

**HUNTER VALLEY**  
OPERATIONS

# **RIVER RED GUM REHABILITATION AND RESTORATION STRATEGY**

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HVOOC-1797567310-4435

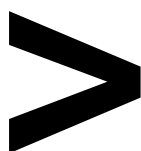
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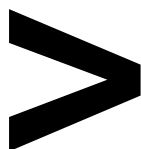
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## 1 | BACKGROUND

Hunter Valley Operations (HVO) is an open cut coal mine located 24 kilometres north-west of Singleton in the Hunter Valley region of New South Wales (**Figure 1-1**). HVO is owned and operated as a joint venture between Yancoal Australia and Glencore Coal Assets Australia in a 51:49 per cent division. The operation consists of Hunter Valley Operations North (HVO North) and Hunter Valley Operations South (HVO South).

HVO North operates under Development Consent DA 450-10-2003 that was issued under Part 4 of the EP&A Act and allows mining of the West Pit and Carrington Pit. This DA allows mining operations to continue to December 2026.

Mining from Carrington Pit ceased in 2019 and has been used as a fine reject emplacement. Carrington Billabong lies immediately to the south of Carrington Pit, and west of the North Pit Tailings Storage Facility (TSF).

Coal & Allied was required by the then Department of Planning (DoP) to prepare a comprehensive Rehabilitation and Restoration Strategy for the Carrington Billabong and its river red gum population (the Strategy) as part of the approval to extend open-cut mining in the Carrington Pit, located in HVO North. In March 2007 Umwelt (Australia) Pty Limited (Umwelt) prepared the Carrington Billabong River Red Gum Rehabilitation and Restoration Strategy. This document that presented appropriate actions to ensure the long- term viability of river red gum stand in the Billabong was approved by DoP on 19 May 2008.

A revision of the Strategy was required as part of the project approval for the HVO South Project (PA06 0261) to include stands of river red gums on the Hunter River and Wollombi Brook, which occurred within the HVO South project approval boundary. This revision was prepared by Umwelt (2017) to satisfy the requirements of condition 30 of the development consent that required:

1. conservation and restoration objectives;
2. short, medium- and long-term measures to be implemented; and
3. completion criteria.

River red gum (*Eucalyptus camaldulensis*) have become increasingly rare in the Hunter Valley, and the entire population occurring within the Hunter Valley is now listed as an Endangered Population under the NSW *Biodiversity Conservation Act 2016* (BC Act).

Naturally occurring river red gums are thought to be largely dependent on groundwater for the majority of their water requirements, occurring mostly in shallow alluvial groundwater systems in the Hunter Valley. Their habitats are therefore considered to be groundwater- dependent ecosystems (GDEs) which are subject to provisions of the *Water Management Act 2000* (WM Act) (DLWC 2002).

### *Carrington Billabong & HVO Priority Sites Monitoring Program 2007-2017*

The Carrington Billabong River Red Gum Rehabilitation and Restoration Strategy set up a monitoring program of river red gum subpopulations and vegetation communities in Carrington Billabong and priority sites on the Hunter River and Wollombi Brook in HVO North and South, shown in **Figure 1-2**. The program prescribed six monitoring events over a ten- year period between 2007 to 2017. These occurred at the Carrington Billabong, at a non-mining river red gum site (the Reference Site previously called 'Camyr Allyn') and priority sites on HVO land (north and south) on the Hunter River and Wollombi Brook.

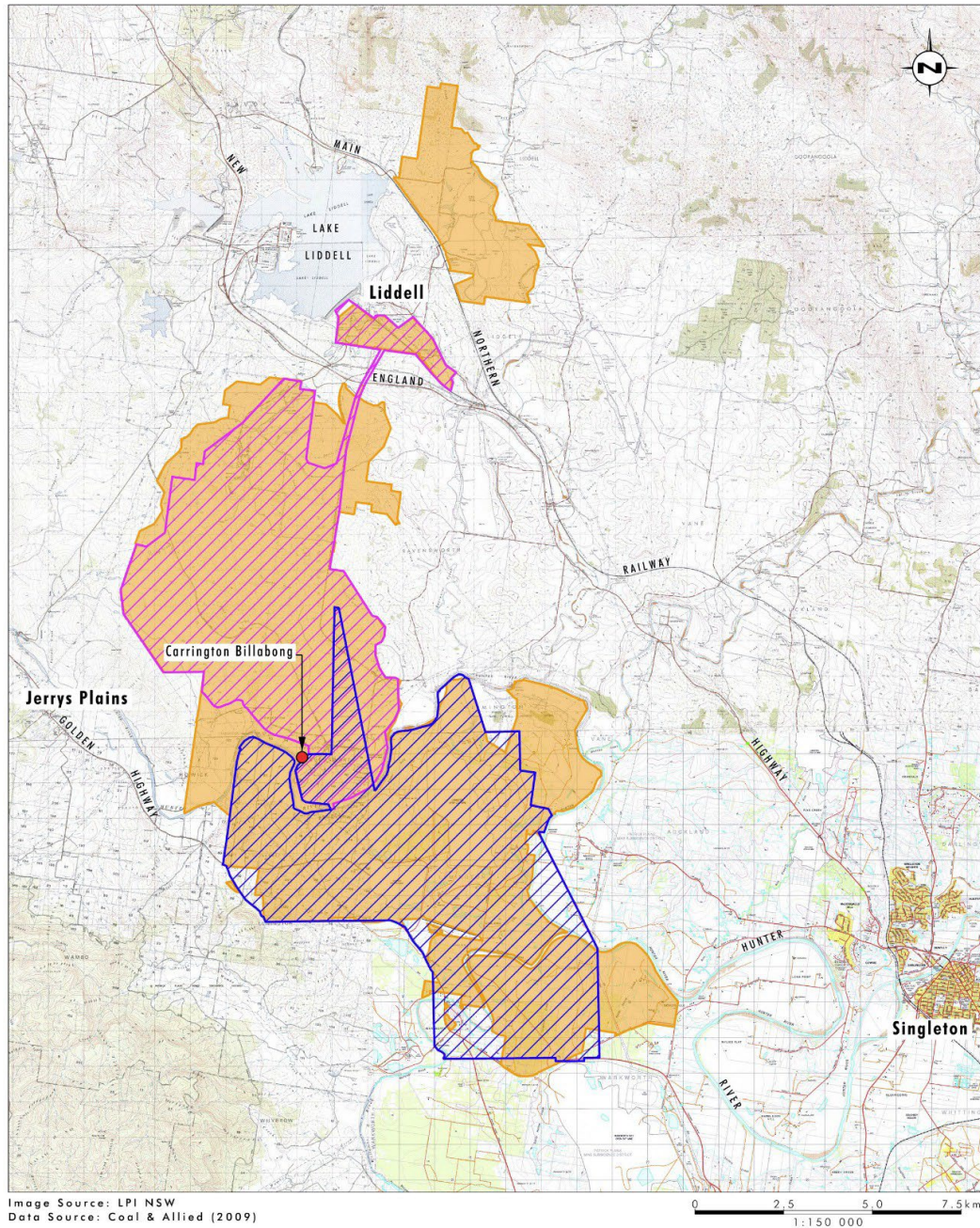
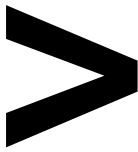


FIGURE 1.1

Location of Carrington Billabong,  
HVO North and South

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Figure 1-1: Location of Carrington Billabong within HVO



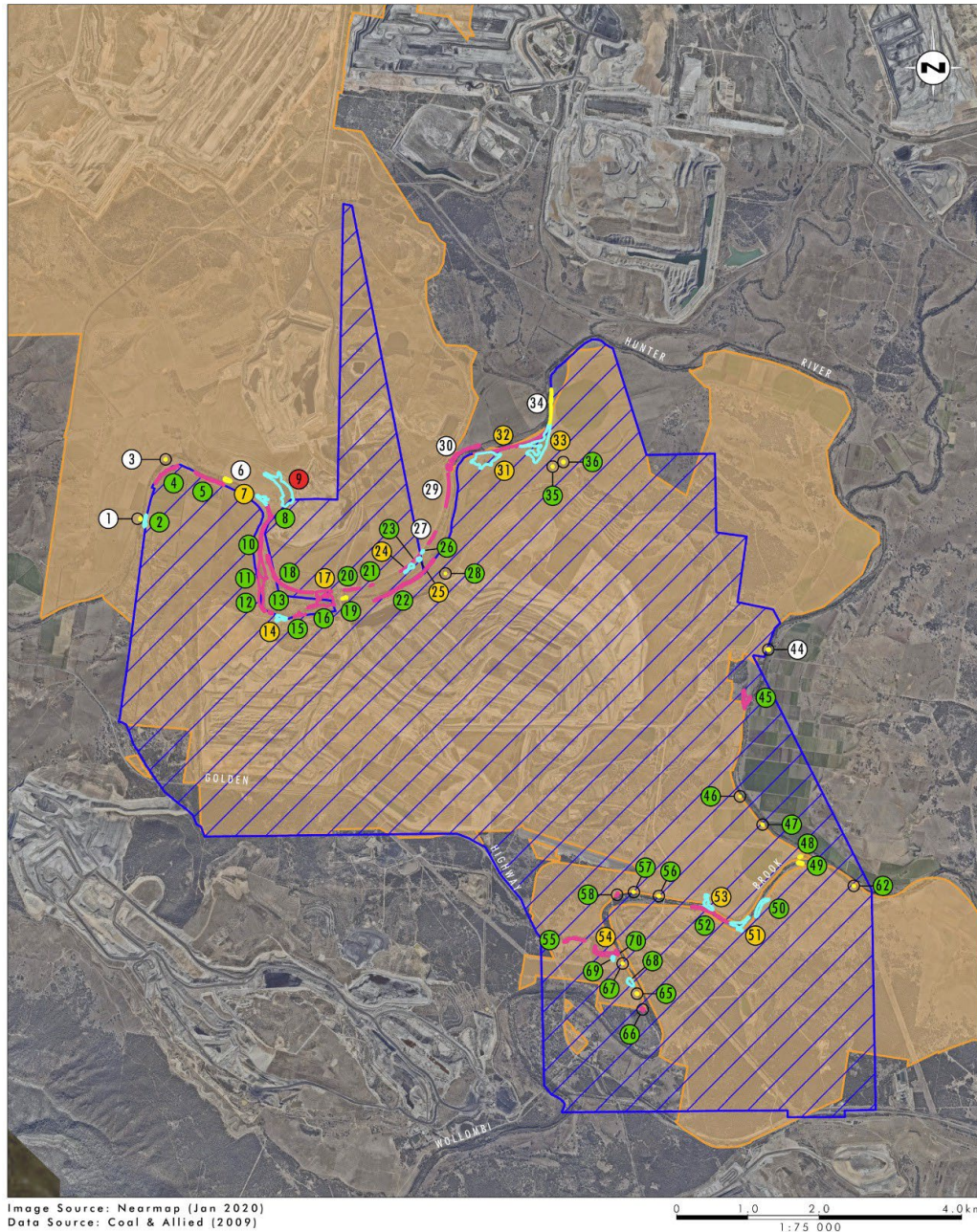
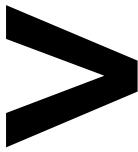


Image Source: Nearmap (Jan 2020)  
Data Source: Coal & Allied (2009)

0 1.0 2.0 4.0 km  
1:75 000

#### Legend

HVO South Project Approved Boundary  
 HVO Owned Lands  
River Red Gum Remnants:  
Frequency of *Eucalyptus camaldulensis*  
 Dominant  
 Common  
 Occasional

Site and Proposed Management Intervention Categories:  
 High Level Management (Carrington Billabong)  
 Moderate Level Management (Priority Sites)  
 Low Level Management  
 Sites Outside of HVO South

FIGURE 1.2

Carrington Billabong and  
HVO River Red Gum Sites

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Figure 1-2 -River Red Gum sites within HVO

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Monitoring included the following survey events and reports:

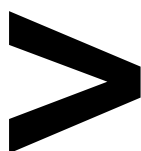
- Baseline survey in April/May 2007 (Umwelt 2007)
- Six month survey in October 2007 (Umwelt 2008c)
- 12 month survey in May 2008 (Umwelt 2008c)
- Three year monitoring in May 2010 (Umwelt 2010)
- Five year monitoring in October 2013 (at HVO priority sites & Carrington Billabong) and May 2014 (at the Reference site) (Umwelt 2014) and
- Ten year monitoring in May 2017 (Umwelt 2019).

**Table 1-1** summarises the timing and details about each of monitoring events that have occurred at Carrington Billabong, HVO Priority Sites and the Reference site.

*Table 1-1 - Summary of All Surveys in Carrington Billabong, HVO & the Reference site*

SITE	MONITORING ACTIVITIES	BASELINE (APR-MAY 07)	6-MTH (OCT 07)	12-MTH (MAY 08)	3-YEAR (MAY 10)	5-YEAR (OCT 13)	10-YEAR (MAY 2017)
<b>Carrington Billabong</b>							
CB Plot1	Full floristic plot Photo- monitoring Remnant health assessment	✓ (Apr. 07)	✓	✓	✓	✓	✓
CB Plot2	Full floristic plot Photo- monitoring Remnant health assessment	✓ (Apr. 07)	✓	✓	✓	✓	✓
CB Plot3	Seedling recruitment and health Photo- monitoring	✓ (Apr. 07)	✓	✓	✓	✓	✓
CB Plot4	Seedling recruitment and health Photo- monitoring	✓ (Apr. 07)	✓	✓	✓	✓	✓
CB Plot5	Full floristic plot photo- monitoring				✓	✓	✓





# PLAN | RIVER RED GUM REHABILITATION AND RESTORATION STRATEGY

SITE	MONITORING ACTIVITIES	BASELINE (APR-MAY 07)	6-MTH (OCT 07)	12-MTH (MAY 08)	3-YEAR (MAY 10)	5-YEAR (OCT 13)	10-YEAR (MAY 2017)
CB Plot6	Seedling recruitment and health Photo- monitoring				✓	✓	✓
CB adult trees	Adult tree health assessment	✓		✓		✓	✓
<b>Reference Site (Camyr Allen)</b>							
CA Plot1	Full floristic plot Photo- monitoring Remnant health assessment	✓ (May 07)	✓	✓			✓ (Jun. 17)
CA Plot2	Full floristic plot Photo- monitoring Remnant health assessment	✓ (May 07)	✓	✓			✓ (Jun. 17)
CA adult trees	Adult tree health assessment	✓ (May 07)		✓			✓ (Jun. 17)
CA	Photo- monitoring (at CA3 and CA4)	✓ (May 07)	✓	✓			✓ (Jun. 17)
HVO sites	Remnant ecological health assessment	✓	✓	✓	✓	✓	✓

Note: CB=Carrington Billabong; CA=The Reference Site – the Control Site/Camyr Allyn; HVO = Hunter Valley Operations

Source: Umwelt (2019)

This update to the Strategy has been informed by the findings of ten years of monitoring of river red gums and associated vegetation community at Carrington Billabong, HVO Priority sites and the Reference site.

## 1.1 | PURPOSE

The 2017 Strategy addressed project approval conditions for HVO North and South. Specifically, to restore and rehabilitate the Carrington Billabong in accordance with the HVO North development consent, and to manage stands of river red gums occurring along the Hunter River and Wollombi Brook at HVO South in accordance with the HVO South project approval (refer to **Figure 1-2**).

The 2017 Strategy was developed in consultation with several Stakeholders over a period of four years. Discussions with relevant regulatory authorities were undertaken from 2005 onwards. At the approval stage for both the Carrington Pit extension and the HVO South project, draft consent conditions were issued regarding the preparation of the Strategy, and Coal & Allied personnel consulted with government agencies and other experts regarding the draft conditions. Umwelt (2017) provides more detail on the stakeholder consultation process that was undertaken in development of the Strategy.

