From: Matthew Hiser
Sent: Tuesday, April 25, 2023 3:43 PM
To: Drew Peebles; Darrell Gardner
Cc: Andrew Proffitt; Benjamin Beasley; Samuel Cuadrado de Jesus; Edward Helvenston
Subject: Hermes Audit Reports
Attachments: Report for Audit Kairos Hermes CP PSAR Chapter 2 Site Characteristics.pdf; Report for Audit Kairos Hermes CP Decay Heat Removal System.pdf; Report for Audit Kairos Hermes CP PSAR Chapter 7 I&C.pdf

Dear Darrell and Drew:

Attached are summaries of three audits conducted by U.S. Nuclear Regulatory Commission (NRC) staff (the staff) of the Hermes test reactor site characteristics, decay heat removal system, and instrumentation and controls as presented in the Preliminary Safety Analysis Report (PSAR). By letter dated September 29, 2021, Kairos Power LLC (Kairos) applied for a construction permit (CP) under Title 10 of the Code of Federal Regulations (10 CFR) Part 50 for its Fluoride Salt-Cooled, High Temperature Non-Power Reactor (Hermes); the application included a preliminary safety analysis report (PSAR) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21272A375). PSAR Chapter 2, “Site Characteristics,” describes the site location, including a discussion of the population in the vicinity, the distribution of infrastructure and natural features, as well as the basis for selection of the Hermes reactor site. PSAR Chapter 6, “Engineered Safety Features,” Section 6.3, “Decay Heat Removal System” (DHRS), describes the DHRS and its safety function of removing decay heat when the normal heat rejection system is unavailable. PSAR Chapter 7, “Instrumentation and Control Systems,” describes the instrumentation and control (I&C) systems that monitor and control plant operations during normal operations and planned transients and also monitor and actuate protection systems in the event of unplanned transients.

These audits allowed the staff to gain a better understanding of Kairos’s PSAR through review and discussion of underlying supporting documentation and aided in assessing the safety of the proposed test reactor. Enhanced understanding and communications provided detailed information to the staff and supported effective and efficient development of information needs. The staff reviewed information through the Kairos Electronic Reading Room (ERR) and held discussions with Kairos staff to understand and resolve questions. In many cases, Kairos updated the Hermes PSAR to resolve items discussed in the audit.

Sincerely,
Matt

Matthew Hiser
Senior Project Manager
Advanced Reactor Licensing Branch 1 (UAL1)
Division of Advanced Reactors and Non-Power Production and Utilization Facilities (DANU)
Office of Nuclear Reactor Regulation (NRR)
US Nuclear Regulatory Commission
Phone: 301-415-2454 **|** *Office: OWFN 6C53*
Matthew.Hiser@nrc.gov

Hearing Identifier: NRR_DRMA
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Created By: Matthew.Hiser@nrc.gov

Recipients:
"Andrew Proffitt" <Andrew.Proffitt@nrc.gov>
Tracking Status: None
"Benjamin Beasley" <Benjamin.Beasley@nrc.gov>
Tracking Status: None
"Samuel Cuadrado de Jesus" <Samuel.CuadradoDeJesus@nrc.gov>
Tracking Status: None
"Edward Helvenston" <Edward.Helvenston@nrc.gov>
Tracking Status: None
"Drew Peebles" <peebles@kairospower.com>
Tracking Status: None
"Darrell Gardner" <gardner@kairospower.com>
Tracking Status: None

Post Office: BLAPR09MB6563.namprd09.prod.outlook.com

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MESSAGE	2484	4/25/2023 3:42:00 PM
Report for Audit Kairos Hermes CP PSAR Chapter 2 Site Characteristics.pdf	201955	
Report for Audit Kairos Hermes CP Decay Heat Removal System.pdf	177438	
Report for Audit Kairos Hermes CP PSAR Chapter 7 I&C.pdf	160871	

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SUMMARY REPORT FOR THE REGULATORY AUDIT OF KAIROS POWER LLC HERMES CONSTRUCTION PERMIT PRELIMINARY SAFETY ANALYSIS REPORT SITE CHARACTERISTICS (CHAPTER 2)

June 2022 – August 2022

1.0 BACKGROUND AND PURPOSE

By letter dated September 29, 2021, Kairos Power LLC (Kairos) applied for a construction permit (CP) under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 for its Fluoride Salt-Cooled, High Temperature Non-Power Reactor (Hermes); the application included a preliminary safety analysis report (PSAR) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21272A375). PSAR Chapter 2, "Site Characteristics," describes the site location, including a discussion of the population in the vicinity, the distribution of infrastructure and natural features, as well as the basis for selection of the Hermes reactor site.

This audit enabled the U.S. Nuclear Regulatory Commission (NRC) staff (the staff) to gain a better understanding of Kairos's PSAR Chapter 2 through review and discussion of underlying supporting documentation. Enhanced understanding and communications supported effective and efficient development of information needs.

2.0 AUDIT REGULATORY BASES

The bases for the audit are the regulations in 10 CFR Part 50, Sections 50.34(a), "Preliminary Safety Analysis Report," specifically 50.34(a)(1)(i) and 50.34(a)(4).

3.0 AUDIT OBJECTIVES

The primary objective of the audit was to enable a more effective and efficient review of PSAR Chapter 2 through the staff's review and discussion of supporting documentation with Kairos. Gaining access to underlying documentation and engaging in audit discussions about site characteristics facilitated the staff's understanding of the Hermes application and aided in assessing the safety of the proposed test reactor. The audit improved communication and provided detailed information for the staff.

4.0 SCOPE OF THE AUDIT AND AUDIT ACTIVITIES

The audit was conducted from June to August 2022, via the Kairos electronic reading room (ERR). The staff conducted the audit in accordance with the Office of Nuclear Reactor Regulation (NRR) Office Instruction NRR-LIC-111, Revision 1 "Regulatory Audits" (ML19226A274).

Members of the audit team, listed below, were selected based on their detailed knowledge of the subject. Audit team members included:

1. Amitava Ghosh, NRR (Technical Reviewer)
2. Yuan Cheng, NRR (Technical Reviewer)
3. Jenise Thompson, NRR (Technical Reviewer)
4. David Heeszel, NRR (Technical Reviewer)
5. Jason White, NRR (Technical Reviewer)
6. Benjamin Beasley, NRR (Project Manager)
7. Edward Helvenston, NRR (Project Manager)

Prior to the audit, the audit team reviewed PSAR Chapter 2 and provided preliminary questions on site characteristics by e-mail on January 10, 2022 (ADAMS Accession No. ML22024A492). Kairos responded to the preliminary questions on February 3, 8, and 9, 2022 (ML22041A337, ML22040A142, ML22040A338). In the audit plan (ML22143B016), the staff provided a series of remaining questions (following the preliminary questions and responses) to be addressed and focused on during the audit.

