Lower River Crane and Duke of Northumberland River

Fish Passage Feasibility Study

Client: Zoological Society of London

Date: July 2025

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EXECUTIVE SUMMARY

The Zoological Society of London (ZSL) commissioned Fishtek to assess and evaluate fish passage options at two sites on the Duke of Northumberland's River (DNR) and the Lower River Crane, referred to as Kidd's Mill Sluice (NGR: TQ 16592 75948); and the Tidal Crane Barrier 8 (TCB-8, NGR: TQ 16323 74271), respectively. The catchment currently has a moderate ecological status under the Water Framework Directive (WFD), with barriers to fish migration listed as a reason for not achieving good ecological status (GES). The DNR and River Crane are home to a broad range of coarse fish and eels, however, a greater diversity of fish species is present downstream in the River Thames including salmonids. Therefore, increasing longitudinal connectivity to the Thames via fish passage easements offers a chance to increase the fish diversity within the catchment.

A site survey of both Kidd's Mill Sluice and TCB-8 was undertaken on the 16th of April 2025 by Dr Will Davison and Stuart Pudwell (Fishtek), with Joe Pecorelli (ZSL), Megan-Rose MacDonald and Lewis Elmes (EA) also in attendance. The structure at Kidd's Mill Sluice consists of three channels: one central channel with an automated tilting weir which controls upstream water levels; one channel on the left bank with a redundant, manually operated undershot sluice that was closed on the day of the survey; and one manually operated overshot sluice within the right hand channel that was used as a backup during flood events. The barrier itself marks the tidal limit of the Thames into the DNR and at low tide the hydraulic head drop across the structure is ~3.83 m making it a complete barrier to fish migration. The channel on the left bank containing the manually operated undershot sluice was identified as being available for modifications for fish passage as currently it is largely unused with the exception of holding a pump fed eel pass installed by Fishtek in 2015, which still provides elver passage over the barrier. The site survey of TCB-8 identified the barrier as a triangular profile crump weir constructed from rip-rap material situated within an open concrete culvert. The weir spans the entire channel width of 8.2 m. On the day of the survey flows were recorded upstream at Marsh Farm at 0.35 m^3s^{-1} which is equivalent to Q_{40} and there was 0.52 m of hydraulic head loss over the structure making it a significant barrier to fish migration.

Although barrier removal is always the preferred mitigation option from a fish passage and WFD perspective, given the size of the structure at Kidd's Mill Sluice, this would be a significant undertaking and jeopardise upstream abstractions and significantly lower water levels. This option has therefore been discounted. Instead, an appraisal matrix has identified a preferred option involving installation of a small (partial length) Alaskan A fish pass into the left channel that facilitates fish passage during high tides when fish are most likely to migrate into the DNR. This style of fish pass would be a single flight pass and would facilitate passage over 2 m of hydraulic head loss respectively. A single flight could be installed into the existing channel and fit within the currently open section, without extending into the culverted section. This style of pass is typically considered suitable for all of the species present in the DNR, Crane and the Thames with the exception of eels. As such, the existing pump fed pass should be retained, or a new gravity fed eel pass installed alongside the Alaskan A pass to reduce the existing maintenance burden incurred by the existing eel pass.

At TCB-8, barrier removal would also typically be the preferred option, however, there are numerous barriers both up and downstream of TCB-8. Removal would lower upstream water levels, making the upstream barriers more impassable and therefore removal would not increase overall fish passage through the catchment. Instead, the appraisal matrix identified a preferred option involving the installation of four downstream pre-barrages with streaming flow notches to concentrate flows during low flow periods. This option would also include adding a streaming flow notch to TCB-8 itself to further reduce the head loss over the structure. If streaming flow is achieved, the proposed modifications would facilitate passage of salmonids, coarse fish and eels into the River Crane, meeting the project objectives regarding fish passage.

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1. Introduction

1.1 Aims and Objectives

The Zoological Society of London (ZSL) have commissioned Fishtek to undertake an options appraisal of potential fish passage solutions at two barriers on the Duke of Northumberland's River (DNR) and the Lower River Crane, referred to as Kidd's Mill Sluice (NGR: TQ 16592 75948) and the Tidal Crane Barrier 8 (TCB-8, NGR: TQ 16323 74271). The specific aims of the study are to:

- Identify options to improve fish passage at the feature
- Investigate and provide other supporting information as part of a desk based review
- Clearly recommend the preferred fish and eel passage solution for each of the two structures

The sites were initially identified as priority target for mitigation in "An Assessment of Barriers to Fish Passage in the Crane River Catchment" (White, T., Day, E., Ziauddin, S., Steyl, I., 2016) undertaken by London Wildlife Trust (LWT) in 2016. This report assessed the passability of all 53 barriers identified in the Crane Catchment using a methodology developed by the Scotland & Northern Ireland Forum for Environmental Research (termed the SNIFFER methodology). This report concluded that Kidd's Mill Sluice as a high priority for mitigation, and TCB-8 as a medium priority. This report will therefore provide suggested fish passage solutions for the identified sites in a semi-quantitative matrix, to form the basis of the options appraisal and enable the identification of the most appropriate solutions. A description of each option is provided, alongside advantages, disadvantages, and any critical assumptions.

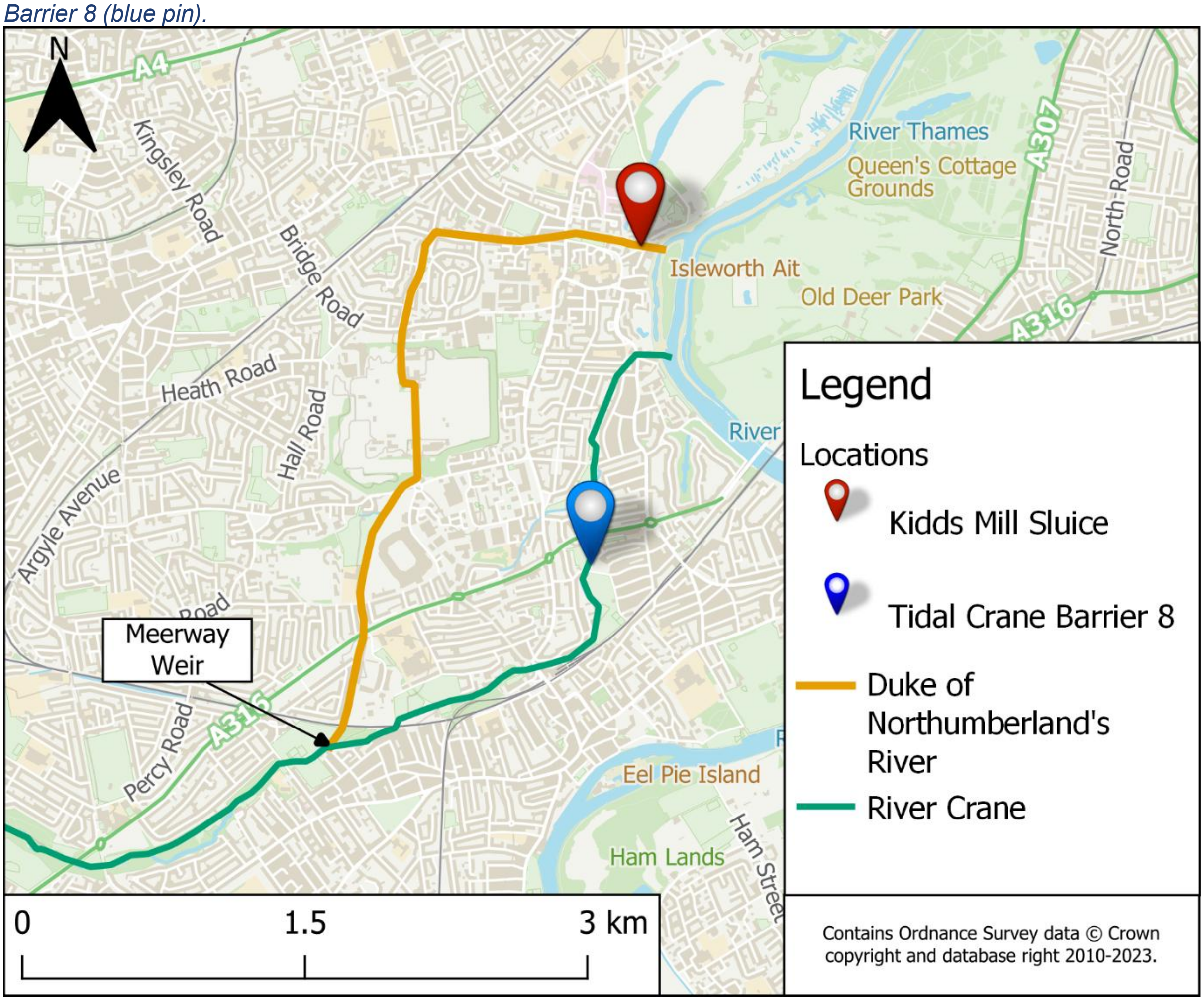
In addition to meeting fish passage requirements of the Environment Agency (EA), this assessment will also consider the following areas: hydraulic/geomorphological impact; wider environmental/ecological risks and opportunities; public/local stakeholder acceptance of the proposal; affordability; amenity value; flood risk; heritage implications; maintenance; buildability and delivery risks. It is anticipated that, while the efficiency of the fish passage solution is the key factor to consider, the overall options appraisal will identify the preferred option through a clear, rational process of optimisation and balance of the various factors that need to be considered.

2. Site Overview

Kidd's Mill Sluice marks the tidal limit of the Duke of Northumberland's River which consists of separate upper and lower artificial waterbodies located in West London (**Figure 2-1**). This report will only consider the lower section of the DNR due to the impact of Kidd's Mill Sluice on its downstream extent. The lower section of the DNR diverts water from the River Crane via Meerway Weir. Originally this channel was created to provide water to supply a number of ornamental ponds at the Duke of Northumberland's estate at Syon Park to the North as well as to supply the, now demolished, Isleworth Flour Mill.

TCB-8 is a barrier across the River Crane, which is a tributary of the River Thames. The River Crane catchment is now highly urbanised with the channel itself having undergone a great deal of river engineering works. In its current form it is predominantly a sunken open culvert channel with vertical concrete walls making up the banks. The banks are highly vegetated with a number of parks surrounding the River. The River Crane has tidal gates at its confluence with the Thames which regulate water flow and prevent tidal ingress during periods of high fluvial flow which may result in upstream flooding.

Figure 2-1- *Map showing the routes of the River Crane (dark green line) and the lower section of the Duke of Northumberland's River (orange line) with the location of Meerway Weir, Kidd's Mill Sluice (red pin) and Tidal Crane Barrier 8 (blue pin).*



2.1 Site Visit

In order to assist with the development of this options appraisal report, a site visit to Kidd's Mill Sluice and TCB-8 was undertaken on 16th of April 2025 by Dr Will Davison and Stuart Pudwell (Fishtek) with Joe Pecorelli (ZSL), Megan-Rose MacDonald and Lewis Elmes (EA) also in attendance. The purpose of this site visit was to gain an understanding of the two barriers under investigation, their operation and purpose as well as gaining a wider understanding of the wider watercourses and any constraints at the sites that may impact the suitability of any fish passage options. Flows on the day of the survey on the DNR were recorded at 0.844 m^3s^{-1} and 0.353 m^3s^{-1} on the River Crane.

2.2 Kidd's Mill Sluice

2.2.1. Form and Morphology of the Barrier

The barrier at Kidd's Mill Sluice was originally constructed to manage water flow for the Kidd's Mill flour mill in the 1700's. The mill ceased operation in 1934 and has since been adapted to maintain upstream water levels for various abstractions, flood relief and to prevent tidal ingress into the Duke of Northumberland's River as it is only 90 m upstream of the confluence with the Thames.

The structure itself now consists of three channels, two within a central section (**Figure 2-2**) and one passing through the true right-hand bank. The upstream water level is currently controlled by an automated tilting gate fixed to the top of a steep vertical weir within the true right-hand channel within the central section. Given this channel houses the automated tilting gate required for maintaining upstream water levels, it is understood that this channel is not available for modification to facilitate fish passage. The majority of the water flows over this tilting gate onto a 2 m wide sloping bed downstream before joining with the other channel within the central section ~8 m downstream at which point the combined channels enter an 11 m long closed culverted section before spilling over a ~0.5 m high sill into a downstream mill basin (**Figure 2-3**). It is understood that the tidal influence downstream regularly drowns this sill and drowns out a significant portion of the central section, reducing the hydraulic head loss over the structure during high tides.

The true left channel (**Figure 2-4** & **Figure 2-5**) within the main section contains a manually operated, 1.5 m wide undershot sluice that can be opened during periods of high flow, although water does currently leak through the gate. This gate spills into an identical channel to the right-hand side before merging into the combined channel ~8 m downstream (**Figure 2-6**). This channel houses a pumped eel pass fixed to the left wall which was installed in 2015 to facilitate passage of eels from the Thames over the barrier and into the DNR. The eel pass still reportedly provides elver passage, although requires regular maintenance to ensure the successful operation of the pass, the cost of which the EA are looking to reduce if possible. The undershot sluice gate is largely unused, as flood flows are diverted down the lower River Crane by Mereway sluices upstream. As a result, this gate could be replaced or incorporated into a fish passage easement.

In addition, there is also a 2.4 m wide overshot sluice on the true right-hand bank which consists of a fixed crest gate that leads to an underground culvert leading back to the downstream basin. It is understood that this acts as a backup spillway that carries water in the event of the automated gate failing. This gate can also be manually lowered to increase the conveyance of the spillway in high flows.

Upstream of the barrier, Kidd's Mill Sluice retains an area of open water with the mill pool exhibiting relatively still water. The banks are colonised with a variety of marginal plant life and likely provide suitable habitat for a range of coarse fish.

Downstream of Kidd's Mill Sluice, the channel is represented by a shallow basin, the morphology of which is largely determined by the tidal influence of the River Thames. The substrate is largely fine silts, mud, and detritus with very minimal signs of macrophyte diversity.

