COMPLIANCE DETERMINATION STRATEGY
RRT 3.2.2.7 POTENTIALLY ADVERSE CONDITION: NATURALLY PRODUCED SURFACE WATER IMPOUNDMENTS

APPLICABLE REGULATORY REQUIREMENTS:

10 CFR 60.21(c)(1)(ii)(B)
10 CFR 60.21(c)(1)(ii)(C)
10 CFR 60.21(c)(1)(ii)(F)
10 CFR 60.31(a)(1)(i)
10 CFR 60.31(a)(2)
10 CFR 60.112
10 CFR 60.122(c)(3)

TYPES OF REVIEW:

Acceptance Review (Type 1)
Safety Review (Type 3)

RATIONALE FOR TYPES OF REVIEW:

Acceptance Review (Type 1) Rationale:

This regulatory requirement topic is considered to be license application-related because, as specified in the license application content requirements of 10 CFR 60.21(c) and in the regulatory guide of the U.S. Nuclear Regulatory Commission (NRC) on "Format and Content for the License Application for the High-Level Waste Repository" (FCRG), it must be addressed by the U.S. Department of Energy (DOE) in its license application. Therefore, the staff will conduct an acceptance review of the license application for this regulatory requirement topic.

Safety Review (Type 3) Rationale:

This regulatory requirement topic is considered to be related to containment and waste isolation. It is a requirement for which compliance is necessary to make a safety determination for construction authorization as defined in 10 CFR 60.31(a) (i.e., regulatory requirements in Subparts E, G, H, and I of 10 CFR 60). Therefore, the staff will conduct a safety review of the license application to determine compliance with this regulatory requirement.

This regulatory requirement topic is concerned with a potentially adverse condition (PAC), naturally-produced surface water impoundments, and focuses on the potential for landslides, subsidence, volcanic activity, or other natural processes which may occur at the surface and cause large-scale surface water impoundments. In addition, it focuses on the possibility of such impoundments affecting regional groundwater and, as a consequence, adversely affecting waste isolation.

This PAC is related to postclosure performance of the repository. As discussed in the Statements of Consideration for the final rule (48 FR 28212), preclosure concerns regarding flooding and the possible effects of flooding on waste isolation are addressed in 10 CFR 60.122(c)(1). The Statements of

Consideration for the final rule also suggest that the facility be designed to preclude massive inflows of water. Flooding from a surface water source through defective borehole, shaft, and ramp seals could result in massive inflows of water to the repository. The adequacy of the design of the seals for boreholes, shafts, and ramps will be covered in the review for 10 CFR 60.134 (review plan 4.3 in the LARP).

Conventional methods exist for the analysis of precipitation, evaporation, and estimation of extreme precipitation events (such as the probable maximum precipitation) under present conditions. DOE's paleoclimate studies should provide an estimate of past climates, including pluvial climatic phases. DOE will also perform studies to estimate future climate change from past climate change. These studies will attempt to identify pluvial conditions sufficiently likely to warrant consideration. Estimates of the probable maximum precipitation and other extreme events associated with pluvial conditions which are sufficiently likely to warrant consideration can be developed, possibly through use of a modern pluvial analog. Under pluvial conditions sufficiently likely to warrant consideration, areas of flooding during extreme events can be identified for the Yucca Mountain site. The same methods used in evaluation of preclosure flooding (see review plan 3.2.2.5 in the LARP) can be used for this purpose. DOE's Quaternary regional hydrology studies will also provide some direct information about paleoflooding events and the effect of recharge on the regional hydrology at modern pluvial analog sites.

Sufficient technical knowledge exists to allow for an adequate investigation and evaluation of the likelihood of this PAC. Based on existing information, it is concluded that a safety determination can be made regarding this PAC by evaluating the technical information submitted by DOE in its license application.

Based on the above considerations, this regulatory requirement topic will be reviewed by the staff at a Type 3 (Safety Review) level. The review is expected to require no additional analyses or tests and so will not necessitate a Type 4 or 5 review. Should future analyses or data arise such that this initial assessment is questioned, the type of review for this regulatory requirement topic will be reassessed in light of the additional information.

No likely scenarios involving naturally produced large-scale surface water impoundments that could significantly affect the regional groundwater system have been identified. However, estimates of future conditions may change as new data become available.

The following assumptions have been made in developing this CDS:

(1) Examination of DOE's study plans transmitted to the NRC dealing with postclosure tectonics reveals no mention of studies for estimating which locations within the site are most susceptible to volcanic activity. Conventional methods for making such predictions do not exist. Only limited information is available concerning which locations within the site are more susceptible than others to landslides, subsidence, and faulting. Information concerning postclosure flooding within the context of climate and regional hydrology is being gathered. The information being gathered could be used to demonstrate compliance for this regulatory requirement topic based on the assumption that natural drainage pathways become obstructed.

(2) The effects of near-surface perched water bodies on the recharge rate will be of particular interest in assessing the effects of naturally produced surface water impoundments. The PAC

related to perched water bodies, stated in the 10 CFR 60.122(c)(3), is addressed in review plan 3.2.2.12 of the LARP.