During the audit, meetings were held between the staff and Kairos on June 9, July 27, and August 4, 2022.

The staff reviewed the following documents via the ERR:

- “Report of Geotechnical Exploration K-33 Site Due Diligence” (Geotech report)
- “Guide to Classification of Soil for Field Boring Logs”
- PSAR pages indicating changes proposed by Kairos in response to various audit questions

5.0 SUMMARY OF AUDIT OUTCOME

The staff’s audit focused on the review of supporting documents associated with the questions identified in the audit plan (ML22143B016). The staff reviewed information through the Kairos ERR and held discussions with Kairos staff to understand and resolve questions. In many cases, Kairos updated the Hermes PSAR to resolve items discussed in the audit. The tables below summarize the resolution of the audit questions.

Resolution of Questions on Nearby Facilities

Question Number	Question	Resolution
2.2-1	In Section 2.2.1.3, the last sentence of the middle paragraph reads "… the annual average daily vehicle count at TN 58 north of the intersection with TN 58 was 12,641 in 2018." Should the first reference to TN 58 in this portion of the sentence refer to TN 327?	The typographical error was corrected to change the second reference to TN 58.
2.2-2	The last paragraph of Section 2.2.2.3 states, "The average flight distance of 37 miles is selected based on the generic flight length provided in Table B-43 of DOE-STD-3014-2006." However, the DOE Standard value of 37 miles is provided as an example; it is not generic. Please clarify the justification for the average flight distance of 37 miles, or revise PSAR Section 2.2.2.3 and Tables 2.2-8 and 2.2-9 as appropriate.	Kairos performed an additional sensitivity analysis to show this value is conservative.
2.2-3	Section 2.2.3.1 does not identify specific stored chemical explosion risks for nearby facilities. Please provide a basis for not considering these explosions or provide assessments of the potential explosion hazards for the chemicals identified in Tables 2.2-3 and 2.2-4.	Kairos verified that other nearby facilities were far enough away and modified the PSAR accordingly.
2.2-4	PSAR Section 2.2.3.1 states that the proposed Oak Ridge Airport will include two 10,000 gallon above-ground tanks for aviation fuels. The PSAR discusses potential explosive hazard from jet fuel tanks but does not appear to consider potential BLEVE. Would potential BLEVE of two jet fuel tanks at the proposed Oak Ridge Airport be a credible hazard to the proposed facility? If not, please explain. If so, please provide an analysis of this hazard in the PSAR.	Kairos analyzed the hazard from the jet fuel tanks and found significant margin based on the distance of Hermes from the airport. The PSAR was modified accordingly.
2.2-5	In PSAR Table 2.2-8, based on footnote (b), it appears Kairos based the “x distance” and “y distance” values on an assumption that all flights either taking off or landing use the same runway end (i.e., all flights take off or touch down at the same point at the same end of the runway). However, the NRC staff notes that it is not clear whether this assumption is correct. Please explain the coordinate system used in assessing “x distance” and “y distance” of the proposed facility from the proposed runway and discuss and justify whether Kairos used an assumption that all flights use the same runway end.	Kairos indicated that the coordinate system is based on distance from the center of the runway and made corrections to the Table. The PSAR was modified accordingly.

Resolution of Questions on Hydrology

Question Number	Question	Resolution
2.4-4	In PSAR Section 2.4, the applicant used different vertical datum, mean sea level (msl), NGVD29 and NAVD88, to indicate flood elevations and the Hermes site grade, respectively. Please provide the elevations using a consistent vertical datum or justify why the provided data are adequate.	PSAR modifications were made to clarify the elevations in Tables 2.4-2 and 2.4-3.
2.4-5	With respect to consideration of potential floods, PSAR Section 2.4 states, “River blockage on the Clinch River arm of the Watts Bar Reservoir, and flow diversion on Poplar Creek and the Clinch River are also considered. Additional information will be provided with the application for the Operating License.” PSAR Tables 2.4-2 and 2.4-3 show the flood elevations for various flood events resulting from river hydraulic computations. Please clarify whether the river blockage and flow diversion as indicated in the quoted statement from Section 2.4 were included in the computations to support the flood elevations shown in the Tables 2.4-2 and 2.4-3. If the Tables are not the result of considering the blockage and diversion, please clarify where the computational result of considering the blockage and diversion may be found in the PSAR. Also, according to PSAR Figure 2.4-1, there are three bridges crossing Poplar Creek. Are blockages on the stream due to potential failures of these bridges included in the river flood computations in Tables 2.4-2 and 2.4-3 or elsewhere in the PSAR?	Factors affecting flooding hazards, such as river blockage and flow diversion events, will be analyzed further and addressed in the FSAR. Analysis will include a blockage assessment for nearby bridges and possible sediment buildup as appropriate.
2.4-6	PSAR Section 2.4.1 states, “The November 28, 1973, and April 4, 1977, [East Fork Poplar Creek] floods were about equal in magnitude. These floods reached an elevation of 770.2 feet NGVD with a recurrence interval of approximately 30 years at 3.3 miles upstream of the confluence with Poplar Creek. Only minor damage occurred as a result of these floods (Reference 5).” The staff notes that the distance from the confluence to the Hermes site is approximately 2 miles. Based on the 2 miles of distance, it appears that floods at the recorded flood elevation of 770.2 feet (based on NGVD29) in the East Fork Poplar Creek may have an impact at the Hermes site, with a grade elevation at 765 feet (based on NAVD88). Please discuss what the potential inundation at the Hermes site could be, if the recorded 1973 and 1977 flood events extended to the Poplar Creek flow near the Hermes site.	Kairos modified the PSAR to clarify that these floods would have no impact to the Hermes site.
2.4-7	PSAR Section 2.4.3 indicates a “site-specific PMF analysis will be discussed with the application for an Operating License.” However, the details and basis of this “site-specific PMF” are not clear. Please clarify whether the “site-specific PMF” is a flood event resulting from a local intense precipitation (LIP) event as PSAR Section 2.4.3.3 appears to indicate, which the staff notes is different from the PMP used to estimate the	Kairos modified the PSAR to clarify the relevant statement and will consider maximum

	PMF in Section 2.4.2.1. Are the meanings of the “local PMP event” and “local intense precipitation [LIP] event” interchangeable as used in Section 2.4.3.3?	credible precipitation as appropriate in the operating license application.
2.4-8	PSAR Section 3.3.2, “External Flooding Events,” states, “The meteorological characterization from Section 2.3 provides a probable maximum precipitation accumulation of water.” As stated in PSAR Section 2.3.2.6, “Precipitation,” “For the site area, using a 100-year return period, the PMP for 6, 12, 24, and 48 hours is 5.0, 6.0, 6.8, and 8.0 inches, respectively (see Table 2.3-20).” Comparing these two quoted statements from Sections 3.3.2 and 2.3.2.6, the staff notes that, given how a PMP is otherwise described in Section 3.3.2, the statement in Section 3.3.2 appears to be inconsistent with the meteorological information from Section 2.3 because Section 2.3 describes a PMP that is based on a storm with a 100-year return period. Please clarify the quoted statement in Section 3.3.2 to confirm that the storm with a 100-year return period is different from the PMP event used in Sections 2.4 and 3.3.2 for evaluation of external floods. In addition, please clarify that the storm with a 100-year return period discussed in Section 2.3 is not applicable to Section 3.3.2, in which Kairos assumed the PMP is an event causing a PMF event with equal probability (see the assumption in Section 2.4.2.1).	Kairos modified PSAR Section 3.3.2 to clarify how external flooding events are considered in terms of hydrological loads on safety-related structures.

