Exelon Generation Company, LLC, Early Site Permit Final Safety Evaluation Report Changed Pages

Attachment

PAGE CONVERSION FROM ACRS MEMO TO FSER

Attachment Page Numbers	02/17/06 FSER Page Numbers	Type of Change
Page 4	Page iv	Editorial
Page 5	Page v	Editorial
Page 6	Page ix	Editorial
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Page 13	Page 1-3	Technical
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Pages 74 to 75	Page C-5	Editorial

WordPerfect Document Compare Summary

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CONTENTS

In accordance with U.S. Nuclear Regulatory Commission Review Standard (RS)-002, “Processing Applications for Early Site Permits,” the chapter and section layout of this safety evaluation report is consistent with the format of (1) NUREG-0800, “Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants,” (2) Regulatory Guide 1.70, “Standard Format and Content of Safety Analysis Reports for Nuclear Power Plants,” and (3) the applicant’s site safety analysis report. Numerous sections and chapters in the NUREG-0800 are not within the scope of or addressed in an early site permit (ESP) proceeding. The reader will therefore note “missing” chapter and section numbers in this document. The subjects of chapters and sections in NUREG-0800 not addressed herein will be addressed, as appropriate and applicable, in other regulatory actions (design certification, construction permit, operating license, and/or combined license) for a reactor or reactors that might be constructed on the EGC ESP site.

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and Champaign-Urbana to the west and east, respectively, and is adjacent to an existing nuclear power reactor, Clinton Power Station, operated by AmerGen Energy Company, LLC (AmerGen).

In accordance with 10 CFR Part 52, Exelon submitted an ESP application that includes (1) a description of the site and nearby areas that could affect or be affected by a nuclear power plant(s) located at the site, (2) a safety assessment of the site on which the facility would be located, including an analysis and evaluation of the major structures, systems, and components of the facility that bear significantly on the acceptability of the site, and (3) the proposed major features of an emergency plan. The application describes how the site complies with the requirements of 10 CFR Part 52 and the siting criteria of 10 CFR Part 100, "Reactor Site Criteria."[1]

This SER presents the conclusions of the staff's review of information the applicant submitted to the NRC in support of the ESP application. The staff has reviewed the information provided by the applicant to resolve the open and confirmatory items identified in the draft safety evaluation report (DSER) and the supplemental DSER for the EGC ESP. In Section 1.6 of this SER, the staff provides a brief summary of the process used to resolve these items; details of the resolution for each open item are presented in the corresponding section of this report.

The staff has identified, in Appendix A to this SER, the proposed permit conditions that it will recommend the Commission impose if an ESP is issued to the applicant. Appendix A also includes a list of COL action items or certain site-related items that will need to be addressed at the COL or construction permit stage, if an applicant desires to construct one or more new nuclear reactors on the EGC ESP site. The staff determined that these items do not affect the staff's regulatory findings at the ESP stage and are, for reasons specified in Section 1.7, more appropriately addressed at these later stages in the licensing process. In addition, Appendix A lists the site characteristics and the bounding parameters identified by the staff for this site.

Inspections conducted by the NRC have verified, where appropriate, the conclusions in this SER. The inspections focused on selected information in the ESP application and its references. This SER identifies applicable inspection reports as reference documents.

The NRC's Advisory Committee on Reactor Safeguards (ACRS) also reviewed the bases for the conclusions in this report. The ACRS independently reviewed those aspects of the application that concern safety, as well as the ~~draft~~ safety evaluation report, and provided the results of its review to the Commission in the interim report dated September 22, 2005, and in a final report dated March 24, 2006. This SER incorporates the ACRS comments and recommendations, as appropriate. ~~Additional comments from the final ACRS full committee~~

[1] The applicant has also submitted information intended to partially address some of the general design criteria (GDC) in Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Domestic Licensing of Production and Utilization Facilities." Only GDC 2, "Design Bases for Protection Against Natural Phenomena," applies to an ESP application, and it does so only to the extent necessary to determine the safe-shutdown earthquake (SSE) and the seismically induced flood. The staff has explicitly addressed partial compliance with GDC 2, in accordance with 10 CFR 52.17(a)(1) and 10 CFR 50.34(a)(12), only in connection with the applicant's analysis of the SSE and the seismically induced flood. Otherwise, an ESP applicant need not demonstrate compliance with the GDC. The staff has included a statement to this effect in those sections of the SER that do not relate to the SSE or the seismically induced flood. Nonetheless, this SER describes the staff's evaluation of information submitted by the applicant to address GDC 2.

meeting, if any, will be addressed in an addendum to this SER before it is formally issued as a final NRC technical report (i.e., a NUREG). The final ACRS reportAppendix E includes a copy of the report by the ACRS on the final safety evaluation report, as required by 10 CFR 52.23, "Referral to the ACRS,." will be included in the addendum as an additional appendix to this SER.