***Figure 2-2**- Image of the upstream end of the central section showing both the right-hand channel with the automated tilting weir (left in picture) and the left-channel containing the manually operated gate (right in picture).*

***Figure 2-3-** View of the outfalls of the central section (right) and the overflow spillway (left) discharging into the downstream mill basin.*

Figure 2-4- *View from within the left-hand channel showing slope immediately downstream of the manual gate. Pump fed eel pass visible on the right side of the image fixed to the channel wall.*

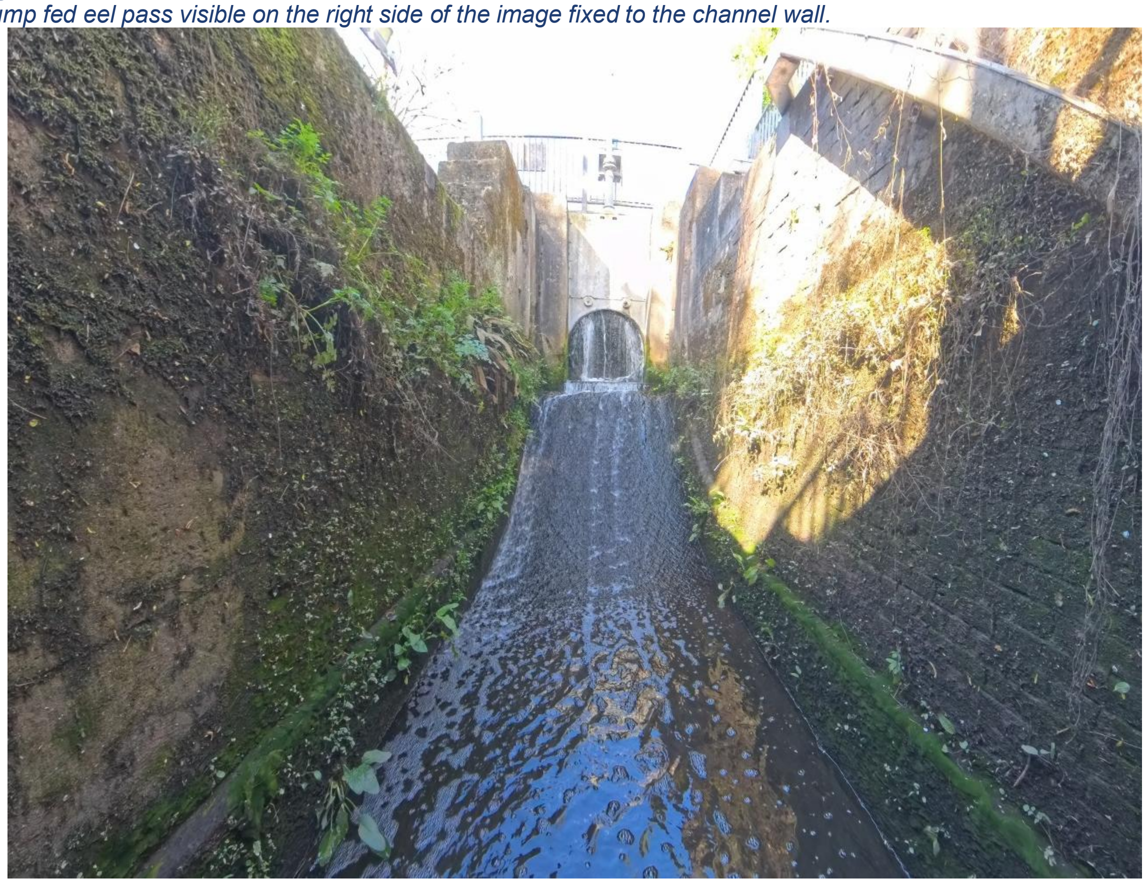


Figure 2-5- *View from within the left-hand channel showing the channel joining with the right-hand channel within the downstream culvert. Pump fed eel pass visible on the left side of the image fixed to the channel wall.*

Figure 2-6- *View from within the mill basin showing the outfalls (right) into the mill basin before flowing under the road bridge into the Thames (left).*

2.3 Tidal Crane Barrier 8

2.3.1. Form and Morphology of the Barrier

Tidal Crane Barrier 8 sits within a heavily modified section of the River Crane consisting of an open concrete culvert. There are a large number of weirs both up and downstream of TCB-8, the function of which are largely unknown but believed to be for regulating flow and maintaining water depth through the culverted sections of the river. The downstream barriers are however believed to be drowned out during high tides and TCB-8 marks the upper tidal limit of the Thames in the Crane catchment. It does not appear that tidal ingress reaches above TCB-8.

The structure itself consists of a triangular profile crump weir constructed from rip-rap material situated within the open concrete culvert. The weir spans the entire channel width of 8.2 m. On the day of the survey there was 0.52 m of hydraulic head loss over the structure. It is understood that weir impounds water to such an extent that under low flow conditions, the section of river downstream can dry out. Furthermore, the downstream water level is determined by another barrier ~200 m downstream, however, at high tides, water levels nearly reach the crest of this barrier and therefore becomes passable. It is not believed that TCB-8 is drowned and therefore it is the most downstream barrier to fish migration in the River Crane.

Both up and downstream of the barrier, the channel is heavily modified, consisting of an open concrete culvert which dominates the bed. While the artificially straightened concrete channel and multiple weirs have severely disrupted natural hydrological processes, there are some signs of sediment transport from more naturalised reaches upstream. Occasional evidence of cobbles and gravel deposition was observed on both sides of TCB-8 but not in significant quantities and were highly mobile.

Figure 2-7- *Tidal Crane Barrier 8 viewed from downstream*

***Figure 2-8-** The view downstream from Tidal Crane Barrier 8 towards the Chertsey Road bridge.*

3. Baseline Data Review

The following section summarises the datasets relevant to the appraisal of fish passage solutions at Kidd's Mill Sluice and the TCB-8. These datasets encompass fisheries, topography, hydrology, heritage, environmental and utilities data.

3.1 Fish Populations

The Environment Agency National Fish Population Database (NFPD) was analysed to identify fish species known to utilise the habitat around Kidd's Mill Sluice and TCB-8. Fish survey sites within a precautionary 10 km buffer around the two sites had data extracted and species identified. Three datasets were identified as being within the buffers, the Crane Rivers and Lakes Freshwater Fish Surveys, the Tidal Thames Freshwater Fish Surveys and the Tidal Thames Transitional and Coastal Fish Surveys. The relevant extracted data is presented in **Appendix 1** and summarised in **Table 1**.

Table 1- *Summary of fish species identified in the NFPD within a 10 km buffer of Kidd's Mill Sluice and the TCB-8 and whether they are present in the River Crane/DNR and the River Thames.*

Common Name	Present in River Crane or Duke of Northumberland's River?	Present in the Thames?
10-spined stickleback	N	Y
3-spined stickleback	Y	Y
Atlantic salmon	N	Y
Barbel	Y	Y
Big scaled sand smelt	N	Y
Bleak	Y	Y
Brown / sea trout	N	Y
Bullhead	Y	Y
Chub	Y	Y
Chub x dace hybrid	Y	N
Common [wild] carp	Y	Y
Common bream	Y	Y
Common carp	N	Y
Common goby	N	Y
Dace	Y	Y
European eel	Y	Y
Feral [brown] goldfish	Y	N
Flounder	Y	Y
Goby sp.	N	Y
Gudgeon	Y	Y
Minnow	Y	Y
Mirror carp	N	Y
Perch	Y	Y
Pike	Y	Y
Roach	Y	Y
Roach x common bream hybrid	N	Y
Roach x rudd hybrid	Y	N
Rudd	Y	Y
Sand goby	N	Y

Sand smelt	N	Y
Sea bass	N	Y
Silver bream	Y	N
Smelt	N	Y
Stickleback sp.	N	Y
Stone loach	Y	Y
Tench	Y	Y
Thick lipped grey mullet	N	Y
Thin lipped grey mullet	N	Y
Zander	N	Y

The fisheries data highlights that the majority of the fish present within the River Crane/DNR are coarse fish and eels. However, downstream of the confluence with the Thames a greater diversity of coarse fish species are present and additionally, Atlantic salmon and brown/sea trout have been recorded in the Thames. Therefore, any fish passage option at one or both of the barriers discussed in the present report should be suitable for the full range of species that may enter the River Crane/DNR from the Thames and simultaneously facilitate downstream migration into the Thames.

3.2 Hydrology and Abstractions

As an urban river, the hydrology of both the DNR and the River Crane are subject to significant anthropogenic impact, most notable is the role of Mereway Weir. Mereway Weir was built in the 1930's and splits the River Crane from the DNR. The weir historically diverted more water into the DNR than the River Crane likely due to the water abstraction needs at Modgen and Syon Park which resulted in frequent drying out of the River Crane. River gauges are available for both Kidd's Mill Sluice on the Duke of Northumberland's River and TCB-8 on the River Crane (
Figure 3-1) which can be used to inform the fish passage options that are possible at each site. Recent alterations to the operating procedure at Mereway have resulted in increased water flow into the Lower Crane.

3.2.1. Duke of Northumberland's River

Hydrology

According to the National River Flow Archive (NRFA), the nearest gauging station to Kidd's Mill Sluice on the Duke of Northumberland's River is Modgen (station ID: 3695TH). This flow gauge (located at TQ1539475197) is ~2km upstream of Kidd's Mill Sluice and has been operational since the 1st of December 1977 and therefore is suitable to be used for the basis of this fish passage options appraisal. However, in 2018 the operational regime for the automated Meerway Weir was altered to provide a greater sweetening flow down the Lower Crane. As such only data since 2019 was used to generate the flow duration curve statistics presented in **Table 2** and **Figure 3-2**. There are concerns regarding the flow data for the DNR as during the site visit flows were recorded at Modgen of 0.844 m^3s^{-1} which based upon the flow duration curve (FDC) presented below would be consistent with a flow scenario above $Q_{5,}$ a very high flow scenario. While it had rained in the days preceding the site visit, the weather was not consistent with such a high flow scenario and similarly, the gauge on the river crane during the site visit was recording flows consistent with a Q_{40} flow scenario. As such, prior to any future design work it is recommended that the flow gauge at Mogden is verified using spot flow gauging surveys.

While there is no water level data available at the site, approximate hydraulic head loss can be estimated at the site using the tidal range of the data recorded at the Crane Tidal Gates (station ID: 3697TH, TQ1662075380). Using this tidal data, the approximate tidal range is 3.82 m between low tide and high tide and assuming that the topographic survey of the weir pool which has been provided by the EA (Drawing No:10538/01) was undertaken at or approaching low tide, the range in hydraulic head loss over Kidd's Mill Sluice can be estimated to be between 3.83 m at low tide and 1.22 m at high tide. However, these values are estimates only and level data should be obtained at the site prior to any future design stages.

***Table 2**- Representative flow duration curve statistics for the Duke of Northumberland's River at Mogden (station ID: 3695TH, TQ1539475197).*

Percentage exceedance (Q%)	Flow (Q m^3s^{-1})
5	0.68
10	0.60
50	0.38
70	0.30
95	0.14
Mean Flow	**0.39**

***Figure 3-1**- Locations of river gauging stations in close proximity to Kidd's Mill Sluice and Tidal Crane Barrier. 8.*

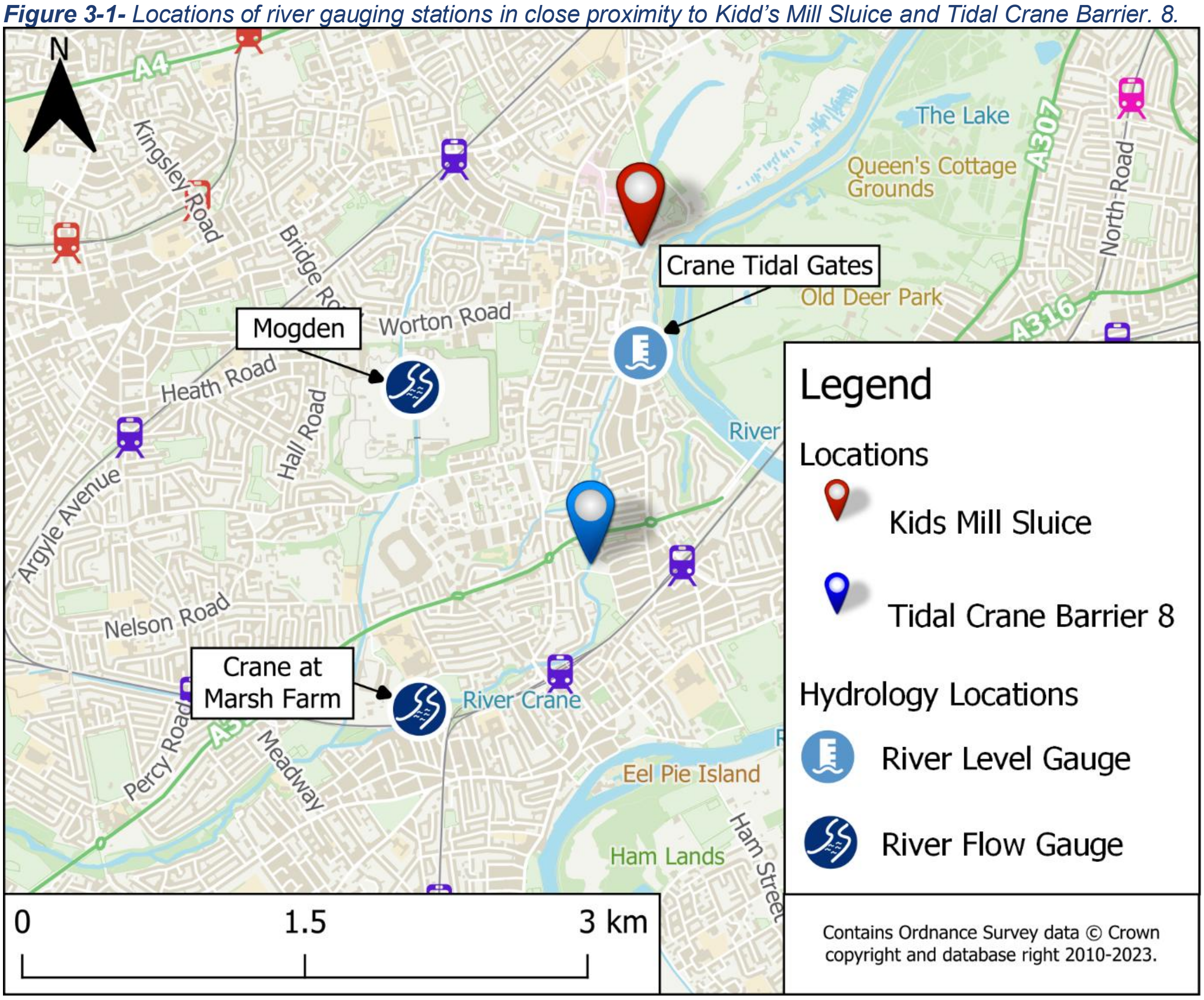
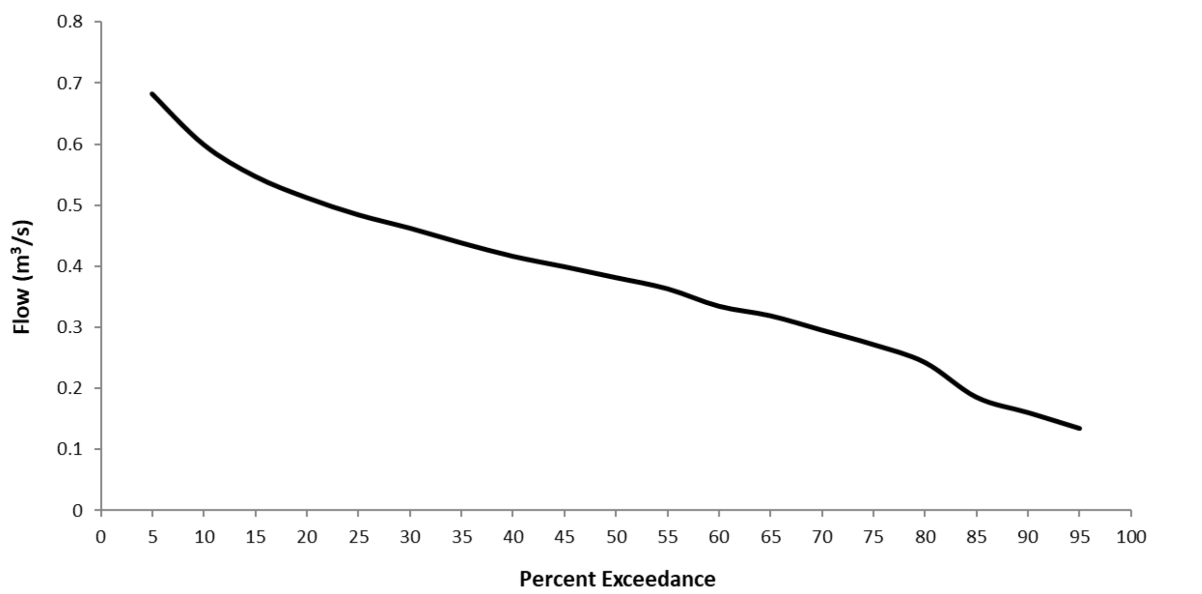


