Balliemeanoch Pumped Storage Hydro

Environmental Impact Assessment Report

Volume 5: Appendices
Appendix 10.1: Material Management Appraisal

ILI (Borders PSH) Ltd

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Quality information

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1. Introduction

This Materials Management Appraisal (MMA) report has been undertaken to provide engineering justification for the management of materials that will be excavated to create the infrastructure associated with the Development and prove that no import of material will be required for the construction of the main components of the scheme. This MMA should be read in conjunction with *Chapter 10: Geology and Soils (Volume 2: Main Report)*.

The MMA outlines the volumes of material that are anticipated to be associated with various components of the Development. The general philosophy behind the project material management is that the main component, the Headpond, will be created by undertaking a large, balance, cut and fill exercise that will be supplemented with material that is generated from a borrow pit within the headpond location and the underground and above ground excavation activities.

This MMA has been produced before any intrusive Site Investigation (SI) works, however, it is anticipated that this appraisal will be updated during the detailed design stage, post consent, where the SI will be undertaken.

The management of peat has been excluded from this appraisal as it is covered separately in *Appendix 10.2: Outline Peat Management Plan (Volume 5: Appendices)*.

The following sections show the processes that have been used to calculate the volumes of material anticipated to be encountered during the construction of the Development.

2. Sources of Information

A number of sources of information have been used to undertake this appraisal, as detailed below:

- ICE Earthworks A guide 2nd Edition
- Autodesk Civil 3D (C3D) Model of the Headpond design
- Site Visits
- Peat Probing

3. Appraisal

The volume of material that will be generated from the construction of the Development has been calculated from the C3D model and from engineering estimates. In both cases, the volumes calculated will have to be bulked or compacted to reflect the actual volumes that will be generated / used during construction. Table 1 details the bulking and compaction factors that have been used.

Table 1. Bulking and Compaction Factors for Rocks and Soils

Component	Bulking	Compaction
Metamorphic Rock	56%	74%
Topsoil	40%	80%
Peat	35%	63%

The bulking and compaction factors are based upon assumptions made following the standard values detailed in ICE Earthworks: A Guide 2nd Edition, 2015, with a net bulking target of 15% maintained throughout this MMA.

Chapter 4: Approach to EIA (Volume 2: Main Report) outlines the enveloping which have been applied to elements of the Development. Note, all **totals** within this appraisal have also been rounded to the nearest ten thousand (10,000) m, m^2 or m^3.

3.1 Material Generated

From the 3D model, the volume generated from the excavation at the Headpond has been determined in Table 2.

Within the Headpond, a large borrow pit has been identified to accommodate the material needed for the project.

Additionally, within the Headpond borrow pit, peat will be encountered and will have to be excavated. The peat has been removed from the volume of excavated material in this appraisal, as shown in Table 2. The calculated volume of peat and how it will be handled, stored and reused is detailed in *Appendix 10.2: Outline Peat Management Plan (Volume 5: Appendices)*.

Table 2. Headpond Excavation

Item	Volume Excavated
BP 01 (m³) Total Volume (C3D)	10,678,044
Volume of Peat (m³)	(-) 642,755
Excavated Volume (m³)	10,035,289
Bulking Factor	56%
Total Volume of Useable Material (m³)	**15,790,000**

Outside of the Headpond excavation, the other two main excavation areas can be described as 'Below Ground Excavation' and 'Above Ground Excavation'.

The 'Below Ground Excavation' is split into 'Waterways' and 'Underground Infrastructure'. The Waterways are all the 'wet' underground components such as the High-Pressure and Low-Pressure Tunnels and Power Cavern pipework, and the Underground Infrastructure are the 'dry' underground components such as the Power Cavern and Access Tunnels.

Table 3 shows a summary of the material that is estimated to be excavated during the construction of the Waterways. All the below ground excavation is anticipated to be constructed using conventional drill and blast.

