VASSE DIVERSION DRAIN UPGRADE PROJECT: WATER QUALITY MONITORING AND MANAGEMENT PLAN

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EXECUTIVE SUMMARY

Water Corporation proposes to upgrade approximately six kilometres of the Vasse Diversion Drain (VDD) to meet current flood mitigation requirements. The project area extends downstream from the Busselton Golf Course, near Chapman Hill Road, to beyond the Busselton Bypass, with works including the reconstruction and widening of some sections of the levee walls and reconstruction of the diversion dam. Construction and earth works associated with the project has the potential to affect the quality of surface waters in both the VDD and the Lower Vasse River. Noting that an aquatic species of conservation significance exists within the Vasse River catchment, potential input of water into the Lower Vasse River, and that the ultimate fate of water within the VDD is dispersal into Geographe Bay, the Water Corporation considered a need to draft and implement a Water Quality Monitoring and Management Plan (WQMMP) which aimed at reducing the risk of impact on priority environmental receptors (PER) present within and adjacent the project area. The objectives of the WQMMP were subsequently defined as being to:

- Identify PER within the VDD, Lower Vasse River and receiving waters of Geographe Bay which may be affected by a reduction in water quality as a result of the upgrade project;
- Ascertain baseline data on surface water quality in the VDD and Vasse River prior to upgrade works being undertaken;
- Detail a surface water monitoring approach to be implemented during construction works to identify when a reduction in water quality occurs;
- Define surface water parameter trigger values (based on the requirements of each PER) which if exceeded results in the implementation of contingency actions; and
- Establish a protocol for the assessment, response (including contingency actions) and reporting of monitoring data.

PER were identified from risk assessments undertaken as part of the VDD upgrade project, historical aquatic fauna surveys undertaken in the Vasse River catchment, and targeted aquatic fauna surveys specifically for the VDD upgrade project. As a result, two PER were identified these being *Westralunio carteri* (Carter's Freshwater Mussel) and seagrass beds of Geographe Bay adjacent the VDD outlet. Water quality parameters to be measured as part of the WQMMP which were relevant to each of the PER were determined from a review of current literature and reports from targeted studies undertaken as part of the upgrade project.

In order to identify water quality issues directly resulting from upgrade works, the WQMMP will establish a baseline water quality data set, derived from historical water quality sampling and data collected upstream of the project area and which is beyond the area which could be

impacted by the upgrade works. Water quality data collected on the downstream sides of two major works areas (referred to as the Vasse River Diversion Dam (VRDD) and Lower VDD work areas) will subsequently be monitored throughout the project and compared to the baseline data relevant to that specific works area in order to identify whether reductions in water quality which may impact either PER were occurring.

Water quality parameters will be measured with the use of loggers installed in the VDD and Lower Vasse River (up and downstream of both the VRDD and Lower VDD work areas) and hand held field meters. In addition water samples will be collected for analysis of select parameters by a National Association of Testing Authorities (NATA) accredited laboratory. Data attained via these methods will be reviewed fortnightly, with the exception of the telemetered logger installed in the lower VDD (downstream of the project area) which will be reviewed every three days.

In the absence of sufficient historical data from the upper Vasse River to facilitate the establishment of trigger values, changes in water quality in the VDD and the Lower Vasse River as a result of works on the VRDD will be identified by comparing incoming and outgoing water quality data. Relevant to the VRDD works area, additional management actions will be considered when:

- Salinity is >1.3 ppt (noting this is approaching the tolerable limit of *W. carteri* of 1.5 ppt); or
- A variation by ±20% in the value of any monitored parameter recorded downstream of the VRDD works area in comparison to that recorded upstream for a period of greater than two weeks.

Unlike the VRDD works area, the opportunity to collect appropriate baseline water quality data from a site upstream of the works area (and beyond the zone of influence) does not exist for the lower VDD works area. This is due to the fact that this works area represents a distinct barrier between water types. Waters on the downstream side of this works area are tidal (i.e. water quality will be influenced by marine waters as well as run-off from adjacent suburbs and swamp), however waters upstream are largely derived from rainfall run-off events and inflow from adjacent lands.

Noting the complex mixing that occurs in the downstream extent of the VDD, data for the purpose of setting a trigger value will be derived from a limited historical data set from waters downstream of the project area and by comparing incoming waters in the VDD. Relevant to the lower VDD works area, additional management actions will be considered when:

- The value of any parameter measured by telemetered logger downstream of the project area is ±20% beyond the range of values attained from historical data; and

- The value of any monitored parameter recorded at the logger upstream of the lower VDD works area is greater than 20% of the value recorded downstream for a period of greater than two weeks, with the exception of salinity and electrical conductivity.

In the event water quality parameter values vary from the defined the trigger values, a number of management actions would be initiated. In summary these may include:

- Identification of whether the exceedance is associated with a climate or sea event;
- An increase in the frequency of monitoring and determination of the spatial extent;
- Investigation of the potential cause of the variation in the specific water quality parameter to determine whether the cause is directly attributable to the upgrade works;
- Determination of the likelihood and magnitude of impact on the relevant PER; and
- Notification of a relevant authority or regulator.
- Consideration of further actions to address water quality issues (in addition to those actions outlined in the ASSDMP and WCMP) including, for example, ceasing flow in bypass pipelines, installation of additional silt curtains downstream works area, or cessation of works until the driver of water quality reduction is understood.

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1.0 INTRODUCTION

1.1 *Project Background*

Water Corporation proposes to upgrade approximately six kilometres of the Vasse Diversion Drain (VDD) to meet current flood mitigation requirements, including the capacity to pass a 1 in 100 year flood event (Water Corporation 2020). The project area extends downstream from the Busselton Golf Course, near Chapman Hill Road, to beyond the Busselton Bypass, with works including the reconstruction and widening of some sections of the levee walls and reconstruction of the Vasse River Diversion Dam (VRDD) (Figure 1). In order to manage flow and facilitate works on the VDD and VRDD, the current proposal includes the installation of several coffer dams (temporary earth bunds) along the length of the VDD at various stages of the project. A coffer dam is also proposed to be installed in the Lower Vasse River immediately downstream of the VRDD, as well as a temporary bypass pipe aimed at maintaining flow to the Lower Vasse River during construction.

