annual results are derived over the 50-year life of Project and consequently there is significantly less variability when compared to the annual (1 year) results (refer to Section 6.3.1.1). The estimated median mean annual release volume is 529 ML with P5 and P95 mean annual volumes of 427 ML and 625 ML respectively.
- The median volume released per event is 126 ML and varies from 99 ML (P5 result) to 151 ML (P95 result).
- The median mean annual number of release days and events is 33.4 days and 4.2 events respectively and the estimated median release duration is 7.9 days.
- Median mean annual mass loading for the contaminant of most concern (Dissolved zinc) is 840 kg and ranges from 678 kg to 992 kg (P5 and P95 results respectively).

Table 71 Scenario 2 – Mean Annual Controlled Release Statistics (Life of Project (50yr) Simulation)

Statistic	Annual Volume Releases	Mean Volume Released per Event	Annual Number of Release Days	Annual Number of Release Events[16]	Mean Release Event Duration	Annual Mass Loading
	ML	ML	days	1/ 1yr	d	kg
Mean	530	127	33.3	4.2	8.0	841
P5	427	99	29.8	3.8	7.0	678
P10	441	103	30.6	3.9	7.1	699
P20	466	109	31.6	4.0	7.5	740
P50	529	126	33.4	4.2	7.9	840
P80	580	145	35.2	4.3	8.6	921
P90	613	148	36.4	4.5	8.8	973
P95	625	151	36.9	4.6	8.9	992

[16] A release event is the occurrence of controlled releases occurring for one or more consecutive days

Table 72 provides details of the estimated annual post-release flush afforded by the Copperfield River at the potential release point while Table 73 and Figure 61 show the flush ratio (mean release volume divided by the mean flush volume) from the proposed release point to Einasleigh:

- The median duration of a post release flush is 31.6 days and has a median volume of 2,867 ML. This ranges from 29.9 days/1,972 ML (P5 result) to 33.9 days/3,679 ML (P95 result).
- As noted previously in Section 6.3.1.1, the volume of receiving flow available after cessation of potential releases provides a significant opportunity for continued down-system movement of released water. The median release to flush ratio is estimated to be 4.5% and does not exceed 6.2% (P95 result). This indicates that at the proposed release point, 95% of releases would be flushed by a minimum of 16 times the release volume.
- At increasing distance from the proposed release point, the additional contribution of tributary inflows adds to the post-release flush volume. This provides a continual reduction in the post release flush ratio as shown in Table 70 and Figure 60:
    - The median post-release flush ratio shows continual reduction as distance from the proposed release point increases such that by Einasleigh, the flush ratio has reduced from 4.5% at the proposed release point to 0.8%. This indicates that at Einasleigh, for 95% of releases, the post release flush at the proposed release point is estimated to exceed 125 times the release volume.
    - It should be noted that due to the manner in which the post release flush duration is calculated no changes in the mean post release duration are incurred as distance downstream from the proposed release point increases.

Table 72 Scenario 2 – Post-Release Flush Statistics (Life of Project (50yr) Simulation)

Statistic	Mean Post Release Flush[17] Duration	Mean Post Release Flush Volume (per Release)	Mean Volume Released per Event	Release to Flush Ratio[18]
	days	ML	ML	%
Mean	31.6	2,761	127	4.7
P5	29.9	1,972	99	3.6
P10	30.3	2,014	103	3.8
P20	30.9	2,164	109	4.0
P50	31.6	2,867	126	4.5
P80	32.2	3,141	145	5.7
P90	32.6	3,611	148	5.9
P95	33.9	3,679	151	6.2

[17] The post-release flush is the period of continued streamflow in the Copperfield River after a controlled release has ceased. The flush duration is taken from the time of release cessation to commencement of the next release or when flow in the Copperfield reaches zero; whichever is sooner.
[18] The release to flush ratio is the mean volume per release event divided by the mean flush volume following each release event. The result is expressed as a percentage.

Table 73 Scenario 2 – Post-Release Flush Ratios (Life of Project (50yr) Simulation, Proposed Release Point to Einasleigh)

Statistic	Proposed Release Point	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	%	%	%	%	%	%	%
Mean	4.7	3.9	3.5	2.7	2.5	2.3	0.8
P5	3.6	3.1	2.9	2.3	2.1	2.0	0.7
P10	3.8	3.3	3.0	2.3	2.1	2.0	0.7
P20	4.0	3.4	3.1	2.4	2.2	2.0	0.7
P50	4.5	3.8	3.4	2.7	2.5	2.3	0.8
P80	5.7	4.6	4.0	3.0	2.7	2.5	0.9
P90	5.9	4.8	4.2	3.1	2.8	2.6	0.9
P95	6.2	5.1	4.5	3.3	3.0	2.8	0.9
Distance downstream (km)	0.0	6.9	19.6	23.4	30.4	35.7	48.3

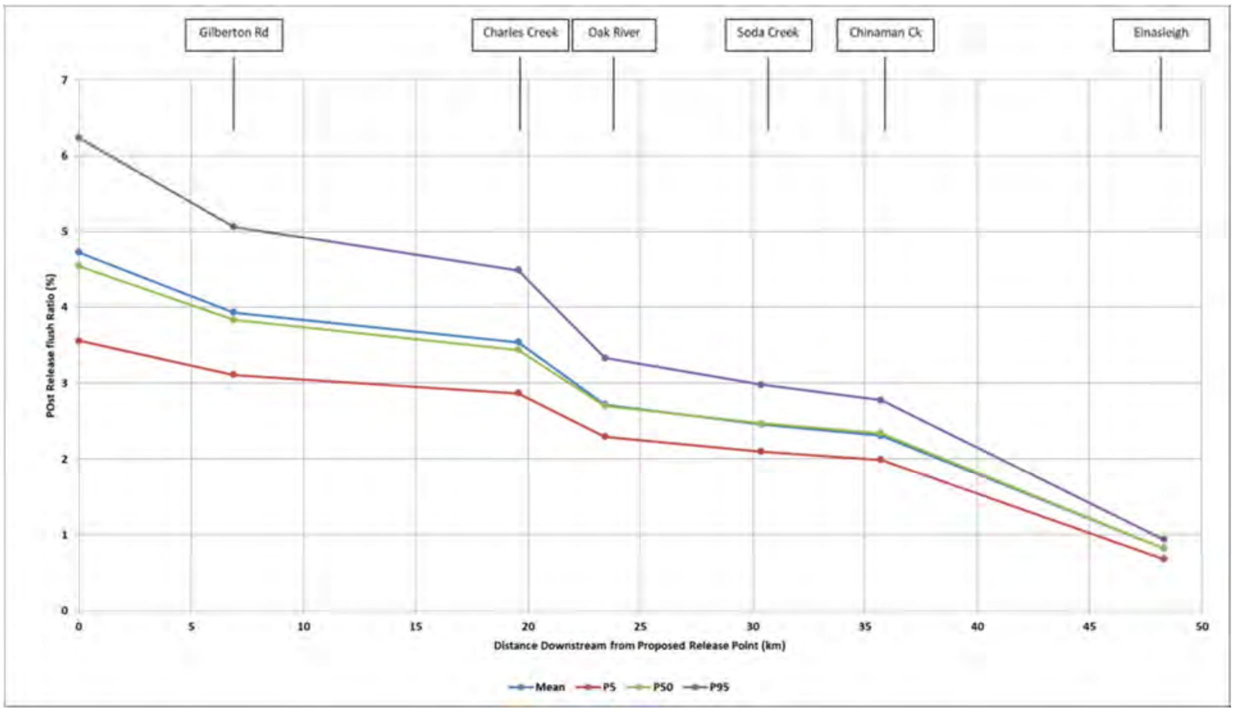


Figure 61 Scenario 2 – Post-Release Flush Ratios (Life of Project (50yr) Simulation, Proposed Release Point to Einasleigh)

6.3.2 Discharge and Flow Duration

Note that the results presented and discussed in the following sections have been based on assessment of deterministic output from the water balance model (Appendix L). The water balance simulation was conducted continuously from 1890 through 2017 with the output analysis using the River Analysis Package (RAP (v3.08).

Table 74 below shows key environmental flow performance indicators of the Water Plan (Gulf) 2007 to assess medium to high modelled streamflow at a node of interest within the WRP Model. Estimated mean and median annual flows show slight increases of 0.53 GL (0.3%) and 0.30 GL (0.5%) respectively as a result of the proposed releases which is consistent with the estimated median mean annual life of Project release volume of 529 ML (refer to Section 6.3.1.2). Event-based flows show a maximum increase for the 1.5 year daily flow of 0.5% reducing to a 0.1% increase for the 20 year event.

Table 74 Water Plan (Gulf) 2007 Performance Indicators – Baseline and with Releases

Indicator*	Units	Discharge			
		Baseline	With Releases	Change	% Change
Mean Annual Flow	GL/yr	162.18	162.71	0.53	0.3%
Median Annual Flow	GL/yr	69.30	69.61	0.31	0.4%
10% Daily Flow	ML/d	391	391	0.00	0.0%
1.5 Year Daily Flow Volume	ML/d	4,674	4,697	22.51	0.5%
5 year Daily Flow Volume	ML/d	30,325	30,413	87.94	0.3%
20 year Daily Flow Volume	ML/d	97,694	97,819	125.41	0.1%

* As per Section 17(b)

Figure 62 below shows annual (hydrological year, November through October) flow duration (representing the likelihood that annual discharge of a specific volume will be equalled or exceeded for any given year). There is no material difference to the annual flow duration curve as a result of the proposed releases. The estimated median mean annual life of project (Section 6.3.1.2) release volume of 529 ML is also shown on the chart for context.

Mean daily discharge for the proposed release point with and without releases is shown below in Figure 63. Daily flows for the dry season months of June through September show no change as a result of the proposed release of water from the Project. During the wet season months of November through May, mean daily flow is slightly increased as a result of potential water releases. The largest increase occurs during the peak wet season month of February when mean daily flow increases from 2,377 ML/d to 2,385 ML/d.

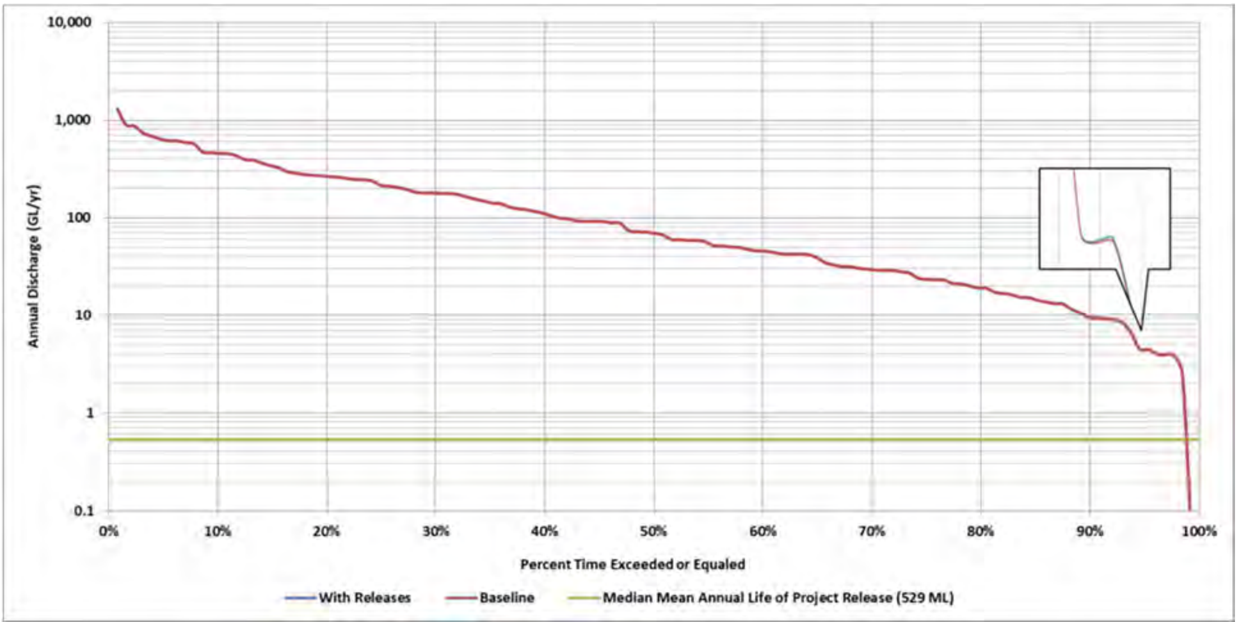
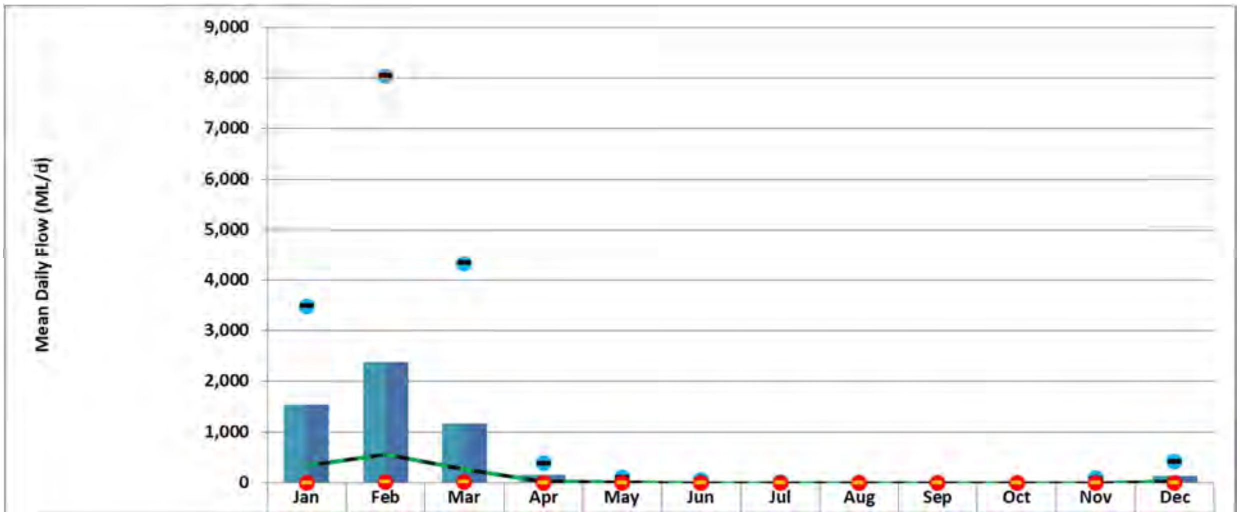


Figure 62 Annual Flow Duration Plot for Copperfield River at Project Site (Water Years Nov – Oct) - Baseline and with Releases



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Mean Baseline	1,545	2,377	1,180	149.9	44.4	22.2	6.4	6.1	3.5	7.3	36.3	146.0
Mean With releases	1,550	2,385	1,184	150.3	44.5	22.2	6.4	6.1	3.5	7.3	36.4	146.5
P90 Baseline	3,482	8,033	4,336	383.6	109.1	56.2	12.9	9.6	3.8	6.2	100.8	424.0
P90 With releases	3,494	8,056	4,357	384.9	109.5	56.2	12.9	9.6	3.8	6.2	101.1	425.9
P50 Baseline	344.8	564.6	273.0	28.6	3.4	0.4	0.1	-	-	0.1	0.7	26.6
P50 With releases	346.4	567.0	274.1	28.6	3.4	0.4	0.1	-	-	0.1	0.7	26.6
P10 Baseline	9.3	21.3	13.2	0.1	-	-	-	-	-	-	-	0.2
P10 With releases	9.3	21.3	13.2	0.1	-	-	-	-	-	-	-	0.2

Figure 63 Mean Daily Discharge for Copperfield River at Project Site - Baseline and with Releases

Daily flow duration for the wet season is shown in Figure 64 below. From the figure it can be seen that the proposed releases have no impact on daily flow duration. The proposed release trigger of 400 ML/d is also shown on the figure for reference. It is reiterated that potential release of water from the Project would not occur whilst receiving flow is below the flow rate.

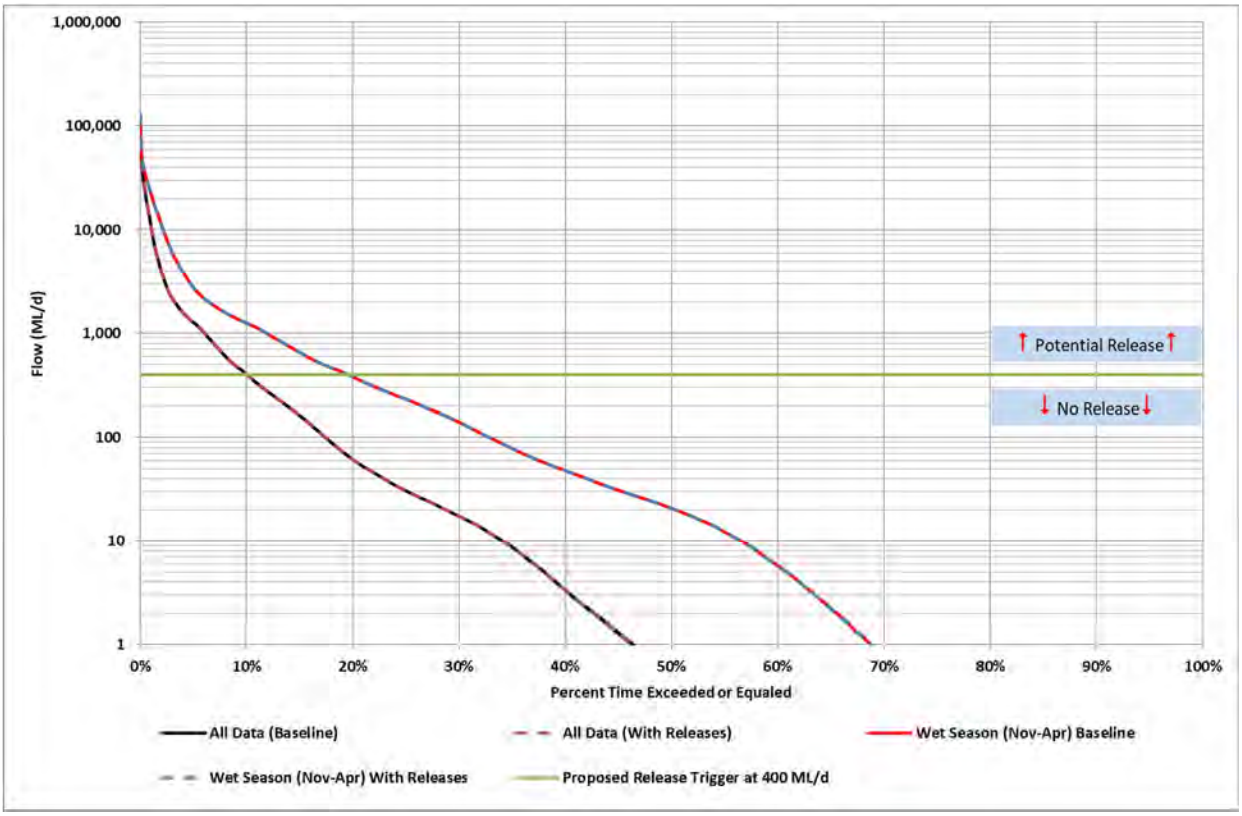


Figure 64 Daily Flow Duration Plot for Copperfield River at Project Site – Baseline and with Releases

6.3.3 Flow Spells

Modelled streamflow data at the proposed release point inclusive of potential releases was subjected to the same statistical analysis as previously described in Section 5.9.3. Adopted definitions are as previously used and are shown in Table 75 below.

Table 75 Flow Spells Assessment – Adopted Definitions

Aspect	Adopted Definition
Seasons	Wet – November through April
	Dry – May through October
Flow Spells	High flow spell - 10%, 5% and 2% daily flow exceedance probability
	Low flow spell – cease to flow condition

Referring to both Table 76 and Table 77:

- There are small changes to the volumetric indicators as a result of the additional water released:
  - The spell threshold for the 5% and 2% events shows slight increases from 1,254 ML/d to 1,260 ML/d and from 3,790 ML/d to 3,809 ML/d due to the additional volumes associated with releases.
  - Discharges for the mean peaks for each spell threshold also show minor increases (Table 76).

- Due to the event-based nature of the proposed releases no changes are noted between the baseline and the baseline with releases (Table 76 and Table 77). This is a result of the proposed releases only occurring during naturally-occurring flow events such that the frequency, duration and timing of flows remain unchanged. Some minor changes to the magnitude of events can be seen which result from the additional water released during a release opportunity.

Table 76 Flow Spells Summary - All Years (Wet Season, Nov-Apr, 1890 to 2017) - Baseline and with Releases

Statistic	Units	High Spell Daily Exceedance Probability						Cease to Flow Condition	
		10%		5%		2%			
		Baseline	Releases	Baseline	Releases	Baseline	Releases	Baseline	Releases
Spell Threshold	ML/d	391	391	1,254	1,260	3,790	3,809	-	-
Number of Spell	Count	509	509	387	388	188	188	1,032	1,032
Longest Spell	Days	123	123	77	77	42	42	272	272
Mean of Spell Peaks	ML/d	6,961	6,980	10,356	10,366	21,398	21,453	-	-
Mean Duration of Spell	Days	9.1	9.1	6.0	6.0	4.9	4.9	19.6	19.6
Mean period Between Spells	Days	82	82	114	113	241	241	25.4	25.4

Table 77 Flow Spells Summary - Inter-Annual Summary (Wet Season, Nov-Apr) - Baseline and with Releases

Statistic	Units	High Spell Daily Exceedance Probability						Cease to Flow Conditions	
		10%		5%		2%			
		Baseline	Releases	Baseline	Releases	Baseline	Releases	Baseline	Releases
Spell Threshold	ML/d	391	391	1,254	1,260	3,790	3,809	-	-
Mean of Wet Season Number of High Spell	Count	3.7	3.7	2.9	2.9	1.5	1.5	8.8	8.8
Mean of Wet Season Longest High Spell	Days	22.4	22.4	11.3	11.2	6.8	6.8	88.3	88.3
Mean of Wet Season Mean Duration of High Spell	Days	11.6	11.6	6.5	6.5	4.5	4.5	21.5	21.5
Mean of Wet Season Mean period Between High Spells	Days	16.6	16.6	16.9	16.9	18.1	18.1	35.7	35.7
Median of Wet Season Number of High Spell	Count	3.0	3.0	3.0	3.0	1.0	1.0	8.0	8.0
Median of Wet Season Longest High Spell	Days	16.0	16.0	9.0	9.0	5.0	5.0	81.5	81.5
Median of Wet Season Mean Duration of High Spell	Days	7.7	7.7	5.0	5.0	4.0	4.0	18.7	18.7
Median of Wet Season Mean period Between High Spells	Days	14.0	14.0	13.0	13.0	13.9	13.9	25.1	25.1

Table 78 shows estimated changes to the rates of rise and fall of flow events which relates to the increase and decrease of flow over time during a storm event. These fluctuations in the flow regime serve important ecological and geomorphic functions in a river system. For example, rapid rates of flow reduction can result in fish stranding and bank erosion and the reproductive success of some species can also be affected by the magnitude and rate of the rise and fall of the flow during breeding seasons (McGregor, Marshall, & Takahashi, 2011).

Some changes to the rate of rise and fall can be seen as a result of the proposed releases however the relative change is rather small. The maximum changes are associated with the mean dry season mean rates of rise and fall which show increases of 2.7% and 2.6% respectively. Potential changes for all other statistics are 2.0% or less.

Table 78 Estimated Changes to Rates of Rise and Fall

Statistic	Units	Baseline	With Releases	Change
Mean rate of Rise	ML/d	523.3	533.9	2.0%
Mean rate of Fall	ML/d	265.3	270.6	2.0%
Mean of Wet Season Mean rate of Rise	ML/d	810.2	813.7	0.4%
Mean of Wet Season Mean rate of Fall	ML/d	403.8	405.4	0.4%
Median of Wet Season Mean rate of Rise	ML/d	309.3	310.8	0.5%
Median of Wet Season Mean rate of Fall	ML/d	139.7	140.5	0.6%
Mean of Dry Season Mean rate of Rise	ML/d	28.1	28.9	2.7%
Mean of Dry Season Mean rate of Fall	ML/d	4.8	5.0	2.6%
Median of Dry Season Mean rate of Rise	ML/d	2.0	2.0	0.0%
Median of Dry Season Mean rate of Fall	ML/d	0.5	0.5	1.7%

6.3.4 Conclusions of Hydrology Impact Assessment

The streamflow record for the proposed release point which includes additional flow as a result of the proposed release conditions outlined in Section 1.0 has been evaluated to assess potential changes to the:

- Timing of flows
- Frequency of flows
- Duration of flows
- Magnitude of flows; and
- Rate of rise and fall of flows.

As a result of the proposed release of water from the Project some minor changes are expected to the magnitude of flows which are a direct result of the additional water added during releases. The magnitude of the increases, however is small and not expected to be of material impact to the existing flow regime.

Due to the event-based nature of the proposed releases, no changes to key temporal indicators (timing, frequency and duration of flow events) were noted as a result of the proposed releases. Some minor increases to the rates of rise and fall were noted however they are not considered to be of sufficient magnitude to result in any adverse impacts.

6.4 Aquatic Ecology Impact Assessment

6.4.1 Water quality

The Project proposes to undertake water releases to the Copperfield River during certain flow events as described in Section 6.2. Such releases have the potential to influence the quality of downstream waters as outlined in Table 65.

Targeted DTA assessments were conducted to determine the required mixing ratios to reduce the potential for environmental harm and ensure 95% species protection is achieved within the receiving environment during operational discharges. The DTA assessment has found that the potential for impacts to aquatic organisms is considered to be relatively low at the dilution ratios and release regimes proposed.

The DTA assessments showed that the dilution ratio to achieve a 95% species protection level ranged from 1:1 (the most likely case) to 1:9 (for a mixture of pit waters composed predominantly from Wises Pit water; i.e. worst case scenario). Proposed releases during the operational phase of the Project exceed this minimum dilution.

The proposed controlled releases will only be undertaken during flow events within the receiving environment with a minimum flow trigger stipulated and the cessation of the release occurring prior to natural flows subsiding to allow for an additional flushing effect.

The proposed release ratio during the operational phase is 200:1, well above that required to achieve 95% species protection. Mixing zone modelling has indicated that the use of a diffused discharge outlet structure will facilitate near field mixing at the outlet such that the WQO for the contaminant of most concern (dissolved zinc) will be met within 625m for the range of scenarios and outlet configurations assessed (most modelled scenarios suggest a mixing zone of between 50 and 70 m downstream). There are no known permanent or semi-permanent pools within 625 m downstream of the release location which could provide refugia for aquatic ecology (refer to Section 5.14). There are no other known sensitive receptors within this mixing zone. All fish species found to be occurring within the Copperfield River display relatively broad tolerances to a wide range of water quality characteristics (refer to Section 3.12.6). However, the macroinvertebrate communities were comprised of families sensitive to environmental change. It is suggested that the adoption and application of appropriate release management strategies, as discussed above, will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values.

A REMP has been drafted (Section 5.2, and Appendix I) which will be developed to monitor the receiving environment for potential impacts from controlled releases. Further, the sensitivity of the macroinvertebrate community suggests it will be an ideal biological indicator for the future Project REMP.

6.4.2 Hydrology

The release of water has the potential to increase flow volumes experienced within the receiving environment. The contribution of flow during the operational phase is considered to be negligible with a release ratio of 200:1.

Assessment of the proposed release regime found that the maximum increase in daily flow volume (compared to natural flows) expected to occur was 1.18%, with mean and median annual flow increases estimated to be 0.44% and 0.88%, respectively. These increases are minor compared to natural variations that would be observed in the system from a year to year basis based on rainfall received.

Many of the fish species that occur in the Copperfield River migrate upstream during the wet season to spawn (refer to Section 3.12.6). Furthermore, macroinvertebrate communities are highly seasonal with water availability and stage in the flow cycle (especially in ephemeral tropical Australian watercourses) a defining factor on their community composition. The extension of flows and/or the permanency of water in the system will allow aquatic flora and fauna to utilise more of the watercourse for a longer period of time each year. Further, if the permanency of water is increased upstream of the Project site, new refuges for aquatic flora and fauna may be developed. This may allow fish to access further upstream (on the Copperfield River or associated tributaries) during subsequent flow events which will last up to an additional nine days. While, if this occurs, it would be considered a change in natural conditions it may not be considered an adverse impact. Note; fish passage will not be reduced by this minor increase in flow. As noted in Section 5.14, there are several identified semi-permanent pools within close proximity to the release location. The majority of waterholes found were minor remnant pools occurring in-channel. Only two substantial pools were noted downstream of the Project site (Pond 5 near W3 and the Sandy Creek site). These two pools have the potential to persist year round, providing refuge to aquatic fauna. The longevity of these pools would be highly correlated with the hydrology of the system on a yearly basis.

As the releases are to be managed to occur as event-based, no changes to key temporal indicators (timing, frequency and duration of flow events) are expected. While some minor increases to the rates of rise and fall are expected, they are not considered to be of sufficient magnitude to result in any adverse impacts to the aquatic ecology values of the system.

6.4.3 Erosion and Sedimentation

Releases have the potential to increase erosion and sedimentation through physical processes/forces. The method in which the water is released (i.e. spillway overtopping, open ended pipe, pump outlet, diffuser, etc.) and the rate can result in scouring of the immediate downstream area and subsequently cause sedimentation further downstream. Erosion and sedimentation processes are known to impact aquatic communities through smothering and the reduction of primary production (Wood & Armitage, 1997; Gleason *et al.*, 2003).

A diffuser will be employed for releases to ensure the mixing rate is maximised. Diffusers also reduce the potential for erosion to occur as a result of the release. The design of the release point and associated diffuser will be finalised during detailed design. However, conceptualisation through CORMIX modelling has shown that appropriate mixing can be achieved, and modelling suggests that the increased flow from the releases will not have any significant effect on the hydraulics of the natural system. Detailed design and construction will need to take into consideration the potential for erosion, and ensure that engineering solutions appropriately mitigate this impact to avoid downstream impacts.

The potential impacts to the downstream environment from increased erosion and sedimentation associated with the release point are expected to be minimal as construction of this component will be strictly limited to the dry season. During operation, impacts are anticipated to be restricted to the immediate area surrounding and downstream of the release point. Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values. Further, photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point.

6.5 Hydraulics and Fluvial Geomorphology Impact Assessment

6.5.1 Hydraulic Impacts Assessment for Releases

The existing condition (base-case) hydraulic model (refer Section 5.10.1) was modified to incorporate the release flow rate into the channel at a release ratio of ratio of 0.503% (based on adopted 200:1 dilution ratio for dissolved zinc). Releases were assumed to be made from the proposed release location as shown by the highlighted cross section in Figure 65 below. The profile for the cross section (7486) is shown in Figure 66.

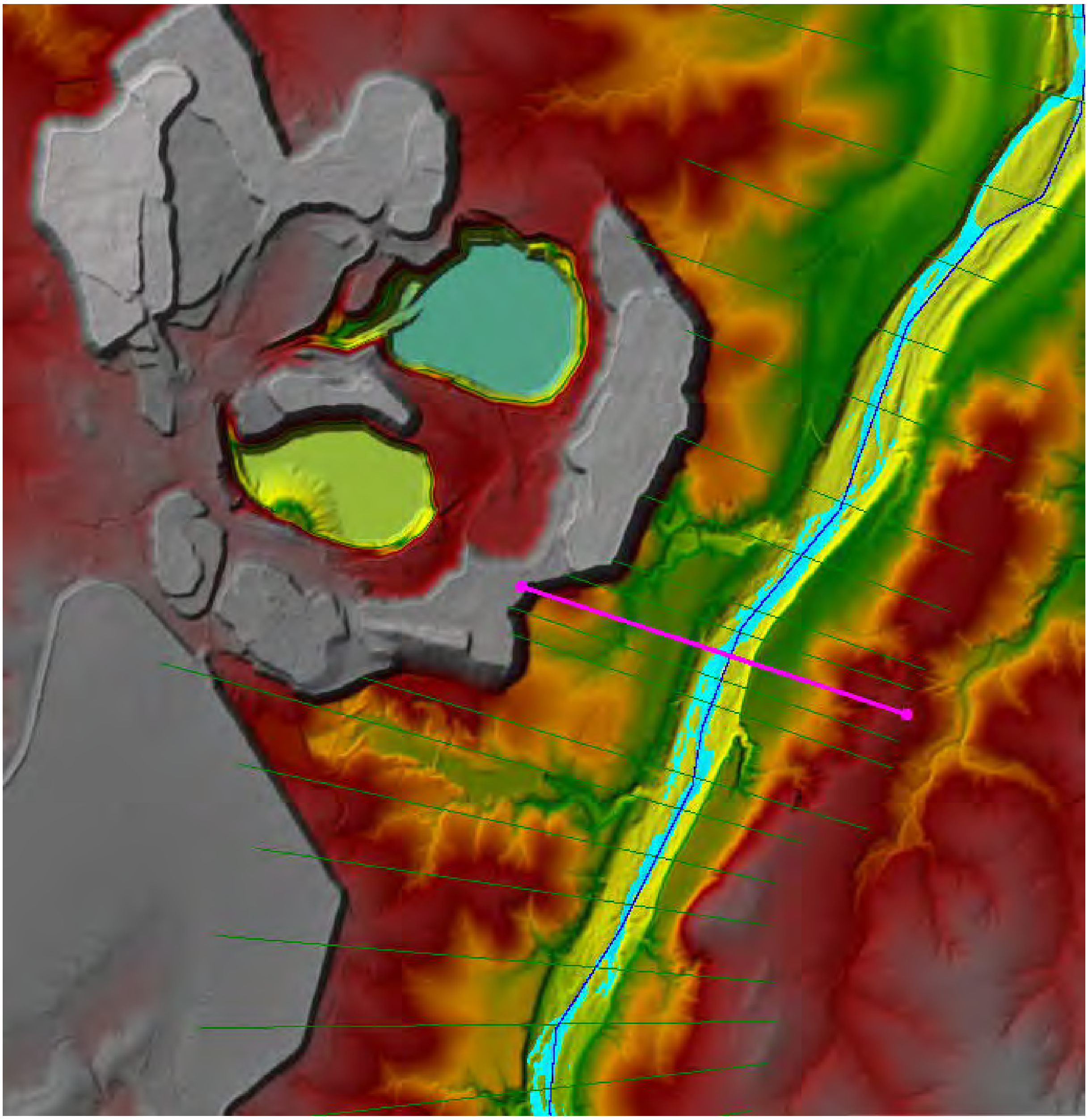


Figure 65 Release Location along channel in HEC-RAS model

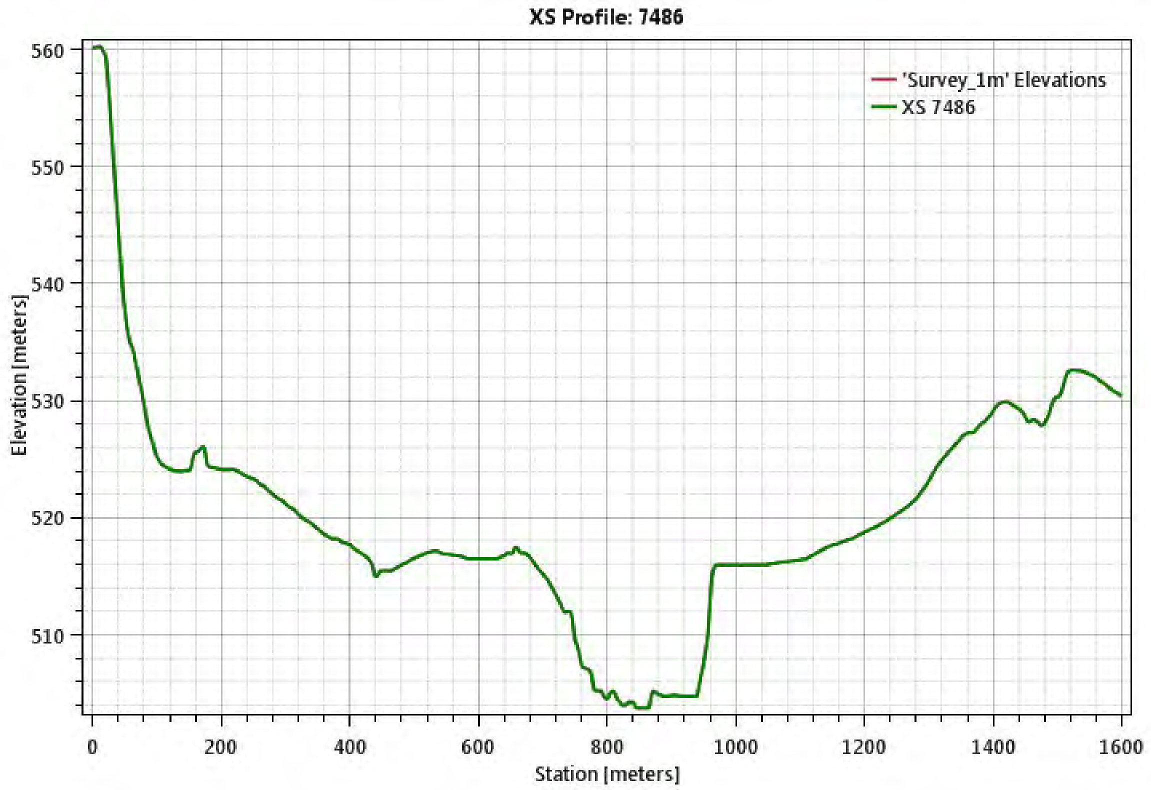


Figure 66 Cross Section of channel at Simulated Release Location

Table 79 below summarises the hydraulic impact assessment scenarios assessed. Release flows are based on an assumed 0.503% release ratio. Mean maximum results value for key hydraulic parameters including velocity, water level, water depth, shear stress, stream power and top width for a 200m reach downstream of the proposed release point were then compared to the receiving flow without the releases to assess potential changes.

Table 79 Impact Scenarios Flows

Hydraulics Assessment Scenario	Description	Receiving flow (m^3/s)	Release flow (m^3/s)	Combined flow (m^3/s)
1	10% receiving flow	4.63	0.024	4.654
2	5% receiving flow	14.7	0.075	14.775
3	2% receiving flow	43.87	0.225	44.095

The results presented in Table 80 show that the proposed release ratio of 0.503% has a negligible impact on the hydraulic characteristics of the channel:

- A maximum change (scenario 2) in water depth of 0.35%
- Maximum increase to shear stress and stream power of 0.27% and 0.43% respectively (scenario 2)
- A maximum increase to channel velocity of 0.31% (scenario 1)
- The estimated increases to water depth are not expected to have a material impact on the integrity of downstream structures or property.

Table 80 Hydraulic Impact Assessment Scenario Results (Mean Results for 200m Reach Downstream of the Proposed Release Point

Parameter	Units	Scenario 1 (10% Receiving Flow)			
		Without Release	Release	Difference	Difference (%)
Water Depth	m	0.29	0.29	0.00	0.00%
Shear Stress	N/m^2	3.68	3.69	0.01	0.23%
Stream Power	N/ms	1.69	1.70	0.01	0.36%
Channel Velocity	m/s	0.45	0.45	0.00	0.31%
Parameter	**Units**	**Scenario 2 (5% Receiving Flow)**			
		Without Release	**Release**	**Difference**	**Difference (%)**
Water Depth	m	0.42	0.42	0.00	0.35%
Shear Stress	N/m^2	5.80	5.81	0.02	0.27%
Stream Power	N/ms	3.57	3.59	0.01	0.43%
Channel Velocity	m/s	0.59	0.59	0.00	0.00%
Parameter	**Units**	**Scenario 3 (2% Receiving Flow)**			
		Without Release	**Release**	**Difference**	**Difference (%)**
Water Depth	m	0.60	0.60	0.00	0.09%
Shear Stress	N/m^2	10.04	10.04	0.00	0.04%
Stream Power	N/ms	8.49	8.50	0.00	0.05%
Channel Velocity	m/s	0.83	0.83	0.00	0.00%

6.5.2 Fluvial Geomorphology

Hydraulic modelling of the proposed releases shows negligible to minor changes to the key hydraulic parameters which are drivers of channel shape and floodplain morphology (e.g. velocity, depth, shear stress and stream power). The estimated changes were found to be negligible and within the bounds of modelling uncertainty for all scenarios. Results for flows with and without the proposed releases are noted be significantly lower than the DRNR 2014 guideline values for stream power, velocity and shear stress (Table 81) which is indicative of the broad channel and downstream of the proposed release location. Once flows exceed the capacity of the low flow channel ongoing increases to streamflow typically result in a greater emphasis in lateral expansion of the flow width rather than increased depth and velocity.

Consequently it is not therefore expected the proposed operational phase releases of water will result in any changes to sediment transport and loads or channel stability – baseline critical shear stress thresholds will not be exceeded more frequently, or for longer, than would otherwise have been the case for a 'no release' scenario. Release volumes as a percentage of the existing flow are sufficiently small that there will be only a negligible increase in overbank events.

Design and construction of the proposed outlet structure will need to make appropriate consideration of the potential for enhanced erosion and scour as a direct result of potential discharge outlet velocities as well as a result of any associated in-stream structures. In order to ensure that erosion and scouring impacts are not occurring a result of operational releases, regular (quarterly) visual inspections of the outlet structure and surrounds are proposed (refer to Section 9.2 for further detail).

