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Environmental Consultants





September 2026

Te Kowhai East- Industrial Development
Black Mudfish Habitat Creation Plan

Prepared for:

Te Kowhai East Limited Partnership

water fauna flora land

Quality Assurance

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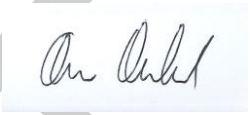
	Owen Woodward Ecologist	
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1.0 Introduction

1.1 Background

This report prepared by Ecological Solutions Ltd presents a Black Mudfish Habitat Creation Plan (BMHCP) for the Te Kowhai East Industrial Development (the Project) by Te Kowhai East Limited Partnership. This BMHCP has been prepared as part of the Te Kowhai East Limited Partnership's substantive application for approvals under the Fast-track Approvals Act 2024 (FTAA). The BMHCP sets out the framework for managing the adverse effects of the Project on black mudfish (*Neochanna diversus*) and their habitat.

The Project Area is 187.5 ha and is commonly referred to by the primary addresses of 270 Te Kowhai Road and 28 Mathers Road. The Project is located in the headwaters of the Mangaheka Stream catchment and a small portion located in the Te Otamanui Stream catchment.

The Project is a large-scale industrial development located on the north-western edge of Hamilton, adjacent to the established Te Rapa industrial area. The development provides for the creation of an integrated industrial precinct, including approximately 210 industrial lots, land for neighbourhood centre activities, reserves for recreation, stormwater management and ecological mitigation and enhancement, and associated roading and infrastructure services.

The Project involves the unavoidable piping, infilling, diversion, and potential drawdown of c. 16,192 m of artificial drain within the Project Area. An ecological impact assessment (EcIA) prepared by Ecological Solutions (2026a) determined that approximately 9,398 m of drain within the Project Area contained suitable black mudfish habitat.

A comprehensive trapping programme undertaken as part of the EcIA concluded that c. 3,582.5 m (i.e. 38.12%) of drains that provided suitable habitat was inhabited by black mudfish (Ecological Solutions 2026a). The EcIA concluded that c. 3,582.5 m² of black mudfish habitat (3,582.5 m at an average channel width of 1 m) will potentially be lost as a result of the development and needs to be compensated.

1.2 Purpose

This BMHCP outlines the measures to be applied, including protocols for pre- and post-works monitoring, the capture, handling, and relocation of black mudfish as well as the design concepts for the habitat creation and relocation responses appropriate to mitigate the adverse effects on this ‘At Risk – Declining’ native species (Dunn et al. 2025).

Specifically, the purpose of the BMHCP is to outline:

- Existing distribution and habitat of black mudfish across the site.
- Pre- and post-translocation monitoring.
- Capture and translocation protocols for black mudfish.
- Black mudfish habitat creation design and construction methodology.
- Reporting requirements.
- Adaptive Management Protocols
- Roles and responsibilities in the delivery of the BMHCP.
- Certification.

1.3 Objectives

The specific objectives of the BMHCP are:

- The creation of self-sustaining black mudfish population with the resilience to adapt to the changing surrounding land use.
- The creation and maintenance of a minimum of 3,582.5 m² of suitable black mudfish habitat to compensate for the reclamation of artificial drains known or expected to be containing black mudfish.
- Restoration of a self-sustaining native riparian zone surrounding the newly created black mudfish wetland habitat that once established, requires minimal management to persist in perpetuity.

1.4 Related Documentation

This BMHCP should be read alongside the following related documents (Table 1):

Table 1: Related Documents.

Plan code	Plan name	Interface with this BMHCP
TKE-FMP-001	Fish Management Plan (Ecological Solutions 2026b)	Fish capture methods, including the species-general capture framework that black mudfish capture builds on.
TKE-STMP-001	Stream Works Management Plan (Maven Associates 2026a)	Drain works construction methodology, hold points, and sediment control. Confirms fish management protocols required before any infilling, piping, or diversion of identified black mudfish drains.
TKE-EcIA-001	Ecological Impact Assessment (Ecological Solutions 2026a)	Source for baseline habitat assessment, effects characterisation and application of effects management hierarchy.
TKE-EWMP-001	Earthworks Management Plan (Maven Associates 2026b)	Bulk earthworks programme that determines drain works timing within each stage.
TKE-MSEP-001	Mangaheka Stream Enhancement Plan (Ecological Solutions 2026c)	BMHCP forms part of the wider restoration framework including the widening and enhancement of Mangaheka Stream.
TKE-CMP-001	Construction Management Plan (Maven Associates 2026c)	Overall construction management, incident reporting, and pre-commencement notification.
TKE-HEA-001	Hydrogeological Effects Assessment (WGA 2026)	Mudfish habitat design concept.

2.0 Waikato-Tainui Environmental Plan

This BMHCP is aligned with the objectives of the Waikato-Tainui Environmental Plan (WTEP) Tai Tumu Tai Pari Tai Ao. The WTEP plan was developed out of the Whakatupuranga 2050 long-term development approach with the key strategic objective ‘to grow our tribal estate and manage natural resources’ with Waikato-Tainui aspiring to restore the environment to the state that Kiingi Taawhiao observed when he composed his maimai

aroha. Sections 7 and 8 of the WTEP specifically address environmental enhancement and managing effects. An enhancement approach requires a holistic approach to the whole environment, which aims for positive ecological and social outcomes.

Effects management in relation to the project have been previously considered as part of the Ecological Impact Assessment (EcIA) (Ecological Solutions 2026a). The BMHCP specifically addresses the offset for effects on black mudfish and aims to enhance the existing environment through the creation of additional wetland area, establishment of a native riparian vegetation community as well as supporting and ideally increasing black mudfish populations within the catchment. The new wetland areas will be created in a way that results in a higher quality aquatic environment. Restoration activities will benefit other flora and fauna that are adapted to wetland environments and increase habitat connectivity at a landscape scale.

The vision and strategy for the Waikato River (Te Ture Whaimana o te Awa o Waikato) recognises the significance of the Waikato River to Waikato-Tainui, with the vision, objectives and strategies applicable to Waikato River tributaries and overall catchment. The project aims to enhance the amount and quality of wetland habitat within the Waikato River catchment and aligns with the objectives of the vision and strategy for the Waikato River.

The protection of Natural Heritage and Biosecurity is covered in Section 15 of the WTEP, which identifies that post 1840, three quarters of indigenous vegetation has been removed with the greatest loss occurring in lowland areas. Habitat for threatened and At-Risk native freshwater fish populations would have been more common prior to historical land clearance and channelisation activities, which have reduced, fragmented, and modified stream habitats. Habitat loss and modification is recognised as one of the major threats to native fish populations. Continued development which potentially result in habitat modifications, continue to threaten native fish populations. The project, and this BMHCP aims to increase the quality of black mudfish habitat within the Mangaheka Stream catchment.

3.0 Site Description

The Project Area covers approximately 187.5 ha of contiguous farmland. The proposed master plan for the site is shown in Figure 1. The Project Area sits at the headwaters of two drainage catchments known to contain black mudfish populations:

- The Mangaheka Stream catchment drains the western and central portions of the site, flowing west to the Waipā River.
- The Te Rapa catchment drains the eastern and southern portions of the site, flowing to the Waikato River system via the Te Rapa drainage network.

