March 2025

Glen Earrach Pumped Storage Hydro

Environmental Impact Assessment Report

Volume 5: Appendices
Appendix 11.1: Water Resource Assessment

Glen Earrach Energy Ltd

Glen Earrach AECOM

Quality information

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1. Introduction

1.1.1 This appendix to **Chapter 11: Flood Risk and Water Resource (Volume 2: Main Report)** assesses the following matters in relation to water resources:

- Potential impact on water resources as a result of the Proposed Development; and
- Appropriate mitigation measures to reduce the impact of the Proposed Development on water resources.

1.1.2 This appendix is organised as follows:

- The objective of the assessment (**Section 1.2**)
- Key receptors and water features (**Section 2**)
- Baseline Environment (**Section 3**)
- Assessment Methodology (**Section 4**)
- Assessment of Effects (**Section 5**)
- Summary of mitigation measures (**Section 6**)
- Conclusion (**Section 7**)

1.1.3 This appendix should be read in conjunction with **Chapter 11: Flood Risk and Water Resource (Volume 2: Main Report).**

1.2 Objective of Assessment

1.2.1 The operational regime of the Proposed Development, i.e. how and when the scheme generates or pumps, is governed by both water resource availability and the electricity market. This assessment considers the effect of the proposed operational regime on water resources and the impact of this effect on receptors in the study area. In addition to the proposed works, consideration is also given to other developments at Loch Ness that may impact on flood risk. These include the Loch na Cathrach and Loch Kemp PSH together with the proposed works at Ness Weir. The following terms (and descriptions) are used throughout this Appendix, unless otherwise stated:

- Ness Weir (colloquially known as Dochfour Weir) – The existing weir, located at the mouth of Loch Dochfour and the River Ness;
- Dochfour Weir Upgrade – Upgrade works proposed as additional mitigation to the Proposed Development; these measures are however not part of the Proposed Development application, and
- Ness Weir II – Proposed works to the Ness Weir by Stratera Energy, the developer of the Loch Kemp PSH scheme.

1.2.2 It is recognised that controls are required to minimise the impact of discharging large quantities of water into Loch Ness during periods of flood and from abstracting large quantities during periods of drought. Hands-off levels are therefore proposed for both pumping and generating based on known constraints at Loch Ness and further downstream. Further details are provided on these in Section 2 of this appendix.

1.2.3 In addition to the potential impact on extreme levels where the Proposed Development could result in increased flood risk or reduced water levels during drought events, the operation of the Proposed Development could have an impact on the variation in water levels and flows downstream that could impact on other considerations detailed elsewhere within this EIAR.

2. Key Receptors and Water Features

2.1 Key Receptor

2.1.1 The key receptors with regard to the impact on water resources are those that are hydraulically linked to the Proposed Development. This includes link to the both the Headpond and the Tailpond. These include the following:

- Loch Ness and Loch Dochfour which are connected via the Bona Narrows
- River Ness
- Caledonian Canal
- Allt Saigh and its tributary Allt Loch an t-Sionnaich

2.2 Loch Ness

2.2.1 Loch Ness is a large glacially eroded freshwater loch covering approximately 55.33 km². It is connected to Loch Dochfour to the northeast via the Bona Narrows; together they form 56km^2 of open water. Water levels in Loch Ness are around 16 m Above Ordnance Datum (AOD)) and the loch is approximately 22.5 km long with a northeast to southwest axis along the Great Glen Fault. It is very deep with a maximum depth of around 230 m.

2.2.2 Loch Ness is connected to Loch Dochfour via the Bona Narrows, it is a water resource for the northern section of the Caledonian Canal and provides a location for various recreational activities.

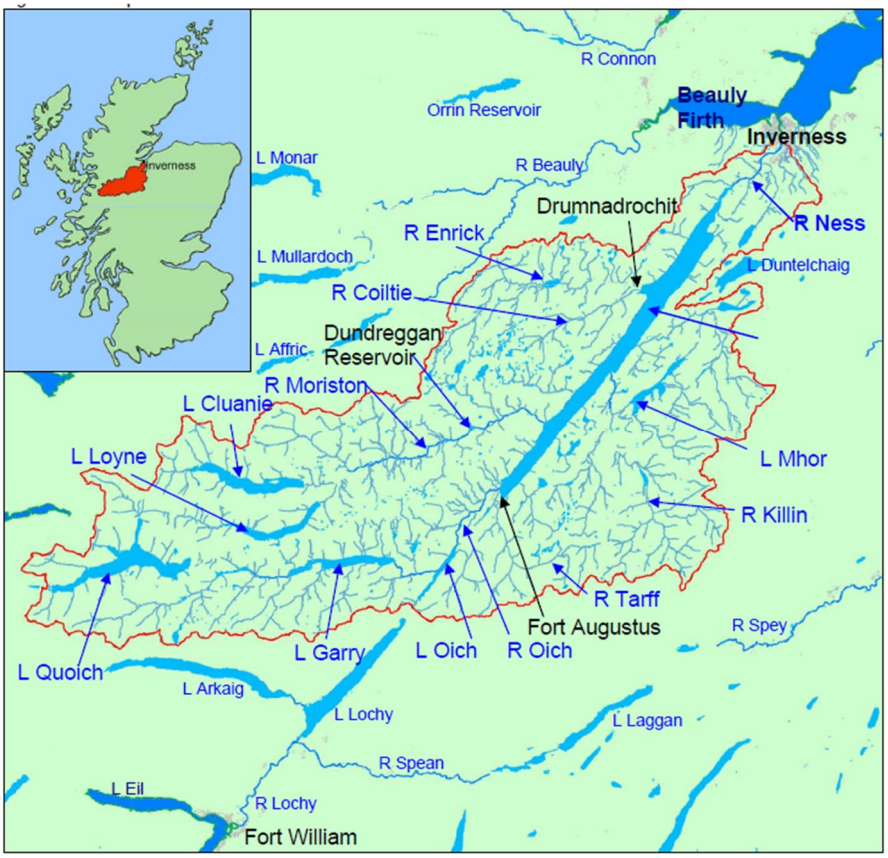
2.2.3 Loch Ness and its upstream catchment feeds flood water into a Potentially Vulnerable Area (PVA) with regard to flood risk – PVA 02/01/17 Inverness. Significant flooding has been experienced in Inverness from the River Ness. This has resulted in The Highland Council (THC) constructing the River Ness Flood Protection Scheme to protect low lying areas of Inverness from tidal flooding. This scheme also provides improved protection against fluvial flooding along the lower reaches of the River Ness downstream of Ness Bridge.

2.2.4 An objective of PVA 02/01/17 is to avoid inappropriate development that increases flood risk in Inverness.

2.2.5 There are also three existing large-scale hydro-electric schemes in operation on Loch Ness, two located at the southeastern end of the loch nearer to Fort Augustus – Foyers and Glendoe and Glenmoriston on the western bank.

2.2.6 The Proposed Development Site is situated on the western side of the Loch Ness catchment. The Headpond and associated Waterways lie between two sub catchments of Loch Ness; Allt Saigh in the south and River Coiltie to the north. An access track from the A831 to the Headpond lies within the River Enrick catchment and the River Coiltie catchment. An existing track running along Allt Saigh would also be used during the operation of the Proposed Development (but is not proposed for use during Pre-Construction and Enabling Phase or Construction Phase). These rivers all flow into Loch Ness from the western shore. The River Coiltie is also a tributary of the River Enrick, with the confluence occurring just before the point at which they flow into Loch Ness at Drumnadrochit.

2.2.7 The Proposed Development is part of the Loch Ness catchment. The Loch Ness catchment spans the Great Glen, and several valleys to the west together with the eastern slopes of the Monadhliath Mountains as indicated in **Insert 1 Loch Ness Catchment Overview** . The total catchment is some 1,790 km^2, 56 km^2 of which is direct open water in Loch Ness and Loch Dochfour with the remaining catchment predominantly shrubland, pasture and forested based on the UKCEH Land Cover Maps 2023.



Insert 1 Loch Ness Catchment Overview[1]

2.2.8 In addition to Loch Ness, the Catchment contains several other significant lochs, including Quoich, Cluanie, Loyne, Garry and Mhór, all of which are controlled for hydropower generation. **Table 1 Ness catchment reservoirs** gives the major loch surface areas and the active storage volumes available for hydropower generation. All of these lochs already provide a significant amount of attenuation of flows through the catchment, reducing the peak flow in the River Ness considerably. The drainage catchment areas for various sub-catchments are given in **Table 2 Loch Ness Sub-catchments.**

Table 1 Ness catchment reservoirs

Reservoir	Surface Area (km^2)	Active Storage Volume (Mm^3)
Loch Ness (not dammed for hydropower generation)	56	N/A
Loch Quoich	18	360
Loch Cluanie	11	200
Loch Loyne	7	43
Loch Garry	6	22
Loch Mhor	4	14

Table 2 Loch Ness Sub-catchments

Sub Catchment	Catchment Area (km^2)	Proportion of total catchment
River Ness at Inverness	1,860	100
Loch Ness at Ness Weir	1,790	96%
River Oich at Fort Augustus	498	27%
River Morriston at Invermoriston	401	22%

[1] Ness flood scheme report, Mott MacDonald

Sub Catchment	Catchment Area (km^2)	Proportion of total catchment
Loch Garry	367	20%
River Foyers (including River Killen and Loch Mhor)	276	15%
River Enrick at Drumnadrochit	148	8%
Loch Quoich	132	7%
River Farigaig at Inverfarigaig	93	5%
Loch Cluanie	85	5%
River Tarff at Fort Augustus	80	4%
River Coiltie at Drumnadrochit	51	3%

2.3 Allt Saigh and its tributary Allt Loch an t-Sionnaich

2.3.1 Allt Saigh is situated on the southwestern end of the Proposed Development Site and drains much of the region south of the proposed Headpond location. The watercourse is approx. 12 km long and is sourced from two small Lochans: Loch Carn Tarsuinn at NGR NH 38137 21482 and an unnamed lochan at NGR NH 37339 21369 within the vicinity of Bhlaraidh Wind Farm. The Allt Saigh flows through approximately eight other lochs and lochans before entering Loch Ness at NGR NH 45625 18882.

2.3.2 The watercourse has been classified as heavily modified due to water storage for hydropower generation. The water intake point is located some 1 km downstream of Loch nam Breac Dearga at NGR NH 41365 19932. This forms part of the wider Great Glen scheme and feeds the Livishie Power Station.

2.3.3 In the upper catchment, there are numerous small lochs. Peat is also present across the surrounding area. The channel meanders through relatively low gradient moorland between areas of high ground. Downstream of Loch a' Mheig, the Allt Saigh has a steep bedrock channel with boulders present and cobbles and gravels which may be transportable. The river in this reach flows through a confined valley, with trees along much of the riparian corridor down to the outflow at Loch Ness. Loch nam Breac Dearga and Allt Loch an t-Sionnaich are both located within Allt Saigh catchment.

