Appendix 7.2

Flood Risk Assessment

Contents

Executive Summary

This Flood Risk Assessment (FRA) has been prepared by Stantec for the proposed 'Cruachan Expansion Project', a pumped storage electricity generating station, in Argyll and Bute.

In accordance with the fundamental objectives of the National Planning Framework (NPF) and Scottish Planning Policy (SPP), this FRA demonstrates that:

- Parts of the proposed development would be located in areas at risk of fluvial flooding from both Loch Awe and the Cruachan Reservoir, on the basis of SEPA flood mapping;
- The proposed development land use type would be considered *'Essential Infrastructure'* under SEPA's Flood Risk and Land Use Vulnerability Guidance;
- SEPA guidance confirms that *'Essential Infrastructure'* land uses may be acceptable in areas that are at risk of fluvial flooding if their location is required for operational reasons;
- The upper elements of the scheme located within Cruachan Reservoir would not in practice be subjected to significant fluvial flood risk, given that water levels within the reservoir are controlled by the existing pumped storage scheme already in place;
- The lower elements of the scheme located along the banks of Loch Awe will be protected from fluvial flood risk from the loch by a retaining wall that will be in place over the lifetime of the development. This retaining wall will afford a current standard of protection to the lower elements of the scheme equivalent to a ca. 1 in 100-year event, although this level of protection would be expected to reduce over the lifetime of the development, due to the anticipated impacts of climate change;
- This level of flood protection is considered suitable on the basis of SEPA guidance, which does not specify a minimum standard of flood protection for *'Essential Infrastructure'* land uses;
- A precautionary approach has been taken that considers flood risk from all sources as well as the predicted long-term implications of climate change;
- The development does not increase fluvial flood risk elsewhere;
- The development does not increase the volume of surface water runoff; therefore, a surface water drainage strategy is not required, however, water quality measures are proposed to protect Loch Awe; and
- The development does not detrimentally impact third parties.
- The development has also taken account of relevant flood risk guidance produced by the Scottish Government and/or SEPA.

The SEPA Flood Maps indicate that Allt Cruachan and Loch Awe have a Low-High likelihood of fluvial flooding. Cruachan Reservoir has a High likelihood of fluvial flooding. Fluvial flood risk is confined to those waterbodies. The area of the quayside is within the boundary of Loch Awe and is therefore subject to High likelihood of fluvial flooding. Cruachan Reservoir and Loch Awe also have a High likelihood of surface water flooding. Surface water flood risk is generally confined to those waterbodies, given the steep topography of the Site area.

Stantec has prepared an accompanying Flood Risk Management Strategy and Drainage Strategy for the Site that involves Drax Cruachan Hydro Ltd. Limited signing up to SEPA's Floodline warning service

for the Argyll and Bute area and having a planned evacuation route to higher ground towards the A85. Furthermore, the quayside development area will need to be served with appropriate silt traps and oil separators to ensure runoff does not form a potential source of pollution to Loch Awe.

SEPA's FRA checklist is provided in Appendix A.

In summary, this FRA demonstrates that the Proposed Development is appropriate for its location, will be served by measures to reduce flood risk to an acceptable level, and will be in accordance with the requirements of national and local planning policy.

Table 1: A summary of key FRA Data

Aspect of flood risk	Applicable Guidance/ Source of Data	Summary	Section of FRA
Site Location	N/A	On land around and to the east of the existing Cruachan Power Station ('Cruachan 1'), and west of Dalmally on the northern banks of Loch Awe in Argyll (National Grid Reference for Cruachan Reservoir: NN 080 282).	2
Existing Ground Levels	Topographic Survey by Malcolm Hughes Chartered Land Surveyors	A maximum of 1104m AOD at Ben Cruachan mountain, approximately 2.5km to the north west of Cruachan Reservoir, and a minimum of approximately 37m AOD at the outfall to Loch Awe.	2
Primary source of flood risk	SEPA Flood Maps	Fluvial and Surface Water/Pluvial.	3
Presence of flood defences	SEPA Flood Maps	No flood defences within/or near the site.	3
Proposed Development	N/A	Expansion of Cruachan power station.	5
Planning Aspects			
Flood Risk Vulnerability	SEPA Flood Risk and Land Use Vulnerability Guidance	Essential Infrastructure	5
Applicable Climate Change Allowances	SEPA's climate change allowances for flood risk assessment in land use planning guidance	+59% (West Scotland)	4
Proposed Mitigation Measures			
Flood Management Plan and Drainage Strategy	N/A	Drax Cruachan Expansion Limited signing up to SEPA's Floodline warning service for the Argyll and Bute area and have a planned excavation route to higher ground towards the A85. Furthermore, the quayside will need to be served	6

		with appropriate silt traps and oil separators to ensure runoff does not form a potential source of pollution to Loch Awe.	

Abbreviations

ABI Association of British Insurers

AOD Above Ordnance Datum

BGS British Geological Survey

BS British Standards

CDM Construction (Design and Management)

CIRIA Construction Industry Research and Information Association

CIWEM Chartered Institute of Water and Environmental Management

FRA Flood Risk Assessment

GIS Geographic Information System

ICE Institution of Civil Engineers

NGR National Grid Reference

NPF National Planning Framework

OS Ordnance Survey

SEPA Scottish Environmental Protection Agency

SPP Scottish Planning Policy

SuDS Sustainable Drainage Systems

1 Introduction

1.1 Scope of Report

1.1.1 This Flood Risk Assessment (FRA) has been prepared for the proposed 'Cruachan Expansion Project', a new pumped storage electricity generating station (referred to hereafter as the 'Proposed Development').

1.1.2 This report is based on the available flood risk information for the site as detailed in **Section 2** and has been prepared in accordance with the planning policy requirements set out in **Section 1.3.** The scope of this FRA is consistent with National Planning Framework (NPF) and Scottish Planning Policy (SPP) requirements.

1.1.3 Stantec has many years of experience in, amongst other areas, the assessment of flood risk, hydrology, flood defence and river engineering. The authors and reviewers of this document are experienced flood risk consultants and either Members or Fellows of the Chartered Institution of Water and Environmental Management (CIWEM).

1.1.4 This report has been prepared solely in connection with the development described within this report. As such, no responsibility is accepted to any third party for all or part of this report.

1.2 Sources of information

1.2.1 This FRA has been prepared based on the following sources of information:

- OS mapping;
- British Geological Survey ('BGS') data;
- Topographic Survey data from Malcolm Hughes Chartered Land Surveyors;
- SEPA Flood Maps (available to view at: https://www.sepa.org.uk/environment/water/flooding/flood-maps/);
- Scottish Water Asset Plans;
- Argyll and Bute Local Development Plan Interactive Map, and other local planning policy;
- Review of operational data and reports provided by Scottish and Southern Electricity Networks (SSE) and Drax Generation Developments Limited; and
- Correspondence with SEPA and Argyll and Bute Council (ABC).

1.3 Relevant Planning Policy and Guidance

1.3.1 This FRA has been prepared in accordance with the relevant national, regional, and local planning policy and statutory guidance as follows:

- **National Planning Framework 3 (NPF3)** published in June 2014 by the Scottish Government. This specifically promotes a catchment-scale approach to sustainable flood risk management and outlines that planning can play a vital role in reducing the vulnerability of development (both existing and future) to flooding; and
- **Scottish Planning Policy (SPP)** – updated in December 2020 by the Scottish Government

1.3.2 The SPP recommends that planning in Scotland should encourage the following with regards to flood risk:

- a precautionary approach to flood risk from all sources, including coastal, water course (fluvial), surface water (pluvial), groundwater, reservoirs and drainage systems (sewers and culverts), taking account the predicted effects of climate change;
- flood avoidance: by safeguarding flood storage and conveying capacity, and locating development away from functional flood plains and medium to high-risk areas;
- flood reduction: assessing flood risk and, where appropriate, undertaking natural and structural flood management measures, including flood protection, restoring natural features and characteristics, enhancing flood storage capacity, avoiding the construction of new culverts and opening existing culverts where possible; and
- avoidance of increased surface water flooding through requirements for Sustainable Drainage Systems (SuDS) and minimising the area of impermeable surfaces.

1.3.3 In summary, the policy states that Proposed Developments should be sited away from areas which have a high probability of flooding where possible and should not cause any increase in flood risk elsewhere.

- Scottish Government Planning Advice Notes (PANs)

1.3.4 PANs set out detailed advice in relation to relevant planning issues. Those applicable to this FRA include:

- PAN 61: Planning and Sustainable Urban Drainage Systems (2001);
- PAN 79: Water and Drainage (2006); and
- Flood Risk: Planning Advice (2015).

- Other relevant guidance that has been taken into consideration includes:
  - Land Use Planning System Guidance Note 2a: Development Management Guidance on Flood Risk (Version 2) (SEPA, 2018), supported by the Planning Background Paper: Flood Risk (SEPA, 2018);
  - Land Use Planning System Guidance Note 2b: Development Management Guidance on the Water Environment (Version 2) (SEPA, 2017), supported by the Planning Background Paper: Water Environment (SEPA, 2018);
  - SEPA Flood Risk Standing Advice for Planning Authorities and Developers (SEPA, 2020);
  - Land Use Planning System Guidance Note 19: Planning Advice on Waste Water Drainage (SEPA, 2011);
  - Land Use Planning System Guidance Note 2: Planning Advice on Sustainable Drainage Systems (SUDS) (SEPA, 2010);
  - Climate Change Allowances for flood risk assessment in land use planning (SEPA, 2019);
  - Flood Risk and Land Use Vulnerability Guidance (SEPA, 2018);
  - Reservoir Inundation Maps – potential use for Land Use Planning;
  - Argyll and Bute Council Local Development Plan (LDP); and
  - Highland and Argyll Local Plan District: Local Flood Risk Management Plan (2016-2022).

1.4 Caveats and Exclusions

1.4.1 This FRA has been prepared in accordance with NPF3, SPP and SEPA's Standing Advice and Technical Advice. The proposed flood management (including ground floor level recommendations) and surface water management strategies are based on the relevant British Standards (BS8533), the standing advice provided by SEPA or based on common practice.

1.4.2 The Construction (Design and Management) Regulations 2015 (CDM Regulations) will apply to any future development of this site which involves "construction" work, as defined by the CDM Regulations. As such it is the responsibility of the proposed developer (ultimate client) to fulfil its duties under the CDM Regulations.

1.4.3 The approach for the FRA and proposals for the surface water management strategy are based on the requirements of SEPA, and Argyll and Bute Council in its role as the Planning Authority. The findings of this FRA are based on data available at the time of the study and on the subsequent assessment that has been undertaken in relation to the development proposal as outlined in Section 3. As such, we recommend the end user reviews the validity of the flood data on an annual basis with SEPA.

1.4.4 The SEPA Flood Maps are a high-level tool developed to support decision making relating to flood risk. The flood extents shown on the maps are indicative in nature and do not guarantee against flooding.

1.4.5 It should be noted that the insurance market applies its own tests to properties in terms of determining premiums and the insurability of properties at flood risk. Those undertaking development in areas which may be at risk of flooding are advised to contact their insurers or the Association of British Insurers (ABI) to seek further guidance prior to commencing development. Stantec does not warrant that the advice in this report will guarantee the availability of flood insurance either now or in the future.

1.4.6 Other general limitations of this assessment are that:

- Various sources have been used to compile this FRA, which Stantec believes to be trustworthy. However, Stantec is unable to guarantee the accuracy of the information that has been provided by others; and
  - This report is based on information available at the time of preparation. Consequently, there is potential for further information to become available. These changes may lead to future alteration to the conclusions drawn in the report for which Stantec cannot be held responsible.

2 Site Setting

2.1 Site Location

2.1.1 The site is located on land around and to the east of the existing Cruachan Power Station ('Cruachan 1'), and west of Dalmally on the northern banks of Loch Awe in Argyll (National Grid Reference for Cruachan Reservoir: NN 080 282). The Site is located within the administrative boundary of Argyll and Bute Council (ABC).

2.1.2 The Proposed Development comprises of an area of 419.82 hectares (ha). A site location plan is provided in Figure 1.

Figure 1: Site Location Plan

2.2 Land Use

2.2.1 The Site is currently occupied by the Cruachan 1 Power Station, Cruachan Reservoir, Loch Awe, the access track to the reservoir, and the A85.

2.3 Topography

2.3.1 The topography (Appendix B) within the Site is steep, with a maximum of 1104m AOD at Ben Cruachan mountain, approximately 2.5km to the north west of Cruachan Reservoir, and a minimum of approximately 37m AOD at the outfall to Loch Awe.

2.4 Geology and Hydrogeology

2.4.1 The bedrock geology within the Site is complex. According to the BGS Geo-Index and the Cruachan Power Station Baseline Hydrology Report (Arcus Consultancy Services Limited), there are four main rock types within the Study Area, comprising:

- quartz – monzodiorites belonging to the Cruachan Intrusion;
- andesites and basalts belonging to the Lorn Plateau Volcanic Formation;
- diorites and quartz diorites belonging to the Quarry Intrusion; and,
- metamorphosed sediments belonging to the Ardrishaig Phyllite Formation.

2.4.2 The majority of the Site is free from superficial deposits, which is consistent with the rocky outcrops, however an area of Hummocky Glacial Deposits – Diamiction, Sand and Gravel, is present to the north of the Cruachan Reservoir.

2.5 Hydrogeology

2.5.1 The SEPA Environment Interactive Map indicates the Site area is a Low productivity aquifer (Class 2c), with only small amounts of groundwater near the surface and within fractures.

2.6 Existing Drainage

2.6.1 According to Scottish Water Asset Plans (Appendix C), there are no mains water supply pipelines within 3km of Cruachan Reservoir. The closest pipeline is a 90mm mains water supply sewer located along the A85. There are no foul water sewers within the Site area.

2.6.2 The Site currently drains mainly via overland flow towards the two surface water bodies, although the Cruachan Reservoir also receives gravity input via aqueducts from adjacent catchments. The existing road and built infrastructure will also contain gravity surface water drainage systems.

2.7 Watercourses

2.7.1 The Proposed Development is located in the River Awe Catchment. The two main surface water bodies within the Site area include Cruachan Reservoir and Loch Awe.

2.7.2 Cruachan Reservoir is impounded by the Cruachan Dam and has a topographical catchment area of ca. 5.87 km^2. The effective catchment area of the Cruachan Reservoir is, however, increased due to the presence of aqueducts, which transfer water via gravity from watercourses in adjacent catchments. Pumped flows from Loch Awe comprise by far the greatest volumetric contribution to Cruachan reservoir, compared with the natural topographic rainfall contributions and gravity transfers.

2.7.3 Loch Awe has a topographical catchment area of ca. 813 km^2 and encompasses two natural lochs: Loch Tulla and Loch Avich. Loch Awe covers an area of 38 km^2 is the third largest freshwater loch in Scotland. Relative to the Cruachan Reservoir, Loch Awe has a large surface area, topographical catchment, and storage volume. Loch Awe is impounded by the Loch Awe Barrage, operated by Scottish and Southern Electricity (SSE).

2.7.4 A number of additional surface water bodies and unnamed overland drains are present within or close to the Proposed Development including the River Orchy and River Awe.

3 Overview of Flood Risk

3.1.1 SPP sets out a flood risk framework to guide development. This outlines three categories for coastal and river/watercourse flooding. The three categories are:

- Little or no risk: annual probability of coastal or watercourse flooding is less than 0.1% (1 in 100 years);
- Low to medium risk: annual probability of coastal or watercourse flooding is between 0.1% and 0.5% (1 in 100 years to 1 in 200 years); and
- Medium to high risk: annual probability of coastal or watercourse flooding is greater than 0.5% (1 in 200 years).

3.1.2 SPP also outlines the requirements for surface water flooding and states that:

- *'Infrastructure and buildings should generally be designed to be free from surface water flooding in rainfall events where the annual probability of occurrence is greater than 0.5% (1 in 200 years)'*; and
- *'Surface water drainage measures should have a neutral or better effect on the risk of flooding both on and off the site, taking account of rain falling on the site and run-off from adjacent areas'*.

3.1.3 SPP states that development plans should have regard to the SEPA flood maps. The SEPA flood maps have been produced to illustrate the flood risk from all sources and its category for Scotland. The SEPA flood maps can be viewed at:

https://www.sepa.org.uk/environment/water/flooding/flood-maps/.

3.2 Flood Risk from Fluvial (River) Flooding

3.2.1 River flooding, often also referred to as fluvial flooding, occurs when a watercourse is overwhelmed or obstructed and bursts its banks.

3.2.2 The SEPA flood extent maps illustrate areas where there may be a high (i.e., 1 in 10-year return period); medium (i.e., 1 in 200-year return period) or low (i.e., 1 in 100-year return period) risk of flooding. This classification aligns with the flood risk framework described in Section 3.1.1. The use of SEPA flood mapping for commercial purposes is not permitted, therefore, the flood maps are not able to be reproduced and can only be viewed online (link given above).

3.2.3 The SEPA Flood Maps[1] indicate that Allt Cruachan and Loch Awe have a Low-High likelihood of fluvial flooding. Cruachan Reservoir has a High likelihood of fluvial flooding. Fluvial flood risk is confined to those waterbodies. The area of the proposed quayside development is within the boundary of Loch Awe and is therefore subject to a High likelihood of fluvial flooding.

3.2.4 SEPA's National Flood Risk Management Strategy indicates potentially vulnerable areas (PVAs), prone to flooding. These are generally indicative without being accurate. The Proposed Development is located within Loch Awe (Potentially Vulnerable Area 01/34) which indicates 91% of flooding impacts in the area are caused by rivers.

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[1] SEPA Flood Maps (arcgis.com)

3.2.5 The Technical Note presented in Appendix D demonstrates that the Cruachan Reservoir is not a natural system, and its water level regime is controlled by pumped discharges and releases from and to Loch Awe as part of the operation of the Cruachan 1 power station. The reservoir is also fed by runoff from a small topographical catchment area and gravity transfers from neighbouring catchments, although Appendix D confirms that the Cruachan 1 pumped storage scheme contributes by far the greatest volume. As such, the Cruachan Reservoir can be considered a controlled waterbody, within which water level variation is principally controlled by the operation of the Cruachan 1 pumped storage scheme, rather than by runoff in response to storm events. As such, the Cruachan Reservoir is not considered to pose a significant flood risk to the upper elements of the proposed development.

3.2.6 The proposed development (i.e. the 'Cruachan 2' power station) will only serve to increase the speed and frequency at which water is pumped from, and discharged back to, Loch Awe, rather than increase the overall volume of water transferred. As such, the proposed development will not significantly alter the range of water level variation historically experienced within the Cruachan Reservoir as a result of the operation of Cruachan 1[2].

3.2.7 Water levels on Loch Awe in the vicinity of the site are also partly controlled by the operation of the Loch Awe barrage by SSE (which is also part of a separate hydropower scheme), in addition to natural runoff from its large catchment. The barrage is served with large radial gates, which can be fully opened in times of flooding on Loch Awe.

3.2.8 The operation of the Cruachan 1 pumped storage scheme does not significantly alter water levels on Loch Awe (Appendix D); the Cruachan 2 scheme would have a similarly neutral effect. The proposed development would, therefore, not be expected to increase flood risk on Loch Awe.

3.2.9 In order to quantify the flood risk from Loch Awe to the proposed quayside elements, HEC-RAS modelling has been completed (Appendix E). This modelling indicates that the proposed retaining wall that will surround the quayside elements (refer to the proposed development drawings in Appendix E; retaining wall crest elevation will be 39.5m AOD) would provide a ca. 1 in 100-year standard of flood protection to the quayside elements (Appendix E). This standard of protection would, however, be expected to reduce over the lifetime of the proposed development due to the impacts of climate change.

3.2.10 This standard of flood protection to the proposed quayside elements is considered appropriate, given that SEPA guidance[3] does not specify a minimum standard of flood protection for *'Essential Infrastructure'* land uses that need to be located in areas of flood risk for operational reasons.

3.2.11 Although the standard of flood protection provided by the new quayside retaining wall is considered appropriate, it is recognised that the proposed quayside will, however, experience flooding during events on Loch Awe in excess of the ca. 1 in 100-year flood, and potentially more frequently over its design lifetime due to the impacts of climate change. As such, this FRA provides an outline Flood Management Plan for the proposed quayside elements; this is described in Section 6 below.

3.2.12 The quayside structure will encroach within Loch Awe itself and will, as such, reduce the storage volume within this waterbody by a small amount. The volume of the quayside structure will be ca. 62,500m^3; the volume of Loch Awe is ca. 1.2km^3 (1200000000m^3). The quayside structure will, therefore, reduce the storage volume available within Loch Awe by 0.005%, which can be considered negligible and will not result in a significant increase in flood risk on this waterbody.

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[2] The proposed development drawings in Appendix F indicate that the proposed development will reduce the minimum operating level in the Cruachan Reservoir when compared to the historical range shown in Appendix D. This, however, is only required to allow Drax to draw down water levels to a lower elevation to facilitate periodic maintenance, and would not represent a change to the routine water level variability in the reservoir shown in Appendix D.

[3] SEPA Planning Background Paper: Flood Risk Version 3 10 July 2018 – Glossary, DM Requirement 1: Flood Risk Context, and also DM.21.

3.3 Flood Risk from Coastal Influences

3.3.1 Coastal flooding occurs when low lying, coastal land is overwhelmed by extreme sea levels. It normally occurs as a combination of four key factors: waves, astronomical tides, storm surges and relative mean sea level. The influence of river discharge can also be fundamental in some catchments.

3.3.2 The lowest elevations within the site are at ca. 37m AOD around the shoreline of Loch Awe. As such, the proposed development is not at risk of coastal flooding. The SEPA flood map for coastal flooding also confirms that the site is not at risk of coastal flooding, both now and in the future. This source of flood risk is, therefore, not considered further.

3.4 Flood Risk from Surface Water

3.4.1 Surface water flooding, otherwise referred to as pluvial flooding, can be defined as flooding which occurs due to rainfall-generated overland flow before the runoff enters any watercourse, drainage, or sewer system.

3.4.2 The SEPA Flood Extent maps show where areas could be potentially susceptible to surface water flooding in an extreme rainfall event. The latest mapping assesses flooding resulting from severe rainfall events based on the following three scenarios:

- 1 in 10 year (10%) annual probability rainfall event ('High' likelihood);
- 1 in 200 year (0.5%) annual probability rainfall event ('Medium' likelihood); and
- 1 in 1000 year (0.1%) annual probability rainfall event ('Low' likelihood).

3.4.3 Land at lower than 1 in 1000 (0.1%) annual probability of flooding is regarded to be at 'Very Low' risk of flooding.

3.4.4 The SEPA Flood Maps indicate that the Cruachan Reservoir and Loch Awe waterbodies have a High likelihood of surface water flooding. Surface water flood risk is generally confined to those waterbodies, given the steep topography of the Site area.

3.4.5 In reality, however, the mechanisms generating the surface water flood risk shown on the SEPA Surface Water Flood Maps will be the same as those that generate the fluvial risk (i.e. rainfall-runoff within the topographical catchments of Loch Awe and the Cruachan Reservoir). In this instance, therefore, pluvial and fluvial flood risk to the site are considered one and the same.

3.5 Flood Risk from Sewer and Drainage Infrastructure

3.5.1 According to the Scottish Water Asset Plans (Appendix C), there are no mains water supply pipelines within 3km of Cruachan Reservoir. The closest pipeline is a 90mm mains water supply sewer located along the A85. There are no foul water sewers within the Site area.

3.5.2 Based on the available information the Proposed Development does not appear to be at risk of sewer flooding.

3.6 Flood Risk from Groundwater

3.6.1 Groundwater flooding occurs when water rises from the underlying rocks or flows from springs and is usually classified in Scotland as a contributing factor to flooding rather than the primary source.

3.6.2 The SEPA Environment Interactive Map indicates the Site area is a Low productivity aquifer (Class 2c), with only small amounts of groundwater near the surface and within fractures.

3.6.3 Any groundwater present beneath the Site is likely to be in hydraulic continuity with water levels in Loch Awe due to this close proximity. This is unlikely to present a groundwater risk to the Proposed Development, considering its surface elevation and steep topography. The Proposed Development should be designed to minimise the risk of groundwater interference as far as practicable and the potential requirement for dewatering should be considered during the construction phase.

3.7 Summary of Flood Risk

3.7.1 Table 2 provides an overview of the flood risk to the Site based on the information obtained and outlined in this section.

Table 2: Flood Risk Summary

Key		
	Low/Negligible Risk - No noticeable impact to the site and not considered to be a constraint to development	
	Medium Risk - Issue requires consideration but not a significant constraint to the development	
	High Risk - Major constraint to the development requiring active consideration in mitigation proposals	

Source of Flooding	**Risk of flooding to the Site**	**Comment/Justification**	**Source of data**	**Mitigation requirements for new development (see Section 6)**	**Risk of Flooding to Site after mitigation**
Fluvial		Allt Cruachan and Loch Awe have a Low-High likelihood of fluvial flooding. Cruachan Reservoir has a High likelihood of fluvial flooding. Fluvial flood risk is confined to those waterbodies. The area of the quayside is within the boundary of Loch Awe and is therefore subject to High likelihood of fluvial flooding.	SEPA Flood Maps (see section 3.2)	Although the standard of flood protection provided by the new quayside retaining wall is considered appropriate, it is recognised that the proposed quayside will, however, experience flooding during events on Loch Awe in excess of the ca. 1 in 100-year flood, and potentially more frequently over its design lifetime due to the impacts of climate change. As such, this FRA provides an outline Flood Management Plan for the proposed quayside elements; this is described in Section 6 below.	
Surface Water/Pluvial		Cruachan Reservoir and Loch Awe have a High likelihood of surface water flooding. Surface water flood risk is generally confined to those waterbodies, given the steep topography of the Site area.	SEPA Flood Maps (see Section 3.3)	Pluvial and fluvial risk to the Site are considered one and the same. Refer to Section 6 for an overview of the impact of the proposed development on surface water flood risk elsewhere.	
Groundwater		The Site area is a Low productivity aquifer (Class 2c), with only small amounts of groundwater near the surface and within fractures. Any groundwater present beneath the site is likely to be in hydraulic continuity with water levels in Loch Awe due to this	The SEPA Environment Interactive Map	N/A	

		close proximity. This is unlikely to present a groundwater risk to the Proposed Development, considering its surface elevation and topography.			
Sewers		There are no mains water supply pipelines within 3km of Cruachan Reservoir. The closest pipeline is a 90mm mains water supply sewer located along the A85. There are no foul water sewers within the Site area.	Scottish Water Asset Plans	N/A	

4 Impact of Climate Change

4.1.1 When considering flood risk to the Site, it is necessary to fully consider the potential impacts of climate change for the lifetime of the Proposed Development as part of the mitigation measures.

4.1.2 Under current best practice[4], SEPA requires contingency allowances to be included for potential increases in peak river flow and rainfall intensity. These have been considered as part of the Proposed Development.

4.1.3 The Proposed Development site is located within the Argyll Basin Region, in the west rainfall uplift region. Therefore, an allowance of +59% should be applied to peak river flows. The Loch Awe HEC-RAS modelling (Appendix E) indicates that the proposed retaining wall that will surround the quayside elements of the proposed development will provide a ca. 1 in 100-year standard of protection at present. Over the lifetime of the development (and with a 59% increase in peak river flow), it is estimated that this standard of protection will reduce to a ca. 1 in 10 to 1 in 20-year event by the year 2100. This standard of protection would still be considered appropriate as described in Section 3.2.10 above.

4.1.4 Climate change would not significantly alter water level variability within Cruachan Reservoir, given that water level variability within this waterbody is (and will continue to be) largely controlled by the operation of the Cruachan 1 power station and pumped storage regime.

4.1.5 The proposed development would not introduce significant new areas of impermeable hard standing which would have the potential to increase the volume and rate of surface water runoff generated (refer to Sections 5 and 6 below). The new quayside elements would, however, need to be served by an appropriate surface water drainage system, and the necessary climate change allowances for peak rainfall intensity will be applied during the detailed design of the associated new drainage infrastructure.

[4] Climate change allowances for flood risk assessment in land use planning, SEPA.

5 Proposed Development and Flood Risk Vulnerability Classification

5.1 Proposed Development

5.1.1 The Proposed Development will comprise the following main elements, as shown on the drawings contained within Appendix F:

- Upper Control Works – A new intake structure including tower, screens, gates, gate hoisting arrangement, etc. would be located within and adjacent to Cruachan Reservoir to direct water into a new headrace tunnel and underground waterway system;
- Underground Waterway System – A series of underground shafts and tunnels carrying water between the upper reservoir (Cruachan) and lower reservoir (Loch Awe), through the underground powerhouse cavern;
- Powerhouse Cavern - A series of underground caverns containing reversible pump-turbines and motor-generators together with associated equipment such as transformers and switchgear. The construction process will require various interconnecting tunnels to allow construction;
- Substation – An above ground substation may be required to provide the connection to the existing 275KV circuit that connects to Dalmally sub-station, located some 7km to the east;
- Ventilation Shaft – A ventilation shaft will be required to circulate fresh air through the underground access tunnel and cavern power station complex. It is noted that this may also include a cable shaft for the 275KV oil filled cable from the transformers to cable sealing ends/sub-station;
- Tailrace Tunnel – A concrete-lined low-pressure tunnel including a downstream surge shaft will conduct water between the pump-turbines and Loch Awe, the lower reservoir. Upstream of the lower control works, the tailrace will contain an underground gate chamber and gate shaft, housing the tailrace tunnel gate;
- Lower Control Works – Comprising a screened inlet/outlet structure and stop logs, positioned in Loch Awe at the end of the tailrace tunnel below the water level. These structures would channel water in and out of Loch Awe;
- Quayside – Constructed on the northern shore of Loch Awe to facilitate the construction of the underground access tunnels, waterway system and powerhouse cavern, and the temporary storage of spoil prior to its off-site removal;
- The Quayside would also house a canopy structure, covering the temporary stockpiles of spoil. The canopy structure would be enclosed on three sides by brick/concrete walls and have a corrugated roof. The primary purpose of this structure would be to prevent the temporary stockpiled material from being mobilised by wind and rain and entering Loch Awe and the surrounding environment, potentially causing a pollution incident;

- Retaining wall – a permanent retaining wall will surround the Quayside elements, which will serve to both help contain the temporary stockpiles of spoil as part of the canopy structure and protect the Quayside elements from flood risk from Loch Awe. This retaining wall will have a crest elevation of 39.5m AOD (Appendix F);

- Administration building - above ground administration and workshop buildings required for day to day operational and maintenance tasks, located on the Quayside;

- Access Tunnels – A main access tunnel would be provided for accessing the underground power plant, close to the shore of Loch Awe. This will cross connect to the existing Cruachan 1 power station to allow personnel to easily move between the plants and provide a further means of access/egress; and

- Existing service roads will be used as far as possible to facilitate the long-term operation of the generating station. Some upgrades of these roads may be required to facilitate access by heavy machinery and the removal of spoil.

