Cromwell Bottom Lagoon – Ecological Impact Assessment of Options

Final report

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Contract

This report describes work commissioned by Robin Dalton on behalf of Calderdale Metropolitan Borough Council. Rebekah Beaumont, Jen Jones and Steven Heathcote of JBA Consulting carried out this work.

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Purpose

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Executive summary

Cormwell Bottom is a Local Nature Reserve developed on re-excavated Pulverised Fuel Ash in the Calder Valley between Elland and Brighouse. JBA Consulting was commissioned by Calderdale Metropolitan Borough Council to carry out an Ecological Impact Assessment of various options to improve the condition of the regionally important reedbed and lagoon on the site.

Proposals assessed include (1) do-nothing, (2) import of water from the River Calder, (3) import of water from the Calder and Hebble Navigation and (4) a reprofiling of the lagoon bed to create islands and deeper pools of water.

An Ecological Impact Assessment has been completed following CIEEM's best practice guidance. This involved identifying key ecological features and project impacts for each option. Each combination of potential impact and ecological features were assessed, then combined to give an overall impact for each of Options 1-4.

The baseline for ecological features was identified based on a series of past reports, including habitat mapping and a condition assessment, invertebrate surveys and breeding bird surveys carried out for the project in previous years. A total of 23 ecological features were screened in.

The assessment of effects on the features identified a range of positive and adverse impacts for each option for the construction and operational phases of the project. Negative impacts before mitigation included disturbance, pollution, introduction of fish, habitat change from altered hydrology. Mitigation is suggested to avoid or reduce these effects as far as possible. No cumulative impacts are identified.

The mitigated impacts show that do-nothing is likely to result in a slow change of the site with the loss of the most valuable habitats, particularly reedbed, lagoon and mire habitats. Importing water prevents these effects, and once mitigation is included, significant benefit to the wetter habitats can be achieved, with only a small negative impact on the lowest-lying dry woodland and its notable plants. Reprofiling the lagoon can also achieve positive impacts although there is uncertainty about the impacts of remobilising PFA.

Overall, the project can achieve a significant positive impact for Cromwell Bottom Nature Reserve and the species and habitats within it by undertaking any of the active intervention options. There is relatively little difference between the options, and consideration of water supply and consenting are likely to be more important in selecting the preferred option.

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Abbreviations

BAP	Biodiversity Action Plan
BoCC	Birds of Conservation Concern
BTO	British Trust of Ornithology
CEMP	Construction Environmental Management Plan
CIEEM	Chartered Institute of Ecology and Environmental Management
CHN	Calder and Hebble Navigation
CMBC	Calderdale Metropolitan District Council
CSM	Common Standards Monitoring
EcIA	Ecological Impact Assessment
ERDF	European Regional Development Fund
INNS	Invasive Non-Native Species
LNR	Local Nature Reserve
LWS	Local Wildlife Site
NCS	Nature Conservation Status
PBDE	Polybrominated diphenyl ethers
PFA	Pulverised Fuel Ash
PFOS	Perfluorooctane sulphonate
RDB	Red Data Book
SEGI	Site of Ecological or Geological Importance
VC63	The Watsonian vice-county of South-east Yorkshire
WFD	Water Framework Directive
WYES	West Yorkshire Ecology Service
ZoI	Zone of Influence

1 Introduction

1.1 Purpose of this report

JBA Consulting was commissioned by Calderdale Metropolitan Borough Council (CMBC) to carry out an Ecological Impact Assessment (EcIA) of habitats at Cromwell Bottom Local Nature Reserve (LNR) and a review of the species of ecological importance recorded at the site in order to inform proposals to improve the habitat condition as part of a European Regional Development Fund (ERDF) project.

1.2 Site Location

Cromwell Bottom Local Nature Reserve is located between the Calder and Hebble Navigation and the Calder Valley Railway, on land adjacent to the meandering River Calder, between Elland and Brighouse. The proposed scheme will focus on a central section of the reserve around a lagoon and reedbeds, in an area known as the Brookfoot Loop. The section to the southwest, south of the Calder, is known as the Tag Loop. The reserve is located around Ordnance Survey grid reference SE127222 and the location and features referred to are shown in Figure 1-1.

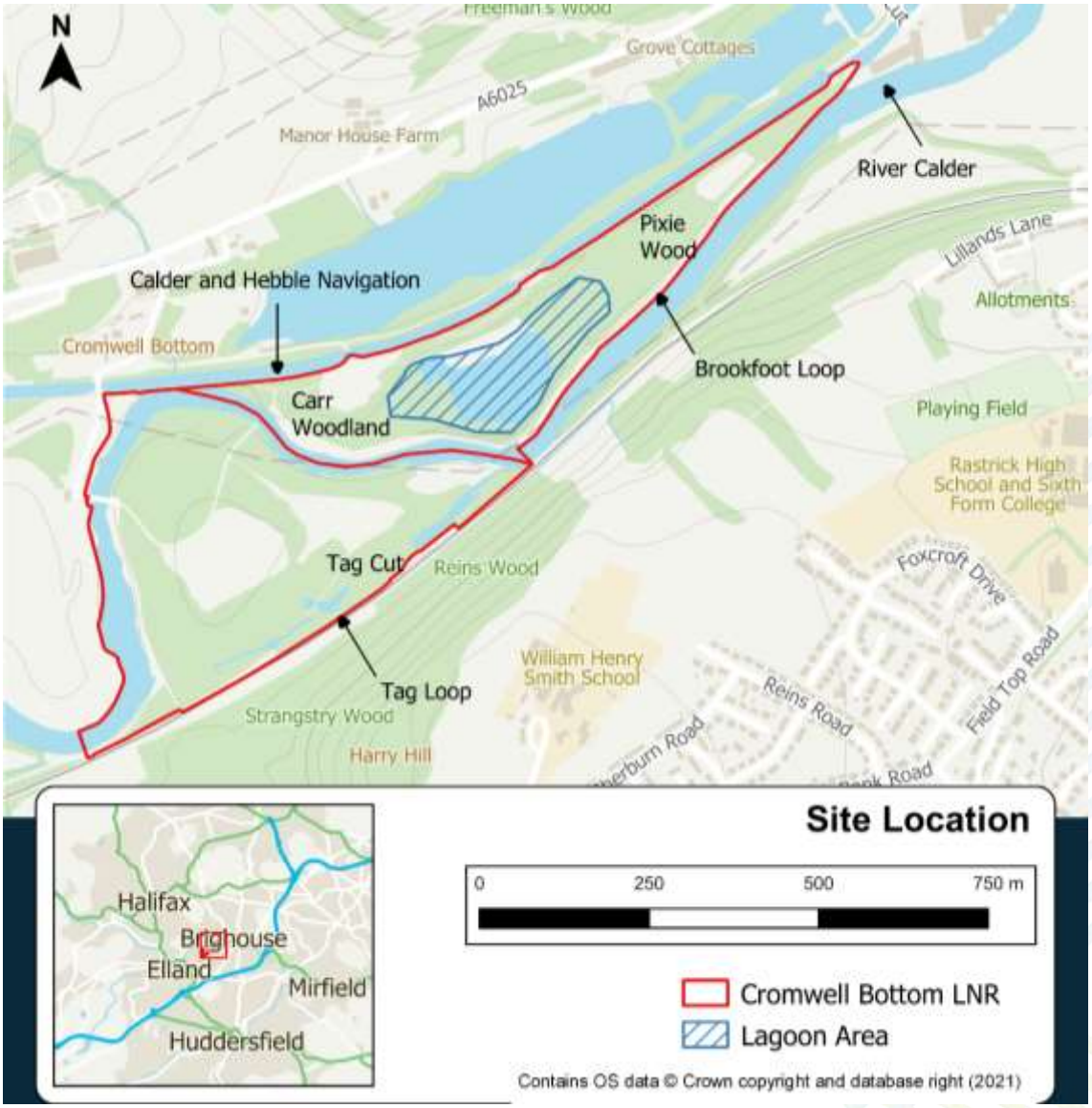


Figure 1-1: Site Location

1.3 Cromwell Bottom LNR History

The history of the site plays an important role in understanding the current habitats and their condition, and is summarised in Wilson (2017) as follows:

"Cromwell Bottom NR extends for approximately 30 ha on land that has been subject to complex disturbances over the last six decades. During the 1950s and 1960s, the glacial gravels were extracted for the building industry and then subsequently infilled with coal washery tailings, Pulverised Fuel Ash (PFA) or used as sludge lagoons during the operational period of the coal-fired Elland Power station (1960s to late 1980s/ early 1990s). Subsequently, the PFA was partially extracted to provide material for the construction of the M62 before some of the gravel pits were infilled with landfill and subsequently capped; or filled with water and managed for angling. However, the sludge lagoon, which is roughly central to Cromwell Bottom NR, was left in situ though landscaped with its mix of PFA, gravels and other materials and subsequently developed a mosaic of vegetation communities which were recognised as supporting regionally important flora and fauna, which is partly considered to be a consequence of its past use."

The site has been managed for nature conservation since 2000, when the first site management plan was produced (Calderdale Council 2000) and now comprises a mix of habitats in a publicly accessible nature reserve.

The PFA substrate is initially calcareous but over time the amount of available calcium decreases, and water testing in 2005 showed that the pH of the lagoons was circumneutral (JBA Consulting 2005). In addition, PFA potentially contains high levels of phytotoxic heavy metals, but these are locked into a relatively stable material and are not easily leached into the environment (University of Huddersfield 2021).

2 Scheme Proposals

The overall aim of the project is to improve the condition of the habitats on site, notably the reedbed, by providing the option of making the lagoon a permanent waterbody, or at least increasing the length of time it holds water, instead of it drying out annually, an aim which stretches back to the site management plan from the year 2000 (Calderdale Council 2000). To achieve this, water would need to be imported into the lagoon, and the options under consideration are all to achieve this. Options have been appraised in a series of reports including a water level management feasibility assessment (JBA 2005), a hydro-ecological assessment (MRB Ecology and Environment 2005) and a flood risk assessment (JBA 2019). A Water Level Management Plan (WLMP) is being prepared concurrently with this EcIA by JBA Consulting. The feasibility studies were largely aimed at providing a year-round water supply for the lagoon and increasing wetness in some of the adjacent areas of wet woodland. The options that have been developed and are considered in this report are:

- Option 1 – No active intervention. This considers the option of non-intervention. Under this scenario the water levels would continue to fluctuate naturally, with the water table falling below the surface in summer. Natural succession would continue to operate, checked by occasional management in the form of reed cutting.
- Option 2a – Water extraction from the River Calder using natural flood flows. This option would require lowering some areas of embankment between the river and the lagoon at the western end of the Brookfoot Loop. This would allow water from the river to enter the site in times of high river flow, but at lower levels than currently. The water would find a natural path through the Carr Woodland to the lagoons, with some opportunity for filtration and settlement. There is the possibility in this option of replacing the woodland with reedbed to increase filtration of the incoming water. This means an increased water supply, although there would be relatively little control over such flows.
- Option 2b – Water extraction from the River Calder using pumps. This option would require pumping water from the River Calder and would need installation of pumping equipment and pipes to get the water from the river to the lagoons.
- Option 3a – Water extraction from the Calder and Hebble Navigation at existing overflow structure. This option would require the installation of a pipe to take water by the shortest route from the Calder and Hebble Navigation to an outfall in Carr Woodland at the western end of the Brookfoot Loop. The water would flow into the Carr Woodland and be allowed to filter down to the Lagoons through the wet woodland. There is the possibility in this option of replacing the woodland with reedbed to increase filtration of the incoming water, although the existing woodland will probably provide similar ecological benefit. The water level in the Calder and Hebble Navigation is perched above the lagoons, so it is expected this system would work by gravity, and the current overflow often has a continuous low level of overspill, which could be directed on the nature reserve without changing water levels in the canal.
- Option 3b – Water extraction from the Calder and Hebble Navigation using new structure near viewing platform. A new structure could be installed at the shortest point between the Calder and Hebble Navigation and the Lagoons, allowing direct water transfer. The water level in the Calder and Hebble Navigation is perched above the lagoons, so it is expected this system would work by gravity.

- Option 4 – Lake topography profiling – This option would sit alongside any of the options relating to water import. It would involve excavation of the lake to increase storage volume and habitat area and re-using material to create islands within the lagoon. The current topography is based on an engineering specification when the PFA material was last extracted for road building. Changing topography to support biodiversity would be expected to enhance the lagoon. This would include a deeper water channel running through the area, creating an access ramp in the north-west corner of lagoon 1 and north-east corner of lagoon 2, and installing a stop log weir over the gap between lagoons 1 and 2.

The 2005 water level reports (JBA Consulting 2005) considered importing water from the lakes (fishing lake and water-ski lake) on the north-west of the Calder and Hebble Navigation as well as obtaining water from a borehole. These options were discounted by CMBC and are not considered in detail here. The impacts of extraction from the lakes would be broadly similar to Option 3, although the baseline condition of the lakes is not known, and the water supply would have the additional complication of having to cross the Calder and Hebble Navigation, and would require active pumping.

A summary of each option is provided in Figure 2-1.

2.1 Differences in water quality between the river, canal and lagoon

A key element of the project is understanding the impact of imported water on the quality of water in the lagoon. A water quality assessment was carried out in 2005 (JBA Consulting 2005) and repeated in 2021 (Appendix C). The 2021 survey of the lagoon at Cromwell Bottom was conducted at a time of very low water, which is considered likely to have resulted in a poorer water quality result compared to times when the water level is higher.

A summary of the water quality assessments is as follows:

- pH in each water body is circumneutral and has changed relatively little over time.
- Nitrates and phosphates are higher in the river than the canal, both are much higher than that concentrations in the lagoon, although organic nitrogen is much higher in the lagoon.
- Ammonia is comparable across all waterbodies, except an anomalous high reading in the lagoon in 2021.
- Dissolved calcium levels in the lagoon are around 5 times higher than either the canal or river, although the total calcium value in the lagoon in 2021 is itself around 50 times higher compared to 2005.
- The lagoon has higher levels of aluminium, potassium and magnesium, but comparable levels of sodium, compared to the canal and river.

This means that import of a reasonable volume of either river or canal water is likely to lead to:

- Dilution of calcium, although probably little change in overall pH;
- Increase in biologically available nitrate and phosphate; and
- Dilution of aluminium, potassium and magnesium.

At this point the River Calder, part of the Calder from Ryburn Confluence to River Colne Water Framework Directive (WFD) waterbody (GB104027062642) is assessed for water quality. In 2019 the river was failing the WFD for mercury, Perfluorooctane sulphonate (PFOS), Polybrominated diphenyl ethers (PBDE). Baseline levels of these chemicals in the canal and lagoon are unknown.

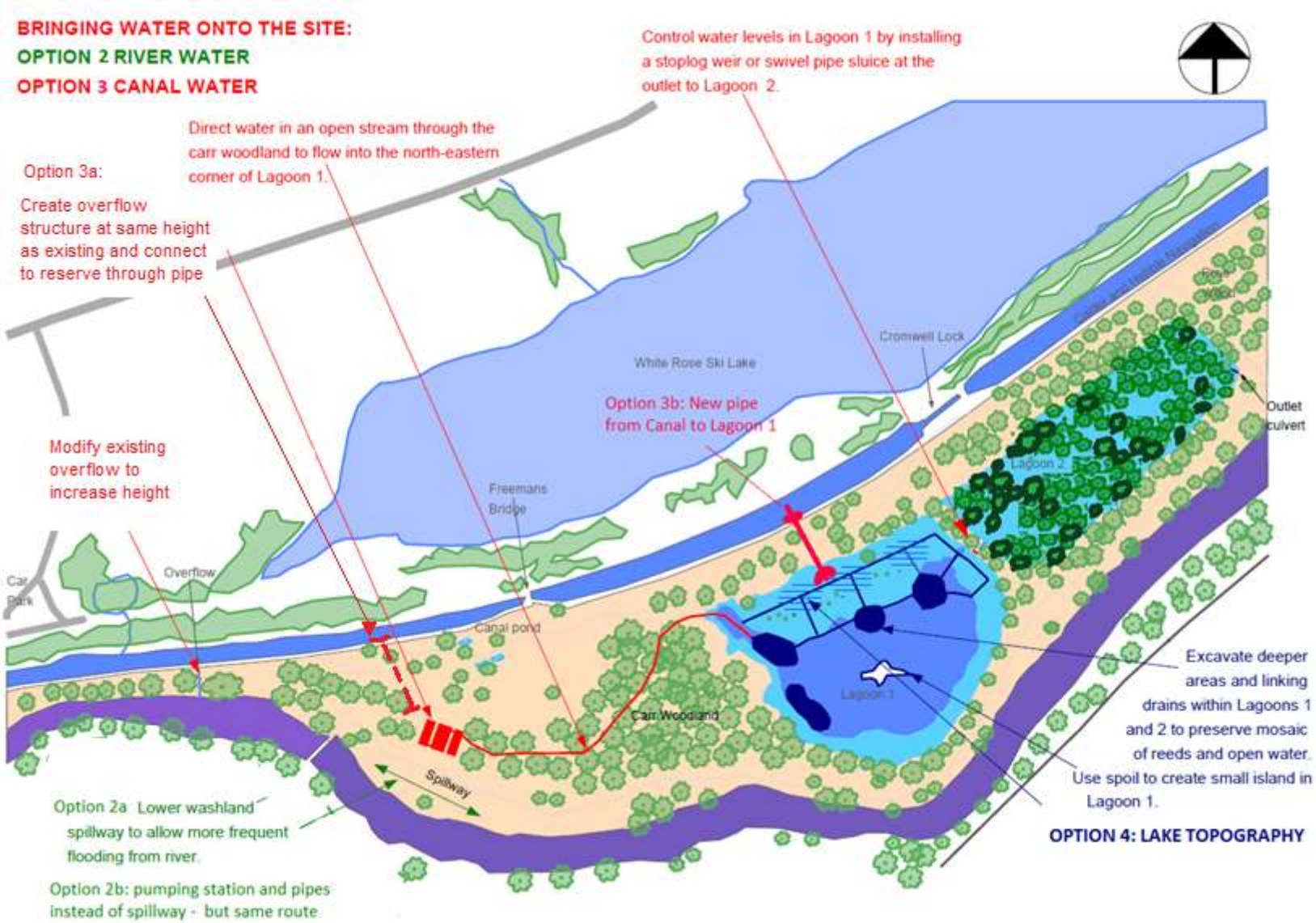


Figure 2-1. Illustration of Options 2, 3 and 4 modified from 2005 eco-hydrology study.

