Loch Kemp Storage Scheme

River Moriston Special Area of Conservation: Habitats Regulations Appraisal Addendum

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ash design + assessment
Suite 2/3, Queens House
19 St Vincent Place
Glasgow G1 2DT
Tel: 0141 227 3388
Fax: 0141 227 3399

Email: info@ashglasgow.com

Web: www.ashdesignassessment.com

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List of Abbreviations

1SW - One-sea-winter (salmon, also known as grilse).

AA – Appropriate Assessment

AI – Additional Information

AOD - Above Ordnance Datum

Bl s^{-1} – Body lengths per second

CAR – Controlled Activities Regulations

CEMP - Construction Environmental Management Plan

ECU – Energy Consents Unit

FCS – Favourable Conservation Status

HRA – Habitats Regulations Appraisal

m/s – Meters per second

ms^{-1} – Meters per second

m – Meters

mAOD – Meters above ordnance datum

MCIEEM - Full Member of the Chartered Institute of Ecology and Environmental Management.

MIFM - Member of the Institute of Fisheries Management

mm – Millimetres

MSW - Multi-sea-winter (salmon)

NDSFB - Ness District Salmon Fishery Board

PPP - Pollution Prevention Plan

PSH – Pumped Storage Hydro / Pumped Storage Hydroscheme

SAC – Special Area of Conservation

sHRA – Shadow Habitats Regulations Appraisal

SIAA – Statement to Inform an Appropriate assessment

SSE – Scottish and Southern Energy

1. Introduction

1.1 Introduction

1.1.1 Gavia Environmental Ltd were commissioned by ASH Design + Assessment Ltd, on behalf of Loch Kemp Storage Ltd (the Applicant), to prepare an addendum to the 'Habitats Regulations Appraisal Report (Stage 1 & 2)'[1] (hereafter referred to as the shadow Habitats Regulations Appraisal (sHRA)) submitted as part of the application for consent to Scottish Ministers under Section 36 (S.36) of the Electricity Act 1989 for the Loch Kemp Storage Scheme (the Proposed Development) in November 2023 (ECU00003398 / 23/06025/S36).

1.1.2 This addendum has been prepared following NatureScot's consultation response (see **Appendix A**) dated 15th January 2025 (ref: CDM177258), in relation to the River Moriston Special Area of Conservation (SAC). In its consultation response, NatureScot conclude that the Applicant '*has not yet demonstrated'* that the following two impact pathways will not undermine Conservation Objective 2a.(ii) Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site:

- Intake flow attracting downstream migrating Atlantic salmon smolts; and
- A reduction in water levels in Loch Ness impeding salmon migration (upstream and downstream and all life stages).

1.2 Summary of Shadow HRA (November 2023) for the River Moriston SAC

1.2.1 This section provides a brief overview of the shadow HRA (Stage 1 and 2) undertaken for the River Moriston SAC1. Information on relevant legislation and policy, HRA methodology and a detailed project description is provided in the original sHRA1 (see Sections 2-4) and is not repeated here. This addendum does not provide any further consideration to any of the other designated sites that were included in the original sHRA[1], such as the Ness Woods SAC[2].

Stage 1: Screening

1.2.2 Stage 1: Screening (Step 3) of the original sHRA[1] identified the River Moriston SAC as a designated site which may be affected by the project. Freshwater pearl mussel (*Margaritiera margritifera*) is the primary qualifying feature of the River Moriston SAC. However, Atlantic salmon is also a qualifying feature of the River Moriston SAC due to the dependencies of freshwater pearl mussel on Atlantic salmon as a host species.

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[1]SLR (2023) Loch Kemp Storage Habitats Regulations Appraisal Report (Stage 1 & 2) Document Reference: 428.V04707.00036 lochkempstorage.co.uk/assets/documents/shadow-hra/loch-kemp-storage---shadow-habitats-regulations-appraisal-report.pdf [last accessed 21/03/2025]

[2] Except Section 2 highlights that potential impacts of the proposed barrier net on otter (*Lutra lutra*), a qualifying feature of the Ness Woods SAC, were considered in 'AI Appendix 10.1: Updates to Terrestrial Ecology Assessment in the Loch Kemp Storage EIA', which was submitted as part of the Additional Information (AI) for the Proposed Development in the September 2024.

1.2.3 Stage 1: Screening (Step 4) of the original sHRA[1] concludes that Stage 2: Appropriate Assessment of the HRA process is required for the River Moriston SAC, due to the identification of Likely Significant Effects (LSEs) on the qualifying interests of the SAC through the following potential pathways:

- Increase in frequency of Loch Ness water level fluctuations;
- Disturbance of salmon from normal migration pathways at multiple life stages during operation periods resulting in a decreased capacity as a host species for mussels; and
- Rapidly changing temperature regimes in the immediate vicinity of the water outlet.

1.2.4 The full Stage 1: Screening assessment for the River Moriston SAC is provided in Section 5.4.4 of the sHRA[1]. In combination effects are also assessed for all of the potential pathways listed above.

Stage 2: Statement to Inform Appropriate Assessment

1.2.5 The majority of impact pathways on features of the River Moriston SAC were screened in for Stage 2 of the sHRA[1]. In the absence of mitigation measures a LSE was predicted undermining Conservation Objectives for both freshwater pearl mussel (2d. (i) Restore the distribution and viability of freshwater pearl mussel host species and their supporting habitats) and salmon (2a. (ii) Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site).

1.2.6 Mitigation measures are proposed for the potential impact pathways undermining Conservation Objectives, including the installation of an appropriately designed fish deterrent system at the intakes of the Proposed Development. The purpose of a deterrent system would be to deter fish from the draw of water from the intakes during abstraction cycles, prevent entrainment / impingement at the intake screens and reduce predation impacts.

1.2.7 Stage 2 of the sHRA[1] concludes that with the adoption of mitigation measures, no Conservation Objectives would be undermined for freshwater pearl mussel. It also concludes that the Conservation Objectives pertaining to the population of Atlantic salmon will not be compromised following adoption and strict enforcement of mitigation measures presented, as well as the enforcement of a Construction Environmental Management Plan (CEMP).

1.2.8 The full Stage 2: Statement to Inform Appropriate Assessment for the River Moriston SAC, including the full list of mitigation measures proposed, is provided in Section 6.2.2 of the sHRA[1].

1.3 Purpose and Scope of Addendum

1.3.1 This addendum to the sHRA[1] has been prepared following NatureScot's consultation response dated 15th January 2025 (see **Appendix A**) in relation to the River Moriston SAC, which concludes the Applicant has not yet provided evidence that the following two impact pathways will not undermine the SAC's conservation objective to restore the Atlantic salmon population as a viable component of the site:

- Intake flow attracting downstream migrating Atlantic salmon smolts; and
- A reduction in water levels in Loch Ness impeding salmon migration (upstream and downstream, all life stages).

1.3.2 The addendum provides further information to inform the 'Statement to Inform Appropriate Assessment (SIAA)' for the River Moriston SAC, as set out in Section 6.2.2 of the sHRA1 for the two impact pathways listed above. For consistency, Section 3 of this addendum follows the same layout as 'Section 6: Stage Two: Statement to Inform Appropriate Assessment' of the original sHRA1.

1.4 Evidence of Technical Competence and Experience

1.4.1 This addendum has been produced by Donald Morrison of Gavia Environmental Ltd. Donald is a Principal Consultant at Gavia Environmental with over 9 years' experience in fisheries and ecology, is trained in Habitats Regulations Appraisal (HRA) of Plans and Projects (Scotland) via Chartered Institute of Ecology and Environmental Management (CIEEM) and a full member of the Institute of Fisheries Management (MIFM).

1.4.2 This report has been technically reviewed by Christopher Baker of Gavia Environmental Ltd. Christopher is a Director at Gavia Environmental with over 20 years' experience in Environmental Impact Assessment, fisheries, ecology and hydrology. Chris is a Chartered Environmentalist (CEnv) and Full Member of the Chartered Institute of Ecology and Environmental Management (MCIEEM).

1.4.3 Commentary has also been provided by Dr. Nick Beevers. Dr Beevers is a Principal Consultant at APEM Ltd. (based in Scotland) with over 18 years' experience in freshwater and marine fisheries science and aquatic environmental management, gained from academia, consultancy and rivers and fisheries Trusts. Nick's expertise centres on ecology and biology of exploited aquatic organisms, particularly salmonid fish and invertebrates.

1.4.4 Commentary has also been provided by Dr Martin O'Farrell from Aztec Management Consultants (Aztec). Dr O'Farrell commenced his fisheries consultancy business in 1985 and during the past four decades has been involved in the assessment of fisheries management issues on industrial rivers fuelling hydroelectric generating stations and supplying cooling water for thermal electricity generating stations in Ireland, UK, mainland Europe, Russia and the USA. These issues have included assessment of turbine passage survival, assessment of fish species life stage migration patterns through the deployment of fish census technology, mitigation measures involving selected generating protocols and hatchery operations and the design and installation of fish deterrent technologies to improve upstream and downstream passage of migratory fish species life stages through and around obstacles in the path of their migrations.

2. NatureScot Consultation Summary

2.1.1 This section summarises the consultation that has been undertaken with NatureScot in relation to the River Moriston SAC since the submission of a S.36 application for consent under the Electricity Act 1989 for the Proposed Development in November 2023. As the statutory body responsible for the protection of internationally designated sites in Scotland, NatureScot provide advice to the competent authority (i.e. the Scottish Government) undertaking the HRA for the River Moriston SAC. The sHRA[1] (including this addendum) provided by the Applicant will serve as the basis of the Stage 2: Appropriate Assessment of the HRA. To date, NatureScot has concluded that the Applicant has not yet provided evidence that the project will not undermine the SAC's conservation objective to restore the Atlantic salmon population as a viable component of the site.

Fish Deterrent System

2.1.2 Following the submission of the original sHRA[1] in November 2023, the Applicant appointed Aztec Management Consultants (Aztec) to provide advice on a suitable fish deterrent system. The Applicant issued a letter (via email) on 15th April 2024 (ref: 120019-M-M1-1.0.0-NS Response – Fish), to inform NatureScot that based on expert advice from Aztec, a barrier net around the inlet structures in Loch Ness was considered the most effective method to prevent Atlantic salmon smolts being attracted to the inlet structures during pumping cycles. This letter also provided a rebuttal to concerns raised by NatureScot about smolts exiting the River Moriston SAC and being attracted to the inlet structures, based on the findings of a smolt tracking study conducted in Loch Lomond in 2020 (Lilly *et al*, 2021)[3]. This study concludes that, although smolt migration routes appear to be indirect, once successful smolts are within ~2 km of the loch outlet at the River Leven, directional cues become apparent.

2.1.3 The Applicant did not receive a formal response to this letter from NatureScot.

Section 36 Consultation Response

2.1.4 On the 6th August 2024, NatureScot provided a response (ref: CDM173569) to the S.36 application for consent for the Proposed Development to the Scottish Government's Energy Consents Unit (ECU). In the response, NatureScot state that the information submitted in the application does not demonstrate that the Proposed Development can operate without undermining the River Moriston SAC's conservation objective to restore the Atlantic salmon population as a viable component of the site. On this basis, NatureScot object to the Proposed Development until further information is provided to enable it to carry out an appraisal of effects.

2.1.5 A list of further information required for NatureScot to complete the appraisal is provided in the response to the S.36 application, relating to two potential impact pathways (the intake flow attracting downstream migrating Atlantic salmon smolts and a reduction in water levels in Loch Ness impeding salmon migration). NatureScot also highlight that, even with this additional information, it may not be

[3] Lilly, J., Honkanen, H. M., McCallum, J. M, Newton, M., Bailey., D. M. & Adams, C. E (2021), Combining acoustic telemetry with a mechanistic model to investigate characteristics unique to successful Atlantic salmon smolt migrants through a standing body of water. Environmental Biology of Fishes (Volume 105 (12), pp 2045-2063). Available at: https://doi.org/10.1007/s10641-021-01172-x.

possible to demonstrate beyond reasonable scientific doubt that the Proposed Development will not undermine this conservation objective.

2.1.6 In the response dated 6th August 2024 (ref: CDM173569), NatureScot also recommend that the option of an acoustic fish deterrent at the inlet structures as a mitigation measure proposed is removed from consideration as it could create a potential barrier to salmon migration in Loch Ness. NatureScot advise that a Pollution Prevention Plan (PPP) and CEMP, containing adequate measures to minimise the risks of toxic and nontoxic pollution entering Loch Ness, must be produced and agreed with the consenting authority (in consultation with NatureScot), as well as an assessment of the noise impact during construction.

2.1.7 On 24th September 2024, the Applicant responded to the NatureScot S.36 consultation response with a Memo (ref: 120019-L-PA1-1.0.0 - Response to NS – Detailed Response), which provides a response to each of NatureScot's requests for further information. In this Memo, the Applicant also confirmed that an acoustic fish deterrent would not be used for mitigation, in line with NatureScot's advice.

Additional Information

2.1.8 On the 17th September 2024, the Applicant submitted Additional Information (AI), to support the application for consent under S.36 of the Electricity Act 1989 for the Proposed Development. The AI includes the following documents relating to Atlantic salmon and the River Moriston SAC:

    - A description of the barrier net proposed as the preferred fish deterrent system for downstream migrating Atlantic salmon smolts at the inlet structures in Loch Ness;
    - Intake flow determination calculations;
    - Memo on Swimming Depth of Atlantic Salmon Smolts[4];

- AI Appendix 13.2: Response to Norwegian Institute of Nature Research (NINA) Report (Simmonds *et al*, 2023), commissioned by Ness District Salmon Fisheries Board; and
- AI Appendix 13.3: Dochfour Weir and Issues Relating to the Upstream Passage of Adult Atlantic Salmon and the Downstream Passage of Atlantic Salmon Smolt.

2.1.9 Furthermore, an assessment of the proposed barrier net on otter (*Lutra lutra*), a qualifying feature of the adjacent Ness Woods SAC, is provided in Section 1.3 of 'AI Appendix 10.1: Updates to Terrestrial Ecology Assessment in the Loch Kemp Storage EIA'. This assessment concludes that no significant effect is predicted upon otter as a result of the proposed barrier net, therefore the conclusions relating to otter as a qualifying feature of the Ness Woods SAC within the sHRA[1] remain unchanged.

Further Consultation

On the 18th December 2024, NatureScot provided a consultation letter in relation to the Ness Woods SAC (ref: CDM177258) in response to the AI. In this letter, NatureScot confirm that it agrees with the Applicant's conclusion in 'AI Appendix 10.1: Updates to Terrestrial Ecology Assessment in the Loch Kemp Storage EIA', that the proposed barrier net will not adversely affect otter. NatureScot advise that the barrier net design could be improved to further minimise the risk of accidental death of individual otter

[4] Also included as Appendix C of this Addendum.

by replacing the top metre of the net with a flexible smooth plastic sheet topped with a floating “cap structure” to provide a good grip for otter to get over.

2.1.10 On the 15th January 2025, NatureScot provided a consultation letter in relation to the River Moriston SAC (ref: CDM177258) in response to the AI and the Memo submitted by the Applicant on 24th September 2024 (see **Appendix A**). In this letter, NatureScot conclude that the Applicant has not yet provided evidence that the following two impact pathways will not undermine the SAC’s conservation objective to restore the Atlantic salmon population as a viable component of the site:

- Intake flow attracting downstream migrating Atlantic salmon smolts; and
- A reduction in water levels in Loch Ness impeding salmon migration (upstream and downstream, all life stages).

2.1.11 NatureScot provide a summary of further information that is still required to complete the appraisal for the River Moriston SAC. Rationale for the information requirements is also provided.

2.1.12 A meeting between the Applicant and NatureScot took place (via MS Teams) on 23rd January 2025 to discuss the further information requested by NatureScot to complete the appraisal for the River Moriston SAC. The Applicant also briefed NatureScot on the modelling work that was being undertaken to inform NatureScot’s request for further information.

2.1.13 Since this meeting, the Applicant has issued a formal response to the NatureScot consultation letter on 3rd April 2025 (Ref: 120019-L-1.0.0- Loch Kemp Storage – River Moriston SAC NS Response Letter). This addendum to the sHRA[1] has also been prepared to provide further information to inform the ‘Statement to Inform Appropriate Assessment (SIAA)’ for the River Moriston SAC for the two impact pathways listed above.

3. Further Information to Inform 'Stage Two: Statement to Inform Appropriate Assessment'

3.1 Step One: Information on the Project and European Sites Concerned

3.1.1 The project is described in detail in Section 4.0 of the original sHRA[1] for the Proposed Development. Information on the European Sites is provided in Table 5-1 in Section 5.3 of the original sHRA[1].

3.2 Steps Two to Four

Step Two, Part One: Identifying Conservation Objectives

3.2.1 River Moriston SAC conservation objectives are provided in Table 5-1 in Section 5.3 of the original sHRA[1]. This addendum to the sHRA[1] only considers the following Conservation Objective:

- **2a. (ii) Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site.**

Step Two, Part Two: Effects of the Project on Conservation Objectives

<u>Atlantic Salmon</u>

3.2.2 Refer to Section 6.2.2 (Step Two, Part Two: Effects of the Project on Conservation Objectives) of the original sHRA[1]. This addendum to the sHRA[1] only considers the following Conservation Objective:

2a. (ii) Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site.

3.2.3 In relation to Conservation Objective 2a. (ii), this part of the addendum provides further information on the following two impact pathways for the project in isolation:

1. Intake flow attracting downstream migrating Atlantic salmon smolts; and
2. A reduction in water levels in Loch Ness impeding salmon migration (upstream and downstream, all life stages).

1. Intake flow attracting downstream migrating Atlantic salmon smolts

3.2.4 Migration routes of salmon from the River Moriston SAC are currently unknown within Loch Ness. Salmon telemetry studies in similar Scottish lochs have shown a wide variation of potential migration pathways, consequently knowledge from existing literature cannot be applied to predict potential migratory pathways. Resultingly, application of the precautionary principle dictates that a proportion of the salmon smolts on migration will be present within the vicinity of the intake screens during periods of abstraction[5].

3.2.5 Smolts in the vicinity of screens during periods of abstraction will not result in mortalities due to impingement, as maximum draw velocities are limited to escapable velocities for salmon at smolt life stages at <0.3 m/s to prevent impingement on the screens. Screens will also be 12.5 mm mesh aperture to prevent entrainment of salmon smolts within the infrastructure. The sustained swimming speed of salmon with a minimum body length of 0.15 m is 0.54 m/s, which is faster than the predicted maximum velocity of the intake, consequently salmon at all life stages are predicted to overcome this[6].

3.2.6 Salmon smolts on migration to sea have the potential to be attracted to the intake flow during periods of water abstraction i.e. when the PSH is pumping water from Loch Ness to Loch Kemp. Deterrence from the migration route can lead to delays and an increased energy burden as fish cover additional distance before reaching the marine environment. Mortality may not occur immediately however post-disturbance mortality at sea due to cumulative energy burdens could in theory occur. Furthermore, the extra time spent in the loch at the intake point increases the risk of predation and mortality.

3.2.7 Considering the mortality risks to salmon smolts under the precautionary principle, the Proposed Development is concluded (without additional mitigation) as being **likely to undermine conservation objective 2a. (ii) for restoring the population of Atlantic salmon, including range of genetic types, as a viable component of the site.**

2. A reduction in water levels in Loch Ness impeding salmon migration (upstream and downstream, all life stages)

3.2.8 Due to operational limits implemented through the relevant Controlled Activities Regulations (CAR) Licences on Loch Ness, the combination of the Proposed Development and the existing Foyers PSH would not cause loch levels to reduce below the existing Foyers PSH stop pumping level (i.e. the baseline scenario), as the Proposed Development would have a higher 'stop pumping' level applied than the existing Foyers PSH scheme (15.27 m Above Ordnance Datum (AOD)) (see Volume 1, Chapter 7: Water Management of the EIA Report for further details). A higher stop pumping level than the Foyers PSH level would also be applied to any future or consented PSH on Loch Ness (see **Step Two, Part Three: In Combination Effects of the Project with Other Plans or Projects**).

3.2.9 There is no peer reviewed literature which attests to deleterious effects on Atlantic salmon population size and structure from the Foyers PSH which has been operational since 1974. Furthermore, neither Foyers nor pumped storage hydro schemes in general are listed as a key factor affecting the qualifying features of the River Moriston SAC in the Conservation Advice Package[7], despite the fact that Foyers had been operational for over 30 years when the site was designated in March 2005.

3.2.10 The main fish pass at Ness Weir (also known as Loch Dochfour) is at a level of **14.93 mAOD**, which is 0.34 mAOD below the stop pumping level of the Foyers PSH and therefore also below the stop pumping

[5] Lilly, J., Honkanen, H. M., McCallum, J. M., Newton, M., Bailey, D. M. and Adams, C. E. (2021). Combining acoustic telemetry with a mechanistic model to investigate characteristics unique to successful Atlantic salmon smolt migrants through a standing body of water. Environmental Biology of Fishes. 105. pp. 2045-2063.

[6] Tang, J. and Wardle, C. S. (1992). Power Output of Two Sizes of Atlantic Salmon (*Salmo salar*) at their Maximum Sustained Swimming Speeds. Journal of Experimental Biology 166.

[7] Available at: https://www.nature.scot/sites/default/files/special-area-conservation/8361/conservation-advice-package.pdf [Last Accessed 20/03/2025]

level that would be applied to the Proposed Development. The operation of the Proposed Development would therefore not restrict or impede the downstream passage of the main Ness Weir fish pass by downstream migrating fish compared to the existing baseline scenario. SSE Sluice gates are also opened when water levels reach below 15.7 mAOD offering downstream passage opportunities for smolts.

3.2.11 The stop pumping level of the existing Foyers PSH scheme (15.27 mAOD) is below the level smolt pass (also referred to as the 'smolt chute') located on the Waste Weir section of the Ness Weir (15.48 mAOD). The smolt pass acts as a potential bypass channel for any smolts which bypass the main fish pass outlet at Ness Weir and enter the entrance to the canal. This highlights a potential existing problem for smolt passage in this area, however there is also a second smolt pass in the form of a sluice gate which Scottish Canals operate at Dochgarroch Lock. This smolt sluice is opened during the smolt run to provide a secondary outlet back to the River Ness for smolts which have bypassed the fish pass and smolt chute.

3.2.12 Although the stop pumping level agreed for the Proposed Development (via a CAR Licence) would be above that of the existing Foyers PSH, it is anticipated that the Proposed Development would also have a 'stop pumping' level below the level of the smolt pass at Ness Weir i.e. below 15.48 mAOD. Short durations where water levels may drop below the smolt chute level at Ness Weir are predicted to occur more frequently compared to the existing scenario where Foyers PSH would operate in isolation. However, modelling dictates that water levels would also increase above the smolt chute level more frequently and more rapidly, due to the pattern of fluctuation arising from generation phases. During periods of higher water levels associated with generation phases, there would also be a greater attraction for smolts to descend the main fish pass, increasing smolt escapement from the loch. This could have a beneficial impact on smolts, by reducing delays on migration compared to the existing situation where only Foyers PSH would be pumping water back into Loch Ness at any given time and would help to counteract the effect of more frequent lower loch levels due to fluctuation.

3.2.13 There is uncertainty about the effectiveness of the smolt chute within the canal in its current state, especially at lower water levels where there is less attraction towards its inlet or when loch levels fall below its level **(Plate 1)**. The Ness District Salmon Fisheries Board consider it to be 'an ineffective design'[8]. It is likely that the existing smolt chute only offers adequate mitigation for smolts at higher loch levels where there is a greater attractive flow at the entrance to the chute. This may be aided by instances of higher peak loch levels during April and May as a result of greater pump storage generation (see **Plates 3 & 4** below).

Plate 1: Smolt Pass (chute) entrance from the Caledonian Canal Loch at 15.42 mAOD.

[8] Ness District Salmon Fisheries Board (2023) Pers Comm Brian Shaw 12th October 2023.

3.2.14 The potential effects on downstream migrating salmon smolts and kelts in relation to predicted modelling of Loch Ness water levels are discussed in more detail separately below.

Smolts

3.2.15 When smolts are physiologically prepared, an environmental trigger is typically needed to initiate downstream migration. The main environmental cues that trigger this migration are water temperature and water discharge. In certain rivers, migration may begin solely due to changes in water temperature, while in others, the increased water discharge during spring spates may play a more significant role[9]. On river catchments affected by hydro-scheme infrastructure, 'freshets' can be used to help mitigate the impact of flow regulation in and facilitate smolt migration. Freshets are regulated artificial spates caused by the release of water from hydro schemes. Results from smolt trapping surveys on the River Moriston in 2023 (see **Plate 2**) indicated that freshets and higher summer compensation flows in April and May respectively were important for initiating downstream migration, with higher smolt captures relating to these peaks in river level[10].

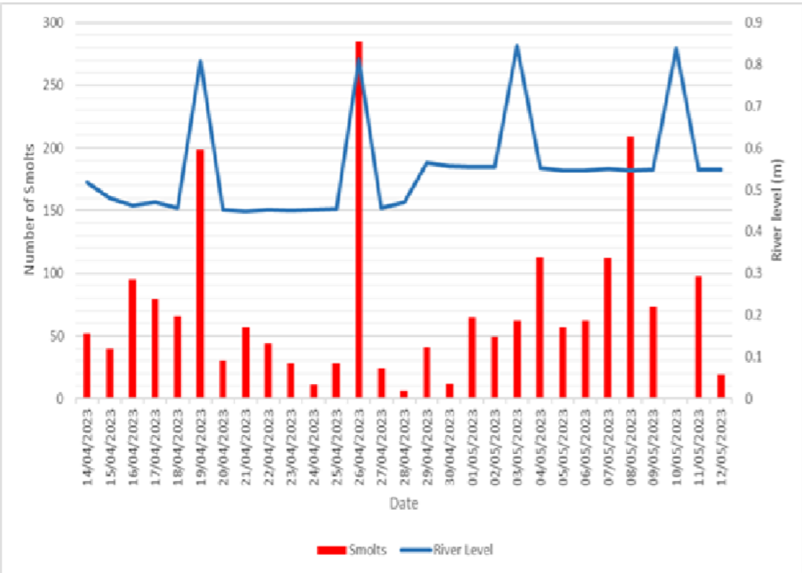

Plate 2: River Moriston 2023 Smolt Captures vs River Level (NDSFB, 2023)

3.2.16 During the months of April and May, when the peak smolt migration in the River Moriston takes place, modelling (see **Appendix B**) indicates regular fluctuation of the loch level above baseline levels at Ness Weir with Kemp PSH in operation, simulating freshet events (see **Plates 3 & 4**). Although there are some short durations when the loch level will be lower than the baseline scenario, the peaks in water level above the baseline scenario are likely to improve the attraction for downstream migrating smolts across Ness Weir, as well as the smolt chute and smolt sluice (mitigation for any smolts which bypass Ness Weir

[9] Barry. J., Whelan. K., Llewelyn. I. & Campbell. R. (2017) Migration timing and behaviour *in:* From Headwater to Headland: Improving smolt survival in rivers and estuaries pp. 6 [Online] Available: atlanticsalmontrust.org/wp-content/uploads/2017/12/TAST-Blue-Fisheries-Book.pdf [Last Accessed 13/03/2025]

[10] Ness District Salmon Fishery Board (2023) River Moriston Smolt Trap *in* 2023 Annual Report pp. 23-24 [Online] Available: ndsfb.org/wp-content/uploads/filr/5128/NDSFB Annual report 2023 Final.pdf#page=2.08 [Last Accessed 13/03/2025]

and enter the entrance to the Caledonian canal) minimising delays to migration. These delays likely occur more often under the current baseline scenario, i.e. less frequent and acute loch level fluctuations.

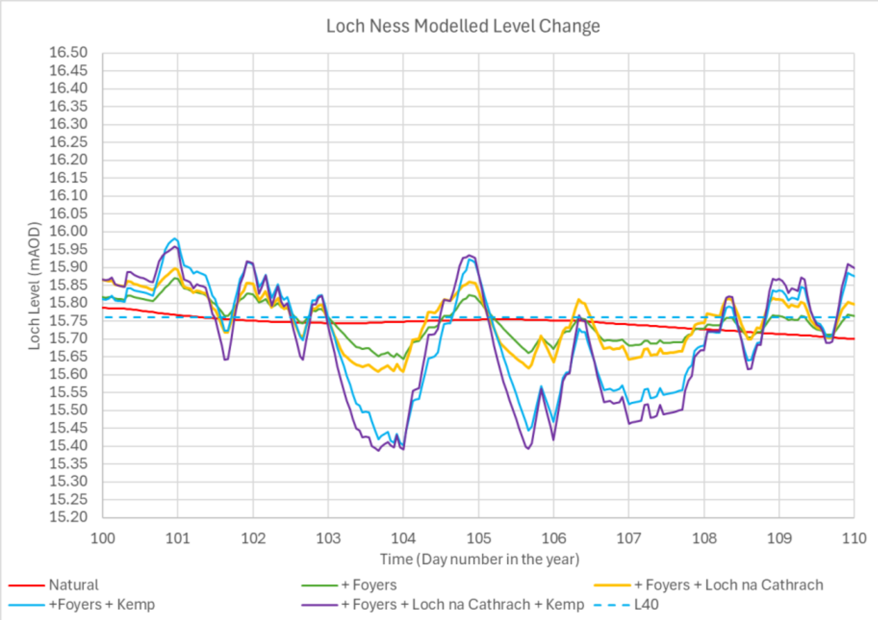

Plate 3: Modelled Level Change in Loch Ness – 10-day period April (Taken from Appendix B)

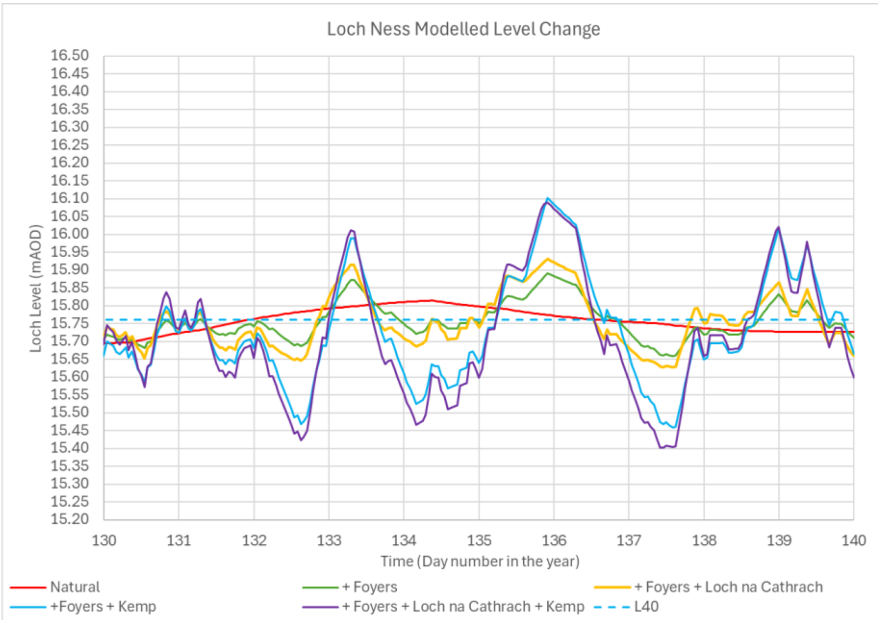

Plate 4: Modelled Level Change in Loch Ness – 10-day period May (Taken from Appendix B)

3.2.17 The Applicant has carried out analysis on the risk of smolts being affected by step flow changes as canal gates open and close during lower loch levels.