(3) The effects of pluvial conditions sufficiently likely to warrant consideration on the magnitude of extreme flooding events, the infiltration rate and associated recharge rate expected during flooding events, the annual precipitation rate, annual evapotranspiration rate, annual pan evaporation rate, and annual recharge rate will be of particular interest in assessing the effects of naturally produced surface water impoundments. The PAC related to pluvial conditions, covered in 10 CFR 60.122 (c)(6), is addressed in review plan 3.2.4.2 of the LARP.

(4) The sensitivity of the regional groundwater flow system to increased recharge will be of particular interest in assessing the effects of naturally produced surface water impoundments. The PAC related to potential for changes in hydrologic conditions, stated in 10 CFR 60.122 (c)(5), is addressed in review plan 3.2.2.9 of the LARP.

REVIEW STRATEGY:

Acceptance Review:

In conducting the acceptance review of the potentially adverse condition (PAC) concerning naturally produced surface water impoundments affecting regional groundwater, the reviewer should determine if the information present in the license application and its references for determining compliance with the regulatory requirements applicable to this PAC is complete in technical breadth and depth as identified in the regulatory guide "Format and Content for the License Application for the High-Level Waste Repository" (FCRG). The reviewer should determine that all appropriate information necessary for the staff to review this PAC is presented such that the assessments associated with total system and subsystem performance objectives can be performed.

The reviewer should determine whether the information in the license application is presented in such a manner that the assumptions, data and logic leading to a demonstration of compliance with the requirement are clear and do not require the reviewer to conduct extensive analyses or literature searches. The reviewer should also determine that controversial information and appropriate alternative interpretations and models have been adequately described and considered.

Finally, the reviewer shall determine if the U.S. Department of Energy (DOE) has either resolved all the NRC staff objections that apply to this regulatory requirement topic, or provided all the information requested in Section 1.6.2 of the FCRG for unresolved objections. The reviewer will evaluate the effects of any unresolved objections, both individually and in combinations with others, on (1) the ability of the reviewer to conduct a meaningful and timely review, and (2) the ability of the Commission to make a decision regarding construction authorization within the three-year statutory period.

Safety Review:

The regulatory requirement topic is limited to consideration of DOE's demonstration, through appropriate investigations, of the evidence for (or against) the PAC related to naturally-produced surface water impoundments affecting regional groundwater within the controlled area (and outside the controlled area, if considered necessary). It is not concerned with preclosure flooding (10 CFR 60.122(c)(1)); the potential effects of structural deformation on groundwater other than the formation of surface water

impoundments (10 CFR 60.122(c)(4)); or the design of seals for shafts, ramps, and boreholes (10 CFR 60.134). These topics will be covered, respectively, under review plans 3.2.2.5, 3.2.2.8, and 4.3 in the LARP. Concerns related to perched water bodies (10 CFR 60.122(c)(23)), changes to hydrologic conditions (10 CFR 60.122(c)(5)), and changes to hydrologic conditions due to climate (10 CFR 60.122(c)(6)) are limited to effects of the PACs on naturally-produced surface water impoundments affecting regional groundwater. These topics will be covered, respectively, under review plans 3.2.2.12, 3.2.2.9, and 3.2.4.2. The specific aspects of the license application on which the reviewer will focus are discussed in the FCRG, and the acceptance criteria will be identified in Section 3.0 of review plan 3.2.2.7 in the LARP.

In conducting the safety review, the reviewer should determine if the information presented in the license application and its references is an acceptable demonstration of compliance with the applicable regulatory requirements. At a minimum, the reviewer will assess the adequacy of the data and analyses presented in the license application to support DOE's demonstration regarding 10 CFR 60.122(c)(3). Specifically, DOE will need to (1) provide information to determine whether and to what degree the PAC of naturally produced surface water impoundments affecting regional groundwater is present; (2) provide information to determine to what degree the PAC of naturally produced surface water impoundments affecting regional groundwater is present but undetected; (3) assure the sufficiency of the lateral and vertical extent of data collection; (4) evaluate the information presented under items (1) and (2), with assumptions and analysis methods that adequately describe the presence of the PAC and ranges of relevant parameters. In general, the reviewer will assess the adequacy of DOE's investigations of the PAC, both at the site and in the geologic setting (i.e., inside and outside the controlled area), in the manner outlined in 10 CFR 60.21(c)(1)(ii)(B).

For this PAC, the four necessary steps defined above can be satisfied by DOE through conduct of the activities described in this paragraph. First, DOE should characterize the following climatic elements of the site, both for the present-day climate and for a pluvial climatic condition deemed sufficiently likely to warrant consideration: precipitation, potential evapotranspiration, infiltration and discharge rates during flooding events, annual recharge rate, and annual pan evaporation. Extreme flooding events, such as the 100-year flood and the probable maximum flood, must also be determined under both present climatic conditions and the likely pluvial conditions. Estimates should be made of the depths of water which could be reasonably impounded if natural drainage pathways were obstructed by a landslide, subsidence, faulting, volcanism, or some other natural process. Estimates of the reasonable duration of time for such obstructions should be made as well. Finally, conclusions drawn from the following efforts should be summarized: evaluation of the formation, effects, and duration of near-surface perched water bodies; evaluation of effects on hydrologic parameters from pluvial conditions deemed sufficiently likely to warrant consideration; modeling of regional groundwater with regard for effects of increased recharge, particularly in flood-prone areas such as Fortymile Wash, the principal surface drainage feature at Yucca Mountain.