2.2 Project Zone of Influence

All of the options under consideration are relatively small-scale, likely to involve a small construction team and fleet, and with a small operational footprint. The options are unlikely to have any ecological impacts beyond the Cromwell Bottom Nature Reserve site, except on the watercourses. In these watercourses, potential impacts could extend upstream by around 500m and downstream by 1km. The Zone of Influence is therefore defined as the site plus a 1.5km length of the Calder and Hebble Navigation and River Calder up and downstream of the Nature Reserve.

2.3 Scheme consultations

Numerous consultations have taken place over a number of years but are not documented here. Where relevant, consultations with implications for the EcIA will be recorded in updated versions of the EcIA and addressed in report revisions.

3 Methodology

This EcIA has been undertaken in line with current best practice guidance (CIEEM 2018) and includes:

- Collating information from previous ecological reports and site surveys
- An assessment of the potential impacts of the works on the habitats and species present at the site and the surrounding areas.
  - Assessing the importance of ecological features affected and assigning these features geographical scales of importance.
  - Characterisation of impacts e.g. extent, magnitude, duration, reversibility, timing and frequency.
  - Identification of cumulative impacts.
  - Identification of significant effects of impacts in the absence of any mitigation.
- The design of suitable avoidance measures and mitigation to ensure ecological impacts are kept to a minimum.
- Proposals for suitable compensation and/or ecological enhancement measures.

3.1 Sources of information used to prepare the baseline

The ecological assessment is based on a search for existing information combined with field surveys. The different elements are discussed in the following sections.

3.2 Zone of Influence (ZoI) and data search area

The project zone of influence has been defined in Section 2.2 to be the site and 1.5km along connected watercourses. The baseline assessment has involved gathering data over a wider area, as biological records are often imprecisely located, and some of the species of interest are highly mobile (e.g. Otter). Therefore data has been collected from the area within a 1km buffer of the site and the River Calder and The Calder & Hebble Navigation canal both 2km upstream and 10km downstream of Cromwell Bottom. This covers areas impacted by water extraction, on site impacts and potential downstream impacts.

3.3 Desk-based assessment

Searches of databases containing ecological records, priority habitats, and information on statutory and non-statutory designated sites were made. The following sources were included in these searches:

- MAGIC mapping service (www.magic.gov.uk)
- Natural England GIS data (www.gis.naturalengland.org.uk/pubs/gis/GIS_register.asp)
- West Yorkshire Ecology Service (WYES)
- Environment Agency Ecology and Fish Data Explorer (https://environment.data.gov.uk/ecology-fish/)
- A bryophyte report (Blockeel, 2013), species lists available from the Cromwell Bottom Wildlife Group website (CBWG, 2020) and Species Audit for Calderdale (Duke & Firman, 2015).

3.4 Field Surveys

A number of field surveys have been carried out to provide baseline information about the ecological condition of the site. Details of these surveys are given in the relevant technical reports referred to in this text and listed in the project baseline (Section 4).

3.5 Method of impact assessment

The assessment of ecological impacts has been undertaken following current best practice provided by the Chartered Institute of Ecology and Environmental Management (CIEEM, 2018). This assessment identifies the potential effects of the proposed works on important ecological features, taken as a proxy for overall biodiversity, within the site boundary and wider zone of influence. It determines the significance of the potential effects for the construction and operational phases.

Ecological features include nature conservation sites, habitats, species assemblages/communities or populations or groups of species. The assessment of the significance of predicted impacts on ecological features has been based on both the 'importance' of a feature and the nature and magnitude of the impact that the project will have on it. Impacts may be direct (e.g. the loss of species or habitats), or indirect (e.g. effects due to noise, dust or disturbance).

The impact assessment process involves:

- Identifying and characterising impacts;
- Incorporating measures to avoid and mitigate (reduce) these impacts;
- Assessing the significance of any residual effects after mitigation;
- Identifying appropriate compensation measures to offset residual effects; and
- Identifying opportunities for ecological enhancement

The assessment includes potential impacts (direct, indirect, secondary and cumulative) on each ecological feature determined as important from all phases of the project and describes in detail the impacts that are likely to be significant, making reference to the following characteristics: Positive or negative; Extent; Magnitude; Duration; Timing; Frequency; Reversibility.

3.5.1 Important ecological features

It would have been impractical to assess the ecological impacts on every ecological feature that may be affected; instead the assessment focuses on those that are important. These are ecological features that are valued in some way and could be affected by the proposed project; other valued ecological features may occur on, or in the vicinity of, the proposed works area but do not need to be considered because there is no potential for them to be affected significantly.

Various characteristics were used to assess the importance of ecological features, for example, naturalness, rarity, diversity, and connectivity. This is done based on protected status, occurrence on national and regional red lists and the presence of species in the Calderdale Biodiversity Action Plan.

The nature conservation sites, habitats and species that have been identified as important ecological features have been evaluated based on the geographical frame of reference. The importance of the feature is defined with reference to the geographical context of the site i.e. the specific importance of the site to each of the habitats or species populations identified as being present within it or making use of it.

For the purposes of this assessment the following frame of reference has been used:

- International and European
- National
- Regional/County (i.e. West Yorkshire)
- Local (i.e. Cromwell Bottom and its vicinity)
- Less than local

Consideration of impacts at all scales is important, and essential if objectives for no net loss of biodiversity and maintenance of healthy ecosystems are to be achieved.

3.5.2 Legally protected species

Notwithstanding what has been said above, there is also a need to identify all legally protected species that could be affected by the proposed works. Therefore, it is inappropriate to assess the project's impacts within the context of species' legal protection, as the scheme will need to comply with legal requirements or in special circumstance may be able to apply for derogations.

Where a protected species is not considered to be an important ecological feature, for example Badger, which is protected for animal welfare reasons rather than nature conservation value, the measures that will be taken to ensure compliance with legislation are outlined within this report.

3.5.3 Determining ecological significant effects

For the purposes of this assessment, a significant effect is an effect that either supports or undermines biodiversity conservation objectives for important ecological features or for biodiversity in general (CIEEM, 2018). Effects can be considered significant at a wide range of scales from international to local.

Significant effects encompass impacts on structure and function of defined sites, habitats or ecosystems and the conservation status of habitats and species (including extent, abundance and distribution). Table 3-1 details the factors that have been considered in the determination of significant effects on ecological features.

Table 3-1: Determining ecologically significant effects

Ecological Feature	Consideration
Designated sites	Will the project undermine the site's conservation objectives? Will the project positively or negatively affect the conservation status of habitats or species for which the site is designated? Will the project have positive or negative effects on the condition of the site or its interest/qualifying features? Will the project remove or change any key characteristics? Will there be an effect on the nature, extent, structure and function of component habitats? Will there be an effect on the average population size and viability of component species? Will there be an impact on wider ecosystem functions and processes?
Habitats	Will the project positively or negatively affect the conservation status of the habitat? Will it affect its extent, structure and function as well as its distribution and its typical species within a given geographical area?
Species	Will the project positively or negatively affect the conservation status of the species? Will it affect its abundance and distribution within a given geographical area?

3.5.4 Residual impacts

Where impacts are identified, mitigation measures are proposed to avoid, reduce or minimise them. Those impacts remaining after implementation of mitigation are the residual impacts. An assessment of the residual impacts has then been undertaken to determine the significance of their effects on ecological features.

3.5.5 Certainty

For residual impacts, an attempt is made to determine the certainty with which they would happen. Ecological systems are sufficiently complex that predictions about their behaviour under change carries a certain degree of uncertainty. Some mitigation can also be uncertain where it is novel, or untested in particular circumstance. Although certainty is difficult to quantify, the definitions in Table 3-2 are used in this document.

Table 3-2. Certainty definitions

Certainty	Probability of occurrence
Certain	>99%
Near certain / high certainty	90% - 99%
Fairly certain	75% - 90%
Moderate uncertainty	50% - 75%
Low certainty	<50%

3.5.6 Precautionary principle

The evaluation of significant effects has been based on current scientific evidence and professional judgement. Where sufficient information is not available to allow a robustly justifiable conclusion of no significant effect, a significant effect is assumed, and any uncertainty is acknowledged.

3.5.7 Cumulative effects

A search of the Local Planning Authority online planning portal was checked for any relevant plans or projects with the potential to act in-combination with the present proposals to increase the impact on the site's biodiversity.

3.5.8 Embedded mitigation

Embedded mitigation includes features that are an integral part of the proposed development and therefore are certain to be implemented. This mitigation is considered as part of the project design and therefore assessed at the initial impact stage. Mitigation suggested following impact assessment is additional to the mitigation already included in the project.

3.6 Limitations and assumptions

The limitations associated with site surveys and species recorded are documented in the technical reports for each species (Wilson 2017, JBA Consulting 2020, 2021). Additional limitations relating to the EcIA are presented below.

3.6.1 Impact Assessment

The baseline for species is based on information from a range of sources but, as with all ecological information, does not completely capture the specific behaviour and distribution of the species at the site. The missing detail is filled using a range of assumptions based on

knowledge of species behaviour and ecology. Gaps in knowledge are highlighted in the species text.

The assessment is based on a working knowledge of implementation of such projects by the authors. However, full details of the methods, and in particular the requirement for temporary works, can only be confirmed following detailed design and contractor appointment. This means some impacts may be overlooked, whilst the potential effect of others overestimated. This assessment is therefore best reviewed after subsequent stages of project development to ensure the assessment remains comprehensive and accurate.

3.6.2 In-combination assessment

Some of the planning applications reviewed in this assessment were not supported by ecological reports. It was therefore assumed that no specific ecological mitigation would be implemented on these schemes when considering their impacts in combination with the present project.

3.7 Competent persons

The Ecological Impact Assessment was completed by Rebekah Beaumont, Jen Jones, Sophie Evans and Steven Heathcote.

Rebekah Beaumont BSc ACIEEM is an Ecologist with four years' of ecological consultancy experience. Rebekah has experience in Preliminary Ecological Appraisal, Ecological Impact Assessment and protected species surveys, particularly birds and terrestrial invertebrates.

Jen Jones BSc MSc QCIEEM is an Assistant Ecologist with two years' experience of consultancy and a first class honour degree in ecology and a Masters degree in entomology. Jen has carried out a range of BNG assessments.

Sophie Evans BSc MSc QCIEEM is an Ecologist with three years consultancy experience. She has a BSc from the University of Reading in Zoology, and an MSc in Species Identification and Survey Skills, also from Reading. Sophie holds a Level 1 (CL08) class licence to survey great crested newts.

Steven Heathcote BA (Hons) DPhil MCIEEM, is a Senior Ecologist with 10 years' experience in ecological consultancy and a full member of CIEEM. Steven is experienced in ecological impact assessment for projects in both the UK and internationally. Steven has particular experience in habitat and botanical surveys and assessments.

4 Ecological Baseline

Baseline environmental data on a range of potential receptors has been collected through a desk-based study and habitat and species surveys of the area to identify key environmental features and constraints associated with the study area. The background data search is detailed in JBA Consulting (2020), and records are referred to here under the relevant ecological feature and a full table of pre-existing records is given in Appendix B.

4.1 Designated sites

A search of MAGIC and data from WYES identified two statutory and six non-statutory designated sites within the search area. Cromwell Bottom Nature Reserve also lies within the Calderdale Wildlife Habitat Network.

4.1.1 Cromwell Bottom Local Nature Reserve (LNR), Local Wildlife Site (LWS)

The site is designated as a result of the diverse habitats present which support a number of regionally important species including: Odonata, Lepidoptera, birds, amphibians and Water Voles. Other qualifying features include; Fe3 – Rich fen, Gr3 – Grassland, Vanl1 – Value for appreciation of nature, Vanl2 – Local Nature Reserve, Ar1 – Diverse range of amphibians, Ar3 - Exceptional population of palmate newts. Whilst each of the individual features are assessed separately, the combination of all these features into a coherent site is carried forwards. Given their designation they are considered to be Regional importance.

4.1.2 Calder and Hebble Canal LWS

The Canal supports a wide range of diverse plant communities, including some regional rarities, *Ceratophyllum demersum* and *Potamogeton obtusifolius,* and has supported populations of the Schedule 8 species Floating Water-plantain *Luronium natans.* The canal is a navigable waterway, maintained by the Canal and River Trust, which includes periodically dredging and removing vegetation growth. The water quality in the canal is generally good, although sampling in autumn 2021 showed increased nutrient and heavy metal concentrations compared to samples from 2005. The canal habitat is a Calderdale BAP priority habitat and impacts on this habitat are included as part of the LWS in this assessment. Key ecological features of the habitat include its function as a wildlife corridor and the presence of aquatic and marginal macrophytes. It can also support a range of priority species.

Water levels in the canal are carefully regulated to maintain navigation so the canal is relatively robust to change, and the flora and fauna in the canal are likely to be used to recreational and maintenance activities and are therefore expected to have low sensitivity. The Canal flows along the northern boundary of Cromwell Bottom and some options relate to abstraction of water from the Canal. The canal is considered to be of Regional importance.

4.1.3 Elland Park Wood LWS and Strangstry Wood LWS

These two woodland sites occupy the slopes to the north and south of the valley in which Cromwell Bottom sits, and both come within a few hundred metres at their closest point.

Elland Park Wood is one of the largest examples of semi-natural oak/birch woodland in the County. The communities present are typical for West Yorkshire and there is good natural regeneration. There are some county rare species present including the Broad-leaved Helleborine *Epipactis helleborine* and Soft Shield-fern *Polystichum setiferum*. The wood supports a diverse range of invertebrates and breeding birds.

Strangstry Wood represents a good example of a regenerating oak woodland. The regeneration of oak/birch woodland over heathland communities is especially good for West Yorkshire. The transition from heathland to the woodland types is good, although the herb layer is species poor in places.

Ancient woodland is an uncommon and irreplaceable habitat, nationally there is around 534,000ha, with 660ha in Calderdale, most of which was, in 2000, listed as being in

unfavourable condition. These woodlands SEGIs are therefore considered to be of Regional importance.

4.1.4 Designated sites within the search area but outside the project zone of influence

Lower Spen Wildlife Area LNR includes the River Spen and adjacent habitats. These flow into the Calder 13km downstream from Cromwell Bottom. Clifton Interchange SEGI is 3.5km downstream, but north of the River Calder and isolated from it. Elland Bypass Road Cutting Local Geological Site is 2km upstream on the River Calder and isolated from the river. As the scheme is considered unlikely to impact upon these sites, none of these sites are considered further in this assessment.

4.2 Habitats

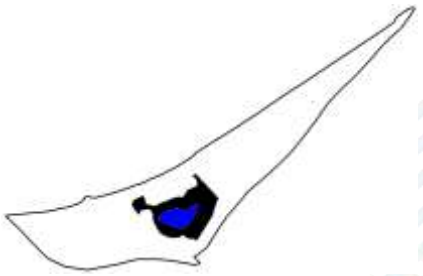
An ecological assessment of habitats at Cromwell Bottom Local Nature Reserve was undertaken in 2020 (JBA Consulting) which consisted of UK Habitat Classification Mapping and Habitat Condition Assessment. The main parcels in the survey area constitute the open water, reedbed and areas of woodland which are surrounded by raised wooded banks. The layout of habitats is shown in Figure 4-1. The condition assessment applied to the habitat parcels shows that the site is largely in moderate or good condition. The vegetation displays many of the attributes expected of good condition habitat. The presence of invasive non-native species (Himalayan Balsam *Impatiens glandulifera* and New Zealand Pygmyweed *Crassula helmsii*) is the main problem preventing scores of good in all habitats.

The following habitats are of Local Importance or greater and will be considered further in the assessment:

- Reedbed and Lagoon
- Wet woodland (Broadleaved Semi-natural woodland)
- Oak and Birch woodland (Broadleaved Semi-natural woodland)
- Valley mire
- Rivers

Canals are a Calderdale Biodiversity Action Plan habitat, but this habitat which forms the Calder and Hebble Navigation is considered as part of the assessment of impacts upon the designated site and is not repeated here.

4.2.1 Reedbed and Lagoon



The central part of Cromwell Bottom Nature Reserve is occupied by a lagoon, informally called Lagoon 1 (Lagoon 2 is now mostly wet woodland and discussed under that heading). The Lagoon has a central area of open water, surrounded by dense Common Reed. The extent of the Reed has been steadily increasing at the expense of open water over many years. The open water and reedbed habitats are in generally good condition, except for the widespread presence of New Zealand Pygmyweed. There is also an invasion of tree species around the margins, kept in check by reed cutting carried out over winter on a proportion of the reeds each year. Common Reed can survive in water depths up to 2m for at least some of the year and as the sole dominant of Reedbed habitat, is likely to be resistant to changes given the habitat has low vulnerability to increases in water level, with drying out the main threat. Water sampling shows the water in the lagoon to be of generally good condition, with a circumneutral pH and moderately elevate nutrient levels.

Reedbed is an uncommon habitat in the local area, and the Reedbed, in combination with the lagoon that sustains it, is of Regional importance.

4.2.2 Wet woodland

The wet woodland at Cromwell Bottom is secondary woodland that has developed in the lagoons where water levels have allowed invasion, meaning that none of the wet woodlands are more than about 30 years old. However, they have developed in a natural way with some careful management in places to enhance their wildlife value. The wet woodland is tolerant of significant inundation, and it is likely the woodland would quickly re-equilibrate with changing water levels, although too much water would probably result in the death of some of the trees. The wet woodland is also expected to expand into areas of birch woodland where the water levels are increased. The water that currently maintains wet conditions in the woodland is presumed to be largely stagnant, creating reducing conditions that favour a field layer of reeds, provided there is sufficient light.

Wet woodland is a Calderdale BAP priority habitat and also a Section 41 Habitat of Principal Importance (HoPI). The Biodiversity Audit of Yorkshire and Humber estimated there are 343ha of wet woodland in the region, although this is thought to be a significant underestimate. Given the relatively small size of these areas of wet woodland and post-industrial nature they are of Regional importance.