3.2.18 Currently, Scottish Canals must fully operate (open) the smolt sluice at Dochgarroch Lock gates during the smolt run to allow smolts which have travelled to the lock gates to egress to the River Ness. It is understood that this sluice is located immediately upstream of the top lock gate, meaning when the lock gates are closed, which they are the majority of the time, especially during the night, there is a constant flow through the smolt sluice, which would provide a signal and passage for smolts that are located within the system upstream of Dochgarroch Lock.

3.2.19 Regarding short-term flows, during lockage, the sluice gates on the upstream lock gates open, resulting in an instantaneous flow into Dochgarroch Lock. The duration of this additional attraction flow is subject to the speed at which the sluices are opened. The speed of filling the lock is a function of the level difference between the up and downstream canal levels at Dochgarroch. When low water levels are experienced in Loch Ness (Loch Dochfour) the anticipated head (level difference) between either side of the lock is deemed to be limited at around 0.5 m. A fill time of around 2 minutes from when the lock gate sluices are opened to when the lock gates open would seem reasonable. It is also worth noting that at 15.27 mAOD (the Foyers PSH stop pumping level) the level difference at Dochgarroch could be even less, and in turn, the volume and flow rate would be less.

3.2.20 Based on the volume of water required to be released from Loch Ness (Loch Dochfour) into the Dochgarroch lock, the average flow is calculated to be around 2.55 m^3/s and lasting for approximately 2 minutes. This is a fraction of the minimum flow of 28.3 m^3/s that is understood to be passed over Ness Weir. It is noted that this assumed no vessels using the canal and, in turn, no account for the displacement caused by the vessel.

3.2.21 So, the additional directional flow subjected to smolts from lockage operations would be <10% of the minimum flow. Given this, the Applicant would not deem this to be a significant proportion of the water flowing over the weir and, as such, would not deem that flow induced by canal operations results in a material distraction away from the dominant flow that is at the fish pass at Ness Weir.

3.2.22 In addition to the above the following is worth noting:

- The results of analysis show that for L90, and L99 on the level duration curve, the inclusion of the Proposed Development's operation actually increases the water level compared to the baseline operation of Foyers. This means that the operation of the Proposed Development would result in an increased flow rate over the weir and fish pass. Thus, resulting in an increased attraction flow for smolts compared to the baseline conditions; and

- The maximum lockage operations stipulated in the Caledonian Canal CAR Licence CAR/L/1010718 is 37 per day, and the average daily locking during peak season, towards the end of the smolt run, is around 15. Using 37 operations per day is therefore deemed a very conservative figure. Based on the worst-case scenario, of maximum lockage operations of 37 per day, the estimated cumulative time during which the additional attraction flow from canal lockage is present is around 74 minutes or approximately 5% of the time during the day. The remaining 95% of the time during the day, the attraction flow from the smolt sluice and main fish pass will be present. This also assumes a worst-case scenario that smolts are on migration during the day when in reality peak smolt migration occurs nocturnally.[11] [12]

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[11] Roberts, L.J., Taylor, J., Gough, P.J., Forman, D.W. & Garcia de Leaniz, C., 2012. Abstract *in:* Night stocking facilitates nocturnal migration of hatchery-reared Atlantic salmon, *Salmo salar*, smolts. *Journal of Fish Biology*, 80(7), pp.2151–2160.

[12] Thorstad, E.B., Whoriskey, F., Uglem, I., Moore, A., Rikardsen, A.H. & Finstad, B., 2011. Diurnal migration pattern within rivers *in:* A critical life stage of the Atlantic salmon *Salmo salar*: behaviour and survival during the smolt and initial post-smolt migration. *Journal of Fish Biology*, 78(6), pp.1632–1651.

3.2.23 Based on the above, for smolts to enter the lower canal system, there is a limited amount of time during the day when the additional attraction flow is present, and the canal lock gates are open for smolt to enter the Dochgarroch Lock (canal). For a smolt to get into this position, they would have had to swim past and ignore the much larger dominant flow (minimum 28.3 m^3/s) from the main fish pass on Ness Weir (Dochfour Weir). Having passed this dominant flow, they would have had to travel towards the canal with the only additional attraction flow being the much smaller flow from the smolt sluice over 1 km away.

3.2.24 During the time the distraction flow from canal lock operations is present, only smolts within a certain distance would be able to enter the lock as their swimming speed is limited. Based on a large smolt length of 15 cm and a maximum swim speed of 10 bl/s (body lengths per second) at 17°C[13], a smolt would need to swim constantly for 2 minutes at its maximum speed in the direction of the canal. This results in the maximum potential zone of influence being around 180 m from the upstream lock gate. A more realistic sustained cruising speed would be 2-3 bl/s, as smolts cannot burst for long durations, which would equate to a realistic zone of influence of around 50 m. Note the distance between the fish pass and lock gates is around 1,070 m so the zone of influence is <5%, for a sustained cruising speed.

3.2.25 Furthermore, once the lock is filled and the top gates are opened, the attraction flow from the lock ceases, and the dominant flow from Ness Weir will be the only downstream flow until the lock gates are closed. Once the top lock gates are closed, as it is their default position, any smolts that have been attracted towards the canal from lock operations, would either pick up the dominant flow from the fish pass at Ness Weir or they would pick up the flow from the smolt sluice at the lock gates. Given the duration of the day that the top lock gates are closed, there would be a significantly greater proportion of the day when smolts are attracted to these flows as opposed to the intermittent flows caused by the canal.

3.2.26 Given the above, the Applicant believes that the operation of Kemp will not have any material impact on increasing the chance of smolts entering the canal system during the occurrence of lower loch levels. As described above, the inclusion of Kemp's operation actually increases the spilling over the weir during certain periods of time, with higher peak flows, thus increasing the attraction flow for smolts.

3.2.27 It is important to note that regular fluctuation is predicted over a daily frequency, offering more regular opportunities for smolts leaving Loch Ness (Loch Dochfour) to be attracted to the downstream River Ness by receiving environmental cues via water discharge, as due to the volumes involved it is considered likely that there will be a greater draw of water towards Ness Weir and various fish passes.

Autumn Parr / Smolts

3.2.28 Although no scientific evidence for the Ness catchment exists, some evidence of movement of juvenile salmon parr during the autumn has been recorded in populations in both North America and Europe[14]. This phenomenon can also be described as autumn smolt migration, with peak migrations occurring in October (**Plate 5**). Similarly to April and May (see **Plates 3 & 4** above), modelling predicts that October

[13] Booth, R.K., Bombardier, E.B., McKinley, R.S., Scruton, D.A. & Goosney, R.F., 1997. Swimming performance of post-spawning adult (kelts) and juvenile (smolts) Atlantic salmon, *Salmo salar*. Canadian Manuscript Report of Fisheries and Aquatic Sciences, 2406.

[14] Thorstad, E. B., Whoriskey, F., Uglem, I., Moore, A., Rikardsen, A. H. & Finstad, B. (2012) Autumn Migration *in:* 'A critical life stage of the Atlantic salmon *Salmo salar*: behaviour and survival during the smolt and initial post-smolt migration', *Journal of Fish Biology*, 81, pp. 500-542. doi: 10.1111/j.1095-8649.2012.03370.x.

will feature several fluctuating peaks over a sample 10-day period, offering more regular opportunities for smolts leaving Loch Ness (Loch Dochfour) to be attracted to the downstream River Ness by receiving environmental cues via water discharge.

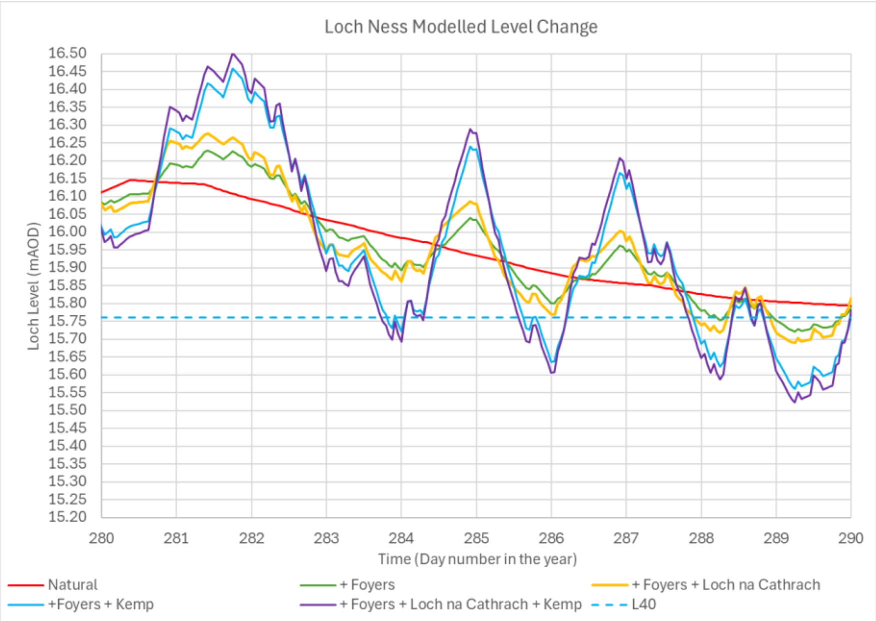


Plate 5: Modelled Level Change in Loch Ness – 10-day period October (Taken from Appendix B)

Kelts

3.2.29 Through scale reading, there is emerging evidence that repeat spawning fish may be of importance within the salmon stock component of the Ness catchment. Scale sampling has shown that some downstream migrating adult salmon (known as kelts) return to sea to regain condition post-spawning before returning back to freshwater to spawn again. The large size of the previous spawners has been noted, as will be their potential contribution to egg deposition (most, although not all previous spawners are female)[15]. This highlights the importance of the unimpeded migration of kelts back out to sea. Modelling predicts that January – May will feature several fluctuating peaks over a sample 10-day period, offering more regular opportunities for kelts leaving Loch Ness (Loch Dochfour) to be attracted to the downstream River Ness by receiving environmental cues via water discharge, with a greater draw of water across Ness Weir and the fish pass (for a full list of graphs showing modelled level changes, see **Appendix C**).

3.2.30 Consequently, in relation to downstream migration of smolts and kelts, the predicted effect of water level change in Loch Ness is **unlikely to undermine conservation objective 2a. (ii) for restoring the population of Atlantic salmon, including a range of genetic types, as a viable component of the site.**

[15] Ness District Salmon Fishery Board (2024) Scale Reading in: 2024 Annual Report pp.31 [Online] Available: ndsfb.org/wp-content/uploads/filr/5257/2024 Annual Report final.pdf#page=36.47 [Last Accessed: 13/03/2025]

Adult Salmon (upstream migrating)

3.2.31 As described above, the Proposed Development will have a stop pumping level above that of the existing Foyers PSH. The main fish pass at Ness Weir is at a level of **14.93 mAOD**, which is 0.34 mAOD below the stop pumping level of the Foyers PSH and therefore also below the stop pumping level that would be applied to the Proposed Development.

3.2.32 Modelling of water depth and velocity within the main fish pass at Ness Weir and SSE Renewables sluice gates has been carried out by hydrological engineers at Mott Macdonald Group Limited. The outputs of this modelling is presented in **Appendix B;** however, a summary is provided below, followed by analysis of the velocity requirements of multi-sea-winter (MSW) salmon and one-sea-winter (1SW), also known as grilse.

Depth

3.2.33 Between the Foyers PSH stop pumping level (15.27 mAOD) and the SSE Renewables sluice gates closing (15.70 mAOD), the upstream depth over the fish pass will always be ≥0.34 m (ranging 0.34 at 15.27 mAOD – 0.77 at 15.70 mAOD), with the critical depth across the crest always ≥ 0.25 m (ranging 0.25 at 15.27 mAOD – 0.60 at 15.70 mAOD). The depth 6.55 m downstream of the crest at the bottom of the weir face will however be shallower and range from 0.12 m at 15.27 mAOD – 0.33 m at 15.70 mAOD as a consequence of slope. When loch level reaches ≥15.33 mAOD, the depth across this section will be ≥0.15 m.

Velocity

3.2.34 Modelling indicates that with the operation of the Proposed Development, flows will follow trend of regular daily fluctuations both above and below the baseline scenario where only Foyers PSH is in operation.

3.2.35 Between the Foyers stop pumping level (15.27 mAOD) and the SSE Renewables sluice gates closing (at 15.70 mAOD), the upstream velocity over the top of the fish pass ranges from 0.93 ms^{-1} at 15.27 mAOD – 1.36 ms^{-1} at 15.70 mAOD), with the critical velocity across the crest ranging from 1.4 ms^{-1} at 15.27 mAOD – 2.0 ms^{-1} at 15.70 mAOD). The velocity 6.55 m downstream of the crest at the bottom of the weir face will however be higher and range from 3.2 ms^{-1} at 15.27 mAOD – 4.2 ms^{-1} m at 15.70 mAOD as a consequence of slope. The full list of flow and depth conditions at both the main fish pass and the SSE Renewables sluice gates is provided in **Appendix B**.

3.2.36 At Loch levels higher than 15.83 mAOD, flows discharge over the full extent of the service and waste weirs. As flows reach 16 mAOD the full extent of the weir, which has a long crest length of 500 m, is then be drowned out. As this occurs flows and velocities are evenly dissipated thus ensuring there is no rapid rise in velocity on the fish pass itself.

3.2.37 As this is occurring, the levels in the River Ness will now be higher than the bottom of the fish pass with the fish pass itself becoming increasingly inundated. In this scenario there is no drop from the fish pass to River Ness with fish passage enabled directly onto the pass itself. The flow across the weir mimics spate river flow conditions at this point making fish passage easier and more akin to natural river conditions. As levels in Loch Ness (Loch Dochfour) continue to rise to and beyond 16.7 mAOD the weir and fish pass become redundant with direct level for level connectivity occurring between Loch Ness (Loch Dochfour) and the River Ness enabling fish passage directly over the structure.

3.2.38 Temperature barriers are well documented on Scottish rivers for early running spring fish. Spring adult salmon are known to migrate through the River Ness very quickly. The Ness catchment differs to other systems in that there are no temperature barriers to impede migration as the water temperature in the River Ness is kept artificially high due to the thermal buffering effect of Loch Ness upstream[16]. Temperature monitoring carried out by the Ness District Salmon Fishery Board (NDSFB) at Dochfour, a few hundred meters downstream of Ness Weir showed a minimum winter temperature of 5.7 °C. This differs considerably from other areas of the catchment i.e. Cluanie, Upper Moriston (1.5 °C) and River Kingie (0.1 °C)[17]. Therefore, no barriers to migration associated with temperature during the coldest periods of the year are anticipated with the operation of the Proposed Development.

Velocity requirements of MSW Salmon

3.2.39 Krasura *et. al*, 2024[18] reviewed the maximum (burst) swim speeds of Atlantic salmon as 7.91 body lengths per second (bl s^{-1}). Using Ness District Salmon Fishery Board salmon 'Length/Weight Estimator' tape, MSW salmon of 8lb – 24lb would range from 0.69 m – 1 m in length. Converting body lengths per second into metres per second, for MSW salmon, this would give a range of 5.46 – 7.91 ms^{-1} maximum swimming speed. It is therefore anticipated that MSW salmon will be able to overcome the range of velocities associated with different loch levels at Ness Weir.

Velocity requirements of 1SW Salmon

3.2.40 Colavecchia *et. al* 1998[19] tested the burst swimming performance of grilse-sized Atlantic salmon on an 18 m long flume under different water velocity conditions. The study found that under the higher mean flow velocity of 2.55 ms^{-1}, the fish swimming capability dropped off after the first 10.77 m of flume, with a maximum speed of 4.06 ms^{-1} achieved. The length of the fish pass section at Ness Weir has been measured at just 6.5 m, much shorter than the 18 m flume used in the study. There is a short section at the bottom of the pass where flow velocity is higher, ranging from 3.2 – 4.2 ms^{-1} depending on the loch level, however flows over the crest section are much less (1.4 – 2.0 ms^{-1}). It is therefore anticipated that grilse would be able to overcome these velocities under most loch levels.

Depth requirements of 1SW / MSW Salmon

3.2.41 SEPA state that >15 cm depth of water is required for adult Atlantic salmon on a ramp in relation to rock-ramp fish passes with <10 metres of ramp between resting pools[20]. Ness Weir is neither a formal

[16] Ness District Salmon Fishery Board (2023) Spring Salmon *in:* Ness Fisheries Management Plan 2023 – 2028. [Online] Available: Ness Fisheries Management Plan [Last Accessed 14/03/2025]

[17] Ness District Salmon Fishery Board (2024) Temperature Loggers *in:* 2024 Annual Report. pp. 37-39. [Online] Available: ndsfb.org/wp-content/uploads/filr/5257/2024 Annual Report final.pdf [Last Accessed 14/03/2025]

[18] Kraskura, K., Patterson, D.A. and Eliason, E.J., (2024). A review of adult salmon maximum swim performance. *Canadian Journal of Fisheries and Aquatic Sciences*, [Online] Available: https://doi.org/10.1139/cjfas-2023-0246 [Last Accessed: 16/03/2025].

[19] Colavecchia, M., Katopodis, C., Goosney, R., Scruton, D.A. and McKinley, R.S., (1998). Measurement of burst swimming performance in wild Atlantic salmon (*Salmo salar* L.) using digital telemetry. *Biotelemetry Research Group, Department of Biology, University of Waterloo, Waterloo, Ontario, Canada; Fisheries and Oceans, Freshwater Institute, Winnipeg, Manitoba, Canada; Fisheries and Oceans, Science Branch, St. John's, Newfoundland, Canada*

[20] SEPA (2015) Guide Design characteristics for rock-ramp fish passes *in*: Guidance for developers of run-of-river hydropower schemes pp.26 [Online] Available: sepa.org.uk/media/383805/guidance-

fish pass solution nor a rock-ramp but the short section between the River Ness and the loch may mimic the ramp section of a rock-ramp giving a good guide as to the depth requirement for passage of adult Atlantic salmon. Although 1SW (grilse) lack the same muscle to weight ratio as MSW fish, they are more agile than larger MSW salmon and can tolerate shallower water depths during ascending obstacles than their counterparts. SEPA do not give criteria for grilse as separate to salmon but for comparison, trout which are smaller than salmon require >10 cm depth. Critical depth across the crest at Ness Weir was modelled ranging from 0.25 m – 0.60 m, well within the depth requirements of adult salmon, however at the lower part of the pass on the weir face, the depth ranges from 0.12 m to 0.34 m. At the lowermost loch levels between the Foyers PSH stop pumping level of 15.27 mAOD and 15.32 mAOD the depth here is 0.12 – 0.14 m. At loch levels of 15.33 mAOD, the depth here becomes ≥ 0.15 m. This indicates that passability of the fish pass structure for adult salmon may only be compromised at the lowermost loch levels of between 15.27 m and 15.32 mAOD and for short durations.

3.2.42 One of the primary environmental triggers for adult Atlantic salmon migration is increased flow, often associated with the rise in river water levels as a result of discharges.[21] Due to the aforementioned pattern of fluctuation arising from pumping and generation cycles, for 9 months of the year (October – June inclusive) there will be more frequent instances of upstream migration conditions for adult salmon being both more optimal and more sub-optimal. Greater instances of water level rises associated with generation cycles may offer more frequent environmental cues to trigger upstream migration of salmon from the River Ness over Ness Weir into the loch. Modelling predicts that during these 9 months, at no point will the loch level will drop below 15.33mAOD, indicating that upstream migrating fish will never be limited by lack of depth across the fish pass as corresponding depth across the face would always be >0.15 m with predominantly much higher levels than this observed during these months.

3.2.43 Due to the predicted lower water loch levels between the months of July – September, there is very little predicted added benefit for adult salmon migrating upstream during this period with the Proposed Development in operation, with fluctuating levels rarely peaking above the baseline scenario for these three months (see July example in **Plate 6**). Loch levels are predicted to fluctuate to below 15.33 mAOD which could pose short duration delays for migration, with corresponding depths on the bottom of the fish pass face of <0.15 m (0.12-0.14 m) at this loch level. Analysis has therefore been carried out below on the importance of the 1SW (grilse) and MSW stock components of the River Moriston SAC which could potentially be affected by temporary delays to migration during July – September.

_for_developers_of_run_of_river_hydropower_schemes.pdf?utm_source=chatgpt.com#page=25.08 [Last Accessed: 16/03/2025]

[21] Arevalo E, Maire A, Tétard S,Prévost E, Lange F, Marchand F, Josset Q,Drouineau H. (2021) Abstract *in*: Does global change increase the risk of maladaptation of Atlantic salmon migration through joint modifications of river temperature and discharge? Proc. R. Soc. B 288: 20211882.https://doi.org/10.1098/rspb.2021.1882

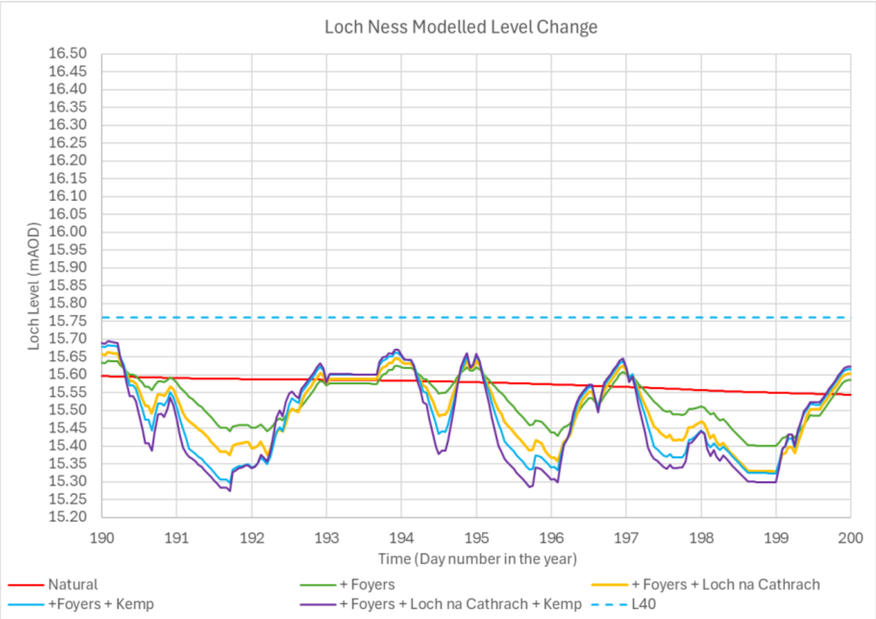


Plate 6: Modelled Level Change in Loch Ness – 10-day period July (Taken from Appendix B)

3.2.44 Monthly rod catch data (2017 – 2022)[22] obtained from Marine Scotland for the River Moriston was analysed. The data indicates that 1SW (grilse) make up an extremely small component of the River Moriston stock (see **Plate 7**). Only 1% of the River Moriston rod catch was of grilse with MSW fish making up the remaining 99%. The grilse (3 no.) were also all captured in one season, 2019.

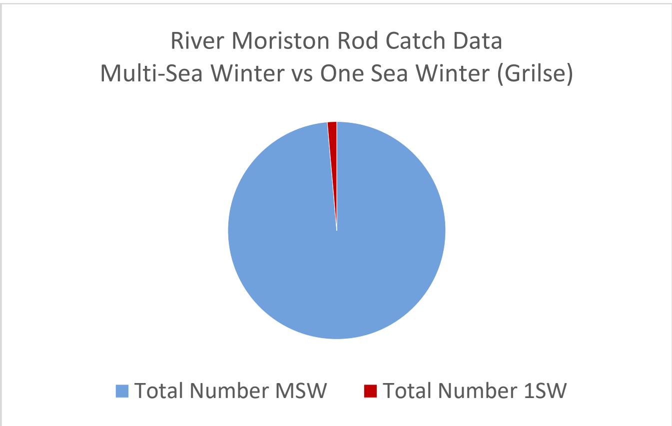


Plate 7: River Moriston Rod Catch Data (2017 – 2022) Multi-Sea Winter & Grilse Catches

3.2.45 Rod catches across the data period were predominantly of multi-sea winter salmon (99%), with MSW catches predominantly January – June (91%) (see **Plate 8**). MSW fish rod captures in July – September were also predominantly captured in 2019 (58%) indicating runs were later and this was an atypical year. There was no further data available on the condition of these fish, it is possible that these individuals

[22] Marine Scotland (2023) Salmon (2011 to 2022) and sea trout (2017-2022) fishery statistics: Rod fishery catch by Assessment Area and month. [Online] Available: Salmon (2011 to 2022) and sea trout (2017-2022) fishery statistics: Rod fishery catch by Assessment Area and month - Rod fishery statistics: salmon 2011 to 2022, sea trout 2017-2022 - reported catch by Stock Assessment Area | Marine Scotland Data Publications [Last Accessed 14/03/2025]

had run over Ness Weir into Loch Ness (Loch Dochfour) or the River Moriston earlier in the season, but were captured later in the season as 'stale' fish.

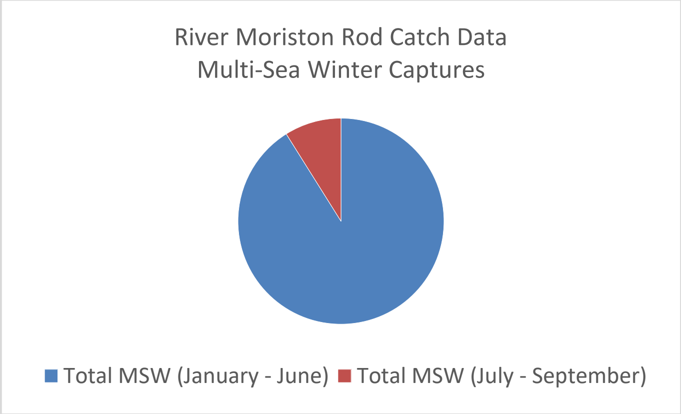


Plate 8: River Moriston Rod Catch Data (2017 – 2022) Multi-Sea Winter Captures

3.2.46 The River Moriston is known as a spring river and for featuring an important spring salmon fishery[23] [24]. The presence of the Invermoriston Falls present a significant obstacle for upstream migrating salmon. It is thought that the high proportion of MSW spring fish in the Moriston is due in large part to the presence of this waterfall in the lower reaches of the catchment, which will be impassable for later running fish, which have a lower muscle to weight ratio than spring fish[25].

3.2.47 Due to stock component of the River Moriston being principally early running (January – June) MSW salmon, identified potential effects on fish migration of lower water levels at Ness Weir during the months of July – September would have little or no bearing on the River Moriston salmon population.

3.2.48 Consequently, in relation to upstream migration of adult salmon (1SW (grilse) and MSW), the predicted effect of water level change in Loch Ness is **unlikely to undermine conservation objective 2a. (ii) for restoring the population of Atlantic salmon, including a range of genetic types, as a viable component of the site.**

[23] Ness District Salmon Fishery Board (2025) River Moriston in: Ness System. [Online] Available: The Ness System | Ness District Salmon Fishery Board [Last Accessed: 20/03/2025]

[24] Glenmoriston Estate (2025) Fishing Information [Online] Available: Fishing | Glenmoriston Estate [Last Accessed: 20/03/2025]

[25] Ness District Salmon Fishery Board (2024) Springer Gene Study in: 2024 Annual Report. pp.36. [Online] Available: ndsfb.org/wp-content/uploads/filr/5257/2024 Annual Report final.pdf [Last Accessed 12/03/2025]

Step Two, Part Three: In Combination Effects of the Project with Other Plans or Projects

3.2.49 Refer to Section 6.2.2 (Step Two, Part Three: In Combination Effects of the Project with other Plans or Projects) of the original sHRA[1]. This addendum to the sHRA[1] only considers the following Conservation Objective:

2a. (ii) Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site.

3.2.50 In relation to Conservation Objective 2a. (ii), this partof the addendum provides further information on the following two impact pathways for the project in combination with other plans or projects:

1. Intake flow attracting downstream migrating Atlantic salmon smolts; and
2. A reduction in water levels in Loch Ness impeding salmon migration (upstream and downstream, all life stages).

