HUNTERSTON B POWER STATION

Technical Safety Support Department Report

Best Practicable Means (BPM) Report for aqueous discharges to sea following fuel free verification

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Executive Summary

During the generating and defueling phases of the power station, Hunterston B (HNB) uses a significant volume of sea water as a tertiary cooling water system. The radioactive discharge permits for both HNA and HNB specify a large volume flowrate of water to make radioactive discharges to sea, which can only be achieved by the main Cooling Water (CW) system.

Following the removal of all nuclear fuel from the site, there will be no justification for the continued use of the main CW Cooling Water system, which requires significant electrical power and maintenance resource. It was therefore necessary to review the most appropriate sustainable options for future effluent discharges.

A dispersion model of the effluent discharges from both HNA and HNB was conducted and a number of optioneering sessions were carried out. Following an option elimination process, three main options were reviewed for this Best Practicable Means Assessment (BPM), as follows; maintaining the existing arrangement, installing a completely new small bore line to a new discharge point or threading a small bore pipe through the existing culvert to the existing discharge point.

Maintaining the existing CW arrangement would be costly and the worst case for the environment, due to the significant electrical power requirements and maintenance of CW system and supporting plant. Retaining the existing systems would also result in a delay to the decommissioning of the CW system and all of the associated auxiliary and supporting plant.

Installing a completely new, small bore line to a new discharge point comes with the risk that the uncertainty of the stability of the seabed could result in significant increase to the cost, damage to the environment, wildlife and marine life. This uncertainty would also lead to he continued use of the CW system for a longer period.

The option to thread a small bore pipe through the existing large CW culvert represented the best value for money and the least environmental risk. This option does require a variation to the EASR18 permits due to the removal of nominal CW flowrates of discharges. In addition, the dispersion modelling demonstrated that a tidal window provides little benefit to dilution and dispersion of the discharges in the Clyde Estuary at the existing discharge point. It is deemed that a tidal window constraint within the permit is therefore disproportionate to the risk.

It is recommended that steps are taken to apply for EASR18 permit variations from both HNA and HNB, to remove the need for the large volume flowrate of water and also the discharge tidal window.

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Report issue/amendment

Revision	Amendment	Date
000	First Issue	Jan 2024

Glossary

Word, Phrase or Acronym	Description
AETP	Active Effluent Treatment Plant
BPM	Best Practicable Means
CAR	Controlled Activities (Water) Regulations
CW	Cooling Water (Sea Water)
EASR or EASR18	Environmental Authorisations (Scotland) Regulations 2018
EDF	Electricity de France
FFV	Fuel Free Verification
HNA	Hunterston A Decommissioning Site
HNB	Hunterston B Power Station
LC	Licence Condition
LLWF	Low Level Waste Facility
SEPA	Scottish Environment Protection Agency

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1 Introduction

Hunterston B Power Station (HNB) extracts sea water from the Clyde Estuary by the main Cooling Water (CW) system, for indirectly cooling plant systems associated with the reactors and fuel route. Once the station reaches Fuel Free Verification (FFV), the need for CW flow is no longer required for the reactor and fuel route safety cases. Therefore, the significant maintenance costs and electrical power required to run the CW system may no longer be justified for radioactive aqueous discharges alone.

Radioactive aqueous discharges to sea from both Hunterston A and B sites, are carried out in accordance with discharge permits issued by the Scottish Environment Protection Agency (SEPA), under the Environmental Authorisations (Scotland) Regulations 2018 (EASR18) (Ref. 1) . The current permits for Hunterston A and B, (Refs. 2 & 3) require a minimum discharge flow rate of $7m^3$/sec. This volume and flow of water can only be achieved using the CW system.

Various options have been investigated to establish a suitable solution for aqueous discharges that are sustainable following FFV and into the deconstruction phase of HNB and the existing deconstruction phase at HNA.

2 Scope

This report describes the optioneering studies carried out to ascertain the Best Practicable Means (BPM) for making radioactive aqueous discharges from HNA and HNB into the Firth of Clyde.

A description of the existing arrangements, in terms of discharge permits and plant layout is provided, alongside a description of three main options that have been investigated to establish a sustainable long term solution for making discharges when both sites are in the decommissioning phase.

The optimisation of the BPM option chosen is discussed, resulting in a brief conclusion section, followed by recommendations.

3 Background

3.1 Main Cooling Water System

HNB holds a Registration from SEPA under the Water Environment (Controlled Activities)(Scotland) Regulations 2005 (Ref. 4), to extract sea water from the Clyde Estuary at grid reference point NS 1754 5068, which lies around 1.5km south of HNB. In basic terms, the sea water (tertiary cooling system) is principally used as a method of cooling secondary cooling systems (demineralised water), which cool the reactor primary cooling systems (CO_2 gas).

The sea water is known as the Cooling Water (CW) at HNB and is drawn into the Cooling Water Pump House using powerful pumps. From the pump house, the water is circulated around plant systems within the Turbine Hall before being discharged via the Siphon Seal pit. The plant layout is shown in Section 4 and Appendices A & B.

3.2 Radioactive Aqueous Discharges

The aqueous discharges at HNB are pumped from the Active Effluent Treatment Plant (AETP) and the Low Level Waste Facility (LLWF) to the Syphon Seal pit (shown in Section 4). The active effluent discharges from HNB are mixed with the Cooling Water in the Syphon Seal pit and carried, via the CW culvert, to the discharge point in the Firth of Clyde.

Aqueous discharges from HNA are pumped directly from the HNA AETP to the land shaft area (shown in Section 4), where it drops into the main CW culvert by gravity and is carried out to the discharge point by HNB Cooling Water. There is a cross-site agreement in place for this arrangement (Ref. 5).

The EASR permits for each station (Refs. 2 & 3) specify the following conditions:

Manner of aqueous radioactive waste disposals

You must ensure that aqueous radioactive waste is only discharged:

a. when the nominal flow of cooling water is no less than 7m^3/s;

b. when the cooling water is discharging to the Firth of Clyde at National Grid Reference NS 1773 5176; and

c. during the interval commencing one hour after high-tide and ending one hour before low tide.

Discharges made from each site are not carried out concurrently. HNA site contacts the Central Control Room at HNB prior to discharging, to ensure that HNB are not discharging at the same time and to ensure that the cooling water is flowing. This is not a specific condition of the discharge permit but is beneficial to the dilution and dispersion of the effluents.

4 Plant layout for aqueous discharges

The discharged CW enters the Siphon Seal pit and flows almost 800m through a deep culvert to the permitted discharge point in the Firth of Clyde. The internal diameter of the culvert is 3.35m for the majority of its length. From the Siphon Seal pit, there is a vertical land shaft (on the side of the main access road to the site) around midway (366m) of the culvert to the discharge point.

The map below shows the aqueous discharge route of the Cooling Water from the Siphon Seal pit to the land shaft and out to the discharge point in the Firth of Clyde. HNB holds a licence to discharge the CW back to sea (Ref. 6).