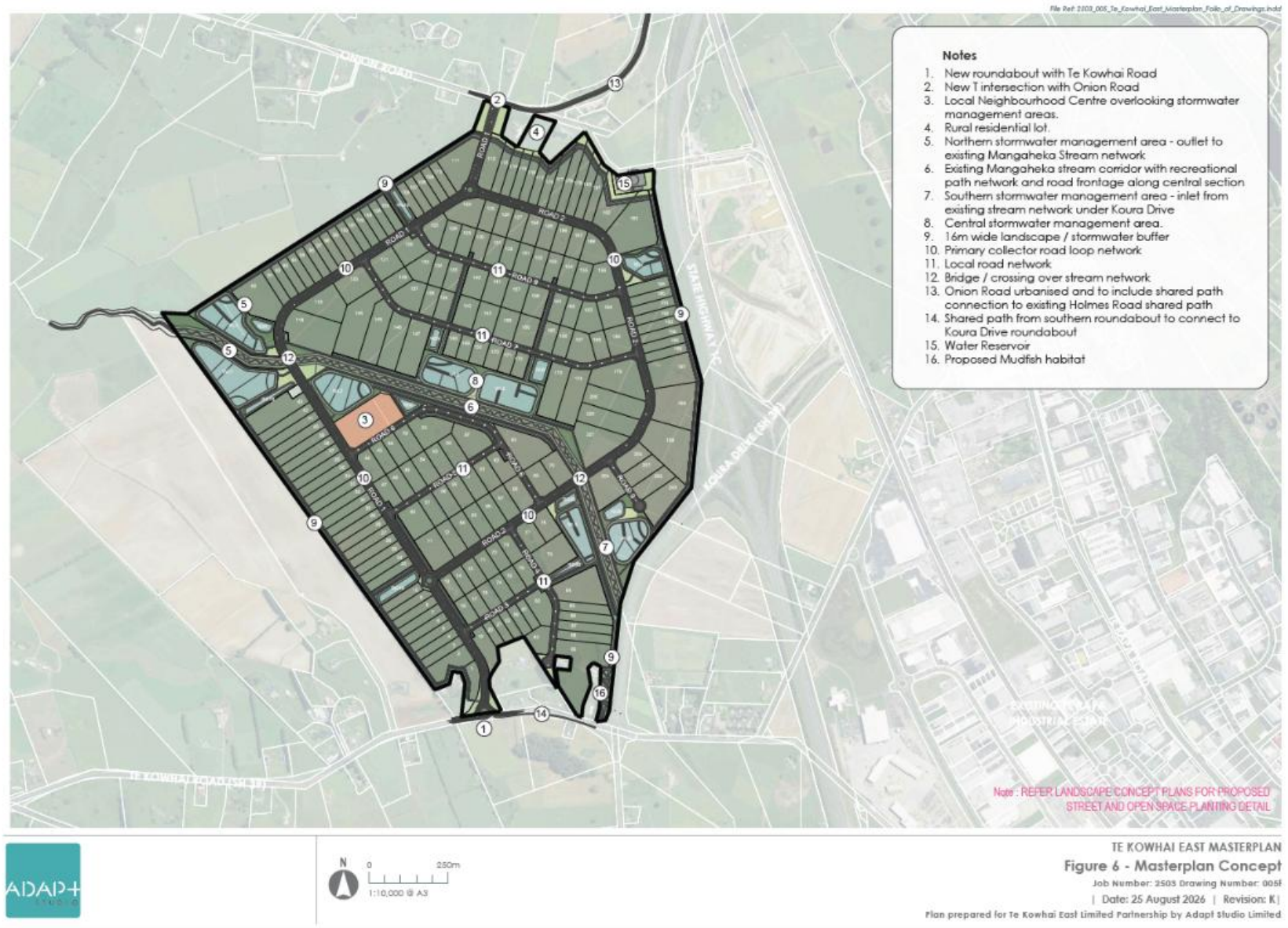

Figure 1. Masterplan Concept (Adapt Studio).

4.0 Regulatory and Policy Framework

There are numerous regulatory and policy documents which provide guidance in relation to the management of adverse effects on black mudfish. These are summarised in Table 2.

Table 2: Summary of regulatory and policy framework relevant to the management of black mudfish.

Instrument	Relevant provision
NZ Threat Classification System	Black mudfish have a conservation status of 'At Risk – Declining' (Dunn et al. 2025).
National Policy Statement for Freshwater Management 2020 (NPS-FM)	Te Mana o te Wai hierarchy. Health and wellbeing of water bodies and indigenous freshwater species prioritised.
National Environmental Standards for Freshwater 2020 (NES-F)	Regulates activities that pose risks to the health of freshwater and freshwater ecosystems. Provides baseline protection standards e.g. fish passage and wetland drainage.
Te Ture Whaimana o Te Awa o Waikato	Vision and Strategy for the Waikato and Waipā Rivers. Restoration of indigenous biodiversity is a core objective.
Waikato-Tainui Environmental Plan (WTEP) Tai Tumu Tai Pari Tai Ao	Strategic objectives include tribal identity and integrity, including to grow the tribal estate and manage natural resources. The plan is designed to enhance Waikato-Tainui participation in resource and environmental management
Fisheries Act 1996	A special permit is required to allow persons or agencies to take aquatic life and relocate it to a suitable habitat where this is necessary or required to mitigate adverse effects of habitat modification on the aquatic life (section 97(1)(c))
Freshwater Fisheries Regulations 1983	A Freshwater Fisheries Regulations 1983 authorisation may be required for instream structures (e.g., culverts, fords, or dams) that may impede fish passage, and temporary stream diversions.
Conservation Act 1987	Relevant permits and authorisations required for capture, handling, holding and translocation of black mudfish will be obtained prior to those activities commencing.

5.0 Black Mudfish Ecology

Black mudfish are a small (typically 60 to 120 mm) native freshwater fish endemic to the North Island of New Zealand. The species belongs to the family Galaxiidae and is one of five species in the genus *Neochanna*, all of which are mudfish, uniquely characterised by the ability to survive periods of drought through aestivation.

5.1 Distribution and Range

Black mudfish are distributed across the lowlands of Northland, Auckland, and Waikato regions. The Waikato region supports a significant proportion of remaining populations, particularly in the peat-derived wetlands and associated drainage networks of the lower Waikato basin. The Te Rapa / Empire drainage system is within their confirmed range.

5.2 Habitat

Black mudfish habitat is characterised by:

- Still or very slow-moving water in wetlands, peat bogs, swamps, and drainage ditches.
- Dense aquatic and emergent vegetation providing cover and structural complexity.
- Organic-rich substrates including peat, mud, and decomposing vegetation.
- Seasonally fluctuating water levels, with capacity for periods of drying.
- Limited or absent populations of pest fish, particularly *Gambusia affinis*.

5.3 Life History

Black mudfish breed in spring (typically September to November). Eggs are deposited on submerged vegetation. Juveniles develop in the same wetland habitat. The species is non-migratory and confined to freshwater throughout its life cycle. Aestivation through dry periods involves burrowing into damp substrate or vegetation, with adults capable of surviving extended dry periods (weeks to months) under suitable conditions.

5.4 Threats

- Habitat loss through wetland drainage and conversion to pasture or development.
- Predation and competition for habitat by both exotic pest fish, particularly *Gambusia*, and native *Anguilla* spp. (eel).
- Water quality decline from nutrient and sediment loading.
- Hydrological alteration including reduction or elimination of seasonal wetting and drying cycles.
- Habitat fragmentation reducing connectivity between populations.