Resolution of Questions on Geology, Seismology, and Geotechnical

Question Number	Question	Resolution
2.5-1	PSAR Section 2.5.2 discusses borings and observation trenches used to explore subsurface conditions at the Hermes site, but some details of results of the borings and trenches do not appear to be provided in the PSAR. Please provide details of observations from the borings, including standard penetration test (SPT) N-values, as well as the trenches. In addition, please discuss how the information has been used in the design of the Hermes facility.	Kairos modified the PSAR to add detailed information on borings from the Geotech report. The actual design will be informed by additional borings that are planned and will be discussed in the operating license application.
2.5-2	PSAR Section 2.5.2 discusses soil types encountered at the Hermes site, but some details of the soils are not clear from the PSAR. Please provide soil classification, different index properties, measured strengths, and stiffness properties (modulus and Poisson’s ratio) for each soil type.	Kairos provided the Geotech report to the staff for viewing in the ERR. Kairos also stated that additional information and

		analysis on soil stiffness and strength properties affecting soil/backfill lateral pressure on the reactor building will be provided in the FSAR.
2.5-3	PSAR Figure 2.5-1 shows the boring plan for the Hermes site. Given that Figures 2.5-2 and 2.5-3 state that "[i]nformation between borings is assumed and actual conditions may vary" and given that the precise footprint of the reactor building is not determined and there are no boreholes in the close vicinity of the anticipated location, NRC staff needs additional information to assure that the site is appropriately characterized. Will the foundation of the safety related portion of the reactor building (basemat) be different than the foundation for the non-safety related portions of the building? Please explain the differences, if any.	Kairos modified PSAR Section 2.5.4.3 to clarify that the location of the Hermes reactor to be approximately 100 feet north of Boring B-5. Kairos modified PSAR Section 2.5.5.2 to clarify that the foundation of the safety-related portion of the Reactor Building will rest on concrete fill down to the bedrock.
2.5-4	PSAR Figures 2.5-2 and 2.5-3 provide subsurface profiles for the Hermes site, but do not appear to indicate the location of the reactor building. Describe the location of the reactor foundation in Figures 2.5-2 and 2.5-3.	Kairos modified PSAR section 2.5.5.2 to clarify that the location of the Hermes reactor will be approximately 100 feet north of Boring B-5.
2.5-5	Section 2.5.5.2.1 states that the underlying rock has adequate bearing capacity. To allow staff to confirm the bearing capacity of the rock, please provide rock fracture network characteristics, such as, number of joint sets and their orientations (dip and dip direction), open or filled joints, degree of weathering of the joints, and spacing of the joint sets. Also provide intact rock strength and stiffness properties (modulus and Poisson's ratio) and the rock mass strength and modulus estimation for each rock type along with the method used.	Kairos provided the Geotech report to the staff for viewing in the ERR. Kairos modified PSAR Section 2.5.5.2.1 to indicate that additional details on bearing capacity, settlement, and lateral pressure will be provided in the FSAR.
2.5-6	Based on the information in Figures in 2.5-2 and 2.5-3, the staff notes the high water table. The water table is not discussed in the text of the PSAR. Provide a discussion on what actions would be taken to address the high water table. Also discuss the seasonal variation of the water table and how the water table at the proposed site location would affect the bearing capacity and settlement of the reactor foundation.	Kairos provided clarifications to PSAR sections 2.4.1.2 and 2.4.4 on how the high water table and seasonal variations in water table will be addressed.

2.5-7	PSAR Section 2.5.2.3.2 states that the north portion of the Hermes site is underlain by the Mascot Formation, which is “medium to thickly bedded.” Please clarify what is meant by “medium to thickly bedded.”	Kairos provided access to “Guide to Classification of Soil for Field Boring Logs” describing soils and rocks that Kairos used.
2.5-8	PSAR Section 2.5.2.3.2 states that the midsection of the Hermes site is underlain by the Pond Springs formation, which is “medium bedded” and “medium jointed.” Please clarify what is meant by “medium bedded” and “medium jointed.”	
2.5-9	PSAR Section 2.5.2.3.2 states that the south end of the Hermes site is underlain by the Murfreesboro dolomitic limestone, which “is light gray, medium, close jointed…”. Please clarify what is meant by this description.	
2.5-10	PSAR Table 2.5-1 includes a description of Bedrock Murfreesboro that states it is “60 [degree],” and has “clay filled fracture at 30.5 [feet].” Please clarify what is meant by this description, including what type of clay the description is referring to.	
2.5-11	PSAR Section 2.5.2.1 states that the geotechnical investigation at the Hermes site encountered indications of karstic activity. PSAR Section 2.5.4.3 states that the “geotechnical subsurface investigation encountered limited evidence of voids or karstic dissolution at or near the reactor building location.” PSAR Section 2.5.4.3 discusses borings on the Hermes site, but it is not clear how the investigations confirmed that there are no unacceptable karst features at the site. However, it is not clear how Kairos plans to thoroughly evaluate the site for karst features. The staff notes that boring may not comprehensively identify karst features, and moreover, there are no boreholes within the reactor footprint that might identify small-scale karst features. How does Kairos propose to evaluate the subsurface rock mass for karst features? Does Kairos propose to use ground-penetrating radar (GPR), or perform other geophysical measurements?	Kairos modified PSAR Section 2.5.2.1 to indicate that additional tests and surveys will be performed and documented in the FSAR, including site reconnaissance, analysis of LiDAR imaging, inventory of surface depressions in the site area, deeper borings at the reactor location, laboratory analysis of rock cores and elaboration of the karst model for Hermes.
2.5-12	PSAR Section 2.5.4.2 states that the Hermes safety-related reactor foundation basemat would be placed on bedrock, and surrounding structures would be placed either on bedrock or engineered soil. However, Kairos’ response dated February 9, 2022 (ML22040A336), to Question 2.5-2 which the staff sent to Kairos by email dated January 10, 2022 (ML22024A492), states that the Hermes foundation will be placed “over an engineered crushed stone or lean concrete fill placed directly over sound rock.” Please clarify the apparent discrepancy, especially with respect to the foundation of the safety-related portions of the reactor building.	Kairos modified the PSAR to clarify the plans for constructing the foundation of the safety-related portion of the Reactor Building