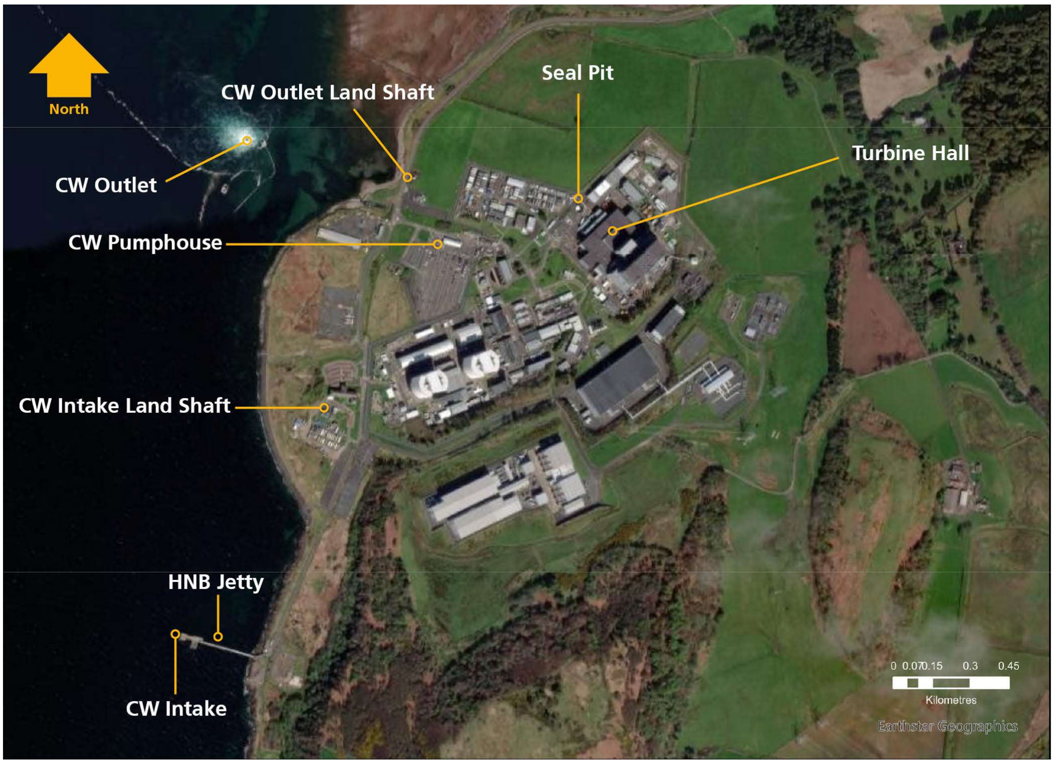


Figure 1 Hunterston Cooling Water Plant Areas

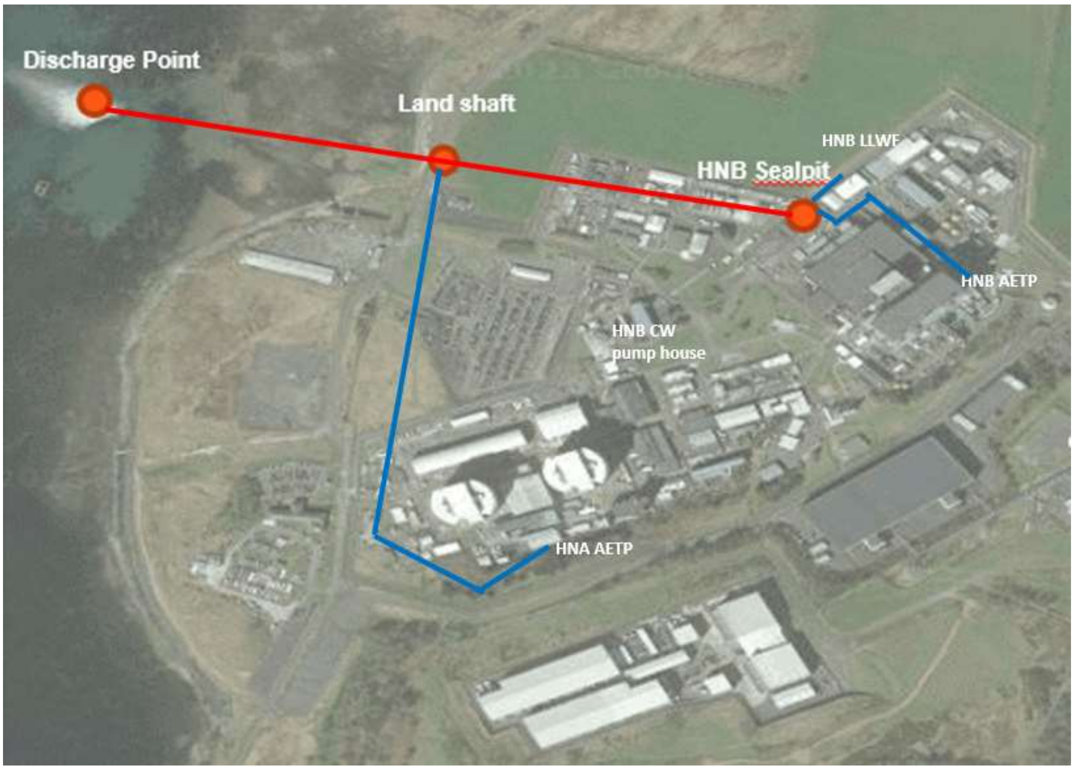


Figure 2 Aqueous discharge routes from HNA and HNB

4.1 HNA aqueous discharge route

Radioactive aqueous discharges from HNA are collected in the AETP and discharges are routed to the rear of HNA and out towards the HNB carpark to the land shaft, where it drops into the culvert by gravity (shown in Figure 2 and Appendix B). HNA makes a discharge every four to six weeks, consisting of approximately 35m^3 of effluent, which is the capacity of each Final Delay Tank within the HNA AETP.

The existing plant arrangement allows for HNA to pump effluent at an average rate of 17 m^3/hr through a 4 inch bore pipe to the land shaft. With this flow rate HNA can fully discharge a tank within three hours (Ref. 7).

4.2 HNB aqueous discharge route

Liquid effluent is collected in tanks in the AETP and the LLWF and is pumped to the Siphon Seal pit during the tidal windows (see Appendix C for the discharge line details at HNB). The Final Delay Tanks in the AETP can hold a volume of up to 100m^3 each and a discharge is carried out, on average, every 7 to 10 days. As HNB has moved from generation through to defueling, the volume of liquid effluent has decreased and will continue to decrease further once the washing of fuel flasks has ceased. Beyond that, HNB will still require wet methods for waste processing within the main B Station building and the fuel cooling pond will be drained in the years to come.

There are also final delay tanks in the Laundry and LLWF (both housed within the LLWF Building). As part of a refurbishment project for the LLWF, all radioactive liquid effluent will be routed to the Laundry tanks as they are newer and both sets of tanks are no longer required due to the Laundry facility being decommissioned. The two Laundry tanks (38m^3 capacity in each) are being repurposed to collect effluent from wet waste processing and wet decontamination practices. Overall, the generation of radioactive liquid effluent is greatly reduced.

The liquid effluent from the AETP and the LLWF is pumped to the Siphon Seal pit within the specified tidal window in the EASR permit (Ref. 3), where the discharges are carried out to the permitted discharge point by the Cooling Water.

4.2.1 HNB Plant issues with existing effluent lines to Siphon Seal pit

The secondary containment of parts of the discharge line from the AETP and LLWF to the Siphon Seal has lost integrity, as discovered during an investigation of standing water in the manholes of the lines. A camera survey showed that parts of the lines between manholes were not intact and some of the manholes were allowing the migration of ground water.