Figure 3-2- *Representative flow duration curve for the Duke of Northumberland's River at Modgen.*



Abstractions

There are two locations on the DNR where a legal right exists to abstract water from the river. The most upstream of the two is at Thames Water's Mogden Sewage Treatment Works (STW) which abstracts water for cooling purposes. The abstraction license has been in place since 1987, however, as of the 31st of March 2025 this license has ceased and the intake to the STW has now been blocked off preventing water from entering the STW. The licenced volumes were 1,752,000 m^3 annually, 7,200 m^3 daily, and 360 m^3 hourly.

The downstream abstraction is located immediately upstream of Kidd's Mill Sluice and is used to top up water levels for a number of fishing lakes at Syon Park to the north of the DNR. The DNR was originally constructed to supply water to these water features at Syon Park and due to their historic nature, there is no formal license linked to this transfer of water as it's right pre-dates the licensing legislation. However, it is understood that Syon Park are no longer intending to abstract from the DNR.

Due to the recent changes to the abstraction regime of the river the calculated FDC may differ from the new values and these should be recalculated once a sufficient duration of flows have been recorded.

3.2.2. River Crane

Hydrology

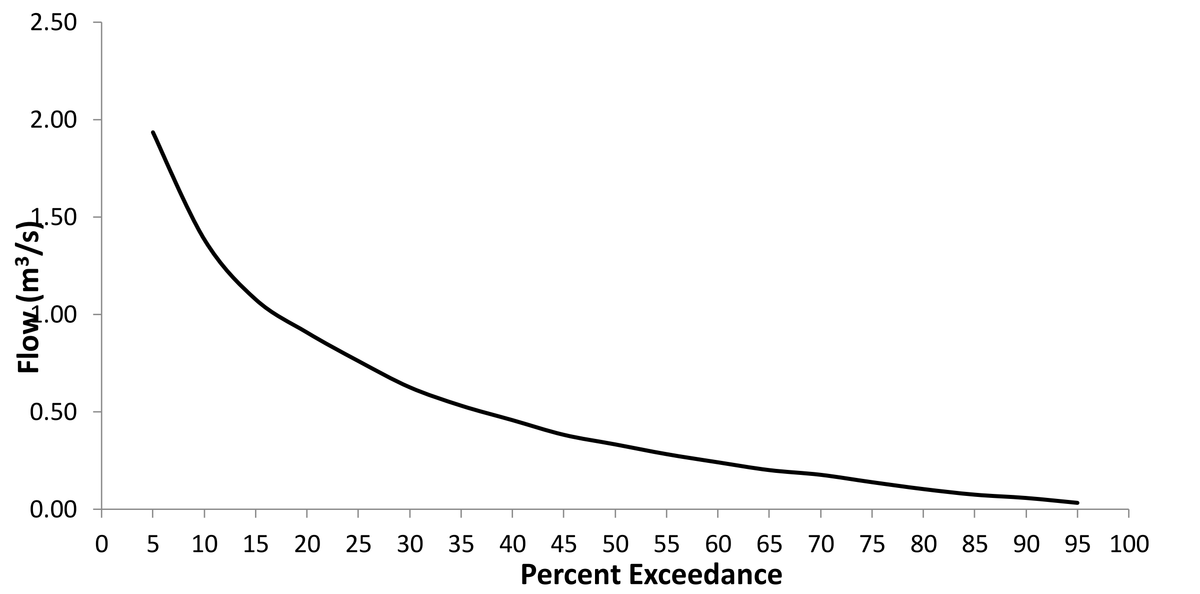
According to the NRFA, the nearest gauging station to TCB-8 on the River Crane is Marsh Farm (station ID: 3680TH). This flow gauge (located at TQ1545573487) is ~1.5km upstream of TCB-8 and has been operational since the 6th of December 1977 and therefore is suitable to be used for the basis of this fish passage options appraisal. However, in 2018 the operational regime for the automated Meerway Weir was altered to provide a greater sweetening flow down the Lower Crane. As such only data since 2019 was used to generate the flow duration curve statistics presented in **Table 3** and **Figure 3-3**.

Table 3- *Representative flow duration curve statistics for the River Crane at Marsh Farm (station ID: 3680TH, TQ1545573487)*

Percentage exceedance (Q%)	Flow (Q m^3s^{-1})
5	1.93
10	1.39

50	0.33
70	0.18
95	0.03
Mean Flow	**0.58**

***Figure 3-3-** Representative flow duration curve for the River Crane at Marsh Farm.*



Abstractions

There are no known abstractions between TCB-8 and the River Thames or upstream to Mereway Weir.

3.3 Water Framework Directive

Under Cycle 3 of the Water Framework Directive (WFD), both the DNR and River Crane fall within the "Crane Water Body" (waterbody ID: GB106039023030) and is covered by the Thames River Basin District Management Plan (RBDMP) and additionally supported by the Crane Valley WFD Catchment Plan. The Crane Waterbody is currently classified as having 'Moderate Ecological Status'. A summary of the individual classifications for the Crane Waterbody is given in **Appendix 2-** Water Framework Directive. The reasons for not achieving good ecological status are dependent on issues related to dissolved oxygen, macrophytes and Phytobenthos, ammonia, invertebrates, phosphate, perfluorooctane sulphonate (PFOS), polybrominated diphenyl ethers (PBDE), hydrological regime, benzo(g-h-i)perylene and fish. Of the issues facing fish in the catchment, barriers and ecological continuity was highlighted as a reason for not achieving good ecological status and therefore, improving fish passage at Kidd's Mill Sluice and TCB-8 would therefore help contribute towards achieving good ecological status under the WFD.

3.4 Environmental Designations

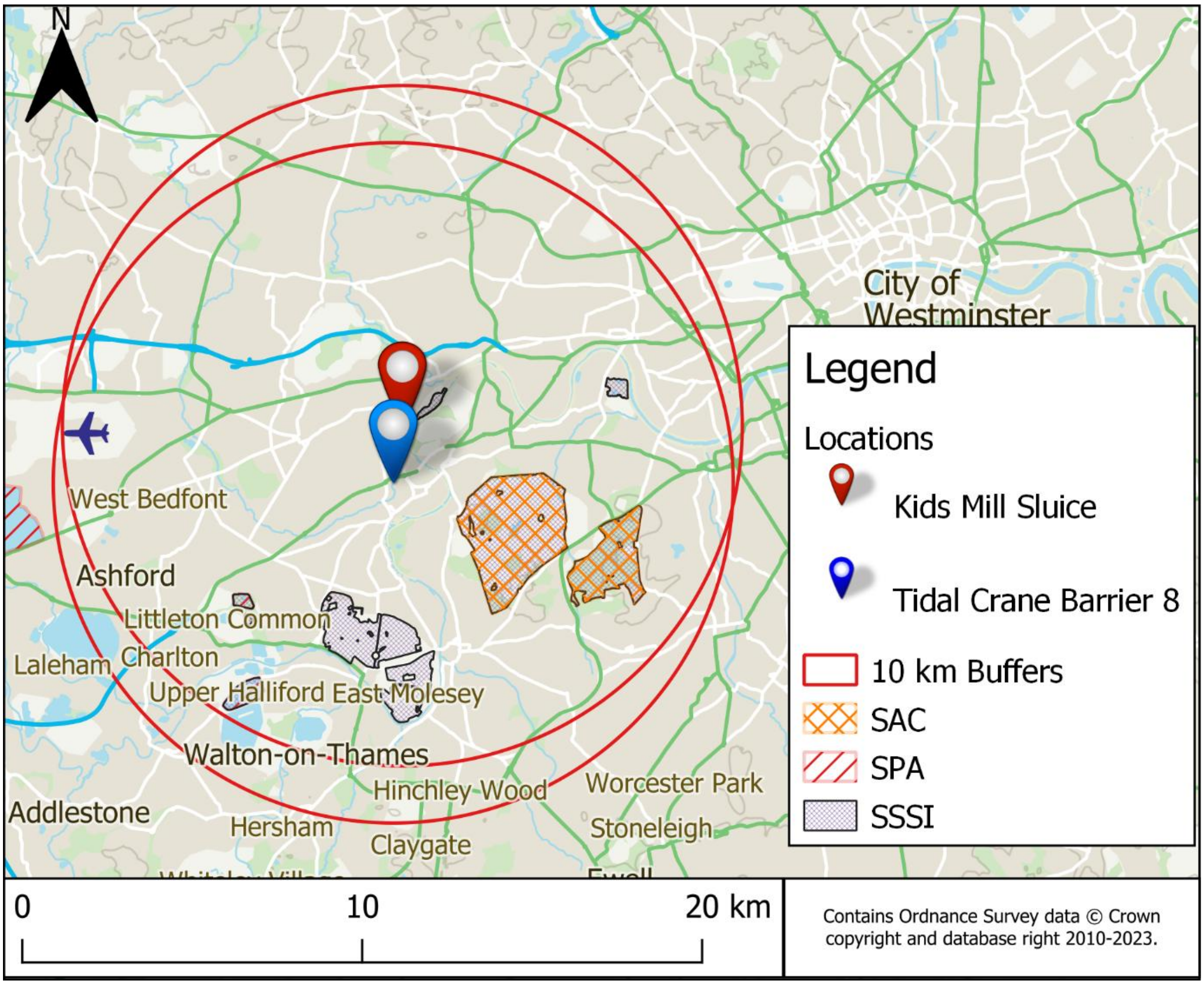
The DEFRA MAGIC map was analysed to identify designated European sites within a precautionary 10 km buffer around the two sites. These sites were then viewed using Natural England Designated Sites Viewer portal to understand the reasons for each sites designations and whether works associated with increasing fish passage at Kids Mill Sluice or TCB-8 would prevent any of the designated sites meeting their conservation objectives.

A summary of the designated sites identified are presented in **Table 4** and **Figure 3-4**. Based on the results of this investigation it is unlikely that any fish passage measures would detrimentally impact any of the protected features or species for which they are designated.

***Table 4-** Designated Sites within 10 km buffer of Kids Mill Sluice and Tidal Crane Barrier 8 and the reasons for each sites designations.*

Site Name	Designation	Reasons for Designation
Richmond Park	SAC & SSSI	• Stag Beetle (*Lucanus cervus*)
Wimbledon Common	SAC & SSSI	• Northern Atlantic wet heaths with *Erica tetralix* • European dry heaths • Stag Beetle (*Lucanus cervus*)
Kempton Park Reservoirs	SSSI	• Neutral grassland- lowland • Standing open water and canals • Aggregations of non-breeding birds- Gadwall (*Mareca strepera*)
Bushy Park and Home Park	SSSI	• Invertebrate assemblage- A2 wood decay • Lowland dry acid grassland • Population of veteran trees
Syon Park	SSSI	• Invert. assemblage W3 permanent wet mire • Lowland wetland including basin fen, valley fen, floodplain fen, water fringe fen, spring/flush fen and raised bog • Fen, marsh and swamp - Lowland
Barn Elms Wetland Centre	SSSI	• Aggregations of non-breeding birds - Gadwall, *Mareca strepera* • Aggregations of non-breeding birds - Shoveler, *Anas clypeata* • Assemblages of breeding birds - Lowland open waters and their margins • Standing open water and canals
Knight & Bessborough Reservoirs	SSSI	• Aggregations of non-breeding birds - Shoveler, *Anas clypeata* • Standing open water and canals
South West London Waterbodies	SPA & Ramsar	• Gadwall, *Mareca strepera* • Shoveler, *Spatula clypeata*

Figure 3-4- Statutory Environmentally Designated Sites within 10 km of Kidds Mill Sluice and Tidal Crane Barrier 8.



3.5 Heritage Designations

A search of statutory heritage sites within 100 m of each barrier was undertaken using Historic England's OpenData Hub to determine whether there are any historic features that may constrain any fish passage options. A summary of the designated sites identified are presented in **Figure 3-5** & **Figure 3-6**.

3.5.1. Kidds Mill Sluice

Kidds Mill Sluice had a number of listed structures within the 100 m buffer zone (**Figure 3-5**). Of key importance is the Royal Botanic Gardens, Kew UNESCO World Heritage Site, the boundary of which passes through the downstream mill basin. While it is unlikely that any works required to improve fish passage at Kidds Mill Sluice would pose a risk to the UNESCO World Heritage Site, a heritage consultation may be required prior to any works commencing. In addition, a number of listed buildings are within the vicinity of the barrier. Indeed, the mill basin itself and downstream bridge are grade II listed structures due their association with the historic mill that used to sit at the site. As such heritage consultations may be required prior to work commencing on any fish passage improvement.

3.5.2. Tidal Crane Barrier 8

No historic structures or heritage sites were detected within 100 m of TCB-8 (**Figure 3-6**).