4.2.3 Oak and Birch woodland

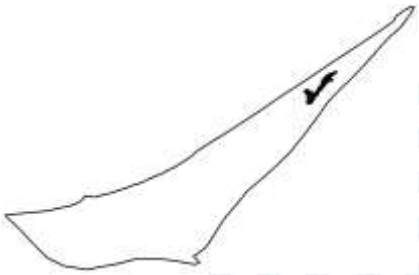
The dry woodland at Cromwell Bottom survives in two separate forms. The embankments support more mature woodland, with a greater mix of species including some planted areas. On the flatter ground inside the banks are areas of primarily birch, which are much younger and with a heathy appearance. In the Carr Woodland they exist in a mosaic with the wet woodland, but at Pixie Wood there is a much more continuous stand of Birch woodland.

These stands are secondary and very fragmented so that the understory is often dominated by bramble. In more open areas, these woodlands support some of the locally notable vascular plant species including Yellow Bird's-nest and Round-leaved Wintergreen.

Calderdale has around 740ha of non-ancient, native woodland, which is a HoPI and Local BAP priority habitat. The small areas at Cromwell Bottom are considered of Local importance.

4.2.4 Valley Mire

The Sphagnum bog, assessed under the habitat category of valley mire, is currently much more wooded than it was in the past, but still supports areas of good mire habitat, referable to the NVC type M6c *Carex echinata-Sphagnum recurvum/auriculatum* mire, *Juncus effusus* sub-community and another area where Common Reed is dominant over *Sphagnum* mosses with no affinities to any published vegetation. The condition is assessed as mostly good, but the cover of saplings is high and probably increasing and the non-native Himalayan Balsam is present in small quantity.



Included within Valley Mire is the bog-moss *Sphagnum medium*, here at the only known natural location in VC63, comprising a small population near the centre of the M6 mire.

Although there is no specific local action plan for valley mires, the mire is very unusual on such a substrate, possibly unique, and is of Regional importance.

4.2.5 Rivers

The River Calder forms the southern boundary of the Brookfoot Loop. The channel has a varied geomorphology as it runs through and along the edge of the reserve, although there are areas of significant bank modification where historic canals are present or where the river runs along the base of the slope up to the railway. There is significant aquatic and marginal vegetation present throughout the reach alongside the reserve, although non-native species plant species (particularly Himalayan Balsam) are common on both banks.

The water quality in the Calder is generally good, although samples taken in 2021 show increased nutrients and heavy metals compared to 2005. The section of the river by the reserve is part of the WFD waterbody "Calder from Ryburn Confluence to River Colne (GB104027062642)". The latest WFD assessment (2019) showed the river to be in moderate or good condition for most indicators, but failing for priority hazardous substances include mercury, Perfluorooctane sulphonate (PFOS), and Polybrominated diphenyl ethers (PBDE). The

assessment suggests that sewage discharge, poor agricultural practice and some physical modification for transport are reasons that the river does not achieve good status for all indicator values (EA Catchment Data Explorer).

The river is a HoPI and Calderdale BAP priority habitat and the habitat of the River Calder is considered to be of Regional importance.

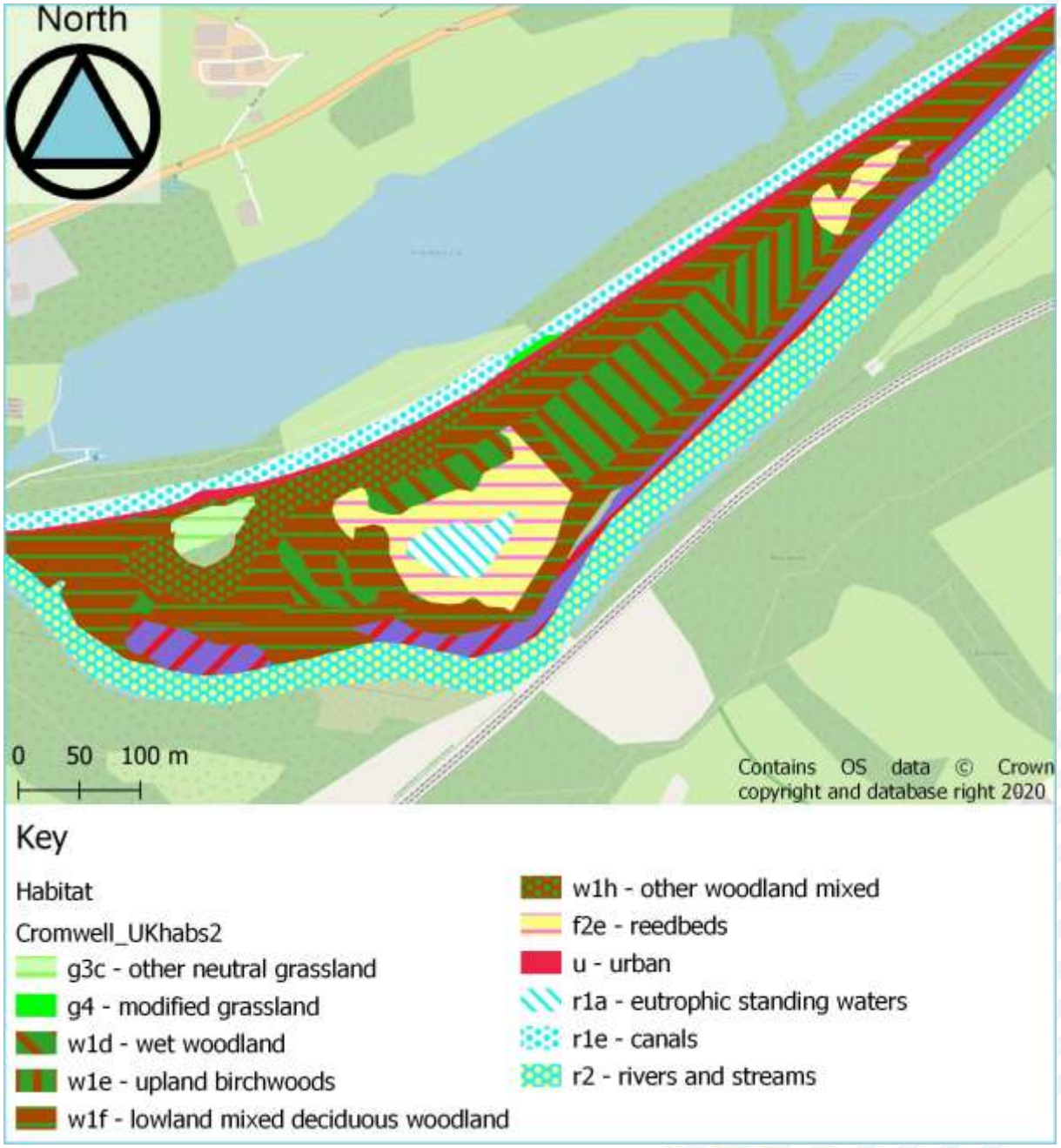


Figure 4-1: UK Habitat Classification habitat map

4.2.6 Plants

The site supports a range of notable vascular plants. For the purpose of the EcIA, these plants are grouped by their general habitat preference.

Plants of dry woodland

Three plants are included here. One of these, Broad-leaved Helleborine *Epipactis helleborine*, a Calderdale BAP species, is widespread across the site, occurring on the wooded embankments and along path edges. Yellow Bird's-nest *Hypopitys monotropa* (UK SoPI and Calderdale BAP; RDB:EN) has a much more restricted distribution, being found on the side of the bank between lagoons 1 and 2. Cromwell Bottom is one of only two sites for this species in West Yorkshire. Round-leaved Wintergreen *Pyrola rotundifolia* (South Yorkshire (vice-county 63) Red Data Book:Rare) is present in the birch woods in the low ground between the north and south embankments in the Carr Woodland. It is relatively widespread in the drier, but still slightly damp, areas. There is another record of Yellow Bird's-nest on an east facing bank in Carr Woodland but this is suspected to be lost. Particularly given the presence of Yellow Bird's-nest this species group is of Regional importance.

Plants of wetland margins and damp habitats

Included here are three county red data book species: Needle Spike-rush *Eleocharis acicularis,* Marsh Helleborine *Epipactis palustris,* and Northern Yellow-cress *Rorippa islandica*. These are all plants of drawdown zones and damp margins of water bodies. The locations and abundance of the other species are not known, but much of the drawdown zone and damp margin of waterbodies are occupied by New Zealand Pygmyweed, creating a severe limit on habitat availability. These plants are of Local importance.

Plants of dry grassland

There is a single notable plant of dry grassland; Spreading Meadow-grass *Poa humilis*, but the record does not have a precise location. The most likely area within the reserve is the larger patch of grassland north of the lagoon. The population size is unknown. This plant is of Local importance.

Aquatic Macrophytes

Included here are two county red data book species: Floating Water-plantain *Luronium natans* (which is also fully protected on Schedule 8 of the Wildlife and Countryside Act 1981) and Whorled Water-milfoil *Myriophyllum verticillatum*. Neither of these have been found within the LNR, but both are known, at least historically, from the Calder and Hebble Navigation. Floating Water-plantain was not found in the canal adjacent to the reserve in 2013 when looked for (Wilmore, 2013), but was recorded by the Canal and River Trust in 2014, and is well known to be dynamic in its occurrence in cycles with canal maintenance. These plants are of Regional importance.

4.2.7 Breeding Bird Surveys March – July 2021 (Cockroft, 2021)

Table 4-1 shows the results of the breeding bird surveys, although only species of conservation concern have been included. The site supports a small number of breeding Bullfinch *Pyrrhula pyrrhula*, Dunnock *Prunella modularis*, Grey Wagtail *Motacilla cinerea*, Kingfisher *Alcedo atthis*, Mallard *Anas platyrhynchos*, Mute Swan *Cygnus olor*, Reed Bunting *Emberiza schoeniculus*, Song Thrush *Turdus philomelos* and Willow Warbler *Phylloscopus trochilus*. These species are listed as conservation priorities either on Schedule 1 of the Wildlife and Countryside Act 1981, BTO Birds of Conservation Concern (BoCC) Amber and Red status, Local Biodiversity Action Plans (BAP) and/or Section 41 of the NERC Act (2006).

The site also provides foraging and / or roosting habitat for a range of species of conservation priority which breed in the UK, including Barn Owl *Tyto alba*, Dipper *Cinclus cinclus*, House Martin *Delichon urbica*, Lesser Redpoll *Carduelis cabaret*, Mistle Thrush *Turdus viscivorus*, Sand

Martin *Riparia riparia*, Starling *Sturnus vulgaris*, Stock Dove *Columba oenas*, Swift *Apus apus* and Whitethroat *Sylvia communis*.

For the purpose of assessing impacts to birds, species have been broadly grouped into assemblages based on their habitat requirements. These assemblages include:

- Wetland
  - Aquatic habitats including standing and running waterbodies, reedbed, wet woodland
- Woodland
  - Broadleaved and coniferous woodland, scrub
- Grassland
  - Grassland, tall ruderal vegetation, farmland, gardens

Grassland species have been screened out due to the small area of grassland present on the reserve which will likely remain unchanged by the Project.

Due to the relatively small numbers of breeding birds, their supporting habitats being present in the wider area and their inclusion in local BAP's (with the exception of Mallard, Mute Swan, Dipper, Lesser Redpoll and Whitethroat), these bird populations are considered to be of Regional importance.

Table 4-1: Breeding bird survey results

Common Name	Scientific Name	Habitat Assemblage	Conservation Status	Observation notes
Barn Owl	*Tyto alba*	Grassland	Sch1_part1; WYBAP	In late June one individual was seen hunting over lagoon 1.
Black-headed Gull	*Larus ridibundus*	Wetland	BoCC:Amber; Calderdale BAP	Birds were seen flying overhead in March and April and occasionally on lagoon 1. No breeding was attempted.
Bullfinch	*Pyrrhula pyrrhula*	Woodland	BoCC:Amber; NERC s.41; WYBAP; Calderdale BAP	Recorded throughout the survey area and two pairs were proven to breed with young birds seen in two separate areas in June.
Common Gull	*Larus canus*	Wetland	BoCC Amber	Birds were seen flying overhead in March.
Common Sandpiper	*Actitis hypoleucos*	Wetland	BoCC Amber	Two birds were on the river for a week in early May but were passage birds and no courtship or breeding was attempted.
Dipper	*Cinclus cinclus*	Wetland	BoCC Amber	No breeding in the survey area but birds can be seen feeding

Common Name	Scientific Name	Habitat Assemblage	Conservation Status	Observation notes
				along the river.
Dunnock	*Prunella modularis*	Woodland	BoCC:Amber; WYBAP; Calderdale BAP	Not as common as it once was with four breeding pairs found in the survey area.
Goldcrest	*Regulus regulus*	Woodland	Calderdale BAP	One pair seen on the riverbank foraging in April.
Green Woodpecker	*Picus viridis*	Woodland	BoCC:Amber; Calderdale BAP	The call of the Green Woodpecker was heard throughout the survey and breeds in nearby woodland. An individual was seen foraging in Pixie Wood and the wet woodland.
Greylag Goose	*Anser anser*	Wetland	BoCC Amber	Four birds (1 hybrid) were present throughout the breeding season on the lagoon.
Grey Wagtail	*Motacilla cinerea*	Wetland	BoCC:Red Calderdale BAP	Common resident breeder with two pairs nesting along the river. Three young were seen feeding on the river in late June.
Herring Gull	*Larus argentatus*	Wetland	BoCC:Red; NERC s.41	Birds were seen flying overhead in March
House Martin	*Delichon urbica*	Wetland	BoCC:Red; WYBAP	Seen feeding along the river, Lagoon and above the canopy throughout the summer.
Kestrel	*Falco tinnunculus*	Grassland	BoCC:Amber; WYBAP; Calderdale BAP	Only seen occasionally.
Kingfisher	*Alcedo atthis*	Wetland	Sch1_part1; BoCC:Amber; Calderdale BAP	A regular sight all around the survey area with two pairs breeding on the river and young birds seen fishing in lagoon 1.
Lesser Redpoll	*Carduelis cabaret*	Woodland	BoCC Red	Small flocks (8+) were seen feeding in the tree top in Pixie Wood on the 7th April and a few single birds flying overhead in April and

Common Name	Scientific Name	Habitat Assemblage	Conservation Status	Observation notes
				May. No breeding was suspected in the survey area.
Mallard	*Anas platyrhynchos*	Wetland	BoCC Amber	A common resident breeder on the lagoon, river and canal. Up to four pairs were seen to breed with young broods seen in early April through to June.
Meadow Pipit	*Anthus pratensis*	Grassland	BoCC:Amber; Calderdale BAP	A small flock of eight birds were feeding along the river in early May.
Mistle Thrush	*Turdus viscivorus*	Woodland	BoCC:Red; Calderdale BAP	There was only one singing male holding territory in early April and no proof of breeding.
Mute Swan	*Cygnus olor*	Wetland	BoCC Amber	A pair with young were regularly seen on the canal.
Reed Bunting	*Emberiza schoeniculus*	Wetland	BoCC:Amber; NERC s.41; WYBAP; Calderdale BAP	Three singing males were recorded in early April and suspected breeding around lagoons 1 and 2. Young birds were seen in two areas in late June.
Sand Martin	*Riparia riparia*	Wetland	BoCC:Amber; Calderdale BAP	Can be seen feeding along the river throughout the summer.
Shoveler	*Anas clypeata*	Wetland	BoCC Amber	In recent years a pair have been seen in February on the Lagoon but usually only stay a couple of days.
Song Thrush	*Turdus philomelos*	Woodland	BoCC:Red; WYBAP; Calderdale BAP	Only three singing males and two nesting pairs were found of this once common species in the survey area.
Snipe	*Gallinago gallinago*	Wetland	BoCC:Amber; Calderdale BAP	Two birds were flushed from the side of Lagoon 1 in late March.
Starling	*Sturnus vulgaris*	Grassland	BoCC:Red; WYBAP; Calderdale BAP	A small group of 20 were seen to leave the area of Phragmites in

Common Name	Scientific Name	Habitat Assemblage	Conservation Status	Observation notes
				Lagoon 1 early morning on the 25th March.
Stock Dove	*Columba oenas*	Woodland	BoCC:Amber; Calderdale BAP	Seen flying over the site. No evidence of breeding on site this year.
Swallow	*Hirundo rustica*	Wetland	WYBAP; Calderdale BAP	Seen feeding along the river, Lagoon and above the canopy throughout the summer.
Swift	*Apus apus*	Wetland	BoCC:Amber; WYBAP	Can be seen catching insects over the treetops and lagoons in the summer months.
Teal	*Anas crecca*	Wetland	BoCC Amber; Calderdale BAP	A pair were seen on the lagoon in early April.
Water Rail	*Rallus aquaticus*	Wetland	Calderdale BAP	One bird was seen and heard calling in early March before the survey started and this seems to be a regular spot for them in the winter months.
Whitethroat	*Sylvia communis*	Wetland	BoCC:Amber	Only one male was heard singing along the river in early June.
Willow Warbler	*Phylloscopus trochilus*	Woodland	BoCC:Amber; Calderdale BAP	Three singing males, and maybe only one or two pairs breeding this year.
Abbreviations of designation are as follows: BoCC = Species listed on Birds of Conservation Concern 4; Calderdale BAP = species listed on the Calderdale Biodiversity Action Plan; WYBAP= species listed on the West Yorkshire Biodiversity Action Plan; NERC s.41 = species on Section 41 of the NERC Act (2006); Sch1_part1 = species receiving special protection listed on Schedules 1 The Wildlife and Countryside Act 1981 (as amended).				

4.2.8 Terrestrial Invertebrates May – August 2017 (Richard Wilson, 2017)

Six survey visits were completed between early May and mid-August 2017. The surveys followed the methodologies described in Drake *et al.* (2007) using a variety of techniques. This included sweeping vegetation and aerial netting for flying invertebrates. This was complemented by vacuum sampling and direct observation. Pitfall traps were set in three locations throughout the study site to collect ground-dwelling (epigeic) invertebrates.

Table 4-2 details the species that were recorded during the surveys which have a formal Nature Conservation Status (NCS). The surveys identified 315 species of which a small proportion (c. 3.5%) are currently assigned a NCS, or are scarce Yorkshire species. Therefore, these species are considered to be of Regional importance.

