The River Dee Trust

Report on the impact of Large Woody Structures on the Muick 2020-2022

February 2023

Impact of Large Woody Structures on the Muick, 2020-2022

Introduction

Large woody structures (LWS) are becoming increasingly recognised as an important management tool for accelerating the rehabilitation of degraded watercourses by:

- Providing habitat for fish – structures provide shelter from high velocity flows, shade, feeding, spawning and nursery sites, as well as refuges from predators.
- Creating diverse habitats - adding complexity to the channel and helping to create pools and gravel beds
- Supporting invertebrate lifecycles - trapping nutrients for key species groups such as mayflies, stoneflies, and caddis species.

Monitoring

As part of a suite of measures to improve habitat complexity and provide shelter from increasing water temperatures in the upper Muick, 67 LWS have been installed from 250m downstream of Loch Muick along the entire length of the upper river to within 2km of the Falls of Muick. The first 25 structures, placed between the loch and the Bogwood Forestry plantation 3.25km downstream, were added in 2020. Six of the proposed locations (3 midstream and 3 bankside structures) and two unchanged control sites were chosen for ongoing monitoring of the LWS on habitat and fish density (**Table 1, Figure 1**).

Table 1: Structure details and fishing dates for each Large Woody Structure (LWS).

	Distance from loch (m)	Structure type	Sampling date		
LWS_5	250	Right	23/08/2020	15/09/2021	23/08/2022
LWS_11	675	Left	20/08/2020	13/09/2021	24/08/2022
LWS_13	900	Medial	07/08/2020	13/09/2021	24/08/2022
LWS_24	1775	Left	24/08/2020	09/11/2021	25/08/2022
LWS_UC	2175	Control	20/08/2020	08/09/2021	25/08/2022
LWS_32	2500	Medial	01/09/2020	08/09/2021	02/09/2022
LWS_38	2950	Medial	19/08/2020	07/09/2021	26/08/2022
LWS_LC	3050	Control	02/09/2020	07/09/2021	26/08/2022

At each location a 200m^2 area (hereafter called 'the site') fixed by the upstream limit of the LWS was created for ongoing monitoring. This area is electrofished to determine the number, size, weight, species, and life stage of fish present. Fixed point photography (FPP) focussed on the LWS and riverbed is taken up and downstream and an aerial image from 33m above the structure is taken to observe physical changes to the river. The site is divided into 3-4 transects and depth, flow, and habitat type measures are recorded every metre along the transect to investigate how they are changing with the addition of the LWS.

Monitoring measurements were first taken in 2020 before the installation of structures and have been repeated post installation in 2021 and 2022. Annual monitoring is expected to take place for the first 5 years before a multi-year approach takes over.

Figure 1: Location of LWS along the River Muick. Green are right bank structures, Yellow are left bank, Blue are medial (mid-stream), and Orange are control sites with no structure.

Results

Fish

Since 2020, the total number of fish captured during electrofishing has increased year on year. The increase is almost entirely due to an increase in fry with limited change in parr numbers (**Table 2, Figure 2**).

Table 2: Total number of fish (separated between lifestage and control vs treatment sites) caught by electrofishing at all sites each year.

	Control (2 sites)		Treatment (6 sites)		Total
Year	**Fry**	**Parr**	**Fry**	**Parr**	**(ex. control)**
2020	41	10	184	16	200
2021	47	4	219	25	244
2022	57	5	279	23	302