EGC	Exelon Generation Company
EIS	environmental impact statement
ENS	Emergency Notification System
EOC	emergency operations center
EOF	emergency operations facility
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
EPZ	emergency planning zone
ER	environmental report
ERDC	U.S. Army Engineering Research and Development Center
ERDS	Emergency Response Data System
ERF	emergency response facility
ERO	emergency response organization
ESBWR	Economic and Simple Boiling Water Reactor
ESDA	DeWitt County Emergency Services and Disaster Agency
ESP	early site permit
ESW	emergency service water
ETE	evacuation time estimate
FAA	Federal Aviation Administration
FAFC	Fluorspar Area fault complex
FBI	Federal Bureau of Investigation
FEMA	Federal Emergency Management Agency
FDD	freezing degree days
FOS	factor of safety
FOSID	frequency of onset of significant inelastic deformation
fps	feet per second
FRERP	Federal Radiological Emergency Response Plan
FSER	final safety evaluation report
ft	feet
GDC	general design criterion/criteria
GIS	geographic information system
gpm	gallons per minute
GPS	global positioning system
GRL	GRL Engineers, Inc.
GT-MHR	Gas Turbine Modular Helium Reactor
HCLPF	high-confidence-low-probability-of-failure
HEC	Hydrologic Engineering Center
HMR	Hydrometeorological Report
HPN	health physics network
Hz	Hertz
IDNR	Illinois Department of Natural Resources
IDNS	Illinois Department of Nuclear Safety
IDOT	Illinois Department of Transportation
IDOW	Illinois Division of Waterways
IDPH	Illinois Department of Public Health
IEMA	Illinois Emergency Management Agency
ILCS	Illinois Complied Statute
INEEL	Idaho National Engineering and Environmental Laboratory

subsequently revised its application to address requests from the NRC staff for additional information. The applicant submitted the most recent version, SSAR Revision ~~2~~4 (application), to the Commission on ~~January~~April 1~~0~~4, 2006 (ADAMS Accession No. ~~ML060460043~~ MLXXXXXXXXX).

Appendix B to this report provides a chronological list of the licensing correspondence between the applicant and the Commission regarding the review of the EGC ESP application under Project No. 718 and Docket No. 52-007. The application and other pertinent information and materials are available for public inspection at the NRC's Public Document Room at One White Flint North, 11555 Rockville Pike, Rockville, Maryland. The application and this safety evaluation report (SER) are also available at the Vespasian Warner Public Library, 310 North Quincy Street, Clinton, Illinois, as well as on the NRC's new reactor licensing public Web site at http://www.nrc.gov/reactors/new-licensing/esp/clinton.html. This SER is also available in ADAMS under Accession No. ML060470383.

This SER summarizes the results of the staff's technical evaluation of the suitability of the proposed EGC ESP site for construction and operation of a nuclear power plant(s) within the plant parameter envelope (PPE) that EGC specified in its application. This SER delineates the scope of the technical matters that the staff considered in evaluating the suitability of the site. NRC Review Standard (RS)-002, "Processing Applications for Early Site Permits," Attachment 2, provides additional details on the scope and bases of the staff's review of the radiological safety and emergency planning aspects of a proposed nuclear power plant site. RS-002, Attachment 2, contains regulatory guidance based on NUREG-0800, "Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants" (hereafter referred to as the SRP). The SRP reflects the staff's many years of experience in establishing and promulgating guidance to enhance the safety of nuclear facilities and in evaluating safety assessments. In addition, this SER documents the resolution of the open and confirmatory items identified in the draft safety evaluation report (DSER) for the EGC ESP, issued on February 10, 2005.

In the DSER, the NRC identified Confirmatory Item 1.1-1 to verify that EGC's future revision of its ESP application is consistent with the information provided in its requests for additional information (RAIs) responses. Throughout the course of the review, the staff requested that the applicant submit additional information to clarify the description of the EGC ESP site. This report discusses some of the applicant's responses to these RAIs. The staff reviewed the revisions of the EGC ESP application, up to and including Revision 2 of the SSAR, and determined that the ESP application is consistent with the information provided in its RAI responses. Therefore, the staff considers DSER Confirmatory Item 1.1-1 to be resolved.

At the time the DSER was issued, the staff had not completed its review in the areas of seismology and geology. In the DSER, the staff identified Confirmatory Item 1.1-2 for issuance of a supplemental DSER at a later date to summarize the results of its technical evaluation of the suitability of the proposed EGC ESP site with respect to the site's seismology and geology. The supplemental DSER was issued on August 26, 2005 (ADAMS Accession

No. ML052310459). Therefore, the staff considers Confirmatory Item 1.1-2 to be resolved.