6.0 Existing Black Mudfish Values

6.1 Black Mudfish within Project Area

Black mudfish presence and habitat was assessed within the Project Area over a period of five years between 2021 and 2025. The assessment combined environmental DNA (eDNA) and Gee-minnow trap surveys. The trapping methodology followed the approach used in the Mudfish Management Plan prepared for Hamilton City Council for the Rotokauri Greenway Project (Beca and Tonkin & Taylor 2022). It involved the overnight setting of ten un-baited Gee-minnow traps (3 mm fine wire mesh) per 100 m in shallow water of drains that were identified as providing suitable habitat.

The Project Area contained c. 16,192 m of artificial drain in addition to the Mangaheka Stream and Te Otamanui Stream. The drains were constructed over the past century to support pastoral drainage and farming activities. Black mudfish were recorded from c. 3,582.5 m of the c. 9,398 m of drains that provided suitable habitat and were trapped (c. 38.12%). The entire length of a drain was counted towards the total if one or more black mudfish were recorded across traps in the reach and this was a conservative approach.

Characteristics of drains identified as black mudfish habitat included:

- Straight channel alignments, uniform widths within each drain with a range of 0.3–1.4 m across all drains, and channel depths ranging from 0.07–0.26 m.
- Slow-moving or stagnant flow with seasonally variable water levels.
- Fine sediment substrate with organic accumulation in many sections.
- Riparian vegetation cover limited to primarily exotic grass.
- Connectivity to the wider Mangaheka or Te Rapa / Empire drainage network.

6.2 Habitat Categories

Artificial drains across the site have been classified into categories of high, moderate and low habitat quality based on habitat characteristics, the confirmed presence of black mudfish and connectivity (Figure 2). The classification informs the management response required for each section of drain affected by the works (Table 3).

Table 3: Drain habitat categories

Habitat category	Approximate length	Definition	Effects management response
High	3,582.5 m (drains where black mudfish confirmed: M1, M4, M5, M7, M11, M12 on TKE; T2-T7 on Empire; plus 850 m NZTA road reserve drain)	Confirmed black mudfish presence; high-quality habitat; significant population likely	Avoid where possible; if works required, comprehensive capture and translocation; created habitat at no less than 1:1 ratio
Moderate	c. 5,818 m (within 9,398 m of trapped potential habitat where mudfish not detected; population presence cannot be ruled out)	Potential presence; suitable habitat features; connectivity, population may be present at low density	Capture and translocation.
Low	c. 6,794 m (drains outside the 9,398 m of potential habitat; no suitable habitat features)	Habitat features absent or marginal; no detections; species unlikely	Pre-works inspection only; standard fish management procedures as per TKE-FMP-001 sufficient

Figure 2. Black mudfish habitat quality in watercourses on Site.

7.0 Effects Management Strategy

Management of adverse effects on black mudfish will follow the effects management hierarchy of avoid, minimise, remedy, offset, compensate (NPS-FM 2020). The priority will be to avoid adversely impacting drains known to contain black mudfish where practicable. Where avoidance is not possible, the extent of the drains to be impacted will be offset. The length of black mudfish drain habitat to be impacted will be offset through the creation of artificial habitat onsite within the development footprint (Figure 3). This habitat will be created in advance of the impacts. Detailed concept design of the black mudfish habitat creation is outlined in Section 8.0 below.

Figure 3: Location of constructed black mudfish wetland.

8.0 Black Mudfish Habitat Design and Construction

8.1 Introduction

Wetland design was prepared by WGA with input from Ecological Solutions to create at least 3,582.5 m² of black mudfish habitat within the site. Black mudfish habitat will be created in the southeastern portion of the site and will have a total area of 3,582.5 m², so will be equivalent to area of confirmed black mudfish habitat impacted.

The proposed design aims to maximise the amount and quality of black mudfish habitat created and will allow for seasonal fluctuations in water level, provide overhanging vegetation for shade and shelter, and be designed to maximise predator exclusion.

The proposed design is shown in Figure 4 and Figure 5.

- Location of created black mudfish wetlands relative to groundwater and adjacent existing potential habitat and mudfish populations.
- Design principles and wetland dimensions.
- Maximum and minimum water levels.
- Detail of wetland habitat features including planting, woody debris placement, floating wetlands, and creation of permanently wet areas.
- Details of wetland maintenance including weed control and plant maintenance during establishment.

8.2 Location of Created Black Mudfish Habitat

The location of the proposed created black mudfish habitat was selected as it is in the vicinity of an NZTA drain that is known to currently support black mudfish, so it indicates the underlying geology and hydrology in this area is suitable. The area where proposed black mudfish habitat will be created is long and relatively narrow so the proposal is to construct a series of discrete wetland habitats that will not be connected within the wider swale or conveyance network. Created wetlands will not be connected with existing watercourses or those with existing black mudfish populations (i.e. offline) in order to minimise threats from predation.

8.3 Design Principles and Wetland Dimensions

Black mudfish wetland habitat will be created by constructing and enhancing two discrete wetlands (Figure 4). Each of the discrete wetlands will be disconnected from each other and will not form a single wetted area during wetter seasons. Concept plans showing the proposed black mudfish wetland habitats are presented in Figure 4 and Figure 5.

Constructing discrete black mudfish wetland habitats within the wider swale will allow each wetland to be managed and monitored separately and will minimise the overall impact if any of them fail or are affected by pest or unwanted fish species (i.e., eradicating or relocating fish from discrete wetlands will be more manageable).

Each of the discrete black mudfish wetland habitats will be constructed along the base of the swale as relatively narrow habitats with variable widths and depths and with a meandering pattern to maximise habitat diversity. Black mudfish wetland habitats will be constructed with variable depths to allow surface water to be present in deeper areas in

summer and a range of plants with varying tolerances to water inundation to be planted. It is envisaged that shallower areas within each wetland will be planted with wetland species that can tolerate being out of water (i.e., in summer) but also being flooded and provide habitat in wetland seasons.

The base of created black mudfish wetlands will be lined with a layer of peat that black mudfish can burrow into if required. Impermeable troughs lined with a layer of peat will be installed in deeper areas in each wetland to retain surface water during dry conditions and provide a refuge for black mudfish. Troughs will be lined with a layer of peat to provide a substrate that black mudfish can burrow into if required.

Peat-lined troughs were included in the created black mudfish habitats at Lake Waiwhakareke and provide a final refuge when there are droughts or periods when there is less surface water. Peat-lined troughs allow black mudfish to move into, if required, and survive these dry periods.

Being peat lined and with woody debris, the troughs provide an environment that will retain surface water more than surrounding habitat as they are disconnected from groundwater and retain enough moisture for black mudfish to aestivate if needed.

Incorporating peat-lined troughs with woody debris within created habitats will increase the chances of long-term population survival and account for extreme weather events (i.e., droughts) by providing a final refuge that the current drain network does not.

Black mudfish wetland habitats will be relatively narrow (as opposed to wide) and will maximise the amount of perimeter to surface water area so that wetlands can be better shaded by bankside vegetation to reduce the potential for elevated water temperatures, provide the overhead cover that black mudfish prefers and increase the amount of near-water vegetation to provide a source of organic matter (e.g., woody debris, leaf litter).

Black mudfish wetland habitats will be planted with older plants to ‘kick-start’ the establishment of shade and organic matter inputs to each wetland. Low stature plants (e.g., sedges) will be densely planted along the edges of each wetland to provide near edge shade and cover. Shade cloth may be installed over planted wetland habitats to minimise the potential for elevated water temperatures, protect relocated black mudfish from potential bird predation and to protect plants.

Figure 4. Concept of constructed black mudfish wetlands.