	In addition, to allow the staff to confirm the adequacy of engineered soils/backfill, please provide characteristics of engineered soils, crushed stone, and lean concrete proposed to be placed between the foundations of the reactor and surrounding structures and the bedrock. Also, please identify the source(s) of these soils and crushed stones and show that both of these materials are available in adequate quantities; clarify whether the lean concrete would be consistent with any standard; and justify why the engineered backfill would not be susceptible to liquefaction.	
2.5-13	Based on the location of the weathered limestone in PSAR Figure 2.5-2 and given that PSAR Section 2.5.4.2 states that the reactor building foundation basemat is deployed at bedrock, the staff notes that the reactor foundation would be below an elevation of 745 feet (below the weathered zone of limestone). Kairos notes in response to NRC question 2.5-2 (ADAMS No. ML22040A338) that "[t]he excavation is planned to reach the approximately 30 ft depth, exposing the surface of the foundation rock." The scale on the left of PSAR Figure 2.5-22 shows that the reactor building foundation would be at an elevation of 760 feet. Figure 2.5-22 also shows an excavation depth of about 20 ft below the existing surface. Please clarify the excavation depth for the proposed site, the depth to sound rock, and the correct elevation of the reactor building.	Kairos corrected the elevations and scale in Figure 2.5-22 to address the question and ensure consistency with other portions of the PSAR.
2.5-14	Regarding Section 2.5.5.2.1, provide an analysis of the estimated bearing capacity (static and dynamic) and foundation settlement. Describe the method(s) used along with the assumptions. Provide the estimated bearing capacity and elastic settlement including the factor of safety against bearing failure. Describe why long-term consolidation settlement is not a concern. Justify why any potential sliding along the interface between Murfreesboro limestone and Pond Springs Formation (Figure 2.5-2) due to the load imposed by construction of the reactor would not affect the stability of the proposed reactor site.	Kairos provided the Geotech report to the staff for viewing in the ERR. Kairos modified PSAR Section 2.5.5.2.1 to indicate that additional details on bearing capacity, settlement, and lateral pressure will be provided in the FSAR.
2.5-15	Regarding Figure 2.5-22, it appears that there is backfill to the side of the safety related portion of the reactor building. Please discuss how the lateral pressure from the backfill placed at side of the reactor building would be assessed.	Kairos corrected the elevations and scale in Figure 2.5-22 to address the question and ensure consistency with other portions of the PSAR. Kairos modified PSAR Section 2.5.5.2.1 to indicate that additional details on bearing

		capacity, settlement, and lateral pressure will be provided in the FSAR.
2.5-16	Liquefaction potential is discussed in Section 2.5.4.2. Section 2.5.2.3 discusses standard penetration tests (SPT) of the soils of different boreholes at the site. The staff notes that the SPT N-values are not corrected, for example, in accordance with Youd, et. al., 2001 for each hole with depth. It is not clear how the liquefaction potential can be assessed with uncorrected values. The reference is Youd, T.L, et al. (2001), "Liquefaction Resistance of Soils: Summary Report from the 1996 NCEER and 1998 NCEER/NSF Workshops on Evaluation of Liquefaction Resistance of Soils," American Society of Civil Engineers Journal of Geotechnical and Geoenvironmental Engineering, October 2001, pp. 817-833.	Kairos modified PSAR section 2.5.4.2 to clarify that the safety-related reactor foundation will be on a concrete fill placed directly on competent bedrock. Therefore, liquefaction is not an issue.
2.5-17	The staff reviewed revised PSAR Figure 2.5-3 as well as the geologic profile provided in the Environmental Report (ER Figure 3.3-3), which appears to follow a similar trendline across the site as the profile shown in revised PSAR Figure 2.5-3. The staff observed that ER Figure 3.3-3 shows slightly different subsurface thicknesses of several units over the similar cross-section to revised PSAR Figure 2.5-3. Specifically, revised PSAR Figure 2.5-3 shows approximately 20 ft of clay fill underlain by a thin lens of alluvial clay that thickens towards the center of the profile and a thick layer of residuum clay to the northwest (B) section of the profile that thins towards the center. Bedrock is encountered below the residuum clay at elevation 710 ft and as high as elevation 740 ft at the base of the alluvial clay. In contrast, ER Figure 3.3-3 shows a thin layer of fill underlain by a layer of clay that thickens from the northwest (A) towards the center of the profile before encountering bedrock between about elevation 745 and 730 ft. The staff is requesting the applicant to clarify the spatial relationship between the profile shown in ER Figure 3.3-3 and that shown in revised PSAR Figure 2.5-3 and confirm the subsurface units between the two profiles, including the types of clay and the approximate thicknesses of these units.	Kairos indicated that Environmental Report Figure 3.3-3 is a more general regional depiction of conditions rather than based on detailed site-specific measurements. For the safety review, site-specific information that is the best representation of the site subsurface based on the actual boreholes at the site can be found in PSAR Figures 2.5-2 and 2.5-3.

6.0 EXIT BRIEFING

The staff conducted an audit closeout meeting on August 23, 2022. At the exit briefing the staff reiterated the purpose of the audit and discussed their activities. Additionally, the staff stated that they did not identify areas where additional information would be necessary to support the review.

There were no deviations from the audit plan.

7.0 ADDITIONAL INFORMATION RESULTING FROM AUDIT

No RAIs were generated as a result of this audit. However, Kairos voluntarily updated the Hermes PSAR as seen in Revision 2 (ML23055A672) to address several items discussed during the audit.

8.0 OPEN ITEMS AND PROPOSED CLOSURE PATHS

Not applicable.

SUBJECT: SUMMARY REPORT FOR THE REGULATORY AUDIT OF KAIROS POWER LLC HERMES CONSTRUCTION PERMIT PRELIMINARY SAFETY ANALYSIS REPORT SITE CHARACTERISTICS (CHAPTER 2) DATED: APRIL 2023

OFFICE	NRR/DANU/UAL1:PM	BC: NRR/DEX/EHB	BC: NRR/DANU/UAL1
NAME	MHiser	BHayes*	AProffitt*
DATE	2 / 8 /2023	2 / 13 /2023	4 / 25 /2023

*concurred by email

SUMMARY REPORT FOR THE REGULATORY AUDIT OF KAIROS POWER LLC HERMES CONSTRUCTION PERMIT PRELIMINARY SAFETY ANALYSIS REPORT DECAY HEAT REMOVAL SYSTEM (CHAPTER 6, SECTION 6.3)

February 2022 – October 2022

1.0 BACKGROUND AND PURPOSE

By letter dated September 29, 2021, Kairos Power LLC (Kairos) applied for a construction permit (CP) under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 for its Fluoride Salt-Cooled, High Temperature Non-Power Reactor (Hermes); the application included a preliminary safety analysis report (PSAR) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21272A375). PSAR Chapter 6, “Engineered Safety Features,” Section 6.3, “Decay Heat Removal System” (DHRS), describes the DHRS and its safety function of removing decay heat when the normal heat rejection system is unavailable. This function is credited in the safety analyses of PSAR Chapter 13, “Accident Analysis,” to maintain acceptable reactor vessel and fuel temperatures.