The applicant also filed an environmental report for the EGC ESP site in which it evaluated those matters relating to the environmental impact assessment that can be reasonably reviewed at this time. The staff discussed the results of its evaluation of the environmental report for the EGC ESP site in a draft environmental impact statement (DEIS) issued on March 2, 2005 (ADAMS Accession No. ML050610364). The applicant also provided a site redress plan, in accordance with 10 CFR 52.17(c), for performing the site preparation and limited construction activities allowed by 10 CFR 52.25(a) (i.e., the activities listed in 10 CFR 50.10(e)(1)). The DEIS also includes the results of the staff's evaluation of that plan.

As described above, the applicant supplemented the information in the SSAR by providing revisions to the document. The staff reviewed these revisions to determine their impact on the conclusions in this SER. On February 17, 2006, the NRC issued its SER for the EGC ESP site and made it publically available. EGC identified that the site characteristic for the probable maximum flood (PMF) elevation proposed by the staff in the SER was somewhat higher than that calculated by EGC in its ESP application. By letters dated March 24, 2006, and April 12, 2005, EGC requested that the staff review its revised PMF analysis and adopt its corresponding PMF level as the site characteristic. By letter dated April 14, 2006, EGC provided Revision 4 to the EGC ESP application, which documented EGC's revised PMF analysis. The changes reflected in Revision 4 of the application included revisions to the tables, figures and text in Section 2.4 to reflect EGC's revised PMF analysis. This included changes to the maximum rainfall rate, the maximum hydrostatic PMF water surface elevation, the coincident wind wave activity, and the maximum storm surge. EGC presented PMF calculations using two different synthetic unit hydrograph methods (the Synder method and the Soil Conservation Service method) with two different conceptual watershed layouts (a two-basin plus lake model and a seven-basin plus lake model). The staff completed its review of the most recent version, Revision 4, of the SSAR, as documented throughout this report and, for the reasons set forth herein, finds it to be acceptable. The changes to the application in Revision 4 resulted in minor modifications to the staff's SER issued February 17, 2006, including the following changes: Section 2.4 of this SER was modified to incorporate EGC's revised PMF analysis and the staff's independent confirmatory analysis; Appendix A of this SER was modified to reflect the new site characteristics related to the revised PMF elevation; Appendix B of this SER was modified to include Revision 4 of the application; and Appendix C of this SER was modified to include reference documents used by the staff in its review of EGC's revised PMF elevation. The changes to this SER also include modifications to Section 2.4 to better describe the technical information in the application regarding EGC's ice thickness calculations. The scope of all other changes to the SER issued on February 17, 2006, resulting from Revision 4, are limited to corrections of factual inaccuracies; these changes did not impact the staff's conclusions.

Appendix A to this SER contains the list of site characteristics, permit conditions, combined license (COL) action items, and the bounding parameters that the staff recommends that the Commission include in any ESP that might be issued for the proposed site. Appendix B to this SER is a chronology of the principal actions and correspondence related to the staff's review of the ESP application for the EGC ESP site. Appendix C lists the references for this SER, Appendix D lists the principal contributors to this report, and Appendix E includes a copy of the report by the ACRS.

WordPerfect Document Compare Summary

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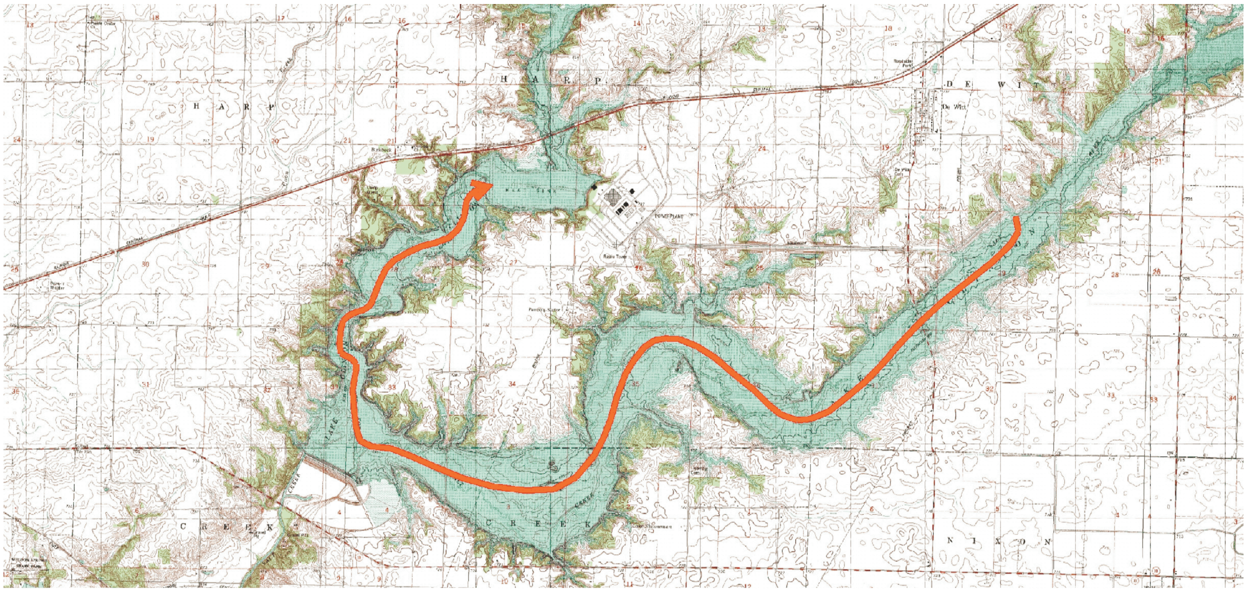