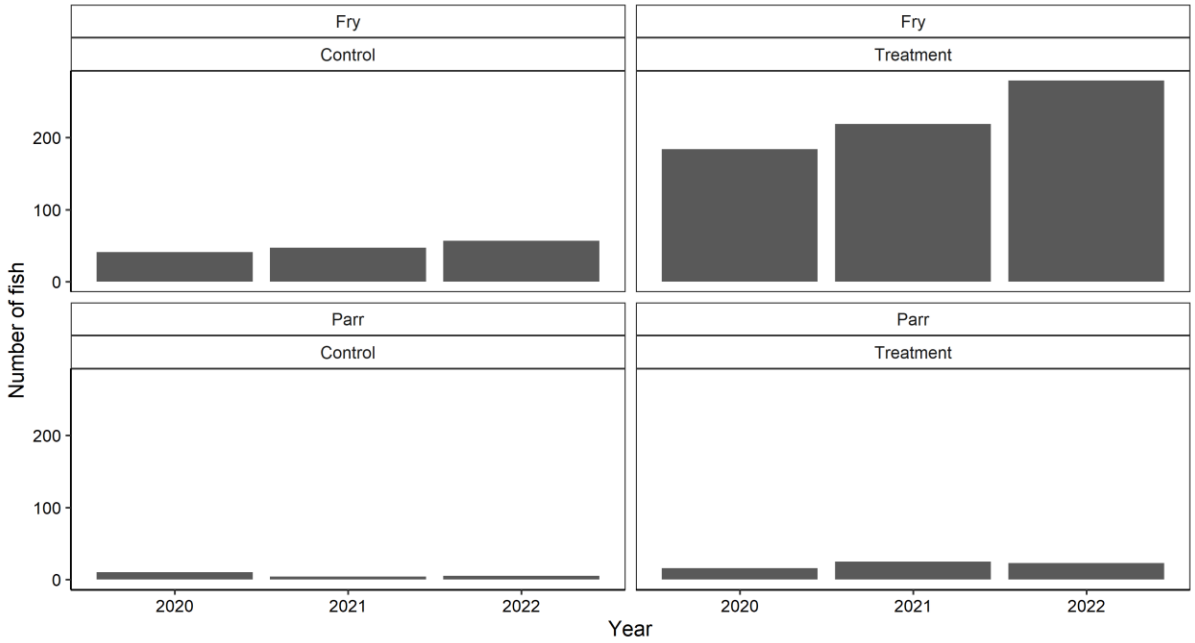

Figure 2: Total number of fry and parr caught by electrofishing each year, control sites (n=2) are in the left panel, sites with LWS (n=6) in the right panel. 2020 is before addition of LWS.

Number of salmon fry have increased since the structures were installed although neither salmon nor trout fry showed a linear increase each year. Parr numbers remained consistent each year with salmon parr more numerous than trout parr each year (**Figure 3**).

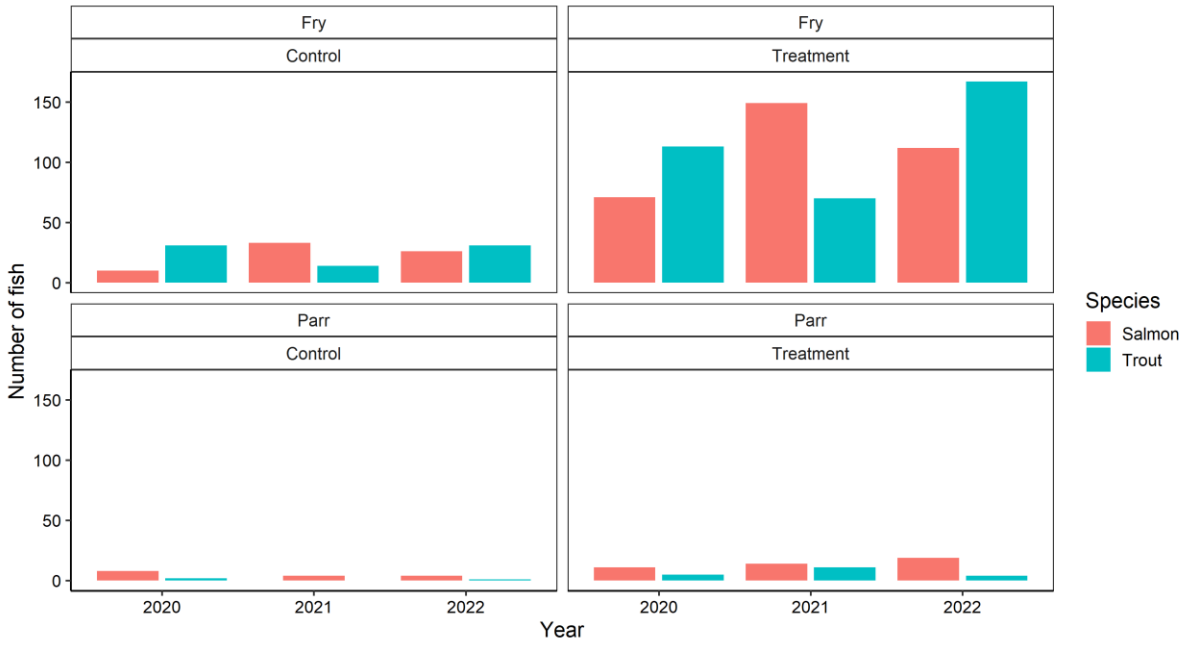

Figure 3: Total number of salmon (red) and trout (blue) fry and parr caught by electrofishing each year, control sites (n=2) are in the left panel, sites with LWS (n=6) in the right panel. 2020 is before addition of LWS.