The primary line for discharges consists of a single walled line without inherent leak detection. To ensure there is no leakage from the primary line, the water in the manholes is sampled monthly to check for potential radioactivity from discharged effluent and pressure tests are carried out periodically, to ensure containment.

A separate project is underway to design new double-walled lines complete with leak detection (from primary) and pressure test capability of the primary and secondary containment. . It is considered that the materials of the new lines prior to the Siphon Seal pit (this section only) may add resistance and slightly reduce the flowrate of the discharge. As a result, new pumps will be designed to ensure a minimum average flowrate of around 31m^3/hr out to the permitted discharge point (without CW flow) using a 6 inch bore pipeline, which is approximately the existing flowrate of effluent to the Siphon Seal pit (Ref. 8). Installing new pumps as part of this project ensures that future discharges, potentially without CW, can be achieved within a few hours and meet the existing tidal window requirements.

It is planned that the new lines and pumps up stream of the Siphon Seal will be installed in 2024.

4.3 HNB Sewage plant

The HNB sewage plant effluent is treated for release directly to sea. It is discharged by gravity into the land shaft and carried out to the discharge point by the HNB Cooling Water, as shown in Figure 2 below.

HNB holds a Controlled Activities (Water) Regulations licence for this activity (Ref. 9) which specifies the same discharge point as the EASR permits for radioactive discharges, but does not specify a flowrate or tidal window condition.

Figure 2 Sewage plant discharges into the land shaft.

5 Discharge Dispersion Modelling

A discharge dispersion modelling exercise was carried out, in order to understand the movement of radioactive effluent entering the Firth of Clyde at the permitted discharge point. A report was produced by Eden Nuclear and Environment Ltd. (Ref. 10).

The report discusses the dilution and dispersion in the environment for five different discharge scenarios, and models the effect of discharge location, discharge timing (relative to the tide) and discharge flow rate on the compartment-scale dilution and dispersion of discharges of radioactive liquid effluent from HNA and HNB, to the Firth of Clyde.

The results from the model were compared to real-world observations and to models run in the standard PC-CREAM 08 software, demonstrating a good level of conformity.

The exercise has shown that the discharge timing (relative to the tide) and flow rate have very little influence on dilution and dispersion in the Firth of Clyde at the permitted discharge point.

Environmental monitoring of the surrounding areas, including sampling of sediment, seaweed and sea life, demonstrates that doses to the public are extremely low. Annual reports are produced by EDF Energy (examples in Refs. 11 to 13) and independently by the environment agencies (Ref. 14) illustrating the extent of sampling and measuring carried out to monitor doses to the public from effluent discharges and other radiation dose pathways. Environmental monitoring will continue throughout the deconstruction phase and consideration will be given to reviewing and optimising the sampling and analysis carried out.

6 Potential aqueous discharge options

6.1 Discarded options

Various options were identified at an early stage of the process and were reviewed for feasibility, in terms of routing aqueous discharges to sea from HNA and HNB. A strategic company paper was written about the credible options for future discharges (Ref. 15), which discussed the Magnox experience following defueling. However, a more specific approach was required at Hunterston and further development of optioneering was carried out on site. The findings were recorded in report HNB/REP/PD/W048/004 (Ref. 16).

The dispersion model (Ref. 10) demonstrated that discharging further out into the deep channel in the Firth of Clyde reduced the radionuclide concentration by an order of two magnitudes. However, the current District Survey Monitoring programme has been supporting the discharge profile with the discharge point in its current location and environmental monitoring of the surrounding areas demonstrates very low dose to the public, therefore extending the line was discarded as an option early on, due to the disproportionate cost compared to risk.

From the site exercise (Ref. 16), thirteen initial options were identified, including eight options that were associated with the continued use of the existing CW culvert pipe as the main conduit for transferring discharges off-site, but none of these eight options were taken forward due to the 3.35m diameter of the pipe. The flow rate of water by any means, other than the existing CW pumps, would not be sufficient to move discharges along the existing culvert to the permitted discharge point.

One option included the use of sending the effluent off-site for disposal (i.e. not to sea). The remaining options included four variations of threading a smaller bore pipe through the existing CW culvert to discharge at the existing permitted discharge point.

One option that was considered for HNA was to remove the requirement for a discharge line and for a tanker to transfer effluent from HNA to a discharge point connection on the HNB line. This option was not taken forward due to the risk associated with cross-site transfer of effluent, the creation of more radioactive waste with a tanker and lack of long term sustainability for discharges from HNA.

Therefore, three main credible options exist to transfer radioactive aqueous discharges out to sea as discussed below in Section 6.2.

6.2 Option A – Maintain CW discharges

Option A requires the existing CW pumps and all associated auxiliary plant and supporting plant to continue to operate, in order to discharge effluent to the sea.

Sea water is currently abstracted approximately 1.5 km south of the HNB station and flows through condensers to cool the secondary circuits, via the turbine hall area (See Appendix A). The CW then routes to the Syphon Seal pit and out to the discharge point in the Firth of Clyde (Shown in Figure 1). To prevent marine growth in the pipes, the CW system is dosed with Sodium Hypochlorite via equipment located at the system inlet.

At present, one of the CW pumps is continuously in service. An operating regime that would require starting and stopping the pumps on a regular basis would not allow for continuous monitoring of the pump performance. It would not be possible to determine that a parameter is drifting because the pump would not be in service, and since the plant is quite old, there is a risk of failure in service. Operational experience of the pumps and motors have shown that start up can be problematic, requiring a number of attempts, which are also restricted. Therefore continuous operation of one pump is the most feasible option for the basis of Option A.

6.3 Option B – Thread small bore pipes to existing discharge point without CW

Option B requires the installation of a small bore pipe (of the order of 6 inch diameter) inside the existing culvert from the Syphon Seal to the discharge point, via the land shaft. In effect, this would be a continuation of the existing discharge lines from the AETP/LLWF at HNB.

It is intended that the existing discharge pumps are uprated during a separate project in 2024 mentioned in Section 4.2.1 due to new pipe materials that may cause resistance, prior to the Siphon Seal pit, but also to accommodate an increase in pipe length from Siphon Seal pit to the discharge point. It is expected that the end of the pipe where it meets the sea will be designed in such a way as to allow for pressure testing of the line but would remain open when in use to prevent further resistance of flow.

This option includes the installation of a single line extension of the HNA discharge line from the land shaft to the existing discharge point. The additional line for HNA would be the same specification as the HNB line. This is discussed further in Section 7.

It is further proposed that the treated sewage outlet continues to be discharged into the CW culvert at the land shaft as at present and that the culvert remains open (with a grating) at the discharge point.

6.4 Option C – New small bore pipes to new discharge point without CW

This option proposes a completely new discharge line (small bore e.g. 6 inch) from the Syphon Seal pit area out to sea. This would require an over ground or underground pipe (or a mixture of both) across the site. The new line would potentially be routed through the adjacent fields, main access road and the adjacent beach area, to a new discharge point in the Firth of Clyde. This option represents an extension of the existing line from the Syphon Seal area to a new point out at sea.

In order to facilitate this option, a new line adjoining the existing section of line from HNA AETP to the land shaft, would be required to meet the new line from HNB.

A new arrangement would have to be implemented for the HNB sewage plant and associated discharges.