1. Intake flow attracting downstream migrating Atlantic salmon smolts; and

3.2.51 As described above, migration routes of salmon from the River Moriston SAC are currently unknown within Loch Ness. Salmon smolts on migration through Loch Ness have the potential to be attracted to multiple sources of intake flow during periods of water abstraction i.e. when Foyers, the consented Loch na Cathrach (previously Red John) PSH and the Proposed Development are pumping water from Loch Ness to their upper reservoirs. Deterrence from the migration route can lead to delays and an increased energy burden as fish cover additional distance before reaching the marine environment. Mortality may not occur immediately however post-disturbance mortality at sea due to cumulative energy burdens could in theory occur. Furthermore, the extra time spent in the loch at the intake point(s) increases the cumulative risk of predation and mortality. Foyers PSH currently has no additional mitigation in place; however Loch na Cathrach proposes to install a bubble curtain to exclude smolts from its intake. Considering the mortality risks to salmon smolts under the precautionary principle, the Proposed Development (without additional mitigation) in combination with other projects is concluded as being **likely to undermine conservation objective 2a. (ii) for restoring the population of Atlantic salmon, including range of genetic types, as a viable component of the site.**

2. A reduction in water levels in Loch Ness impeding salmon migration (upstream and downstream, all life stages).

3.2.52 As discussed above, there are perceived benefits for downstream migrating fish at Ness Weir including smolts and kelts. As shown in **Plates 3**, **4, 5** and **6**, modelling of Loch Ness level change demonstrates that the operation of the consented Loch na Cathrach PSH in addition to Foyers PSH and the Proposed Development in combination will broadly mimic the fluctuation trend of Foyers PSH and Proposed Development together in isolation, with a difference of ~0.05 m between the two scenarios at lower loch levels. At higher loch levels, there is very little difference between the two scenarios.

3.2.53 Consequently, in relation to downstream migration of smolts and kelts, the predicted effect of water level change in Loch Ness is **unlikely to undermine conservation objective 2a. (ii) for restoring the population of Atlantic salmon, including a range of genetic types, as a viable component of the site.**

3.2.54 Issues were highlighted in step two for upstream migrating MSW and 1SW salmon during the months of July – September. In combination effects are broadly similar, given the similarities Foyers PSH and the Proposed Development operating together in isolation and Loch na Cathrach being added to the models, however there is slightly more of an effect on lower loch level with all of the schemes abstracting at the same time (~0.05 m). Analysis of the stock component of MSW salmon and 1SW (grilse) during the months of July – September was undertaken and it was considered that any impacts on fish migration at Ness Weir during July – September would have little or no bearing on the River Moriston salmon population.

3.2.55 Consequently, in relation to upstream migration of adult salmon (1SW (grilse) and MSW), the predicted effect of water level change in Loch Ness as a result of multiple PSH working simultaneously is **unlikely to undermine conservation objective 2a. (ii) for restoring the population of Atlantic salmon, including a range of genetic types, as a viable component of the site.**

3.2.56 All other conservation objectives are not undermined when considering in-combination effects with other projects.

Step Three: Effects on Integrity

3.2.57 Refer to Section 6.2.2 (Step Three: Effects on Integrity) of the original sHRA[1]. This addendum to the sHRA[1] only considers the following Conservation Objective:

2a. (ii) Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site.

3.2.58 In relation to Conservation Objective 2a. (ii), this part of addendum provides further information on effects on integrity associated to the following two impact pathways:

1. Intake flow attracting downstream migrating Atlantic salmon smolts; and
2. A reduction in water levels in Loch Ness impeding salmon migration (upstream and downstream, all life stages).

3.2.59 The extent of potential impact on salmon smolts in relation to attraction to intakes cannot currently be determined due to the lack of long-term, detailed River Moriston / Loch Ness specific salmon tracking studies on migration pathways. Migrating salmon smolts have a potential risk in that migration routes may be in close proximity to the Proposed Development resulting in adverse effects such as delays to migration and predation on the species during pumping cycles. Equally, if migration routes do not pass the Proposed Development potential impacts will be greatly minimised. The effects (if present) on salmon smolts are likely to occur for the lifetime of the Proposed Development, however, appropriate mitigation measures (discussed in Step Four) will mitigate these effects.

3.2.60 Loch levels will fluctuate more rapidly with the operation of the Proposed Development and other PSH's versus the baseline scenario. This may offer some potential benefits for upstream and downstream migrating fish (October – June), with rapid increases in flow providing increased environmental cues to initiate migration upstream or downstream across Ness Weir. Due to stock component of the River Moriston being principally early running (January – June), multi-sea winter salmon, identified potential effects on fish migration of lower water levels at Ness Weir during the months of July – September are not likely to undermine conservation objective 2a. (ii).

3.2.61 The operation of the canal gates at Dochgarroch Lock is unlikely to materially affect smolts due to several factors. The additional flow from the lock gates during lockage is minimal, constituting less than 10% of the minimum flow over Ness Weir, which is the dominant attractive flow for smolts. The attraction flow from the canal is limited in both time and space, with smolts needing to bypass the much larger flow from the fish pass at Ness Weir and swim towards the lesser flow from the canal when gates open. The zone of influence is considered to be around 50 m with the distance between the lock gates and the main fish pass at Ness Weir being 1,070m. Furthermore, the canal lock gates are typically closed for most of the day and predominantly at night when smolts are known to migrate, meaning smolts are more likely to be attracted to the dominant flows from Ness Weir or the smolt sluice. The operation of the Proposed Development periodically increases peak flow over the weir through rapid water level rise, further enhancing the smolt attraction flow, which reduces the likelihood of smolts being diverted by the canal gates. Therefore, the canal operations during lower loch levels are not expected to materially affect smolts.

3.2.62 In worst case circumstances, in the absence of mitigation (see Step Four below), Conservation Objective 2a. (ii) Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site could be compromised.

Step Four: Mitigation Measures

3.2.63 Refer to Section 6.2.2 (Step Four: Mitigation) of the original sHRA[1]. This addendum to the sHRA[1] only considers the following Conservation Objective:

2a. (ii) Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site.

3.2.64 In relation to Conservation Objective 2a. (ii), this section of addendum provides further information on mitigation associated to the following impact pathway:

1. Intake flow attracting downstream migrating Atlantic salmon smolts; and

3.2.65 No further mitigation measures are proposed in relation to potential impact pathway 2. a reduction in water levels in Loch Ness impeding salmon migration; however embedded mitigation via a CAR licence will impose operational stop pumping and generating limits on the Proposed Development.

3.2.66 The original sHRA[1] (see Section 6.2.2) proposed that an appropriately designed fish deterrent system would be installed as mitigation, which will deter fish from the draw of water from the intake, preventing entrainment / impingement at the screens and reducing predation impacts. It concludes that Conservation Objectives of the River Moriston SAC pertaining to the population of salmon will not be compromised following adoption and strict enforcement of mitigation measures, including the fish deterrent system.

3.2.67 Following the submission of the S.36 Application for the Proposed Development in November 2023, which included the sHRA[1], the Applicant appointed Aztec Management Consultants to provide advice on a suitable deterrent system for Atlantic salmon smolts to meet the conclusions of the original sHRA[1] for Atlantic salmon smolts. Aztec's recommendation was that the most effective mitigation method to deter smolts from the inlet structures during a pumping cycle would be to install a buoyed barrier net at a distance out from the intake structures where smolts will not be able to detect navigational cues. A description of the proposed barrier net was provided in 'AI Appendix 13:1 Update to Mitigation Measures Proposed for Fish', submitted as part of the AI for the Proposed Development in September 2024.

3.2.68 It is proposed that the barrier net would extend to a depth of at least 10 m from the water surface and be fixed in place by anchors. A barrier net with a depth of 10 m from the water surface is proposed following a review of the scientific literature undertaken by Aztec, which provides evidence that salmon smolts are generally surface orientated and tend to occupy the upper layers of freshwater bodies (see **Appendix C**). The articles referenced in **Appendix C** provide evidence that a barrier net extending to a depth of 10 m from the loch surface level would effectively exclude Atlantic salmon smolt from the area surrounding the proposed inlet structures in Loch Ness. For example, one study cited in **Appendix C** (Nash *et al*, 2022)[26] identified that >99.9 % of Atlantic salmon smolt detections were in the top 10 m of water in a 30 m deep lake in Norway.

3.2.69 The barrier net will have square mesh aperture spacing of 10 mm[27], preventing smolts from passing through the net into the zone of influence, or becoming impinged on the net. Regular maintenance will be carried out to prevent fouling causing indirect impacts on flow velocity. The distance from the intake at which the barrier net should be sited has been considered in relation to 3-dimensional (3D) Computational Fluid Dynamic (CFD) flow modelling and available literature on water flow cues for navigation in migrating Atlantic salmon smolts (see **Appendix D**).

<u>Flow Modelling in relation to the Barrier Net</u>

3.2.70 Project engineers from Fichtner Consulting Engineers Limited (Fitchner) in collaboration with academics at University of College London (UCL), conducted 3D CFD modelling to computationally model the maximum pumping flow velocity impacts in Loch Ness as a result of the Proposed Development. This modelling is presented in **Appendix D** and includes assessment of a barrier net structure with 10 mm mesh spacing extending to a depth of 10 m below the surface level, positioned at a range of distances from the intake screens (27 m and 40 m), to assess varying flow impacts with this mitigation option in place. Using the precautionary principle, only the <u>maximum</u> pumping flow of Q=360 m^3/s was applied in this assessment and is considered as a worst case scenario when in reality, pumping flow will be 85-90% of this.

3.2.71 Key findings of the study were:

- A barrier net of 10 mm spacing square mesh demonstrates very low water permeability and significantly attenuates flows passing through it.
- Placement of a barrier net **27 m** away from the intake screens is deemed **unsuitable**, attributed due to flow acceleration effects underneath the barrier net creating uneven flow distribution at the intake screens and flow velocity exceeding 0.3 m/s across sections of the intake screens. Despite this, surface flow velocities in Loch Ness at the barrier net remain low at approximately **0.05 - 0.08 m/s**.
- Placement of the barrier net **40 m** away from the intake screens is deemed **suitable** as uniform flow distribution across the intake screens with velocities <0.3 m/s can be achieved. Surface flow velocities at the barrier net decrease to approximately **0.02 m/s** in this configuration (see **Plate 9**)
- Surface flow velocities in Loch Ness beyond the barrier net continue to decrease to **< 0.01 m/s**.

[26] Nash, A.J., Vollset, K.W., Hanssen, E.M. & Berhe, S., 2022. A tale of two fishes: depth preference of migrating Atlantic salmon smolt and predatory brown trout in a Norwegian lake. *Canadian Journal of Fisheries and Aquatic Sciences*, 79(12), pp. 2150-2160. DOI: 10.1139/cjfas-2022-0016.

[27] Note in 'AI Appendix 13:1 Update to Mitigation Measures Proposed for Fish' (submitted as part of the AI for the Proposed Development in September 2024), the mesh size proposed was 12.5 mm. However, the mesh size proposed has been reduced to 10 mm in line with SEPA Guidance (SEPA (2015) Intake design and screening *in:* Guidance for developers of run-of-river hydropower schemes).

- Excavation of the Loch Ness bed to facilitate intake construction would increase the water depth, and available flow distribution volume, below a barrier net structure in turn likely reducing any flow impacts presented above.

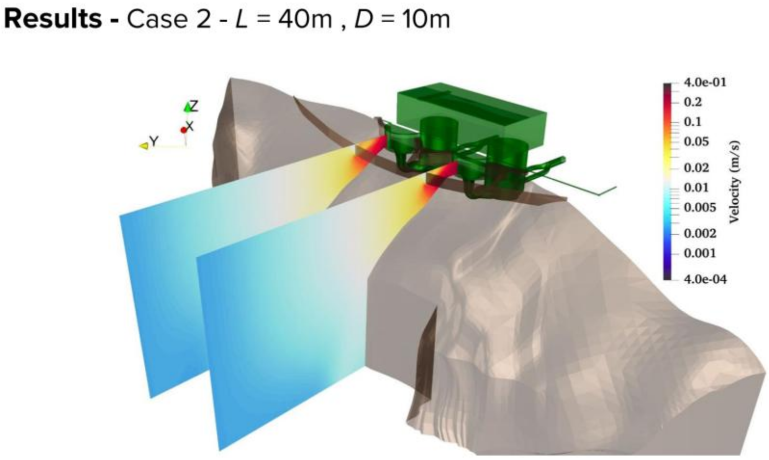


Plate 9: Contours of the velocity magnitude (in m/s) in two selected longitudinal sections (from Appendix D)

3.2.72 In the model, the water surface was assumed to be flat, and the velocity gradients at the surface were set to zero in order to conservatively assess the impact of the intake on water velocity, independent of environmental variables. The prevailing wind at the barrier net on Loch Ness is predominantly from the south-west, blowing perpendicular to (and away from) the inlet structures. These prevailing winds would not increase the water velocity towards the barrier net (i.e. < 0.02 m/s). Therefore, any seiche formation as a result of wind conditions would occur perpendicular to the flows from the inlet structures. Records indicate that the wind direction blows from the north / northeast (i.e., towards the inlet structure) <10% of the time.[28]

3.2.73 In summary, it has been concluded that a 10 m deep barrier net located up to 40 m from the inlet screens (subject to further modelling and net specifications) will be sufficient for excluding smolts which are known to use surface currents for migration.[29] A 10 mm mesh aperture is proposed for the barrier net which is recognised by Scottish Environmental Protection Agency (SEPA) as the appropriate mesh aperture for screening on hydropower developments to exclude salmon smolts.[30] This would also prevent the risk of any impingement of smolts on the barrier net. A 10 mm mesh size is considered

[28] Davis, N.N., Badger, J., Hahmann, A.N., Hansen, B.O., Mortensen, N.G., Kelly, M., Larsén, X.G., Olsen, B.T., Floors, R., Lizcano, G., Casso, P., Lacave, O., Bosch, A., Bauwens, I., Knight, O.J., van Loon, A.P., Fox, R., Parvanyan, T., Hansen, S.B.K., Heathfield, D., Onninen, M., Drummond, R., 2023. The Global Wind Atlas: A high-resolution dataset of climatologies and associated web-based application. *Bulletin of the American Meteorological Society*, 104(8), pp. E1507–E1525. DOI: The Global Wind Atlas: A High-Resolution Dataset of Climatologies and Associated Web-Based Application in: Bulletin of the American Meteorological Society Volume 104 Issue 8 (2023)

[29] Kundegorski, M.E., Honkanen, H.M., Stephen, A., Torney, C.J., Killen, S. and Adams, C.E., (2025) Defining the water flow cues for navigation in migrating Atlantic salmon smolts. *Scottish Centre for Ecology and the Natural Environment, SBOHVM, University of Glasgow, Glasgow, UK*.

[30] SEPA (2015) Intake design and screening *in:* Guidance for developers of run-of-river hydropower schemes

conservative, as River Moriston smolts have been recorded in monitoring programmes as larger than smolts from other catchments with an average length 125 mm with 41% ≥130 mm[31].

3.2.74 Modelled flows with the net set at 40 m from the intake screens was preferable to a net set at 27 m, as flows across the intake screens of <0.3 m/s can be maintained. Surface flow at 40 m with the barrier net in situ reduced to 0.02 m/s and beyond 40 m this reduces further to <0.01 m/s (see **Appendix D**). A recent study by Kundegorski *et. al* (2024)[29] found that Smolts required a directional flow in excess of 8.9 cm/s (0.089 m/s) to exhibit effective directional orientation towards the current.[32] A similar study by Veselov et al. (1998)[33] reported values of ~ 5.5 cm/s (0.055 m/s). The surface flows at and beyond the barrier net as a result of the Proposed Development will be much lower than these. There should not therefore be an attractive flow 40 m or beyond from the intake for smolts which could cause delays to migration, associated with greater energy burden and predation.

3.2.75 Flow modelling, combined with recent literature indicates that this option will be effective for mitigating the likely significant effect of *Intake flow attracting downstream migrating Atlantic salmon smolts.* Following the implementation of this mitigation, no residual effects from the Proposed Development alone or in combination with other PSH are anticipated in relation to *Intake flow attracting downstream migrating Atlantic salmon smolts* and thus the conservation objective *2b, (ii) Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site* will **not be undermined**.

[31] Ness District Salmon Fishery Board (2023) River Moriston Smolt Trap *in:* 2023 Annual Report. pp. 23-24. [Online] Available: ndsfb.org/wp-content/uploads/filr/5128/NDSFB Annual report 2023 Final.pdf#page=2.08 [Last Accessed 14/03/2025]

[32] Kundegorski, M.E., Honkanen, H.M., Stephen, A., Torney, C.J., Killen, S. and Adams, C.E., (2025) Defining the water flow cues for navigation in migrating Atlantic salmon smolts. *Scottish Centre for Ecology and the Natural Environment, SBOHVM, University of Glasgow, Glasgow, UK*.

[33] Veselov, A. E., Kazakov, R. V., Sysoyeva, M. I., & Bahmet, I. N. (1998). Ontogenesis of rheotactic and optomotor responses of juvenile Atlantic salmon. Aquaculture, 168, 17–26

4. Conclusion

4.1.1 This addendum to the sHRA[1] has been prepared in response to NatureScot consultation response dated 15th January 2025 (see **Appendix A**) in relation to the River Moriston SAC, which concludes the Applicant '*has not yet demonstrated'* that the following two impact pathways will not undermine Conservation Objective 2a. (ii) Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site:

1. Intake flow attracting downstream migrating Atlantic salmon smolts; and
2. A reduction in water levels in Loch Ness impeding salmon migration (upstream and downstream, all life stages).

4.1.2 The addendum provides further information to inform the Stage 2: Statement to Inform Appropriate Assessment for the River Moriston SAC, as set out in Section 6.2.2 of the sHRA1 for the two impact pathways listed above.

4.1.3 In worst case circumstances, in the absence of mitigation, Conservation Objective 2a. (ii) could be undermined, as migrating smolts have the potential to be attracted to the intake flow from the inlet structures during periods of water abstraction. Deterrence from the migration route can lead to delays and an increased energy burden as fish cover additional distance before reaching the marine environment. Furthermore, the extra time spent in the loch at the intake point increases the risk of predation and mortality. A buoyed barrier net installed at a distance out from the intake structures (up to 40 m) where smolts will not be able to detect navigational cues is proposed as mitigation.

4.1.4 In relation upstream migration of adult salmon (1SW and MSW) and the downstream migration of smolts and kelts, the predicted effect of water level change in Loch Ness (Loch Dochfour) is unlikely to undermine conservation objective 2a. (ii). Loch levels will fluctuate more rapidly with the operation of the Proposed Development and other PSH's versus the baseline scenario. This may offer some potential benefits for upstream and downstream migrating fish (October – June), with rapid increases in flow providing increased environmental cues to initiate migration upstream or downstream across the weir. During these 9-months, modelling predicts that the loch level will not be drawn down below 15.33 mAOD and therefore depth across the downstream face of the main fish pass will always be >0.15 m, allowing upstream passage. Due to stock component of the River Moriston being principally early running (January – June), MSW salmon, identified potential effects on fish migration of lower water levels at Ness Weir during the months of July – September are **not likely to undermine conservation objective 2a. (ii).**

4.1.5 Following the implementation of mitigation in the form of a barrier net, no residual effects from the Proposed Development alone or in combination with other PSH are anticipated in relation to Intake flow attracting downstream migrating Atlantic salmon smolts and thus the conservation objective 2b*, (ii) Restore the population of Atlantic salmon, including range of genetic types, as a viable component of the site* will **not be undermined**.

Appendix A: Consultation from NatureScot Relating to the River Moriston SAC

James MacKenzie
Strategic Co-ordination & Consents Division
5 Atlantic Quay
150 Broomielaw
Glasgow
G28LU

By Email

15 January 2025
Our ref: CDM177258

Dear James

Application For Consent Under Section 36 of The Electricity Act 1989 For Construction And Operation Of The Loch Kemp Storage Scheme
Consultation on Additional Information
The Electricity Works (Environmental Impact Assessment) (Scotland) Regulations 2017

Thank you for allowing us additional time to consider the implications of the Additional Information for the River Moriston SAC. As agreed at our meeting on 16th December, this response contains our updated advice on the Moriston SAC and should be read alongside our partial response dated 18th December 2024, which covered our advice on the implications for Ness Woods SAC.

This response is based on our understanding of the proposal and information about its environmental effects taken variously from: the original application and EIAR; the Additional Information; and the memo from Andrew Troup to Alan Brogan, ECU, dated 29/09/24.

1 Summary

1.1 River Moriston SAC

Having assessed the Additional Information, we continue to advise that the proposal could affect internationally important natural heritage interests and we **therefore object to this proposal until further information is provided**, as detailed below. This will enable us to carry out an appraisal of these effects and help you determine this proposal. Even with this further information, there is a risk that it may not be possible to show with the certainty required by the Habitats Regulations that the conservation objectives of this SAC will not be undermined.

2 Appraisal of the impacts of the proposal and advice, River Moriston SAC

2.1 Introduction

The Additional Information, and memo from Andrew Troup to Alan Brogan, ECU, dated 24 September 2024 contain updated proposals and information to address risks arising from two key impact pathways we highlighted in our response to the application (August 2024). These impact pathways could delay salmon migration and cause additional mortality, which would undermine the SAC's conservation objective to *restore the Atlantic salmon population as a viable component of the site*:

- the intake flow attracting downstream migrating Atlantic salmon smolts
- a reduction in water levels in Loch Ness impeding salmon migration

In relation to both impact pathways, the applicants have mostly chosen different approaches to providing further information to those we recommended. This reflects our advice in our August 2024 response that alternative approaches might be possible, and that we would be happy to discuss outline proposals with the applicant. The applicant did not take up this offer before submitting the Additional Information, but has explained their approach in the memo from Andrew Troup to Alan Brogan, ECU, dated 24 September 2024.

In general there are a number of inconsistencies in the various documents, gaps in explanations of the methods used in surveys, calculations and models, and some key assertions that aren't backed up by evidence. As a result of these and other issues described below **our overall conclusion is that the applicant has not yet demonstrated that these two impact pathways will not undermine this conservation objective**.

We detail our assessment of the Additional Information in relation to both impact pathways below, and provide recommendations on further information needed to assess whether the impacts are sufficiently small, or capable of being mitigated, to allow conditions suitable to restore the population as a viable component of the site.

2.2 Updated NatureScot advice on the risks of the intake flow attracting downstream migrating Atlantic salmon smolts

Instead of the acoustic and light mitigation measures previously proposed as a fish deterrent system, a barrier net is now proposed to mitigate the risk of smolts being attracted to the intake.

To our knowledge, using a barrier net to mitigate smolts being attracted to the intake is a novel and untested approach. The predicted efficacy of the net therefore needs to be demonstrated using firm evidence, transparent data and realistic worse case scenarios in order to conclude beyond reasonable scientific doubt that this impact pathway will not undermine this conservation objective.

Our assessment of the information submitted raises a number of uncertainties as to whether the barrier net as currently proposed will effectively mitigate the risk of smolts being attracted to the intake, to allow conditions suitable to restore the population as a viable component of the site. We advise the following further information is required to address these uncertainties.

Information	Rationale
1. Demonstration that the proposed mesh size of 12.5mm will prevent the accidental capture of, or injury to, the entire size range of smolts known to exit the River Moriston.	The mesh size is higher than the maximum 10mm spacing for solid screens recommended to prevent the passage of downstream-moving fish into hydro intakes (SEPA 2015). A net will function differently to a solid screen, being comprised of softer stretchable material. This could risk smaller fish being gill netted.
2. Clear explanation and demonstration of the velocity-area calculations (or any other method) used in the hydraulic assessment in Appendix B of Appendix 13.1 to allow the estimates to be audited. The applicant should check the calculations in Appendix B to confirm whether the final calculation fails to account for the fact that the area of equal velocity is a half cylinder shape, and therefore should be divided by Πh (rather than 2Πh), and supply revised calculations if required.	The hydraulic assessment does not detail the method used and may include an error resulting in distances from the intakes screen where velocity falls to the target level being too low.
3. A transparent, robust, and precautionary rationale for a proposed appropriate target velocity associated with pumping which can be safely concluded is below the minimum water velocities at which Atlantic Salmon smolts start to pick up directional cues	Currently no firm evidence available for water velocities at which Atlantic salmon smolts start to pick up directional cues. Glasgow University work not published or peer reviewed so can't be relied upon. Not safe to assume that background water flows in Loch Ness do not attract smolts. Hence at present no robust basis for deciding on an appropriate target flow velocity associated with pumping, to help determine net position.

4. If background flows in Loch Ness do form an element of the rationale for an appropriate target velocity associated with pumping to avoid smolts picking up directional cues, evidence to demonstrate how representative the flow velocity survey conducted by Aspect Land and Hydrographic in June 2023 at the mouth of the River Moriston is of conditions typically experienced within the loch by migrating smolts during their migration season, and to confirm the extent to which the flows measured can be considered a reasonable worst case scenario. This should include details of the velocity profile locations and antecedent flow and weather conditions expressed relative to typical conditions during smolt migration.	Without the details of the survey it is not possible to ascertain how representative the locations of these velocity measurements are of conditions within the wider loch. For example, it is unclear whether the higher flow values are indicative of the outflows of the river Moriston rather than the typical conditions in Loch Ness. Furthermore, without details of the antecedent meteorological conditions such as temperature and wind speed (which influence seiche formation) or the outflows (expressed as a flow percentile) from the river Moriston it is not possible to assess how the conditions during the brief survey relate to the range of conditions during smolt migration period, and whether they do represent a reasonable worst case scenario as claimed.
5. Demonstration that the net will remain in place, intact and effective during high flows associated with generation or discharge, and during periods of high natural flows in Loch Ness. This should be based on a review of evidence of high loch flow velocities[1], and details of any additional net features required to ensure efficacy in sub-optimal conditions (eg bottom anchors).	Given the potential net supplier suggests optimal conditions for the net to function would be in water with a velocity of 0.1 m/s or less, and AI Appendix 13.1, Figure 1 indicates that the velocities resulting from operation of the scheme would be greater than this at the indicative proposed net locations, it's not clear the net will remain effective during periods when the scheme is discharging or pumping, nor during periods of high natural flows in Loch Ness.
6. Demonstration that local velocities and directions around and through the net will not attract or confuse smolt passage when high natural loch velocities and high flows to or from the intake coincide.	No evidence provided on the local effects of the net on loch flows, nor of the potential for turbulence or other effects to attract or confuse smolt migration

[1] For example, it is likely additional sources are available: THORPE, S., HALL, A. & CROFTS, I. The Internal Surge in Loch Ness. *Nature* **237**, 96–98 (1972). https://doi.org/10.1038/237096b0

7. A revised proposed location for the net based on a transparent and precautionary assessment of the distances required to avoid any risk of Atlantic Salmon smolts starting to pick up directional cues; and the net functioning effectively during periods of natural or scheme-induced high flow. It should be clearly stated whether the location is based on distance from the inlet screens, or the inlets themselves (which are 18m away).	Due to the uncertainties identified above, and the inconsistency in the documents submitted as to the exact distance proposed, and whether it is measured from the inlet screens or the inlets.
8. The proposed regime for net deployment, inspection, maintenance, repair and replacement	To ensure net remains intact and in place for effective function

Given the uncertainties around the effective function of the barrier net outlined above**, we continue to conclude this impact pathway - *Intake flow attracting downstream migrating Atlantic salmon smolts* - could undermine the conservation objective to restore the population as a viable component of the site.**

2.3 Updated NatureScot advice on the risks of a reduction of water levels in Loch Ness impeding migration

Additional information relating to this impact pathway has been submitted as follows:

- an expert opinion on upstream passage of adult Atlantic salmon and the downstream passage of Atlantic salmon smolt at the Dochfour (Ness) Weir under existing conditions, which concludes that fish passage through the weir when the Loch Ness level is at the 'stop pumping' level of the existing Foyers PSH scheme (15.27 m AOD) or above provides good conditions for upstream and downstream fish passage over the weir (AI Appendix 13.3).
- Calculations of the flows from Loch Ness into the Caledonian Canal and into the River Ness, making the argument that average daily flow rates into the canal are 1.5% of flows over the fish pass into the River Ness, so the draw towards the river would be substantially greater than to the canal (p17, memo from Andrew Troup to Alan Brogan, ECU, dated 29/09/24), and stating that most of the time the predominant flow direction in Loch Dochfour would be towards Loch Ness, particularly when water levels are likely to be lower in the late summer
- Reference back to EIA Chapter 7: Water Management, and Appendix 7.1: Loch Ness PSH – hydrological modelling Technical Note, stating that the models are in fact based on worst case scenarios (memo from Andrew Troup to Alan Brogan, ECU, dated 29/09/24)
- Reinforcement of the statement in the EIAR that the impact of future climate change will be to result in longer periods of curtailment of operation of the Kemp scheme due to the 'stop pumping' level stipulated in any CAR licence, rather than in reduced water flows over

Ness weir into the River Ness (memo from Andrew Troup to Alan Brogan, ECU, dated 29/09/24).

We have identified a number of issues with the Additional Information, which collectively mean uncertainties remain in relation to

- whether there is a risk that the operation of Kemp immediately prior to dry conditions would lead to subsequent minimum levels at Ness weir bottoming out at a lower level than would otherwise be experienced and/or
- whether the operation of Kemp in combination with the other PSH schemes would lead to more extended periods at which levels at Ness weir were at or approaching the Foyers minimum stop pumping level of 15.27mAOD than currently modelled, and if so the implications for smolt migration
- the ability of adult Atlantic salmon to migrate upstream over Ness weir and the SSE sluice at low loch levels

We advise the following further information is required to address these uncertainties.