Total fry numbers appear to have remained consistent or increased at each site, except at LWS_24 where fry numbers decreased. Parr numbers were very low and showed no obvious trend (**Figure 4**).

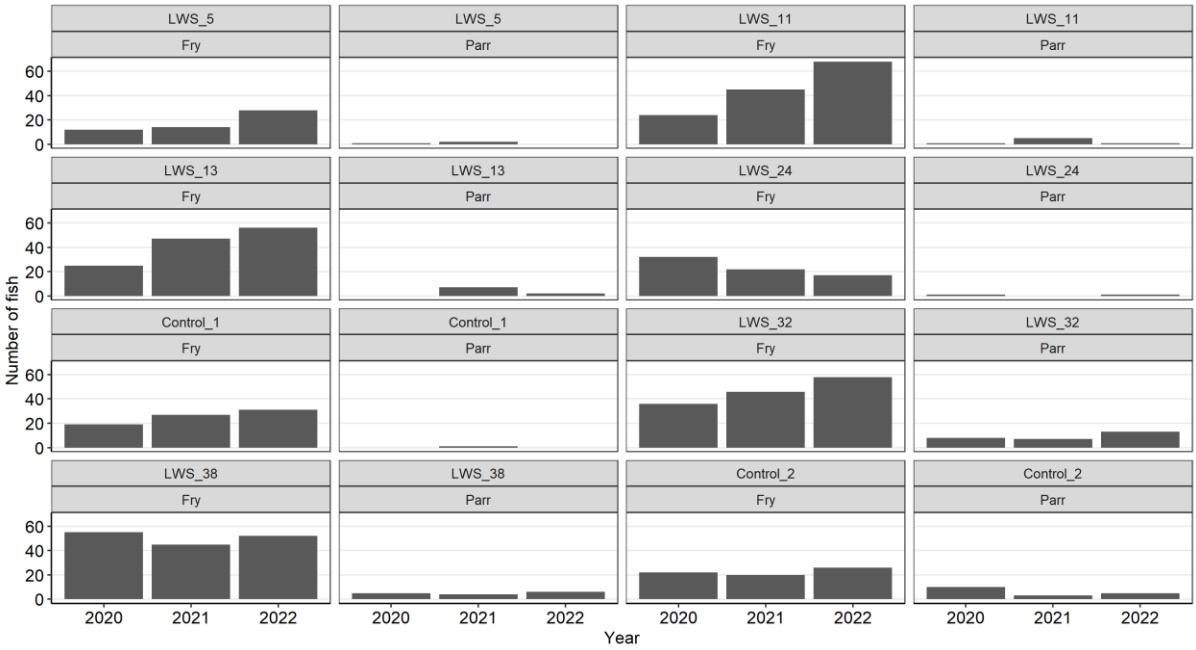

Figure 4: Figure 2: Total number of fry and parr caught by electrofishing at each 200m^2 site. 2020 is before addition of LWS. Treatment and Control sites are arranged upstream to downstream.

Looking more closely at fry numbers, **Figure 5** demonstrates that numbers at the control sites have remained similar with little annual variation. For the treatment sites, the number of fry caught was similar in 2020 (before any LWS addition) and has exhibited greater variability in numbers in the following years. Linear models of the relationship between fish counts and year indicate increasing fish numbers at LWS_5, LWS_11, LWS_13, LWS_32 and a decrease at LWS_24 and LWS_38. None of the slopes were significant and the wide error bars on the plot demonstrate that there was large interannual variation in the numbers of fish caught each year.