Figure 3-5- *Statutory Historic Sites within 100 m of Kidds Mill Sluice.*

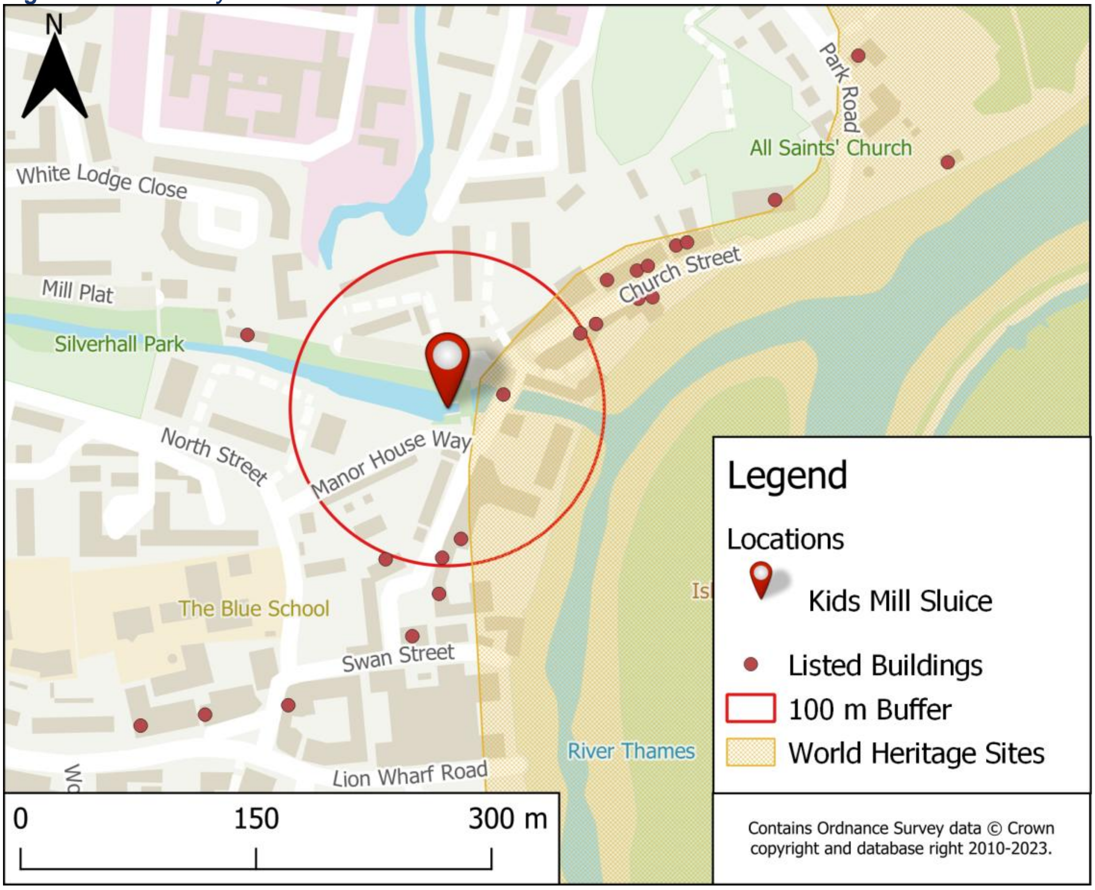
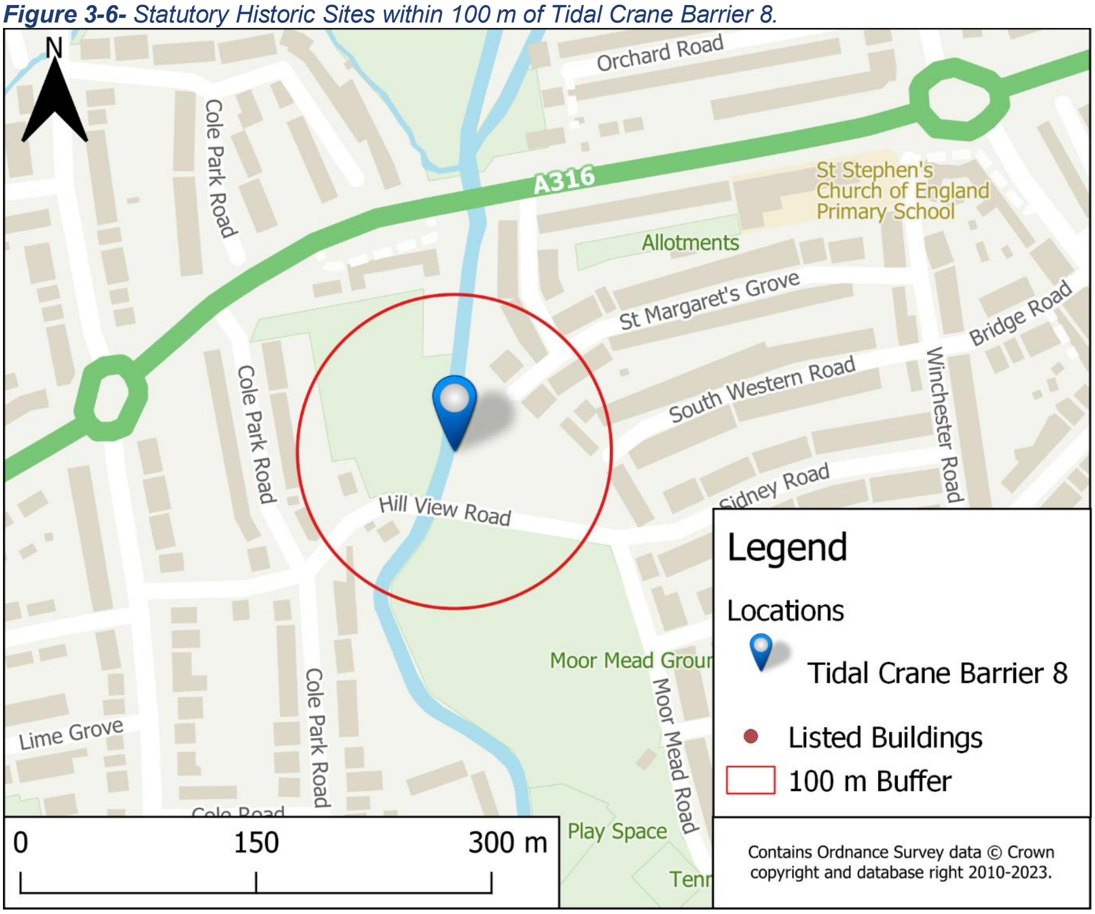


Figure 3-6- *Statutory Historic Sites within 100 m of Tidal Crane Barrier 8.*



3.6 Access Constraints

3.6.1. Kidds Mill Sluice

There are very few access constraints at Kidds Mill Sluice as the barrier falls within an EA owned site compound, complete with lockable gates from the main road. One constraint would be the weight limit of the grade II listed Isleworth Bridge across which all road traffic coming to site must cross. There is also an existing gantry over the sluices to facilitate operation of the sluices. Material can also be transported to the downstream end of the culvert by barge from the Thames, but this can only occur during elevated tides as otherwise there is insufficient water depth in the mill basin.

3.6.2. Tidal Crane Barrier 8

Access to TCB-8 is more limited due to its location within a culverted section of the river. Fences on both banks currently prevent direct access to the channel either side of the weir and access during the site visit was via an EA owned gate approximately 1 km upstream. The land on the true right bank of the weir consists of the Moormead and Bandy Recreation Ground owned by the London Borough of Richmond upon Thames and could be used as the location of a site compound with arrangement with the borough council. There is an access ladder immediately downstream of the weir on the true left bank of the channel that could be used as an access point during construction. Ownership of this ladder is currently undetermined. The land on the true left bank of the weir is currently in use as allotment gardens and owned by the London Borough of Richmond upon Thames and therefore vehicle access through this land could be limited. However, conversations with a nearby homeowner during the site visit indicated that a 0.5 m wide strip of land immediately adjacent to the riverbank is held under separate ownership and a brief land registry search has confirmed this. The homeowner indicated this strip was owned by the EA however, EA staff in attendance during the site visit queried this. It is recommended that ownership of this strip should be determined prior to commencement of any works. There is no access to the weir via barge from the main Thames as low water depths and downstream weirs would prevent upstream transport.

3.7 Aesthetics and Recreation

3.7.1. Kidds Mill Sluice

Given that many of the buildings surrounding the site compound are residential, any mitigation measures should carefully consider the aesthetics of the site, considering the bridge and mill basin are both listed for their historic value and should therefore be in keeping with their current design.

3.7.2. Tidal Crane Barrier 8

Given that access is very limited at this site it is unlikely that there is any aesthetic or recreational value to the site. However, proximity to the recreation grounds could provide opportunity for public engagement with the proposed fish passage works including signs to educate passers by regarding the benefits of fish passage improvements and habitat restoration.

3.8 Utilities

A high-level utilities search of both sites was undertaken using LineSearchBeforeUDig (LSBUD) to determine whether there are any major utilities assets within the vicinities of both barriers that may impact the suitability of any fish passage options which are summarised below and detailed in **Appendix 3**.

3.8.1. Kidds Mill Sluice

A low-pressure gas main was identified below the road on Church Street and Manor House Way, within 25 m of Kidd's Mill Sluice. The gas main also runs under Mill Plat outside of the 25 m boundary but does run under the ground at the site compound entrance. It is unlikely that any fish passage measure would impact this asset, but this will need to be considered at subsequent design stages. No further utilities data was returned by the free search and therefore it is recommended that a full utilities data search is undertaken prior to construction of any future fish passage option. During the site visit, two manholes were observed in the top surface of the culverted section the DNR runs under. At the time of the writing, it is not known what these manholes provide access to although it is assumed to be some form of utility conduit. Furthermore, there is an electrical substation on the true right bank immediately downstream of Kidd's Mill Sluice and this must be considered during any subsequent design phases.

3.8.2. Tidal Crane Barrier 8

No gas mains were identified within the vicinity of TCB-8 by the free utilities search, however no further utilities data was returned by the free search and therefore it is recommended that a full utilities data search is undertaken prior to construction of any future fish passage option.

4. Long List

This section presents the long list of potential fish passage improvement options considered as part of the appraisal for Kidds Mill Sluice and Tidal Crane Barrier 8. The various interventions aim to restore connectivity and improve ecological function by enabling fish to bypass or move past in-channel barriers.

4.1 Kidds Mill Sluice Options Appraisal

There are numerous options available to improve fish passage past barriers including: barrier removal, technical fish passes (T), naturalised fish passes (N), and low cost easements (E). Variations of these options are discussed and presented in **Table 5** for Kidds Mill Sluice .

***Table 5-** Summary of long-list options considered within the options appraisal ('T' are technical solutions, 'E' are easements and 'N' are naturalised fish passes) for fish passage at Kidd's Mill Sluice.*

Option	Description	Short-listed (Y/N)	Reason
Full Barrier Removal	Weir removal, either partial or full, is the preferred mitigation option from a fish passage and WFD perspective. Weir removal would facilitate restoration of up and downstream habitat connectivity and pre-sluice construction river processes (i.e. sediment transport). However, several factors must be considered including flood risk, geomorphological impact, heritage implications and civil constraints. Partial weir removal involves lowering the weir or removing a complete lateral section of the weir face.	N	Given the large hydraulic head loss at the structure, removal would require regrading a significant section of the modified river channel to prevent nick-point migration. In addition, removal of the sluice would lower upstream water levels and structures on the adjacent land for a significant distance upstream.
Natural bypass channel (N)	A continuous channel is built around the obstruction and the channel's wetted perimeter is lined with vegetation and perturbation boulders to reduce velocities to within a range manageable by the target species. Bypass channels provide a close to natural fish passage solution and are suitable for a wide range of species. Typical slope gradients for natural bypass channels are 1-2% for semi natural channels, though lower gradients (0.1 - 0.3 %) can be used for low discharge lowland channels.	N	Given the large hydraulic head loss over the structure, a natural bypass channel that would facilitate passage over the barrier would be prohibitively large; and given the constriction of residential properties adjacent to both banks, there is not sufficient land available to construct this style of naturalised fish pass.
Rock Ramp (N)	A rock ramp consists of a ramp of bedrock and mixed bed material located downstream of an existing weir. It creates a semi-natural riverbed of reasonable gradient (<5%) that allows upstream fish passage over a low head (<1 m). Typically, the ramp covers the whole width of the river channel.	N	Kidd's Mill Sluice has a hydraulic head loss that is above the recommended guidance for rock ramp fish passes. In addition, a rock ramp that could mitigate the entire ~5 m head loss over the structure would be required to project up to 100 m downstream and given the confluence with the Thames is only 90 m downstream, this option is not possible.

Larinier (super active baffle) (T)	The Larinier fish pass typically consists of a single sloping channel that can be constructed in a range of widths. Baffles are organised along the base of the pass only and generate heterogeneity in flows that are exploitable by a range of species. The maximum recommended slope is 15 %, with a maximum head drop over a single flight of ca. 1.5 m for coarse fish and 1.8 m for salmonids.	Y	A pre-fabricated Larinier fish pass could be installed within the left-hand channel of the central section with various options depending on whether the pass should be passable at all times, or whether passage is only required during high tides. These options are discussed below.
Pool and traverse/vertical slot (T)	Pool and traverse passes work by splitting a single large head drop into multiple smaller head drops. Between each smaller head drop is a pool, which dissipates the energy of the falling water.	N	Given the size of the left-hand channel width and the hydraulic head loss over the structure, any pool and traverse/vertical slot pass would require excavation into the left bank and would project upstream approximately 50 m. The size and scale of this structure along with health and safety aspects, would therefore make it unfeasible at the site.
Low-cost baffles (E)	Water flow on a sloping weir accelerates towards a critical flow, resulting high velocities and shallow depths that reduce the ability of fish to pass. A series of baffles down the face of a sloping surface can increase the depths and reduce velocities. A notch, at a specified size to discharge a given flow, is cut into each baffle. The notches are staggered in order to avoid a jet of deeper water through the baffles.	N	The barrier at Kidd's Mill would is not suitable for low-cost baffles as it is not a sloping weir structure. Furthermore, they are best suited to low-head structure (compared to Alaskan type fish passes, see beow).
Alaskan (T)	Alaska 'A' fish passes consist of a single sloping channel of 0.56 m width. Baffles located on both the side and the base of the pass dissipate the energy and reduce velocities. Alaskan 'A' fish passes can be installed with a slope of up to 25%, over a maximum of 3 m head drop (before a resting pool is required).	Y	While Alaskan 'A' fish passes are typically only recommended for large salmonids, when sited at tidally influenced sites, they have been shown to be passable to coarse fish. This pass could be installed within the left-hand channel of the central section.
Pre-barrages (E)	Pre-barrages function similarly to pool and traverse passes in that they create one or more pools in series, to reduce the head drop across an obstruction into smaller, more manageable ones for fish. They are placed downstream of the obstruction and are often used in	N	Given the head drop of the structure, pre-barrages would not be suitable for Kidd's Mill Sluice as this site would require a prohibitively large number of

	conjunction with a notch or gap designed to discharge a given flow. Pre-barrages can be formal, constructed with pre-cast concrete blocks, or a more informal structure using a series of large rocks or boulders.		barrages and extend a further downstream than is available.
Baulk (E)	Most baulks are constructed by fixing timber beams, stone, or concrete rectangular structures diagonally across a weir face, extending the full distance from the weir crest to the weir toe. The installation of a baulk will increase the depth of water over a sloping weir. A notch should be located above the baulk, to concentrate flows and allow fish to pass over the crest. Baulks can be installed on weirs with a total head drop up to 2 m, with a slope <25 %.	N	The barrier at Kidd's Mill Sluice is not suitable for baulks as it is not a sloping weir structure. Furthermore, they are not suitable for coarse fish.
Notch weir (E)	Notches or gaps are perhaps the simplest form of fish pass and are generally only effective at low head structures, unless used in combination with another form of fish pass. Notches aim to provide a section of weir with a reduced head and increased flow. Notches must be at least 0.3 m and 0.6 m wide for coarse fish and migratory salmonids respectively.	N	The head drop at Kidd's Mill Sluice is sufficiently large that notching the tilting weir structure would not improve fish passage at the site.
Brush-furnished pass (T)	A brush pass consists of a shallow sloping channel into which bristle brushes are fixed. The maximum slope is 8 %, and while there is no specific minimum width, about 0.6 m is recommended for ecological purposes, and a minimum of 0.5 m wider than the largest boat expected where it is a dual-purpose facility (i.e. also for kayakers). Brushes consist of bundles of five or six individual polyethylene bristles. The brushes are spread evenly over the channel with gaps of 20 – 40 cm between them, depending on the species and sizes of fish to be accommodated. The channel bed can be natural or artificial, but the use of natural river substances such as stone, cobble, and gravel is recommended to increase roughness and habitat heterogeneity even further. In this way the channels can accommodate passage of a wide range of fish and invertebrates.	N	Due to the lower gradient required by brush furnished pass, the total pass length would exceed 50 m. Even utilising 180 ° switchbacks, each flight would exceed 20 m which is beyond the size of land available at the site.