Information	Rationale
1. A clear evidenced statement as to which pumping period for Loch Kemp was chosen in the study by Lane Clark and Peacock LLP, as referred to in EIA *Volume 4 - Appendix 7.1 - Loch Ness Hydrological Modelling Technical Note* as a reasonable worst case scenario for modelling the impacts on levels in Loch Ness, and what stop pumping level was used.	It is not clear which operating scenario has been used in the modelling. In section 7.9.5 & 7.9.6 of EIA *Volume 1 - Chapter 7 - Water Management* it is implied that a 4-hour pumping cycle has been used as a worst case scenario. However, the memo from Andrew Troup to Alan Brogan, ECU, dated 29/09/24 page 19 para 2, states that a 15-hour pumping period was used. In addition, s4.2 of EIA Appendix 7.1 states that although the preliminary CAR licence application for Kemp proposed a stop-pumping level of 15.33mAOD, a higher value (15.42m) was used in the modelling work. As 15.33mAOD is lower, it would result in lower loch levels and is therefore a worse case scenario than the level stated as used in the model. The memo from Andrew Troup to Alan Brogan, ECU, dated 29/09/24p19, however, states that worst case scenarios were used. Which of these is true is critical for assessing the evidence of modelled loch level minima and low loch level duration,

	and whether the operation of Kemp immediately prior to dry conditions could lead to subsequent minimum levels at the weir bottoming out at a lower level than would otherwise be experienced, and/or more extended periods of low loch levels than currently predicted.
2. Reanalysis of the impact on Loch Ness levels of the operation of the PSH schemes to demonstrate the impacts during the smolt migration season. This should be undertaken using the synthetic inflow time series based upon historical data and also one perturbed by the relevant climate change e.g. by using the eFLaG dataset. The operational rules used for this modelling should be based on transparent, justified, reasonable worst case scenarios.	The modelling results outlined in EIA Appendix 7.1 demonstrate that the operation of Loch Kemp would contribute to extended durations where levels sit at or just above 15.27mAOD. This information is provided as an annual level duration curve so it is not possible to determine how much of this extended duration occurs during the smolt migration season. Climate change has not been accounted for within the level modelling but could lead to still longer periods of low loch levels.
3. If the reanalysis described at 2 above indicates there will be more extended periods of low loch levels during the smolt migration season, further assessment of the effect of the Caledonian canal on flows and the potential to attract smolts into the canal. This should be based on available understanding of how smolts respond to flows, and where there are evidence gaps a precautionary approach should be taken, for example by considering short term flows rather than daily averages.	The applicants estimate an average daily flow rate towards the canal and conclude that given that these flows are only 1.5 % of flows typically going over the weir, they are not significant. However a daily average flow masks the fact that lock operation produces step flow changes as they open and close. Instantaneous flow rates when locks open to allow downstream navigation will be much higher than the daily average. A rough calculation based on the applicant's lockage data suggests, when loch levels are at the Foyers stop pumping level of 15.27 mAOD, instantaneous flow rates could be a significant proportion of the flow over the weir. This suggests there could be a risk that smolts are attracted towards the canal at low loch levels. Extending the duration at

	these levels may worsen this situation; if the modelling shows this is likely, the impacts need to be assessed.
4. Revised analysis in AI Appendix 13.3 section 1.9 based on evidence for Atlantic salmon swimming performance and barrier passability	This analysis is based on somewhat dated evidence relating to Pacific Salmonids, which may not apply to Atlantic salmon. There are a number of sources of evidence relating to Atlantic salmon, we list some examples below[2].
5. Expanding the analysis in AI Appendix 13.3 section 1.9 to provide evidence, in the form of a transparent hydraulic calculation of the velocities and depths through the sluice orifice, to support the claim made in 1.9.8 that the SSE sluice system does not represent a barrier to upstream migrating Atlantic salmon at the Foyers 'stop pumping' level.	No evidence or rationale provided

Overall, with the information available at present, **we conclude this impact pathway - *Reduction in water levels in Loch Ness impeding migration* - could undermine the conservation objective to restore the population as a viable component of the site.**

[2] Armstrong, G.S., Aprahamian, M.W., Fewings, G.A., Gough, P.J., Reader, N.A., Varallo, P.V., 2010. *Environment Agency Fish Pass Manual: Guidance Notes on the Legislation, Selection and Approval of Fish Passes in England and Wales.* Environment Agency, Bristol, UK, p. 369. https://ifm.org.uk/wp-content/uploads/2020/09/Fish-Pass-Manual.-GoodVersion-pdf.pdf

Kraskura, K., Patterson, D.A. & Eliason, E.J. (2024). A review of adult salmon maximum swim performance. *Canadian Journal of Fisheries and Aquatic Sciences*. **81**(9): 1174-1216. https://doi.org/10.1139/cjfas-2023-0246

Hvas, M. & Oppedal, F. (2017) Sustained swimming capacity of Atlantic salmon. *Aquacult. Environ. Interact*., **9**:361-369. https://doi.org/10.3354/aei00239

Remen, M., Solstorm, F., Bui, S. & Klebert, P. and others (2016) Critical swimming speed in groups of Atlantic salmon *Salmo salar*. *Aquacult. Environ. Interact*., **8**:659 -664. https://doi.org/10.3354/aei00207

SNIFFER (2010) *WFD111 (2a) Coarse resolution rapid-assessment methodology to assess obstacles to fish migration.* https://www.sniffer.org.uk/Handlers/Download.ashx?IDMF=8ad81836-e172-4365-9acb-47fa8174aa06

2.4 Mitigation and modifications in relation to the impacts of construction and the proposed acoustic fish deterrent

We welcome the removal of the acoustic fish deterrent proposed as mitigation; and the commitments to prepare a PPP and CEMP, and an assessment of the noise impact during construction, in line with our advice on the application. Incorporation of these changes will address the impacts of construction and of the previously proposed acoustic fish deterrent on the Atlantic salmon qualifying interest of this SAC.

As agreed at our meeting on 16th December 2024, we recommend a meeting to discuss the issues highlighted above and assist the applicant in determining their way forwards. We are seeking to arrange this meeting under separate correspondence.

If you require any further information on this letter please contact Corrina.mertens@nature.scot or Debbie.greene@nature.scot

Yours sincerely

Chris Donald
Head of Operations, Central Highland

CC
Susan Haslam, SEPA
Andrew Troup, Stratera
Roddy Dowell, The Highland Council

Appendix B: Dochfour Weir Hydraulic Assessment Technical Note

Loch Kemp Storage
A STATERA COMPANY

Dochfour Weir Hydraulic Assessment

Technical Note

March 2025

Document History			
Revision:	**Date:**	**Prepared by:**	**Reason for Revision:**
0	19/3/25	Statera Energy Ltd	Internal Issue
1	21/3/25	Statera Energy Ltd	Final Issue

Introduction

The following Technical Note covers the impact the Loch Kemp Storage Project (the Proposed Development) has on water levels in Loch Ness and, in turn, on the hydraulics of Dochfour Weir. This Technical Note provides further substantiation and information about the impact of the Proposed Development and is intended to assist with responding to Statutory Consultees as part of the s36 Application (ECU00003398).

Mott Macdonald Group Limited (Mott Macdonald) has produced the data presented in this Technical Note.

Water Levels

The Proposed Development is an open-loop Pumped Storage Hydropower (PSH) project that is located within the Ness catchment and uses Loch Ness as its tail pond. During operation, the Proposed Development will generate (discharge) and pump (abstract) water into and out of Loch Ness, which will directly impact water levels in Loch Ness.

The Ness system is a complex, highly augmented catchment that has various water users. As part of the cumulative impact assessment, the Proposed Development is required to be assessed against the baseline conditions experienced today, including the existing Foyers PSH scheme, as well as any other planned developments, i.e. other PSH projects. The cumulative assessment has been carried out based on the following scenarios. Note the operational profiles used are based on the same 2030 LCP data that was used in the *EIA Report: Volume 1 (Main Report) Chapter 7: Water Management*.

- Baseline[1] – This is described as the 'natural' simulation that has been derived using synthesised back-calculated inflow time series (1973 to 2022) from gauging data downstream (Ness-side), including the attenuating effect of Loch Ness. The flow data used to derive the baseline conditions implicitly reflects the operations of existing schemes today. Given that this same time series will be used to model PSH profiles, this is understood to provide the most representative baseline;
- Foyers – This is Foyers on its own, following the 2030 LCP profile for the year. Note that LCP predicts increased utilisation of the PSH scheme in the future; thus, there is more volatility compared to the baseline.
- Foyers + Loch na Cathrath – Both schemes are synchronised and follow the 2030 LCP profiles in both modes of operation.
- Foyers + Kemp – Both schemes are synchronised and follow the 2030 LCP profiles in both modes of operation.
- Foyers + Loch na Cathrath + Kemp – All schemes are synchronised and follow the 2030 LCP profiles in both modes of operation.

The results of the assessment are shown in Appendix 1. These are sample 10-day periods taken throughout the year and are based on the following assumptions and parameters:

- Scheme operations are based on the profiles provided by LCP; the implementation in the model assumes that the schemes would operate "in sync" except where a recharging scheme reaches its storage capacity ahead of others and, conversely, when a discharging scheme is empty before others.
- All schemes operate in sync in both modes of operation, i.e. generate (discharge) and pump (abstract). The data presented is based on an hourly time step.

[1] Operational data for SSE's assets has been unable to be obtained so natural baseline has been developed.

- Each scheme has a different Stop Pumping Level (SPL). When these levels are reached within the combined scenarios, each scheme stops operating accordingly. The SPL's are Foyers – 15.27 mAOD; Loch na Cathrach – 15.33 mAOD; and Kemp 15.42 mAOD.
- All scenarios, except the baseline, are based on model simulations using an estimated inflow time series; simulated peaks due to higher inflows would not necessarily occur at the same time as actual peaks. Consequently, comparing instantaneous and absolute differences could be misleading.
- For computational purposes, no allowance has been made for attenuation differences between each project as they are located in different areas of Loch Ness.

To visually demonstrate the impact of water levels Figure 1 shows a 2-day snapshot in June when the baseline conditions are such that SPL's are not reached during pumping modes. As you can see, the greater the combination of schemes, the greater the rate of change in both falling as well as rising levels. Due to the synthesised nature of the baseline date the baseline line shown in Figure 1 is smoothed out and does not represent daily rates of change. A more representative profile of current loch level fluctuations would be the + *Foyers*.

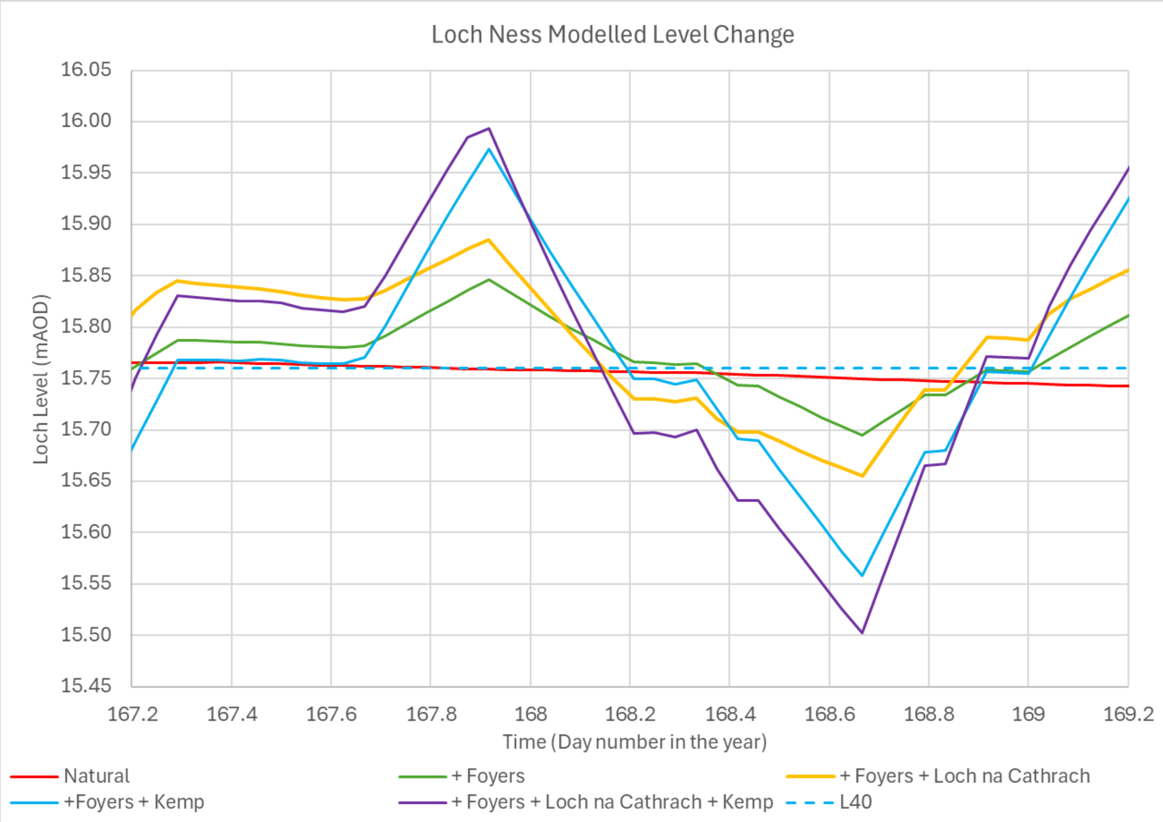


Figure 1: Loch Ness Modelled Level Change – Sample 2-day period in June

The results show that the inclusion of PSH schemes increases the frequency of higher and lower water events occurring in Loch Ness. As loch levels are generally correlated with flow rates downstream, a similar pattern occurs when analysing flow rates in the River Ness.

When compared to a statistically typical year[2] the frequency of moderate flows, i.e. Q30 to Q50 flows, increases. For example, the inclusion of Kemp generally increases the frequency of Q40 events from 9 per month to around 12 per month.

[2] Based on 2022 data from Loch Ness a Foyers https://waterlevels.sepa.org.uk/Station/498342/

Dochfour Weir Hydraulic Assessment

Mott Macdonald has assessed the hydraulics of the existing Dochfour Weir arrangement today. The weir today consists of different hydraulic features, including the SSE Sluice Gates, Fish Pass, Service Weir and Waste Weir, as shown in Figure 2. The focus of the assessment is on the relationship between the SSE Sluice Gates and the Fish Pass and to determine the hydraulic conditions of both elements at different loch levels.

Figure 2: Southern end of Dochfour Weir

The boundary of the Fish Pass hydraulic assessment extends from the crest to the bottom of the apron of the Fish Pass and does not consider further downstream conditions, including the plunging flow into pools, hydraulic jumps, and in-river features. This is due to geometric uncertainty and insufficient survey information.

The assessment assumptions for each hydraulic feature of Dochfour Weir that conveys water has a different elevation, as stated in Table 1.

Table 1: Dochfour Weir hydraulic features and assessment assumptions

Feature	Assessment assumptions
Fish pass	**Crest level** – 14.93 mAOD **Weir size** Based on the specific fish pass dimensions stated in the APEM Fisheries Impact Assessment 2017 report; Archive Drawings Engineers Office, Caledonian Canal, Inverness 4 March 1933; 1m DTM LiDAR Survey 2024; Bathymetry Survey 2025; Aerial Survey 2024; and Site Visit 2023 (Appendix 2). Calculated flows were found using Mannings standard step approach with the following parameters: • Weir length = 5.6m central crest, 4.5 m side slopes (1:7.5) • Weir apron slope = 1:9.4 • Apron length = 6.55 m • Mannings n = 0.02 (Gravel bottom with sides of random stone mortar)
Service Weir	**Crest level** = 15.53 mAOD **Crest length** = 170 m
Waste Weir	**Crest level** = 15.76 mAOD
SSE sluices	**Maximum gate opening height** – 900 mm **Width** – 8 m

	Invert level – 14.32mAOD (from Loch Dochfour S47 report) **Orifice flow discharge coefficient** - Swamee's equation for free flow Free flow $C_d = 0.611\left(\frac{y_1 - b}{y_1 + 15b}\right)^{0.072}$ (3) **Vena contracta ratio** – 0.61 **Apron length** - ~8 m (estimated from aerial imagery)
Environmental Flow	**Minimum Environmental Flow** = 28.3 m³/s

The hydraulic assessment of the Fish Pass focuses on three key areas of water flow, as shown in Figure 3. These are as follows:

1. Upstream depth of water over the weir
2. Critical depth at downstream edge of crest
3. Normal depth at the bottom of the apron

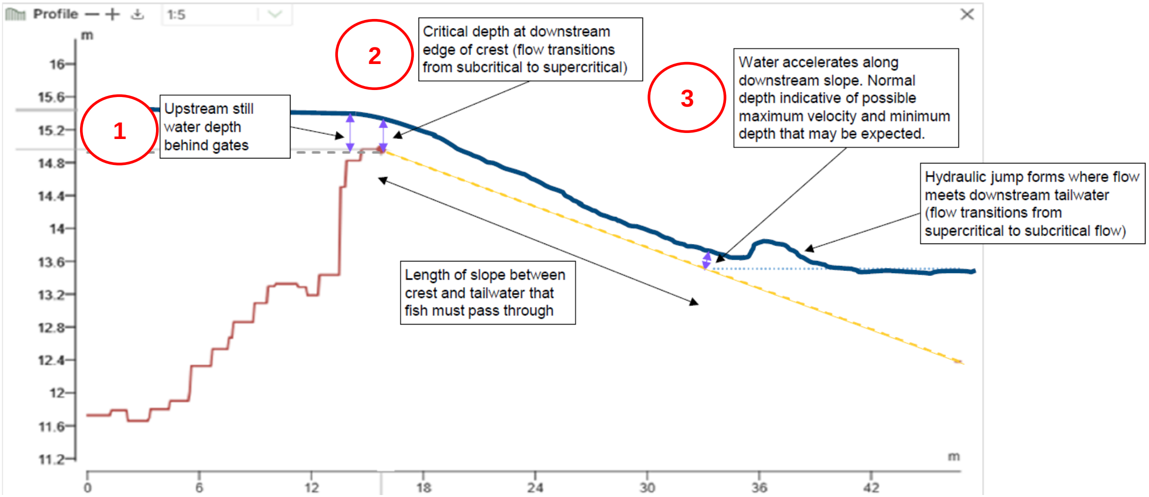


Figure 3: Indicative Sketch of Dochfour Weir Fish Pass

The hydraulic assessment of the Fish Pass focuses on three key areas of water flow, as shown in Figure 4. These are as follows:

1. Upstream still water depth behind sluice gates
2. Gate(s) opening height
3. Vena contracta depth

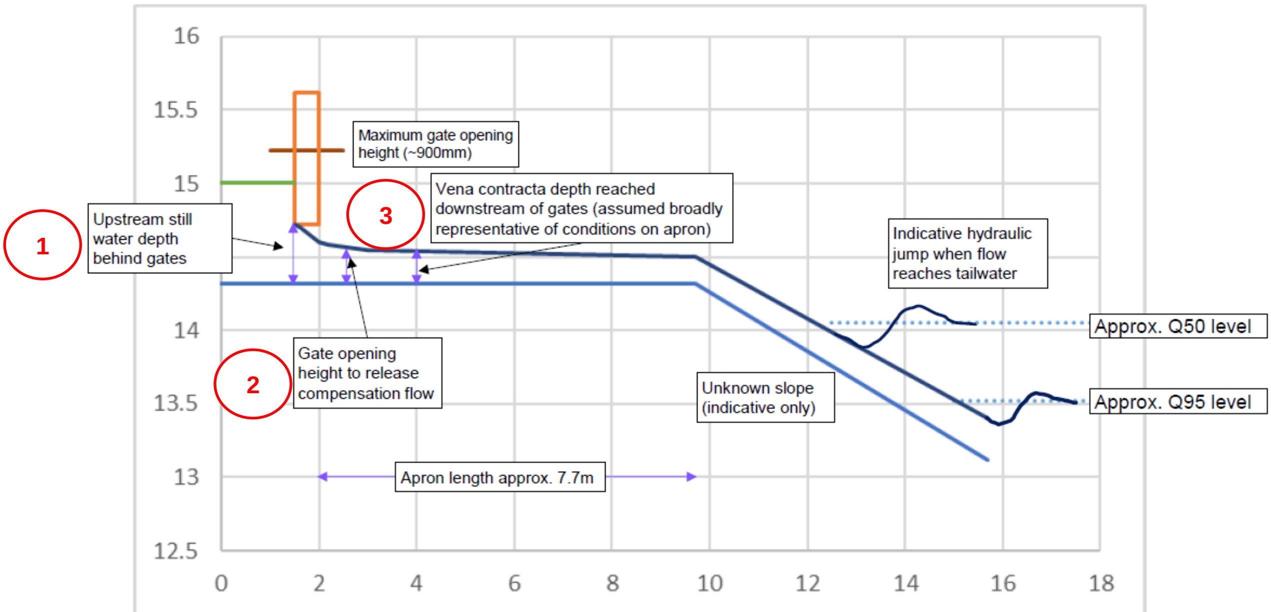


Figure 4: Indicative Sketch of SSE Sluice Gates

The scope of the hydraulic assessment extends from when the SSE Sluice Gates start to operate down to the minimum SPL of 15.27 mAOD. The SSE Sluice Gates are estimated to start operating at around a loch level of 15.70 mAOD, at this level water is spilling over both the Service Weir and Fish Pass.

As water levels fall towards the SPL of 15.27 mAOD, the SSE Sluice Gates are required to open further to maintain the environmental flows (28.3 m^3/s) downstream in the River Ness. This results in the distribution of flow changing across the Service Weir, Fish Pass and SSE Sluice Gates. As shown in the results of the hydraulic assessment in Appendix 3.

At Loch levels higher than 15.83mAOD, flows are discharging over the full extent of the service and waste weir. As flows reach 16 mAOD, the full extent of the weir, which has a long crest length of 500 m, is drowned out. As this occurs flows and velocities are evenly dissipated thus ensuring no there is no rapid rise in velocity on the fish pass itself.

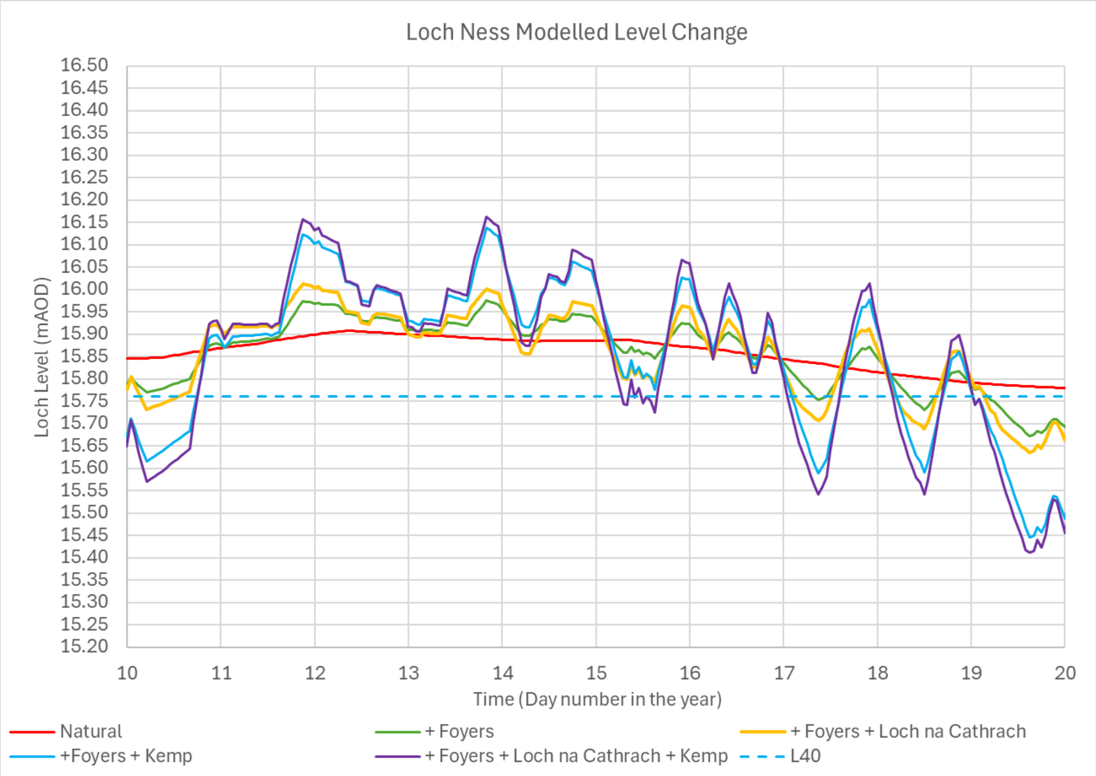
As this is occurring, the levels in the River Ness will become higher than the bottom of the fish pass, with the fish pass itself becoming increasingly inundated. In this scenario there is no drop from the fish pass to River Ness with fish passage enabled directly onto the pass itself. The flow across the weir mimics a spate river flow conditions at this point making fish passage easier and more akin to natural river conditions.

As levels in Loch Ness continue to rise to and beyond 16.7mAOD, the weir and fish pass become redundant with direct level for level connectivity occurring between Loch Dochfour and the River Ness enabling fish passage directly over the structure.