This document updates the 2017 River Red Gum Rehabilitation and Restoration Strategy to reflect the findings of 10 years of monitoring from 2007 to 2017 of Carrington Billabong, HVO Priority Sites and the Reference Site, and apply these results to the works going forward.

## 1.2 | SCOPE

This updated Strategy applies to the Carrington Billabong, which is situated in HVO North, as well as the Hunter River and Wollombi Brook stands of river red gum occurring within HVO South. Although not formally part of the strategy, the scope of this document also includes the management of stands at HVO located outside of the HVO South consent boundary (refer to **Figure 1-2**).

## 1.3 | REGULATORY FRAMEWORK

### 1.3.1 | THE BIODIVERSITY CONSERVATION ACT 2016

River red gum (*Eucalyptus camaldulensis*) was listed as an Endangered Population in the Hunter Catchment under Part 2 of Schedule 1 of the *Threatened Species Conservation Act 1995* (TSC Act) in April 2005. The BC Act replaced the TSC Act when the latter was repealed in 25 August 2017, and all listings that were under the TSC Act were adopted by the BC Act.

The population was listed as endangered due to a lack of natural regeneration and the occurrence of significant dieback of the tree throughout its range in the Hunter. Additionally, the river red gum population in the Hunter Valley is at the eastern limit of its range in NSW and is disjunct from other occurrences of the tree in NSW. These factors combine to make the Hunter catchment population of high conservation value (NSW Scientific Committee 2005).

Hunter Floodplain Red Gum Woodland was listed as an endangered ecological community (EEC) under the TSC Act in 2010 and is therefore currently listed under the BC Act. The preliminary listing for this community was made after the lodgement of the HVO South Environmental Assessment in February 2008. Therefore, the 2017 Strategy was prepared for river red gum Endangered Populations at HVO. Nevertheless, management of river red gum populations in Carrington Billabong and the HVO Priority sites also benefits Hunter Floodplain Red Gum Woodland EEC.

### 1.3.2 | WATER MANAGEMENT ACT 2000

The WM Act provides for the protection, conservation and ecologically sustainable development of the water resources in NSW. The WM Act also provides for the requirement of rules to be set for the identification, establishment and maintenance of environmental water for all groundwater dependent ecosystems (GDEs) in NSW, through the development of management plans.

### 1.3.3 | DEVELOPMENT APPROVALS

Mining in the Carrington Pit was initially approved in 2000 by the then Department of Infrastructure, Planning and Natural Resources in accordance with the *Environmental Planning and Assessment Act 1979* (EP&A Act) (DA 106-6-99).

The West Pit Extension and Minor Modifications Environmental Impact Statement (EIS) (ERM 2003) resulted in a consolidated consent which incorporated the Carrington Pit (DA 450-10-2003).

In 2006 an application to extend the Carrington Pit was approved under DA 450-10-2003 (M1). The application was for mining in the Carrington Pit to extend further south and to the east of previously approved limit of mining. This would result in mining operations occurring close to the Carrington Billabong.

As part of this modification Coal & Allied was required to develop and implement a Rehabilitation and Restoration Strategy for Carrington Billabong. The preparation of this Strategy specifically related to Consent Condition 31, which stated:

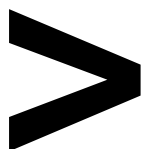
*By 30 June 2007, the Applicant shall prepare and implement a comprehensive Rehabilitation and Restoration Strategy for the Carrington billabong and river red gum population, in consultation with [the Department of Natural Resources], and to the satisfaction of the Director-General. This Strategy must be prepared by suitably qualified expert/s, and must include:*

- (a) the rehabilitation and restoration objectives for the billabong and associated river red gum population;*
- (b) a description of the short, medium and long term measures that would be implemented to rehabilitate and restore the billabong and associated river red gum population (including measures to address matters which affect the long term health and sustainability of the billabong and river red gums such as surface and ground water supply, and controlling weeds, livestock and feral animals); and*
- (c) detailed assessment and completion criteria for the rehabilitation and restoration of the billabong and associated river red gum population.*

The 2008 Carrington Billabong River Red Gum Rehabilitation and Restoration Strategy was prepared to fulfil the requirements of the Consent Condition 31 stated above. The strategy was submitted to DoP and the DECCW for review, and comments were received from DECCW; however the strategy was never finalised and was replaced by the 2017 Strategy.

The HVO South Coal Project was approved in March 2009 by DoP in accordance with the EP&A Act (PA 06\_0261). As part of this project approval (Condition 30 of Schedule 3), Coal & Allied was required to develop a River Red Gum Restoration Strategy that additionally covered the Hunter River and Wollombi Brook river red gum stands within the HVO south area.

The 2017 Strategy set out a 10-year monitoring program for the river red gum populations at Carrington Billabong and the HVO Priority sites (refer **Table 1-1**). The results of monitoring have informed the update to the Strategy provided herein.



**Table 1-2** provides a brief history of development, mining and associated approvals for Carrington Pit (source: SLR 2019).

*Table 1-2 - Carrington Pit Development, Mining and Associated Approvals*

YEAR	DETAILS
1991	Coal & Allied granted original exploration Authorisation (AUTH) 435, covering the Carrington Pit Area
1997	Exploration Licence (EL) 5417 granted to determine extent of coal seam to the west
1997	EL 5418 granted to test and monitor groundwater to the south-east.
1999	Exploration boundaries have been extended to the north into Mining Lease (ML) 1428, joint venture with Howick Coal.
2000	Development Consent DA 106-6-99 granted for Carrington Pit
2004	Carrington Pit integrated into West Pit Extension and Minor Modifications consent, DA 450-10-2003
2006	Statement of Environmental Effects (SEE) for extension to Carrington Pit approved by the former NSW Department of Planning (ERM 2005)
2013	Modification to consent DA 450-10-2003 granted for Carrington West Wing (CWW) Extension (CWW Extension will not commence during RMP term)
2014	Modification to consent DA 450-10-2003 granted for HVO North Fine Reject Emplacement
2017	Modification to consent DA 450-10-2003 granted for HVO North Carrington In-pit Fine Reject Emplacement
2017	Modification to consent DA 450-10-2003 granted to amend the development consent boundary
2018	The receipt of tailings to the North Pit TSF ceased
2019	In-pit tailings commenced in Carrington Pit

Source: HVO North Mining Operations Plan (SLR 2019)



## 1.4 | CONSULTATION

Following the 10 year review of the RRGRRS, on the 19 June 2020, HVO consulted with the Biodiversity Conservation Division (BCD) of the Department of Planning, Industry and Environment (DPIE) for their review of the updated Strategy. The details of the BCD review and HVO's response and edits to the Strategy are outlined in Appendices B and C.

In 2021, the draft RRGRRS that included the edits in response to the BCD request, was provided to the DPIE for approval. The DPIE provided a request for information which required additional edits to complete the draft revised Strategy. The information requested by DPIE is outlined in **Table 1-3** and Appendix D: with the response to the request.

*Table 1-3 - DPIE Request for Information and HVO Response*

DPIE REQUEST FOR INFORMATION	HVO RESPONSE
Update the HVRRGRRS to include current assessment criteria and completion criteria for conservation and restoration of the river red gum populations, to meet the requirements of condition 30 c), schedule 3 of MP 06_0261. This action was not included in the response table.	<p>The assessment criteria and completion criteria are the same as those proposed in the previous version of the Strategy. This is to ensure continuity of existing data and the approach to measuring the effectiveness of the proposed management strategies.</p> <p>This is outlined in Section 4.2 Goals and Objectives, and the new Section 4.3 Completion Criteria.</p>
The HVRRGRRS does not include a protocol for managing and reporting complaints, non-compliances with statutory requirements and exceedances of the impact assessment criteria and/or performance criteria in accordance with Condition 1A (g), Schedule 5. Update HVRRGRRS to address Condition 1A (g), Schedule 5. Section 6 of the HVORRGRRS has been updated to include a new Section 6 which only describes reporting incidents to DPIE.	<p>A protocol has been inserted (Section 6 Reporting) with the commitment to investigate all incidents, complaint, potential non-compliance with statutory requirements or potential exceedance of the impact assessment and/or performance criteria.</p> <p>DPI&amp;E will be informed of the investigation and advised of the follow up action(s) if the action(s) are determined to be necessary.</p>

## 1.5 | RESPONSIBILITIES FOR IMPLEMENTATION OF STRATEGY

Responsibilities for review and approval of various aspects of the updated HVO River Red Gum Rehabilitation and Restoration Strategy are provided in **Table 1-4**.

*Table 1-4 - Responsibilities for Implementation of Strategy*

POSITION	RESPONSIBILITY
HVO Manager Environment and Community	<ul style="list-style-type: none"> <li>• Provide that adequate resources are available for the implementation of the strategy.</li> <li>• Provide adequate resources are allocated in the budget planning cycle for the implementation of this strategy.</li> </ul>
HVO Environment and Community Coordinator	<ul style="list-style-type: none"> <li>• Coordinate the implementation of the updated strategy.</li> <li>• Periodically review progress with meeting objectives and completion criteria, including rehabilitation monitoring.</li> <li>• Periodic review of the Strategy.</li> </ul>

## 2 | ENVIRONMENTAL CONTEXT OF REGION

### 2.1 | LOCATION AND LAND USE

Hunter Valley Operations is located approximately 24 kilometres west-north-west of Singleton, NSW (refer to **Figure 1-1**). HVO is surrounded mostly by mining and agricultural cropping and grazing land uses.

The activities at HVO comprise coal mining areas, coal preparation plants, rail loading facilities, administration areas and workshops. HVO activities are bisected by the Hunter River, which divides the mine into HVO North and HVO South.

The Hunter River traverses the landscape in a general southeast direction. Forming an arc along the northern and eastern areas of HVO South, it is joined by Wollombi Brook, which enters from the south-west. Stands of river red gums occur along both the Hunter River and Wollombi Brook, and have been mapped by Umwelt (2008c).

Flow in the Hunter River adjacent to HVO is managed by WaterNSW by regulating discharge from the upstream Glenbawn Dam. Current hydrology of the Hunter River has a significant influence on the nature of flooding events.

Carrington Billabong contains the largest stand of river red gums within HVO. The billabong is located within HVO North adjacent to the Hunter River (refer to **Figure 1-1**), west of North Pit and immediately south of Carrington Pit. It is situated on a former river channel about 200 metres to the northeast of the present-day channel of the Hunter River. It is loosely connected to the Hunter River by one main and several lesser flood runners. There are no obvious impediments to surface water flow between the Hunter River and Carrington Billabong. The Carrington Billabong is fenced (completed mid 2008) to prevent cattle from grazing and camping.

## 2.2 | BIOPHYSICAL SETTING

### 2.2.1 | GEOLOGY

Carrington Billabong and the stands of river red gums along the Hunter River and Wollombi Brook are located on Quaternary alluviums (Kovac and Lawrie 1991; Beckett 1993).

Quaternary sediments are located along the channels and immediate surrounds of the major rivers and creeks of the central Hunter Valley (Peake 2006). Carrington Billabong is located above an ancient river bed (palaeochannel) of the Hunter River which now forms the floodplain of the river (Mackie Environmental Research 2005).

### 2.2.2 | SOIL

The soil landscape of this area is the Hunter alluvial soils, which occur on the level plains and river terraces of the Hunter River and Wollombi Brook with elevations of 20-60 metres above sea level (Kovac and Lawrie 1991). The soil fertility (chemical) is generally moderate to high, soil salinity is low to moderate and the water-holding capacity is generally moderate to high (Kovac and Lawrie 1991). Hunter alluvial soils are subject to minor bank erosion on watercourses and minor sheet and gully erosion on adjacent terraces (Kovac and Lawrie 1991).

### 2.2.3 | RIVER GEOMORPHOLOGY

Cook and Schneider (2006) applied the River Styles<sup>®</sup> framework to rivers, streams and creeks in the Hunter Catchment. The River Styles framework, developed by Brierley and Fryirs (2005), is a simple and effective internationally recognised method that provides consistent and comparable assessment of the biophysical health of watercourses.

#### **Carrington Billabong and the Hunter River**

This study identified the River Styles<sup>®</sup> category which each watercourse corresponds to, based on the identification of key geomorphic units and riparian vegetation function. The section of the Hunter River adjacent to Carrington Billabong and flowing through the entirety of HVO South was identified as 'Partly Confined Valley Setting – Planform Controlled, Low Sinuosity, Gravel'. Watercourses within this category generally comprise a single, continuous, symmetric channel with gravel as the dominant substrate on the streambed. The channel sinuosity is low (i.e. the channel is close to straight with low levels of bending or curving) due to valley confinement and irregular bedrock steps which assist in controlling slope and sinuosity. The main controls within watercourses of this category are bedrock steps and infrastructure such as causeways and culverts. Large woody debris also assists in channel stability and hydraulic/geomorphic diversity. The condition of this section of the Hunter River was rated as 'poor' (i.e. degraded) with a 'moderate recovery potential'.

The condition of a watercourse relates to linkages or connections with the floodplain and up and downstream reaches and assesses the effects of human disturbance on its current evolutionary stage.

#### **Wollombi Brook**

The geomorphic category of the Wollombi Brook section of HVO South was defined as a 'Planform Controlled, Low Sinuosity Sand in Moderate Condition'. Watercourses within this category generally comprise a single, continuous, typically symmetric channel with a sand dominated substrate. Channel sinuosity is largely variable yet is generally low due to valley confinement and irregular bedrock steps that assist in controlling slope and sinuosity. The condition of this section of Wollombi Brook was rated as 'moderate' with a 'high recovery potential'.

## 2.2.4 | FRESHWATER WETLAND FORMATION – CARRINGTON BILLABONG

Carrington Billabong is an ephemeral freshwater wetland within the low-lying floodplains along the Hunter River. In general, wetlands play an important role in buffering against floods and contribute to natural hydrological cycles.

Ecological functions of wetlands include habitat, refuge, and food and water for native flora and fauna. Wetlands are highly sensitive to changes in the environment, and usually respond rapidly to changes in water supply or water quality. For this reason they are often used as indicators of ecological health.

## 2.2.5 | HYDROLOGY

The former Department of Water and Energy undertook monitoring of regional groundwater trends over years, to contribute to the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources*, which was amended in 2016. Its analysis suggests a high level of connectivity between surface and groundwaters. For the alluvial groundwaters in the Hunter, no long-term trends were detected given the rapid response of the aquifers to stream flow.

The aquifers tend to draw down during dry periods as water is lost to stream base flow and evapotranspiration. They rapidly recharge following wet weather and increased stream flow.

### Carrington Billabong

Carrington Billabong is subject to periodic flooding which occurs during periods of high flow in the Hunter River. With the drought conditions experienced in the Hunter Valley, and the installation of Glenbawn Dam as a flood mitigation measure (1958), it is thought that Carrington Billabong and the stands of river red gums along the Hunter River and Wollombi Brook have been experiencing much lower frequencies of flooding than in the past. The level of surface water runoff that would normally flow into the Hunter River via Carrington Billabong is also thought to be likely to decrease during the life of the Carrington Pit as a result of the Carrington Pit extension (Mackie Environmental Research 2005). An annual assessment of the groundwater impacts at Carrington Billabong is undertaken and the results are presented in the Annual Environmental Management Report (AEMR).

The groundwater of the Carrington Billabong area was partly recharged by rainfall due to several higher rainfall events, including 2007 and 2015. Larger seedling recruitment events in Carrington Billabong are as a result of these rainfall events. Due to the predicted impacts associated with de-watering of the alluvial aquifers, a groundwater barrier was constructed between Carrington Pit and the Carrington Billabong.

In June 2007, the Hunter Valley was subject to a significant storm event that resulted in flooding throughout much of the mid and lower Hunter. During this event, Carrington Billabong was inundated from the Hunter River for a period of about six weeks. A small area of ponded water was retained in the southern section of Carrington Billabong for several months after June 2007. The pond created was in the lowest part of the billabong in an area that has held water following previous flood events. All seedlings of river red gums that are naturally recruited in Carrington Billabong are found on the margins of ponding water. There have been some less extreme flooding events since 2007 that have also led to the recruitment of more river red gum seedlings in Carrington Billabong.