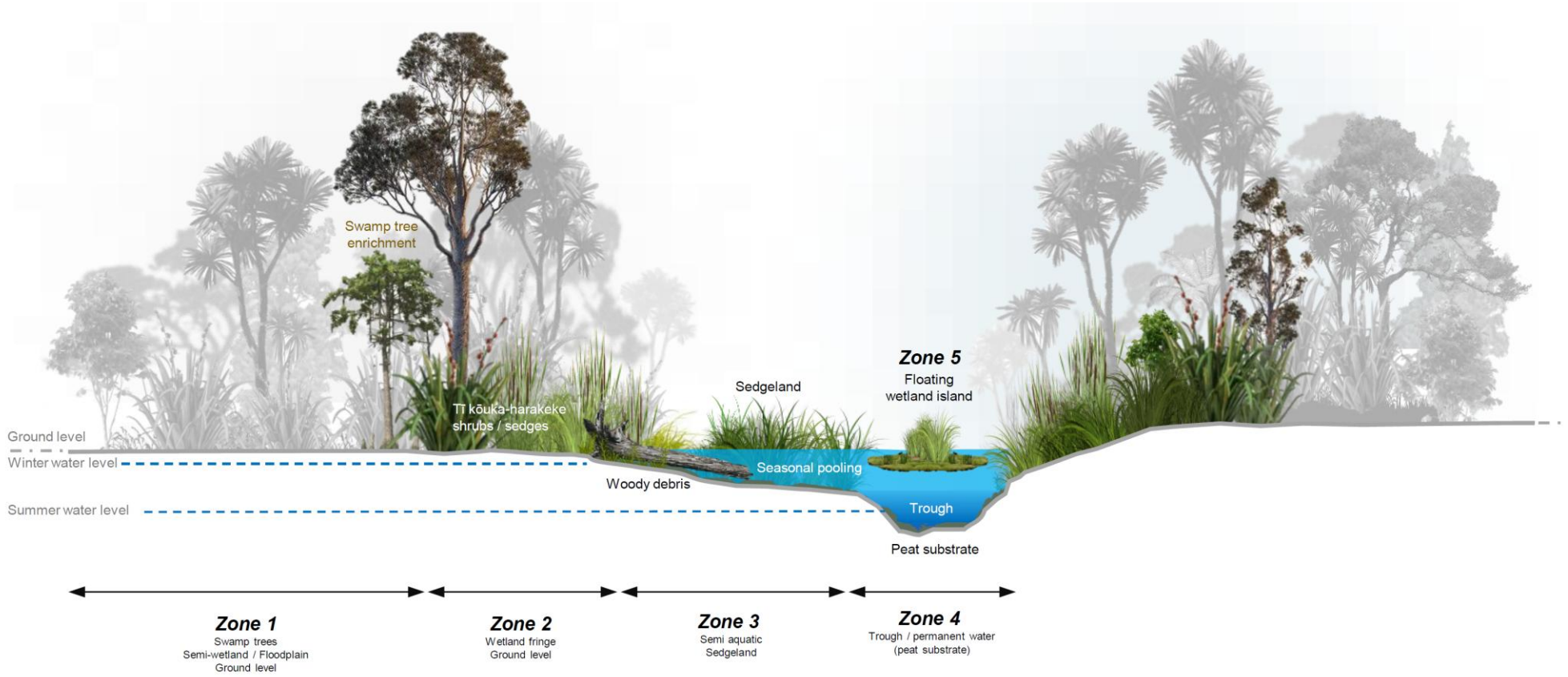

Figure 5. Concept showing cross-section of constructed black mudfish wetland.

8.4 Water Levels

Constructed black mudfish wetland habitats will primarily be fed by groundwater. The aim of the design is to create discrete disconnected wetland habitats that will limit the potential for other fish species to enter and compete or predate black mudfish. Water levels will be controlled by local groundwater conditions. Prior to construction, groundwater depths will be further monitored (i.e., winter, early spring) to inform the final location and depths of each discrete wetland within the wider swale.

Black mudfish habitat will be created by lowering the ground level via earthworks to intercept groundwater to provide a source of surface water within the wetland. Created habitat will aim to have a range of water depths and provide suitable black mudfish habitat over a range of hydrological conditions and account for seasonal variability in surface water levels. Initial hydrological investigations by WGA (2026) have found groundwater in the proposed black mudfish wetland habitat creation area to range between approximately 0.9–2.2 m below the existing ground level. Further field investigations and/or groundwater modelling of groundwater level fluctuations will be undertaken to inform final excavation depths.

Water levels within the created black mudfish wetlands are anticipated to range seasonally between 27.5–28.5 m RL (Figure 6) and provide permanent and intermittent habitat over a range of hydrological conditions (WGA 2026). In winter, wetland areas will have standing water at or just below the depth of the surrounding ground level. In summer, there may be no water or only shallow water in shallower areas of the wetlands but permanent water however be maintained in troughs installed in deeper portions of each wetland to provide a refuge for black mudfish. Additional groundwater level monitoring will be undertaken within the identified enhancement area with shallow (<2 m) piezometers installed by a hydrogeologist to determine local groundwater conditions more accurately and to ensure that wetland depths comply with resource consent conditions that require the depth to be set at the summer groundwater level.

8.5 Habitat Enhancement Features

Previous studies have shown that mudfish are associated with cover and particularly vegetative cover. Several methods will be used to provide cover for black mudfish within created black mudfish wetland habitats (e.g., impermeable troughs to retain surface water in summer, layer of peat, woody debris, wetland vegetation). These features will also provide habitat and substrates for zooplankton and macroinvertebrates that will provide a source of food for black mudfish and increase overall biodiversity within created wetlands.

8.5.1 Woody debris habitat enhancement

Woody debris (e.g., tree branches, stumps) habitat enhancement will occur throughout wetland areas and within troughs installed in deeper areas of each wetland. Woody debris will be installed by or under the direct guidance of the project ecologist. Large pieces of wood such as trunks and stumps will need to be sourced and transported to the site. Woody debris may include weed species but consideration will need to be given to ensure it is dead wood and poses no issue regarding re-sprout.