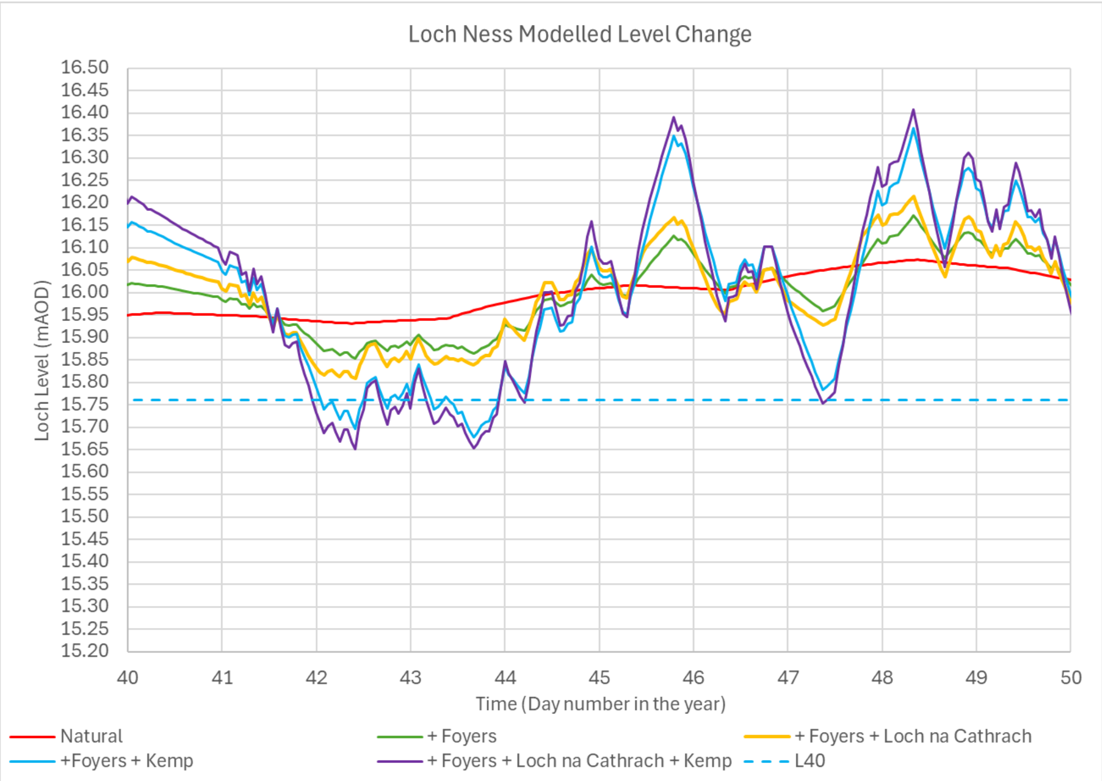
Appendix 1

Modelled Loch Ness levels LCP Profiles – Monthly 10-day Periods

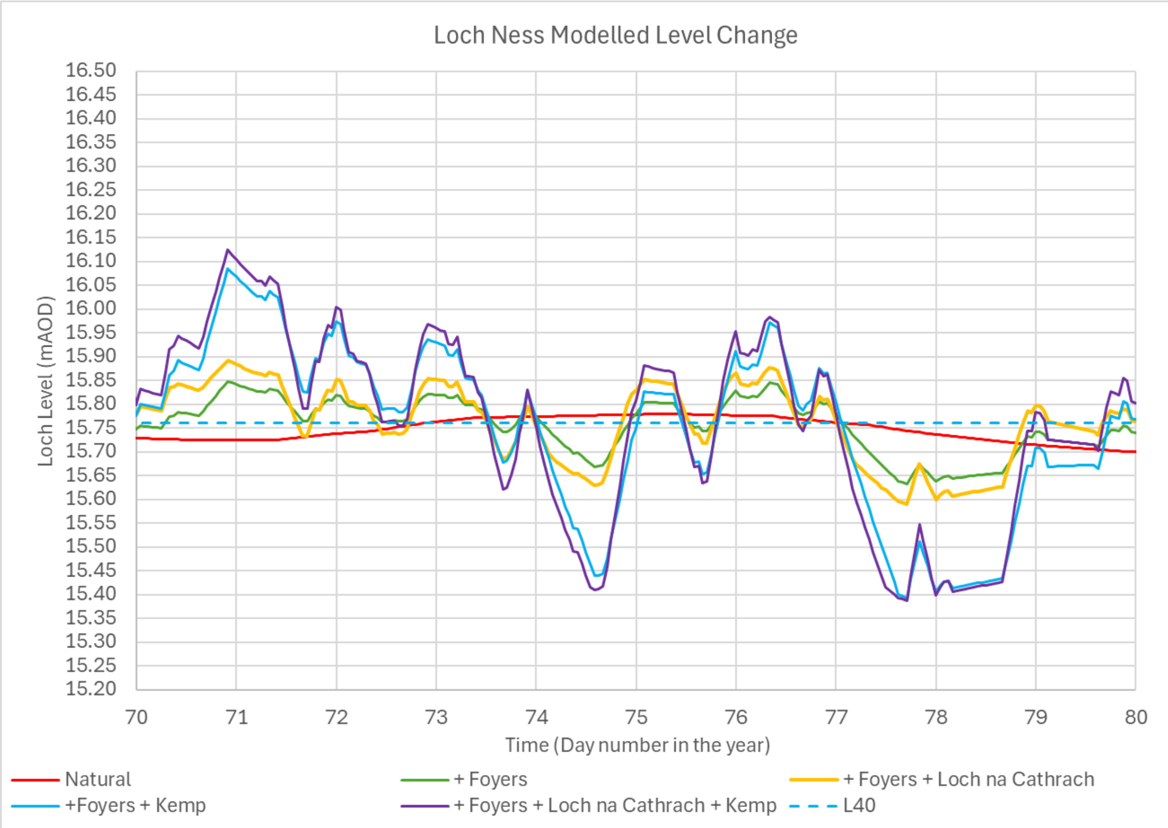
January



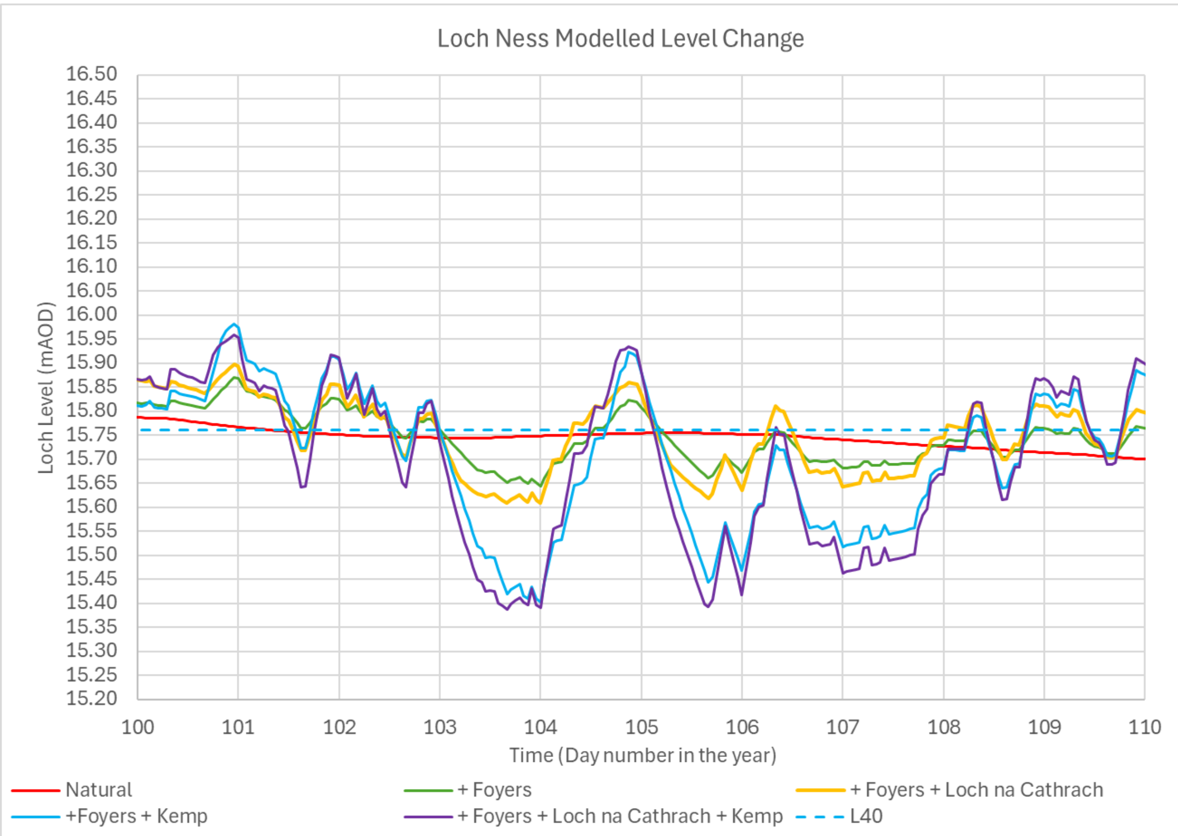
February



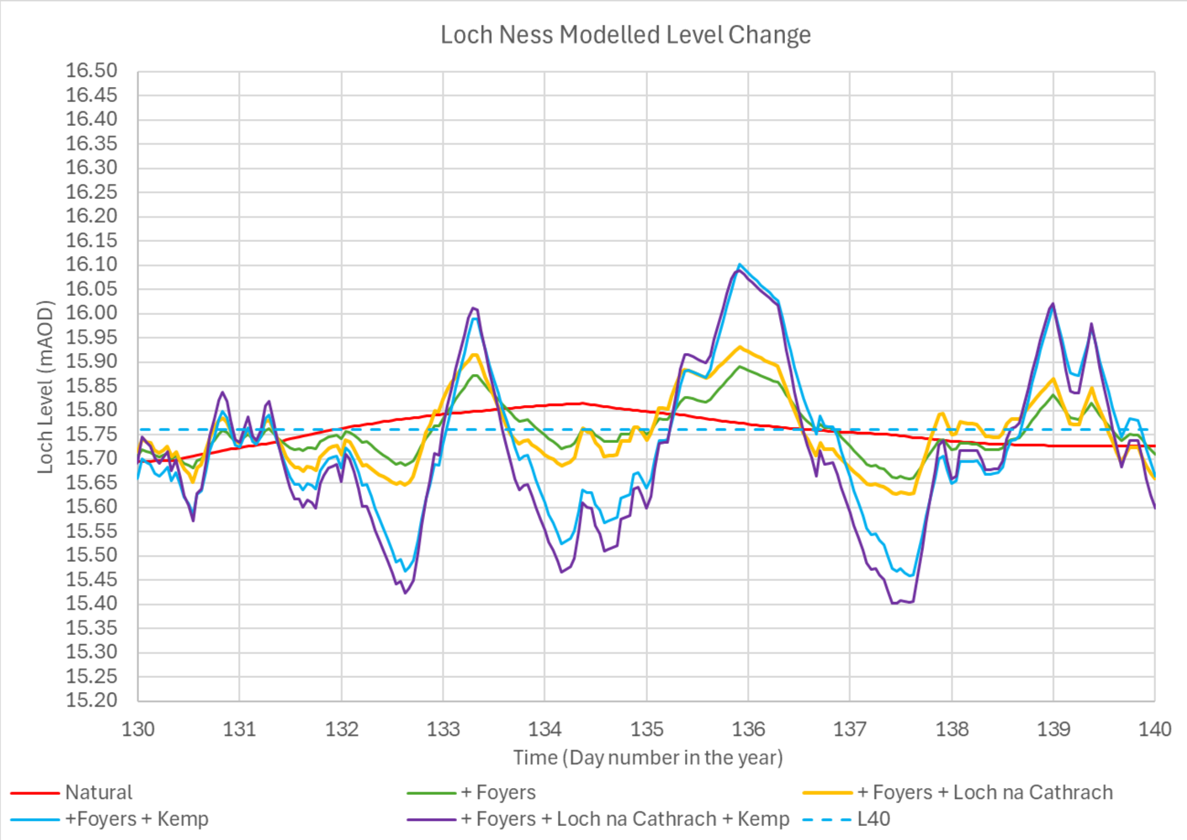
March


Loch Ness Modelled Level Change
Loch Level (mAOD)
16.50
16.45
16.40
16.35
16.30
16.25
16.20
16.15
16.10
16.05
16.00
15.95
15.90
15.85
15.80
15.75
15.70
15.65
15.60
15.55
15.50
15.45
15.40
15.35
15.30
15.25
15.20
70
71
72
73
74
75
76
77
78
79
80
Time (Day number in the year)
Natural
+ Foyers
+ Foyers + Loch na Cathrach
+Foyers + Kemp
+ Foyers + Loch na Cathrach + Kemp
L40

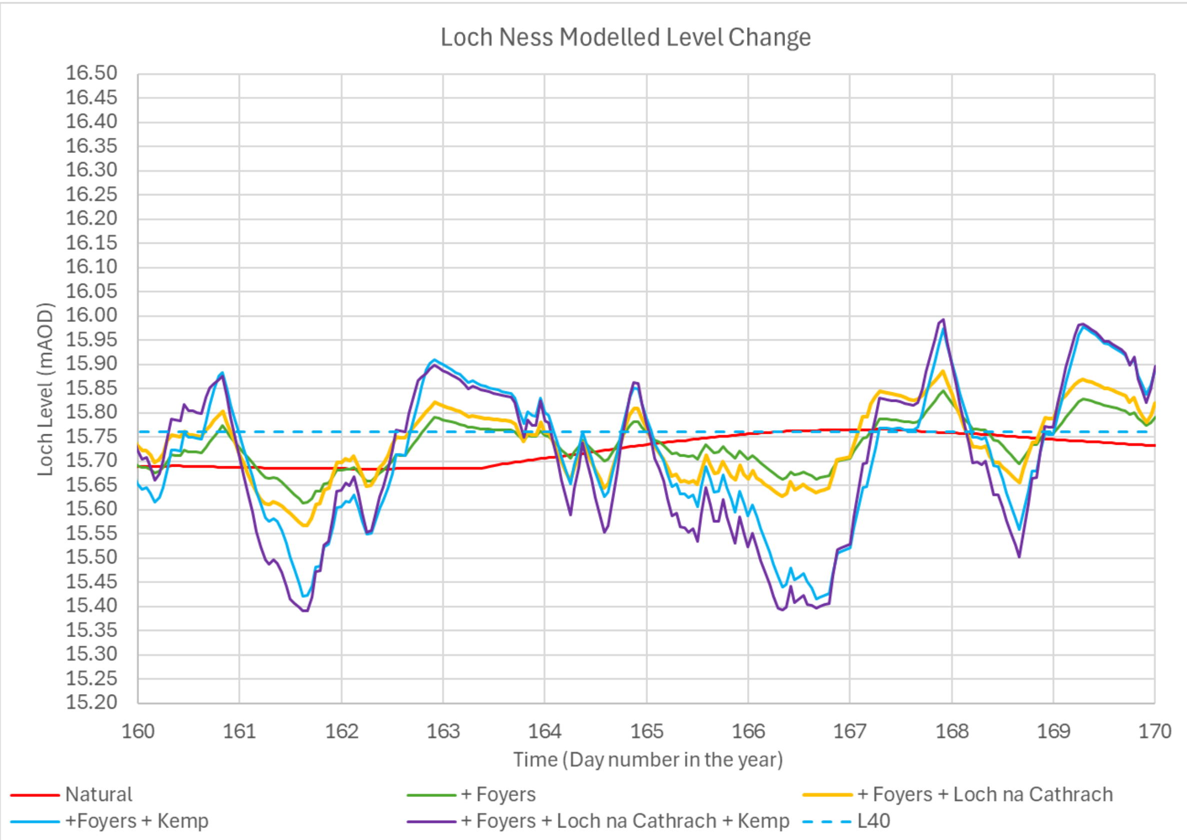
April


Loch Ness Modelled Level Change
Loch Level (mAOD)
16.50
16.45
16.40
16.35
16.30
16.25
16.20
16.15
16.10
16.05
16.00
15.95
15.90
15.85
15.80
15.75
15.70
15.65
15.60
15.55
15.50
15.45
15.40
15.35
15.30
15.25
15.20
100
101
102
103
104
105
106
107
108
109
110
Time (Day number in the year)
Natural
+ Foyers
+ Foyers + Loch na Cathrach
+Foyers + Kemp
+ Foyers + Loch na Cathrach + Kemp
L40

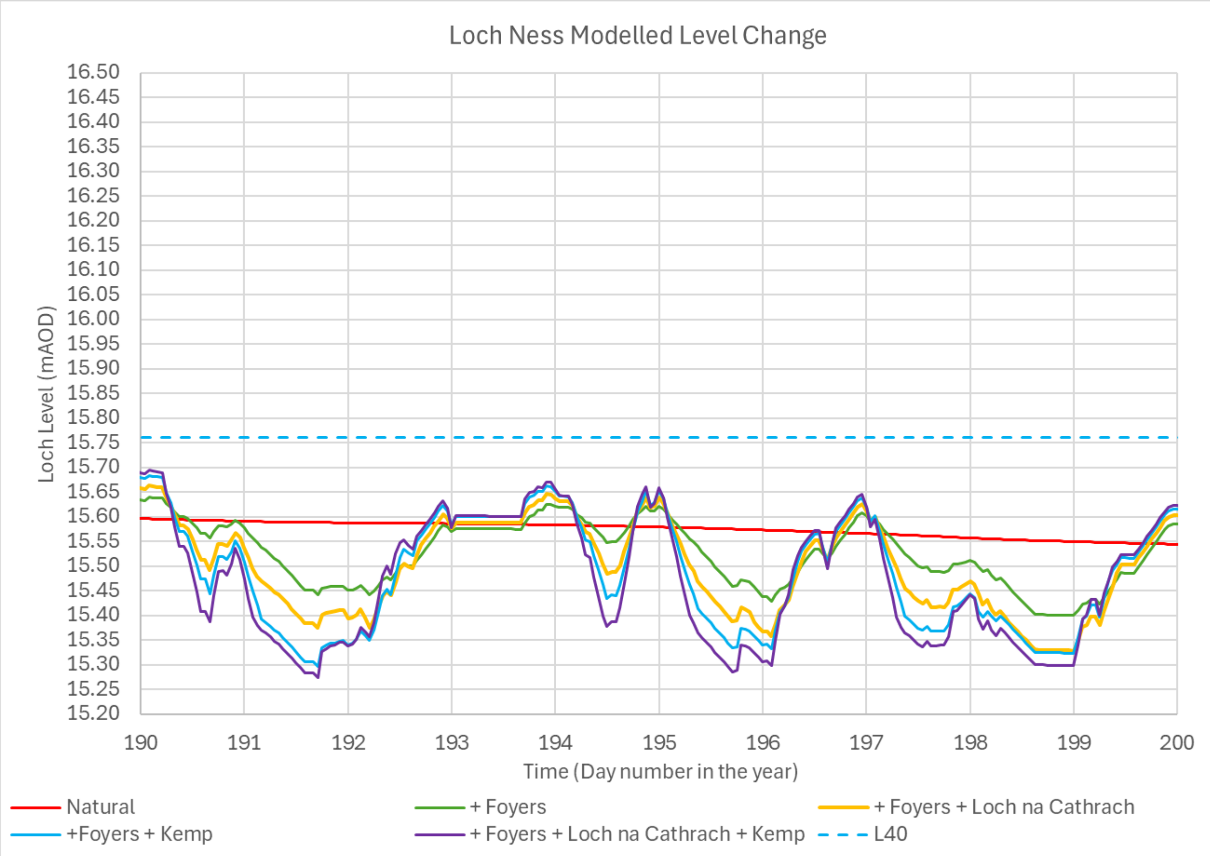
May


Loch Ness Modelled Level Change
Loch Level (mAOD)
16.50
16.45
16.40
16.35
16.30
16.25
16.20
16.15
16.10
16.05
16.00
15.95
15.90
15.85
15.80
15.75
15.70
15.65
15.60
15.55
15.50
15.45
15.40
15.35
15.30
15.25
15.20
130
131
132
133
134
135
136
137
138
139
140
Time (Day number in the year)
Natural
+ Foyers
+ Foyers + Loch na Cathrach
+Foyers + Kemp
+ Foyers + Loch na Cathrach + Kemp
L40

June

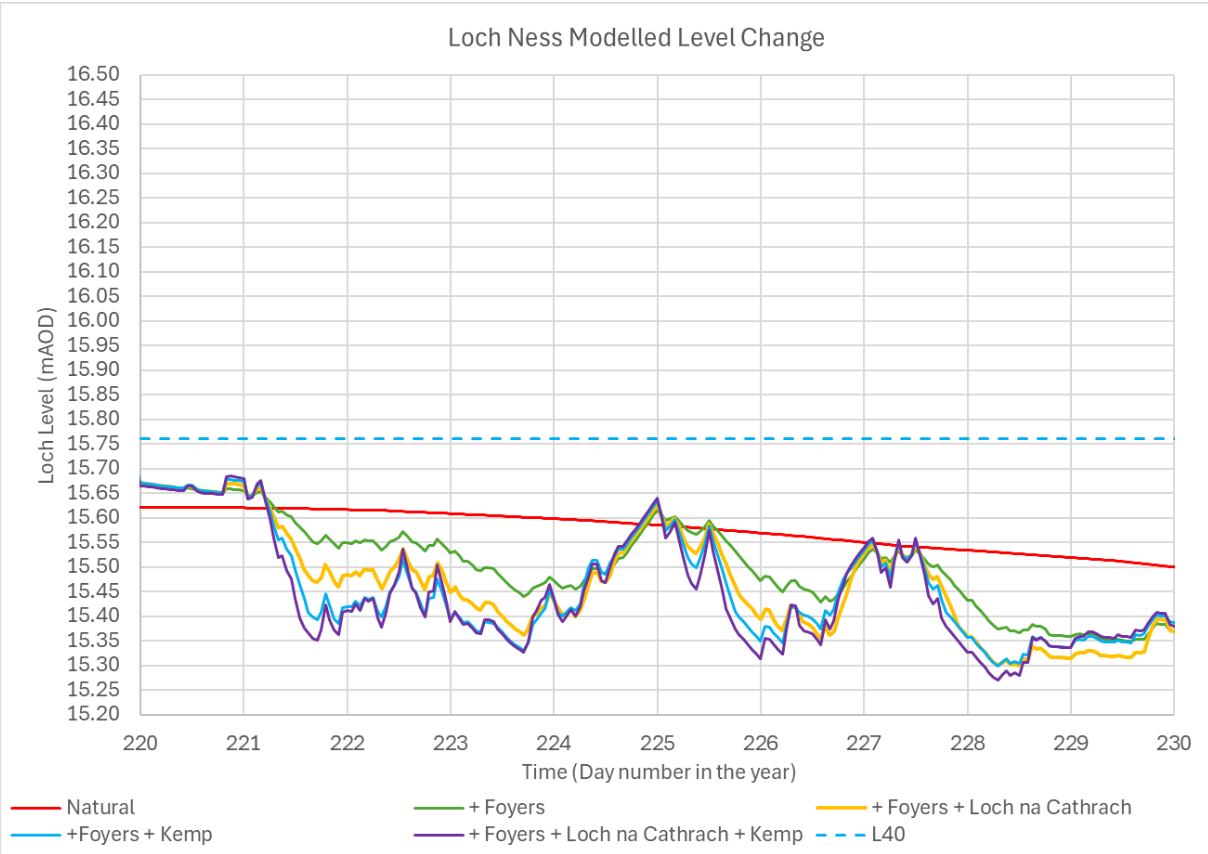

Loch Ness Modelled Level Change
Loch Level (mAOD)
16.50
16.45
16.40
16.35
16.30
16.25
16.20
16.15
16.10
16.05
16.00
15.95
15.90
15.85
15.80
15.75
15.70
15.65
15.60
15.55
15.50
15.45
15.40
15.35
15.30
15.25
15.20
160
161
162
163
164
165
166
167
168
169
170
Time (Day number in the year)
Natural
+ Foyers
+ Foyers + Loch na Cathrach
+Foyers + Kemp
+ Foyers + Loch na Cathrach + Kemp
L40

July



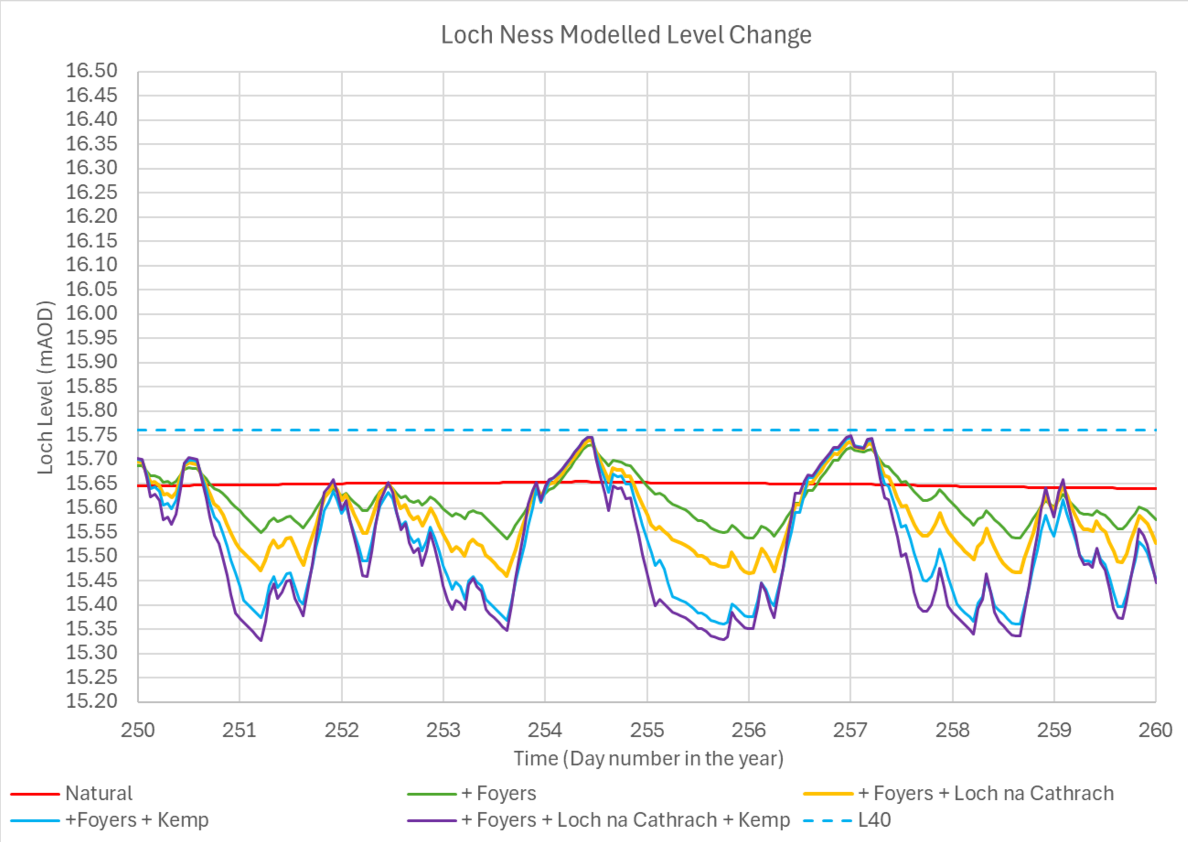
Loch Ness Modelled Level Change
Loch Level (mAOD)
16.50
16.45
16.40
16.35
16.30
16.25
16.20
16.15
16.10
16.05
16.00
15.95
15.90
15.85
15.80
15.75
15.70
15.65
15.60
15.55
15.50
15.45
15.40
15.35
15.30
15.25
15.20
190
191
192
193
194
195
196
197
198
199
200
Time (Day number in the year)
Natural
+ Foyers
+ Foyers + Loch na Cathrach
+Foyers + Kemp
+ Foyers + Loch na Cathrach + Kemp
L40

August

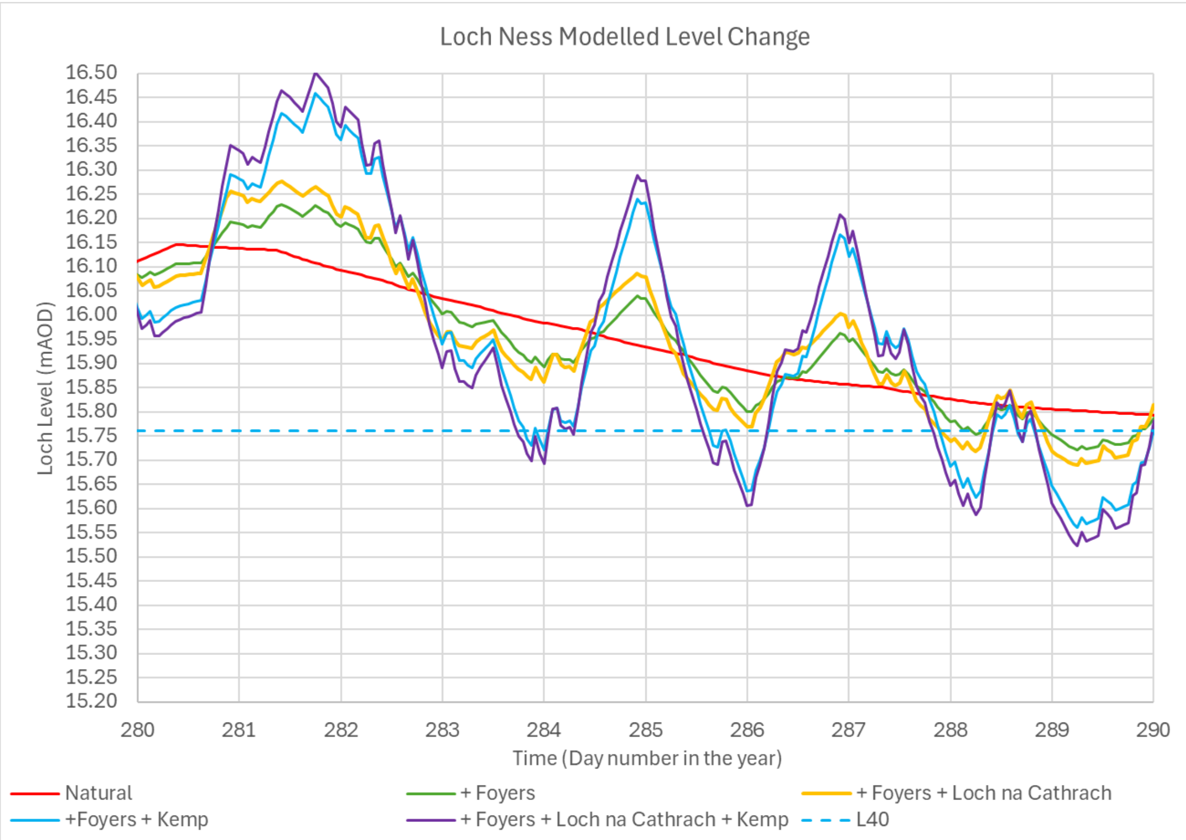


Loch Ness Modelled Level Change
Loch Level (mAOD)
16.50
16.45
16.40
16.35
16.30
16.25
16.20
16.15
16.10
16.05
16.00
15.95
15.90
15.85
15.80
15.75
15.70
15.65
15.60
15.55
15.50
15.45
15.40
15.35
15.30
15.25
15.20
220
221
222
223
224
225
226
227
228
229
230
Time (Day number in the year)
Natural
+ Foyers
+ Foyers + Loch na Cathrach
+Foyers + Kemp
+ Foyers + Loch na Cathrach + Kemp
L40

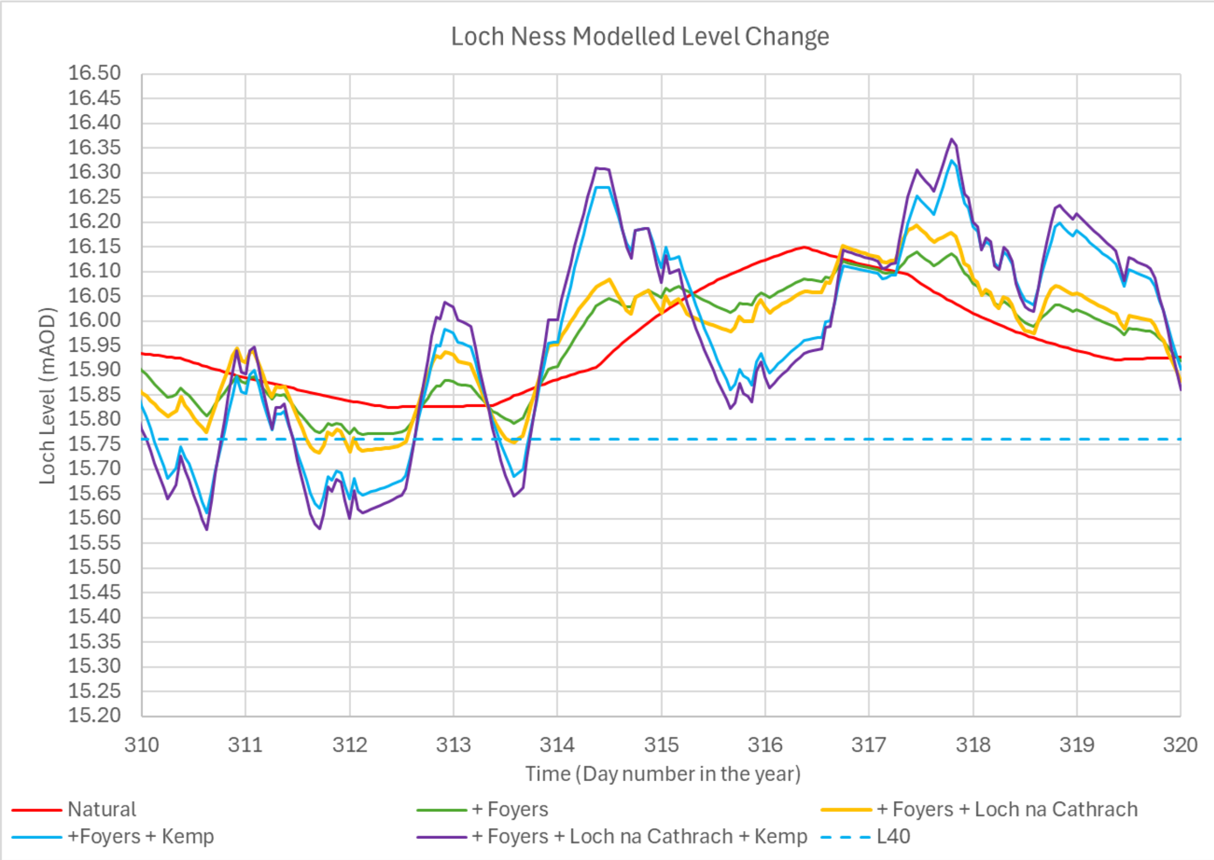
September



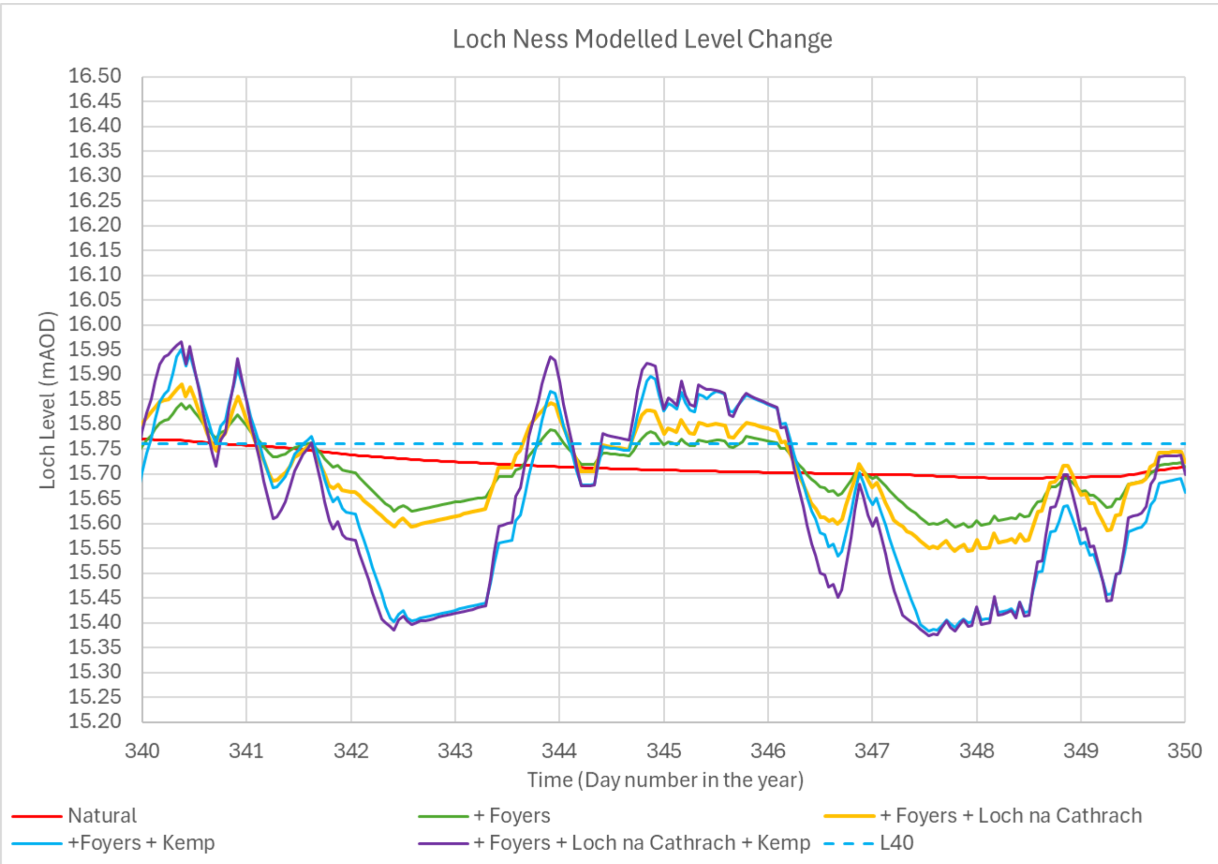
October



November



December



Appendix 2

Site Visit Photos 13/6/23 – Loch Ness Level ~15.42 mAOD

2-A Fish Pass Crest

2-B Fish Pass Apron

2-C Bottom of Fish Pass Apron

Appendix 3

3-A Hydraulic Summary Sheet – Fish Pass and SSE Sluice Gates at 28.3 m^3/s

Table 1. A review of the flow over the fish pass and under the gate for various loch levels (assuming 28.3m^3/s compensation flow)