1.2 *Potential Effects on Surface Water and Management*

Construction and earth works associated with the project has the potential to affect the quality of surface waters in both the VDD and Lower Vasse River. This may be as a result of:

- Mechanical excavation of levee walls or within construction areas leading to increased turbidity, liberation of unexpected analytes or those in elevated concentrations, or acid sulphate soil;
- Dewatering activities to facilitate VRDD construction resulting in groundwater with differing chemistry being introduced into the Lower Vasse River; and
- Creation of an atypical flow regime between the Vasse River and Lower Vasse River.

The documents of Water Corporation (2020), RPS (2020) and Indo-Pacific Environmental (2020) outline management actions for controlling surface water inflow and outflow in works areas, sedimentation, and the carriage of water from upstream of the construction areas to downstream. Despite these mechanisms being put into place, potential exists for reductions in surface water quality to occur and subsequently affect biota present within the Lower Vasse River, VDD and in marine waters of Geographe Bay.

Figure 1. Location of the development footprint in addition to the Lower Vasse Diversion Drain (VDD) and the Vasse River Diversion Dam (VRDD) works areas. Indicative water quality logger locations are also displayed.

1.3 *Objectives of the Water Quality Monitoring and Management Plan*

Noting that an aquatic species of conservation significance exists within the Vasse River catchment, potential input of water into the Lower Vasse River, and that the ultimate fate of water within the VDD is dispersal into Geographe Bay, Water Corporation considered a need to draft and implement a Water Quality Monitoring and Management Plan (WQMMP) which aimed at reducing the risk of impact on priority environmental receptors (PER) which may result from a reduction in water quality as a result of works undertaken as part of the VDD upgrade project. In order to achieve this, the objectives of the WQMMP were defined as being:

- Identify PER within the VDD, Lower Vasse River and receiving waters of Geographe Bay which may be affected by a reduction in water quality as a result of the upgrade project;
- Ascertain baseline data on surface water quality in the VDD and Vasse River prior to upgrade works being undertaken;
- Detail a surface water monitoring approach to be implemented during construction works capable of identifying a reduction in water quality should it occur;
- Define surface water parameter trigger values (based on the requirements of each PER) which, if exceeded, results in the implementation of contingency actions; and
- Establish a protocol for the assessment, response (including contingency actions) and reporting of monitoring data.

2.0 PRIORITY ENVIRONMENTAL RECEPTORS

2.1 *Identification of Priority Environmental Receptors*

PER were identified from risk assessments undertaken as part of the VDD upgrade project, historical aquatic fauna surveys undertaken in the Vasse River catchment, and targeted aquatic fauna surveys specifically for the VDD upgrade project. In addition, habitats which receive outflow water from the VDD and Vasse River which may be affected by a reduction in water quality were considered, as well as the biota present. As a result, the following PER were identified:

- *Westralunio carteri* (Carter's Freshwater Mussel); and
- Seagrass beds of Geographe Bay adjacent the VDD outlet.

Discussions with the Department of Water and Environmental Regulation (DWER) around the implementation of the WQMMP were undertaken prior to its drafting. This included the identification and suitability of the PER outlined above. As well as identifying the PER, these discussions also assisted with determining the water quality parameters as they relate to each PER which would be monitored.

2.2 *Priority Environmental Receptors and Water Quality Parameters*

2.2.1 *Westralunio carteri*

The Vasse River is known to contain *W. carteri* (Slack-Smith 2006; Lymbery *et al.* 2008; Ma 2018). *Westralunio carteri* is listed as Vulnerable under the *Environment Protection and Biodiversity Conservation Act 1999 (*EPBC Act) and Western Australian *Biodiversity and Conservation Act 2016* (BC Act). In order to support project approvals, Water Corporation commissioned studies investigating the distribution and abundance of *W. carteri* in the sections of the VDD designated for the upgrade (Beatty 2019; GHD 2019). Those studies found live *W. carteri* to be generally confined to the uppermost ~700 metre section of the project area and upstream of the bridge on Chapman Hill Road. As a result of the species presence in the project area, Water Corporation commissioned the drafting and implementation of the Vasse Diversion Drain Upgrade Project *Westralunio Carteri* Management Plan (WCMP) (Indo-Pacific Environmental 2020).

The overarching aim of the WCMP was to manage potential impacts of the works to mitigate a population level effect of *W. carteri* in the Vasse River. Specific management objectives of this WCMP to achieve this overarching aim included:

- Minimising disturbance of known habitat within the project area;

- Minimising disturbance of known habitat and *W. carteri* located upstream and downstream of the project area; and
- Minimising mortality of individuals located within the project area as a direct result of earthworks.

The WCMP defined a manage approach aimed at mitigating risk of impact to *W. carteri.* Key to the management of *W. carteri* in the VDD was the proposed relocation of individuals located within the project footprint to comparable habitat located immediately upstream. While this largely mitigates the risk of the potential effects a reduction in water quality may have on individuals from the VDD, consideration must be given to *W. carteri* in the Lower Vasse River immediately downstream of the VRDD works area and beyond. The presence of *W. carteri* in the Lower Vasse River was indeed part of the reason the WCMP also proposed the drafting and implementation of this WQMMP.

The works of Klunzinger (2013) provided guidance on key water and environmental parameters which have bearing on *W. carteri* distribution and persistence. These included:

- Presence of perennial water;
- Turbidity;
- Water electrical conductivity and salinity (i.e. salinity of no greater than 1.5 ppt (g/L);
- pH;
- Total nitrogen;
- Total phosphorous;
- Water temperature;
- Fine bed sediments; and
- Presence/absence of host fish species.

As a result of that review, and studies of the species in the Vasse River catchment, key water quality parameters for monitoring which were relevant to *W. carteri* as part of the WQMMP were considered to be:

- Turbidity;
- Electrical conductivity;
- Salinity;
- pH;
- Total nitrogen;
- Total phosphorous; and

- Temperature.

2.2.2 *Seagrass*

Geographe Bay is located within the Ngari Cape Marine Park, and is one of the four areas which are considered to be representative of the Leeuwin–Naturaliste marine bioregion (Department of Environment and Conservation 2013). Each of these four areas possesses distinct differences in geomorphology, oceanography, habitats and flora and fauna. In relation to Geographe Bay, this area represents extensive perennial seagrass habitat and communities which are dominated by *Posidonia sinuosa*. Long term monitoring of seagrass has been undertaken in Geographe Bay since 2012 (McMahon and Dunham 2018). These works have identified that extensive seagrass habitat exists in waters adjacent the VDD outlet and which represents one of the long term monitoring sites of that study.