Do nothing.	No works or alterations are carried out, current conditions are maintained resulting in no improvement for fish passage.	Y	Given the size and complexity of the site, it may be more financially viable to utilise the Lower River Crane as a bypass channel to avoid fish having to bypass Kidd's Mill Sluice altogether.

4.2 Tidal Crane Barrier 8 Options Appraisal

There are numerous options available to improve fish passage past barriers including: barrier removal, technical fish passes (T), naturalised fish passes (N), and low-cost easements (E). Variations of these options are discussed and presented in **Table 6** for Tidal Crane Barrier 8.

***Table 6-** Summary of long-list options considered within the options appraisal ('T' are technical solutions, 'E' are easements and 'N' are naturalised fish passes) for fish passage at TCB-8.*

Option	Description	Short-listed (Y/N)	Reason
Full Barrier Removal	Weir removal, either partial or full, is the preferred mitigation option from a fish passage and WFD perspective. Weir removal would facilitate restoration of up and downstream habitat connectivity and pre-sluice construction river processes (i.e. sediment transport). However, several factors must be considered including flood risk, geomorphological impact, heritage implications and civil constraints. Partial weir removal involves lowering the weir or removing a complete lateral section of the weir face.	N	Given the number of weirs in this stretch of river, water levels are heavily controlled by the weirs themselves. Removal of one weir would result in the water level therefore becoming determined by the next most downstream weir. In this instance it would result in the next most upstream barrier becoming more difficult to ascend.
Natural bypass channel (N)	A continuous channel is built around the obstruction and the channel's wetted perimeter is lined with vegetation and perturbation boulders to reduce velocities to within a range manageable by the target species. Bypass channels provide a close to natural fish passage solution and are suitable for a wide range of species. Typical slope gradients for natural bypass channels are 1-2% for semi natural channels, though lower gradients (0.1 - 0.3 %) can be used for low discharge lowland channels.	N	While a natural bypass could be used to facilitate passage around TCB-8, installation of this option would require routing it through either the allotment gardens on the left bank or the public park on the right bank. This option would also require extensive excavation given that the bank height is substantially higher than the downstream water level.
Rock Ramp (N)	A rock ramp consists of a ramp of bedrock and mixed bed material located downstream of an existing weir. It creates a semi-natural riverbed of reasonable gradient (<5%) that allows upstream fish passage over a low head (<1 m). Typically, the ramp covers the whole width of the river channel.	Y	Given the relatively small head loss over the structure, a full width rock ramp would be suitable for provision of fish passage for a variety of fish species.
Larinier (super active baffle) (T)	The Larinier fish pass typically consists of a single sloping channel that can be constructed in a range of widths. Baffles are organised along the base of the pass only and generate heterogeneity in flows that are exploitable by a range of species. The maximum recommended slope	Y	A Larinier fish pass could be installed at TCB-8 if a section of the weir is removed to accommodate a ~3 m long pass. While Larinier fish passes are not typically suited to eels, given the already

	is 15 %, with a maximum head drop over a single flight of ca. 1.5 m for coarse fish and 1.8 m for salmonids.		roughened substrate making up the weir face, a separate eel pass may not be required.
Pool and traverse/vertical slot (T)	Pool and traverse passes work by splitting a single large head drop into multiple smaller head drops. Between each smaller head drop is a pool, which dissipates the energy of the falling water.	N	Given the relatively low hydraulic head loss over the barrier, a pool and traverse/vertical slot pass would facilitate fish passage for all species present. However, this style of pass is relatively complex to design and build and there are other, less complicated options available that would achieve the same end result.
Low-cost baffles (E)	Water flow on a sloping weir accelerates towards a critical flow, resulting high velocities and shallow depths that reduce the ability of fish to pass. A series of baffles down the face of a sloping surface can increase the depths and reduce velocities. A notch, at a specified size to discharge a given flow, is cut into each baffle. The notches are staggered in order to avoid a jet of deeper water through the baffles.	N	While the weir is sloping, the relatively steep gradient and roughened surface of the weir would require the embedded rocks to be removed from the face and the weir face extended to a suitable gradient before the fitting of low cost baffles would be possible.
Alaskan (T)	Alaska ‘A’ fish passes consist of a single sloping channel of 0.56 m width. Baffles located on both the side and the base of the pass dissipate the energy and reduce velocities. Alaskan ‘A’ fish passes can be installed with a slope of up to 25%, over a maximum of 3 m head drop (before a resting pool is required).	N	Given that there is space available for alternative options available which are more suited to the species present in the River Crane, it is not recommended that this option is taken forward.
Pre-barrages (E)	Pre-barrages function similarly to pool and traverse passes in that they create one or more pools in series, to reduce the head drop across an obstruction into smaller, more manageable ones for fish. They are placed downstream of the obstruction and are often used in conjunction with a notch or gap designed to discharge a given flow. Pre-barrages can be formal, constructed with pre-cast concrete blocks, or a more informal structure using a series of large rocks or boulders.	Y	Given the relatively small hydraulic head loss over TCB-8, pre-barrages with streaming flow notches would be suitable to facilitate fish passage for all species present.

Baulk (E)	Most baulks are constructed by fixing timber beams, stone, or concrete rectangular structures diagonally across a weir face, extending the full distance from the weir crest to the weir toe. The installation of a baulk will increase the depth of water over a sloping weir. A notch should be located above the baulk, to concentrate flows and allow fish to pass over the crest. Baulks can be installed on weirs with a total head drop up to 2 m, with a slope <25 %.	N	Given the steep gradient of the sloping face of TCB-8, baulks would not be appropriate for facilitating fish passage over this barrier.
Notch weir (E)	Notches or gaps are perhaps the simplest form of fish pass and are generally only effective at low head structures, unless used in combination with another form of fish pass. Notches aim to provide a section of weir with a reduced head and increased flow. Notches must be at least 0.3 m and 0.6 m wide for coarse fish and migratory salmonids respectively.	N	Given the shallow water depths downstream (~20cm), it would likely not be possible for a single notch in the weir to achieve the streaming flow conditions required to pass eels and poor swimming coarse fish.
Brush-furnished pass (T)	A brush pass consists of a shallow sloping channel into which bristle brushes are fixes. The maximum slope is 8 %, and while there is no specific minimum width, about 0.6 m is recommended for ecological purposes, and a minimum of 0.5 m wider than the largest boat expected where it is a dual-purpose facility (i.e. also for kayakers). Brushes consist of bundles of five or six individual polyethylene bristles. The brushes are spread evenly over the channel with gaps of 20 – 40 cm between them, depending on the species and sizes of fish to be accommodated. The channel bed can be natural or artificial, but the use of natural river substances such as stone, cobble, and gravel is recommended to increase roughness and habitat heterogeneity even further. In this way the channels can accommodate passage of a wide range of fish and invertebrates.	Y	A brush-furnished pass could be installed at TCB-8 , providing that a section of the weir is excavated and a concrete channel is built to accommodate a ~6 m pass. This pass is considered suitable for all of the fish species likely to be present in the River Crane.
Do nothing.	No works or alterations are carried out, current conditions are maintained resulting in no improvement for fish passage.	Y	Given the number of barriers on the Lower River Crane, it may be more beneficial to focus resources on making the DNR passable and

			therefore allowing it to act as a bypass channel around the barriers on the Lower River Crane.

5. Short Listed Options

Following the short-listing of options, several potential mitigation options were identified to improve fish passage for each site. The following sections summarise these potential options.

5.1 Kidd's Mill Sluice

5.1.1. Option 1- Full length Larinier

A Larinier Fish Pass is a technical fish pass that consists of a sloping channel that can be constructed in a range of widths. Given the relatively low flows at the Kidds Mill Sluice site and the function of the tilting weir, the proposed pass would be constructed of a single set of baffles of 0.6 m width. Multiple flights can be combined to facilitate passage over large hydraulic head losses with resting pools provided between them (**Figure 5-1**). Baffles (normally 75 mm, 100 mm or 150 mm) are organised along the base of the pass only and generate heterogeneity of flows that can be exploited by a range of salmonids and coarse fish. The maximum recommended slope is 15%, with a maximum head drop over a single flight of <1.5 m for coarse fish and 1.8 m for salmonids.

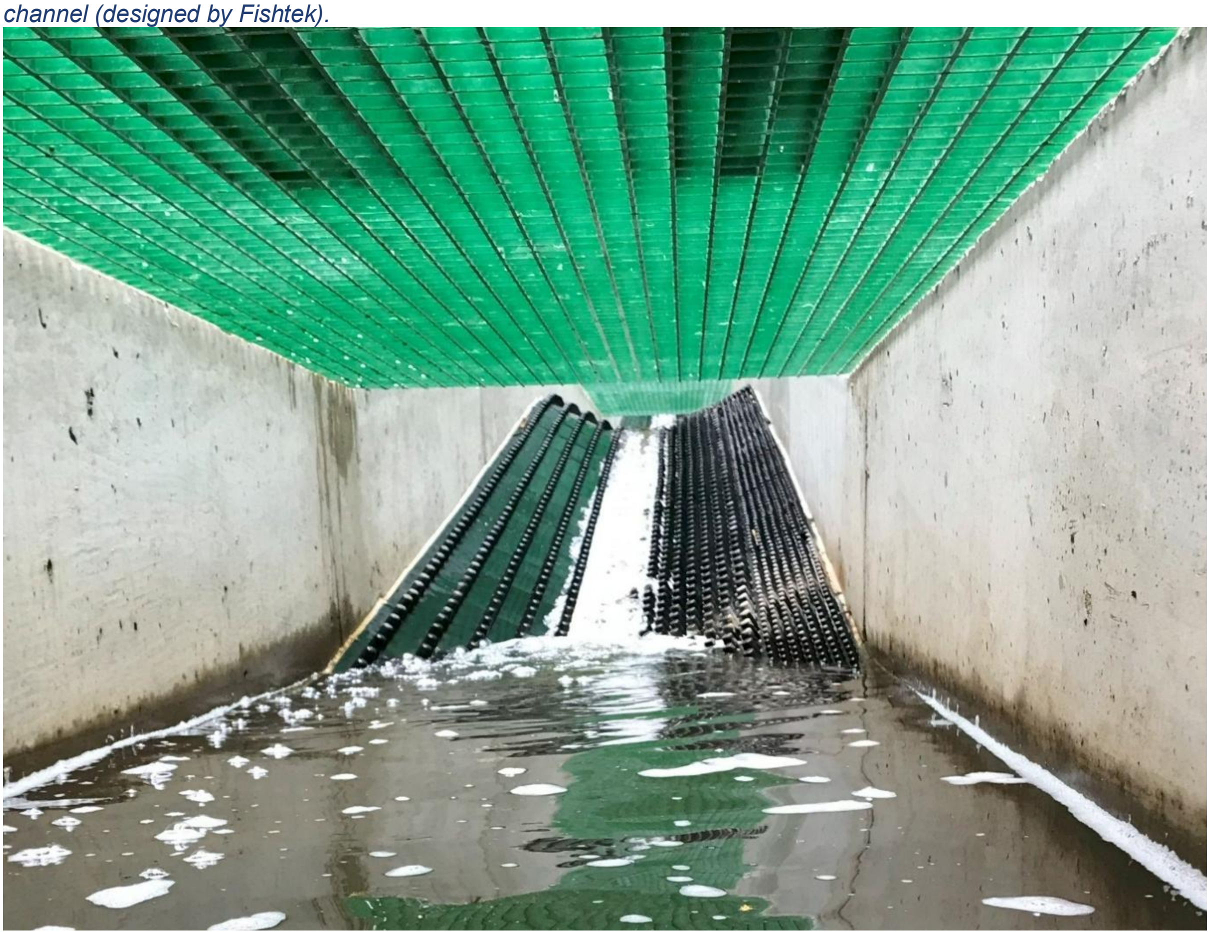
Given the head drop over the Kidds Mill Sluice structure can reach 3.83 m between the upstream weir pool and the downstream tide pool downstream of the culvert at low tide, a minimum of 3 flights would be needed each approximately 10 m in length. With the inclusion of 2 m long resting pools between each flight, an overall pass length of 34 m. A linear arrangement of the Larinier flights would therefore have to project approximately 12 m upstream of the current sluice. However, if the flights were staggered in a **switchback design**, the overall length of the pass could be significantly reduced. While this would require additional excavation of the land adjacent to the current channel to accommodate the switchbacks and therefore increased cost, it could facilitate fish passage for a large proportion of tidal cycle.

The downstream extent of the pass would end within the current culverted section and require some form of downstream pool to be included to provide a sufficient depth of water for fish waiting to ascend the pass or fish travelling down the pass. This would also allow fish to enter the pool during high tide and continue to ascend even after the tide has fallen below the level of the pool. A 0.6 m wide pass with a 15 % gradient could be designed to carry 100% of Q_{95} flows with a water depth of 0.3 m over the baffles. This would increase as upstream water levels rise and may result in the pass becoming overcharged at higher flow scenarios. However, the function of the adjacent automated tilting weir and backup spillway should be able to mitigate this impact when necessary.