7 Best Practicable Means Assessment

This section provides some discussion of the various attributes assessed for the options listed.

7.1 Nuclear Safety and Impacts on Site Licence (including LC 32 & LC34)

LC32 Accumulation of Radioactive Waste. LC32(1) states that:- *The licensee shall make and implement adequate arrangements for minimising so far as is reasonably practicable the rate of production and total quantity of radioactive waste accumulated on the site at any time and for recording the waste so accumulated.*

Both HNA and HNB manage the production and storage of radioactive effluent currently and will continue to manage this waste in accordance with the EASR permit and site licence conditions. The tidal window condition of the permit will create more of a burden when shift work is reduced/stopped at HNB after defueling.

LC34 Leakage and escape of radioactive material and radioactive waste. LC34(1) states that:- *The licensee shall ensure, so far as is reasonably practicable, that radioactive material and radioactive waste on the site is at all times adequately controlled or contained so that it cannot leak or otherwise escape from such control or containment.*

Option A would mean the original design of the CW system would remain in place. There is currently no means of testing the line for leakage from the Siphon Seal to the discharge point or from the land shaft to the discharge point.

Options B and C include the design capability to pressure test the new lines to the existing discharge point or to a new discharge point prior to commissioning and periodically thereafter, which would be an improvement on the current process inherent to Option A. A review of the feasibility to install leak detection instrumentation on the sections of line from Siphon Seal or the land shaft out to sea, would be carried out for Option B and C.

New lines may create some small volume of additional radioactive waste (pipeline) to be disposed of at final decommissioning of the lines. This waste may be LLW with the potential to be VLLW waste or out of scope of the regulations (Ref. 1), but in any case, will have a viable disposal route. The detailed design stage would ensure that the pipes/materials used are optimised to limit the amount of potential radioactive waste created.

7.2 Public Radiation Exposure and Safety

None of the options represent a significant impact to public dose. The public dose from liquid effluent discharges from HNA and HNB is extremely low.

For Options A and B, there is no need to perform an additional assessment to ensure that the discharges would be dispersed in a similar manner to that currently achieved, as these options propose that the effluent is discharged at the same point currently used. Although, consideration will be given to reviewing the environmental monitoring process to ensure it is optimised.

The Dispersion Modelling report mentioned in Section 5 was commissioned to assess the dispersion of effluent in the Clyde (Ref. 10), which determined that the dispersion of effluent (and subsequent dose to the public) would be unchanged if the discharge line came out at the same point (i.e. the cooling water outfall) and that the tide restriction and flowrate of the effluent made no difference to the dispersion.

EDF Energy produces an annual report on doses to the public in the vicinity of the power stations. Annual dose reports (Refs. 11 to 13) show that when the station was operating at power, doses to the public were very low. Since moving into the defueling phase, the doses to the public from radioactive effluent discharges have remained unchanged. It is expected that the doses to the public from liquid effluent will reduce over time.

A new dispersion model would be required for Option C. The current District Survey Monitoring programme has been supporting the discharge profile with the discharge point in its current location. Movement of the discharge point would require a review of the existing survey programme to be undertaken.

A report entitled 'Radioactivity in Food and the Environment' (RIFE) is produced by the Environment Agencies every year. The latest report available (RIFE 28, Ref. 14) shows that doses to the public in the vicinity of Hunterston are very low.

7.3 Operator Radiation Exposure

None of the options present any change to operator radiation exposure. The operation of the plant proposed in Option B and C plant is no different to that currently installed as in Option A, with regard to working in the radiological controlled areas.

7.4 Conventional Safety

Option A presents the largest conventional safety risk due the extensive maintenance required to continue to the run the CW system and the associated support systems. A large team of staff and contractors would be required on a continuous basis and the work carries inherent industrial safety hazards that necessitates mitigation. Option A also requires the continued use of Sodium Hypochlorite dosing of the sea water as it is abstracted from the sea into the CW system, to reduce biological growth within the systems.

In Option B, the installation of new pipeline would present some safety challenges, however the proposal is a well-established method of underwater piping and presents the lowest conventional safety risk in the long term. After commissioning, periodic leak testing can be carried out, again using well established methods. All work would be carried out away from public areas. Consideration will be required for the CW culvert with regard to bio-growth without the CW flow and Sodium Hypochlorite dosing. Periodic inspection and potential cleaning could result in safety challenges and this will need to be factored into the detailed design.

Option C could present increased conventional safety hazards and risks than Option B, due to the requirement for digging and laying new pipeline in areas of public access, including areas of the roadway and beach. Exposed parts of a new line provide benefits for inspection, however investigation of the line in parts that are buried, without a culvert, could result in some significant safety challenges that would require careful consideration in the design phase. It has been ascertained that a modification was made to the existing CW culvert at the time of installation. The culvert was changed to rise up towards the end of the pipeline, due the instability of the seabed in that location, as shown in Appendix B. It is possible that similar issues would occur if drilling out a new line close by. Disruption to the seabed may affect the existing culvert.

7.5 Radioactive Substances Regulation Impacts and Compliance

Option A would not require a variation to the EASR permits for HNA or HNB, as all conditions of the exiting permits would be met with regard to the flowrate and the discharge point.

Option B would require a variation to the EASR permits due to a change in the flowrates of the discharge. The discharge point would remain unchanged. If required, discharges can be achieved within a 3 to 4 hour window by uprating the pumps at HNB, due to the potential volume of effluent to be discharged (Final Delay tanks can contain up to 100m^3 each at HNB AETP). The Final Delay Tanks at HNA are much smaller and a full tank could be discharged within a 3 to 4 hour window with the existing pumps and extension to the line from the land shaft to the discharge point (Ref. 7). Consideration would have to be given to the fact that some of the discharged effluent will remain within a new pipeline and naturally displace to the discharge point, after a tidal window. Therefore, the variation would require the removal of the tidal window condition to ensure all discharges are fully authorised.

Careful consideration needs to be given to work windows within the culvert when threading new pipes in Option B. Arrangements need to be made to ensure discharges can be made throughout the installation period. Experienced contractors have stated that CW flow could be made through the culvert at intervals during installation of the new small bore pipes and therefore, there should be no significant disruption to effluent discharges.

Option C would require a variation to the EASR permits due to a change in the discharge flowrates and a new discharge point. One of the benefits of Option C would be that a new line can be installed and the existing CW line can continue to be used during the new line installation. Conversely, potential issues with the seabed, if drilling near to the existing discharge line, could damage the existing line and pose a significant risk to carrying out discharges.

7.6 Non-radioactive Environmental Impacts and Compliance

7.6.1 CAR Licence for sea water abstraction and discharge

Option A would require the existing CAR Licences for abstraction and discharge of sea water (Refs. 4 & 5) to be retained and a licence to remove seaweed from around the inlet of the CW system may also be required, if the system is to be run in the long term. The previous licence was surrendered.

The CAR Licences for abstraction and discharge of sea water could be surrendered with Options B and C.

7.6.2 CAR Licence for treated sewage water discharge

The CAR Licence for the discharge of treated sewage effluent (Ref. 9) would remain unchanged with Option A. The treated effluent would continue to be discharge into the CW culvert and transferred to the discharge point by the CW.

There would be no need for a change to the existing sewage CAR Licence with Option B. Correspondence with a SEPA representative (Ref. 17) confirmed that this licence would remain unchanged even if CW is no longer available for discharges. The treated sewage effluent could be discharged into the large CW culvert, as it is currently, and displaced to the existing discharge point by the natural movement of the sea.