In order to define the key water quality parameters for monitoring which would be relevant to seagrass as part of the WQMMP, the studies of Kendrick *et al.* (2002), Lavery and McMahon (2011) and McMahon and Dunham (2018) were reviewed. In addition, discussion with DWER around beneficial water quality monitoring parameters relevant to meadows adjacent the VDD outlet was also undertaken. As a result the following key water quality parameters for seagrass for which monitoring would be undertaken as part of the WQMMP were considered to be:

- Total suspend solids;
- Turbidity;
- pH;
- Electrical conductivity;
- Temperature;
- Dissolved oxygen;
- Total nitrogen; and
- Total phosphorous.

3.0 WORKS AREAS AND WATER MANAGEMENT INFRASTRUCTURE

3.1.1 *Works Areas*

While upgrade works are proposed to occur throughout approximately six kilometres of the VDD, two major works areas are the main focus of the WQMMP due to the fact works undertaken in these areas are likely to have greatest bearing on water quality as they relate to PER. This includes the 'VRDD works area' which represents the area at the confluence of the Vasse River (Lower Vasse River) and VDD where construction of the VRDD and the Vasse River Overflow Structure (VROS) will be undertaken (Figures 1 and 2). The second works area, 'lower VDD works area' refers to that section in the downstream extent of the project area (Figures 1 and 3). In this area, reconstruction and recontouring of the VDD levee banks will be undertaken in order to accommodate a higher flood level and provide vehicle access along the whole drain. A coffer dam installed on the downstream end of the works area represents the downstream extent of the project area and aims to restrict the tidal movement of water back up the VDD.

3.1.2 *Water Management Infrastructure*

The documents of Water Corporation (2020) and RPS (2020), as well as the WCMP (Indo-Pacific Environmental 2020), outline management actions for controlling water inflow and outflow in works areas, sedimentation generated by the works, and the carriage of water from upstream of the work areas to downstream. This WQMMP assumes that the infrastructure outlined in those documents is installed and that stated management of various aspects of the VDD upgrade project are adhered to. The aforementioned documents should be reviewed and considered in conjunction with this WQMMP. The primary types of infrastructure proposed to be installed, and relied upon to assist with the management of water quality, detailed in those documents are outlined below. Proposed locations of this infrastructure within the project area can be seen in Figures 1 to 3.

- Coffer dams:

  Temporary coffer dams will likely be of earth and steel board construction, and utilised in in the Vasse River, Lower Vasse River and the VDD. These dams will allow works areas to be dewatered to facilitate the mechanical excavation of VDD batters and concrete works, such as those associated with the VRDD;

- Silt curtains:

  Silt curtains will be bottom weighted and span the full width of channel. Silt curtains will be installed in the Vasse River, Lower Vasse River and the VDD in close proximity to coffer dams and downstream of bypass pipe outlets. Silt

curtains aim to contain mobilised sediment particles in order to reduce turbidity and transport of suspended solids.

- Bypass pipes:

  A bypass pipe and pump is proposed to be installed for the carriage of waters from the Vasse River (upstream of the VRDD works area) to the Lower Vasse River to maintain flow throughout the project duration. A bypass pipe and pump may also be used in the lower VDD works area for the carriage of water from the VDD upstream of the coffer dam to the VDD downstream of the works area.

Table 1 and Figure 1 outline the location of infrastructure proposed to be utilised within the VRDD and lower VDD works areas. The location of this infrastructure has been taken into account when identifying water quality sampling sites for the WQMMP to ensure water quality issues which directly relate to VDD upgrade project works can be identified as opposed to water quality issues which may result from other land uses or practices which border the VDD and Lower Vasse River. This includes, for example, nutrient inputs from adjacent agricultural land, earth works undertaken in close proximity to the Lower Vasse River or run-off which results in increased turbidity or an observable plume.