The first step in the NRC review will be to evaluate DOE's analysis and determine if the assumptions discussed under the Type 3 safety review rationale have been met. If these assumptions are met, the review will consist primarily of: (1) evaluating probable maximum precipitations computed under present and pluvial conditions sufficiently likely to warrant consideration; (2) evaluating calculated flows and water levels and verifying that the flood-prone areas of the site are properly delineated; (3) evaluating the calculated impoundment depth, area, and duration of the impounding event; (4) evaluating the calculated effect on the formation of perched water bodies and increased recharge; (5) evaluating the calculated effect on the regional groundwater flow system and the water table in the vicinity of the

repository from the increase in recharge. If the assumptions are not met, the review may require independent confirmation of the likely location of landslides, subsidence, faulting events, or volcanic events. In this case, the review would also require independent confirmation of the probability and consequences with respect to the formation of large-scale surface water impoundments at other locations. DOE may be able to show the locations of concern are unlikely to experience the geologic events which form the necessary precursors for surface water impoundments. If DOE chooses to present such arguments in addition to evaluating the hydrologic and climatic conditions, a higher level review will be required. Conventional methods do not exist for the prediction of the precise location of such events, and theories concerning the prediction of such events are controversial. Some of the data identified as necessary for the review of this PAC are derived in other sections of the license application and its review. If these data are difficult to locate, in a form which requires extensive supplemental calculations before use, or are absent altogether, this review will be delayed. In addition, if any of the shafts, ramps, or boreholes are located in areas considered flood-prone under either present conditions or pluvial conditions sufficiently likely to warrant consideration, the review process for the affected shafts, ramps, or boreholes will become more complex than is currently envisioned.

DOE will also need to provide an explanation of the measures used to support models applied in assessment of the presence or absence of evidence of this PAC on naturally produced surface water impoundments affecting regional groundwater. Analyses and models that will be used to predict future conditions and changes in the geologic setting shall be supported by using an appropriate combination of such methods as field tests, *in-situ* tests, laboratory tests representative of field conditions, monitoring data, and natural analog studies.

In conducting the aforementioned evaluations, the reviewer should determine that DOE uses (1) analyses that are sensitive to evidence of the PAC; and (2) assumptions which are not likely to underestimate its effects. In general, the reviewer will assess the adequacy of DOE's investigations for evidence of the PAC, both within the controlled area and outside the controlled area, as necessary.

Reviews of DOE models will be required whether or not the assumptions are satisfied. A model review should consist of the following: (1) a determination that the quantitative hydraulic models chosen are appropriate (for example, steady vs. unsteady flow); (2) a check of input data to confirm they are representative of the site; (3) confirmation that DOE models reflect the natural system; (4) assurance that assumptions used are valid and applicable to the site; and (5) determination that conclusions presented are consistent with the model outputs. At the reviewers discretion, simple confirmatory calculations may be performed using appropriate procedures. Site visits will assist the staff with verifying that DOE's analyses accurately reflect conditions at the site.

In order to conduct an effective review, the reviewers will rely on their own expertise and independently acquired knowledge, information and data such as the results of research activities being conducted by the NRC's Office of Nuclear Regulatory Research, in addition to that provided by the DOE in its license application. For example, regional groundwater modeling exercises with studies of sensitivity to the recharge rate in low-lying areas such as Fortymile Wash (e.g., NUREG/CR-5890, NRC, 1992) should be consulted. The reviewer should focus on additional data which can refine knowledge of the PAC and should perform, as necessary, additional analyses to confirm the resolution capabilities of the methodologies. It is incumbent upon the reviewer to have acquired a body of knowledge regarding these and other critical considerations in anticipation of conducting the review to assure that the regional groundwater modeling, climatology, and flood evaluation program is sufficient in scope and depth to provide the information necessary for resolution of the concerns.

Finally, the following DOE site characterization study plans are expected to provide data and analyses needed in this review for addressing the presence (or absence) of this PAC:

Study Plan No.	*Title*
8.3.1.2.1.4	*Regional Hydrologic System Synthesis and Modeling*
8.3.1.5.1.1	*Characterization of Modern Regional Climate*
8.3.1.5.1.2	*Paleoclimate Study: Lake, Playa, and Marsh Deposits*
8.3.1.5.1.6	*Characterization of the Future Regional Climate and Environments*
8.3.1.5.2.1	*Characterization of the Quaternary Regional Hydrology*
8.3.1.5.2.2	*Characterization of the Future Regional Hydrology Due to Climate Change*

RATIONALE FOR REVIEW STRATEGY:

None

Contributing Analysts:

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Date of Analysis: February 22, 1993

APPLICABLE REGULATORY REQUIREMENTS FOR EACH TYPE OF REVIEW:

Type 1:
10 CFR 60.21(c)(1)(ii)(B)
10 CFR 60.21(c)(1)(ii)(C)
10 CFR 60.21(c)(1)(ii)(F)
10 CFR 60.31(a)(1)(i)
10 CFR 60.31(a)(2)
10 CFR 60.112
10 CFR 60.122(c)(3)

Type 3:
10 CFR 60.21(c)(1)(ii)(B)
10 CFR 60.21(c)(1)(ii)(C)
10 CFR 60.21(c)(1)(ii)(F)
10 CFR 60.31(a)(1)(i)
10 CFR 60.31(a)(2)
10 CFR 60.122(c)(3)

REFERENCES:

U.S. Nuclear Regulatory Commission, "Format and Content for the License Application for the High-Level Waste Repository" (FCRG), Office of Nuclear Regulatory Research.