5.2 Flood Risk Vulnerability

5.2.1 SEPA's Flood Risk and Land Use Vulnerability Guidance Table 1 confirms the *'Land Use Vulnerability Classification'* of a site, depending upon the proposed usage. This classification is subsequently applied to Table 3: SEPA's Matrix of Flood Risk to determine whether the Proposed Development is suitable for the flood zone within which it is located.

5.2.2 The proposed development land use type would be considered *'Essential Infrastructure'* under SEPA's Flood Risk and Land Use Vulnerability Guidance[5], i.e., *"Essential utility infrastructure that has to be located in a flood risk area for operational reasons (this includes electricity generating power stations and grid and primary sub-stations, sewage treatment plants and water treatment works, wind turbines and other energy generating technologies)."*

5.2.3 SEPA guidance[6] states that *'Essential Infrastructure'* land uses may be acceptable in areas that are at risk of fluvial flooding if they require a flood risk location for operational reasons, as is the case with the proposed development. The operational need for the development is for the planning authority to determine.

[5] SEPA Flood Risk and Land Use Vulnerability Guidance Version 4 10 July 2018

[6] SEPA Planning Background Paper: Flood Risk Version 3 10 July 2018 - DM Requirement 1: Flood Risk Context (also DM.21).

6 Flood Risk Management Plan and Drainage Strategy

6.1 Flood Risk Management Plan

6.1.1 Although the standard of flood protection provided by the new quayside retaining wall is considered appropriate, it is recognised that the proposed quayside will, however, experience flooding during events on Loch Awe in excess of the ca. 1 in 100-year flood, and potentially more frequently over its design lifetime due to the impacts of climate change.

6.1.2 Therefore, it is recommended that Drax Generation Developments Limited subscribes to the SEPA Floodline warning service for the Argyll and Bute area, so they are aware when flood events are likely and can prepare.

6.1.3 The Administration Building will be part of the proposed Quayside elements (protected by the retaining wall) and will be served by an appropriate Flood Management Plan. Clear signage will be provided for safe evacuation routes from this building to higher ground towards the A85. The evacuation routes will be used as necessary upon receipt of SEPA Flood Warnings. The Administration Building would not provide overnight accommodation for staff, and would only be used periodically, meaning that flood hazard to its users would be relatively low.

6.1.4 SEPA Floodline provides live flooding information and advice on how to prepare for or cope with the impacts of flooding 24 hours a day, 7 days a week.

6.1.5 The Flood Warning service is outlined in Figure 2.

Figure 2: SEPA Floodline Warning Alerts

6.2 Drainage Strategy

6.2.1 The net increase in hardstanding areas from the new quayside elements and the widened area of the A85 is negligible. The area of the proposed A85 widening is currently disused hardstanding and is proposed to be retained as hardstanding, therefore there will be no increase in surface water runoff from this area. The proposed quayside structure will encroach into the Loch Awe waterbody itself. All rainfall that currently falls onto the surface of the waterbody will enter Loch Awe directly, therefore, the construction of the quayside structure will not increase the volume or rate of runoff entering the loch.

6.2.2 Therefore, no additional mitigation is required, assuming that industry standard surface water drainage infrastructure is installed within the quayside structure design, including non-return valves, to allow surface water to freely discharge into Loch Awe.

6.2.3 The quayside will need to be served with appropriate silt traps and oil separators to ensure runoff does not form a potential source of pollution to Loch Awe.

7 Conclusion

7.1.1 This Flood Risk Assessment (FRA) has been prepared by Stantec for the proposed 'Cruachan Expansion Project', a pumped storage electricity generating station, in Argyll and Bute.

7.1.2 In accordance with the fundamental objectives of the National Planning Framework (NPF) and Scottish Planning Policy (SPP), this FRA demonstrates that:

- Parts of the proposed development would be located in areas at risk of fluvial flooding from both Loch Awe and the Cruachan Reservoir, on the basis of SEPA flood mapping;
- The proposed development land use type would be considered *'Essential Infrastructure'* under SEPA's Flood Risk and Land Use Vulnerability Guidance;
- SEPA guidance confirms that *'Essential Infrastructure'* land uses may be acceptable in areas that are at risk of fluvial flooding if their location is required for operational reasons;
- The upper elements of the scheme located within Cruachan Reservoir would not in practice be subjected to significant fluvial flood risk, given that water levels within the reservoir are controlled by the existing pumped storage scheme already in place;
- The lower elements of the scheme located along the banks of Loch Awe will be protected from fluvial flood risk from the loch by a retaining wall that will be in place over the lifetime of the development. This retaining wall will afford a current standard of protection to the lower elements of the scheme equivalent to a ca. 1 in 100-year event, although this level of protection would be expected to reduce over the lifetime of the development, due to the anticipated impacts of climate change;
- This level of flood protection is considered suitable on the basis of SEPA guidance, which does not specify a minimum standard of flood protection for *'Essential Infrastructure'* land uses;
- A precautionary approach has been taken that considers flood risk from all sources as well as the predicted long-term implications of climate change;
- The development does not increase fluvial flood risk elsewhere;
- The development does not increase the volume of surface water runoff; therefore, a surface water drainage strategy is not required, however, water quality measures are proposed to protect Loch Awe; and
- The development does not detrimentally impact third parties.

7.1.3 In summary, this FRA demonstrates that the Proposed Development is appropriate for its location, will be served by measures to reduce flood risk to an acceptable level, and will be in accordance with the requirements of national and local planning policy.

Appendix A SEPA FRA Checklist

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 13 - Last updated 15/04/2015)

This document should be attached within the front cover of any flood risk assessments issued to Local Planning Authorities (LPA) in support of a development proposal which may be at risk of flooding. The document will take only a few minutes to complete and will assist SEPA in reviewing FRAs, when consulted by LPAs. This document should not be a substitute for a FRA.

Development Proposal

Site Name		Cruachan Expansion Project			
Grid Reference	Easting:	207767	Northing:	726842	
Local Authority		Argyll and Bute Council			
Planning Reference number (if known)		N/A			
Nature of the development		Utility Infrastructure	If residential, state type:		
Size of the development site		419.82	Ha		
Identified Flood Risk	Source:	Combined	Source name:	Fluvial, surface water.	

Supporting Information

Have clear maps / plans been provided within the FRA (including topographic and flood inundation plans)	Yes			
Has a historic flood search been undertaken?	No			
Is a formal flood prevention scheme present?	No	If known, state the standard of protection offered	N/A	
Current / historical site use	Existing Cruachan Power Station, the A85, Loch Awe, and Cruachan Reservoir			

Hydrology

Area of catchment	813 (Loch Awe)	km^2		
Qmed estimate	295	m^3/s	Method:	Gauged Record
Estimate of 200 year design flood flow	735	m^3/s		
Estimation method(s) used *	Pooled analysis		If other (please specify methodology used):	
			If Pooled analysis have group details been included	Yes

Hydraulics

Hydraulic modelling method		1D dynamic	Software used:	HEC-RAS		
If other please specify						
Modelled reach length		5500	m			
Any structures within the modelled length?		Combination	Specify, if combination	SSE's existing Loch Awe Barrage - combined radial gate and fish		
Brief summary of sensitivity tests, and range:						
variation on flow (%)		0	%			
variation on channel roughness		0				
blockage of structure (range of % blocked)		0	%	Reference CIRIA culvert design guide R168, section 8.4		
boundary conditions:		**Upstream**		**Downstream**		
(1) type		Flow		Normal depth		
	Specify if other		Specify if other			
(2) does it influence water levels at the site?		Yes		No		
Has model been calibrated (gauge data / flood records)?		Yes				
Is the hydraulic model available to SEPA?		No				
Design flood levels	200 year	39.8	m AOD	200 year plus climate change	42.32	m AOD

Flood Risk Assessment (FRA) Checklist

(SS-NFR-F-001 - Version 13 - Last updated 15/04/2015

Coastal

Estimate of 200 year design flood level		N/A	m AOD			
Estimation method(s) used		Other	If other (please specify methodology used):	N/A		
Allowance for climate change (m)		N/A	m			
Allowance for wave action etc (m)		N/A	m			
Overall design flood level		N/A	m AOD			

Development

Is any of the site within the functional floodplain? (refer to SPP para 255)		Yes		If yes, what is the net loss of storage	Negligible	m^3
Is the site brownfield or greenfield		Brownfield				
Freeboard on design water level (m)		N/A	m			
Is the development for essential civil infrastructure or vulnerable groups?		No		If yes, has consideration been given to 1000 year design flood?	No	
Is safe / dry access and egress available?		Vehicular and Pedestrian		Min access/egress level	ter levels on L	m AOD
If there is no dry access, what return period is dry access available?		current ca. 100-yea	years			
If there is no dry access, what is the impact on the access routes?	Max Flood Depth @ 200 year event:	N/A	m	Max Flood Velocity:	N/A	m/s
Design levels	Ground level	N/A	m AOD	Min FFL:	N/A	mAOD

Mitigation

Can development be designed to avoid all areas at risk of flooding?		No
Is mitigation proposed?		Yes
If yes, is compenstory storage necessary?		No
Demonstration of compensatory storage on a "like for like" basis?		No
Should water resistant materials and forms of construction be used?		Yes

Comments

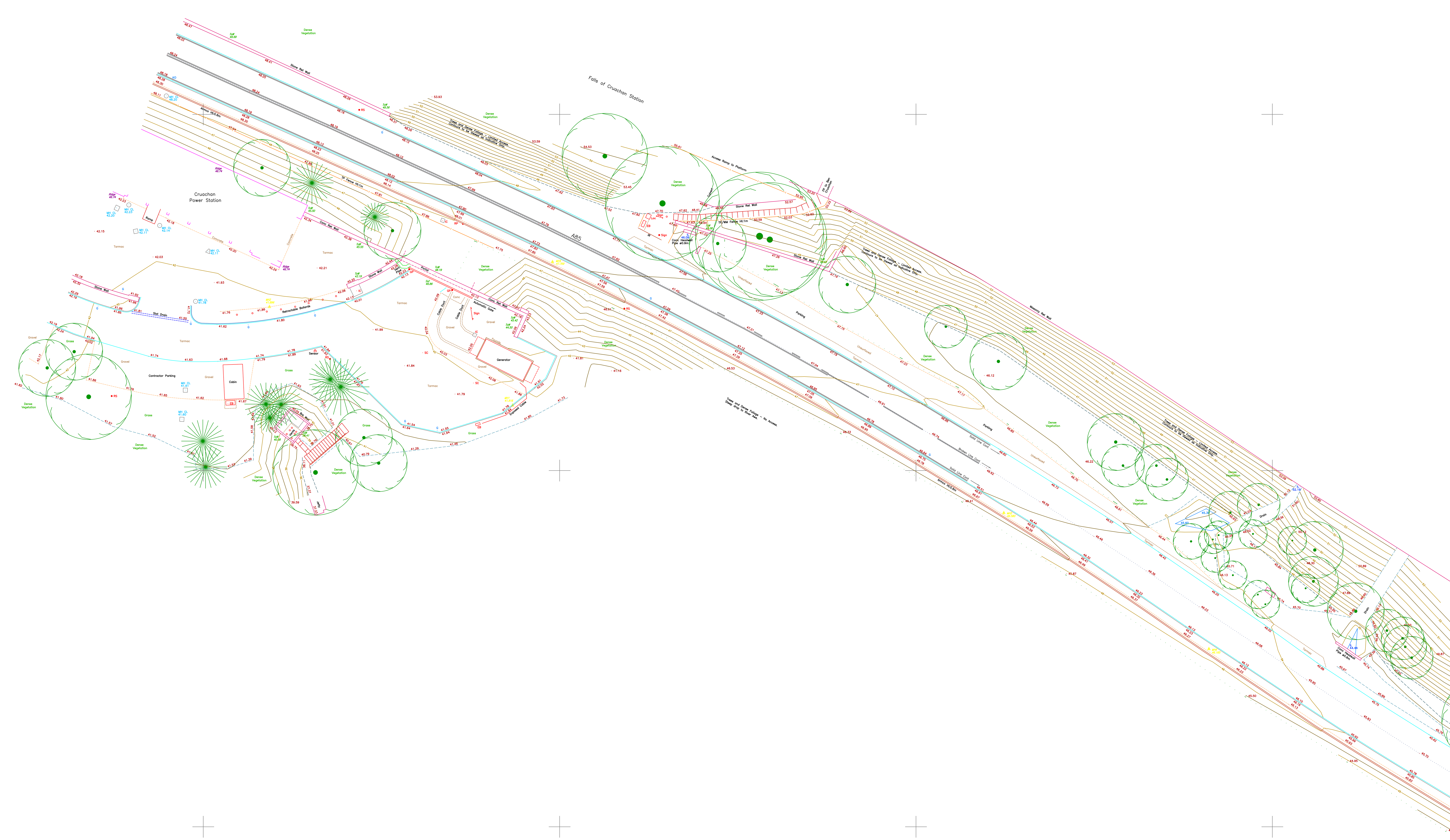
Any additional comments:		The quayside elements of the proposed development will be served by a new retaining wall, which will provide a ca. 1 in 100-year present day protection, which will reduce to between the 10-20-year standard with climate change to 2100. SEPA guidance indicates that this level of protection will be appropriate for Essential Infrastructure uses (i.e. no minimum standard

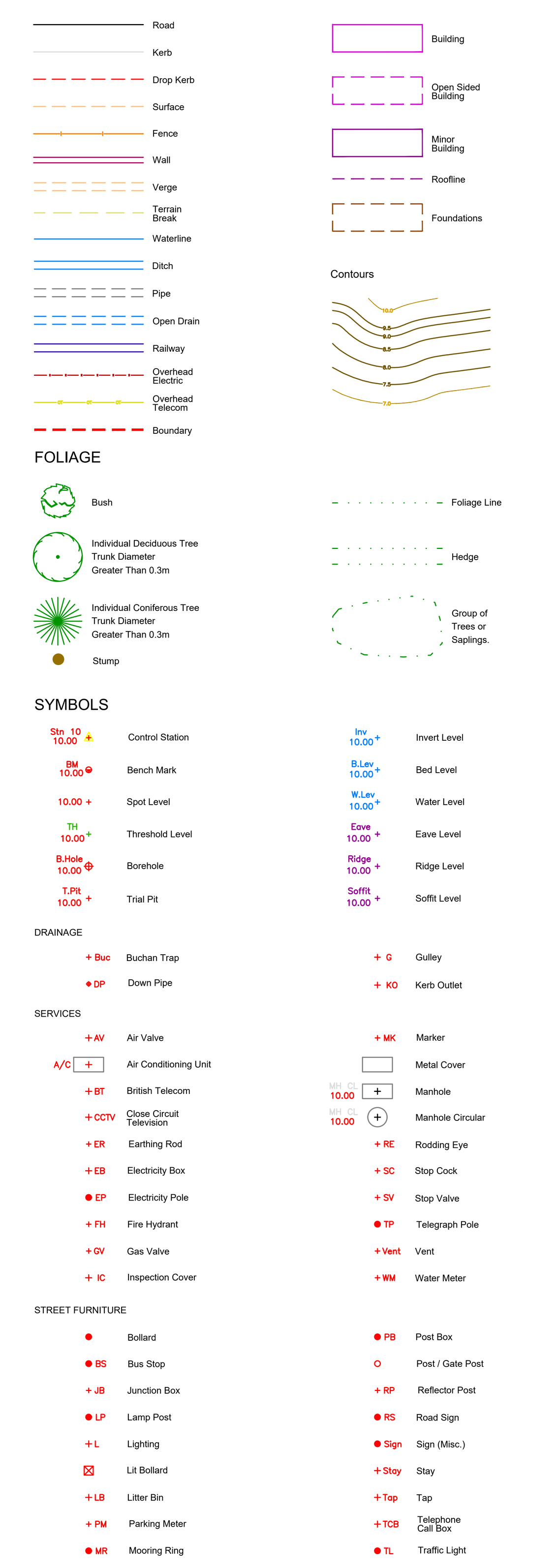
Approved by:	**K Limbrick**	
Organisation:	**Stantec**	
Date:		**09-May-22**

Note: Further details and guidance is provided in 'Technical Flood Risk Guidance for Stakeholders' which can be accesssed here:- **CLICK HERE**

**** ReFH2 is now accepted by SEPA for flow estimates in Scotland. Any use of this method should be compared with other accepted methods.***

Appendix B Topographical Survey





Accuracy commensurate with scale of drawing.

NORTH

> Station Coordinates.

	Easting	Northing	Elevation	Type
MH1	207993.402	726709.154	41.916	Nail.Washer
MH2	207959.291	726722.985	41.896	Nail.Washer
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MH20	208670.131	726390.968	40.175	Nail.Washer

> Coordinates based on OS National Grid at STN4 (OSTN15).
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> Tied to Sept 2020 Bathymetric Survey (34JJ100220_01).

Revision	Description	Date

Contract Title

A85
Cruachan Power Station

Plot Title

Topographic Survey
Sheet 1/4

Stantec UK Ltd
Eastfield House, Eastfield Road
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EH28 8LS
0131 335 4200

MALCOLM HUGHES
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1 Paisley Road Renfrew PA4 8JH
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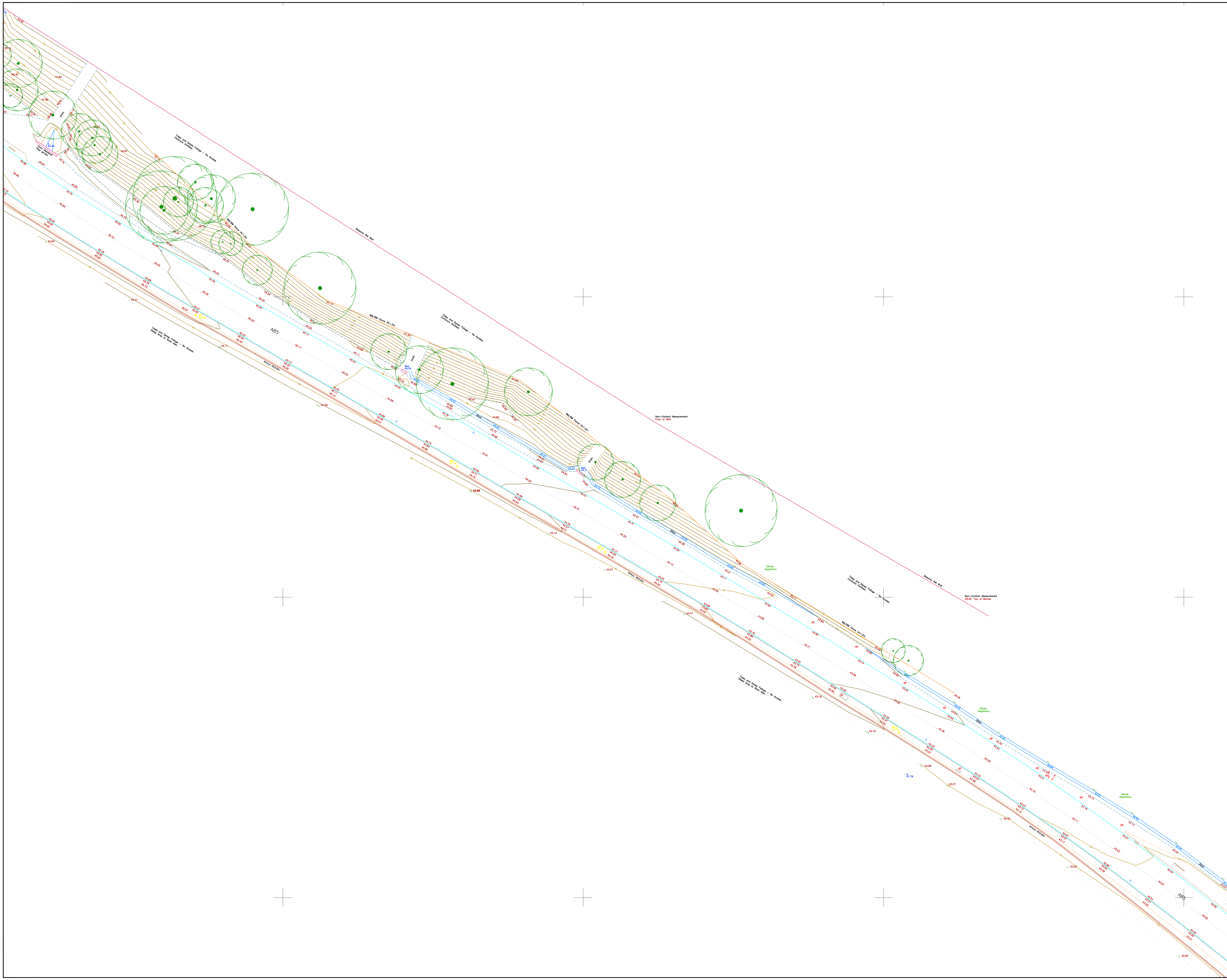

Road
Kerb
Drop Kerb
Surface
Fence
Wall
Verge
Terrain Break
Waterline
Ditch
Pipe
Open Drain
Railway
Overhead Electric
Overhead Telecom
Boundary

Building
Open Sided Building
Minor Building
Roofline
Foundations

Contours

FOLIAGE

Bush
Individual Deciduous Tree Trunk Diameter Greater Than 0.3m
Individual Coniferous Tree Trunk Diameter Greater Than 0.3m
Stump
Foliage Line
Hedge
Group of Trees or Saplings

SYMBOLS

Stn 10 10.00	Control Station	Inv 10.00	Invert Level
BM 10.00	Bench Mark	B.Lev 10.00	Bed Level
10.00 +	Spot Level	W.Lev 10.00	Water Level
TH 10.00	Threshold Level	Eave 10.00	Eave Level
B.Hole 10.00	Borehole	Ridge 10.00	Ridge Level
T.Pit 10.00	Trial Pit	Soffit 10.00	Soffit Level

DRAINAGE

+ Buc	Buchan Trap	+ G	Gulley
DP	Down Pipe	+ KO	Kerb Outlet

SERVICES

+ AV	Air Valve	+ MK	Marker
A/C +	Air Conditioning Unit		Metal Cover
+ BT	British Telecom	MH CL 10.00	Manhole
+ CCTV	Close Circuit Television	MH CL 10.00	Manhole Circular
+ ER	Earthing Rod	+ RE	Rodding Eye
+ EB	Electricity Box	+ SC	Stop Cock
EP	Electricity Pole	+ SV	Stop Valve
+ FH	Fire Hydrant	TP	Telegraph Pole
+ GV	Gas Valve	+ Vent	Vent
+ IC	Inspection Cover	+ WM	Water Meter

STREET FURNITURE

	Bollard	PB	Post Box
BS	Bus Stop		Post / Gate Post
+ JB	Junction Box	+ RP	Reflector Post
LP	Lamp Post	RS	Road Sign
+ L	Lighting	Sign	Sign (Misc.)
	Lit Bollard	+ Stay	Stay
+ LB	Litter Bin	+ Tap	Tap
+ PM	Parking Meter	+ TCB	Telephone Call Box
MR	Mooring Ring	TL	Traffic Light

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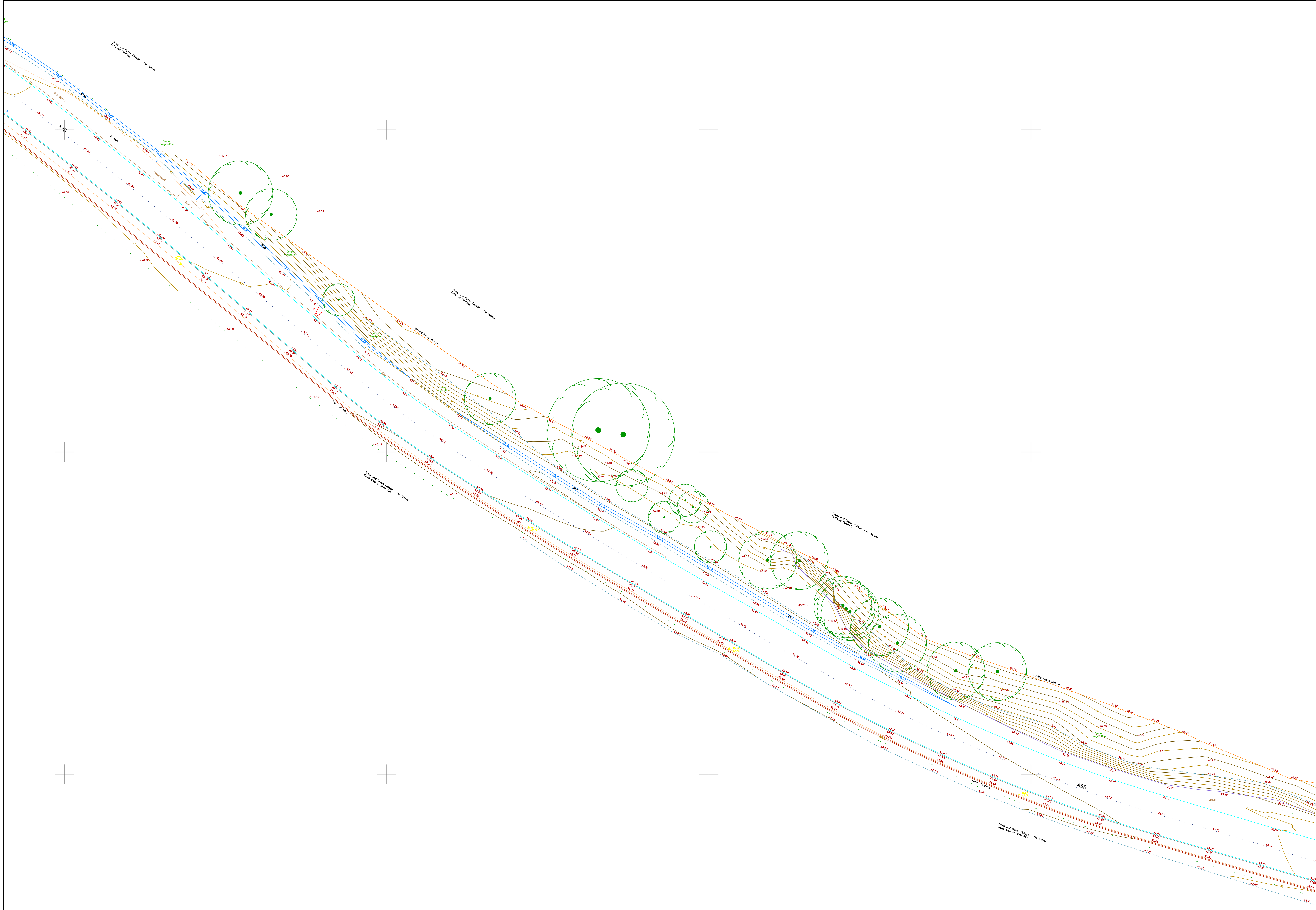