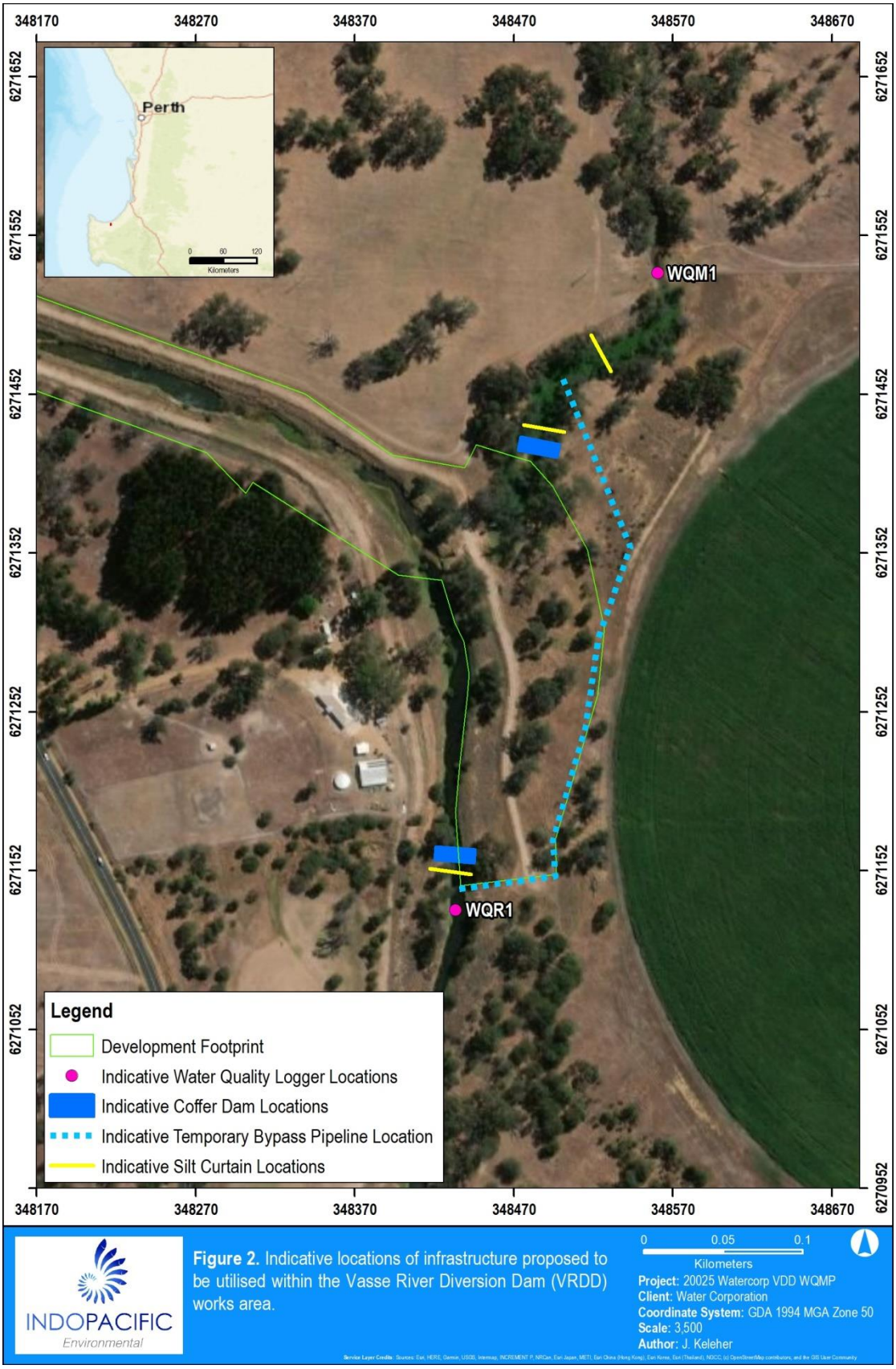

Figure 2. Indicative locations of infrastructure proposed to be utilised within the Vasse River Diversion Dam (VRDD) works area.

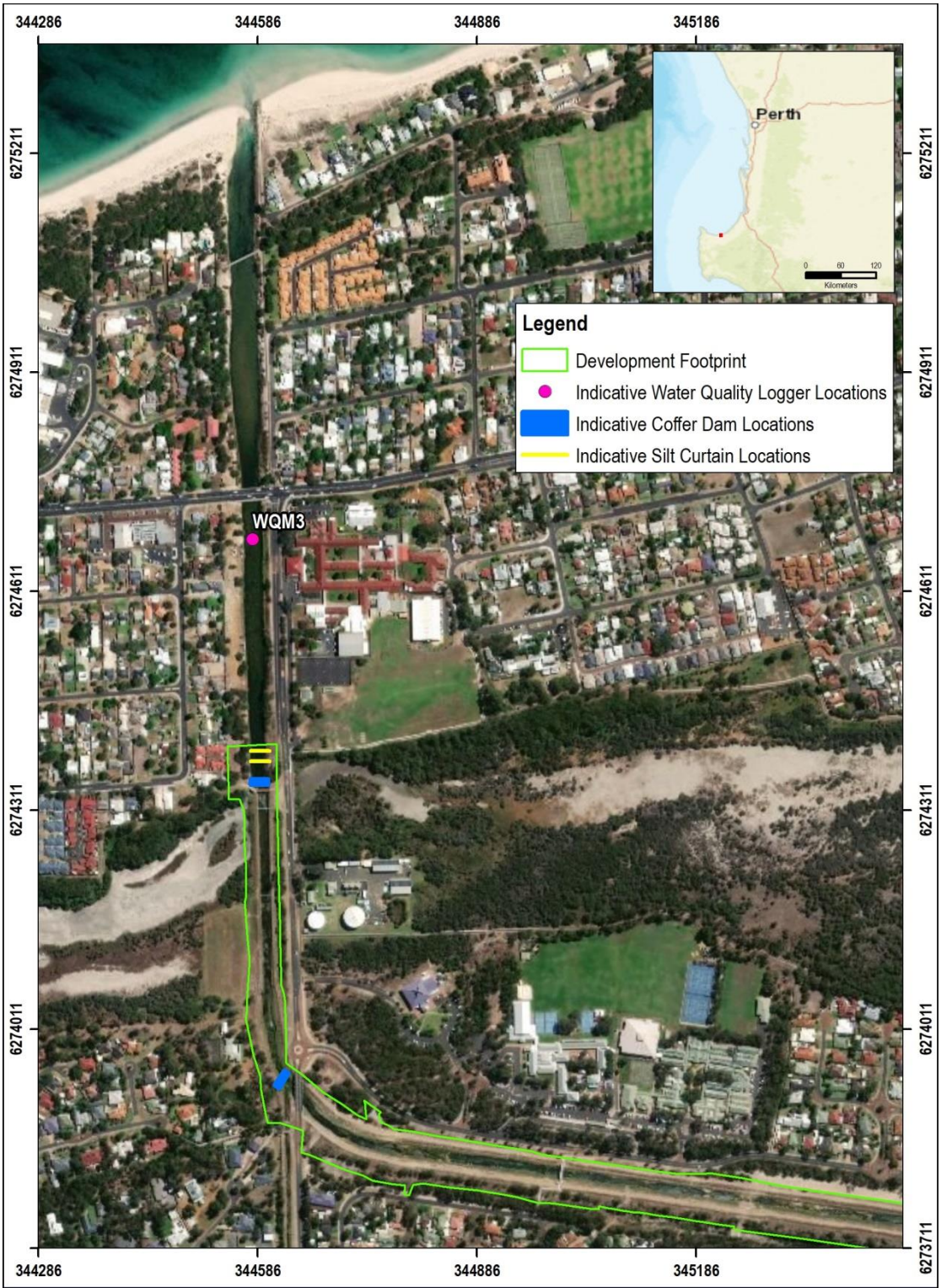

Figure 3. Indicative locations of infrastructure proposed to be utilised within the Lower Vasse Diversion Drain (VDD) works area.

Table 1. Proposed water management infrastructure in Vasse River Diversion Dam (VRDD) and Lower Vasse Diversion Drain (VDD) works areas.