Mackie Environmental Research (2005) reports that: the alluvium around the Hunter River at Carrington Billabong attains a thickness of 15-20 metres and supports gravels that were contiguously deposited with silts and clays; the alluvium has a saturated thickness of up to seven metres, and supports brackish to saline water with an electrical conductivity range of typically 7,000 to 11,000  $\mu\text{S}/\text{cm}$  (4200 to 6600  $\text{mg}/\text{L}$ ) and it is likely that the poor quality has resulted from sustained upwards leakage of coal measures groundwater into the basal sections of the alluvium, although it is likely that mining has depressurised the system and reduced the rate of upwards leakage. River red gums are known to be able to tolerate salinity levels of up to about 10,000  $\mu\text{S}/\text{cm}$  (Primary Industries and Resources SA 2000).

## Hunter River and Wollombi Brook

The banks of both the Hunter River and Wollombi Brook are Quaternary to recent alluvial deposits, consisting of silts, clays, sands and gravels found in river sediments and floodplains (ERM 2008). The depth of alluvium along the Hunter River and Wollombi Brook are estimated to vary between two and 20 metres, and form shallow aquifers but only to a limited extent; these aquifers are potentially in connection with surface water bodies (ERM 2008).

ERM also monitored water flow at gauging stations along both the Hunter River and Wollombi Brook. The average flow at the gauging station on Wollombi Brook in Warkworth was 468 ML/day, with a maximum flow of 322,576 ML/day recorded on 26 February 1955. The average flow recorded at a gauging station located 10 kilometres upstream from HVO on the Hunter River was 100ML/day, with a maximum flow of 208,070 ML/day recorded on 5 March 1977. The average flow recorded at a gauging station located six kilometres downstream of the junction between the Hunter River and Wollombi Brook was 1121 ML/day, with a maximum flow of 115,815 recorded on 10 August 1998.

ERM (2008) suggested that a conservative estimate for the 100 year ARI flood event was 59.1 metres AHD for both the Hunter River and Wollombi Brook. Two major flood events have been recorded in Wollombi Brook, the larger of the two was in June 1949 and the smaller in February 1955; the largest flood event recorded in the Hunter River was in February 1955 (with flood waters reaching 42.2 metres AHD in Singleton) (ERM 2008). The 100 year ARI flood level at the Hunter River is estimated to vary between 59.1 metres AHD at its junction with Wollombi Brook, and 73.2 metres AHD adjacent to Dam 4S at HVO South (ERM 2008).

Results from monitoring that took place at seven locations along the Hunter River (ERM 2008), indicated that water quality was significantly influenced by weather and flow conditions; with high levels of TSS and low levels of pH and electrical conductivity associated with high flow levels.

From monitoring that took place at three locations along Wollombi Brook (ERM 2008) electrical conductivity levels ranged between 480  $\mu\text{S}/\text{cm}$  and 3390  $\mu\text{S}/\text{cm}$ , with the brook historically recorded as being saline as well as areas of the brook being frequently dry. The pH ranges of Wollombi Brook were neutral to alkaline, ranging between 7.4 and 9.2.

## 2.2.6 | VEGETATION

### Carrington Billabong

Carrington Billabong supports open woodland covering an area of 5.7 hectares. The vegetation of Carrington Billabong was mapped by Peake (2006) as the Hunter Floodplain Red Gum Woodland Complex (Map Unit 13), which is equivalent to the listed EEC Hunter Floodplain Red Gum Woodland.

Peake (2006) indicated that this community often comprises river red gum as a key canopy species, with forest red gum (*E. tereticornis*), yellow box (*E. melliodora*) and rough-barked apple (*Angophora floribunda*) also co-dominating in places, or they may also be exclusively dominant.

River oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*) also commonly occurs within this community, particularly along unstable river banks. Shrubs are generally absent and the groundcover is strongly influenced by the degree of, and time since, disturbance (Peake 2006).

In Carrington Billabong, the red gum woodland is highly modified and prior to HVO north commencing operations, was reduced to an aged stand of river red gums over a disturbed understorey that comprises almost exclusively of weeds. Yellow box (*E. melliodora*) has also been recorded in the billabong. The location was managed in the past for cattle grazing and cattle used the red gum remnant heavily for shade and shelter.

Subsequent to fencing of Carrington Billabong by HVO with the exclusion of cattle grazing, flood events that have involved ponding water retained for several weeks have resulted in an improvement in age diversity of river red gums within the billabong. In the 10-year monitoring event of river red gum population in Carrington Billabong, a diversity of ages in the river red gum trees was recorded as a result of these flood-related recruitment events. However, the native understorey diversity had not recorded a similar improvement, as shrub and ground strata continue to be dominated by weed species (Umwelt 2019).

### Hunter River and Wollombi Brook

Vegetation along the Hunter River and Wollombi Brook in the study area forms a typically broken, narrow stand of one to two trees wide growing on the riverbank. Remnants also occur on the adjacent floodplain in positions similar to Carrington Billabong. Some locations support a larger, more extensive community. Many of the locations classed as priority sites in **Section 4.3.2** include these larger remnants.

Species composition in remnants on the Hunter and Wollombi Brook stream bank and floodplain is very similar to Carrington Billabong. Common and dominant trees along the riverbanks include river oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*), rough-barked apple (*Angophora floribunda*) and river red gum. River red gum and yellow box (*E. melliodora*) also occur on the floodplain. In most remnants, the understorey is modified and has a dominance of weed species, particularly the floodplain sites.

Monitoring as part of the 2017 Strategy has recorded natural recruitment of river red gums on several priority sites on the Hunter River floodplain and Wollombi Brook. However, the understorey continues to be dominated by weed species (Umwelt 2019).

## 2.3 | ECOLOGICAL CONDITION ASSESSMENTS

### 2.3.1 | BACKGROUND AND CONTEXT

To enable the original and 2017 versions of the Strategy to address the key causal factors that have contributed to the decline of river red gums in Carrington Billabong and at HVO South, it was necessary to first assess the most pertinent outcomes of ecological investigations in both areas. The causal factors are those issues that were identified and recognised to contribute to the decline of the river red gum populations in both areas.

Addressing these issues, either in full or at least in part, will assist in the reversal of the decline and will help to promote the development of river red gum stands that can persist in the long-term. The results of monitoring over 10 years (Umwelt 2019) and future monitoring provides information to inform and direct management actions that will promote survival of river red gum populations in HVO properties.

**Section 1.0** lists the ecological assessments that have been carried out at Carrington Billabong, HVO Priority Sites and the Reference Site (previously called 'Camyr Allyn').

### 3 | ECOLOGICAL MONITORING 2007-2017

Full detail regarding methods and results of ecological condition assessment over ten years of monitoring in Carrington Billabong, the Reference Site (Camyr Allyn) and HVO Priority Sites is provided in relevant reports listed in **Section 1.0**. A summary is included here for convenience. **Table 1-1** summarises all monitoring surveys carried out over ten years of survey for this project.

#### 3.1 | METHODS

At Carrington Billabong, monitoring consisted of six monitoring events (including Baseline survey). Monitoring comprised the following sampling techniques:

- **Floristic Sites:** Three permanent sites (plots) of 400 m<sup>2</sup> for monitoring changes in flora (labelled CB1, CB2 and CB3). These comprise two plots set up in 2007 and one set up in autumn 2010.
- **Seedling Sites:** Three permanent sites (plots) of 400 m<sup>2</sup> for monitoring river red gums seedling recruitment and success. These comprise two plots set up in 2007 and one set up in autumn 2010.
- **Seedling Counts:** three temporary sites (plots) of 400 m<sup>2</sup> were set up in areas of recruiting river red gums seedlings. Locations of these plots were selected to representatively sample different seedling densities that occurred in the billabong at the time of survey. Seedling counts made within plots were extrapolated for total seedling numbers for the entire billabong.
- **Tree health assessment:** Qualitative assessment of health of all adult river red gums trees (living and dead) that were tagged in 2007. Note: some of the original tagged trees could not be located. It was assumed they had fallen and been broken up since the last survey.
- **Photo monitoring:** photographic record of sites taken from permanent photo points.

At the Reference Site (previously referred to as 'Camyr Allyn'), monitoring consisted of four monitoring events including Baseline survey (2007), six-month survey (2007), twelve-month survey (2008) and ten-year survey (2017). Monitoring comprised the following sampling techniques:

- **Floristic Sites:** Two permanent sites (plots) of 400 m<sup>2</sup> for monitoring changes in flora. These were set up in 2007.
- **Tree health assessment:** Qualitative assessment of health of adult river red gums trees that were tagged in 2007.
- **Photo monitoring:** photographic record of sites taken from permanent photo points.

At HVO Priority Sites, monitoring consisted of six monitoring events (including Baseline survey). Monitoring comprised the following sampling techniques:

- **Remnant ecological health assessment:** semi-quantitative, rapid assessment at six locations within river red gum remnants on the Hunter River and Wollombi Brook. These were set up in 2007.
- **Photo monitoring:** photographic record of sites taken from permanent photo points.

## **3.2 | MONITORING RESULTS**

### **3.2.1 | FLORISTIC COMPOSITION**

Floristic Survey in Carrington Billabong in year 10 of monitoring (Umwelt 2019) found that the vegetation continues to support a low native diversity in flora with only 28 and 35 per cent of species recorded in CB1 and CB2, respectively, being native. It is dominated by weeds in both density and species diversity (67 per cent of total species recorded were weeds).

Similar results were found in the Reference Site, with 64 per cent of species recorded being weeds. Native diversity has reduced in both the Reference site and Carrington Billabong since baseline survey in 2007, with a reduction from 59 percent in 2007 to 33 percent in 2017 in Carrington Billabong.

There has been little change in the dominant species over the monitoring period with many of the same species dominating each vegetation strata. In particular, no native recruitment has been recorded in Carrington Billabong, apart from river red gum seedlings, which have been recruiting to the sites since 2007.

The results of floristic monitoring over time within CB1 and CB2, from baseline monitoring in 2007 to 10-year monitoring in 2017 found the following changes:

- decline in plant diversity of all species: a reduction in total species counts of 13 (from 46 to 33 species)
- increase in dominance of weed species: from 46 per cent to 67 per cent
- no native recruitment to the mid- or upper (canopy) strata in CB1, CB2 or CB5
- ground cover remains dominated by weeds, with no notable native recruitment.

There are a number of factors combining to affect this lack of improvement, including:

- Widespread vegetation clearance and native diversity loss over the past, long-term
- Isolation of native vegetation remnants, including Carrington Billabong, due to vegetation clearance
- Historic, long-term stock grazing and pasture improvement leading to the modification of vegetation, habitat and soils
- Loss of topsoil due to land management practices leading to soil erosion
- Weed invasion

Comparison of survey results recorded in the Reference Site and Carrington Billabong has shown that the changes in flora over the 10 years of monitoring is not so markedly different such that it could be concluded that mining had impacted Carrington Billabong much more than these other, catchment-wide factors. For example, the Reference Site has also shown a lack of native recruitment; weed dominance and a reduced native diversity over the 10 years of monitoring. Therefore, although mining may have impacted the river red gum woodland at Carrington Billabong, there are also a number of interrelated factors working at the site, as they are at the Reference site. The relative influence of these factors is not able to be measured.

### **3.2.2 | RIVER RED GUM SEEDLING RECRUITMENT**

River red gum seedlings have been recruiting to Carrington Billabong since June 2007 following the flood of the Hunter River in that year. Similarly, recruitment of river red gums has been recorded in HVO sites and the Reference site, but only in locations where water is retained on or near the surface for extended periods.



It was estimated that 9000 river red gum seedlings were present in Carrington Billabong at the time of the 10-year survey in 2017, which have regenerated since baseline survey in 2007. However, river red gum seedlings were only found in the southern half of the billabong. It appears that seedling recruitment is limited to locations within Carrington Billabong and elsewhere in HVO where water is retained on the surface in depressions and/or within the topsoil (likely due to soil water-holding properties) for several weeks. No recruitment occurred in any permanent floristic plots in Carrington Billabong, probably due to their location outside of such water retaining locations.

Once established, river red gum seedlings appear to be capable of competing successfully with weeds, particularly annual weeds with short growth seasons. In Carrington Billabong, sites that supported denser seedling growth also recorded lower weed cover. Seedling growth in the billabong is also successful, with seedlings in all seedling monitoring plots recording good growth rates of between 231 per cent and 372 per cent increase in size from 2007 to 2017.

However, as seedlings increase in size, they exhibit higher stress indicators including more dieback and insect/fungal damage. This increase in tree stress is likely to continue as the trees become larger and have higher resource requirements, including an increased need for water.

The successful regeneration of river red gum seedlings in Carrington Billabong is essential for the viability of this remnant woodland. However, it is also important that a diverse, native understorey is developed, either through natural regeneration (which has not occurred to date) or plantings. Several factors are important to seedling and tree survival ecological functioning in the billabong: diversity in floristic composition and structure; improved connection to surrounding native forest and a more natural flooding regime that will lead to improved soil water levels.

### 3.2.3 | ADULT TREE HEALTH

Across the ten years of monitoring, the health of adult river red gum trees in Carrington Billabong has been declining. This is demonstrated by the death of 8 adult trees since the start of survey work in 2007.

Additionally, adult tree stress levels have increased with 91.7 per cent of adult trees showing stress levels of 6 (stressed) or above in 2017. Only 8.3 per cent of adult trees recorded low levels of stress in the 10-year monitoring survey.

The Reference Site also recorded a similar declining trend in adult tree health. This suggests that the factors impacting adult tree health are likely to be catchment-wide issues.

The decline in tree health is likely to be related to a range of factors, including:

- competition for water and nutrients by weed species
- fragmentation (remnant isolation) and the influences of edge effects such as increased exposure to weather conditions (wind and solar radiation), insect attack and weed invasion
- long-term modification of flooding regimes resulting from land-clearing and other detrimental processes within the Hunter catchment
- localised modifications to hydrology associated with clearing of the natural floodplain vegetation
- compaction of the soil, tree root damage, altered soil nutrient balance and possible alteration of soil profile (including loss of topsoil) due to prolonged cattle grazing prior to fencing of the remnant and
- parrot defoliation including by galahs and cockatoos – Large numbers of parrots were observed defoliating trees during survey in 2017.

Trees in the remnants are more vulnerable to storm damage as a result of the high exposure due to the absence of any buffering vegetation (surrounding pasture lacks any treed cover). Additionally, high stress levels weaken trees, making them more prone to storm damage.

### 3.2.4 | REMNANT ECOLOGICAL HEALTH

Remnant river red gum stands in the Hunter occur in three landscape positions: streambanks, floodplains (closed depressions) and floodplains (shedding). River red gum remnants in the study area were classified into one of these forms based on position in the landscape flood history:

- Form 1: River bank and river bed;
- Form 2: Floodplain, and water-holding: i.e. closed depressions that holds/ponds water in major over-bank floods such as the June 2007 flood. Carrington Billabong is an example of this form; and
- Form 3: Floodplain and water shedding: i.e. alluvial plain/flat that does not hold/pond water in major over-bank floods such as the June 2007 flood.

All three forms of river red gum woodland are part of the EEC and are represented in the study area. The woodland remnants are grouped into these forms to provide more information on their character, which is important for developing suitable management strategies.

The floodplain forms generally have the highest level of modification and degradation. These forms generally also support the oldest river red gum trees, probably as remnants retained by previous land managers for stock shelter. It has been observed that the older trees tend to exhibit the highest level of dieback, which may reflect their higher resource requirements not being satisfied, particularly water, compared to younger trees. In addition, floodplain sites may have been subjected to higher levels of stock utilisation, and consequent impacts such as soil compaction, soil stripping and soil enrichment. Floodplain remnants are often more isolated than streambank remnants which more commonly have connectivity through gallery forest remnants.