Level in Loch Dochfour (mAOD)	Flow over the Service Weir (m3/s)	Dochfour Weir Fish Pass - Flow Conditions								SSE Sluice Gate - Flow Conditions					
		Flow over the Fish Pass (m^3/s)	1. Still water upstream of fish pass		2. Critical depth flow over fish pass crest		3. Downstream face normal depth (m)		Total flow under the gates (m^3/s)	1. Depth of opening under the gates (m)		Velocity directly under the gates - two gates open (m/s)	2. Depth at vena contracta (m)	Velocity at vena contracta - two gates open (m/s)
			Upstream water depth over weir (m)	Velocity from still water depth (m/s)	Critical depth (m)	Critical velocity (m/s)	Water depth (m)	Velocity at (m/s)		1 No. gate open only	2 No. gates open at equal heights			
15.7	**17.3**	**11.6**	**0.77**	**1.36**	**0.60**	**2.0**	**0.34**	**4.2**	**0.0**	**Closed**	**Closed**	**Closed**	**Closed**	**Closed**
15.67	12.9	10.8	0.74	1.33	0.58	1.9	0.32		4.4					
15.65	10.2	10.3	0.72	1.31	0.56	1.9	0.31		7.6					
15.62	6.7	9.5	0.69	1.28	0.54	1.9	0.29		12.0					
15.61	5.6	9.2	0.68	1.27	0.53	1.8	0.29		13.4					
15.6	**4.6**	**9.0**	**0.67**	**1.26**	**0.52**	**1.8**	**0.28**	**4.2**	**14.7**	**0.75**	**0.34**	**2.7**	**0.21**	**4.4**
15.59	3.6	8.7	0.66	1.26	0.51	1.8	0.28		15.9					
15.58	2.8	8.5	0.65	1.25	0.51	1.8	0.27		17.0					
15.57	2.0	8.2	0.64	1.24	0.50	1.8	0.27		18.0					
15.56	1.3	8.0	0.63	1.23	0.49	1.7	0.26		19.0					
15.55	0.7	7.7	0.62	1.22	0.48	1.7	0.26		19.8					
15.54	0.2	7.5	0.61	1.21	0.48	1.7	0.25		20.5					
15.53	SW Starts	7.3	0.6	1.20	0.45	1.8	0.25	4.0	21.0	Insufficient	0.53	2.5	0.32	4.0
15.52	N/A	7.0	0.59	1.19	0.44	1.8	0.24		21.2					
15.51	N/A	6.8	0.58	1.18	0.44	1.8	0.24		21.5					
15.50	N/A	6.6	0.57	1.17	0.43	1.8	0.23	3.9	21.7	Insufficient	0.56	2.4	0.34	4.0
15.49	N/A	6.4	0.56	1.16	0.42	1.7	0.23		21.9					
15.48	N/A	6.2	0.55	1.15	0.41	1.7	0.22		22.1					
15.47	N/A	6.0	0.54	1.14	0.40	1.7	0.22		22.3					
15.46	N/A	5.8	0.53	1.13	0.40	1.7	0.21		22.5					
15.45	N/A	5.6	0.52	1.13	0.39	1.7	0.21	3.8	22.7	Insufficient	0.61	2.3	0.37	3.8
15.44	N/A	5.4	0.51	1.12	0.38	1.7	0.20		22.9					
15.43	N/A	5.2	0.5	1.11	0.37	1.7	0.20	3.7	23.1	Insufficient	0.63	2.3	0.39	3.7
15.42	N/A	**5.0**	**0.49**	**1.10**	**0.36**	**1.6**	**0.19**		**23.3**					
15.41	N/A	4.8	0.48	1.09	0.36	1.6	0.19		23.5					
15.40	N/A	4.6	0.47	1.08	0.35	1.6	0.18		23.7					
15.39	N/A	4.4	0.46	1.07	0.34	1.6	0.18		23.9					
15.38	N/A	4.3	0.45	1.05	0.33	1.6	0.17		24.0	Insufficient	0.69	2.2	0.42	3.6
15.37	N/A	4.1	0.44	1.04	0.33	1.6	0.17		24.2					
15.36	N/A	3.9	0.43	1.03	0.32	1.5	0.16		24.4	Insufficient	0.71	2.1	0.44	3.5
15.35	N/A	3.8	0.42	1.02	0.31	1.5	0.16		24.5					
15.34	N/A	3.6	0.41	1.01	0.30	1.5	0.15		24.7					
15.33	N/A	3.4	0.4	1.00	0.29	1.5	0.15	3.5	24.9	Insufficient	0.76	2.1	0.46	3.4
15.32	N/A	3.3	0.39	0.99	0.29	1.5	0.14		25.0					
15.31	N/A	3.1	0.38	0.98	0.28	1.5	0.14		25.2					
15.30	N/A	3.0	0.37	0.97	0.27	1.4	0.14		25.3					
15.27	N/A	**2.6**	**0.34**	**0.93**	**0.25**	**1.4**	**0.12**	**3.2**	**25.7**	Insufficient	**0.88**	**1.8**	**0.54**	**3.0**

Appendix C: A Note on Salmon Smolt Swimming Depth

Appendix C: A Note on Salmon Smolt Swimming Depth

March 2025

AZTEC
MANAGEMENT
CONSULTANTS

Contents

Swimming Depth of Atlantic Salmon Smolt

1.1 Introduction

1.1.1 Loch Kemp Storage Ltd (the Applicant) previously appointed Aztec Management Consultants (Aztec) to provide advice on a suitable fish deterrent system at the inlet structure of the Proposed Loch Kemp Storage Pumped Storage Hydro (PSH) Scheme, to prevent Atlantic salmon (*Salmo salar*) smolt from being attracted to the inlet structure during pumping cycles. Aztec advised that the most effective method to deter smolt from the inlet would be to install a buoyed barrier net with 12.5 mm mesh spacing during the smolt season (March – June). Aztec also advised that the net would need to extend up to 10 m below the surface level of to exclude salmon smolt.

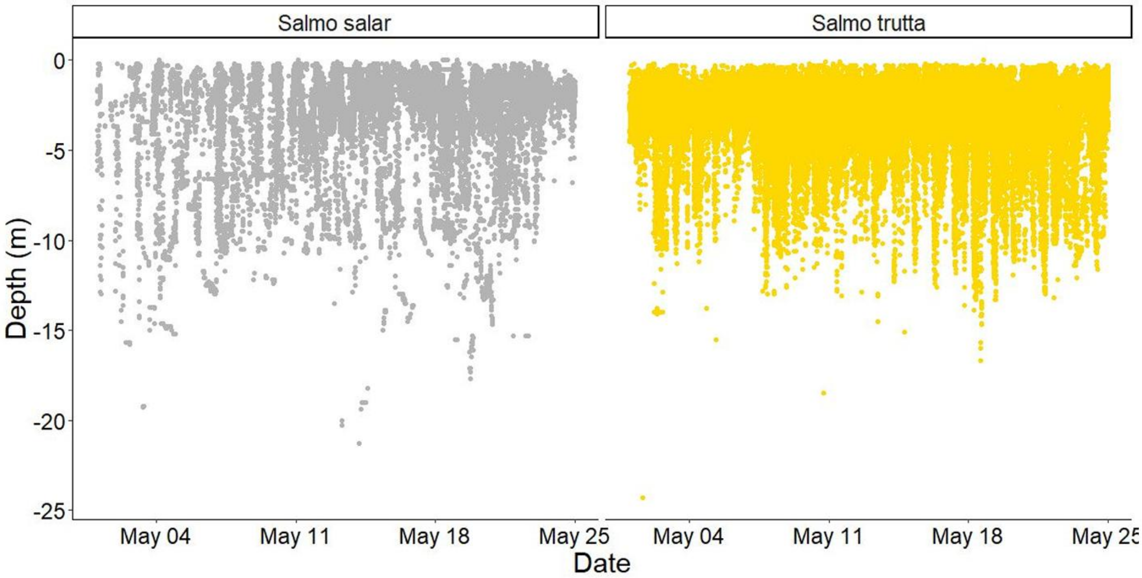
1.1.2 Following the advice provided on the smolt deterrent system previously, the Applicant has requested that Aztec advise on the effectiveness of a net extending to a depth of 10 m below the surface of Loch Ness for excluding salmon smolt, given the loch depth may be deeper than 10 m at some locations around the inlet screens. The purpose of this Memo is therefore to provide additional information on the swimming depths of Atlantic salmon smolt in freshwater lakes, which will provide evidence that a barrier net extending up to 10 m below the surface level of Loch Ness would effectively exclude Atlantic salmon smolt from the area surrounding the inlet structures of the proposed Loch Kemp Storage PSH Scheme.

1.1.3 While the scientific literature is replete with accounts of salmon smolt migrating in rivers and lakes, there is a dearth of information relating to the depths at which they swim in freshwater lakes. However, the scientific literature that is available strongly suggests that salmon smolt are generally surface orientated and tend to occupy the upper layers of waterbodies. In this note, scientific articles are referenced which document the depths occupied by Atlantic salmon smolt in a Norwegian lake, by Atlantic salmon post-smolt in a Norwegian fjord and finally, by Atlantic salmon post-smolt in the open sea (in the context of avian predation).

1.2 Evidence from the Scientific literature

1.2.1 Nash *et al* (2022) studied the water depths at which Atlantic salmon smolt migrated in a Norwegian lake. Nash *et al* (2022) also studied the water depths occupied by piscovorous brown trout (Salmo trutta) during the salmon smolt migration period. Nash *et al* (2022) tracked 20 Atlantic salmon smolts and their most prevalent predator, brown trout (N=21), and recorded their depth use in a basin of Lake Evanger, Norway with acoustic telemetry during May 2020. Both salmon smolts (3.8 ± 3.3 SD m) and trout (2.9 ± 1.7 SD m) were distributed relatively close to the surface of the lake despite depths in the area largely exceeding 30 m. Both species were deeper at midday and smolts tended to be deeper in the water earlier in the migration, overlapping less with trout early in May, but as daily daylight increased and water temperature warmed, vertical distribution of smolts and trout increasingly overlapped. Figure 2 of Nash *et al (*2022) is reproduced as Graph 1 below and illustrates that the vast majority of detections of salmon smolt were at 0-5 m and 5-10 m from the surface. Deeper detections may have been associated with attempts to escape piscovorous predators.

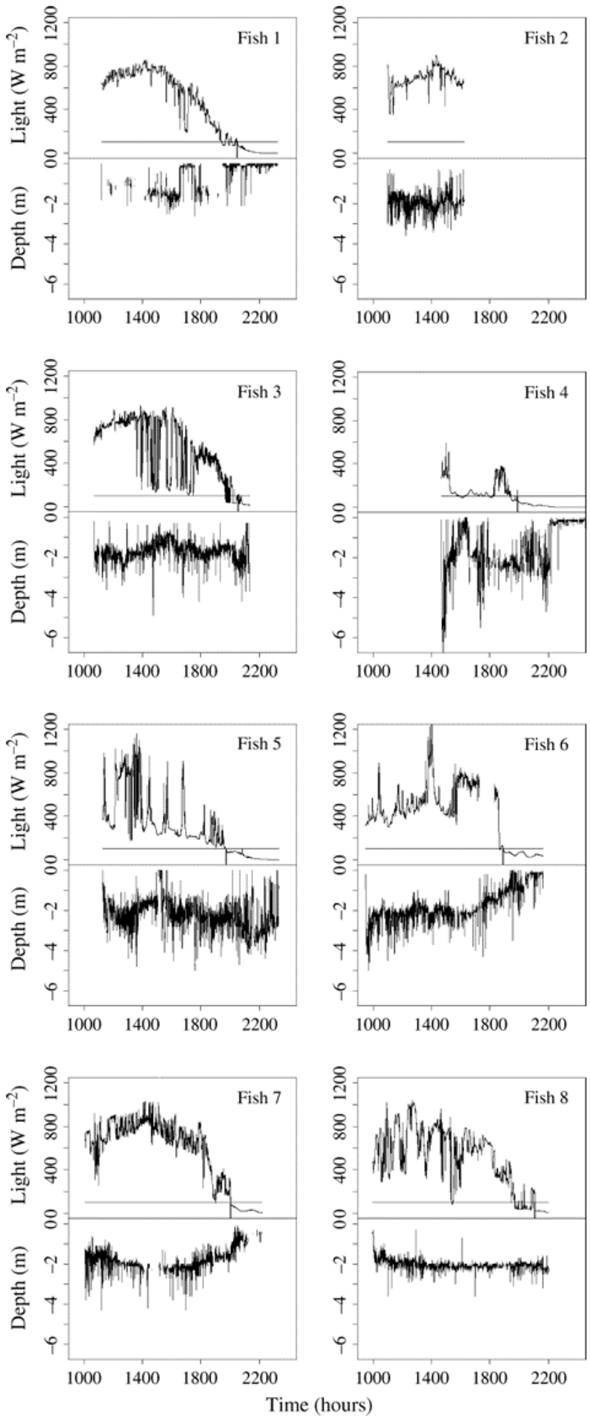
Graph 1: Raw Detections (N=822836) of Atlantic salmon (Salmo salar; grey) and brown trout (Salmo trutta; gold) in the eastern basin of Lake Evenger with individual depth. Taken from Nash *et al* (2022) (Figure 2).



1.2.2 After leaving freshwater, there is further evidence that Atlantic salmon post-smolt maintain their surface orientated behaviour and ecology. Davidsen *et al* (2008) studied the behaviour of eight hatchery-reared Atlantic salmon *Salmo salar* post-smolts, implanted with acoustic depth sensing transmitters and manually tracked for 5–12 h in the Hardangerfjord (Norway). They found that these fish spent most of their time (49–99%) at 1–3 m depth during the day, whereas four of seven fish tracked were found close (<0.5 m) to the surface at night, with a strong negative cross-correlation between general swimming depth and surface light intensity. No cross-correlations were found between light intensity and swimming depth during daytime periods with rapid changes in light intensity, indicating that other factors than light intensity were important in initiating the irregular dives that were recorded down to 6.5 m depth.

1.2.3 Fig.1 from Davidsen *et al* (2008) is reproduced as Graph 2 below, describes the depths occupied by each tagged Atlantic salmon post-smolt over the study period of up to 12h.

Graph 2: Depths occupied by tagged Atlantic salmon (*Salmo salar*) post-smolt over a study period of up to 12h in the Hardangerfjord (Norway)



1.2.4 When Atlantic salmon post-smolt enter the open ocean there is also evidence that they maintain a surface orientation which makes them vulnerable to avian predators. Northern gannets (*Morus bassanus*), the largest seabird species breeding in Canada, plunge-dive into surface waters to capture pelagic prey, including post-smolt Atlantic salmon that frequently swim in surface waters.

1.2.5 Similarly, adult Atlantic salmon returning to natal rivers from distant marine feeding areas are vulnerable to surface orientated commercial fishing gear e.g. drift nets as they approach coastal waters. Typically, these drift-nets fish the top 10 metres of water and because of their indiscriminate nature (capable of catching salmon destined for one to several natal rivers) they have now been outlawed in most countries where rivers support Atlantic salmon populations.

1.3 Summary

1.3.1 In summary, while the fry / parr stage of the salmon life-cycle is spent in shallow fast flowing sections of rivers and streams where the young fish are orientated benthically – using their large pectoral fins against the current to maintain station close to the river bed, once smoltification occurs the fish become surface orientated and this orientation continues throughout their migration through freshwater rivers and lakes and also in estuarine and open sea habitat and even continues throughout their return marine migration as adult salmon before they enter the natal river. The colouration of salmon smolt, post-smolt and adults at sea and on their immediate return as adults to freshwater is generally a white underbelly, silver sides and darker dorsal appearance. These colouration characteristics may make post-smolt more vulnerable from diving avian predators such as gannets but probably assist smolt, post-smolt and adults in minimising predation from below.

1.3.2 Whilst the scientific literature relating to the depths at which salmon smolt swim in freshwater lakes, provides evidence that salmon smolt are generally surface orientated and tend to occupy the upper layers of freshwater bodies. The scientific articles referenced within this note document the depths occupied by Atlantic salmon smolt in a Norwegian lake, which provide evidence that a barrier net extending to a depth of 10 m from the loch surface level, would effectively exclude salmon smolt in Loch Ness from the area surrounding the inlet structures of the proposed Loch Kemp Storage Scheme.

1.4 References

Davidsen JG, N Plantalech Manel-la, F Økland, OH Diserud, EB Thorstad, B. Finstad, R Sivertsgard, RS Mckinley and AH Rikardsen (2008), Changes in swimming depths of Atlantic salmon Salmo salar post-smolts relative to light intensity. Journal of Fish Biology (2008) **73**, pages 1065–1074.

Montevecchi WA, DK Cairns and RA Myers (2002), Predation on marine-phase Atlantic salmon (Salmo salar) by gannets (Morus bassanus) in the Northwest Atlantic. Can. J. Fish. Aquat. Sci. **59**: pages 602–612.

Nash AJ, KW Vollset, EM Hanssen, S Berhe, AG Salvanes, TE Isaksen, BT Barlaup, RJ Lennox (2022)), A tale of two fishes: depth preference of migrating Atlantic salmon smolt and predatory brown trout in a Norwegian lake. Canadian Journal of Fisheries and Aquatic Sciences **79** (12).

Appendix D: Loch Kemp Pumped Hydro - 3D CFD Simulations on Fish Screen Location and Depth

Loch Kemp Pumped Hydro

3D CFD Simulations on Fish Screen Location and Depth

Thorsten Stoesser and Shaswat Saincher
University College London

Final DRAFT
09/04/25

Background

Understanding the effect of water flow velocities within watercourses and waterbodies to is critical to determine design parameters to mitigate potential environmental impacts during operation of hydropower schemes.

This 3D CFD assessment has been conducted to computationally model the maximum pumping flow velocity impacts in Loch Ness as a result of the Loch Kemp pumped storage hydropower (PSH) facility. This modelling includes the assessment of a fish barrier net structure, positioned at a range of distances from the intake screens to assess varying flow impacts. The impacts of the scheme on fish, particularly protected species such as Atlantic Salmon, must be understood in terms of both the likelihood of: fish entrainment in pumping flows (the inability to swim against the scheme abstracting water); and flow signal generation which could affect the migration of juvenile salmon smolt migration through Loch Ness. The currently accepted escape velocity criterion for salmon smolts is 0.30 m/s, whilst an accepted velocity criterion for salmon smolt flow signal cues has been determined at 0.092 m/s (the lower 95% confidence limit for wild Atlantic salmon smolts from Kundegorski et al 2025).

Therefore, this modelling aims to assist in determining if the deployment of the fish barrier net structure would reduce pumping flow velocities in the surface waters of Loch Ness to negligible velocities, therefore significantly reducing the likelihood of a flow signal being perceivable by migratory salmon smolt.

Aim and Objectives

The overarching aim of the simulations is to quantify the hydrodynamics in Loch Ness around the powerhouse intake structure, and to demonstrate the effectiveness of various fish barrier net locations in reducing local flow velocities. The following objectives to achieve this aim are to:

1. perform numerical simulations of three-dimensional flows in the area of the intake powerhouse,
2. evaluate the effectiveness of fish barrier net of nominal 10m depth, located at distances of 27m and 40m away from the intake screen,
3. quantify flow speeds through and around the fish barrier net, in view of achieving minimal velocities, ideally significantly lower than previous observed natural background flow velocities (c.0.10 m/s),
4. assess the velocity distribution at the intake screen, ideally as uniform as possible and at 0.3m/s over the entire screen.

In order to meet these objectives, high-resolution, three-dimensional numerical simulations using the method of computational fluid dynamics are carried out.

Computational Approach

For the simulations, a Reynolds-averaged Navier Stokes (RANS) solver is employed. The code solves the RANS equations, on an unstructured mesh with collocated arrangement of velocity and pressure. Advective terms are approximated with a first order scheme whereas diffusive terms are approximated using the central scheme. The pressure is solved using the SIMPLE pressure correction scheme which requires the solution of a Poisson equation. The simulations are run in steady state mode, i.e. the time derivative is zero and the solver starts from a uniform velocity distribution and iterates until the three momentum equations and the continuity equation are converged (convergence criteria is ε=0.0005). The Reynolds stresses are approximated with the k-ω SST model, a reliable two-equation approach. The simulations are performed on a Linux-based workstation employing 30 cores.

Domain and Boundary Conditions

The numerical simulations require boundary conditions at all boundaries of the computational domain (which is presented in Figure 0.0). Inflow conditions at the deep end of the bathymetry are specified as constant volumetric flow rate of $Q = 360\ m^3/s$ which is distributed evenly over the inflow plane. The no-slip condition is applied at the bottom of the domain and at all structures. The two intake screens represent the outlet of the flow domain and here a constant pressure is prescribed with the volume flux prescribed as $Q_1 = 180\ m^3/s$ for Intake 1 and $Q_2 = 180\ m^3/s$ for Intake 2 so that the total volumetric flow rate is distributed evenly between the two intakes. The water surface is assumed to be flat and the velocity gradients at the water surface are set to zero (rigid lid approximation). The barrier net is a porous wall and the permeability is low, i.e. the same as P_1 described in the preliminary 2D simulations (see Figure 0.2).

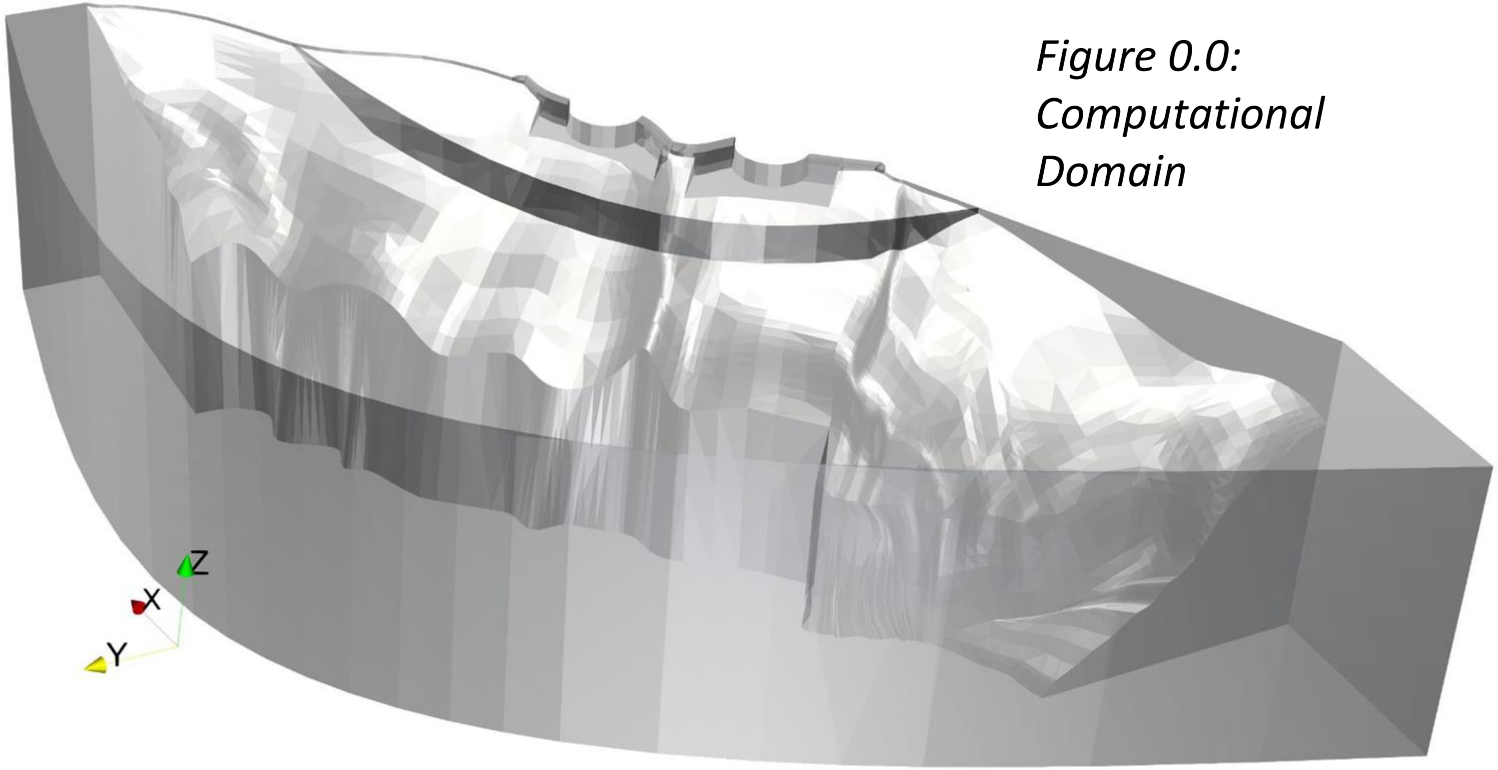


Figure 0.0: Computational Domain

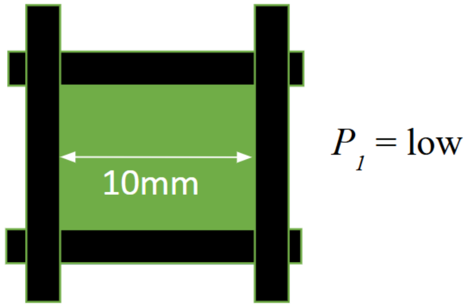


Figure 0.1: Fish screen dimensions

Computational Domain

Coordinates of key points (approx.)		
Point	$x(m)$	$y(m)$
1	-105	0
2	**0**	**0**
3	161.5	90
4	261	198
5	424	322
6	498	400
7	498	440

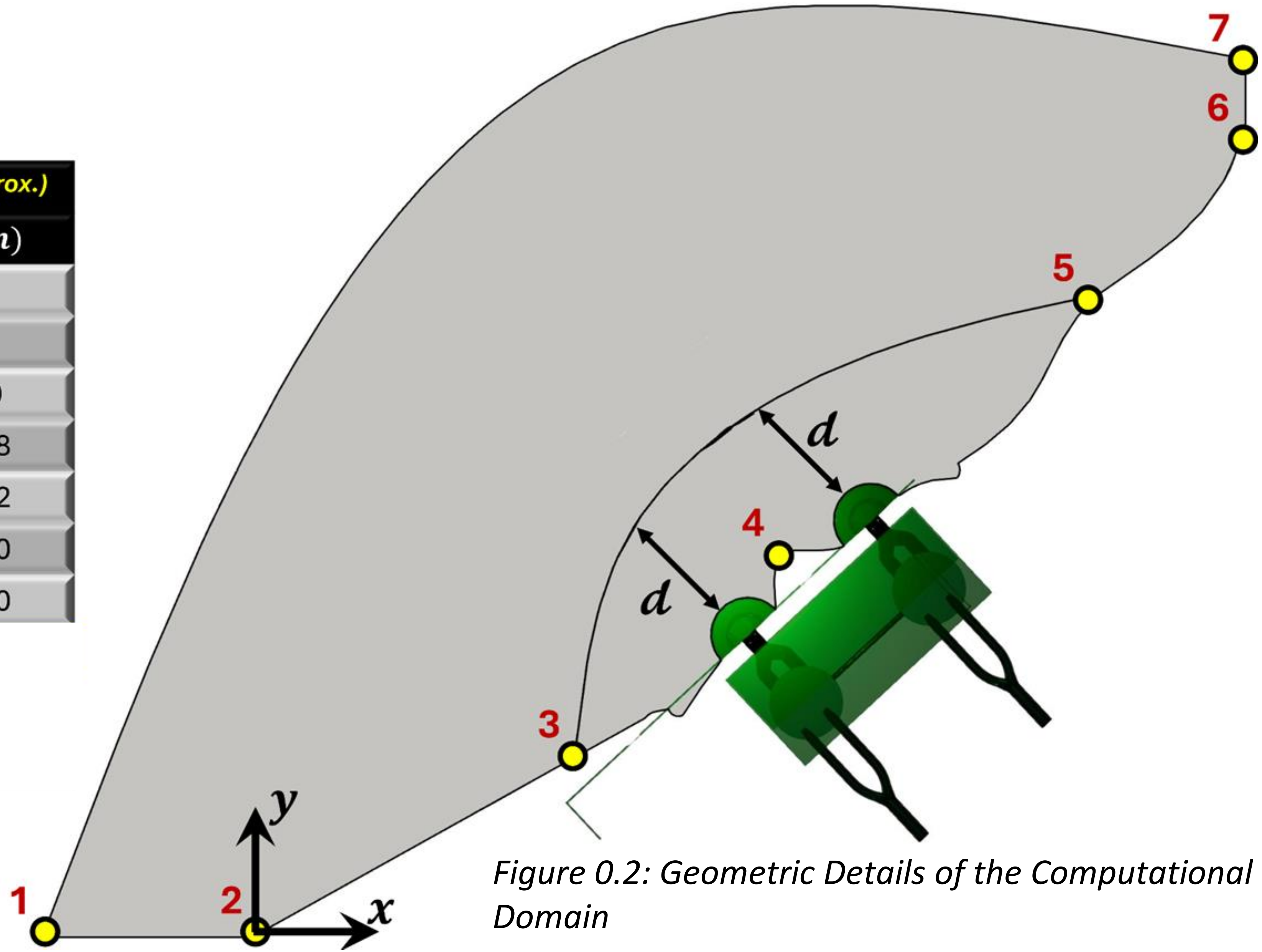


Figure 0.2: Geometric Details of the Computational Domain

Computational Mesh

The computational mesh consists of **2.8 million** cells in total, derived from bathymetric surveys conducted in Loch Ness; Figure 0.3 presents a plan view of the mesh in the horizontal plane at the water surface. The mesh is fairly coarse at the peripheral boundaries, where the water is deep and velocities are very small, of the order of (a couple of) mm/s; the mesh size in the coarse mesh region is approximately **5m** in the horizontal and **4m** in the vertical. At the pivot point of the bathymetry the mesh is refined due to the occurrence of extremely steep geometrical gradients and this fine mesh is being maintained towards the intake structure. At the intake structure the mesh is refined to **1m** in both the horizontal and vertical directions. At the barrier net location, the mesh is **0.1m** in the horizontal and **1m** in the vertical direction. An oblique view of the mesh with two longitudinal planes is depicted in Figure 0.4; the refinement towards the intake structure can be appreciated.