Domain	Proposed Infrastructure
VRDD works area	• A coffer dam will be constructed in Vasse River upstream of the construction area (CH6200) • A coffer dam will be constructed within the Lower Vasse River immediately downstream of the construction area. • A bypass pipe with an inlet located upstream of the coffer dam at CH6200, and an outlet downstream of the coffer dam in the Lower Vasse River, will be utilised to maintain flow to the Lower Vasse River. • A silt curtain will be installed immediately downstream of the VRDD construction site • A silt curtain will be installed downstream of the bypass pipe outlet reduce the mobilisation of suspended matter downstream
Lower VDD works area	• A coffer dam will be constructed at the downstream extent of the project area (~CH800) to restrict the tidal movement of water back up the VDD. • A coffer dam will be constructed on the upstream side to prevent any inflow into the construction area (~CH1240) to restrict flow from the Vasse Sub-A drain. • A bypass pumping system may be used to transfer water across the construction area. • A silt curtain will be installed to minimise turbid plumes flowing downstream of the construction works.

4.0 WATER QUALITY MONITORING

4.1 *Baseline Data*

The development of trigger values for various water quality parameters requires the collection and understanding of baseline (background) data to provide a means of comparison for water quality which results from works associated with the upgrade project. A baseline is often derived from historical data collected over a timeframe which conveys the range in parameter values experienced prior to project works. Alternatively, when the timeframe to collect baseline data prior to a project being initiated is insufficient for describing pre-project water quality conditions, data from waters collected upstream of a project area (i.e. beyond the zone of influence) can be used to ascertain whether changes in water quality have occurred as it passes through a project area and beyond.

4.1.1 *Review of existing data*

To assist with defining trigger values for the WQMMP, historical water quality and flow rate monitoring data undertaken in the Vasse River and its tributaries by DWER was reviewed for the period between May 2018 and June 2020. While a number of long term water quality sampling points exist on the Vasse River catchment, only one is located within the project area that being within the VDD downstream of the VRDD (AWRC Reference Code 610014). Noting that this monitoring location is downstream of the Vasse Diversion Dam works area, its use in providing baseline data is limited to providing some indication of water quality parameter ranges in the VDD itself over time. Another water quality sampling point is located upstream of the project area in the Sabina Diversion Drain (AWRC 610025). However, as there is no accurate means of determining water quality from the area located immediately upstream of the project area, and which is downstream of the confluence of the Sabina Diversion Drain with the upper Vasse River, the use of this data in providing a baseline is limited.

A limited amount of water quality data collected from the downstream extent of the VDD (i.e. downstream of Queen Elizabeth Avenue) was also provided by DWER (Table 2). This area is typically influenced by tidal marine waters and as such does not provide data suitable for use as a baseline for freshwaters present in the vicinity of the VRDD works area. While this water quality data dated back to 2002, data was only collected during a few random sampling events since that time and over no extended duration. The water quality parameters measured also varied between sampling events. Furthermore, it is unclear whether any QA/QC procedures were applied. While this data set was not considered to be sufficient for setting trigger values for water quality monitoring in the lower VDD works area alone, this data provided some indication of ranges that might be expected at various times throughout the year. Table 2

provides a summary of historical data for sampling conducted at sites downstream of the proposed lower VDD works area.

Table 2. Historical water quality data ranges collected by DWER (June 2002, Feb-April 2003, Feb 2019) and RPS (March 2020) from sample sites located downstream of the lower VDD works area.

	Unit	N	Min	Max
Conductivity	µS/cm	24	43122	54292
NOx-N	mg/L	5	<0.010	0.016
Total N	mg/L	5	0.222	0.7
NH3-N/NH4-N	mg/L	5	0.011	0.02
DO	%	38	0	105
DO	mg/L	39	0	7.35
Total P	mg/L	5	0.028	0.13
pH		29	7.45	732
Reactive P	mg/L	5	<0.010	0.02
Salinity	ppt	19	33.6325	34500
TSS	mg/L	5	1	86
Temperature	^{o}C	38	15.3	23.89
Turbidity	NTU	16	0.185	16.1

As part of the VDD Upgrade Project, an Acid Sulfate Soils (ASS) Detailed Site Assessment (DSA) was undertaken by RPS (2020) to identify potential areas within the VDD project area where ASS may occur. That study included a single water quality sampling event conducted in March 2020 to collect surface water samples for analysis from 23 sites within the Vasse River, VDD and Lower Vasse River. While it is acknowledged that the study by RPS (2020) was not undertaken for the purpose of informing trigger values for the WQMMP, that data is not considered appropriate for use as a baseline for WQMMP due the fact it represents a snap shot of water quality only (i.e. that in March 2020). Noting that the VDD upgrade project is proposed to be undertaken from November 2020 until June 2021, a dataset collected over an equivalent period at least which captures the ranges of water quality parameters as they occur throughout various seasons would have been beneficial. Table 2 includes that data collected as part of the ASSDSA from the sampling site located downstream of the project area.

4.1.2 *Collection of baseline*

VDD upgrade works are proposed to begin in November 2020. Noting the deficiencies in existing data sets to provide baseline data for the purpose of setting trigger values, and the less than three month timeframe to collect additional data, it is proposed that water quality data be collected in the Vasse River directly upstream of the project area throughout the works program. This will provide a more reliable data set for the purpose of comparison aimed at identifying whether upgrade works on the VRDD are affecting water quality downstream of the

works area. To facilitate collection of comparison data, a monitoring site directly upstream of the VRDD works area has been included in this WQMMP (Figure 2).

In relation to the lower VDD works area, additional water quality data from the downstream extent of the project area will also need to be collected prior to the works being undertaken. However, noting the limited time until the upgrade works begin and the fact that water quality data cannot be captured for all seasons prior to the works being undertaken, the baseline data set also considers relevant historical data provided by DWER, despite its limitations.

4.2 *Alignment with the Acid Sulphate Soils and Dewatering Management Plan*

As discussed in Section 4.1.1, an ASSDSA was undertaken to inform the Vasse Diversion Drain upgrade project. As a result, an Acid Sulphate Soils and Dewatering Management Plan (ASSDMP) was drafted which identified the potential risk of ASS interactions and management relating to major components of the project including the VDD levee bank works, installation of a gauging station, and the construction of the VROS/VRDD (RPS 2020). Section 8 of the ASSDMP outlines the water quality parameters which were considered during that study, and which are common to the analysis of both surface water and ground water samples. A number of the water quality parameters assessed in the ASSDMP are consistent with those water quality parameters identified in Section 2 for monitoring PER. As a result, it was considered appropriate to align the sampling regime of the WQMMP with that proposed in the ASSDMP where possible to increase efficiencies.