Streambank remnants often support an overall younger population of river red gum trees and record higher levels of natural recruitment – possibly due to the greater availability of water and a comparatively lower impact from stock. However, streambank sites are also subject to more erosion, with bank undercutting and slumping the most serious erosional processes observed. Streambank sites also support a higher native diversity, although weeds still have a significant impact, with balloon vine, wandering Jew, peppertree and blue morning glory being common problematic species. Streambank erosion was significantly higher at sites with stock access. Fencing of these areas or otherwise excluding stock is essential.

Over 10 years of monitoring, remnant ecological health was poor throughout the survey areas including HVO priority sites; Carrington Billabong and the Reference Site. The sites recording the lowest health scores occurred on the Hunter River, in which weed invasion was a serious problem and poor native regeneration was minimal or non-existent. Carrington Billabong and the Reference site did record minor improvements in remnant ecological health over the ten years of monitoring, which is mostly attributable to native regeneration, specifically of river red gums.

Remnants are degraded mostly due to historic agricultural practices, vegetation clearance and subsequent fragmentation/isolation, stock grazing, pasture improvement and weed invasion. On the Hunter River, remaining vegetation comprising mainly scattered canopy trees and remnants in narrow, linear shapes with small core areas: including mainly river red gums and river oak (*Casuarina cunninghamiana* subsp. *cunninghamiana*). There has been no substantial improvement or decline in the health of these remnants since the baseline monitoring surveys in 2007 and weed invasion has become a greater issue.

In all HVO Priority Sites, weeds dominate the understorey, particularly the ground cover and would restrict natural native recruitment. Over the 10 years of monitoring, the extent of, and impact from, weed invasion has increased. The most serious weeds in the HVO Priority Sites are listed in **Table 3-1**.

*Table 3-1 -Most Serious Weeds in HVO Priority Sites*

COMMON NAME	SCIENTIFIC NAME
greater beggars ticks	<i>Bidens subalternans</i>
galenia	<i>Galenia pubescens</i>
castor oil plant	<i>Ricinus communis</i>
wandering Jew	<i>Tradescantia fluminensis</i>
pepper tree	<i>Schinus areira</i>
balloon vine	<i>Cardiospermum grandiflorum</i>
prairie grass	<i>Bromus cartharticus</i>
fierce thornapple	<i>Datura ferox</i>
black-berry nightshade	<i>Solanum nigrum</i>
lucerne	<i>Medicago sativa</i>
African olive	<i>Olea europaea</i> subsp. <i>cuspidata</i>
kikuyu grass	<i>Pennisetum clandestinum</i>
curled dock	<i>Rumex crispus</i>
rambling dock	<i>Acetosa sagittata</i>
blue morning glory	<i>Ipomoea indica</i>

## 3.2.5 | SUMMARY

The key results obtained from 10 years of monitoring survey of the Carrington Billabong and other river red gums along the Hunter River and Wollombi Brook (Umwelt 2019) are:

- There is generally relatively low recruitment of river red gums except for locations on the floodplain where water is retained for several weeks following flooding. These locations include the lower-lying parts in the southern end of Carrington Billabong where thousands of new seedlings have recruited and matured.
- Stands of river red gum populations and communities continue to support a low native diversity, with native species typically comprising 30 per cent or less of total species recorded.
- Native groundcover or shrub species and native recruitment has not occurred in any sites.
- Adult tree stress, as shown by dieback and foliage/branch loss, has increased and several have died.
- Adult trees have been lost due to erosion of streambanks in some HVO Priority Sites.
- There is an abundance of herbaceous weed species that persist in the billabong and are abundant in riverine sites in HVO.

Taking into consideration the key results, as well as information gained from consultation with other experts and from an assessment of relevant literature, the key causal factors that are likely to be contributing to the decline of river red gums at Carrington Billabong and HVO South are:

- Alteration of the water regime through irrigation and surface water extraction across the catchment.
- Alteration of the water regime after the commissioning of Glenbawn Dam in 1958 and recently modified surface runoff.
- Access to most remnant stands has mostly been unrestricted, which has enabled relatively uncontrolled livestock access over a long period. The resulting impacts include soil compaction, rubbing damage on trees from livestock, excessive nutrient addition, weed transport and grazing of saplings.
- Historical vegetation clearance has meant that most remnants, including Carrington Billabong and HVO sites, are ecologically denuded: most have effectively no ecological connectivity to nearby remnants; their area of coverage are mostly small; most have a high edge to area ratio, resulting in a small 'core' and large 'edge' habitats; and their structural and floristic compositions have been heavily modified over time through human activities, which has continued to suppress the natural recovery of the remnants.
- The remnant populations have been affected by numerous drought conditions, with the recent droughts including the Millenium drought of 2001-2009 and the drought of 2017-2020.
- Based upon key findings from the groundwater assessment undertaken by ERM for the Carrington Pit Extension SEE (ERM 2005), connectivity between Carrington Billabong and the groundwater aquifer was confirmed; these findings also indicated that reductions to water table levels were at least partially attributable to drought and mining activities. Consequently it is likely that local mining activities have interfered with the water usage regime of the river red gums at Carrington Billabong, although the extent of this is believed to be relatively minor, and
- The surface water catchment around Carrington Billabong has been temporarily modified due to local mining activities such that surface water runoff to the billabong is currently reduced.

These factors are most likely to have significantly contributed to the decline of the remnant populations at Carrington Billabong and HVO South and are manifested in the poor health, poor recruitment, tree death, high weed incidence and low diversity that are exhibited as symptoms of the remnants' ecological decline.

## 4 | RIVER RED GUM REHABILITATION AND RESTORATION STRATEGY

### 4.1 | PRIORITISING MANAGEMENT ACTIONS: TIERED APPROACH

The three-tiered management approach taken in the 2017 Strategy has been adopted for this updated version. The tiered approach facilitates targeting work towards higher priority sites which have a greater chance for successful rehabilitation and/or a priority for development approval consent conditions.

A description of the three tiers is provided in **Table 4-1**. **Figure 1-2** shows the location of each site.

*Table 4-1 - Management Tiers Adopted in Strategy*

MANAGEMENT TIER	SITE NAME	REASONING
High	Carrington Billabong	<ul style="list-style-type: none"> <li>Has been thoroughly investigated; 10 years of data exists.</li> <li>One of the largest and most important remnants of River Red Gum Woodland in the Hunter.</li> <li>Consent conditions for the Carrington Pit Extension.</li> </ul>
Intermediate	HVO Priority Sites: 5 sites on the Hunter River 1 on Wollombi Brook	<ul style="list-style-type: none"> <li>Has been thoroughly investigated; 10 years of data exists.</li> <li>Vegetation has relatively higher ecological integrity and resilience.</li> <li>Management actions are more likely to result in positive outcomes for river red gums.</li> </ul>
Low	HVO Low Priority Sites	<ul style="list-style-type: none"> <li>Vegetation is in relatively poor ecological condition, with low integrity and very limited recovery potential.</li> <li>Intervention would reduce available resources for priority sites.</li> <li>Won't be directly impacted by mining based on current approvals.</li> </ul>

## 4.2 | GOALS AND OBJECTIVES

The River Red Gum woodland may contain a diverse flora assemblage and provides habitat for various fauna species. Long term conservation gains will be achieved through improved condition and connectivity of habitat for these species.

The sustainability of the River Red Gum community is directly related to a whole-of-ecosystem approach. River Red Gums are known to recruit predominately following flood events. While the Hunter River is essentially a managed flow, in ensuring that the community is healthy and sustaining we can maximise the opportunities for recruitment when flood events do occur. To ensure that the community is healthy and sustaining, opportunities are to be provided for diverse flora species to recruit in an environment that has a reduced weed load, which will provide habitat for resident bird species to manage insect predation within the vegetation community and habitat for ground-dwelling mammals to assist with soil turnover, water infiltration and the management of beneficial fungi.

Given the location of the River Red Gums at HVO within agricultural and mining environments, fencing to prevent grazing and the subsequent compaction of soils within the community, and increasing the size and connectivity of each stand to adjacent habitat areas will assist each stand to withstand storm damage, and allow movement corridors for various fauna species.

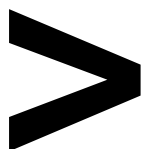
The key performance indicators can be broadly summarised as being related to condition improvement, an increase in habitat, and the provision of ecological values. The list of management actions and monitoring events to measure progress towards the achieving the objectives are discussed in subsequent sections.

The completion criteria established for year 10 of the 2017 Strategy were only partially achieved. Umwelt (2019) provides details. **Table 4-2** summarises the achievement of completion criteria, which has been reproduced here from Umwelt (2019).

Table 4-2 - Completion Criteria Year 10 - Results

10 YEAR COMPLETION CRITERIA	RESULTS YEAR 10 MONITORING SURVEY
Species assemblages within the Carrington Billabong are improved as compared to Year 5 results. The remnant displays:	<b>Achieved:</b> About 9000 <i>Eucalyptus camaldulensis</i> seedlings/juveniles were estimated to be present in Carrington Billabong during the 2017 monitoring survey, ranging from about 1 year old (<1m high) to 10+ years old (<10m high).
evidence of natural regeneration of native species;	<b>Partly Achieved:</b> Native regeneration of <i>E. camaldulensis</i> is evident in Carrington Billabong.  No native regeneration of other native species is evident: native species diversity in Carrington Billabong reduced from 2013 to 2017. Although the overall number of native species increased from 10 to 11, this represented a drop from 36% to 33% of total species recorded in floristic plots CB1 and CB2.  Note: Plantings of understorey species in several patches of Carrington Billabong have been carried out and appeared to be successful during survey in 2017.
evidence of increase in native species in the ground stratum compared to Year 5 results; and	<b>Not Achieved:</b> No increase in native species in the ground cover compared to any previous results. Weeds continue to dominate.
each stratum is dominated by native species.	<b>Partly Achieved:</b> The canopy is dominated by native species: river red gum ( <i>E. camaldulensis</i> ). Mid stratum 1 is dominated by native species: cooba ( <i>Acacia salicina</i> ). Mid stratum 2 (shrub) is <u>not</u> dominated by native species. Weed species dominate, including cobbler's pegs ( <i>*Bidens pilosa</i> ), hairy brassica ( <i>*Hirschfeldia incana</i> ) and other species. Lower stratum is not dominated by native species. Weed species dominate, including galenia ( <i>*Galenia pubescens</i> ), red-flowered mallow ( <i>*Modiola caroliniana</i> ) and other species.
<b>Ecological Condition of Remnant</b> The monitored remnant shows no net loss in extent or quality from Year 5 results unless unavoidable external factors have contributed towards a decline.	<b>Achieved:</b> A marginal increase in ecological health of Carrington Billabong was recorded; However, this is attributable to the successful regeneration of <i>E. camaldulensis</i> seedlings and does not reflect the overall lack of native recruitment to the understorey, continued dominance by weeds and increased death and dieback in adult trees.





10 YEAR COMPLETION CRITERIA	RESULTS YEAR 10 MONITORING SURVEY
<p>The canopy cover of river red gums is higher than Year 5 results, unless unavoidable external factors have contributed towards a decline.</p>	<p><i>Not Achieved:</i></p> <p>There has been no increase in canopy cover of river red gums. In fact, due to an increase in dieback (leaf and branch loss), canopy cover has decreased with more trees dropping into lower canopy cover classes of less than 30-40%.</p>
<p><b>Fauna Diversity and Habitat</b></p> <p>Improvement of diversity of habitat to encourage native fauna species compared to results from Carrington Pit Extension SEE Ecology Survey (ERM 2005).</p>	<p><i>Not Achieved:</i></p> <p>Fauna habitat has not improved in Carrington Billabong. Some tree hollows have been lost through fallen <i>E. camaldulensis</i> limbs.</p>
<p><b>Surface Water</b></p> <p>Rehabilitation of mining activities north of the billabong in progress.</p>	<p>Refer to MOP</p>
<p><b>Groundwater</b></p> <p>The barrier wall has been installed.</p>	<p><i>Achieved:</i> refer to MOP</p>
<p><b>Fencing and Access Control</b></p> <p>Fencing to protect the billabong, remnants and regeneration areas is established and maintained.</p>	<p><i>Achieved:</i></p> <p>Carrington Billabong is fenced and stock is being excluded.</p>
<p><b>Pest and Weed Management</b></p> <p>Pest and weed control program is effective and does not require increased management.</p>	<p><i>Not Achieved:</i></p> <p>Weeds in Carrington Billabong continue to dominate the understorey. Data about pests n/a.</p>
<p><b>Final Landform and Drainage</b></p> <p>The surface water catchment area for the billabong is reinstated in accordance with the Carrington Pit Mining Operations Plan.</p>	<p>Refer to MOP</p>

In summary:

- Restoration and rehabilitation of the woodland in Carrington Billabong is in its early stages, with completion criteria only partially completed.
- There is a lack of native species recruitment or regeneration that is needed for the woodland to represent a floristic and structurally diverse example of Hunter Floodplain Red Gum woodland EEC.
- There has been good regeneration of river red gums with recruitment of thousands of seedlings to the billabong following flooding events in 2007 and subsequent years. The drought that followed restricted recruitment and impacted the health and vigour of trees in the billabong since 2007.
- Weeds continue to dominate the shrub and ground stratum in Carrington Billabong, which restricts native recruitment.
- The ecological health of the Carrington Billabong remnant has improved only marginally, which is attributable to natural recruitment of river red gum seedlings.
- The canopy percentage cover of the woodland in Carrington Billabong has declined due to dieback and foliage loss in adult river red gum trees.

Many variables operate at catchment or regional scales outside the influence of HVO, such as river flows and pest outbreaks. Other factors that operate at continental or even global scales, such as climatic influences (including floods or droughts brought about by La Niña and El Niño events), could significantly influence the long-term viability of the river red gum stands. To this end, the completion and performance criteria are designed to provide an appropriate benchmark against which to assess the management of the Carrington Billabong river red gums and HVO South priority sites and the resulting improvements.

Goals and objectives that were presented in the 2017 Strategy have been adopted for this updated Strategy. These are provided in **Table 4-3** within the context of the three-tiered approach of (1) Carrington Billabong, (2) HVO Priority Sites and (3) HVO Low Priority Sites. The goals and objectives from the earlier Strategy have been retained to continue the progress using the information gathered and lessons learnt from the previous 10 years of management. The management activities utilised in the updated Strategy, will trial alternative methods outlined in this Plan to achieve these objectives.

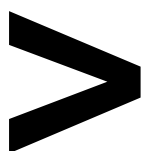


Table 4-3 - Goals and Objectives for HVO RRGRS Update

GOALS	OBJECTIVES	CARRINGTON BILLABONG	PRIORITY SITES	LOW PRIORITY SITES
To reduce the impacts of threatening processes on the stands.	To suppress or eradicate the <i>in situ</i> environmental factors that are acting to reduce the viability of this remnant population.	✓	✓	✓
	To improve the conditions within this population such that it can withstand reasonable periods of stress, predation and shortage of water supply.	✓	✓	
To aid the establishment of the appropriate conditions to promote the health of the river red gum populations.	To identify the likely <i>ex situ</i> factors that are contributing to the reduction in viability of this population and the health of the billabong and act, where possible, to control those factors or to take account of those factors in management approaches if they are not able to be directly controlled.	✓	✓	
	To ensure that the results of ongoing monitoring are appropriately used to modify the management regime in response to new or unexpected information.	✓	✓	✓
Increase the understanding of the water requirements of river red gums.	Develop an understanding of water requirements through the timely monitoring of responses of river red gums to flood and storm events.	✓	✓	
To enhance the river red gum population to enable it to persist as a viable,	To assist this population to continue to self-propagate to ensure ample replacement of senescing trees with juvenile recruits.	✓	✓	

GOALS	OBJECTIVES	CARRINGTON BILLABONG	PRIORITY SITES	LOW PRIORITY SITES
functioning population.	To support the establishment of a self- sustaining, functional and viable ecosystem that resembles what is likely to have been present in Carrington Billabong prior to European settlement.	✓		
	To support the establishment of a self- sustaining, functional and viable ecosystem.		✓	
To increase biodiversity including residence habitat, foraging habitat and native flora and fauna species.	To increase habitat for the identified and potential native flora and fauna species.	✓	✓	

## 4.3 | COMPLETION CRITERIA

**Table 4-4** lists the assessment and completion criteria to be achieved to address the goals of the HVO River Red Gum Strategy.