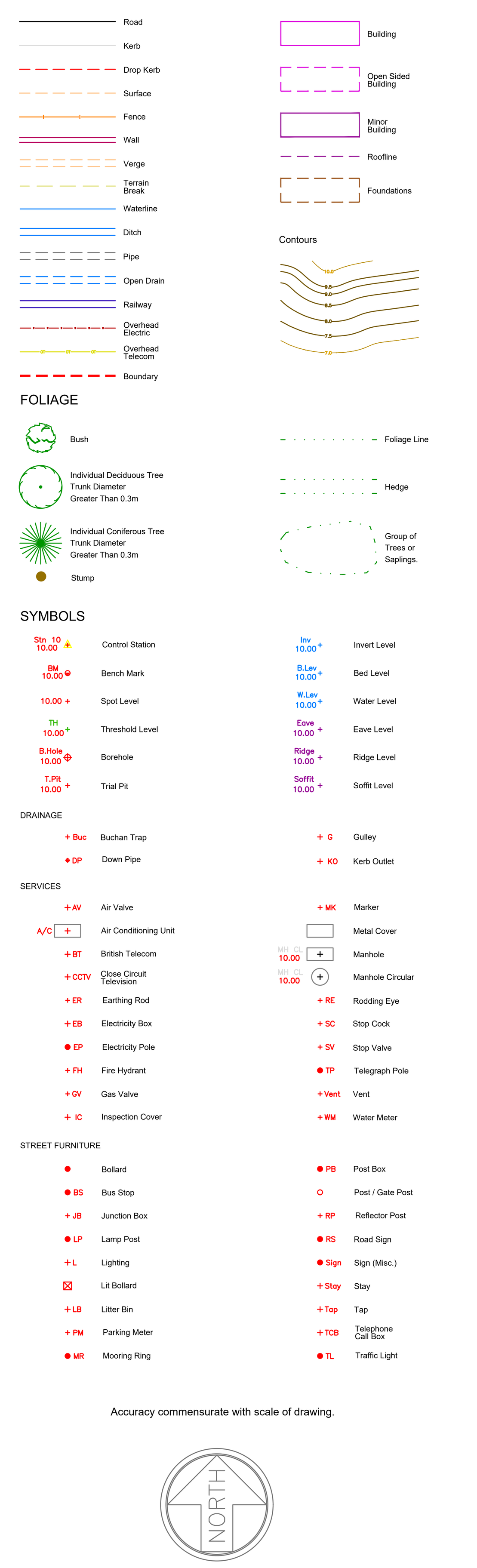

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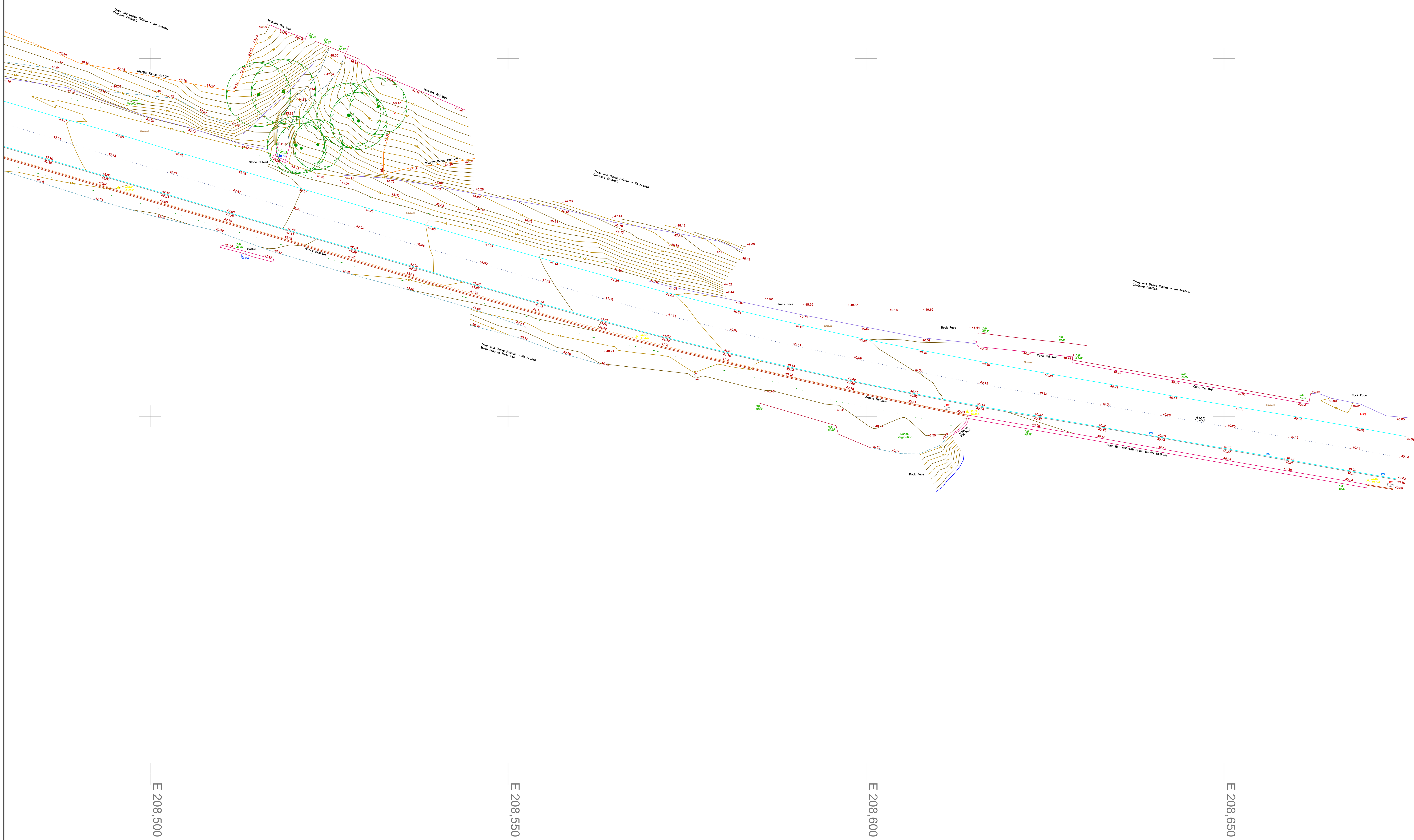

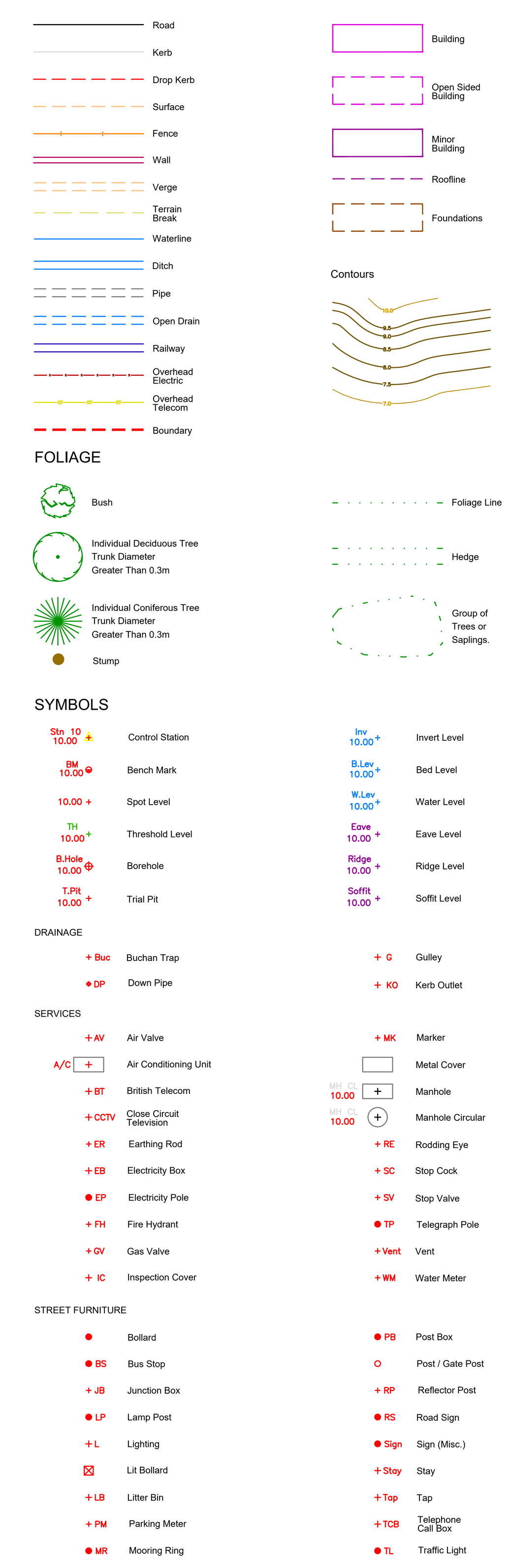

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Appendix C Scottish Water Asset Plans

Warning! Damaging a large diameter trunk main (12"/300mm and above) can result in loss of life and major water supply and water quality problems. If you're planning any extension work in the vicinity of any large diameter mains shown on our maps, you must contact Scottish Water to arrange a site visit 08000 778 778 WELL IN ADVANCE OF THE WORKS.

N

OP-OBONS212 - Water & Wastewater Plan

SCALE: 1:2,646

Plotted By: brian.mcmaster@national-one-call.co.uk
Date Plotted: 07/02/2022

The representation of physical assets and the boundaries of areas in which Scottish Water and others have an interest does not necessarily imply their true positions. For further details contact the appropriate District office.

Castle House,
6 Castle Drive,
Dunfermline,
KY118GG

Tel No: 08000 778 778

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Appendix D Cruachan 2 Environmental Impact Assessment Understanding likely scheme impact on water levels within Cruachan Reservoir and on Loch Awe

Authors:	Christopher Barry/Kelvin Limbrick	Contributors:	Craig Scott (Stantec); Steve Marshall (Drax)
File:	mem_WaterLevelsEIA_v4	Date:	May 28, 2021

Cruachan 2 Environmental Impact Assessment: understanding likely scheme impact on water levels within Cruachan Reservoir and on Loch Awe

BACKGROUND

The existing Cruachan power station (Cruachan 1), owned and managed by Drax, is a pumped storage hydroelectric plant. It draws on water from Loch Awe to store potential energy in Cruachan Reservoir, which it subsequently releases in periods of high energy demand from the National Grid; the difference in water level between the two water bodies is approximately 350m.

The locations of Loch Awe and the Cruachan Reservoir are shown in Figure 1. Loch Awe has a topographical catchment area of ca. 813 km^2, which is fairly steep-sided, and encompasses narrow valleys, steep grass-covered slopes and two natural lakes: Loch Tulla and Loch Avich. Cruachan Reservoir is impounded by the Cruachan Dam and has a much smaller topographical catchment area of ca. 5.87 km^2. Its catchment is also steep-sided and grass-covered. The effective catchment area of the Cruachan Reservoir is, however, increased due to the presence of aqueducts, which transfer water via gravity from rivers in adjacent catchments (this is discussed further below).

ENVIRONMENTAL IMPACT ASSESSMENT

Drax is planning to construct a new underground power station, Cruachan 2, which will provide greater power generation capacity (600 MWe) when compared with the existing power station (440 MWe). Although Cruachan 2 will be separate from the existing power station, it will use Loch Awe for abstraction and the Cruachan Reservoir for storage and generation, and as such the principles of its operating regime will be similar to that of Cruachan 1. The proposals for Cruachan 2 do not involve increasing the maximum storage capacity currently available within the Cruachan Reservoir or increasing the storage volume available within Loch Awe.

The proposal for Cruachan 2 has, however, triggered the requirement for an Environmental Impact Assessment (EIA). The impact of the scheme on the water environment has been scoped in as part of the EIA. The water environment chapter of the EIA will, therefore, need to consider the impact of the Cruachan 2 scheme on: water resources; the potential for pollution of the water environment; and flood risk.

OBJECTIVES

The objective of this Technical Note is to establish the impact that Cruachan 2 will have on water resources. Specifically, the impact that the scheme will have on water level variability within Cruachan Reservoir and on Loch Awe have been examined. This has been achieved through the analysis of historical water level time series data for Cruachan Reservoir and Loch Awe. The causal mechanisms driving historical water level variability within each water body are explained and the interdependency between the water level time series quantified. The likely impact of the Cruachan 2 scheme has, therefore, been assessed within the context of these causal mechanisms and water level interdependency.

IMPACT ON WATER LEVELS WITHIN CRUACHAN RESERVOIR

Overview

Cruachan 1 functions as a load-leveler to the National Grid, using excess energy during periods of low demand to pump water up from Loch Awe to the Cruachan Reservoir, then releasing it through the turbines to generate energy during periods of high demand.

With Cruachan 2 in place, overall power generation will increase from 440 to 1040 MWe. As power generation is directly related to the rate and volume of water discharge, this means that the combined existing and proposed power stations will be able to drain and fill Cruachan Reservoir more quickly than at present.

Cruachan Reservoir has an operational water level range of between 380.64m AOD (Black Start level) and 399.90m AOD (maximum operational level); this is a maximum water level range of almost 20m. Water level variability within the reservoir is changeable and governed by demand and antecedent conditions, although typically water levels pass through much of this range and back once or more per week and, at times, more frequently. The maximum and minimum operational water level boundaries will be maintained with Cruachan 2 in place.

The inflows to the reservoir include, in order of magnitude: water pumped up from Loch Awe; water imported by gravity drainage from adjacent catchments via the Main, Brander and Awe Village aqueducts; and natural rainfall-runoff from its modest topographical catchment. The outflows from the reservoir include the discharge for power generation back to Loch Awe (losses via evaporation and leakage are not thought to be significant by comparison).

Timeseries Analysis

Drax has provided a time series of water levels within the Cruachan Reservoir from 2015 to present. The time step for the water level data is 6 hours; sufficient to discern sub-daily variation. Figure 2 shows a collection of timeseries plots of water levels within the Cruachan Reservoir. The time series demonstrates how water levels within the reservoir pass through much of the operational range on a regular, near-cyclical basis.

The amplitude and frequency of variation in water level are both significant. The rate and extent of water level rise and decline within the reservoir far exceeds that which might be expected to occur within a 'natural' system. The time series displays frequent examples of near-weekly cyclicity in water level variation: water levels in the reservoir can rise at the start of a week as water is abstracted from Loch Awe and the reservoir fills; water levels fall towards the end of the week as water is released back into Loch Awe to generate energy.

Water Balance Analysis

Drax has also provided data on daily abstractions from Loch Awe to the Cruachan Reservoir; daily generation discharges from the reservoir back to Loch Awe; daily inflows from the three gravity aqueducts; and daily rainfall. Figure 3 shows the results of a monthly water balance analysis undertaken using these data[1].

The current operation of Cruachan 1 (i.e. pumping from Loch Awe and discharges for power generation) comprises the near-totality of the monthly water balance (Figure 3). The pumped inflows and discharges for power generation are the dominant features of the water balance; they are many times greater in magnitude

[1] For this analysis, it was assumed that 100% of all rainfall falling within the modest topographical catchment draining to the Cruachan Reservoir is converted directly to runoff. This assumption is likely to over-estimate the contribution of natural runoff to the Cruachan Reservoir water balance.

than the other components. Over a monthly timescale, net storage change mostly cancels out. The aqueducts provide a smaller but significant inflow although natural runoff from the topographical catchment is less significant in comparison.

Statistical Analysis

The dominance of the current operation of Cruachan 1 on the water level regime at Cruachan Reservoir is further demonstrated by statistical analysis. Plotting water level change within a day (midnight to midnight) against daily flow components reveals correlations between water level and flow components. The correlation can be quantified by the R^2 metric (for which 0 represents no correlation and 1 represents a perfect linear relationship). This analysis is shown in Figure 4. Of all the contributing factors analysed, the power station operational balance (pumping minus generation) shows the greatest correlation with water level variation, giving an R^2 of 0.81. Inflows from the gravity aqueducts and natural catchment runoff both appear to have little influence on the rate of water level change in the reservoir (with R^2 values at ca. 0.04 and 0.01 respectively).

Conclusion

The rate and extent of water level rise and decline within the reservoir far exceeds that which might be expected to occur within a 'natural' system. The amplitude and frequency of variation in water level are both significant. Water levels within the reservoir pass through much of the operational range (i.e. between 380.64m and 399.90m AOD) on a regular, near-cyclical basis.

The water balance analysis concludes that the water level regime in Cruachan Reservoir is almost entirely artificially controlled. The statistical analysis shows that water level rise and fall in Cruachan Reservoir is closely controlled by the operation of Cruachan 1 (i.e. pumping from Loch Awe and discharges for power generation), and not significantly influenced gravity inflows from the aqueducts or by natural rainfall-runoff.

The operational water level range within the reservoir will not change with the Cruachan 2 scheme in place. Similarly, the proposals for Cruachan 2 do not involve increasing the maximum storage capacity currently available within the Cruachan Reservoir or increasing the storage volume available within Loch Awe.

The principal impact of the Cruachan 2 scheme will be that the rate at which water levels within the reservoir could rise and fall in the future could be more rapid than the significant water level dynamics shown in Figure 2 above. The maximum and minimum operational water levels that would be achieved with Cruachan 2 in place would, however, be constrained within the reservoir's operational levels as illustrated by the black lines shown in Figure 2, as has been the case to date. Therefore, the nature of the water level regime in Cruachan Reservoir will not fundamentally change with Cruachan 2, with artificial factors already being dominant over naturally driven variation.

IMPACT ON WATER LEVELS ON LOCH AWE

Loch Awe is impounded by the Loch Awe Barrage. The barrage is operated by Scottish and Southern Electricity (SSE). The barrage controls water levels within Loch Awe to provide working storage for hydropower generation at SSE's Inverawe Power Station. SSE operates the barrage to maintain target water level ranges for power generation of between 36.27 to 37.06m AOD (from April to November), and 35.96 to 36.57m AOD (from December to March).

The barrage operates in 'flood-release' mode when water levels within Loch Awe exceed 37.06 and 36.57m AOD during these two respective periods. During periods of low rainfall or drought conditions, SSE either limits or halts power generation at its Inverawe Power Station, and modulates the outflow rate from the barrage, until water levels within the Loch recover to within the aforementioned ranges. The barrage appears to have a minimum invert level of 35.35m AOD.

Relative to the Cruachan Reservoir, Loch Awe has a large surface area, topographical catchment, and storage volume. Drax has provided a time series of water levels recorded within Loch Awe. The water level gauge from which this time series is sourced is located close to the existing inlet/outlet of Cruachan 1. The following timeseries and statistical analyses examine the interdependencies between the current operation of Cruachan 1 and water levels within Loch Awe, and between natural rainfall-runoff within the Loch Awe catchment and its attendant water level variability.

Timeseries Analysis

The responses of water levels within Loch Awe to rainfall and the operation of Cruachan 1 can be illustrated by investigating sections of the timeseries data. Figure 5**Error! Reference source not found.** illustrates that periods of rainfall in early September and late October 2020 produced a clear high water level response in Loch Awe. However, during a period of no rainfall between 12th and 18th October, Loch Awe's water level showed almost no variation despite the ongoing operation of Cruachan 1, as shown by the water level variability in Cruachan Reservoir.

Figure 6**Error! Reference source not found.** shows water levels within Loch Awe responding to rainfall events on the 17th and 23rd May 2020, but not to the strong net abstraction from Loch Awe that resulted in a rise in water levels within the Cruachan Reservoir between the 22nd and 24th May.

Statistical Analysis

Statistical analysis has been used to demonstrate that the observations from the timeseries apply to the whole data period. Daily water level data for Loch Awe are held from 2013 to 2020; daily abstraction returns by Cruachan 1 (including the pumping and power generation flows) are held from 2014 to 2020; and rainfall data are held from 2017 to 2020 (inclusive in all cases). The following analysis is based on the period of overlapping data, covering the four years from 2017 to 2020 inclusive.

It is possible to show from statistical analysis that the operation of Cruachan 1 probably has negligible influence on water levels within Loch Awe, compared with natural rainfall-runoff inputs (and possibly the controlling influence of the Loch Awe Barrage). Figure 7**Error! Reference source not found.** shows the linear regressions between water level and the previous 7 days' accumulated rainfall and between water level and the previous 7 days' net inflow from the power station (in both cases, the correlation is best – that is, R^2 is highest – when taken against the previous 7-day accumulations rather than a longer or shorter accumulation period). There is a much stronger correlation with rainfall and there is not a significant statistical relationship between water level and the power station operation.

The statistical correlation between rainfall and Loch Awe water level is considered significant, even though 0.48 would be a relatively low value for R^2 in other contexts. 7-day accumulated rainfall has been used in an attempt to account for the natural lag between rainfall events and increases in loch water level (the topographical catchment area of Loch Awe is relatively large and there will be a delay between rainfall events and upturns in water level). Only data on total rainfall accumulations were available for this study. Not all rainfall events result in the generation of rainfall-runoff. Runoff within the Loch Awe catchment will only occur after soil moisture deficits have been replenished. The use of Hydrologically Effective Rainfall would be expected to generate a higher R^2 value, although these data are currently unavailable. Water levels on Loch Awe are also modulated by the Loch Awe Barrage; this influence may also help to explain the R^2 value.

Ideally, the daily water level change would be compared against net inflows from the pumping station within a shorter period, because over 7 days, the inflows and outflows from the power station would tend to cancel out. However, there are no midnight water level readings from Loch Awe as there are for Cruachan Reservoir (in fact, the timings of the readings are not given for Loch Awe), so this is not feasible. Nonetheless, there are enough occasions where there is a significant positive or negative accumulation of flow from Cruachan 1 (this can be seen in the distribution in Figure 7) to give confidence that water level is not noticeably influenced by the power station's operation.

If water levels within Loch Awe were significantly influenced by the operation of Cruachan 1, then the near-weekly cyclicity in water levels within Cruachan Reservoir (described above) would be mirrored in the daily water level series on Loch Awe.

This analysis can also be placed into context through a simple calculation. The Cruachan Reservoir has a total available volume of ca. 7 million m^3. The Loch Awe surface area is ca. $38km^2$, within which the water level gradient is reasonably flat (controlled largely by the Loch Awe Barrage). If the total volume of the Cruachan Reservoir was released into Loch Awe (in the absence of any natural inflows or outflows on the loch), this would result in a water level rise of ca. 220mm.

Water Velocity

In terms of water velocity at the proposed Cruachan 2 intake (which will also be the new outlet when generating), the new smolt screens have been designed such that maximum velocities through the screens will not exceed 0.3 m/s; a velocity that is unlikely to cause additional scour or morphological damage to the bed and banks of Loch Awe.

Conclusion

Given that there is no significant water level response within Loch Awe to the current operation of Cruachan 1, even at a water level monitoring point close to the inlet/outlet point, it is reasonable to conclude that Cruachan 2 will not result in a discernible impact on Loch Awe water levels. This is because the main impact of Cruachan 2 will be to increase the rate of level rise and fall within the Cruachan Reservoir, rather than increase its storage volume (and thus total volume abstracted from, and discharged back to, Loch Awe).

FIGURES

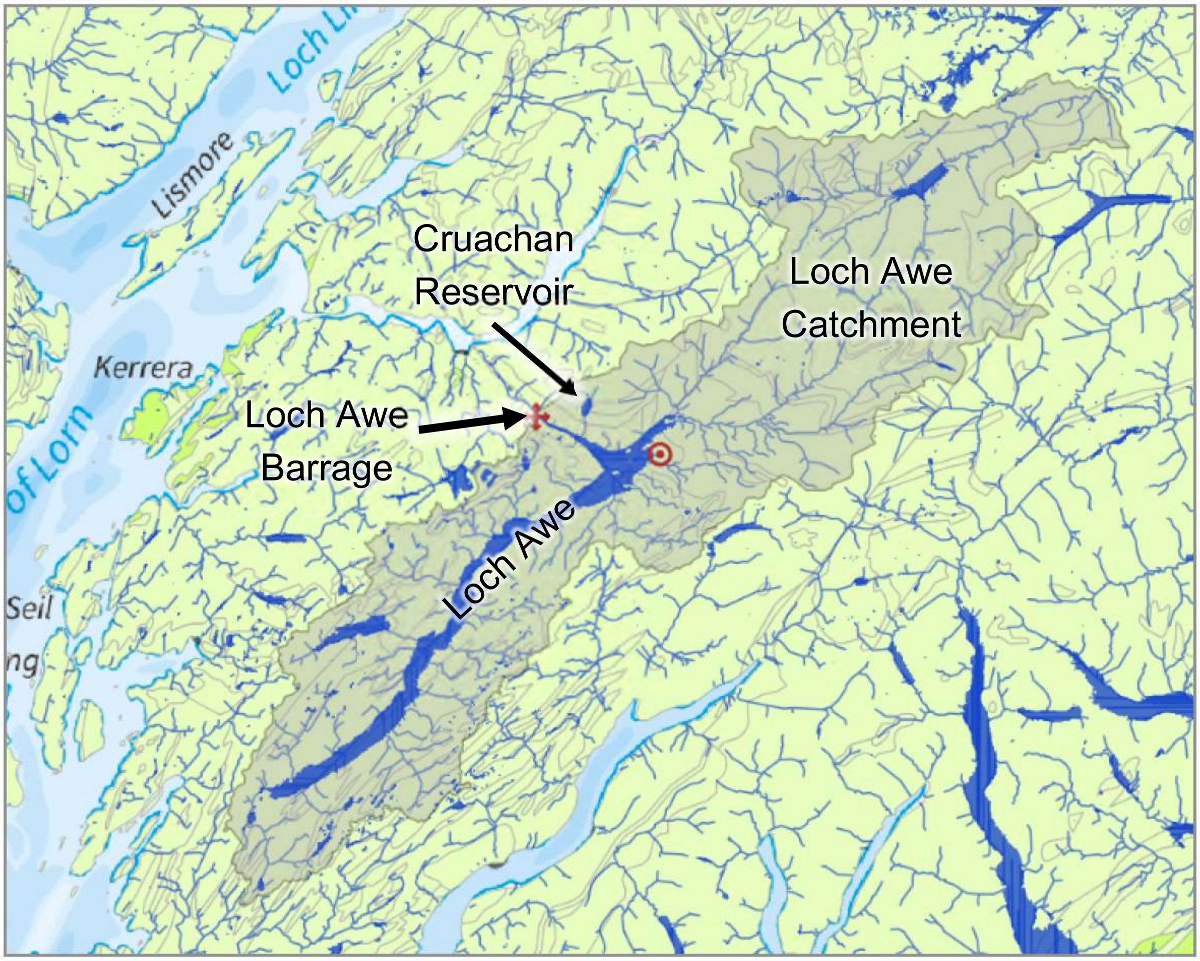
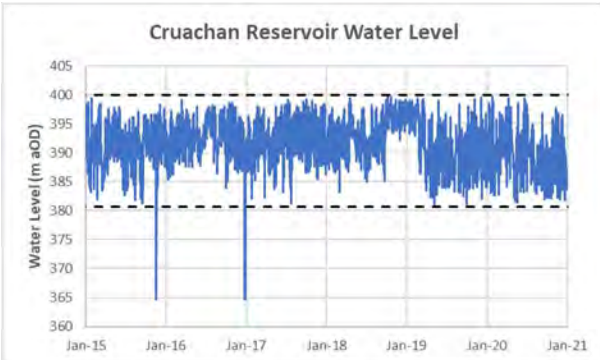


Figure 1: Cruachan Reservoir and Loch Awe setting

Whole Data Period



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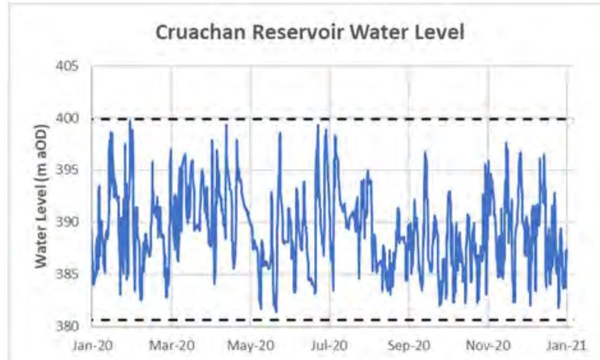
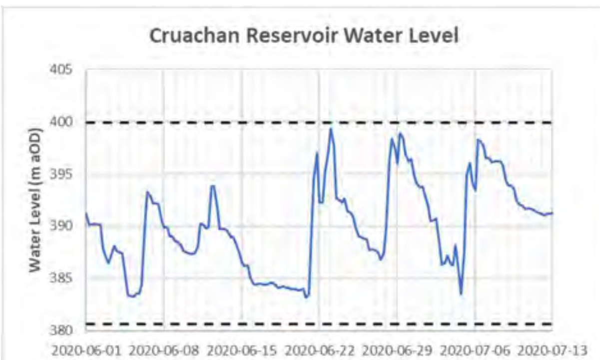
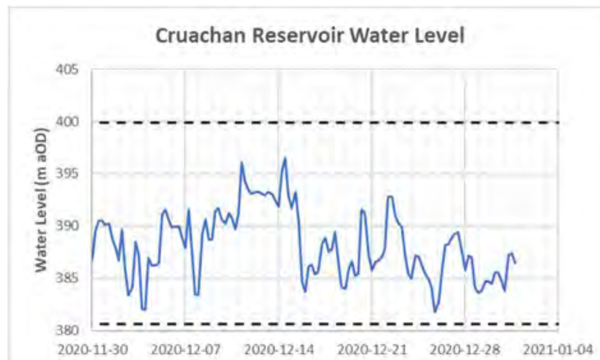


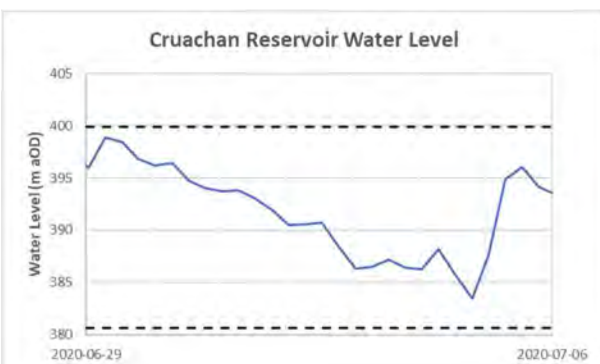
June 2020[1]



December 2020[1]



Example week in June 2020[1]



Example week in December 2020[1]

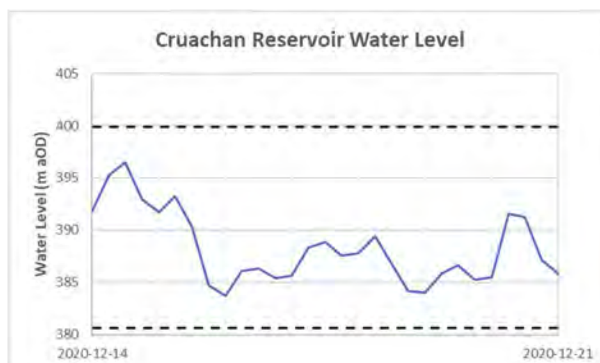


Figure 2: Cruachan Reservoir Water Level Timeseries plots

1. The 1-week and 1-month plots each start on a Monday, with gridlines marking days.

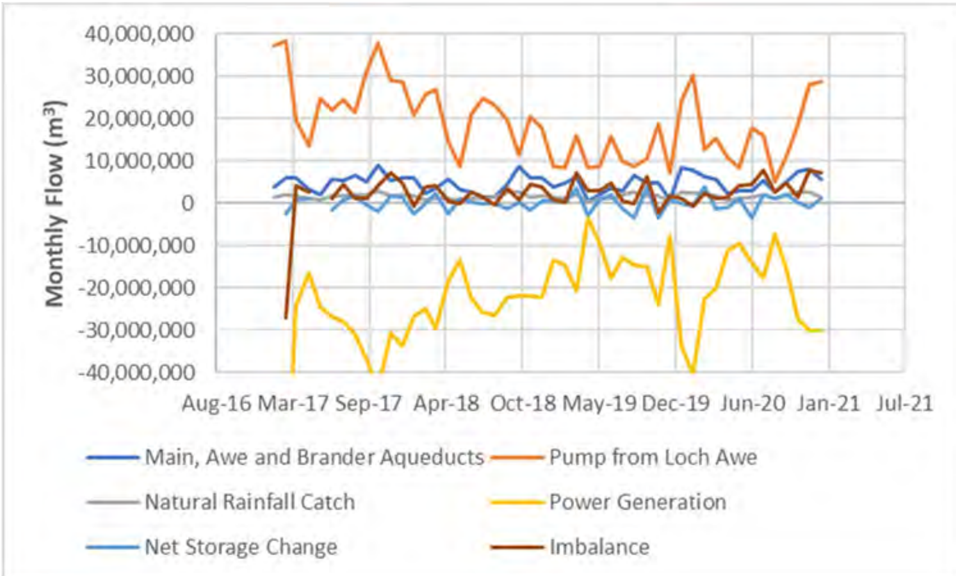


Figure 3: Cruachan Reservoir Monthly Water Balance

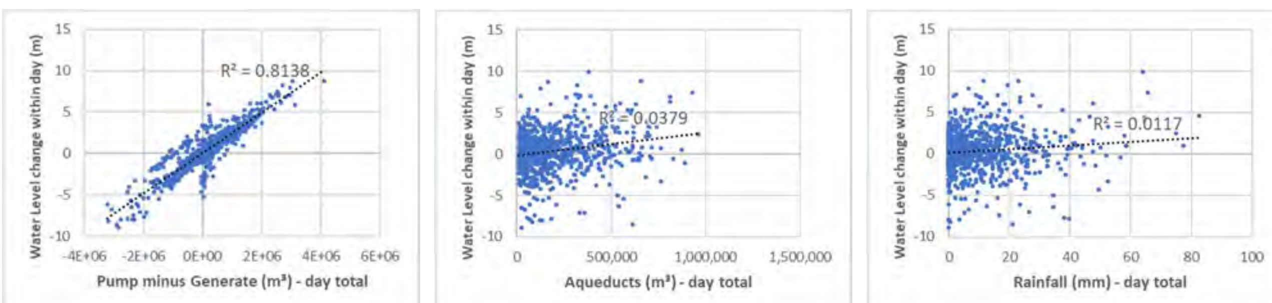


Figure 4: R^2 Analysis of Cruachan Reservoir Water Level against Preceding Flow Components