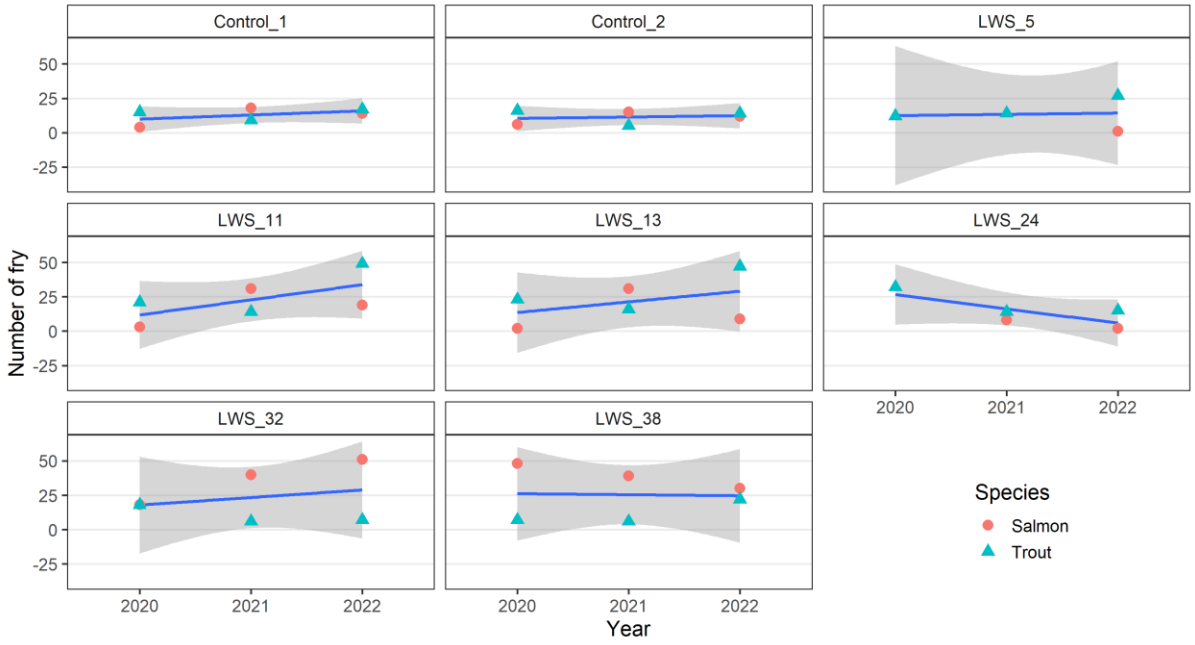

Figure 5: Number of fry caught at each site, trendline is for salmon and trout numbers combined. The contribution of each species is indicated by the different colour and shape of points. Blue line shows a linear trend line, the grey area represents the 95% confidence interval. Treatment sites are arranged upstream to downstream.

The change in total fry numbers cannot be attributed to an increase in just one species and each site shows a different pattern in numbers most likely related to habitat type. At LWS_5, the most upstream location, almost all fish captured were trout and the number of trout fry have increased each year. At LWS_32, salmon fry numbers increased yearly while trout numbers remain low. Similarly, despite the low numbers of parr, there is an upstream-downstream pattern in parr numbers with trout parr more frequently caught in the upstream sites and increasing numbers of salmon parr caught in the downstream sections (**Figure 6**).

There was no observable impact of LWS on the length or weight of either species at either life stage. Based on scale sampling, both salmon and trout remained as fry up to 70mm in length and the parr were generally 1 or 2 years in the river suggesting that Muick fish will smolt after 3 years in the river.