Appendix D of the ASSDMP provides an earthworks and dewatering operating strategy for the construction of the VROS/VRDD. Appendix D outlines that surface water sampling would be undertaken at two sites above the project area. Those sites are referred to as SW04, which is located in the Vasse River behind the Busselton Golf Course, and SW03, which is located immediately upstream of the coffer dam proposed to be installed at the upstream extent of the project area (see Figure D-A of the ASSDMP). In addition two surface water monitoring sites, referred to as SW01 and SW02, are proposed in the Lower Vasse River. Those two sites are located immediately downstream of the coffer dam below the VROS/VRDD. As these sampling sites are considered to be appropriate monitoring sites for informing the WQMMP, sampling locations for the WQMMP will also be aligned with those sites proposed in the ASSDMP.

4.3 *Monitoring Parameters and Frequency*

Justification of the water quality parameters to be monitored as part of this WQMMP for the purpose of managing PER is provided in Section 2.2. While total phosphorous and total nitrogen were identified as key parameters for both *W. carteri* and seagrass adjacent the VDD outlet in Geographe Bay, the additional monitoring of total ammonia, NOx-N, reactive

phosphorus, in accordance with the ASSDMP, was also seen appropriate in this instance noting the bearing nutrients can have on these species and the extent of agricultural land (and thus inputs) which surrounds the Vasse River and VDD. Table 3 subsequently defines the water quality parameters to be monitored as part of the WQMMP.

Data will be collected through the use of data loggers installed in the Lower Vasse River and VDD channels, *in situ* water quality readings taken with a portable meter, and water samples collected for laboratory analysis. Table 3 outlines the frequency at which parameters will be measured and water samples collected.

Data loggers will be utilised at four locations. At the request of DWER, one telemetered logger will be installed immediately downstream of the project area in the lower VDD. Data from this locality (referred to as WQM3) will be reviewed every two days to assess water quality against defined trigger values. This aims to identify water quality issues within a short timeframe should they arise, and reduce the time to initiate any mitigation actions, noting that water at this locality ultimately exits the VDD outfall into Geographe Bay. The remaining loggers will be downloaded once a fortnight and data reviewed as soon as practicable.

Measurement of water quality parameters with a hand held field meter will also be collected at the time loggers are downloaded. This data will provide a secondary data set for some of the parameters for quality control purposes. Water samples will be collected in appropriate sample bottles and placed in an esky for transport to a National Association of Testing Authorities (NATA) accredited laboratory for analysis.

Table 3. Water quality parameters measured as part of the WQMMP, sampling method utilised and frequency of measurement.

WQ parameters	Unit	Logger	Hand Held Meter	Water Sample
Temperature	^{o}C	Hourly	Fortnightly	
pH		Hourly	Fortnightly	
Electrical conductivity	µS/cm	Hourly	Fortnightly	
Salinity	ppt		Fortnightly	
Dissolved Oxygen	mg/L	Hourly	Fortnightly	
Dissolved Oxygen	%		Fortnightly	
Total Suspended Solids	mg/L			Fortnightly
Turbidity	NTU	Hourly	Fortnightly	
Total nitrogen	mg/L			Fortnightly
Total Ammonia	mg/L			Fortnightly
NOx-N	mg/L			Fortnightly
Total phosphorous	mg/L			Fortnightly
Reactive Phosphorus	mg/L			Fortnightly

4.4 *Monitoring Locations*

Table 4 and Figure 1 outlines proposed monitoring sites for the WQMMP. These monitoring locations have been selected to aid in determining whether changes in water quality downstream of a works area is directly attributable to the upgrade works themselves as opposed to changes in water quality resulting from other inputs in the VDD and Lower Vasse River derived from, for example, agricultural or residential land.

Table 4. Proposed monitoring locations.

Site	Location
WQR1	Non-telemetered logger immediately upstream of the project area in the vicinity of SW03 outlined in the ASSDMP to provide reference data.
WQM1	Non-telemetered logger immediately downstream of the bypass pipe outlet in the Lower Vasse River in the vicinity of SW02 outlined in the ASSDMP.
WQM2	Non-telemetered logger in the VDD downstream of VRDD/VROS. This logger will be relocated upon completion of the VRDD/VROS works and installed immediately upstream of the coffer dam at the lower VDD works area (~CH1240) in the vicinity of the Vasse Sub-A drain.
WQM3	Telemetered logger installed downstream of the lower VDD works area to monitor water quality prior to discharge to the ocean.

4.5 *Water Quality Data Comparison, Trigger Values and Management*

4.5.1 *Vasse River Diversion Dam Works Area*

Changes in water quality in the VDD and the Lower Vasse River as a result of works on the VRDD will be identified in the following way:

- Water quality data for the parameters outlined in Table 3 collected at WQM1 and WQM2 will be compared to that recorded at the reference site WQR1 at the frequencies indicated in Table 3.

A trigger value which will result in the instigation of additional management actions is considered to be:

- Salinity of greater than 1.3 ppt recorded at WQM1 (noting this is approaching the tolerable limit for the species is 1.5 ppt); or
- A variation by ±20% in the value of any monitored parameter at WQM1 or WQM2 in comparison to the corresponding value at WQR1 for a period of greater than two weeks.

An exceedance of a trigger value will result in the following actions:

- Inform Water Corporation Environmental Advisor;
- Logger download and *in situ* sampling frequency in the Lower Vasse River will be increased to once every 3 days. Additional *in situ* measurements and/or water samples targeting the parameter showing variation will be collected downstream of WQM1 to determine an area of extent;
- Investigate potential cause of the variation in the specific water quality parameter to determine whether the cause is attributable to the VRDD upgrade works;
- If the cause is likely to be attributable to the VRDD upgrade works, assess the potential risk to the PER, in this case *W. carteri*, to determine likelihood and magnitude of impact on PER, and inform the Water Corporation;
- Water Corporation to consider notifying the relevant authority or regulator; and
- If the likelihood and magnitude of the impact on the PER is high, Water Corporation to consider further actions to address water quality issues (in addition to those actions outlined in the ASSDMP and WCMP). For example:
    - Cease flow in bypass pipeline;
    - Installation of additional silt curtains downstream of WQM1;
    - Cessation of works until driver of water quality reduction is understood; and
    - Construction of additional coffer dam downstream of WQM1 to retard water flow in the Lower Vasse River.