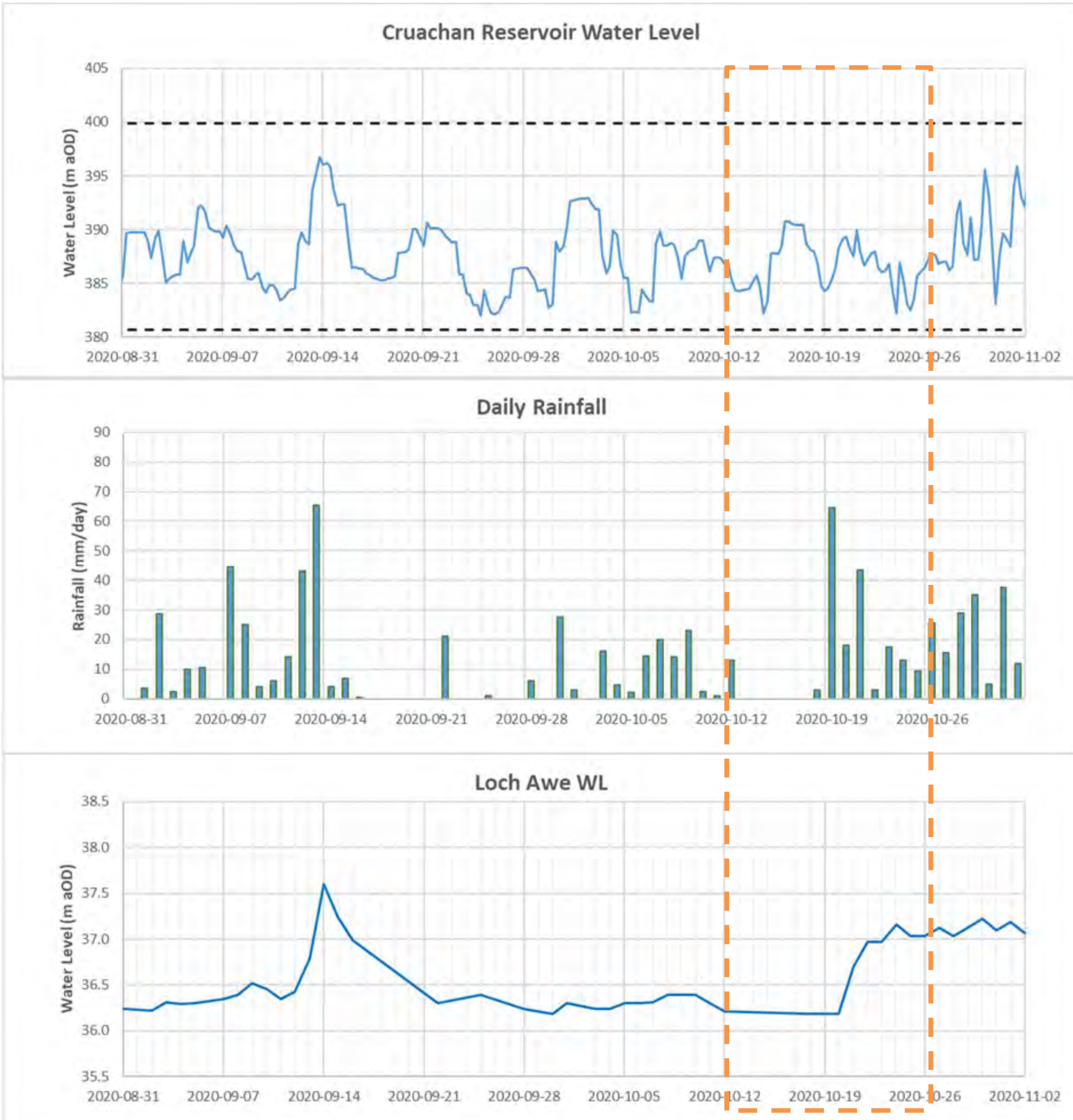


Figure 5: Loch Awe Water Level compared to Rainfall and Cruachan Operation, September to October 2020

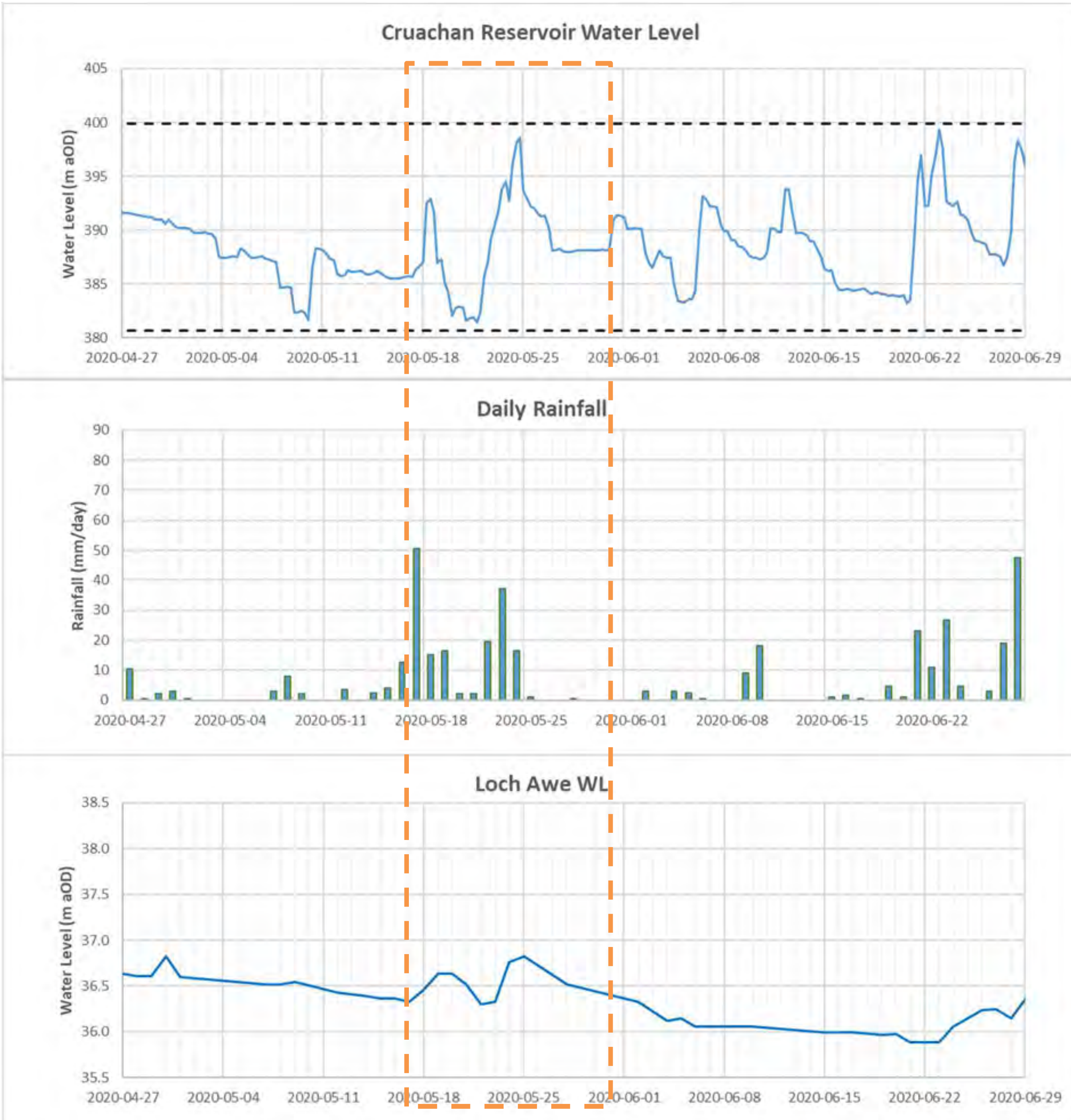


Figure 6: Loch Awe Water Level compared to Rainfall and Cruachan Operation, May to June 2020

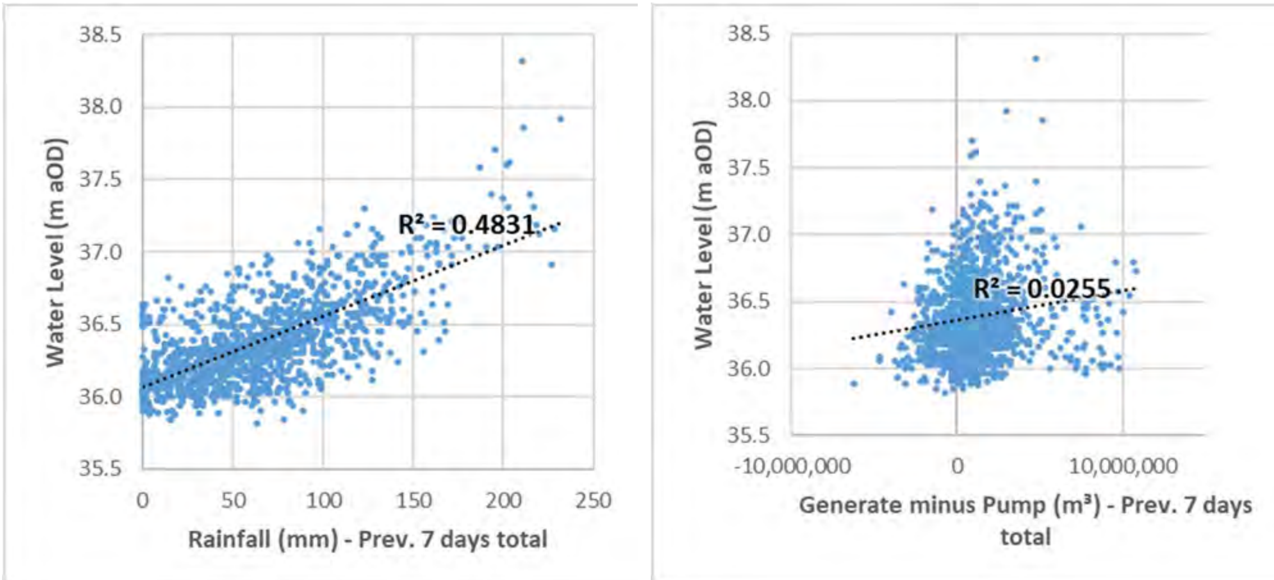


Figure 7: Correlations between Loch Awe Water Level and 7-day Flow Accumulations

Appendix E HEC-RAS Modelling Technical Note

TECHNICAL NOTE

TO:	Steve Marshall, Drax	DATE:	28 April 2022
FROM:	Krishna Dey	CC:	Kelvin Limbrick
PROJECT NAME:	Cruachan 2		
PROJECT NO:	331201086.100.010101		
SUBJECT:	HEC-RAS 1D Hydraulic Modelling for flood level estimation on Loch Awe		
FILE LOCATION:	\\GB1006-PPFSS01\Shared_projects\331201086\Rivers and catchments\Technical Note\		

1 INTRODUCTION

Stantec has been instructed by Drax to conduct hydraulic modelling of Loch Awe for the purpose of estimating flood levels on the loch as part of its Cruachan 2 pumped storage hydropower project.

The one-dimensional (1D) hydraulic modelling software package HEC-RAS was used to build the Loch Awe model, which has been used to estimate flood levels. The baseline model was built using cross-sections derived from the 1m LiDAR DTM data with the loch bed elevation adjusted based on the bathymetric survey undertaken by UTEC. The bed levels of the loch upstream of SSE's Loch Awe barrage are at ca. -18 mAOD and this level has been used to generate the revised cross-section data. The HEC-RAS modelling was undertaken using unsteady-state solutions and was used to estimate flood levels on Loch Awe for a range of design events.

The following sections outline the model build and results.

2 HEC-RAS MODELLING

2.1 Cross-sections

The cross sections for Loch Awe were extracted from open-source LiDAR DTM data (Scottish LiDAR Remote Sensing datasets | Scottish Government) at an interval of 200m. The locations of the cross sections are shown in Appendix A.1. A smaller extent of bathymetric survey was available near to the Cruachan 2 site, undertaken by UTEC in September 2020. The bed levels upstream of the Loch Awe barrage are fairly constant. Thus, a constant bed level of -18 mAOD was chosen to represent the loch bed based on the bathymetric survey data and accordingly all cross-sections derived from LiDAR data were amended. This amendment was necessary as the LiDAR DTM data only provides the top water surface elevation of the channel. Figure 1 below shows a typical cross-section at chainage 4800m.

All cross sections were imported into HEC-RAS following the Loch Awe planform as shown in Appendix A.1. Channel bank stations were assigned based on a visual examination of the shape of each cross-section. Manning's N values of 0.04 and 0.06 were assigned for the channel and floodplains, respectively. Overall, there were 18 cross sections within the baseline model. The HEC-RAS model includes a representation of the Loch Awe barrage. The dimensions of the Loch Awe barrage (see Table 1) were estimated based on the LiDAR DTM data, site photographs and open-source mapping (Figure 2). The HEC-RAS schematic of the Loch Awe barrage is shown in Appendix A.2.

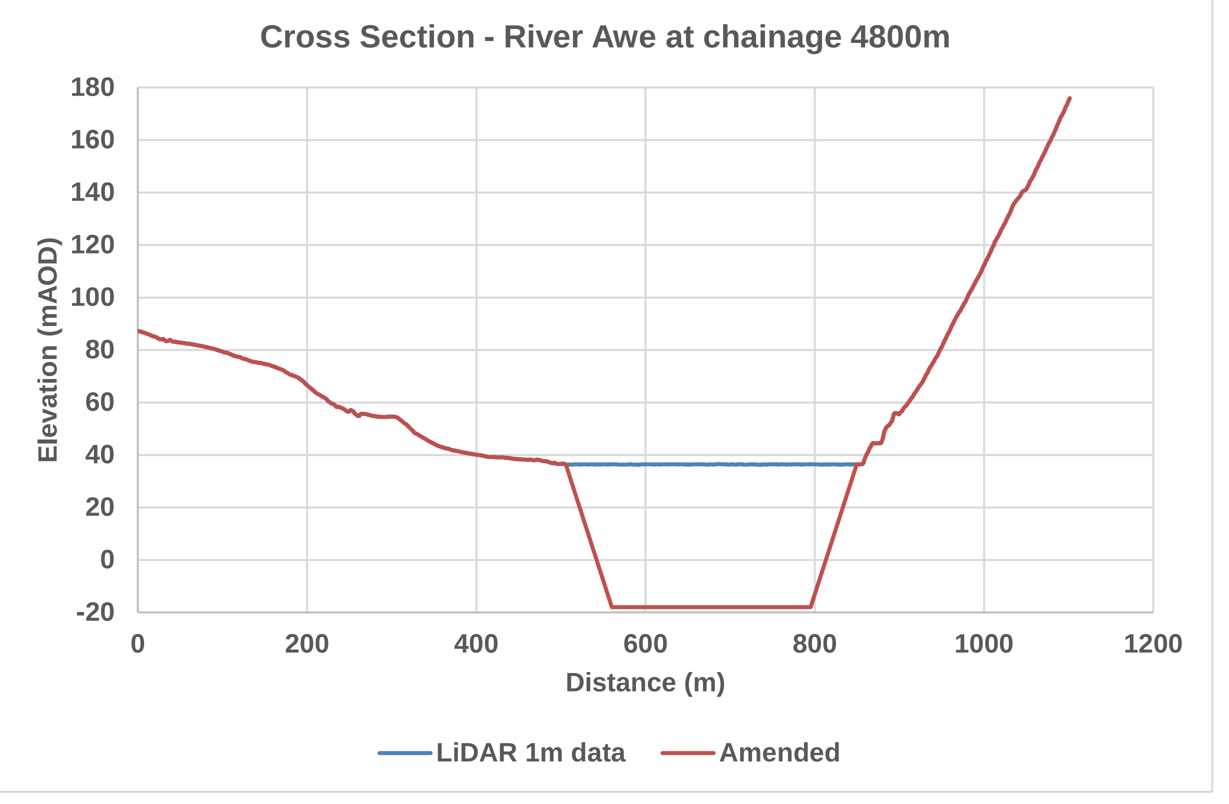


Figure 1: Typical River Awe cross section at chainage 4800m

Table 1: Estimated dimensions of the Loch Awe Barrage structures used in the HEC-RAS model

Gates	Height (m)	Width (m)	Invert Level (mAOD)
1	5.0	9.0	31.0
2	5.0	9.0	31.0
3	5.0	9.0	31.0
4	1.5	3.0	34.9

Figure 2: Site photograph and Bing map, Loch Awe Barrage

The long profile for the River Awe based on the HEC-RAS model schematic is shown in Appendix A.3.

2.2 Derivation of Flows

To determine the flood flows, catchment descriptors at the Loch Awe Barrage were downloaded from the FEH Webservice[1]. Along with the catchment descriptors, a catchment shapefile was also downloaded which shows the entire catchment for the River Awe at the Loch Awe Barrage, see Appendix B. Table 2 below includes the characteristics of the River Awe catchment to determine which method to be employed in deriving the design inflows.

[1] https://fehweb.ceh.ac.uk/

Table 2: Methods employed for estimating model inflows for River Awe.

Catchment	Catchment Area (km^2)	URBEXT2000	BFIHOST19	Comments	Methods
River Awe at Loch Awe Barrage	816.39	0.0003	0.381	The River Awe catchment is essentially rural as the URBEXT 2000 value <0.03. BFIHOST19 < 0.65 thus ReFH2 and Statistical methods are recommended.	Both ReFH2 and FEH Statistical estimates would be applied.

The ReFH2 method used both the rural and urbanised models to calculate the peak flows. Table 3 below shows the estimated peak flows for River Awe catchment using these two models.

Table 3: Peak flow estimates for the River Awe using the ReFH2 method.

Catchment	Calculation Model	Peak flow (m^3/s)				Comments
		50yr	75yr	100yr	200yr	
River Awe at Loch Awe Barrage	Rural	1464.05	1568.76	1648.18	1864.71	Both urbanised and rural models produce similar peak flows
	Urbanised	1464.22	1568.94	1648.37	1864.92	

The FEH Statistical method using data transfer and an urban adjustment to QMED was also used to assess peak flows for the River Awe. Table 4 below shows the different catchment descriptor parameters for each of the donor catchments. Donor station 18003 (Teith @ Bridge of Teith) was selected for the donor transfer process due to its similarity with the River Awe catchment. The first six donor stations were examined based on the similarity of catchment parameters such as URBEXT2000, SAAR, BFIHOST19 and FARL for each donor. Donor station 18003 showed the greatest similarity in terms of FARL based on the subject catchment although was less similar for the other parameters. Thus, donor station 18003 has been used for these statistical estimates. Table 5 shows the peak flow estimates using the ReFH2 and Statistical methods. The design hydrographs estimated using the statistical method for the River Awe are shown in Figure 3. These design hydrographs were applied as input to the 1D HEC-RAS model of the River Awe.

Table 4: Catchment descriptors: potential donor catchments, River Awe.

	Station	Distance	URBEXT	Use QMED Obs Deurbanised	QMED Obs	QMED Deurbanised	QMED CDs	Centroid X	Centroid Y	
1	999200 (gb 204550 728750 (nn 04550 2		0.000					212781	725607	816.3
2	86002 (Eachaig @ Eckford)	31.38	0.000	☐	**80.978**	80.978	89.480	212330	694235	138.6
3	85001 (Leven @ Linnbrane)	40.20	0.004	☐	**124.173**	123.698	141.988	240564	696549	786.1
4	15016 (Tay @ Kenmore)	41.56	0.001	☐	**196.788**	196.668	178.111	253567	733600	598.2
5	18003 (Teith @ Bridge of Teith)	42.31	0.001	☐	**223.376**	223.112	131.825	252997	712464	515.6
6	90003 (Nevis @ Claggan)	43.78	0.001	☐	**121.753**	121.678	90.809	216794	769202	69.21
7	15011 (Lyon @ Comrie Bridge)	48.48	0.000	☐	**217.392**	217.369	205.713	256969	745549	388.3
8	15007 (Tay @ Pitnacree)	48.54	0.001	☐	**354.832**	354.572	377.806	259167	739906	1149.
9	91802 (Allt Leachdach @ Intake)	52.48	0.000	☐	**6.350**	6.350	11.806	226882	776154	6.540
10	15003 (Tay @ Caputh)	62.15	0.001	☐	**860.508**	859.882	663.310	268184	753767	3211.
11	16001 (Earn @ Kinkell Bridge)	63.05	0.003	☐	**203.984**	203.408	177.272	275774	722834	584.6

Site of Interest Selected Donor

	Station	Centroid Y	Area	SAAR	BFIHOST	FARL	Years of data	QMED Suitability	Pooling Suitability	Weight
1	999200 (gb 204550 728750 (nn 04550 2	725607	816.390	2519	0.355	0.725				
2	86002 (Eachaig @ Eckford)	694235	138.670	2470	0.380	0.836	19	Yes	Yes	0.245
3	85001 (Leven @ Linnbrane)	696549	786.110	2023	0.436	0.681	43	Yes	Yes	0.206
4	15016 (Tay @ Kenmore)	733600	598.280	2130	0.423	0.760	44	Yes	Yes	0.200
5	18003 (Teith @ Bridge of Teith)	712464	515.610	2001	0.458	0.755	49	Yes	Yes	0.197
6	90003 (Nevis @ Claggan)	769202	69.210	2913	0.428	0.998	37	Yes	Yes	0.192
7	15011 (Lyon @ Comrie Bridge)	745549	388.330	2005	0.439	0.907	47	Yes	Yes	0.174
8	15007 (Tay @ Pitnacree)	739906	1149.080	1950	0.442	0.836	55	Yes	Yes	0.174
9	91802 (Allt Leachdach @ Intake)	776154	6.540	2554	0.397	0.992	34	Yes	Yes	0.161
10	15003 (Tay @ Caputh)	753767	3211.230	1609	0.437	0.807	68	Yes	Yes	0.133
11	16001 (Earn @ Kinkell Bridge)	722834	584.670	1505	0.487	0.894	58	Yes	Yes	0.130

Site of Interest   Selected Donor

Table 5: Peak flow estimates for the River Awe using ReFH2 and Statistical methods.

Catchment	Method	Peak flow (m^3/s)				Comments
		50yr	75yr	100yr	200yrd	
River Awe at Loch Awe Barrage	ReFH2	1464.22	1568.94	1648.37	1864.92	ReFH2 estimates are extremely high. Thus, peak flow estimates using statistical method was employed for River Awe modelling.
	Statistical	573.89	617.04	649.56	735.15	

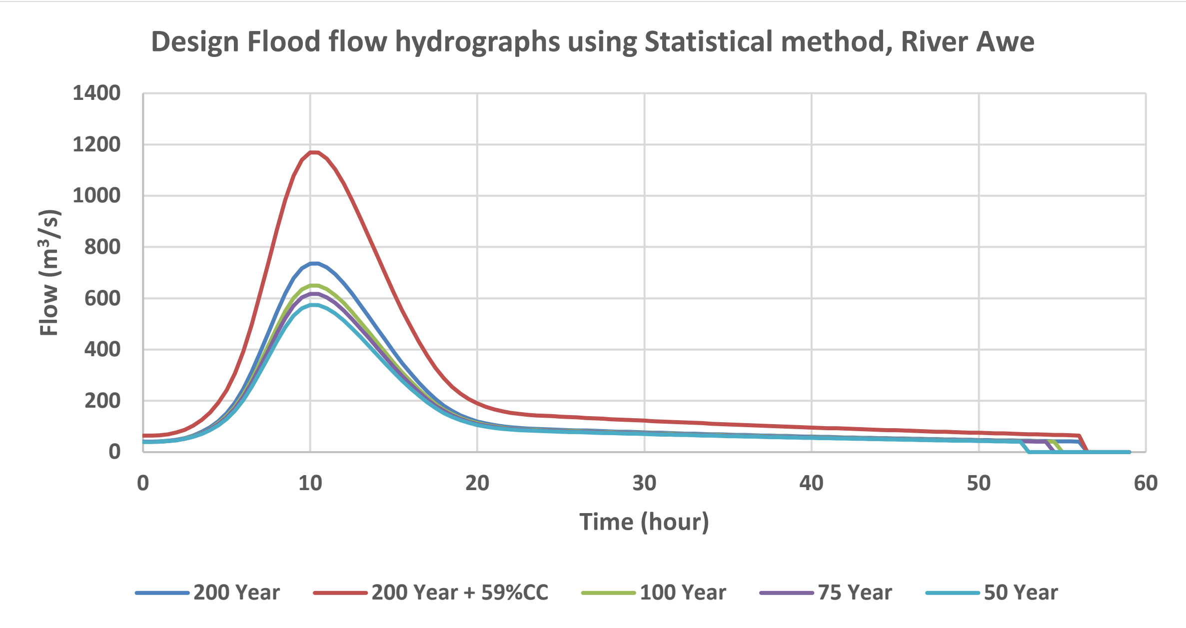


Figure 3: Design hydrographs used for the 1D modelling of the River Awe (estimated using the Statistical method).

2.3 Model Runs

2.3.1 Calibration

An attempt has been made to calibrate the modelled water level against a typical water level on Loch Awe of 36.5 mAOD, based on the measured water level as shown in Figure 4 below. The average water level based on the recorded data was found to be ca. 36.5 mAOD. In order to assist the calibration, the NRFA gauging station close to the subject site (18003 – Teith at Bridge of Teith) was identified, which has a similar FARL (Flood Attenuation by Reservoirs and Lakes) value with reference to the Loch Awe catchment. The mean flow at NRFA station 18003 over the 1957 to 2015 period was found to be 24.644 m^3/s. The mean flow at station 18003 was used estimate the mean flow for the Loch Awe catchment as shown in Table 6 below (the mean flow estimation was undertaken by pro-rating based on catchment area).

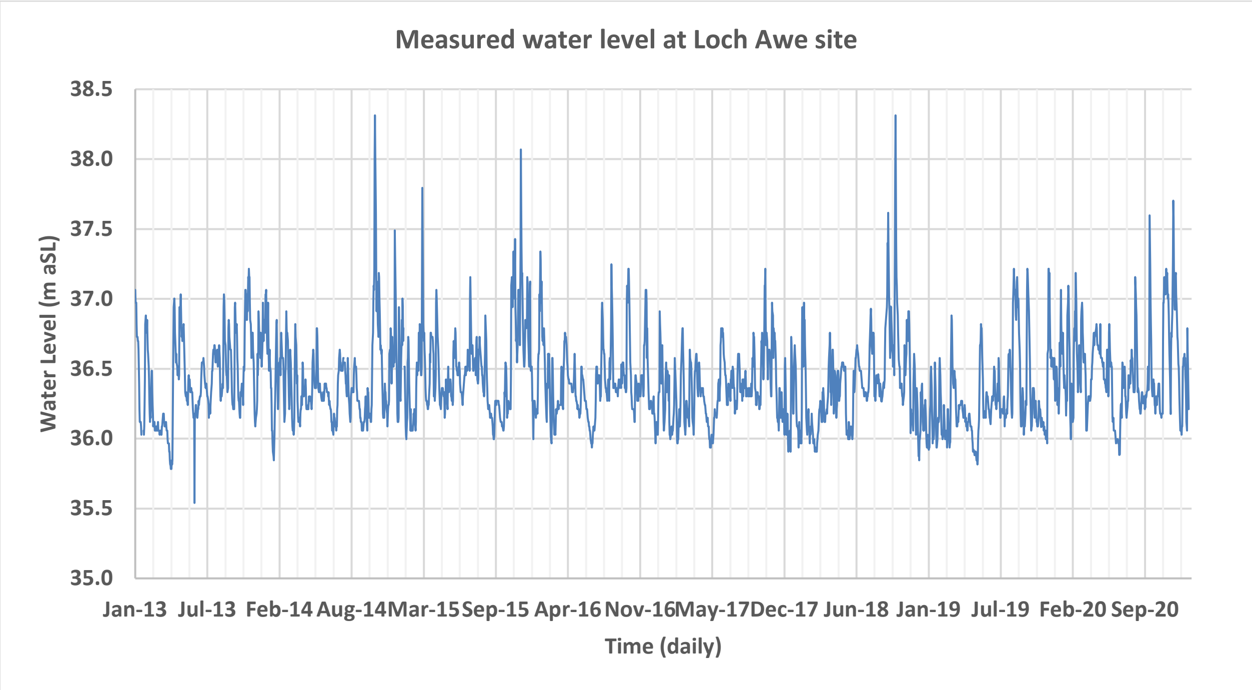


Figure 4: Recorded daily water level at Loch Awe 2013 to 2020.

Catchment	Area (km^2)	Ratio	Mean flow (m^3/s)	Comments
18003	517.70		24.644	Observed
Loch Awe	816.39	1.58	38.862	Pro-rated

Table 6: Pro-rated mean flow for Loch Awe catchment

The unsteady-state HEC-RAS model was run to calibrate a typical water level of 36.5 mAOD assuming a mean flow of 38.862 m^3/s (see Table 6) through the adjustment of gate openings of the Loch Awe barrage. It is evident from Figure 2 that SSE does not routinely open all the barrage gates. To match the gate openings as evident from Figure 2, the HEC-RAS model was run by closing all the gates except the third gate which was kept open by 0.693m to achieve the typical water level of 36.5 mAOD, see Figure 5 (top – adjusted gate openings; bottom – calibrated water level at the site RS 4600).