2.4 Existing Infrastructure

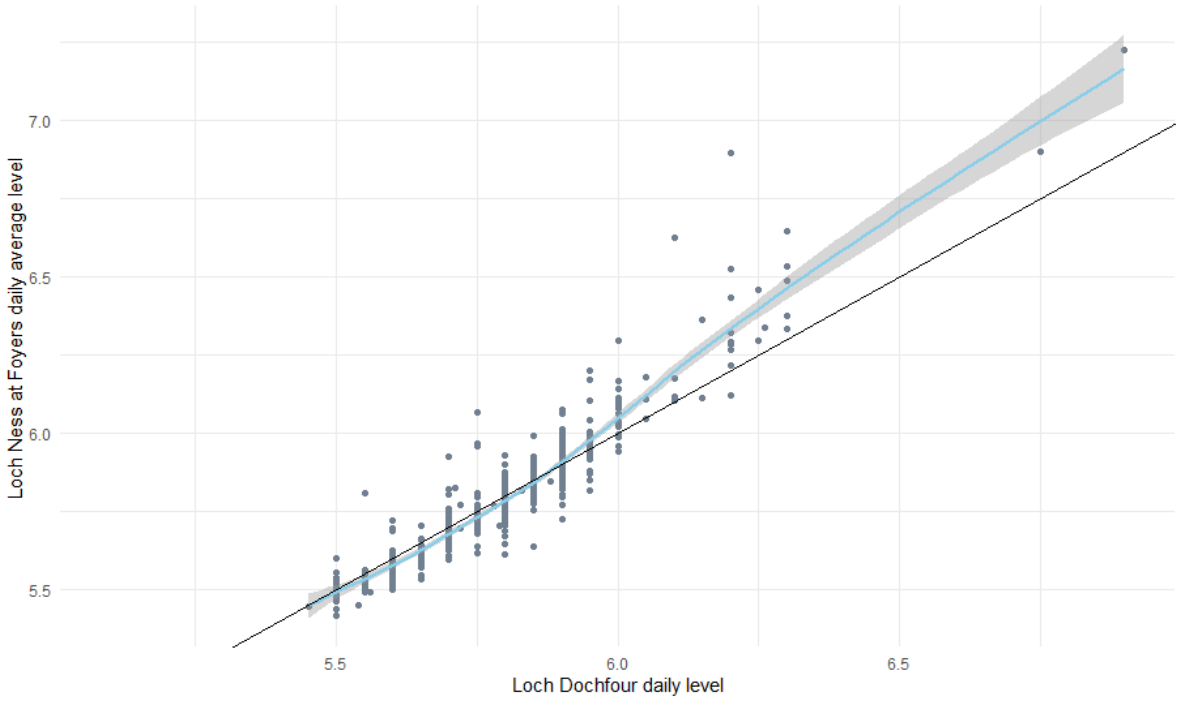
Great Glen Overview

2.4.1 The Loch Ness catchment spans the Great Glen, and several valleys to the west which flow into it. Over the last two centuries the Great Glen has been modified by humans resulting in changes to flow regimes and attenuation. The major interventions are the Caledonian Canal and then more recently the Great Glen hydro arrangements, Foyers PSH scheme and Glendoe conventional hydro scheme.

Caledonian Canal

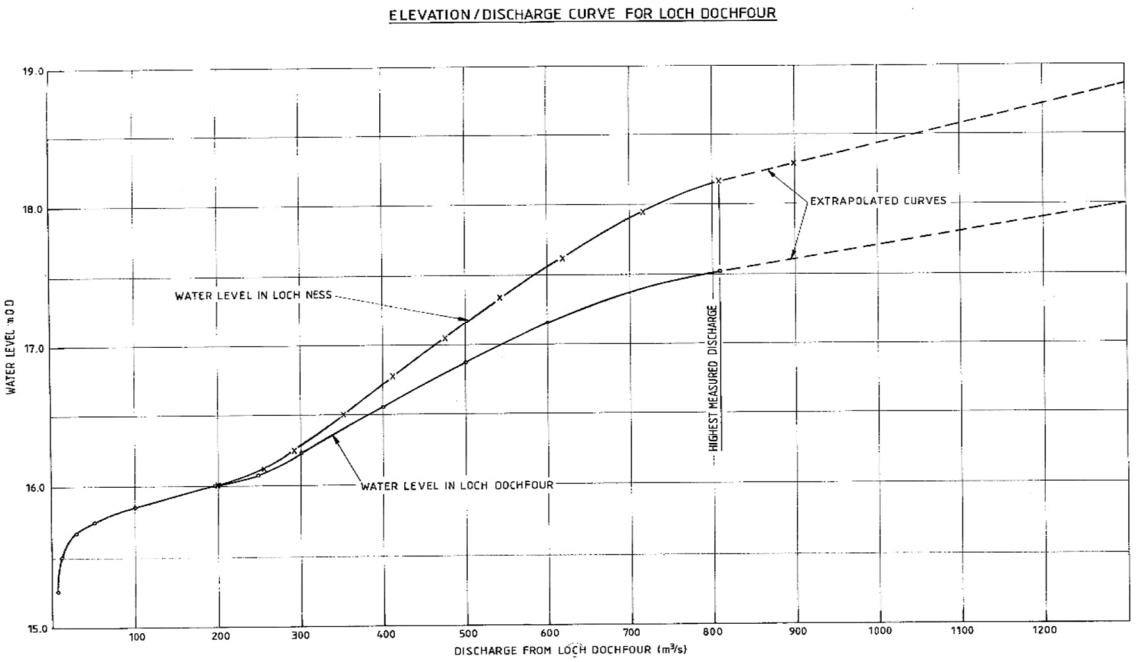
2.4.2 As part of the Caledonian Canal works, water levels are controlled in Loch Oich and Loch Ness in the Ness catchment together with Loch Lochy further west to feed the canalised sections between the lochs.

2.4.3 Water levels are further controlled in Loch Ness during higher water levels by the hydraulic constraint of the Bona Narrows next to Lochend. A review of the relationship between water levels at Loch Dochfour next to the canal lock gate (Scottish Canals data) and Loch Ness at Foyers (SEPA data, as shown **in Insert 2 Divergence in Water Levels Between Loch Ness and Loch Dochfour**), indicates divergence when water levels exceed 6 m based on local datum.



Insert 2 Divergence in Water Levels Between Loch Ness and Loch Dochfour

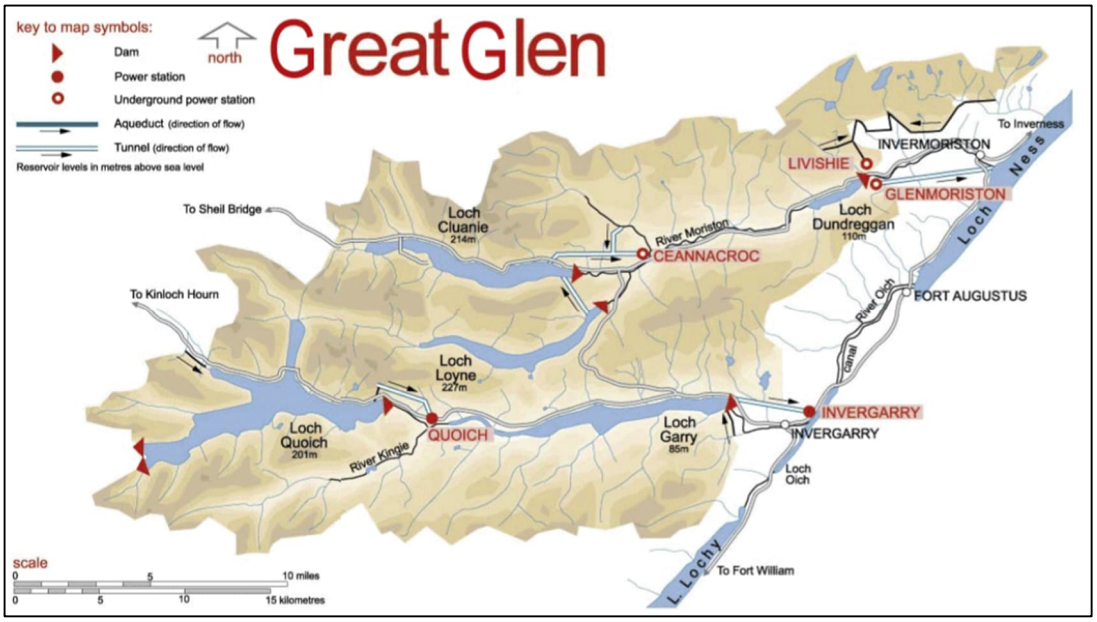
2.4.4 **Insert 3 Level-discharge Curves for Lochs Dochfour and Ness** looks at more extreme historic flood events which show the level difference continuing to increase. As these levels are well outside the normal range of Loch Ness, this hydraulic constraint is more relevant for conducting a flood risk assessment for the Proposed Development (**Appendix 11.2: Flood Risk Assessment (Volume 5: Appendices)**).



Insert 3 Level-discharge Curves for Lochs Dochfour and Ness Hydro Electric Schemes[2]

2.4.5 The catchment has several hydro schemes which have some influence on flow. The Great Glen hydro scheme includes a series of dams and power stations which control flow from the western side of the catchment, as shown in **Insert 4 Great Glen hydro scheme.**

[2] Loch Dochfour Reservoirs Act Section 10 Inspection 1987



Insert 4 Great Glen hydro scheme[3]

2.4.6 Flows in the tributaries feeding Loch Ness are heavily influenced by impoundments and diversions through hydro generation. Significant impoundments can impact on flows both during summer and winter months. Within the Allt Saigh catchment a number of small intake structures are located that divert water to the Livishie Power Station and away from its natural catchment. One of the water intake points is located some 1 km downstream of Loch nam Breac Dearga. Details of the abstraction arrangement and the impact on downstream flows are unknown. The abstraction removes flow from the catchment resulting in reduced flows downstream from this point.

2.5 Existing Water Resources Regimes

2.5.1 Water levels in Loch Ness and Loch Dochfour are driven by a combination of catchment inflows (a large proportion of which are modified by reservoirs and hydro schemes), operation of Foyers PSH, and spill over Ness Weir and Dochgarroch Lock. Levels are controlled within Loch Ness in order to ensure that water supply into the Caledonian Canal is maintained to ensure navigability and minimum flows are maintained in the River Ness.

2.5.2 A minimum draft of 5.1 m at the sill of Dochgarroch Lock is required for the canal to allow the passage of watercraft. This equates to a water level of 15.27 m AOD at Loch Dochfour and Loch Ness.

2.5.3 The normal operating level in the canal within the reach between Dochgarroch Lock and Muirton Basin is set at 15.328 m AOD with a level 1 trigger at 50 mm below and second trigger at 100 mm below this level.

2.5.4 No operational regimes were provided by SSE for Loch Ness and their hydro operations. The assessment has therefore been carried out on the basis of the above operational regimes only.

2.5.5 Extensive works have been undertaken to reduce flood risk within the City of Inverness through the construction of the River Ness Flood Protection Scheme. This has increased the standard of protection from the River Ness downstream of Ness Bridge from tidal flooding. Areas between the Ness Bridge and Ness Islands are not defended as part of the scheme and remain at risk during extreme fluvial flood events Based on the SEPA Flood Maps.

2.5.6 The detailed flood risk assessment undertaken as part of the River Ness (River Ness Flood Scheme – Details of Hydraulic Modelling undertaken for Development of Preferred Scheme – The Highland Council / Mott MacDonald October 2011) flood protection scheme shows that the areas between Ness Bridge and Ness Island has a standard of protection of between 1 in 10 and 1 in 25 years.

[3]Power from the Glens: SSE (formerly Scottish Hydro Electric)

2.5.7 Flood defence measures have been constructed along the banks of the River Ness in Inverness. Increasing flood risk as a result of increased flood levels in Loch Ness and downstream flows in the River Ness would be contrary to the guidance set out in the Highland Council Supplementary Guidance, Flood Risk & Drainage Impact, and in Policy 22 of NPF4.

2.5.8 In order to avoid having a detrimental impact on the flood risk to others and compromise the standard of protection provided by the River Ness Scheme, an upper operating level (stop generation) of 17.6 mAOD is proposed and forms the basis of this assessment. This is the current 1 in 10 year flood level in Loch Ness.