Figure 4 provides a visual representation of the water quality monitoring and management process for the Vasse River Diversion Dam Works Area, including response trigger values and subsequent actions that should be adhered to.

4.5.2 *Lower Vasse Diversion Drain Works Area*

Unlike the VRDD works area, the opportunity to collect appropriate baseline water quality data from a site upstream of the works area (and beyond the zone of influence) does not exist for the lower VDD works area. This is due to the fact that this works area represents a distinct barrier between water types. Waters on the downstream side of this works area are tidal (i.e. water quality will be influenced by marine waters as well as run-off from adjacent suburbs and swamp), however waters upstream side are largely derived from rainfall run-off events and inflow from adjacent lands.

The tidally influenced section downstream of the lower VDD works area represents an area of complex mixing where water quality will vary greatly throughout the year and is additionally

influenced by factors such as inputs from adjacent land, whether connectivity between the VDD and marine waters of Geographe Bay exists, and flow in the VDD. Noting this existing complexity, and lack of a robust historical water quality data set, the setting of trigger values aimed at determining whether a change in water quality is attributable to the VDD upgrade works is difficult at this point in time. However, connectivity of water from upstream to downstream of the lower VDD works area will only be as a result of the potential installation of a bypass pipeline. As such, the application of a trigger value aimed at addressing water quality changes as a direct result of the upgrade works will only occur when water is being actively pumped through the bypass pipeline. Furthermore, as the aim of the WQMMP is the mitigation of water quality impacts on a PER, in this case seagrass in Geographe Bay, the application of a trigger value will not occur when the mouth of the VDD is closed to the sea and there is no connectivity to the PER.

Changes in water quality downstream of the project area as a result of works in the lower VDD works area will be identified in the following way:

- Water quality data will be collected from WQM3 prior to works being undertaken to provide some baseline data. Historical data provided by DWER will also be considered;
- During the upgrade works, water quality data collected from the telemetered logger installed at WQM3 will be reviewed every three days and compared to baseline data collected prior to the works and to historical water quality data ranges collected by DWER at sites downstream of the lower VDD works area; and
- During the upgrade works, water quality data for the parameters outlined in Table 3 collected at WQM2 (logger to be relocated to immediately upstream of the lower VDD works after completion of the VDD works) will also be compared to that recorded at WQM3 at the frequencies indicated Table 3.

A trigger value which will result in the instigation of additional management actions is considered to be where:

- The value of any parameter measured by telemetered logger downstream of the project area is ±20% beyond the range of values attained from historical data; and
- The value of any monitored parameter recorded at the logger upstream of the lower VDD works area is greater than 20% of the value recorded downstream for a period of greater than two weeks, with the exception of salinity and electrical conductivity.

An exceedance of a trigger value will result in the following actions:

- Inform Water Corporation Environmental Advisor;
- Identify whether the exceedance is associated with a climate or sea event;

- Logger download and *in situ* sampling frequency at WQM2 and WQM3 will be increased to once every three days. Additional *in situ* measurements and/or water samples targeting the parameter showing variation will be collected close to the confluence of the VDD and marine waters of Geographe Bay;
- Investigate potential cause of the variation in the specific water quality parameter to determine whether the cause is attributable to the upgrade works in the lower VDD works area;
- If cause is likely to be attributable to the upgrade works, assess the potential risk to the PER, in this case seagrass in Geographe Bay, to determine likelihood and magnitude of impact on PER, and inform the Water Corporation;
- Water Corporation to consider notifying the relevant authority or regulator; and
- If the likelihood and magnitude of the impact on the PER is high, Water Corporation to consider further actions to address water quality issues (in addition to those actions outlined in the ASSDMP and WCMP). For example:
    - Cease flow in bypass pipeline;
    - Installation of additional silt curtains downstream of WQM3; and
    - Cessation of works until driver of water quality reduction is understood.

Figure 5 provides a visual representation of the water quality monitoring and management process for the Lower Vasse Diversion Drain Works Area, including response trigger values and subsequent actions that should be adhered to.

4.6 *Data Review and Reporting*

Telemetered logger data from WQM3 will be reviewed every three days. Non-telemetered logger data (WQR1, WQM1 and WQM2) will be reviewed on a fortnightly basis as soon as practicable after the logger download. Data from the laboratory analysis of water samples will be undertaken on a fortnightly basis as soon as results become available. Summary reporting will be made to the Water Corporation on a fortnightly basis. However, in the event a trigger value is exceeded reporting will be undertaken immediately.

4.7 *Roles and Responsibilities for Implementation*

The WQMMP will be managed on behalf of the Water Corporation by a suitably qualified environmental consultant. The environmental consultant will ensure adherence to the monitoring regime outlined in this WQMMP, including the management of data and reporting to the Water Corporation.