For the purpose of assessing impacts to terrestrial invertebrates, species have been broadly grouped into assemblages based on their habitat requirements. These assemblages include:

- Open habitats
  - Short sward & bare ground, Tall sward & scrub, upland
- Tree-associated
  - Arboreal, decaying wood, shaded woodland floor, wet woodland
- Wetland
  - Lake, marshland, peatland, running water, wet woodland

Table 4-2: Species recorded with a NCS (nationally and within Yorkshire), from Richard Wilson Ecology (2017)

Species	Habitat Assemblage	Status	Ecology
† *Porrhomma errans (Arachnida, Linyphiidae)*	Open habitats	Nationally Scarce	A rarely recorded species whose ecology is inadequately known. Most records relate to grassland with some element of bare ground. A single male was collected in a pitfall trap set in the reedbed on the northern edge of Lagoon 1 between the 8th May and 3rd June 2017. This represents the first modern record for VC 63; and only the fifth record for Yorkshire as a whole in the last 25 years.
† *Dacrila fallax (Coleoptera, Staphylinidae)*	Wetland	Nationally Scarce	A scarce species associated with wetland leaf-litter. The Cromwell Bottom NR specimen represents the 10th record for Yorkshire (Bob Marsh, personal communication).
Notaris scirpi (Coleoptera, Erirhinidae)	Wetland	Nationally Scarce (Nb)	A wetland species associated with lesser pond sedge (*Carex acutiformis*) and Reedmace (*Typha latifolia*) that is widely distributed in England and Wales. Two individuals were collected in a pitfall trap set in the reedbed on the northern edge of Lagoon 1 between the 8 thMay and 3rd June 2017.
Grypus equiseti (Coleoptera, Erirhinidae)	Wetland	Nationally Scarce (Nb)	A wetland species associated with horsetails, particularly field (*Equisetum arvense*) and marsh (*E. palustre*), within which the larvae develop. Habitats within which it has been recorded include willow carr. Recorded in a pitfall trap from the willow/ birch carr woodland between the 8th May and 3rd June 2017; where there is a scattering of horsetail plants.
† *Glocianus punctiger (Coleoptera, Curculionidae)*	Open habitats	Nationally Scarce (Nb)	A species of weevil that is associated with free-draining areas and phytophagous on dandelions (*Taraxacum agg.*). In Yorkshire, it is particularly scarce, being known from only two other locations in Yorkshire: Thorne Moors (1984) and Cali Heath Yorkshire Wildlife Trust Reserve (2007). An individual was vacuum sampled from the remnant dry grassland in the north-west corner of the Brookfoot Loop section, opposite Freeman's Bridge (SE 1276 2236) on the 13th July 2017.
† *Parasyrphus nigritarsis*	Tree-associated /	Nationally Scarce	A hoverfly associated with wet woodland, particularly sallows (*Salix sp.*); alder and docks (*Rumex sp.*) as its larvae are

Species	Habitat Assemblage	Status	Ecology
(Diptera, Syrphidae)	Wetland (wet woodland)		predaceous on leaf-beetle larvae associated with these plants. The adults are frequently observed and recorded from umbellifers associated with woodland edge or wider rides on the edge of wetlands that support these plants. It is a north-western species that is widely distributed but remains scarce. This record represents the first for VC 63. A single individual was swept from the path-side vegetation in May 2017.
White-letter hairstreak (*Satyrium w-album*) (Lepidoptera, Lycaenidae)	Tree-associated	Endangered; SoPI	The butterfly is scarce within the Calder Valley; WYER holding only three records from 2004 in the wider area but within 500m; and a single record from the Brookfoot Loop section of Cromwell Bottom on the 18th June 2006 (though this is supposedly of a single egg which if so, is questionable). Records of this species are continuing to decline throughout Yorkshire, including for the most recent year available (2016). A single adult was observed nectaring on Creeping Thistle *Cirsium arvense* on the 13th July 2017; which must be considered a significant record in a local context.
† *Philhygra gyllenhalli (Coleoptera, Staphylinidae)*	Wetland	Uncommon in Yorkshire	A very uncommon rove beetle with only 25 records in Yorkshire, including previous records for Cromwell Bottom NR. It is a species associated with ground litter in wetlands (Bob Marsh, personal communication)
† *Polydrusus pilosus (Coleoptera, Curculionidae)*	Tree-associated	Scarce in Yorkshire	A scarce weevil with only 18 records for Yorkshire, though widely distributed in Great Britain. An arboreal species recorded from both deciduous and coniferous trees; the larvae are root feeders in herbaceous plants with the adults occurring on tree foliage (Bob Marsh, personal communication)
† *Campiglossa malaris (Diptera, Tephritidae)*	Open habitats	Scarce in Yorkshire	The larval foodplant is thought to be Hoary Ragwort *Senecio erucifolius*. A single individual was swept from grassland with ragwort noted in July 2017. The specimen is retained in Steven Falk's collection.
Blackneck (*Lygephila pastinum*) Lepidoptera, Erebidae	Open habitats	Uncommon	The larvae feed on Tufted Vetch *Vicia cracca* in damp situations. It is more frequent in the south of England, becoming scattered further north. Within Yorkshire, it is most frequent in VC 63 but

Species	Habitat Assemblage	Status	Ecology
			is still considered to be relatively uncommon.
Key: †New for Cromwell Bottom NR			

4.2.9 Aquatic Invertebrates

The desk study returned no aquatic invertebrate records and no surveys have been undertaken to provide baseline data for aquatic invertebrates at Cromwell Bottom LNR or the adjacent watercourses. It is likely due to the habitats present on site that Cromwell Bottom supports wetland species associated with lakeside emergent/aquatic vegetation, temporary water dependant, aquatic: sparsely & well vegetated, and drawdown zone: mud/shallow litter. As the lagoon and reedbed are uncommon habitats in the local area, it is presumed that invertebrates associated with these habitats will also be uncommon and therefore are considered to be of Regional importance unless proven incorrect from further survey work.

4.2.10 Amphibians

Cromwell Bottom LWS is noted for supporting a diverse range of amphibians and an exceptional population of Palmate Newts which are therefore considered of Regional importance. Great Crested Newt have never been recorded on the site despite many amphibian surveys. The lagoon and surrounding scrub and woodland habitats provide suitable breeding and refuge habitat for amphibians.

4.2.11 Fish

The River Calder and CHN which are the two major waterbodies that flow through Cromwell Bottom LNR support a variety of fish species. These species will be assessed together. The Project aims to extract water from one of these waterbodies and therefore may impact Locally important fish populations.

4.2.12 Mammals

Water Vole, Otter and Water Shrew have been recorded locally, and wetland habitats (i.e. lagoon, river and canal) provide suitable habitat for these species. There are no records of these species from the reserve itself and they are considered to be absent, or in the case of Otter, using the site infrequently as part of a larger territory. Overall the site is considered to be of Local importance for these species

Badger setts have not been recorded on the reserve, however habitats such as woodland and grasslands provide suitable foraging habitat and areas for sett creation. Badgers are addressed separately and are not discussed further in this EcIA.

4.2.13 Bats

The Project will not directly impact foraging, commuting or roosting habitats for bats. The Project aims to maintain a variety of habitats across the reserve and consequently provide a variety of foraging potential for bat species. Greater benefits are likely to be seen from species which rely on wetland habitats such as Daubenton's. Therefore, these species have been screened out from further assessment.

4.2.14 Reptiles

No reptiles have been recorded on the reserve and habitats present provide limited opportunities for these species, with Grass Snake being the most likely to utilise the wetland habitats. As the Project aims to improve wetland habitats, this could only prove beneficial for Grass Snake and therefore reptiles have been screened out from further assessment.

4.2.15 Invasive Non-Native Species

Several species of INNS have been recorded on Cromwell Bottom LNR, including New Zealand Pygmyweed *Crassula helmsii* (within the Lagoon), Japanese Knotweed *Fallopia japonica,* Himalayan Balsam *Impatiens glandulifera* and American Mink *Neovison vison*. The Project has potential to cause the spread of these species within and outside of Cromwell Bottom LNR.

4.3 Baseline summary and ecology features screened in

The table below provides a summary of baseline ecology features which have been screened in for further assessment.

Table 4-3: Ecology features screened in for further assessment

Ecological Feature	Importance at development site
Cromwell Bottom Local Nature Reserve (LNR), Local Wildlife Site (LWS) and Site of Ecological or Geological Importance (SEGI)	Regional
Calder and Hebble Canal SEGI	Regional
Elland Park Wood SEGI and Strangstry Wood SEGI	Regional
Reedbed and Lagoon	Regional
Wet woodland (Broadleaved Semi-natural woodland)	Regional
Oak and Birch woodland (Broadleaved Semi-natural woodland	Local
Valley mire	Regional
River	Regional
Birds - Wetland	Regional
Birds - Woodland	Regional
Invertebrates – Open habitats	Regional
Invertebrates - Tree-associated	Regional
Invertebrates - Wetland	Regional
Invertebrates - Aquatic	Regional
Plants of dry woodland	Regional
Plants of wetland margins and damp habitats	Local
Plants of dry grassland	Local
Aquatic Macrophytes	Regional
Amphibians	Regional
Fish	Local
Aquatic mammals (Water Vole, Otter, Water Shrew)	Local
Invasive Non-Native Species	NA

5 Assessment of effects

5.1 Potential Ecological Impacts

The potential ecological impacts for each option are summarised in Table 5-1. This assessment is based on the impacts on the ecological features on the site itself and the impacts caused by each option to the watercourses beyond the site boundary. The impacts can be both positive and negative.

Table 5-1. Potential ecological impacts for each option

Project Elements	Options that include element
Construction	
Temporary Land-take	For all options existing hardstanding areas can be used as temporary working locations. In addition, the following temporary land would be required. Option 2: Modification to small area of scrub and riverbank likely including riparian trees to alter bank or install pump and pipe. Option 3: Temporary cutting back of trees to install pipe from collection point to discharge. Option 4: Temporary clearance of reedbed to allow reprofiling of lake.
Species disturbance	Options 2-4: All options will result in the presence of construction machinery on site for an extended period (likely to be several months).
Invasive Non-Native Species (INNS) spread into site	Options 2-3: There is the potential for construction work to cause INNS to spread onto and within the site.
INNS spread from the site	All options: There is the potential for works (as well as do-nothing) to result in INNS spreading from the site into the surrounding landscape.
Pollution incident damaging habitats/species	Options 2-4: The presence of construction activities on site mean that pollutants, such as hydrocarbons, will be brought onto the site. There is also the potential for liquid cement or concrete spills if these are part of construction activities.
Operation	
Habitat change	All options: the combination of changes in water levels and natural succession will result in habitat change. Changes in the amount of each habitat will impact on the species that use that habitat. Changes in the water level in the lagoon and wet woodland will also alter the condition of these habitats, as well as the species that use them.
Permanent Land-take	Only Option 2b will have a significant permanent land take where the artificial river bank is lowered. Options 2 and 3 may have further land-take if woodland is cleared to make way for reedbed to filter the incoming water. Option 4 will require creation of small access ramps into the lagoon.
Introduction of fish onto the site	Options 2-3 may result in the transfer of fish from the canal or river into the lagoon.
INNS spread into site	Options 2-3 may allow INNS from the river or canal to enter the site or may increase the frequency with which they do.
INNS spread from the site	All options, INNS present on site may be able to leave the site more easily and enter into the wider landscape.

Project Elements	Options that include element
Changes in water quality in lagoons (nutrients)	All options: the water quality in the lagoon is changing naturally over time. Importing water will cause further changes in nutrient status, depending on the nutrient levels of the source water. Analysis in 2021 showed that the overall water quality in both canal and river is good, although the nutrient levels were raised compared to values from the lagoon in 2005.
Changes in water quality in lagoons (pH and metals from PFA)	Option 4 – analysis shows water sources for Options 2 and 3 have similar pH to the lagoons and relatively low heavy metal concentrations. However, disturbing the PFA substrate could result in the release of previously immobile material. Typically, PFA is strongly calcareous and has high concentrations of heavy metals. The extent to which these might be released is uncertain.
Impacts of water abstraction on ecology in canal/river	Options 2-3: Taking water from the canal or river will result in less water in these waterbodies. This could potentially result in effects on their ecology.
Changes in water quality in the River Calder on discharge (nutrients, PFA metals)	Options 2-4: If the water on site is increased, it is likely that there will be increased discharge to the River Calder, or a change in the quality of water that is currently discharged.

5.2 Assessment Matrix

The screened in ecological features (Table 4-3) have been assessed against the potential impacts of the project (Table 5-1) for each option. The net effect of impacts for each ecological feature have then been summarised to produce an overall assessment for each option. The results of this screening are presented in Table 5-2, with details for each option included in Appendix D. A brief summary of impacts for each of the ecological features is presented below.

5.3 Designated nature conservation sites

5.3.1 Cromwell Bottom LNR, LWS & SEGI

Option 1: Under a do-nothing scenario, natural succession is expected to lead to the loss of the most important features of the site, resulting ultimately in a closed canopy woodland, with the lagoon and mire areas becoming wet woodland.

Options 2 and 3: Both options are likely to lead to a net positive impact as the condition of wet woodland, reedbed and lagoon would be improved. However, there are some construction risks that would need mitigation along with a plan to control the spread of INNS, so that without mitigation they are considered to have minor negative effects.

Option 4: Changing the topography of the lagoon is likely to lead to long-term positive impact through the increased diversity of aquatic habitat, although there is high uncertainty around this.

5.3.2 Calder and Hebble Canal SEGI

The proposals are unlikely to have much overall effect on the Calder and Hebble Navigation. There are temporary construction impacts, but on the artificial canal these would not have an impact. The proposal is not expected to draw water down below current managed level, but if it did there are potentially significant impacts, so Option 3 is considered to have a potential negative operational impact in the absence of mitigation.

5.3.3 Elland Park Wood SEGI and Strangstry Wood SEGI

No impacts are expected on either of these sites under any of the options.

5.4 Habitats

5.4.1 Reedbed and Lagoon

The proposed project will restore the lagoon towards optimum hydrology for wildlife value, and therefore Options 2 and 3 will lead to a net positive effect. In contrast, under the do-nothing scenario, natural succession to woodland is likely to occur. Reprofiling (Option 4) will result in an increased diversity of microhabitats which has a long-term benefit despite temporary disturbance.

5.4.2 Wet woodland

The wet woodland is the main habitat that would benefit from the do-nothing scenario (Option 1). Under the other options it is unlikely to change significantly, but some construction-related impacts could be negative in the absence of mitigation.

5.4.3 Oak and Birch woodland (Broadleaved Semi-natural woodland)

Under Options 2 and 3 there is likely to be an increase in the water levels in the Carr woodland, resulting in a shift from drier birch woodland to wet woodland, and could potential result in full conversion, which would be a loss of this habitat. There are potential short-term negative impacts of construction in the absence of mitigation.

5.4.4 Valley Mire

With the do-nothing scenario, the valley mire is likely to remain in balance between the colonising scrub trying to invade the habitat, and the management to keep this in check. No changes are expected to the valley mire under any option as it is hydrologically isolated from the lagoon.

5.5 Notable plant species

Under a do-nothing scenario, plants of dry woodland are expected to expand at the expense of aquatic and marginal species within Cromwell Bottom. Under options 2 and 3 this trend would be reversed, and in the absence of mitigation some dry woodland plants would become confined to a very small band of habitat at the woodland margin, possibly leading to the loss of some species. There is high uncertainty about this as it depends on how wet the drier birch woodland in the basin becomes.

5.6 Birds

The Project aims to improve the condition of the reedbed habitat by increasing wetness and supressing natural succession into woodland, providing long-term positive impacts for wetland bird species and no change for woodland bird species. Without intervention it is likely that woodland would expand, meaning increased habitat for woodland birds at the expense of the habitat of wetland birds.

The construction works required to allow extraction of water into the reserve and lake reprofiling have potential to cause short-term disturbance to local bird populations. Additionally, any vegetation clearance or ground works during the Project within the bird breeding season could cause direct harm to nesting birds and a temporary, short-term loss of breeding and foraging habitat for both wetland and woodland birds.

5.7 Invertebrates

The Project will likely benefit the invertebrate assemblages present by reversing the trend towards drier habitat communities. This will at least slow down or reverse the declining fortunes of species associated with wetland biotopes, including stenotopic species associated with marshland and peatland habitats. Re-wetting the woodland carr will increase humidity and thus benefit wood decay communities. The construction works required to allow extraction of water

into the reserve has potential to cause temporary, short-term disturbance and / or loss of habitat.

5.8 Amphibians

The improvement of wetland habitat and preventing annual drying of the lagoon will provide long-term enhanced breeding habitat for amphibians provided that predatory fish do not enter the lagoon in significant numbers. The construction works required to allow extraction of water into the reserve and lake reprofiling has potential to cause short-term disturbance to local amphibian populations and/or injury to individuals present within these areas in the absence of mitigation.

5.9 Fish

Fish are currently absent from Cromwell Bottom, but a range of species are present in the Canal and river. Construction activities at the abstraction point could impact fish, but changes in ecology of the river or canal would not be significant for fish. If fish were allowed onto site, there is a risk of significant mortality if the lagoon dried out as there would be no way back to the river or canal for them.

5.10 Mammals

Minor disturbance from construction is expected to be offset by improved condition of the reedbed and lagoon, resulting in a small positive impact for aquatic and riparian mammals. There are legal implications for disturbing Otter, Water Vole and their breeding and resting places, but no such places are known around the reserve.

5.11 INNS

The extraction of water into Cromwell Bottom LNR, release of excess water into the River Calder and increased wetness of the site has the potential to introduce INNS onto, around and off the LNR, through hydrological processes or during working operations. These impacts are mostly considered through their effects on other ecological features, but the management of INNS is best done as a single co-ordinated mitigation. INNS are already relatively widespread both on the site and along the canal and river, so additional spread is unlikely to have a significant impact. There are already efforts to control INNS on the site, and this will reduce the possibility of increased spread, but in the absence of mitigation, there remains a risk of increasing spread that would lead to the introduction of INNS in places where they are currently absent.

5.12 Summary

For each of the proposals there are a range of positive and negative impacts in the absence of mitigation. The next sections examine the potential for these impacts to act in-combination with other projects, then looks at mitigating any impacts before assessing the overall residual effects likely to result from each option.