Table 81 Guideline Values for Average Stream Powers, Velocity and Shear Stresses for Streams within the Bowen Basin (DNRM, 2014)

Flow	Stream Power (N/ms)	Velocity (m/s)	Shear Stress (N/m^2)
50% AEP (vegetated)	<60	<1.5	<40
2% AEP (vegetated)	<150	<2.5	<50

It is proposed to confirm the location of the actual release point as the Project progresses through detailed design. Key criteria for site selection will include not only consideration of geomorphic stability but additional factors such as riparian vegetation, constructability, accessibility (construction and operation) and the Kidston cultural heritage area.

6.6 Hydrogeology Impact Assessment

During operations the predictive groundwater modelling by AGE, 2019 (Appendix H) indicates that the Eldridge Pit will continue to act as a groundwater sink, reducing seepage migration risks to the north of the Project (and downstream in the Copperfield River).

During operation the water discharged from the Project will contribute a maximum of 0.5% additional flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime. Further groundwater impact considerations during the operational phase are provided in Table 82 below.

Table 82 Potential Impacts of Project Water Discharges

Potential Impact	Operation	Decommissioning	Cumulative
Impacts on water levels affecting GDEs and licensed groundwater users	Limited change in surface water levels during discharge is unlikely to alter surface water-groundwater interaction (refer to Section 5.11.12).	None	None
Water quality alteration of groundwater resources (including alluvial groundwater)	Discharge of water into the Copperfield River is not expected to significantly influence groundwater quality (recharge during high flow events). It is anticipated that by the time that the flow in the Copperfield River has reached the trigger level required prior to discharges commencing that the stream alluvial beds have been largely saturated. The concentrations of key contaminants will be monitored during both construction and operational discharges as part of the additional monitoring. The post discharge flushing will aim to return the water quality in any standing water to baseline condition, monitoring will be undertaken to confirm the efficacy of the discharge flushing. Refer to Section 6.2 for further detail.	None – flush with time	Potential minimal additional groundwater recharge not considered a negative impact on seasonal groundwater resources
Change in groundwater flow, including throughflow impacting on down gradient users	Limited increased groundwater recharge during high flow (discharge) events (refer to Section 5.11.9).	None	Minor additional groundwater recharge not considered a negative impact on seasonal groundwater resources

Potential Impact	Operation	Decommissioning	Cumulative
Water quality alteration of surface water resources	Potential for migration between former mine area and Copperfield River where a hydraulic connection between the fault system and river is present, impacting water quality in semi-permanent pools. Refer to Section 6.2 for further detail.	None	Potential minor impact to surface water quality

As discussed in Section 5.11.8, it is considered that in the instance a hydraulic connection between the fault system and the river is present, there is potential for migration between the former mine area and the Copperfield River. In order to ensure that impacts are not occurring as a result of potential migration between the former mine area and the Copperfield River, ongoing water and sediment quality monitoring is proposed at the following semi-permanent waterhole locations (refer to Section 5.14 for detail regarding these waterholes):

- Pond 3 (approximately 1.4 km upstream of the proposed release location)
- Pond 5 (approximately 5.8 km downstream of the proposed release location).

Furthermore, potential impacts to groundwater will be assessed through ongoing monitoring at bores BA06 and BA07. Further detail regarding monitoring is presented in Section 9.2.

7.0 Impact Assessment – Temporary Construction Releases

7.1 Approach

A comprehensive assessment has been undertaken to develop an understanding of the potential impacts of the Project on the EVs of the receiving environment. The assessment included an impact assessment of both the construction and operational phases of the Project. This section addresses the potential impacts relating to temporary construction releases on water quality, ecology, hydrology, geomorphology and hydrogeology of the receiving environment.

Whilst any construction impacts are considered to be temporary, the development of appropriate discharge limits (similar to operational releases) has been used as a primary mitigation measure to ensure that environmental impacts are appropriately minimised. To achieve this, applicable EVs were used to set WQOs with consideration of practical discharge requirements. Where WQOs were available for more than one EV, the lowest, more stringent value was applied (in most cases, this was associated with the protection of aquatic ecosystems). This approach ensures that relevant EVs are protected, including downstream users of the Copperfield River.

Extensive monitoring as outlined in the REMP (Appendix I) is proposed to be undertaken during the construction and operational phases to ensure potentially unacceptable impacts are identified in a timely manner so that adaptive management of the release regime can respond and where necessary implement further mitigation strategies (refer to Section 9.3).

7.2 Preliminary Construction Phase Assessment

7.2.1.1 Key Objectives

A preliminary construction phase assessment (refer to Appendix K) has been completed with the key objectives of:

- Completing a detailed review of the proposed construction and pit dewatering staging schedule in order to confirm and define:
  - Dewatering volumes and rates
  - Critical dates
  - Key schedule-based objectives
  - Model objective functions – i.e. key metrics with which to compare the relative efficacy of each model scenario.
- Reviewing and developing model assumptions for the transition of Wises Pit from its existing condition as an open cut mine pit with an external (runoff) catchment to its constructed condition with an extensive water surface area and no external catchment.
- Completing a number of model simulations to test the sensitivity of key assumptions (dilution ratio, discharge capacity, catchment area and runoff coefficient for Wises Pit, increases to the storage capacity, FSL and spillway RL of the Wises upper reservoir, and additional water disposal) against adopted model objective functions.

7.2.1.2 Construction Stages and Model Objective Functions

A key requirement of the Project construction phase is the need to dewater the existing Eldridge Pit down to RL 305 m AHD in order to facilitate various construction works associated with both the access and tailrace tunnel construction. Key aspects of the construction phase are summarised in Table 83 and as follows:

- Stage 1 will transfer approximately 7.64 GL (the maximum volume able to be added to Wises Pit at its current capacity) from Eldridge Pit into the Existing Wises Pit.
- Upon completion of the proposed Wises upper reservoir embankment the remaining volume of water (20.39 GL) will be transferred from Eldridge Pit to the fully constructed Wises upper reservoir (stage 2).
- Based on the current water inventory in both pits and without the revised design measures outlined in Section 4.2.2.5 and assessed below, the stage 2 transfer would result in a final water level in the Wises upper reservoir of approximately 552.60 m AHD or approximately 1.1 m above the planned spillway elevation and 1.6m above the FSL:
  - This could result in an estimated construction phase water excess of 1.85 GL if the proposed Wises upper reservoir spillway elevation (551.5 m AHD) is not exceeded by dewatering pumping; or
  - 2.56 GL if the proposed FSL elevation (551 m AHD) is not exceeded by dewatering pumping.

These high excess water volumes were found to be the primary driver in the requirement for a significantly lower dilution ratio and higher maximum discharge capacity when compared to the operational phase. Consequently, further optimisation of the Project design (refer to Section 4.2.2.5) has been completed in include increases to the capacity of the Wises upper reservoir as well as temporary increases to its FSL and spillway RL during the construction phase. This has resulted in a significant reduction in the excess construction water volume and allowed operational phase release criteria to be adopted for the construction phase.

For the purpose of construction phase scenario assessment, the key model objective functions adopted were:

- Target the scheduled stage 2 dewatering duration of 268 days up to the 80th percentile (P80). Due to the whilst adopting the operational phase release conditions (refer to Section 9.1) i.e.:
  - 400 ML/d day release trigger in the Copperfield River at the proposed release location
  - 200 to 1 dilution ratio for dissolved zinc (0.5033% release ratio); and
  - A maximum release capacity of 1.0 m^3/s (86.4 ML/d).

Table 83 Key Construction Phase Stages

Stage	Description	Stage Schedule Details		
		Scheduled Stage Start	Scheduled Stage End	Scheduled Stage Duration (days)
1	Dewatering of Eldridge Pit for safe access to allow main access tunnel construction. Dewatering to continue up to the maximum allowable fill (RL 525m AHD) in the existing Wises Pit without impacting ongoing embankment works.	11/12/2019	16/04/2020	127
2	Final dewatering of Eldridge Pit to the completed Wises upper reservoir. Eldridge lowered to RL suitable for the safe construction of tailrace outlet works (305 m AHD).	18/11/2020	13/08/2021	268
3	Refill of Eldridge Pit to MOL RL (328.4 m AHD)	28/01/2022	11/02/2022	779 (total from start of stage 1 to end of stage 3)

7.2.1.3 Construction Phase Assessment

A total of 30 sensitivities and scenarios (refer to Appendix K) were assessed in order identify how the Project operational phase release conditions outlined above and in Section 9.1 could also be employed during the construction phase whilst still meeting the stage 2 dewatering objective. In summary, this was achieved by:

- Increasing the storage capacity of the Wises upper reservoir by 1.5 GL through the removal of 1.5 Mm^3 of waste rock material from below the MOL;
- Temporarily increasing the Wises upper reservoir spillway RL during the critical part of the construction phase (refer to Section 4.2.2.5) by 300mm to 551.8 m AHD; and
- Temporarily increasing the Wises upper reservoir FSL to 551.7 m AHD during the critical part of the construction phase (refer to Section 4.2.2.5).

The assessment also indicated that possible releases of Genex's existing allocation (4,650 ML) from the Copperfield Dam to augment streamflow in the Copperfield River at the proposed release point would not be required. In addition, it was also assumed that construction activities such as dust suppression and bulk earthworks would consume up to 0.5 ML/d of water from the pits during the construction phase. No uncontrolled (overflow) discharges were noted under the proposed conditions, input climate data and assumed operational rules.

Sensitivity Assessment

Additional modelling scenarios were completed to assess the sensitivity of key model input assumptions regarding the existing Wises Pit catchment area. The sensitivities considered both the runoff coefficient applied to the catchment as well as the size and timing of the catchment as it becomes part of the Wises upper reservoir (and transfers from an external runoff catchment into a direct rainfall catchment). The sensitivity assessment found that the key model result of the estimated stage 2 dewatering duration was relatively insensitive to the Wises Pit runoff catchment area or runoff coefficient.

7.2.1.4 Proposed Construction Phase Release Conditions

Proposed temporary construction phase release conditions are presented in Table 84 below.

Table 84 Proposed Temporary Construction Phase Release Conditions

Aspect	Proposed Condition	Comment
Copperfield River release trigger	400 ML/d	As per operational phase. Releases may be made at any time during the construction phase as long as the receiving flow is in excess of the trigger.
Dilution ratio	200:1	As per operational phase
Release ratio	0.503%	As per operational phase
Release capacity	1 m^3/s	As per operational phase
Temporary spillway RL	551.8 m AHD	For construction phase only
Temporary FSL RL	551.7 m AHD	For construction phase only

7.2.2 Constituents of Most Concern

Applying the adopted construction period dilution ratio of 200:1 for the construction phase, a mass balance assessment has been undertaken to determine the likely concentration in the receiving environment post mixing of a release. This has been undertaken by applying:

1. The maximum concentration of each parameter in the Eldridge Pit
2. The maximum concentration of each parameter observed in both pits and mixing at a ratio of nine parts Eldridge Pit to one part Wises Pit.

These values are considered to be highly conservative given that the maximum value was applied. Results are presented in Table 85.

- Only total nitrogen is predicted to exceed the WQO in the receiving environment post-mixing during the construction period. Elevated baseline concentrations (above the default WQO) are contributing to these exceedances.

Table 85 Worst-Case Final Concentrations of Constituents in Receiving Environment (Construction Phase)

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)		Baseline Receiving Water Concentration (mg/L)[4]	Final Concentration in Receiving Environment for Construction Period Releases (mg/L)	
		Maximum Mixture for Both Pits[2]	Maximum for Eldridge Pit[3]		Maximum Mixture for Both Pits	Maximum for Eldridge Pit
Electrical Conductivity @ 25°C	500	*5311*	*4790*	167	194	191
Total Dissolved Solids (Calc.)		NA		NA	NA	NA
Total Hardness as CaCO3		1809.8	1754	56.2	65.2	65.0
Hydroxide Alkalinity as CaCO3		NA	NA	NA	NA	NA
Carbonate Alkalinity as CaCO3		NA	NA	NA	NA	NA
Bicarbonate Alkalinity as CaCO3		NA	NA	NA	NA	NA
Total Alkalinity as CaCO3		162.1	170	51.5	52.3	52.4
Sulfate as SO4 - Turbidimetric	250	*2690*	*2500*	10	23.5	22.5
Chloride	175	100	91	7	7.5	7.5
Calcium		506.8	495	12	14.5	14.5
Magnesium		132.4	126	7	7.7	7.6
Sodium	115	*318.4*	*287*	10	11.6	11.4
Potassium		51.3	44	2	2.3	2.2
Aluminium (F)	0.57	0.0185	0.02	0.16	0.16	0.16
Arsenic (F)	0.013	*0.1694*	*0.056*	0.0005	0.0013	0.0008
Beryllium (F)[5]	0.00013	0.0005	0.0005	0.0005	0.0005	0.0005

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)		Baseline Receiving Water Concentration (mg/L)[4]	Final Concentration in Receiving Environment for Construction Period Releases (mg/L)	
		Maximum Mixture for Both Pits[2]	Maximum for Eldridge Pit[3]		Maximum Mixture for Both Pits	Maximum for Eldridge Pit
Barium (F)		0.0362	0.036	0.023	0.0232	0.0232
Cadmium (F)	0.0003	*0.02901*	*0.0321*	0.00005	0.0002	0.0002
Chromium (F)	0.0017	0.0005	0.0005	0.0005	0.0005	0.0005
Cobalt (F)	0.0028	*0.0283*	*0.029*	0.0005	0.0006	0.0006
Copper (F)	0.0024	*0.0047*	*0.005*	0.001	0.0010	0.0010
Lead (F)	0.0075	0.0005	0.0005	0.0005	0.0005	0.0005
Manganese (F)	1.9	*2.5868*	*2.86*	0.035	0.048	0.049
Molybdenum (F)	0.034	*0.0623*	*0.06*	0.0005	0.0008	0.0008
Nickel (F)	0.019	*0.0352*	*0.038*	0.0005	0.0007	0.0007
Selenium (F)	0.011	0.005	0.005	0.005	0.005	0.005
Uranium (F)	0.01	NA	NA	NA	NA	
Vanadium (F)	0.006	0.005	0.005	0.005	0.005	0.005
Zinc (F)	0.0136	*1.5874*	*1.75*	0.0025	0.0104	0.0113
Boron (F)	0.37	0.0285	0.025	0.025	0.0251	0.0251
Iron (F)	0.3	0.025	0.025	0.113	0.1131	0.1131
Mercury (F)	0.00006	0.00005	0.00005	0.00005	0.0001	0.0001
Aluminium (T)	1.52	0.234	0.21	0.45	0.4512	0.4511
Arsenic (T)	0.01	*0.368*	*0.26*	0.001	0.0028	0.0023
Beryllium (T)	0.06	0.0005	0.0005	0.0005	0.0005	0.0005
Barium (T)	1	0.0422	0.042	0.027	0.0272	0.0272
Cadmium (T)	0.002	*0.04186*	*0.046*	0.00005	0.0003	0.0003
Chromium (T)	0.05	0.00055	0.0005	0.0005	0.0005	0.0005

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)		Baseline Receiving Water Concentration (mg/L)[4]	Final Concentration in Receiving Environment for Construction Period Releases (mg/L)	
		Maximum Mixture for Both Pits[2]	Maximum for Eldridge Pit[3]		Maximum Mixture for Both Pits	Maximum for Eldridge Pit
Cobalt (T)	0.05	*3.5151*	*3.84*	0.0005	0.0181	0.0197
Copper (T)	0.2	0.061	0.06	0.002	0.0023	0.0023
Lead (T)	0.01	*0.1723*	*0.19*	0.0005	0.0014	0.0015
Manganese (T)	0.1	*3.622*	*3.77*	0.073	0.0911	0.0919
Molybdenum (T)	0.01	*0.122*	*0.1*	0.0005	0.0011	0.0010
Nickel (T)	0.02	*0.0505*	*0.045*	0.0005	0.0008	0.0007
Selenium (T)	0.01	NA	NA	NA	NA	NA
Uranium (T)	0.01	NA	NA	NA	NA	NA
Vanadium (T)	0.1	NA	NA	NA	NA	NA
Zinc (T)	2	*2.352*	*2.28*	0.0025	0.0143	0.0139
Boron (T)	0.5	NA	NA	NA	NA	NA
Iron (T)	0.43	0.3065	0.225	0.22	0.2215	0.2211
Mercury (T)	0.001	0.00005	0.00005	0.00005	0.0001	0.0001
Free Cyanide	0.08	NA	NA	NA	NA	NA
Total Cyanide		NA	NA	NA	NA	NA
Weak Acid Dissociable Cyanide		NA	NA	NA	NA	NA
Fluoride	1	*3.03*	*2.8*	0.2	0.2152	0.2140
Ammonia as N	0.5	0.211	0.2	0.02	0.0211	0.0210
Nitrite as N	1	0.005	0.005	0.005	0.0050	0.0050
Nitrate as N	0.7	*4.935*	*5.45*	0.0325	0.0572	0.0598
Nitrite + Nitrate as N		NA	NA	NA	NA	NA

Parameter	WQO (mg/L)[1]	Release Water Concentration (EOP) (mg/L)		Baseline Receiving Water Concentration (mg/L)[4]	Final Concentration in Receiving Environment for Construction Period Releases (mg/L)	
		Maximum Mixture for Both Pits[2]	Maximum for Eldridge Pit[3]		Maximum Mixture for Both Pits	Maximum for Eldridge Pit
Total Kjeldahl Nitrogen as N		NA	NA	NA	NA	NA
Total Nitrogen as N[5]	0.15	*6.39*	*7*	0.25	0.2820	0.2850
Total Phosphorus as P	0.01	*0.0315*	*0.025*	0.005	0.0052	0.0051
Reactive Phosphorus as P		NA		NA	NA	NA

[1] Including site-specific WQOs and HMTVs as presented in Section 5.6.12.

[2] Maximum value for Eldridge Pit and Wises Pit, mixed at 9 parts Eldridge to 1 part Wises

[3] Maximum value for Eldridge Pit

[4] Median value for W2 (based on data collected since 2012)

[5] Baseline receiving environment concentration (or LOR) above WQO.

NA = No data available

Red italicised values denote an exceedance of the WQO in the release water (i.e. prior to release). This does not necessarily indicate that concentrations in the receiving environment will also be above the WQO.

Grey shaded values denote an exceedance of the WQO post-release.

7.3 Water Quality Impact Assessment

Potential impacts to water quality associated with temporary construction releases are as follows:

1. Increased water temperature and reducing natural thermal variability.
2. Scouring of Copperfield River near the temporary outfall or diffuser location resulting in increased sediment suspension.
3. Increased toxicant loads in Copperfield River resulting in adverse impacts to aquatic ecosystems.
4. Impacts to drinking water quality.
5. Visual impact at Einasleigh Gorge, through precipitation of dissolved contaminants.
6. Residual water quality changes following discharge events, pooling in Copperfield River.
7. Accumulation of contaminants in sediment.
8. Water quality changes in Pit water as level in Eldridge Pit falls and exposes pit walls.

In order to assess whether these impacts are likely to occur the following key tasks were undertaken:

a. A mass balance analysis has been undertaken in order to develop an understanding of the mass loading at various locations from the release point down to Einasleigh. Mass balance modelling was undertaken for selected key constituents. Detail is presented in Section 7.3.2 and Section 7.3.3. Near-field CORMIX modelling was not undertaken for temporary construction releases, as mass balance calculations have indicated that the concentration of the constituent of most concern (dissolved zinc) will be similar to operational releases.
b. Results of the far-field (mass balance) assessments described above were used to assess the water quality-related impacts to each EV.

7.3.1 Near Field Mixing Zone Assessment

As the Project construction phase will utilise the same release conditions as those proposed for the operational phase additional CORMIX near field modelling has not been completed for the construction phase. The CORMIX modelling previously undertaken for the operational phase is considered to be applicable to the temporary construction phase. Construction phase releases will be made under the same release criteria and consequently it is expected that any additional assessment will result in the same rate of nearfield mixing as that previously estimated in Section 6.2.1. CORMIX modelling completed for the operational phase (Section 6.2.1) has shown that near field mixing of released water can meet downstream WQOs under a range of potential release conditions and conceptual outlet arrangements

As outlined in Section 4.1.2, design and construction of the operational phase outlet works has been identified for early works however, in the unlikely event that the works are not complete prior to this, initial releases during the construction phase may be via a simple outfall structure (incorporating relevant erosion and sedimentation control measures). This is necessary for the Project to take advantage of potential release opportunities as soon as the construction phase commences. It is anticipated that this would only be required for a short period during the first wet season of the construction phase prior to commissioning of the operational phase release infrastructure.

Ongoing releases during the remainder of the construction phase are anticipated to be via the completed operational phase release infrastructure (instream diffused, outlet structure). Any temporary outfall structure would subsequently be decommissioned and removed as soon as practical following commissioning of the operational phase outlet works.

7.3.2 Far Field Assessment of Sustainable Load (Mass Balance)

A mass balance analysis has been undertaken in order to develop an understanding of the release potential of water from the Project and to assess the sustainable load in terms of frequency, volumes, mass loading and downstream cumulative impact. The analysis has been conducted using water balance assessment with development of the model described in Appendix L.

Estimated downstream dilution of released water by tributary and residual inflows has been assessed for the following construction phase scenarios:

- Assumed release water quality based on the median value of parameters in the Eldridge Pit, using a receiving environment dilution ratio of 200 parts receiving environment water to one part release water (scenario 3a, refer to Table 86 below).
- Assumed release water quality based on the maximum value of parameters in the Eldridge Pit, using a receiving environment dilution ratio of 200 parts receiving environment water to one part release water (scenario 3b, refer to Table 86 below).
- Assumed release water quality based on the median value of parameters in both pits, mixed at a ratio of nine parts Eldridge to one part Wises, using a receiving environment dilution ratio of 200 parts receiving environment water to one part release water (scenario 4a, refer to Table 86 below).
- Assumed release water quality based on the maximum value of parameters in both pits, mixed at a ratio of nine parts Eldridge to one part Wises, using a receiving environment dilution ratio of 200 parts receiving environment water to one part release water (scenario 4b, refer to Table 86 below).

In-stream concentrations for each downstream location have only been estimated on those days when releases occurred and have been calculated assuming mass-conserved advective transport only. A number of scenarios were considered for the assessment as outlined in Table 86 below. Key assumptions are shown in Table 87 with all release parameters based on the contaminant of most concern, dissolved zinc.

For dissolved cadmium and dissolved zinc, the HMTV has been applied up to approximately 7 km downstream of the release location (junction with East Creek) due to the elevated baseline in the receiving environment (median hardness of 56 mg/L at Copperfield River monitoring location W2).

Table 86 Construction Phase Downstream Mass Balance Scenarios Assessed

Scenario	Release Water Quality Assumption	Comment
1a	Median	Detailed downstream mass balance assessment focussed on contaminant of most concern, dissolved zinc in releases of water from Eldridge Pit only
1b	Maximum	
2a	Median	Detailed downstream mass balance assessment focussed on contaminant of most concern, dissolved zinc in release of water from both pits mixed at a ratio of nine parts Eldridge to one part Wises
2b	Maximum	
3a	Median	Comparative downstream mass balance assessment of releases from Eldridge Pit only for: • EC and sulfate, • Cadmium (F), cobalt (F), dissolved zinc, arsenic (T), cobalt (T), manganese (T) and total nitrogen (as N)
3b	Maximum	
4a	Median	Comparative downstream mass balance assessment of releases mixed pit water at a ratio of nine parts Eldridge to one part Wises for: • EC and sulfate, Cadmium (F), cobalt (F), zinc (F), arsenic (T), cobalt (T), manganese (T) and total nitrogen (as N)
4b	Maximum	

Table 87 Construction Phase Downstream Mass Balance – Key Assumptions

Scenario	Release Parameters Derived for Contaminant of Most Concern (Dissolved Zinc)			Assumed Concentration for Contaminant of Most Concern (Dissolved Zinc)
	Dilution Ratio (1 in xx)	Release Ratio	Assimilative Capacity Utilisation	
1a	200	0.5%	29.9%	Median Eldridge: 0.688 mg/L
1b	200	0.5%	76.3%	Maximum Eldridge: 1.750 mg/L
2a	200	0.5%	27.4%	Median mixed release: 0.6298 mg/L
2b	200	0.5%	69.0%	Maximum mixed release: 1.5874 mg/L
3a	200	0.5%	Dependant on contaminant. Maximum of 29.9% for dissolved zinc.	Median Eldridge Pit concentrations for all 9 contaminants as detailed in Table 86.
3b	200	0.5%	Dependant on contaminant. Maximum of 76.3% for dissolved zinc.	Maximum Eldridge Pit concentrations for all 9 contaminants as detailed in Table 86.
4a	200	0.5%	Dependant on contaminant. Maximum of 27.4% for dissolved zinc.	Median concentrations from both pits mixed at a ratio of nine parts Eldridge to one part Wises for all 9 contaminants as detailed in Table 86.
4b	200	0.5%	Dependant on contaminant. Maximum of 69.0% for dissolved zinc.	Maximum concentrations from both pits mixed at a ratio of nine parts Eldridge to one part Wises for all 9 contaminants as detailed in Table 86.

Detailed mass balance results for dissolved zinc for scenarios 1a to 2b are presented in Sections 7.3.3.1 to 7.3.3.4 below. Mass balance results for scenarios 3a to 4b are presented in Section 7.3.3.5 and a summary discussion is presented in Section 7.3.5.

7.3.3 Dissolved Zinc Mass Balance Results

Sections 7.3.3.1 to 7.3.3.4 below present results for the dissolved zinc mass balance assessment (scenarios 1a to 2b):

- Scenario 1a: All mass balance calculations for dissolved zinc are below the HMTV (release point to East Creek) or default WQO (Charles Creek to Einasleigh) for 95% species protection.
- Scenario 1b: Mass balance calculations for dissolved zinc indicate that concentrations will be below the HMTV at the release point down to East Creek. There may be minor exceedances of the default WQO from East Creek to Chinaman Creek (approximately 36 km downstream), however given this is a 'maximum' modelled value, the likelihood of these concentrations being released is very low. All results for this scenario are below the guideline for 90% species protection.
- Scenario 2a: All mass balance calculations for dissolved zinc are below the HMTV (release point to East Creek) or default WQO (Charles Creek to Einasleigh) for 95% species protection.

- Scenario 2b: All mass balance calculations for dissolved zinc are below the HMTV at the release point down to East Creek. There may be minor exceedances of the default WQO from East Creek to Charles Creek (approximately 20 km downstream), however given this is a 'maximum' modelled value, the likelihood of these concentrations being released is very low. All results for this scenario are below the guideline for 90% species protection.

7.3.3.1 Scenario 1a – Median Eldridge Concentration for Dissolved Zinc

Table 88 Scenario 1a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Eldridge Pit, Median Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0059	0.0053	0.0051	0.0046	0.0044	0.0044	0.0033
P5	0.0057	0.0051	0.0048	0.0043	0.0041	0.0040	0.0030
P10	0.0057	0.0052	0.0049	0.0043	0.0041	0.0041	0.0031
P20	0.0058	0.0052	0.0050	0.0044	0.0042	0.0041	0.0031
P50	0.0059	0.0053	0.0051	0.0046	0.0044	0.0044	0.0033
P80	0.0059	0.0054	0.0052	0.0048	0.0046	0.0045	0.0034
P90	0.0059	0.0055	0.0053	0.0048	0.0047	0.0046	0.0036
P95	0.0059	0.0055	0.0053	0.0050	0.0049	0.0048	0.0037
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

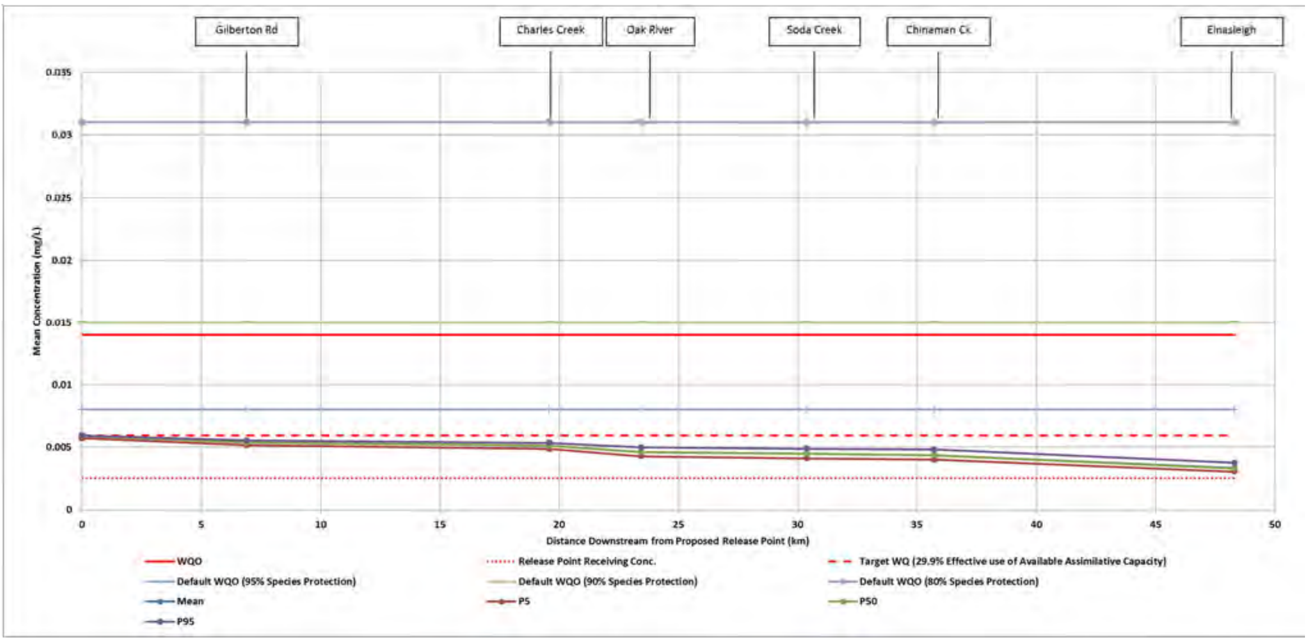


Figure 67 Scenario 1a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Eldridge Pit, Median Release Concentration)

7.3.3.2 Scenario 1b – Maximum Eldridge Concentration for Dissolved Zinc

Table 89 Scenario 1b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Eldridge Pit, Maximum Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0111	0.0097	0.0091	0.0079	0.0075	0.0072	0.0046
P5	0.0107	0.0092	0.0085	0.0070	0.0065	0.0063	0.0038
P10	0.0107	0.0093	0.0086	0.0071	0.0067	0.0065	0.0040
P20	0.0109	0.0094	0.0088	0.0074	0.0069	0.0067	0.0041
P50	0.0111	0.0097	0.0091	0.0079	0.0075	0.0072	0.0045
P80	0.0113	0.0100	0.0094	0.0083	0.0078	0.0076	0.0049
P90	0.0113	0.0101	0.0096	0.0084	0.0080	0.0078	0.0052
P95	0.0113	0.0102	0.0097	0.0088	0.0085	0.0083	0.0056
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

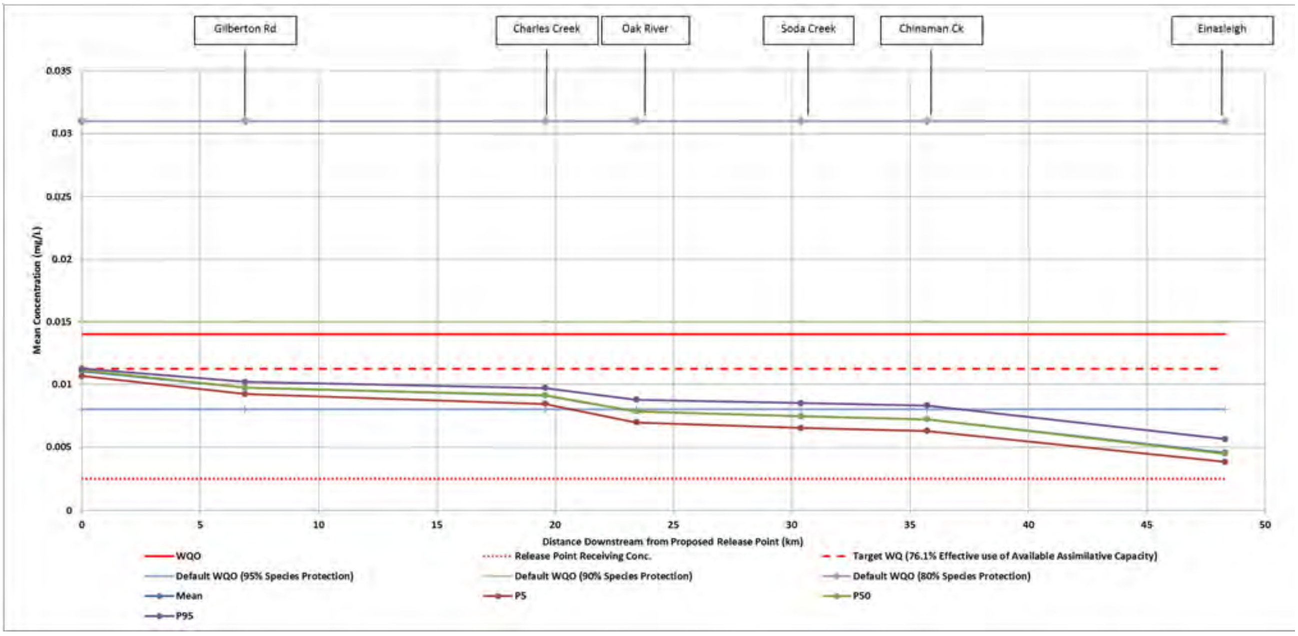


Figure 68 Scenario 1b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Eldridge Pit, Maximum Release Concentration)

7.3.3.3 Scenario 2a – Median Mixed Pit Water Release Concentration for Dissolved Zinc

Table 90 Scenario 2a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Mixed Pit Water Release, Medium Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0056	0.0051	0.0049	0.0044	0.0043	0.0042	0.0032
P5	0.0054	0.0049	0.0046	0.0041	0.0039	0.0039	0.0030
P10	0.0055	0.0049	0.0047	0.0042	0.0040	0.0039	0.0030
P20	0.0055	0.0050	0.0047	0.0042	0.0041	0.0040	0.0031
P50	0.0056	0.0051	0.0049	0.0044	0.0043	0.0042	0.0032
P80	0.0056	0.0052	0.0050	0.0046	0.0044	0.0043	0.0033
P90	0.0056	0.0052	0.0050	0.0046	0.0045	0.0044	0.0035
P95	0.0056	0.0053	0.0051	0.0048	0.0047	0.0046	0.0036
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

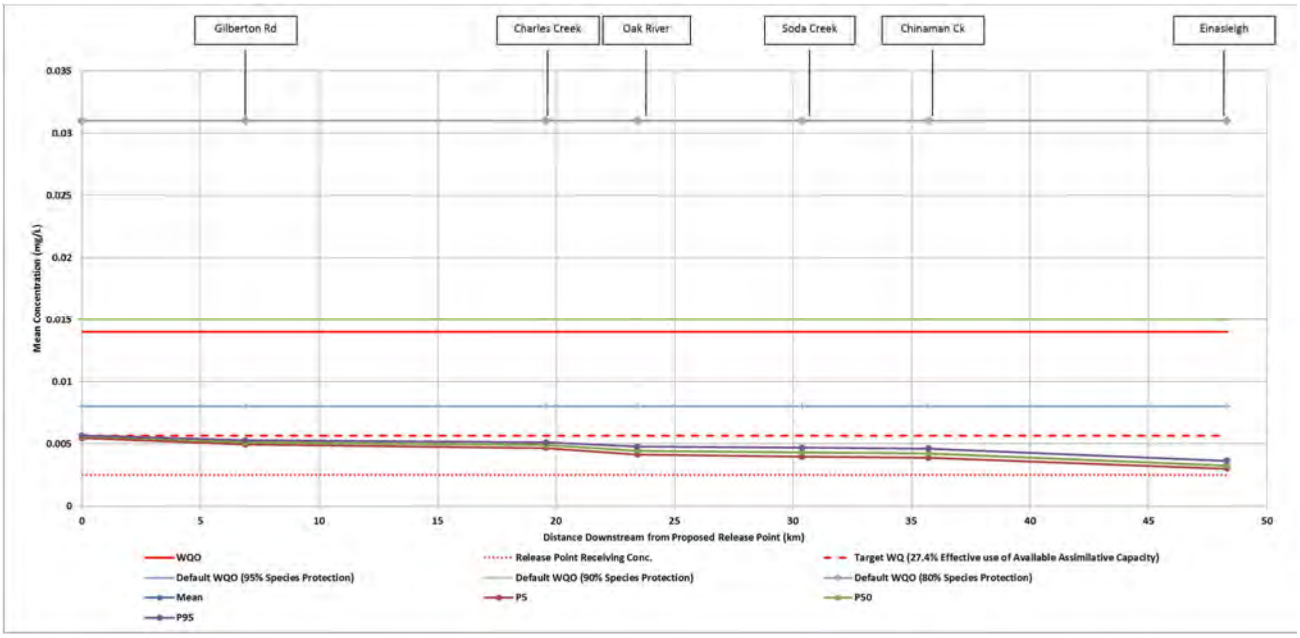


Figure 69 Scenario 2a – Downstream Mass Balanced Concentrations for Dissolved Zinc (Mixed Pit Water Release, Medium Release Concentration)

7.3.3.4 Scenario 2b – Maximum Mixed Pit Water Release Concentration for Dissolved Zinc

Table 91 Scenario 2b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Mixed Pit Water Release, Maximum Release Concentration)

Statistic	Proposed Release Point After Discharge	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Mean	0.0103	0.0091	0.0085	0.0074	0.0070	0.0068	0.0044
P5	0.0099	0.0086	0.0079	0.0066	0.0062	0.0059	0.0037
P10	0.0100	0.0087	0.0080	0.0067	0.0063	0.0061	0.0038
P20	0.0101	0.0088	0.0082	0.0069	0.0065	0.0063	0.0039
P50	0.0103	0.0091	0.0085	0.0074	0.0070	0.0068	0.0043
P80	0.0104	0.0093	0.0088	0.0077	0.0073	0.0071	0.0046
P90	0.0104	0.0094	0.0089	0.0079	0.0075	0.0073	0.0050
P95	0.0104	0.0095	0.0090	0.0082	0.0079	0.0078	0.0053
Distance from Release (km)	0	6.9	19.58	23.43	30.39	35.72	48.32

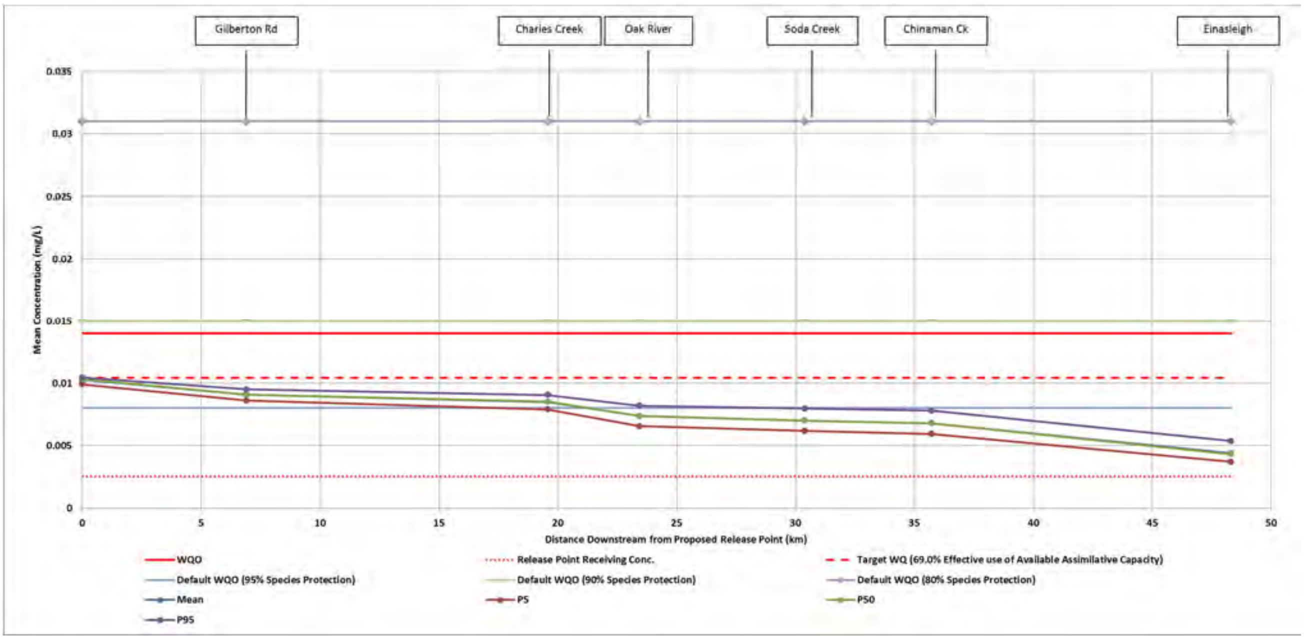


Figure 70 Scenario 2b – Downstream Mass Balanced Concentrations for Dissolved Zinc (Mixed Pit Water Release, Maximum Release Concentration)

7.3.3.5 Scenarios 3 & 4 - Annual Mass Balance Simulation for Comparative Assessment of Nine Constituents of Most Concern

Concentrations have been estimated for the contaminants of most concern as per the assumptions detailed in Section 6.1.1.3. Results are presented in Table 92 (releases from Eldridge Pit) and Table 93 (mixed pit water releases).