*Table 4-4 - Completion Criteria for the HVO RRGRRS Update*

GOALS AND ASSESSMENT CRITERIA	COMPLETION CRITERIA
<p>Species assemblages within the Carrington Billabong are improved as compared to Year 5 results.</p> <p>The remnant displays:</p> <p>juveniles in various strata (1-5 years/ 5-10 years/10-15 years);</p> <p>evidence of natural regeneration of native species;</p> <p>evidence of increase in native species in the ground stratum compared to Year 5 results; and each stratum is dominated by native species.</p> <p><b>Ecological Condition of Remnant</b></p> <p>The monitored remnant shows no net loss in extent or quality from Year 5 results unless unavoidable external factors have contributed towards a decline.</p> <p>The canopy cover of river red gums is higher than Year 5 results, unless unavoidable external factors have contributed towards a decline.</p> <p>The canopy cover of river red gums is higher than Year 5 results, unless unavoidable external factors have contributed towards a decline.</p> <p><b>Fauna Diversity and Habitat</b></p> <p>Improvement of diversity of habitat to encourage native fauna species compared to results from Carrington Pit Extension SEE Ecology Survey (ERM 2005).</p> <p><b>Fencing and Access Control</b></p> <p>Fencing to protect the billabong, remnants and regeneration areas is established and maintained.</p>	<p>Observed and measured increase in species diversity in each strata over 10 years (measured biennially) when compared to Year 5 results.</p> <p>Observed and measured increase and/or maintained Rapid Condition Assessment scores over 10 years (measured annually).</p> <p>Observed and measured increase in the extent of each HVO RRG site and species diversity in each strata over 10 years (measured biennially) when compared to Year 5 results.</p> <p>Observed and measured increase and/or maintained Rapid Condition Assessment scores over 10 years (measured annually).</p> <p>Observed and measured increase and/or maintained Rapid Condition Assessment scores over 10 years (measured annually).</p> <p>Observed trajectory towards and/or attainment of the Rapid Condition Assessment scores for the reference site over 10 years (measured annually).</p> <p>Fencing integrity is maintained across 10 years in accordance with the Strategy.</p>

GOALS AND ASSESSMENT CRITERIA	COMPLETION CRITERIA
<p><b>Weed Management</b> Weed control program is effective and does not require increased management.</p>	<p>Monitoring demonstrates a reduction or maintenance of the weed population percentage relative to the native flora component within the HVO sites when compared to the reference site.</p>
<p><b>Final Landform and Drainage</b> The surface water catchment area for the billabong is reinstated in accordance with the HVO Mining Operations Plan.</p>	<p>The final landform in the HVO Mining Operations Plan is shown as reinstating drainage from the rehabilitation area north of the billabong.</p>

## 4.4 | OVERVIEW OF MANAGEMENT ACTIONS

Details regarding the execution of the HVO River Red Gum Rehabilitation and Restoration Strategy are presented in Appendix A1.1.

### 4.4.1 | CARRINGTON BILLABONG

Target actions that are likely to contribute to the improvement of the remnant population of the Carrington Billabong are detailed below. These actions are generally in keeping with those provided in the 2017 Strategy, with several changes provided in response to learnings from the ten years of monitoring carried out (Umwelt 2019).

#### Fencing and Access Control:

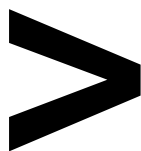
Maintain existing fencing around the remnant to ensure stock are excluded from Carrington Billabong and an area that is significantly larger than the remnant population to facilitate recruitment and support the expansion of the remnant over time. This should include the flood runners/drainage lines and closed depressions that occur between the billabong and the Hunter River, where natural recruitment of river red gums is most likely to occur as a result of higher soil moisture levels and flood-water retention.

#### Regeneration

Passive regeneration actions will be carried out to support the natural recruitment of river red gums. This includes removal of stock, restriction of access by stock, vehicles and people, weeding and control of feral animals.

However, assisted regeneration is necessary to establish a diverse, native understorey and groundcover in the river red gum woodland. This includes supplementary planting of native grasses, forbs and shrubs tubestock and seeds. It may also include ripping the soil and extensive weed control.

Where possible, the use of species and seed resources sourced from the immediate area will be attempted in assisted regeneration; except in cases where the species is unable to be sourced from within HVO lands. HVO may source seed from a wider area should species be unable to be sourced from within HVO, or if studies determine that sourcing from a wider area is likely to improve the sustainability of the population.



## Assisted revegetation

Native recruitment in Carrington Billabong was rarely recorded throughout the ten years of monitoring (2008-2018), except for river red gum seedlings following flood events. Therefore, establishment of a native understorey and ground cover in Carrington Billabong is highly likely to require planting of tubestock and/or seeding using locally endemic species; especially grasses, forbs and shrubs.

Establish a seed harvesting and propagation program and/or source locally collected seedbanks to provide material for revegetation programs.

## Weed & Pest Control:

Undertake an appropriate weed and pest control program, with selection of targeted species informed by the results of ecological monitoring.

## Artificial Flooding

As recruitment of river red gums requires the presence of standing water for several weeks, should drought conditions occur and flooding of the Billabong not happen for several years, artificial flooding of the billabong should be considered using clean water being pumped into closed depressions in the billabong and floodplain. Although this may not be possible at HVO, artificial flooding of river red gum remnants at Dartbrook mine was found to promote native plant recruitment, particularly river red gums (Dartbrook Coal Mine 2006; Umwelt 2008 a & b).

## Ecological Monitoring:

Design and implement an updated ecological monitoring program that will assess the success of the rehabilitation and restoration strategy going forward, as well as inform ongoing management actions. The new monitoring program should utilise existing monitoring data and adopt relevant survey methods where appropriate.

The proposed study area for this survey and future monitoring includes Carrington Billabong and adjacent floodplain areas to the north, west and south of the Billabong. This area is shown in Appendix A: A2.1. Areas outside of Carrington Billabong on the floodplain will be surveyed to record occurrence of natural recruitment and assisted revegetation should be considered if necessary.

Assess the response of the river red gum stand post-flooding and use information to inform land management activities. The extent, frequency and duration of flood events will be recorded, including inundation of the Carrington Billabong. Flood events will be considered in the ecological surveys to document the extent of any natural, native recruitment. Future monitoring can then follow the success and growth of any recruitment linked to known flood events.

## 4.4.2 | PRIORITY SITES

The following actions are listed for priority sites, which will promote remnant health:

- establish and maintain appropriate fencing around the remnants (the fencing should cover areas larger than the remnant populations to facilitate recruitment and support the expansion of the remnants over time)
- where existing groundwater monitoring sites are proximate, review data obtained from such monitoring
- undertake regular ecological monitoring, making use of existing baseline monitoring
- undertake an appropriate weed and pest control program
- monitor the response of the river red gum stands post-flooding



- encourage the natural recruitment of river red gums through the control of weeds and management of grazing. Weeds are a major impact to riparian vegetation on the Priority sites
- encourage natural regeneration of other native species, especially grasses, forbs and select shrubs.

#### 4.4.3 | LOW PRIORITY SITES

The following actions are listed for low priority sites, which will promote remnant health:

- undertake weed control and feral fauna management
- ensure grazing is at such rates that minimise disturbance to recruitment
- apply relevant river red gum monitoring results undertaken elsewhere at HVO to low priority sites to aid in their management.

## 5 | MONITORING PROGRAM 2020 ONWARDS

Monitoring of river red gums across HVO has been ongoing since early 2007. Baseline monitoring commenced initially within the Carrington Billabong and continued at other stands of river red gums at HVO over 10 years. A total of six surveys occurred between 2007 and 2017 at HVO, and are shown in **Table 1-1**.

These 10 years of survey work were set out in the 2007 and 2017 Strategies, and various reports provide results of those surveys. The final, 10-year monitoring survey event was carried out in 2018 and reported on in Umwelt (2019).

HVO will continue monitoring of the river red gum populations at HVO. The proposed monitoring program from 2020 and onwards is outlined in the sections below.

### 5.1 | CARRINGTON BILLABONG

#### 5.1.1 | MONITORING OBJECTIVES

The monitoring program for Carrington Billabong will build upon the 10-years of survey that was conducted from 2007 to 2017.

The objectives of the monitoring program at Carrington Billabong are:

- to determine if there is any improvement or deterioration in river red gums within Carrington Billabong
- to determine if there is any improvement or deterioration of the natural habitat at Carrington Billabong and
- to provide management recommendations to achieve further improvements in the ecological management of the site to assist in the recovery of river red gums and their habitat.

## 5.1.2 | PAST SURVEYS 2007-2017

Comprehensive surveys were undertaken by Umwelt from 2007 until 2017 (see **Table 1-1**). The attributes measured comprised the following:

- unique identification tagging and GPS way-pointing of every mature river red gum
- a tree health assessment, which included the assessment of:
  - age class
  - diameter at breast height (DBH)
  - canopy (living foliage) percentage density
  - canopy health (foliage dieback and epicormic growth)
  - evidence of flowering/fruitletting
  - evidence of insect and/or fungal damage
  - other relevant information (e.g. direct threats to individual) and
- flora health assessment, including the following components:
  - floristic survey of two permanent 20 x 20 metre plots
  - survey of three permanent plots for recruitment only
  - photo-monitoring of each mature tree and
  - photo-monitoring of the site from other fixed points.

## 5.1.3 | FUTURE MONITORING

The continued survey of monitoring sites should be undertaken by a suitably qualified and experienced ecologist. All future monitoring surveys should be preferably undertaken in the same season to minimise the risk of biasing the data as a result of seasonal factors. In summary:

- Monitoring surveys should be undertaken annually from 2021 for the first four years then biennially until year 10. The monitoring surveys may be undertaken annually should significant events, including flooding and groundwater triggers, being met.
- The monitoring surveys should be undertaken in spring (September to November) when presence of reproductive material on plants will assist in the identification of species.

It is recommended that monitoring continues until the vegetation community in Carrington Billabong demonstrates strong signs of recovery and self-sustainability, including:

- nil or very low dieback
- natural regeneration in all strata
- establishment of a native understorey (ground cover and shrub strata) through natural regeneration and/or assisted regeneration, and
- connection to adjacent native remnants (e.g. Hunter River riparian vegetation) and/or enlargement of the Carrington Billabong remnant due to natural and/or assisted regeneration on the adjacent floodplain.

The monitoring surveys will comprise a fundamental sampling regime as described below. Additional surveys may be included should events, such as flooding or groundwater triggers, warrant investigation.

Sampling will extend into areas of new regeneration, such as the adjacent floodplain, as these develop.

The effectiveness of the monitoring survey methods will be considered during the survey activities, and the need to alter the methods for the next survey will be discussed should it be required.

*Table 5-1 - Proposed Monitoring*

SEASON AND YEAR	MONITORING EVENT
Spring 2020	Carrington Billabong & HVO Priority Sites
Annual spring surveys for the first four years then biennially until year 10, from 2021 and onward	As above, with changes to be proposed based on findings of 2020 survey
Additional surveys – Trigger: Flooding	Annual surveys to record natural regeneration associated with flood waters should flooding occur during the preceding monitoring period.
Additional surveys – Trigger: Groundwater Monitoring	Following groundwater monitoring triggers, within three months of trigger being recorded and for one year following cessation of trigger/s levels.
Additional surveys – Triggers identified by HVO or other applicable Stakeholders	As required

## 5.1.4 | GROUNDWATER MONITORING

HVO undertakes regular groundwater monitoring across its operations. The results of all relevant groundwater monitoring will be made available to the persons undertaking the ecological monitoring and reporting and will be assessed to determine the impact that fluctuating groundwater levels may have on the health of Carrington Billabong. Furthermore, when groundwater monitoring triggers are met, additional ecological monitoring should be undertaken with methods informed by results and nature of triggers.

## 5.1.5 | REPORTING ON MONITORING RESULTS

Reports on each monitoring event will be provided to HVO as a written report, and verbal advice will be supplied as needed, such as to provide important information on any specific issues detected which require immediate remediation or action.

Reporting should include:

- details on the monitoring methods, prevailing weather conditions and general hydrological information, such as notes on recent flooding or records of groundwater movement
- all results, in summarised format in the report but included in their entirety in appendices
- compare and contrast the results from the monitoring event against those obtained from previous monitoring events

- a comprehensive discussion of the interpretation of the results and what they mean in relation to the rehabilitation of Carrington Billabong
- recommendations on specific actions required to alleviate any particular issues, or to encourage other outcomes, including the need for planting, soil disturbance, flooding or modifications to the fencing and access and
- recommendations on future monitoring frequency and any changes to methods.

## 5.1.6 | SURVEY METHODS

Survey methods will draw on those used in previous work (Umwelt 2019 etc), with some modifications based on learnings.

### 5.1.6.1 | PERMANENT PLOT & MEANDERING TRANSECT SURVEYS

Two permanent plots set up for previous work in Carrington Billabong should continue to be sampled using methods for full floristic sampling. Umwelt (2019) should be referred to for full description of floristic sampling methods.

However, additional floristic survey is needed to locate and characterise additional areas of native regeneration, where it is not occurring in the permanent plots. Meandering transects through the study area are recommended to achieve this. If substantial native regeneration is identified by meandering transects, additional permanent plots should be set up as required for allowing quantitative floristic sampling. This survey method should be extended onto the floodplain adjacent to Carrington Billabong if natural regeneration occurs of river red gums and other native shrubs and trees.

### 5.1.6.2 | RIVER RED GUM SEEDLING SURVEYS

The recruitment of river red gum seedlings to Carrington Billabong and adjacent floodplain areas should be recorded based on field survey and API using recent aerial photography. Estimates or actual seedling counts, depending on the number of seedlings recruited, should be made during survey. Mapping of areas of seedling recruitment will provide information on spatial patterns of recruitment based on biophysical attributes. This will provide valuable information on assisted regeneration efforts, if they are needed.

The previous method of tagging each new seedling was found impractical due to the large numbers of seedlings germinating in Carrington Billabong and the rapid growth of the seedlings causing the loss of tags. If large numbers of seedlings recruit, estimates of numbers based on representative sampling is the most appropriate method to use.

### 5.1.6.3 | ADULT TREE HEALTH MONITORING:

The health of adult trees will be assessed using a representative sampling method, where trees selected to sample should represent the Carrington Billabong population regarding age class, spatial distribution across the study area and elevational position (informed by land contour mapping). The specifics of the sampling should be developed at the first monitoring event. Each tree sampled should be surveyed for the attributes that were used in past monitoring, which are described in Umwelt (2019). These include:

- age class
- diameter at breast height (DBH)
- canopy (living foliage) percentage density
- canopy health (foliage dieback and epicormic growth)

- evidence of flowering and/or fruiting
- number of hollows
- extent of epicormic growth
- number of mistletoes
- evidence of insect and/or fungal damage and
- other relevant information (e.g. direct threats to individual tree).

A total count of adult trees should also be made using recent aerial photography and field survey, in order to identify the number of lost or recruited trees.

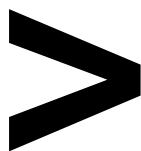
#### 5.1.6.4 | REMNANT ECOLOGICAL HEALTH

Remnant ecological health should be scored for Carrington Billabong (as well as for Priority Sites). Methods are to be based on previous work which are described in Umwelt (2019), which employs a semi-quantitative, rapid assessment technique that is repeatable. Thirteen attributes are scored 1, 2 or 3 in order of increasing ecological health and notes about each attribute are recorded where applicable. The attributes scored include:

- grazing by stock
- logging or clearing
- weed invasion
- clearing or mowing of understorey
- dieback in crown
- canopy plants age diversity/regeneration
- native diversity of mid-strata
- native diversity of lower strata/groundcover
- erosion
- time since last flood (from records)
- fire history of remnant (from records)
- connectivity of remnant
- remnant shape.