This audit enabled the U.S. Nuclear Regulatory Commission (NRC) staff (the staff) to gain a better understanding of Kairos’s PSAR Chapter 6, Section 6.3 through review and discussion of underlying supporting documentation. Enhanced understanding and communications supported effective and efficient development of information needs.

2.0 AUDIT REGULATORY BASES

The bases for the audit are the regulations in 10 CFR Part 50, Sections 50.34(a), “Preliminary Safety Analysis Report,” specifically 50.34(a)(1)(i), 50.34(a)(3), and 50.34(a)(4).

3.0 AUDIT OBJECTIVES

The primary objective of the audit was to enable a more effective and efficient review of PSAR Chapter 6, Section 6.3 through the staff’s review and discussion of supporting documentation with Kairos. Gaining access to underlying documentation and engaging in audit discussions about the DHRS facilitated the staff’s understanding of the Hermes application and aided in assessing the safety of the proposed test reactor. The audit improved communication and provided detailed information for the staff.

4.0 SCOPE OF THE AUDIT AND AUDIT ACTIVITIES

The audit was conducted from February to October 2022, via teleconference and the Kairos electronic reading room (ERR). The staff conducted the audit in accordance with the Office of Nuclear Reactor Regulation (NRR) Office Instruction NRR-LIC-111, Revision 1 “Regulatory Audits” (ML19226A274).

Members of the audit team, listed below, were selected based on their detailed knowledge of the subject. Audit team members included:

1. Alex Siwy, NRR (Technical Reviewer)
2. Jeff Schmidt, NRR (Technical Reviewer)
3. Ben Adams, NRR (Technical Reviewer)
4. Alexander Chereskin, NRR (Technical Reviewer)
5. Benjamin Beasley, NRR (Project Manager)
6. Edward Helvenston, NRR (Project Manager)

Prior to the audit, the audit team reviewed PSAR Chapter 6, Section 6.3 and provided a series of topics in the audit plan, dated February 17, 2022 (ML22039A226), to be addressed during the audit. On June 16, 2022, the staff transmitted an additional list of questions to be addressed during the audit (ML22167A117).

During the audit, meetings were held between the staff and Kairos on June 28, August 2, August 9, and August 16, August 30, 2022.

The staff reviewed the following documents via the ERR:

- “Hermes Decay Heat Removal System Design Description”
- “Performance Predictions for the DHRS During Postulated Event Conditions” (Reference 4 of “Hermes Decay Heat Removal System Design Description”)
- Document discussing DHRS qualification testing programs
- “Onset to Freezing – Results from a Preliminary Analysis” document
- Draft change pages for the PSAR and for technical report KP-TR-018, “Postulated Event Analysis Methodology,” indicating changes proposed by Kairos in response to various audit questions

5.0 <u>SUMMARY OF AUDIT OUTCOME</u>

The staff’s audit focused on the review of supporting documents associated with the topics identified in the audit plan and subsequently transmitted questions. The staff reviewed information through the Kairos ERR and held discussions with Kairos staff to understand and resolve questions. In many cases, Kairos updated the Hermes PSAR to resolve items discussed in the audit. The table below replicates specific audit questions 6.3-1 through 6.3.12 transmitted by email dated June 16, 2022, and summarizes the resolution of the questions. In addition, the table lists and summarizes the resolution of additional “follow-up” questions the staff asked Kairos during the audit.

Question Number	Question	Resolution
6.3-1	The NRC staff would like to review Reference 4 (“Performance predictions for the DHRS during nominal reactor scram conditions”) of the Hermes Decay Heat Removal System Design Description. Please make this reference available for NRC audit.	Kairos provided “Reference 4” for staff audit. Kairos stated that the purpose of this document is to provide the basis for scoping out heat transfer limits for the DHRS, and ensure it is consistent with the Hermes design.
6.3-2	Does Reference 4 (see #1) support the KP-SAM model results for reactor vessel temperature? If not, is there another reference that does, and may the NRC staff audit it?	During an audit meeting, Kairos confirmed that yes, “Reference 4” supports the model results by establishing a temperature boundary condition.
6.3-3	The NRC staff would like more information about how the DHRS is modeled in KP-SAM. Is a document that explains the detailed modeling and associated assumptions available for audit?	During an audit meeting, Kairos noted that the DHRS is modeled by a boundary condition in KP-SAM. Reactor vessel heat removal is relatively insensitive to DHRS temperature, but KP-SAM uses a correlation to account for the relationship. Kairos stated that KP-SAM doesn’t explicitly model the heat transfer resistance term due to the gas gap in the double-walled structure of the DHRS. However, it is accounted for by using information from “Reference 4” to inform the input to the KP-SAM model.
6.3-4	Please further explain why the net heat removal performance of the thimbles is not affected if a float valve fails open. (E.g., do the thimbles in the affected train continue to remove the same integrated amount of heat as they would if they were not affected; do the other DHRS trains compensate for any degradation in the affected train; or is there some other explanation?)	Kairos stated that net heat transfer is not affected because the temperature of DHRS surfaces do not change, so radiative heat transfer does not significantly change. Kairos stated it plans to do testing to confirm this understanding of system performance. In response to further staff questions during audit discussion about potential steam cooling in the axially higher parts of the