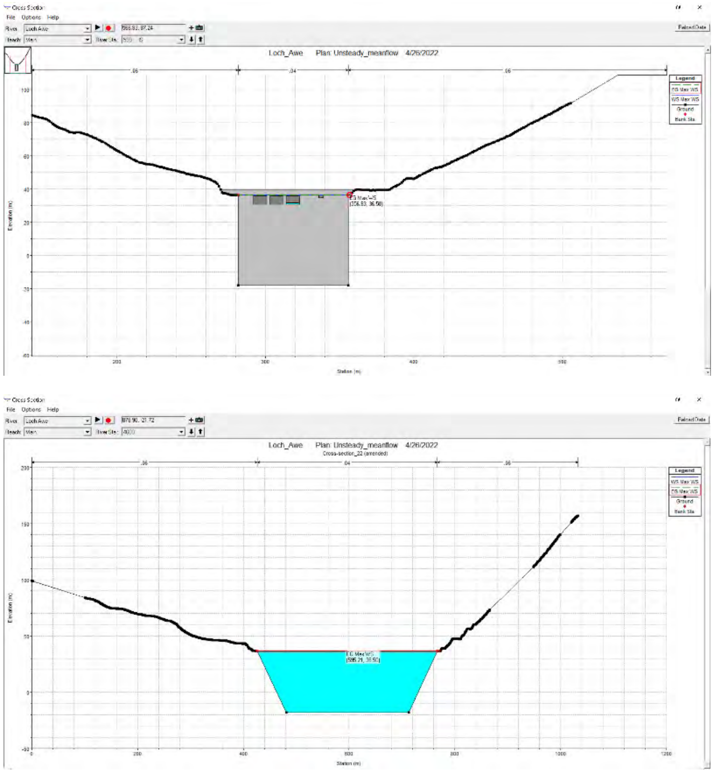


Figure 5: Gate settings of Loch Awe barrage (top) and calibrated water level at the site (RS4600 - bottom)

2.3.2 Design Runs for flood flows

The unsteady model was run with the flood flows shown in Figure 3 above. All the gates of the Loch Awe barrage were set to be fully open during these runs. The 1D model simulation provided a range of hydraulic outputs such as: stream power, velocity, and water level.

2.4 Model Results

The simulated flood levels on Loch Awe (RS 4600) for various design events are shown in Appendix C.1. Table 7 below shows the peak flood levels for various design events. The long profile for various design events is shown in Appendix C.2

Table 7: Flood Levels on Loch Awe (RS 4600) for various design events

Location	Flood level (mAOD)				
	50 Year	75 Year	100	200	200 Year +59%
Loch Awe Site (RS4600)	38.35	38.75	39.05	39.80	42.32

2.5 Standard of Protection (SoP) – Retaining Wall Structure

The new retaining wall structure to be constructed on the banks of Loch Awe as part of the Cruachan 2 project is shown in Figure 6. The design crest level of this wall has been set at 39.5 mAOD. The HEC-RAS model was run for a range of flows through an iterative process to achieve a water level of 39.5mAOD on Loch Awe. The standard of flood protection for this retaining wall structure was estimated to be equivalent to a 107-year return period. Thus, any events greater than a 107-year return period would cause the wall to overtop.

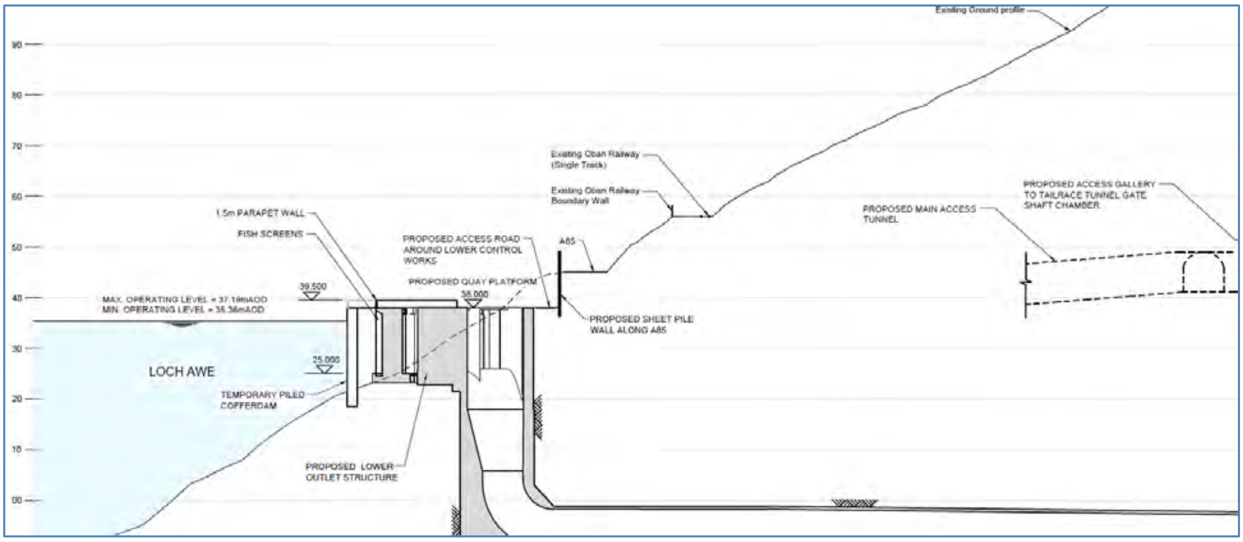


Figure 6 -

2.6 Audit Trail

A modelling log file as a spreadsheet has been maintained throughout the model build process (included in Appendix D.1). An independent check and review of the modelling process was undertaken as part of the internal audit. Appendix D.2 includes the signed copy of the independent auditor’s form.

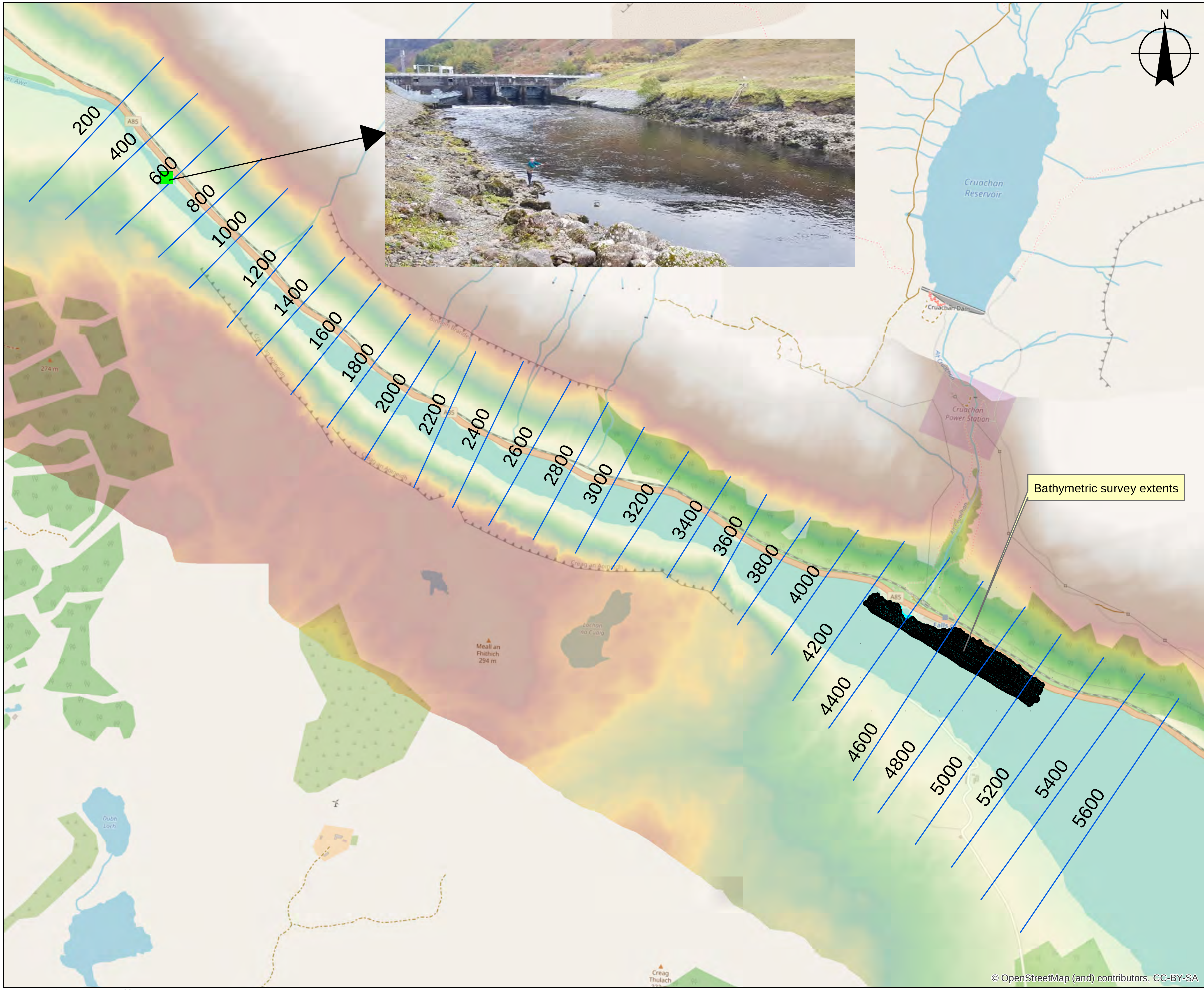
2.7 Conclusions

A 1D hydraulic model of the River Awe at Loch Awe has been built using the HEC-RAS modelling software (version 4.1.0 Jan 2010) to estimate flood levels on Loch Awe for a range of design events.

The results of this modelling study will be used to inform the Flood Risk Assessment (FRA) for Drax’s Cruachan 2 pumped hydropower project.

Appendix A

Appendix A.1 - Loch Awe Model Extents
Appendix A.2 - Loch Awe Barrage structure schematic
Appendix A.3 - Long profile of River Awe based on HEC-RAS model schematic



DO NOT SCALE - IF IN DOUBT ASK

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Warrington
WA3 6UT

NOTES

1. ALL DIMENSIONS IN MILLIMETRES AND ALL LEVELS IN METRES UNLESS SHOWN OTHERWISE

0 0.4 0.8
km

REFERENCES

DRAWING NUMBER	DRAWING TITLE

Legend

- Loch Awe Barrage
- Cross Section locations

LiDAR DTM - 1m resolution (mAOD)

High : 704.24

Low : -1.26

CURRENT VERSION INFORMATION

Iss	Description	Dsgnr	Chkd	Appd	Date
A	xxx	KD	KJL	KJL	30MAR2022

SSE PLC

Inveralmond House200 Dunkeld Road,
Perth PH1 3AQ

Location Code:	OS Reference:	Security Reference:	Drawn By:
...	NN077268	UBR	KD

Project Group: ...

Sub Process: ...

Location / Town: Cruachan Power Station, A85, Lochawe, Argyll and Bute, Scotland, PA33 1AN

Site Name: ...

Project Name: ...

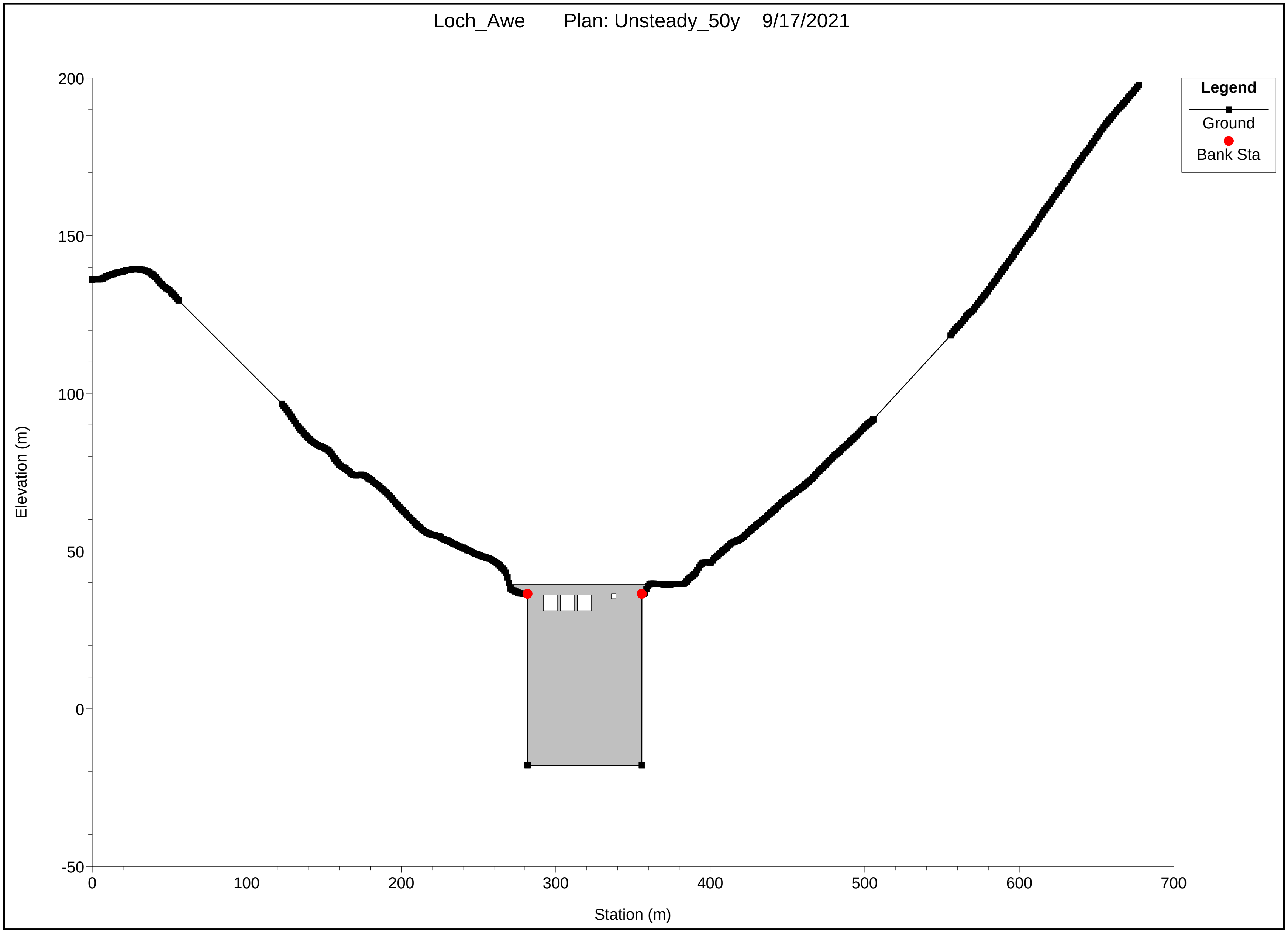
Contract Name:

Drawing Title:

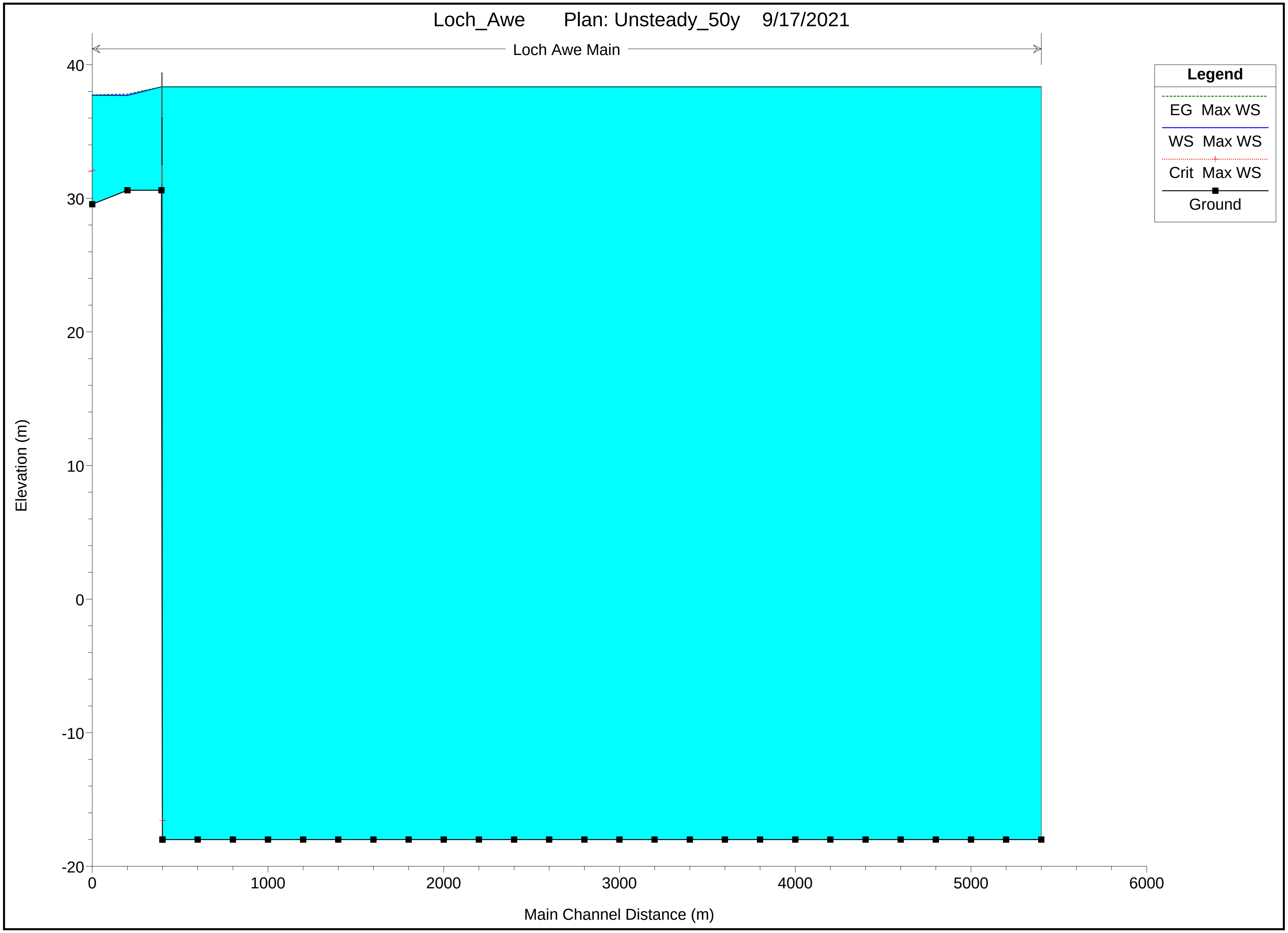
Appendix A.1
Location of Cross Sections, Loch Awe

Drawing No.:	Scale:	Sheet Size:	Rev:
01	1:15,000	A3	A

PLOTTED ON 3/30/2022 12:16:55 PM BY kdey
LOCATION : U:\331201086\Rivers and catchments\Technical Note\Appendix A\Appendix A.1 - Loch Awe Model Extents.mxd



Loch_Awe Plan: Unsteady_50y 9/17/2021
Legend
Ground
Bank Sta
Elevation (m)
Station (m)
200
150
100
50
0
-50
0
100
200
300
400
500
600
700



Loch_Awe Plan: Unsteady_50y 9/17/2021
Loch Awe Main
Legend
EG Max WS
WS Max WS
Crit Max WS
Ground
Elevation (m)
40
30
20
10
0
-10
-20
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (m)

Appendix B Loch Awe catchment Area

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NOTES

1. ALL DIMENSIONS IN MILLIMETRES AND ALL LEVELS IN METRES UNLESS SHOWN OTHERWISE

0 5 10
km

REFERENCES

DRAWING NUMBER	DRAWING TITLE

Legend

- Loch Awe Barrage
- Cross Section locations
- FEH Catchment at Loch Awe Barrage

CURRENT VERSION INFORMATION

Iss	Description	Dsgnr	Chkd	Appd	Date
A	xxx	KD	KJL	KJL	01APR2022

SSE PLC
Inveralmond House200 Dunkeld Road,
Perth PH1 3AQ

Location Code:	OS Reference:	Security Reference:	Drawn By:
...	NN077268	UBR	KD

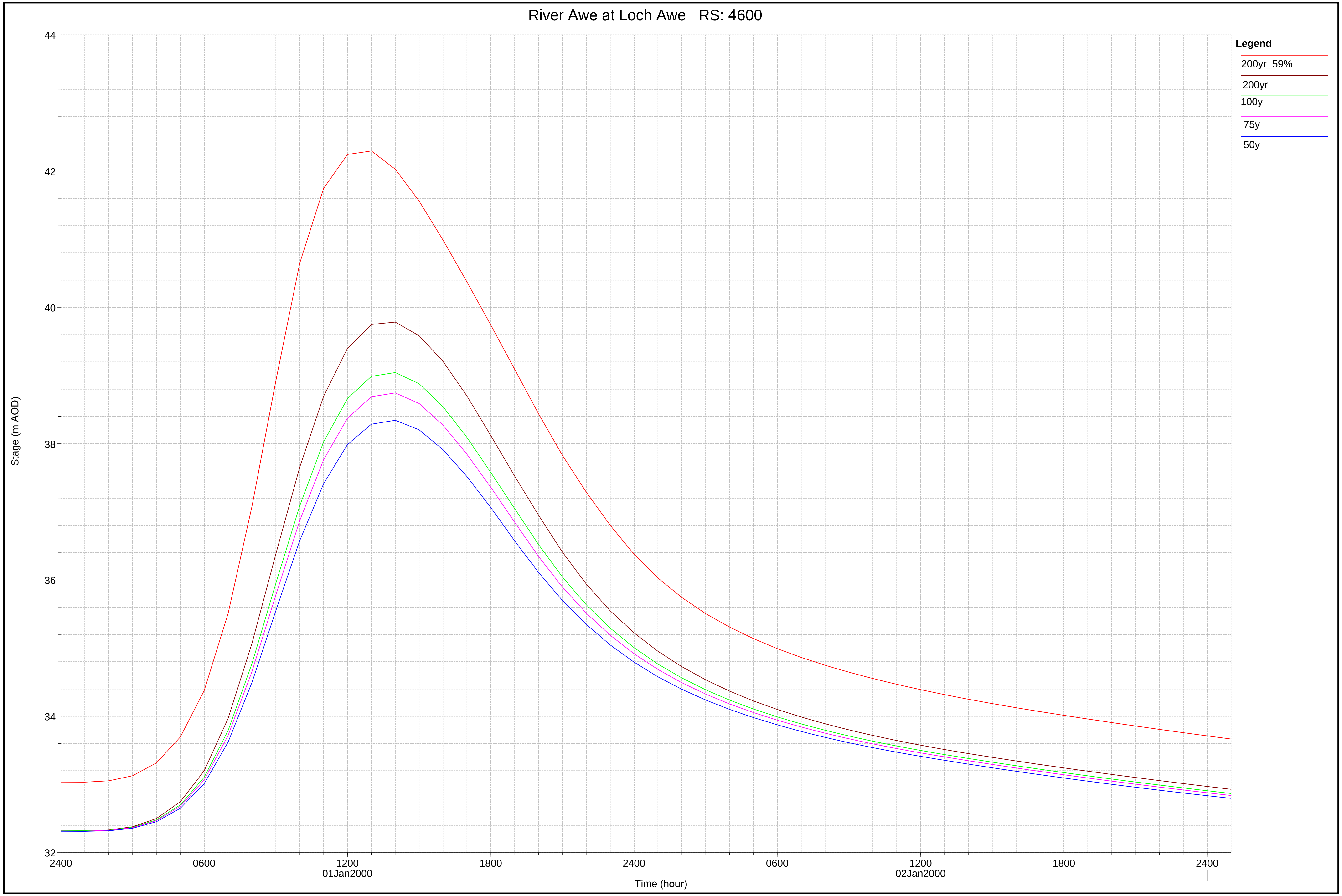
Project Group: ...
Sub Process: ...
Location / Town: Cruachan Power Station, A85, Lochawe, Argyll and Bute, Scotland, PA33 1AN
Site Name: ...
Project Name: ...
Contract Name:

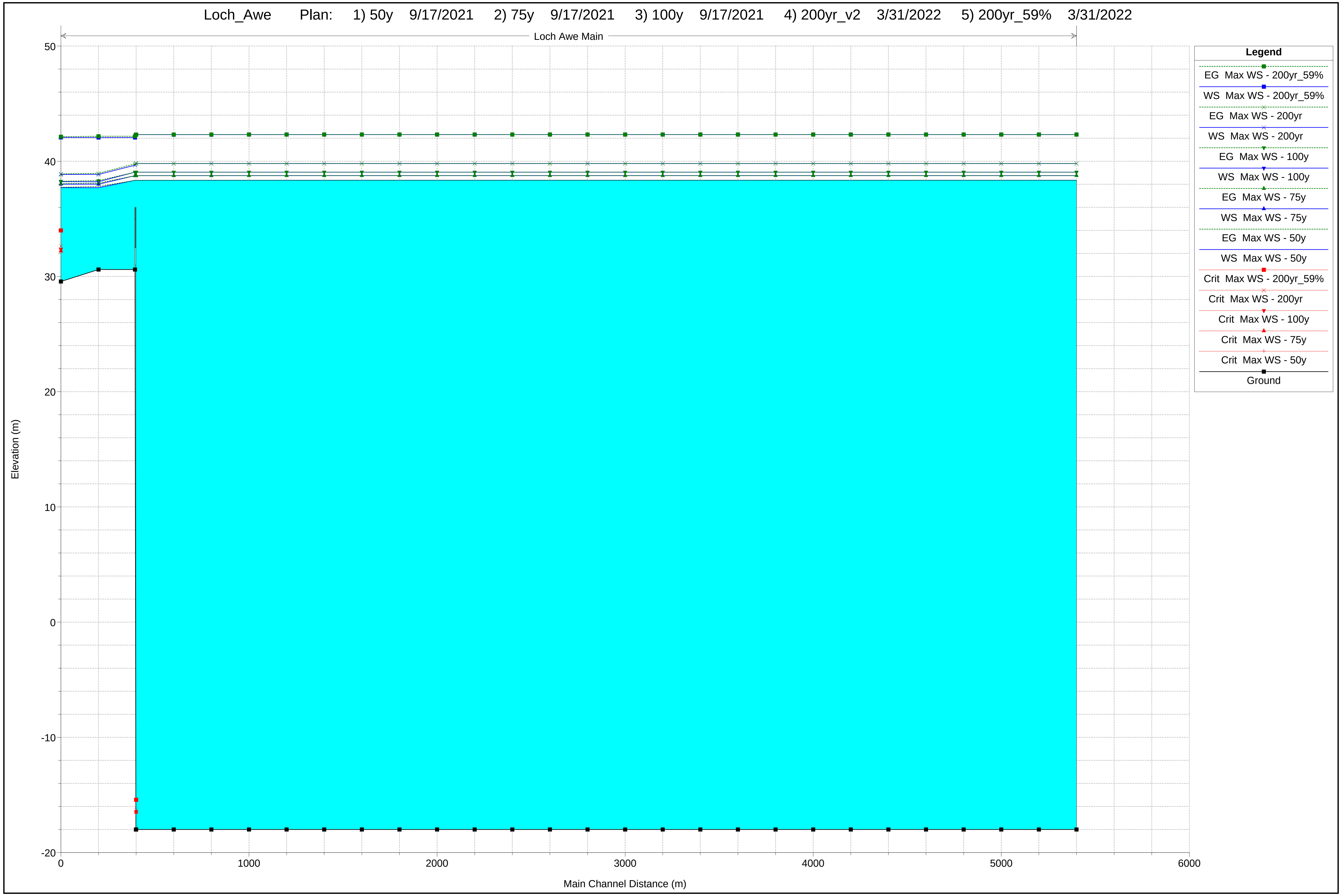
Drawing Title:
Appendix B
FEH catchment boundary at Loch Awe Barrage

Drawing No.:	Scale:	Sheet Size:	Rev:
01	1:201,519	A3	A

Appendix C

Appendix C.1 - Simulated stage hydrographs at Site_design_events
Appendix C.2 - Long profiles_design_events


River Awe at Loch Awe RS: 4600
Stage (m AOD)
44
42
40
38
36
34
32
2400
0600
1200
01Jan2000
1800
2400
0600
1200
02Jan2000
1800
2400
Time (hour)
Legend
200yr_59%
200yr
100y
75y
50y


Loch_Awe Plan: 1) 50y 9/17/2021 2) 75y 9/17/2021 3) 100y 9/17/2021 4) 200yr_v2 3/31/2022 5) 200yr_59% 3/31/2022
Loch Awe Main
Legend
EG Max WS - 200yr_59%
WS Max WS - 200yr_59%
EG Max WS - 200yr
WS Max WS - 200yr
EG Max WS - 100y
WS Max WS - 100y
EG Max WS - 75y
WS Max WS - 75y
EG Max WS - 50y
WS Max WS - 50y
Crit Max WS - 200yr_59%
Crit Max WS - 200yr
Crit Max WS - 100y
Crit Max WS - 75y
Crit Max WS - 50y
Ground
Elevation (m)
50
40
30
20
10
0
-10
-20
0
1000
2000
3000
4000
5000
6000
Main Channel Distance (m)

Appendix D

Appendix D.1 – Modelling Log File
Appendix D.2 - Check and Review Record

Appendix D.1 - Modelling Log File - Flood Level Assessment (1D HEC-RAS Modelling; HEC-RAS Version: 4.1.0), Loch Awe