Table 92 Scenario 3 Construction Phase Mass Balance Results – Releases from Eldridge Pit only

Description		Median Concentrations for Releases from Eldridge Pit (Scenario 3a)									Worst Case Maximum Concentration for Releases from Eldridge Pit (Scenario 3b)								
Contaminant		Electrical Conductivity @ 25°C	Sulfate as SO_4 - Turbidimetric	Cadmium (F)	Cobalt (F)	Zinc (F)	Arsenic (T)	Cobalt (T)	Manganese (T)	Total Nitrogen as N	Electrical Conductivity @ 25°C	Sulfate as SO_4 - Turbidimetric	Cadmium (F)	Cobalt (F)	Zinc (F)	Arsenic (T)	Cobalt (T)	Manganese (T)	Total Nitrogen as N
Relevant Environmental Value		Aquatic Ecosystems (physico-chemical stressor)	Drinking Water - Aesthetic	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Drinking Water - Health	Long Term Irrigation	Recreation	Aquatic Ecosystems (physico-chemical stressor)	Aquatic Ecosystems (physico-chemical stressor)	Drinking Water - Aesthetic	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Drinking Water - Health	Long Term Irrigation	Recreation	Aquatic Ecosystems (physico-chemical stressor)
Units		µS/cm	mg/L	mg/L*	mg/L	mg/L*	mg/L	mg/L	mg/L	mg/L	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Baseline Median at W2		167	10	0.00005	0.0005	0.0025	0.001	0.0005	0.073	0.25	167	10	0.00005	0.0005	0.0025	0.001	0.0005	0.073	0.25
WQO (80% species protection for aquatic ecosystems)		**N/A**	**N/A**	**HMTV 0.0014 [0.0008]**	**N/A**	**HMTV 0.0527 [0.031]**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**HMTV 0.0014 [0.0008]**	**N/A**	**HMTV 0.0527 [0.031]**	**N/A**	**N/A**	**N/A**	**N/A**
WQO (90% species protection for aquatic ecosystems)		**N/A**	**N/A**	**HMTV 0.0007 [0.0004]**	**N/A**	**HMTV 0.0255 [0.015]**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**N/A**	**HMTV 0.0007 [0.0004]**	**N/A**	**HMTV 0.0255 [0.015]**	**N/A**	**N/A**	**N/A**	**N/A**
WQO (95% species protection for aquatic ecosystems)		**500**	**250**	**HMTV 0.0003 [0.0002]**	**0.0028**	**HMTV 0.0140 [0.008]**	**0.0100**	**0.0500**	**0.1000**	**0.1500**	**500**	**250**	**HMTV 0.0003 [0.0002]**	**0.0028**	**HMTV 0.0140 [0.008]**	**0.0100**	**0.0500**	**0.1000**	**0.1500**
Propose Release Point (0 km)	Mean	180.647	17.306	0.00015	0.00052	0.0059	0.0011	0.00062	0.079	0.283	189.669	22.210	0.00021	0.00064	0.011	0.0023	0.019	0.091	0.283
	Median	180.765	17.369	0.00015	0.00052	0.0059	0.0011	0.00062	0.079	0.283	189.865	22.315	0.00021	0.00064	0.011	0.0023	0.019	0.091	0.283
	P95	180.937	17.462	0.00015	0.00052	0.0059	0.0011	0.00062	0.079	0.284	190.151	22.469	0.00021	0.00064	0.011	0.0023	0.020	0.092	0.284
East Creek (Gilberton Rd) (6.9 km)	Mean	169.704	14.932	0.00013	0.00052	0.0053	0.0010	0.00060	0.073	0.276	177.323	19.073	0.00018	0.00062	0.010	0.0020	0.016	0.083	0.276
	Median	169.925	14.973	0.00013	0.00052	0.0053	0.0010	0.00060	0.073	0.276	177.572	19.089	0.00018	0.00062	0.010	0.0020	0.016	0.083	0.276
	P95	173.683	15.674	0.00014	0.00052	0.0055	0.0011	0.00061	0.075	0.279	181.664	20.047	0.00019	0.00063	0.010	0.0021	0.017	0.086	0.279
Charles Creek (19.6 km)	Mean	164.604	13.827	0.00013	0.00052	0.0051	0.0010	0.00059	0.070	0.273	171.571	17.613	0.00017	0.00061	0.009	0.0019	0.015	0.079	0.273
	Median	164.814	13.875	0.00013	0.00052	0.0051	0.0010	0.00059	0.070	0.273	171.839	17.667	0.00017	0.00061	0.009	0.0019	0.015	0.079	0.273
	P95	170.216	14.971	0.00013	0.00052	0.0053	0.0010	0.00060	0.073	0.276	177.821	19.044	0.00018	0.00062	0.010	0.0020	0.016	0.083	0.276
Oak River (23.4 km)	Mean	154.202	11.573	0.00011	0.00051	0.0046	0.0009	0.00058	0.063	0.267	159.840	14.637	0.00015	0.00059	0.008	0.0016	0.012	0.071	0.267
	Median	154.061	11.569	0.00011	0.00051	0.0046	0.0009	0.00058	0.063	0.267	159.764	14.649	0.00015	0.00059	0.008	0.0016	0.012	0.071	0.267
	P95	162.571	13.349	0.00012	0.00052	0.0050	0.0010	0.00059	0.068	0.272	169.218	16.961	0.00017	0.00060	0.009	0.0018	0.014	0.077	0.272
Soda Creek (30.4 km)	Mean	150.878	10.853	0.00011	0.00051	0.0044	0.0009	0.00057	0.061	0.265	156.092	13.686	0.00014	0.00058	0.007	0.0015	0.011	0.068	0.265
	Median	150.616	10.832	0.00011	0.00051	0.0044	0.0009	0.00057	0.061	0.265	155.870	13.686	0.00014	0.00058	0.007	0.0015	0.011	0.068	0.265
	P95	159.969	12.790	0.00012	0.00052	0.0049	0.0009	0.00058	0.067	0.270	166.290	16.225	0.00016	0.00060	0.009	0.0017	0.014	0.075	0.270
Chinaman Creek (35.7km)	Mean	148.959	10.437	0.00010	0.00051	0.0044	0.0008	0.00057	0.060	0.264	153.929	13.138	0.00014	0.00058	0.007	0.0015	0.011	0.067	0.264
	Median	148.570	10.395	0.00010	0.00051	0.0044	0.0008	0.00057	0.060	0.264	153.580	13.110	0.00014	0.00058	0.007	0.0015	0.011	0.066	0.264
	P95	158.432	12.459	0.00012	0.00051	0.0048	0.0009	0.00058	0.066	0.269	164.560	15.790	0.00016	0.00059	0.008	0.0017	0.013	0.074	0.269
Einasleigh (48.3 km)	Mean	126.999	5.683	0.00007	0.00051	0.0033	0.0006	0.00053	0.047	0.250	129.170	6.863	0.00009	0.00053	0.005	0.0009	0.005	0.050	0.250
	Median	126.391	5.545	0.00007	0.00051	0.0033	0.0006	0.00053	0.046	0.250	128.496	6.665	0.00009	0.00053	0.004	0.0009	0.005	0.049	0.250
	P95	135.588	7.562	0.00009	0.00051	0.0037	0.0007	0.00054	0.052	0.256	138.887	9.355	0.00011	0.00055	0.006	0.0011	0.007	0.056	0.256

*Indicates HMTV. Default WQO presented in brackets.

Red values denote exceedance of WQO (for 95% species protection where multiple levels of protection are available). The HMTV has been applied up to ~7km downstream due to the elevated baseline in the receiving environment (median hardness of 56 mg/L at Copperfield River monitoring location W2).

Table 93 Scenario 4 Construction Phase Mass Balance Results – Releases of Mixed Pit Water

Description		Median Concentrations for Mixed Pit Water Releases (Scenario 4a)									Worst Case Maximum Concentration for Mixed Pit Water Releases (Scenario 4b)								
Contaminant		Electrical Conductivity @ 25°C	Sulfate as SO4 - Turbidimetric	Cadmium (F)	Cobalt (F)	Zinc (F)	Arsenic (T)	Cobalt (T)	Manganese (T)	Total Nitrogen as N	Electrical Conductivity @ 25°C	Sulfate as SO4 - Turbidimetric	Cadmium (F)	Cobalt (F)	Zinc (F)	Arsenic (T)	Cobalt (T)	Manganese (T)	Total Nitrogen as N
Relevant Environmental Value		Aquatic Ecosystems (physico-chemical stressor)	Drinking Water - Aesthetic	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Drinking Water - Health	Long Term Irrigation	Recreation	Aquatic Ecosystems (physico-chemical stressor)	Aquatic Ecosystems (physico-chemical stressor)	Drinking Water - Aesthetic	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Aquatic Ecosystems (Toxicant)	Drinking Water - Health	Long Term Irrigation	Recreation	Aquatic Ecosystems (physico-chemical stressor)
Units		µS/cm	mg/L	mg/L*	mg/L	mg/L*	mg/L	mg/L	mg/L	mg/L	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
Baseline Median at W2		167	10	0.00005	0.0005	0.0025	0.001	0.0005	0.073	0.25	167	10	0.00005	0.0005	0.0025	0.001	0.0005	0.073	0.25
WQO (80% species protection for aquatic ecosystems)		N/A	N/A	HMTV 0.0014 [0.0008]	N/A	HMTV 0.0527 [0.031]	N/A	N/A	N/A	N/A	N/A	N/A	HMTV 0.0014 [0.0008]	N/A	HMTV 0.0527 [0.031]	N/A	N/A	N/A	N/A
WQO (90% species protection for aquatic ecosystems)		N/A	N/A	HMTV 0.0007 [0.0004]	N/A	HMTV 0.0255 [0.015]	N/A	N/A	N/A	N/A	N/A	N/A	HMTV 0.0007 [0.0004]	N/A	HMTV 0.0255 [0.015]	N/A	N/A	N/A	N/A
WQO (95% species protection for aquatic ecosystems)		500	250	HMTV 0.0003 [0.0002]	0.0028	HMTV 0.0140 [0.008]	0.0100	0.0500	0.1000	0.1500	500	250	HMTV 0.0003 [0.0002]	0.0028	HMTV 0.0140 [0.008]	0.0100	0.0500	0.1000	0.1500
Propose Release Point (0 km)	Mean	181.769	18.145	0.00014	0.00052	0.0056	0.0011	0.00061	0.079	0.280	192.224	23.142	0.00019	0.00064	0.010	0.0028	0.018	0.090	0.280
	Median	181.897	18.215	0.00014	0.00052	0.0056	0.0011	0.00061	0.079	0.280	192.442	23.255	0.00019	0.00064	0.010	0.0028	0.018	0.091	0.280
	P95	182.083	18.318	0.00014	0.00052	0.0056	0.0011	0.00061	0.079	0.281	192.760	23.421	0.00020	0.00064	0.010	0.0028	0.018	0.091	0.281
East Creek (Gilberton Rd) (6.9 km)	Mean	170.652	15.640	0.00013	0.00052	0.0051	0.0010	0.00059	0.072	0.274	179.481	19.860	0.00017	0.00062	0.009	0.0024	0.015	0.082	0.274
	Median	170.883	15.672	0.00013	0.00052	0.0051	0.0010	0.00059	0.072	0.274	179.736	19.881	0.00017	0.00062	0.009	0.0024	0.015	0.082	0.274
	P95	174.684	16.422	0.00013	0.00052	0.0053	0.0011	0.00060	0.074	0.276	183.898	20.885	0.00018	0.00062	0.009	0.0026	0.016	0.085	0.276
Charles Creek (19.6 km)	Mean	165.471	14.474	0.00012	0.00052	0.0049	0.0010	0.00059	0.069	0.271	173.544	18.333	0.00016	0.00061	0.009	0.0023	0.014	0.078	0.271
	Median	165.660	14.515	0.00012	0.00052	0.0049	0.0010	0.00059	0.069	0.271	173.828	18.384	0.00016	0.00061	0.009	0.0023	0.014	0.078	0.271
	P95	171.163	15.668	0.00013	0.00052	0.0051	0.0010	0.00059	0.072	0.274	179.974	19.817	0.00017	0.00061	0.009	0.0024	0.015	0.082	0.274
Oak River (23.4 km)	Mean	154.904	12.097	0.00011	0.00051	0.0044	0.0009	0.00057	0.063	0.265	161.437	15.219	0.00014	0.00059	0.007	0.0019	0.011	0.070	0.265
	Median	154.771	12.095	0.00011	0.00051	0.0044	0.0009	0.00057	0.063	0.265	161.378	15.231	0.00014	0.00059	0.007	0.0019	0.011	0.070	0.265
	P95	163.399	13.967	0.00012	0.00052	0.0048	0.0010	0.00058	0.068	0.270	171.099	17.648	0.00015	0.00060	0.008	0.0022	0.013	0.077	0.270
Soda Creek (30.4 km)	Mean	151.526	11.337	0.00010	0.00051	0.0043	0.0009	0.00056	0.061	0.263	157.568	14.225	0.00013	0.00058	0.007	0.0018	0.010	0.068	0.263
	Median	151.273	11.320	0.00010	0.00051	0.0043	0.0009	0.00056	0.061	0.263	157.314	14.228	0.00013	0.00058	0.007	0.0018	0.010	0.068	0.263
	P95	160.756	13.377	0.00011	0.00051	0.0047	0.0010	0.00058	0.066	0.268	168.079	16.877	0.00015	0.00060	0.008	0.0021	0.013	0.075	0.268
Chinaman Creek (35.7km)	Mean	149.578	10.899	0.00010	0.00051	0.0042	0.0009	0.00056	0.060	0.262	155.336	13.651	0.00013	0.00058	0.007	0.0018	0.010	0.066	0.262
	Median	149.193	10.858	0.00010	0.00051	0.0042	0.0009	0.00056	0.059	0.262	154.998	13.626	0.00013	0.00058	0.007	0.0018	0.010	0.066	0.262
	P95	159.194	13.029	0.00011	0.00051	0.0046	0.0009	0.00058	0.065	0.267	166.295	16.422	0.00015	0.00059	0.008	0.0021	0.012	0.073	0.267
Einasleigh (48.3 km)	Mean	127.269	5.885	0.00007	0.00050	0.0032	0.0007	0.00053	0.047	0.250	129.784	7.087	0.00008	0.00053	0.004	0.0011	0.005	0.049	0.250
	Median	126.653	5.733	0.00007	0.00050	0.0032	0.0006	0.00053	0.046	0.249	129.092	6.882	0.00008	0.00053	0.004	0.0010	0.004	0.049	0.249
	P95	135.998	7.869	0.00008	0.00051	0.0036	0.0007	0.00054	0.052	0.255	139.821	9.696	0.00010	0.00055	0.005	0.0013	0.007	0.056	0.255

*Indicates HMTV. Default WQO presented in brackets.

Red values denote exceedance of WQO (for 95% species protection where multiple levels of protection are available). The HMTV has been applied up to ~7km downstream due to the elevated baseline in the receiving environment (median hardness of 56 mg/L at Copperfield River monitoring location W2).

7.3.4 Assessment of Water Quality Impacts to Environmental Values

Results of the DTA and far-field (mass balance) assessment was used to assess the water quality-related impacts to each EV as a result of temporary construction releases. Results are presented in Table 94.

Table 94 Potential Construction Phase Water Quality Impacts to Relevant Environmental Values

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
Aquatic ecosystems (incorporating Habitat value)	Mass balance assessment indicates that parameters relevant to the aquatic ecosystem EV are below the WQO at all locations, with the exception of total nitrogen and dissolved zinc. The concentration of total nitrogen is above the WQO at all modelled locations, partly due to the elevated baseline concentrations (also above the WQO). Under a worst case scenario, there may be rare and very marginal exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Soda Creek (modelled concentrations of 0.009 or 0.010 mg/L compared with the default WQO of 0.008 mg/L). For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment. The exceedances are within the likely margin of error of the various methods used in the assessment. Whist concentrations of nitrate are elevated in release waters, concentrations post-release are expected to be well below the WQO for aquatic ecosystem protection post-release during the construction phase (refer to Table 85). It was therefore considered unnecessary to include nitrate in the mass balance assessment.	Baseline total nitrogen is already elevated in the receiving environment and is thereby contributing to the exceedance of the WQO. Elevated nitrogen concentrations in waterways may under certain circumstances lead to algal blooms, which can impact aquatic ecosystems. Whilst the levels of nitrogen exceed the WQO, the exceedance is not likely to cause such impacts given the nature of the receiving environment and composition of the discharge water, namely the limited availability of phosphorus. Monitoring undertaken as part of the REMP (refer to Section 8.2) will ensure that any impacts are appropriately managed, and if necessary that additional mitigation measures are implemented (see Section 9.3). Nitrate concentrations are expected to be well below the WQO post-release and therefore impacts associated with nitrate are considered negligible. Although there may be rare and very marginal exceedances of the 95% level of protection for dissolved zinc from Charles Creek to Chinaman Creek, the DTA results (refer to Section 4.9) indicate that the proposed releases will not result in toxicity-related impacts to aquatic ecosystems. Under the DTA, a minimum dilution ratio of nine parts receiving environment water to one part release water is required to meet 95% species protection. In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. During the construction phase, the simulated releases are well in excess (200:1) of this minimum dilution ratio. The mass balance assessment indicates that the HMTV will not be exceeded around the release location (down to East Creek, which is located approximately 7 km downstream). As outlined in Section 5.14, there are two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, however they are both less than 7 km downstream and therefore the HMTV is not expected to be exceeded in either pool. Impacts to these

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
		pools are therefore anticipated to be negligible. With regards to scour around the outfall contributing to increased sedimentation, modelling suggests that the increased flow from the releases will not have any significant effect on the hydraulics of the natural system (refer to Section 7.6 for further detail). Detailed design and construction will need to take into consideration the potential for erosion, and ensure that engineering solution appropriately mitigate this impact to avoid downstream impacts. The potential impacts to the downstream environment from increased erosion and sedimentation associated with the release point are expected to be minimal as construction of this component will be strictly limited to the dry season. Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values. Further, photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point.
Irrigation (Short Term < 20 years)	As set out in Section 5.4, WQOs for short term irrigation do not apply as the lowest applicable WQO for any parameter.	Modelling has shown that more stringent WQOs for other EVs will not be exceeded as a result of Project releases. It therefore concluded that the Project is unlikely to result in impacts to the short term irrigation EV during the construction period due to high dilution rates (200:1).
Irrigation (Long Term ~100 years)	The WQO for total cobalt is specific to the protection of the long term irrigation EV. Modelling has shown that the WQO for total cobalt will not be exceeded post-mixing in the receiving environment.	Impacts to long term irrigation during the construction phase are not anticipated, as concentrations of total cobalt post releases are modelled to be below the relevant WQO for long term irrigation at all downstream locations.

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
Farm supply (e.g. fruit washing, milking sheds, intensive livestock yards)	As set out in Section 5.4, WQOs for farm supply do not apply as the lowest applicable WQO for any parameter.	The high dilution rate for the construction phase of the Project (200:1) means that all relevant WQOs will be met post-release in the receiving environment. The ANZECC/ARMCANZ 2000 guidelines includes trigger values for assessing the corrosiveness and fouling potential of water. pH and hardness in the releases post-mixing indicates limited potential for both corrosion and fouling potential. Impacts to the farm supply EV in the receiving environment are therefore considered highly unlikely.
Stock watering (e.g. grazing cattle)	As set out in Section 5.4, WQOs for stock watering do not apply as the lowest applicable WQO for any parameter.	ANZECC/ARMCANZ 2000 WQOs for stock watering are presented in Table 29. The worst case concentrations in the receiving environment based on maximum concentrations (Table 55) indicates that WQOs for stock watering will not be exceeded. It therefore concluded that the Project is unlikely to result in impacts to the stock watering EV during the construction period.
Aquaculture	This EV was considered and is not applicable to downstream receiving environment	This EV was considered and is not applicable to downstream receiving environment
Human consumption (e.g. of wild or stocked fish)	As set out in Section 5.4, WQOs for human consumption do not apply as the lowest applicable WQO for any parameter.	ANZECC/ARMCANZ 2000 WQOs for human consumption are presented in Table 29. The worst case concentrations in the receiving environment based on maximum concentrations (Table 55) indicates that WQOs for human consumption will not be exceeded. It therefore concluded that the Project is unlikely to result in impacts to the human consumption EV during the construction period.
Primary recreation (fully immersed in water e.g. swimming)	The WQO for total manganese is specific to the protection of the recreation EV. Modelling has shown that the WQO for total manganese will not be exceeded post-mixing in the receiving environment.	Impacts to recreation during the construction phase are not anticipated, as concentrations of total manganese post releases are modelled to be below the relevant WQO for recreation at all downstream locations.
Secondary recreation (possibly splashed with water, e.g. sailing)		
Visual appreciation (no contact with water, e.g. picnics)	No specific WQOs associated with the protection of visual appreciation. See above for recreation.	Modelling has shown that more stringent WQOs for other EVs will not be exceeded as a result of Project releases. It therefore concluded that the Project is unlikely to result in impacts to the visual appreciation EV during the construction period due to dilution rates (200:1).

Environmental Value	Relevant Parameter and Copperfield River Location	Impact Assessment
Drinking water (raw water supplies taken for drinking)	The WQOs for sulfate and total arsenic are specific to the protection of the drinking water EV (sulfate for aesthetics and arsenic for health). Modelling has shown that the WQO for these parameters will not be exceeded post-mixing in the receiving environment.	Impacts to drinking water during the construction phase are not anticipated, as concentrations of sulfate and total arsenic post releases are modelled to be below the relevant WQO for drinking water at all downstream locations.
Industrial use (e.g. power generation, manufacturing, road maintenance)	As set out in Section 5.4, WQOs for industrial use do not apply as the lowest applicable WQO for any parameter.	Modelling has shown that more stringent WQOs for other EVs will not be exceeded as a result of Project releases. It is therefore concluded that the Project is unlikely to result in impacts to the industrial use EV during the construction period due to high dilution rates (200:1).
Cultural and spiritual values	No specific WQOs associated with the protection of cultural and spiritual values.	It is assumed that by protecting other EVs relevant to the receiving environment, cultural and spiritual values will also be protected.

7.3.5 Conclusions of Water Quality Impact Assessment

An assessment of far-field water quality modelling and DTA results indicates that any impacts occurring as a result of construction releases are temporary and reversible. This is evidenced by the following:

- For temporary construction releases, it is proposed that a maximum of 76.3% of the assimilative capacity of the receiving environment be utilised (this equates to an effective dilution ratio of 200 parts receiving environment to one part release water from the Eldridge Pit). The assumptions behind calculating effective dilution ratios are highly conservative (based on maximum pit water qualities). In reality the actual assimilative capacity usage will be lower than 76.3% in most cases.
- Parameters relevant to the aquatic ecosystem EV are below WQOs at all locations, with the exception of total nitrogen and dissolved zinc.
- Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek. Given that these exceedances represent a ‘maximum’ modelled value, the likelihood of these concentrations being released is very low. In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. For the scenarios assessed, the 90% species protection WQO will not be exceeded at any of the modelled location in the receiving environment.
- The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible.
- During the construction phase, the simulated releases are well in excess (200:1) of the minimum dilution ratio for toxicity-related impacts in the receiving environment (9:1).
- Concentrations of parameters relevant to other EVs are all modelled to be below the specified WQO.

Further information regarding potential water quality impacts and mitigation measures is presented in the risk assessment (Section 8.0).

7.4 Hydrology Impact Assessment

Streamflow data from the GoldSim model (Appendix L) for the Copperfield River at the proposed release point inclusive of potential releases based on the key criteria presented in Section 7.2.1.4 has been subjected to a number of different analysis as described below and summarised in Table 95:

1. Analysis of releases - volumes, timing and duration of potential releases during the construction phase were assessed. Analysis was conducted both annually and under both wet and dry season conditions.
2. Assessment of post release flushes - timing and duration of potential post-release flushes during the construction phase were assessed. Analysis was again conducted on both an annual and seasonal (wet and dry) basis.

Deterministic analysis to form the basis for additional assessment of flow duration and flow spells analysis was not considered due to the short period assessed for the construction period (approximately 2.15 years). Typically such analysis requires longer duration simulation (at least ten years) and extended simulation of the construction phase is not considered appropriate given the staged nature of construction and dewatering during the proposed construction phase[19]. As a result assessment has focussed on analysis of release s and release post-release flushing as outlined in Table 95. In addition, the utilisation of the same release conditions for the construction phase as those proposed for the operational phase is likely to result in a similar outcome.

Table 95 Hydrology Impact Assessment Summary

Aspect	Aspects Assessed	Reference
Analysis of releases	Volumes, release events and durations, seasonal variation (wet and dry season).	Section 7.4.1
Analysis of post release flushing	Flush volumes, durations, flush ratio, spatial and seasonal (wet and dry season) variation.	Section 7.4.2

7.4.1 Estimated Construction Phase Releases

Referring to Table 96, Table 97 and Table 98:

- The median mean annual release volume is 409 ML (Table 96) however:
  - The majority of releases are restricted to the wet season with a median release volume of 400 ML (Table 97);
  - The median dry season release volume is 0 ML (Table 98);
  - This strong temporal distribution of release volumes is also shown on Figure 71 which shows that the probability of a release occurring between May through November is less than 5%.
- The median mean annual number of release days is 33.1 (Table 96), 32.4 during the wet season (Table 97) and zero during the dry season (Table 98).
- The median release event:
  - On an annual basis is approximately 101 ML, occurs 4.2 times and has an estimated duration of 7.7 days per event (Table 96);
  - During the wet season is approximately 107 ML, occurs 4.2 times and has an estimated duration of 7.7 days per event (Table 97); and
  - During the dry season (Table 98) is 0 ML.

[19] Long term deterministic simulation of the operational phase was considered appropriate as the system operates under a fixed set of assumptions and can therefore be modelled over extended periods.

- Median mass loading for dissolved zinc during the wet season is 701 kg (Table 97, reducing to 0 kg in the dry season (Table 98). Note that this is a worst case result assuming releases from the Eldridge pit only and at the maximum concentration of 1.75 mg/L. Under all the additional release water source scenarios considered in Section 7.2, mass loading would be lower.

Table 96 Construction Phase Controlled Release – Mean Annual Statistics

Statistic	Mean Annual Release Volume	Mean Volume Released per Event	Mean Annual Number of Release Days	Mean Annual Number of Release Events[20]	Mean Release Event Duration	Mean Annual Mass Loading (zinc (F))
	ML	ML	days	1/ 1yr	d	kg
Mean	612	157	38.1	4.5	9.1	1,071
P5	74	19	13.0	2.3	3.6	130
P10	124	25	17.4	2.8	4.1	216
P20	194	41	23.0	3.2	5.3	340
P50	409	101	33.1	4.2	7.7	716
P80	954	248	50.9	5.6	12.5	1,670
P90	1,420	332	67.0	6.9	14.9	2,485
P95	1,636	550	81.2	7.7	19.4	2,863

Table 97 Construction Phase Controlled Release – Wet Season (Nov through April) Statistics

Statistic	Mean Season Release Volume	Mean Volume Released per Event	Mean Number of Release Days per Season	Mean Number of Release Events[21] per Season	Mean Release Event Duration	Mean Mass Loading per Season (zinc (F))
	ML	ML	days	1/ 1yr	d	kg
Mean	605	166	37.0	4.2	9.5	1,059
P5	72	19	12.4	1.9	3.6	127
P10	108	26	16.1	2.3	4.2	188
P20	193	41	22.7	2.8	5.3	337
P50	400	107	32.4	4.2	8.3	701
P80	954	250	50.4	5.1	12.4	1,669
P90	1,405	374	64.8	6.1	15.4	2,459
P95	1,624	573	79.7	7.2	21.6	2,842

[20] A release event is the occurrence of controlled releases occurring for one or more consecutive days
[21] A release event is the occurrence of controlled releases occurring for one or more consecutive days

Table 98 Construction Phase Controlled Release – Dry Season (May through October) Statistics

Statistic	Mean Season Release Volume	Mean Volume Released per Event	Mean Number of Release Days per Season	Mean Number of Release Events[22] per Season	Mean Release Event Duration	Mean Mass Loading per Season (zinc (F))
	ML	ML	days	1/ 1yr	d	kg
Mean	7	11	1.1	0.3	1.7	12
P5	-	-	-	-	-	-
P10	-	-	-	-	-	-
P20	-	-	-	-	-	-
P50	-	-	-	-	-	-
P80	12	16	2.8	0.6	3.2	21
P90	19	27	3.2	0.9	4.1	34
P95	25	44	3.7	0.9	5.6	43

[22] A release event is the occurrence of controlled releases occurring for one or more consecutive days

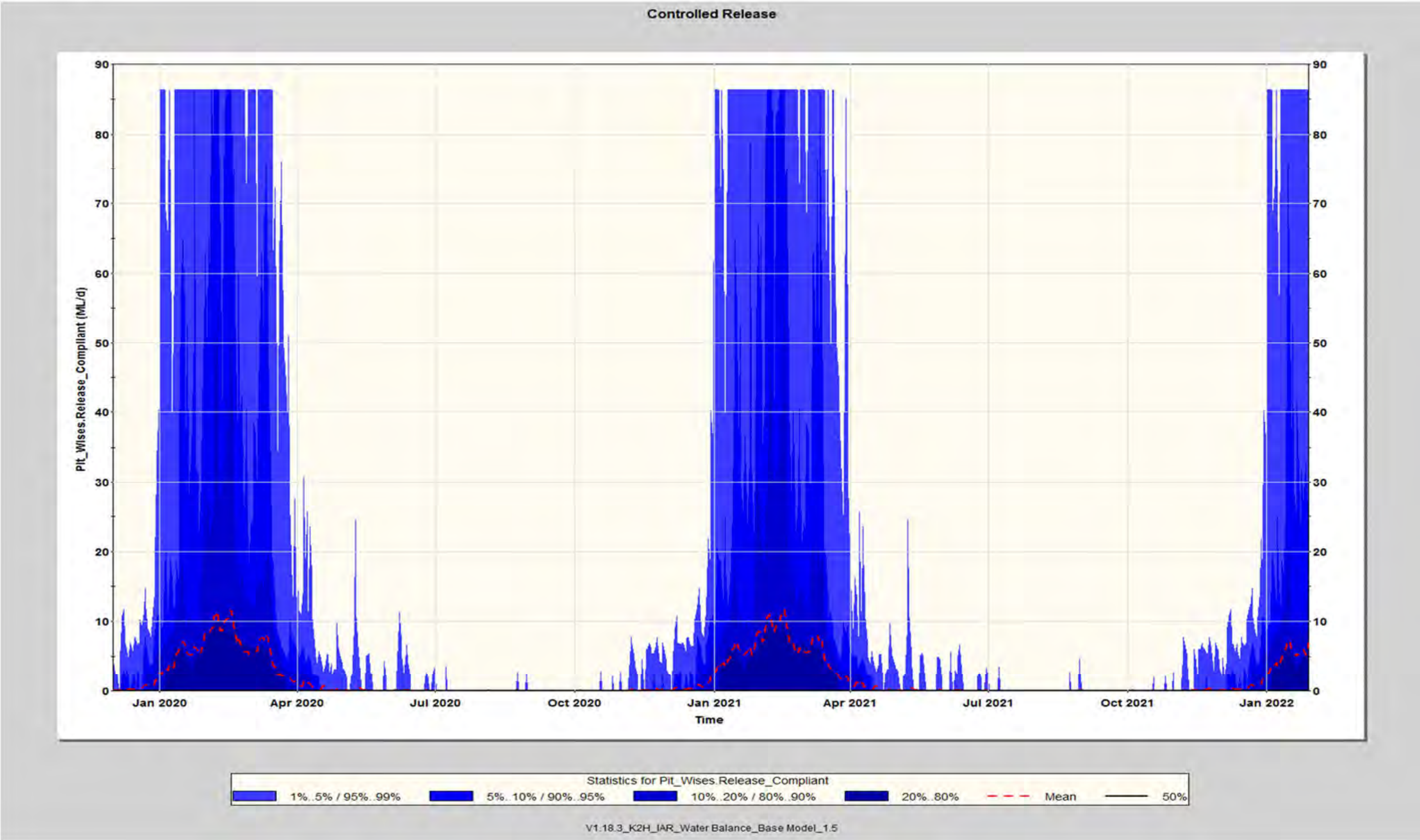


Figure 71 Temporal Distribution of Releases During the Construction Phase

7.4.2 Estimated Construction Post-Release Flushes

Table 99, Table 100 and Table 101 detail the estimated post release flush duration and volume at the proposed release point (mean release volume per event is also shown for context) on an annualised basis as well as per the wet and dry seasons. In summary:

- The estimated median post release flush is 28.9 days in duration and 1,676 ML (Table 99) at the proposed release point, compared to a median event release volume of 101ML.
- During the wet season (Table 100), the estimated median post release flush is 19.6 days in duration and 1,650 ML.
- Based upon the estimated median result, no release, and consequently no post release flush is expected during the dry season (Table 101).

Table 99 Construction Phase Post-Release Flush – Annual Statistics

Statistic	Mean Post Release Flush[23] Duration	Mean Post Release Flush Volume	Mean Volume Released per Event
	days	ML	ML
Mean	31.6	1,830	157
P5	15.9	921	19
P10	18.7	1,147	25
P20	22.7	1,318	41
P50	28.9	1,676	101
P80	39.6	2,229	248
P90	46.2	2,606	332
P95	53.9	3,399	550

[23] The post-release flush is the period of continued streamflow in the Copperfield River after a controlled release has ceased. The flush duration is taken from the time of release cessation to commencement of the next release or when flow in the Copperfield reaches zero; whichever is sooner.

Table 100 Construction Phase Post-Release Flush – Wet Season (November through April) Statistics

Statistic	Mean Post Release Flush[24] Duration	Mean Post Release Flush Volume	Mean Volume Released per Event
	days	ML	ML
Mean	20.8	1,667	166
P5	10.9	937	19
P10	13.2	1,091	26
P20	15.4	1,276	41
P50	19.6	1,650	107
P80	25.1	1,990	250
P90	29.2	2,279	374
P95	35.3	2,559	573

Table 101 Construction Phase Post-Release Flush – Dry Season (May through October) Statistics

Statistic	Mean Post Release Flush[25] Duration	Mean Post Release Flush Volume	Mean Volume Released per Event
	days	ML	ML
Mean	20.7	652.8	11
P5	-	-	-
P10	-	-	-
P20	-	-	-
P50	-	-	-
P80	43.4	1,021	16
P90	56.4	1,760	27
P95	86.4	2,899	44

Table 102, Table 103 and Table 104 show post-release flush ratios (the mean event release volume divided by the mean post-release flush volume) at the proposed release point as well as a number of locations downstream to Einasleigh.

[24] The post-release flush is the period of continued streamflow in the Copperfield River after a controlled release has ceased. The flush duration is taken from the time of release cessation to commencement of the next release or when flow in the Copperfield reaches zero; whichever is sooner.
[25] The post-release flush is the period of continued streamflow in the Copperfield River after a controlled release has ceased. The flush duration is taken from the time of release cessation to commencement of the next release or when flow in the Copperfield reaches zero; whichever is sooner.

From the tables it can be seen that the tributary inflows downstream of the proposed release point provide continual additional flow during the post-release flush period resulting in a continual reduction in the flush ratio with increasing distance downstream of the proposed release point. Figure 72 provides additional representation of the reduction flush ratio with increasing distance from the proposed release point. Flush ratios are generally seen to be higher during the wet season (Table 103) than the dry (Table 104). This is a function of the low frequency of dry season releases (0.7 per dry season, Table 98, P50 result). During the wet season, the number of releases is significantly higher (4.0, Table 97, P50 result) and predominantly occur within a relatively discrete period (Figure 71). Consequently, there is a greater likelihood that that the recessional flow contributing to the post release flush volume is curtailed by the commencement of another streamflow event and release. Conversely, during the dry season, the continuing recessional flow is less likely to be curtailed by another event.

Table 102 Construction Phase Post-Release Flush Ratios – Annual Statistics

Statistic	Proposed Release Point	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	%	%	%	%	%	%	%
Mean	7.4	6.0	5.4	4.1	3.7	3.4	1.2
P5	1.7	1.4	1.3	1.0	0.9	0.8	0.3
P10	2.0	1.6	1.5	1.1	1.0	0.9	0.3
P20	2.9	2.3	2.1	1.5	1.4	1.3	0.4
P50	5.6	4.6	4.1	3.1	2.8	2.6	0.9
P80	11.8	9.8	8.8	6.6	5.9	5.5	1.9
P90	15.1	12.5	10.9	8.2	7.3	6.8	2.4
P95	18.0	14.8	13.5	10.7	9.7	9.1	3.4

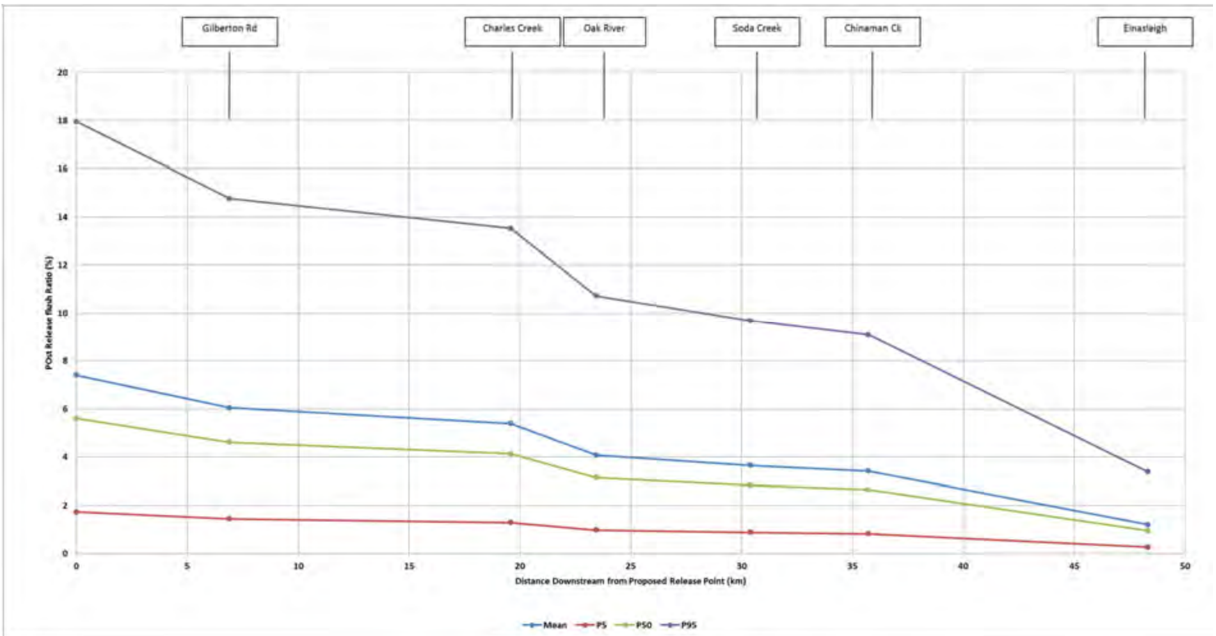


Figure 72 Construction Phase Post-Release Flush Ratios – Annual Results

Table 103 Construction Phase Post-Release Flush Ratios – Wet Season (Nov through April) Statistics

Statistic	Proposed Release Point	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	%	%	%	%	%	%	%
Mean	9.1	7.5	6.7	5.0	4.5	4.2	1.5
P5	1.7	1.4	1.3	1.0	0.9	0.8	0.3
P10	2.1	1.7	1.5	1.1	1.0	1.0	0.3
P20	3.0	2.4	2.1	1.6	1.4	1.3	0.5
P50	6.6	5.1	4.7	3.6	3.2	3.0	1.0
P80	13.6	11.0	9.9	7.4	6.6	6.2	2.0
P90	18.3	15.9	14.4	10.6	9.6	9.0	3.1
P95	27.8	23.3	20.8	15.7	14.3	13.4	5.0

Table 104 Construction Phase Post-Release Flush Ratios – Dry Season (June through October) Statistics

Statistic	Proposed Release Point	East Creek (Gilberton Rd)	Charles Creek	Oak River	Soda Creek	Chinaman Creek	Einasleigh
	%	%	%	%	%	%	%
Mean	0.8	0.7	0.7	0.5	0.5	0.5	0.3
P5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P10	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P20	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P50	0.0	0.0	0.0	0.0	0.0	0.0	0.0
P80	1.8	1.5	1.4	1.2	1.1	1.0	0.5
P90	2.5	2.1	1.9	1.5	1.4	1.3	0.7
P95	3.3	2.9	2.7	2.3	2.1	2.0	1.2

7.4.3 Conclusions of Hydrology Impact Assessment

Construction phase releases are proposed to utilise the same release conditions (including a release trigger of 400 ML/d) as operational phase releases. As shown previously in Section 6.3.3, this is unlikely to materially impact on the existing flow regime in terms of the timing, frequency, duration and magnitude of flows. Releases will coincide with naturally occurring streamflow events in the Copperfield River at the proposed release point and cease as streamflow recesses below the proposed 400 ML/d trigger. The use of the same dilution ratio (200 to 1) during the construction phase as the operational phase dilution ratio will result in a similar contaminant mass loading per release event. Possible stranding of releases in downstream pools and waterholes is however considered unlikely due to the significant post release flush volumes following each release event. In summary:

- By all measures assessed, estimated potential releases made during the dry season represent a minor proportion of the total release potential. For example, the median mean annual dry season release volume was estimated to be 0 ML compared to 400 ML for the wet season.
- The estimated median mean number of releases during the dry season was found to be 0, whereas the number of release events during the wet season was estimated to be 4.2 with a release duration of 8.3 days and a release volume of 107 ML.