A variation to the CAR Licence for the sewage discharge (Ref. 9) would be required due to a change of the discharge point or new arrangement entirely (e.g. change in plant location) with Option C.

7.6.3 Marine Licence

A Marine licence from Marine Scotland may be required if investigation or repair work is carried out to the existing CW culvert in order to continue use of the system in Option A. This would depend on the extent of works required, if any.

Work in the Firth of Clyde for Option B will require a Marine Licence. The extent of works will become available once a detailed design has been agreed. However, the work will not involve digging or disruption to the seabed or beach areas, as threading through new pipes into the existing culvert would not present significant disturbance to the surrounding areas. It is thought that the work in the sea can be carried out within a few months.

Option C would also require a Marine Licence. The work to place a new pipeline would be extensive and take several months. As mentioned in Section 7.4, there would be disturbance to the beach and seabed areas and potentially adjacent fields. This could impact wildlife and marine life in the vicinity of the works. Issues with the seabed that were discovered during installation of the existing CW culvert could be experienced when attempting to install a new line.

7.6.4 Non radioactive contaminants in the effluent

The quality of the discharge effluent is not a distinguishing factor in any of the options, as there is no change to the treatment and processes prior to discharge. There is no change to the type of waste passing through these systems.

HNB has reduced its holding of hazardous chemicals since it stopped generating electricity and continues to remove hazardous materials from site throughout the defueling phase. HNB has a ’nil to drain’ policy.

The effluent collected in the AETP comes from various sources and is predominately town's water from cleaning operations. The plant includes various filtration methods and a Vertical Gravity Separator (VGS) and supporting plant to remove oil. The AETP contains sand filters, ceramic filters and cloth filters that clean the water as it passes through the system. This cleaning removes the majority of particulate. The AETP has a number of systems designed to ensure that the effluent reaching the final delay tank is suitable for discharge. A pre-sample is taken from the final delay tank to ensure the quality is acceptable for discharge and a further sample is taken during discharge.

Although the plant is less complex in the LLWF, the same principles apply and sampling is carried out prior to and during discharge.

Similar arrangements are employed at HNA where discharges are less frequent and much smaller volumes than HNB at present.

Any new waste processing methods will be designed to have local/built in filtration and abatement prior to effluents being transferred though the AETP and LLWF plant.

7.6.5 Other non-radioactive environmental impacts

Option A requires significant power consumption to operate the pumps and auxiliary systems. The CW plant and support systems also require small amounts of chemicals and oils during operation. Sodium Hypochlorite dosing of sea water would have to continue in Option A. In addition, the anti-foaming agent Nalfloc, would have to be retained if the CW system were to remain in use.

Option B does not pose any additional environmental impact than those mentioned already under the previous sub sections of Section 7. Option C would require more raw/building materials than Option B.

Options B and C provide an opportunity to significantly reduce the non-radiological environmental impact of the existing arrangements due to the independence from other plant systems.

7.7 Cost

The cost of making the discharge from the various collection points would be the same regardless of the option chosen. At HNB the uprating of pumps in AETP is required in any case, for the section of line up to the Siphon seal, discussed in Section 4.2.1.

Option A

Operation of the CW pumps and associated plant has become more difficult due to ageing of plant that has been in operation for over 48 years, which is beyond the original design basis. A Life-cycle Asset Management Plan (LAMP) review has been carried out, which describes the extensive plant systems required to support the CW systems and all of the interdependencies (Ref. 18).

The CW pumps were designed for continuous running to maintain cooling for the reactors. Intermittent operation of the pumps to support active discharges alone, introduces an increased risk of failures and/or damage as the components are worn primarily during initial start-up and, importantly, as deterioration of the pumps from continual assessment of 'live' parameters such as motor current and bearing temperature cannot be detected when the pump is idle.

Continued operation of the pumps would require both emergent and ongoing/planned maintenance supported by a dedicated team. Ongoing maintenance of the pumps is expensive. The pump components are large, need careful examination and are not easily accessible. The retention of a maintenance team specifically to maintain the CW pumps is considered disproportionate.

The power consumption of the pumps (1.7 MW per pump) would need to be taken into consideration. Is it estimated that the electrical power cost is in the region of ~ £3M per year (based on £206 per MWh (2024 forecast)) to run one pump continuously. This cost could vary significantly year on year.

The cost of the Sodium Hypochlorite chemical, its use, and the maintenance of the plant to inject the chemical, add to the costs associated with this option.

Option B

It is estimated that Option B would cost in the region of £2-3M pounds for design and installation (Ref. 19). This is based on the cost at other facilities (e.g. other Magnox sites) that have threaded through existing pipelines, and the initial investigation with experienced contract companies.

There would be minimal maintenance costs of the threaded lines after installation with the exception of periodic testing e.g. pressure testing methods and periodic inspection of the culvert. There is no reliance on other plant systems.

This option would not generate significant volumes of radioactive or non-radioactive waste and costs for waste disposal/transfer would be kept to a minimum.

Option C

It is estimated that the design and installation costs of Option C could be, at least, double that of Option B at around £5-6M (Ref. 19). Considerable ground works would be required to install the pipe underground, and although a majority of the line could be installed above ground, there would be an underground section to pass under the main access road. The installation would impact areas that are currently accessible to the public. As with Option B, the on-going maintenance costs after installation would be minimal and there is no reliance on other plant systems.

A greater volume of raw materials would be required to complete the installation of a new line and a greater potential for the creation of waste as a result of Option C.

An additional cost for Option C would be the need to perform a further dispersion model as the point of discharge into the environment would be different.

Additional costs would be incurred for Option C as further dispersion modelling would be necessary to account for a change in the permitted discharge point into the environment.

There is a significant risk with the cost estimate of installing a new line. The condition and stability of the seabed is unknown and there is a potential for costs to escalate if additional mitigations are required to complete installation works.

Option C is likely to take more time for permits variations and marine licences, resulting in the continued use of the CW system for a longer period than Option B, which adds to the cost of this option.

7.8 Others

7.8.1 Decommissioning

At HNB, large plant areas such as the Turbine Hall, Cooling Water Pumphouse and supporting systems would have to be redundant to optimise deconstruction of HNB within a reasonable timescale.

The continued use of the CW system at HNB would prevent a large proportion of the site from being decommissioned and would require significant maintenance and investment.

Liquid effluent discharges will continue throughout the deconstruction phase at HNB. There is a potential for HNA to require the continued use of its discharge line beyond the requirement at HNB. Therefore, a design that negates interdependency between the sites, would be the best solution for a sustainable aqueous waste disposal route, regardless of the decommissioning forecast for each site. Therefore, only Options B or C can realistically be taken forward into the deconstruction phase of HNB.

For the same reason, maintaining separate lines from HNB and HNA within the existing culvert (Option B) or with a new line (Option C), rather than directing effluent into a shared line from the land shaft would be the optimised solution for decommissioning (discussed further in Section 8).

