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Ross,

Heat Sink Qualitative ALARP Assessment

As requested I have extracted the Qualitative ALARP Assessment for the Heat Sink from the PCSR2 Heat Sink Summary Document (HPC-NNBOSL-U0-RET-000011) and included as an attachment to this letter.

Yours sincerely

Neil Shire
Design Authority,
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Extract from

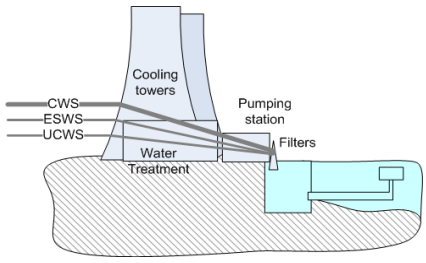
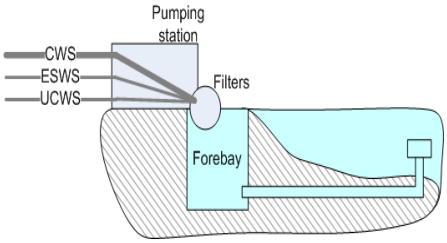
HPC PCSR2 – Heat Sink Summary Document, HPC-NNBOSL-U0-RET-000011 Rev 1.0

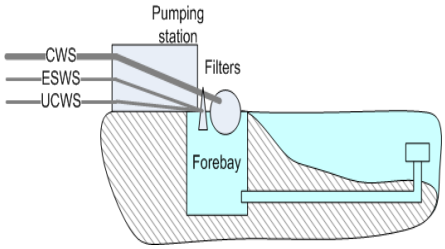
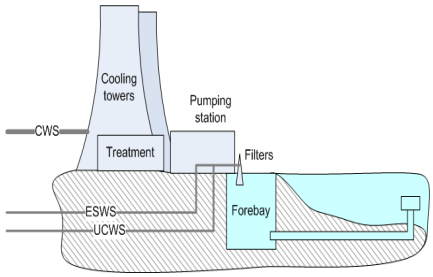
Appendix F – QUALITATIVE ALARP ASSESSMENT

F.1 Open versus Closed Systems

The advantages and disadvantages of the identified options are summarised in Table F.1 which has been developed with reference to [92]. In order to simplify the comparisons between open and closed systems certain details are not presented, including the ACWS and the form of filtration.

Where filtering is shared between the safety systems and the CWS/ACWS, the risk of safety system clogging is reduced because the filters are inherently over-sized in relation to the safety system flow-rate. The 'over-capacity' of the filters is indicated by the ratio of the total flow-rate (safety plus non-safety) to the safety flow-rate (see Table 1). This is significant where the ESWS is shared with the CWS (>15:1) and still appreciable when the ESWS is shared with the ACWS (~2.5:1).

Option Description	Schematic	Pros and Cons
OPTION 1 CWS closed ESWS closed UCWS closed Typical no. of towers per unit: 2 large 2 small		**PROS** ○ Not vulnerable to marine hazards (ships, clogging, drought) due to water reserve. ○ Minimal impact on the marine environment. **CONS** ○ Limited OpEx associated with water treatment and potential long term implications for reliability. ○ Water treatment would reduce power output. ○ Significant waste would be generated which would require disposal. ○ Potentially vulnerable to extreme weather hazards. ○ Localised warming and large visual impact with naturally vented towers. ○ High land-take.
OPTION 2 CWS open ESWS open UCWS open CWS/ESWS/ UCWS shared filtering.		**PROS** ○ Well proven technology and extensive OpEx. ○ No need for water treatment and low levels of waste generation. ○ No significant visual impact. ○ Less vulnerable to extreme weather effects. **CONS** ○ Slight vulnerability to clogging (reduced by shared filtration with CWS). ○ Vulnerable to other marine hazards (e.g. ship collision, drought). ○ Long, large diameter tunnel required. ○ Environmental impact due to fish capture and aquatic thermal discharge (and possibly chemical dosing).

Option Description	Schematic	Pros and Cons
OPTION 3 CWS open ESWS open UCWS open ESWS/UCWS filtering separate from CWS filtering.		**PROS** ○ Independent filtering of safety systems and CWS means hardening requirements are less. ○ Well proven technology and extensive OpEx. ○ No need for water treatment and low levels of waste generation. ○ No significant visual impact. ○ Less vulnerable to extreme weather effects. **CONS** ○ Some vulnerability to clogging (non-oversized filters provide less clogging protection). ○ Vulnerable to other marine hazards (e.g. ship collision, drought). ○ Long, large diameter tunnel required. ○ Environmental impact due to fish capture and aquatic thermal discharge (and possibly chemical dosing).
OPTION 4 CWS closed ESWS open UCWS open ESWS/UCWS shared filtering. Typical no. of towers per unit: 2 large		**PROS** ○ Diverse means of cooling between safety systems and CWS means hardening requirements are less (cooling towers not safety classified) and water intake structures can be much smaller, reducing costs. ○ Less vulnerable to extreme weather effects. **CONS** ○ Some vulnerability to clogging (non-oversized filters provide less clogging protection). ○ Vulnerable to other marine hazards (e.g. ship collision, drought). ○ Water treatment would be required which would reduce power output. ○ Significant waste would be generated which would require disposal. ○ Localised warming and large visual impact with naturally vented towers. ○ Minor fish capture and aquatic thermal discharge (and possibly chemical dosing). ○ High land-take.