		thimbles, Kairos noted that steam in the thimbles is mixed phase, i.e., never completely steam.
6.3-5	Please explain how the thimbles are oriented in each steam separator and the overall orientation around the reactor vessel.	Kairos stated that each DHRS train has six thimbles and the thimbles (from all four trains) are evenly distributed around the vessel with each train covering one quarter of the vessel circumferentially.
6.3-6	Please confirm the location of the equipment and structure cooling system (ESCS) relative to the DHRS and insulation.	Kairos stated that the ESCS is located immediately outside the insulation, while the DHRS thimbles are between the insulation and the reactor cavity.
6.3-7	The design description states that ESCS operation post-shutdown will result in increased cooling rate relative to DHRS operation alone. Has ESCS operation been considered in the analysis of overcooling events?	Kairos stated that the ESCS does not interfere with view factors for the DHRS thimbles because insulation separates the thimbles and the ESCS. Kairos noted that it will consider the effects of ESCS operation and insulation in sensitivity studies for the FSAR. Kairos also noted that for overcooling analyses in Chapter 13 (i.e., relating to analyses of potential accidents) for an operating license application, it would need to consider maximum DHRS performance as well as parasitic heat losses to capture the most challenging overcooling event.
6.3-8	Have sensitivity studies been performed to quantify the effects of uncertainties in view factors (e.g., due to the reactor thermal management system heaters)?	Kairos noted that the PSAR indicates that Hermes will be designed to mitigate factors that could affect heat removal between the vessel and the DHRS. Kairos also noted that the reactor thermal management system heaters will not have a significant impact on DHRS function as they will simply absorb and re-emit heat like the vessel wall.
6.3-9	The design description acknowledges that loss of function over time is a credible failure path due to accumulation of	Kairos clarified that a “credible failure path”

	fouling within the separator float valves; however, redundancy of the four separate DHRS loops prevents loss of the required safety function. The NRC staff notes that if one train fails in this mode, the other trains may be prone to fail in this manner around the same time. How will this type of scenario be prevented?	does not mean failure is likely or expected. The DHRS will be subject to technical specifications (i.e., limiting conditions for operation and surveillances) to ensure operability and identify any failure or degradation that could prevent DHRS from performing its safety function. Kairos also stated that the DHRS will have appropriate design features to prevent fouling, and there will be testing to further evaluate potential failure modes and ensure float valves function properly.
6.3-10	Has any analysis been performed to evaluate the magnitude and impact of thermal gradient asymmetry in the event of loss of inventory in one DHRS train?	Kairos noted that radiation heat transfer would be reduced in that scenario. However, a final analysis will be provided in the FSAR. Kairos also noted that PSAR Section 4.3.2 (specifically, the discussion of PDC 31) indicates that the reactor vessel design will account for transient stresses in analyzing reactor vessel integrity.
6.3-11	If a leak occurs in one DHRS train and water enters the leak barrier, what is the impact on DHRS performance in the affected train?	Kairos indicated that it expects the effect would be limited. Kairos noted that boil-off of the water may actually cause slightly increased heat removal for the affected thimble. Kairos stated that during normal operations, a leak would be detected and addressed.
6.3-12	PSAR Subsection 7.3.1.2, "Decay Heat Removal System," states that the water tank isolation valves fail open upon loss of power. However, PSAR Figure 6.3-1, "Functional Diagram of the DHRS," shows that the isolation valve fails in the last position. Similarly, the Hermes Decay Heat Removal System Design Description states that the isolation valves fail in place (in an as-is state). Please clarify the apparent discrepancy in the PSAR and make any necessary changes.	Kairos confirmed that the figure and description in PSAR Chapter 6 is correct. PSAR Chapter 7 referred to the DHRS orientation when the DHRS is operating. Kairos provided proposed revisions to PSAR Chapter 7 to clarify that the valves fail in place (which, during normal operation above

		the threshold power, is open). Kairos subsequently submitted the PSAR changes to the docket by letter dated June 30, 2022 (ML22181B053).
Follow-up "A"	(Primarily follow-up to questions 6.3-1, 6.3-2, and 6.3-3) As a follow up, the staff asked Kairos to provide further information regarding DHRS qualification testing programs. The staff requested that this include information on physical phenomena (e.g., heat loading) and discussion of how the physical phenomena are evaluated, or why they are precluded. The staff also specifically asked if DHRS qualification testing included low pressure quenching tests to ensure that stable heat removal can be established because the guide thimble and evaporator tube will initially be empty and hence relatively hot prior to its startup (upon reaching the threshold power). In addition, the staff specifically asked if a thimble feedwater float valve failing to close as heat demand decreases was included in the DHRS qualification testing.	Kairos provided a document discussing DHRS qualification testing programs for staff audit. The staff indicated that it would require the information to be docketed to support its review. Kairos submitted the document to the docket by letter dated September 1, 2022 (ML22244A235).
Follow-up "B"	(Primarily follow-up to questions 6.3-1, 6.3-2, and 6.3-3) As a follow up to its review of "Reference 4" during the audit, the staff asked Kairos whether the preliminary calculations for DHRS sizing conservatively consider the possibility for reactor overcooling (e.g., incorporating assumptions such as a fresh core and maximum DHRS performance).	Kairos confirmed that the final DHRS sizing will be informed by final design calculations to ensure acceptance criteria are met on both ends (i.e., overheating and overcooling). The calculation in "Reference 4" was primarily intended as a scoping calculation. In response to discussion with the staff regarding whether it would be possible to provide preliminary analyses of a more conservatively modeled overcooling event, Kairos provided the document "Onset to Freezing Preliminary Analysis" for staff audit. In response to discussions following staff review of this document, Kairos provided for

		audit proposed revisions to KP-TR-018 and PSAR Chapter 13 to reflect that Kairos plans to design the DHRS to preclude core freezing by design for at least 72 hours following a reactor shutdown. Kairos stated that it could change this commitment in an OL application but understands it would need to provide justification for such a change. In response to further audit discussions with the staff, Kairos provided for audit updated proposed revisions to KP-TR-018 and PSAR Chapter 13 to further clarify the prevention of Flibe freezing for 72 hours and make additional conforming changes. Kairos subsequently submitted the KP-TR-018 and PSAR Chapter 13 changes to the docket by letter dated October 13, 2022 (ML22286A240).
Follow-up "C"	(Primarily follow-up to questions 6.3-1, 6.3-2, and 6.3-3) Regarding Appendix B of "Reference 4," the staff noted that the correlation used for critical heat flux analysis is for a flat plate and asked whether Kairos considered a correlation more consistent with the evaporator tube geometry. In addition, the staff asked where Kairos obtained the value of the constant "C."	Kairos stated that the correlation is used for the preliminary analysis because it is a scoping calculation and Kairos considers a flat plate analysis to be more conservative. Kairos clarified that the value of constant "C" was obtained from a paper referenced in the "Reference 4" document.
Follow-up "D"	(Primarily follow-up to questions 6.3-1, 6.3-2, and 6.3-3) The staff requested that Kairos provide figure(s) better describing the design of the DHRS.	The DHRS system design description document that Kairos provided for staff audit included some DHRS figures with additional detail. Following audit discussions, Kairos indicated that it would add 2 additional figures to the PSAR to show steam separator and float

		valve geometries relative to each other, and how fluid flows through guide tube and up evaporator tube. Kairos provided for audit proposed revisions to PSAR Chapter 6, and subsequently submitted these changes to the docket by letter dated August 24, 2022 (ML22236A593).
Follow-up “E”	(Primarily follow-up to questions 6.3-1, 6.3-2, and 6.3-3) The staff noted that the “Reference 4” provided for audit appeared to contain a typographical error in its Equation 5.1-9. The staff asked Kairos to clarify whether the typo carried over to underlying calculations in the document.	During an audit meeting, Kairos confirmed that Equation 5.1-9 contains a typo, but it does not carry over to underlying calculations.
Follow-up “F”	Regarding instrumentation to ensure DHRS operability, the staff asked Kairos how ensuring DHRS operability would be accomplished and whether additional measurements or instrumentation would be needed for this.	Kairos stated that it has not yet determined what parameters will need to be monitored, because it is still looking into what the complete set of potential DHRS failure mechanisms is. However, Kairos confirmed that there will be specific instrumentation to show the DHRS is performing as expected.