3. Baseline Environment

3.1 Sources of Data

3.1.1 To inform the assessment, information has been obtained from the following sources:

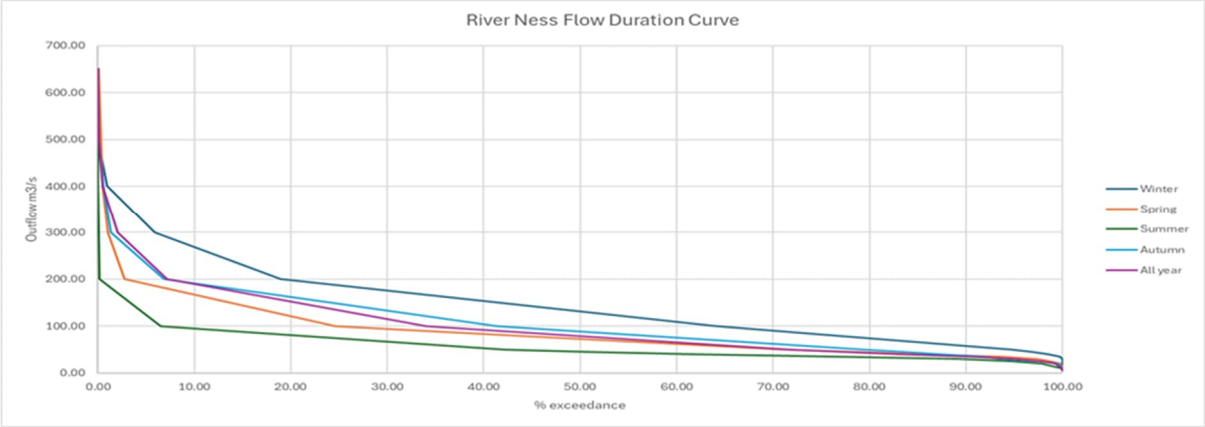
- Loch Ness water levels at Foyers (SEPA) 2015 – 2024, 15-minute data
- River Ness flow data at Ness Side (SEPA) 1973 – 2024, 15-minute data
- Dochgarroch Lock Water levels (Scottish Canals) -2018 – 2024, daily data
- Dochfour Weir (Ness Weir) dimensions and discharge curve (extract from Loch Dochfour Reservoirs Act Section 10 Inspection 1987) - Scottish Canals
- Glen Earrach proposed generation profile
- Loch na Cathrach operating regime – CAR Licence 1176082
- Loch Kemp proposed operating regime – S36 submission EIAR
- River Ness Flood Scheme - Details of Hydraulic Modelling undertaken for Development of Preferred Scheme - The Highland Council / Mott MacDonald October 2011

3.2 Loch Ness and River Ness

3.2.1 Gauged flow and water level data is collected for the River Ness at Ness Point and Loch Ness at Foyers. Analysis of this data shows the range of flows and levels over the year.

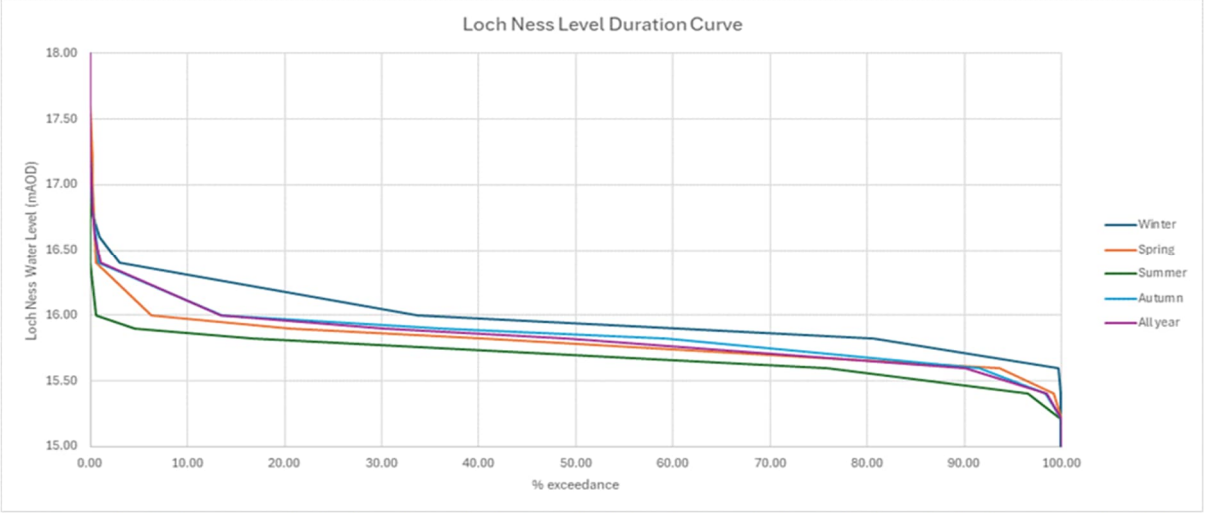
3.2.2 Flow and Stage duration curves are generated on both an annual and seasonal basis as a baseline for the assessment of the impact of the scheme and other schemes on the water features. The baseline data for both Loch Ness water levels and River Ness flows are based on recorded data that already takes into account the operational impact of Foyers PSH and Glendoe and Glenmoriston Hydro schemes. These schemes are therefore captured in the baseline data and are not explicitly assessed and modelled in the assessment.

3.2.3 The annual and seasonal flow duration curves for the River Ness and level duration curves for Loch Ness based on baseline scenario are summarised in **Insert 5 River Ness Baseline Flow Duration Curves** and Insert **6 Baseline Loch Ness Level Duration Curve**. The flows in the River Ness and the water levels in Loch Ness follow a similar pattern with higher flows and water levels and greater variation in winter.



Insert 5 River Ness Baseline Flow Duration Curves

3.2.4 The above flow duration curve shows the range in flows and the seasonal variation. The summer flows are substantially lower than those experienced during the winter whilst the spring and autumn flows are close to the annual average.



Insert 6 Baseline Loch Ness Level Duration Curve

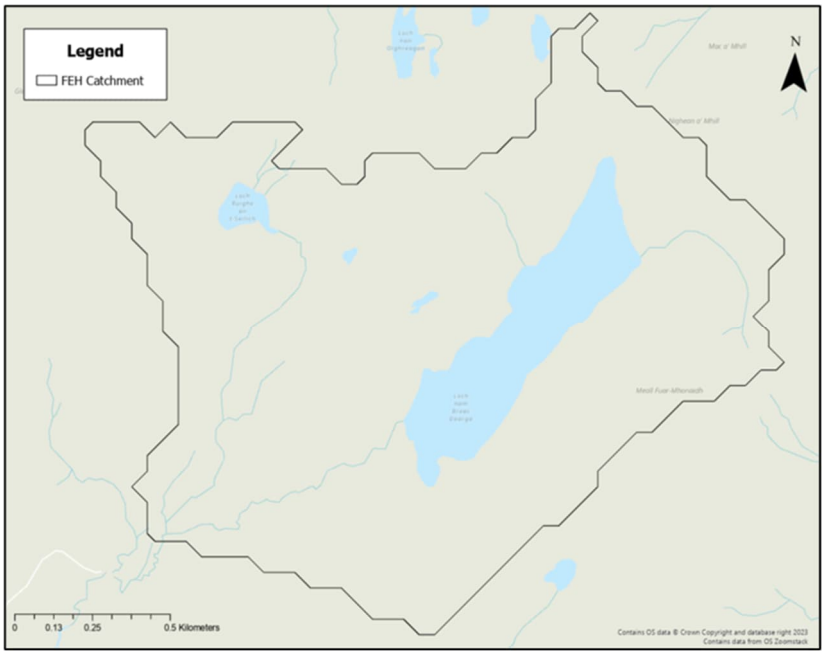
3.2.5 In a similar manner to that of the River Ness flow duration curve, water levels in the winter months are higher than the summer. Water levels in Loch Ness generally sit between 15.5 and 16.0 mAOD except for extreme events. Based on the modelled result based on the recorded flows with Proposed Development not operating the key parameters are as follows:

- Max water level over simulation period – 17.53 mAOD
- Minimum water level of simulation period – 15.27 mAOD
- Mean water level over simulation period – 15.82 mAOD
- Median water level over simulation period – 15.81 mAOD

3.2.6 The modelled results are in close corelation with the historic recorded data, see Section 4.3 and provided the basis for the assessment of the impact of the Proposed Development and the cumulative impact with other developments.

3.3 Allt Loch an t-Sionnaich

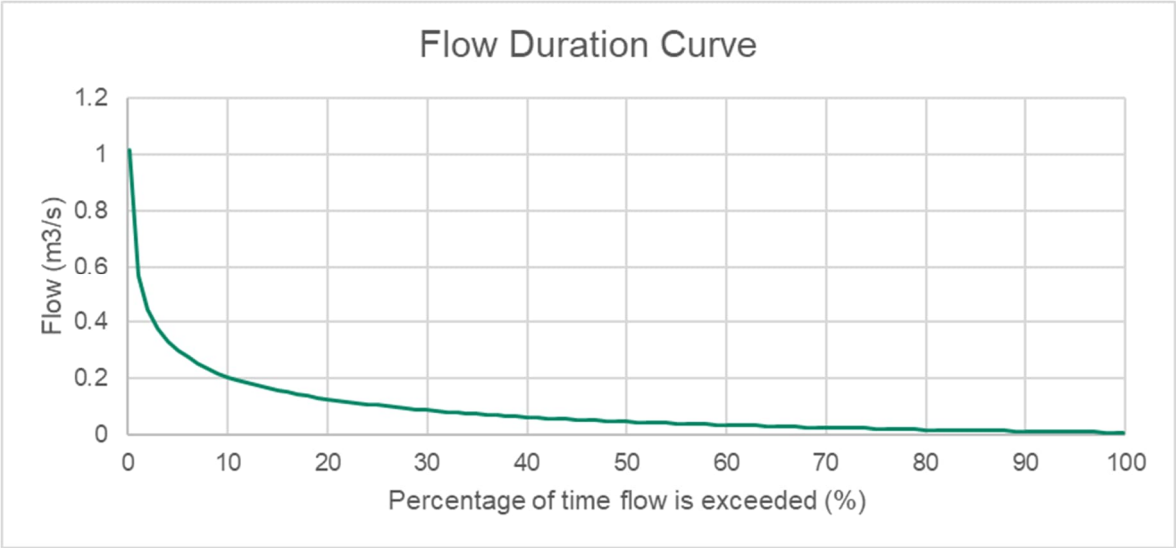
3.3.1 No gauged data is available for the Allt Loch an t-Sionnaich catchment and therefore the flow duration curve has been derived using Low Flows 2 software. This flow duration curve provides an indication of the flows in the watercourse. The catchment area used to calculate the flow duration curve has been taken from the FEH webservice and has an area of 2.5 km^2 (catchment is shown in **Insert 7 Allt Loch an t-Sionnaich Upper Catchment Area Used in Low Flows 2** below).



Insert 7 Allt Loch an t-Sionnaich Upper Catchment Area Used in Low Flows 2

3.3.2 A conservative approach has been taken by estimating the flow duration curve at the confluence between the downstream watercourse of the Loch nam Breac Dearga and the downstream watercourse of the Loch Ruighe an t-Seilich. The Headpond embankment (Main Dam) would be located approximately 400 m upstream of this point. However, it would span across both watercourses, therefore both catchments would be affected by the proposed PSH.

3.3.3 The Low Flows software includes an option to account for the lochs within the catchment. However, given the small size of the lochs, they have not been picked up by the software therefore this option was not available for this catchment. This would provide a conservative assessment as it disregards any attenuation of flows by the lochs. **Insert 8 Allt Loch an t-Sionnaich Upper Catchment Annual Flow Duration** Curve shows the flow duration curve for the catchment shown in **Insert 7 Allt Loch an t-Sionnaich Upper Catchment Area Used in Low Flows 2**. This shows that the annual Q50 flow is 0.047 m^3/s, increasing to 0.127 m^3/s at the Q20, and decreasing to 0.013 m^3/s at the Q90.