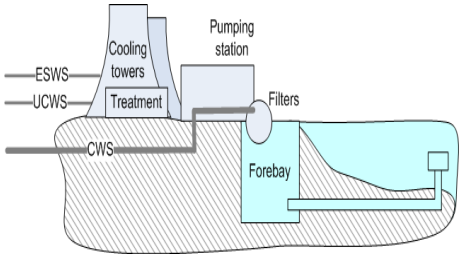
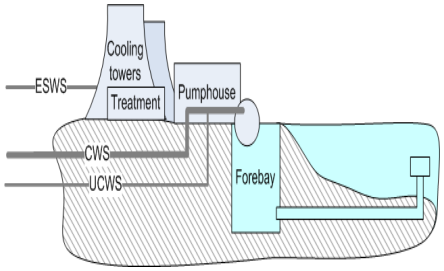
Option Description	Schematic	Pros and Cons
OPTION 5 CWS open ESWS closed UCWS closed Typical no. of towers per unit: 2 small		**PROS** ○ Diverse means of cooling between safety systems and CWS means hardening requirements are less (pumping station not safety classified), reducing costs. ○ Not vulnerable to marine hazards (ship collision, clogging, drought) due to water reserve. **CONS** ○ Limited OpEx associated with water treatment and potential long term implications for reliability. ○ Low volumes of water treatment would be required which would reduce power output. ○ Potentially vulnerable to extreme weather hazards. ○ Low levels of waste would be generated which would require disposal. ○ Minor visual impact, depending on cooling tower design. ○ Major fish capture and aquatic thermal discharge (and possibly chemical dosing). ○ Increase in land-take. ○ Relatively expensive due to requirement for open and closed systems.
OPTION 6 CWS open ESWS closed UCWS open or *vice-versa* CWS/UCWS or CWS/ESWS shared filtering. Typical no. of towers per unit: 2 small		**PROS** ○ Diverse means of cooling between ESWS and CWS/UCWS (or *vice-versa*) means hardening requirements are less, reducing costs. ○ Diverse means of cooling water collection between ESWS and UCWS increases safety. ○ Less vulnerable to marine hazards (ships, clogging, drought) due to water reserve. **CONS** ○ Limited OpEx associated with water treatment and potential long term implications for reliability. ○ Low volumes of water treatment would be required which would reduce power output. ○ Low levels of waste would be generated which would require disposal. ○ Minor visual impact, depending on cooling tower design. ○ Major fish capture and aquatic thermal discharge (and possibly chemical dosing). ○ Increase in land-take. ○ Relatively expensive due to requirement for open and closed systems.

Table F.1 Open versus Closed Option Appraisal

Discussion of Open versus Closed Options

Option 1 (entirely closed circuit) offers advantages compared to Options 2 and 3 (entirely open circuit) in relation to its independence from the marine environment and associated hazards. However, providing the dominant clogging hazard is controlled, these advantages are outweighed by the significant disadvantages of using large cooling towers with turbid, salty water. A water treatment plant would be required to process the make-up water leading to increased land-take, a reduction in power output and the generation of significant amounts of waste requiring disposal. Further disadvantages of the closed circuit option are the major land-take and the visual impact of large cooling towers. The potential vulnerability of cooling towers to extreme weather hazards is an additional factor which favours an open circuit solution. For Options 2 and 3, the available operating experience of open circuit designs at coastal power station sites is an advantage. Manageable solutions exist for the drawbacks associated with the marine hazards, as described in Section 4. Options 2 and 3 are therefore favoured over Option 1.

Option 2 has an advantage over Option 3 in that filtering is shared between the safety systems and the CWS, thereby benefiting from the 'over-sized' filtering arrangement and reducing the impact of marine clogging. Option 2 is therefore favoured over Option 3.

Option 4 offers a diverse means of cooling between safety systems (open circuit) and the CWS (closed circuit). This reduces hardening requirements as the cooling towers are not safety classified, and reduces the size of the water intake structures, leading to reduced costs. However, all of the disadvantages relating to large cooling towers in Option 1 remain, together with the disadvantage of using dedicated filters for the safety systems, potentially making them more vulnerable to clogging hazards. Option 2 is therefore favoured over Option 4.

The disadvantages for closed circuit systems are reduced if cooling towers are used only for the safety systems, i.e. the ESWS and/or UCWS, as presented in Options 5 and 6. It is assumed here that water treatment would still be required for the make-up water and there would be associated waste generation and disposal requirements but all at a significantly lower volume than for a closed circuit CWS. These issues may be avoided if townswater could be used as make-up instead of sea water, or if some form of roof-mounted cooling fan system could be used in place of the cooling towers. If a large open circuit water intake structure is provided for the CWS, then the expense of constructing an additional cooling arrangement for the safety systems appears disproportionate to the safety benefit gained. Option 2 is therefore favoured over Options 5 and 6.

Option 2 (entirely open circuit with shared filtering) is selected as the ALARP solution as it meets the technical feasibility and safety requirements and offers the least risk in terms of programme delivery.