Ecological Receptor	Intervention without mitigation			
	Option 1 - No active intervention	**Option 2 – Water extraction from the River Calder using a) natural flood flows, or b) pumps**	**Option 3 – Water extraction from the Calder and Hebble Navigation a) at existing overflow structure, or b) using new structure near viewing platform**	**Option 4 – Lake topography profiling**
Cromwell Bottom Local Nature Reserve (LNR), Local Wildlife Site (LWS)	Wetland habitats and species distribution will slowly reduce, whilst scrub and woodland species will expand and replace these.	Minor loss of open habitats that support regionally important species. Increased extent and quality of wetland habitats, although some impact of increased nutrients may affect balance of species in lagoon. Significant risk of INNS spread into site which could outcompete valuable, native plant species. Habitats particularly sensitive to pollution events that could occur without mitigation.	Minor loss of open habitats that support regionally important species. Increased extent and quality of wetland habitats, although some impact of increased nutrients may affect balance of species in lagoon. Significant risk of INNS spread into site which could outcompete valuable, native plant species. Habitats particularly sensitive to pollution events that could occur without mitigation.	Minor temporary loss of important habitats (including reedbed) during construction. Small amount of permanent habitat loss for access ramps, but habitats will recover quickly. Excavations will have significant temporary impacts on species which use gravel microhabitats. Once complete, increased habitat heterogeneity and a deeper channel will be hugely beneficial for a range of species.
Calder and Hebble Canal LWS	No change	No change	Current regulation and management mean that the canal system is robust to change. Increased amount of spillway negligible although signficant drawdown of water below current levels could impact aquatic habitat and species.	No change
Elland Park Wood LWS and Strangstry Wood LWS	No change	No change	No change	No change
Reedbed and Lagoon	The Reedbed is currently undergoing a succession (a typical hydrosere) in which Reeds are encroaching on open water, and scrub is encroaching in the reeds. Over time the reedbed will change to wet woodland (as has happened in Lagoon 2). This means that both open water and reedbed will decrease until completely lost. Currently active management by cutting reduces the spread of scrub into the Reedbed, and in theory this could be maintained indefinitely, although eventually if dry enough it would be difficult to prevent the scrub from becoming dominant.	Reduction in frequency and length of dry periods, therefore an increase in extent and quality of reedbed and specialist species it supports. Potential for Crassula (already widespread) to be spread further around site. Habitat can withstand physical disturbance, but without mitigation, there is a chance of chemical pollution during construction.	Reduction in frequency and length of dry periods, therefore an increase in extent and quality of reedbed and specialist species it supports. Potential for Crassula (already widespread) to be spread further around site. Habitat can withstand physical disturbance, but without mitigation, there is a chance of chemical pollution during construction.	Habitat cleared for reprofiling works will have a significant temporary impact on a range of species before it recovers (relatively short time frame). Moderate risk of pollution event during construction which could change the species assembly or reduce water quality. Long-term reduction/elimination of dry periods, therefore an increase in extent and quality of reedbed and specialist species it supports.

Ecological Receptor	Intervention without mitigation			
Wet woodland (Broadleaved Semi-natural woodland)	With no intervention the wet woodland is expected to expand into the areas currently occupied by the reedbed, lagoon and Sphagnum bog, prevented from doing so only by ongoing cutting. The existing woodland would be maintained. There would therefore be a slight increase in wet woodland habitat.	Potential for invasive plant species to colonise habitat from river, if ignored could change soil chemistry and alter habitat in long-term. Habitat generally tolerant of inundation, but over long-term, more water flowing will likely change tree species assemblage and cause death of some less water-tolerant trees. Habitat likely to expand into birch woodland.	Certain reduction of small amount of habitat for option 3b to facilitate pipe installation. Potential for invasive plant species to colonise habitat from River and Canal, if ignored could change soil chemistry and alter habitat in long-term. Habitat generally tolerant of inundation, but over long-term, more water flowing will likely change tree species assemblage and cause death of some less water-tolerant trees. Habitat likely to expand into birch woodland.	No change
Oak and Birch woodland (Broadleaved Semi-natural woodland)	This woodland is likely to be able to maintain itself indefinitely. There would probably be a slow shift in composition towards Oak-dominated rather than Birch-dominated canopy, but the effects of this would be small.	Long-term reduction in extent of habitat due to conversion to wet woodland, impact likely sooner using option 2b. Some migration of the specialist plant, invertebrate and bird species the habitat supports to the drier margins.	Long-term reduction in extent of habitat due to conversion to wet woodland, impact likely sooner using option 2b. Some migration of the specialist plant, invertebrate and bird species the habitat supports to the drier margins.	No change
Valley Mire	The valley mire is likely to slowly succeed to scrub, as is currently happening. Cutting back of the scrub can help slow this process, but the long-term survival of the habitat is dependent on receiving sufficient water to prevent ongoing scrub invasion, or maintaining this management. In the most likely scenario there will be a small loss of condition as scrub slowly expands but is kept under control by ongoing management.	No change	No change	No change
Birds - Wetland	Bird assemblage would remain the same in the short term, simplifying to mainly woodland birds in time as wetland habitat scrubs up and dries	Insignificant temporary loss of feeding habitat. Construction works during breeding season likely to cause temporary reduced breeding success and loss of breeding and foraging habitats. Improved condition and extent of reedbed provides long-term positive impacts (increased food resources, breeding success and survival) for wetland specialists.	Insignificant temporary loss of feeding habitat. Construction works during breeding season likely to cause temporary reduced breeding success and loss of breeding and foraging habitats. Improved condition and extent of reedbed provides long-term positive impacts (increased food resources, breeding success and survival) for wetland specialists. Positive impacts likely to be observed promptly after works.	Construction works during breeding season likely to cause temporary reduced breeding success and loss of breeding and foraging habitats. Improved condition and extent of reedbed provides long-term positive impacts (increased food resources, breeding success and survival) for wetland specialists. Likely to result in a subtle change from reedbed to island breeding species.
Birds - Woodland	Bird assemblage would remain the same in the short term, increasing in time as woodland habitat expands and matures.	Insignificant temporary loss of feeding habitat during construction. Construction works during breeding season likely to cause temporary reduced breeding success and loss of breeding and foraging habitats. Improved condition and extent of reedbed provides increased food resources.	Insignificant temporary loss of feeding and nesting habitat during construction. Construction works during breeding season likely to cause temporary reduced breeding success and loss of breeding and foraging habitats. Improved condition and extent of reedbed provides increased food resources.	No change

Ecological Receptor	Intervention without mitigation			
Invertebrates – Open habitats	No change	Possible change in balance between closed and open habitat depending on impacts of flooding (high uncertainty). Unlikely but potential competition with non-native species. Invasive plant spread to the site may replace native plants that some specialist invertebrates rely on, and populations may suffer as a result.	Possible change in balance between closed and open habitat depending on impacts of flooding (high uncertainty). Unlikely but potential competition with non-native species. Invasive plant spread to the site may replace native plants that some specialist invertebrates rely on, and populations may suffer as a result.	Minor temporary loss of feeding and breeding habitats. Some permanent loss of open areas as they follow succession to wetter and more wooded habitats. Increased topographic variation may provide some additional benefit but this is uncertain.
Invertebrates - Tree-associated	Assemblage would remain the same in the short term, increasing in time as woodland habitat expands and matures, however those that rely on wood decay and humidity would likely decrease.	Minor immediate loss of feeding and nesting habitat as some riparian trees removed to facilitate construction. Generally tolerant of pollution events and invasive plants due to connectivity with wider landscape. Long-term loss of dry habitat trees may cause a decline in associated specialists as habitats change. Likely increase in species that rely on wood decay and humidity.	Minor immediate loss of feeding and nesting habitat as some riparian trees removed to facilitate construction. Generally tolerant of pollution events and invasive plants due to connectivity with wider landscape. Long-term loss of dry habitat trees may cause a decline in associated specialists as habitats change. Likely increase in species that rely on wood decay and humidity.	Minor permanent loss of some specialists as dry habitats (including woodland) succeed to wetter habitats. Likely increase in species that rely on wood decay and humidity.
Invertebrates - Wetland	Assemblage would remain the same in the short term, reducing in time as wetland habitat scrubs up and dries.	Minor loss of riverbank habitat during construction. Without mitigation, pollution events could cause a decrease in population size or alter vegetation that specialists rely on for food and nesting. Colonisation of the site by Himalayan Balsam would reduce the extent of wetland habitat available for wetland invertebrates. Increasing the extent and quality of wetland habitats will increase population sizes, availability of nesting and foraging habitats, and improve breeding success for wetland	Without mitigation, pollution events could cause a decrease in population size or alter vegetation that specialists rely on for food and nesting. Colonisation of the site by Himalayan Balsam would reduce the extent of wetland habitat available for wetland invertebrates. Increase in the extent and quality of wetland habitats will increase population sizes, availability of nesting and foraging habitats, and improve breeding success for wetland invertebrates.	Minor temporary loss of breeding and foraging habitat (reedbed). Increase in the extent and quality of wetland habitats will increase population sizes, availability of nesting and foraging habitats, and improve breeding success for wetland invertebrates. Without mitigation, changes to water quality (through pollution and release of PFA) could alter species assemblage.
Aquatic Invertebrates	As wetland habitat scrubs up and dries, foraging and breeding habitat will be reduced for aquatic life stages.	Without mitigation there is a fine balance between the improvement in habitat condition and quality and the negative effects if predatory fish are able to colonise permanently.	Without mitigation there is a fine balance between the improvement in habitat condition and quality and the negative effects if predatory fish are able to colonise permanently.	Potential temporary disturbance/injury/mortality impact during reprofiling and ramp construction. Potential for pollution and sedimentation to reduce survival, but increased connectivity to adjacent aquatic habitats mitigates this. Variation in topography will improve niche availability and increase the extent and quality of wetland habitats, and in turn increase population sizes, availability of nesting and foraging habitats, and improve breeding success for wetland invertebrates.

Ecological Receptor	Intervention without mitigation			
Plants of dry woodland	The plants of dry woodland would likely be maintained with little change.	Spread of Himalayan Balsam on disturbed ground would likely outcompete many native species. Drier habitats will become wetter, reducing the extent of suitable area for plants of dry woodland to exist. Some, including important and notable species, will likely eventually be restricted to a much smaller area.	Without mitigation, removal of some woodland plants will occur during construction. Spread of Himalayan Balsam would likely outcompete many native species. Drier habitats will soon become wetter, reducing the extent of suitable area for plants of dry woodland to exist. Some, including important and notable species, will likely be eventually be restricted to a much smaller area.	No change
Plants of wetland margins and damp habitats	These plants would likely decrease as there is an increase in scrub and a drying out and shading of the waterbodies following scrub encroahcment and change to wet woodland.	Increase of suitable habitat as the site becomes wetter and connectivity increases. Although colonisation of wetland margins severely impeded by presence of Crassula. The overall balance is uncertain.	Increase of suitable habitat as the site becomes wetter and connectivity increases. Although colonisation of wetland margins severely impeded by presence of Crassula. The overall balance is uncertain.	Minor temporary loss of marginal habitat during reprofiling works. Without mitigation, some plants could be destroyed during reprofiling and ramp construction. Increase of suitable, stable habitat as the site becomes wetter and connectivity increases. Changes to water quality (through pollution and release of PFA) could alter species assemblage. The overall balance is uncertain.
Plants of dry grassland	No change	No change	No change	No change
Aquatic Macrophytes	No change	These are lost on site, but may be able to recolonise from the river if connected. The introduction of fish may reduce macrophyte numbers. Increasing the extent and quality of wetland habitats will increase the extent of suitable habitat that aquatic macrophytes can colonise. The overall balance is uncertain.	These are lost on site, but may be able to recolonise from the river if connected. The introduction of fish may reduce macrophyte numbers. Increasing the extent and quality of wetland habitats will increase the extent of suitable habitat that aquatic macrophytes can colonise. The overall balance is uncertain.	Increase of suitable, stable habitat as the varied topography increases niches. Changes to water quality (through pollution and release of PFA) could alter species assemblage.
Amphibians	As wetland habitat scrubs up and dries, breeding habitat will be reduced.	Extraction of water into the site could cause injury to individuals, and short-term disturbance to populations. Without mitigation, the introduction of predators (fish) could have considerable negative effects on populations. Increasing the extent and quality of wetland habitats will provide improved breeding habitat for amphibians. A slight loss of drier, terrestrial habitats is expected.	Extraction of water into the site could cause injury to individuals, and short-term disturbance to populations. Without mitigation, the introduction of predators (fish) could have considerable negative effects on populations. Increasing the extent and quality of wetland habitats will provide improved breeding habitat for amphibians. A slight loss of drier, terrestrial habitats is expected.	Without mitigation, the reprofiling and ramp construction works will cause injury to individuals. An increase in extent, quality and stability of wetland habitats will provide improved breeding habitat for amphibians. A slight loss in drier, terrestrial habitats is expected. Changes to water quality (through pollution and release of PFA) could alter population levels temporarily.
Fish	No change	Construction and extraction of water into the site could cause injury to individuals, and short-term disturbance to populations. Fish introduced to the site could be trapped and killed when the lagoon dries out. Pollution events could also have major impacts, as freshwater fish are sensitive to them.	Construction and extraction of water into the site could cause injury to individuals, and short-term disturbance to populations. Fish introduced to the site could be trapped and killed when the lagoon dries out. Pollution events could also have major impacts, as freshwater fish are sensitive to them.	No change

Ecological Receptor	Intervention without mitigation			
Aquatic mammals	As wetland habitat scrubs up and dries, foraging habitat will be restricted.	Temporary disturbance and loss of habitat availability will occur during construction for Water Vole, Otter and Water Shrew. There is a small risk of mammals using the pipe installations for commuting without mitigation, but this is outweighed by the increased extent and quality of aquatic habitats provided. Long-term, it is likely that habitat extent, connectivity and breeding success will be improved.	Temporary disturbance and loss of habitat availability will occur during construction for Water Vole, Otter and Water Shrew. There is a small risk of mammals using the pipe installations for commuting without mitigation, but this is outweighed by the increased extent and quality of aquatic habitats provided. Long-term, it is likely that habitat extent, connectivity and breeding success will be improved.	No change
Invasive Non-Native Species	INNS are considered in terms of their impact on other species and are not assessed separately here.			

6 In-combination and cumulative effects

A search of Calderdale Planning Portal (https://www.calderdale.gov.uk/v2/residents/environment-planning-and-building/planning/search-and-comment-planning-applications) was undertaken on 10th November 2021 to identify any projects which could result in in-combination impacts with the proposed works. The results of this search are presented in Table 6-1.

Calderdale Local Plan (Draft) proposes a number of new housing and mixed development sites to the south of Cromwell Bottom LNR within areas of pasture grasslands, adjacent to Strangstry Wood.

Table 6-1: Projects assessed for in-combination effects

Planning Reference Number and Status	Description	Location	Potential for Cumulative Effects	Significance
17/01556/FUL Granted 2018	Demolition of existing buildings and erection of 100 residential units in three blocks plus gymnasium, car parking, public realm, landscaping and ancillary works.	Building North West Of Princess Works Birds Royd Lane Brighouse Calderdale	The project has potential to impact the River Calder through reduced water quality, river habitats, and disturbance to Otter. A Landscape Ecological Management Plan and Construction Environment Management Plan (CEMP) will be adhered to during the Project. Additionally, a Biodiversity Protection Zone of river corridor and screening of lighting along the river will be implemented. Therefore, the Project is unlikely to have adverse ecological or in-combination impacts.	Not significant
20/01368/MCO Approve Conditions 2021	Periodic Review of Planning Conditions in relation to Interim Development Order 95/00063/IDO	Former Calder Brick Works Shaw Lane Elland Calderdale	Quarrying works will take place until 2042. Previous ecological surveys identified deciduous woodland, standing water and scrub habitat of moderate ecological value. Impacts to species were limited to birds and bats due to disturbance during quarrying operations. Subject to the suggested mitigation measures being implemented and a scheme of Biodiversity Enhancement the conclusion is that there would be no	Not significant

			significant detrimental impacts on local or national wildlife populations Ongoing analysis of water confirms that there is no contamination reaching the River Calder from this site. Furthermore, as the current drainage pattern is being used for the long-term drainage of the site, there is little risk of future contamination. Therefore, there should be no in-combination effects.	
21/00824/FUL Pending Consideration 2021	New railway station with car park, new pedestrian accesses, landscaping and associated works	Former Rail Land Adjacent To Units A3 And A5 Old Power Way Lowfields Elland Calderdale	The proposals will result in significant loss of habitats (notably Lowland Deciduous Mixed Woodland) which lies within the Calderdale Wildlife Habitat Network and is of value to species, particularly birds and bats. The Biodiversity Net Gain calculation shows a Net LOSS of 79.5%, after onsite habitat retention, creation and enhancement has been considered. A Biodiversity Enhancement & Management Plan (BEMP) and CEMP will be drawn up and implemented during the project. Given the off-site compensatory habitat interventions and on-site mitigation measures, the project will not be likely to result in a significant adverse residual effect or in-combination impacts on any features of nature conservation importance throughout its construction or operation.	Not significant
21/00017/LAA Deemed Permit 2021	Elland access package - construction of x2 pedestrian and cycleway bridges in Elland and West Vale. Cycleway and pedestrian highway improvements. Landscaping and public	Land Between A629 And B6112 Stainland Road Elland Calderdale	New pedestrian and cycle infrastructure for new railway station at Elland. The construction works will result in a loss of tall ruderal, scrub and some individual trees and a temporary loss of amenity grassland and ornamental tree species. Other impacts include pollution incidents impacting the Calder and Hebble Canal, and artificial	Not significant

	realm improvements.		lighting impacts to bats and Otter. A CEMP, BEMP and lighting design strategy will be drawn up. No significant residual negative effects on habitats, notable or legally protected species are predicted should the mitigation, compensation and enhancements specified.	
21/00709/OUT Pending Consideration 2021	Residential development of up to 17 dwellings (Outline)	Former Unit 1 The Maltings Halifax Road Elland Calderdale	Outline planning application for the development of up to 17 residential units. To date no ecological reports have been submitted. Potential impacts include pollution incidents impacting the Calder and Hebble Canal, loss of small areas of scrub and broadleaved woodland and consequent impacts to protected species.	Not significant
18/01544/FUL Permit 2020	Proposed improvement works to A629 Huddersfield Road/B6112 Stainland Road corridor and A6026 Wakefield Road junction comprising construction of new road bridge over Calder and Hebble Navigation; new roundabout on B6112; new link road between A629 and B6112 and associated works including landscaping and infrastructure.	Land Between A629 And B6112 Stainland Road Elland Calderdale	The proposed works will result in the loss of 0.7ha of Ancient Woodland, broadleaved woodland, scrub, grassland, and disturbance to waterways. Further impacts to amphibians (during construction and road deaths), bats (loss of two roosts, lighting), breeding birds (reduction in habitat) and Otter (disturbance, contamination, lighting, deaths) anticipated. To mitigate these impacts several documents will be drawn up and implemented including, 5-10 year woodland management plans, CEMP, installation of bat / bird boxes, lighting strategy, biodiversity mitigation and enhancement plan and a landscaping plan.	Not significant

6.1 Summary

There are no projects with the potential to act in-combination with the proposed works at Cromwell Bottom Lagoon.