6.0 EXIT BRIEFING

The staff conducted an audit closeout meeting on October 11, 2022. At the exit briefing, the staff reiterated the purpose of the audit and discussed their activities. Additionally, the staff stated that they did not identify areas where additional information would be necessary to support the review.

There were no deviations from the audit plan.

7.0 ADDITIONAL INFORMATION RESULTING FROM AUDIT

No RAIs were generated as a result of this audit. However, Kairos voluntarily updated the Hermes PSAR (ML22181B053, ML22286A240, and ML22236A593) and a technical report (ML22286A240) and submitted additional information on the docket (ML22244A235) to address several items discussed during the audit.

8.0 OPEN ITEMS AND PROPOSED CLOSURE PATHS

Not applicable.

SUBJECT: SUMMARY REPORT FOR THE REGULATORY AUDIT OF KAIROS POWER LLC HERMES CONSTRUCTION PERMIT PRELIMINARY SAFETY ANALYSIS REPORT DECAY HEAT REMOVAL SYSTEM (CHAPTER 6, SECTION 6.3)
DATED: APRIL 2023

OFFICE	NRR/DANU/UAL1:PM	BC: NRR/DANU/UTB2	BC: NRR/DANU/UAL1
NAME	MHiser	CDeMessieres*	AProffitt*
DATE	4 / 13 /2023	4 / 24 /2023	4 / 25 /2023

*concurred by email

SUMMARY REPORT FOR THE REGULATORY AUDIT OF KAIROS POWER LLC HERMES CONSTRUCTION PERMIT PRELIMINARY SAFETY ANALYSIS REPORT INSTRUMENTATION AND CONTROL (CHAPTER 7)

April 2022 – July 2022

1.0 BACKGROUND AND PURPOSE

By letter dated September 29, 2021, Kairos Power LLC (Kairos) applied for a construction permit (CP) under Title 10 of the *Code of Federal Regulations* (10 CFR) Part 50 for its Fluoride Salt-Cooled, High Temperature Non-Power Reactor (Hermes); the application included a preliminary safety analysis report (PSAR) (Agencywide Documents Access and Management System (ADAMS) Accession No. ML21272A375). PSAR Chapter 7, "Instrumentation and Control Systems," describes the instrumentation and control (I&C) systems that monitor and control plant operations during normal operations and planned transients and also monitor and actuate protection systems in the event of unplanned transients.

This audit enabled the U.S. Nuclear Regulatory Commission (NRC) staff (the staff) to gain a better understanding of Kairos's PSAR Chapter 7 through review and discussion of underlying supporting documentation. Enhanced understanding and communications supported effective and efficient development of information needs.

2.0 AUDIT REGULATORY BASES

The bases for the audit are the regulations in 10 CFR Part 50, Sections 50.34(a), "Preliminary Safety Analysis Report," specifically 50.34(a)(1)(i), 50.34(a)(3), and 50.34(a)(4).

3.0 AUDIT OBJECTIVES

The primary objective of the audit was to enable a more effective and efficient review of PSAR Chapter 7 through the staff's review and discussion of supporting documentation with Kairos. Gaining access to underlying documentation and engaging in audit discussions about the I&C design facilitated the staff's understanding of the Hermes application and aided in assessing the safety of the proposed test reactor. The audit improved communication and provided detailed information for the staff.

4.0 SCOPE OF THE AUDIT AND AUDIT ACTIVITIES

The audit was conducted from April to July 2022, via the Kairos electronic reading room (ERR) and in person at the Kairos facility in Albuquerque. The staff conducted the audit in accordance with the Office of Nuclear ReactorRegulation (NRR) Office Instruction NRR-LIC-111, Revision 1 "Regulatory Audits" (ML19226A274).

Members of the audit team, listed below, were selected based on their detailed knowledge of the subject. Audit team members included:

1. Joe Ashcraft, NRR (Technical Reviewer)
2. Calvin Cheung, NRR (Technical Reviewer)
3. Benjamin Beasley, NRR (Project Manager)

Prior to the audit, the audit team reviewed PSAR Chapter 7 and provided a series of questions in the audit plan (ML22089A166) to be addressed during the audit.

During the audit, meetings were held between staff and Kairos in Alameda, California and Albuquerque, New Mexico on April 12 and 13, 2022, respectively.

The staff reviewed the following documents:

- Draft PSAR pages indicating changes proposed by Kairos in response to various audit questions

5.0 SUMMARY OF AUDIT OUTCOME

The staff's audit focused on the review of supporting documents associated with the questions identified in the audit plan (ML22089A166). The staff reviewed information through the Kairos ERR and held discussions with Kairos staff to understand and resolve questions. In many cases, Kairos updated the Hermes PSAR to resolve items discussed in the audit. The table below summarizes the resolution of the audit questions.

Question Number	Question	Resolution
7.1-1	Section 7.1, Reference 2, states the version used for Institute of Electrical and Electronics Engineers (IEEE) 7-4.3.2 is 2003. Clarify why the 2003 version is used instead of a more recent version.	Kairos indicated that the 2003 version was selected because it is the current NRC-endorsed version in RG 1.152.
7.1-2	Section 7.1.2 states that for both plant control system (PCS) and reactor protection system (RPS) "activation and actuation" setpoints are calculated. What is the difference between "activation" and "actuation" setpoints?	Kairos modified the PSAR to remove use of the term "activation" to avoid confusion.
7.1-3	Describe the methodology and rigor used to establish non-safety setpoints.	Kairos modified the PSAR to remove reference to setpoints for non-safety systems, which are not needed for a safety finding.
7.2-1	Is there any redundancy in the PCS platform or non-safety sensors? This is in conjunction with request number 7.2-5 in this section, concerning PCS failure modes.	Kairos indicated that the level of redundancy will be informed by the reliability design requirements of the PCS hardware selected. The PCS hardware and its reliability will be provided in the FSAR.
7.2-2	Figure 7.1-1 does not identify the subsystems in the PCS to which the RPS sensors input.	Kairos modified PSAR Section 7.2.3 to clarify that the PCS is designed to not be able to interfere with the RPS's ability to perform its safety functions. Kairos indicated that PCS has dedicated sensors equivalent to the sensors in RPS with additional sensors that are only provided to PCS.
7.2-3	For the one-way data diode shown in Figure 7.1-1, there is no information that discusses how the data diode is implemented into the architecture and whether it will be controlled via hardware or software.	Kairos modified PSAR Figure 7.1-1 and PSAR Section 7.3.3 to clarify that the data diode is integrated into the RPS hardware platform.
7.2-4	The four subsystems of the PCS shown in Figure 7.1-1 do not reflect the reactor auxiliary heating system (RAHS) and there is no discussion of the RAHS in Section 7.2. Update Figure 7.1-1 and provide a discussion for the RAHS in Section 7.2.	Kairos modified PSAR Table 7.2-3 but will need to further clarify the RAHS description in Table 7.3-2 and Section 7.3 for the OL application.