Insert 8 Allt Loch an t-Sionnaich Upper Catchment Annual Flow Duration Curve

4. Assessment Methodology

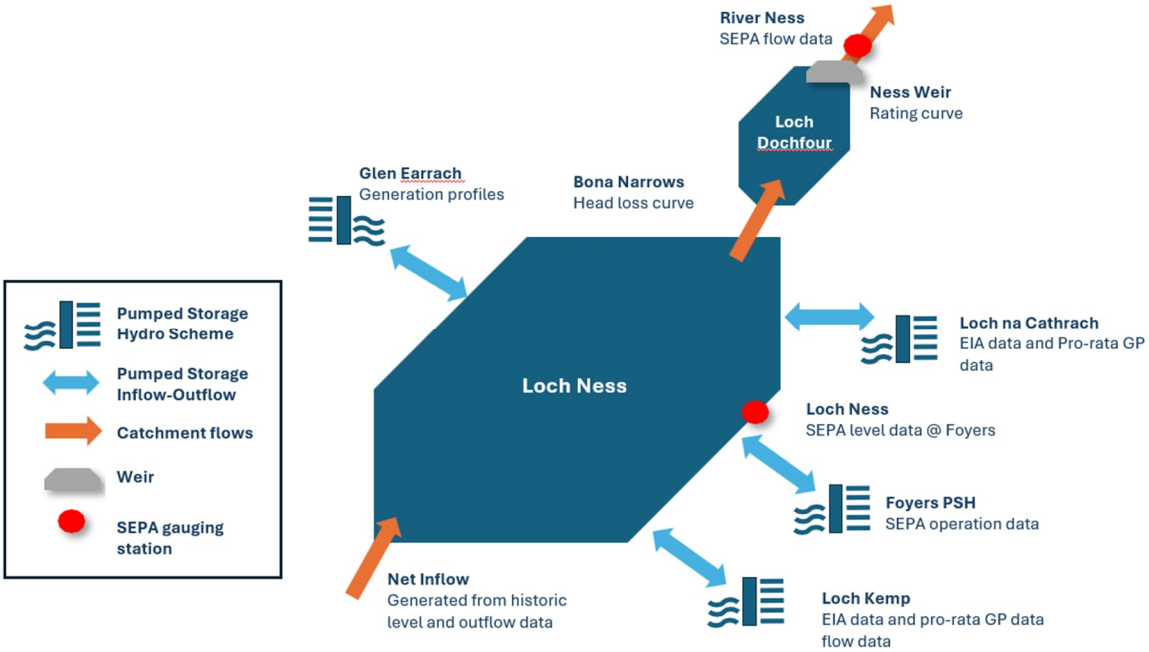
4.1 Introduction

4.1.1 The following section sets out the methodology for assessing the impact on water resources from the Proposed Development during the operational phase together with the cumulative impact of other existing and proposed schemes at Loch Ness. The following should be noted:

- The impact on Loch Ness and the River Ness is based on the operation of the scheme and the discharge of water into, and abstraction from, Loch Ness.
- The impact on flows in the Allt Loch an t-Sionnaich are assessed based on the impoundment of the catchment at Loch nam Breac Dearga.

4.2 Loch Ness Water Balance Assessment

4.2.1 The objective of water balance modelling is to assess the impact of the scheme on water level and flows in Loch Ness. The model developed for this assessment considers the impact of the Proposed Development with and without mitigation measures and indicates the degree of constraint on scheme operation imposed by these mitigation measures. The cumulative impact from other existing and permitted schemes is also considered. The model calculates flows and storage volumes between focal water bodies in the Loch Ness catchment. **Insert 9 Loch Ness Water Balance Model Schematic** presents the model schematic, outlining the key variables and flows used to perform water balance calculations.



Insert 9 Loch Ness Water Balance Model Schematic

Loch Ness Inflow

4.2.2 The Loch Ness catchment is highly modified and controlled and while extensive flow gauging is carried out, only a limited amount of the catchment is either natural flow or not heavily influenced by hydroelectric activities. In the absence of data on the hydroelectric activities over the period of recorded data it is not possible to build a representative model of the Loch Ness catchment based on the gauged data. Net inflow can instead be estimated for the period from 2014 to 2024 through a water balance calculation with River Ness flows, Loch Ness level changes and Foyers operation. The net inflow implicitly accounts for evaporation from Loch Ness. Once the net daily average inflows for this period are calculated, a

statistical transformation of Ness-side outflow, from 1974 to 2024 can be used to generate a 50 year inflow series by matching probabilities on the respective flow duration curves.

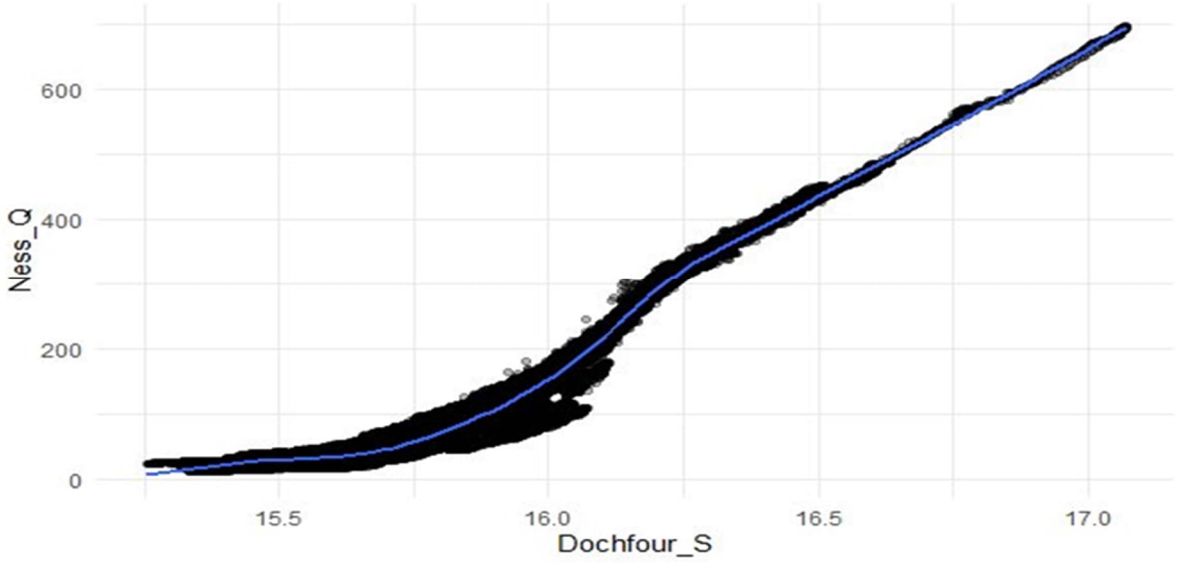
4.2.3 A simplified approach is therefore adopted using a net inflow record to Loch Ness derived from the change in volume in Loch Ness using data from the Foyers level gauge on Loch Ness and outflow data from the River Ness flow gauge at Ness-side, both operated by SEPA.

4.2.4 The net inflow approach implicitly accounts for all inflows and losses. This includes direct rainfall on the loch, evaporation from the loch, generation and pumping flows from the Foyers PSH, and operation of the conventional hydro schemes discharging into Loch Ness. The operation of Foyers PSH and other existing hydro schemes is therefore built into the baseline conditions.

Loch Dochfour Outflow

4.2.5 There are two methods to calculate the outflow from Loch Dochfour into the River Ness (the flow into the Caledonian Canal is not significant, so is excluded from the modelling). The empirical method considers the Loch Dochfour level and River Ness flows and fits a cubic equation. The numerical method considers the geometry of the Ness Weir and calculates a level-flow relationship based on the weir equation, with the selection of a suitable weir coefficient.

4.2.6 The operation procedures for the radial gates at Ness Weir are unknown and therefore cannot be accounted for in the numerical model. The empirical model is however based on actual recorded data and therefore captures the periods when the gates were opened. This is therefore more appropriate for the purpose of this study. The Ness Weir stage discharge rating can be seen in **Insert 10 Plot of Loch Dochfour Levels against River Ness Gauged Flows** where the Loch Dochfour levels are compared to the River Ness flows at the Ness Point gauge.



Insert 10 Plot of Loch Dochfour Levels against River Ness Gauged Flows

Bona Narrows Head Loss

4.2.7 The Bona Narrows connecting Loch Ness and Loch Dochfour are a constraint to flows when Loch Ness levels are high. A level curve has been generated based on observed data to convert Loch Ness levels into the respective Loch Dochfour levels to calculate the outflow. A headloss against flow relationship has been derived and included in the model. It should be noted that the head loss is only evident when flow exceeds approximately 200 m^3/s and therefore is not applicable for most of the time.

PSH Operating Profile

4.2.8 A detailed assessment of the operating profile of the Proposed Development has been undertaken by energy consultant New Stream Renewables. Using their proprietary storage optimisation algorithm, which looks at the periods of generation and pumping on an hourly timestep over a yearly period, New

Stream Renewables further refined this model for the Applicant. This has been used to assess the impact of the scheme on water levels in Loch Ness and on flows in the River Ness.

4.2.9 As part of the cumulative assessment the same profile has been used for the Loch na Cathrach and Loch Kemp schemes, with an adjustment taking account of the generation and pump rates together with their respective headpond volumes. The Foyers PSH and other hydro schemes discharging into Loch Ness is taken into account in the baseline net inflow data and are therefore not considered further.

4.2.10 For the purpose of the cumulative assessment, it is assumed that all schemes would operate at the same time subject to Headpond volume constraints. This is based on all schemes operating in the same market. This is a conservative assumption and provides the worst-case scenario with greatest impact which is appropriate for this assessment.

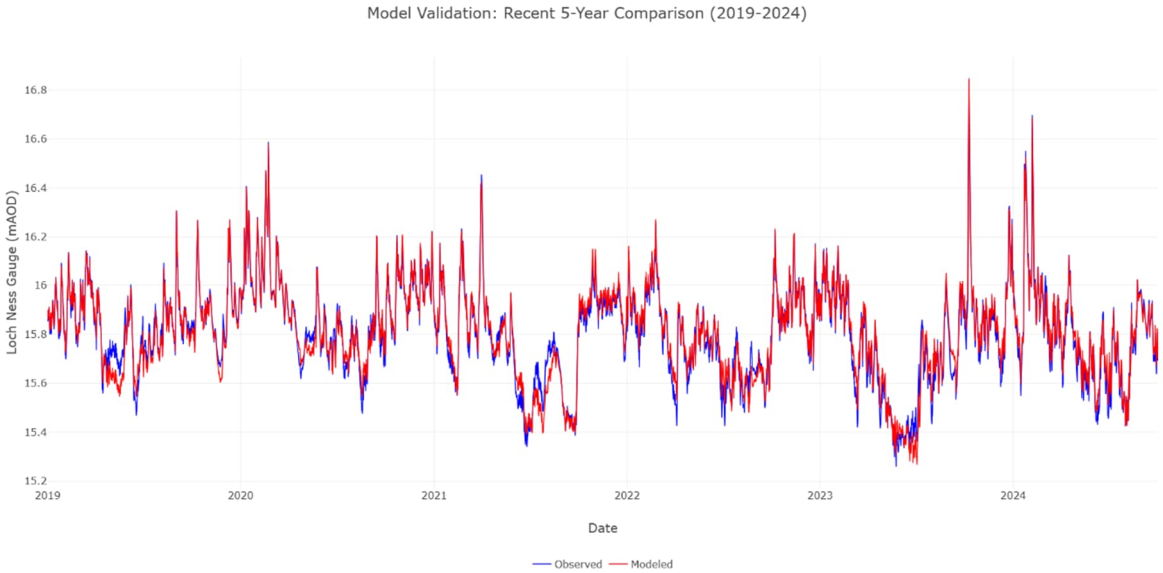
4.2.11 The key parameters of the three PSHs considered are summarised in **Table 3 PSH capacity, flow rates and operating limits**. It should be noted that the Foyers PSH scheme is included within the baseline data and therefore this data Is not used as part of the assessment.