U.S. Nuclear Regulatory Commission, "Regional Groundwater Modeling of the Saturated Zone in the Vicinity of Yucca Mountain, Nevada," NUREG/CR-5890(CNWRA92-001), October 1992.

U.S. Nuclear Regulatory Commission, "Disposal of High-Level Radioactive Wastes in Geologic Repositories: Final Rule," Federal Register Vol 48, No. 120, June 21, 1983, pp 28194-28229

U.S. Nuclear Regulatory Commission, "License Application Review Plan for the Review of a License Application for a Geologic Repository for Spent Nuclear Fuel and High-Level Radioactive Waste, Yucca Mountain, Nevada" (LARP), Office of Nuclear Material Safety and Safeguards.

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COMPLIANCE DETERMINATION STRATEGY

Review Plan 3.2.2.7
POTENTIALLY ADVERSE CONDITION: Naturally Produced Surface Water Impoundments

APPLICABLE REGULATORY REQUIREMENTS:

~~60.122(c)(3)~~
~~60.21(c)(1)(i)(D)~~
~~60.21(c)(1)(ii)(A)~~
~~60.21(c)(1)(ii)(B)~~
~~60.21(c)(1)(ii)(F)~~
~~60.31(a)(1)(i)~~

10 CFR 60.21(c)(1)(ii)(B)
" " " " (C)
" " " " (F)
10 CFR 60.31(a)(1)(i)
10 CFR 60.31(a)(2)
10 CFR 60.112
10 CFR 60.122(c)(3)

TYPES OF REVIEW:

Acceptance Review (Type 1)
Safety Review (Type 3)

RATIONALE FOR TYPES OF REVIEW:

Acceptance Review (Type 1) Rationale:
This regulatory requirement topic is considered to be License Application-related because, as specified in the License Application content requirements of 10 CFR 60.21(c) and the regulatory guide "Format and Content for the License Application for the High-Level Waste Repository (FCRG)", it must be addressed by the U.S. Department of Energy (DOE) in its license application. Therefore, the staff will conduct an Acceptance Review of the license application for this regulatory requirement topic.

Safety Review (Type 3) Rationale:
This regulatory requirement topic is considered to be related to containment and waste isolation. It is a requirement for which compliance is necessary to make a safety determination for construction authorization as defined in 10 CFR 60.31(a) (i.e., regulatory requirements in Subparts E, G, H, and I of 10 CFR 60). Therefore, the staff will conduct a Safety Review of the license application to determine compliance with this regulatory requirement.

This regulatory requirement topic, ~~concerning~~ is concerned with a potentially adverse condition (PAC), naturally produced surface water impoundments, and focuses on the potential for landslides, subsidence, volcanic activity, or other natural processes ~~to~~ which may occur at the surface and ~~create~~ cause large-scale surface water impoundments. In addition, it focuses on the ability of any such impoundments to affect the regional groundwater and, as a consequence, adversely affect waste isolation.

This PAC is ~~addressed~~ related to postclosure performance of the repository. As ~~is~~ discussed in the Statements of Consideration for the final rule (48 FR 28212), preclosure concerns regarding flooding and the possible effects of flooding on waste isolation are addressed in 10 CFR 60.122(c)(1). The Statements of

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Consideration for the final rule also suggest that the facility be designed to preclude massive inflows of water. Flooding from a surface water source through defective borehole, shaft, and ramp seals could easily result in massive inflows of water to the repository.

The adequacy of the design of the seals for boreholes, shafts, and ramps will be covered in the review for 10 CFR 60.134 (Review Plan 4.3~~4~~). ~~The general design criteria in 10 CFR 60.134 require that "seals for shafts and boreholes shall be designed so that following permanent closure they do not become pathways that compromise the geologic repository's ability to meet the performance objectives for the period following permanent closure."~~

Conventional methods exist for the analysis of precipitation, evaporation, and estimation of extreme precipitation events (such as the probable maximum precipitation) under present conditions. DOE's paleoclimate studies (SP 8.3.1.5.1.2) should provide an estimate of past climates, including pluvial climates. DOE ~~is~~ also performing studies ~~(8.3.1.5.1.6) which seek~~ to estimate future climate change from past climate change. These studies ~~seek~~ will attempt to identify pluvial conditions sufficiently likely to warrant consideration. Estimates of the probable maximum precipitation and other extreme events associated with pluvial conditions sufficiently likely to warrant consideration can be developed, possibly making use of a modern pluvial analog to the site. Under pluvial conditions sufficiently likely to warrant consideration, areas of flooding during extreme events can be identified for the Yucca Mountain site. The same methods used in evaluating preclosure flooding (see Review Plan 3.2.2.5) can be used for this purpose. DOE's Quaternary regional hydrology studies ~~(SP 8.3.1.5.1.8)~~ will also provide some direct information about paleoflooding events and the effect of recharge on the regional hydrology at modern pluvial analog sites.