7.9 Relative risk between options

The discussion points throughout Section 7 have been summarised in the table below:

RELATIVE RISK BETWEEN OPTIONS - SUMMARY									
Relative Risk between Options	**Option A**			**Option B**			**Option C**		
	H	**M**	**L**	**H**	**M**	**L**	**H**	**M**	**L**
Nuclear Safety and Impacts on Site Licence (including LC 34)	☐	☒	☐	☐	☐	☒	☐	☐	☒
Public Radiation Exposure and Safety	☐	☐	☒	☐	☐	☒	☐	☐	☒
Operator Radiation Exposure	☐	☐	☒	☐	☐	☒	☐	☐	☒
Conventional Safety	☒	☐	☐	☐	☐	☒	☐	☒	☐
Radioactive Substances Regulation Impacts and Compliance	☐	☐	☒	☐	☒	☐	☐	☒	☐
Non-radioactive Environmental Impacts and Compliance	☒	☐	☐	☐	☐	☒	☒	☐	☐
Cost	☒	☐	☐	☐	☐	☒	☐	☒	☐
Others (Decommissioning)	☒	☐	☐	☐	☐	☒	☐	☒	☐

It is clear from the summary that Option B holds the least risk across most of the attributes, with the exception of the RSR Impacts and compliance, due the fact that a variation of the existing EASR permits is required to implement this option.

Therefore Option B is the preferred option representing the Best Practicable Means.

8 Optimisation of the BPM Option

There is an opportunity to build in optimisation of Option B with regard to ensuring radioactive waste arisings and environmental impact are reasonably minimised. A HAZID exercise was carried out to review some of the details relating to the design of a threaded pipeline (Ref. 20).

8.1 Open ended culvert and outlet pipes

The existing design of the culvert includes a metal grid over the outlet (See Appendix B). The design was to prevent marine life from entering the culvert. This would have been unlikely with the constant high volume flow rate and Sodium Hypochlorite dosing. The detailed design phase of a new threaded line will review an open ended culvert with grating, and consideration for the potential for marine life to grow. If the culvert is left open with a grating as pre the existing design, the culvert can be inspected routinely using remote means.

If the end of the culvert were to be closed, a new separate pipe for the sewage discharge would be required to be threaded though the culvert alongside the new discharge lines from HNA and HNB.

The new design will consider the materials to be used for the new lines to limit marine fouling if the new lines are left open. As stated earlier, the ability to pressure test the lines can be achieved by temporary blanking of the end of each pipe with a flange fitting, whereby the blank can be removed after testing. This method is used in many piping installations to sea.

If the end of the new pipe lines have a type of non-return arrangement there could be a risk that the end piece would not open during the discharge or pressure towards the end of the discharge would not be sufficient to allow the free passing of the discharged effluent into the sea.

Capping off the pipes and culvert creates a larger maintenance and inspection burden that is likely to be disproportionate to the risk from marine growth. However, the detailed design phase will consider various options to optimise a reduced maintenance arrangement.

8.2 Flow rate of effluent discharges

The nominal discharge flow rate from HNB is 31m^3/hr. This rate is currently achieved between the AETP/LLWF and the Syphon Seal pit. It is also the flowrate used in the dispersion modelling report at the discharge point out at sea (Ref. 10).

The pressure of the discharge at the start with a full Final Delay Tank can be as much as 44m^3/hr, tapering off as the tank empties to a possible 12m^3/hr towards the end of the discharge. This bounds the case for discharges from the AETP and the LLWF at HNB (Ref. 8). Currently, a large Final Delay Tank at HNB can take just over 3 hours to discharge, which fits into the tidal window condition in the permit.

As mentioned in Section 4.2.1, new pumps are being installed at the HNB AETP to ensure that the average nominal flow rate is retained at 31m^3/hr, taking account of the new materials on the pipeline between the AETP/LLWF and the Siphon Seal pit and the additional length of pipeline from the Siphon Seal pit to the discharge point.

At HNA, the current average flowrate is ~17m^3/hr and takes under 3 hours to empty a Final Delay Tank (35m^3 in each tank). HNA currently has a 4 inch bore pipe to the land shaft which would be retained (Ref. 7).

HNA have evaluated that pumping through an additional section of line from land shaft to the discharge point has a small impact, with flowrates of ~15m^3/hr to 17m^3/hr being achieved (based on 6 inch bore pipe from the land shaft). This will allow for discharge of a tank within a 3 to 4 hour window, if required, without the need to change the existing pumps (Ref. 7).

The information above from both HNA and HNB is based on an open pipe without added resistance of non-return valves or flap at the discharge point. If the pipes are not completely open, a review of pump rating may be required.

8.3 Potential to flush

The discharge lines at HNA and HNB are completely underground, providing protection to the lines and also providing protection from dose rates from the pipes (although very low levels). As the station is now in the defueling phase, the levels of radioactivity will continue to decline.

For the sections of pipes to the Siphon Seal pit at HNB and the land shaft at HNA, there is currently residual effluent left in the line after discharges. The discharged effluent is subsequently diluted and transferred out by the CW system at these points. Ceasing the CW system will mean that the new sections of pipes to the discharge point will contain residual effluent after discharges and the capability to flush the lines should be considered.

Flushing the line with towns-water would require a new plant system or the ability to fill the Final Delay Tanks with towns-water after a discharge. There is no readily available water supply large enough to fill the tanks rapidly (only domestic supply in the AETPs and the LLWF). Therefore, it would take considerable time (days) to obtain enough water to flush the lines without a new plant system being installed.

As mentioned, the new pipelines would have a pressure testing capability designed in and therefore a method of determining a leak along the full length of both the HNA and the HNB lines from their collection points, would be available.

The environmental impact and cost detriment of installing a flush system is considered to be disproportionate to the risk of residual low level radioactive effluent within the lines. For this reason it is not considered BPM to install a system that would allow for flushing of the discharge lines.

8.3.1 Tidal windows in the EASR Permits

If no tide conditions are stated in the EASR permits, there would be no need for flushing the line as continuous discharges would be permitted. Once a discharge has finished, the natural migration of remaining effluent into the Firth of Clyde would be authorised.

8.4 Tidal window

The current EASR permits stipulate that the effluent must be discharged during the interval commencing one hour after high tide, and ending one hour before low tide. While it is possible to discharge a full final delay tank from HNB, this restriction sometimes requires discharges to be undertaken outside normal working hours. This forms part of normal operations when the station is generating and defueling, but could become restrictive as HNB moves from defueling into decommissioning, when there is unlikely to be shift workers available. Other decommissioning sites do not have tidal window conditions in their permits to discharge.

HNA makes liquid effluent discharges less frequently than HNB due to less water activities in its current stage of decommissioning and can manage liquid effluent waste arisings in conjunction with working day time tidal windows.

It would be more efficient and also minimise resource burdens to discharge effluent during normal day working hours, rather than employing shift teams to manage discharges. This would allow for more flexibility on the use of the existing tank capacity rather than having to manage tanks around tides on certain days, with the potential to stop decommissioning processes until the tanks are emptied.

The dispersion model report (Ref. 10) indicates that a tidal window has no impact on dispersion or dilution in the Firth of Clyde and, as such, the condition in the discharge permit is disproportionate to the risk.

8.5 Leak detection capability

A review of leak detection capability with a new line, can be carried out during the detailed design phase. As a minimum, the end of the new small bore pipes can include a means (e.g. a flange) for fitting a blank to allow pressure testing of the lines from HNA and HNB and identify any line breaches.

Leak detention capability/pressure testing is a significant benefit of installing new lines.