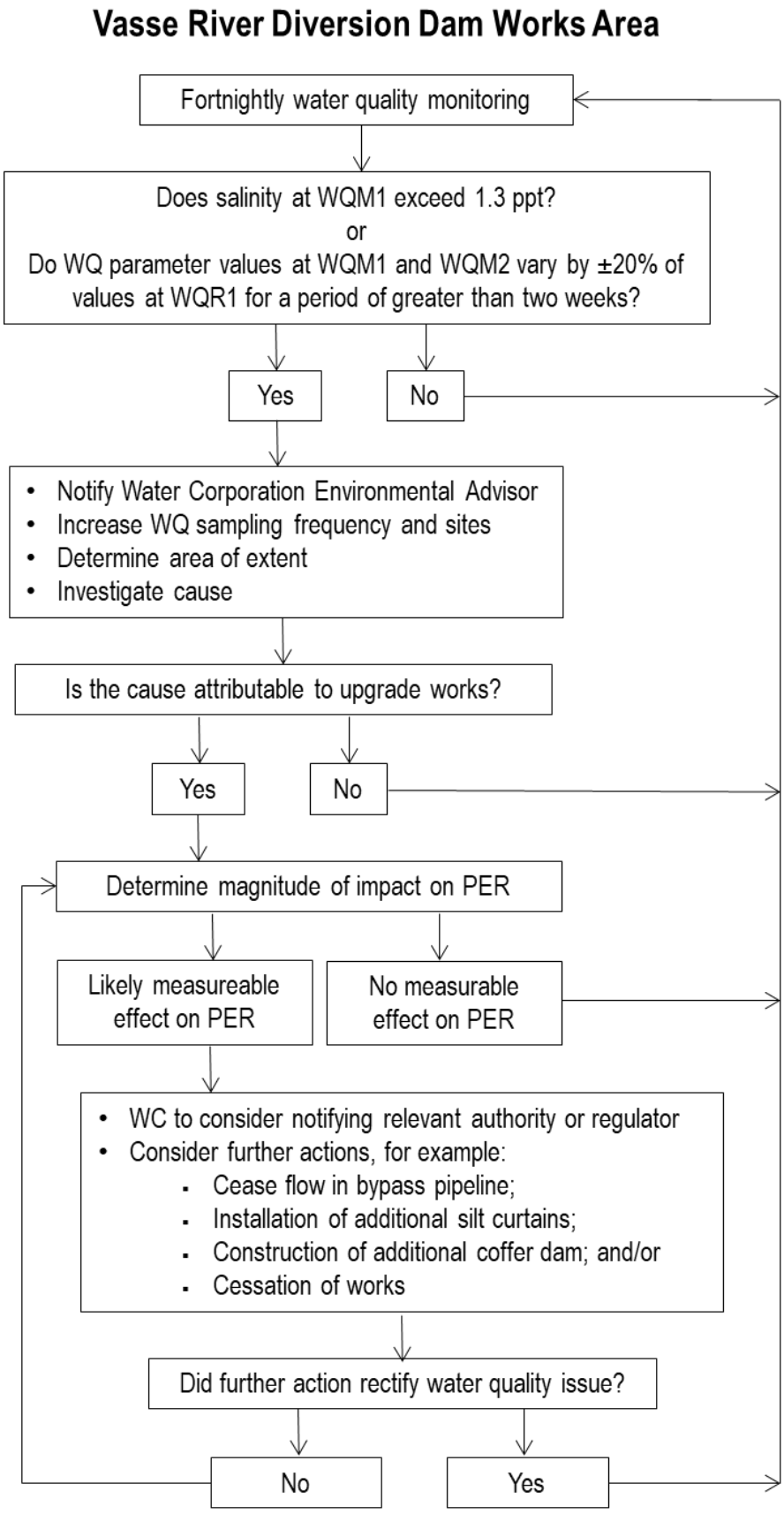

Figure 4. Water quality monitoring and management process for the Vasse River Diversion Dam Works Area.

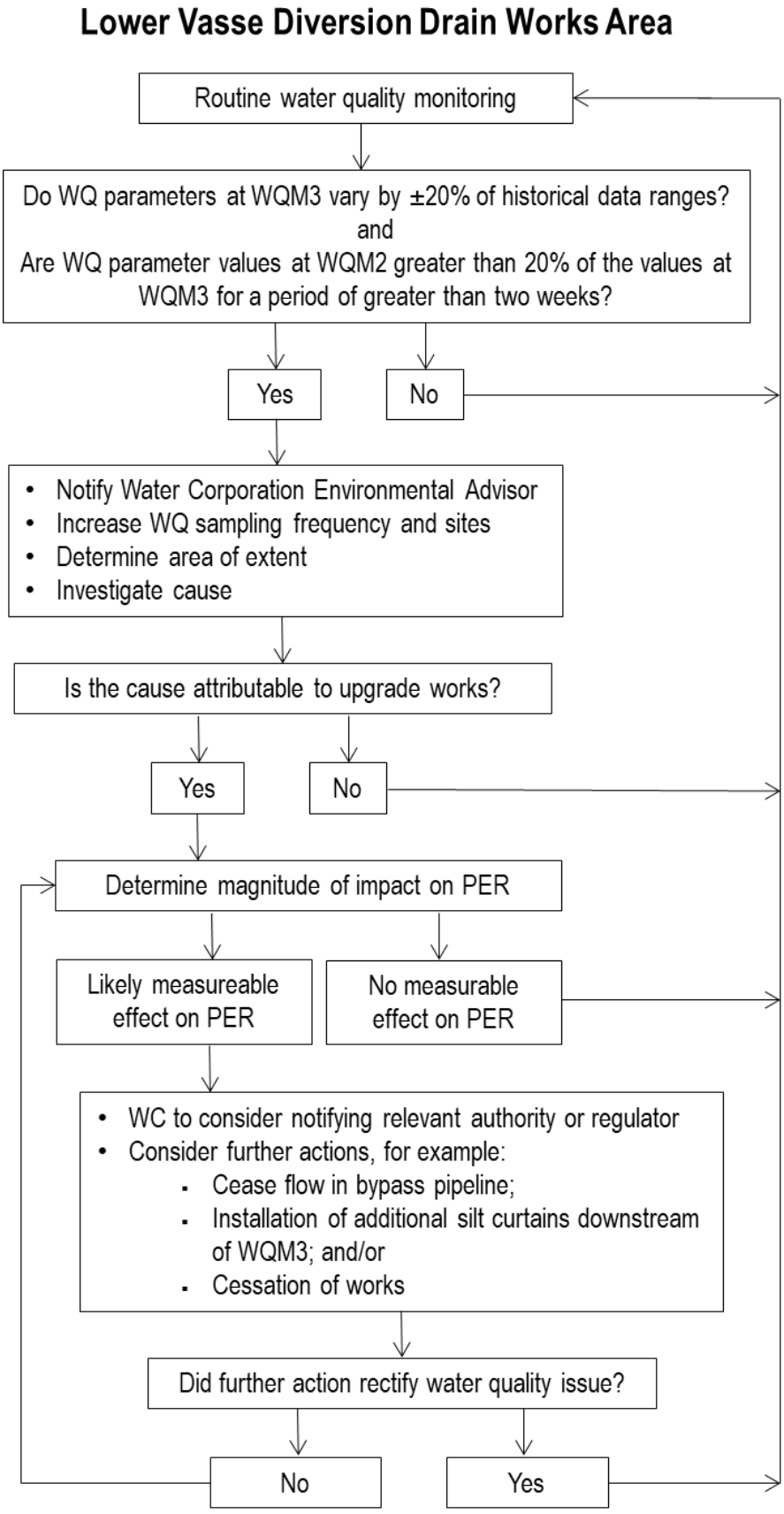

Figure 5. Water quality monitoring and management process for the Lower Vasse Diversion Drain Works Area.

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