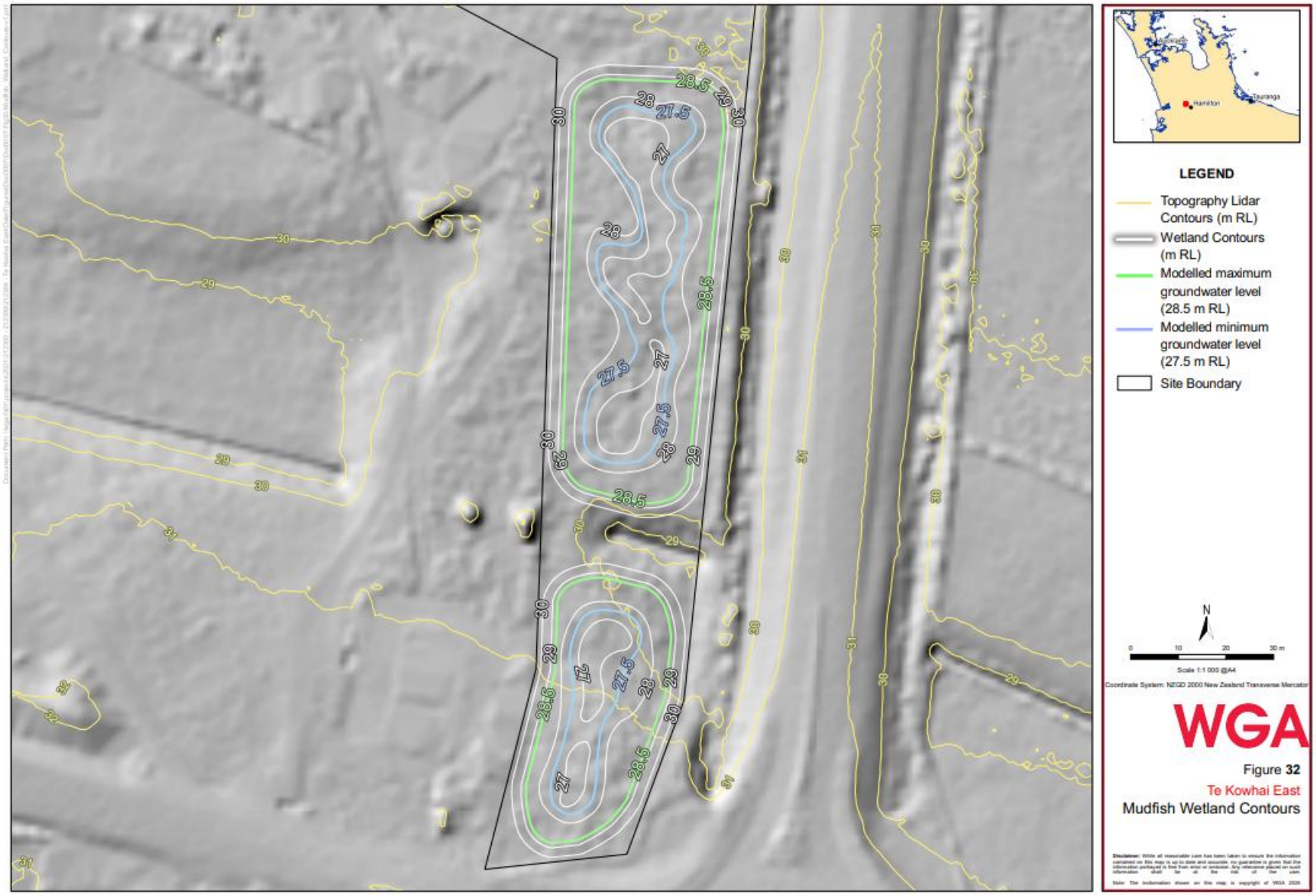

Figure 6: Groundwater contours of the proposed black mudfish habitat.

8.5.2 Vegetation establishment

To aid in the rapid establishment of cover, edge vegetation and habitat for black mudfish, vegetation such as *Carex secta* will be planted. To improve habitat complexity within wetlands, vegetation can be established within wetted areas using hay bales as a planting media. Hay bales will provide a substrate and protect root structures from water logging until they are at a suitable depth to be self-sufficient (Burkepile 2016). Increasing habitat complexity by using such species (e.g., *Carex secta*) within the wetland will complement wetland plants around the shallower margins, placement of woody debris and overhead canopy shade. Riparian vegetation establishment is discussed below in Section 9.0.

8.5.3 Peat substrate

Peat will be added to all troughs and on the bed in deeper areas of each wetland. The layer of peat will provide a substrate for vegetation to grow in and also create suitable microclimates that black mudfish are known to prefer. The peat will be sourced or mined from a suitable environment and may contain suitable ecosystem components (e.g., zooplankton in diapause).

8.5.4 Floating wetlands

Floating wetlands have been used for water filtration and treatment purposes but are also known to have biodiversity benefits. Floating wetlands will increase the amount of cover for black mudfish and enhance overall wetland complexity and diversity by allowing plants to occur in areas where it may be difficult for them to establish due to deep water depths.

Floating wetlands may be constructed using sealed PVC piping to provide the necessary flotation with rooted emergent wetland plants growing in a non-woven geotextile mat. The aim is for floating wetlands to rise and fall with fluctuating water levels. As a minimum, floating wetland will be installed over each of the troughs installed in deeper areas and anchored so they remain over the surface area of the troughs in summer. Ideal species to be planted in floating wetlands include *Carex virgata*, *Carex secta* and *Cyperus ustalus.*

Floating wetlands will be maintained in accordance with the requirements for pest plant control and replacement planting in Section 10.2 to ensure they are functioning as intended.

9.0 Habitat Riparian Establishment Planting

9.1 Rehabilitation Concept

Revegetation restoration projects are based on the natural successional processes and incorporate ecological concepts such as colonisation, connectivity/fragmentation and ecological function. The planting at this site involves establishing pioneer shrub species around the open mudfish habitat areas by planting pioneer shrub species with the intention of fast-tracking canopy closure in anticipation of creating suitable growing conditions for taller broadleaf and conifer trees. In addition to this, revegetation will be required along the edges and within the scalloped-out areas with suitable wetland species, adapted to permanently and intermittently wet habitats, will be required to provide cover and shade.

The choice of pioneer shrubs selected for revegetation planting is limited by plants that are suited to artificial propagation, and in this case species that are adapted to wet or moist soil conditions. Mānuka *(Leptospermum scoparium agg*.) is a common New Zealand pioneer species that propagates well and grows in damp conditions.

The first goal of revegetation planting within the site is to achieve canopy closure by

planting with a high proportion of pioneer species, keeping in mind that the process of achieving closure typically takes between 2–5 years. Additional time is required if weed control measures are ineffective, soil fertility is poor, inappropriate plants have been chosen, or plants are in poor health, were poorly planted or were planted at only low densities.

Adverse weather conditions (drought or flood) can also delay achievement of canopy closure. Obtaining canopy closure reduces weed seed germination and provides sheltered conditions for other species to either establish naturally or be planted at a later stage. It also provides habitat, shading, filtration and stabilisation of the watercourses.

Forest remnants and local reserves (both protected and un-protected) in the area, are a potential source of local seed via wind and bird dispersal as well as a potential destination of seed from within the proposed planting areas. Birds will play a key role in future succession at the site and for that reason a range of species attractive to birds such as New Zealand flax *(Phormium tenax)* and fruiting *Coprosma* spp. have been included in the proposed species lists.

Eco-sourcing is a practice fundamental to the long-term success of a revegetation programme. Each ecological region has been defined by the underlying geology, landforms and soils which affect the plant species found within an area. The benefits of eco-sourcing include: the maintenance of local biodiversity/genetic variability, the plants are adapted to growing in local conditions and subsequently the threat of disease is lessened. All plants selected for the site will be sourced from the Hamilton Ecological District or failing that, the wider Waikato Ecological Region.

9.2 Plant Pest Control

It is envisaged that weed control and revegetation will be undertaken as part of the ongoing works to ensure that the delivery and outcomes are consistent. Ongoing weed control should be undertaken quarterly for three years following planting (and weed control measure will be monitored as detailed in Section 11.0).

9.3 Plant Species Selection and Zones

Plant selection will be in accordance with species found within the Hamilton Ecological District (Clarkson et al. 2007). Plants are to be sourced from the Hamilton Ecological District; or in specific instances; obtained within the wider Waikato Ecological Region where stronghold populations of these noted species persist i.e., cane rush (*Sporadanthus ferrugineus*) and/or wire rush (*Empodisma minus*) may only be available within the wider Waikato Ecological Region where stronghold populations of these species persist.

Species layout and assemblages follow site-specific vegetation zones based on geomorphic position, soil and moisture gradients identified during the site visit and following Clarkson et al. (2014; 2018). Revegetation and habitat enhancement is planned to accommodate the transition in ecological communities from wetland edge to drier riparian/buffer shrubland.