7 Mitigating Impacts

7.1 General mitigation measures benefitting a range features

There are some standard measures that can be implemented during the construction phase that can eliminate a number of common negative impacts. These are presented in this section and apply across a range of ecological features to avoid or mitigate the impact of construction works. They are all long-established methods and can be implemented with a high degree of certainty. Most would be captured in a standard Construction Environmental Management Plan (CEMP).

7.1.1 Pollution prevention

There are a wide range of documents setting out the best-practice for pollution prevention. e.g. CIRIA Guidance: Control of water pollution from construction sites, Guidance for consultants and contractors (C532D) (Masters-Williams, 2001). A detailed CEMP should be produced that includes, but is not limited to:

- Storing fuel, hydrocarbons and contaminated water away from watercourses and sensitive habitats in bunded areas;
- Proper maintenance, including daily inspections for leaks, of construction vehicles and equipment;
- Keeping vehicles to agreed access routes and work areas, and where necessary having these routes clearly marked out;
- Having careful management plans and emergency spill response plans for using concrete and other potentially damaging substances near watercourses.

7.1.2 Species disturbance

Disturbance from construction activities can have a negative impact on a range of species. The following measures are necessary to avoid disturbance impacts during construction:

- Vegetation clearance should take place outside bird nesting season, or for small areas, a check for bird nests should be made prior to clearance, and if found the nests protected until fledged;
- Works should only take place in daylight hours and finish 30 minutes before sunset each day;
- Materials should be stored securely overnight and no excavations left open unless provided with an escape ramp.
- A walkover survey should be completed prior to construction to ensure mobile species have not established new resting or breeding locations.

7.1.3 INNS management during construction

A management plan should be prepared for construction activities and post-construction management of areas that have been subject to disturbance. Management of INNS is ongoing on the site, but construction poses an increased risk of spreading species. The following measures should be included:

- Check, clean and dry equipment and clothing on entering and leaving the site;
- Wash-down areas should be provided for vehicles leaving the site to prevent the spread of fragments of New Zealand Pygmyweed;
- Measures to remove or control INNS within the construction footprint should be included, which should include Himalayan Balsam control to prevent accidental

dispersal of seed, and clearing of New Zealand Pygmyweed from proposed works areas. Ideally a composting areas should be identified in advance, and young Himalayan Balsam pulled by hand and added to the composting area, or areas of Pygmyweed collected by machine and added to the composting area. There should be no possibility of vegetation fragments being washed from the composting area into any watercourses.

- Plans for post-works monitoring of revegetation should be in place to ensure INNS do not take over disturbed ground, or if they are noted that they can be controlled early.

7.1.4 PFA chemistry

There are unlikely to be significant effects of disturbing PFA, but this remains a notable uncertainty, and there could be short-term to medium-term impacts on some aquatic species from changes in water chemistry. However, this is likely to result in conditions reverting back to those found on site in the recent past, rather than a catastrophic change. Minimising the amount of PFA movement would reduce this impact, but under Option 4 this would be counter to the aim of the work.

7.2 Mitigating impacts on canal hydrology

Abstracting excessive water from the canal could impact its hydrology. Therefore, the proposal should use an inlet no lower than the current overflow located slightly upstream on the River Calder. This means the water level will not change from current levels. The design should provide flexibility to close the new inlet and revert to the original overflow in order to remove any uncertainty over impacts on canal hydrology.

7.3 Mitigating impacts on water quality in the lagoon

Although the quality of imported water is not expected to be much worse than that currently on site (Appendix C), there is the potential for increases in nitrate and phosphate concentrations. However, some attenuation can be achieved if the water is released into the wet woodland at the western end and allowed to flow through the woodland before reaching the reedbed and lagoon. The woodland is likely to be able to take up additional nutrients without much change in overall ecology, meaning the quality of water arriving at the reedbed and lagoon would be better. This overland flow path would also result in sediment being deposited in the woodland preventing siltation of the lagoon.

7.4 Mitigating impacts on fish and from fish

If a dry working area is needed in the canal to install the new overflow to get water onto the site, then a fish rescue may be necessary when dewatering to prevent fish being killed. Any pumps used for dewatering should be fish-friendly pumps. The works to the canal or river would also need to be undertaken in the close season for fish (July – September) other special permission from the Environment Agency may be required.

The new pipe should include measures to prevent fish from being able to enter the pipe and therefore to get into the lagoon and reedbed. By preventing their access significant negative impacts can be avoided.

7.5 Mitigating impacts on plants of dry woodland

The potential loss of the notable plants of dry (or dampish) birch woodland is one of the more challenging impacts to mitigate and includes a significant degree of uncertainty. The increase in water is likely, but not certain, to cause the suitable habitat for these species to move from the drier areas of Carr woodland to the margins. If they can't disperse here naturally then they risk being lost. Therefore, the best option is to facilitate their movement through translocation of seeds, vegetative propagules or whole plants. A separate strategy may be needed for each species. Consideration may need to be given to retaining the Yellow Bird's-nest in its location,

as it is a parasite with a close relationship with *Tricholoma* fungi and trees (Lockton & Walker, 2022), and would likely be difficult to establish in new locations.

7.6 Mitigating construction impacts on amphibians

Areas of habitat suitable for amphibians and needed for construction should be carefully checked for their presence prior to ground clearance. In the active season (March − October) any amphibians should be moved to a safe alternative refuge. No refuges should be removed or altered in the hibernation season.

Ecological Receptor	Ecological impact after mitigation (effects of pollution control, avoiding disturbance and preventing INNS spread included in all cases)			
	Option 1 - No active intervention	**Option 2 – Water extraction from the River Calder using a) natural flood flows, or b) pumps**	**Option 3 – Water extraction from the Calder and Hebble Navigation a) at existing overflow structure, or b) using new structure near viewing platform**	**Option 4 – Lake topography profiling**
Cromwell Bottom Local Nature Reserve (LNR), Local Wildlife Site (LWS)	**Summary**: Vegetation succession leading to late successional communities which are more common than mid-succesional lagoon, reedbed and mire. **Net effect:** Permanent negative **Certainty**: there is moderate uncertainty around future habitat change.	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Key mitigation**: filtering water through wet woodland before entering lagoon/reedbed **Net effect**: Permanent positive impact **Certainty**: Moderate uncertainty over reliability of water supply from river.	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Key mitigation**: filtering water through wet woodland before entering lagoon/reedbed **Net effect**: Permanent positive impact **Certainty**: High certainty as canal water supply is more reliable.	**Summary**: Improvement in habitat quality and condition from increased niche diversity. **Net effect**: Permanent positive impact **Certainty**: Near certain
Calder and Hebble Canal LWS	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: With mitigation in place there should be no change on canal ecology. **Key mitigation**: design of water intake to ensure no change on canal water levels. **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain
Elland Park Wood LWS and Strangstry Wood LWS	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain
Reedbed and Lagoon	As for Cromwell Bottom LNR	As for Cromwell Bottom LNR	As for Cromwell Bottom LNR	As for Cromwell Bottom LNR
Wet woodland (Broadleaved Semi-natural woodland)	**Summary**: Succession to dry woodland but expansion to reedbed and mire if management cannot keep up with successional changes. **Net effect**: Small positive medium-term **Certainty**: Some uncertainty from balance of management compared to rate of successional changes.	**Summary**: Expansion to areas of damp birch woodland as water levels rise, improved condition with more water supply, with flood disturbance favouring wet woodland. **Net effect**: Small permanent positive impact **Certainty**: Fairly certain although water supply from river unreliable.	**Summary**: Expansion to areas of damp birch woodland as water levels rise, improved condition with more water supply. **Net effect**: Small permanent positive impact **Certainty**: Fairly certain.	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain
Oak and Birch woodland (Broadleaved Semi-natural woodland)	**Summary**: Minor successional changes. **Net effect**: Small permanent positive impact **Certainty**: Near certain	**Summary**: Small loss through conversion to wet woodland. **Net effect**: Small permanent negative impact **Certainty**: Near certain	**Summary**: Small loss through conversion to wet woodland. **Net effect**: Small permanent negative impact **Certainty**: Near certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain
Valley Mire	As for Cromwell Bottom LNR	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain
Birds - Wetland	**Summary**: Loss of habitat leading to declines. **Net effect**: Major permanent negative impact **Certainty**: Near certain	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Net effect**: Permanent positive impact **Certainty**: Moderate uncertainty over reliability of water supply from river.	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Net effect**: Permanent positive impact **Certainty**: High certainty as canal water supply is more reliable.	**Summary**: Improvement in habitat quality and condition from increased niche diversity. **Net effect**: Permanent positive impact **Certainty**: Near certain

Ecological Receptor	Ecological impact after mitigation (effects of pollution control, avoiding disturbance and preventing INNS spread included in all cases)			
Birds - Woodland	**Summary**: Minor successional changes. **Net effect**: No significant effect **Certainty**: Species changes always have uncertainty.	**Summary**: Minor successional changes. **Net effect**: No significant effect **Certainty**: Species changes always have uncertainty.	**Summary**: Minor successional changes. **Net effect**: No significant effect **Certainty**: Species changes always have uncertainty.	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain
Invertebrates – Open habitats	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain
Invertebrates - Tree-associated	**Summary**: Minor successional changes. **Net effect**: No significant effect **Certainty**: Species changes always have uncertainty.	**Summary**: Minor successional changes. **Net effect**: No significant effect **Certainty**: Species changes always have uncertainty.	**Summary**: Minor successional changes. **Net effect**: No significant effect **Certainty**: Species changes always have uncertainty.	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain
Invertebrates - Wetland	**Summary**: Loss of habitat leading to declines. **Net effect**: Major permanent negative impact **Certainty**: Near certain	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Net effect**: Permanent positive impact **Certainty**: Moderate uncertainty over reliability of water supply from river.	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Net effect**: Permanent positive impact **Certainty**: High certainty as canal water supply is more reliable.	**Summary**: Improvement in habitat quality and condition from increased niche diversity. **Net effect**: Permanent positive impact **Certainty**: Near certain
Aquatic Invertebrates	**Summary**: Loss of habitat leading to declines. **Net effect**: Major permanent negative impact **Certainty**: Near certain	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Key mitigation**: Measures to prevent fish being able to access site. **Net effect**: Permanent positive impact **Certainty**: Some uncertainty over reliability of water supply from river.	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Key mitigation**: Measures to prevent fish being able to access site. **Net effect**: Permanent positive impact **Certainty**: High certainty as canal water supply is more reliable.	**Summary**: Improvement in habitat quality and condition from increased niche diversity. **Net effect**: Permanent positive impact **Certainty**: Near certain
Plants of dry woodland	As for Oak and Birch woodland	As for Oak and Birch woodland	As for Oak and Birch woodland	As for Oak and Birch woodland
Plants of wetland margins and damp habitats	**Summary**: Loss of habitat leading to declines. **Net effect**: Major permanent negative impact **Certainty**: Near certain	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Key mitigation**: Measures to prevent fish being able to access site. **Net effect**: Permanent positive impact **Certainty**: Moderate uncertainty over reliability of water supply from river.	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Key mitigation**: Measures to prevent fish being able to access site. **Net effect**: Permanent positive impact **Certainty**: High certainty as canal water supply is more reliable.	**Summary**: Improvement in habitat quality and condition from increased niche diversity. **Net effect**: Permanent positive impact **Certainty**: Near certain
Plants of dry grassland	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain
Aquatic Macrophytes	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Key mitigation**: Measures to prevent fish being able to access site. **Net effect**: Permanent positive impact **Certainty**: Moderate uncertainty over reliability of water supply from river.	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Key mitigation**: Measures to prevent fish being able to access site. **Net effect**: Permanent positive impact **Certainty**: High certainty as canal water supply is more reliable.	**Summary**: Improvement in habitat quality and condition from increased niche diversity. **Net effect**: Permanent positive impact **Certainty**: Near certain

Ecological Receptor	Ecological impact after mitigation (effects of pollution control, avoiding disturbance and preventing INNS spread included in all cases)			
Amphibians	**Summary**: Loss of habitat leading to declines. **Net effect**: Major permanent negative impact **Certainty**: Near certain	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Key mitigation**: Measures to prevent fish being able to access site. Search and rescue in construction footprint. **Net effect**: Permanent positive impact **Certainty**: Moderate uncertainty over reliability of water supply from river.	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Key mitigation**: Measures to prevent fish being able to access site. Search and rescue in construction footprint. **Net effect**: Permanent positive impact **Certainty**: High certainty as canal water supply is more reliable.	**Summary**: Improvement in habitat quality and condition from increased niche diversity. **Net effect**: Permanent positive impact **Certainty**: Near certain
Fish	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain	**Summary**: Currently absent from site but present in canal and river **Key mitigation**: Measures to prevent fish being able to access site. **Net effect**: No change **Certainty**: Low certainty, with using flood water it may not be possible to stop fish accessing the site and becoming stranded.	**Summary**: Currently absent from site but present in canal and river **Key mitigation**: Measures to prevent fish being able to access site. **Net effect**: No change **Certainty**: Near certain: any canal overflow would be easier to manage to prevent fish entry.	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain
Aquatic mammals	**Summary**: Some habitat change but not significant to mammals. **Net effect**: No impact **Certainty**: Near certain	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Net effect**: Permanent positive impact **Certainty**: Moderate uncertainty over reliability of water supply from river.	**Summary**: Improvement in habitat quality and condition from increased wetness of the lagoon, reedbed and wet woodland. **Net effect**: Permanent positive impact **Certainty**: High certainty as canal water supply is more reliable.	**Summary**: No pathways **Net effect**: No impact **Certainty**: Certain
Invasive Non-Native Species	INNS are considered in terms of their impact on other species and are not assessed separately here.			

8 Impact assessment with mitigation

The impacts identified in Table 5-2 are re-assessed with this mitigation in place and shown in Table 8-1. The overall effect of mitigation is to remove nearly all of the negative impacts for Options 2-4, and to increase the positive impacts.

8.1 Residual negative impacts and uncertainty

For all three options for doing something, there is a clear net positive outcome. However, the residual negative impacts need to be acknowledged as unavoidable consequences of the work, and uncertainty in the assessment also requires acknowledgement.

Option 2a: For the option to bring water onto site from the river via a spillway, the only negative impact following mitigation is on the dry woodland and associated plants, which would be expected to become wetter and therefore change from dry to wet woodland, with the associated changes in ground flora.

Significant uncertainty surrounds the supply of water using this approach, particularly as it relies on unpredictable flood waters to top up water levels in the reserve. The uncertainty over water supply leads to significant uncertainty over the ability of this method to achieve the improvement in habitat condition desired.

Option 2b: The same negative impacts would apply via this option. It provides more certainty as it could be used on demand, although any abstraction would require a licence and the conditions included with this would likely exclude abstraction during low water flows when water would be most needed.

Option 3: For the option to bring water onto site from the canal, the same residual negative impact exists as for option 2, with the only negative impact following mitigation being on the dry woodland and associated plants, which would be expected to become wetter and therefore change from dry to wet woodland, with the associated changes in ground flora.

Uncertainty for this option relates largely to the difficulty of predicting responses to the change in water level, but overall, this option provides the most reliable source of additional water and is therefore the least uncertain in terms of potential changes.

Option 4: This option involves the most construction disturbance. the lagoon already has extensive *Crassula* meaning habitats and species that would be disturbed are limited. and the construction impacts are readily mitigated, leaving no residual negative impacts.

As with the other options, there are uncertainties of the ecological response to changes in the environment. For the lagoon, this includes the unlikely but possible changes in chemistry relating to remobilised PFA and the response of different species to this, as well as uncertainty over whether the scale of changes would provide sufficient microhabitat variation to diversify the species present.

8.2 Addressing uncertainty with further survey work

8.2.1 Invertebrates

There have not been any surveys for aquatic invertebrate species, except for incidental records in Richard Wilson Ecology (2017). The lagoon is currently strongly seasonal and an increase in water supply would be expected to alter the assemblage towards species of permanent lagoons. The effects are likely to be relatively minor, but the present of notable species that may be lost in the transition is unknown.

A pre-work survey and subsequent monitoring programme would allow an inventory of the species and an understanding of the changes the result from the works. This should include an appropriately designed invertebrate survey which should be completed over two seasons within a year and carried out in subsequent years to document the change.

8.2.2 PFA Analysis

There is some uncertainty about the impacts of re-working the PFA (Option 4) in terms of whether there would be a release of contaminants. The PFA has been shown to be relatively stable, and currently any heavy metals and the remaining calcium are locked into the material and not biologically available. Re-working the material could release these substances, although the extent of this is not clear. It would be possible to take cores of PFA and carry out leachability tests at different depths to determine if there is potential for the release of heavy metals or other substances from the PFA if it were re-worked.

8.3 Changes in water quality

The changes in water quality have been assessed based on water sampling in 2005 and 2021 at a single time point. Although these give comparable data, the 2021 sample from the lagoon was taken during a time of low water, and the results are therefore less reliable, and show some extreme values. An additional water sample from the lagoon at a time of high water would provide added confidence in the impact of imported water on the overall water quality in the lagoon.

9 Summary of option impacts and key mitigation

9.1 Do-nothing Scenario

The assessment of impacts has identified that under a do-nothing scenario the natural succession of habitats will lead to a change in habitats from open water and reedbed to wet woodland, and an associated simplification of species from those of the current mix of habitats towards woodland specialists. This is currently kept in check by management, but ongoing drying out means that the management requirement is likely to become more intensive over time.