- Post-release flushing was estimated from the proposed release point to Einasleigh in order to examine the effect of progressive tributary inflows on the post-release flush ratio. Ongoing tributary inflows downstream of the proposed release point provide significant additional flushing such that the median mean flush ratio of 5.6 % at the release point is reduced to 0.9 % by Einasleigh.
- Assessment of wet and dry season flush ratios indicates that flush ratios during the dry season are typically lower than during the wet season. This results from the greater number of releases occurring during the wet season and their tendency to occur within a relatively discrete period (Figure 71). Consequently, there is a greater likelihood that that the recessional flow contributing to the post release flush volume is curtailed by the commencement of another streamflow event and release. Conversely, during the dry season, the continuing recessional flow is less likely to be curtailed by another event.

7.5 Aquatic Ecology Impact Assessment

7.5.1 Water Quality

The Project proposes to undertake water releases to the Copperfield River during certain flow events as described in Section 4.7.1. Such releases have the potential to influence the quality of downstream waters as described in Section 4.4.1.4.

Targeted DTA assessments were conducted to determine the required mixing ratios to reduce the potential for environmental harm and ensure 95% species protection is achieved within the receiving environment during operational discharges. The DTA assessment has found that the potential for impacts to aquatic organisms is considered to be relatively low at the dilution ratios and release regimes proposed.

The DTA assessments showed that the dilution ratio to achieve a 95% species protection level ranged from 1:1 (the most likely case) to 9:1 (for a mixture of pit waters composed predominantly from Wises Pit water; i.e. worst case scenario). All proposed releases during both the construction phase of the Project exceed this minimum dilution.

The proposed controlled releases will only be undertaken during flow events within the receiving environment with a minimum flow trigger stipulated and the cessation of the release occurring prior to natural flows subsiding to allow for an additional flushing effect.

The proposed release ratio during the operational phase is 200:1, well above that required to achieve 95% species protection. Mixing zone modelling has indicated that the use of a diffused discharge outlet structure will facilitate near field mixing at the outlet such that the WQO for the contaminant of most concern (dissolved zinc) will be met within 625m for the range of scenarios and outlet configurations assessed (most modelled scenarios suggest a mixing zone of between 50 and 70 m downstream). There are no known permanent or semi-permanent pools within 625 m downstream of the release location which could provide refugia for aquatic ecology (refer to Section 5.14). There are no other known sensitive receptors within this mixing zone. All fish species found to be occurring within the Copperfield River display relatively broad tolerances to a wide range of water quality characteristics (refer to Section 3.12.6). However, the macroinvertebrate communities were comprised of families sensitive to environmental change. It is suggested that the adoption and application of appropriate release management strategies, as discussed above, will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values.

A REMP has been drafted (Section 5.2, and Appendix I) which will be developed to monitor the receiving environment for potential impacts from controlled releases. Further, the sensitivity of the macroinvertebrate community suggests it will be an ideal biological indicator for the future Project REMP.

7.5.2 Hydrology

The release of water has the potential to increase flow volumes experienced within the receiving environment. The contribution of flow during temporary construction releases is considered to be negligible with a release ratio of 200:1.

Assessment of the proposed release regime found that the maximum increase in daily flow volume (compared to natural flows) expected to occur was 1.18%, with mean and median annual flow increases estimated to be 0.44% and 0.88%, respectively. These increases are minor compared to natural variations that would be observed in the system from a year to year basis based on rainfall received.

Many of the fish species that occur in the Copperfield River migrate upstream during the wet season to spawn (refer to Section 3.12.6). Furthermore, macroinvertebrate communities are highly seasonal with water availability and stage in the flow cycle (especially in ephemeral tropical Australian watercourses) a defining factor on their community composition. The extension of flows and/or the permanency of water in the system will allow aquatic flora and fauna to utilise more of the watercourse for a longer period of time each year. Further, if the permanency of water is increased upstream of the Project site, new refuges for aquatic flora and fauna may be developed. This may allow fish to access further upstream (on the Copperfield River or associated tributaries) during subsequent flow events which will last up to an additional nine days. While, if this occurs, it would be considered a change in natural conditions it may not be considered an adverse impact. Note; fish passage will not be reduced by this minor increase in flow. As noted in Section 5.14, there are several identified semi-permanent pools within close proximity to the release location. The majority of waterholes found were minor remnant pools occurring in-channel. Only two substantial pools were noted downstream of the Project site (Pond 5 near W3 and the Sandy Creek site). These two pools have the potential to persist year round, providing refuge to aquatic fauna. The longevity of these pools would be highly correlated with the hydrology of the system on a yearly basis.

As the releases are to be managed to occur as event-based, no changes to key temporal indicators (timing, frequency and duration of flow events) are expected. While some minor increases to the rates of rise and fall are expected, they are not considered to be of sufficient magnitude to result in any adverse impacts to the aquatic ecology values of the system.

7.5.3 Erosion and Sedimentation

Releases have the potential to increase erosion and sedimentation through physical processes/forces. The method in which the water is released (i.e. spillway overtopping, open ended pipe, pump outlet, diffuser, etc.) and the rate can result in scouring of the immediate downstream area and subsequently cause sedimentation further downstream. Erosion and sedimentation processes are known to impact aquatic communities through smothering and the reduction of primary production (Wood & Armitage, 1997; Gleason *et al.*, 2003).

A diffuser will be employed for releases to ensure the mixing rate is maximised. Diffusers also reduce the potential for erosion to occur as a result of the release. As outlined in Section 4.1.2, design and construction of the operational phase outlet works has been identified for early works however, in the unlikely event that the works are not complete prior to this, initial releases during the construction phase may be via a simple outfall structure (incorporating relevant erosion and sedimentation control measures). The design of the release point and associated diffuser will be finalised during detailed design. However, conceptualisation through CORMIX modelling has shown that appropriate mixing can be achieved, and modelling suggests that the increased flow from the releases will not have any significant effect on the hydraulics of the natural system. Detailed design and construction will need to take into consideration the potential for erosion, and ensure that engineering solutions appropriately mitigate this impact to avoid downstream impacts.

The potential impacts to the downstream environment from increased erosion and sedimentation associated with the release point are expected to be minimal as construction of this component will be strictly limited to the dry season. During operation, impacts are anticipated to be restricted to the immediate area surrounding and downstream of the release point. Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values. Further, photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point. On-going sediment quality monitoring will be undertaken at numerous locations as part of the REMP (refer to Section 9.2) in order to assess whether any impacts are occurring.

7.5.4 Development of the Release Point

The discharge release infrastructure design will consider the potential risk of scouring as a result of the construction discharges which may cause localised erosion resulting in increased sedimentation. This is particularly relevant to the first wet season discharges when a temporary outfall structure may be utilised (refer to Section 4.1.2). Stabilisation of banks where discharge is proposed may be necessary to minimise these impacts. This will be further considered during detailed design.

The construction of the release point can impact the aquatic ecology values of the receiving environment through various pathways, including:

- Clearing of riparian vegetation to allow access;
- Disturbing the substrate; and
- Spills of potential contaminants.

The major concerns associated with the construction activities are the increase in sedimentation and the potential for contaminants to enter the system. However, all of these pathways are feasibly easily mitigated against using best practice environmental management techniques. The main mitigation measures are proposed to be that:

- All spillway infrastructure construction works will be undertaken during the dry season when flows have subsided;
- Silt curtains (or other similar measure) will be employed for any remnant pools;
- All spills will be cleaned up immediately with any contaminated sediment removed; and
- The riparian zone will be rehabilitated through stabilisation once construction has been completed.

The potential impacts to the downstream environment from potential sedimentation and potential contaminants from construction activities are expected to be negligible and restricted to the immediate area surrounding the working area. Appropriately applied best practice environmental management practices will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values.

7.6 Fluvial Geomorphology Impact Assessment

Construction phase releases will be made at the same release ratio as the operational phase (0.5%) and therefore any potential changes to key hydraulic are expected to be similar to those presented in Section 6.5.1. As previously noted, the modelling showed negligible changes to the key drivers of channel shape and floodplain morphology (e.g. velocity, depth, shear stress and stream power). Results for flows with and without the proposed releases are noted be significantly lower than the DRNR 2014 guideline values for stream power, velocity and shear stress (Table 81) which is indicative of the broad channel and downstream of the proposed release location.

It is not therefore expected that proposed construction phase releases of water will result in any changes to sediment transport and loads or channel stability – baseline critical shear stress thresholds will not be exceeded more frequently, or for longer, than would otherwise have been the case for a ‘no release’ scenario.

Design and construction of the release infrastructure will consider the potential risk of scouring which may cause localised erosion resulting in increased sedimentation further downstream. This may increase the sediment coarse fraction, which may impact the downstream environment by affecting turbidity and potentially impacting aquatic communities as discussed in Section 7.5. According to Section 5.12, the coarse fraction does not exceed trigger values and appears not to have been significantly affected by historic mining activities.

Design and construction of the release infrastructure is planned as part of an early works programme. Should commissioning of the release infrastructure be delayed beyond the commencement of the construction phase the releases may be made via the proposed temporary outfall structure (Section 4.1.2). During this period visual inspections of the outlet structure and surrounds will be undertaken following each release until such time that the final diffuser structure is in place. Thereafter ongoing regular (quarterly) visual inspections will be undertaken. Sedimentation potential will be monitored through regular sediment monitoring. Further detail regarding monitoring is presented in Section 9.2.

7.7 Hydrogeology Impact Assessment

During construction the predictive groundwater modelling (Appendix H) indicates that the water levels in the Eldridge Pit will be at their lowest and that the pit will continue to act as a groundwater sink, reducing seepage migration risks to the north of the Project (and downstream in the Copperfield River). During construction the water discharged from the Project will contribute a maximum of 4.2% of the flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime. Further groundwater impact considerations are provided in Table 105 below.

Table 105 Potential Impacts of Project Water Discharges

Potential Impact	Construction
Impacts on water levels affecting GDEs and licensed groundwater users	None
Water quality alteration of groundwater resources (including alluvial groundwater)	Discharge of water into the Copperfield River is not expected to significantly influence groundwater quality (recharge during high flow events). It is anticipated that by the time that the flow in the Copperfield River has reached the trigger level required prior to discharges commencing that the stream alluvial beds have been largely saturated. The concentrations of key contaminants will be monitored during both construction and operational discharges as part of the additional monitoring. The post discharge flushing will aim to return the water quality in any standing water to baseline condition, monitoring will be undertaken to confirm the efficacy of the discharge flushing.
Change in groundwater flow, including throughflow impacting on down gradient users	Limited increased groundwater recharge during high flow (discharge) events
Water quality alteration of surface water resources	Potential for migration between former mine area and Copperfield River where a hydraulic connection between the fault system and river is present, impacting water quality in semi-permanent pools

As discussed in Section 5.11.8, it is considered that in the instance a hydraulic connection between the fault system and the river is present, there is potential for migration between the former mine area and the Copperfield River. In order to ensure that impacts are not occurring as a result of potential migration between the former mine area and the Copperfield River, ongoing water and sediment quality monitoring is proposed at the following semi-permanent waterhole locations (refer to Section 5.14 for detail regarding these waterholes):

- Pond 3 (approximately 1.4 km upstream of the proposed release location);
- Pond 5 (approximately 5.8 km downstream of the proposed release location).

Furthermore, potential impacts to groundwater will be assessed through ongoing monitoring at bores BA06 and BA07. Further detail regarding monitoring is presented in Section 9.2.

8.0 Risk Assessment

8.1 Methodology

The risk assessment methodology set out in (AS/NZS) ISO 31000:2009 *Risk Management – Principles and Guidelines* (2009) was adopted for this report. Criteria used to rank the likelihood and consequences of potential impacts and how they are combined to determine the level of impact are set out in Table 106 to Table 108 below.

The classifications (major, high, moderate, low or negligible) for significance of an impact are as follows:

- **Major** significance of impact - arises when an impact will potentially cause irreversible or widespread harm to an EV that is irreplaceable because of its uniqueness or rarity. Avoidance through appropriate design responses is the only effective mitigation.
- **High** significance of impact - occurs when the proposed activities are likely to exacerbate threatening processes affecting the intrinsic characteristics and structural elements of the EV. While replacement of unavoidable losses is possible, avoidance through appropriate design responses is preferred to preserve its intactness or conservation status.
- **Moderate** significance of impact - although reasonably resilient to change, the EV would be further degraded due to the scale of the impact or its susceptibility to further change. The abundance of the EV ensures it is adequately represented in the region, and that replacement, if required, is achievable.
- **Low** significance of impact - occurs where an EV is of local importance and temporary and transient changes will not adversely affect its viability provided standard environmental management controls are implemented.
- **Negligible** significance of impact - impact on the EV will not result in any noticeable change in its intrinsic value and hence the proposed activities will have negligible effect on its viability. This typically occurs where the activities occur in industrial or highly disturbed areas.

Table 106 Description of Sensitivity Criteria

Sensitivity	Description
High	• The EV is listed on a recognised or statutory state, national or international register as being of conservation significance. • The EV is intact and retains its intrinsic value. • The EV is unique to the environment in which it occurs. It is isolated to the affected system/area which is poorly represented in the region, territory, country or the world. • It has not been exposed to threatening processes, or they have not had a noticeable impact on the integrity of the EV. Project activities would have an adverse effect on the value.
Moderate	• The EV is recorded as being important at a regional level, and may have been nominated for listing on recognised or statutory registers. • The EV is in a moderate to good condition despite it being exposed to threatening processes. It retains many of its intrinsic characteristics and structural elements. • It is relatively well represented in the systems/areas in which it occurs but its abundance and distribution are limited by threatening processes. • Threatening processes have reduced its resilience to change. Consequently, changes resulting from project activities may lead to degradation of the prescribed value. • Replacement of unavoidable losses is possible due to its abundance and distribution.

Sensitivity	Description
Low	• The EV is not listed on any recognised or statutory register. It might be recognised locally by relevant suitably qualified experts or organisations e.g., historical societies. • It is in a poor to moderate condition as a result of threatening processes which have degraded its intrinsic value. • It is not unique or rare and numerous representative examples exist throughout the system / area. • It is abundant and widely distributed throughout the host systems / areas. • There is no detectable response to change or change does not result in further degradation of the EV. • The abundance and wide distribution of the EV ensures replacement of unavoidable losses is achievable.

Table 107 Description of Magnitude Criteria

Magnitude	Description
High	An impact that is widespread, long lasting and results in substantial and possibly irreversible change to the EV. Avoidance through appropriate design responses or the implementation of site-specific environmental management controls are required to address the impact.
Moderate	An impact that extends beyond the area of disturbance to the surrounding area but is contained within the region where the project is being developed. The impacts are short term and result in changes that can be ameliorated with specific environmental management controls.
Low	A localised impact that is temporary or short term and either unlikely to be detectable or could be effectively mitigated through standard environmental management controls.

Table 108 Significance Assessment Matrix

Magnitude of Impact	Sensitivity of Environmental Value		
	High	Moderate	Low
High	Major	High	Moderate
Moderate	High	Moderate	Low
Low	Moderate	Low	Negligible

8.2 Project Risk Assessment

Table 109 below summarises the potential pre-mitigation risks associated with the release of water at the proposed Copperfield River release location. As discussed in Section 4.0 above, the aquatic ecosystem EV is considered to be the most relevant in the case of the proposed Copperfield River release.

Table 109 Risk Assessment and Mitigation Measures

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
Changes in water quality								
Increased water temperature and reducing natural thermal variability	Aquatic ecosystems	The Copperfield River is an ephemeral waterway with high naturally occurring variability in water temperature. Temperatures during a single sampling campaign ranged from approximately 21°C to 25.7°C. Temperatures within the reservoirs are unlikely to change significantly and are therefore highly unlikely to exceed the natural variability in the receiving environment. As discharges are limited to flow periods in the Copperfield River, and only make up a relatively small proportion of the flows the change is likely to be negligible.	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Implementation of REMP. • Continuous real-time monitoring of flow and other physical parameters such as temperature, EC, pH, etc. in the receiving environment upstream and downstream of the proposed release location.	Low (2C)	• Adjustments would be made to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger. • Modification of the REMP.
Increased toxicant loads in Copperfield River due to construction releases resulting in adverse impacts to aquatic ecosystems.	Aquatic ecosystems	Far-field mass balance modelling has indicated that WQOs may be exceeded for dissolved zinc and total nitrogen during the construction phase. However at a dilution ratio of 200:1, the simulated releases are well in excess of the minimum dilution ratio determined through DTA (9:1) required to meet 95% species protection. This indicates that the proposed releases will not result in toxicity-related impacts to aquatic ecosystems.	Moderate	Moderate	Moderate (2B)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d. • Implementation of REMP,	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger. • Modification of the REMP. • Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring. This may require cessation of further discharges until additional controls can be
	Stock watering	The maximum mixed pit concentrations scenario identified that the cattle	Low	Low	Negligible (3C)		Negligible (3C)	

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
		drinking water WQOs will not be exceeded at the point of discharge, or further downstream.				including aquatic ecology monitoring to determine whether impacts may be occurring. • Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values from scour. Further, photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point. •		effectively implemented
	Recreational	The WQO for total manganese is specific to the protection of the recreation EV. Modelling has shown that the WQO for total manganese will not be exceeded post-mixing in the receiving environment.	Low	Moderate	Low (3B)		Negligible (3C)	
	Irrigation	Impacts to short term and long term irrigation during the construction phase are not anticipated, as concentrations of relevant constituents post releases are modelled to be below the WQO at the release point and all downstream locations.	Low	Moderate	Low (3B)		Negligible (3C)	
	Drinking water	The WQOs for sulfate and total arsenic are specific to the protection of the drinking water EV (sulfate for aesthetics and arsenic for health). Modelling has shown that the WQO for these parameters will not be exceeded post-mixing in the receiving environment.	High	Low	Moderate (1C)		Low (2C)	
Increased toxicant loads in Copperfield River due to operational releases resulting in adverse impacts to aquatic ecosystems.	Aquatic ecosystems	Parameters relevant to the aquatic ecosystem EV are below the WQO at all locations, with the exception of total nitrogen and dissolved zinc. The concentration of total nitrogen is above the WQO at all modelled locations, partly due to the elevated baseline concentrations (also above the	Moderate	Moderate	Moderate (1C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Verification that the releases	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger. • Modification of the REMP. • Other adaptive management

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
		WQO).. Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek. For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment. The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible. At a dilution ratio of 200:1, the simulated releases are well in excess of the minimum dilution ratio determined through DTA (9:1) required to meet 95% species protection. This indicates that the proposed releases will not result in toxicity-related impacts to aquatic ecosystems.				are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load objective is being met and environmental outcomes achieved. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d. • Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values associated with scour. Further, photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point. • Implementation of REMP.		strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.
	Stock watering	The worst case concentrations in the receiving environment based on maximum concentrations indicates that WQOs for stock watering will not be exceeded. It therefore concluded that the Project is unlikely to result in impacts to the stock watering EV during the operations period.	Low	Low	Negligible (3C)		Negligible (3C)	

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
	Recreational	Impacts to recreation during the operations phase are not anticipated, as concentrations of total manganese post releases are modelled to be below the relevant WQO for recreation at all downstream locations.	Moderate	Low	Low (2C)		Low (2C)	
	Irrigation	Impacts to short term and long term irrigation during the operations phase are not anticipated, as concentrations of relevant constituents post releases are modelled to be below the WQO at the release point and all downstream locations.	Low	Low	Negligible (3C)		Negligible (3C)	
	Drinking water	Impacts to drinking water during the operations phase are not anticipated, as concentrations of sulfate and total arsenic post releases are modelled to be below the relevant WQO for drinking water at all downstream locations.	High	Low	Moderate (1C)		Low (2C)	
Visual impact at Einasleigh Gorge, through precipitation of dissolved contaminants during construction.	Recreation	Visual aesthetics may be impaired by precipitation of minerals from release water at Einasleigh Gorge. Hydrogeochemical modelling of the predicted water quality at the Gorge suggests, however, that mineral precipitation is not expected beyond that already associated with the (pre-release) Copperfield River.	Low	Moderate	Low (3B)	• Verification that the releases are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load objective is being met and environmental outcomes achieved. • Implementation of REMP.	Negligible (3C)	• Modification of the REMP. • Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.
	Cultural and spiritual value		Low	Moderate	Low (3B)		Negligible (3C)	

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
Visual impact at Einasleigh Gorge, through precipitation of dissolved contaminants during operations.	Recreation	The median post-release flush ratio shows continual reduction as distance from the proposed release point increases such that by Einasleigh, the flush ratio has reduced from 3.5% at the proposed release point to 0.6%. For 95% of releases, the post release flush at Einasleigh is estimated to exceed 41 times the release volume. Hydrogeochemical modelling of precipitation of minerals from the water reaching Einasleigh indicates that precipitation is not expected beyond that already associated with the (pre-release) river water.	Low	Moderate	Low (3B)	• Verification that the releases are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load objective is being met and environmental outcomes achieved. • Implementation of REMP.	Negligible (3C)	• Modification of the REMP. • Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.
	Cultural and spiritual value		Low	Moderate	Low (3B)		Negligible (3C)	
Residual water quality changes following discharge events, pooling in Copperfield River during construction.	Aquatic ecosystems	The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible. Ongoing streamflow following cessation of each release (post-release flush) will provide the means to facilitate the ongoing dilution and down-system transport of released water. This will aid in ensuring that pooled water is representative of upstream quality. The median post-release flush ratio (ratio of volume released to volume of post-release flush) is estimated	Moderate	Moderate	Moderate (2B)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Verification that the releases are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load objective is being met and environmental outcomes achieved.	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger. • Modification of the REMP. • Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
		to be 5.6% at the proposed release point. However, continued tributary inflows downstream of the release will progressively contribute additional dilutionary flow adding to the post-release flush volume. Consequently, the median flush ratio at Eldridge is estimated to reduce significantly to 0.9%. For 95% of releases, the post release flush at the proposed release point is estimated to exceed 29 times the release volume.				• Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d. • Implementation of REMP. •		
	Recreation	The WQO for total manganese is specific to the protection of the recreation EV. Modelling has shown that the WQO for total manganese will not be exceeded post-mixing in the receiving environment.	Low	Moderate	Low (3B)		Negligible (3C)	
Residual water quality changes following discharge events, pooling in Copperfield River during operations.	Aquatic ecosystems	The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible. The median post-release flush ratio (ratio of volume released to volume of post-release flush) is estimated to be 3.5% at the proposed release point i.e. a flush volume approximately 28 times the volume released. Continued tributary inflows downstream of the release will provide additional dilutionary	Moderate	High	High (2A)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Verification that the releases are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger. • Modification of the REMP. • Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
		inflow and progressively add to the post-release flush volume. Consequently, the median flush ratio at Eldridge is estimated to be 0.6%.				objective is being met and environmental outcomes achieved. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d. • Implementation of REMP.		
Accumulation of contaminants in sediment	Aquatic ecosystems	Low likelihood, given times of discharges being high flow / high energy events. Ongoing monitoring will be undertaken as part of the REMP. Any observed increases in contaminants in sediments will be managed accordingly.	Moderate	Low	Low (2C)	• Implementation of REMP.	Low (2C)	• Modification of the REMP. • Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.
Water quality changes in Pit water as level in Eldridge Pit falls and exposes pit walls	Aquatic ecosystems Cultural and spiritual value	The wall wash study suggests that the deterioration in water quality is relatively minor.	Moderate	Low	Low (2C)	• Ongoing monitoring and additional testing (kinetic testing). • Pit water quality will be monitored and compositional trends will be assessed.	Low (2C)	• Modification of the REMP.
Changes in stream hydrology								
Alteration of flow regime leading to changing cues of flow sensitive species (e.g. for migration and spawning) - Construction	Aquatic ecosystems	The contribution of flow during the construction phase is expected to be the same as during operation (0.503%).. Temporary construction releases are unlikely to materially impact on the existing flow regime in terms of the timing, frequency, duration	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger. • Other adaptive management strategies such as those

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
		and magnitude of flows. Releases will coincide with naturally occurring streamflow events in the Copperfield River at the proposed release point and cease as streamflow recesses below the proposed 400 ML/d trigger.				reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.		outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.
Alteration of flow regime leading to changing cues of flow sensitive species (e.g. for migration and spawning) - Operation	Aquatic ecosystems	Operational releases are unlikely to materially impact on the existing flow regime in terms of the timing, frequency, duration and magnitude of flows. Releases will coincide with naturally occurring streamflow events in the Copperfield River at the proposed release point and cease as streamflow recesses below the proposed 400 ML/d trigger.. The base-case hydraulic model confirmed that the release into the channel at a ratio of 200:1 does not have a significant impact on the hydraulic characteristics of the Copperfield River.	Low	Low	Negligible (3C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.	Negligible (3C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.
Biota with critical life history links to flow having insufficient time to complete life cycle in an altered flow regime - Construction	Aquatic ecosystems	Many of the fish species that occur in the Copperfield River migrate upstream during the wet season to spawn. Furthermore, macroinvertebrate communities are highly seasonal with water availability and stage in the flow cycle is a defining factor on their community composition. The extension of flows and/or the permanency of water in the system will allow	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.
Biota with critical life history links to flow having insufficient time to complete life cycle in an altered flow regime - Operation			Low	Low	Negligible (3C)		Negligible (3C)	

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
		aquatic flora and fauna to utilise more of the watercourse for a longer period of time each year.				approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.		
Increased hydrological connectivity affecting migration of invasive species - Construction	Aquatic ecosystems	If the permanency of water is increased upstream of the Project site, new refuges for aquatic flora and fauna may be developed. This may allow fish to access further upstream (on the Copperfield River or associated tributaries) during subsequent flow events which will last up to an additional nine days. It is currently unclear if any permanent pools already exist and provide this ability at, or upstream of, the Project site. While, if this occurs, it would be considered a change in natural conditions it may not be considered an adverse impact. Fish passage will not be reduced by this minor increase in flow.	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.
Increased hydrological connectivity affecting migration of invasive species - Operation			Low	Low	Negligible (3C)		Negligible (3C)	
Increased flow rates selecting against species which inhabit low flow areas of boundary layers - Construction	Aquatic ecosystems	As the releases are to be managed to occur as event-based, no changes to key temporal indicators (timing, frequency and duration of flow events) are expected. While some minor increases to the rates of rise and fall are expected, they are not considered to be of sufficient magnitude to result in any adverse impacts to the aquatic ecology values of the system.	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed	Low (2C)	• Adjustments to the release ratio as required. • Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.
Increased flow rates selecting against species which inhabit low flow areas of boundary layers - Operation			Low	Low	Negligible (3C)		Negligible (3C)	

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
						release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.		
Changes in stream hydraulics and geomorphology								
Increased flow rates leading to bank and/or bed erosion and subsequent reduction of habitat - Construction	Aquatic ecosystems	Releases have the potential to increase erosion and sedimentation through physical processes/forces. Modelling suggests that the increased flow from the releases will not have any significant effect on the hydraulics of the natural system. The potential impacts to the downstream environment from increased erosion and sedimentation associated with the release point are expected to be minimal as construction of this component will be strictly limited to the dry season. During operation, impacts are anticipated to be restricted to the immediate area surrounding and downstream of the release point.	Moderate	Low	Low (2C)	• Detailed design and construction will need to take into consideration the potential for erosion, and ensure that engineering solutions appropriately mitigate this impact to avoid downstream impacts. • A diffuser will be employed for all releases (except in the event that commissioning of the release infrastructure is delayed) to ensure the mixing rate is maximised. Diffusers also reduce the potential for erosion to occur as a result of the release. • Photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point. Until such time as a permanent diffuser is in place, visual inspections of the release point will be undertaken following each release to ensure that no adverse geomorphological impacts are occurring.	Low (2C)	• Other adaptive management strategies such as those outlined in Section 9.3 will be implemented where monitoring indicates that an unacceptable post-mitigation impact may be occurring.
Increased flow rates leading to bank and/or bed erosion and subsequent reduction of habitat - Operation			Moderate	Low	Low (2C)		Low (2C)	

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
Increased water levels leading to waterlogging of fringing and riparian vegetation that provide habitat for biota	Aquatic ecosystems	The proposed release ratio of 0.5% has a negligible impact on the hydraulic characteristics of the channel, with a maximum change in water depth of 0.35%.	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.	Low (2C)	• Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.
Increased flow rates leading to bank and/or bed erosion and subsequent reduction of habitat			Moderate	Low	Low (2C)		Low (2C)	
Increased flow altering the suspended particle size distribution, which could affect light penetration and subsequently affect productivity in the water body	Aquatic ecosystems	The proposed release ratio of 0.5% has a negligible impact on the hydraulic characteristics of the channel, with a maximum increase to channel velocity of 0.31%.	Moderate	Low	Low (2C)	• The location of the actual release point will be confirmed during detailed design. • Key criteria for site selection will include not only consideration of geomorphic stability but additional factors such as riparian vegetation, constructability, accessibility (construction and operation) and the Kidston cultural heritage area.	Low (2C)	• Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.

Potential Impact	Relevant Environmental Value/s	Impact summary	Pre-mitigation Risk			Mitigation Measures	Post-Mitigation Risk	Management of residual risks
			Sensitivity	Magnitude	Significance			
Changes in hydrogeology								
Potential discharges to the Copperfield River affecting groundwater regime (including alluvial groundwater)	Aquatic ecosystems Farm water supply Stock watering Cultural and spiritual value	The Pit is understood to continue to function as a groundwater 'sink', during both construction and operation. The water discharged from the Project (during both construction and operations) will contribute a maximum of 0.5% additional flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime	Moderate	Low	Low (2C)	• Discharges will be restricted to flow periods in the Copperfield River, maximising the natural buffering capacity of the Copperfield River. No releases into the receiving environment when flows are equalled or less than 400 ML/d. • Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d. • The concentrations of key contaminants will be monitored during both construction and operational discharges as part of the additional monitoring. The post discharge flushing will aim to return the water quality in any standing water to baseline condition, monitoring will be undertaken to confirm the efficacy of the discharge flushing.	Low (2C)	• Changes to the proposed discharge regime such as extension of the post-release flush through increases to the release cease trigger.

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Step 4 – Circumstances, Limits and Monitoring Conditions

9.0 Release Criteria and Monitoring

9.1 Summary of Proposed Release Criteria

The proposed controlled release of water from the Project is governed by the availability of a release opportunity in the Copperfield River at the proposed release point; the amount of water released is dependent on the release ratio and discharge capacity. Table 110 summarises the key proposed release criteria that is required.

Table 110 Proposed Project Release Criteria

Aspect	Construction	Operations	Comment
Controlled Release Triggers	400 ML/d	400 ML/d	No releases into receiving environment when flows are equalled or less than 400 ML/d.
Dilution Ratio	200 to 1	200 to 1	
Release Ratio	0.5%	0.5%	Operational release ratio is based on a 69% utilisation of the available assimilative capacity for the contaminant of most concern, dissolved zinc which results in an effective total dilution ratio of 200:1. During construction, the utilisation of available assimilative capacity may increase to 76% due to the higher concentration of dissolved zone in the Eldridge Pit.
Maximum controlled release capacity	86.4 ML/d ($1.0\ m^3/s$)	86.4 ML/d ($1.0\ m^3/s$)	

It is important to note that the proposed release ratio (i.e. the ratio of the release flow to the receiving flow) is dependent on assumptions regarding:

- Concentration of the contaminant of most concern in the potential release water;
- Concentration of the contaminant of most concern in the receiving environment; and
- Adopted utilisation of the available assimilative capacity for the contaminant of most concern.

However, real time monitoring in the receiving environment and the Eldridge and Wises Pits for some key contaminants such as metalloids is not practical. Potential changes to the concentration of contaminants in either the release water or the receiving environment can influence the effective assimilative capacity utilisation. The proposed release ratio of 0.5% for the operational phase of the Project has been based on:

- A conservatively high release concentration of 1.5874 mg/L for dissolved zinc (based on the maximum values observed in the Wises and Eldridge Pits)
- A median (monitoring point W2) receiving environment concentration of 0.0025 mg/L for dissolved zinc
- A conservative adoption of a 69% utilisation of the dissolved zinc available assimilative capacity; and
- Maintenance of the same release ratio (0.5%) during the construction phase may result in a slightly greater use of the available assimilative capacity (76%) when water is released solely from the Eldridge pit where the observed maximum concentration of dissolved zine is 1.75 mg/L.

Consequently, at the proposed release ratio of 0.5%, these assumptions provide additional contingency to allow for possible increases to either the receiving environment or release concentrations releases to continue to meet the dissolved zinc HMTV.

Referring to Figure 73 and Figure 74 below:

- Sufficient contingency exists within the proposed release criteria (specifically a 69% utilisation of the available dissolved zinc assimilative capacity) that releases made at the proposed release ratio of 0.503% will continue to meet the total dissolved zinc HMTV up to:
  - A receiving environment concentration of 0.00613 mg/L. This represents a more than doubling of the concentration when compared to the median W2 concentration of 0.0025 mg/L (Figure 73); or
  - An end of pipe release concertation of 2.3 mg/L. This represents a potential increase of approximately 45% compared to the assumed concentration of 1.5874 mg/L (Figure 74).

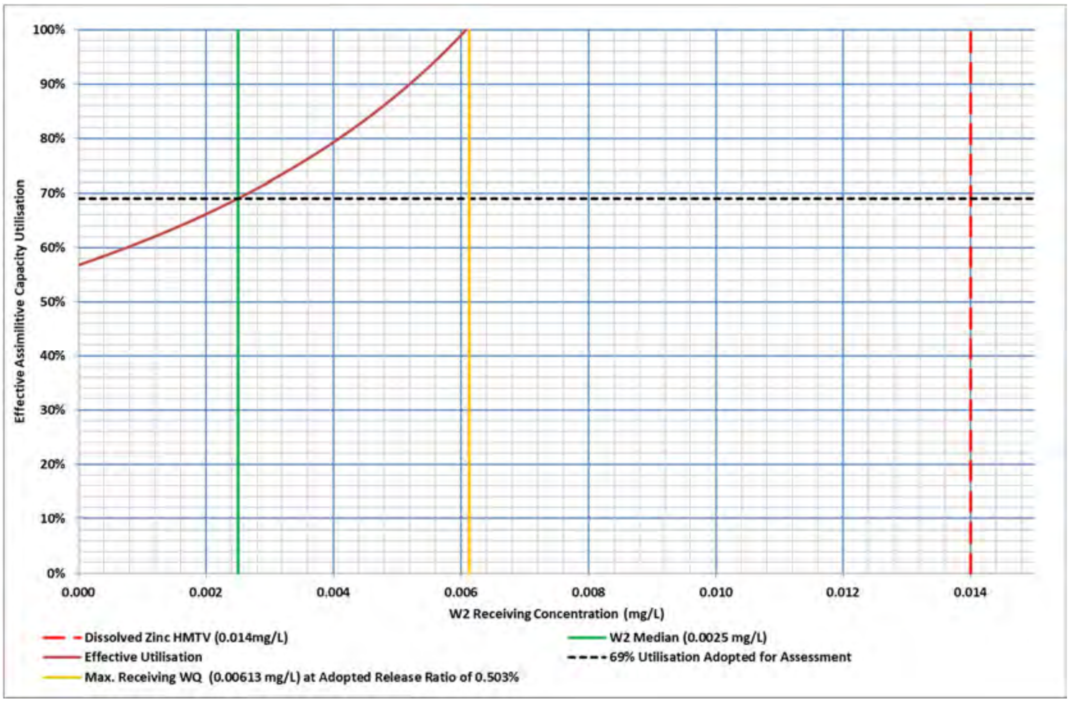


Figure 73 Effective Utilisation of Dissolved Zinc Assimilative Capacity Utilisation with Changing Receiving Environment Concentration (0.503% Release Ratio)

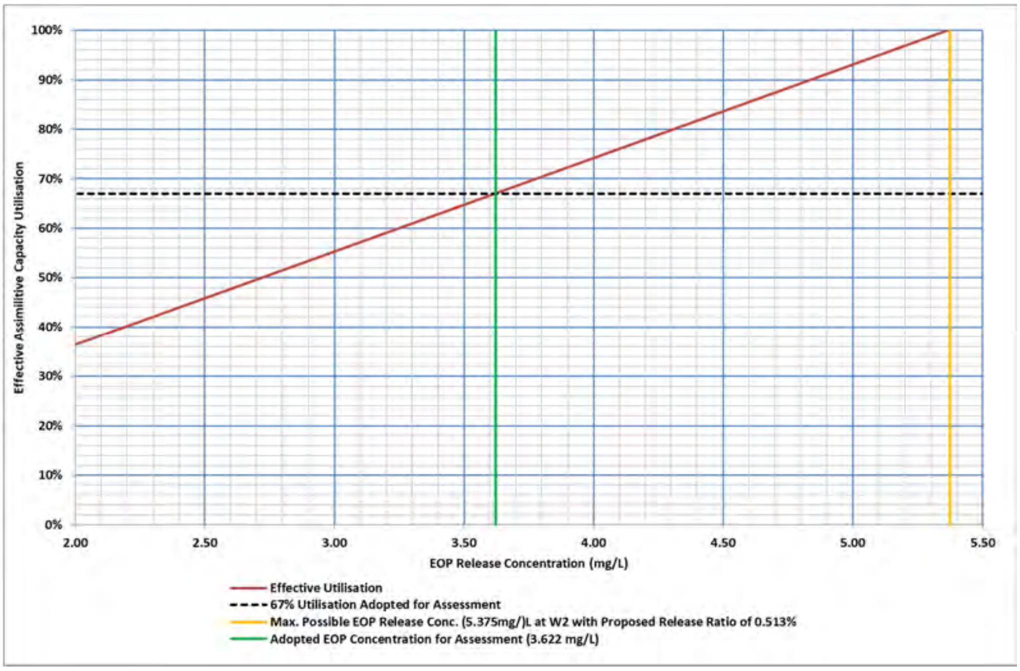


Figure 74 Effective Utilisation of Dissolved Zinc Assimilative Capacity Utilisation with Changing EOP Release Concentration (0.503% Release Ratio)

Ongoing monitoring of both water in the pits and the receiving environment will be used to inform the release ratio. Dynamic adjustment of the release ratio during release events is not practical or intended. The proposed release conditions have been based on conservative, maximum values for dissolved zinc and as long as ongoing monitoring continues to indicate that current concentrations are lower than this, the proposed release conditions will result in significantly less utilisation of the available assimilative capacity. In the event that monitoring indicates that concentrations of key contaminants in the pits significantly increase to the point that exceedance of the maximum values used to determine the proposed release ratio is likely, the release ratio can be adjusted (prior to a release) to ensure utilisation of available assimilative capacity is maintained at an appropriate level.

9.1.1 Approach to Releases

Definition of the proposed release operation is subject to ongoing refinement through detailed design however an indicative approach of the proposed release strategy would likely include the following key steps:

1. Continuous real-time monitoring of flow and other physical parameters such as temperature, electrical conductivity, pH, etc. in the receiving environment upstream and downstream of the proposed release location.
2. Continuous monitoring of flow in Copperfield River upstream of the proposed release location will provide an indication of when the proposed flow release trigger of 400 ML/d has been exceeded and a potential release opportunity is available.
3. The maximum release rate can be determined by multiplying the upstream monitored flow rate by the release ratio and could be adjusted based on real time data from the upstream stream gauge.
4. Verification that the releases are supporting downstream WQOs can be undertaken by collection of water quality samples at the downstream monitoring location(s) downstream of the proposed release point during the release event to demonstrate that the sustainable load objective is being met and environmental outcomes achieved.
5. Releases can be gradually reduced as data from the streamflow gauge indicates that flow recession is approaching the proposed release trigger of 400 ML/d. Releases will cease once the receiving flow equals or falls below the proposed release trigger of 400 ML/d.
6. On the basis of ongoing monitoring of the receiving environment, water in the pits and collection of samples during release events, adjustments would be made to the release ratio as required.

9.2 Monitoring

A draft REMP for the Project has been prepared (refer to Appendix I) and will be finalised following the approvals process. The following types of monitoring are proposed:

1. Surface water quality
2. Sediment
3. Biological
4. Flow; and
5. Groundwater quality and level.

An overview of the monitoring program for the Project, including monitoring locations and frequencies is presented in Table 111 and Figure 75.

The monitoring set out below will be supplemented with existing monitoring programs currently being undertaken for the mine site (for example, groundwater monitoring). In addition, should commissioning of the release infrastructure be delayed, the temporary release location infrastructure will be monitored visually for signs of erosion and channel/bank scouring following each release, until the final diffuser structure is in place. Thereafter, visual inspections should be undertaken quarterly. Photographic monitoring of the release point over time will document and monitor the rate of erosion and deposition occurring at and downstream of the release point. Inspections will look for signs of:

- Localised changes to channel bed and stream bank morphology such as undercutting, slumping or rotation
- localised changes, loss or damage to riparian vegetation
- Localised downstream sedimentation visible through the development of new lateral depositional features
- Notable changes to instream water clarity (turbidity) immediately downstream of the release point.