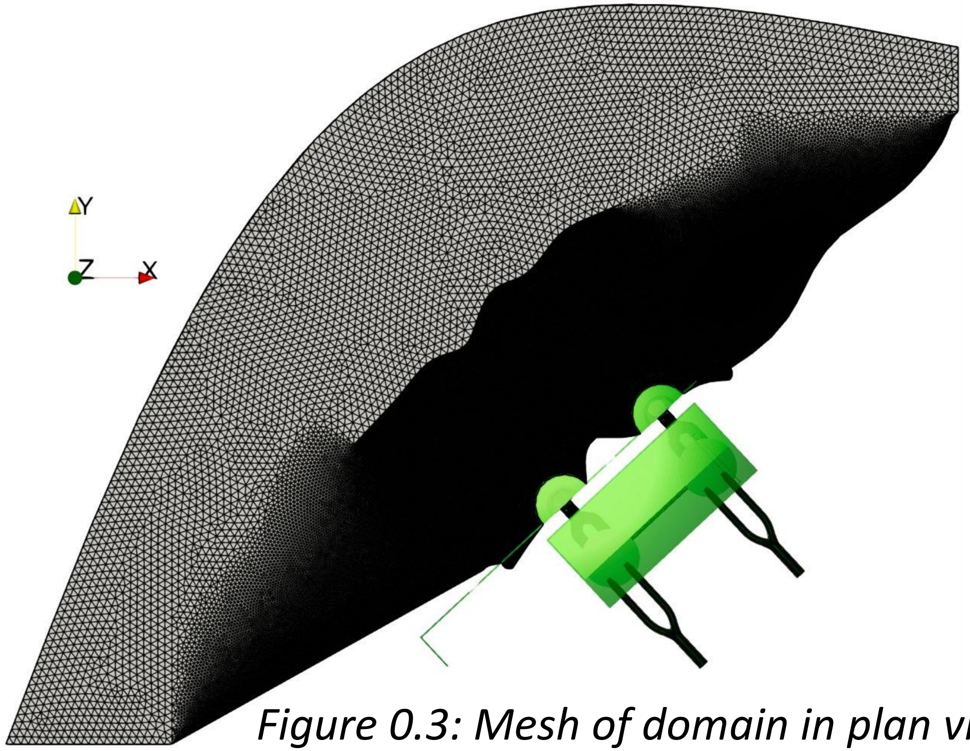


Figure 0.3: Mesh of domain in plan view

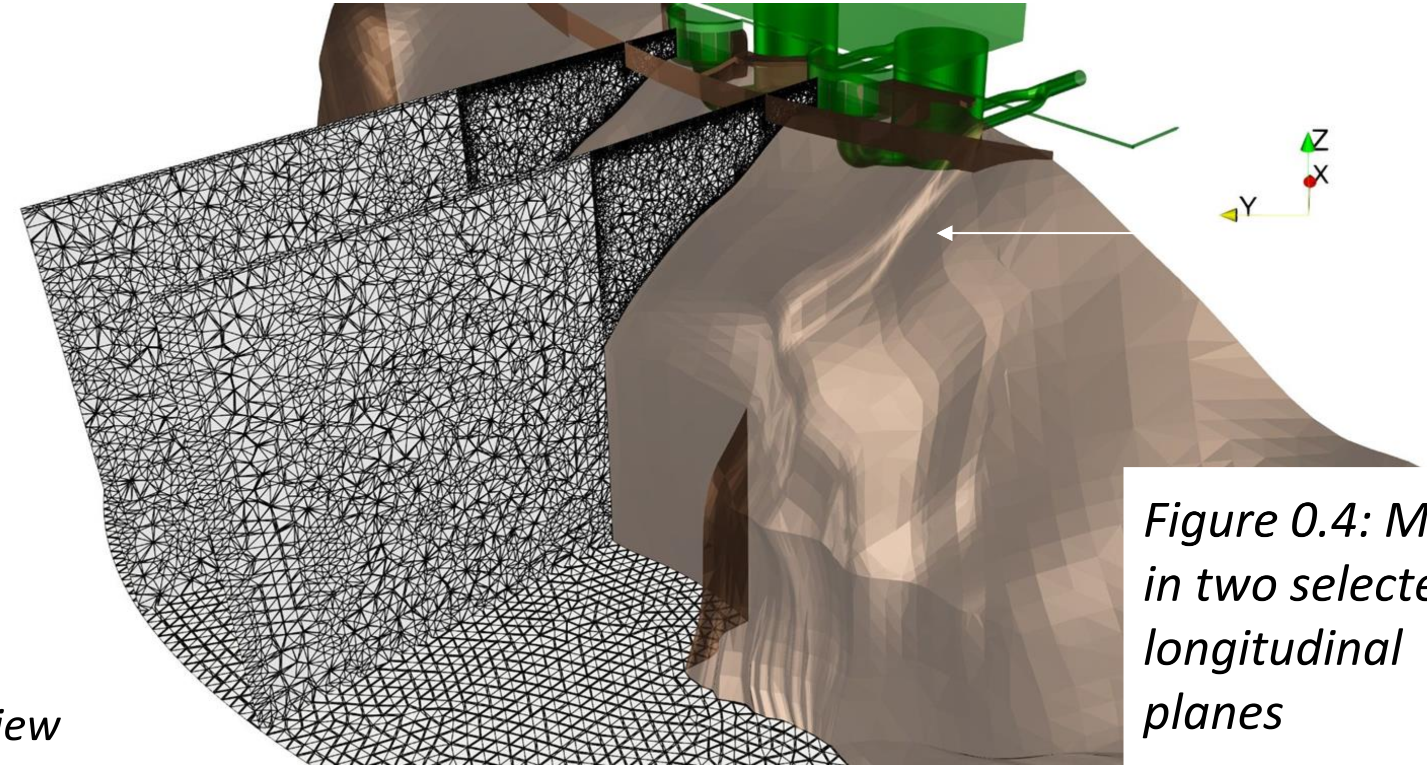


Figure 0.4: Mesh in two selected longitudinal planes

Results - Case 1 - *L* = 27m , *D* = 10m

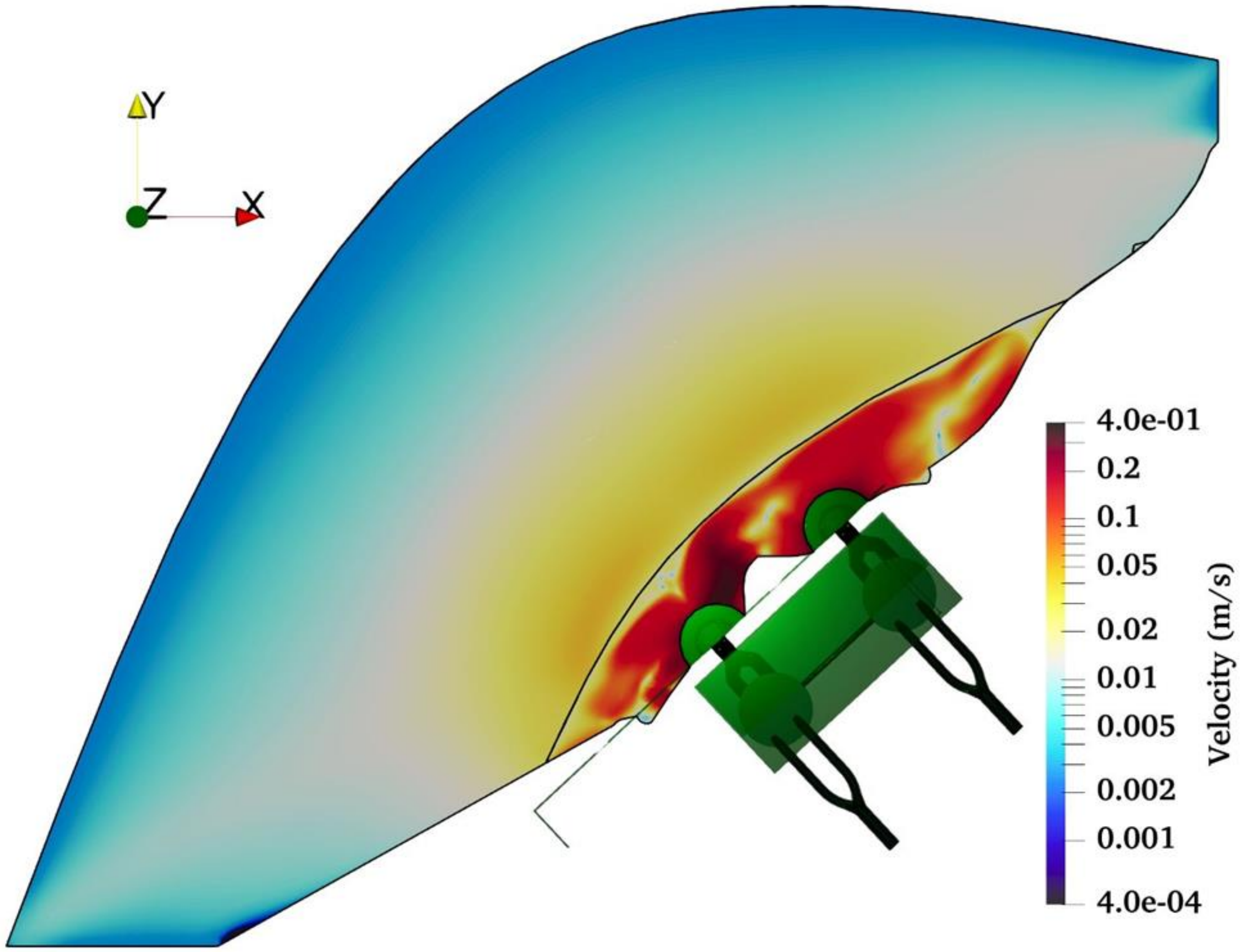


Figure 1.1: Contours of the velocity magnitude (in m/s) in a horizontal plane at the water surface

Results - Case 1 - *L* = 27m , *D* = 10m

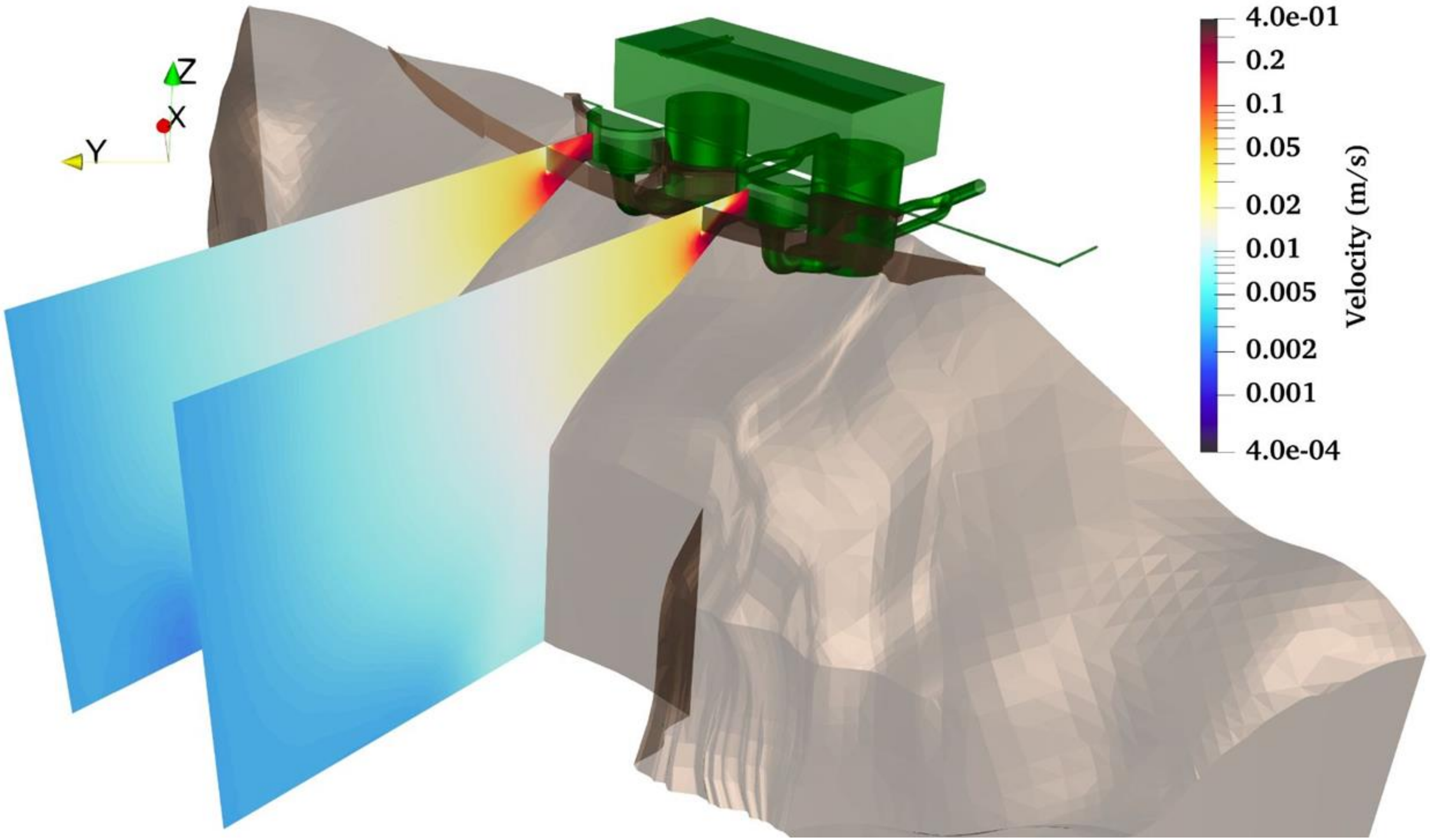


Figure 1.2: Contours of the velocity magnitude (in m/s) in two selected longitudinal sections

Results - Case 1 - *L* = 27m , *D* = 10m

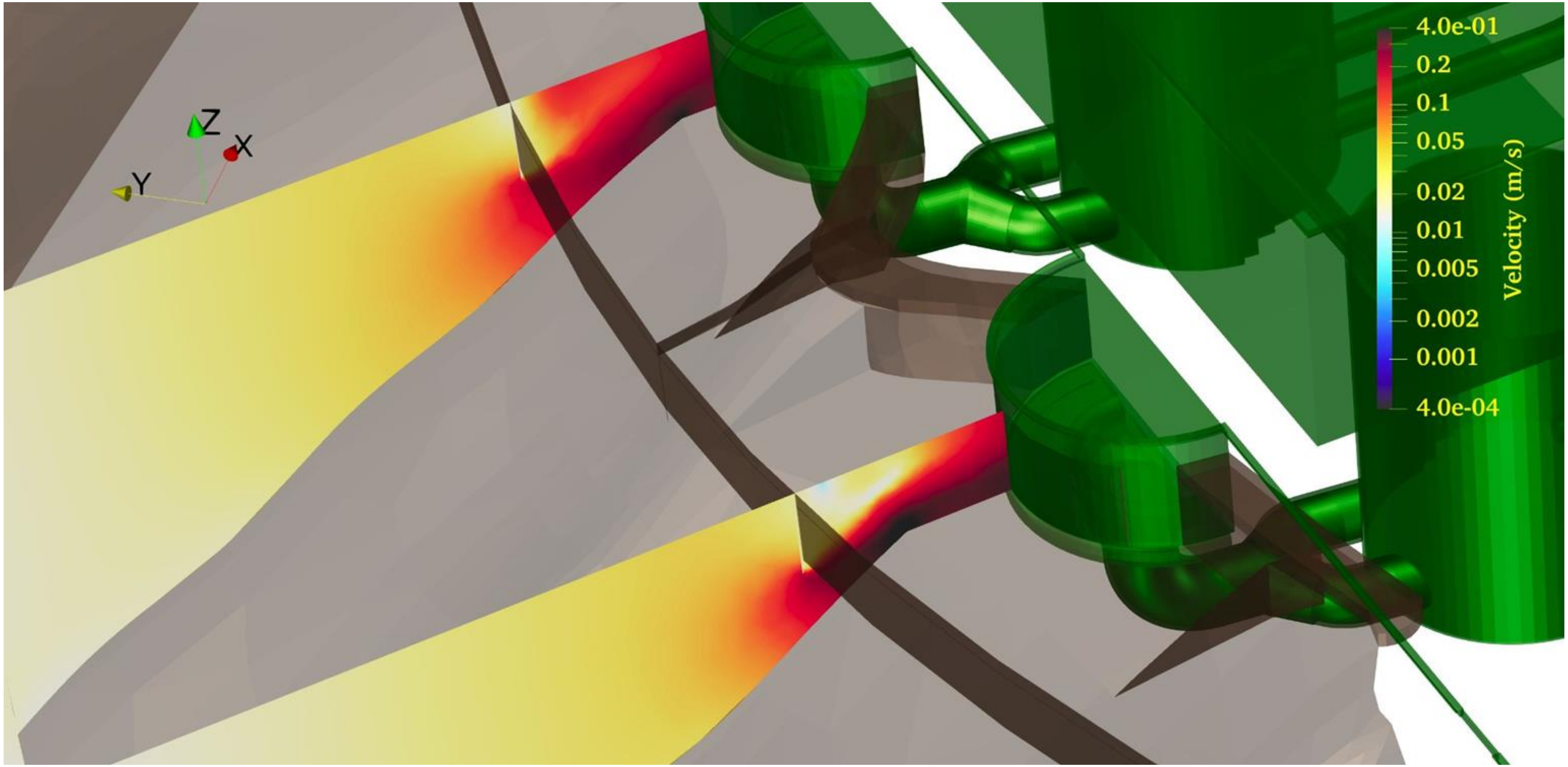


Figure 1.3: Contours of the velocity magnitude (in m/s) in the vicinity of the barrier net and intakes

Results - Case 1 - *L* = 27m , *D* = 10m

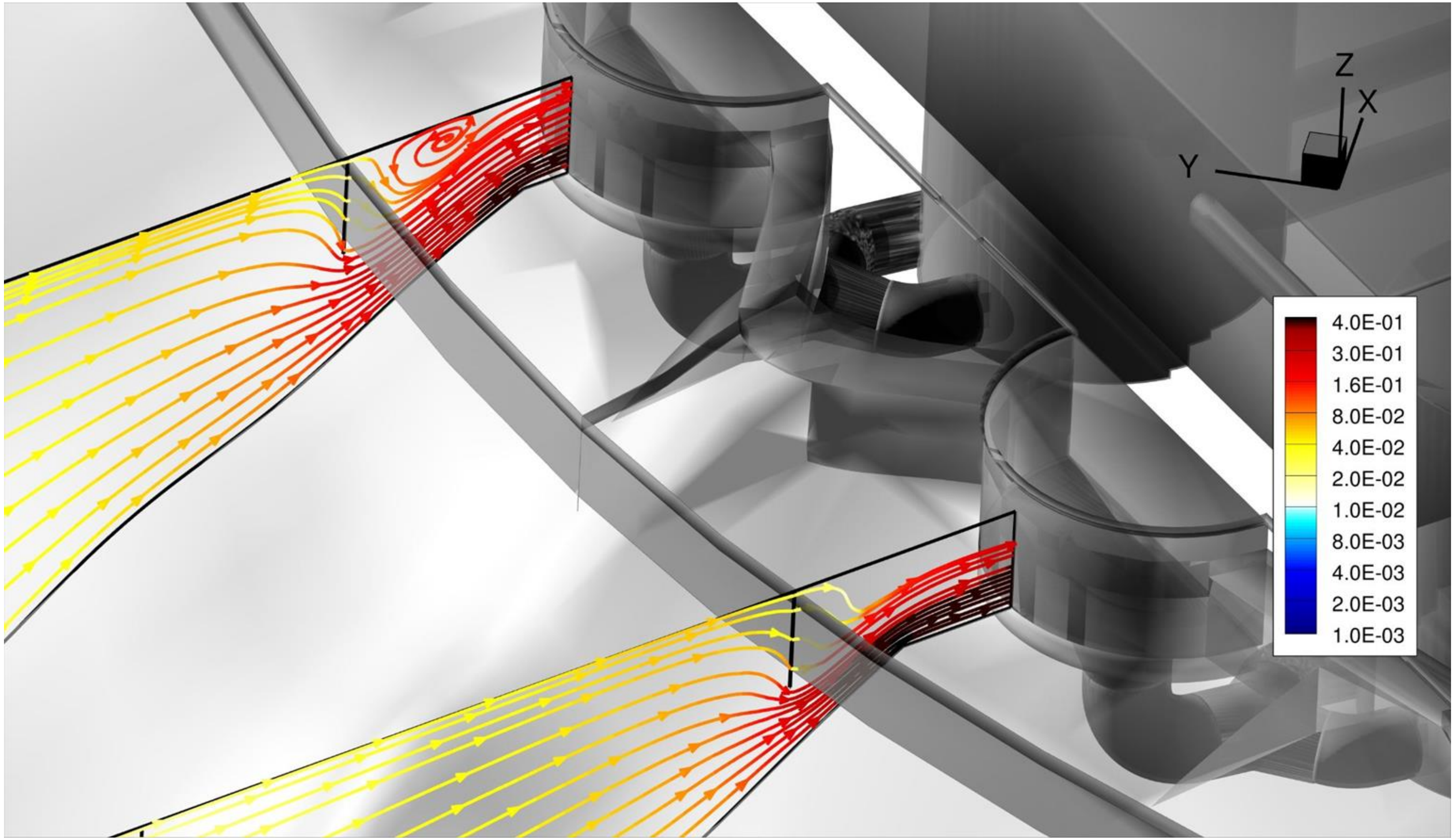


Figure 1.4: Streamtraces coloured with contours of velocity magnitude (in m/s) in the vicinity of the barrier net and intakes

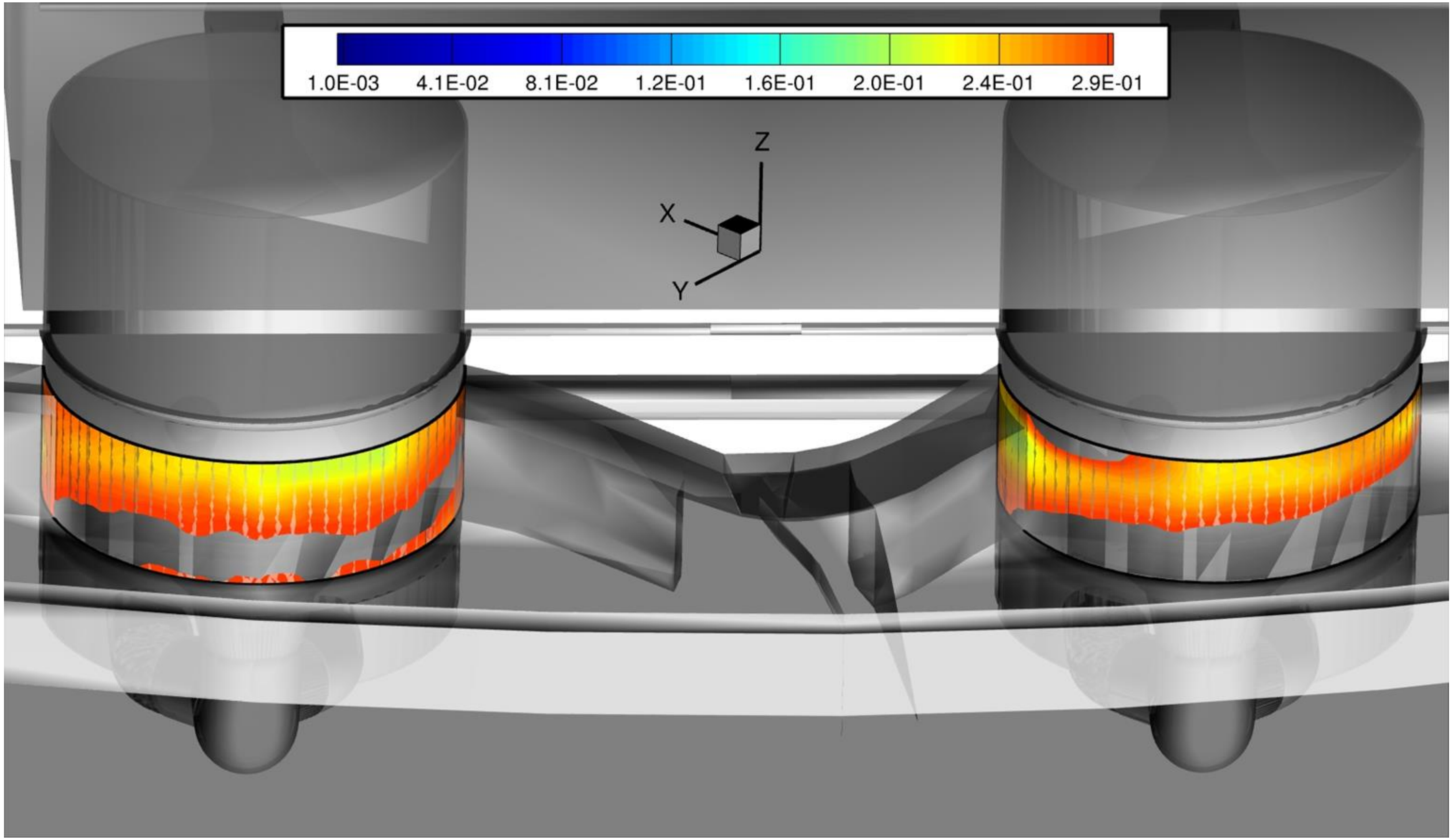


Figure 1.5: Contours of the velocity magnitude (in m/s) at the intakes; areas where the velocity is > 0.3m/s are blanked out.

Discussion - Case 1 - *L* = 27m , *D* = 10m

Figure 1.1: Presents contours of the velocity magnitude in a horizontal plane near the water surface. With the barrier net located 27m away from the intake screen, the calculated velocities are approximately 0.05 - 0.08 m/s both upstream and downstream of the barrier net. Beyond this point, surface flow velocities continue to decrease to <0.01 m/s i.e. <10 mm per second. Therefore, the low permeability of the 10mm mesh spacing barrier net demonstrates a strong flow attenuation within the surface 10 m depth of Loch Ness.

At the intakes, the flow accelerates underneath the barrier net and remains highest near to the loch bed (Figure 1.2 and Figure 1.3). This is detrimental to the performance of the intake screen, at which an uneven velocity distribution is observed, particularly at the southern intake. Streamlines of the velocity are presented in Figure 1.4 and these quantify the acceleration underneath the barrier net where the velocity becomes >0.3 m/s in places. The flow into both intakes is non-uniform and where flow velocities of 0.3 m/s are exceeded, these are displayed in Figure 1.5 as blanked areas.

Based on the above flow distribution and velocities at the intake screen, the 27 m location is not considered suitable for barrier net placement.