The modification process at both HNA and HNB would take into account a change in the Maintenance Schedule requirements for this additional testing.

8.6 Shared or separate lines from the land shaft

Consideration was given to whether there should be one shared line from the land shaft area, where the HNA line would join into the new HNB line. This would require the installation of non-return valves and interdependency of the two sites.

It is unknown if HNA will continue to be in the deconstruction phase beyond HNB entering the Care and Maintenance phase, where there will be no planned discharges from HNB. Separate lines allows each site to make discharges independently from each other and avoids significant future work to decouple the HNA and HNB discharge arrangements.

Although separate lines will utilise double the materials for the pipelines and ultimately double the radioactive waste when the lines are decommissioned, the waste activity will be very low level and perhaps out of scope of the EASR regulations (Ref. 1). It is regarded that this would be the BPM option given that separate lines would be required in the future in any case as HNA and HNB are at different stages of decommissioning and the decommissioning forecast for each is different.

8.6.1 Install parallel pipe lines for redundancy

A second line parallel to the new HNA and HNB lines running from the land shaft to the discharge point was considered in terms of providing redundancy (i.e. two lines each for HNA and HNB). A second line would mitigate the risk of one line becoming blocked e.g. due to marine growth at the discharge point, although the likelihood of this is expected to be low. The additional line itself would also be at risk of marine growth as this is a common mode of risk on all pipes and idle pipes may indeed have increased risk. The design of the new pipes is expected to take account of the management of marine growth.

Secondary lines would also introduce more materials, which would itself ultimately become waste, and more valves would increase the levels of maintenance.

Consideration will be given to the potential to switch between the lines (HNA and HNB) at the land shaft, for redundancy, as part of the detailed design.

9 Conclusions

Option A to maintain the existing arrangements with the CW system results in the highest environmental risk and the highest cost detriment of all options due to the excessive electrical power requirements and maintenance and inspection of the system and all supporting systems. The only benefit of Option A would be that a variation to the EASR permits would not be required. This option scored the highest risk in most of the attributes of the BPM assessment.

Option C to install a completely new small bore discharge line to a new discharge point, has been discounted on the basis of historical evidence relating to the instability of the seabed and the resultant costs incurred due to potential design modifications. The uncertainty of the stability of the seabed means the cost could also rise significantly in terms of extending the use of the CW system, whilst trying to resolve unquantified problems. Notwithstanding the potential increased costs of mitigating seabed instability, the cost was deemed to be around double that of Option B. Environmentally, this option represented the worst case for disturbing both wildlife and marine life.

It is clear from this assessment that Option B represents the best value for money and the least environmental risk and scored the lowest risk in most attributes of the BPM assessment. Other key factors are:

- Maintaining the existing discharge point maintains the long standing District Survey Monitoring Programme.
- Threading small bore pipe through the existing culvert is an established method already utilised at other sites, without causing disruption to the seabed or beach areas.
- This option does require a variation to the EASR permits due to the decrease in flowrates of the discharges. The dispersion modelling that was carried out demonstrated that the CW flow and a tidal window provides little benefit to dilution and dispersion of the discharges in the Firth of Clyde.

In summary, Option B provides the sustainable lowest risk overall with the requirement to request a variation to the EASR permits to; lower the flowrate of the discharges to those achievable by the Final Delay Tank pumps (at HNA and HNB) and to remove the tidal window condition.

10 Recommendations

10.1 HNB and HNA to apply for a variation to the EASR18 permits (Ref. 2 & 3) to remove the requirement for a flow rate of 7m^3/s and a discharge tidal window.

10.2 HNB to liaise with Marine Scotland regarding an application for a Marine Licence to carry out the threading through of small bore pipes in the culvert.

10.3 HNB to produce detailed design plans for implementing Option B, to ensure that the existing discharge point is maintained.

10.4 HNB to assess the arrangements for switching to a new discharge arrangement with Option B, whilst maintaining permitted discharges from both HNA and HNB.