Notable damage to any hydraulic structures In the instance that signs of erosion or sedimentation are noted the following would be undertaken:

- Record, report and assess for severity and determine any requirement for mitigation.
- If required, suitable measures including (but not limited to) placement of appropriately dimensioned hard rock material, gabions, etc. could be employed to prevent further worsening.
- Issues not requiring immediate action will be subject to additional monitoring to determine the rate of, or potential for, ongoing propagation and any requirement for future mitigation (noting that the dynamic nature of bed material transport is to some extent, a natural part of fluvial process at the proposed release point).

Table 111 Overview of Receiving Environment Monitoring Program

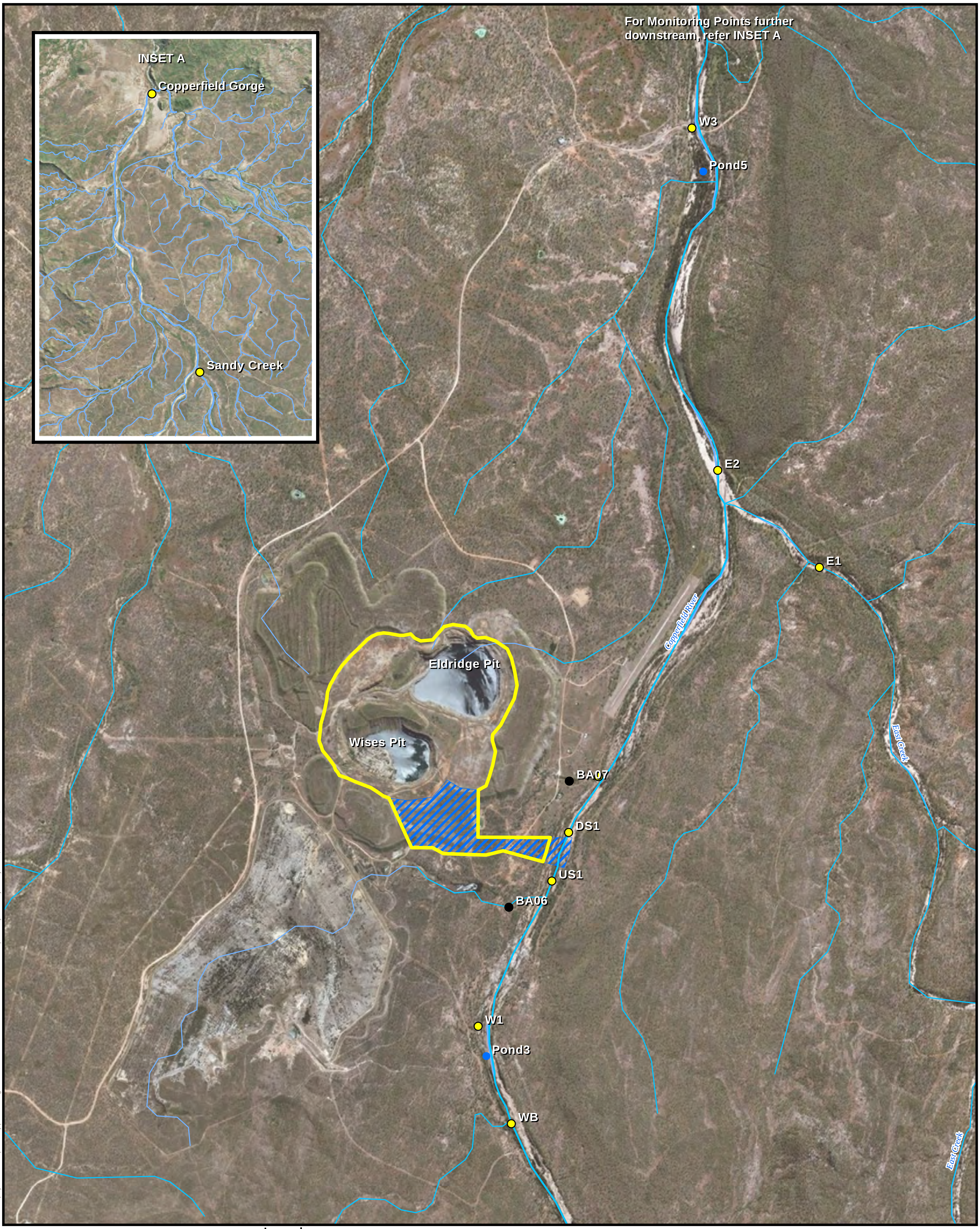
Group	Site	Easting	Northing	Description	Monitoring Frequency			
					Water Quality	Sediment Quality	Biological	Flow
Regional Monitoring – Background Sites	WB	201087	7907273	Upstream of all influences on the Copperfield River	**Baseline Monitoring** • Within 1 week of the commencement of flow • Monthly thereafter for as long as water persists	**Initial Sediment Study** • Dry Season 2019 • 5x replicates from each site **Thereafter** • 3x replicates from each site[2] • At the end of the Wet Season after releases have ceased	• At least six weeks after flows recede to <1000 ML/d towards the end of the wet season (March – May) • Early wet season sampling if possible (i.e. 6 weeks following flows receding to <1000ML/d) typically during November – February	N/A
	Pond 3	200868	7907862	Pool situated 1.4km upstream				
	E1	203774	7912124	East Creek upstream of the confluence with the Copperfield River				
Regional Monitoring – Impact Sites	W1	200799	7908133	Downstream of the Tailings Storage Facility on the Copperfield River	**Baseline Monitoring** • Within 1 week of the commencement of flow • Monthly thereafter for as long as water persists **During Releases** • Within the first 24 hours of the commencement of release • Every 3 days thereafter until seven days after the release ceases	**Initial Sediment Study** • Dry Season 2019 • 5x replicates from each site **Thereafter** • 3x replicates from each site[2] • At the end of the Wet Season after releases have ceased	• At least six weeks after flows recede to <1000 ML/d towards the end of the wet season (March – May) • Early wet season sampling if possible (i.e. 6 weeks following flows receding to <1000ML/d) typically during November – February	N/A
	W2	201851	7910299	Downstream of Manager's Creek Dam on the Copperfield River				
	W3	202667	7915973	At the causeway entrance to the Kidston Project on the Copperfield River. Most downstream monitoring point.				
	E2	202887	7912971	East Creek downstream of the confluence with the Copperfield River			N/A	
	Pond 5	202761	7915578	Pool situated 7.0km downstream		N/A	N/A	
	Copperfield River at the confluence with Sandy Creek (waterhole)	197509	7929897	Pool situated 20km downstream		N/A	• At least six weeks after flows recede to <1000 ML/d towards the end of the wet season (March – May) • Early wet season sampling if possible (i.e. 6 weeks following flows receding to <1000ML/d) typically during November – February	
	CG1	TBA[1]	TBA[1]	Copperfield Gorge		**Initial Sediment Study** • Dry Season 2019 • 5x replicates from each site **Thereafter** • 3x replicates from each site[2] At the end of the Wet Season after releases have ceased	N/A	

<table>
<tr><th rowspan="2">Group</th><th rowspan="2">Site</th><th rowspan="2">Easting</th><th rowspan="2">Northing</th><th rowspan="2">Description</th><th colspan="4">Monitoring Frequency</th></tr>
<tr><th>Water Quality</th><th>Sediment Quality</th><th>Biological</th><th>Flow</th></tr>
<tr><td rowspan="2">Near-field monitoring - Mixing Zone</td><td>US1</td><td>TBA[#]</td><td>TBA[#]</td><td>Immediately upstream of release location</td><td rowspan="2">Baseline Monitoring
• Within 1 week of the commencement of flow
• Monthly thereafter for as long as water persists
During Releases
• Within the first 24 hours of the commencement of release
• Every 3 days thereafter until seven days after the release ceases</td><td rowspan="2">Initial Sediment Study
• Dry Season 2019
• 5x replicates from each site
Thereafter
• 3x replicates from each site[2]
• At the end of the Wet Season after releases have ceased</td><td>N/A</td><td>Continuous</td></tr>
<tr><td>DS1</td><td>TBA[#]</td><td>TBA[#]</td><td>Immediately downstream of mixing zone for releases from the K2H Project</td><td>N/A</td><td>Continuous</td></tr>
<tr><td rowspan="3">Release Water</td><td>Eldridge Pit</td><td>TBA[#]</td><td>TBA[#]</td><td>Eldridge Pit at the Ramp</td><td rowspan="2">Baseline Monitoring
• Monthly for the first 24 months of Operation
• Quarterly thereafter</td><td rowspan="3">N/A</td><td rowspan="3">N/A</td><td>N/A</td></tr>
<tr><td>Wises Pit</td><td>TBA[#]</td><td>TBA[#]</td><td>Wises Pit at the Ramp</td><td>N/A</td></tr>
<tr><td>Release Water</td><td>TBA[#]</td><td>TBA[#]</td><td>Sample of waters at the Release Point into the Copperfield River</td><td>• Within 24 hours of commencement of release
• Every day thereafter while releases are occurring.</td><td>N/A</td></tr>
<tr><td rowspan="2">Groundwater Monitoring</td><td>BA06</td><td>201067</td><td>7909160</td><td>6.0m deep well installed in river loam and sand.</td><td rowspan="2">Construction Phase
• Monthly
Operational Phase
• Quarterly</td><td rowspan="2">N/A</td><td rowspan="2">N/A</td><td rowspan="2"><u>WATER LEVEL:</u>
Construction Phase
• Monthly
Operational Phase
• Monthly</td></tr>
<tr><td>BA07</td><td>201595</td><td>7910262</td><td>5.0m deep well installed in river loam and sand.</td></tr>
</table>

[1] The most suitable location for monitoring at the Copperfield Gorge to be defined prior to the first release. Location is to be suitable for access in wet-weather events and suitable for water quality monitoring. NOTE: the sediment monitoring location may be different than the water quality sampling location as it would be ideal to capture sediment just upstream of the gorge in the dry river bed

[#] Location to be determined after installation of appropriate infrastructure.

[2] The initial sediment study is to determine whether replicates are required at each site for ongoing monitoring.



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DATUM GDA 1994, PROJECTION MGA ZONE 56

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metres

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Legend

- Groundwater Bore
- Monitoring Point
- Pond
- Watercourse - Major
- Watercourse - Minor
- Key Project Infrastructure Footprint
- Spillway Options Corridor

KIDSTON PUMPED STORAGE HYDRO PROJECT
IMPACT ASSESSMENT REPORT

REMP Monitoring Points

PROJECT ID	60544566
CREATED BY	RF
LAST MODIFIED	FraserR2I - 11 Jan 2019
VERSION:	2

Figure
75

A3 size

Filename: P:\605X\60544566\4. Tech Work Area\4.99 GIS\04_Outgoing\20190108_RF_K2H_MPs\20190108_RF_K2H_MPs.mxd

9.3 Adaptive Mitigation Strategies

A number of strategies have been identified to provide further mitigation strategies. These strategies are adaptive in their nature and can be applied if found to be necessary based on feedback from the downstream monitoring programme outlined in the REMP (Appendix I). Each strategy is discussed below:

9.3.1 Extending the Flushing Period through Asymmetrical Release Triggers

The use of asymmetrical release triggers has the potential to increase the duration and volume of the post release flushing. By increasing the receiving flow rate trigger at which releases stop potential release events are curtailed at an earlier point in the flow event's recessional flow period thus extending the post-release flush. This is illustrated in Figure 76 which employs a cease to release trigger of 700 ML/d as an example. An advantage of this strategy is the potential for seasonal variability such that the cease to release trigger could be altered near the end of the wet season to ensure that any residual water remaining in the system during the dryer month benefits from further flushing. This mitigation measure would only be required if the monitoring undertaken as part of the proposed release program identifies that the flushing that is currently proposed is shown to be insufficient to adequately flush construction releases.

9.3.2 Extended Flushing using Releases from the Copperfield Dam

A controlled release of water from the Copperfield Dam could provide a means of diluting, flushing and assisting in the downstream movement of water contained within the pools and waterholes downstream of the proposed release point. Possible causative scenarios could be:

- Unexpectedly rapid flow recession leading to insufficient flushing; or
- Insufficient mixing of flush water through downstream waterholes and pools.

In the instance that monitoring identifies potential stranding of released water then a release of water from the Copperfield Dam could be employed to assist in the dilution and downstream movement of water by extending the natural flushing of the Copperfield River.

9.3.3 Cessation of Releases during the Dry Season

Complete cessation of releases during the dry season or a defined period within the dry season could be utilised as a measure to exclude the potential for stranding of released water in downstream pools and waterholes. This mitigation measure would only be required if the monitoring undertaken as part of the proposed release program identifies that the flushing that is currently proposed is shown to be insufficient to flush construction water releases during the dry season.

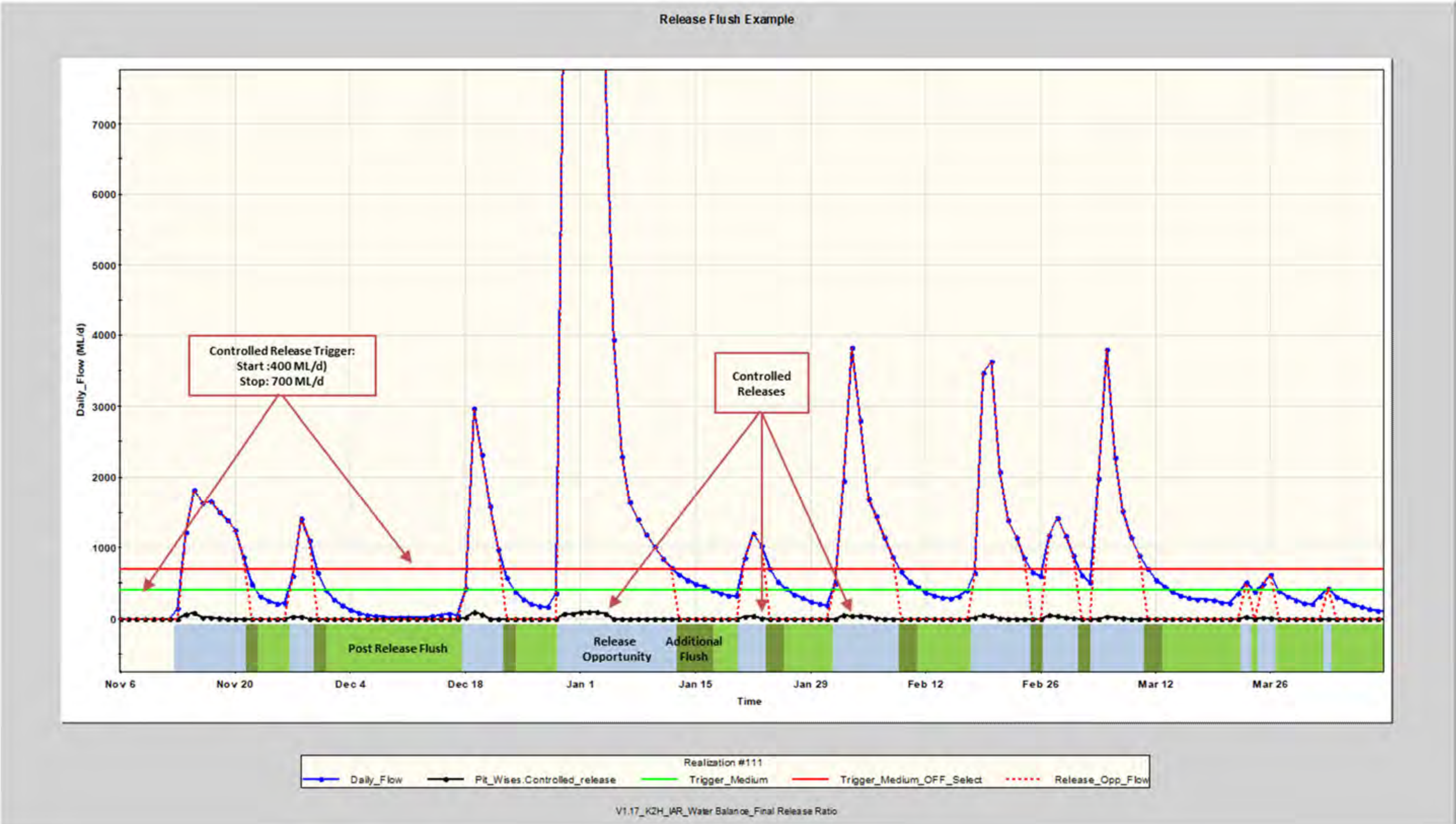

Figure 76 Example of Controlled Releases and Post-Release Flushes with use of Asymmetrical Release Triggers

10.0 Summary

Operational Releases

The operational releases will continue to be required throughout the life of the Project and the development of appropriate discharge limits has been used as a primary mitigation measure to ensure that environmental impacts are appropriately minimised. For operational releases, it is proposed that a maximum of 69% of the assimilative capacity of the receiving environment be utilised (this equates to an effective dilution ratio of 200 parts receiving environment to one part release water). By limiting the use of assimilative capacity to 69%, this allows for preservation of a portion of the capacity for future development. The assumptions behind calculating effective dilution ratios are highly conservative (based on maximum pit water qualities). In reality the actual assimilative capacity usage will be lower than 69% in most cases.

A comprehensive assessment has been undertaken to develop an understanding of the potential impacts of operational releases on the EVs of the receiving environment including potential impacts on water quality, hydrology, geomorphology, hydrogeology and ecology of the receiving environment. Key findings are summarised below.

Water Quality Impacts for Operational Releases

An assessment of near-field and far-field water quality modelling and DTA results indicates no significant adverse impacts to EVs relevant to the Project area resulting from operational releases. This is evidenced by the following:

- Parameters relevant to the aquatic ecosystem EV are below the WQO at all locations, with the exception of total nitrogen and dissolved zinc.
- Proposed releases are subject to initial mixing within the near field and predicted water quality within the mixing zone reaches the HMTV for dissolved zinc (the constituent of most concern), within a maximum (worst-case) distance of 625 m. Other modelled scenarios indicate a much smaller mixing zone of between 50 and 70 m downstream.
- The concentration of total nitrogen is modelled to drop below the WQO by Einasleigh. Nitrogen does not have many toxicological impacts on aquatic organisms; rather it is a nuisance nutrient that promotes algal growth. It is noted however that there is no evidence of algal growth currently and phosphorus concentrations (required to trigger algal growth) in the Copperfield River are low.
- Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek (95 concentrations). In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. For the scenarios assessed, the 90% species protection WQO will not be exceeded at any location in the receiving environment.
- The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible.
- During the operations phase, the simulated releases are well in excess (200:1) of the minimum dilution ratio for toxicity-related impacts in the receiving environment (9:1).
- Concentrations of parameters relevant to other EVs are all modelled to be below the specified WQO.

Hydrology Impacts for Operational Releases

As a result of the proposed release of water from the Project, some minor changes are expected to the magnitude of flows that are a direct result of the additional water added during releases. The magnitude of the increases is however small and is not expected to be of material impact to the existing flow regime.

Due to the event-based nature of the proposed releases, no changes to key temporal indicators (timing, frequency and duration of flow events) were noted as a result of the proposed releases. Some minor increases to the rates of rise and fall were noted; however, they are not considered to be of sufficient magnitude to result in any adverse impacts.

Confirming that sufficient streamflow continues in the Copperfield River after cessation of any potential releases is required to ensure that potential releases continue to move downstream, are subject to ongoing dilutionary inflows and do not become stranded due to natural streamflow recession. The median duration of each post release flush at the proposed release point is 32 days with a volume of 1,758 ML.

Aquatic Ecology Impacts for Operational Releases

It is suggested that the adoption and application of appropriate release management strategies for operational releases will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values for the following reasons:

- The proposed controlled releases will only be undertaken during flow events within the receiving environment with a minimum flow trigger stipulated and the cessation of the release occurring prior to natural flows subsiding to allow for an additional flushing effect.
- The proposed release ratio during the operational phase is 200:1, well above that required to achieve 95% species protection determined through DTA.
- Mixing zone modelling has indicated that the use of a diffused discharge outlet structure will facilitate near field mixing at the outlet such that the WQO for the contaminant of most concern (dissolved zinc) will be met within 625m for the range of scenarios and outlet configurations assessed (most modelled scenarios suggest a mixing zone of between 50 and 70 m downstream).
- All fish species found to be occurring within the Copperfield River display relatively broad tolerances to a wide range of water quality characteristics, however, the macroinvertebrate communities were comprised of families sensitive to environmental change.
- As the releases are to be managed to occur as event-based, no changes to key temporal indicators (timing, frequency and duration of flow events) are expected. While some minor increases to the rates of rise and fall are expected, they are not considered to be of sufficient magnitude to result in any adverse impacts to the aquatic ecology values of the system. Fish passage will not be reduced by the minor increases in flow.
- The potential impacts to the downstream environment from increased erosion and sedimentation during the operation are anticipated to be restricted to the immediate area surrounding and downstream of the release point. Appropriate design and management of the diffuser will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values.

Hydraulics and Fluvial Geomorphology Impacts for Operational Releases

The base-case hydraulic model confirmed that the release into the channel at a ratio of 200:1 does not have a significant impact on the hydraulic characteristics of the Copperfield River. Minor increases to main channel depth of up to 0.01m were predicted, however this did not alter the overall water surface elevation for the river reach. The velocity for the high flow events did not change, and minor increases of 2% were noted in the medium flow scenario. With shear stress values increasing by only minor values (less than 2%) for the 'with releases' scenario, there is unlikely to be any increase in sediment transport as a result of Project releases.

Hydrogeology Impacts for Operational Releases

During the operational phase of the Project, the predictive groundwater modelling indicates that the Eldridge Pit will continue to act as a groundwater sink, reducing seepage migration risks to the north of the Project (and downstream in the Copperfield River). During operations the water discharged from the Project will contribute a maximum of 0.5% additional flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime.

Temporary Construction Releases

Temporary construction releases are anticipated to be required for a duration of approximately 2.15 years. For temporary construction releases, it is proposed that a maximum of 76.3% of the assimilative capacity of the receiving environment be utilised (this equates to an effective dilution ratio of 200 parts receiving environment to one part release water from the Eldridge Pit). By limiting the use of assimilative capacity to 76.3%, this allows for preservation of a portion of the capacity for future development. The assumptions behind calculating effective dilution ratios are highly conservative (based on the maximum pit water quality for Eldridge Pit). In reality the actual assimilative capacity usage will be lower than 76.3% in most cases.

A comprehensive assessment has been undertaken to develop an understanding of the potential impacts of temporary construction releases on the EVs of the receiving environment including potential impacts on water quality, hydrology, geomorphology, hydrogeology and ecology of the receiving environment. Key findings are summarised below.

Water Quality Impacts for Temporary Construction Releases

An assessment of far-field water quality modelling and DTA results indicates that any impacts occurring as a result of construction releases are temporary and reversible. This is evidenced by the following:

- Parameters relevant to the aquatic ecosystem EV are below WQOs at all locations, with the exception of total nitrogen and dissolved zinc. Concentrations of parameters relevant to other EVs are all modelled to be below the specified WQO.
- Under a worst case scenario, there may be rare and very minor exceedances of the default 95% species protection WQO for dissolved zinc from Charles Creek to Chinaman Creek. Given that these exceedances represent a ‘maximum’ modelled value, the likelihood of these concentrations being released is very low. In addition, the exceedances are within the likely margin of error of the various methods used in the assessment. For the scenarios assessed, the 90% species protection WQO will not be exceeded at any of the modelled location in the receiving environment.
- The mass balance assessment indicates that the HMTV will not be exceeded in either of the two semi-permanent pools (Pond 4 and Pond 5) located downstream of the release location, therefore impacts to these pools are therefore anticipated to be negligible.
- During the construction phase, the simulated releases are well in excess (200:1) of the minimum dilution ratio for toxicity-related impacts in the receiving environment (9:1).

Hydrology Impacts for Temporary Construction Releases.

Construction phase releases are proposed to utilise the same release conditions (including a release trigger of 400 ML/d) as operational phase releases. This is unlikely to materially impact on the existing flow regime in terms of the timing, frequency, duration and magnitude of flows. Releases will coincide with naturally occurring streamflow events in the Copperfield River at the proposed release point and cease as streamflow recesses below the proposed 400 ML/d trigger. The use of the same dilution ratio (200 to 1) during the construction phase as the operational phase dilution ratio will result in a similar contaminant mass loading per release event. Possible stranding of releases in downstream pools and waterholes is however considered unlikely due to the significant post release flush volumes following each release event.

Ongoing tributary inflows downstream of the proposed release point provide significant additional flushing such that the median mean flush ratio of 5.6 % at the release point is reduced to 0.9 % by Einasleigh.

Aquatic Ecology Impacts for Temporary Construction Releases

It is suggested that the adoption and application of appropriate release management strategies for temporary construction releases will sufficiently reduce the level of residual risk posed to the downstream aquatic ecology values for the following reasons:

- The proposed controlled releases will only be undertaken during flow events within the receiving environment with a minimum flow trigger stipulated and the cessation of the release occurring prior to natural flows subsiding to allow for an additional flushing effect.
- The proposed release ratio during the operational phase is 200:1, well above that required to achieve 95% species protection determined through DTA.
- Mixing zone modelling has indicated that the use of a diffused discharge outlet structure will facilitate near field mixing at the outlet such that the WQO for the contaminant of most concern (dissolved zinc) will be met within 625m for the range of scenarios and outlet configurations assessed (most modelled scenarios suggest a mixing zone of between 50 and 70 m downstream).
- All fish species found to be occurring within the Copperfield River display relatively broad tolerances to a wide range of water quality characteristics, however, the macroinvertebrate communities were comprised of families sensitive to environmental change.
- As the releases are to be managed to occur as event-based, no changes to key temporal indicators (timing, frequency and duration of flow events) are expected. While some minor increases to the rates of rise and fall are expected, they are not considered to be of sufficient magnitude to result in any adverse impacts to the aquatic ecology values of the system. Fish passage will not be reduced by the minor increases in flow.
- The potential impacts to the downstream environment from increased erosion and sedimentation during the construction phase are anticipated to be restricted to the immediate area surrounding and downstream of the release point. This is particularly relevant to the first wet season discharges when a temporary outfall structure may be utilised for a short period of time. Stabilisation of banks where discharge is proposed may be necessary to minimise these impacts. This will be further considered during detailed design.

Hydraulics and Fluvial Geomorphology Impacts for Temporary Construction Releases

The base-case hydraulic model confirmed that the release into the channel at a ratio of 200:1 does not have a significant impact on the hydraulic characteristics of the Copperfield River. Minor increases to main channel depth of up to 0.01m were predicted, however this did not alter the overall water surface elevation for the river reach. The velocity for the high flow events did not change, and minor increases of 2% were noted in the medium flow scenario. With shear stress values increasing by only minor values (less than 2%) for the 'with releases' scenario, there is unlikely to be any increase in sediment transport as a result of Project releases.

The discharge release infrastructure design will consider the potential risk of scouring as a result of the construction discharges which may cause localised erosion resulting in increased sedimentation. This may increase the sediment coarse fraction, which may impact the downstream environment by affecting turbidity. In order to ensure that erosion and scouring impacts are not occurring as a result of temporary construction releases, it is proposed that visual inspections of the outlet structure and surrounds are undertaken at appropriate times during the construction of the Project.

Hydrogeology Impacts for Temporary Construction Releases

During the construction phase of the Project, the predictive groundwater modelling indicates that the Eldridge Pit will continue to act as a groundwater sink, reducing seepage migration risks to the north of the Project (and downstream in the Copperfield River). During construction, the water discharged from the Project will contribute a maximum of 0.5% additional flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime.

Hydrogeology Impacts for Temporary Construction Releases

During construction the predictive groundwater modelling indicates that the water levels in the Eldridge Pit will be at their lowest and that the pit will continue to act as a groundwater sink, reducing seepage migration risks to the north of the Project (and downstream in the Copperfield River). During construction the water discharged from the Project will contribute a maximum of 4.2% of the flow volume to the Copperfield River and only occur during medium and high flow events. The scale and timing of these discharges is therefore not expected to materially influence the groundwater regime.

Conclusions

This impact assessment has investigated the implications of the Project on the identified receiving environment receptors (e.g., ecosystems, hydrology etc.). The assessment has been largely desktop-based, with some supplementary testing and analysis completed, and as such is subject to limitations of the largely historical database. In addition, model outcomes are determined by the assumptions made, which are based on the information available.

The assessment first determined a set of WQOs, supported by the DTA, with which to design the modelled operational and temporary construction releases. These models were used to simulate the likely Project regimes. Available information was used to assess the impacts of the Project regimes on the receptors.

Outcomes of the assessment indicate that operational releases are likely to result in relatively low impacts on the receptors in the receiving environment. During temporary construction releases, some impacts are predicted; however, these are expected to be temporary and reversible.

A Project REMP will be developed and implemented as part of the Project (refer to draft REMP contained in Appendix I). The Project REMP includes monitoring of water quality, sediment, biology and stream flow. The main objectives of the Project REMP are to verify assumptions presented in this assessment and report against relevant WQOs in order to monitor whether impacts to the receiving environment and associated EVs are potentially occurring and if further refinement of the release program is required to achieve acceptable environmental outcomes.

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12.0 Standard Limitations

AECOM has prepared this Report in accordance with the usual care and thoroughness of the consulting profession for the use of Genex Power Ltd and is based on generally accepted practices and standards at the time it was prepared. No other warranty, expressed or implied, is made as to the professional advice included in this Report.

This Report should be read in full. No responsibility is accepted for use of any part of this report in any other context or for any other purpose or by third parties. This Report does not purport to give legal advice. Legal advice can only be given by qualified legal practitioners.

The development and use of the GoldSim water balance model utilised for this assessment has included information that has been provided to AECOM by third parties. Where this data has been utilised, AECOM has made no independent verification of this information except as expressly stated in the Report. AECOM assumes no liability for any inaccuracies in or omissions to that information.

Model results are based on historical climate data (SILO Data Drill) obtained from the Qld Department of Environment and Science. While this data is derived from the Bureau of Meteorology's weather station network, the algorithms used to produce a data Drill are occasionally revised which may result in minor changes to future Data Drills derived for the same location.

Modelling of the Project has been based on a number of simplified operational rules dictating operations such as when releases or topups of water from the Copperfield dam can be made. These rules are subject to ongoing refinement as the Project progresses through detailed design and subsequent operation.

To the extent permitted by law, AECOM expressly disclaims and excludes liability for any loss, damage, cost or expenses suffered by any third party relating to or resulting from the use of, or reliance on, any information contained in this Report. AECOM does not admit that any action, liability or claim may exist or be available to any third party. It is the responsibility of third parties to independently make inquiries or seek advice in relation to their particular requirements and proposed use of the site.

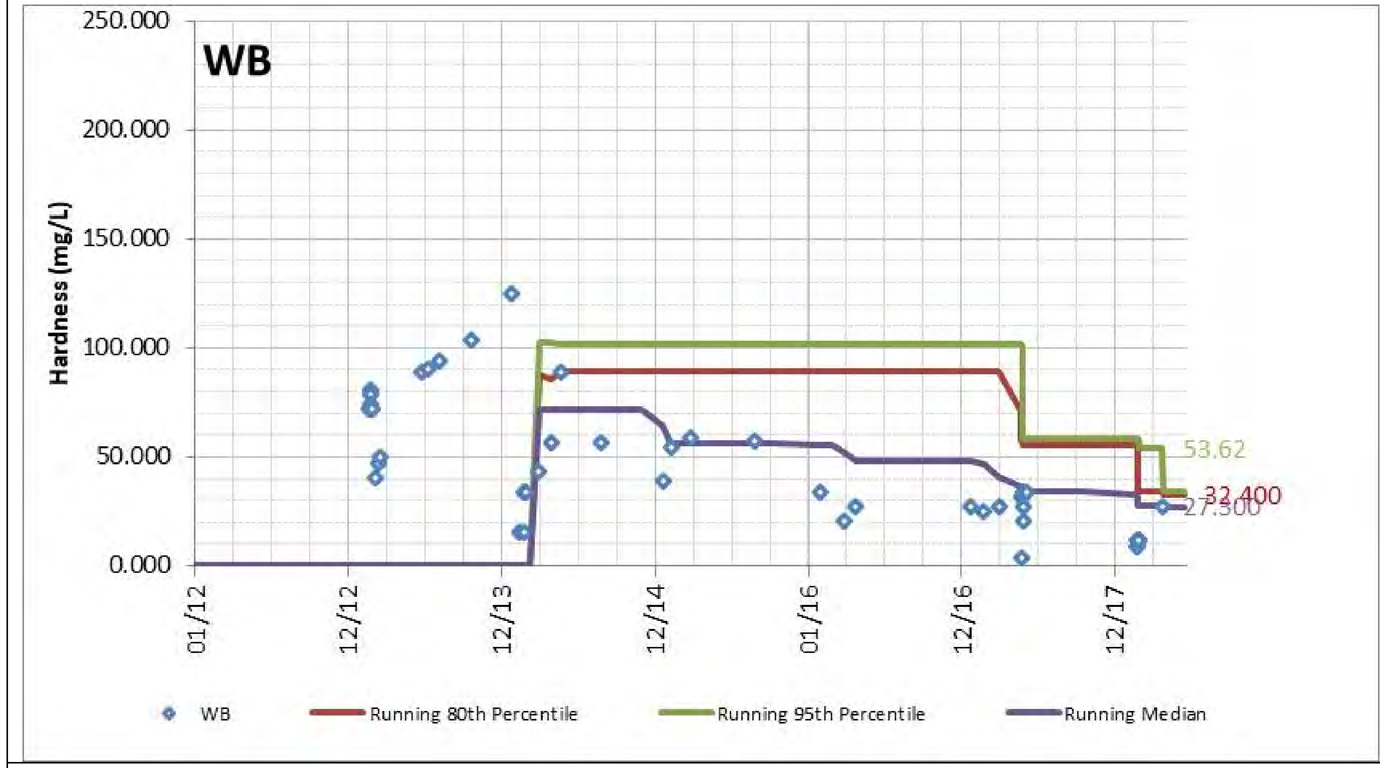
Any estimates of potential costs which have been provided are presented as estimates only as at the date of the Report. Any cost estimates that have been provided may therefore vary from actual costs at the time of expenditure.

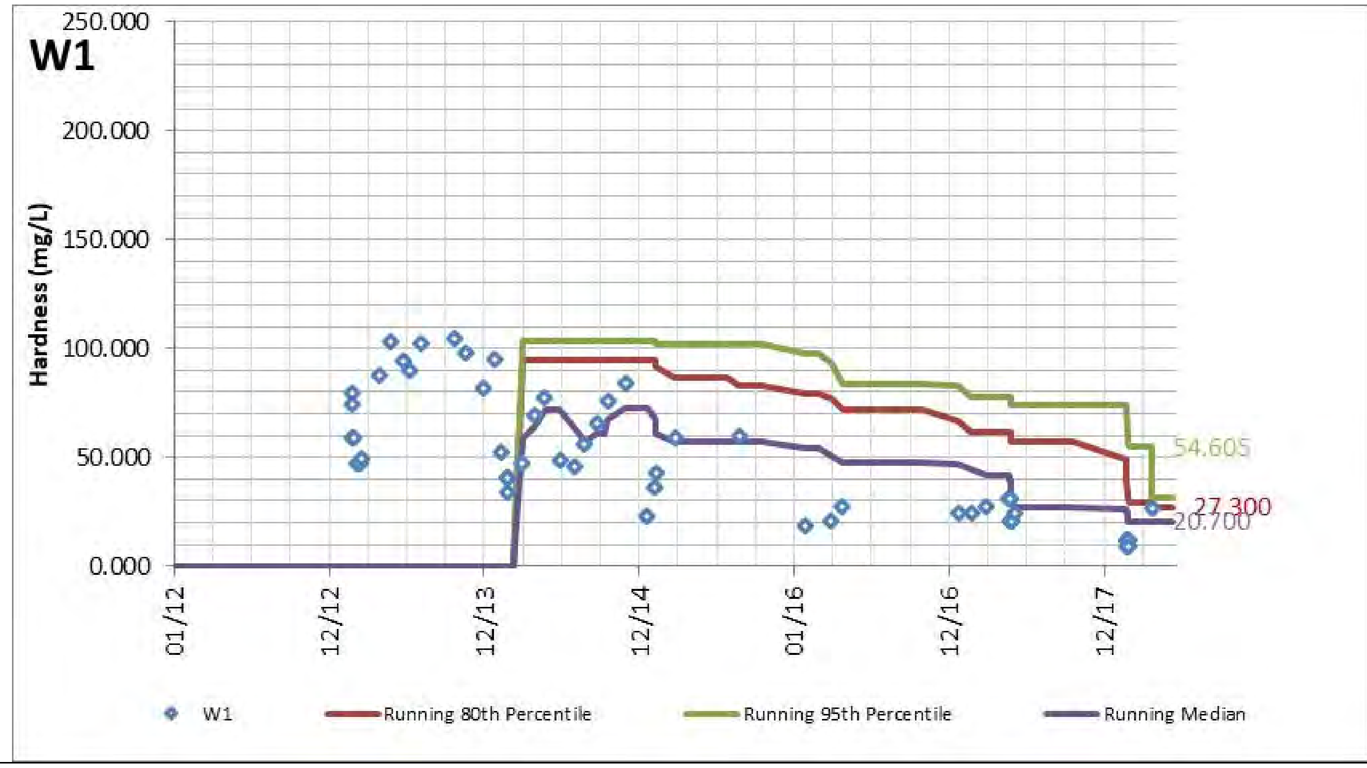
Appendix A

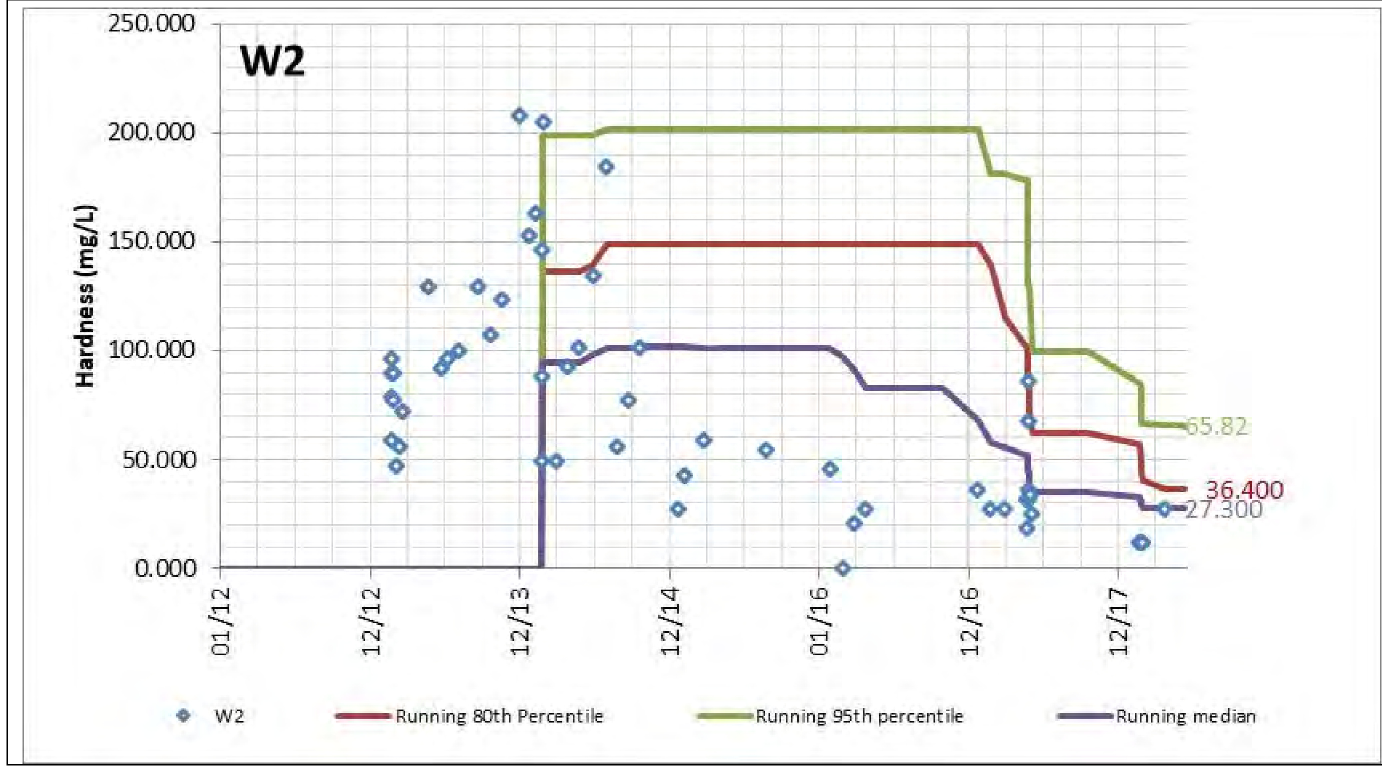
Receiving Environment Water Quality Charts