Sufficient species diversity will be present within the mix to create vegetation structure classes in distinct zones, providing ease for the planting and so the contractor can determine the position of plants in their preferred ‘micro-sites’ in general accordance with plant design illustrations presented in Figure 4 and Figure 5.

Plant selection for each zone will be based on:

- Their ability to establish quickly and provide a suitable habitat and shade.

- Their ability to tolerate hydrological fluctuations in water depth/ duration of wetness (e.g., permanent, intermittent and semi-dry conditions; summer and winter).
- Their ability to grow in a high or low light situation.
- Contribution to historical vegetation cover (e.g., specimen tree planting of swamp maire, kahikatea and pukatea).
- Their reliability/seed dispersal in establishing in revegetation plantings elsewhere.
- Their ability to add aesthetic and ecological value, and contribution to successional processes such as water filtration, aquatic/terrestrial fauna habitat and connectivity.

All plants selected are to be true to their name and species, healthy and free of disease, with no visible weed contamination or damage at the time of planting. Plant numbers indicated may vary depending on availability.

Plants should be equivalent (or no smaller) to those specified including: PB3/4, 1/2L, 1L, PB2, PB3 or PB5 (i.e., 20–60 cm tall at the time of planting. The plants for the wetland zone should be larger (PB5) to ensure rapid establishment.

Planting densities should be at 0.70 m spacing within wetland Zones 1, 1a and 2 to establish quickly. Densities of between 2-1 plants per m^2 are in line with the recommendations in the Planting Guide for Hamilton Basin, Department of Conservation guidelines.

The proposed planting areas will be separated into zones with the dominant species in each zone defined by the local growing conditions including the slope, drainage and water levels.

The plant species used in the black mudfish habitat creation at Lake Waiwhakareke for the Rotokauri Greenway project will be used as a guide for the restoration plantings within and on the margins of the mudfish habitat areas.

9.4 Guidelines

Plants will be planted in accordance with the following guidelines.

- The roots of kānuka and mānuka are sensitive to root disturbance so care will be taken to keep this to a minimum.
- All plants around the edges of the scallops are to be planted with a slow-release fertiliser tablet and care will be taken to ensure this does not directly touch the plants root mass. No additional fertiliser use is required.
- The area has a shallow water table (high groundwater level) and ongoing hydration will not be required.
- Plant holes are to be made three times the diameter of the plants root mass and at least one and a half times the depth of the root mass. Care will be taken to ensure no additional top soil is added around the base of the plants stem.
- Any rocks, rubble or undesirable debris is to be removed from the plant hole and once the plant is in, the hole will be backfilled with a mix of 100% topsoil sourced from the site.
- All plants will be soaked thoroughly before planting, and shall not be removed from their container until planted.
- Large tree species will be planted in small groups of 3–5 trees with mānuka between them to mimic a natural pattern and allow them to spread as they grow.

- The use of mulch in buffer areas is not required for the site initially, however its application later in the project has been left to the discretion of the developer and property owner. If it is to be used it would be confined to dry slope (buffer) areas only, where there is no risk of it ending up in the wetland. Only organic mulches are recommended. Grass clippings, sawdust and bark chip will not be used. The ground will be thoroughly wet/ sodden before mulch is applied.
- The use of staking or ties is optional.

10.0 Black Mudfish Capture and Translocation

10.1 Approach

The black mudfish salvage and translocation methodology is intended to manage effects on black mudfish only. While other native fish species may be salvaged while following this methodology it has not been designed to manage direct effects of construction of the Project on all native fish. This is because black mudfish are only found in specific areas of the project footprint as shown in Figure 2.

The Mangaheka Stream and 'low' category drains will utilise a different fish salvage methodology as outlined in the Fish Management Plan (Ecological Solutions 2026b).

The capture and translocation of black mudfish will be undertaken in two phases and be correlated with the specific earthwork stages of the project. The specific approach will include the following:

- Salvage of black mudfish within habitats that will be lost when the Project is constructed.
- Seed/stock habitats created to support new black mudfish populations as part of the mitigation measures outlined above

10.2 Objectives

- Minimise the number of fish directly injured or killed through construction of the Project.
- Establish new sustainable mudfish sub-populations to offset the loss of mudfish habitat through construction of the Project.

All capture and translocation activities will be supervised by a suitably qualified freshwater ecologist, herein referred to as the Project Ecologist, and in accordance with conditions attached to any required permits and approvals. At the time of writing the required permits and approvals include:

- A special permit from the Ministry of Primary Industries to capture fish using methods outside of amateur fishing regulations.
- An approval to transfer aquatic life under either section 26ZM(2) or (3) of the Conservation Act 1987.

10.3 Salvage

The black mudfish salvage programme will be undertaken through the following steps:

Timing and staging of salvage

The timing of black mudfish salvage work will depend on the construction schedule and weather conditions, but will ideally occur in late winter (early September through to mid-November) (Ling et al. 2013) The Project Ecologist shall consult with the Construction Site Manager to decide the start times for fish salvage activities, which must occur before construction works commence. These matters will need to be balanced in the timing and staging of the works. Ideally mudfish salvage should occur immediately prior to the commencement of any drawdown or drain reclamation.

The Construction Site Manager will provide at least 20-days' notice of the intended construction start dates. This notice period takes into account the 10-day notification period typically required for Ministry of Primary Industries (MPI) special permit conditions.

Work site isolation

Due to the patchy distribution of black mudfish sub-populations, salvage activities will occur at multiple salvage sites in accordance with the 'high' category class of drains within the Project Area (Figure 1). The potential for mudfish to re-enter sites where salvage has occurred is considered low due to the poor connectivity of the drains and the extend of earthworks and drawdown.

Stop nets or similar permeable barriers will be installed to isolate mudfish salvage activities. The location of the stop nets will be at the discretion of the Project Ecologist but should be no further downstream than the predicted drawdown footprint. The stop nets should have a mesh size no larger than 3 mm.

Fish capture

Salvage methodologies will be based on existing fish survey protocols and guidelines (e.g. Joy et al. 2013 and Ling et al. 2013). These protocols were designed to collect reproducible data rather than maximise the capture of fish and as such will be modified where appropriate to suit the salvage objectives. Trapping using non-baited fine-mesh fyke nets and Gee minnow traps will be the primary method of capturing mudfish. Hand netting may be suitable in situations where small juveniles are present or there is no instream cover present.

Depending on the water depth and area of drain habitat, the target trap density used will be nine fyke nets and 18 fine-mesh Gee minnow traps per 150 m of watercourse channel. The actual trap density used in each reach will depend on the available habitat, channel size and water depth. For example, fewer traps will be set in the reach if channel width is narrow and pool habitats are small. Where there is insufficient water depth or channel width to deploy fyke nets, extra Gee minnow traps will be deployed in their place. All fyke nets used will have an internal exclusion system to separate larger fish from smaller fish and reduce the risk of predation on black mudfish by eels.

Where there is a risk of night-time hypoxia (e.g., slow-flowing macrophyte dominated streams and/or wetlands), traps will not be fully submerged so as to allow the fish to surface breathe. Where possible, trapping should be timed to coincide with overnight rain as this is known to increase capture rates. Traps will be set over night and checked the following morning. Any pest fish species caught in the traps will be humanely euthanised and disposed of appropriately. Any native fish species will be recovered from the traps and transferred to holding bins. Eels will be kept separate from other native fish species.