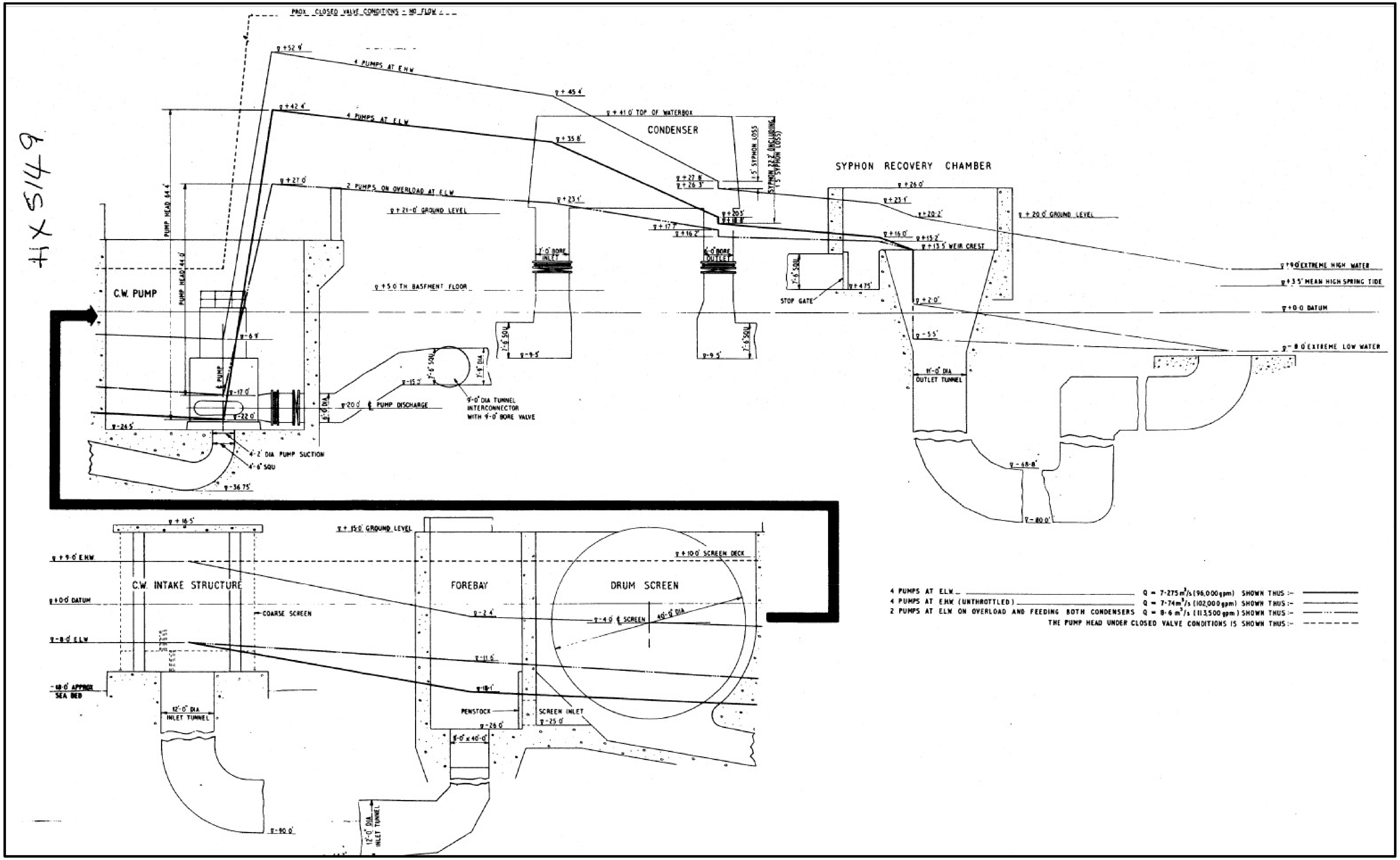
11 References

Ref.	Document Identifier	Document Title
1.	EASR18	Environmental Authorisations (Scotland) Regulations 2018
2.	EAS/P/1173609	Hunterston A Site EASR18 permit
3.	EAS/P/1173596	Hunterston B Site EASR18 permit
4.	CAR/R/1012347	SEPA CAR Registration to abstract sea water as cooling water HNB
5.	HNB AEDT Agreement	Agreement between Scottish Nuclear Limited and Nuclear Electric Plc entitled 'Active Effluent Treatment and Discharge at Hunterston' dated 27th March 1996.
6.	CAR/L/1000649	SEPA CAR Licence to discharge cooling water and other trade effluent from HNB.
7.	HNA/2912/ED/CS/1556	HNA Engineering flow calculations form and relevant email from Hunterston A Decommissioning Site dated 30/11/2023, Anthony Lapsley (System Engineer)
8.	HPS/ENG/DR2729	Active Effluent Discharge Flow considerations, HNB Engineering departmental report.
9.	CAR/L/1010509	SEPA CAR Licence to discharge treated sewage effluent
10.	ENE – 0328A/R1	Dispersion of aqueous effluent from Hunterston power stations, Eden Nuclear and Environment.
11.	ERO/REP/0232/GEN	Public Radiation Dose in the Vicinity of EDF Energy Nuclear Power Stations in 2018
12.	ERO/REP/0259/GEN	Public Radiation Dose in the Vicinity of EDF Energy Nuclear Power Stations in 2020
13.	ERO/REP/0273/GEN	Public Radiation Dose in the Vicinity of EDF Energy Nuclear Power Stations in 2022
14.	RIFE 28	Radioactivity in food and the environment, 2022. Government Publications (gov.uk)
15.	ND/REP/TAD/0019/GEN/22	Liquid Active Effluent Discharge Credible Options Fleet Review
16.	HNB/REP/PD/W048/004	Post Fuel Free Active Effluent Discharge Arrangements Preferred Option Selection.
17.	Personal statement from SEPA	Email from SEPA representative dated 03/02/2023, Simon Kirk.
18.	HNB/REP/LAMP2/G31/001	Life-cycle Asset Management Plan 2.0: Hunterston B Power Station, G31 Circulating Water Plant
19.	W048 Power Point	HNB Active Effluent Discharge Line - Alternative discharge line to sea, David Lappin.
20.	W048 HAZID worksheet	Active Effluent Discharge Line - HAZID for new line from Siphon Seal pit 07/11/2023.

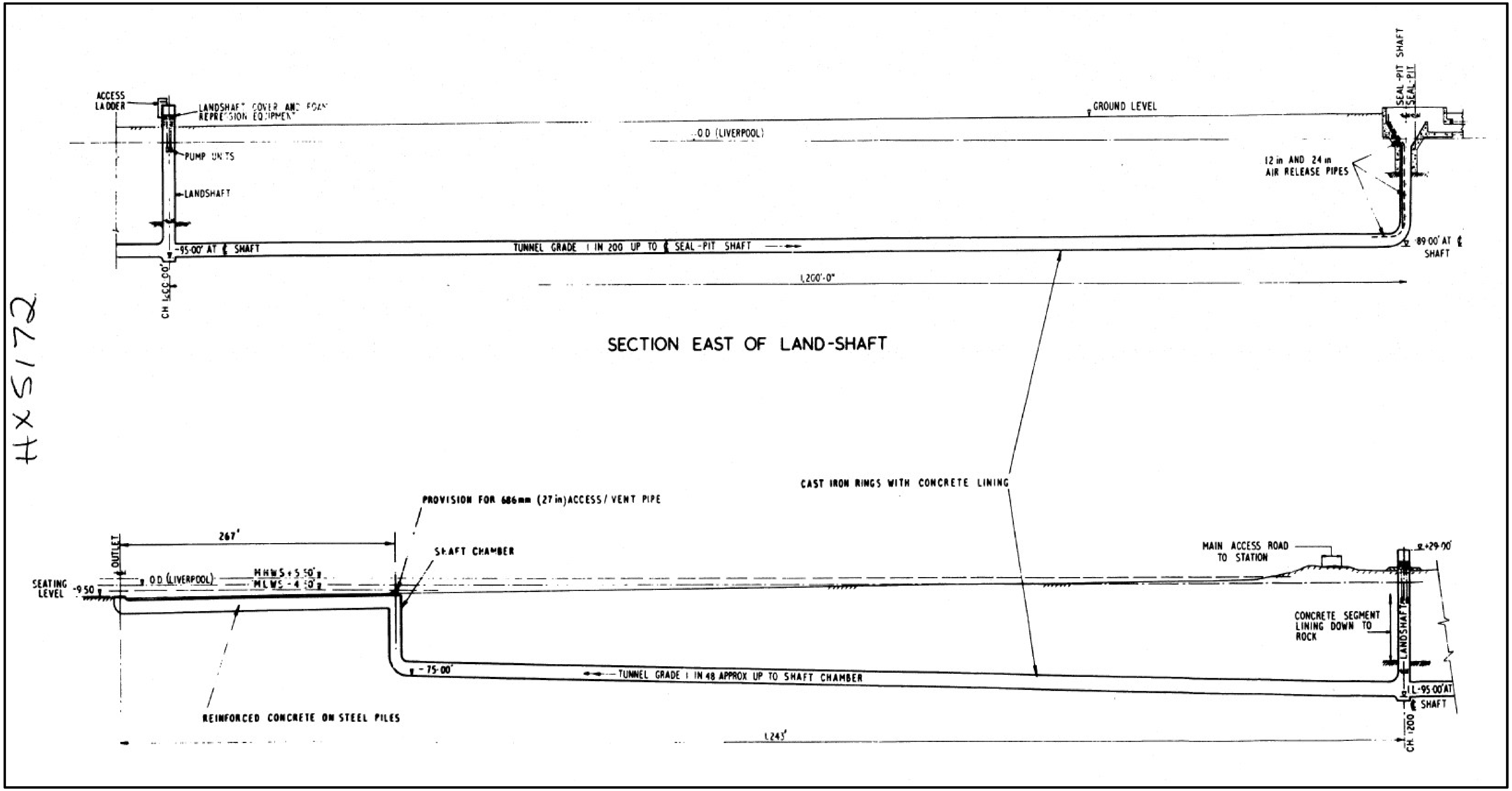
12 Distribution List

Name	Position / Location
[redacted]	Environmental Safety Group Head (RPA)
[redacted]	Environmental Safety Engineer (Acc RWE/RWA)
[redacted]	Technical Safety Support Manager
[redacted]	Transfer and Deconstruction Preparations Manager
[redacted]	Transfer and Deconstruction Programme Manager
[redacted]	Transfer and Deconstruction Project Manager

Appendix A Cooling Water intake and discharge



Appendix B Cooling Water Culvert cross section



Appendix C AETP and LLWF active effluent lines at HNB