Table 3. Below Ground Excavations – Waterways

Item	Tailrace	Headrace (Low Pressure)	Tailrace (High Pressure)	Upper Surge Shaft	Lower Surge Shaft
Internal Diameter (m)	13	13	13	13	13
Excavated Area (m²)	153.94	153.94	153.94	153.94	153.94
Lining Surface Area (m²)	16.84	16.84	16.84	16.84	16.84
Length (m)	2,423	231	476	506	83
Lining Volume (m³)	40,801	3,890	8,015	8,521	1,398
Excavation Volume (m³)	372,992	35,560	73,275	77,893	12,777
Bulking Factor					56%
Bulked Volume (m³)	581,867	55,473	114,308	121,513	19,932
Bulked Total (m³)					**890,000**

Assumptions:

The dimensions stated above are based on initial design and are approximate values based on a reasonable maximum component size. Excavated areas of tunnels allows for 900mm additional diameter for lining and overbreak, as follows:

- *Drill and blast lining = 400mm*
- *Drill and blast overbreak = 500mm*

Table 4 shows a summary of the material that is estimated to be excavated during the construction of the underground infrastructure. It is assumed all the components stated below will be excavated using conventional drill and blast.

The excavated area has been estimated based on the internal dimensions plus the assumptions that are stated below for the different infrastructure components.

Table 4. Below Ground Excavation - Underground Infrastructure

Item	Power Cavern	Transformer Cavern	MIV Cavern	Cable Gallery x 3	Ventilation shafts*	Cable / Power Tunnel**	Access Tunnel	Construction Tunnel
Internal Dimension (X)	200	200	200	60	5	8	9	5
Internal Dimension (Y)	25	25	15	15	5	8	6	2.5
Excavated Area (m²)	5,454	5,454	3,434	1,054	28.27	108.3	104	32
Lining Surface Area (m²)	226	226	216	76	6.79	15.2	14.6	7.71
Length / Height (m)	50	30	30	5	1,275	3,605	2,050	2,160
Lining Volume (m³)	11,300	6,780	6,480	380	8,650	54,788	29,984	16,660
Excavation Volume (m³)	272,700	163,620	103,020	5,270	36,041	390,453	213,753	69,416
Bulking Factor					56%			
Bulked Volume (m³)	425,412	255,247	160,711	24,664	56,224	609,106	333,455	108,289
Bulked Total (m³)								**1,970,000**

Assumptions:

- *Power Cavern, Transformer Cavern, MIV Cavern & Cable Gallery drill and blast lining = 500mm*
- *Power Cavern, Transformer Cavern, MIV Cavern & Cable Gallery drill and blast overbreak = 500mm*
- *Tunnels drill and blast lining = 400mm*
- *Tunnels drill and blast overbreak = 500mm*

** Where circular tunnels are assessed, dimensions (x) = internal diameter*

** Where tunnels are 'D' shaped, dimension (x) = internal diameter and dimension y = height of rectangular section*

The 'Above Ground Excavations' comprise of the excavation works that will be undertaken at the Tailpond inlet / outlet and at Tunnel Portal Adits. Table 5 shows the estimated volume of material that will be generated from works at the inlet / outlet Structure at the Tailpond and the Construction Adits.

Table 5. Tailpond Inlet / Outlet & Adits

Item	Inlet / Outlet Tailpond	Construction Adits
Excavated Volume (m³)	490,813	77,120
Bulking Factor	56%	56%
Bulked Volume (m³)	795,668	120,307
Bulked Total (m³)		**890,000**

Assumptions:

- *Volume is estimated from excavation works required at the Tailpond.*
- *The majority of the material is assumed to be metamorphic rock and would be usable in the Headpond Embankment Structures.*

In addition to the excavation works described above, striping of surface vegetation will also be required. The main area where surface vegetation will have to be stripped is the Headpond, which will require vegetation to be cleared before the excavation works commence. The model of the Headpond assumed that on average 500mm of organic material and topsoil would not be able to be used for the construction of the Headpond Embankments. Table 6 shows the estimated volume of material the is generated from the vegetation strip.

Table 6. Headpond Vegetation Strip

Item	Depth (m)	Excavated Area (m²)	Excavation Volume (m³)	Bulking Factor	Bulked Total (m³)
Headpond Vegetation Strip	0.5	693,236	346,618	35%	**470,000**

Table 7 summarises the total volume of material that will be excavated during construction.