9.2 Benefits of a wetter site

Under Options 2 and 3 the site would become wetter and the increased water levels would provide significant benefit to the reedbed, lagoon and wet woodland habitats. Species that use these habitats (wetland birds, wetland invertebrates, riparian mammals) would therefore also benefit. Impacts of construction can largely be mitigated, but increased wetness is likely to result in the conversion of some dry woodland into wet woodland, leading to a change in this habitat that may also affect the notable plant species Yellow Bird's-nest and Round-leaved Wintergreen. These are unavoidable impacts of wetting the site, which ultimately would result in significant habitat improvement and better conditions for a wide range of species. The works needed to bring the water onto site would involve some construction activity but impacts of this on key ecological features can be avoided by the inclusion of appropriate mitigation e.g. timing of the works. Overall, there is a strong ecological case for increasing the supply of water onto the site.

9.3 Differences in using canal and river water

There are relatively few ecological differences between using the canal and river water. Using flood water from the river by lowering a section of bank has the highest level of uncertainty of supply and is not controllable, and has a risk of fish entering the site. However, periodic major flooding can create significant disturbance effects that benefit wet woodland and lagoon habitats, resetting the successional processes to some extent.

Using water pumped from the river or taken from the canal overflow provides a more reliable supply of water, and the inlet structures can be designed to prevent fish from entering the reserve. Overall, therefore, the differences in the two water sources makes little ecological difference.

9.4 Reprofiling the lagoon

Reprofiling the lagoon will increase the microhabitat diversity, providing an increased range of hydrological conditions, albeit on a relatively small scale. This would benefit a range of species by providing drier or wetter niches as the water level changes. It may also encourage an increased range of breeding bird species. The negative impacts during the works can be mitigated, and the extensive presence of *Crassula* in the lagoon means construction impacts are lower than might be otherwise. However, there is uncertainty around the impact of reworking the PFA and the release of contaminants that may occur with this.

9.5 Summary and next steps

The report highlights that the ideal scenario is to implement at least one of options 2 or 3, and that option 4 could also provide benefit. Ecologically, the net effect of the canal is slightly more certain, but given the small overall difference, the Water Level Management Plan and issues around consents and permits are likely to be a more significant driver of the overall decision. The next steps should be selection of a preferred option with identification of the detailed construction approach, combined with consultation with relevant stakeholders. Once this is in place the EcIA should be reviewed and the appraisal of the final option, including assessing relevant mitigation, should be carried out.

10 Preferred Option

10.1 Outline for preferred option

Subsequent to the preparation of the EcIA and WLMP, the preferred option has been identified to use passive flow from the Calder and Hebble Navigation to allow the natural overflow from the canal to the river to pass through the reserve. It would be piped from the canal into the Carr Woodland, and allowed to filter through the woodland into the lagoon. Included in the plans are a base and pipework to allow the pumping of river water as a backup, but this would not be the primary means of water supply. A number of water control structures would be included to help manage the water levels. The concept is shown in Figure 10-1.

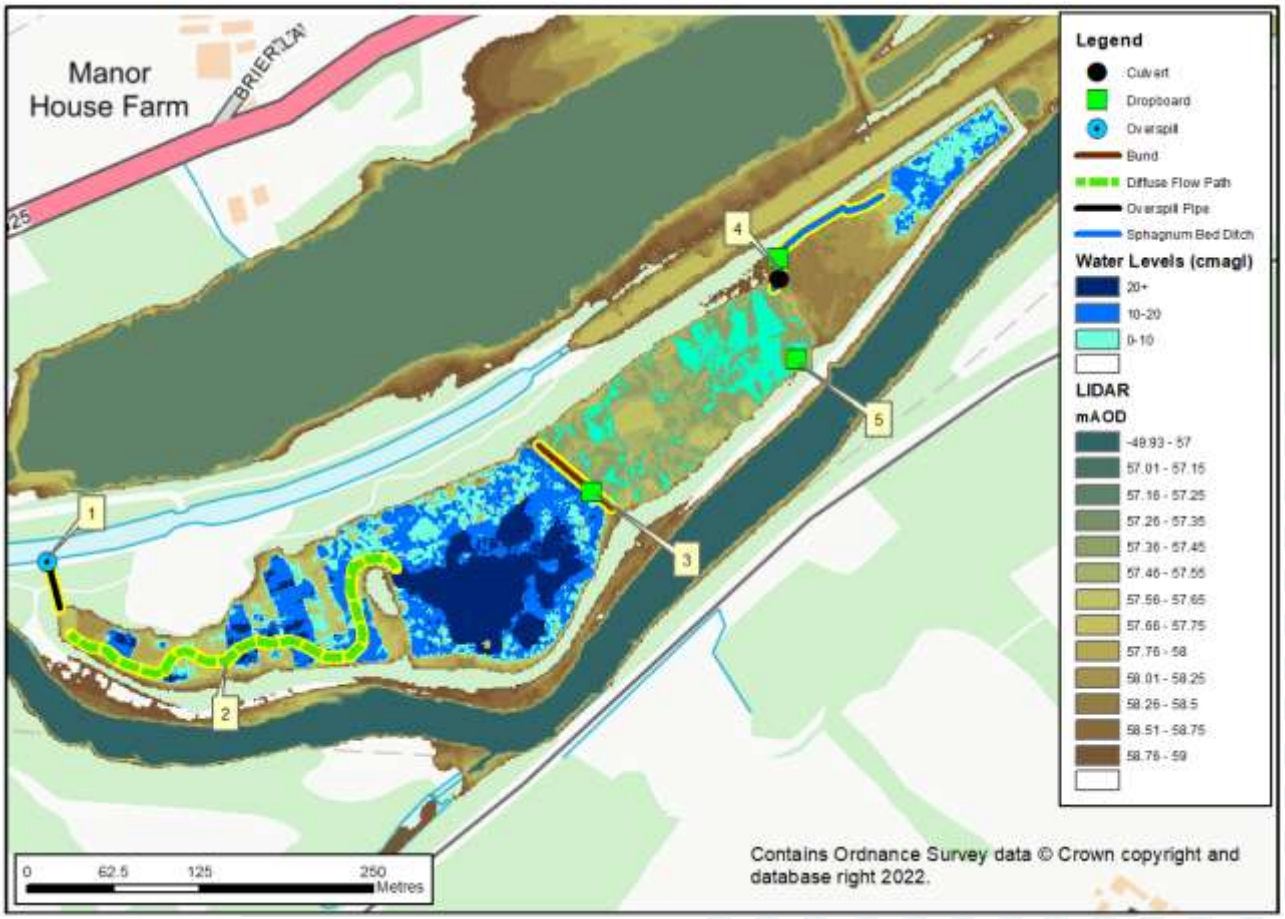


Figure 10-1. Details of the preferred option

10.2 Confirmation of impacts and mitigation

The impacts and mitigation relevant to the preferred option are those set out of Option 3a in the main report.

Appendices

A Legislative and Planning Context

A.1 Natural Environment and Rural Communities (NERC) Act 2006

Section 40 of the Natural Environment and Rural Communities Act (2006) states that 'Every public authority must, in exercising its functions, have regard, so far as is consistent with the proper exercise of those functions, to the purpose of conserving biodiversity'. Section 40(3) also states that 'conserving biodiversity includes, in relation to a living organism or type of habitat, restoring or enhancing a population or habitat'.

Section 41 of the NERC Act requires the Secretary of State to publish a list of species of flora and fauna and habitats considered to be of principal importance for the purpose of conserving biodiversity. To meet this requirement, the England Biodiversity List (the S41 list) has been developed. Species and habitats listed under Section 41 of the NERC Act 2006, whilst not necessarily being legally protected, can be a material planning consideration.

The S41 list, which replaces the list published under Section 74 of the Countryside and Rights of Way (CRoW) Act 2000, should be used to guide decision-makers such as public bodies, including local and regional authorities, in implementing their duty under section 40 of the NERC Act 2006 'to have regard' to the conservation of biodiversity in England, when carrying out their normal functions.

A.2 Statutory designated nature conservation sites

Sites with statutory designations receive varying degrees of legal protection under UK statute. There are several statutory designations used for sites of high nature conservation value in the UK, which are applied depending upon the importance of the site in a local, regional, national or international context. This includes:

- Ramsar Sites (International designation)
- SAC and SPA (National Site Network designations)
- National Nature Reserves (NNR) and SSSI (National designations)
- Local Nature Reserves (LNR) (Local designation)

A.3 Non-statutory designated sites

Non-statutory sites are afforded no statutory legal protection, but are normally recognised by local planning authorities and statutory agencies as being of local nature conservation value. The protection afforded to such sites is usually discretionary, through Local Plan policies. Non-statutory sites are designated by the local authority, usually in partnership with the County Wildlife Trust (or equivalent).

A.4 Protected species

Several species are protected under UK and international legislation. In the UK, primary protection is provided under the Wildlife and Countryside Act 1981 (as amended). Species of European importance receive additional protection in England under the Conservation of Habitats and Species Regulations 2017 (as amended); others may receive protection through specific legislation. Further details on specific species and their levels of protection are provided below.

A.4.1 Birds

All wild birds are protected under the Wildlife and Countryside Act 1981 (as amended). This makes it an offence to:

- intentionally take, damage or destroy the nest of any wild bird whilst it is in use or being built
- take, destroy or possess the egg of any wild bird.

Certain species, such as the Barn Owl *Tyto alba*, receive additional protection under Schedule 1, which makes it an offence to intentionally or recklessly disturb birds and also their young at, on or near an active nest.

A.4.2 Otter

The European Otter *Lutra lutra* is an EPS protected under the Conservation of Habitats and Species Regulations 2017 (as amended), making it an offence to:

- deliberately capture, injure or kill an Otter
- deliberately disturb an Otter such as to affect local populations or breeding success
- damage or destroy an Otter holt, possess or transport an Otter or any part of an Otter
- sell or exchange an Otter.

Otters also receive protection under the Wildlife and Countryside Act 1981 (as amended), this makes it an offence to:

- intentionally or recklessly disturb any Otter whilst within a holt
- intentionally or recklessly obstruct access to a holt.

A.4.3 Water Vole

The Water Vole *Arvicola amphibius* is protected under the Wildlife and Countryside Act 1981 (as amended). This makes it an offence to:

- intentionally kill, injure or capture a Water Vole
- possess or control a Water Vole, living or dead, or any part of a Water Vole
- intentionally or recklessly damage, destroy or obstruct access to any place of shelter, or disturb a Water Vole within such a place
- sell or offer for sale a Water Vole living or dead, or part of a Water Vole.

A.4.4 Reptiles and other amphibians

Under the Wildlife and Countryside Act 1981 (as amended) Adder *Viperus berus*, Grass Snake *Natrix natrix/Natrix helvetica*, Common Lizard *Zootoca vivipara* and Slow Worm *Anguis fragilis* are protected from intentional killing or injuring, additionally Common Frog *Rana temporaria*, Common Toad *Bufo bufo* and other newt species are prohibited from sale.

A.4.5 Fish

The Salmon and Freshwater Fisheries Act (1975) affords protection to fish and to the spawning grounds of fish. Section 2(5) makes it an offence to wilfully disturb spawning fish or the spawn of fish. Section 4(1) makes it an offence to knowingly permit the introduction of material to a watercourse such that it becomes injurious to fish, the spawn of fish or the spawning grounds of fish.

A.5 Invasive non-native species

Schedule 9 of the Wildlife and Countryside Act 1981 (as amended) lists plant species, groups of plants and animal species for which it is illegal to plant, release, allow to escape or cause to spread into the wild. Examples of species listed on Schedule 9, which are most likely to be encountered, include Japanese Knotweed *Reynoutria japonica*, Himalayan Balsam *Impatiens glandulifera*, and Signal Crayfish *Pacifastacus leniusculus*.

Some species are also classed as 'controlled waste' under the Environmental Protection Act 1990 and must be disposed of properly (i.e. Japanese Knotweed and Giant Hogweed). These provisions mean that, if these species occur on a site proposed for development or other work which may disturb the ground, control of these species is likely to be required.

B Protected and priority species within project ZoI

Latin name	Common Name	Status	Number of records and date of most recent	Recorded in wetland habitats or likely to use them?
Amphibians				
Bufo bufo	Common Toad	UKBAP, Calderdale BAP	10 records (2020)	Associated with lagoon and wet woodland
Rana temporaria	Common Frog	Calderdale BAP	27 records (2018)	Recorded within lagoon
Lissotriton helveticus	Palmate Newt		11 records (2014)	Associated with lagoon and wet woodland
Lissotriton vulgaris	Smooth Newt		10 records (2014)	Associated with lagoon and wet woodland
Birds				
Actitis hypoleucos	Common Sandpiper	BoCC Amber List	1 record (2000)	Associated with lagoon and rivers
Alcedo atthis	Kingfisher	W&CA Sch. 1, BOCC Amber List, Calderdale BAP	2 records (2014)	Associated with lagoon
Anas clypeata	Shoveler	BoCC Amber List	1 record (2000)	Associated with lagoon
Anas crecca	Teal	BoCC Amber List, Calderdale BAP	1 record (2000)	Associated with lagoon and reedbed habitats
Anas strepera	Gadwall	BoCC Amber List	1 record (2000)	Associated with lagoon and reedbed habitats
Apus apus	Swift	BoCC Amber List, WYBAP	1 record (2011)	Associated with lagoon
Aythya ferina	Pochard	BoCC Red List	1 record (2000)	Associated with lagoon and reedbed habitats
Botaurus stellaris	Bittern	W&CA Sch. 1, BoCC Red List, UKBAP, WYBAP	1 record (2000)	Associated with lagoon and reedbed habitats
Bucephala clangula	Goldeneye	BoCC Amber List	1 record (2000)	Associated with lagoon and reedbed habitats
Carduelis flammea	Common Redpoll	BoCC Amber List	1 record (2000)	Associated with woodland habitat
Charadrius dubius	Little Ringed Plover	W&CA Sch. 1. Calderdale BAP	1 record (2000)	Associated with lagoon and reedbed habitats
Charadrius hiaticula	Ringed Plover	Calderdale BAP	1 record (2000)	Associated with lagoon and reedbed habitats
Delichon urbica	House Martin	BoCC Amber List,	1 record (2000)	Associated with freshwater and woodland

Latin name	Common Name	Status	Number of records and date of most recent	Recorded in wetland habitats or likely to use them?
		WYBAP		
Dendrocopos minor	Lesser Spotted Woodpecker	BoCC Red List, UKBAP, Calderdale BAP, WYBAP	2 records (2005)	Associated with moist – dry woodland habitat and tree-lined watercourses
Emberiza schoeniclus	Reed Bunting	BoCC Amber List, Calderdale BAP, UKBAP	1 record (2000)	Associated with lagoon and reedbed habitats
Falco tinnunculus	Kestrel	BoCC Amber List, Calderdale BAP, WYBAP	1 record (2000)	Associated with wetland and open woodland habitat
Gallinago gallinago	Snipe	BoCC Amber List, Calderdale BAP	1 record (2000)	Associated with wet woodland clearings
Gavia arctica	Black-throated Diver	BoCC Amber List, UKBAP	1 record (2000)	Associated with lagoon and reedbed habitats
Haematopus ostralegus	Oystercatcher	BoCC Amber List, Calderdale BAP	1 record (2000)	Associated with lagoon and reedbed habitats
Larus argentatus	Herring Gull	BoCC Red List; UKBAP	1 record (2000)	Associated with lagoon and reedbed habitats
Larus canus	Common Gull	BoCC Amber List	1 record (2000)	Associated with lagoon and reedbed habitats
Larus fuscus	Lesser Black-backed Gull	BoCC Amber List	1 record (2000)	Associated with lagoon and reedbed habitats
Larus marinus	Great Black-backed Gull	BoCC Amber List	1 record (2000)	Associated with lagoon and reedbed habitats
Larus ridibundus	Black-headed Gull	BoCC Amber List, Calderdale BAP	2 records (2018)	Associated with lagoon and reedbed habitats
Locustella naevia	Grasshopper Warbler	BoCC Red List, UKBAP, Calderdale BAP	1 record (2000)	Associated with reedbed habitats
Lymnocryptes minimus	Jack Snipe	BoCC Amber List	1 record (2000)	Associated with wetland habitats
Motacilla cinerea	Grey Wagtail	BoCC Red List, Calderdale BAP	1 record (2000)	Associated with lagoon and reedbed habitats
Numenius arquata	Curlew	BoCC Red List, UKBAP, WYBAP, Calderdale BAP	1 record (2000)	Associated with grassland, freshwater and wetlands
Parus montanus	Willow Tit	BoCC Red List, UKBAP, Calderdale BAP	1 record (2000)	Associated with wet woodland
Passer domesticus	House Sparrow	BoCC Red List, UKBAP,	5 records (2019)	Associated with urban, scrub, hedgerow and

Latin name	Common Name	Status	Number of records and date of most recent	Recorded in wetland habitats or likely to use them?
		WYBAP, Calderdale BAP		woodland edge habitat
Picus viridis	Green Woodpecker	BoCC Amber List, Calderdale BAP	1 record (2000)	Associated with woodland habitat
Podiceps cristatus	Great Crested Grebe	Calderdale BAP	1 record (2000)	Associated with lagoon and reedbed habitats
Podiceps grisegena	Red-necked Grebe	BoCC Red List	1 record (2000)	Associated with lagoon and reedbed habitats
Prunella modularis	Dunnock	BoCC Amber List, UKBAP, WYBAP, Calderdale BAP	3 records (2018)	Associated with hedgerows, scrub and woodland habitat
Pyrrhula pyrrhula	Bullfinch	BoCC Amber List, Calderdale BAP, WYBAP	2 records (2018)	Associated with hedgerows and woodland habitat
Rallus aquaticus	Water Rail	Calderdale BAP	1 record (2000)	Associated with lagoon and reedbed habitats
Regulus regulus	Goldcrest	Calderdale BAP	2 records (2018)	Associated with woodland habitat
Riparia riparia	Sand Martin	BoCC Amber List, Calderdale BAP	1 record (2000)	Associated with lagoon and reedbed habitats
Sturnus vulgaris	Starling	BoCC Red List, UKBAP, Calderdale BAP	1 record (2000)	Associated with open woodland and woodland edge habitat
Sylvia curruca	Lesser Whitethroat	Calderdale BAP	1 record (2000)	Associated with reedbed habitats
Tachybaptus ruficollis	Little Grebe	BoCC Amber List	1 record (2000)	Associated with lagoon and reedbed habitats
Tadorna tadorna	Shelduck	BoCC Amber List, Calderdale BAP	1 record (2000)	Associated with lagoon and reedbed habitats
Tringa totanus	Redshank	BoCC Amber List, Calderdale BAP	1 record (2000)	Associated with lagoon and reedbed habitats
Turdus philomelos	Song Thrush	BoCC Red List, UKBAP, Calderdale BAP	1 record (2000)	Associated with woodland edge and scrubby birchwood
Turdus viscivorus	Mistle Thrush	BoCC Red List, Calderdale BAP	5 records (2019)	Associated with open woodland and woodland edge habitat
Vanellus vanellus	Lapwing	BoCC Red List, UKBAP, WYBAP, Calderdale BAP	1 record (2000)	Associated with lagoon and reedbed habitats