7.2-5	Section 7.2 does not discuss PCS failure modes. Please describe the PCS failure modes.	Kairos modified PSAR Section 7.2.3 to clarify that the PCS is designed to not be able to interfere with the RPS's ability to perform its safety functions. The PCS hardware and a reliability evaluation, consistent with the safety classification of the PCS, will be provided in the FSAR.
7.3-1	Regarding Section 7.3, clarify if the RPS technology platform will be based on an NRC-approved topical report platform and if plant-specific action items will be addressed.	Kairos will provide the technology platform in the FSAR.
7.3-2	Figure 7.1-1 shows safety-related isolation devices. A bullet in Section 7.3.1 lists the gateways as two non-safety RPS gateways. The gateways are shown in Figure 7.1-1 as part of the main control room (MCR) and the PCS. Please clarify whether the gateways provide isolation from the RPS and if so, why are the gateways not safety related.	The typographical error in the bullets of PSAR Section 7.3.1 was corrected to change the bullet on gateways to "RPS isolation hardware."
7.3-3	There is no discussion of function allocation in Section 7.3, which needs to be considered for defense in depth. Please describe RPS function allocation.	Kairos will provide additional specificity in the FSAR, either by referencing the Highly Integrated Protection System (HIPS) topical report (ML17256A894) or explaining functional allocation if not referencing the topical report.
7.3-4	Regarding Figure 7.1-1, it is not clear if the post-accident monitoring (PAM) displays in the remote onsite shutdown panel are non-safety related or safety related (based on the color in the figure). As stated in Section 7.4, the remote onsite shutdown panel (ROSP) is not safety related. Later in Section 7.4, it is stated that no operator actions are needed, thus no PAM A variables are provided and PAM displays can be non-safety related and should have a diode to isolate them from the RPS. This topic should be addressed by Kairos as part of the application for an Operating License. Specifically, the final safety analysis report needs to discuss how they are planning to implement this one-way communication.	Kairos corrected the typographical error in PSAR Figure 7.1-1 to clarify that the ROSP is non-safety related. Kairos indicated isolation as a separate device is not needed because it will be built into the platform technology.
7.3-5	The isolation between manual trips and RPS seems to conflict with how it is shown in 7.4-1. (In Figure 7.1-1 an	Kairos modified PSAR Figure 7.4-1 to match Figure 7.1-1 with the intent to shown that no separate

	isolation device is shown and Figure 7.4-1 shows a gateway.) The arrow that shows that the signal goes both ways from the RPS in Figure 7.4-1. Please clarify.	isolation is needed because isolation occurs at the point of generation.
7.3-6	Regarding Figure 7.1-1, if PAM displays in the ROSP are non-safety related, then please clarify why they aren't isolated from the RPS.	Kairos indicated isolation as a separate device is not needed because it will be built into the platform technology.
7.4-1	PSAR Section 7.4.3.1 states that the "MCR is located at a distance from the Reactor Building such that the radiological consequences of unfiltered air in the MCR during postulated events does not exceed 5 rem TEDE for the duration of the event." PSAR Section 3.5.1 states that the main control building is a standalone building on the site that contains the plant control system and reactor protection system human system interface consoles (main control room). However, PSAR Table 3.6-1 indicates that the main control room is in the Auxiliary Building and PSAR Section 7.4 also states that the main control room is in the Auxiliary Building. Environmental Report Figure 2.2-3 gives the expected site layout and shows that the location of the Auxiliary Building is attached to the Reactor Building. Clarify the location of the main control room and relationship to the Reactor Building. Provide information on potential radiological release locations and control room HVAC intakes and access openings for the MCR.	Kairos indicated that the I&C architecture is designed to allow control room location flexibility. Kairos modified the PSAR, including Section 7.4.3.1, to clarify the MCR will be in a separate stand-alone building away from the Reactor and Auxiliary Buildings. The location of the building housing the MCR and the MCR HVAC intakes and access openings will be provided in the FSAR designed to keep doses below 5 rem TEDE. The only radiological release location will be the Reactor Building. Table 3.6-1 will need to be updated with the OL application to confirm the MCR location consistent with Section 7.4.3.1.
7.5-1	Section 7.3.2 states that the "RPS is designed in accordance with IEEE Std 603-2018." Please discuss the use of IEEE Std 603-2018 for safety sensors rather than other versions. Also, if there are any digital safety-related sensors, then common cause failure needs to be addressed along with other IEEE criteria.	Kairos indicated that based on the final selection of sensors, appropriate failure analysis will be conducted and documented in the FSAR, including common cause failure for digital sensors if they are used in combination with a HIPS platform.

6.0 EXIT BRIEFING

The staff conducted an audit closeout meeting on July 8, 2022. At the exit briefing the staff reiterated the purpose of the audit and discussed their activities. Additionally, the staff stated that they did not identify areas where additional information would be necessary to support the review.

7.0 ADDITIONAL INFORMATION RESULTING FROM AUDIT

No RAIs were generated as a result of this audit. However, Kairos voluntarily updated the Hermes PSAR as seen in Revision 2 (ML23055A672) to address several items discussed during the audit.

8.0 OPEN ITEMS AND PROPOSED CLOSURE PATHS

Not applicable. There were no deviations from the audit plan.

SUBJECT: SUMMARY REPORT FOR THE REGULATORY AUDIT OF KAIROS POWER LLC HERMES CONSTRUCTION PERMIT PRELIMINARY SAFETY ANALYSIS REPORT INSTRUMENTATION AND CONTROL (CHAPTER 7)
DATED: APRIL 2023

OFFICE	NRR/DANU/UAL1:PM	BC: NRR/DEX/EICB	BC: NRR/DANU/UAL1
NAME	MHiser	MWaters*	AProffitt*
DATE	4 / 13 /2023	4 / 14 /2023	4 / 25 /2023

*concurred by email