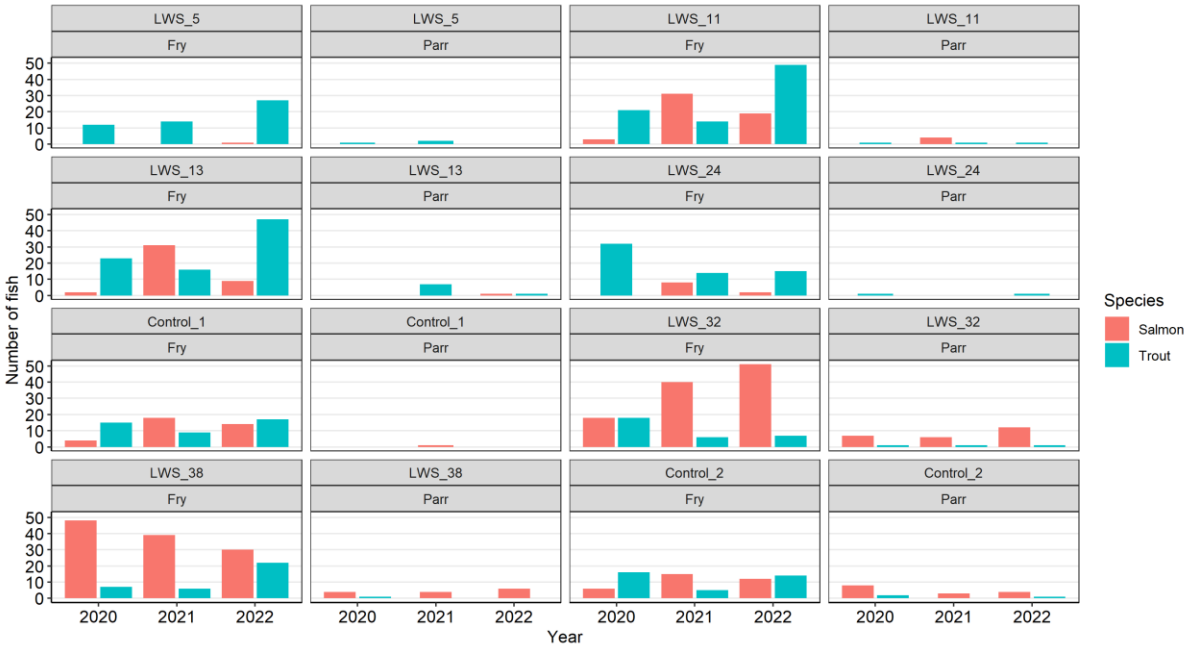

Figure 6: Total number of salmon (red) and trout (blue) fry and parr caught by electrofishing at each 200m2 site. 2020 is before addition of LWS.

Habitat characteristics

At each site, 3-4 fixed transects crossing the river and encompassing the 200m^2 survey area have been identified. At each 1m interval along each transect, a measurement of depth, flow, and substrate type is recorded. The impact of the LWS is hypothesised to increase habitat complexity leading to a greater variety of depth, flow, and habitat type within the sampling area. The Coefficient of Variation (CV) is a measure of how variable the observed data is around the overall mean. A low CV indicates that the data distribution is closer to the mean, while a high CV indicates that the distribution has more variability. In this study, a high CV indicates a more complex and diverse (variable) site indicating the impact of the LWS.

LWS will influence the hydrology of the river over multiple years and so it is unclear over what timescale the true impact of the structures will be observable. In the two years since the structures were added there are some indications that they are changing the conditions within the site (**Figure 7)**. The CV calculated for each transect in the control sites - the sites with no LWS addition - should show a similar pattern in relation to each other across years reflecting the lack of anthropogenic impact on the site, although similarly affected by the environmental conditions (for example increased water will cause an increase in depth across all transects). For the other sites, 2020 represents pre LWS addition with the impact (in combination with the environmental conditions) being discernible in the diverging and separating transects in 2021 and 2022.