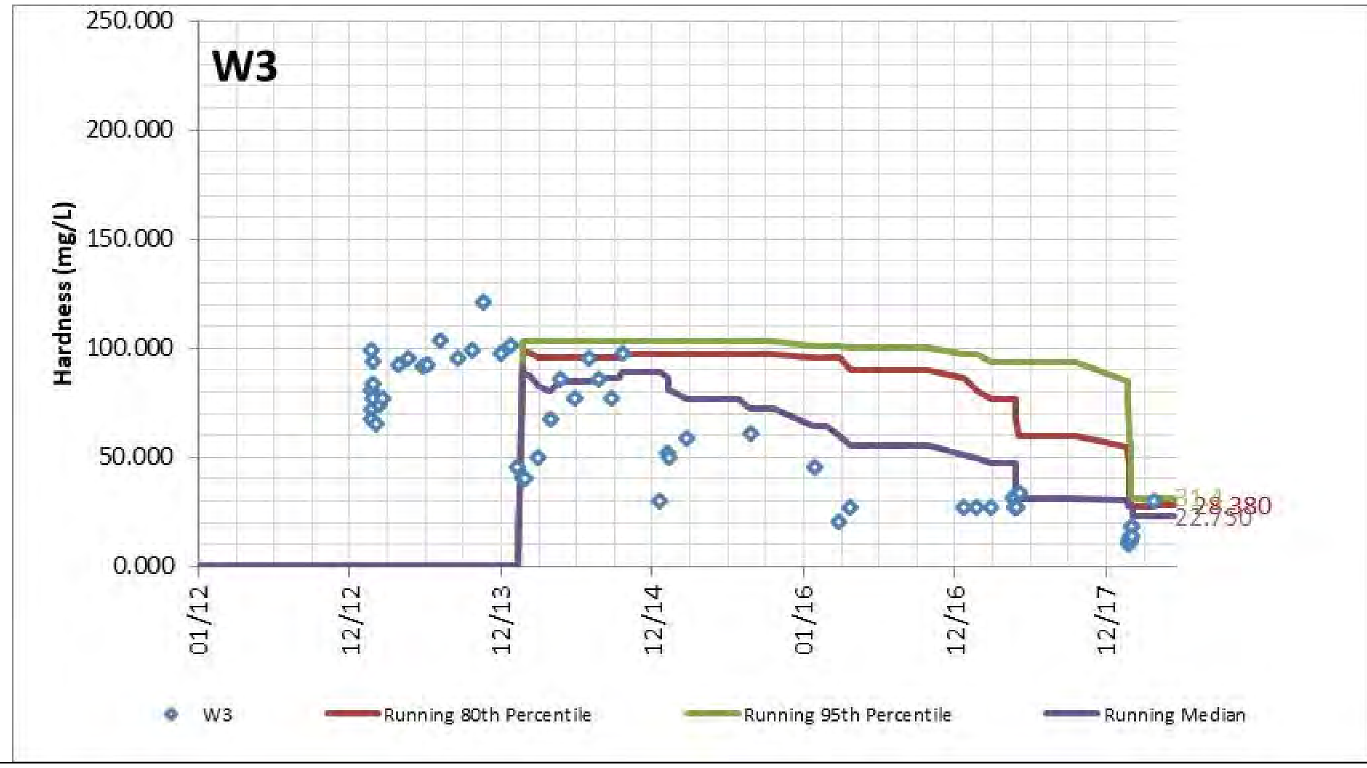
Appendix A Receiving Environment Water Quality Charts

Hardness

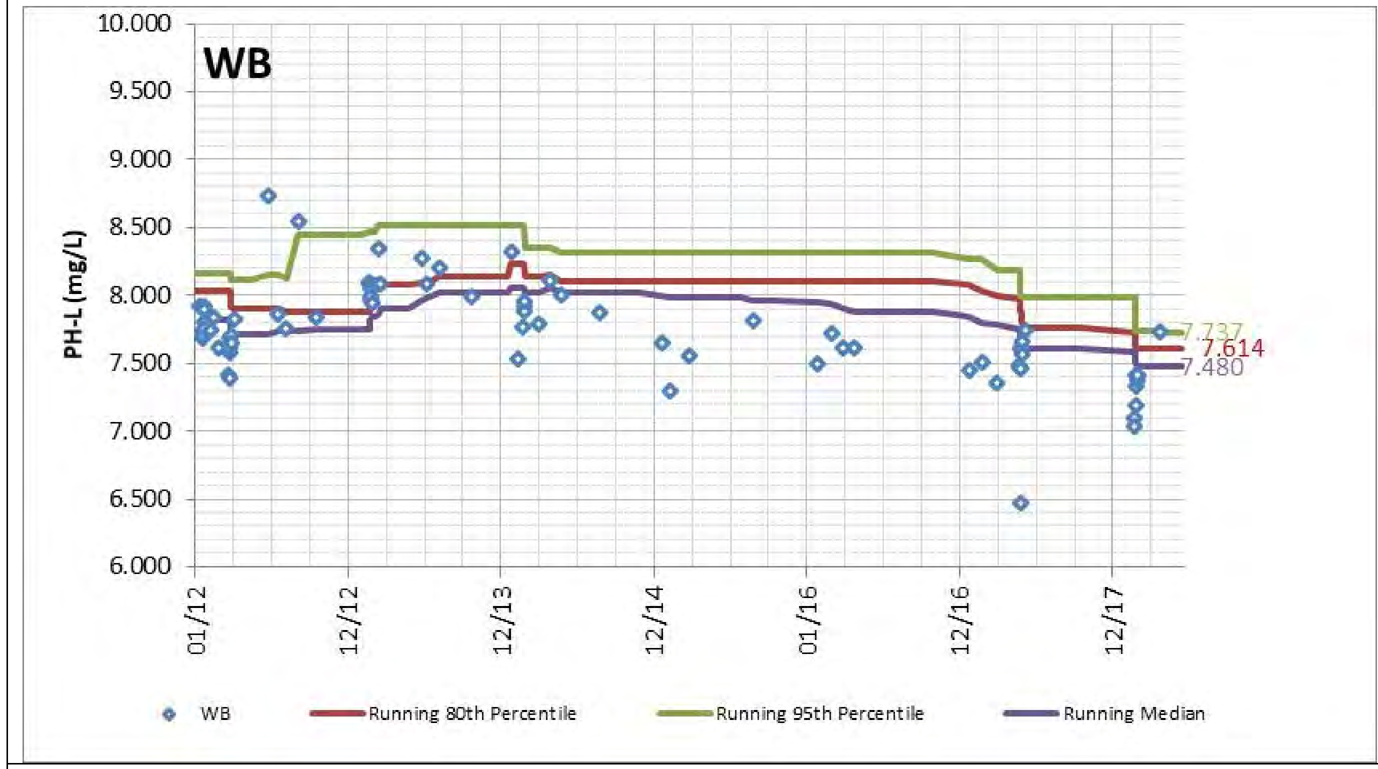


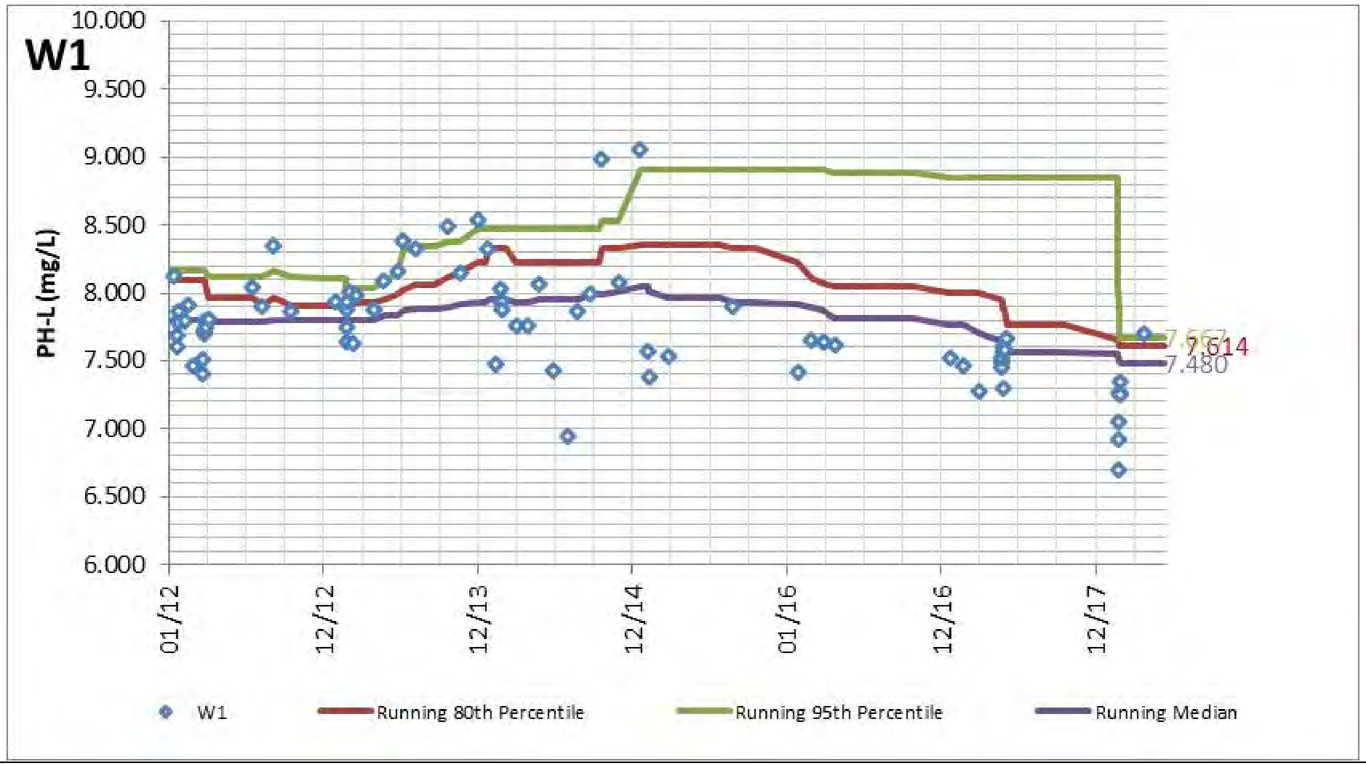


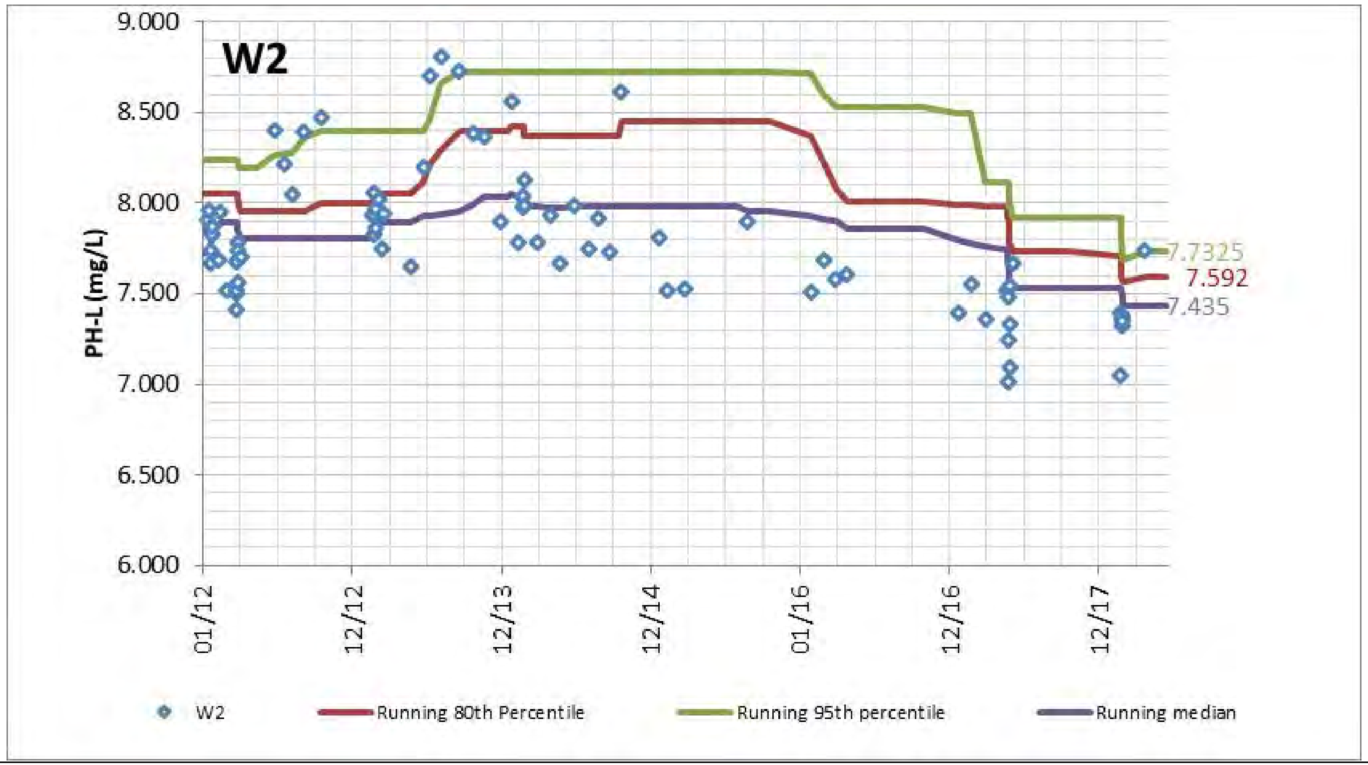


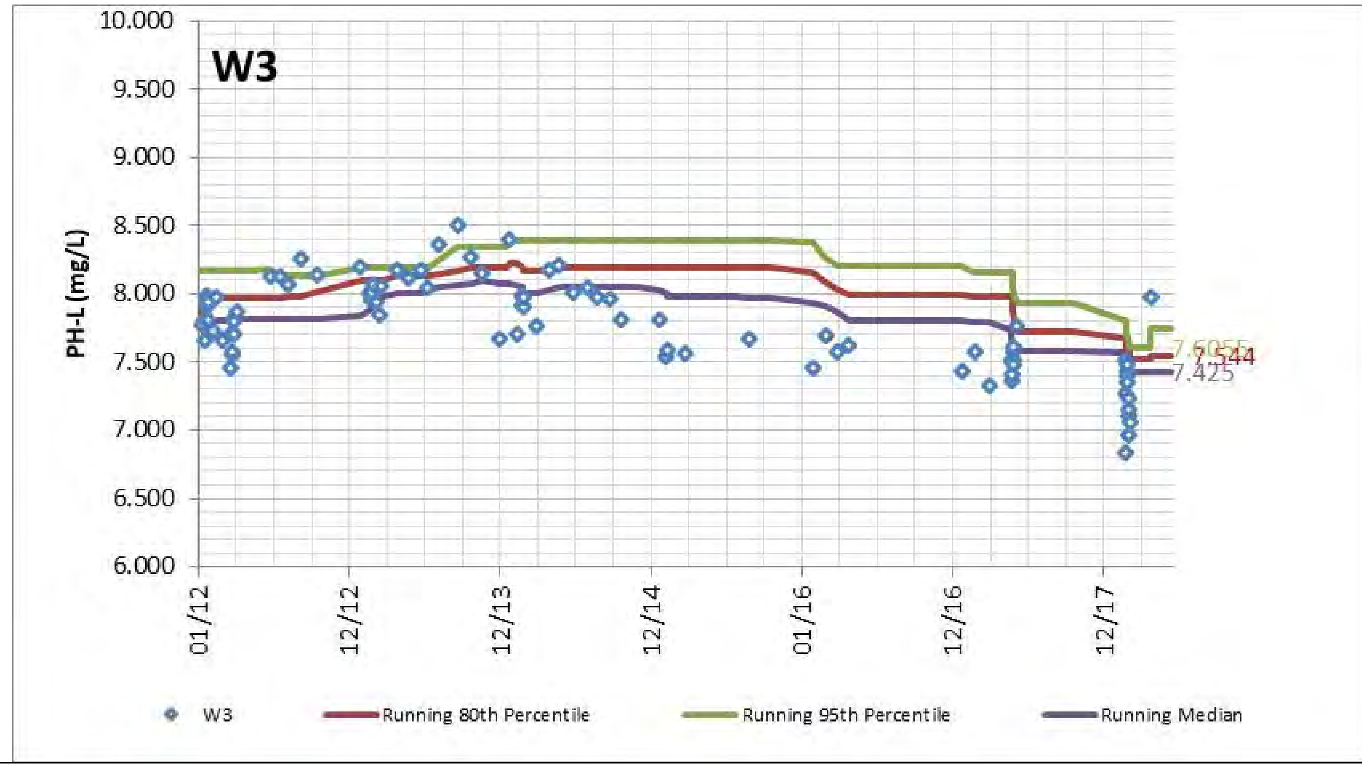


pH

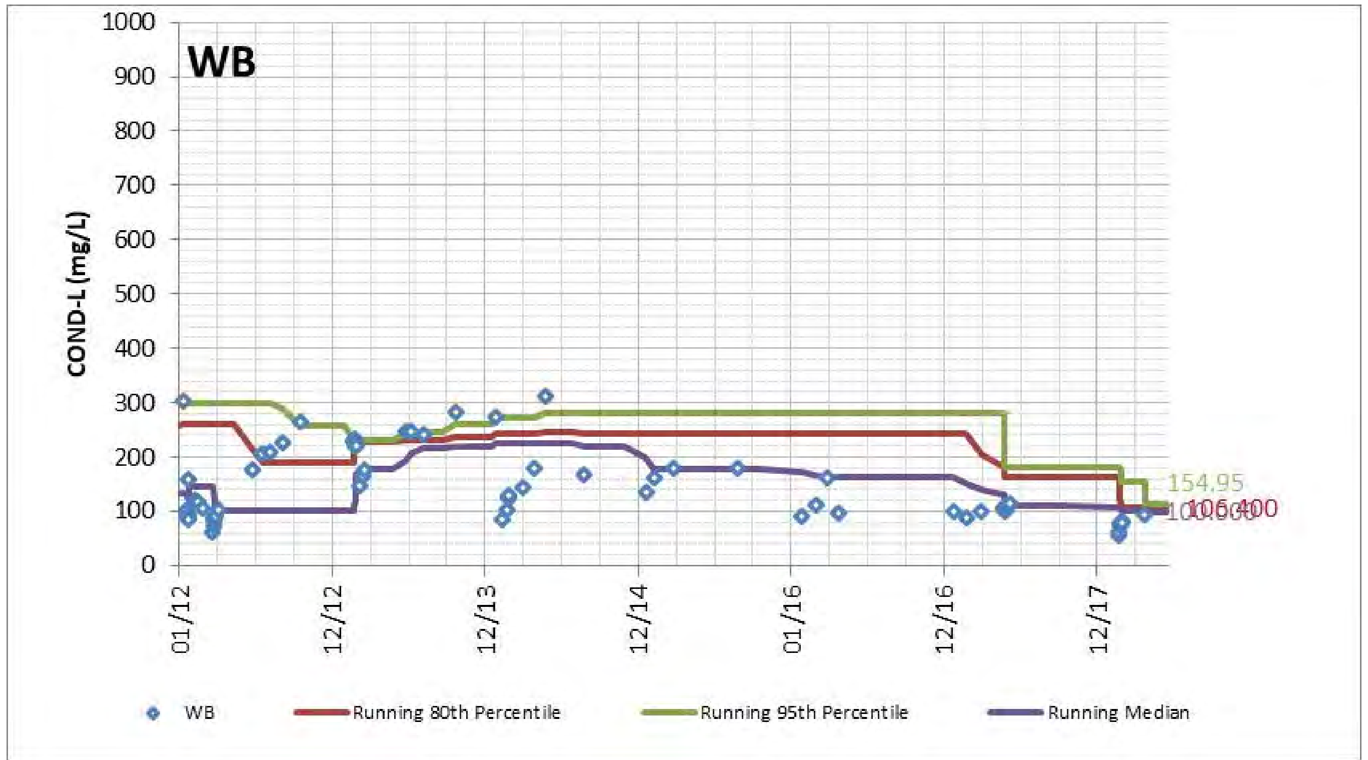

WB
10.000
9.500
9.000
8.500
8.000
7.500
7.000
6.500
6.000
PH-L (mg/L)
01/12
12/12
12/13
12/14
01/16
12/16
12/17
7.737
7.614
7.480
WB
Running 80th Percentile
Running 95th Percentile
Running Median

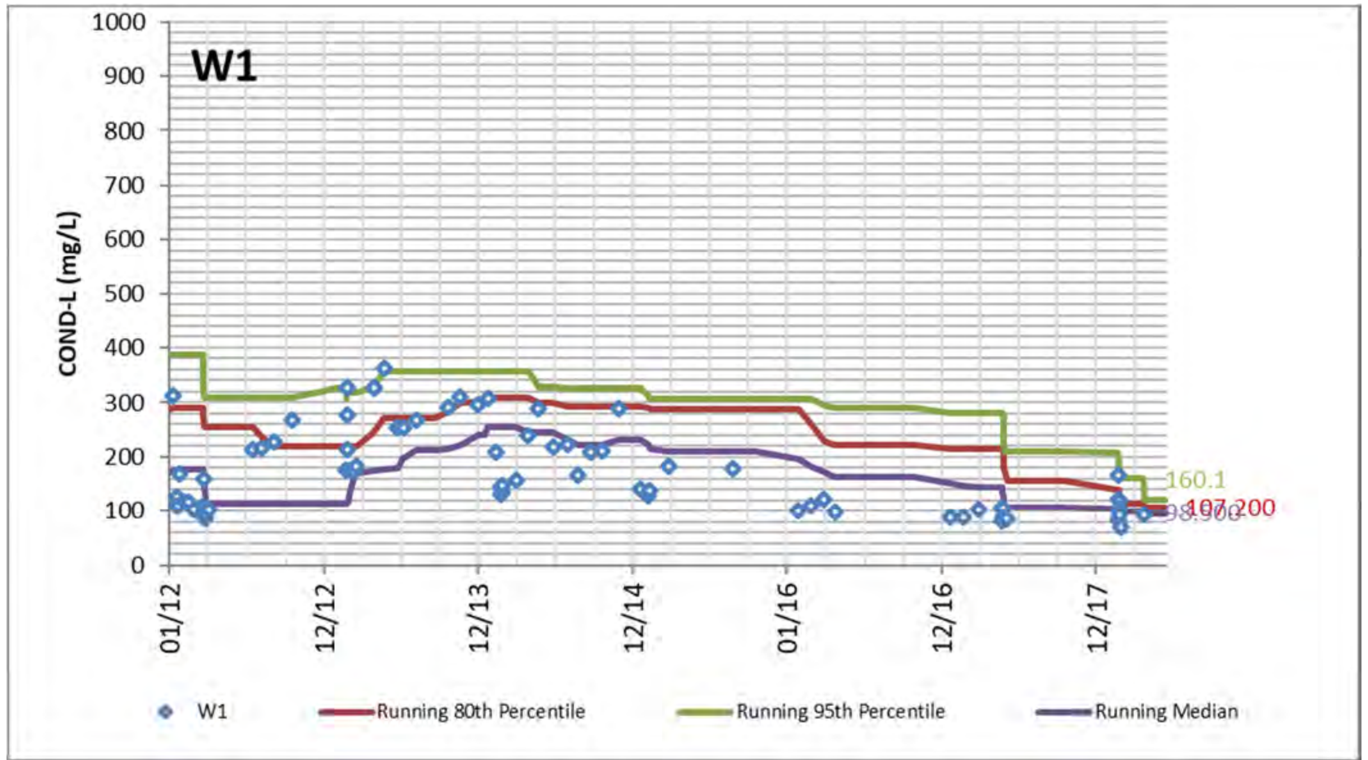

W1
10.000
9.500
9.000
8.500
8.000
7.500
7.000
6.500
6.000
PH-L (mg/L)
01/12
12/12
12/13
12/14
01/16
12/16
12/17
7.614
7.480
W1
Running 80th Percentile
Running 95th Percentile
Running Median

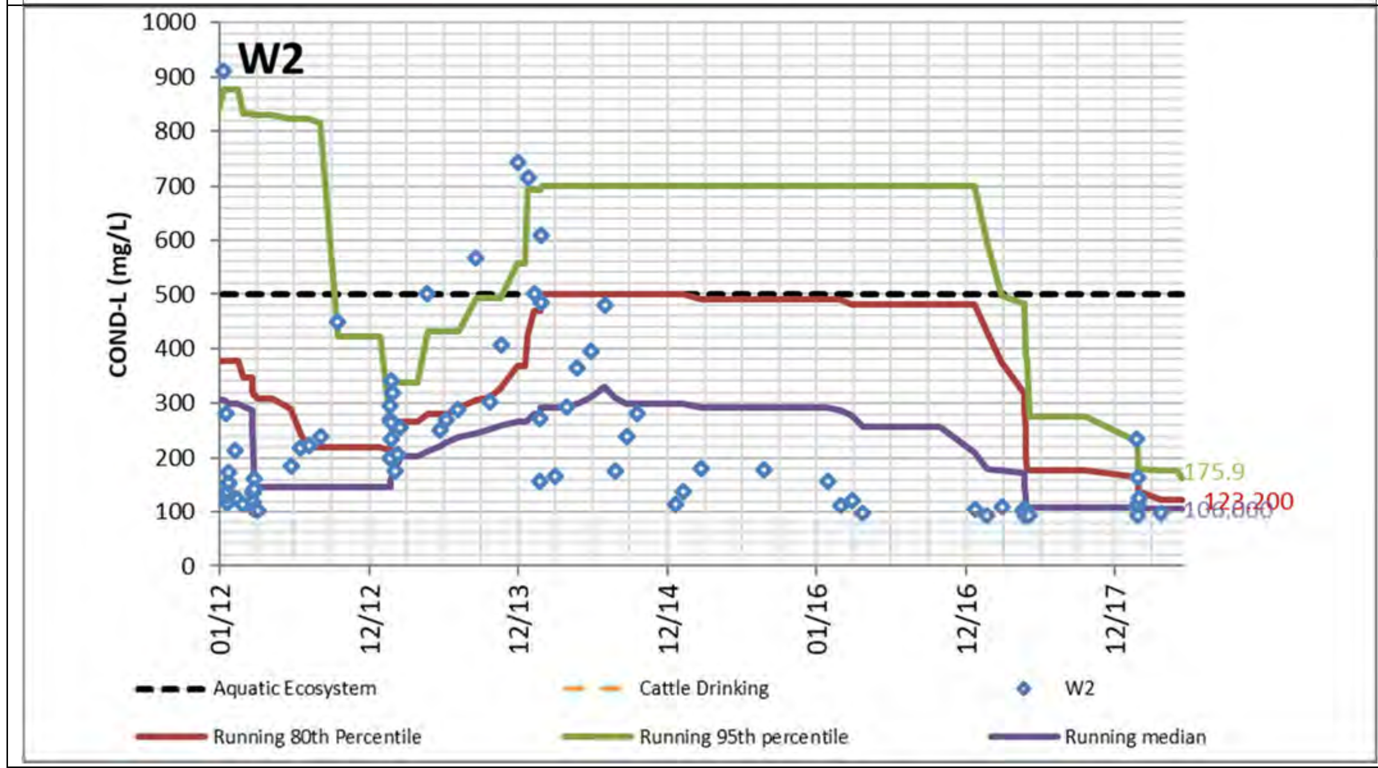

W2
9.000
8.500
8.000
7.500
7.000
6.500
6.000
PH-L (mg/L)
01/12
12/12
12/13
12/14
01/16
12/16
12/17
7.7325
7.592
7.435
W2
Running 80th Percentile
Running 95th percentile
Running median

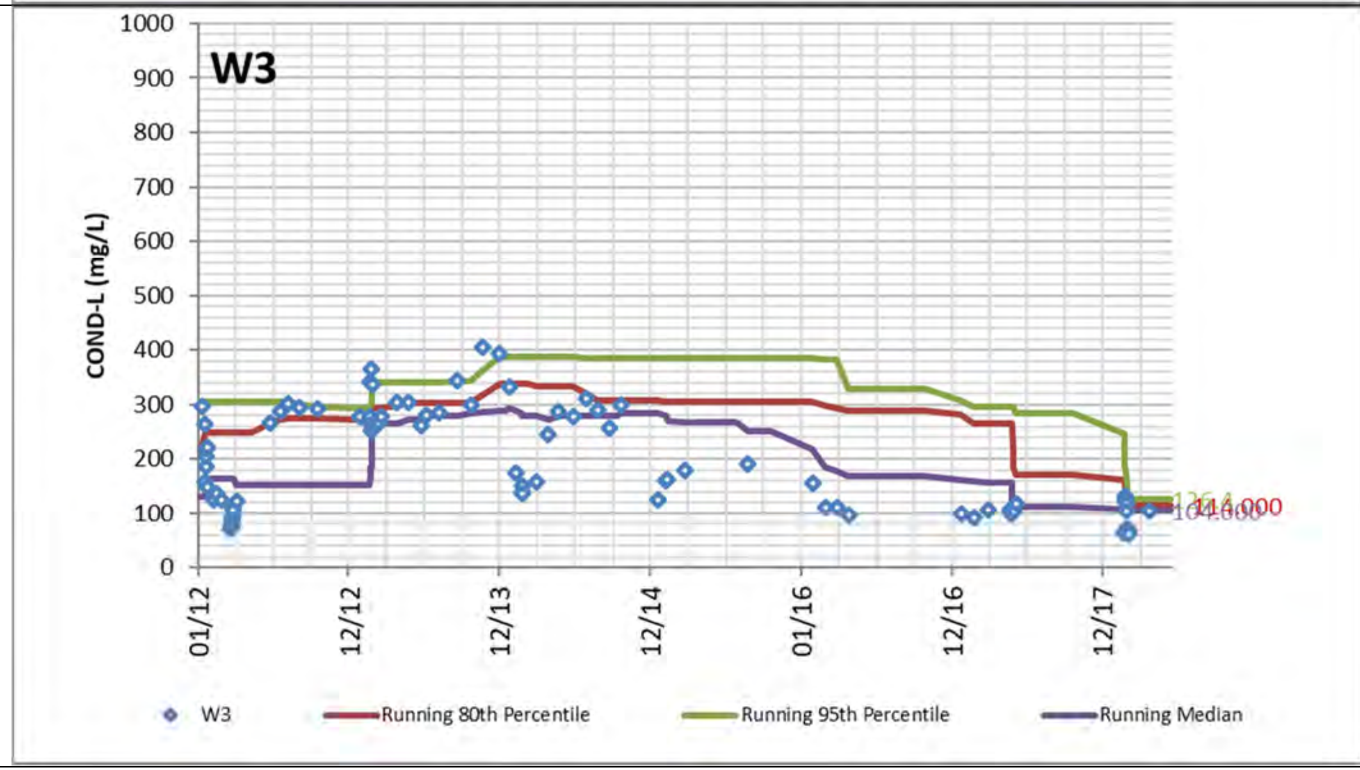

W3
10.000
9.500
9.000
8.500
8.000
7.500
7.000
6.500
6.000
PH-L (mg/L)
01/12
12/12
12/13
12/14
01/16
12/16
12/17
7.425
W3
Running 80th Percentile
Running 95th Percentile
Running Median

EC

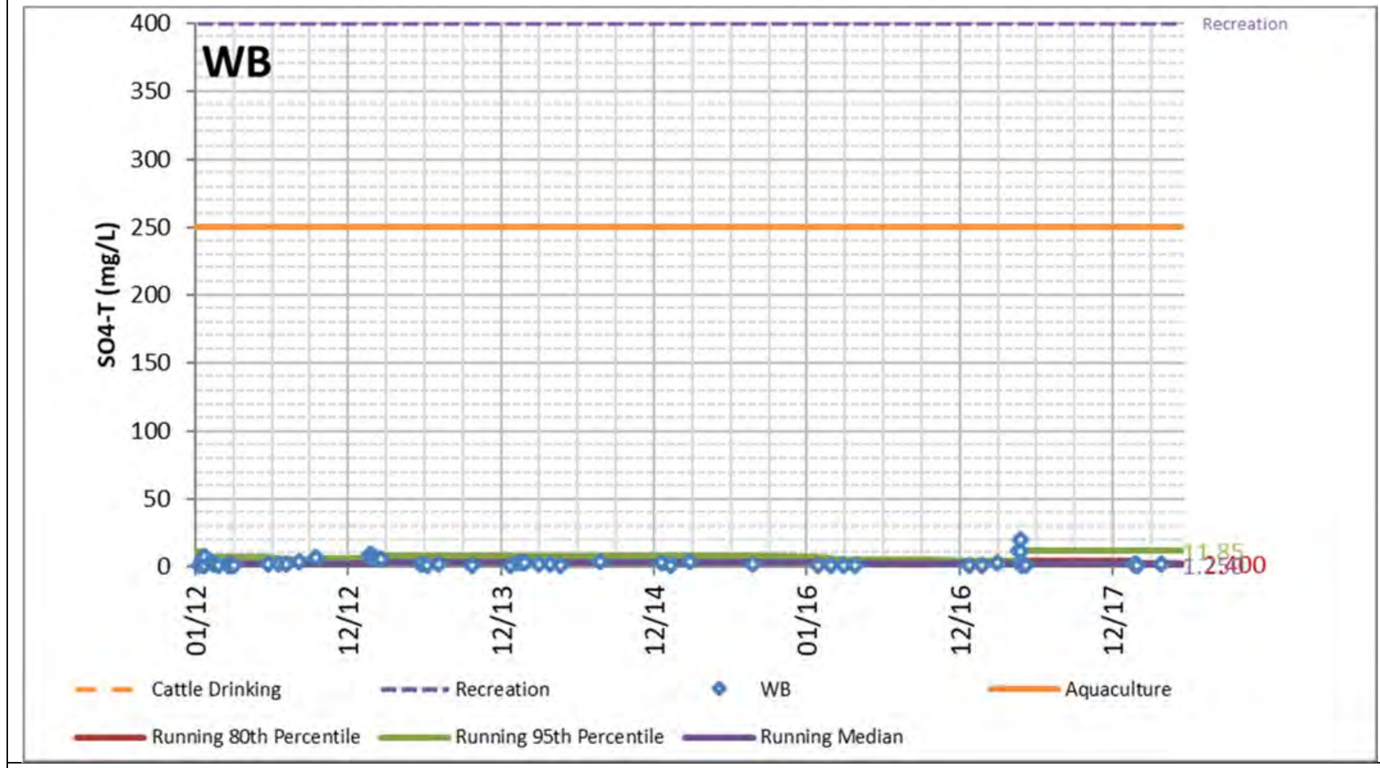

WB
COND-L (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
01/12
12/12
12/13
12/14
01/16
12/16
12/17
154.95
WB
Running 80th Percentile
Running 95th Percentile
Running Median

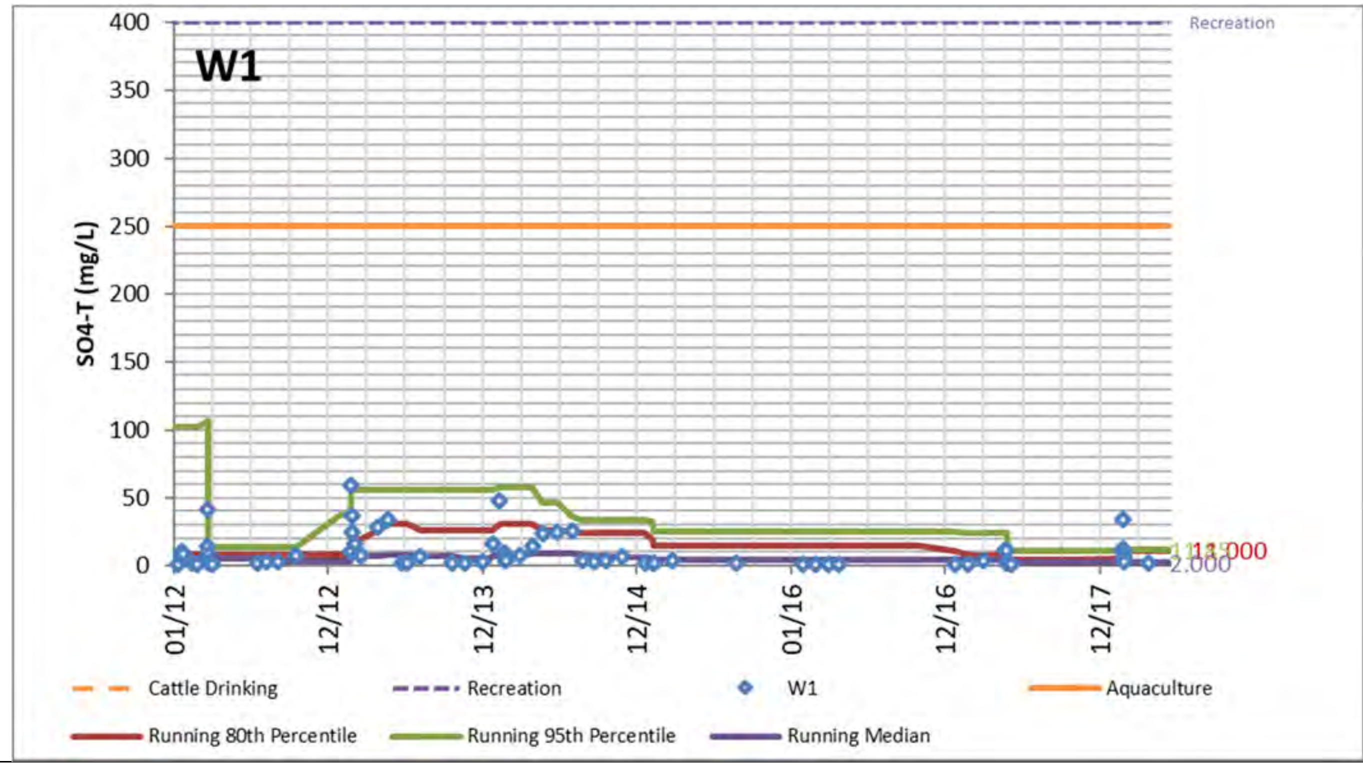

W1
COND-L (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
01/12
12/12
12/13
12/14
01/16
12/16
12/17
160.1
W1
Running 80th Percentile
Running 95th Percentile
Running Median

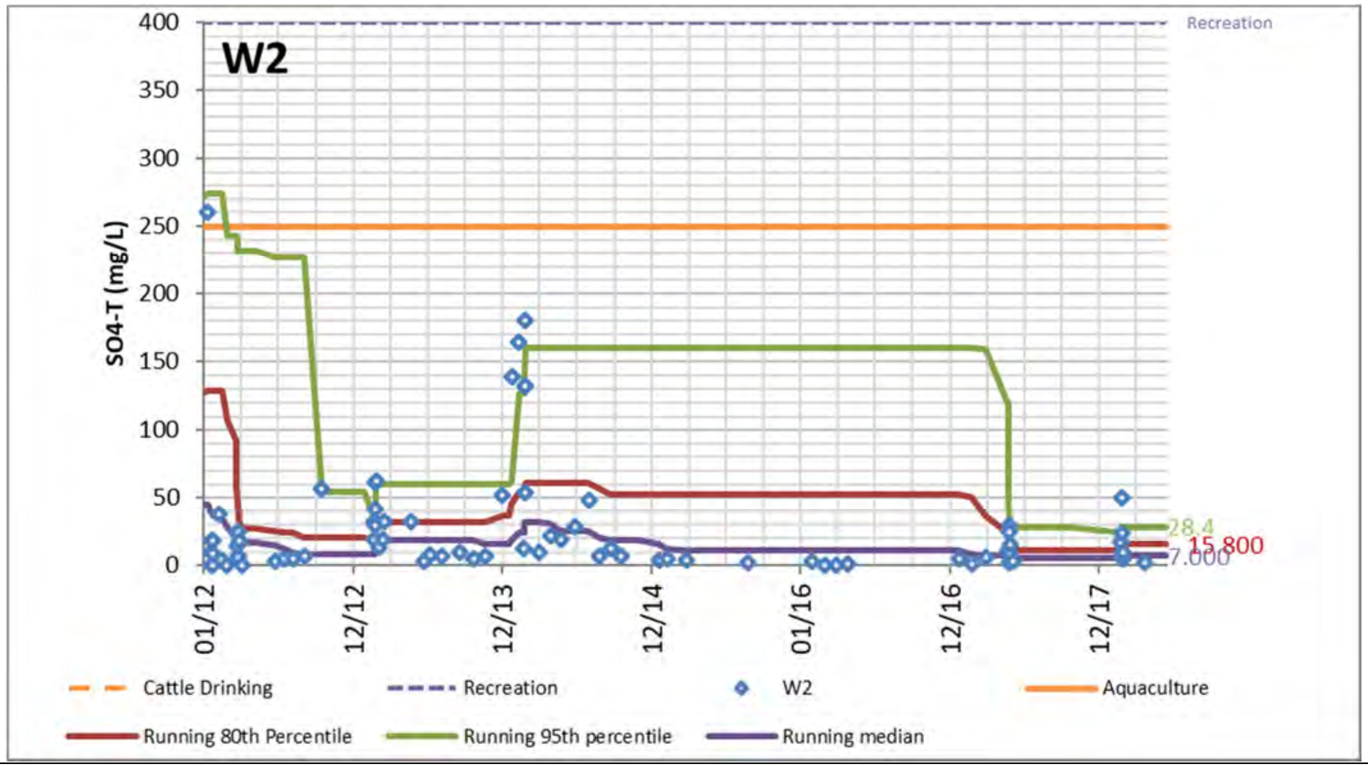

W2
COND-L (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
01/12
12/12
12/13
12/14
01/16
12/16
12/17
175.9
Aquatic Ecosystem
Cattle Drinking
W2
Running 80th Percentile
Running 95th percentile
Running median