Design Period (Year)	Unsteady Flow	Project	Plan	Geometry		Model File location	Date of Run	Comments
				Geometry File	Name			
Baseline - 50year	Q - 50 year (Loch_Awe.u05)	Loch_Awe.prj	Unsteady_50y (Loch_Awe.p10)	Loch_Awe.g04	Loch_Awe_amended_v2	\\GB1006-PPFSS01\Shared_projects\331201086\Rivers and catchments\HEC-RAS\	17/09/2021	River Awe (Loch Awe) 1D model has been built using cross-sections derived from 1m LiDAR DTM data with amendments of riverbed set to be -18mAOD based on bathymetric survey undertaken at the top end of the model. Manning's n value for the channel and the adjoining floodplains set to be 0.04 and 0.06 respectively. Model inflows were derived using FEH statistical method. The inflows to the u/s boundary was set at RS5600. The downstream normal depth boundary was set at RS200. The Loch Awe Barrage has been included in the model and all gates are kept fully open. The model was run for unsteady solution for 50yr and successfully completed.
Baseline - 75year	Q - 75 year (Loch_Awe.u04)	Loch_Awe.prj	Unsteady_75y (Loch_Awe.p09)	Loch_Awe.g04	Loch_Awe_amended_v2	\\GB1006-PPFSS01\Shared_projects\331201086\Rivers and catchments\HEC-RAS\	17/09/2021	River Awe (Loch Awe) 1D model has been built using cross-sections derived from 1m LiDAR DTM data with amendments of riverbed set to be -18mAOD based on bathymetric survey undertaken at the top end of the model. Manning's n value for the channel and the adjoining floodplains set to be 0.04 and 0.06 respectively. Model inflows were derived using FEH statistical method. The inflows to the u/s boundary was set at RS5600. The downstream normal depth boundary was set at RS200. The Loch Awe Barrage has been included in the model and all gates are kept fully open. The model was run for unsteady solution for 75yr and successfully completed.
Baseline - 100year	Q - 100 year (Loch_Awe.u03)	Loch_Awe.prj	Unsteady_100y (Loch_Awe.p08)	Loch_Awe.g04	Loch_Awe_amended_v2	\\GB1006-PPFSS01\Shared_projects\331201086\Rivers and catchments\HEC-RAS\	17/09/2021	River Awe (Loch Awe) 1D model has been built using cross-sections derived from 1m LiDAR DTM data with amendments of riverbed set to be -18mAOD based on bathymetric survey undertaken at the top end of the model. Manning's n value for the channel and the adjoining floodplains set to be 0.04 and 0.06 respectively. Model inflows were derived using FEH statistical method. The inflows to the u/s boundary was set at RS5600. The downstream normal depth boundary was set at RS200. The Loch Awe Barrage has been included in the model and all gates are kept fully open. The model was run for unsteady solution for 100yr and successfully completed.
Baseline - 200year	Q - 200 year (Loch_Awe.u02)	Loch_Awe.prj	Unsteady_200y_v2 (Loch_Awe.p07)	Loch_Awe.g04	Loch_Awe_amended_v2	\\GB1006-PPFSS01\Shared_projects\331201086\Rivers and catchments\HEC-RAS\	31/03/2022	River Awe (Loch Awe) 1D model has been built using cross-sections derived from 1m LiDAR DTM data with amendments of riverbed set to be -18mAOD based on bathymetric survey undertaken at the top end of the model. Manning's n value for the channel and the adjoining floodplains set to be 0.04 and 0.06 respectively. Model inflows were derived using FEH statistical method. The inflows to the u/s boundary was set at RS5600. The downstream normal depth boundary was set at RS200. The Loch Awe Barrage has been included in the model and all gates are kept fully open. The model was run for unsteady solution for 200yr and successfully completed.
Baseline - 200year+59%CC	Q - 200 year (Loch_Awe.u02)	Loch_Awe.prj	Unsteady_200y_59% (Loch_Awe.p11)	Loch_Awe.g04	Loch_Awe_amended_v2	\\GB1006-PPFSS01\Shared_projects\331201086\Rivers and catchments\HEC-RAS\	31/03/2022	River Awe (Loch Awe) 1D model has been built using cross-sections derived from 1m LiDAR DTM data with amendments of riverbed set to be -18mAOD based on bathymetric survey undertaken at the top end of the model. Manning's n value for the channel and the adjoining floodplains set to be 0.04 and 0.06 respectively. Model inflows were derived using FEH statistical method. The inflows to the u/s boundary was set at RS5600. The downstream normal depth boundary was set at RS200. The Loch Awe Barrage has been included in the model and all gates are kept fully open. The model was run for unsteady solution for 200yr+59% Climate change and successfully completed.
Baseline - mean flow	Q - normal flow (Loch_Awe.u07)	Loch_Awe.prj	Unsteady_meanflow (Loch_Awe.p12)	Loch_Awe.g04	Loch_Awe_amended_v2	\\GB1006-PPFSS01\Shared_projects\331201086\Rivers and catchments\HEC-RAS\	26/04/2022	River Awe (Loch Awe) 1D model has been built using cross-sections derived from 1m LiDAR DTM data with amendments of riverbed set to be -18mAOD based on bathymetric survey undertaken at the top end of the model. Manning's n value for the channel and the adjoining floodplains set to be 0.04 and 0.06 respectively. Mean flow data for Loch Awe catchment was derived based on the NRFA gauging station 18003 closest to the Loch Awe catchment. A steady state model run was undertaken to calibrate a typical water level of 36.5 mAOD at the water level monitoring site at RS 4600 through the adjustment of Loch Awe barrage gate openings.
Baseline - Standard of Protection (SoP) return period estimates for new retaining wall structure	Q - 100 year_plus_SOP (Loch_Awe.u08)	Loch_Awe.prj	Unsteady_100y_plus_SOP (Loch_Awe.p13)	Loch_Awe.g04	Loch_Awe_amended_v2	\\GB1006-PPFSS01\Shared_projects\331201086\Rivers and catchments\HEC-RAS\	26/04/2022	River Awe (Loch Awe) 1D model has been built using cross-sections derived from 1m LiDAR DTM data with amendments of riverbed set to be -18mAOD based on bathymetric survey undertaken at the top end of the model. Manning's n value for the channel and the adjoining floodplains set to be 0.04 and 0.06 respectively. 100 year flow data has been uplifted until the water level at RS4600 achieves 39.5 mAOD which is the design crest level of the retaining wall to be constructed at the site to identify the standard of protection return period. The flow corresponding to the 39.5 mAOD was found to be 107 year.

Check and Review Record

This Record Sheet is used to record the step-by-step completion of Work Product Checks and Reviews in accordance with Project Governance Framework and Stantec UK QP 017 Checks and Reviews

Project Code:	331201086.100.010101	**Project Name:**	Loch Awe Flood Level Assessments

Product Description: *Give a brief description of the Work Product and ref. / version no.*

- **1D hydraulic model built using HEC-RAS modelling software to assess flood levels at Loch Awe proposed site for a range of design events.**
- **Water level plots**
- **Production of Technical Note on Flood Level Assessment**

Self– Check — The *Originator signs to verify that the Self-Check has been completed*

Originator: Name	**Signed**	**Date**
Krishna Dey	[signature]	30/03/2022

Check

Corrections required: None

Check completed: The Approved Checker signs to verify that he/she is satisfied that any required corrections have been completed and the Work Product is complete, correct, and meets standards

Checker: Name	**Signed**	**Date**
Kelvin J Limbrick	[signature]	28/04/2022

Review

Amendments required: None

Review completed: The Approved Reviewer signs to verify that he/she is satisfied that any required amendments have been completed and the Work Product meets the requirements of the latest Client Brief

Reviewer: Name	**Signed**	**Date**
Kelvin J Limbrick	[signature]	28/04/2022

Authorise for Issue

Authorise for issue: Name	**Signed**	**Date**
		28/04/2022

Appendix D.2 - Stantec UK QF 017.01 Check and Review Record_Loch_Awe_Apr_2022

Appendix F Proposed Development Drawings

NOTES

1. ALL DIMENSIONS IN MILLIMETRES AND ALL LEVELS IN METRES UNLESS SHOWN OTHERWISE.
6. THIS IS A CONCEPT PHASE DRAWING TO ILLUSTRATE THE PROJECT BASE CASE. ALL DIMENSIONS AND ELEVATIONS ARE APPROXIMATE AND WILL BE REVIEWED AND UPDATED AS PROJECT DESIGN STUDIES CONTINUE. ALL CONCEPTS, DETAILS, DIMENSIONS AND ELEVATIONS INDICATED ON THIS DRAWING WILL REQUIRE FURTHER REFINEMENT DURING A SUBSEQUENT DESIGN PHASE.

REFERENCE

SCALE 1 : 25000

m1000 0 1000m

CURRENT VERSION INFORMATION

B. SITE LAYOUT UPDATED.

DATE	DRWN	CHKD	REVD	VER	REASON FOR ISSUE
28.02.22	PPS	SS	CS	B	FOR INFORMATION
21.09.21	RAB	SS	CS	A	FOR INFORMATION

DRAX CRUACHAN EXPANSION LTD

CRUACHAN 2

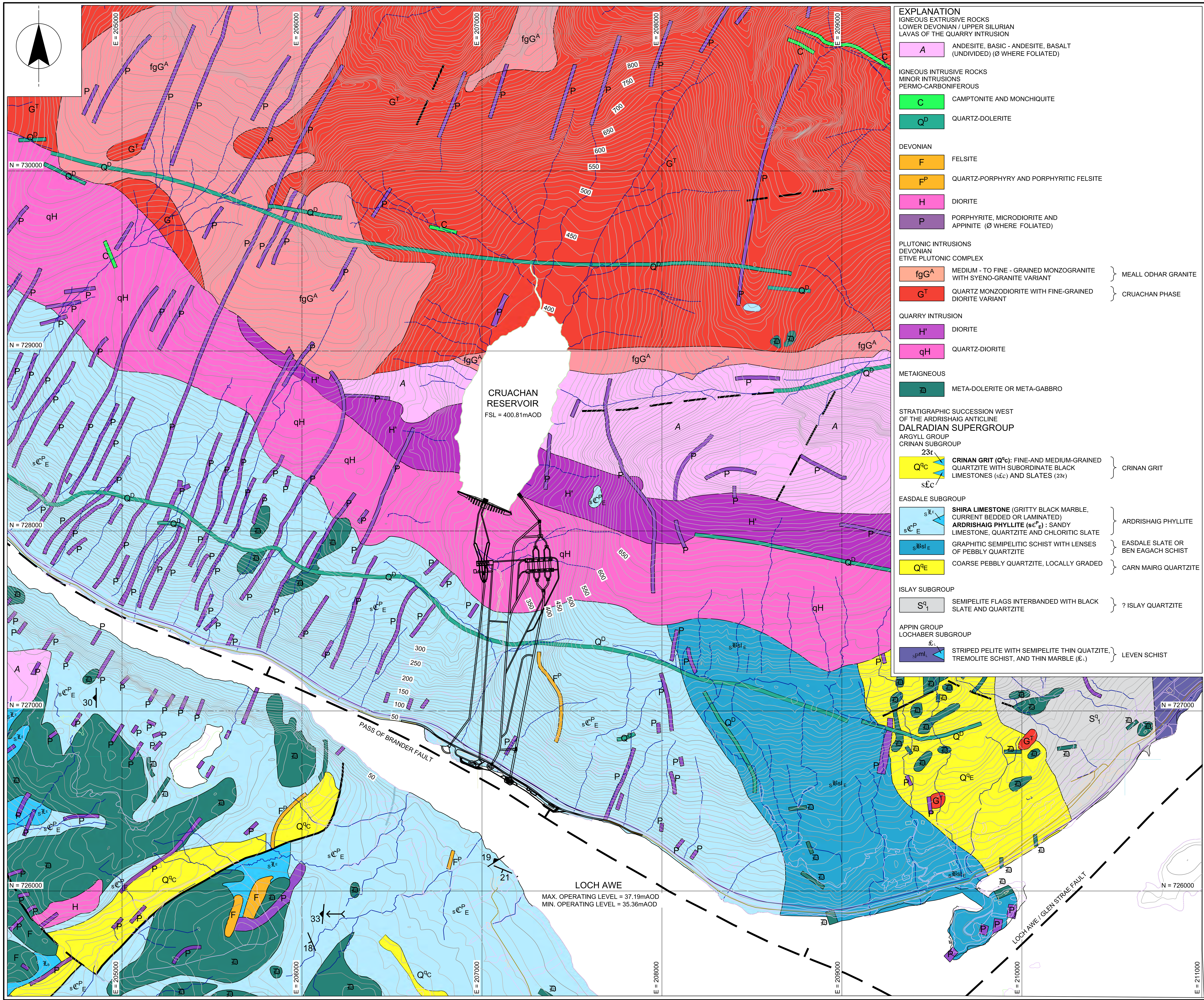
SITE LOCATION PLAN

drax

Stantec

CONTRACT NO.	SCALE	MASTER SIZE
01	1:25000	A1

DRAWING NO.	VERSION
331201086/01/C/0001	B



EXPLANATION

IGNEOUS EXTRUSIVE ROCKS
LOWER DEVONIAN / UPPER SILURIAN
LAVAS OF THE QUARRY INTRUSION

A	ANDESITE, BASIC - ANDESITE, BASALT (UNDIVIDED) (Ø WHERE FOLIATED)	

IGNEOUS INTRUSIVE ROCKS
MINOR INTRUSIONS
PERMO-CARBONIFEROUS

C	CAMPTONITE AND MONCHIQUITE	
Q^D	QUARTZ-DOLERITE	

DEVONIAN

F	FELSITE	
F^P	QUARTZ-PORPHYRY AND PORPHYRITIC FELSITE	
H	DIORITE	
P	PORPHYRITE, MICRODIORITE AND APPINITE (Ø WHERE FOLIATED)	

PLUTONIC INTRUSIONS
DEVONIAN
ETIVE PLUTONIC COMPLEX

fgG^A	MEDIUM - TO FINE - GRAINED MONZOGRANITE WITH SYENO-GRANITE VARIANT	MEALL ODHAR GRANITE
G^T	QUARTZ MONZODIORITE WITH FINE-GRAINED DIORITE VARIANT	CRUACHAN PHASE

QUARRY INTRUSION

H'	DIORITE	
qH	QUARTZ-DIORITE	

METAIGNEOUS

Ɒ	META-DOLERITE OR META-GABBRO	

STRATIGRAPHIC SUCCESSION WEST OF THE ARDRISHAIG ANTICLINE

DALRADIAN SUPERGROUP

ARGYLL GROUP
CRINAN SUBGROUP

Q^qC (23ɛ, s£c)	**CRINAN GRIT (Q^qc):** FINE-AND MEDIUM-GRAINED QUARTZITE WITH SUBORDINATE BLACK LIMESTONES (s£c) AND SLATES (23ɛ)	CRINAN GRIT

EASDALE SUBGROUP

$s£_E$, $s€^P_E$	**SHIRA LIMESTONE** (GRITTY BLACK MARBLE, CURRENT BEDDED OR LAMINATED) **ARDRISHAIG PHYLLITE ($s€^P_E$)** : SANDY LIMESTONE, QUARTZITE AND CHLORITIC SLATE	ARDRISHAIG PHYLLITE
$sBlsl_E$	GRAPHITIC SEMIPELITIC SCHIST WITH LENSES OF PEBBLY QUARTZITE	EASDALE SLATE OR BEN EAGACH SCHIST
Q^q_E	COARSE PEBBLY QUARTZITE, LOCALLY GRADED	CARN MAIRG QUARTZITE

ISLAY SUBGROUP

S^q_1	SEMIPELITE FLAGS INTERBANDED WITH BLACK SLATE AND QUARTZITE	? ISLAY QUARTZITE

APPIN GROUP
LOCHABER SUBGROUP

$_Spml_L$ (£L)	STRIPED PELITE WITH SEMIPELITE THIN QUATZITE, TREMOLITE SCHIST, AND THIN MARBLE (£L)	LEVEN SCHIST

NOTES

1. ALL DIMENSIONS IN MILLIMETRES AND ALL LEVELS IN METRES UNLESS SHOWN OTHERWISE.

LEGEND

- INCLINED DIP IN DEGREES } BEDDING AND / OR FOLIATION
- INCLINED DIP IN DEGREES } PROMINENT CLEAVAGE OR SCHISTOSITY
- DIRECTION OF YOUNGING
- GEOLOGICAL BOUNDARY, CERTAIN
- GEOLOGICAL BOUNDARY, UNCERTAIN
- S SLIDE
- FAULT, CROSSMARK ON DOWNTHROW SIDE
- SENSE OF MOVEMENT ON TRANSCURRENT FAULT STRUCTURES
- * Mo MINERAL LOCALITY (MOLYBDENITE)

REFERENCE

GEOLOGICAL MAP REPRODUCED FROM THE BRITISH GEOLOGICAL SURVEY, 1 : 50000 SERIES SHEET 45E (SCOTLAND) DALMALLY SOLID GEOLOGY (1992)

SCALE 1 : 10000

m100 0 1000m

CURRENT VERSION INFORMATION

DATE	DRWN	CHKD	REVD	VER	REASON FOR ISSUE
28.02.22	PPS	SS	CS	A	FOR INFORMATION

DRAX CRUACHAN EXPANSION LTD

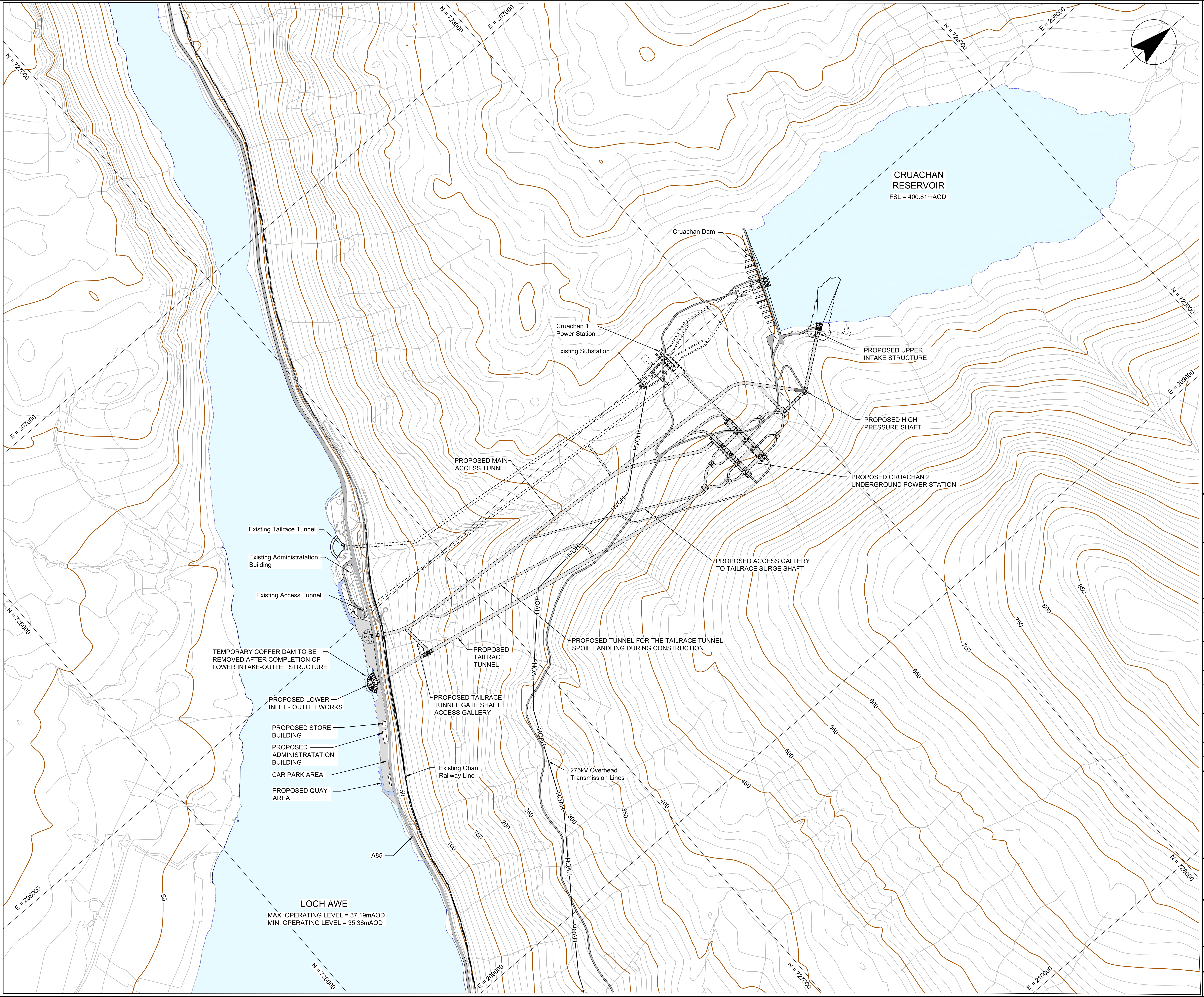
CRUACHAN 2

GEOLOGICAL MAP

drax

Stantec

CONTRACT NO. 01	SCALE 1:10000	MASTER SIZE A1
DRAWING NO. 331201086/01/C/0010		VERSION A



Based upon Ordnance Survey Digital Data with the permission of the controller of H.M.S.O. Crown Copyright Reserved Licence No. WU298506

NOTES

1. ALL DIMENSIONS IN MILLIMETRES AND ALL LEVELS IN METRES UNLESS SHOWN OTHERWISE.
2. THIS IS A CONCEPT PHASE DRAWING TO ILLUSTRATE THE PROJECT BASE CASE. ALL DIMENSIONS AND ELEVATIONS ARE APPROXIMATE AND WILL BE REVIEWED AND UPDATED AS PROJECT DESIGN STUDIES CONTINUE. ALL CONCEPTS, DETAILS, DIMENSIONS AND ELEVATIONS INDICATED ON THIS DRAWING WILL REQUIRE FURTHER REFINEMENT DURING A SUBSEQUENT DESIGN PHASE.

SCALE 1 : 5000

m100 0 400m

CURRENT VERSION INFORMATION

B. SITE LAYOUT UPDATED

DATE	DRWN	CHKD	REVD	VER	REASON FOR ISSUE
28.02.22	PPS	SS	CS	B	FOR INFORMATION
21.09.21	RAB	SS	CS	A	FOR INFORMATION

DRAX CRUACHAN EXPANSION LTD

CRUACHAN 2

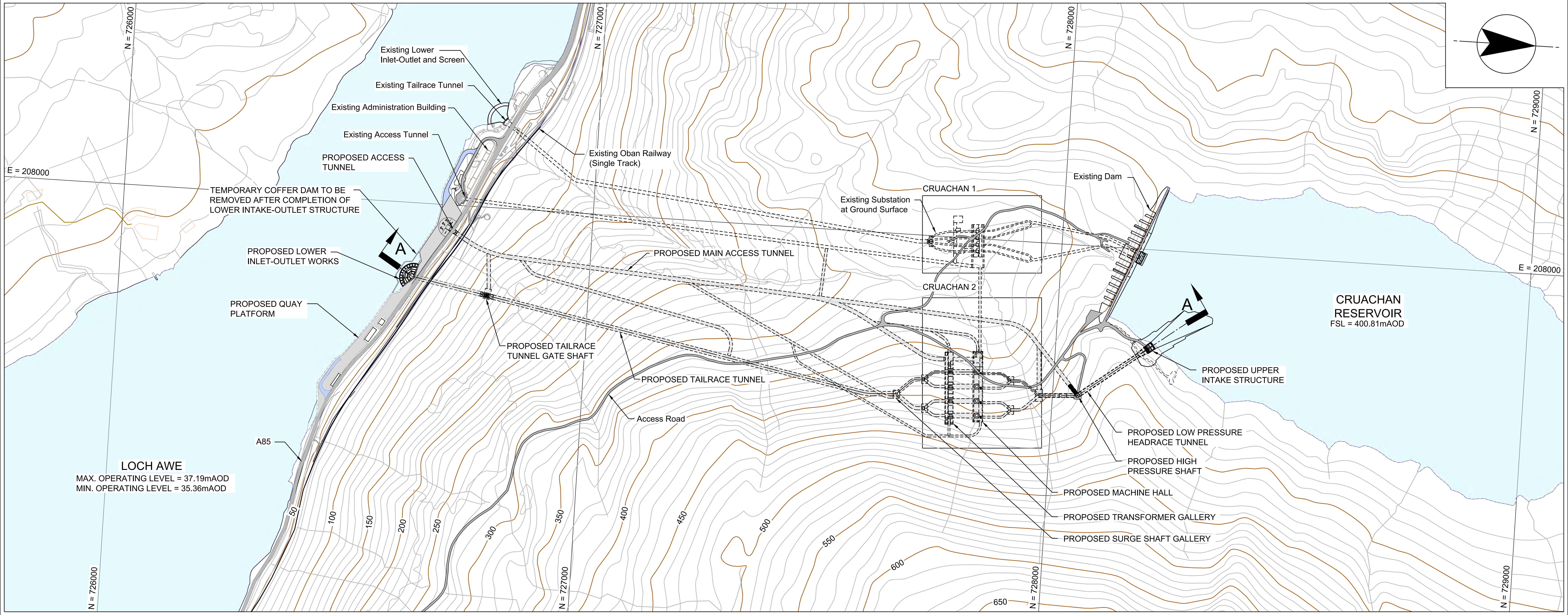
4 x 150 MW GENERAL ARRANGEMENT PLAN
ALTERNATE MAIN ACCESS TUNNEL
AND UPPER INTAKE ARRANGEMENT
OPTION-2

drax

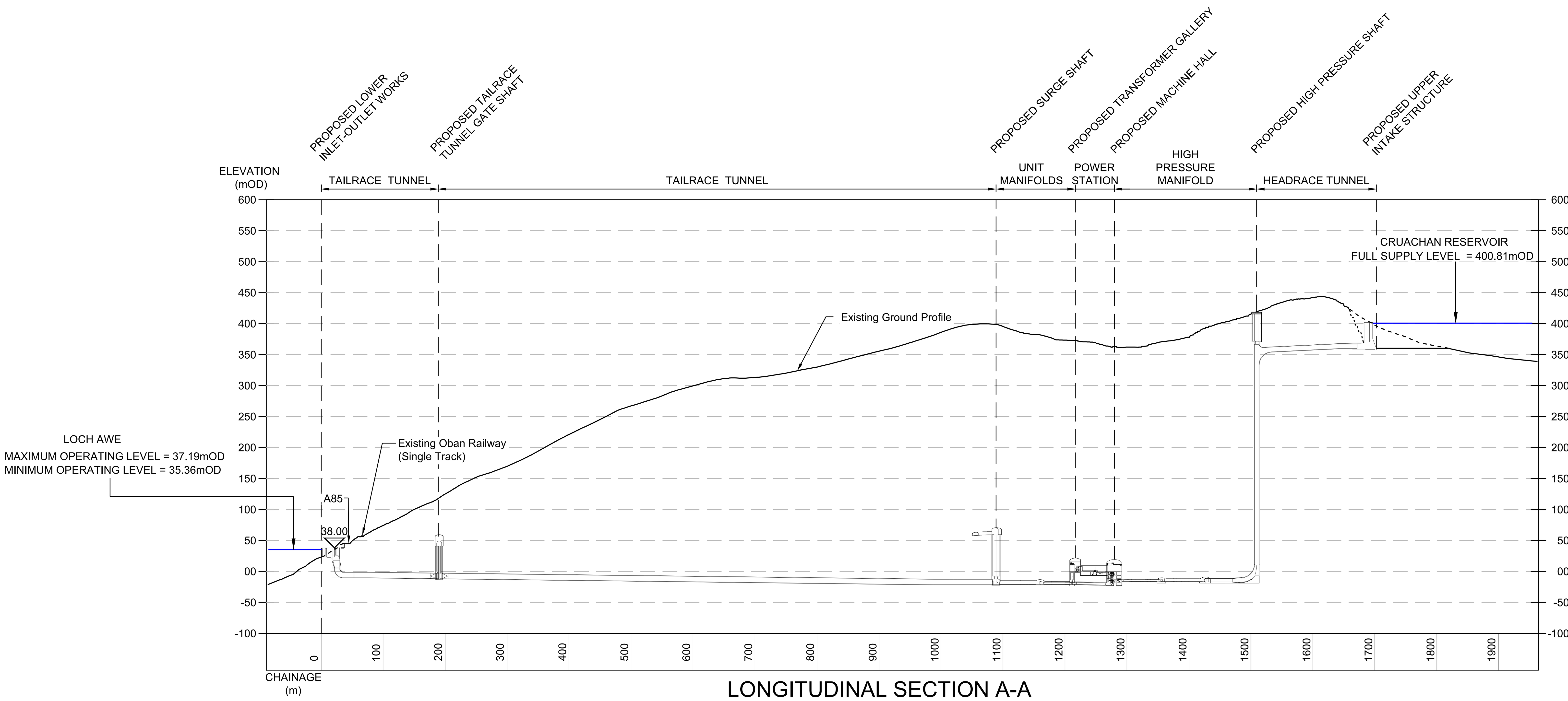
Stantec

CONTRACT NO.	SCALE	MASTER SIZE
01	1:5000	A1

DRAWING NO.	VERSION
331201086/01/C/0961	B



PLAN



LONGITUDINAL SECTION A-A

NOTES

1. ALL DIMENSIONS IN MILLIMETRES AND ALL LEVELS IN METRES UNLESS SHOWN OTHERWISE.
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LEGEND