The sum of all attribute scores provides an indication of the relative ecological health for each assessment site, which can be compared to other sites and/or future ecological assessments carried out at the same location.

Dominant and/or common plant species, as well as other species that are significant are recorded in the vicinity of each of the permanent remnant ecological health assessment locations to help characterise and describe the vegetation at each site. This opportunistic recording of plants also helps to identify significant species such as threatened species and important weed species. This floristic survey is non-quantitative, being done without the use of semi-quantitative plot-sampling. As such, it does not facilitate accurate replication. Basic structural information at each health assessment site will be recorded, including height, cover and dominant species for each stratum.



## 5.1.6.5 | PHOTO MONITORING

The same permanent photo points used in previous work in Carrington Billabong should be used, based on the methods which are described in Umwelt (2019). Five photos are to be taken aligned with each of the four primary compass bearings, plus the ground location, which facilitates comparison of changes over time.

Previous single-tree photo monitoring was found to be very onerous and did not provide useful information commensurate to the effort required. Therefore, permanent photo points that provide overview of the remnant from good viewpoints are recommended for future monitoring. These should include the permanent photo points set up in previous work, as well as several other points as determined onsite.

## 5.2 | MONITORING OF THE REFERENCE SITE

Previous work for the 2017 Strategy included survey and monitoring of the reference site (previously known as 'Camyr Allyn' or the Control Site). Ongoing monitoring survey of the reference site is to provide a comparison (non-mining related) to monitoring of Carrington Billabong and HVO Priority Sites. However, as this site is privately owned, access for monitoring surveys would need to be formalised for future work if it is to continue to be used.

Therefore, monitoring surveys of the reference sites has not been included in the Strategy update. If access to the reference site becomes available, the same monitoring timing and methods will be applied to the reference site as is used for Carrington Billabong. This will facilitate comparison of both sites.

## 5.3 | PRIORITY SITES

### 5.3.1 | MONITORING OBJECTIVES

The monitoring program for priority sites will build upon previous monitoring surveys that were conducted.

The objectives of the monitoring program at priority sites are:

- to determine if there is any improvement or deterioration in river red gums at priority sites
- to determine if there is any improvement or deterioration of the natural habitat at priority sites and
- to provide management recommendations to achieve further improvements in the ecological management of the priority sites to assist in the recovery of river red gums and their habitat.

### 5.3.2 | PAST SURVEYS 2007-2017

Comprehensive monitoring surveys were undertaken by Umwelt from 2007 until 2017 (see Table 1.1).

These permanent monitoring sites consisted of ecological health assessments which were assessed using a semi-quantitative, rapid assessment technique. The same methods are recommended for future surveys.

### 5.3.3 | FUTURE MONITORING

The continued monitoring survey of priority sites should be undertaken by a suitably qualified and experienced ecologist. All future monitoring should be preferably undertaken in the same season to minimise the risk of biasing the data as a result of seasonal factors. Priority site surveys should be carried out at the same time that survey in Carrington Billabong occurs.

In summary:

- Monitoring surveys should be undertaken annually from 2021 for the first four years then biennially until year 10. The monitoring surveys may be undertaken annually should significant events, including flooding and groundwater triggers, being met.
- Monitoring surveys should be undertaken in spring (September to November) when presence of reproductive material on plants will assist in the identification of species.

## 5.3.4 | MONITORING SURVEY METHODS

Monitoring survey methods will draw on those used in previous work (Umwelt 2019 etc), with some modifications based on learnings.

Methods should follow those described in **Section 5.1.6.4** | and **Section 5.1.6.5** |, where sites were scored for each ecological health attribute.

This floristic survey was not systematic without the use of plot-based sampling or recording of cover abundance for each plant.

## 5.3.5 | REPORTING ON MONITORING SURVEY RESULTS

Reports on the outcomes of each monitoring survey event should be provided as described in **Section 5.1.5** | with results from work in Carrington Billabong.

## 5.4 | LOW PRIORITY SITES

No specific monitoring surveys are proposed for low priority sites. However, HVO undertakes regular inspections of all land under its control, including areas where river red gums occur along the Hunter River and Wollombi Brook. During such future inspections the following matters at any river red gum stands will be assessed:

- prevalence of weeds and significant environmental weeds, including abundance and threats posed;
- presence of signs of pest species and threats posed to river red gums by their activity;
- presence of significant erosion that might threatened the viability of river red gums;
- any significant recruitment or senescence of river red gums; and
- the condition of fencing, where present, and the need for any maintenance works.

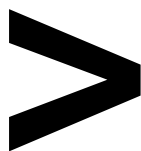
The outcomes of any such monitoring surveys will be reported to the Environmental Coordinator, who will then determine the appropriate course of action to remediate any issues or threats posed.

## 6 | REPORTING

Following the receipt of information regarding an incident, complaint, potential non-compliance with statutory requirements or potential exceedance of the impact assessment and/or performance criteria, HVO will undertake an investigation to determine the accuracy of the information.

DP&E will be advised of the investigation within 7 days of the initial report and, should the exceedance or non-compliance be realised, HVO will update the notification with advice to DP&E regarding actions to be implemented to remediate, rectify or additional monitoring to be undertaken following the development of such actions. The advice will be provided within 30 days of the initial receipt of information.





## 7 | REFERENCES

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## 8 | CHANGE INFORMATION

Full details of the document history are recorded in the document control register, by version. A summary of the current change is provided in table below.

REGULATOR VERSION	HVO SHAREPOINT VERSION	DATE	CHANGE DETAILS	REVIEW TEAM	REGULATOR APPROVAL DATE
	V1.0	09/2019	<i>Revise Strategy following 10 year review incorporating review outcomes and contemporary template</i>	<i>Trescinda Brown Michael Lloyd</i>	
	V1.1	08/2020	<i>Update following consultation with BCD</i>	<i>Michael Lloyd</i>	
	V1.2	08/2021	<i>Update following RFI from DPIE</i>	<i>Keith Simkin Michael Lloyd</i>	19/05/2022
	V1.3	08/2023	<i>Update following Audit to include additional consultation outcomes, change information and formatting update</i>	<i>Michael Lloyd</i>	
	V2.0	08/2025	<i>Minor edits. Revision following submission of 2024 AR and DA 450-10-2003 Mod 8 Approval</i>	<i>Michael Lloyd</i>	26/08/2025

## 9 | GLOSSARY

ABBREVIATION	MEANING
BC Act	NSW <i>Biodiversity Conservation Act 2016</i>
CEEC	Critically Endangered Ecological Community
DBH	Diameter at Breast Height
DoEE	Commonwealth Department of the Environment and Energy (now DAWE)
DAWE	Australian Department of Agriculture, Water and the Environment (now DCCEEW)
EEC	Endangered Ecological Community
DCCEEW	Department of Climate Change, Energy, the Environment and Water
EP&A Act	NSW <i>Environment Planning and Assessment Act 1979</i>
EPBC Act	Commonwealth <i>Environment Protection and Biodiversity Conservation Act 1999</i>
KTP	Key Threatening Process
NSW	New South Wales
OEH	NSW Office of Environment and Heritage (subsumed into DPIE)
DPIE	NSW Department of Planning, Industry and Environment
PCT	Plant Community Type
PMST	Protected Matters Search Tool
REF	Review of Environmental Factors
TEC	Threatened Ecological Community
Umwelt	Umwelt (Australia) Pty Limited

## APPENDIX A: HVO RIVER RED GUM REHABILITATION & RESTORATION STRATEGY UPDATE (2020) IMPLEMENTATION PLAN

### A1.1 INTRODUCTION

This document has been developed to provide further guidance on the implementation of the River Red Gum Rehabilitation and Restoration Strategy. The management actions include increased maintenance activities, specific research and focussed monitoring which will all contribute to the rehabilitation and restoration of the river red gums and their associated environment across HVO. Most management actions are related to the rehabilitation and restoration of Carrington Billabong, due to the high level of commitment focussed on the recovery of this site.

The following sections provide further information on each of these issues, as they pertain to Carrington Billabong, the priority sites, and the low priority sites. Further information can be sourced in the main report.

### A2.1 STRATEGY FOR CARRINGTON BILLABONG

#### A2.1 Fencing and Access Control

The river red gums in Carrington Billabong have historically been impacted by grazing. Uncontrolled access by stock can result in the loss of biodiversity through soil compaction limiting natural regeneration, increased nutrients and tree damage through stock rubbing and soil erosion.

In order to manage access to the site, the establishment and maintenance of appropriate fencing is critical to exclude cattle, pests, both native and introduced, and restrict unauthorised access.

During the initial development of the Strategy a two-step process was followed to ensure that access to the site is controlled:

- Establish restrictive fencing with locked access gates around the existing stand of river red gums; and
- fence off a larger area to facilitate the expansion of the remnant through regeneration and possibly revegetation.

This program was completed with the resulting fenced area being substantial to facilitate the regeneration and revegetation of river red gum across a broad area connecting with the Hunter River. However, natural regeneration has been restricted to the lower soaks/closed depressions in the south end of Carrington Billabong and along the drainage line that meanders from the central-west side of the billabong to the Hunter River.

The area is appropriately signed and access to the billabong and regenerating areas is restricted in accordance with HVO procedures.

#### Future Actions:

Existing fencing and signage around Carrington Billabong and the adjoining floodplain should be maintained, with domestic stock excluded.

Extending the fenced area is recommended to include adjacent areas on the floodplain that contain closed depressions, soaks and drainage lines. Natural recruitment of river red gums is most likely to occur in these locations as a result of higher soil moisture levels and flood- water retention. **Figure 9-1** shows the area that could be considered. This area should be monitored for natural regeneration, and where it occurs, ecological monitoring surveys should be extended into new growth areas.

The 2017 Strategy stated that HVO would review monitoring results to determine if macropod-proof fencing was necessary. This type of fence was not set up by HVO around the billabong, since monitoring did not specifically identify grazing by feral or native animals as a major impediment to native recruitment. However, several small-sized quadrats with native tubestock plantings were established with macropod-proof fencing in Carrington Billabong by HVO during the ten years of monitoring. Initial observations indicated that these plantings were successful; however, in recent drought conditions, many of the planted shrubs and ground cover species have died. Despite recent plant losses, this patch-based planting is a practical approach to regeneration as it allows management actions to focus on smaller sites, including focused weed control and exclusion of native and feral grazers. As such, future plantings should consider using a similar approach, although watering should be ongoing during dry, hot weather.

The need for such fencing in the future will be assessed through ongoing monitoring, and if identified as necessary, will be recommend for implementation.

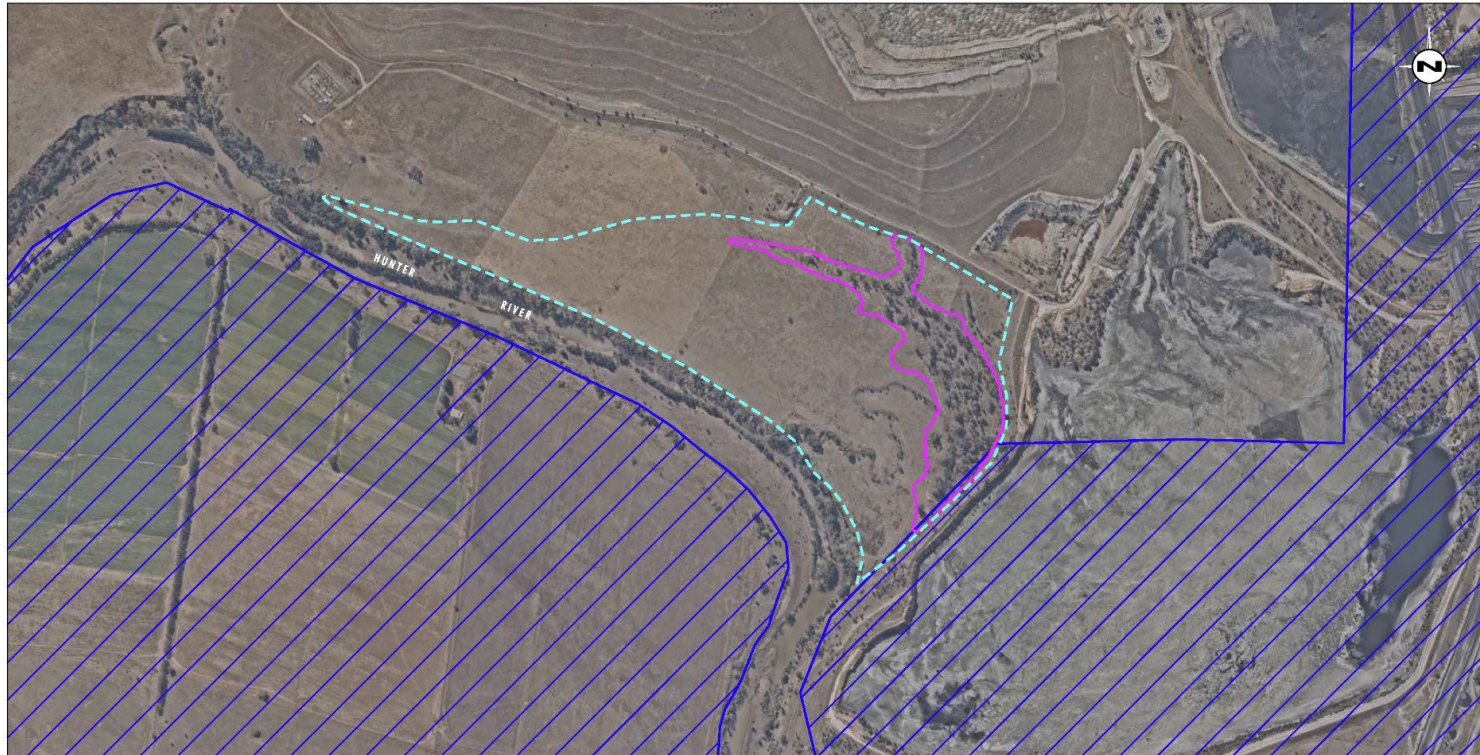
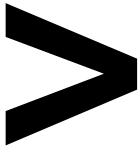


Image Source: Nearmap (Aug 2019)  
Data Source: Coal & Allied (2009)

#### Legend

- HVO South Project Approved Boundary
- Carrington Billabong
- Floodplain (adjacent) Study Area

File Name (A4): R01/4821\_003.dgn  
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FIGURE 1  
Carrington Billabong and  
Adjacent Floodplain Study Area

Figure 9-1 - Carrington Billabong and Adjacent Floodplain Study Area

**Number:** HVOOC-1797567310-4435  
**Owner:** Environment and Community Coordinator

**Status:** Approved  
**Version:** 2.0  
Uncontrolled when printed

**Effective:** 18/08/2025  
**Review:** 18/08/2027

## A2.2 Regeneration

The term ‘regeneration’ is used to identify areas where native vegetation will be allowed to return naturally, generally by removing existing impacts such as weed density or physical disturbances such as grazing. The below actions, which are already occurring in Carrington Billabong, will continue and be extended into the adjacent floodplain. Passive regeneration will be used to achieve revegetation naturally, without the need for replanting or other ground-disturbing activities. Assisted regeneration will be employed where it is identified that passive regeneration is not successful.

### Passive Regeneration

Actions that may be used to assist in the passive regeneration of native vegetation will include:

- removal of stock (stock grazing in Billabong was removed over 10 years ago)
- fencing to prevent access by stock and vehicles
- restrictions to human access
- signage to identify regeneration areas
- selective weeding and grass control and
- control of feral animals such as rabbits, pigs and goats.

### Assisted Regeneration

Assisted regeneration will be employed based on the results of monitoring and may include:

- soil disturbance (ripping)
- supplementary seeding with locally collected native seed
- tubestock planting of local provenance target species and
- extensive weed removal, including exotic grasses.