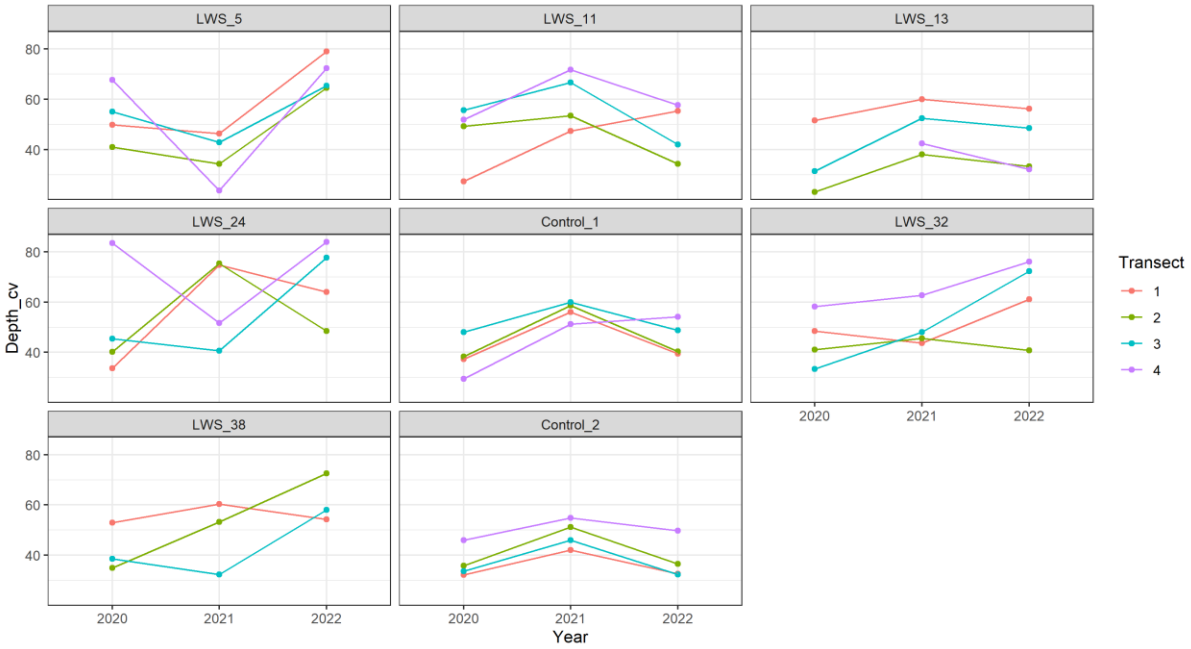

Figure 7: Coefficient of Variation for depth for each transect at each site. Higher CV indicates more variability, transect lines crossing and/or separating each other indicate greater changes over time. Control sites did not receive any LWS addition and show consistency in CV over year although there is an annual effect linked to the climate conditions (i.e. rainfall) prior to sampling.

Discussion

These results indicate an increase in the total number of fish captured by electrofishing at the sites of Large Woody Structures although many more years of monitoring is required to separate the effects of the LWS addition from natural environmental variation.

There are several caveats to consider before firm conclusions can be drawn, however. 2020 saw the installation of a new fish ladder at the falls of Muick and consequently the number of fish that ascended the falls to spawn increased significantly (**Table 3**). It is therefore likely that the increased number of spawners has resulted in more fry being present in the system. Similarly, due to the close association of LWS with redds, combined with the structural habitat provided by the structures, LWS are likely to act as fish aggregation devices and have higher fish numbers than in other, habitat-poor areas.

Table 3: Number of salmon and sea trout recorded ascending the Falls of Muick fish ladder. nb storms in 2021 caused power outages leading to fish not counted passing through the fish counter.

	2018	2019	2020	2021	2022
Salmon	4	6	44	24	45
Sea trout	14	58	66	69	37
Total	18	64	110	93	82

Parr numbers were low across all sites and salmon parr are almost non-existent in the upper section of the river. This is primarily due to a lack of suitable parr habitat but is compounded by the difficulty in electrofishing for parr around the deeper, more structurally diverse, root wads of the LWS. As the number of fry increase within the river it will be informative to see if parr numbers increase over time with the LWS sites contributing the, currently lacking, parr habitat.

The transect data and photography of the site highlight some of the hydro-morphological changes caused by the LWS (see **Appendix**). Prior to their addition the Muick had limited structural habitat within the river or at the bank edge due to a lack of bankside vegetation. The addition of LWS leads to suitable redd habitat being formed just downstream of the structure and most redds recorded in the Muick have been associated with LWS. Equally, the root wads and boulders that help to fix the LWS in place lead to deep scours appearing which provide refuge for fish from predators.

While the largest increase of fish numbers in the upper Muick is likely due to the fish ladder, the LWS should have the effect of providing shelter and refuge for juvenile salmonids which will, ultimately lead to increased survival and emigration of smolts.

Despite the increase in fish numbers, the number of salmon present in the system is still well below what Marine Scotland Science estimates the average expected density for each site should be. As we continue to undertake restoration activities and monitor their effects the density of salmon should ideally approach and then exceed the expected density. An increase in juvenile survival and consequently smolt emigration, leading to an increase in the number of spawning adults entering the upper Muick will be fundamental to increasing the number of salmon within the system.

In 2023 we intend to use a rotary screw trap to count the number of emigrating smolts from the Muick above the falls which will provide a baseline of fish production and an understanding of what age smolts emigrate. Smolt trapping can then be repeated in future years to better understand the impact of the restoration work taking place in the upper river. Monitoring of the LWS will continue annually for a few more years before following a multi-year approach.

Appendix

Appendix 1: Fixed Point Photography of LWS_13, a midstream structure. Photos from 2020 and 2022

Appendix 2: Aerial photography of LWS_13 taken in 2020 and 2022.