REFERENCE

SCALE 1 : 5000

m100 0 400m

CURRENT VERSION INFORMATION

DATE	DRWN	CHKD	REVD	VER	REASON FOR ISSUE
28.02.22	PPS	SS	CS	A	FOR INFORMATION

DRAX CRUACHAN EXPANSION LTD
CRUACHAN 2

GENERAL ARRANGEMENT
PLAN AND LONGITUDINAL SECTION - 4 x 150 MW OPTION

drax

Stantec

CONTRACT NO.	SCALE	MASTER SIZE
01	1:5000	A1

DRAWING NO.	VERSION
331201086/01/C/0016	A

NOTES

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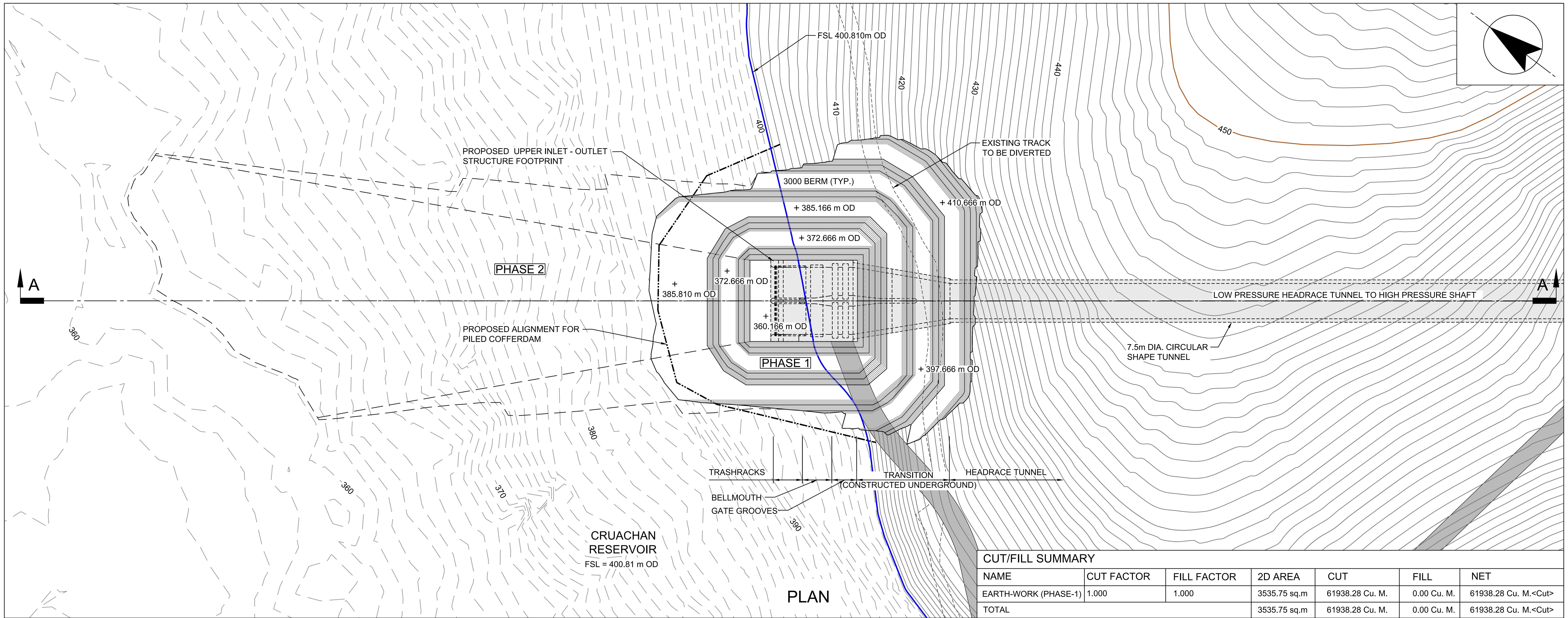
LEGEND

EXISTING CONTOURS

BATHYMETRIC CONTOURS

REFERENCE

331201086/01/C/0711 PLAN AND SECTION - PHASE 2 - EXCAVATION



CUT/FILL SUMMARY

NAME	CUT FACTOR	FILL FACTOR	2D AREA	CUT	FILL	NET
EARTH-WORK (PHASE-1)	1.000	1.000	3535.75 sq.m	61938.28 Cu. M.	0.00 Cu. M.	61938.28 Cu. M.<Cut>
TOTAL			3535.75 sq.m	61938.28 Cu. M.	0.00 Cu. M.	61938.28 Cu. M.<Cut>

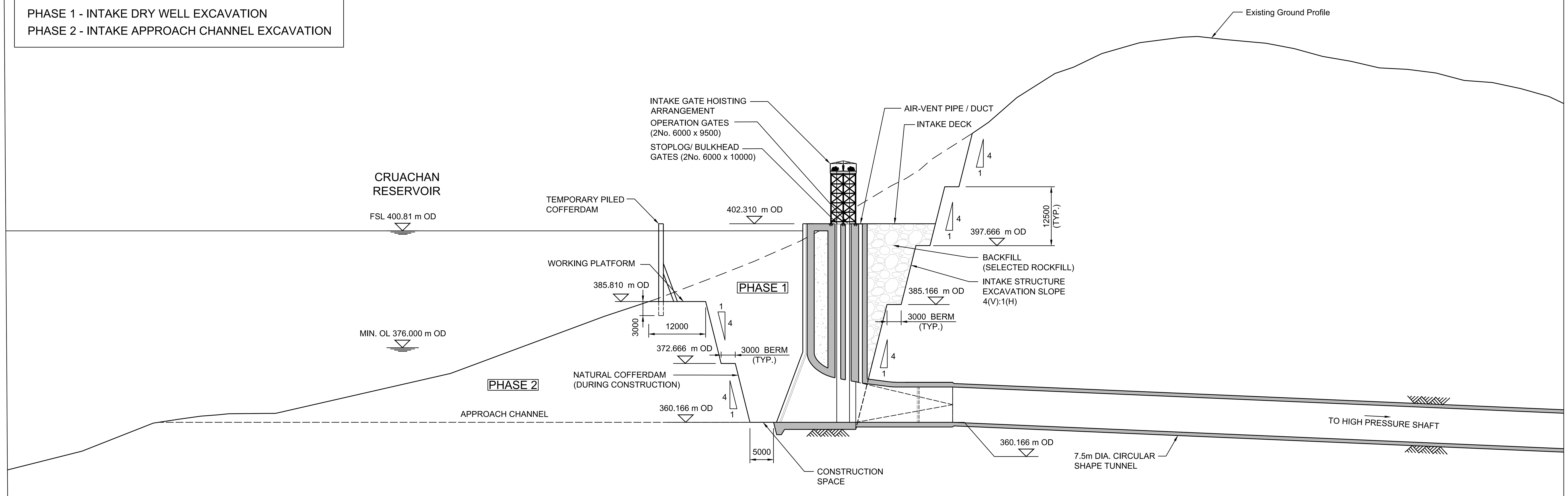
SCALE 1 : 500

m10 0 40m

INTAKE EXCAVATION PHASES :

PHASE 1 - INTAKE DRY WELL EXCAVATION

PHASE 2 - INTAKE APPROACH CHANNEL EXCAVATION



SECTION A-A

CURRENT VERSION INFORMATION

B. HEADRACE TUNNEL DIAMETER UPDATED.

DATE	DRWN	CHKD	REVD	VER	REASON FOR ISSUE
28.02.22	PPS	SS	CS	B	FOR INFORMATION
01.02.21	RRS	SS	CS	A	FOR INFORMATION

DRAX CRUACHAN EXPANSION LTD

CRUACHAN 2

UPPER INTAKE STRUCTURE

PLAN AND SECTION

PHASE1 - EXCAVATION

OPTION-5

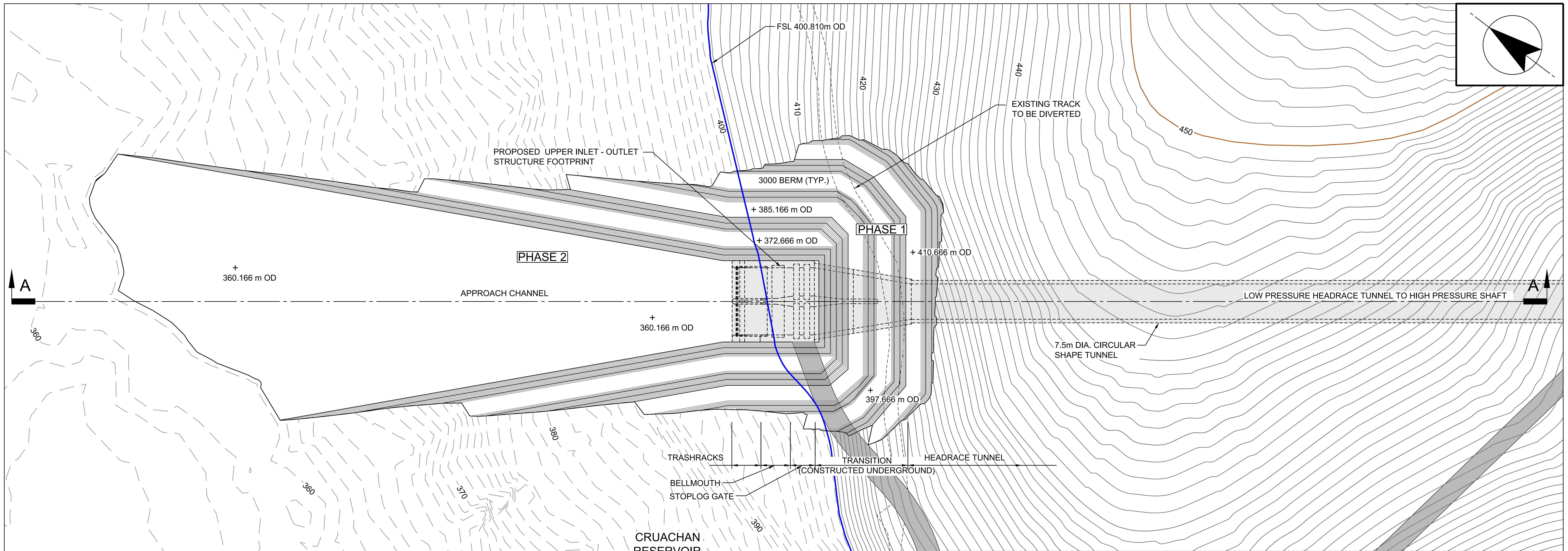
drax

Stantec

CONTRACT NO.	SCALE	MASTER SIZE
01	1:500	A1

DRAWING NO. 331201086/01/C/0710

VERSION B

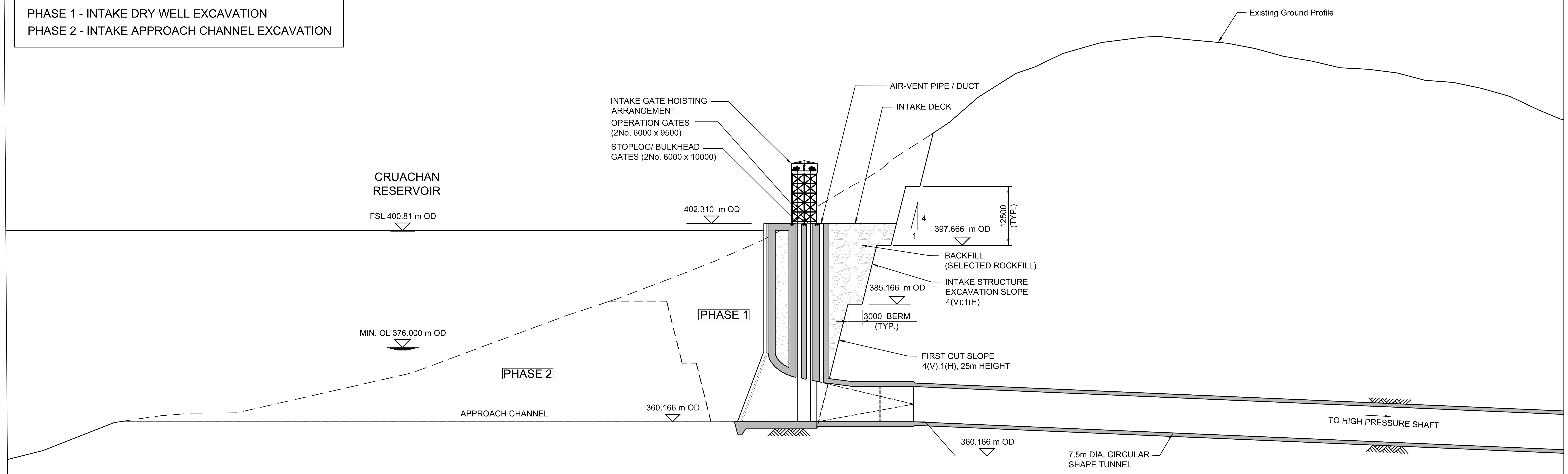


PLAN

CUT/FILL SUMMARY

NAME	CUT FACTOR	FILL FACTOR	2D AREA	CUT	FILL	NET
EARTH-WORK (PHASE-1 AND 2)	1.000	1.000	8470.02 sq.m	117368.28 Cu. M.	0.00 Cu. M.	117368.28 Cu. M.<Cut>
TOTAL			8470.02 sq.m	117368.28 Cu. M.		117368.28 Cu. M.<Cut>

INTAKE EXCAVATION PHASES :
PHASE 1 - INTAKE DRY WELL EXCAVATION
PHASE 2 - INTAKE APPROACH CHANNEL EXCAVATION



SECTION A-A

NOTES

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LEGEND

EXISTING CONTOURS

BATHYMETRIC CONTOURS

REFERENCE

331201086/01/C/0710 PLAN AND SECTION - PHASE 1 - EXCAVATION

SCALE 1 : 500

m10 0 40m

CURRENT VERSION INFORMATION

B. HEADRACE TUNNEL DIAMETER UPDATED.

DATE	DRWN	CHKD	REVD	VER	REASON FOR ISSUE
28.02.22	PPS	SS	CS	B	FOR INFORMATION
01.02.21	RRS	SS	CS	A	FOR INFORMATION

DRAX CRUACHAN EXPANSION LTD
CRUACHAN 2

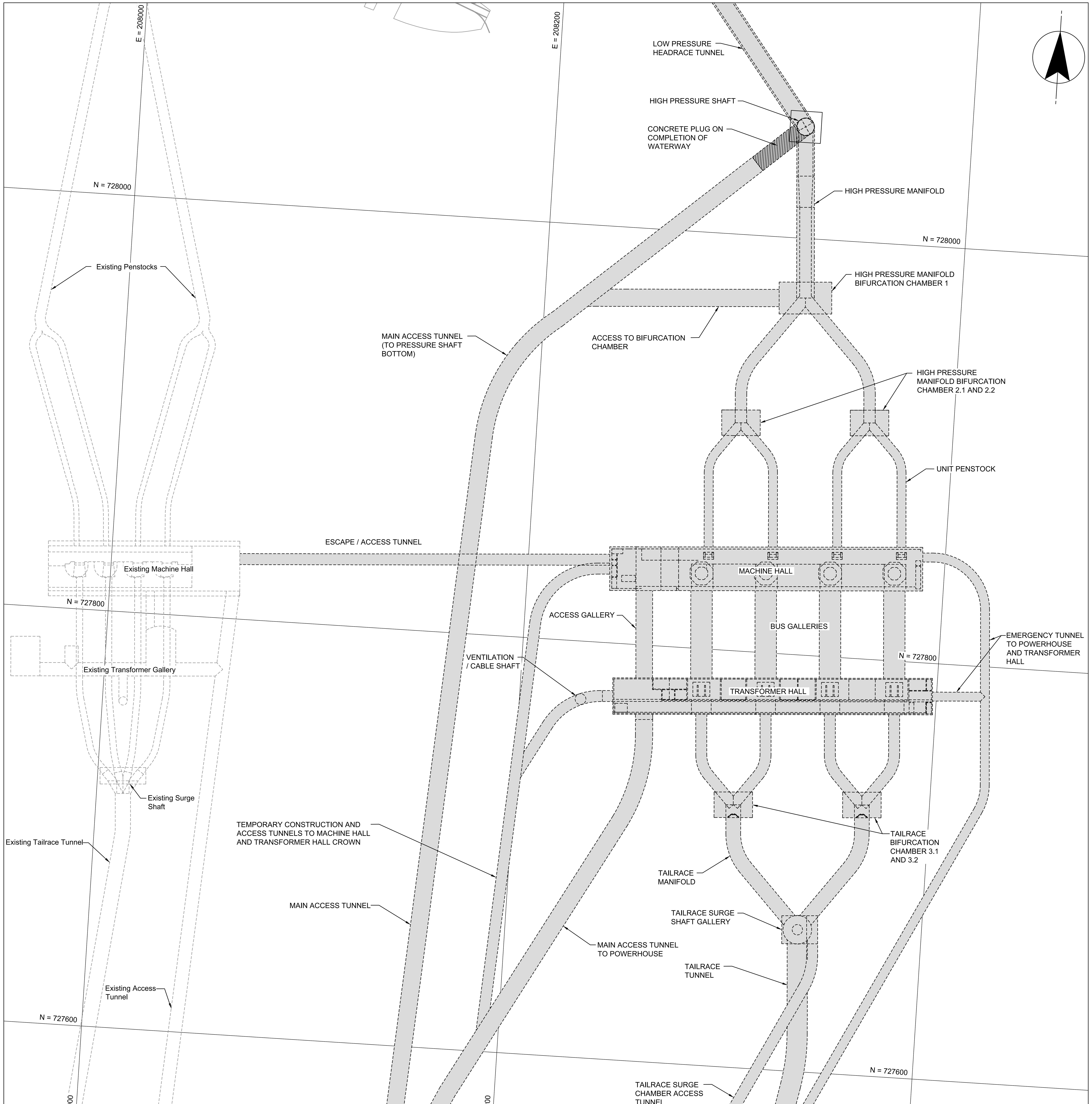
UPPER INTAKE STRUCTURE
PLAN AND SECTION
PHASE 2 - EXCAVATION
OPTION-5

drax

Stantec

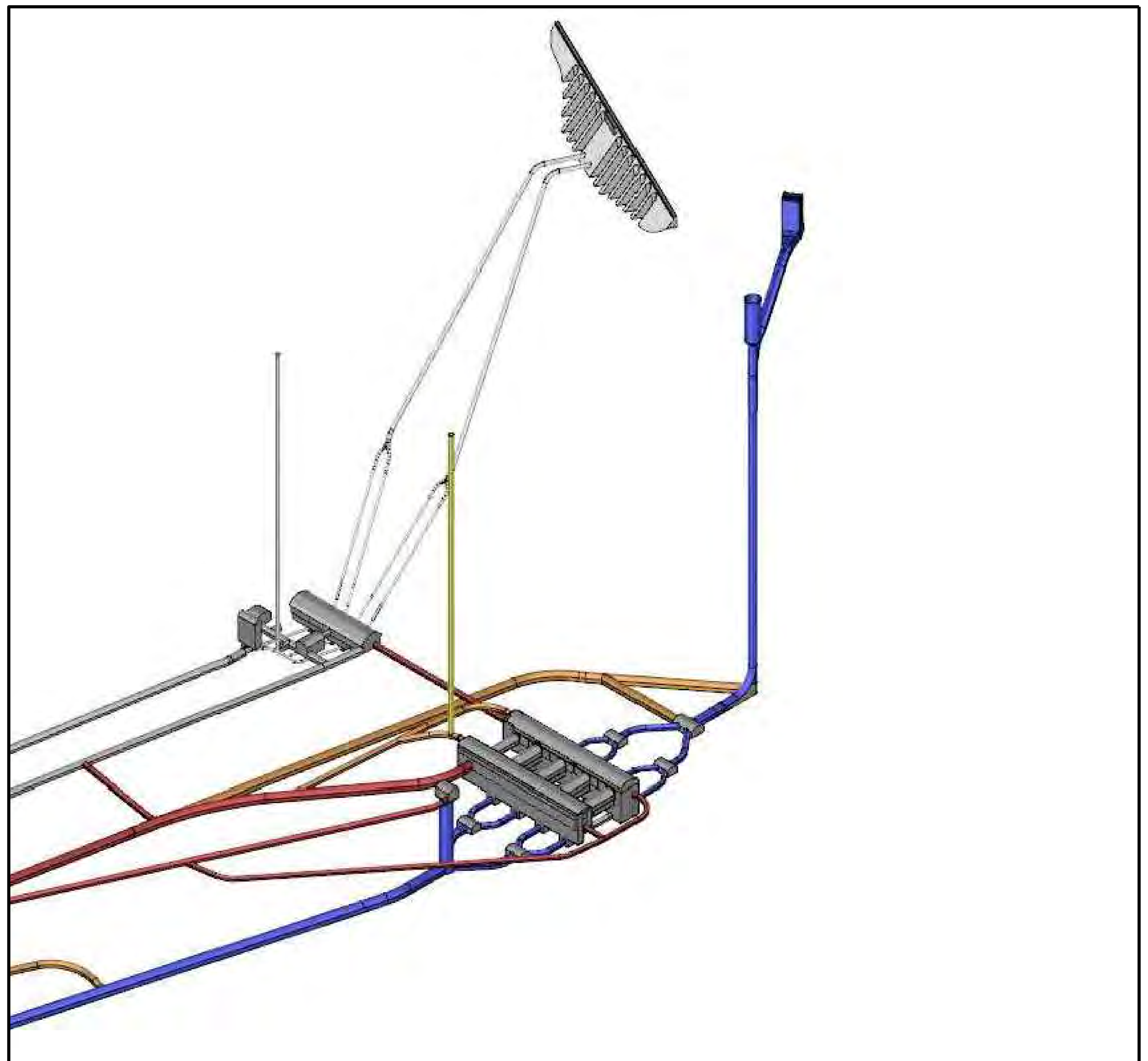
CONTRACT NO.	SCALE	MASTER SIZE
01	1:500	A1

DRAWING NO. 331201086/01/C/0711 VERSION B



PLAN

SCALE 1:1000



ISOMETRIC VIEW

SCALE NTS

NOTES

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3. VENTILATION ARRANGEMENT NOT SHOWN ON THE DRAWING FOR CLARITY PURPOSE.
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SCALE 1 : 1000

m10 0 100m

CURRENT VERSION INFORMATION

DATE	DRWN	CHKD	REVD	VER	REASON FOR ISSUE
28.02.22	RAB	SS	CS	A	FOR INFORMATION

DRAX CRUACHAN EXPANSION LTD

CRUACHAN 2

GENERAL ARRANGEMENT

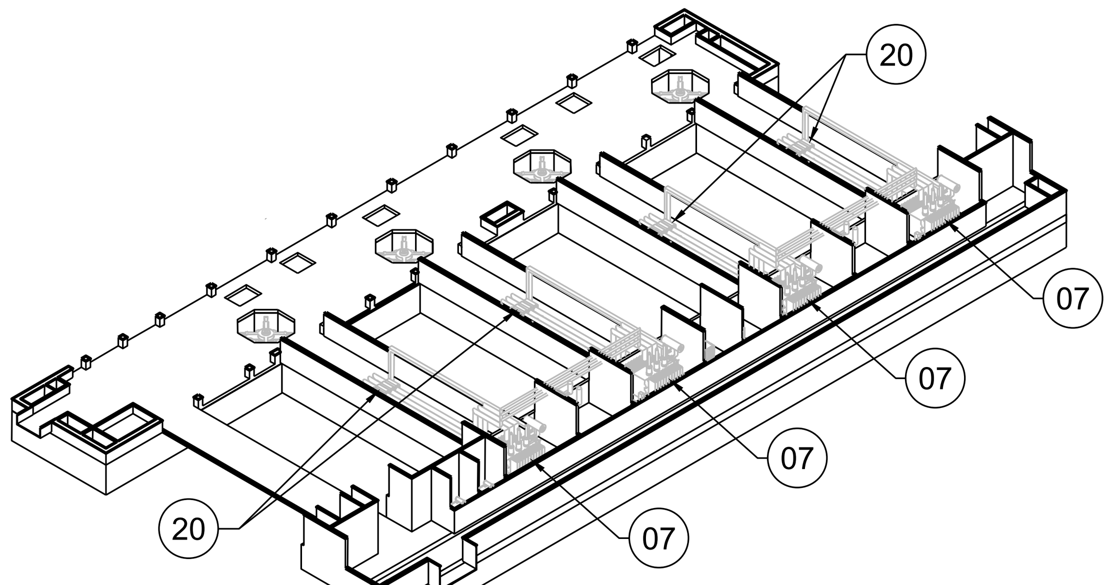
POWER STATION COMPLEX - 4 x 150 MW OPTION

drax

Stantec

CONTRACT NO.	SCALE	MASTER SIZE
01	1:1000	A1

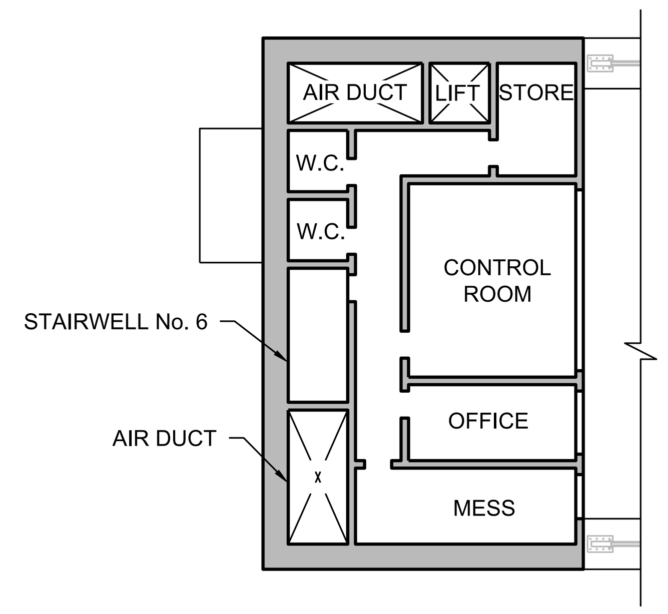
DRAWING NO.	VERSION
331201086/01/C/0015	A



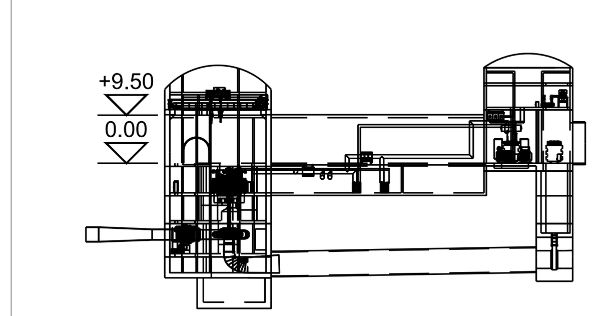
ISOMETRIC VIEW
POWERHOUSE
SCALE 1:1000

EQUIPMENT QUANTITIES

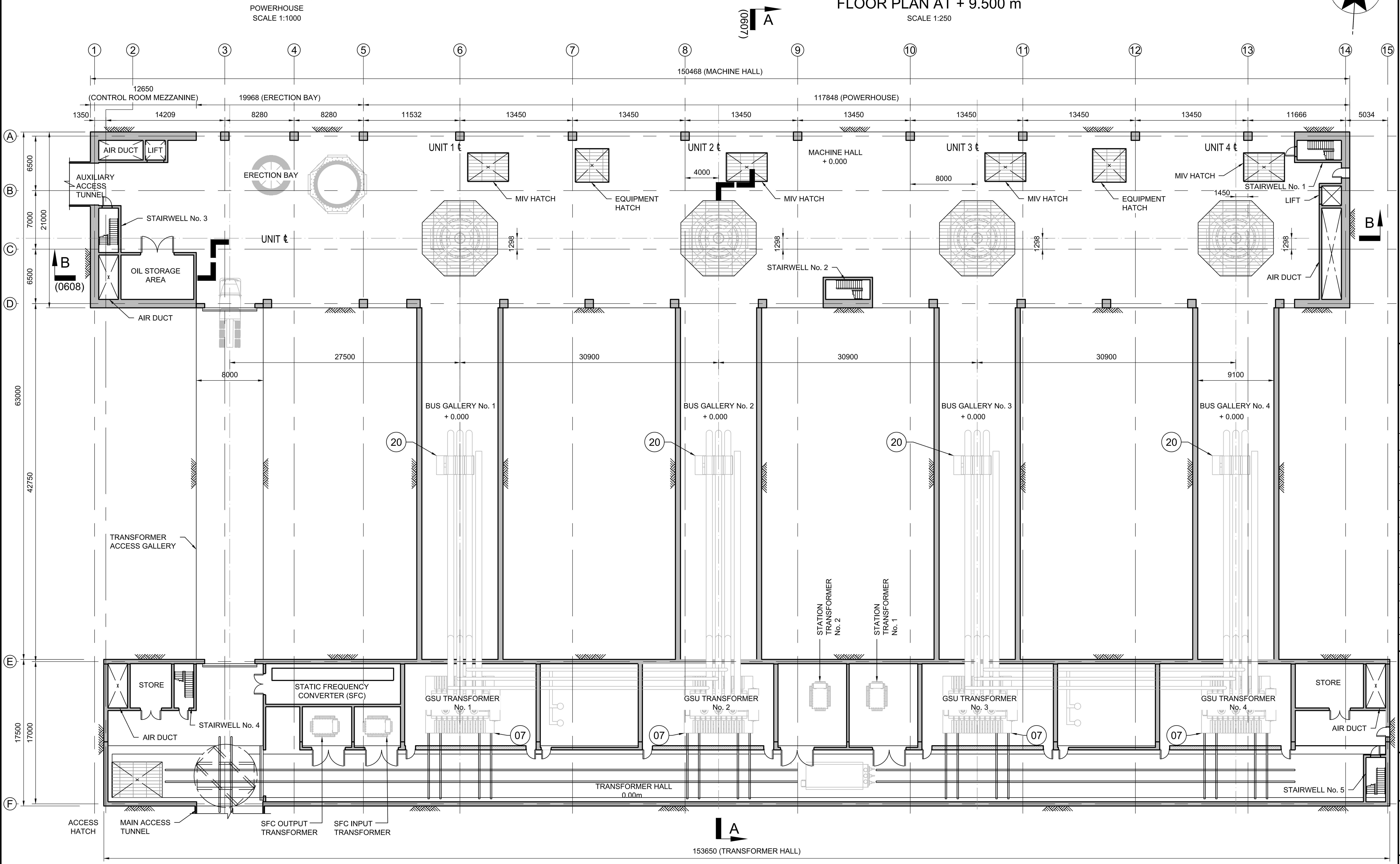
ITEM	QUANTITY	DESCRIPTION
07	4	MAIN POWER TRANSFORMER
20	4	GENERATOR-MOTOR CIRCUIT BREAKER



CONTROL ROOM MEZZANINE FLOOR PLAN AT + 9.500 m
SCALE 1:250



KEY PLAN
SCALE 1:1250



MACHINE-HALL FLOOR PLAN AT 0.00m
SCALE 1:250

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REFERENCES
331201086/01/C/0015 POWERHOUSE - PLAN (4 x 150 MW)
331201086/02/C/0607 U/G POWER STATION - SECTION A-A
331201086/02/C/0608 U/G POWER STATION - LONGITUDINAL SECTION