Results - Case 2 - L = 40m , D = 10m

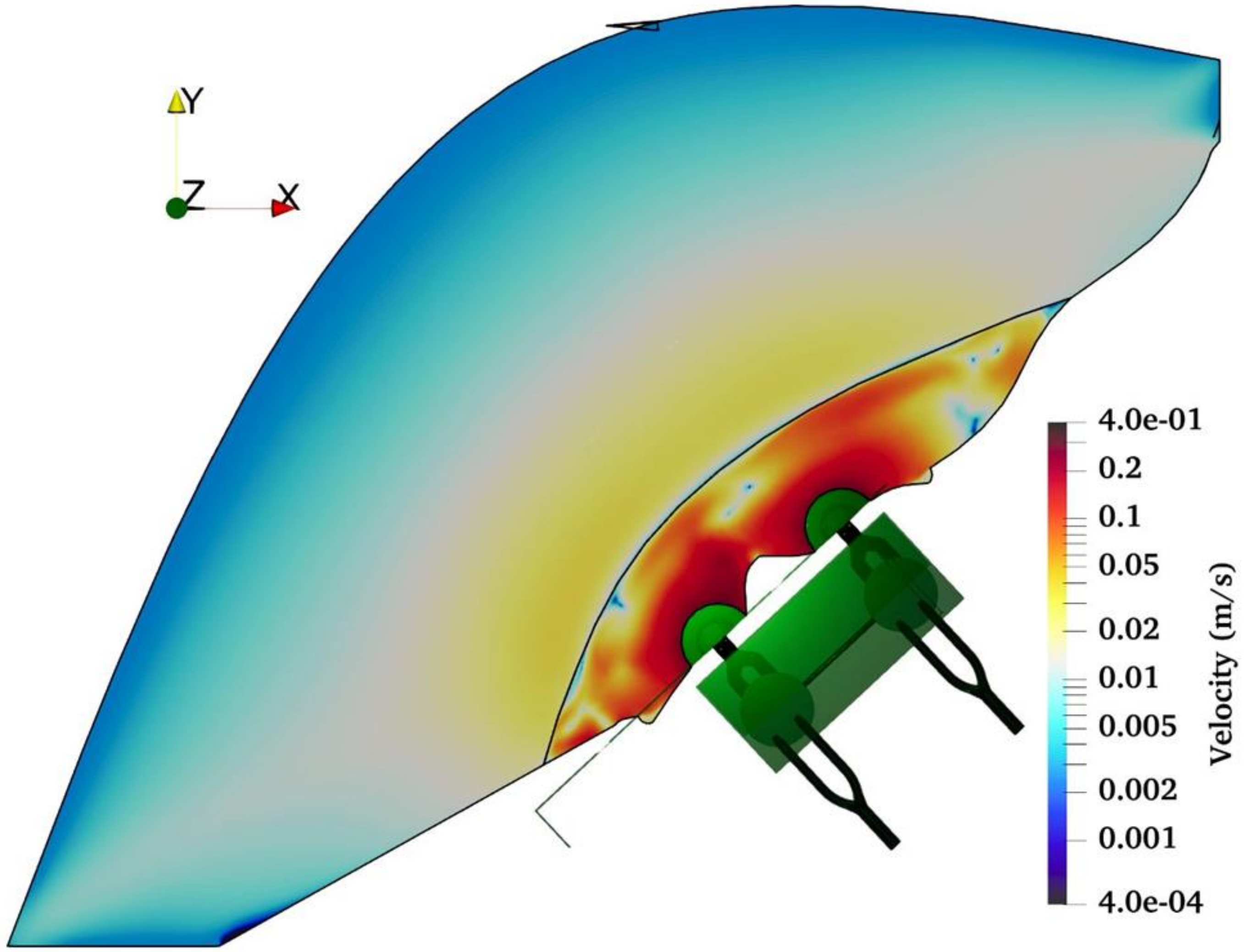


Figure 2.1: Contours of the velocity magnitude (in m/s) in a horizontal plane at the water surface

Results - Case 2 - *L* = 40m , *D* = 10m

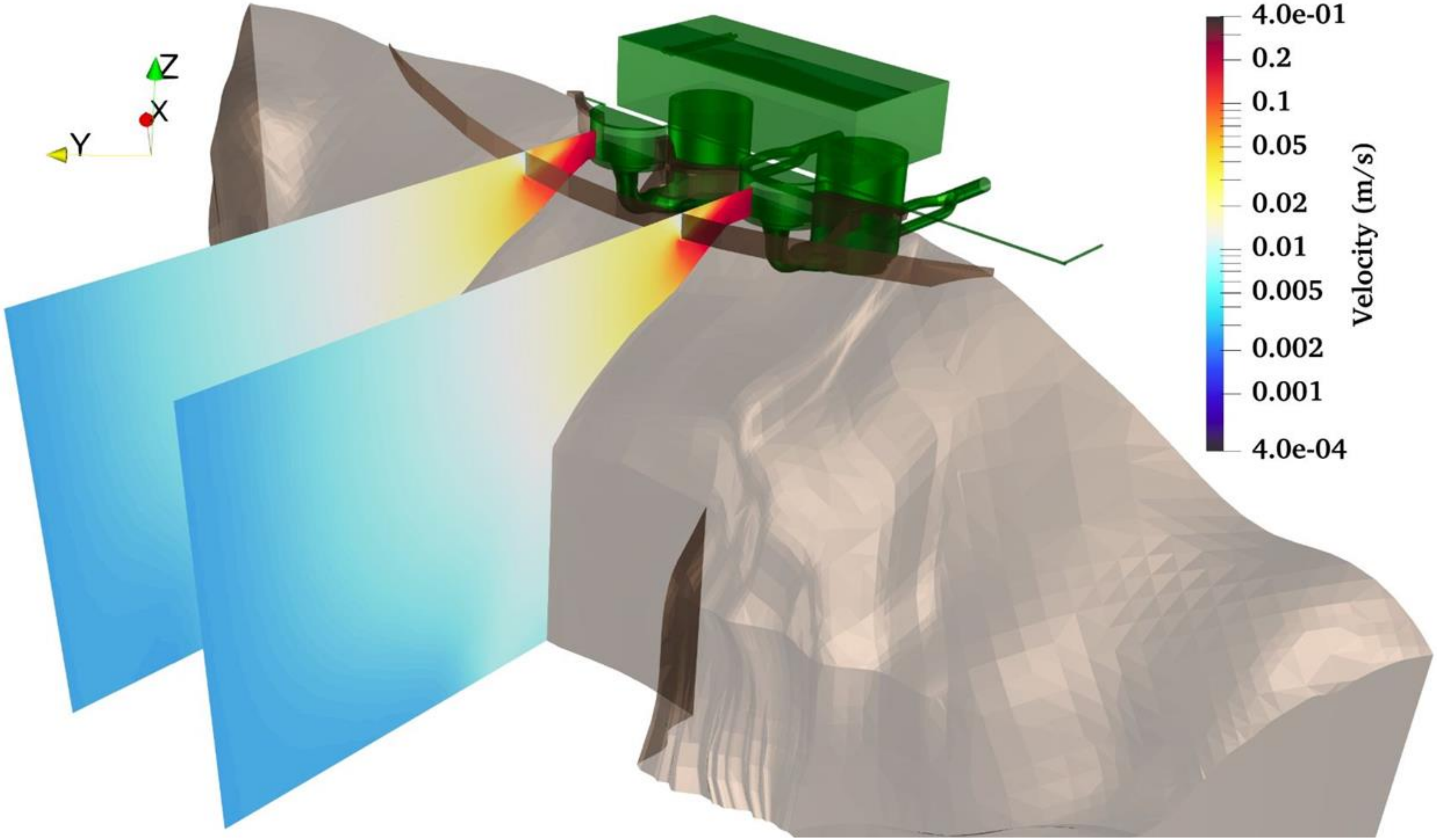


Figure 2.2: Contours of the velocity magnitude (in m/s) in two selected longitudinal sections

Results - Case 2 - *L* = 40m , *D* = 10m

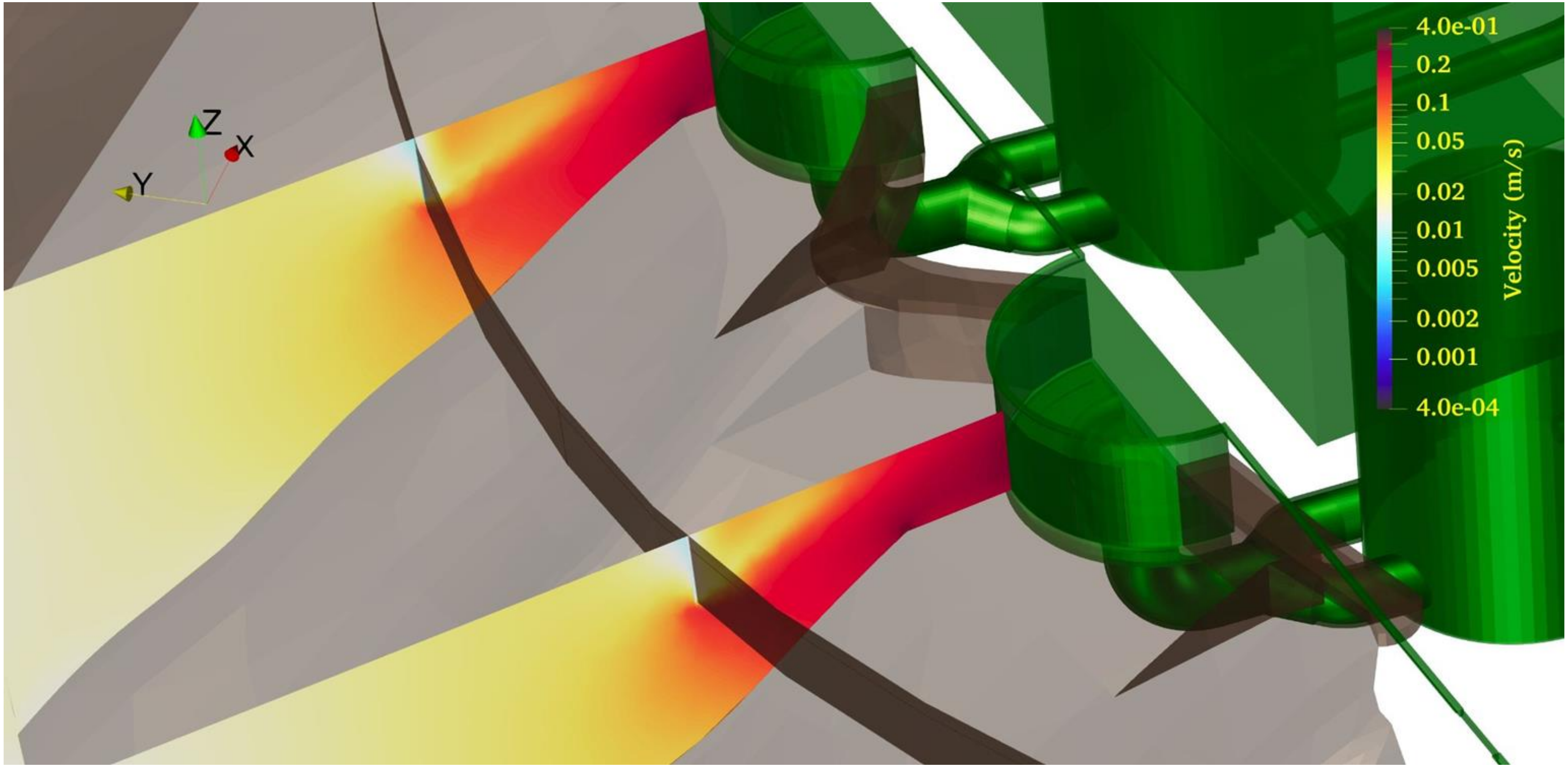


Figure 2.3: Contours of the velocity magnitude (in m/s) in the vicinity of the barrier net and intakes

Results - Case 2 - *L* = 40m , *D* = 10m

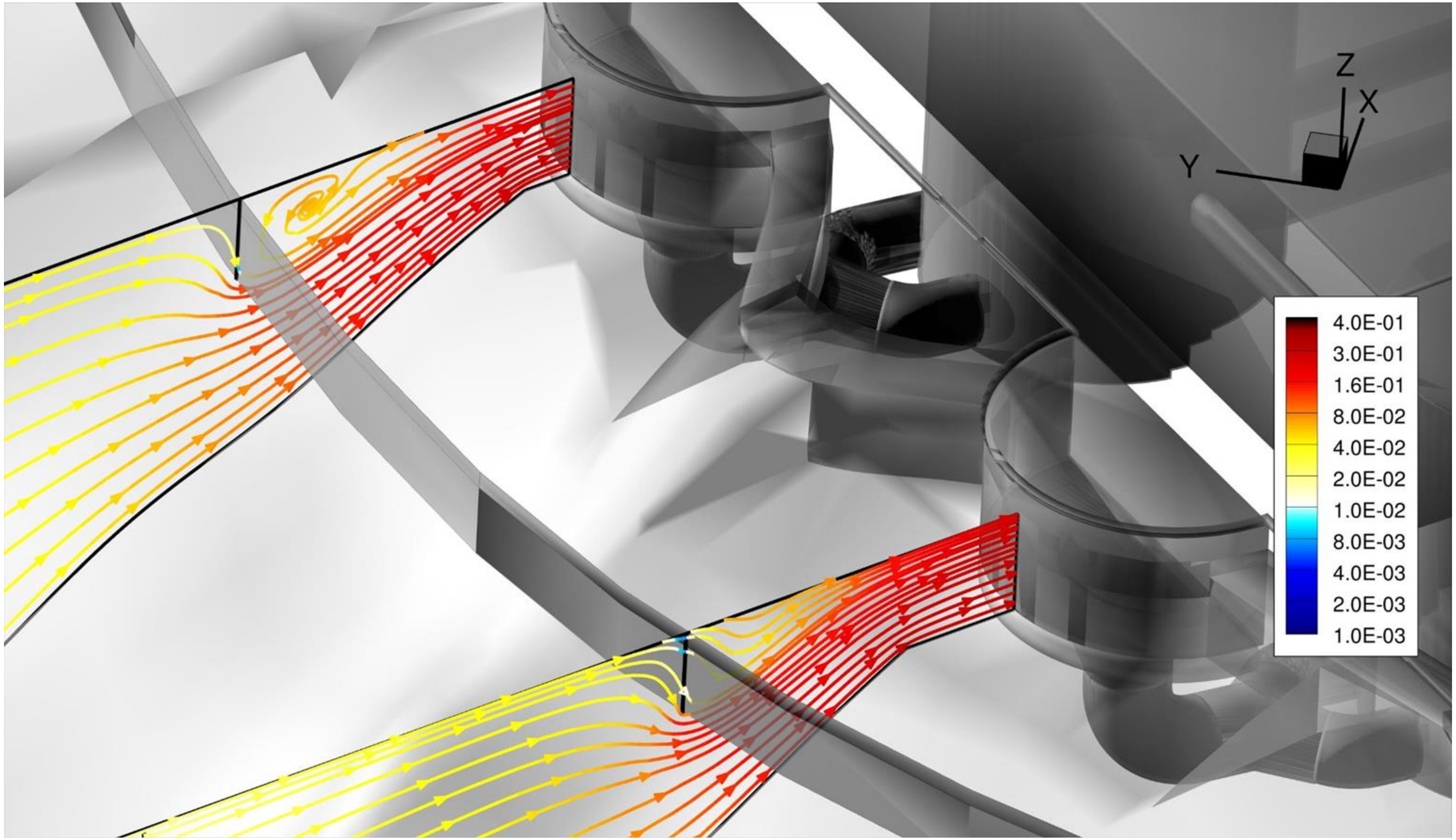


Figure 2.4: Streamtraces coloured with contours of velocity magnitude in the vicinity of the barrier net and intakes

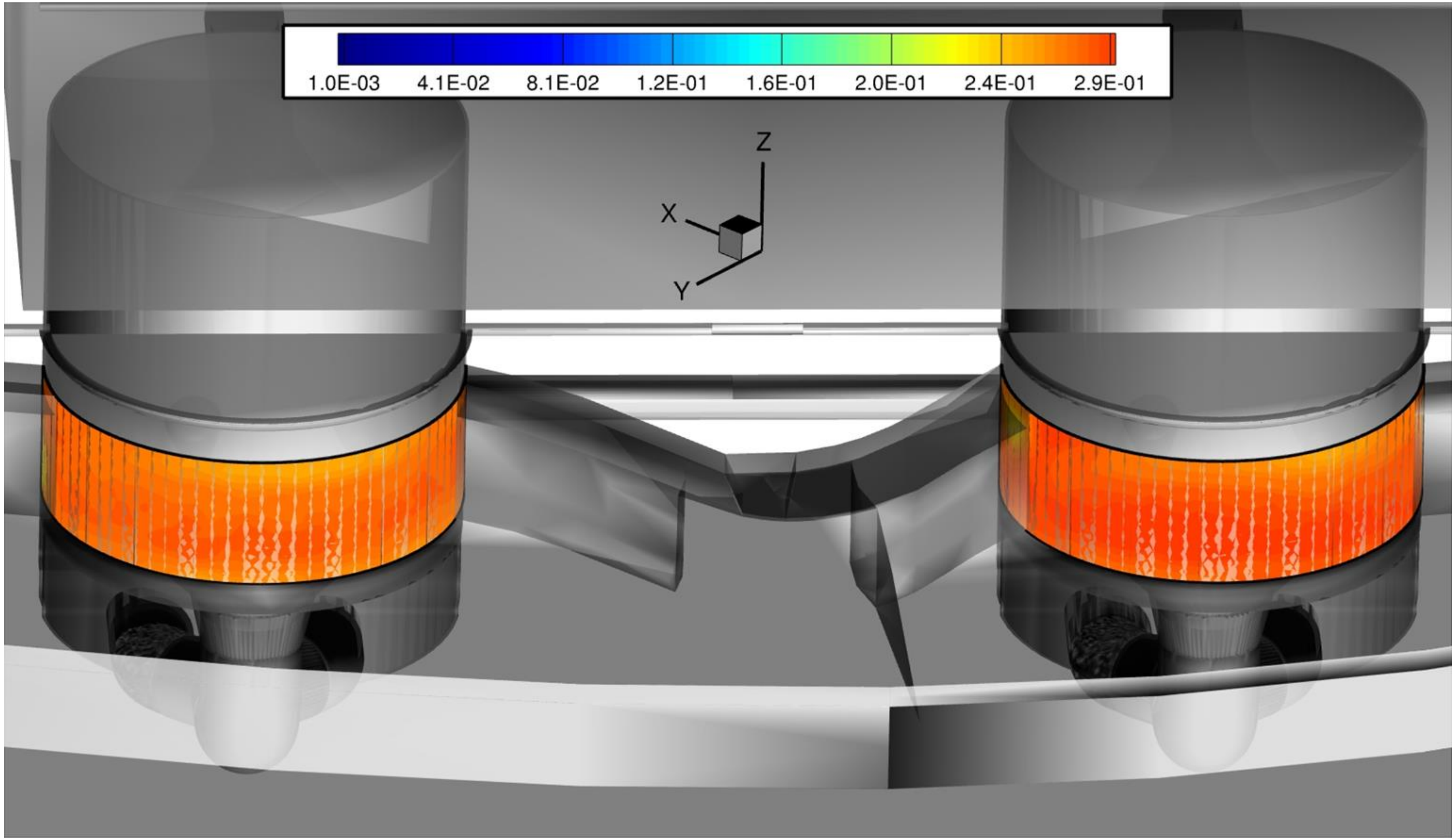


Figure 2.5: Contours of the velocity magnitude (in m/s) at the intake screens.

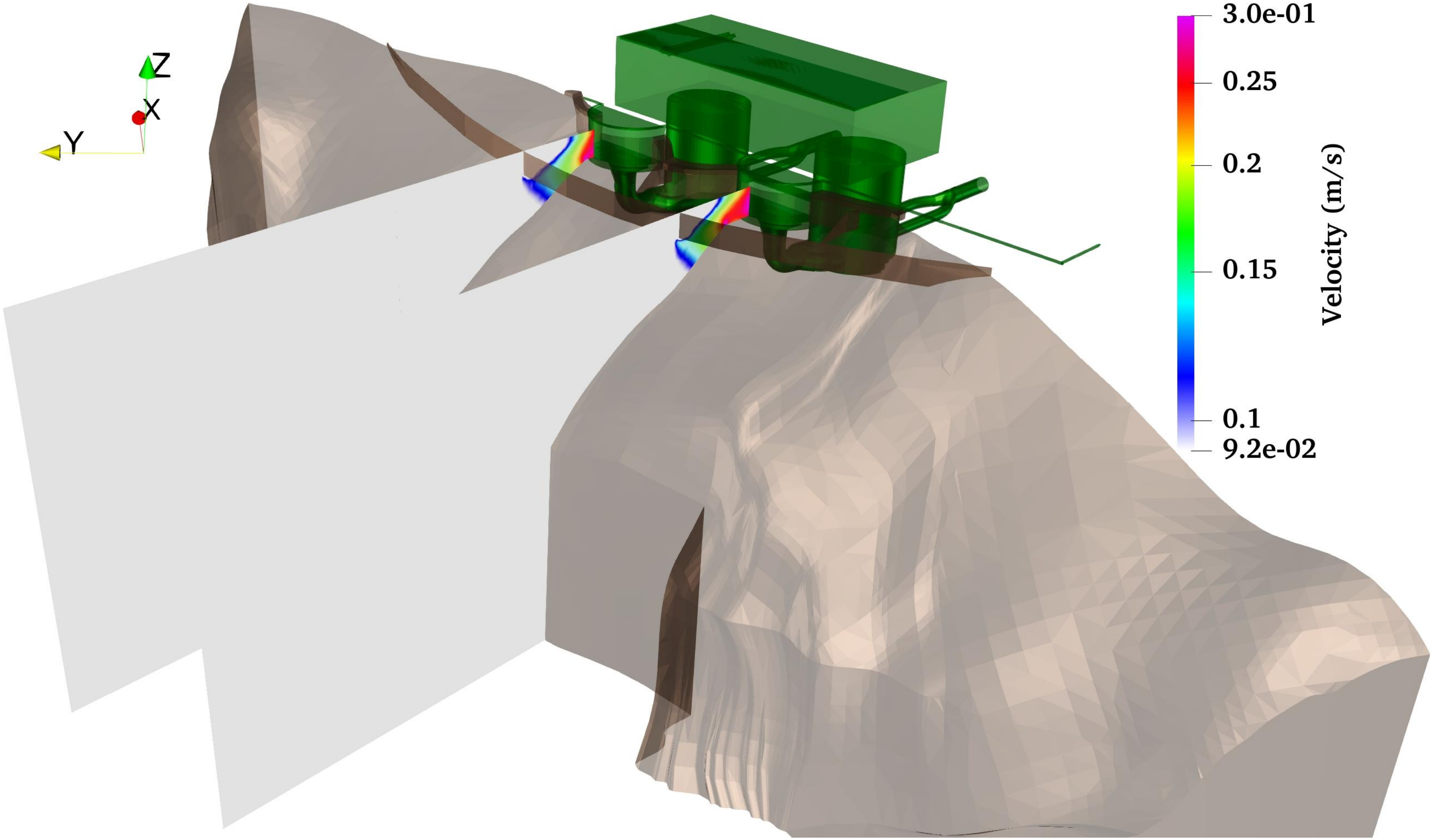


Figure 2.6: Contours of the velocity magnitude (in m/s) in two selected longitudinal sections with velocities <0.092 m/s left blank

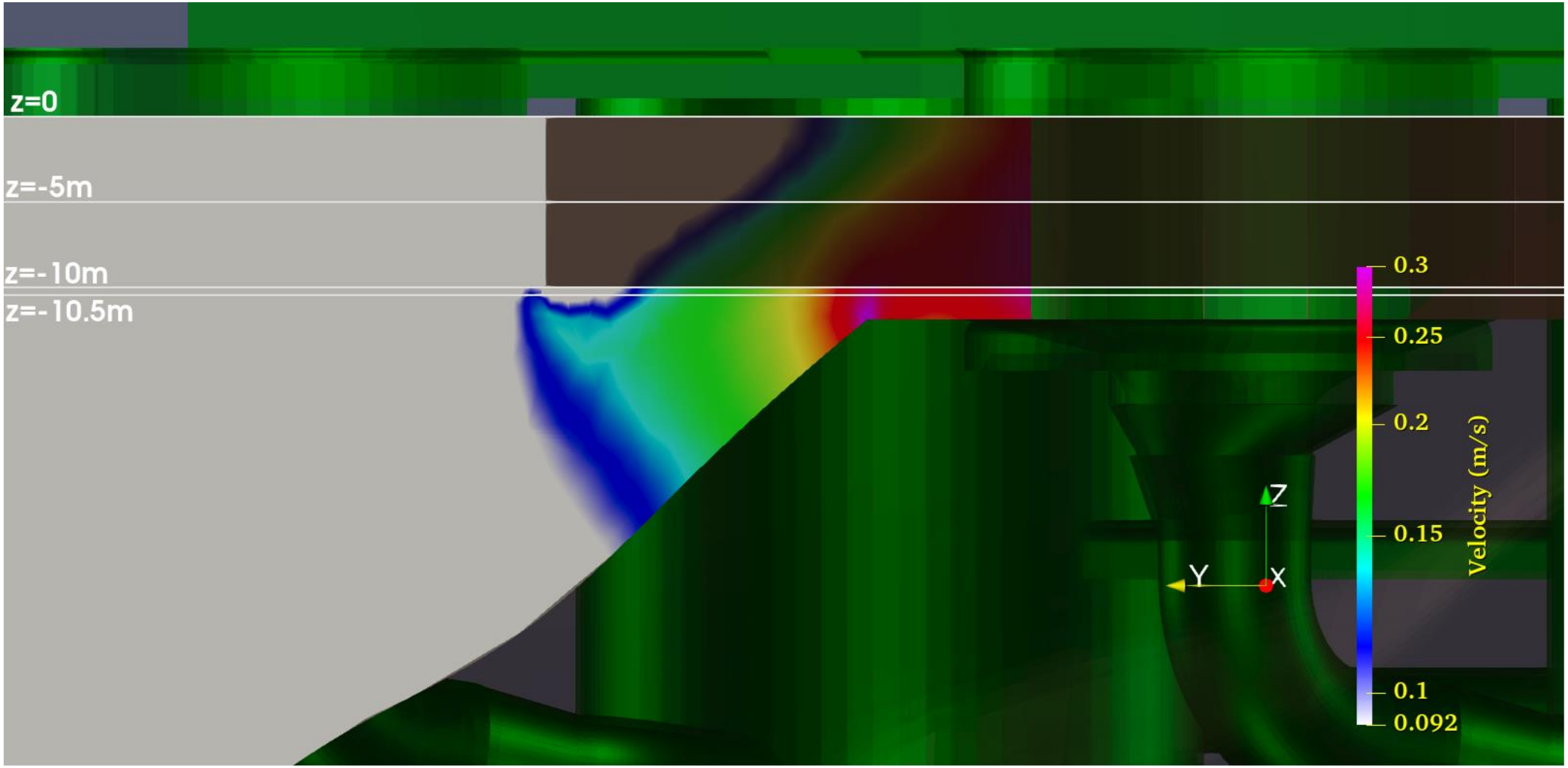


Figure 2.7: Horizontal section of velocity magnitude (in m/s) below the net with velocities <0.092 m/s left blank

Discussion - Case 2 - *L* = 40m , *D* = 10m

Figure 2.1 presents contours of the velocity magnitude in a horizontal plane near the water surface. With the barrier net located 40m away from the intake screen, velocities are visibly reduced upstream of the barrier net to approximately 0.02 - 0.03 m/s. Again, beyond the barrier net, surface flow velocities continue to decrease to <0.01 m/s.

At 40 m, the flow continues to accelerate underneath the barrier net remaining highest near the loch bed (Figure 2.2 and Figure 2.3), at around 0.20 m/s. However, the increased loch depth at this point increases the volume available for flow distribution, which in turn decreases the acceleration effect.

There are mild recirculation regions behind the barrier net, which force the accelerated flow to remain near the bed. The resultant abstraction flow direction has a strong vertical component, rather than simply horizontally across Loch Ness. The velocity distribution is relatively uniform at the intake screens and velocities of >0.3 m/s are unlikely to be experienced. (Figures 2.4, 2.5).

In maximum pumping conditions, a highly localised area of flow of velocity >0.092 m/s (approximately 0.10 – 0.13 m/s) is observed around the net structure at c.10 m depth (Figures 2.6, 2.7). Based on low flow velocities in the surface 10 m depth at the barrier net, and relatively uniform flow conditions across the intake screens, the placement of the barrier net at a distance of approximately 40 m from the intake screens is considered suitable.

Additionally, it is understood that for structural reasons, the intake structure design would require the excavation of superficial material depositions on the loch bed down to bedrock. Consequently, the volume of water available for flow distribution below the barrier net would increase, in turn decreasing the acceleration effect of flow underneath the barrier net. Therefore, it is expected the flow velocities presented within this assessment would decrease slightly.

Summary and Conclusions

Three-dimensional numerical simulations of the hydrodynamics near the Loch Ness intake of the Loch Kemp pumped storage hydropower scheme have been performed using a three-dimensional RANS-based CFD model. Only the maximum pumping flow scenario of $Q = 360\ m^3/s$ has been considered as this is deemed the worst-case scenario for operation. Barrier net locations at distances of 27m (Case 1) and 40m (Case 2) away from the intake screens have been considered. Due to the bathymetry of Loch Ness and the layout of the powerhouse with two intakes, three-dimensional effects take place and have been visualised in contour plots of the velocity magnitude. The most important findings are:

1. A barrier net of 10mm spacing square mesh demonstrates very low permeability and significantly attenuates flows passing through it;
2. Placement of a barrier net c.27m away from the intake screens is deemed unsuitable, due to flow acceleration effects underneath the barrier net creating uneven flow distribution at the intake screens and flow velocities exceeding 0.3 m/s across sections of the intake screens. Despite this, surface flow velocities in Loch Ness at the barrier net remain low at approximately 0.05 - 0.08 m/s.
3. Placement of the barrier net c.40m away from the intake screens is deemed suitable as uniform flow distribution across the intake screens with velocities <0.3 m/s can be achieved. Surface flow velocities at the barrier net decrease to approximately 0.02 m/s in this configuration. A highly localised area of flow velocity >0.092 m/s is observed around the barrier net at c.10 m depth.
4. Surface flow velocities in Loch Ness beyond the barrier net continue to decrease to <0.01 m/s.
5. Excavation of the Loch Ness bed to facilitate intake construction would increase the water depth, and available flow distribution volume, below a barrier net structure in turn likely reducing any flow impacts presented above.