~~Using the results of the review for the effects of perched water bodies (10 CFR 60.122(c)(23), Review Plan 3.2.2.12), the review for the effects of pluvial conditions on hydrologic parameters (10 CFR 60.122(c)(6), Review Plan 3.2.2.13), and the review for the effects of changes in hydrologic parameters (10 CFR 60.122(c)(5), Review Plan 3.2.2.9), the reviewer can evaluate the effect on the recharge rate of the increase in moisture levels and the possible formation of a perched water table associated with the hypothesized flooding and impoundment event. The reviewer can then evaluate the effect of such an increase in the recharge rate on the regional groundwater flow. The reviewer, in evaluating these factors, will consider the duration of the hypothesized flooding and impoundment event.~~

Sufficient technical knowledge exists to allow for an adequate investigation and evaluation of the likelihood of this PAC. Based on the information ~~already known about the site and nearby environs related to this review plan topic, the analysts~~ concludes that a safety determination can be made by evaluating the technical information submitted by DOE in its license application. ~~The review is expected to require no additional analyses or tests (Types 4 or 5 reviews).~~ regarding this PAC

The review is expected to require no additional analyses or tests and so will not necessitate a Type 4 or 5 review

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Based on the above considerations, this regulatory requirement topic will be reviewed by the staff ~~as~~ a Type 3 (Safety Review). Should future analyses ~~and/or~~ data arise such that this initial assessment is questioned, the type of review of this regulatory requirement topic ~~should receive~~ will be reassessed in light of the additional information.

No likely scenarios involving naturally produced large-scale surface water impoundments have ~~presently~~ been identified that could significantly affect the regional groundwater system. However, estimates of future conditions may change as new data become available.

~~To summerize,~~ The following ~~statements and~~ assumptions have been made in developing this CDS:

(1) Examination of ~~the~~ DOE's study plans transmitted to NRC dealing with postclosure tectonics reveals no mention of studies which seek to estimate which locations within the site are more susceptible to volcanic activity than others. ~~The NRC has no information suggesting that such studies will be contained in study plans which have not yet been transmitted, nor information suggesting how such studies would be performed.~~ Conventional methods for making such predictions do not exist. Only limited information is available concerning which locations within the site are more susceptible to landslides, subsidence, and faulting than others ~~than others is available~~. Information concerning postclosure flooding within the context of climate and regional hydrology is being gathered. The information being gathered could be used to demonstrate compliance for this regulatory requirement topic based on assuming that natural drainage pathways become obstructed. There are two approaches that can be taken for the demonstration of compliance with this regulatory requirement topic: (a) depend on estimates of where landslides, subsidence, faulting, or volcanic activity are most likely to occur, or (b) analyze the duration and effects of the type of impoundment which such effects could create. If approach (a) is chosen, the NRC review may require independent confirmation of the likely location of landslides, subsidence, faulting events, or volcanic events. In this case, the review would also require independent confirmation of the probability and consequences with respect to the formation of large scale surface water impoundments of events in other locations. If, on the other hand, approach (b) is chosen, conventional methods should be usable for this purpose once the necessary data have been collected.

(2) ~~The formation, effects, and duration of perched water bodies will be evaluated in the review for 10 CFR 60.122(c)(23) (Review Plan 3.3.2.12).~~ The effects of near-surface perched water bodies ~~near the surface~~ on the recharge rate will be of particular interest in assessing the effects of naturally produced surface water impoundments; The PAC related to perched water bodies stated in 10 CFR 60.122(c)(3), is addressed in review plan 3.2.2.12 of the LARP.

(3) ~~The effects of pluvial conditions on hydrologic parameters will be evaluated in the review for 10 CFR 60.122(c)(6) (Review Plan 3.2.2.13).~~ The effects of pluvial conditions sufficiently likely to warrant consideration on the magnitude of extreme flooding events, the infiltration rate and associated recharge rate expected during flooding events, the annual precipitation rate, annual evapotranspiration rate, annual pan evaporation rate, and annual recharge rate will be of particular interest in assessing the effects of naturally produced surface water impoundments. The PAC related to pluvial conditions covered in 10 CFR 60.122(c)(6), is addressed in review plan 3.2.4.2 of the LARP

(4) ~~The effects of changes in the hydrologic conditions will be evaluated in the review for 10 CFR 60.122(c)(5) (Review Plan 3.2.2.9).~~ The sensitivity of the regional groundwater flow system to increased recharge will be of particular interest in assessing the effects of naturally produced surface water impoundments. The PAC related to changes in hydrologic conditions, stated in 10 CFR 60.122(c)(5), is addressed in review plan 3.2.2.9 of the LARP.