Due to its disturbance history, much of Carrington Billabong requires assisted regeneration. Results from ten years of monitoring support this conclusion, which recorded very limited to no regeneration of native grasses, forbs and shrubs.

Natural regeneration of river red gum (*Eucalyptus camaldulensis*) has occurred in Carrington Billabong and along the main drainage line between the billabong and Hunter River. Natural regeneration of river red gums in the billabong during the ten years of monitoring between 2007 and 2018 indicates that supplementary planting of this species is not necessary at this point. However, planting and/or seeding of native forbs, grasses and shrubs would be beneficial.

In particular the areas on the Hunter River floodplain between Carrington Billabong and the river are more likely to need assisted revegetation due to their more substantial grazing and cropping history.

Schneider (2007) and Peake (2003) provide revegetation guidance for rehabilitation planning to ensure that appropriate revegetation techniques are employed to re-establish the floristic and structural diversity within the high conservation value Carrington Billabong.

In 2023, genetic investigations of river red gums across NSW were undertaken by the Research Centre for Ecosystem Resilience (RECER) in the Botanic Gardens of Sydney. The findings identified that, within the HVO stands, the Carrington Billabong individuals were highly genetically diverse. Populations on the Wollombi Brook however, had an historical linkage with the coastal species, *Eucalyptus amplifolia* (cabbage gum). As such, to maintain genetic integrity of the river red gums at HVO, seed from the Wollombi Brook populations should not be planted anywhere other than along the Wollombi Brook. There



is no such restrictions placed on river red gum seed originating along the Hunter River, including the Carrington Billabong, and these individuals can be planted within any suitable areas at HVO.

As such, in the absence of further genetic findings, if planting is undertaken in Carrington Billabong, local provenance species whose seeds are collected from within Carrington Billabong or other nearby stands of river red gum will be sourced. Regardless of whether planting occurs within the Carrington Billabong, the site may be used for seed harvesting to assist in the rehabilitation of other relevant sites at HVO.

While other *Eucalyptus* species found within the listed ecological community may be included to supplement the assisted regeneration efforts to provide ecological diversity, given that *Eucalyptus tereticornis* (forest red gum) is known to hybridise with *Eucalyptus camaldulensis*, this species will not be intentionally included in the planting options.

## A2.3 Weed Control

Non-native plants (weeds) are widespread and abundant in Carrington Billabong. Weeds compete with native species for resources such as space, water and nutrients, and are able to significantly impede natural regeneration and modify habitat. Weeds of concern are listed in the *Biosecurity Act 2015* and outlined in **Table 3-1**.

Weed control will continue to be undertaken to reduce the density of weeds to a point that allows natural regeneration to occur.

Several methods exist to control weeds in natural sites (refer to **Table 9-1**). These methods will be considered for application to Carrington Billabong and appropriate techniques will be employed to control or remove weeds.

*Table 9-1 - Weed Control Techniques*

TECHNIQUE	DETAILS
Selective Hand Picking (Weeding)	The aim of this method is to create as little disturbance to the soil as possible and to avoid damage to all native species. Selective hand picking of weed species is labour-intensive but is generally very effective and only target weed species are removed.
Weed Mats or other Suppressants	<p>The use of weed mats may be necessary if supplementary plantings of river red gums are necessary. In this case weeds mats (or hay, mulch or old sacks) would be placed one metre around the base of each seedling for the first two years to allow plants to develop strong root systems free of competition.</p> <p>The need for weed matting will be assessed if planting is necessary, and if monitoring or other expert advice determines that they are necessary. Weed mats will also suppress natural regeneration, so they would only be used selectively such as around native seedlings.</p>

TECHNIQUE	DETAILS
Herbicide Application	<p>Herbicides may be used to control problematic weeds that are not able to be managed through mechanical means.</p> <p>Herbicide use will consider:</p> <ul style="list-style-type: none"> <li>• native plant sensitivity to chemicals;</li> <li>• manufacturer's directions;</li> <li>• weather conditions (no spraying on windy or wet days);</li> <li>• potential days of dry weather following application;</li> <li>• appropriate method for application e.g. foliar spray, wiper, injection, cut stump, drill-and-fill, frilling, basal bark, and bark strip-and-paint;</li> <li>• the appropriate herbicide type and application method will be determined by the weed species to be targeted;</li> <li>• location of water bodies and watercourses (herbicides can cause unwanted damage to non-target plants and other non-target organisms such as frogs and aquatic life, as well as causing water contamination which will affect landholders and water users downstream); and</li> <li>• herbicide mobility, persistence and toxicity.</li> </ul> <p>The use of a weed control method other than herbicides will be considered if there is a reasonable likelihood of damage to non- target organisms in or around a water course. If herbicide use is to occur in proximity to a water course, the guidelines for herbicide use in and around water (Ainsworth and Bowcher 2005) will be taken into consideration.</p>

## A2.4 Pest Control

Pests impacting the Carrington Billabong and river red gums include hares, pigs, rabbits, insect and fungus. In addition wild dogs, foxes and cats can impact upon the native fauna. Pest control techniques are discussed in **Table 9-2**.

*Table 9-2 - Pest Control Techniques*

PEST	COMMENTS
Rabbit and Hare	<p>Infestations of rabbits and hares can result in the loss of ecosystem biodiversity through grazing and the construction of warrens. Where appropriate, rabbits and hares will be controlled through several means such as disease, poisoning and warren destruction. If rabbit or hare numbers are considered high enough to warrant control of these species the use of 1080 poison (sodium monofluoroacetate) combined with warren destruction will be considered, as it is likely to provide the most effective outcome. 1080 poison would only be used under the supervision of a suitably qualified operator and all carcasses would be collected to prevent poisoning of predators.</p> <p>Warren destruction will prevent rabbits surviving the summer months and rearing young and is highly labour intensive and results in severe soil disturbance.</p>
Insect and Fungus	<p>Insect and fungus attacks can contribute to tree dieback, especially in trees that are in highly stressed situations, and are usually indicators of an unhealthy ecosystem which is unable to cope with attacks by these organisms. In rural areas, tree dieback is often caused by repeated defoliation by native insects. Trees that have suffered severe defoliation can then become susceptible to fungi, which cause lesions in the branches, causing them to suffer dieback. Tree dieback resulting from insect or fungus attacks should be closely monitored and addressed if a serious problem becomes evident. The management of insect and fungus infestation in particular, and tree dieback in general, at Carrington Billabong will use the principles recommended by Nadolny (2000), that is focusing on retaining as many juvenile eucalypts as possible, controlling livestock access and increasing fauna habitat and structural diversity of vegetation to encourage a diversity of wildlife species.</p>
Pigs	<p>Feral pigs in Australia can cause severe damage to the environment, including eating native plants and trampling and uprooting vegetation. Pigs digging for food can lead to soil erosion, especially on rivers and lagoons, and the spread of soil and water pathogens. They can cause water contamination by wallowing in waterholes and wetlands and spread several diseases, including leptospirosis and brucellosis. Pigs have also been known to hunt native fauna such as frogs, birds and small mammals. Pig control is part of HVO's pest program.</p>
Wild Dogs, Foxes and Cats	<p>Wild dogs, foxes and cats are predatory species and can result in the decline of native fauna in the area, resulting in a reduced level of biodiversity. Control of these feral populations would be managed through an ongoing trapping and 1080 baiting program to ensure the numbers of these populations are kept at a minimum to allow for an increase in biodiversity in the area.</p>

## A2.5 Artificial Flooding

As native recruitment of river red gums requires the presence of standing water for several weeks, should drought conditions occur and flooding of the Billabong not happen for several years, artificial flooding of the billabong may be effective to promote natural recruitment. This approach would require clean water to be pumped into closed depressions in the billabong and floodplain. Artificial flooding of river red gum remnants at Dartbrook mine was found to be very effective at promoting native plant recruitment, particularly river red gums (Dartbrook Coal Mine 2006; Umwelt 2008a and 2008b).

Artificial flooding has been considered by HVO as a means of providing nourishment to seedlings and help reduce competition from weed species by causing their death from inundation. However, as the volume of water likely to be required to simulate natural flooding is substantial, endorsement from regulators would be required. Furthermore, during periods of drought or low river levels, artificial flooding may not be possible due to low water supply.

In the future, artificial flooding may be considered if adequate surplus water allocations exist and natural recruitment is not occurring in Carrington Billabong.

## A2.6 Other Potential Future Actions

During the implementation of the Strategy, it is possible that alternative management actions are identified and considered appropriate to implement to assist with the rehabilitation and restoration of Carrington Billabong. The implementation of the Strategy is therefore flexible and able to respond to new information.

While it is not possible at this stage to predict what further actions will be required, **Table 9-3** indicates what actions may be considered in future.

*Table 9-3 -Future Opportunities for Management Actions*

OPPORTUNITY	DETAILS
Revegetation	<p>Revegetation of Carrington Billabong, by means other than passive ones such as natural regeneration, will be used if it is determined that river red gums are not recruiting adequately. Revegetation will take the form of either tubestock planting, or direct seeding, or both. Adequate water provision to seedlings and management of the area around the revegetated area will occur.</p> <p>If sufficient seed resources become available, HVO propose to use local provenance material that is collected as seed from Carrington Billabong, or other nearby river red gum remnants, in order to maintain genetic integrity.</p>
Fauna Diversity and Fauna Habitat Monitoring	<p>HVO will consider any benefit that might be derived from monitoring select fauna species and key habitat features, such as tree hollows and the presence of bird perching sites and logs. The assessment of fauna species would rely on recording readily available data, and would most likely comprise the monitoring of birds, frogs, mammals and signs of fauna usage. The collection of such data could be useful in assessing the provision of habitat to fauna species and how it changes over time as Carrington Billabong is rehabilitated.</p>

OPPORTUNITY	DETAILS
Establishment of Trial Sites	HVO will consider the establishment of trial sites at Carrington Billabong and the application of various management treatments. If trials are established these will be done with appropriate consideration of any existing or previous trials carried out by others (e.g. at Dartbrook). The types of trial management regimes that may be considered include weeding, watering (irrigation or inundation), planting and pest control, as well as combinations of the above.

## A3.1 STRATEGY FOR PRIORITY SITES

### A3.1 Fencing and Access Control

As outlined in **A2.1** for the Carrington Billabong, river red gums at many sites at HVO, particularly those occurring on floodplains, have, historically, been negatively impacted by the various impacts of grazing. Grazing by macropods, particularly the eastern grey kangaroo (*Macropus giganteus*), is extensive, particularly around the base of mature and immature river red gums.

Uncontrolled access by stock can result in the loss of biodiversity through soil compaction limiting natural regeneration, increased nutrients and tree damage through stock rubbing and soil erosion. Furthermore, human access could potentially result in damage to the site if unauthorised personnel entered and were unaware of the site's environmental significance.

In order to manage stock and human access to the sites, the establishment and maintenance of appropriate fencing is critical. Fencing may also facilitate the exclusion of pests, both native and introduced.

HVO will undertake a review of the existing fencing around the priority sites and will seek to establish or upgrade, where required, fencing to restrict stock access. Fencing will be located appropriately to enable remnants to expand naturally over time through natural regeneration and will avoid areas at high risk of damage from floods and erosion.

The areas will be appropriately signed and access to the stands will be restricted in accordance with relevant HVO procedures.

HVO will review any future monitoring results to determine the effectiveness of fencing and will undertake regular maintenance inspections and works to ensure that fences are sound and working as designed.

### A3.2 Regeneration

The term 'regeneration' is used to identify areas where native vegetation will be allowed to return naturally to an area, generally by removing existing impacts such as weed density or physical disturbances such as grazing. The below actions, which are already occurring in HVO, will continue and be extended in new sites if applicable. Passive regeneration will be used to achieve revegetation naturally, without the need for replanting or other ground- disturbing activities.

Actions that can be used to assist in the passive regeneration of native vegetation may include:

- removal of stock
- fencing to prevent access by stock and vehicles
- restrictions to human access
- signage to identify regeneration areas

- selective weeding and
- control of feral animals such as rabbits, pigs and goats.

HVO will consider the use of assisted regeneration based on the results of monitoring. This may include:

- soil disturbance (ripping)
- supplementary seeding with locally collected native seed
- tubestock planting of local provenance target species and
- extensive weed removal, including exotic grass.

While other *Eucalyptus* species found within the listed ecological community may be included to supplement the assisted regeneration efforts to provide ecological diversity, given that *Eucalyptus tereticornis* (forest red gum) is known to hybridise with *Eucalyptus camaldulensis*, this species will not be intentionally included in the planting options.

### A3.3 Weed Control

Non-native plants (weeds) are widespread and abundant at most priority sites. Many of these species occur in riparian zones, and the control of such weeds is difficult because propagules of weeds enter the HVO properties via transport down the Hunter River and Wollombi Brook. Weeds compete with native species for resources such as space, water and nutrients, and are able to significantly impede natural regeneration and modify habitat.

Weed control will continue to be carried out to reduce the density of weeds to a point that allows natural regeneration to occur.

The focus of weed control will be on serious weeds and include those identified under the *Biosecurity Act 2015* and outlined in **Table 3-1**. Other important environmental weeds will also be addressed where appropriate. The weed control technique to be employed will depend on the weeds requiring control and the advice given by weed specialists. The techniques outlined in **Table 9-1** will be considered as appropriate.

### A3.4 Pest Control

Pests impacting priority sites include hares, rabbits, insect and fungus. In addition, wild dogs, foxes and cats can impact upon the native fauna. Pest control will be undertaken in accordance with HVO vertebrate pest management protocols and will consider the range of approaches outlined in **Table 9-2**.

### A3.5 Seed Harvesting and Propagation

If planting is required at any priority sites, in the absence of updated genetic information, it is proposed to use local provenance species whose seeds are collected from within the target site or other nearby similar stands of river red gum where possible. As outlined in Section A2.2, seed from the Wollombi Brook populations should not be planted anywhere other than along the Wollombi Brook. There is no such restrictions placed on river red gum seed originating along the Hunter River. If unavailable from within the HVO local area, species utilised within the rehabilitation plantings may be sourced from a wider area if seed resources are not available locally.

### A3.6 Other Potential Future Actions

During the implementation of the Strategy, it is possible that alternative management actions are identified and considered appropriate to implement to assist with the management of priority sites. The Strategy is therefore flexible and able to respond to new information. Any new information regarding site management or river red gum management that is obtained in future, particularly as part of the restoration and rehabilitation of Carrington Billabong, will be applied in the management of the priority sites, where appropriate.

## A4.1 STRATEGY FOR LOW PRIORITY SITES

### A4.1 Fencing and Access Control

Some of the low priority sites are fenced off from grazing, or do not have any active stock grazing present, while others are grazed or partially grazed. Some sites occur where there are natural barriers preventing the intrusion of stock. For those sites that are currently fenced, or will require fencing in future for other purposes, HVO will ensure that these fences are maintained and appropriately designed for the task. Fences will be regularly monitored to ensure that they are in a good state of repair.

### A4.2 Regeneration

The term 'regeneration' is used to identify areas where native vegetation will be allowed to return naturally to a particular area, generally by removing existing impacts such as weed density or physical disturbances such as grazing. Passive regeneration will be used to achieve revegetation naturally, without the need for replanting or other ground-disturbing activities.

Actions that may be used to assist in the passive regeneration of native vegetation will include:

- maintenance of fencing to ensure stock exclusion, where appropriate fencing already exists;
- selective weeding; and
- control of feral animals such as rabbits and goats.

Non-native plants (weeds) are widespread and abundant at most priority sites. Many of these species occur in riparian zones, and the control of such weeds is difficult because propagules of weeds enter the HVO properties via transport down the Hunter River and Wollombi Brook. Weeds compete with native species for resources such as space, water and nutrients, and are able to significantly impede natural regeneration and modify habitat.

Weed control will continue to be undertaken to reduce the density of weeds to a point that allows natural regeneration to occur.