In addition, adjacent to this fish pass, a gravity fed eel pass could be combined with this design to replace the current pump fed eel pass and reduce the ongoing maintenance requirements for the pass (**Figure 5-2**). This style would involve a lateral sloped channel with either pre-fabricated bristles, embedded granular material or pre-fabricated eel tiles as substrate (see **Figure 5-7**) to facilitate passage of a wide size range of eels across a range of water levels.

***Figure 5-1**- Example image of a 2 flight Larinier with a resting pool in the centre and gravity fed eel channel adjacent (covered by green mesh) installed at Saltaire (designed by Fishtek).*

***Figure 5-2-** Example image of Armley gravity fed lateral V-shaped eel pass with mixed stud sizing and a central channel (designed by Fishtek).*



5.1.1. Option 2- Partial Length Larinier

Whilst there is a large hydraulic head loss over the structure at low tide, given that Kidd's Mill Sluice marks the tidal limit of the Duke of Northumberland's River, the hydraulic head loss is reduced by approximately ~2.6 m to ~1.2 m during high tides. There may therefore be a cost saving opportunity available whereby fish passage is only provided during periods of high water, when fish are most likely to be migrating upstream. A shorter Larinier could be constructed consisting of only 1 flight, facilitating passage over 1.5 m of hydraulic head loss which would occur at approximately mean high tide.

This option could include a separate gravity fed eel pass at a steeper gradient alongside the pass to replace the existing pumped pass. However, given the arched sofit of the culvert head, a single flight Larinier would not provide sufficient clearance between the invert of the pass and the sofit of the culvert resulting in water impacting the culvert. Furthermore, this design would also require a downstream pool at the downstream extent of the single-flight Larinier to facilitate fish passage which would be very close to the roof of the culvert. This would not provide sufficient access for maintenance and could impact the structural integrity of the culvert. Therefore, this pass could not be constructed without significant alterations to the culverted sections and rerouting of the utilities that are believed to be housed within it. Given that this pass would only provide fish passage at the upper end of the tidal cycle, it is not recommended that this pass design is progressed.

5.1.2. Option 3- Full Length Alaskan A Fish Pass

An Alaskan 'A' fish pass is a technical fish pass consisting of a series of 3-dimensional baffles situated within a box-like sloping channel (example image given in **Figure 5-3**). Sections which are usually 1-3 m long can be prefabricated offsite and then bolted together on site. The channel has a fixed width of 0.56 m and is more effective hydraulically than similarly sized plane baffles due to lower velocities and reduced helical currents between baffles. While gradients up to 30% have been used to pass salmonids, it is not recommended to exceed 20% for other species and so 20 % would be the maximum gradient at Kidd's Mill Sluice.

To facilitate passage over the ~3.83 m head loss at the Kidds Mill Sluice structure, a minimum of 2 flights would be needed each approximately 10 m in length. With the inclusion of 2 m long resting pools between each flight, an overall pass length of 22 m staggered in a switchback design similarly to Option 1. While this would require additional excavation of the land adjacent to the left bank of the current channel to accommodate the switchbacks and therefore increased cost, it could facilitate fish passage across a greater proportion of the tidal cycle.

The pass would require ~50% of Q_{mean} flows to provide the minimum water depth of 0.325 m, which while more than the recommended 10 % of Q_{mean}, is still below the volume of water required by the Larinier design. Similarly to the Larinier design, there is a risk it may become overcharged if the function of the tilting weir is not modified to account for the new pass. The downstream extent of the pass would end within the current culverted section and require some form of downstream pool to be included to provide a sufficient depth of water for fish waiting to ascend the pass or fish travelling down the pass. This would also allow fish to enter the pool during high tide and continue to ascend even after the tide has fallen below the level of the pool.

In addition, adjacent to this fish pass, a gravity fed eel pass could be combined with this design to replace the current pump fed eel pass and reduce the ongoing maintenance requirements for the pass. This style would involve a laterally sloped channel with either pre-fabricated bristles, embedded granular material or pre-fabricated eel tiles as substrate (see **Figure 5-7**) to facilitate passage of a wide size range of eels across a range of water levels.

Figure 5-3- *Example image of a two-flight Alaskan A fish pass with central resting pool constructed at Primrose Lodge on the River Ribble (designed and fabricated by Fishtek).*

5.1.3. Option 4- Partial length Alaskan A Fish Pass

Similarly to Option 2, cost savings can be made by facilitating fish passage only at high tides using a shortened Alaskan A pass. A single flight Alaskan A fish pass of 10 m in length would facilitate passage over 2 m of hydraulic head loss, and therefore facilitate a greater degree of passage than Option 2. In order to fit the pass within the available space, the upstream intake would need to be sited ~3 m upstream of the current undershot sluice in order for the top of the baffles to not block the sofit of the culvert. This would also provide space for the first of a series of downstream resting pools within the culverted section at the tail of the pass, fish could enter the pools during rising tides and then ascend the pass at any point in the tidal cycle. Offsetting the invert of these pre-barrages to create an additional short pool and weir pass downstream that could also further increase the hydraulic head loss passed by the fish pass up to 2.4 m. The pass would require ~50% of Q_{mean} flows to provide the minimum water depth of 0.325 m, which while more than the recommended 10 % of Q_{mean}, is still below the volume of water required by the Larinier design. There is also sufficient space within the channel to also include a gravity fed eel pass alongside the Alaskan A pass matching the 20% gradient thereby replacing the existing pump fed pass and reducing maintenance requirements. One of the main issues faced by Alaskan A passes is the risk of blockage with debris, however, there is a debris boom upstream of the screen and if deflection screens are included in the end design this should be minimal.

5.1.1. Option 5- Do Nothing

No works or alterations are carried out, current conditions are maintained resulting in no improvement in fish passage. Under the present situation, there is likely to be no fish passage over Kidd's Mill Sluice. This option is only included as a baseline for other options and cannot be a preferred solution. However, depending on site constraints (i.e. costs, stakeholder agreement, flood risk, planning requirements etc.) 'doing nothing' may be an outcome at any given site.

5.2 Tidal Crane Barrier 8

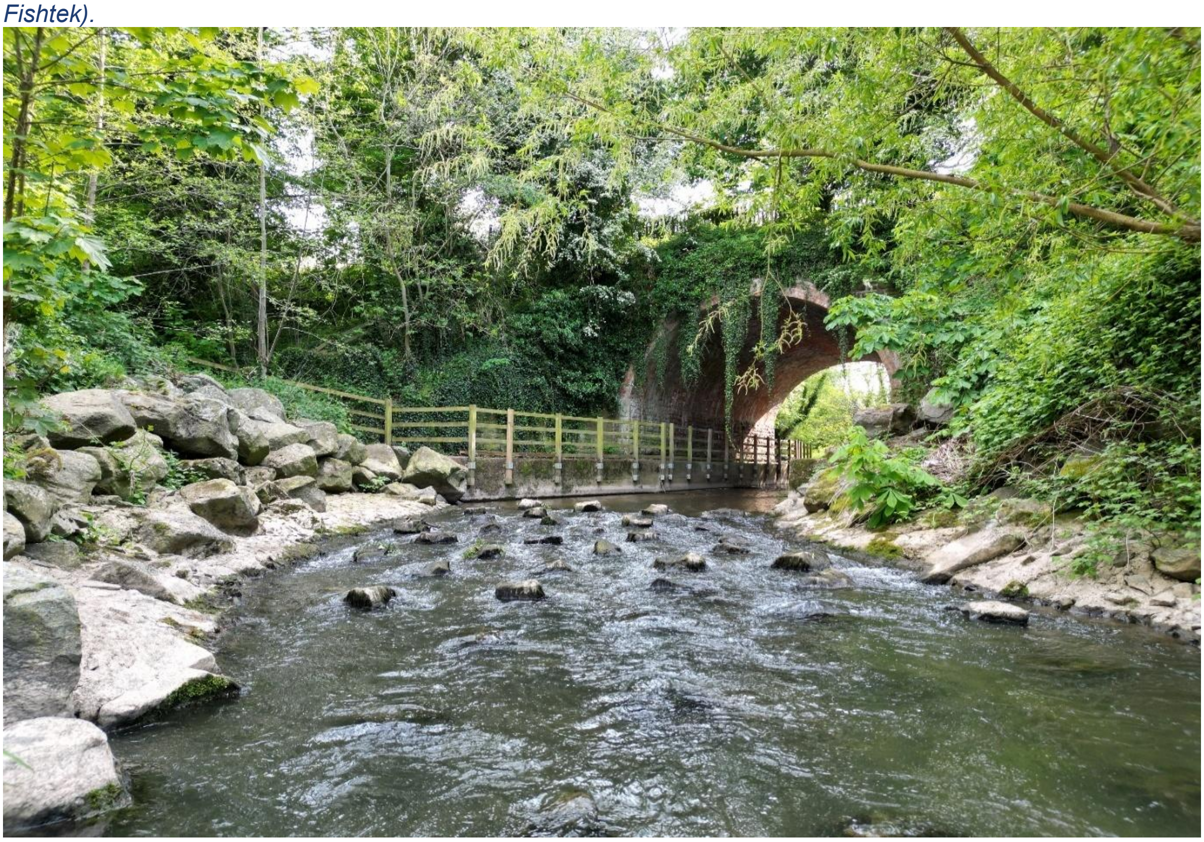
5.2.1. Option 1- Rock Ramp

Option 1 would involve installation of a ramp constructed from mixed bed material downstream of the weir to create a semi-naturalised river channel of reasonable gradient to allow fish passage over TCB-8 (see example image **Figure 5-4**). To overcome the 0.52 m of hydraulic head loss over TCB-8 and meet the typical 5% gradient required for a rock ramp, the rock ramp would need to project downstream ~11 m. Given the relatively low flows and therefore low water depths reported in this section of the Crane during dry periods, installing the rock ramp within a narrower concrete channel and setting the upstream invert lower than the current weir invert would concentrate water flows during low flow periods and reduce the risk of low water depths rending the ramp impassable. This option would also reduce the total volume of material required to create the 5% gradient compared to a rock ramp that spans the entire channel. Transverse rows of perturbation boulders would also be installed within the channel to aid in retaining water depths over the ramp (and therefore improve fish passage) and providing heterogeneity of flows that can be exploited by a wide range of species.

Rock ramps are widely suitable to all species present in the Lower Crane including eels. Given the diversity of fish species present in the Thames and the Crane itself, provision of a wide range of water conditions and velocities is paramount to provide suitable fish passage, this can be further increased by providing a cross slope in the ramp to provide areas of fast flow and areas of low flow.

Given the highly modified channel, the rocks used in the construction would need to be anchored securely into the bed to prevent high flows from dislodging them and rendering the ramp impassable, which could be achieved by embedding them in riprap or directly anchoring them into the concrete culvert bed.

Figure 5-4- *Example of a small rock ramp with perturbation boulders installed on the Rea Brook (designed by Fishtek).*



5.2.2. Option 2- Larinier

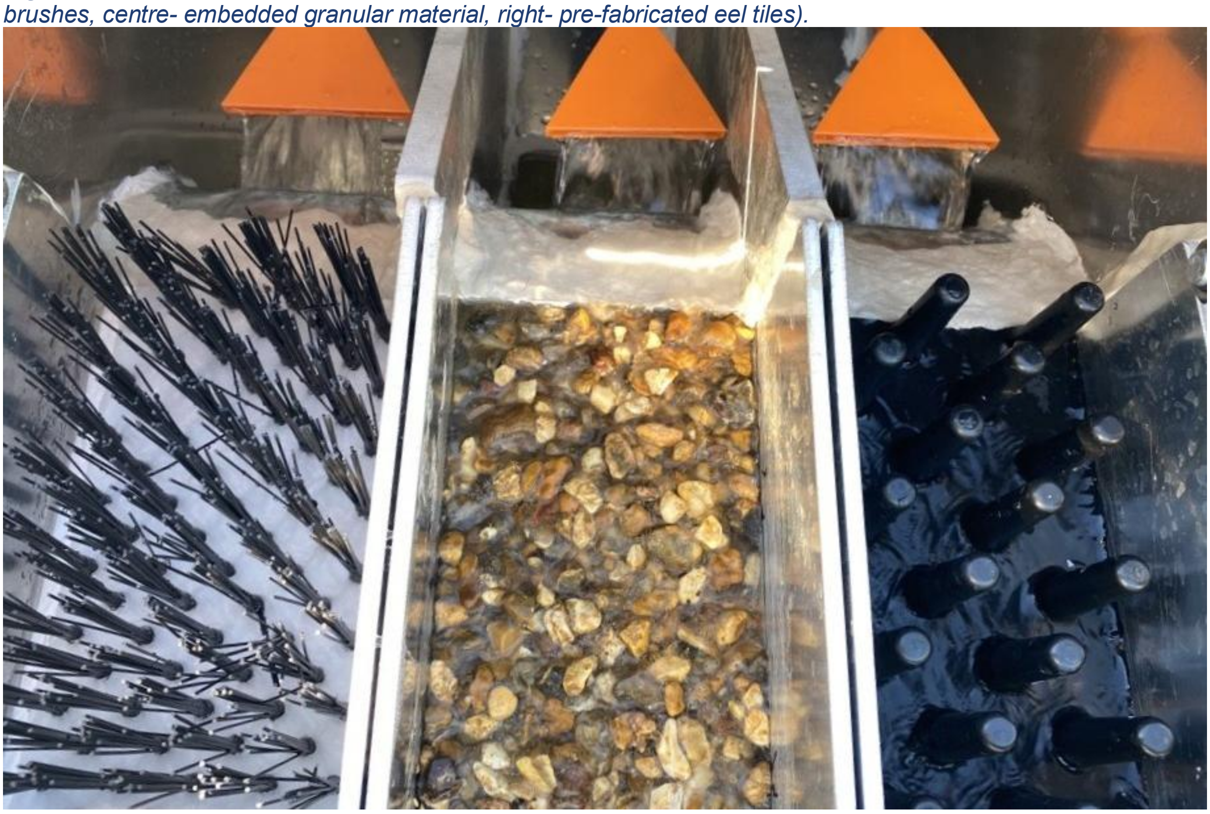
Option 2 involves a Larinier Fish Pass which is a technical fish pass that consists of a single sloping channel that can be constructed in a range of widths. Baffles (normally 75 mm, 100 mm or 150 mm) are organised along the base of the pass only and generate heterogeneity of flows that can be exploited by a range of salmonids and coarse fish. The maximum recommended slope is 15%, and given the head drop over the structure is ~0.52 m, the pass would be approximately 3.5 m in length. The short length and low hydraulic head of the pass would therefore not require a resting pool.

To ensure fish are able to locate the pass, the downstream invert would need to be within ~2m of the toe of the weir and therefore, the concrete culvert bed may need to be excavated in order to ensure there is adequate depth over the most downstream baffle which increases the complexity of the build.