Table 7. Total Excavated Volume (Bulked)

	Surface Excavation Headpond (Table 2)	Below Ground Excavation (Table 3 & Table 4)	Above Ground Excavation (Table 5)	Vegetation Strip (Table 6)	Total
Excavated Volume (m³)	15,790,000	2,860,000	890,000	470,000	**20,010,000**

3.2 Reuse of Excavated Material

The main construction component that will utilise the material excavated during construction is the Headpond Embankments. The C3D model includes the Embankment and Table 8 details the volume required for construction. The volume taken from the C3D model represents a compacted volume of material, therefore, the actual volume of material is greater – as detailed in Table 8.

Table 8. Embankment Volumes

Item	Embankment 1 Volume	Embankment 2 Volume	Compaction Factor	Total Bulked (m³)
Volume (m³)	12,506,063	79,335	74%	**17,010,000**

Assumptions

- *The majority of the makeup of the embankment will be made with metamorphic material. Thus, a compaction factor for metamorphic material has been used, as shown in Table 1.*

The design of the Headpond Embankments is essentially a cut and fill exercise with the aim to balance the two. The majority of the material used to construct the Embankments will come from the borrow pit excavation carried out within the Headpond. However, it is anticipated that not all the material will be suitable for use in the Embankment. As such, a wastage of 5% has been factored into the assessment.

Table 9 provides a breakdown of the cut / fill exercise undertaken for the Embankments using only the surface excavated material from the Headpond.

Table 9. Headpond Borrow Pit Excavation – Material Reuse

Surface Excavated Material (m³)	Percentage of Reuse (%)	Material to be used in Embankment (m³)	Surplus (m³)	Wastage / Loss @ 5% (m³)	Volume of Embankments (m³)	Deficit of Material for the Embankment (m³)
15,790,000	91	14,368,900	1,421,100	718,445	17,010,000	-3,359,545

Assumptions

- *Reuse of material from the Headpond excavation = 91% is based on engineering judgement.*
- *Wastage of material from processing (as dust and particulates), transportation (as dust), and runoff (as suspended solids) has been estimated at 2% based on the ICE Earthworks, A guide 2nd Edition. This material has been assumed to be lost and is not included in the rest of this MMA.*

- *Lining foundations 'transition zone' of the embankment, as shown in Figure 2.9 (EIA Report Volume 3), has been included in 'Volume of Embankment' as it is assumed that the 'transition zone' will be made up of high-quality material that is anticipated to be sourced from the excavation activities;*
- *The lining on the inside face of the Headpond Embankment has not been included in the 'Volume of Embankment' as it is assumed that this material will be constructed with concrete.*

As demonstrated in Table 9, there is a shortfall in the volume of material required to build the Headpond Embankments from the surface excavated material alone. To make up this shortfall, the material excavated from below ground will be used.

Table 10 provides a breakdown of how the material excavated from below ground will be utilised.

Table 10. Underground Excavation - Material Reuse

Underground Excavated Material (m³)	Percentage of Reuse (%)	Material to be used in Embankment (m³)	Surplus (m³)	Wastage / Loss @ 5% (m³)	Remaining Volume of Embankment (m³)	Excess (m³)
3,750,000	94.5	3,543,750	206,250.00	177,187.50	3,359,545	7,017.50

Assumptions

- *Reuse of material generated from the tunnelling works in the Headpond = 92% is based on engineering judgement.*
- *Wastage of material from processing (as dust and particulates), transportation (as dust), and runoff (as suspended solids) has been estimated at 2% based on the ICE Earthworks, A guide 2nd Edition. This material has been assumed to be lost and is not included in the rest of this MMA.*

Note, while the percentage of reuse shown is reasonably high (> 90%), this includes a built in 5% wastage estimate, as shown in Table 9 and Table 10. As such, where actual volumes are considered, the overall estimate of material used will equate to 85% and 86% respectively.

Table 10 shows there will be an excess of approximately 7,000 m³ of material suitable for use within the Headpond Embankment. The total volume of excess material following excavation of all works and construction of the Headpond embankment is shown in Table 11. The volume has been calculated based on the total surplus material and any excess material as shown in Table 9 and Table 10.

Table 11. Total Excess Material

Item	Surface Excavation Surplus	Underground Excavation Surplus	Underground Excavation Excess	Total Excess Material
Bulked Volume (m³)	1,421,100	206,250	7,017.50	**1,630,000**

The surplus material detailed in Table 11 represents material that is unsuitable for use in the construction of the Headpond Embankments. The excess material represents material that is assumed to be suitable for use in the construction of the Embankments but will not be used as the volume of suitable material is greater than the volume required.