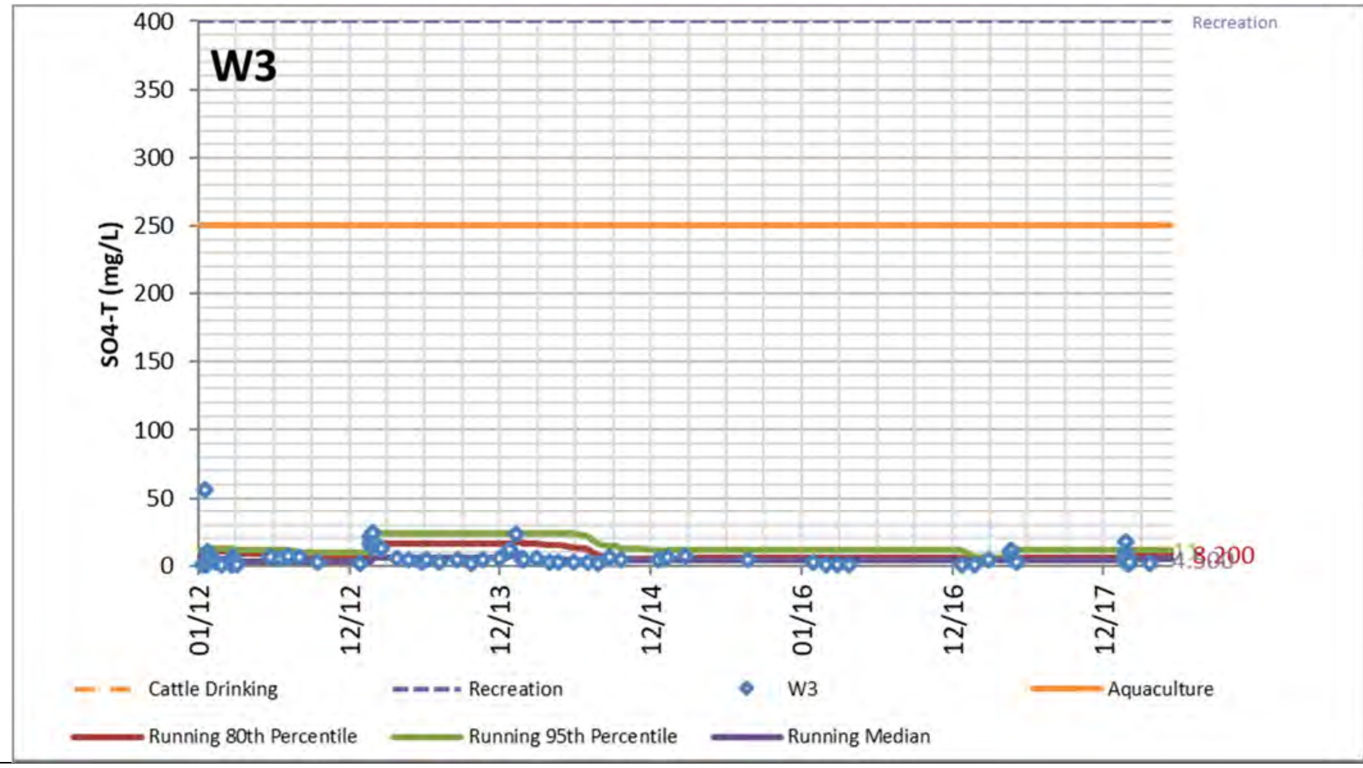

W3
COND-L (mg/L)
1000
900
800
700
600
500
400
300
200
100
0
01/12
12/12
12/13
12/14
01/16
12/16
12/17
W3
Running 80th Percentile
Running 95th Percentile
Running Median