Table 3 PSH capacity, flow rates and operating limits

Scheme	Headpond capacity (Mm^3)	Discharge rate (m^3/s)	Pump rate (m^3/s)	Stop pumping level (mAOD)	Stop Generating Level (mAOD)
Foyers	15	200	140	15.27	17.44
Loch na Cathrach	5	220	154	15.33	17.6
Loch Kemp	21	416	289	15.42	17.44
Proposed Development	29	425	382	15.42	17.60

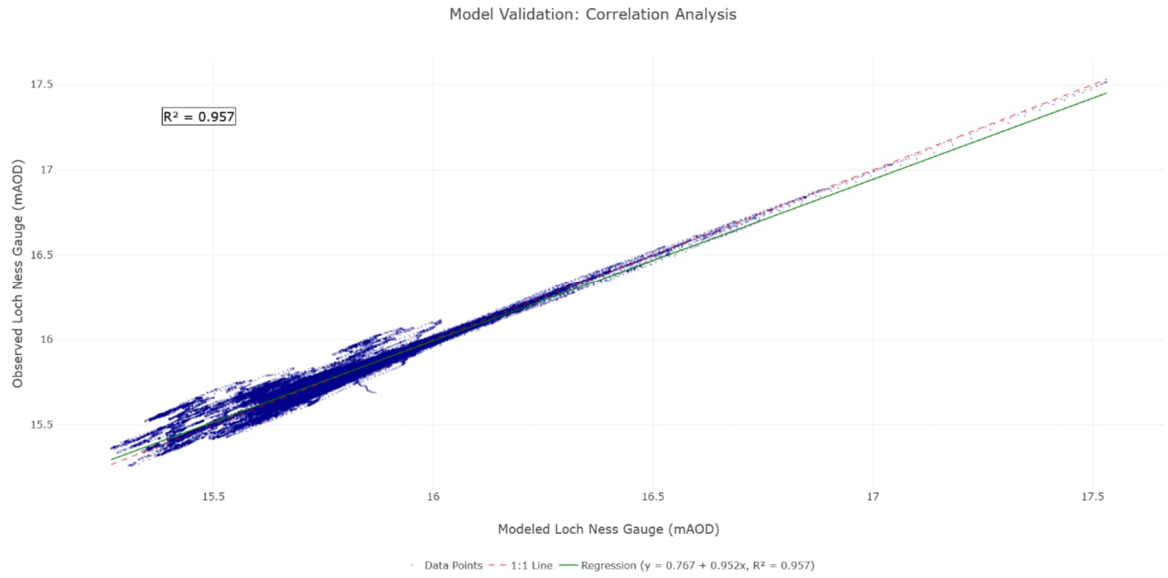
4.3 Model validation of Baseline Model

4.3.1 The results from the existing scenario model have been compared with observed water levels for the period from 2015-2024, where Loch Ness level data is available from the Loch Ness at Foyers water level gauging station.



Insert 11 Gauged Loch Ness Levels and Modelled Loch Ness Levels Time Series Extract

4.3.2 A review of the modelled data against the gauged data shows a very good fit, as can be seen in **Insert 11 Gauged Loch Ness Levels and Modelled Loch Ness Levels Time Series Extract.** The coefficient of determination (R^2) measures how well a statistical model predicts an outcome. The R2 value for the model fit is 0.96 and therefore a very good representation of the water balance in Loch Ness, **Insert 12 Gauged Loch Ness Levels vs Modelled Loch Ness Levels Plot**.



Insert 12 Gauged Loch Ness Levels vs Modelled Loch Ness Levels Plot

4.4 Model Simulation Scenarios

4.4.1 The objective of this modelling is to understand the impact of the operation of the Proposed Development on the water resources in Loch Ness, including other existing and proposed PSH schemes, on loch levels and outflow from Loch Ness.

4.4.2 The model has also been used to run the cumulative impact scenarios based on the inclusion of generating profiles for Loch na Cathrach and Loch Kemp.

4.4.3 The model duration is 10 years from October 2014 to September 2024. This duration allows for the impact of the scheme over a broader range of hydrological conditions, compared to running single year scenarios. A single year is unlikely to align with the average variability of Loch Ness levels.

4.4.4 Extending back to October 2014 allows us to capture the March 2015 high water level period together with the June 2023 low water level period. A generation profile data set was generated for the period 2016 to 2024. The profile for 2016 was therefore used for 2014 and 2015 to capture the impact during the periods of raised water levels.

Table 4 Model Scenarios

Scenario	Description
Baseline	**Model run without any schemes (Foyers included in baseline)**
The Proposed Development	Water Balance model with GEE scheme operating in line with generation profile and operating window
The Proposed Development and Loch na Cathrach PSH	Water Balance model with GEE scheme as above together with Loch na Cathrach operating based on a similar profile to GEE with adjustment for scheme capacity.
The Proposed Development, Loch na Cathrach and Loch Kemp PSH	Water Balance model with GEE scheme as above together with Loch na Cathrach and Loch Kemp operating based similar profile to GEE with adjustment for scheme capacities

4.4.5 In addition to the cumulative impact of the existing and proposed PSH schemes, a further set of simulations has been undertaken taking account of the Dochfour Weir Upgrade at the downstream end of Loch Dochfour. As noted in **Chapter 11: Flood Risk and Water Resource (Volume 2: Main Report)**, the full proposals for these upgrades are at an early stage and is subject to a separate application. Further details on the Dochfour Weir Upgrades can be seen in **Appendix 2.1 Dochfour Weir Upgrade Description.**

4.4.6 Assessment of flood risk in **Appendix 11.2 Flood Risk Assessment (Volume 5: Appendices)** has shown that a variable weir operated to full height all year, or a permanently raised weir would have a significant impact on flood risk and, as such, has been discounted. A variable weir operating from April to September has therefore been considered as part of this water resources assessment. A set of simulations has been carried out with the seasonal variable weir in operation based on a mitigation measure as described in **Appendix 2.1 Dochfour Weir Upgrade Description (Volume 5: Appendices).**

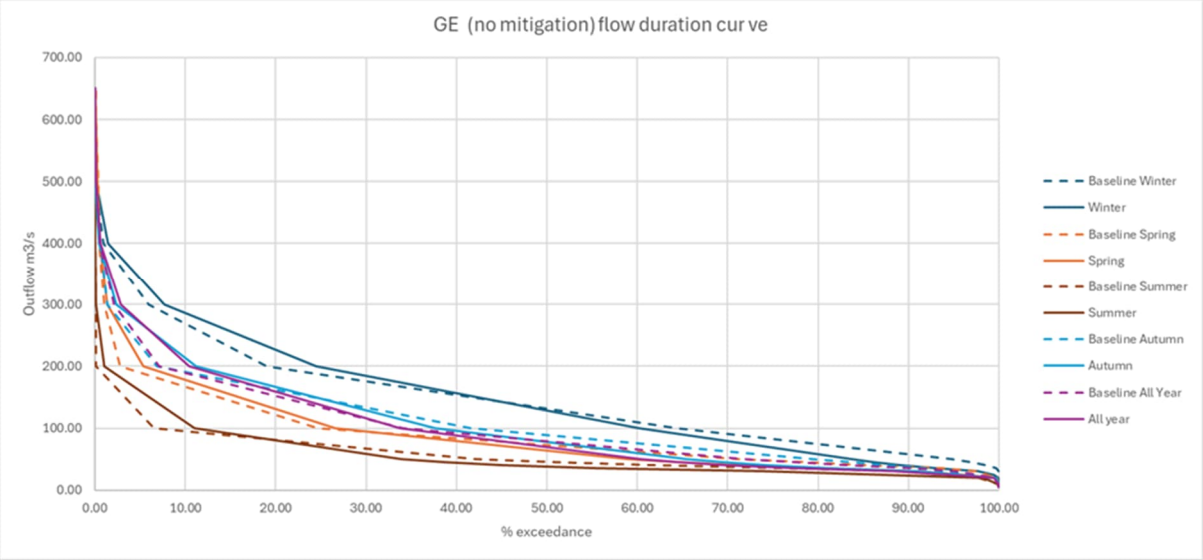
5. Assessment of Effects

5.1 Proposed Development

5.1.1 The following section summarises the impact of the operation of the Proposed Development on water levels and pass-forward flows in the River Ness together with the impact that the scheme would have on flows from the catchment of the headpond at Allt Loch an t-Sionnaich.

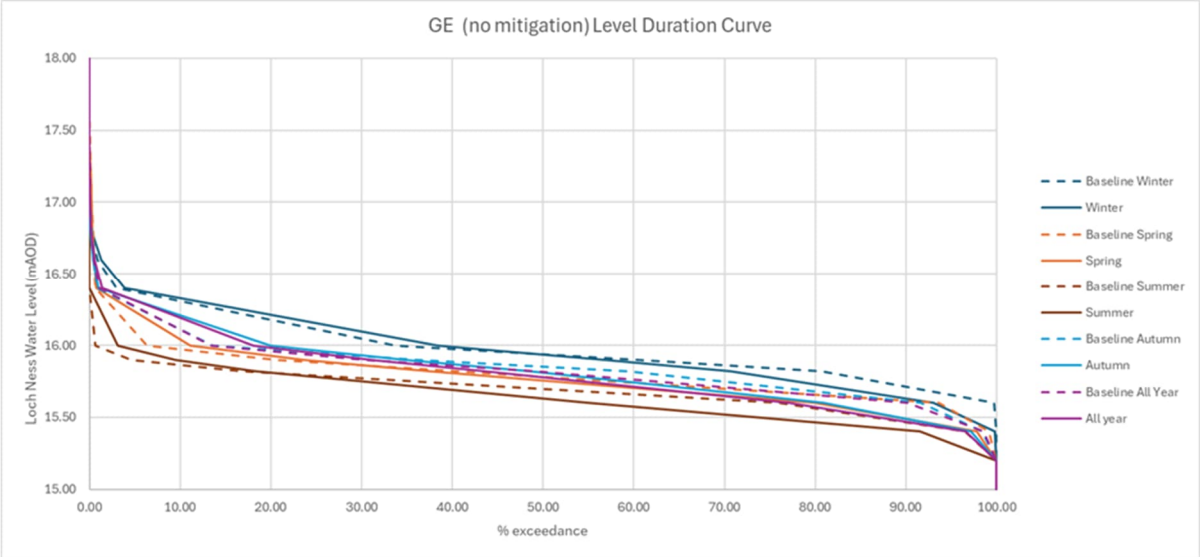
Loch Ness Water Balance Assessment

5.1.2 The following section summarises the impact of the operation of the Proposed Development, with no changes to Ness Weir on water levels and pass-forward flows in the River Ness and on the level duration curve in Loch Ness.



Insert 13 River Ness Flow Duration Curve with the Operation of the Proposed Development

5.1.3 The operation of the Proposed Development shows variations in the flow in the River Ness, with no changes to Ness Weir both on an annual and seasonal basis. Extreme events (both flood and droughts) are not impacted based on the hands-off levels being in place as part of the Proposed Development design.



Insert 14 Loch Ness Level Duration Curve with the Operation of the Proposed Development

5.1.4 The operation of the Proposed Development shows variations in the water levels in Loch Ness both on an annual and seasonal basis. Extreme events, both flood and droughts are not impacted based on the hands-off levels being in place as part of the scheme design.

- Max water level over simulation period – 17.40 mAOD (reduction of 130 mm from baseline)
- Minimum water level of simulation period – 15.27 mAOD (no change from baseline)
- Mean water level over simulation period – 15.79 mAOD (reduction of 30 mm from baseline)
- Median water level over simulation period – 15.78 mAOD (reduction of 30 mm from baseline)

5.1.5 The operation of the Proposed Development would result in increased fluctuation in water level in Loch Ness as a result of the generation and pumping cycles. The water level would however remain within the operational regimes set out for the Proposed Development and in line with the level duration curves noted above.