Larinier fish passes also typically require a minimum head over the top baffle of 0.5 m for trout and coarse fish which for TCB-8 is only achieved at flow scenarios equivalent to Q_{45}. As such this pass would only function in periods of high flow around 40 % of the time. Larinier fish passes are also not suitable for the passage of eels and therefore a separate gravity fed eel pass would need to be constructed alongside the Larinier to ensure compliance with the eels regulations. This would likely take the form of a laterally slopped channel, bankside of the Larinier fish pass containing either pre-fabricated bristles, embedded granular material or pre-fabricated eel tiles to facilitate eel's crawling locomotion (**Figure 5-6**).

Figure 5-5- *Example image of a single flight Larinier with adjacent eel pass on the River Teme (designed by Fishtek).*

Figure 5-6- *Example image of available substrates for eel pass designs from Fishtek's test facility (left- bristle brushes, centre- embedded granular material, right- pre-fabricated eel tiles).*



5.2.3. Option 3- Pre-Barrages

Option 3 would involve the construction of a number of downstream weirs (check weirs or pre-barrages) to reduce the head loss across TCB-8. Due to the relatively low river flows and the head loss over each pre-barrage should be between 0.12 m to facilitate passage of coarse fish so 4 pre-barrages would be recommended to break the assumed ~0.5 m total hydraulic head into manageable steps. However, 3 pre-barrages in combination with a notch in the weir crest would achieve the same result and reduce the volume of material required. Each pre-barrage should be spaced ~2-3 m apart (dependent on power dissipation calculations during subsequent design stages).

The barrage themselves would also be designed to achieve streaming flow using an adherent nappe profile. This can be aided by notching the pre-barrage and the weir itself to concentrate flows under low water conditions. The notches should be a minimum of 0.2 m wide to facilitate passage of coarse fish, however, if passage of salmonids is also required, notches should be up to 0.3 m wide. These dimensions achieve a free discharge of each notch of 0.026 m^2s^{-1} which would facilitate streaming flow conditions up to Q_{90} and plunging flow at lower flow conditions above Q_{90}. If constructed using natural materials such as rip-rap or block stone, the interstitial spaces provided can also provide suitable crawling substrate to achieve passage by eels and indeed can provide wider habitat heterogeneity at the site.

5.2.4. Option 4- Brush Furnished Pass

Option 5 would function similarly to Option 2, with the installation of a technical fish pass that consists of a single sloping channel into which a range of brushes baffles are fitted to dissipate water velocity and provide heterogeneity of flow conditions through the pass. Th pass requires a maximum of an 8 % gradient to be effective and therefore the pass would be 6.5 m in length to overcome the 0.52 m head drop over the structure. This pass design would also require excavation of the existing weir and part of the culvert bed to embed the pass and construction of a concrete channel in which to fit the brush units so it's downstream invert is aligned with the tail of the weir. Due to the low flows in the River Crane this pass would only function in flow scenarios equivalent to Q_{35}.This pass is also passable to eels and lamprey so would not require a separate eel pass to be constructed.

5.2.5. Option 5- Do Nothing

No works or alterations are carried out, current conditions are maintained resulting in no improvement in fish passage. Under the present situation, there is likely to be very limited fish passage over the weirs apart from when the river is in flood. This option is only included as a baseline for other options and cannot be a preferred solution. However, depending on site constraints (i.e. costs, stakeholder agreement, flood risk, planning requirements etc.) 'doing nothing' may be an outcome at any given site.

6. Short Listed Options Appraisal Matrix

The options discussed above in **Section 5** are appraised in **Table 7** and **Table 8**. Options are scored between 1-5 for the following criteria with 1 being the best, and 5 being the worst:

Function: Ability to pass the greatest diversity of fish present in the river over the greatest range of flows, including having a good attraction flow to enable fish to locate the fish pass.

Buildability: Simple to construct without the need for excessive machinery, excavation, river drying & diversions.

Aesthetics: Achieves a look that is in keeping with the current site curtilage. Use of natural materials where possible and low use of concrete, metal and other less aesthetically pleasing materials.

Maintenance: Low maintenance requirements including debris removal, inspection, repair/relace parts, ground maintenance (e.g. grass cutting).

Cost: Cost scoring is based on design and build cost where 1 = £0-250,000, 2 = £250,000 - £500,000, 3 = £500,000 – £1,000,000, 4 = £1,000,000 – £2,000,000, 5 = £2,000,000 +. These costs are budgetary estimates only.

Impacts to other structures: Low impact to other structures and existing flow regimes

Flood Risk: Low risk of increasing localised flood risk due to impediment by the structure itself or likelihood of structural failure or blockage with debris.

6.1 Kidd's Mill Sluice

***Table 7-** Appraisal matrix of shortlisted options for achieving fish passage at Kidd's Mill Sluice.*

Option	Advantages	Disadvantages	Function	Buildability	Aesthetics	Maintenance	Cost	Impacts to other structures	Flood Risk	Total
Option 1- Full Length Larinier	• This style of fish pass has the potential to contribute to achieving good ecological status regarding fish passage under the WFD (i.e. fish passage reinstated). • This style of fish pass is regarded as suitable for a wide range of species, including salmon, sea trout, grayling, and coarse fish. • The incorporation of an eel pass (either the existing pass or a new gravity fed pass) will comply with the Eels regulations. • Provides fish passage across the a large percentage of the tidal cycle.	• Other WFD objectives not addressed if a technical fish pass is installed • Potential for the operation of the tilting weir to have an effect on function and attraction flows. • Complex and costly design and build phase due to excavation and switchbacks.	1	5	3	2	4	5	2	**22**
Option 2- Partial length Larinier	• This style of fish pass has the potential to contribute to achieving good ecological status regarding fish passage under the WFD (i.e. fish passage reinstated). • This style of fish pass is regarded as suitable for a wide range of species, including salmon, sea trout, grayling, and coarse fish. • The incorporation of an eel pass (either the existing pass or a new gravity fed pass) will comply with the Eels regulations. • Lower design and build costs than full length Larinier.	• Doesn't provide fish passage throughout the whole tidal cycle. • Other WFD objectives not addressed if a technical fish pass is installed • Potential for the operation of the tilting weir to have an effect on attraction flows.	3	3	4	3	2	4	2	**21**

Option 3- Full Length Alaskan A Fish Pass	• This style of fish pass has the potential to contribute to achieving good ecological status regarding fish passage under the WFD (i.e. fish passage reinstated). • This style of fish pass is regarded as suitable for a wide range of species, including salmon, sea trout, grayling, and coarse fish. • The incorporation of an eel pass (either the existing pass or a new gravity fed pass) will comply with the Eels regulations. • Provides fish passage across the whole tidal cycle • Fewer flights required than Option 1.	• Other WFD objectives not addressed if a technical fish pass is installed • Potential for the operation of the tilting weir to have an effect on attraction flows. • Complex and costly design and build phase due to excavation and switchbacks.	1	4	3	4	3	4	2	**21**
Option 4- Partial Height Alaskan A Fish Pass	• This style of fish pass has the potential to contribute to achieving good ecological status regarding fish passage under the WFD (i.e. fish passage improved). • This style of fish pass is regarded as suitable for a wide range of species, including salmon, sea trout, grayling, and coarse fish. • The incorporation of an eel pass (either the existing pass or a new gravity fed pass) will comply with the Eels regulations. • Reduced costs compared to full heigh options.	• Doesn't provide fish passage throughout the whole tidal cycle. • Other WFD objectives not addressed if a technical fish pass is installed • Potential for the operation of the tilting weir to have an effect on attraction flows.	2	2	4	3	2	2	2	**18**
Option 7- Do Nothing	• Funds could be allocated elsewhere to achieve greater environmental benefits.	• No increase in fish passage. • Kidd's Mill Sluice marks the most downstream barrier on the Duke of Northumberland's River and therefore remediation would mark a significant increase in access to upstream habitat.								**N/A**

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6.2 Tidal Crane Barrier 8

***Table 8-** Appraisal matrix of shortlisted options for achieving fish passage at Tidal Crane Barrier 8.*

Option	Advantages	Disadvantages	Function	Buildability	Aesthetics	Maintenance	Cost	Impacts to other structures	Flood Risk	Total
Option 1- Rock Ramp (N)	• This style of fish pass has the potential to contribute to achieving good ecological status regarding fish passage under the WFD (i.e. fish passage reinstated). • This pass is a naturalised style of pass and provides wider habitat benefits. • This style of fish pass is regarded as suitable for a wide range of species, including salmon, sea trout, grayling, and coarse fish and eels. • Doesn't require a separate eel pass to be compliant with Eels Regulations. • High aesthetic value.	• Fully naturalised rock ramps without suitable anchoring may settle or disintegrate in high flows if not constructed robustly. • Construction access constraints as perturbation boulder installation would require crane access. • Large material requirements.	1	4	1	2	2	1	3	**14**
Option 2- Larinier (super active baffle) (T)	• This style of fish pass has the potential to contribute to achieving good ecological status regarding fish passage under the WFD (i.e. fish passage reinstated). • This style of fish pass is regarded as suitable for a wide range of species, including salmon, sea trout, grayling, and coarse fish. • The incorporation of an eel pass (either the existing pass or a new gravity fed pass) will comply with the Eels regulations.	• Does not function at flows below Q_{45}. • Other WFD objectives not addressed if a technical fish pass is installed. • Lower aesthetic appeal than naturalised solutions. • Higher risk of debris blockage than naturalised solutions.	3	2	4	3	1	1	2	**16**
Option 3- Pre-barrages (E)	• This style of fish pass has the potential to contribute to achieving good ecological status regarding fish passage under the WFD (i.e. fish passage reinstated). • This pass is a naturalised style of pass and provides wider habitat benefits.	• Streaming flow conditions lost above Q_{90} so poor swimming species may struggle to ascend at low flow conditions. • Fully naturalised pre-barrages without suitable anchoring may settle or disintegrate in high flows if not constructed robustly.	2	3	1	1	1	1	2	**11**

	• This style of fish pass is regarded as suitable for a wide range of species, including salmon, sea trout, grayling, and coarse fish and eels. • Doesn't require a separate eel pass to be compliant with Eels Regulations. • High aesthetic value.	• Construction access constraints if block stone used requiring crane access.								
Option 5- Brush-furnished pass (T)	• This style of fish pass has the potential to contribute to achieving good ecological status regarding fish passage under the WFD (i.e. fish passage reinstated). • This style of fish pass is regarded as suitable for a wide range of species, including salmon, sea trout, grayling, and coarse fish and eels. • Can be designed for use by canoes and therefore provide recreational benefits.	• Only functions at high flows scenarios. • Other WFD objectives not addressed if a technical fish pass is installed. • Lower aesthetic appeal than naturalised solutions. • Higher risk of debris blockage than naturalised solutions. • Shorter design life due to bristles requiring replacement.	4	2	4	4	2	1	3	**20**
Do nothing.	• Funds could be allocated elsewhere to achieve greater environmental benefits.	• No increase in fish passage. • TCB-8 marks the most downstream barrier on the River Crane that is not reduced during high tides and therefore remediation would mark a significant increase in access to upstream habitat.								**N/A**

7. Preferred Option

7.1 Kidd's Mill Sluice

The preferred option identified by the appraisal matrix for Kidd's Mill Sluice is **Option 4** involving **installation of a small (partial length) Alaskan A fish pass** that would facilitate passage across Kidd's Mill Sluice during high tides. This style of pass is able to facilitate passage of salmonids and coarse fish into the DNR and retaining or replacing the existing eel pass would also provide passage of eels into the DNR, meeting the project objectives regarding fish passage.

Estimations of the fish pass characteristics (inverts, lengths, widths, flows etc.) are based on available data and there would be benefit from undertaking additional survey work to refine this and inform the subsequent design phases. The additional survey requirements would include a topographic survey specifically to inform the fish pass design, up and downstream water level measurements to establish hydraulic head loss over the structure across the tidal range, spot flow gauging surveys and ground investigation and structural surveys.

While barrier removal or naturalised passes are typically preferred from an ecological perspective, the constraints at this site have ruled out these options. Instead, a technical Alaskan A fish pass is a suitable compromise to permit passage of all species likely to be at the site. Installation of a partial height Alaskan A pass is also a trade off between function and cost, with the full length options representing a significant design and build cost involving large amounts of excavation to achieve the required switchbacks. The partial height Alaskan A also facilitates passage during rising tides which is when most fish attempt to migrate into tidal channels and therefore represents the greatest opportunity for fish passage.

7.2 Tidal Crane Barrier 8

The preferred option identified by the appraisal matrix for TCB-8 is **Option 3** which involves the **installation of three downstream pre-barrages with streaming flow notches**. This option would also include adding a streaming flow notch to TCB-8 itself to further reduce the head loss over the structure. If streaming flow is achieved, this pass is able to facilitate passage of salmonids, coarse fish and eels into the River Crane up to Q_{90}, meeting the project objectives regarding fish passage.

Estimations of the fish pass characteristics (inverts, notch widths, notch depths, flows etc) are based on available and there would be benefit from undertaking additional survey work to refine this and inform the subsequent design phases. The additional survey requirements would include a topographic survey specifically to inform the fish pass design, water level measurements and structural surveys of the culverted channel.

While the River Crane is a heavily modified channel, installation of pre-barrages and notching the weir represent a more naturalised approach to achieving fish passage. Use of natural materials for the construction of each pre-barrage can not only improve aesthetic appeal, but provide added ecological benefits in the form of added habitat and flow heterogeneity.

8. REFERENCES

Tom White, Emma Day, Zara Ziauddin, Ilse Steyl, 2016. An Assessment of Barriers to Fish Passage in the Crane River Catchment (Scientific Report). London Wildlife Trust.