Insulated bins will be used to hold mudfish if there is a risk that water temperatures in the bins may rise above 20°C in response to atmospheric conditions. Bubblers will also be used to maintain dissolved oxygen concentrations if concentrations drop below 6 mg/L. If temperature and dissolved oxygen conditions cross the above thresholds, black mudfish will

be transported and released immediately. Black mudfish will not be kept in holding bins for any longer than six hours. Fish capture and salvage will continue until the mean catch rate for black mudfish within a salvage site falls to less than 0.25 fish/net/night.

10.4 Release Sites

Fish salvaged from the project footprint will be released into the newly created mudfish habitats described above. This new habitat will be created to offset for black mudfish habitat loss and will also be undertaken for restoration/enhancement purposes. The newly created habitat will be of a higher quality compared to the habitat being lost.

Prior to the release of black mudfish, the habitat enhancements and newly created aquatic ecosystem will be assessed to ensure the habitat is suitable for the release of black mudfish. This pre-translocation assessment will be undertaken in accordance with the pre-translocation monitoring protocols outlined below in Section 11.3.

Mudfish will not be salvaged or released into the newly created habitat areas until the pre-translocation monitoring results confirm the ecosystem is suitable.

11.0 Monitoring and Maintenance

11.1 Plant Monitoring

Monitoring plant survival and the presence of plant pest species by a suitably qualified and experienced individual will occur approximately three months after planting has concluded to record survival and successful establishment.

Once plantings have established (after three months), monitoring will be undertaken at least once annually for five years (during spring or autumn).

An example monitoring report sheet is provided in Appendix A. Monitoring shall include, but not be limited to the following:

- Record success rates, including growth rate and number of plants lost and analysis of the distribution of losses.
- Record canopy closure, including notes on natural ecological processes such as the use of the area by birds and presence of natural native seedling establishment.
- Record plant health, noting any indicators of insect or disease damage.
- Include a running record of fertilisation and weed pest control.
- Include a running record on the replacement of dead plants.
- Comments on the conditions of fencing.

Monitoring reports will be submitted annually to WRC and will also make recommendations on any follow-up maintenance required in terms of the above (e.g., weed control, animal pest control, plant replacement (blanking), plant disease control, and fence maintenance).

11.2 Plant Maintenance

General Plant Maintenance

General plant maintenance will involve the following for the first five years:

- Control of insects and disease by treatment with an appropriate chemical.

- Removal of any damaged or diseased plant material (to prevent further spread).
- Fill of any soil compaction and sinkage around plants (common post planting once the soil has settled).

Plant Releasing

Plant releasing is the process of releasing young plants primarily from grass growth until they can either compete effectively or have over-topped less desirable species. Extensive plant releasing is not foreseen for the site as a canopy of mature exotic vegetation will remain mostly in place particularly in buffer areas which has shaded out most terrestrial grasses. However, should plant releasing be required, it will be completed using the following methods:

- Hand/manual releasing, which can involve the use of a scrub bar or hand tools to cut back grass and weed growth around plants which have or are at risk of becoming suppressed. This method is labour intensive but low risk to plant health.
- Spray releasing with herbicide, this method depends on the herbicide to be used and the skill of the contractor. Typically, selective herbicides such as Galant are able to be applied safely around/over most native species (excluding monocots such as cabbage tree, flax and *Carex* and *Cyperus* species). In the instance where spray releasing can reduce labour, incompatible species can be manually cleared as per manual release above.
- Non-selective herbicides (such as glyphosate) will not be used due to the high risk of spray drift and associated non-target mortality.

If spray releasing with herbicide is the method selected, the methodology in Section 9.2 will be applied.

Plant Replacement

A 5–10% mortality rate can be expected in revegetation plantings due to natural causes such as insect damage, frosts and drought along with mortality from animal pest damage and spray drift. Plant mortality of 5% is expected in the first-year post planting, followed by 3% in the second year, and a further 2% after the third year.

Plant Pest Maintenance

Plant pest control will be completed throughout the enhancement project over a duration of five years with a particular emphasis on keeping the pest species present in the site at low densities. Recommended weed control methods are discussed in Section 9.2, it is expected that pest plant control will be undertaken with the ongoing maintenance activities of the park.

11.3 Pre-translocation Release Site Monitoring

Initial black mudfish monitoring will be undertaken using eDNA at the newly created mudfish habitat areas. Pre translocation monitoring will be undertaken to ensure that newly created habitat areas do not already contain pest fish prior to the release of salvaged mudfish. This monitoring will be undertaken between 1 June and 31 October when/if standing water is available and will include setting traps and the collection of eDNA.

eDNA Survey

eDNA sampling will be used to assist with establishing the presence of pest fish within the release sites. Composite eDNA samples (where samples from multiple sites are pooled and

a minimum of 3 replicate samples filtered) and will be collected from clusters of habitat areas to identify which areas may be supporting pest fish and to help target the use of Gee-minnow trapping effort. Samples will be analysed for comprehensive multi- species analysis to ensure they detect the presence or absence of the following species: shortfin eel, longfin eels, brown bullhead catfish, gambusia and zooplankton/crustacean species.

If the pre-translocation monitoring determines the presence of resident predatory fish such as shortfin eels, surveys will be undertaken to remove predatory fish before black mudfish are released into the enhanced sites. This will be undertaken using fine mesh fyke nets with specific protocols and methods provided in the Fish Management Plan (FMP) (condition 10). Specific fish capture and handling procedures for native fish will also be provided in the FMP (Ecological Solutions 2026b).

Reporting

The black mudfish monitoring results will be reported annually to the WRC within 1 month of the completion of the survey. The report will include:

- Fish species caught.
- Number caught (including any accidentally killed).
- Length.
- Health/condition.
- Location of capture (GPS coordinates).
- eDNA survey results (reported as number of eDNA reads).
- Invertebrate/zoplankton survey results (taxa and abundance).

11.4 Post-works Black Mudfish Monitoring

The post wetland enhancement monitoring will be carried out for five years, with the results reported annually to WRC by 31 October. Post wetland enhancement monitoring will be carried out at least annually for a period of 5 years and include:

- Wetland water levels and extent of wetted marginal areas.
- Wetland and riparian planting establishment (covered in Section 8.2).
- Food source and abundance for relocated mudfish (eDNA).
- The presence or absence of predatory fish (shortfin eels).
- The persistence and reproduction of relocated mudfish at discrete relocation sites, using eDNA and trapping.

For mudfish monitoring, this will include eDNA sampling every year and trapping for the first three consecutive years and in the fifth/final year, up to a total of four trapping rounds.

Measurement of Success

The wetland enhancement will be deemed ‘successful’ when monitoring can demonstrate that the relocated mudfish are persisting and reproducing. This will be determined when trapping fish length data demonstrates that multiple size classes of mudfish (including juveniles) are present (and are therefore reproducing) in any enhancement sites developed under this consent where mudfish were not previously identified prior to relocation. This may be supported, if required, by eDNA samples (standardised by volume filtered) where the number of reads demonstrates a stable or increasing mudfish population after at least

three years following relocation. 'Success' will be determined by a suitably qualified and experienced freshwater ecologist using a range of methods and tools.

Wetland Water Levels and Extent of Wetted Marginal Areas

Groundwater level piezometers will be installed within the enhancement areas following mudfish release. The minimum and maximum water levels within selected scalloped out areas will also be measured annually for five years using a metre ruler during the mudfish surveys (trapping and eDNA). These measurements along with groundwater monitoring records will be used to determine if alterations to depth of the scalloped areas are required.