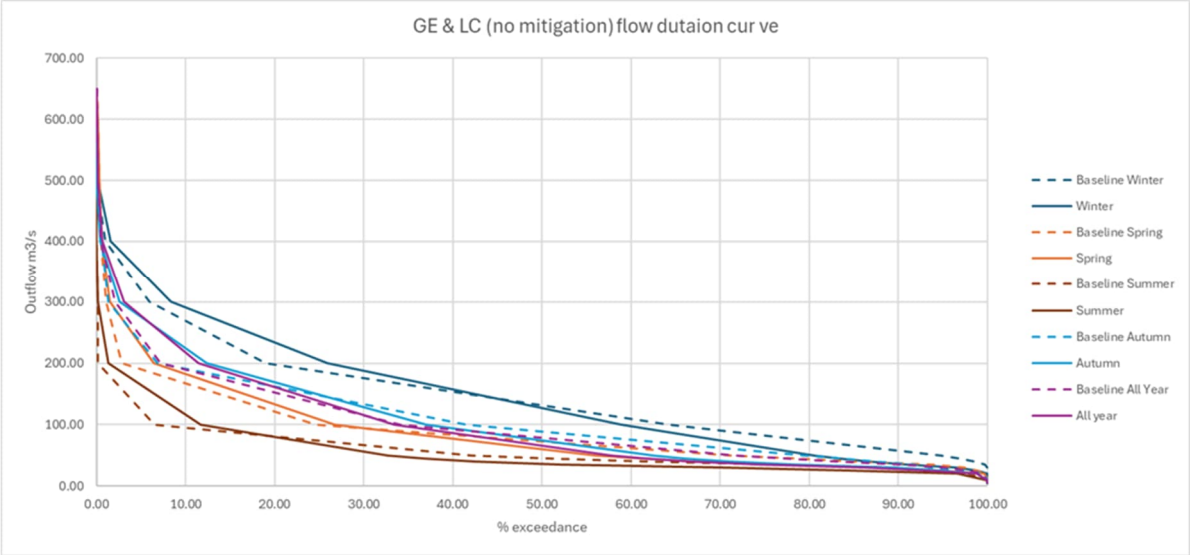
Impact on Allt Loch an t-Sionnaich Flows

5.1.6 The construction of the Headpond at Loch nam Breac Dearga would result in the impoundment of the loch outflow and other small tributaries of the Allt Loch an t-Sionnaich. The current flow regime would as a result cease to exist once the Proposed Development has been completed and is operational. The impact on flows in the Allt would be significant and compensation flow arrangements would be required to address this.

5.1.7 During construction Phase the flows would need to be maintained to prevent the Headpond from impounding water, to provide compensation flow in the channel for ecological requirements and to maintain flow in the channel for the hydro scheme inlet. This can be maintained through the diversion of the channel whilst the Low Level Outlet is constructed and then through the Low Level Outlet.

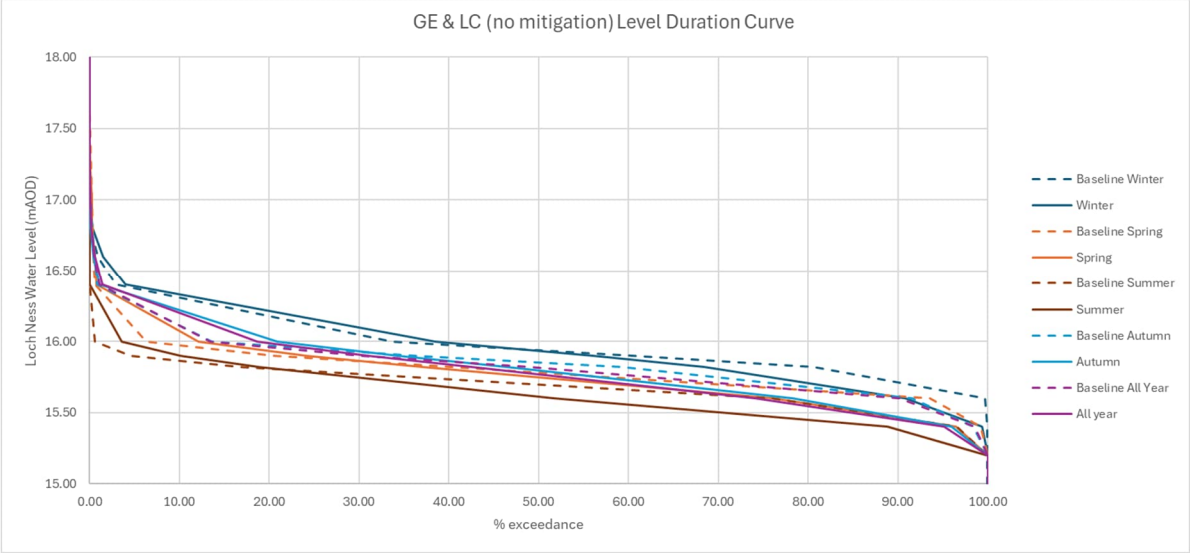
5.2 Cumulative Impact without Dochfour Weir Upgrade

5.2.1 The following section summarises the modelling results based on the cumulative impact of the Proposed Development and the consented Loch na Cathrach PSH. This section is based on no works to the Ness Weir. The impact on the Allt Loch an t-Sionnaich flows would be unchanged as it is not affected by any other schemes.



Insert 15 River Ness Flow Duration Curve with Proposed Development & Loch na Cathrach PSH

5.2.2 The operation of the schemes shows variations in the flow in the River Ness both on an annual and seasonal basis. Extreme events, both flood and droughts are not impacted based on the hands-off levels being in place as part of the scheme design. The variations are greater than those for Proposed Development alone.

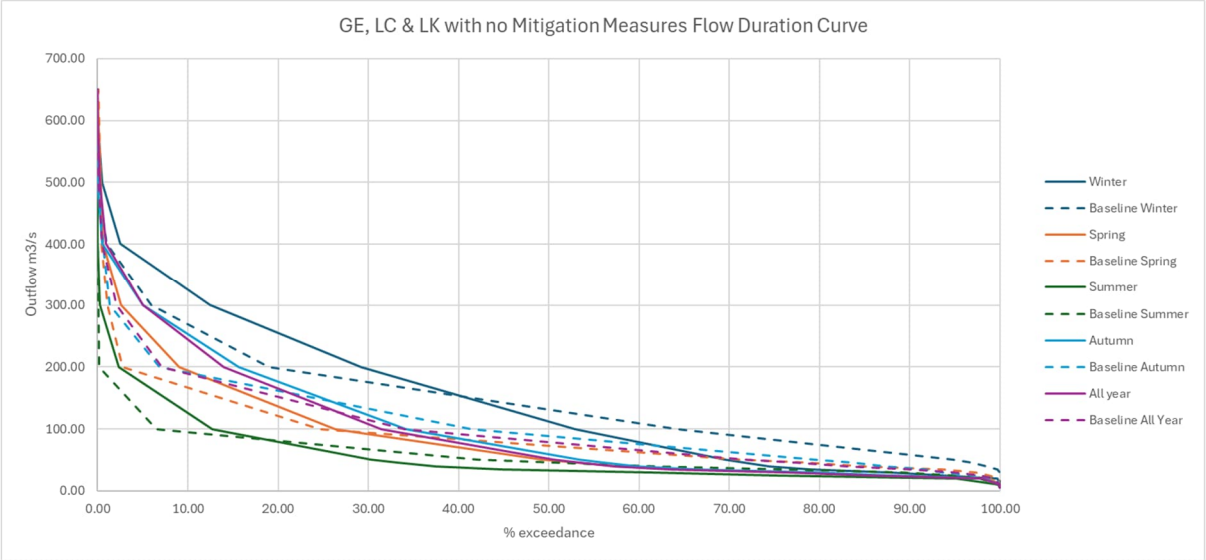


Insert 16 Loch Ness Level Duration Curve with Operation of the Proposed Development and Loch na Cathrach PSH

5.2.3 The operation of the schemes show variations in the water levels in Loch Ness both on an annual and seasonal basis. Extreme events, both flood and droughts are not impacted based on the hands-off levels being in place as part of the scheme design.

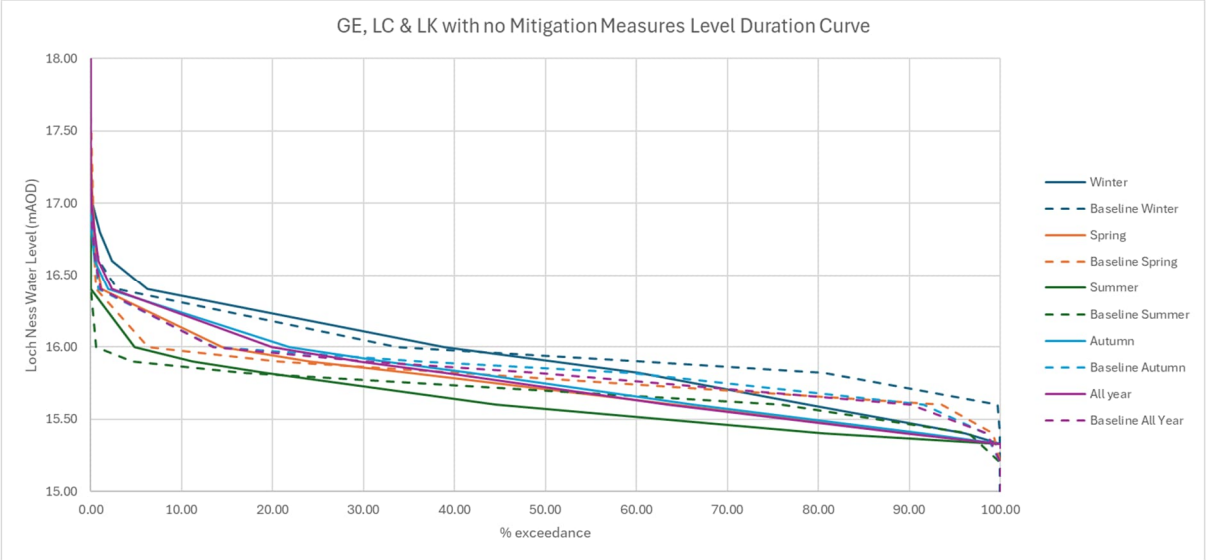
- Max water level over simulation period – 17.36 mAOD (reduction of 170 mm from baseline)
- Minimum water level of simulation period – 15.27 mAOD (no change from baseline)
- Mean water level over simulation period – 15.78 mAOD (reduction of 40 mm from baseline)
- Median water level over simulation period – 15.77 mAOD (reduction of 40 mm from baseline)

5.2.4 The following section summarises the modelling results based on the cumulative impact of the Glen Earrach, the consented Loch na Cathrach PSH and the proposed Loch Kemp PSH which has been submitted for planning. The impact on the Allt Loch an t-Sionnaich flows would be unchanged as it is not affected by any other schemes.



Insert 17 River Ness Flow Duration Curve with the Operation of the Proposed Development, Loch na Cathrach and Loch Kemp PSH

5.2.5 The operation of the schemes shows variations in the flow in the River Ness both on an annual and seasonal basis. Extreme events, both flood and droughts are not impacted based on the hands-off levels being in place as part of the scheme design. The variations are greater than those for the Proposed Development alone.



Insert 18 Loch Ness Level Duration Curve with the Operation of the Proposed Development, Loch na Cathrach and Loch Kemp PSH

5.2.6 The operation of the schemes show variations in the water levels in Loch Ness both on an annual and seasonal basis. Extreme events, both flood and droughts are not impacted based on the hands-off levels being in place as part of the scheme design.