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APPENDIX 1- FISHERIES DATA

Crane Rivers and Lakes FW Fish

Site Name	Site ID	River	Nº of Surveys	First Survey	Last Survey	Species Recorded	Location relative to Kidd's Mill Sluice	Location Relative to Tidal Crane Barrier 8
Crane Park	17310	River Crane	10	09/05/2000	27/09/2022	3-spined stickleback, Barbel, Bleak, Bullhead, Chub, Dace, European eel, Gudgeon, Minnow, Perch, Roach, Stone loach	U/S	U/S
Cranford Park	14618	River Crane	10	06/06/2000	14/09/2022	3-spined stickleback, Bullhead, Chub, Dace, Gudgeon, Minnow, Perch, Roach, Stone loach	U/S	U/S
Harlequins	70224	Duke of Northumberland's River	3	06/09/2017	17/09/2019	3-spined stickleback, Bullhead, Chub, Common bream, Dace, European eel, Gudgeon, Minnow, Roach, Stone loach	U/S	N/A[1]
Hatton Road	16390	Duke of Northumberland's River	7	13/06/2000	08/10/2024	3-spined stickleback, Bleak, Bullhead, Chub, Common bream, Dace, European eel, Feral [brown] goldfish, Gudgeon, Minnow, Perch, Pike, Roach, Roach x rudd hybrid, Stone loach, Tench	U/S	U/S

[1] N/A indicates that this site is on a channel which is parallel to this barrier

Hounslow Heath	14617	River Crane	10	20/05/2005	14/09/2022	3-spined stickleback, Barbel, Bullhead, Chub, Dace, European eel, Gudgeon, Minnow, Pike, Roach, Rudd, Stone loach, Tench	U/S	U/S
Marsh Farm	70524	River Crane	3	12/10/2017	23/10/2019	3-spined stickleback, Bullhead, Chub, Dace, European eel, Gudgeon, Minnow, Pike, Roach, Stone loach	N/A	U/S
Mill Platt	16391	Duke of Northumberland's River	3	06/10/2005	04/10/2017	3-spined stickleback, Bleak, Chub, Dace, European eel, Gudgeon, Minnow, Roach, Stone loach	U/S	N/A
Moor Lane	14620	Duke of Northumberland's River	4	15/06/2000	05/09/2017	Bleak, Bullhead, Chub, Common [wild] carp, Common bream, Dace, European eel, Gudgeon, Minnow, Perch, Pike, Roach, Stone loach, Tench	U/S	U/S
Moor Mead Bridge	24123	River Crane	1	25/03/2000	25/03/2000	3-spined stickleback, Barbel, Chub, Chub x dace hybrid, Dace, European eel, Flounder, Gudgeon, Minnow, Perch, Roach, Stone loach, Tench	N/A	U/S
Riverside Walk	14615	Duke of Northumberland's River	6	25/05/2005	10/10/2024	3-spined stickleback, Bullhead, Chub, Dace, European eel, Gudgeon,	U/S	U/S

						Minnow, Pike, Roach, Rudd, Silver bream, Stone loach		
Twickenham	70243	Duke of Northumberland's River	3	12/09/2017	17/09/2019	3-spined stickleback, Bullhead, Chub, Dace, European eel, Gudgeon, Minnow, Pike, Roach, Rudd, Stone loach	U/S	N/A
Yeading Meadows D/S	51571	River Crane	1	08/10/2013	08/10/2013	3-spined stickleback, Dace, Gudgeon, Minnow, Stone loach	U/S	U/S
Yeading Meadows U/S	51570	River Crane	1	08/10/2013	08/10/2013	3-spined stickleback, Gudgeon, Minnow, Stone loach	U/S	U/S

Tidal Thames FW Fish

Site Name	Site ID	River	Nº of Surveys	First Survey	Last Survey	Species Recorded	Location relative to Kidd's Mill Sluice	Location Relative to Tidal Crane Barrier 8
The Causeway, Wandsworth	32234	Bell Lane Creek	1	29/06/1994	29/06/1994	Dace, European eel, Perch, Roach	D/S	D/S

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Tidal Thames TraC Fish

Site Name	Site ID	River	Nº of Surveys	First Survey	Last Survey	Species Recorded	Location relative to Kidd's Mill Sluice	Location Relative to Tidal Crane Barrier 8
Brentford Beam Trawl	20293	Thames Upper	8	25/05/1993	20/10/1998	3-spined stickleback, Common goby, European eel, Flounder, Perch, Roach, Smelt	D/S	D/S
Brentford Kick sample	20294	Thames Upper	5	25/05/1993	26/05/1998	European eel, Flounder	D/S	D/S
Brentford Seine Net	20295	Thames Upper	13	19/06/1992	01/06/1999	3-spined stickleback, Bleak, Brown / sea trout, Chub, Common bream, Common goby, Dace, European eel, Flounder, Gudgeon, Perch, Roach, Sand smelt, Sea bass, Smelt, Thin lipped grey mullet	D/S	D/S
Chelsea Creek Seine Net	20324	Thames Upper	4	17/11/1992	08/09/1993	Common bream, Common carp, Common goby, Dace, European eel, Flounder, Perch, Roach, Sand smelt, Sea bass, Smelt, Thin lipped grey mullet	D/S	D/S
Chelsea Seine Net	20325	Thames Upper	2	02/07/1992	17/11/1992	3-spined stickleback, Common bream, Dace, Flounder, Roach, Sand	D/S	D/S

						goby, Sand smelt, Sea bass		
Chiswick Beam Trawl	20326	Thames Upper	44	30/11/1992	03/10/2024	3-spined stickleback, Big scaled sand smelt, Common bream, Common goby, European eel, Flounder, Roach, Sea bass	D/S	D/S
Chiswick Seine Net	20328	Thames Upper	80	19/06/1992	03/10/2024	3-spined stickleback, Common bream, Common goby, Dace, European eel, Flounder, Roach, Sand smelt, Sea bass	D/S	D/S
Fulham Seine Net	20394	Thames Upper	1	01/07/1992	01/07/1992	3-spined stickleback, Dace, European eel, Flounder, Roach	D/S	D/S
Hammersmith Beam Trawl	20432	Thames Upper	9	06/09/1993	22/10/1998	3-spined stickleback, Common goby, European eel, Flounder, Gudgeon, Roach, Sea bass, Smelt, Thin lipped grey mullet	D/S	D/S
Hammersmith Kick sample	20433	Thames Upper	5	09/06/1994	11/06/1998	3-spined stickleback, Common goby, Dace, Flounder	D/S	D/S
Hammersmith Seine Net	20434	Thames Upper	15	01/07/1992	22/10/1998	10-spined stickleback, 3-spined stickleback, Bleak, Common bream, Common carp, Common goby, Dace, European eel, Flounder, Perch, Roach, Roach x common bream hybrid, Sand goby, Sand smelt, Sea bass, Smelt,	D/S	D/S

						Tench, Thin lipped grey mullet		
Kew Beam Trawl	20462	Thames Upper	41	01/09/1999	02/10/2024	3-spined stickleback, Bullhead, Common bream, Common goby, Dace, European eel, Flounder, Perch, Roach, Roach x common bream hybrid, Sand goby, Sand smelt, Sea bass, Smelt, Stickleback sp.	D/S	D/S
Kew Kick sample	20463	Thames Upper	36	01/06/2001	02/10/2024	3-spined stickleback, Dace, European eel, Flounder, Smelt, Thin lipped grey mullet	D/S	D/S
Kew Seine Net	20464	Thames Upper	81	21/07/1989	02/10/2024	3-spined stickleback, Bleak, Brown / sea trout, Bullhead, Chub, Common bream, Common goby, Dace, European eel, Flounder, Goby sp., Gudgeon, Mirror carp, Perch, Pike, Roach, Roach x common bream hybrid, Sand goby, Sand smelt, Sea bass, Smelt, Stone loach, Thick lipped grey mullet, Thin lipped grey mullet, Zander	D/S	D/S
Putney Seine Net	20549	Thames Upper	4	16/11/1992	08/09/1993	3-spined stickleback, Brown / sea trout, Common goby, Dace, European eel, Flounder,	D/S	D/S

						Perch, Roach, Sand goby, Sand smelt, Sea bass		
Richmond Kick Sample	20560	Thames Upper	36	22/06/1993	11/10/2022	3-spined stickleback, Bullhead, Common bream, Common goby, Dace, European eel, Flounder, Perch, Sand goby	Parallel River Channel	Parallel River Channel
Richmond Seine Net	20562	Thames Upper	96	21/05/1992	27/09/2023	3-spined stickleback, Atlantic salmon, Barbel, Big scaled sand smelt, Bleak, Brown / sea trout, Bullhead, Chub, Common bream, Common carp, Common goby, Dace, European eel, Flounder, Goby sp., Gudgeon, Minnow, Mirror carp, Perch, Roach, Roach x common bream hybrid, Rudd, Sand goby, Sand smelt, Sea bass, Smelt, Stickleback sp., Thin lipped grey mullet	Parallel River Channel	Parallel River Channel

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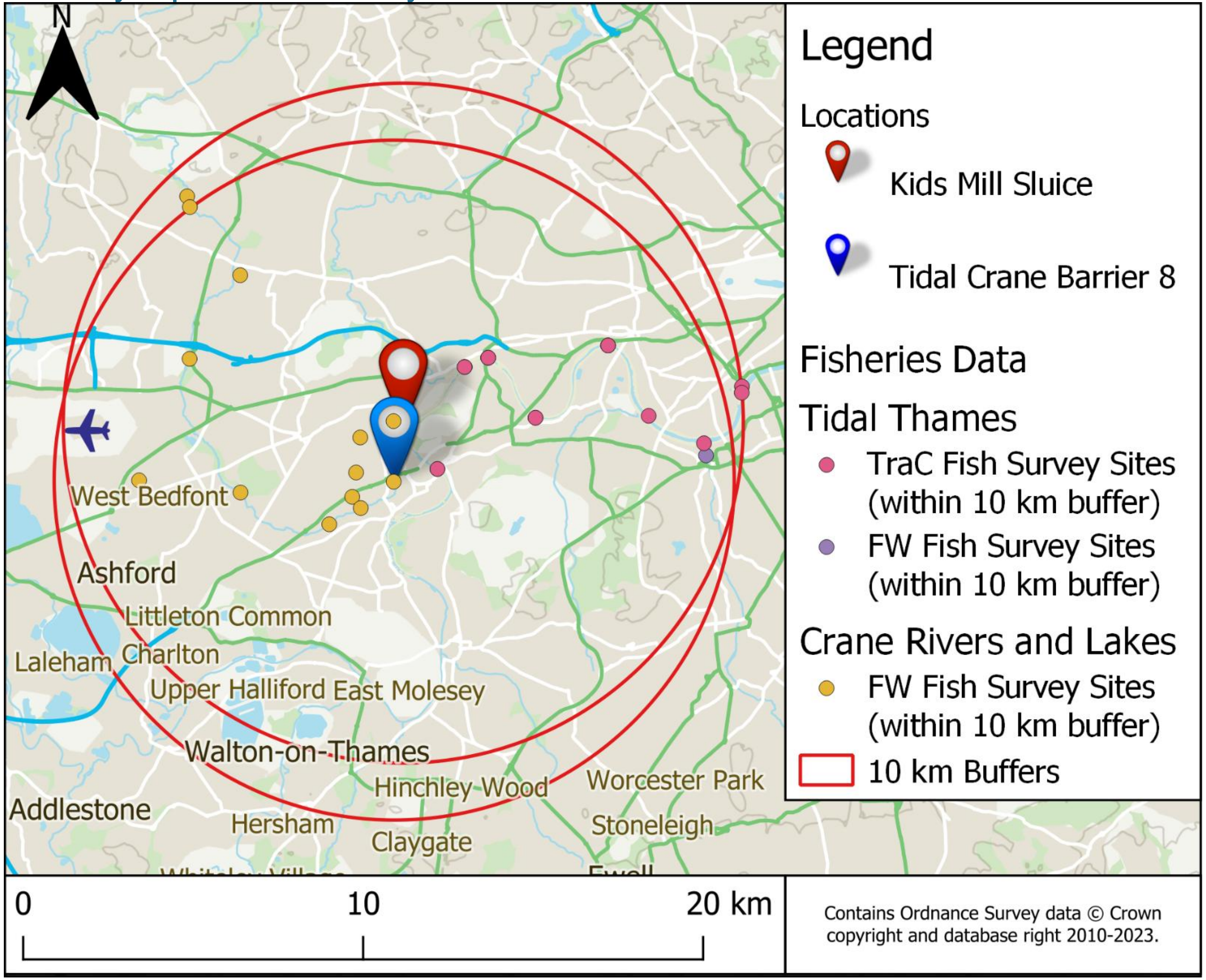
Summary map of EA NFPD survey sites within 10 km of Kidd's Mill Sluice and Tidal Crane Barrier 8.



APPENDIX 2- WATER FRAMEWORK DIRECTIVE

Crane Waterbody Data

Classification Item	2019	2022
Ecological	**Moderate**	**Moderate**
Biological quality elements	**Moderate**	**Moderate**
Fish	**Moderate**	**Moderate**
Invertebrates	**Moderate**	**Good**
Macrophytes and Phytobenthos Combined	**Moderate**	**Moderate**
Macrophytes Sub Element	**Moderate**	**Good**
Phytobenthos Sub Element	**Moderate**	**Moderate**
Physico-chemical quality elements	**Moderate**	**Moderate**
Acid Neutralising Capacity	**High**	**High**
Ammonia (Phys-Chem)	**Good**	**High**
Biochemical Oxygen Demand (BOD)	**Moderate**	**High**
Dissolved oxygen	**Poor**	**Good**
Phosphate	**Poor**	**Poor**
Temperature	**Moderate**	**High**
pH	**High**	**High**
Hydromorphological Supporting Elements	**Not high**	**Not high**
Hydrological Regime	**Does not support good**	**Does not support good**
Specific pollutants	**High**	**High**
Chlorothalonil	**High**	**High**
Chromium (VI)	**High**	**High**
Copper	**High**	**High**
Iron	**High**	**High**
Manganese	**High**	**High**
Pendimethalin	**High**	**High**
Triclosan	**High**	**High**
Zinc	**High**	**High**
Chemical	**Fail**	**Does not require assessment**
Priority hazardous substances	**Fail**	**Does not require assessment**
Benzo(a)pyrene	**Good**	
Benzo(b)fluoranthene	**Good**	
Benzo(g-h-i)perylene	**Fail**	
Benzo(k)fluoranthene	**Good**	
Cadmium and Its Compounds	**Good**	
Di(2-ethylhexyl)phthalate (Priority hazardous)	**Good**	
Dioxins and dioxin-like compounds	**Good**	
Heptachlor and cis-Heptachlor epoxide	**Good**	

	Hexabromocyclododecane (HBCDD)	Good	
	Hexachlorobenzene	Good	
	Hexachlorobutadiene	Good	
	Hexachlorocyclohexane	Good	
	Mercury and Its Compounds	Good	
	Nonylphenol	Good	
	Pentachlorobenzene	Good	
	Perfluorooctane sulphonate (PFOS)	Fail	
	Polybrominated diphenyl ethers (PBDE)	Fail	
	Quinoxyfen	Good	
	Tributyltin Compounds	Good	
Priority substances		Good	**Does not require assessment**
	1,2-dichloroethane	Good	
	Aclonifen	Good	
	Alachlor	Good	
	Benzene	Good	
	Bifenox	Good	
	Cypermethrin (Priority)	Good	
	Dichloromethane	Good	
	Dichlorvos (Priority)	Good	
	Fluoranthene	Good	
	Lead and Its Compounds	Good	
	Nickel and Its Compounds	Good	
	Terbutryn	Good	
	Trichloromethane	Good	
Other Pollutants		Good	**Does not require assessment**
	Carbon Tetrachloride	Good	
	DDT Total	Good	
	para - para DDT	Good	

APPENDIX 3- UTILITIES DATA

Files provided separately.