Food Source and Abundance for Relocated Mudfish

The food source and abundance for relocated mudfish will include an assessment of the zooplankton and macroinvertebrates present in the enhancement areas by collecting composite sweep net samples in each of the wetland areas. Samples will be collected using a sweep (mesh size 500 µm) in accordance with the WRC protocol for soft-bottomed habitats (Collier and Kelly 2005).

The following macroinvertebrate metrics and indices were assessed:

- *Community composition* – relative abundance of the main taxonomic groups making up the macroinvertebrate communities recorded from each site.
- *Taxa number* – a measure of the overall health of the benthic macroinvertebrate community and habitat and water quality.
- *Abundance* – a measure of the total number of individuals in a sample.

A suitable zooplankton population is important as newly hatched larvae are 4-9 mm long and can generally only consume small prey such as zooplankton immediately (Eldon 1978). Assessment of the macroinvertebrate population is important as they provide a food source to adult mudfish.

Gee-minnow Trap Survey

Fine wire mesh (3 mm) un-baited minnow traps will be set overnight in the newly created scalloped out areas and in the immediate lake edge/wetland areas. Each trap will be numbered and the location of each trap will be marked by GPS to ensure the same locations are sampled over time and at approximately the same water level and time of year to demonstrate persistence/reproduction.

eDNA Survey

eDNA sampling will be used to assist with establishing the black mudfish distribution at the restoration site. Composite eDNA samples will be collected from clusters of scalloped out areas to identify which scalloped out areas are supporting black mudfish and to help target the use of Gee-minnow trapping effort. Samples will be couriered to Wilderlab Ltd within 24 hours of collection.

12.0 Reporting

The black mudfish monitoring results will be reported annually to the WRC within 1 month of the completion of the survey. The report will include the completed inspection checklist for plant monitoring and maintenance as well as the inspection checklist for the habitat creation areas (Appendix A) which will include the following specific information:

- Fish species caught.
- Number caught (including any accidently killed).
- Length.
- Health/condition.
- Location of capture (GPS coordinates).
- eDNA survey results (reported as number of eDNA reads), including presence or absence of predatory fish (shortfin eels).
- Invertebrate survey results (taxa and abundance).
- Further monitoring recommendations and/or remediation proposals if the monitoring shows that works have adversely affected black mudfish.

13.0 Adaptive Management Protocols

13.1 Introduction

An adaptive management approach is a structured, iterative way of managing uncertainty. While the black mudfish habitat creation design and principles used here are based on successful experiments previously consented for different projects, there is inherent uncertainty in the outcomes attributable to the proposed habitat creation for the Te Kowhai East Industrial Development.

The core principles of adaptive management include clear objectives, specific management actions, monitoring and evaluation followed by decision rules.

The objectives of the black mudfish habitat creation are identified in Section 1.3.

The specific design and management actions are outlined in Section 8.0.

The monitoring protocols for pre and post release including performance criteria are outlined in Section 11 and Appendix A.

The decision rules or triggers are outlined below.

13.2 Decision rules

Detailed monitoring of pre and post relocation habitat conditions including hydrology, habitat enhancement features, zooplankton and macroinvertebrates, temperature, dissolved oxygen concentrations and presence of black mudfish adults and juveniles will form the criteria for habitat creation success. These performance criteria for the proposed design and management actions are outlined in the Monitoring Field Sheet for Mudfish Enhancement (Appendix A). Should any of the performance criteria fail to meet expectations, the performance outcomes will be documented and remediation actions designed in consultation with the Waikato Regional Council. Should residual effects persist after habitat creation and black mudfish release, alternative management and design factors will be reviewed and agreed to with Waikato Regional Council prior to implementation.

14.0 Roles and Responsibilities

Table 4: Summary of roles and responsibilities

Role	Party	Responsibilities
Consent holder	Te Kowhai East Ltd Partnership	Overall implementation, engagement of specialists, provision of monitoring reports, implementation of remedial measures and compliance with the certified BMHCP.
Freshwater Ecologist	Ecological Solutions Ltd	Habitat design input, pre-release suitability certification, black mudfish salvage and translocation, monitoring, interpretation of results and adaptive management recommendations.
Habitat Engineer	Maven Associates	Detailed habitat geometry and construction design, supervision, and as-built certification.
Hydrogeologist	WGA	Groundwater monitoring, hydrological design input, and assessment of wetland water-level performance.
Principal Contractor	To be appointed:	Construction in accordance with the certified BMHCP and engineering design.
Department of Conservation	DOC	Oversight of native species protection; receipt of monitoring reports.
Waikato Regional Council	WRC	Consent certifying authority; compliance monitoring; receipt of annual monitoring reports.
TWWG	TWWG	Mātauranga input into mitigation strategy and habitat design; receipt of monitoring reports.

15.0 Certification

This BMHCP shall be submitted to Waikato Regional Council for technical certification 20 working days prior to works affecting confirmed or potential black mudfish habitat commencing, in accordance with the relevant resource consent conditions.

The Consent Holder shall undertake the creation and establishment of replacement habitat, black mudfish capture and translocation, monitoring, and maintenance in accordance with the certified BMHCP. Monitoring will include the performance criteria outlined in the Monitoring Field Sheet for Mudfish Enhancement (Appendix A). Should monitoring signal that a residual effect remains after black mudfish habitat creation is completed, specific adaptive management measures will be decisioned in consultation with Waikato Regional Council.

Any material amendments to the certified BMHCP shall be submitted to Waikato Regional Council for technical certification where required by the resource consent conditions.

16.0 References

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APPENDIX A

Monitoring Field Sheets

MONITORING FIELD SHEET FOR NATIVE PLANTING

Example field sheet for completion and submission to Council if required.

Date (d/m/y)	
Resource consent number	
Address	
Property owner and contact details	
Has property changed owners in the last year, yes or no?	
If yes, who was previous owner?	
Fencing (if applicable)	
Condition	
Previous works undertaken	
Additional comments	
Survival Rate	
Percentage survival	
Growth estimate (cm/year)	
Percent ground cover	
Requirement for blanking (yes/ no)	
Distribution of plant losses	
Signs of disease or insect damage	
Additional comments	
Fertilization	
Date applied	
What used	
Areas applied	
Quantity used	
Additional comments	

Weed control	
Date undertaken	
Sprays used	

Weeds targeted	
Areas targeted	
Additional comments	
Replacement planting	
Date undertaken	
Species being replaced	
Species planted	
Number of plants replaced	
Additional comments	

Problems *(for example are certain weeds proving difficult to control and detrimental to the planting, are animal pests causing significant problems)*

Nature of problem

Recommended solutions

Analysis of plant losses (are losses greater than expected, are there any obvious reasons, are losses in certain areas, are certain species showing high losses, what are possible solutions?)

MONITORING FIELD SHEET FOR MUDFISH ENHANCEMENT

Example field sheet for completion and submission to Council if required. Multiple comma separated values can be displayed.

Date (d/m/y)	
Resource consent number	

Cluster number	**A**	**B**	**C**	**D**	**E**	**F**	**G**
Water present (y/n)							
Average water depth (m)							
Enhancement features present and functioning (y/n)							
Zooplankton and macroinvertebrates present (y/n: quick check with a net)							
Temperature							
Dissolved oxygen concentration							
Pest fish present (y/n)							
Black mudfish present (adults/Juveniles (y/n))							

Inspection of troughs	**1**	**2**	**3**	**4**	**5**	**6**
Peat substrate condition - check depth, signs of anoxia etc.						
Enhancement structures present and functioning (y/n)						
Other vegetation present and condition						
Zooplankton and macroinvertebrates present (quick check with a net)						
Temperature						
Dissolved oxygen concentration						