(5) ~~The direct effects of structural deformation on groundwater and indirect effects other than the formation of surface water impoundments will be evaluated in the review for 10 CFR 60.122(c)(4) (Review Plan 3.2.1.5);~~

(6) ~~Preclosure flooding will be evaluated in the review for 10 CFR 60.122(c)(1) (Review Plan 3.2.2.5);~~

(7) ~~The design of seals for shafts, ramps, and boreholes will be part of the review for 10 CFR 60.134 (Review Plan 4.3).~~

REVIEW STRATEGY:

Acceptance Review:

In conducting the Acceptance Review of the potentially adverse condition (PAC) concerning ~~of~~ naturally produced surface water impoundments affecting regional groundwater, the reviewer should determine if the information present in the license application and its references for determining compliance with the regulatory requirements applicable to this PAC is complete in technical breadth and depth as identified in the regulatory guide "Format and Content for the License Application for the High-Level Waste Repository" (FCRG). The reviewer should determine that all appropriate information necessary for the staff to review this PAC is presented such that the assessments associated with total system and subsystem performance objectives can be performed.

The reviewer should determine whether the information ~~presented~~ in the license application ~~should be~~ is presented in such a manner that the assumptions, data and logic leading to a demonstration of compliance with the requirement are clear and do not require the reviewer to conduct extensive analyses or literature searches. The reviewer should also determine that controversial information and appropriate alternative interpretations and models have been adequately described and considered.

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Finally, the reviewer shall determine if the U.S. Department of Energy (DOE) has either resolved all the NRC staff objections that apply to this regulatory requirement topic or provided all the information requested in Section 1.6.2 of the FCRG for unresolved objections. The reviewer will evaluate the effects of any unresolved objections, both individually and in combinations with others, on: (1) the ~~reviewers~~ ability to conduct a meaningful and timely review; and (2) the Commission's ability to make a decision regarding construction authorization within the three-year statutory period.

Safety Review:
The regulatory requirement topic is limited to consideration of DOE's demonstration, through appropriate investigations, of the evidence for (or against) the PAC of naturally produced surface water impoundments affecting regional groundwater within the controlled area (and outside the controlled area, if considered necessary). It is not concerned with preclosure flooding (10 CFR 60.122(c)(1)), the potential effects of structural deformation on groundwater other than the formation of surface water impoundments (10 CFR 60.122(c)(4)), or the design of seals for shafts, ramps, and boreholes (10 CFR 60.134). These topics will be covered under Review Plans 3.2.2.5, 3.2.2.8, and 3.4, ~~respectively~~. ~~Its~~ Concern with perched water bodies (10 CFR 60.122(c)(23)), changes to hydrologic conditions (10 CFR 60.122(c)(5)), and changes to hydrologic conditions due to climate (10 CFR 60.122(c)(6)) is limited to ~~their~~ effects on naturally-produced surface water impoundments affecting regional groundwater. These topics will be covered under Review Plans 3.2.2.12, 3.2.2.9, and 3.2.~~2.13~~, ~~respectively~~. The specific aspects of the license application on which the reviewer will focus are described below and the *Acceptance Criteria* are identified in Section 3.0 of ~~this~~ review plan, 3.2.2.7 in the LARP.

In conducting the Safety Review, the reviewer should ~~first confirm whether assumptions made in developing the rationale have been met. Then, the~~ determine if the information presented in the license application and its reference is an acceptable demonstration of compliance with the applicable regulatory requirements. reviewer will, at a minimum, ~~determine~~ the adequacy of the data and analyses presented in the license application to ~~determine~~ DOE's ~~compliance with~~ 10 CFR 60.122(c)(3). Specifically, DOE will need to (1) provide information to determine whether and to what degree the PAC of naturally produced surface water impoundments affecting regional groundwater is present; (2) provide information to determine to what degree the PAC of naturally produced surface water impoundments affecting regional groundwater is present but undetected; (3) assure the sufficiency of the lateral and vertical extent of data collection; (4) evaluate the information presented under items (1) and (2), with assumptions and analysis methods that adequately describe the presence of the PAC and ranges of relevant parameters. In general, the reviewer will assess the adequacy of DOE's investigations of the PAC, both at the site and in the geologic setting (i.e., need to include the controlled area), in the manner outlined in 10 CFR 60.21(c)(1)(ii)(B). For this PAC, the above items can be satisfied by proper characterization of the precipitation, potential evapotranspiration, infiltration rates and associated recharge rates during flooding events, annual recharge rate, and annual pan evaporation at the site under present and pluvial conditions sufficiently likely to warrant consideration; determination of the extreme flooding events, such as the 100 year flood and the probable maximum flood, under present and pluvial conditions sufficiently likely to warrant

Entire paragraph re-written (see attached page) to include more than one long sentence!!

[2] Replace paragraph on page ~~4~~ 5 with the following paragraph:

For this PAC, the four necessary steps defined above can be satisfied by DOE through conduct of the activities described in this paragraph. First, DOE should characterize the following climatic elements of the site, both for the present-day climate and for a pluvial climatic condition deemed sufficiently likely to warrant consideration: precipitation, potential evapotranspiration, infiltration and discharge rates during flooding events, annual recharge rate, and annual pan evaporation. Extreme flooding events, such as the 100-year flood and the probable maximum flood, must also be determined under both present climatic conditions and the likely pluvial conditions. Estimates should be made of the depths of water which could be reasonably impounded if natural drainage pathways were obstructed by a landslide, subsidence, faulting, volcanism, or some other natural process. Estimates of the reasonable duration of time for such obstructions should be made as well. Finally, conclusions drawn from the following efforts should be summarized: evaluation of the formation, effects, and duration of near-surface perched water bodies; evaluation of effects on hydrologic parameters from pluvial conditions deemed sufficiently likely to warrant consideration; modeling of regional groundwater with regard for effects of increased recharge, particularly in flood-prone areas such as Fortymile Wash, the principal surface drainage feature at Yucca Mountain.