LEGEND
CONCRETE IN SECTION
(X) ITEM

SCALE 1 : 250 — m10 0 10m
SCALE 1 : 1000 — m10 0 100m
SCALE 1 : 1250 — m50 0 50m

CURRENT VERSION INFORMATION

DATE	DRWN	CHKD	REVD	VER	REASON FOR ISSUE
28.02.22	RAB	SS	CS	A	FOR INFORMATION

DRAX CRUACHAN EXPANSION LTD
CRUACHAN 2

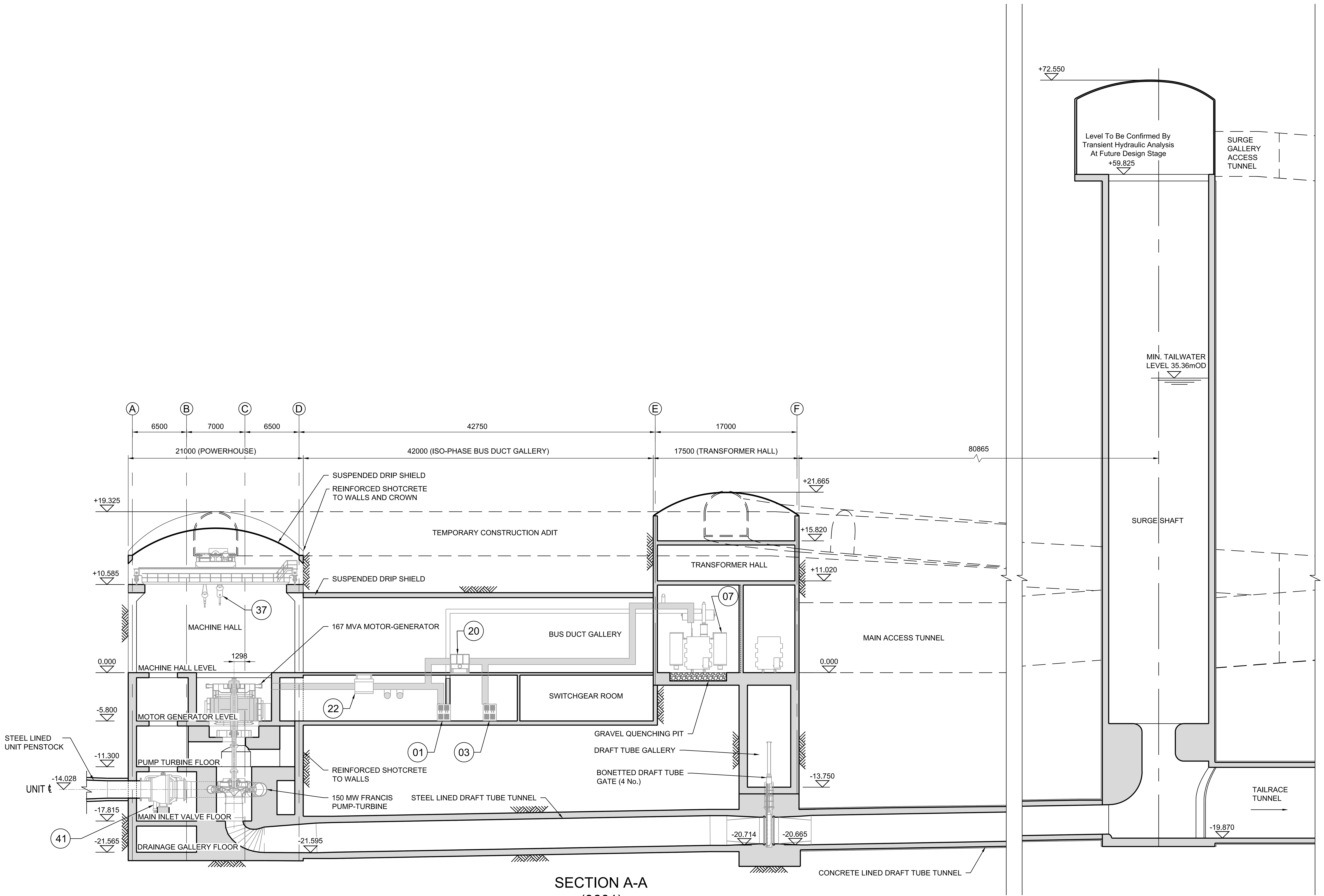
UNDERGROUND POWER STATION
4 x 150 MW - 500 RPM CONFIGURATION
MACHINE HALL FLOOR AT LEVEL 0.00m

drax

Stantec

CONTRACT NO.	SCALE	MASTER SIZE
01	AS SHOWN	A1

DRAWING NO.	VERSION
331201086/01/C/0601	A



SECTION A-A
(0601)
SCALE 1:250

EQUIPMENT QUANTITIES		
ITEM	QUANTITY	DESCRIPTION
L2	1	SPIRAL CASE LEVEL
41	4	INLET SPHERICAL VALVE
42	4	INLET VALVE HYDRAULIC PRESSURE UNIT
L3	1	TURBINE LEVEL
86	8	COOLING WATER CIRCULATING PUMP
L4	1	GENERATOR LEVEL
01	4	STARTING BREAKER
03	4	EXCITATION TRANSFORMER

EQUIPMENT QUANTITIES		
ITEM	QUANTITY	DESCRIPTION
L4	1	GENERATOR LEVEL
14	4	UNIT GOVERNOR ELECTRICAL GOVERNOR
22	4	PHASE REVERSAL SWITCH
L5	1	MACHINE HALL
07	4	MAIN POWER TRANSFORMER
20	4	GENERATOR -MOTOR CIRCUIT BREAKER
37	1	BRIDGE CRANE
L6	1	TRANSFORMER AREA - 2ND FLOOR
49	4	GIS CIRCUIT BREAKER

NOTES

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REFERENCES

331201086/01/C/0015 POWERHOUSE - PLAN (4x150 MW)
331201086/01/C/0601 U/G POWERSTATION - MACHINE HALL FLOOR AT LEVEL 0.00m
331201086/01/C/0608 U/G POWER STATION - LONGITUDINAL SECTION

LEGEND

CONCRETE IN SECTION
X ITEM

SCALE 1 : 250
m10 0 10m

CURRENT VERSION INFORMATION

DATE	DRWN	CHKD	REVD	VER	REASON FOR ISSUE
28.02.22	RAB	SS	CS	A	FOR INFORMATION

DRAX CRUACHAN EXPANSION LTD
CRUACHAN 2

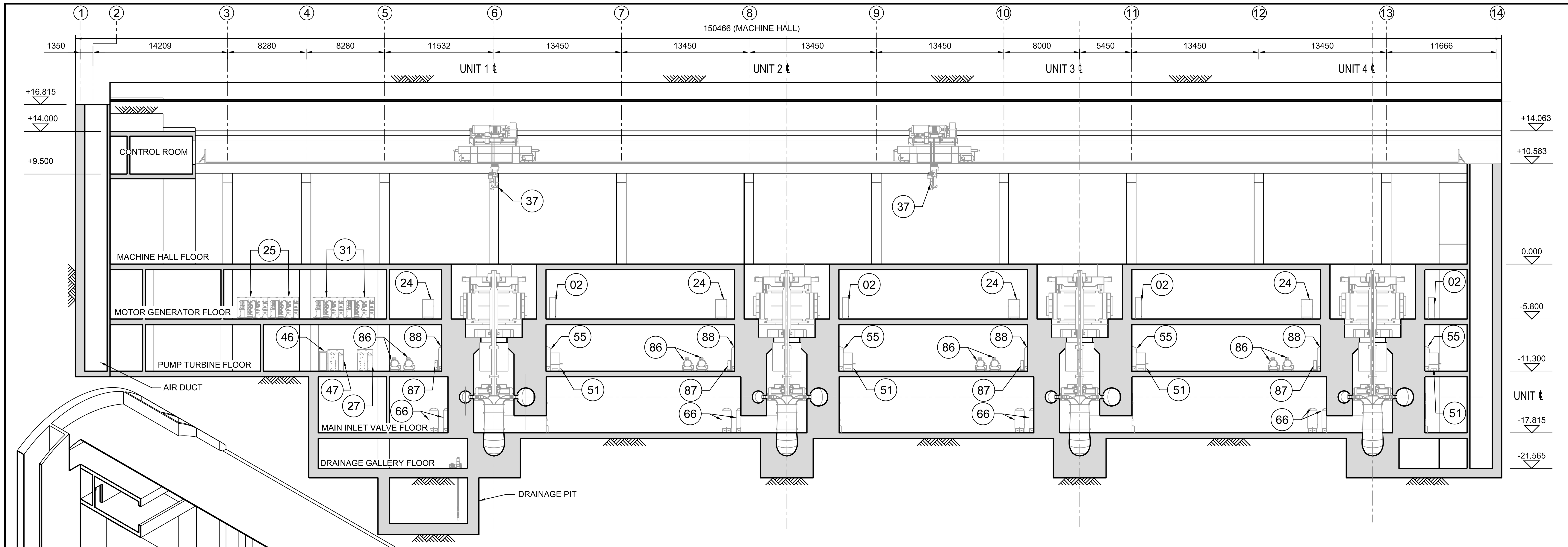
UNDERGROUND POWER STATION
4 x 150 MW - 500 RPM CONFIGURATION
SECTION A-A

drax

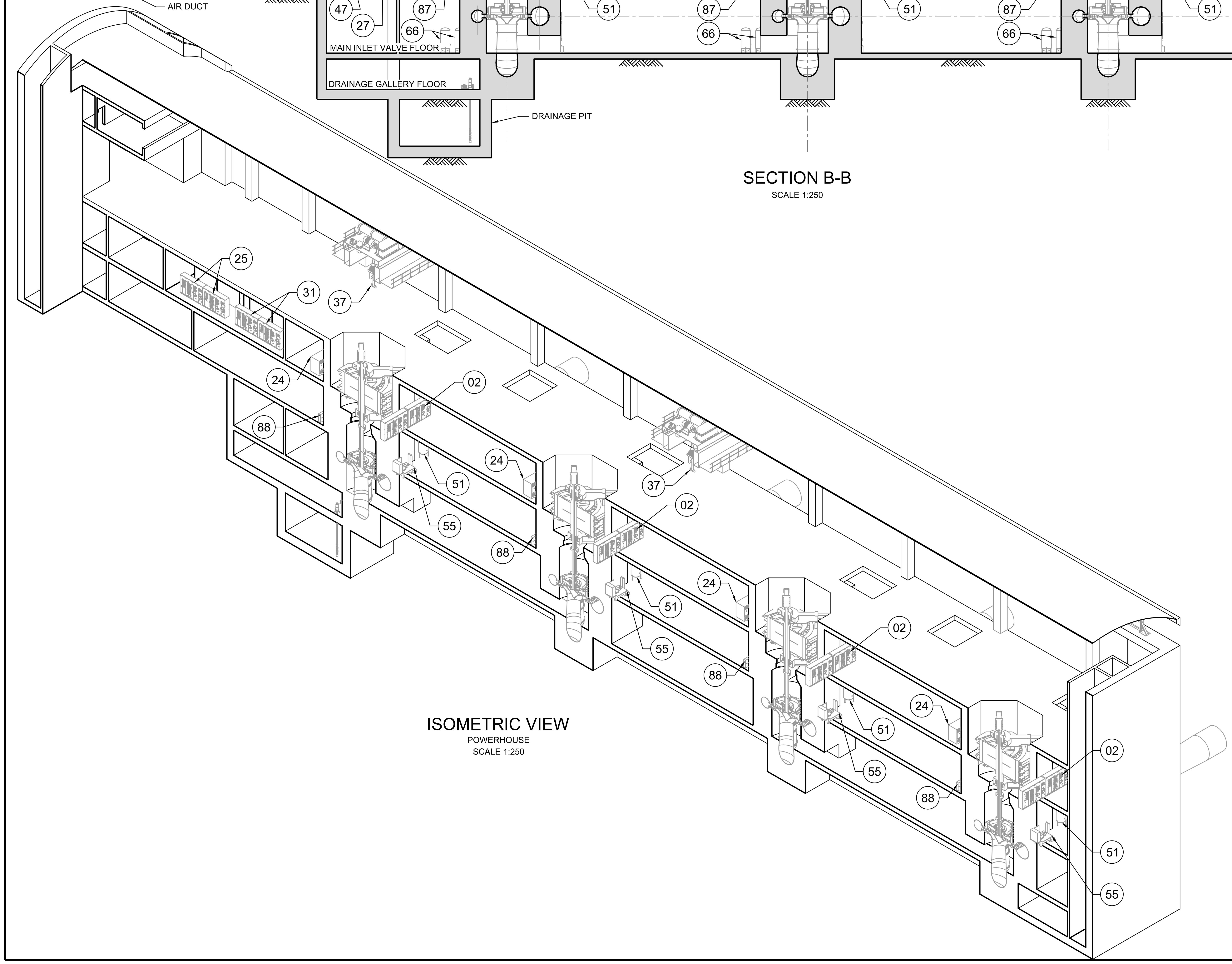
Stantec

CONTRACT NO.	SCALE	MASTER SIZE
01	1:250	A1

DRAWING NO.	VERSION
331201086/01/C/0607	A



SECTION B-B
SCALE 1:250



ISOMETRIC VIEW
POWERHOUSE
SCALE 1:250

NOTES

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REFERENCES

331201086/01/C/0015 POWERHOUSE - PLAN (4x150 MW)
331201086/01/C/0601 POWERHOUSE - PLAN AT MACHINE FLOOR (4x150 MW)
331201086/01/C/0607 POWERHOUSE - TRANSVERSE SECTION (4x150 MW)

LEGEND

CONCRETE IN SECTION

① ITEM

SCALE 1 : 250
m10 0 10m

EQUIPMENT QUANTITIES

ITEM	QTY.	DESCRIPTION
L1	1	DRAFT TUBE LEVEL
76	2	DEWATERING PUMP
61	4	EMERGENCY DRAINAGE PUMP
92	3	SEEPAGE STATION DRAINAGE PUMP
77	1	OIL WATER SEPARATOR
L2	1	SPIRAL CASE LEVEL
41	4	INLET SPHERICAL VALVE
42	4	INLET VALVE HYDRAULIC PRESSURE UNIT
65	8	DRAFT TUBE DEPRESSION SYSTEM AIR COMPRESSOR
66	8	DRAFT TUBE DEPRESSION SYSTEM ACCUMULATOR
L3	1	TURBINE LEVEL
86	8	COOLING WATER CIRCULATING PUMP
87	4	COOLING WATER HEAT EXCHANGER
51	4	HYDRAULIC GOVERNOR
55	4	GOVERNOR COMPRESSED AIR RECEIVER
88	4	COOLING WATER EXPANSION TANK
29	2	BATTERY BENCH
46	2	BATTERY CHARGER
47	2	UPS AND EMERGENCY AC PANEL
27	1	DC DISTRIBUTION PANELBOARD
L4	1	GENERATOR LEVEL
01	4	STARTING BREAKER
03	4	EXCITATION TRANSFORMER
25	4	POWERHOUSE COMMON TRANSFORMER AND DISTRIBUTION SWITCHBOARD
31	4	STATION SERVICE SWITCHGEAR
13	4	UNIT CONTROL SWITCHBOARD AND PROTECTIVE RELAYING
14	4	UNIT GOVERNOR ELECTRICAL GOVERNOR
12	4	UNIT MOTOR CONTROL CENTER
02	4	EXCITATION SWITCHGEAR
15	4	UNIT-DISTRIBUTED CONTROL UNIT
24	4	UNIT TRANSFORMER
14A	4	UNIT TRANSFORMER SWITCHBOARD
26	4	NEUTRAL GROUNDING CUBICLE
22	4	PHASE REVERSAL SWITCH
L5	1	MACHINE HALL
07	4	MAIN POWER TRANSFORMER
20	4	GENERATOR-MOTOR CIRCUIT BREAKER
37	1	BRIDGE CRANE
L6	1	TRANSFORMER AREA - 2ND FLOOR
49	4	GIS CIRCUIT BREAKER

CURRENT VERSION INFORMATION

DATE	DRWN	CHKD	REVD	VER	REASON FOR ISSUE
28.02.22	RAB	SS	CS	A	FOR INFORMATION

DRAX CRUACHAN EXPANSION LTD
CRUACHAN 2

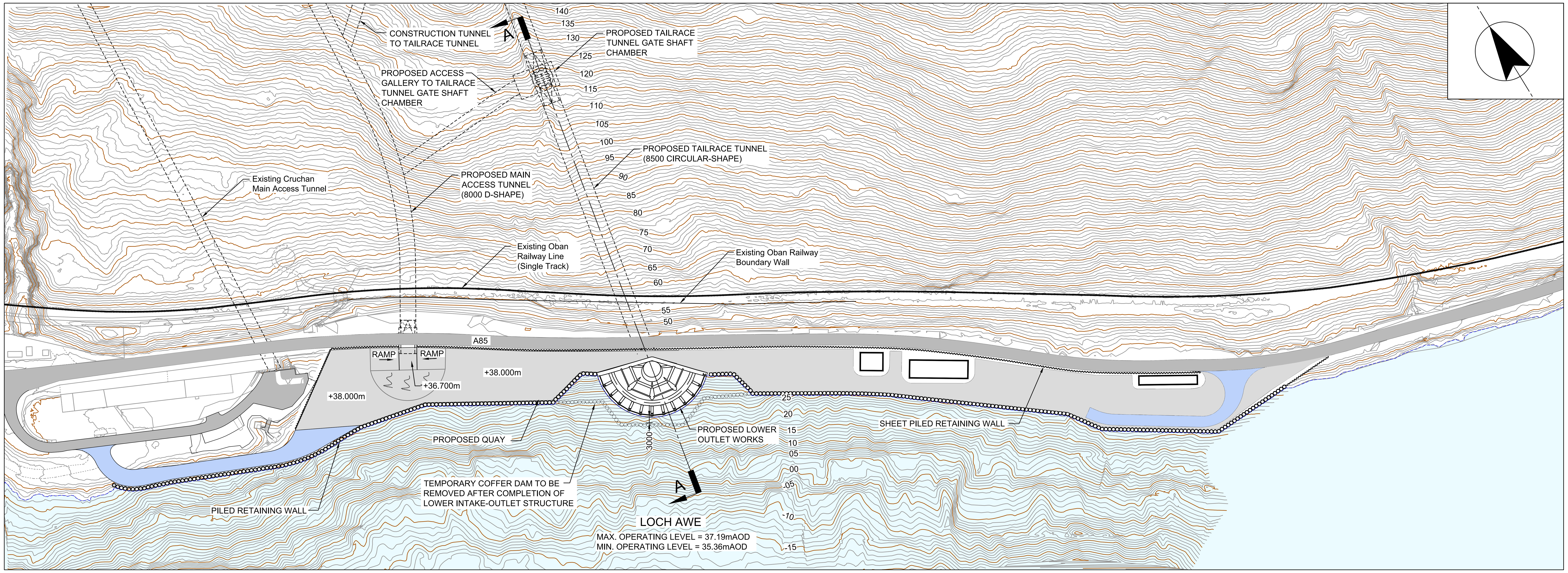
UNDERGROUND POWER STATION
4 x 150 MW - 500 RPM CONFIGURATION
LONGITUDINAL SECTION

drax

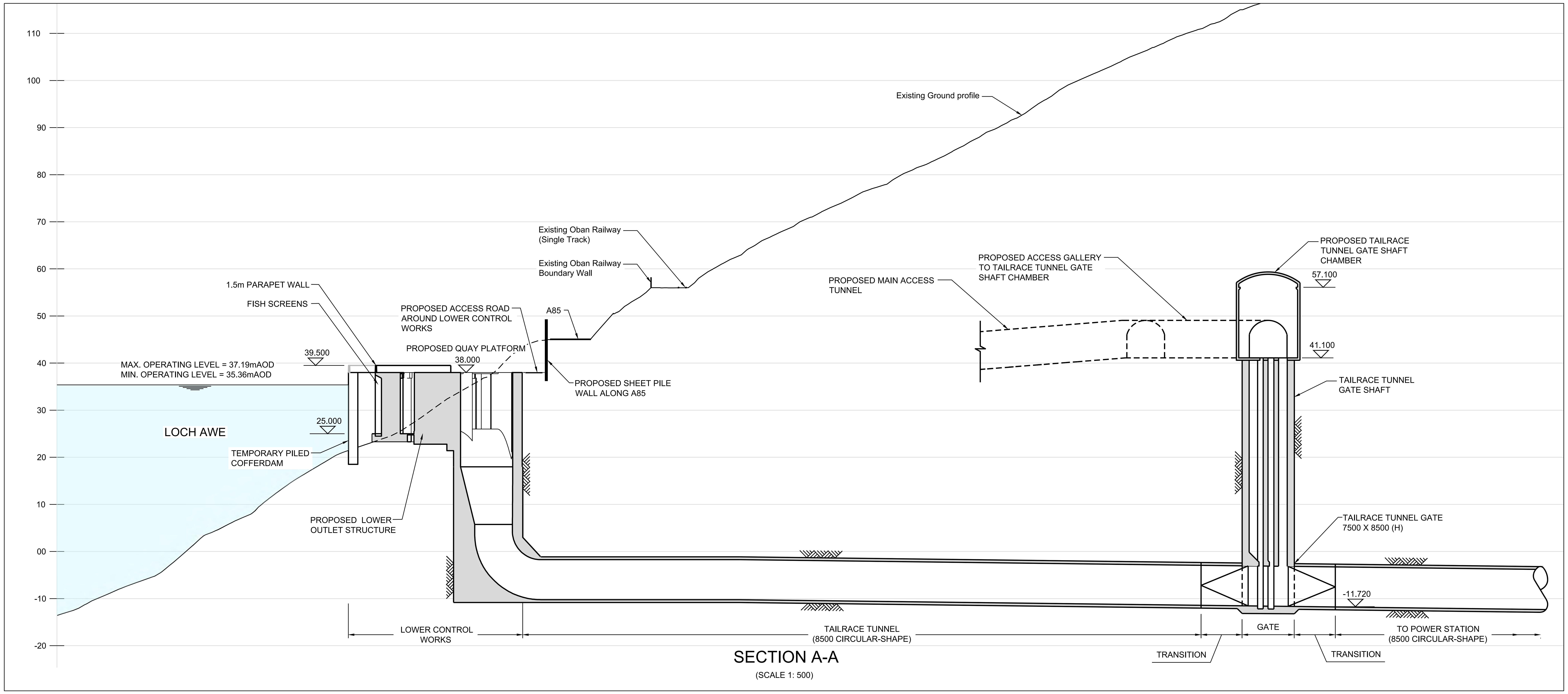
Stantec

CONTRACT NO.	SCALE	MASTER SIZE
01	1:250	A1

DRAWING NO.	VERSION
331201086/01/C/0608	A



PLAN
(SCALE 1: 1250)



SECTION A-A
(SCALE 1: 500)

NOTES

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LEGEND

- Existing Road
- PROPOSED QUAY AREA
- ACCESS TO QUAY

SCALE 1 : 1250
m50 0 50m

SCALE 1 : 500
m10 0 40m

CURRENT VERSION INFORMATION

B. TAILRACE TUNNEL DIAMETER AND SHAPE UPDATED.

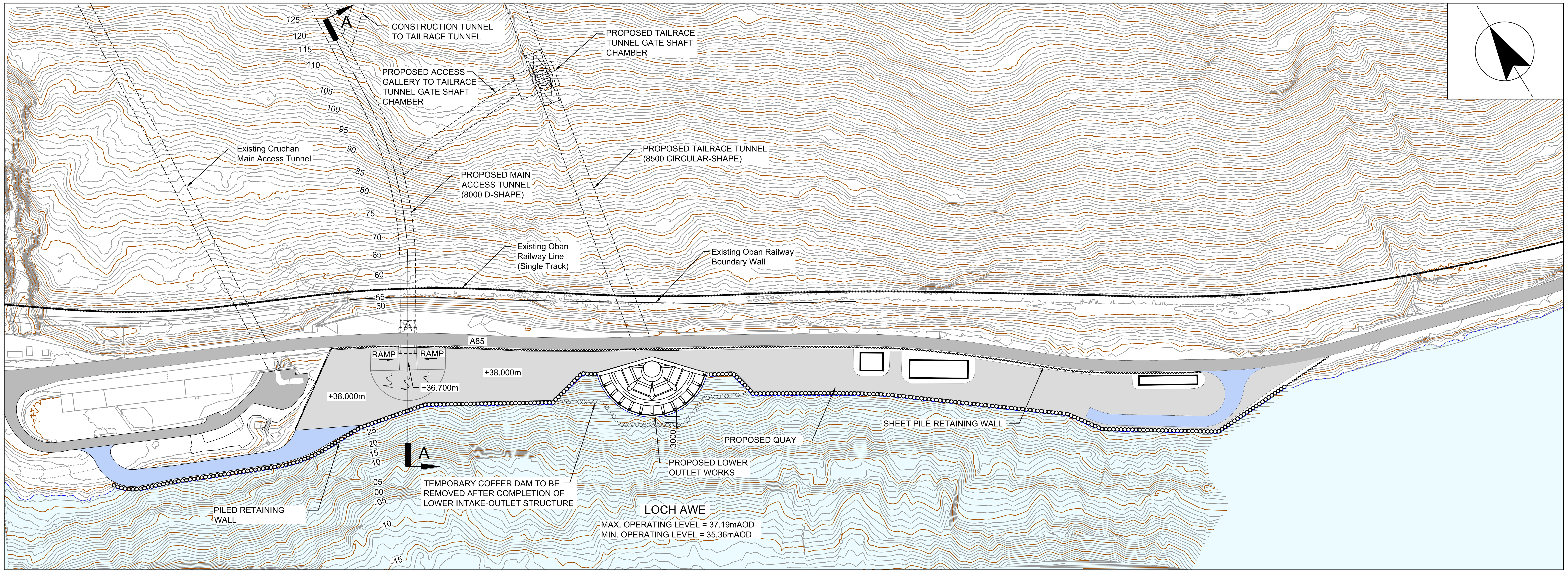
DATE	DRWN	CHKD	REVD	VER	REASON FOR ISSUE
28.02.22	PPS	SS	CS	B	FOR INFORMATION
11.02.21	PPS	SS	CS	A	FOR INFORMATION

DRAX CRUACHAN EXPANSION LTD
CRUACHAN 2

LOWER CONTROL WORKS
TAILRACE TUNNEL
PLAN AND SECTION

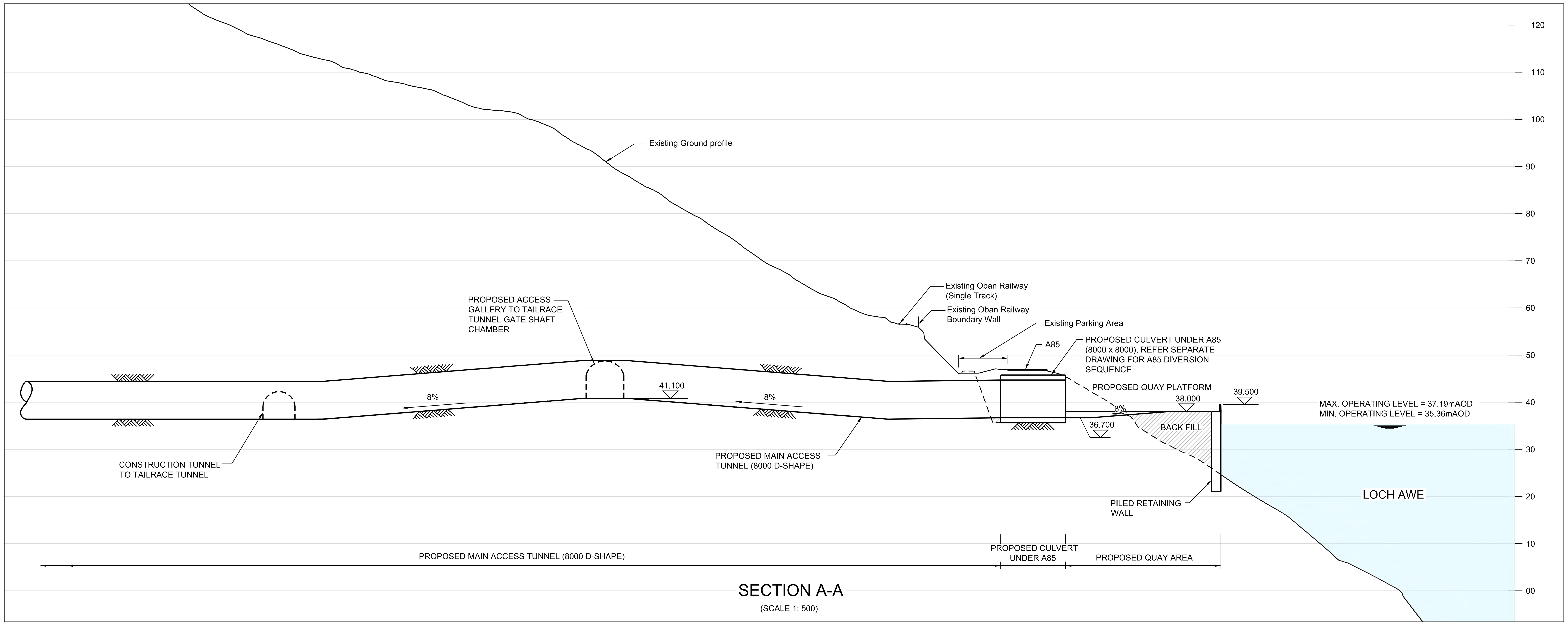
CONTRACT NO.	SCALE	MASTER SIZE
01	AS SHOWN	A1

DRAWING NO.	VERSION
331201086/01/C/0901	B



PLAN

(SCALE 1: 1250)



SECTION A-A

(SCALE 1: 500)

NOTES

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LEGEND

- Existing Road
- PROPOSED QUAY AREA
- ACCESS TO QUAY

SCALE 1 : 1250 — m50 0 50m

SCALE 1 : 500 — m10 0 40m

CURRENT VERSION INFORMATION

B. TAILRACE TUNNEL DIAMETER UPDATED.

DATE	DRWN	CHKD	REVD	VER	REASON FOR ISSUE
28.02.22	PPS	SS	CS	B	FOR INFORMATION
11.02.21	PPS	SS	CS	A	FOR INFORMATION

DRAX CRUACHAN EXPANSION LTD
CRUACHAN 2

LOWER CONTROL WORKS
MAIN ACCESS TUNNEL
PLAN AND SECTION

drax

Stantec

CONTRACT NO.	SCALE	MASTER SIZE
01	AS SHOWN	A1

DRAWING NO. 331201086/01/C/0902 — VERSION B