Latin name	Common Name	Status	Number of records and date of most recent	Recorded in wetland habitats or likely to use them?
Ferns				
Dryopteris carthusiana	Narrow Buckler-Fern	Calderdale BAP	1 record (2000)	Associated with wet woodland
Polystichum setiferum	Soft Shield-Fern	Calderdale BAP	6 records (2009)	Associated with shaded deciduous woodland, hedgerows, lane banks and sheltered stream sides
Fish				
Anguilla anguilla	European Eel	WYBAP	6 records (2015)	Associated with watercourses
Barbatula barbatula	Stone loach	-	1 record (2016)	
Gasterosteus aculeatus	3-spined stickleback	-	77 records (2016)	
Phoxinus phoxinus	Minnow	-	83 records (2016)	
Salmo trutta	Brown Trout	WYBAP	27 records (2018)	
Flowering Plants				
Eleocharis acicularis	Needle spike-rush	VC63 LRDB: Occasional	1 record (2000)	Associated with lagoon
Epipactis helleborine	Broad-leaved Helleborine	Calderdale BAP	1 record (2007)	Associated with deciduous woodland, hedgerows, shady banks and stream sides
Epipactis palustris	Marsh Helleborine	VC63 LRDB: Very Rare	1 record (2000)	Associated wetland habitats
Hypopitys monotropa	Yellow Bird's-nest	RDB Post 2001 Endangered, UKBAP, Calderdale BAP	2 records (2015)	Recorded within wet woodland habitat
Luronium natans	Floating Water-Plantain	VC63 LRDB: Rare	3 records (2014)	Associated with lakes, pools, slow-flowing rivers, and abandoned or little-used canals
Myriophyllum verticillatum	Whorled Water-milfoil	VC63 LRDB: Rare	1 record (2000)	Associated with lagoon habitats
Neottia ovata	Common Twayblade	Calderdale BAP	1+ records (2015)	Found on bank near western wet woodland at Cromwell Bottom NR
Poa humilis	Spreading Meadow-Grass	VC63 LRDB: Rare	1 record (2000)	Associated with grasslands, including along riverbanks
Pyrola rotundifolia subsp. rotundifolia	Wintergreen	VC63 LRDB: Rare	1 record (2017)	Associated with damp habitats

Latin name	Common Name	Status	Number of records and date of most recent	Recorded in wetland habitats or likely to use them?
Rorippa islandica	Northern Yellow-cress	VC63 LRDB: Casual only – Very Rare	1 record (2000)	Associated with lagoon habitats
Mosses				
Ulota calvescans	Balding Pincushion	Nationally Scarce	1 record (2013)	Yes, epiphyte of Salix
Sphagnum medium	Magellanic Bog-moss	Only VC63 site	1 record (2020)	No, recorded in Sphagnum bog
Mammals				
Arvicola amphibius	Water Vole	W&CA Sch. 5, UKBAP, Calderdale BAP	4 records (2001)	Recorded in wet woodland and along River Calder. Species associated with reedbed habitat
Lutra lutra	Otter		7 records (2018)	Associated with watercourses, carr woodland and reedbed
Myotis daubentoni	Daubenton's Bat	W&CA Sch5; WYBAP; Calderdale BAP, EPS	1 record (2008)	Associated with watercourses
Neomys fodiens	Water Shrew	Calderdale BAP	1 record (Calderdale species audit, 2015)	Associated with wetland habitats
Invertebrates - Beetles				
Agelastica alni	-	Sch1_part1; RDB:Pre94:Insu	1 record (2017)	Leaf beetle associated with carr woodland.
Bembidion fumigatum	-	Notable: B, Calderdale BAP	6 records (2000)	Associated with floodplain grazing marsh
Dacrila fallax	-	Nationally scarce	1 record (2017)	Species associated with wetland leaf-litter
Dromius sigma	-	Calderdale BAP	1 record (2000)	Associated with fens
Grypus equiseti)	-	Nationally Scarce (Nb) , Calderdale BAP	2 records (2017)	Associated with carr woodland
Melasis buprestoides	-	Notable:B; Calderdale BAP	1 record (2000)	Associated with woodland
Nephus quadrimaculatus	-	RDB:Pre94:VU	1 record (2017)	Associated with woodlands and other habitats where the host plant Ivy is prevalent
Notaris bimaculatus	-	Calderdale BAP	1 record (2000)	Associated with reedbeds
Notaris scirpi	-	Nationally scarce (Nb)	2 records (2017)	Associated with lagoon

Latin name	Common Name	Status	Number of records and date of most recent	Recorded in wetland habitats or likely to use them?
Ocypus fuscatus	-	Notable:B; Calderdale BAP	1 record (2000)	Associated with leaf litter and decaying matter
Rhizophagus nitidulus	-	Notable:B; Calderdale BAP	1 record (2000)	Associated with fungi and woodand
Stenus pusillus	-	Notable:B	1 record (2000)	Associated with wetland
Trechus discus	-	Calderdale BAP	1 record (2000)	Associated with riverbanks and floodplains
Invertebrates – Lepidoptera				
Archiearis parthenias	Orange Underwing	Calderdale BAP	2 records (2001)	Associated with birch woodland
Chiasmia clathrata	Latticed Heath	UKBAP; WYBAP; Calderdale BAP	5 records (2010)	Associated with open habitats, including grassland and waste ground
Coenonympha pamphilus	Small Heath	S41	1 record (2000)	Associated with well-drained grassland and woodland rides
Diarsia rubi	Small Square-spot	WYBAP, UKBAP	1 record (2000)	Species associated with damp habitats
Drepana falcataria	Pebble Hook-tip	Calderdale BAP	1 record (2001)	Associated with woodland
Ecliptopera silaceata	Small Phoenix	WYBAP, UKBAP	3 records (2018)	Species associated with woodland
Ennomos fuscantaria	Dusky Thorn	Calderdale BAP	2 records (2018)	Species associated with deciduous woodland and woodland edge habitats
Eugnorisma glareosa	Autumnal Rustic	UKBAP, WYBAP, Calderdale BAP	1 record (2001)	Associated with woodland edge
Hepialus humuli	Ghost Moth	Calderdale BAP, UKBAP	2 records (2001)	Associated with grassy and weedy places in woodland and open areas.
Gynnidomorpha alismana	-	Calderdale BAP	1 record (2001)	Associated with habitats near water - river margins, ponds, lakes and fens.
Mythimna comma	Shoulder-striped Wainscot	WYBAP, UKBAP	2 records (2001)	Associated with scrub, grassland, fens and open woodland
Odezia atrata	Chimney Sweep	Calderdale BAP	1 record (2000)	Associated with woodland edge, hedgerows and wet grassland
Pelurga comitata	Dark Spinach	WYBAP, UKBAP, Calderdale BAP	1 record (2000)	Associated with suburban habitats, including waste ground
Satyrium w-album	White-letter Hairstreak	Endangered; SoPI; UKBAP; WYBAP;	2 records (2017)	Associated with elm woodlands

Latin name	Common Name	Status	Number of records and date of most recent	Recorded in wetland habitats or likely to use them?
		Calderdale BAP		
Scotopteryx chenopodiata	Shaded Broad-bar	WYBAP, UKBAP	4 records (2017)	Species associated with woodland rides
Spilosoma lubricipeda	White Ermine	WYBAP, UKBAP	3 records (2001)	Species associated with woodland
Spilosoma luteum	Buff Ermine	WYBAP, UKBAP	10 records (2017)	Associated with woodland and hedgerows
Tyria jacobaeae	Cinnabar	WYBAP, UKBAP	4 records (2001)	Associated with open grassy habitats including waste ground and woodland rides
Watsonalla binaria	Oak Hook-tip	WYBAP, UKBAP	2 records (2000)	Associated with oak woodland and hedgerows
Xanthia icteritia	Sallow	WYBAP, UKBAP	3 records (2001)	Species associated with damp woodland
Xanthorhoe ferrugata	Dark-barred Twin-spot Carpet	UKBAP; WYBAP; Calderdale BAP	2 records (2001)	Species associated with a variety of habitats including fens and bogs
Invertebrates – True Flies				
Parasyrphus nigritarsis	-	Nationally Scarce	1 record (2017)	Species found in woodland carr
Invasive Non-Native Species				
Elodea nuttallii	Nuttall's Waterweed	WACA 1981: Schedule 9	5 records (2014)	Associated with still or slowly flowing, shallow or deep water.
Fallopia japonica	Japanese Knotweed		15 records (2018)	Associated with waste ground, roadsides, railway banks, along canal, stream and river banks.
Impatiens glandulifera	Himalayan Balsam		45 records (2018)	Associated with wetland habitats
Neovison vison	American Mink		2 records (2015)	Associated with watercourses

C Water Quality Analysis

The following pages provide the results of water quality analysis completed to inform this EcIA.

TECHNICAL NOTE

JBA Project Code	2021s1009
Contract	Cromwell Bottom Lagoon EcIA
Client	Calderdale Metropolitan Borough Council
Day, Date and Time	September 2021
Author	Brendon McFadden
Reviewer / Sign-off	Michael McDonald
Subject	Water quality analysis

1 Introduction

This technical note summarises the water quality analysis completed at Cromwell Bottom Nature Reserve as part of the Ecological Impact Assessment. As part of the evaluation of water level management options it is necessary to quantify the water quality of potential water sources, including River Calder and the Calder and Hebble Navigation canal.

Extracting from the river or canal could introduce relatively nutrient rich water on to the lagoon site, which is likely to have an impact on ecology. As per the 2005 Hydro-ecological assessment, careful consideration must be given to whether it is advisable to introduce onto site water which is more highly nutrient rich than the existing lagoon water.

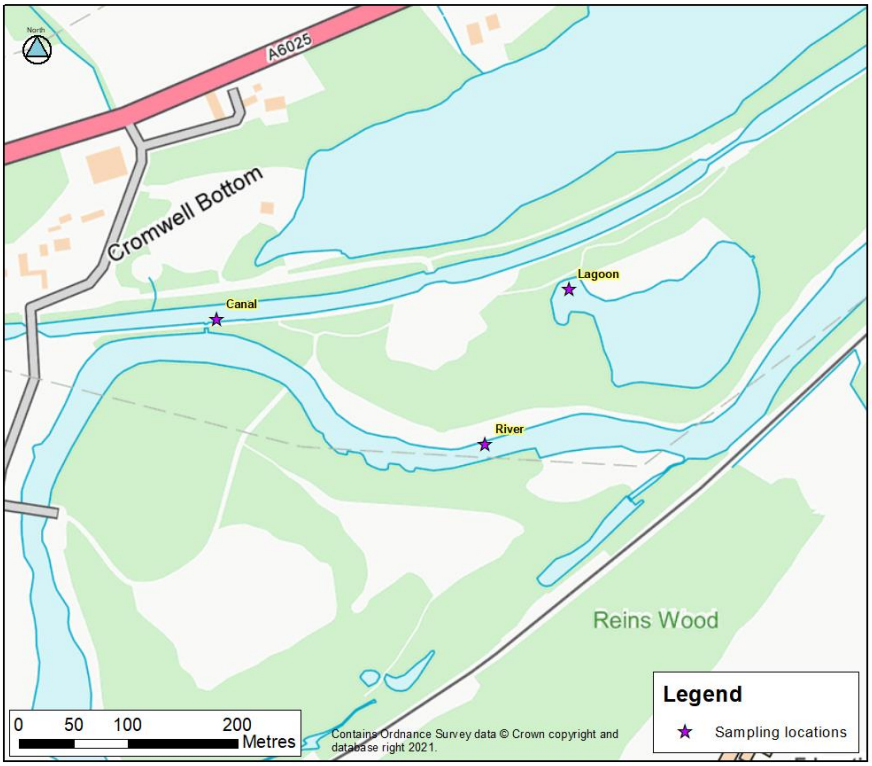
2 Methodology

2.1 Sampling locations

Water samples were collected from three locations (see Figure 1) for laboratory analysis on 15 September 2021;

- Canal (Calder and Hebble Navigation)
- River (River Calder)
- Lagoon (Cromwell Lagoon)

Figure 1 - Sampling locations



The following points are made regarding the sampling visit:

- The lagoon was very dry (the client noted that it was the driest time of year), which made finding accessible standing water for sample collection difficult. The area was also inundated with high reeds/other vegetation due to the drier conditions. Much of the area was saturated soils with no standing water.
- The client noted that some areas of the lagoon were invaded by crassula, which were avoided. There was an area visible in the centre of the lagoon (from the viewing platform in the north) that was bright green, which is likely to be standing water covered in crassula in the deepest part of the lagoon.
- The lagoon sample was taken from an isolated area of standing water in the north-west of the lagoon which remained accessible. The area was highly muddy due to the shallow standing water levels, and may not be a representation of the lagoon as a whole during higher water levels.

2.2 Analysis suite

Laboratory water analysis was carried out for a broad range of determinands to allow for general comparison to earlier assessments, and included;

- pH,
- Electrical conductivity (EC),
- Biological Oxygen Demand (BOD),
- Chemical Oxygen Demand (COD),
- Nitrogen, Nitrate, Nitrite, Ammonia, Phosphate,
- Metals; Sodium, Calcium, Magnesium, Iron, Potassium, Aluminium; and,
- Sulphate and Chloride.

3 Results

The laboratory analysis results are summarised in Table 3-1, with comparison to results in 2005.

The results show that within the canal the water quality has largely remained similar or improved since the analysis completed in 2005. Chloride and metal concentrations have all reduced, while nitrates have increased slightly.

The water quality within the river is generally of similar quality to the canal. pH and sulphate are slightly lower than in the canal, while nitrate/nitrites/nitrogen, and phosphates are slightly higher, with generally similar metal content.

The lagoon results show that the water quality has reduced relative to the 2005 concentrations. The recent sample shows concentrations of COD, ammoniacal nitrogen, chloride, nitrogen, sulphate and various metals much higher than previously found within the lagoon. This is likely to be a consequence of the available water for sampling. In the 2005 sampling visit it was completed in February, following winter rainfall where lagoon water levels were much higher. During the 2021 sampling visit there was little standing water available for sampling, which is likely to have resulted in a water sample that is highly concentrated with nutrients due to the evaporation/drying of the lake. It is notable however, that a reduction in water volumes as a consequence of seasonal changes leads to an apparent reduction in water quality.

When comparing the canal and river quality to the 2005 (more conservative) values for the lagoon there is a higher concentration of; chloride, nitrate, phosphate, sulphate and most total metals apart from potassium and aluminium (previous testing LOD was 0.1mg/l).

Table 3-1 - Water quality analysis results and comparison

Determinand	Units	Canal		River	Lagoon	
		2005	2021	2021	2005	2021
pH (w)	pH	7.39	7.65	7.08	7.43	7.1
Electrical conductivity @ 20degC (w)	µs/cm	337	303	322	120	875
COD (settled)	mg/l	<17	14	17	<17	162
BOD (settled, 5 day)	mg/l	<2.9	<1	1	<9.5	<1
Ammoniacal nitrogen as N (w)	mg/l	<0.05	0.07	0.37	0.868	6.97
Ammonia / Ammoniacal Nitrogen as NH3 (w)	mg/l		0.083	0.446		8.509
Chloride (w)	mg/l	47.4	36	41	<20	27
Nitrite (w)	mg/l	<0.08	<0.1	0.5	<0.08	<0.1
Nitrate (w)	mg/l	2.93	6.3	16.7	<0.4	<0.1
Nitrogen, Total Organic (w)	mg/l		0.6	0.9		79
Nitrogen (kjeldahl) (w)	mg/l		0.7	1.3		86
Phosphate (orthophosphate) as PO4 (w)	mg/l	<0.1	0.06	0.44	<0.1	<0.02
Sulphate (w)	mg/l	43.6	44	37	4.43	273
Aluminium (dissolved)	µg/l		33	<10		<10
Aluminium (total)	µg/l	211	55.5	33.3	<100	89800
Calcium (dissolved)	mg/l		24	22		119

Calcium (total)	mg/l	30.6	26	24	4.12	254
Iron (dissolved)	µg/l		139	196		14800
Iron (total)	µg/l	485	441	475	162	322000
Magnesium (dissolved)	mg/l		7	6		22
Magnesium (total)	mg/l	8.61	8	6	2.07	46
Potassium (dissolved)	mg/l		2	5		13
Potassium (total)	mg/l	3.2	3	5	6.14	19
Sodium (dissolved)	mg/l		27	31		24
Sodium (total)	mg/l	32.7	27	33	7.05	26

4 Summary and recommendations

Based on this analysis the following summary and recommendations are made:

- The water quality within the river and canal appear to be good, although there is higher concentrations of chloride, nitrate, phosphate, sulphate and most total metals relative to the more conservative 2005 lagoon water quality results.
- The 2021 lagoon results show that the water quality has reduced relative to the 2005 sample concentrations. This is likely to be a consequence of the limited availability of water for sampling. In the 2005 sampling visit it was completed in February, following winter rainfall where lagoon water levels were much higher. During the 2021 sampling visit there was little standing water available for sampling, which is likely to have resulted in a water sample that is highly concentrated with nutrients due to the evaporation/drying of the lake.
- It is recommended that the lagoon is sampled again during highest water levels (likely after the winter rainfall period early 2022) to confirm the potential range in water quality due to variation in water levels/re-connection of the lake. This will give a better comparison to samples taken in February 2005.

D Detailed Impact Assessment of Options 2, 3 & 4

The following tables assess the ecological impacts of Option 2 (River water), Option 3 (canal water) and Option 4 (reprofiling).

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