Then start...

The first step in the NRC review...

"pg 6"

(1) through (7) deleted

assessing the effects of naturally produced surface water impoundments;

(3) The effects of pluvial conditions on hydrologic parameters will be evaluated in the review for 10 CFR 60.122(c)(6) (Review Plan 3.2.2.13). The effects of pluvial conditions sufficiently likely to warrant consideration on the magnitude of extreme flooding events, the infiltration rate and associated recharge rate expected during flooding events, the annual precipitation rate, annual evapotranspiration rate, annual pan evaporation rate, and annual recharge rate will be of particular interest in assessing the effects of naturally produced surface water impoundments;

(4) The effects of changes in the hydrologic conditions will be evaluated in the review for 10 CFR 60.122(c)(5) (Review Plan 3.2.2.9). The sensitivity of the regional groundwater flow system to increased recharge will be of particular interest in assessing the effects of naturally produced surface water impoundments;

(5) The direct effects of structural deformation on groundwater and indirect effects other than the formation of surface water impoundments will be evaluated in the review for 10 CFR 60.122(c)(4) (Review Plan 3.2.1.5);

(6) Preclosure flooding will be evaluated in the review for 10 CFR 60.122(c)(1) (Review Plan 3.2.2.5);

(7) The design of seals for shafts, ramps, and boreholes will be part of the review for 10 CFR 60.134 (Review Plan 4.3).

The first step in the NRC review will be to validate DOE's analysis and determine if the assumptions discussed under the Type 3 safety review have been met

If these assumptions are met, the review will consist primarily of: (1) evaluating probable maximum precipitations computed under present and pluvial conditions sufficiently likely to warrant consideration; (2) evaluating calculated flows and water levels and verifying that the flood-prone areas of the site are properly delineated; (3) evaluating the calculated impoundment depth, area, and duration of the impounding event; (4) evaluating the calculated effect on the formation of perched water bodies and increased recharge; (5) evaluating the calculated effect on the regional groundwater flow system and the water table in the vicinity of the repository from the increase in recharge. If these assumptions are not met, the review may require independent confirmation of the likely location of landslides, subsidence, faulting events, or volcanic events. In this case, the review would also require independent confirmation of the probability and consequences with respect to the formation of large-scale surface water impoundments ~~of events in~~ other locations. DOE may be able to show that the locations of concern because of the potential for surface water impoundments are unlikely to experience the geologic events which form the necessary precursors. If DOE chooses to present such arguments in addition to evaluating the hydrologic and climatic conditions, a higher level review will

be required. Conventional methods do not exist for the prediction of the precise location of such events, and theories concerning the prediction of such events are controversial. Some of the data identified as necessary for the review of this PAC are derived in other sections of the license application and its review. If these data are difficult to locate, in a form which requires extensive supplemental calculations before use, or are absent altogether, this review will be delayed. In addition, if any of the shafts, ramps, or boreholes are located in areas considered flood-prone under either present conditions or pluvial conditions sufficiently likely to warrant consideration, the review process for the affected shafts, ramps, or boreholes will become more complex than is currently envisioned ~~(see Review Plan 4.3)~~.

DOE will also need to provide an explanation of the measures used to support models ~~used to assess~~ the presence or absence of evidence of the PAC ~~of~~ naturally produced surface water impoundments affecting regional groundwater. Analyses and models that will be used to predict future conditions and changes in the geologic setting shall be supported by using an appropriate combination of such methods as field tests, *in-situ* tests, laboratory tests that are representative of field conditions, monitoring data, and natural analog studies.

In conducting the aforementioned evaluations, the reviewer should determine that DOE uses: (1) analyses that are sensitive to evidence of the PAC; and (2) assumptions which are not likely to underestimate its effects. In general, the reviewer will assess the adequacy of DOE's investigations for evidence of the PAC, both within the controlled area and outside the controlled area, as necessary.

Reviews of DOE models will be required whether or not the assumptions are satisfied. A model review should consist of: (1) a determination that the quantitative hydraulic models chosen are appropriate (for example, steady vs. unsteady flow); (2) a check of input data to confirm that they are representative of the site; (3) confirmation that DOE models reflect the natural system; (4) assurance that assumptions used are valid and applicable to the site; and (5) determination that the conclusions presented are consistent with the model outputs. At the reviewers discretion, simple confirmatory calculations may be performed using appropriate procedures. ~~Finally, a brief site visit will allow the staff to verify that DOE's analyses accurately reflect conditions at the site.~~ The visits will assist the staff with verifying that DOE's analyses accurately reflect conditions at the site. In order to conduct an effective review, the reviewers will rely on their own expertise and independently acquired knowledge, information and data such as the results of research activities being conducted by the NRC's Office of Nuclear Regulatory Research, in addition to that provided by the DOE in its license application. For example, regional groundwater modeling exercises with studies of sensitivity to the recharge rate in low-lying areas such as ~~40 Mile~~ Wash, ~~such as~~ (NUREG/CR-5890, (NRC, 1992), should be consulted. The reviewer should focus on additional data which can refine knowledge of the PAC of naturally produced surface water impoundments affecting regional groundwater, and should perform, as necessary, additional analyses to confirm

Footnote

the resolution capabilities of the methodologies. It is incumbent upon the reviewer to have acquired a body of knowledge regarding these and other critical considerations in anticipation of conducting the review to assure that the regional groundwater modeling, climatology, and flood evaluation program is sufficient in scope and depth to provide the information ~~to resolve the~~ concerns.