3.3 Excess Material Re-use

As noted in Table 11 there is an estimated material surplus of 1,630,000 m³.

As detailed in *Appendix 10.2: Outline Peat Management Plan (Volume5: Appendices)*, a number of measures have been implemented to support the management of peat on the Development. Of these measures, the following are relevant for this MMA:

- Reduction of the volume of peat excavated for the Development by avoiding excavation and permanently 'flooding' peat in-situ.
- Re-using excavated peat within the Headpond borrow pit and 'flooding' of peat.

To reduce the volume of peat excavated at the Headpond, all peat located below the bottom water level (BWL) of 374m AOD will be left in-situ. Prior to commissioning, the peat will be covered with a geotextile layer and overlain with a layer of excavated rock. Similarly, to re-use excavated peat at the Headpond borrow pit, a similar approach will be taken. The peat excavated for the quarrying works will be temporarily stored within the Headpond and reinstated on the finished surface of the borrow pit at the end for the quarrying phase. The peat will be covered with a geotextile layer and overlain with excavated peat.

Table 12 shows a breakdown of how much of the excess material will be used as detailed above.

Table 12. Excess Material Re-use

	Headpond Borrow Pit	Existing Ground below BWL (374m AOD)
Plan Area for Reuse (m²)	288,258	436,654
Depth of Rock	0.75	0.75
Compacted Volume of Rock (m³)	216,193	327,490
Compaction Factor		74%
Bulked Volume (m²)	292,153	442,554
Total Bulked Volume (m³)		**730,000**

An estimated 730,000 m³ of the excess material will be used within the headpond for peat management purposes.

Table 13 shows that after additional re-use measures, there will be an excess of around 1,090,000 m³ of material from the Headpond borrow pit excavation works.

Table 13. Final Excess Material

Item	Excess Material Pre-Re-use Measures	Material used for Re-use	Total Excess Material
Bulked Volume (m³)	1,630,000	730,000	**900,000**

3.4 Material Balance – Excess Material

The balance of the excavated material from the Headpond borrow pit is based on a number of assumptions, notably, to prove that no import material will be required to construct the Headpond Embankments.

Table 13 illustrates that approximately 900,000 m³ of excess material will be produced during the construction of the Development, however, in reality, this will likely be negligible.

The volume of material that will be excavated from the borrow pit will be dependent on the result of detail design and intrusive SI, along with the operational regime of the pit. It is likely that the borrow pit will be excavated by the contractor in conjunction with the construction of the Embankments. Accordingly, the material will be excavated for immediate use, rather than a stockpiling exercise. Where material is required, the excavation of the borrow pit will be manipulated to suit – based on judgement from the contractor. As such, the volume of the borrow pit is likely to be significantly smaller than the initial estimates, hence a mass reduction in excess material.

Additionally, where a surplus is found during construction, excess material can be used to support other areas of the Development, as follows:

- Construction Compounds – reinstatement, dressing and bunding.
- Access tracks – resurfacing of existing access tracks on-site.
- Switching Station – use for construction of the switching station hardstanding / access tracks.

Overall, it is assumed that the excess material will be negligible at construction, and no import of material will be required.

4. Conclusion

This appraisal has been undertaken to demonstrate how the main component of the Development – the Headpond – will be constructed and managed from a material point of view.

It is estimated that 20,010,000 m³ of material will be excavated during construction. This material will primarily be used to construct the Headpond Embankments, with an excess excavated material of around 1,630,000 m³.

Although this appraisal shows an excess volume, it is anticipated that there will be a negligible excess volume of material during construction as the borrow pit will be excavated on a needs-must basis during construction. While on site, should there be excess material, this will be used across the site as detailed in Section 3.4, for compounds, access tracks, and onsite switching station.

As a result of this MMA, it is not anticipated that any excess material will have to be left on-site. Should any material have to be exported off-site it is anticipated to be a relatively small volume, the impact of transporting excess / unsuitable material off-site is detailed in *Appendix 14.1 Construction Traffic Management Plan (CTMP) (Volume 5: Appendices)*.