The focus of weed control will be on serious weeds and include those identified under the *Biosecurity Act 2015* and outlined in **Table 3-1**. Other important environmental weeds will also be addressed where appropriate. The weed control technique to be employed will depend on the weeds requiring control. The techniques outlined in **Table 9-1** will be considered as appropriate.

### A4.3 Pest Control

Pests impacting priority sites include hares, rabbits, insect and fungus. In addition, wild dogs, foxes and cats can impact upon the native fauna. Pest control will be undertaken in accordance with HVO vertebrate pest management protocols and will consider the range of approaches outlined in **Table 9-2**.

### A4.4 Seed Harvesting and Propagation

If planting is undertaken at any of the low priority sites, in the absence of updated genetic information, it is proposed to use local provenance species whose seeds are collected from within the target site or other nearby similar stands of river red gum where possible. As outlined in **Section A2.2**, seed from the Wollombi Brook populations should not be planted anywhere other than along the Wollombi Brook. There is no such restrictions placed on river red gum seed originating along the Hunter River. If unavailable from within the HVO local area, species utilised within the rehabilitation plantings may be sourced from a wider area if seed resources are not available locally.

## A5.1 ECOLOGICAL MONITORING

Monitoring of river red gums across HVO has been ongoing since early 2007, commencing initially with baseline monitoring at Carrington Billabong and continuing with monitoring at several stands of river red gums at HVO.

The 10 years of survey work was set out in the 2007 and 2017 Strategies and various reports provide results of those surveys. The final, 10-year monitoring survey event was carried out in 2018 and reported on in Umwelt (2019).

HVO will continue to monitor the river red gums at HVO. The proposed monitoring program from 2020 and onwards is described in **Section 5.0** of the main report.

In summary, the ecological monitoring program will include:

### **Carrington Billabong**

Annual spring surveys and reporting on tree health, floristic composition and structure, river red gum seedlings recruitment, regeneration and remnant health. Photo monitoring from permanent points will be undertaken.

The floodplain adjacent to the Carrington Billabong will be examined to identify any natural regeneration of river red gums and other native trees and shrubs. Should it occur, the floristic surveys can be extended to include new areas of native regeneration, when appropriate.

### **Priority Sites**

Annual spring surveys and reporting in line with survey work in Carrington Billabong, which will include remnant health and dominant flora. Photo monitoring from permanent points will be undertaken.

### **Low Priority Sites**

No targeted monitoring is proposed. However, regular inspections by HVO of all land under its control is carried out, which will include observations on weeds, pest animals, erosion, fencing and general health of vegetation.

### **Additional Monitoring**

In addition to the scheduled ecological monitoring, supplementary examination or surveys (as appropriate) will be triggered by key events including:

- Flooding leading to standing water on the floodplain
- Groundwater monitoring triggers being reached
- Serious weather events such as extreme winds or drought
- Other triggers assessed as having the potential to seriously impact ecology of Carrington Billabong and HVO Priority Sites.

**Section 5.0** of the main report provides further detail.



## APPENDIX B: CONSULTATION WITH DPIE BCD



Planning,  
Industry &  
Environment

Our ref: DOC20/489342-2

Your ref: DA 450-10-2003/ PA 06\_0261

Mr Michael Lloyd

Environment and Community Coordinator Hunter  
Valley Operations [Michael.Lloyd@hvo.com.au](mailto:Michael.Lloyd@hvo.com.au)

Dear Mr Lloyd

Hunter Valley Operations River Red Gum Rehabilitation and Restoration Strategy

I refer to your e- mail dated 19 June 2020 requesting that Biodiversity and Conservation Division (BCD) review the updated *HVO River Red Gum Rehabilitation and Restoration Strategy* (the Strategy). The Strategy has been prepared to meet Schedule 4, Condition 31 of the Project Approval for the Hunter Valley Operations North Coal Project (DA 450-10-2003 MOD 4) and Schedule 3, Condition 30 of the Project Approval for the Hunter Valley Operations South Coal Project (PA 06\_0261 MOD 4). BCD has reviewed the draft document.

Biodiversity and Conservation Division's (BCD) recommendations are provided in **Attachment A** and detailed comments are provided in **Attachment B**. If you require any further information regarding this matter, please me on 4927 3154 or via email at [rog.hcc@environment.nsw.gov.au](mailto:rog.hcc@environment.nsw.gov.au)

Yours sincerely



ROBERT GIBSON  
Acting Senior Team Leader Planning Hunter  
Central Coast Branch Biodiversity and  
Conservation Division

Enclosure: Attachments A and B

## BCD's recommendations

### Hunter Valley Operations River Red Gum Rehabilitation and Restoration Strategy

1. BCD recommends that the Table of Contents is revised to include the titles and page numbers of figures and tables, and a reference to Appendix 1 in the River Red Gum Rehabilitation and Restoration Strategy.
2. BCD recommends that decision triggers are included in the Strategy.
3. BCD recommends that monitoring uses baseline data and comparisons between monitoring events to assess the needs and success of management actions on native species recruitment and weed invasion, rather than the 'Camyr Allyn' reference site.
4. BCD recommends that the use of local provenance native species in active revegetation actions is identified as a requirement of the Strategy.
5. BCD recommends that the Strategy includes a discussion of the saline seep from the North Void Tailings Dam Facility towards Carrington Billabong. Further, BCD recommends that the Strategy discusses the monitoring strategy, triggers, and possible management actions to ensure that the saline groundwater does not harm river red gums at this site.

## BCD's detailed comments

### Hunter Valley Operations River Red Gum Rehabilitation and Restoration Strategy

#### 1. *The Table of Contents would benefit from having a list of figures and tables*

The Table of Contents of the River Red Gum Rehabilitation and Restoration Strategy (the Strategy) does not include any details of the figures, tables or Appendix 1 in the document; particularly their titles and on what page they occur. This makes it difficult to find some information. BCD recommends that the revised Table of Contents in the Strategy includes details about figures and tables.

#### Recommendation 1

BCD recommends that the Table of Contents is revised to include the titles and page numbers of figures and tables, and a reference to Appendix 1 in the River Red Gum Rehabilitation and Restoration Strategy.

#### 2. *Decision triggers should be included in the Strategy*

Decision triggers are defined thresholds in the status of monitored variables that indicate when to undertake management. Appendix 1 of the Strategy details the actions proposed to manage threats to the River Red Gum populations. However, the Strategy does not include measurable thresholds for when management intervention is necessary, based on the monitored variables. Without the inclusion of decision triggers, there is no clear consensus between HVO and Government on what are acceptable risks or impacts to the River Red Gum populations before intervention is needed.

#### Recommendation 2

BCD recommends that decision triggers are included in the Strategy.

3. *Comparison between baseline data on HVO land would be more appropriate than the Reference Site for decisions triggers at Carrington Billabong*

Section 3.2.1 of the Strategy notes that similar increases in weeds were recorded during the 2007-2017 monitoring between Carrington Billabong and 'Camyr Allyn' (the Reference Site). The monitoring concludes the lack of factors, including native recruitment, weed dominance and a reduced native species diversity occurs throughout the catchment. Therefore, the influence of mining activities on the River Red Gum woodland, relative to these other factors, is not able to be measured.

BCD agrees that the influence of adjacent mining on native recruitment, weed dominance and a reduced native diversity within River Red Gum woodlands cannot be easily measured. However, to meet Schedule 3, Condition 30 (b) and (c) of PA 06\_0261 monitoring must be able to evaluate the short, medium and long-term success of management actions in relation to the established rehabilitation objectives. This type of monitoring would be best suited to using baseline data and results between monitoring events within the HVO-managed sites, rather than the 'Camyr Allyn' reference site. Once management actions, such as extensive active weed control are implemented, the value of analysing the results of the Reference site for this variable is greatly diminished.

Recommendation 3

BCD recommends that monitoring uses baseline data and comparisons between monitoring events to assess the needs and success of management actions on native species recruitment and weed invasion, rather than the 'Camyr Allyn' reference site.

4. *The Strategy should require the use of local provenance native species in active restoration*

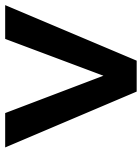
Appendix 1 of the Strategy recommends the use of local provenance species in restoration actions. Sourcing species from the local area is important for maintaining generic integrity and ensuring that the chosen plants are suited to local environmental conditions. In particular, the genetics of River Red Gum in the Hunter River catchment are unique – and the main reason why they have been listed as an Endangered Population - and must be maintained. The wording of the Strategy could be improved to clearly identify the use of local provenance plantings as a requirement, rather than a recommendation.

Recommendation 4

BCD recommends that the use of local provenance native species in active revegetation actions is identified as a requirement of the Strategy.

5. *Monitoring of saline seepage towards Carrington Billabong is recommended to protect River Red Gums at this site*

In 2017 a saline seep was detected flowing from the North Void Tailings Facility towards Carrington Billabong. It was identified as posing a risk to the river red gum population there. BCD recommends that the Strategy includes a summary of this saline seep, with details of the monitoring strategy, and that it includes triggers, and proposed management actions to protect river red gums if any thresholds are crossed.



## Recommendation 5

BCD recommends that the Strategy includes a discussion of the saline seep from the North Void Tailings Dam Facility towards Carrington Billabong. Further, BCD recommends that the Strategy discusses the monitoring strategy, triggers, and possible management actions to ensure that the saline groundwater does not harm river red gums at this site.

## APPENDIX C: RESPONSE TO DPIE BCD CONSULTATION RECOMMENDATIONS

**HVO Response to DPIE BCD recommendations outlined in Appendix A.**

### **Recommendation 1:**

The suggestion to include details on the figures and tables within the Table of Contents will be accepted. This suggestion will be incorporated into the final version that is placed on the HVO website.

### **Recommendation 2:**

The majority of the actions proposed to manage threats are already being undertaken or are effectively managed by HVO at the Carrington Billabong to date. For example; additional planting at the Carrington Billabong is scheduled to occur in autumn 2021, HVO is undertaking rabbit burrow inspections of the areas identified at HVO as containing River Red Gums, and an investigation of alternative weed management strategies at the billabong is occurring.

As many of the alternative suggestions outlined in the Implementation Plan in Appendix A are being investigated with the trigger being the results of the monitoring program, a decision trigger on the use of these options is not required.

### **Recommendation 3:**

The suggestion that HVO exclude the use of Camyr Allen as a reference site to determine the impacts of mining on the Carrington Billabong in preference for baseline data on HVO land is unfair. Recent climatic conditions have resulted in a proliferation of specific weed species across the Hunter Valley. These conditions are beyond the reasonable control or management of HVO. Comparisons of the HVO stands between years will occur but will reflect variability in climate. Management actions arising from these climatic conditions will need to intensify and the use of Camyr Allen as a comparison demonstrates that the species content within the understory as a result of climatic variability is not the result of mismanagement of the Billabong by HVO.

Camyr Allen is the second largest known stand of river red gums in the Hunter Valley. The use of Camyr Allen as a control site was agreed to by the then OEH during the initial discussions and development of the original Strategy. As such, HVO has developed a database in monitoring the Camyr Allen stand in which the Carrington Billabong is able to be compared.

In addition, the use of the Camyr Allen as a reference site by mining companies requires a negotiated outcome with the Camyr Allen landholder. This typically results in the seed collection, propagation and planting of river red gum trees back into the Camyr Allen remnant, which results in the stand becoming larger and more resilient.

### **Recommendation 4:**

The recommendation of the use of local provenance species in active regeneration is acknowledged. HVO intends to aim for this practice where possible except in cases where the species is unable to be sourced from within HVO lands. This suggestion has been emphasised in the Strategy.



**Recommendation 5:**

The saline seep from the North Void Tailings Dam is the subject of a recent Ecological Risk Assessment (ERA) that was undertaken by Umwelt. The ERA provides a TARP that indicates recommended actions in the event that ecological monitoring in Carrington Billabong identifies a notable decline in ecological condition potentially related to groundwater seepage. In addition, a monitoring program is also provided in the event that the TARP is instigated. This monitoring program has been designed to be consistent with the monitoring that forms part of this River Red Gum Rehabilitation and Restoration Strategy.



APPENDIX D: DPIE PLANNING CONSULTATION

HUNTER VALLEY  
OPERATIONS

22 August 2021

Daniel Martin  
NSW Department of Planning, Industry and Environment (DPIE)  
Via: Major Projects portal

Dear Daniel,

**Hunter Valley Operations South Coal Project (MP 06\_0261) & Hunter Valley Operations North (DA 450-10-2003) HVO River Red Gum Rehabilitation and Restoration Strategy – Request for Additional Information**

I refer to the request for information (RFI) provided to Hunter Valley Operations. Please find attached a revised version of the HVO River Red Gum Rehabilitation and Restoration Strategy (RRGRS) which has been updated as per the response to DPIE comments below.

DPIE Request for Information	HVO Response
Update the HVRRGRS to include current assessment criteria and completion criteria for conservation and restoration of the river red gum populations, to meet the requirements of condition 30 c), schedule 3 of MP 06_0261. This action was not included in the response table.	The assessment criteria and completion criteria are the same as those proposed in the previous version of the Strategy. This is to ensure continuity of existing data and the approach to measuring the effectiveness of the proposed management strategies. This is outlined in Section 4.2 Goals and Objectives, and the new Section 4.3 Completion Criteria.
The HVRRGRS does not include a protocol for managing and reporting complaints, non-compliances with statutory requirements and exceedances of the impact assessment criteria and/or performance criteria in accordance with Condition 1A (g), Schedule 5. Update HVRRGRS to address Condition 1A (g), Schedule 5. Section 6 of the HVORRGRS has been updated to include a new Section 6 which only describes reporting incidents to DPIE.	A protocol has been inserted (Section 6 Reporting) with the commitment to investigate all incidents, complaint, potential non-compliance with statutory requirements or potential exceedance of the impact assessment and/or performance criteria.  DPI&E will be informed of the investigation and advised of the follow up action(s) if the action(s) are determined to be necessary.

Please contact me on Keith Simkin on keith.simkin2@hvo.com.au or 0427 701 534 if you would like to discuss this matter.

Yours sincerely,

Keith Simkin  
Environment & Community Coordinator

1011 Lemington Road, Ravensworth, NSW 2330  
HV Operations Pty Limited ABN 76 606 478 399

## APPENDIX E: DPHI APPROVAL

Department of Planning, Housing and Infrastructure



Our ref: MP06\_0261-PA-173

Environment and Community Team  
HV Operations Pty Ltd  
1011 Lemington Road  
Lemington, NSW, 2330

26/08/2025

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**Subject: Revised River Red Gum Rehabilitation and Restoration Strategy – HVO South (MP06\_0261)**

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I refer to your submission dated 11 August 2025 requesting approval of the revised River Red Gum Rehabilitation and Restoration Strategy (Version 2.0, dated 18 August 2025) submitted to meet the requirements of Schedule 3, condition 30 of MP06\_0261 and Schedule 3, condition 31 of DA450-10-2003.

The Department has carefully reviewed the document and is satisfied that it has been updated to reflect the 2024 Annual Review dated 31 March 2025 and the approval of HVO North Mod 8 granted 24 April 2025.

The Department also notes that given the minor nature of the updates that consultation with public authorities listed in Schedule 3, condition 30 of MP06\_0261 is not required, per Schedule 5, condition 1C of MP06\_0261.

Accordingly, as nominee of the Planning Secretary, I approve the revised River Red Gum Rehabilitation and Restoration Strategy (Version 2.0, dated 18 August 2025) under Schedule 3, condition 30 of MP06\_0261.

You are reminded that if there are any inconsistencies between the Plan and the conditions of approval, the conditions prevail. Please ensure you make the document publicly available on the project website at the earliest convenience.

If you wish to discuss the matter further, please contact Kiera Plumridge at [kiera.plumridge@dpie.nsw.gov.au](mailto:kiera.plumridge@dpie.nsw.gov.au).

Yours sincerely,



Jack Turner  
Team Leader  
Resource Assessments

As nominee of the Planning Secretary