Finally, DOE The following site characterization plan studies are expected to ~~in particular, will~~ provide data needed ~~to address the evaluation of this PAC:~~ regional hydrologic system synthesis and modeling (SP 8.3.1.2.1.4), characterization of the future regional climate and environments (SP 8.3.1.5.1.6), characterization of modern regional climate (SP 8.3.1.5.1.1), paleoclimate study: lake, playa, and marsh deposits (SP 8.3.1.5.1.2), characterization of the Quaternary regional hydrology (SP 8.3.1.5.2.1), and characterization of the future regional hydrology due to climate change (SP 8.3.1.5.2.2)

Contributing Analysts:

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CNWRA: Gerry L. Stirewalt, ~~John Hagan~~ Sitaharanta Mohanty

Date of Analysis: 02/22/93

APPLICABLE REGULATORY REQUIREMENTS FOR EACH REVIEW TYPE:

Type 1:

10 CFR 60.21(a)(1)(D)
60.21(c)(1)(ii)(A)
60.21(c)(1)(ii)(B)
60.21(c)(1)(ii)(F)
60.31(a)(1)(i)

Type 3:
10 CFR 60.122(c)(3)

10 CFR 60.21(c)(1)(ii)(B)
" " " (C)
" " " (F)
10 CFR 60.31(a)(1)(i)
10 CFR 60.31 (a)(2)
10 CFR 60.112
10 CFR 60.122(c)(3)

REFERENCES:

Nuclear Regulatory Commission, "Format and Content for the License Application for the High-Level Waste Repository," Office of Nuclear Regulatory Research. [Refer to the "Products List" for the Division of High-Level Waste Management to identify the most current edition of the FCRG in effect.]

Nuclear Regulatory Commission, "Regional Groundwater Modeling of the Saturated Zone in the Vicinity of Yucca Mountain, Nevada," NUREG/CR-5890(CNWRA92-001), October 1992. (Prepared by the Center for Nuclear Waste Regulatory Analyses)

10 CFR 60.21(c)(1)(ii)(B)
" " " (C)
" " " (F)
10 CFR 60.31 (a)(1)(i)
10 CFR 60.31 (a)(2)

February 25, 1993

Nuclear Regulatory Commission, "Disposal of High-Level Radioactive Wastes in Geologic Repositories: Final Rule," Federal Register Vol 48, No. 120, June 21, 1983, pp 28194-28229

Department of Energy, "Regional Hydrologic System Synthesis and Modeling", Study Plan 8.3.1.2.1.4, Revision 0, Office of Civilian Radioactive Waste Management, Washington, DC, July 1991.

Department of Energy, "Characterization of Future Regional Climate and Environment", Study Plan 8.3.1.5.1.6, Revision 0, Office of Civilian Radioactive Waste Management, Washington, DC, Not Yet Available.

Department of Energy, "Characterization of Modern Regional Climate", Study Plan 8.3.1.5.1.1, Revision 0, Office of Civilian Radioactive Waste Management, Washington, DC, Not Yet Available.

Department of Energy, "Paleoclimate Study: Lake, Playa, and Marsh Deposits", Study Plan 8.3.1.1.1.2, Revision 0, Office of Civilian Radioactive Waste Management, Washington, DC, October 1991.

Department of Energy, "Characterization of the Quaternary Regional Hydrology", Study Plan 8.3.1.5.2.1, Revision 2, Office of Civilian Radioactive Waste Management, Washington, DC, March 1992.

Department of Energy, "Characterization of the Future Regional Hydrology Due to Climate Change", Study Plan 8.3.1.5.2.2, Revision 0, Office of Civilian Radioactive Waste Management, Washington, DC, November 1992.

LAKE ry
[illegible]

FEB 25 1993

NOTE TO: Larry McKague, Geologic Setting
Program Element Manager
Center for Nuclear Waste Regulatory Analyses

FROM: David Brooks, NRC-Hydrologic Transport Section
Program Element Manager
Hydrology and Systems Performance Branch
Division of High-Level Waste Management

SUBJECT: TRANSMITTAL OF PRELIMINARY NRC STAFF APPROVAL OF THE COMPLIANCE DETERMINATION STRATEGY FOR REVIEW PLAN 3.2.2.7: NATURALLY PRODUCED SURFACE WATER IMPOUNDMENTS

The purpose of this note is to transmit the subject compliance determination strategy (CDS) that has received preliminary approval by the NRC staff. Final approval of the CDS is subject to our review and resolution of any comments or changes made by the Center for Nuclear Waste Regulatory Analyses.

Enclosure: As stated

cc: BJYoungblood/HLWM
JLinehan/HLWM
DLoosley/PMDA
MSilberberg/RES
MLee/HLWM
PMackin/CNWRA
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C = COVER E = COVER & ENCLOSURE N = NO COPY

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