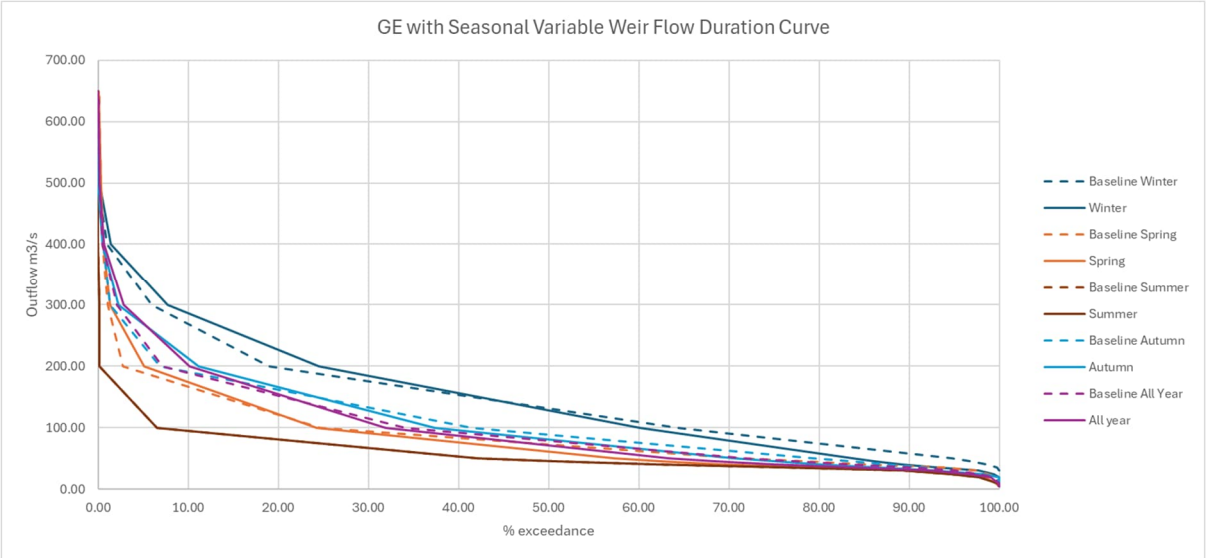
- Max water level over simulation period – 17.35 mAOD (reduction of 180 mm from baseline)
- Minimum water level of simulation period – 15.27 mAOD (no change from baseline)
- Mean water level over simulation period – 15.75 mAOD (reduction of 70 mm from baseline)
- Median water level over simulation period – 15.73 mAOD (reduction of 80 mm from baseline)

5.3 Cumulative Impact with Dochfour Weir Upgrades

5.3.1 The following section summarises the modelling results based on the cumulative impact of various combinations of the Proposed Development operating with the Dochfour Weir Upgrade variable weir operating between April and September which forms additional mitigation to the Proposed Development.

Proposed Development with Dochfour Weir Upgrades – Seasonal Weir

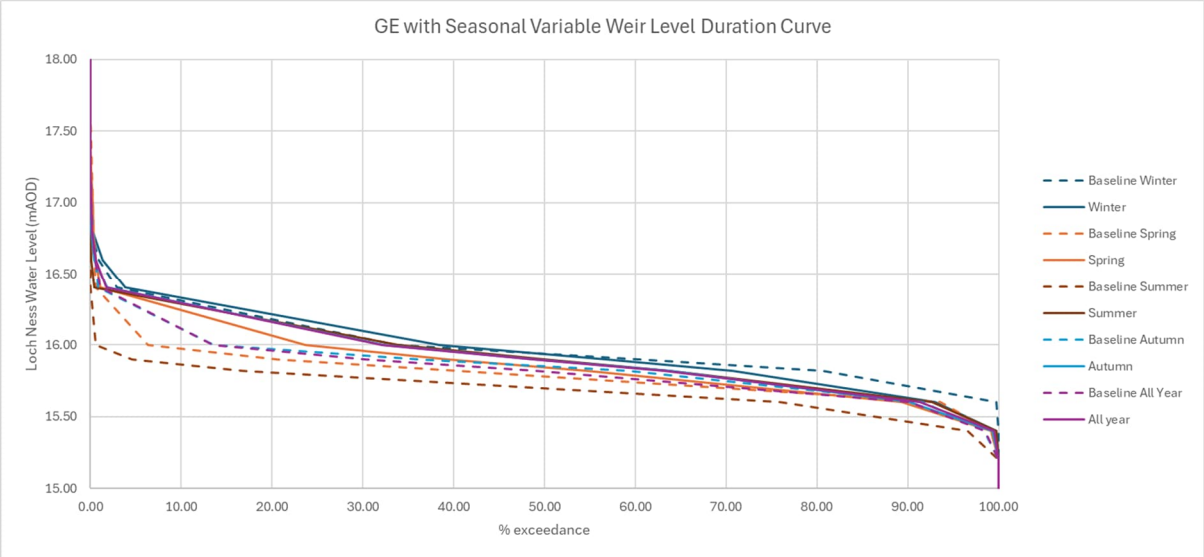
5.3.2 The operation of the variable weir results in the flow duration curve during the operational period of the variable weir. This can be seen by the summer season flow duration curve for both the baseline and with the scheme being equal in **Insert 19 River Ness Flow Duration Curve with the Operation of the Proposed Development PSH with the Seasonal Variable Weir at Dochfour Weir**.



Insert 19 River Ness Flow Duration Curve with the Operation of the Proposed Development PSH with the Seasonal Variable Weir at Dochfour Weir

5.3.3 The operation of the Proposed Development shows variations in the water levels in Loch Ness both on an annual and seasonal basis **Insert 20 Loch Ness level duration curve with the operation of the Proposed Development together with the seasonal variable weir at Dochfour Weir**. Extreme events, both flood and droughts are not impacted based on the hands-off levels being in place as part of the scheme design.

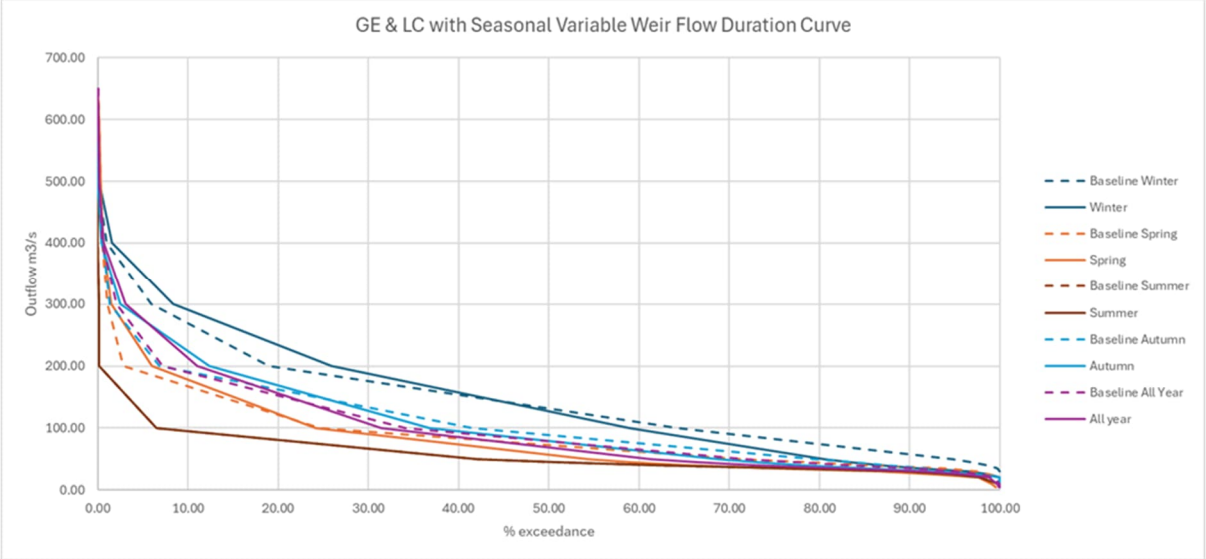
- Max water level over simulation period – 17.40 mAOD (reduction of 130 mm from baseline)
- Minimum water level of simulation period – 15.36 mAOD (increase of 90 mm from baseline)
- Mean water level over simulation period – 15.90 mAOD (increase of 80 mm from baseline)
- Median water level over simulation period – 15.89 mAOD (increase of 80 mm from baseline)



Insert 20 Loch Ness level duration curve with the operation of the Proposed Development together with the seasonal variable weir at Dochfour Weir

The Proposed Development and Loch na Cathrach PSH and seasonal variable weir at Dochfour Weir

5.3.4 The operation of the variable weir results in the flow duration curve during the operational period of the variable weir. This can be seen by the summer season flow duration curve profile for both the baseline and the with Proposed Development following the same profile(dashed and solid summer profile lines are the same) in **Insert 21 River Ness flow duration curve with the operation of the Proposed Development and Loch na Cathrach PSH together with the seasonal variable weir at Dochfour Weir**.

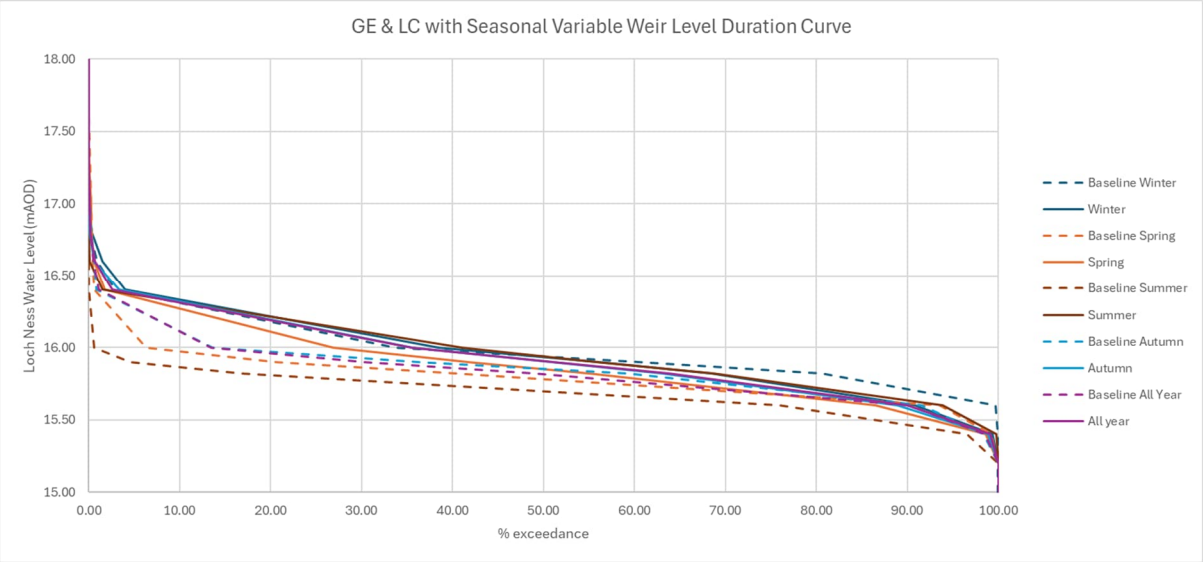


Insert 21 River Ness flow duration curve with the operation of the Proposed Development and Loch na Cathrach PSH together with the seasonal variable weir at Dochfour Weir

5.3.5 The operation of the schemes show variations in the water levels in Loch Ness both on an annual and seasonal basis (**Insert 22 Loch Ness level duration curve with the operation of the Proposed Development and Loch na Cathrach PSH together with the seasonal variable weir at Dochfour Weir**). Extreme events, both flood and droughts are not impacted based on the hands-off levels being in place as part of the scheme design.