Sulfate as SO4

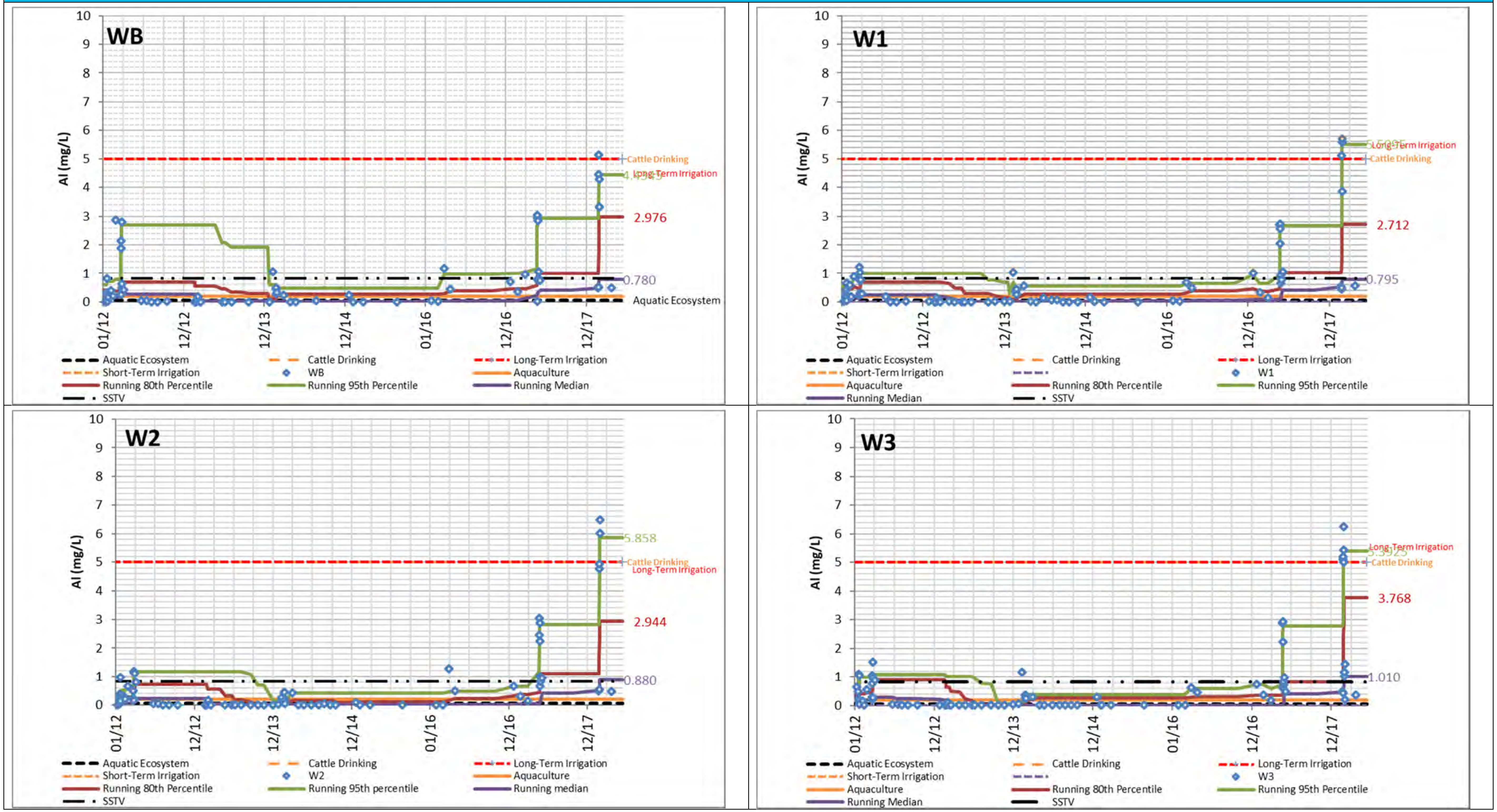




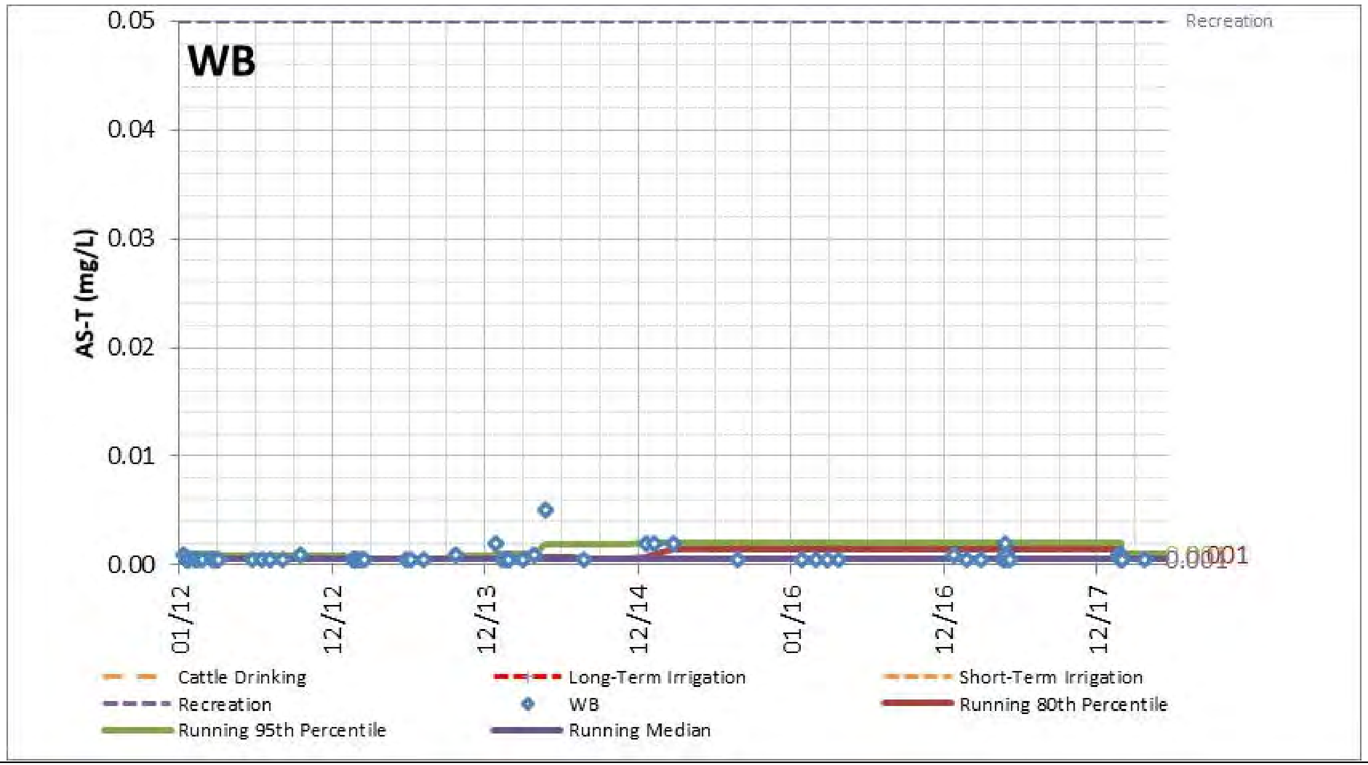


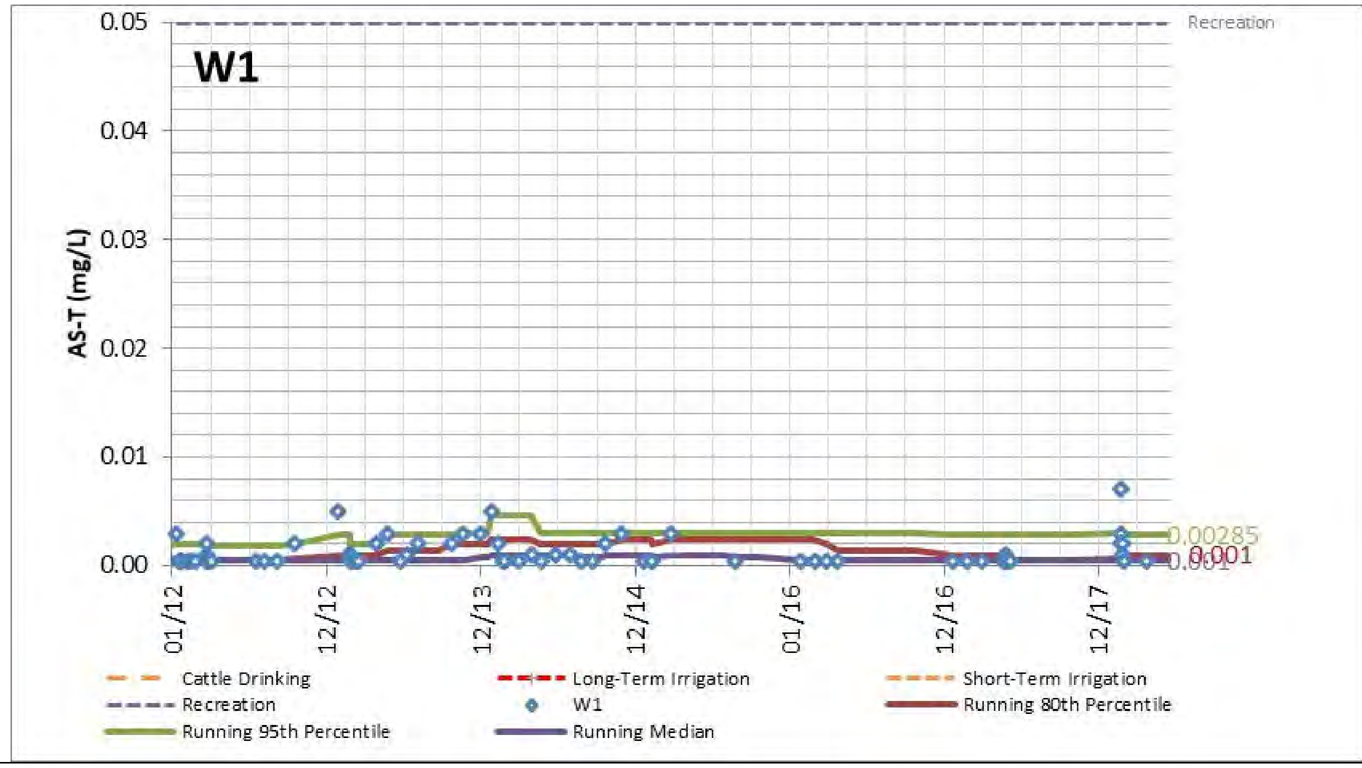


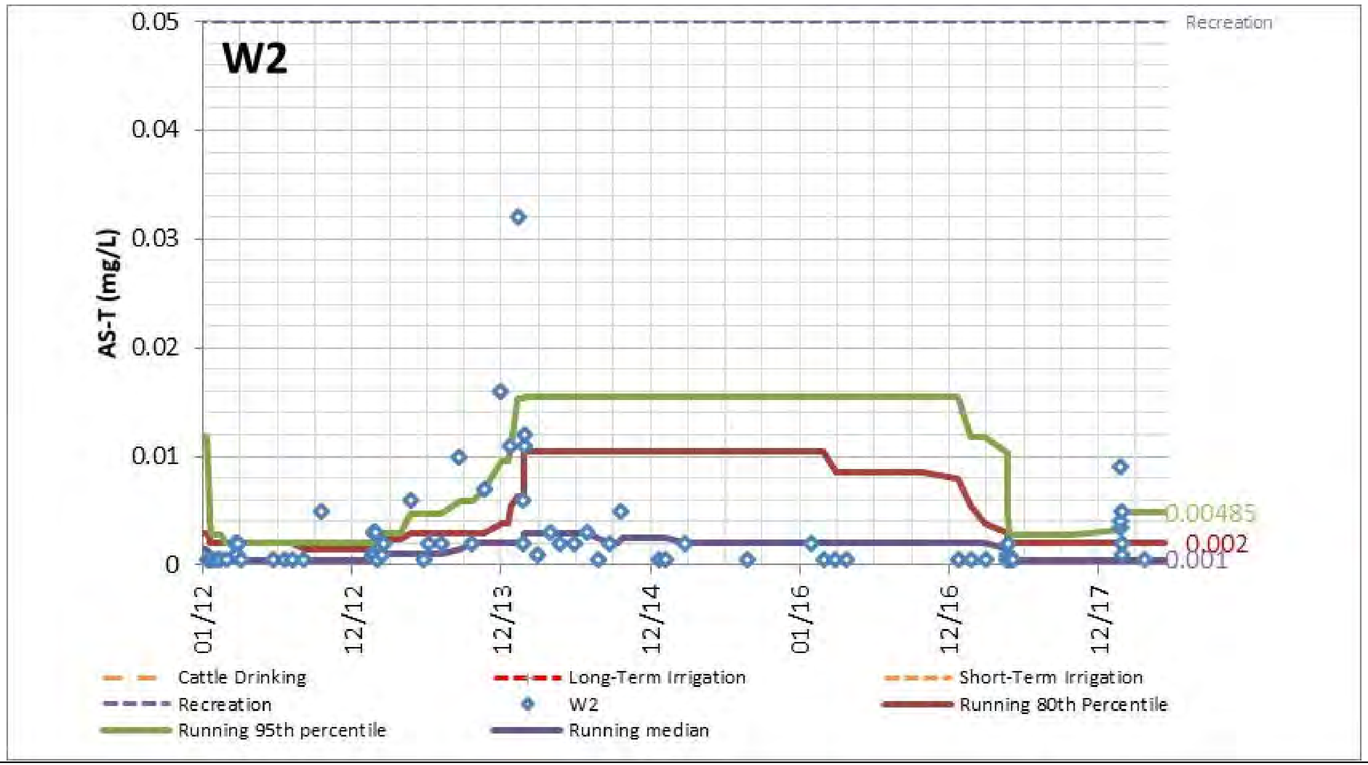
Dissolved Aluminium

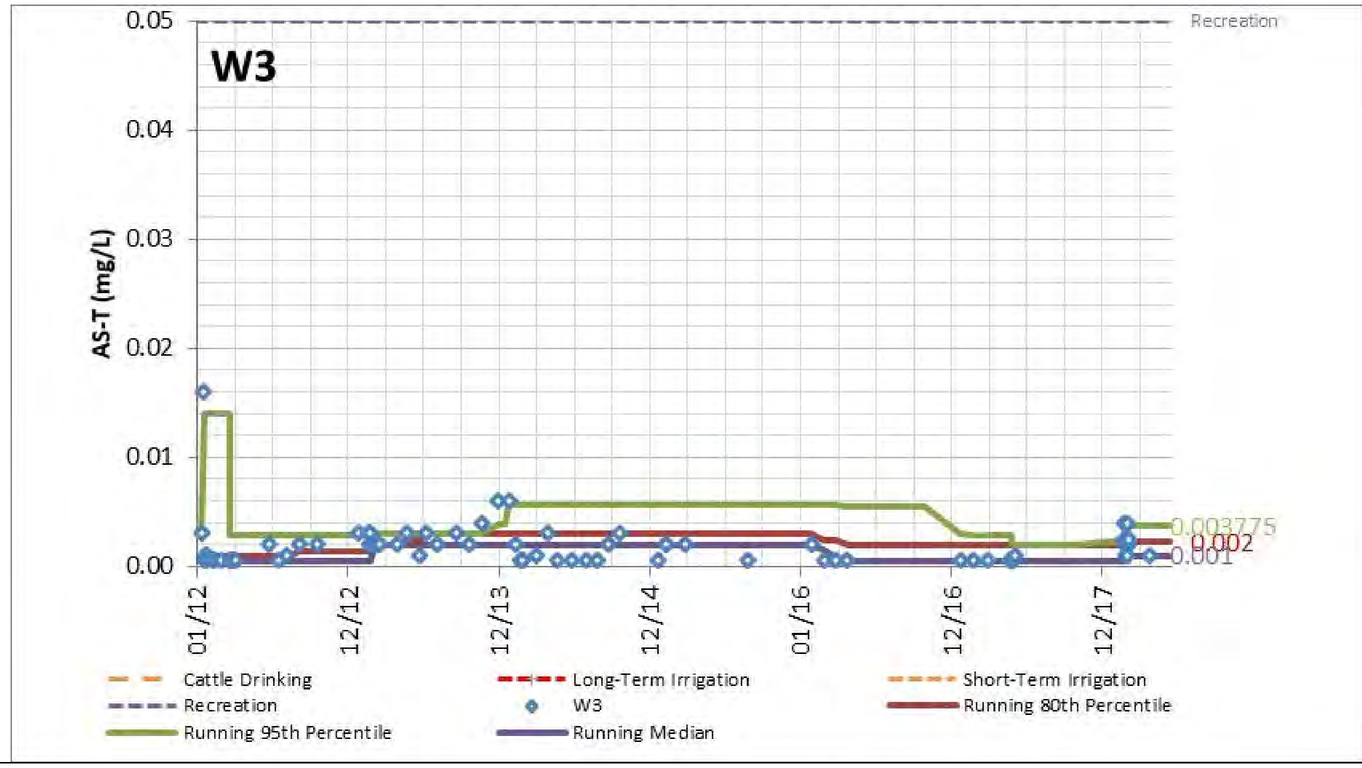


Total Arsenic

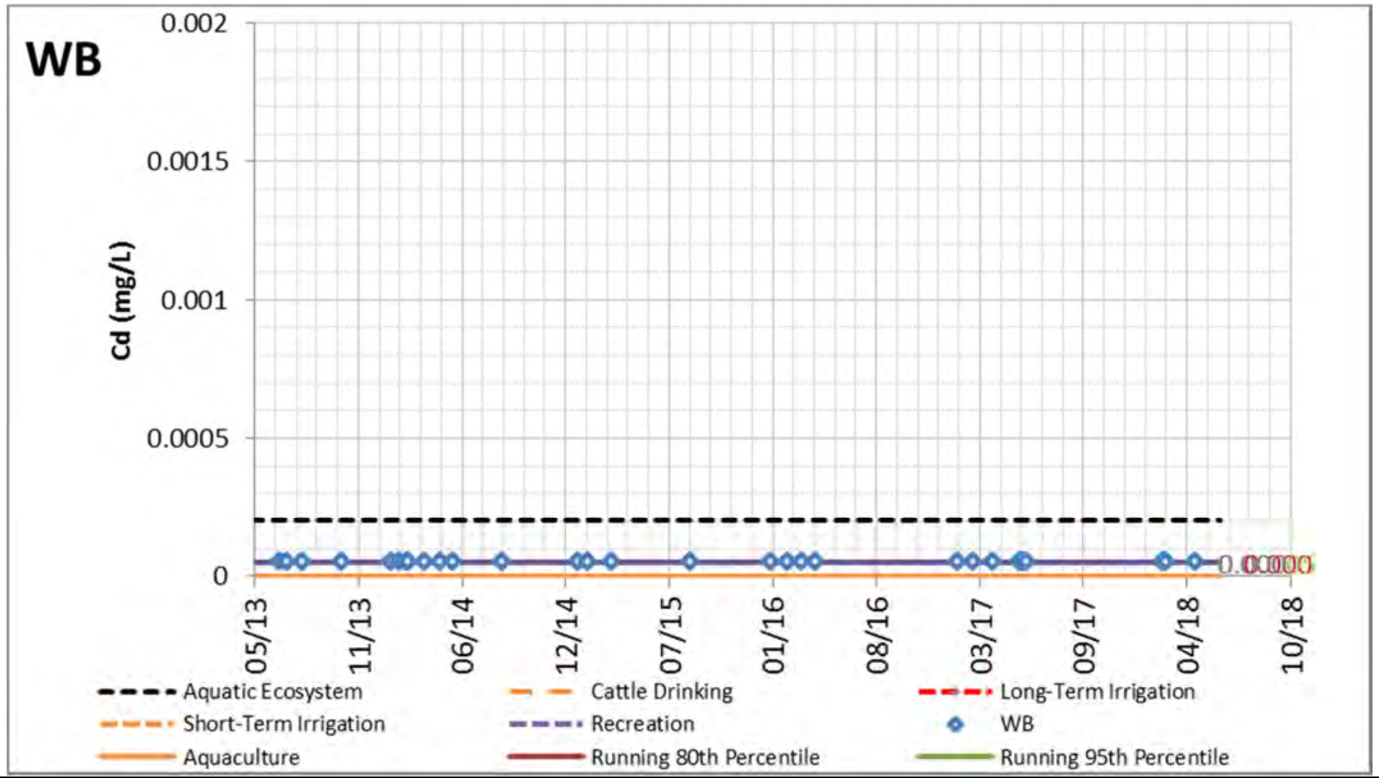


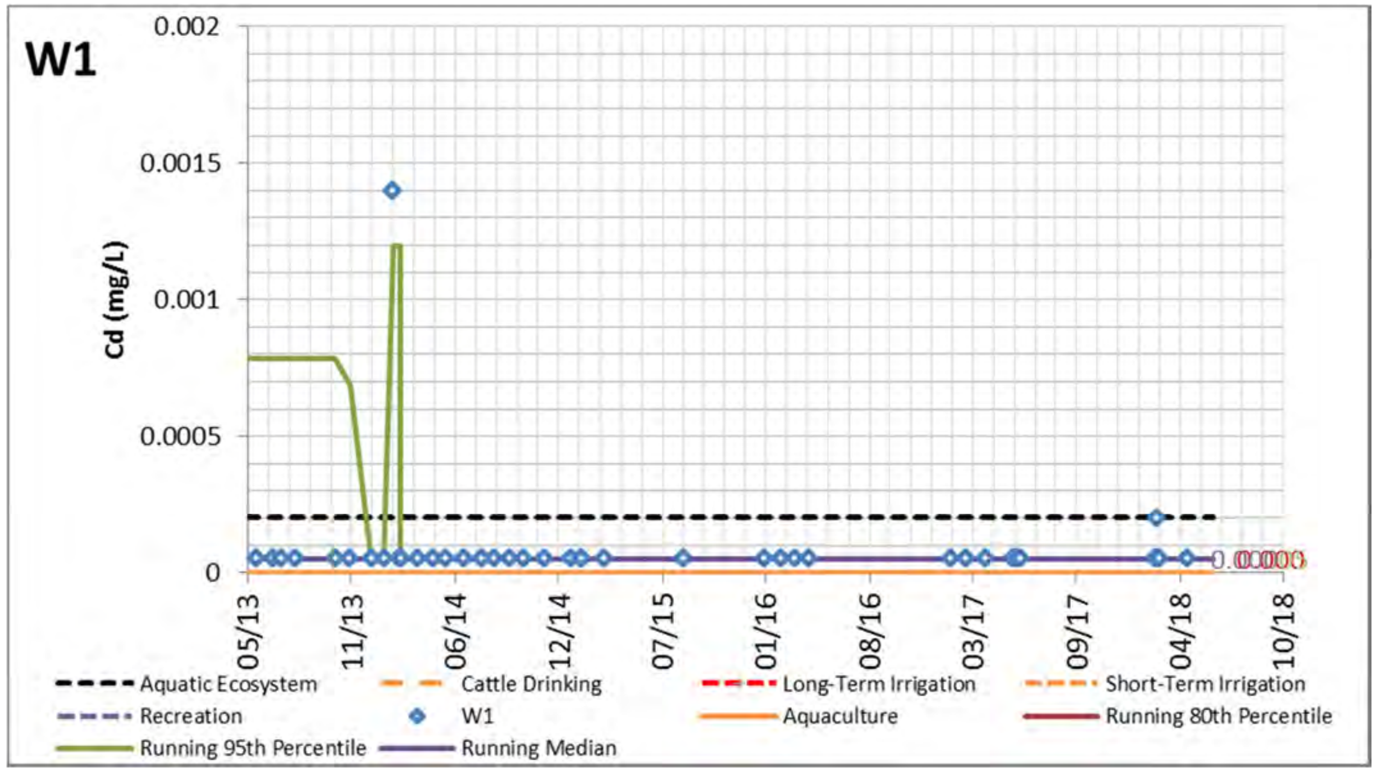


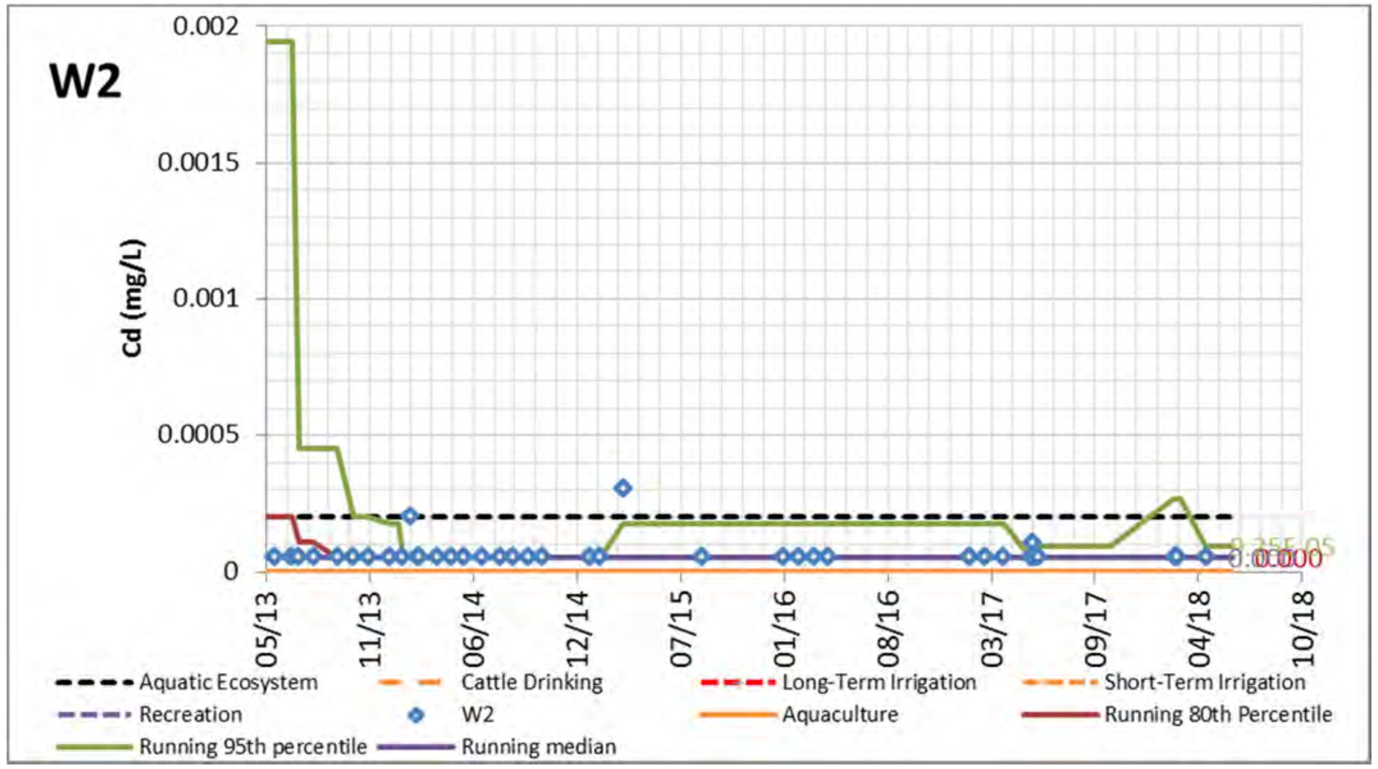




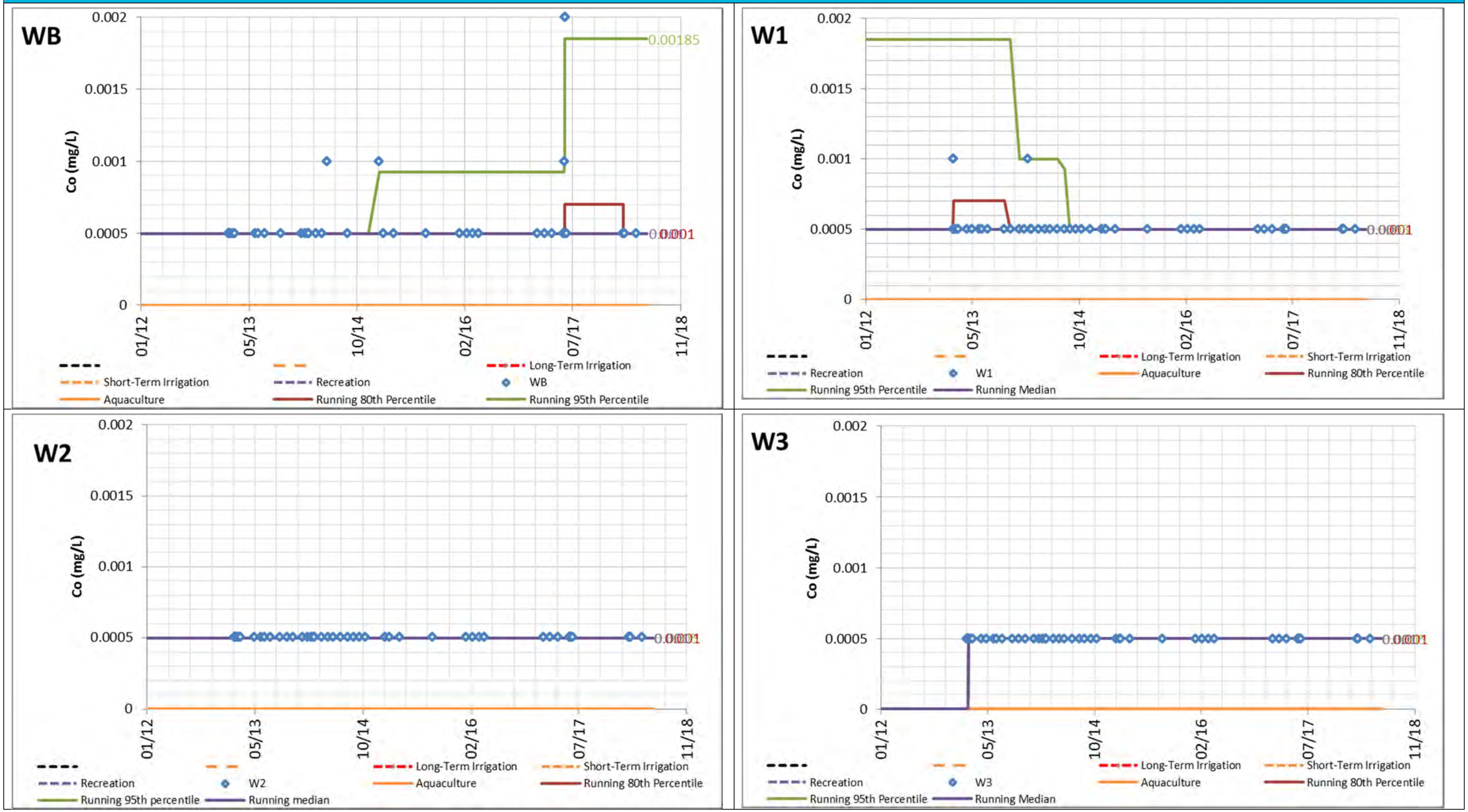
Dissolved Cadmium



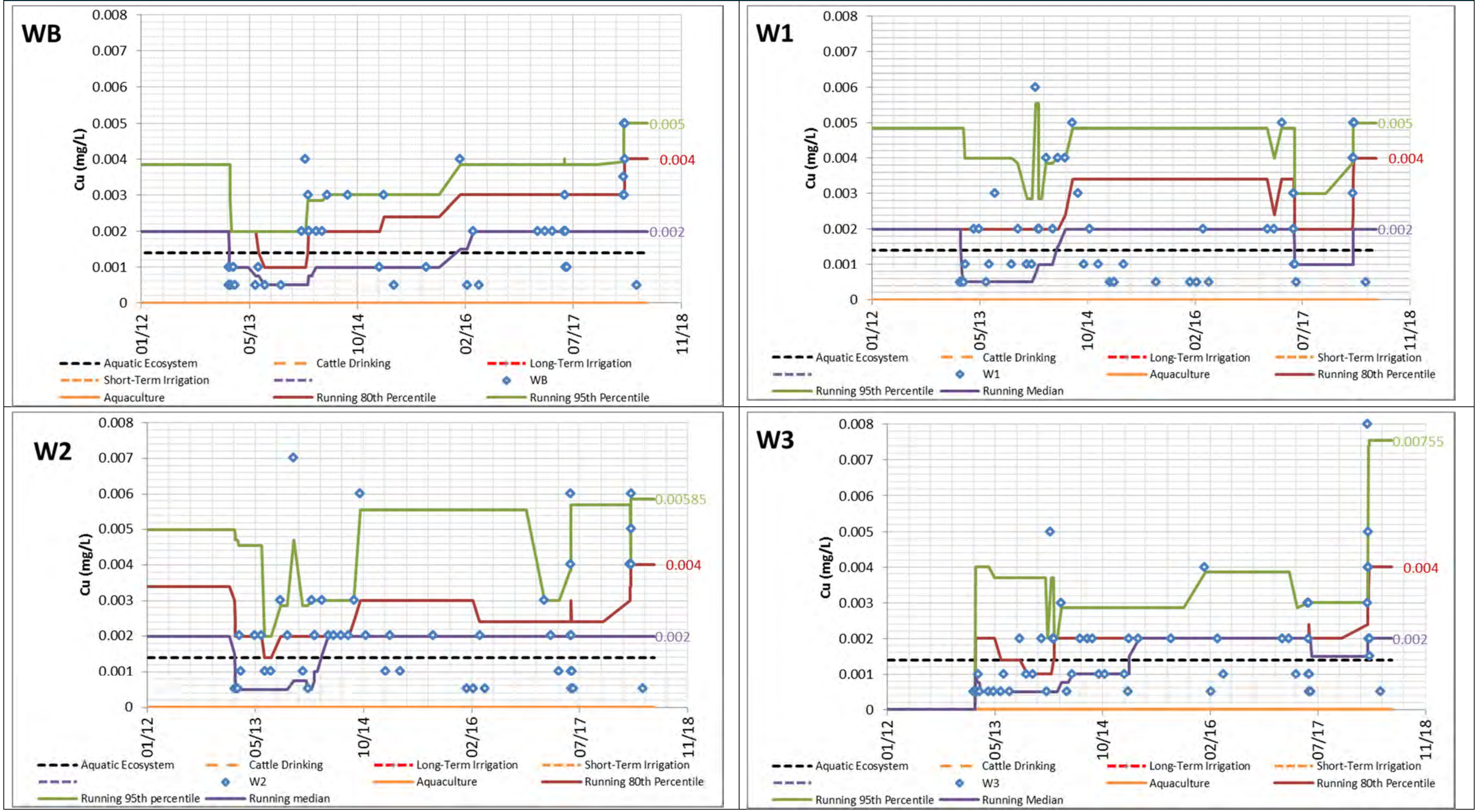




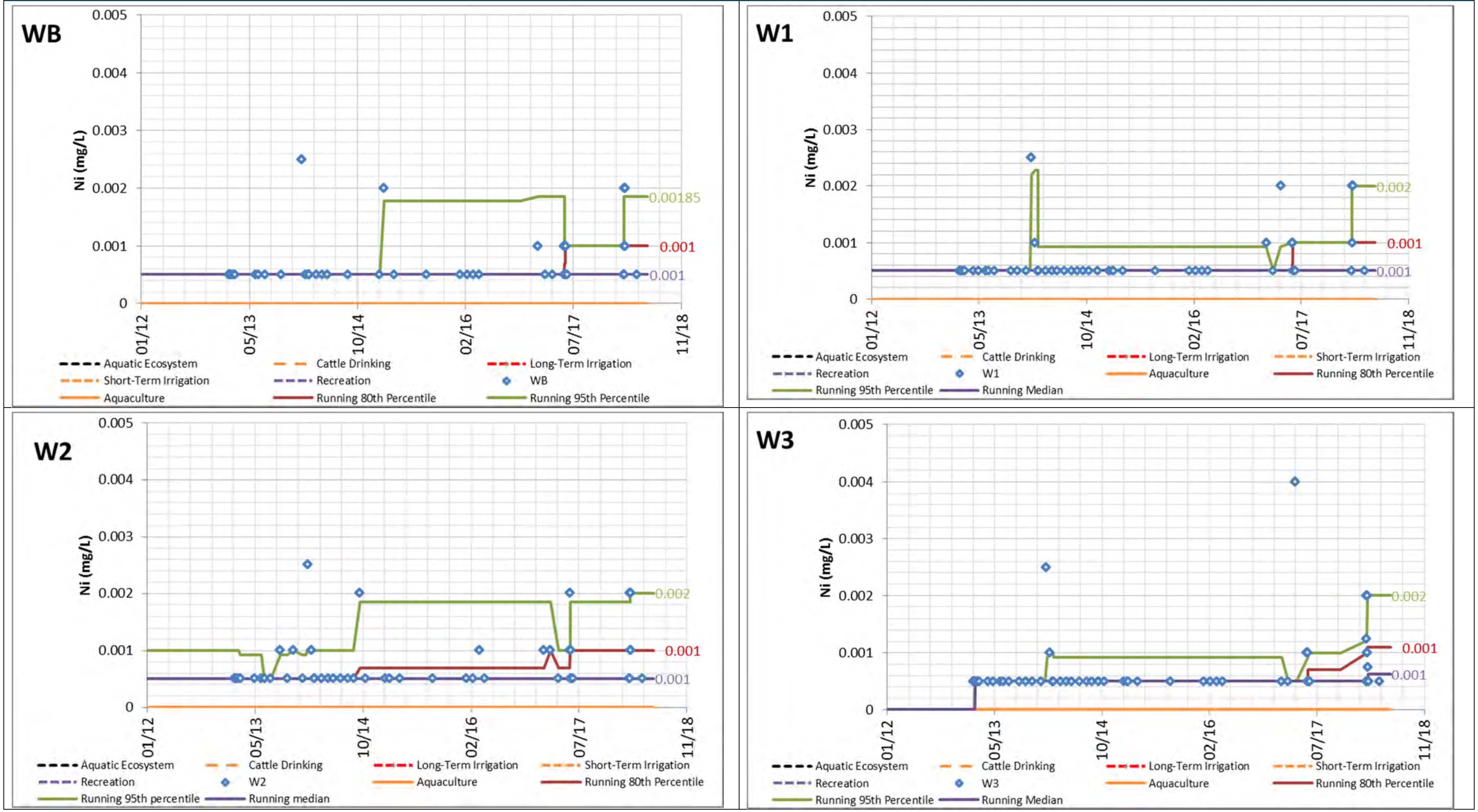
Dissolved Cobalt



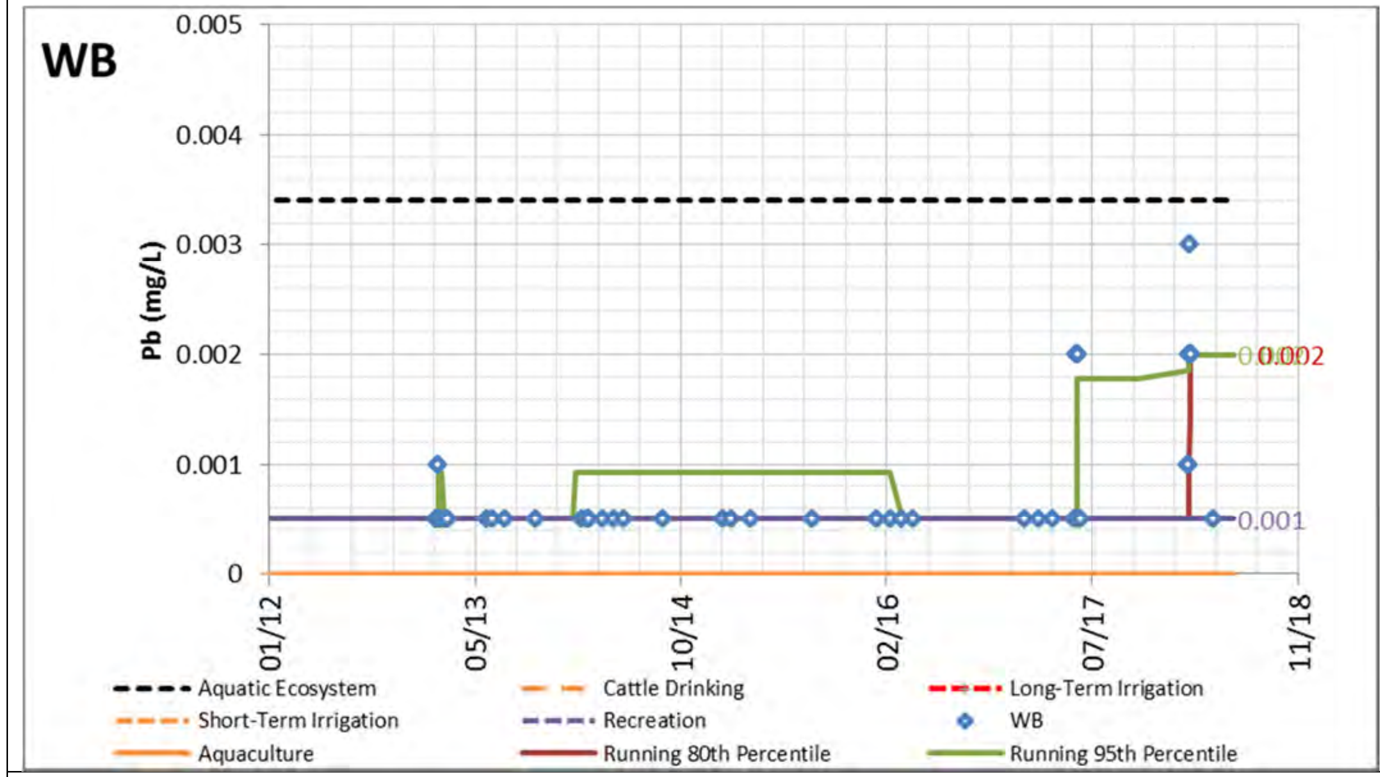
Dissolved Copper

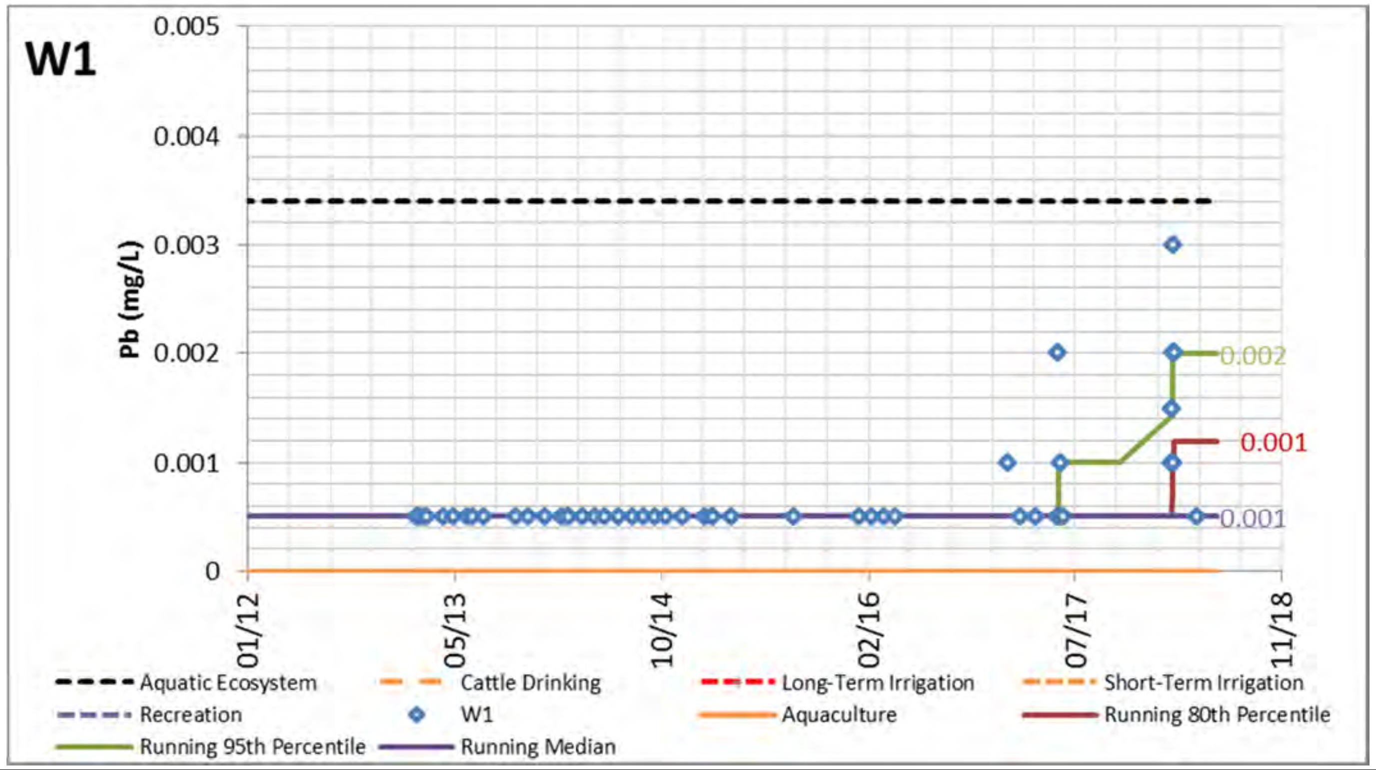


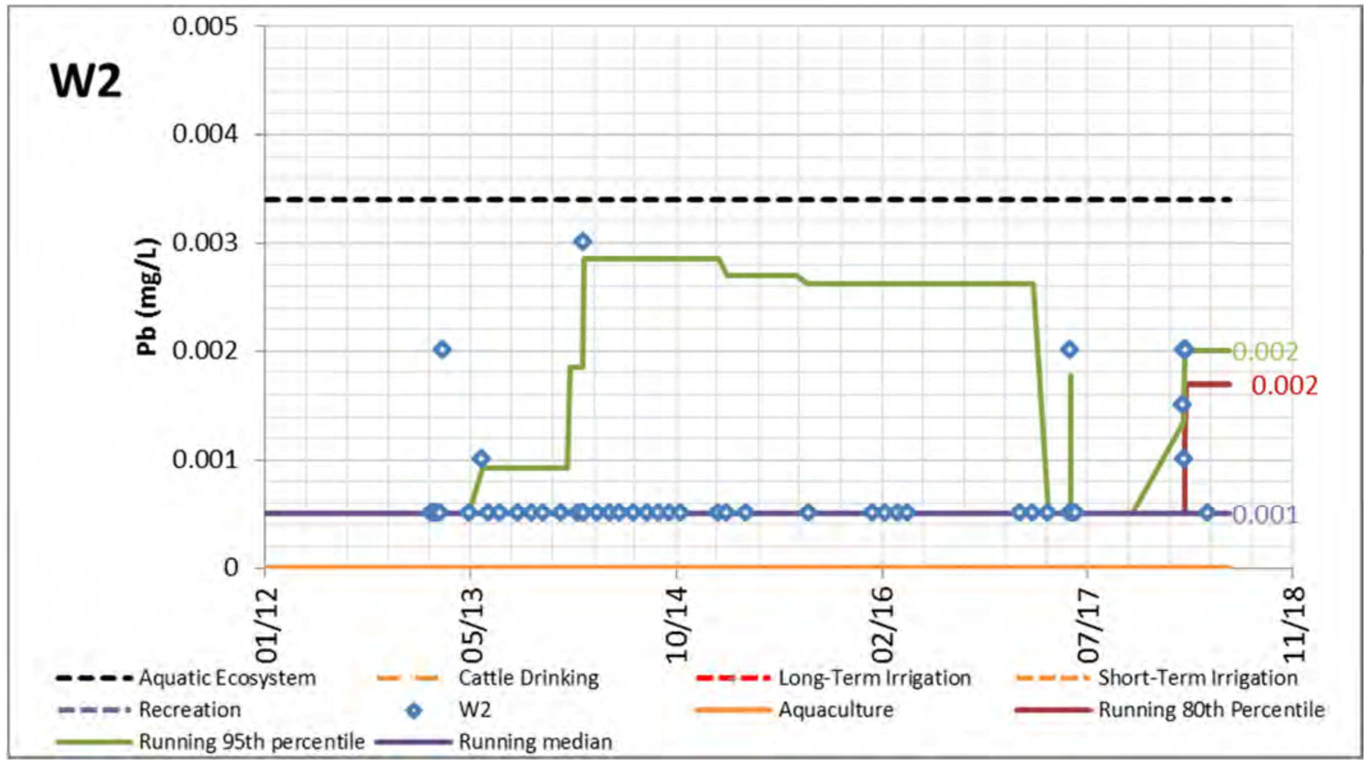
Dissolved Nickel

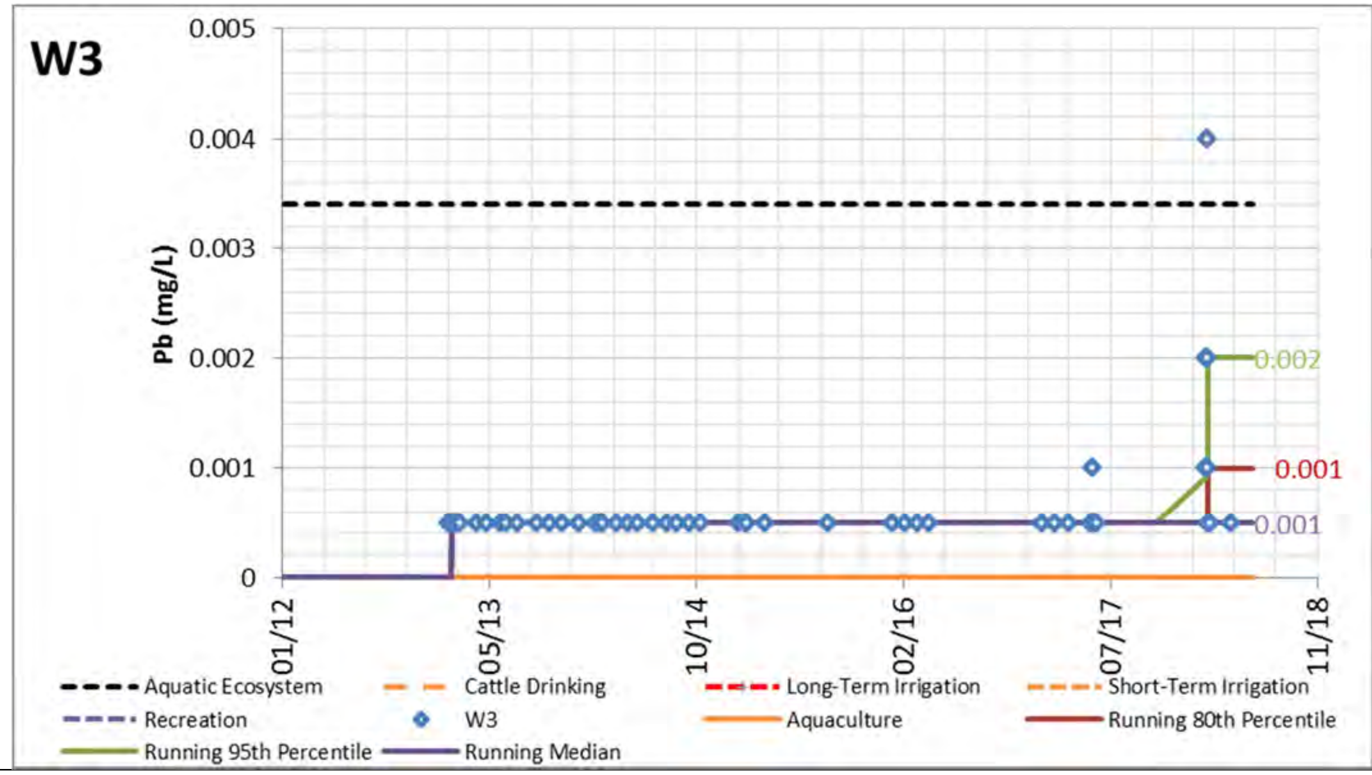


Dissolved Lead

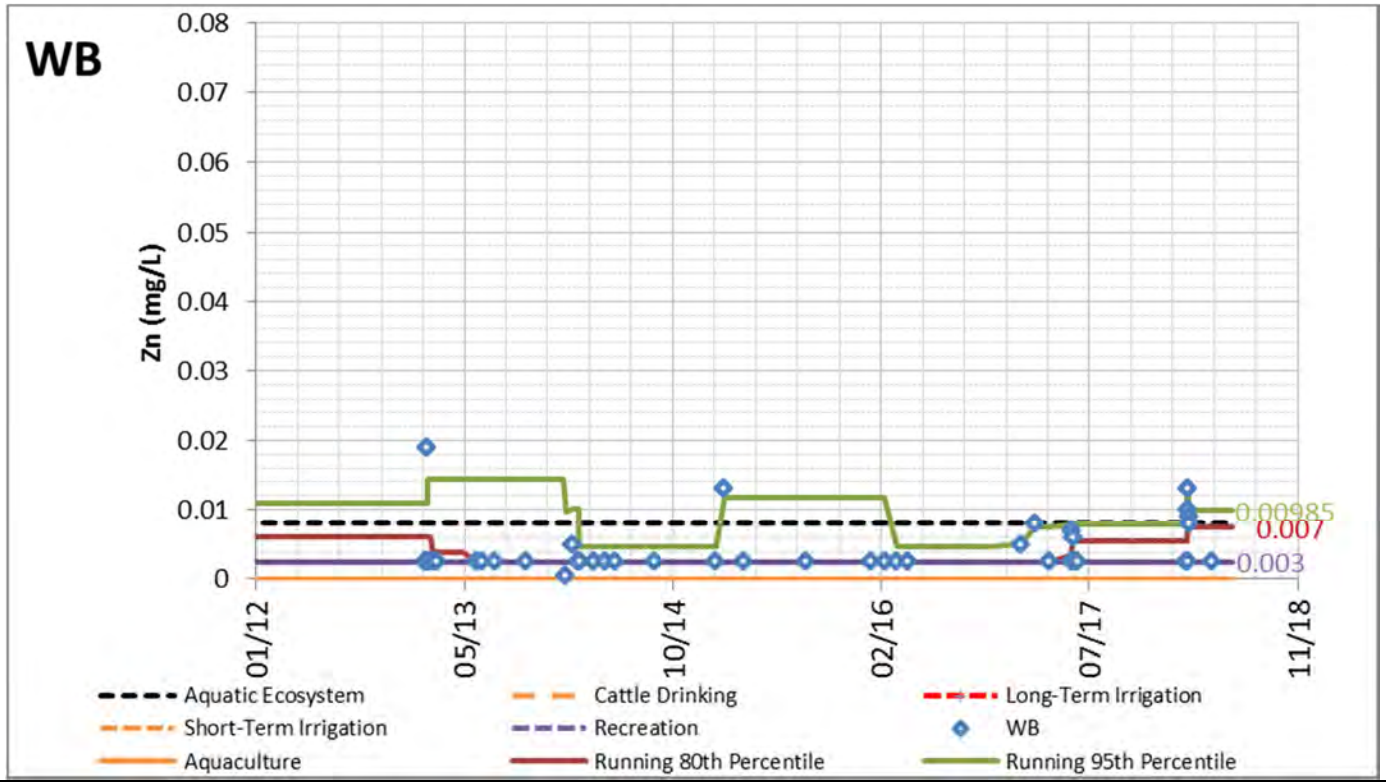


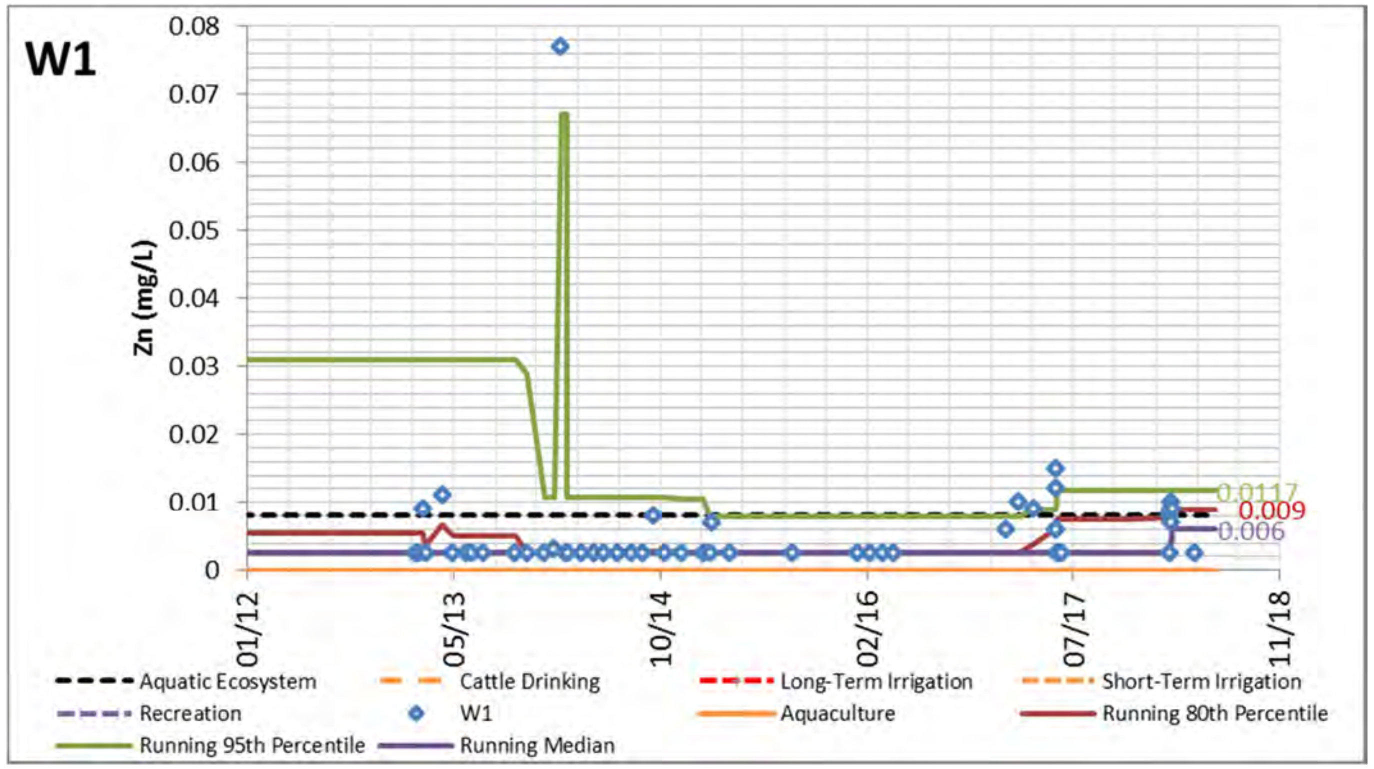


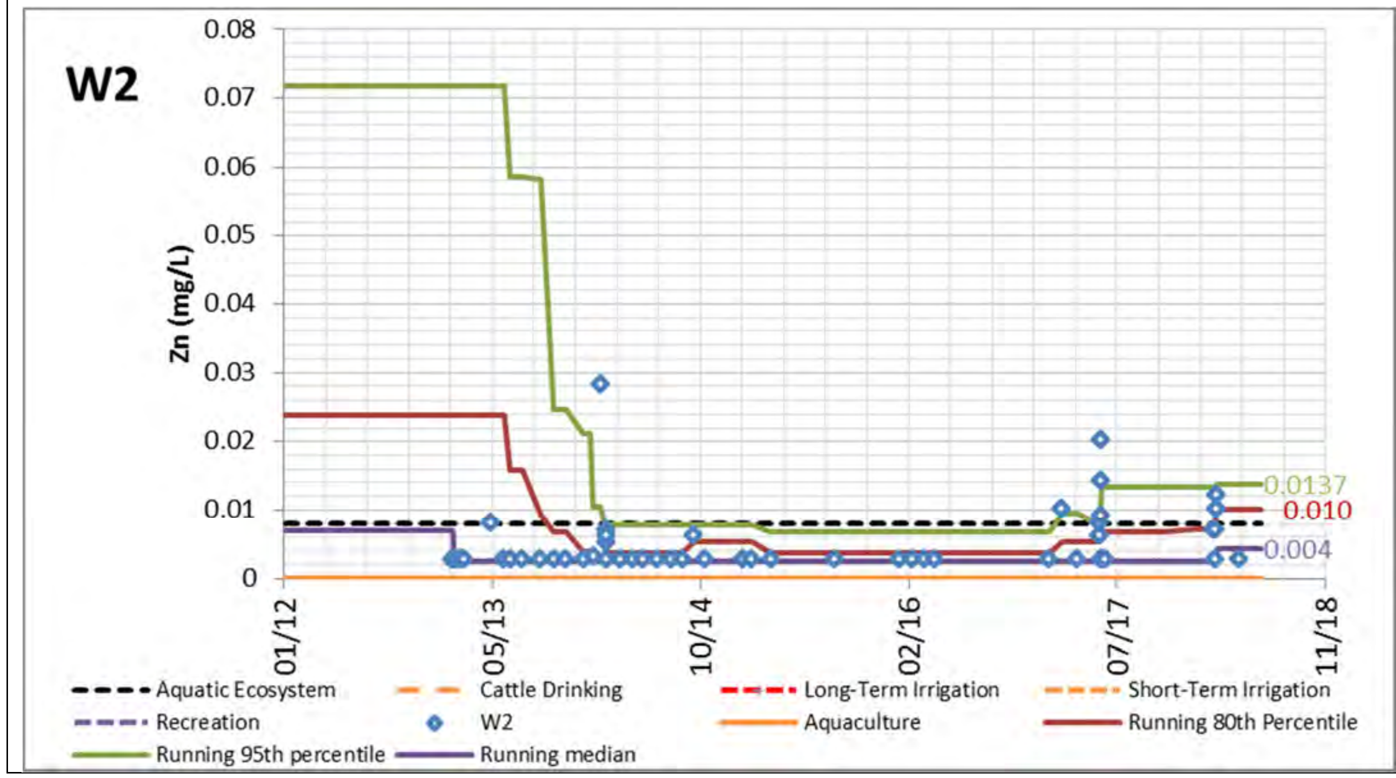


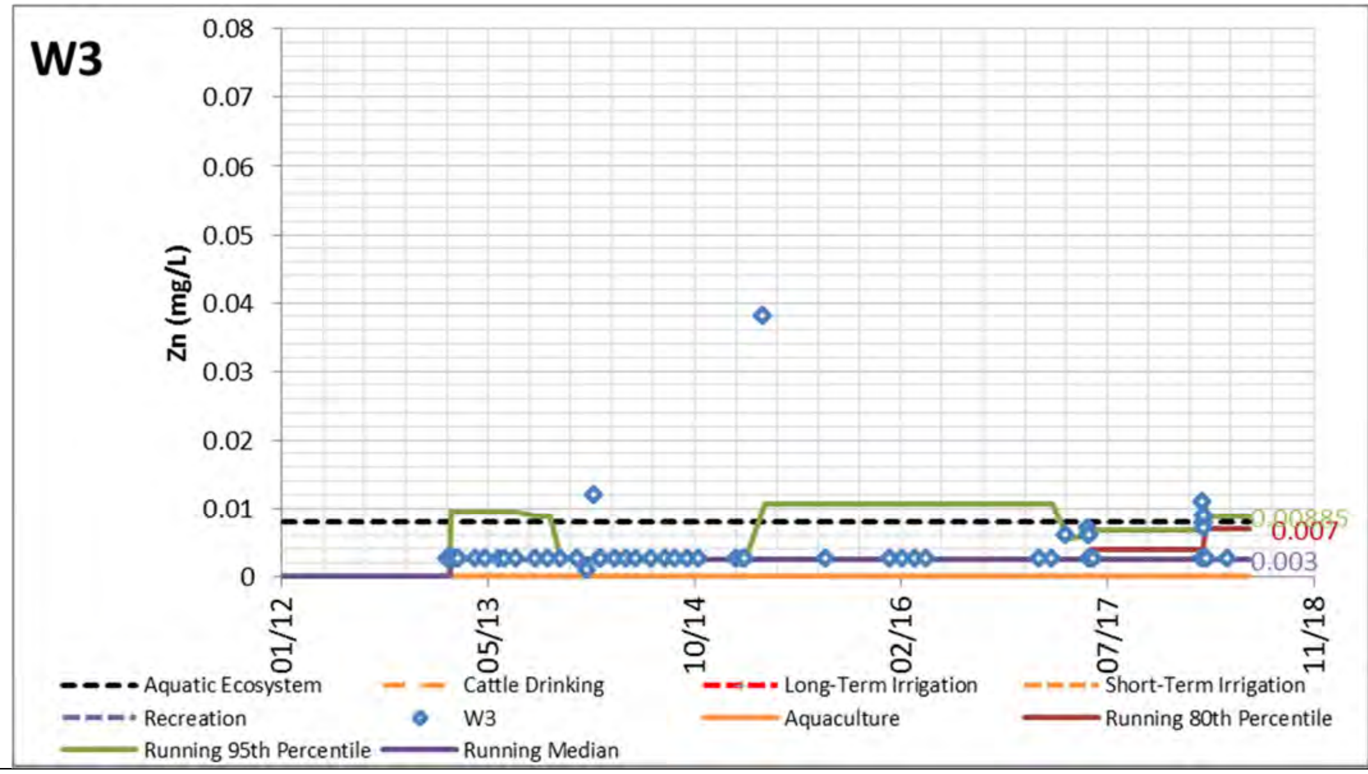


Dissolved Zinc

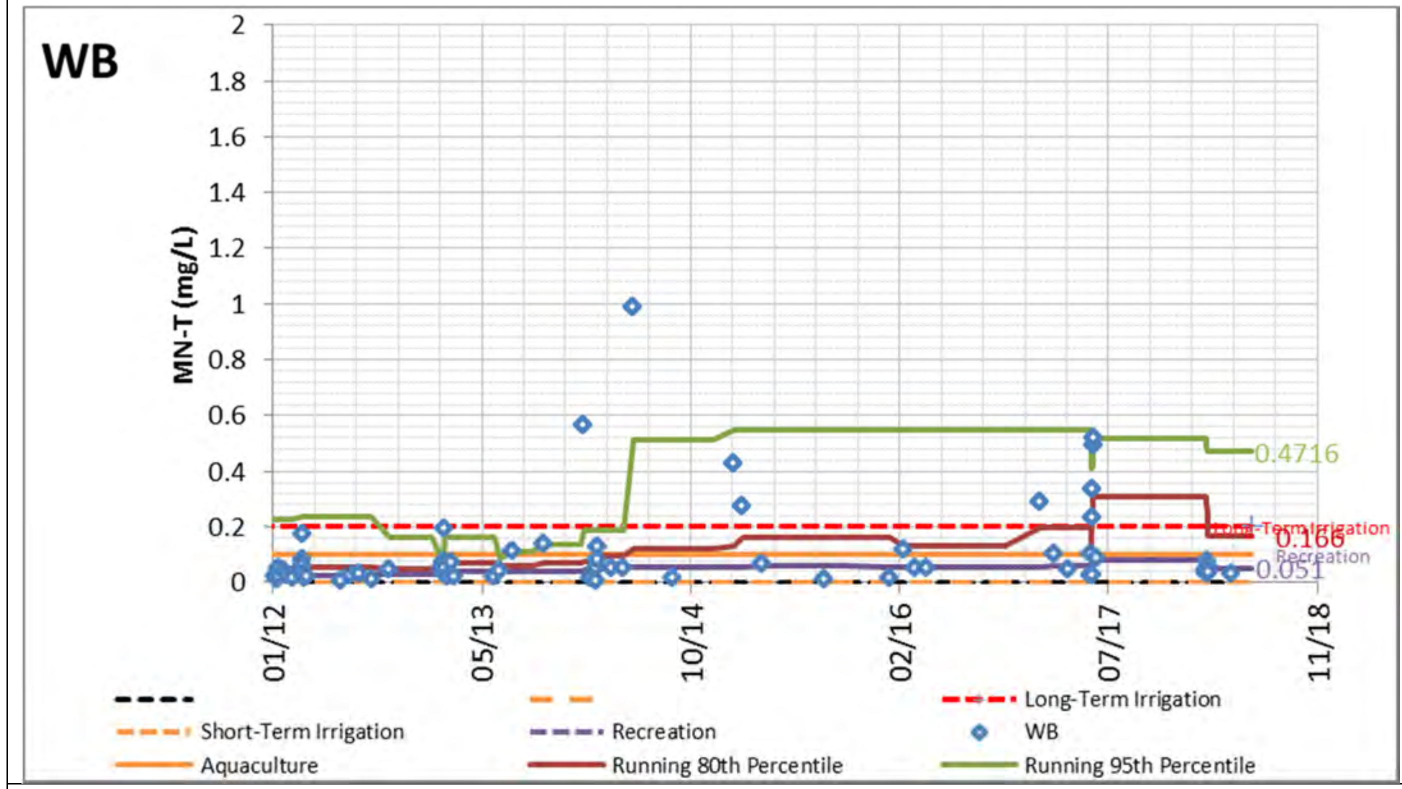


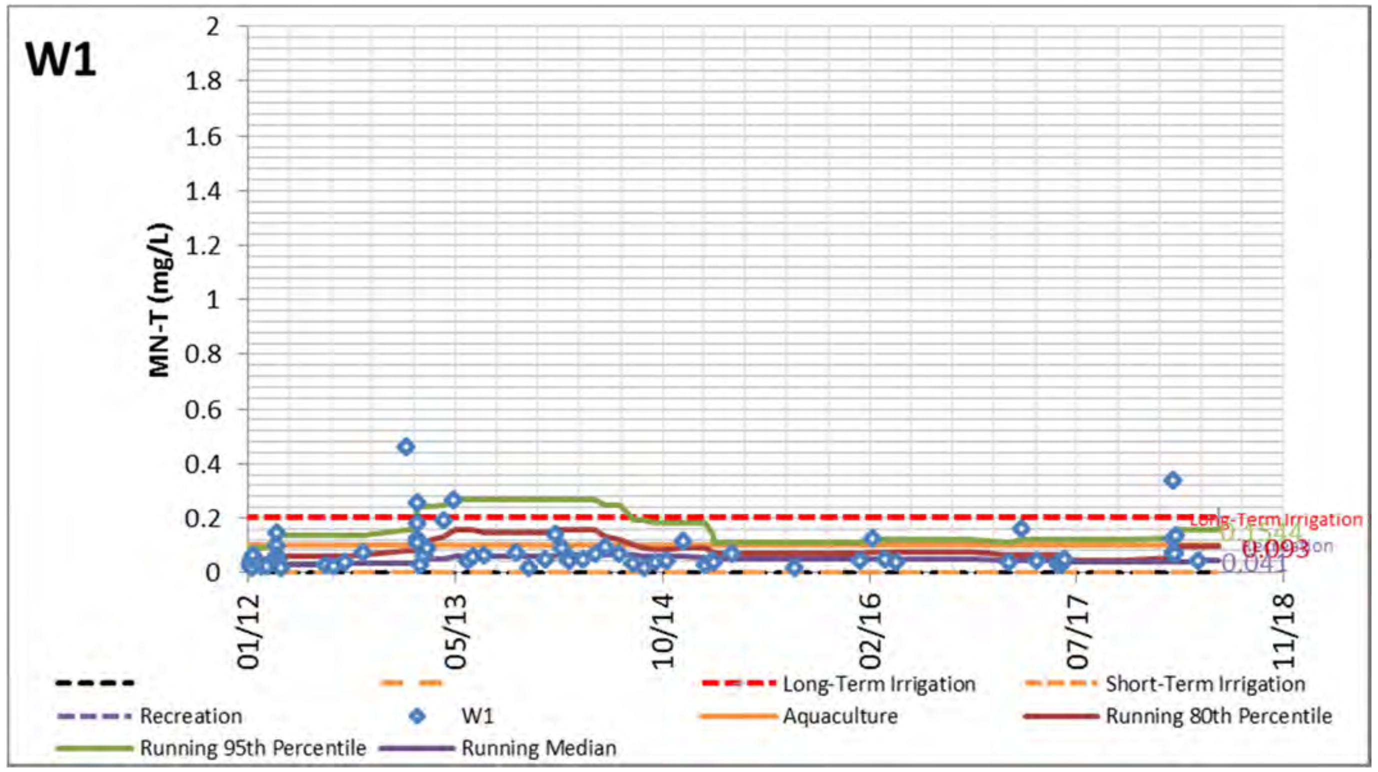


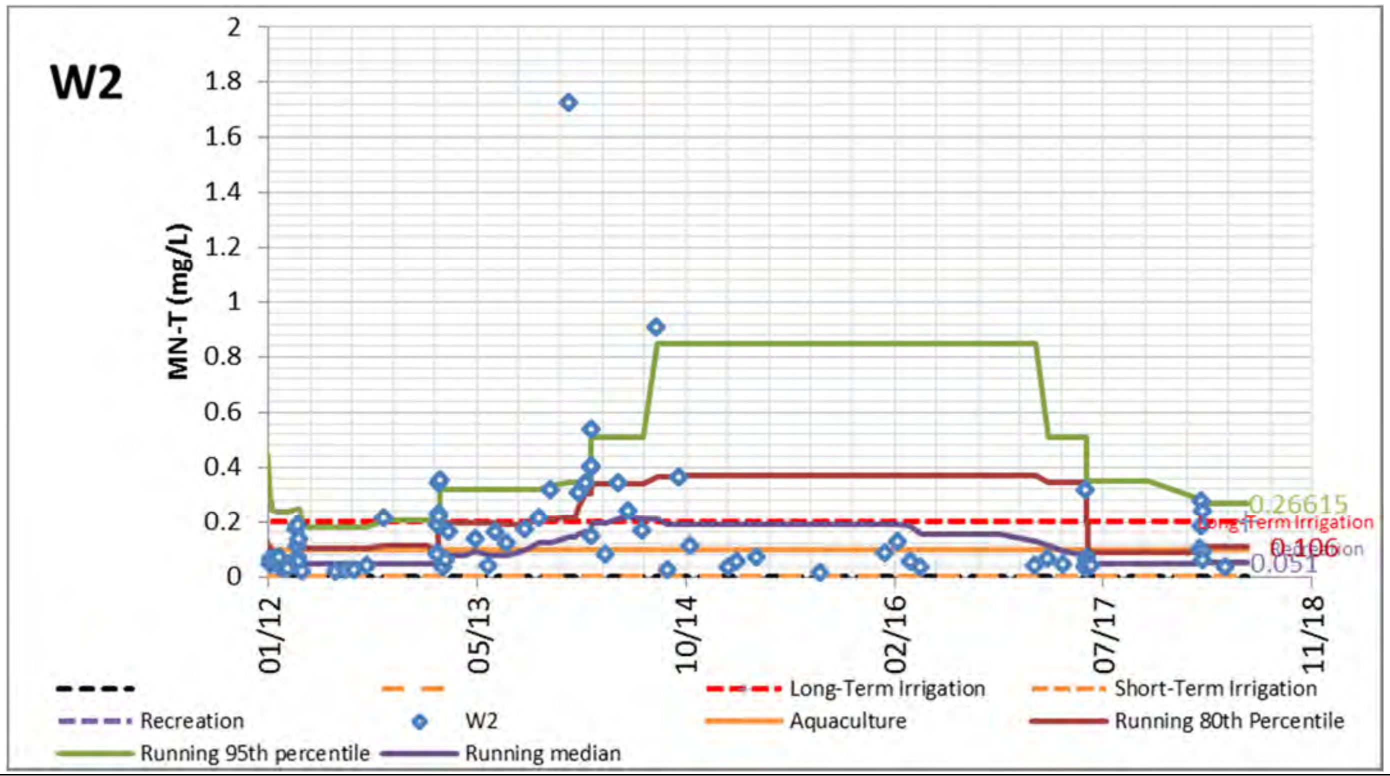


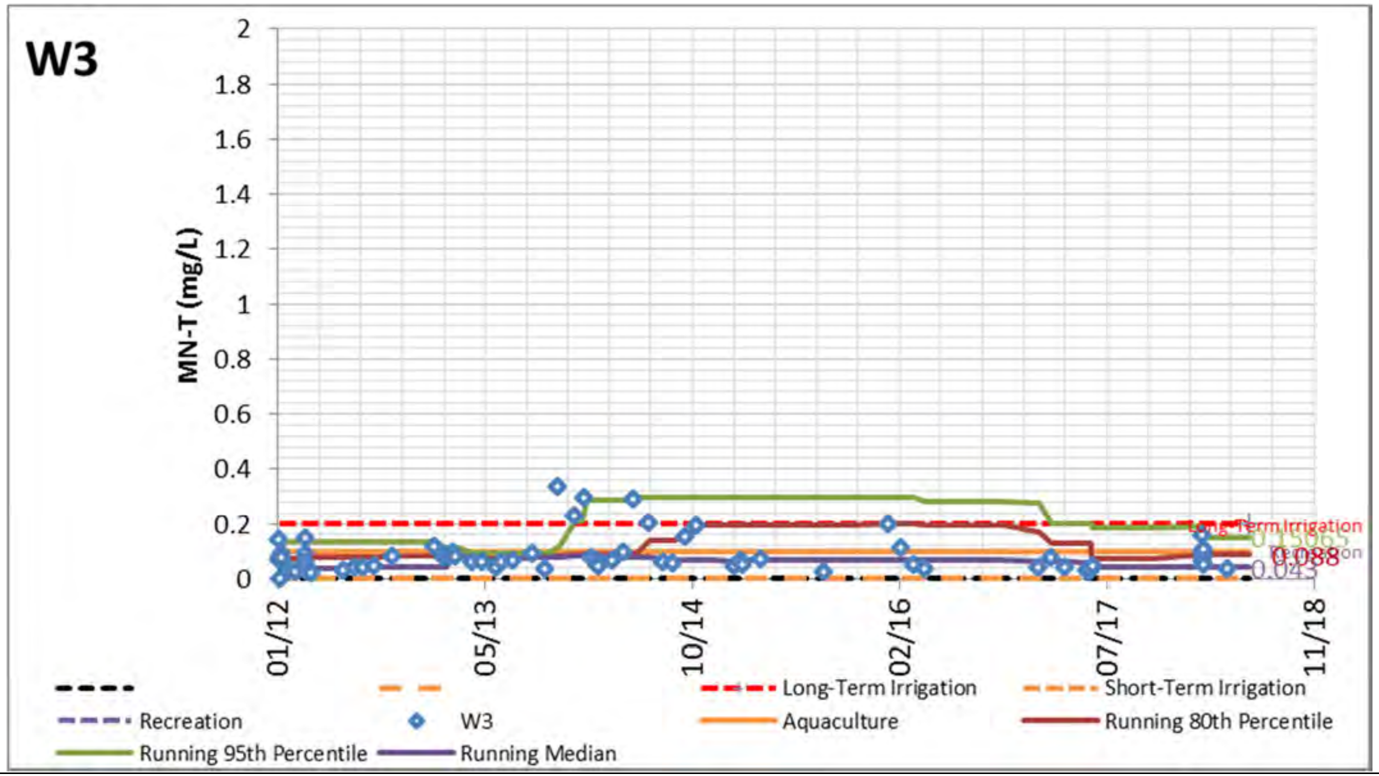


Total Manganese









Total Molybdenum