- Max water level over simulation period – 17.36 mAOD (reduction of 170 mm from baseline)

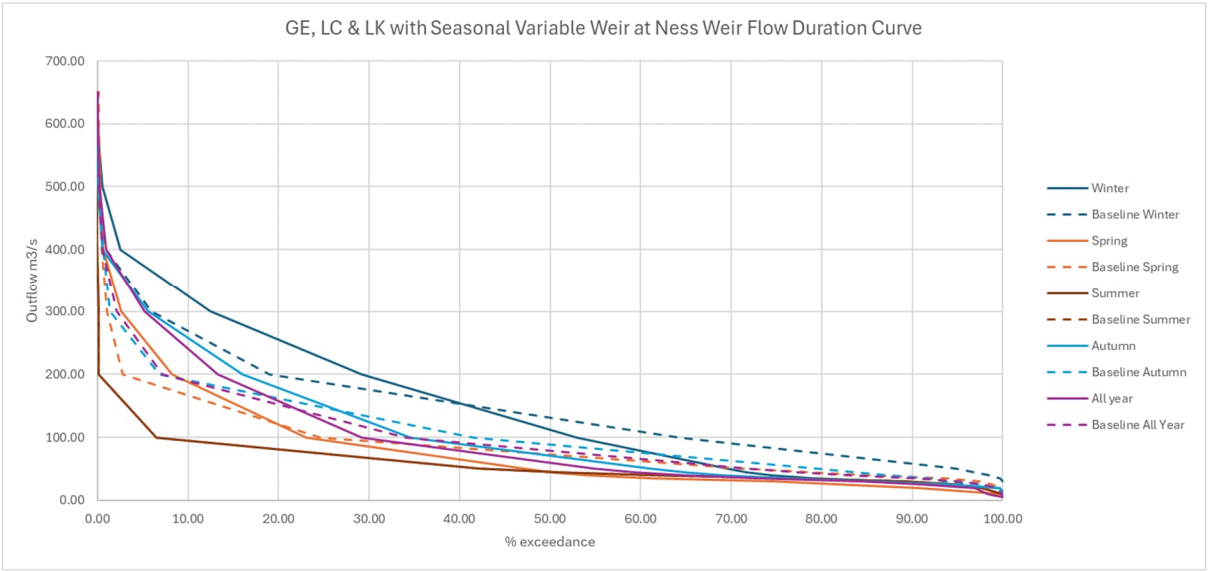
- Minimum water level of simulation period – 15.35 mAOD (increase of 80 mm from baseline)
- Mean water level over simulation period – 15.91 mAOD (increase of 90 mm from baseline)
- Median water level over simulation period – 15.91 mAOD (increase of 100 mm from baseline)



Insert 22 Loch Ness level duration curve with the operation of the Proposed Development and Loch na Cathrach PSH together with the seasonal variable weir at Dochfour Weir

The Proposed Development, Loch na Cathrach and Loch Kemp PSH and seasonal variable weir at Dochfour Weir

5.3.6 The operation of the variable weir results in the flow duration curve during the operational period of the variable weir. This can be seen by the summer season flow duration curve for both the baseline and with scheme being equal in **Insert 23 River Ness flow duration curve with the operation of the Proposed Development and Loch na Cathrach and Loch Kemp PSH together with the seasonal variable weir at Dochfour Weir.**



Insert 23 River Ness flow duration curve with the operation of the Proposed Development and Loch na Cathrach and Loch Kemp PSH together with the seasonal variable weir at Dochfour Weir

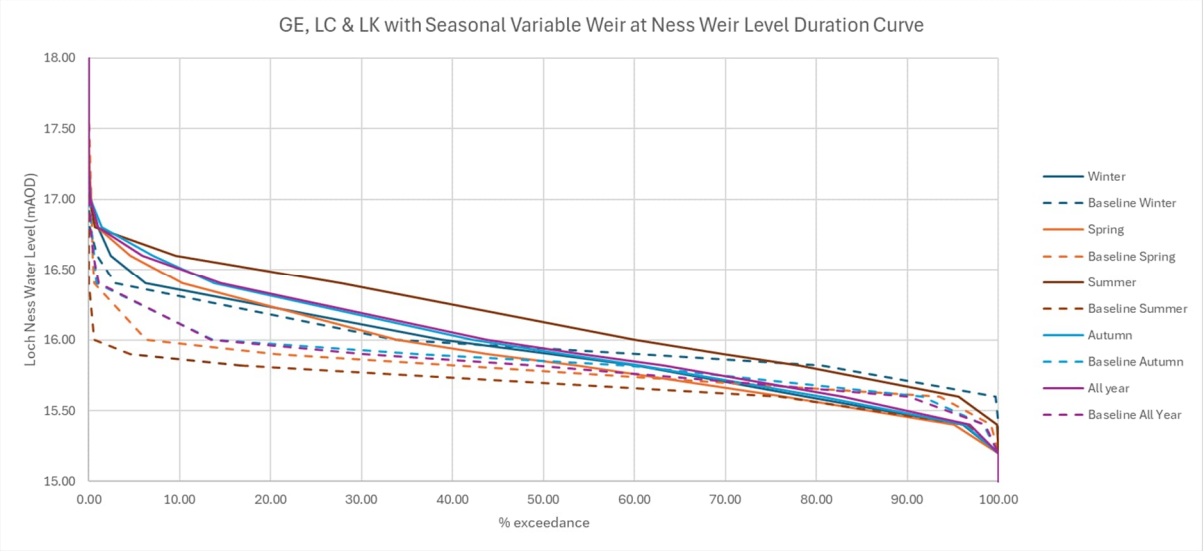
5.3.7 The operation of the schemes show variations in the water levels in Loch Ness both on an annual and seasonal basis (**Insert 24 Loch Ness level duration curve with the operation of the Proposed**

Development and Loch na Cathrach and Loch Kemp PSH together with the seasonal variable weir at Dochfour Weir). Extreme events, both flood and droughts are not impacted based on the hands-off levels being in place as part of the scheme design.

- Max water level over simulation period – 17.36 mAOD (reduction of 160 mm from baseline)
- Minimum water level of simulation period – 15.33 mAOD (increase of 60 mm from baseline)
- Mean water level over simulation period – 15.97 mAOD (increase of 150 mm from baseline)
- Median water level over simulation period – 15.93 mAOD (increase of 120 mm from baseline)

5.3.8 The operation of the Glen Earrach Proposed Development would result in increased fluctuation in water level in Loch Ness because of the generation and pumping cycles. The water level would however remain within the operational regimes set out for the Glen Earrach Proposed Development and in line with the level duration curves noted above.

5.3.9 The introduction of the variable weir would isolate the fluctuations in water levels in Loch Ness from the pass-forward flows in the River Ness. Fluctuations in flows in the River Ness would therefore not be experienced when the variable weir is in operation.



Insert 24 Loch Ness level duration curve with the operation of the Proposed Development and Loch na Cathrach and Loch Kemp PSH together with the seasonal variable weir at Dochfour Weir

6. Mitigation Measures

6.1 Introduction

6.1.1 The mitigation measures outlined below are required to reduce the impacts on water resources to a level which is considered to be Not Significant as detailed in **Section 11.15** of **Chapter 11: Flood Risk and Water Resource (Volume 2: Main Report).**

6.2 Operational Regime

6.2.1 An effective operational regime is required to ensure the Proposed Development continues to operate effectively whilst ensuring that water resources are not impacted and key receptors are not placed at risk.

6.2.2 In order to mitigate impacts on water resources and key receptors the operating levels for the Proposed Development, as modelled in this assessment, should be set as follows:

- Hands-off low level (stop pumping) 15.42 mAOD

- Hands-off high Level (stop generation) 17.60 mAOD

6.2.3 The Hands-off low level will ensure that reduction in water levels in Loch Ness during normal and low flows do not impact the maintenance of environmental minimum flow in River Ness and operation of Caledonian Canal.

6.3 Compensation Flows

6.3.1 The construction of the Headpond at Loch nam Breac Dearga would result in the upper part of the tributary of the Allt Loch an t-Sionnaich being impounded and the flow of water being impeded from passing downstream. A compensatory flow arrangement is included within the scheme as embedded mitigation and would maintain flows down this watercourse.

6.3.2 The compensatory flow arrangement would be based on a variable flow and head arrangement to take account of the continuous fluctuation in water levels in the Headpond and the seasonal variation in flows in the watercourse. A submerged discharge valve arrangement would provide the range of flows as calculated in the low flow assessment and for the range of water levels.

6.3.3 The seasonal variation would be based on the average monthly flows for each calendar month. The overall monthly volume of discharge would be maintained at the existing volume. In addition to the compensatory flow occasional higher flow would be released as part of the scour valve operation.

6.3.4 The assessment in this Appendix has been based on calculated flow parameters based on Low Flows, software widely used in the industry and by regulators. In line with good practice, flow monitoring would be undertaken over a number of years to confirm the monthly flow duration curves.

6.4 Implementation of the Dochfour Weir Upgrades

6.4.1 The Dochfour Weir Upgrades, whilst not part of the Proposed Development has been considered as part of this assessment. The upgrades consist of the construction and operation of a variable weir that will adjust the height of the weir to contain the pumped storage hydro operation flows within Loch Ness and isolate the flows in the River Ness from the impact of the PSH activities.

6.4.2 The weir should be restricted to summer operation only (April to September) to avoid the potential to increase flood risk if operated all year. This restriction should remain until an appropriate regime can be developed that will not increase flood risk. This could include the use of forecasting information and a limited operation of the variable weir such as it is not raised any further than the maximum volume that can be lowered to the existing Ness Weir sill level in one day so as not to increase the flood risk. Any such proposal will be assessed in detail to ensure that such operation does not impact on flood risk at Loch Ness or along the River Ness.

6.4.3 The Dochfour Weir Upgrades is not part of the application for the Proposed Development and will be subject to a separate application. Details of the Dochfour Weir Upgrade can be seen in **Appendix 2.1 Dochfour Weir Upgrade Description (Volume 5: Appendices)**.

7. Conclusion

7.1.1 The Proposed Development would introduce the ability to transfer large volumes of water between the Headpond and Loch Ness. The Headpond operating volume is 29 Mm^3 and the generation and pump flow rates are 425 and 382 m^3/s respectively.

7.1.2 An assessment of the impact that the Proposed Development would have on the flows in the Allt Loch an t-Sionnaich concludes that during construction stage these flows can be maintained. Once the Headpond is impounded the upper part of the catchment would be cut off from the downstream watercourse. This would have a significant impact on the flows in the initial reach of the watercourse. Through the introduction of a compensation flow regime this impact can be mitigated and flows in the channel can be supplemented from the Headpond to replicate the seasonal variation and volume of discharge. The impact following the implementation of the mitigation measures is therefore negligible.

7.1.3 The operation of the Proposed Development based on the generation profile would result in changes to the water levels and pass-forward flows in the River Ness. This overall impact is managed through the introduction of hands-off levels, both upper and lower which would be managed through the CAR licence process.

7.1.4 The implementation of the proposed variable weir arrangement at Dochfour Weir would address the summer impacts on pass-forward flows down the River Ness from the cumulative PSH schemes on Loch Ness.

7.1.5 This would result in increased water level in Loch Ness during summer months of 80 mm over the year based on the Proposed Development alone, increasing to 150 mm with the cumulative impact of the proposed Loch na Cathrach and Loch Kemp PSH. These are however within the normal range of Loch Ness.

8. References

1. EU Directive 2000/60/EC (Water Framework Directive (WFD))
2. Water Environment and Water Services Act (Scotland) 2003 (‘the WEWS Act’)
3. Water Environment (Controlled Activities) (Scotland) Regulations 2011 (CAR) in respect of discharges to surface or groundwater (‘the CAR Regulations’)
4. PAN 1/2013 – Environmental Impact Assessment, Scottish Government Planning Department
5. UK Climate Projections (UKCP18) website. [Online]. Available: http://ukclimateprojections.metoffice.gov.uk/21678
6. National River Flow Archive [Online], available at https://nrfa.ceh.ac.uk/data/search,
7. Loch Dochfour, 1987, Reservoirs Act 1975, British Waterways Board.
8. Climate change allowances for flood risk assessment in land use planning Version 5, August 2024, SEPA
9. Engineering in the water environment: good practice guide River crossings - Second edition – SEPA, SNH
10. Loch Dochfour Reservoirs Act Section 10 Inspection 1987
11. Power from the Glens: SSE (formerly Scottish Hydro Electric)
12. UKCEH aggregated Land Cover Maps2023 – viewed online on the nrfa.ceh.ac.uk/data/station/spatial/6007

Glen Earrach AECOM