Figure 2.4-2 CPS once-through discharge and subsequent mixing and cooling path

The submerged dam is located approximately 1 mile west of the CPS intake structure. The top of the submerged dam is at elevation 675 ft MSL. A baffle dike divides the submerged UHS pond in approximately equal halves (see Figure 2.4-3 of this SER). The top of the baffle dike is at an elevation of 676 ft MSL. The UHS surface area at the design water surface elevation of 675 ft MSL is 158 ac with a total volume of 1067 acre-feet (ac-ft) or 46.62 million cubic feet (ft^3).

The intake for CPS Unit 1 is located on the submerged UHS pond (see Figure 2.4-3 of this SER). During emergency operation, CPS Unit 1 UHS discharges into the submerged UHS pond downstream (i.e., south) of the baffle, allowing mixing and heat exchange to the atmosphere to occur before the discharge reaches the intake. The ESP facility would have a similar UHS intake structure (see Figure 2.4-3 of this SER). The ESP facility UHS blowdown will be discharged to the discharge flume.

The applicant has not designed site drainage at the ESP facility because portions of this system will depend upon the reactor(s) design selected for the ESP facility. The nominal grade elevation of 735 ft MSL provides more than 20 ft of elevation difference for drainage between the site grade and maximum flood water elevation in Clinton Lake. The applicant stated that this elevation difference is large enough to allow the design of a drainage system to handle maximum site precipitation without requiring any active components.

In Revision 4 of the SSAR, the applicant revised the maximum rainfall rate site characteristic to reflect information contained in HMR 52. The revised maximum rate for the 1-hr PMP is 18.15 in. and for the 5-minute PMP is 6.08 in. The applicant stated that these local PMP values will be used to mitigate impacts of local site flooding based on grading and drainage design at the COL stage.

The applicant stated in Revision 4 of SSAR Section 2.4.2.2 that the maximum water surface elevation (excluding the effects of coincident wind, storm surge, and seiche activity) that could be expected for Clinton Lake is 709.8 ft MSL. This elevation is based on flood calculations using a cumulative PMP depth of 27.8 in. The postulated PMP was preceded by a standard project storm (SPS) equal to 40 percent of the PMP depth. Methods for computing the maximum water elevation are discussed more fully in Section 2.4.3 of this SER and references to previous application of the USACE SPRAT computer program have been removed. The applicant stated that all safety related structures at the ESP facility will either be above the maximum combined effects Clinton Lake water surface elevation (716.5 ft MSL) or be designed to withstand the effects of inundation.

2.4.2.2 Regulatory Evaluation

SSAR Table 1.5-1 describes the applicant's conformance to the NRC RGs. In RAI 1.5-1, the staff requested that the applicant provide a comprehensive listing of the NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the applicable NRC regulations. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to the hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

Section 2.4.2 of RS-002, Attachment 2, provides the review guidance used by the staff in evaluating this SSAR section. The acceptance criteria address 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the hydrologic features of the site. The regulations at 10 CFR 52.17(a) and 10 CFR 100.20(c) require the NRC to take into account the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability to host a nuclear reactor(s).

To satisfy the hydrologic requirements of 10 CFR Parts 52 and 100, the applicant's safety assessment should describe the surface and subsurface hydrologic characteristics of the site

1-mi^2 PMP. The staff used HMR 52 guidelines to estimate 1-hour, 1-mi^2 PMP depth for the ESP site. Table 2.4-2 of this SER, Column 2, lists the multiplication factors recommended in HMR 52 that are applied to 1-hour, 1-minute^2 PMP depth to estimate the PMP depths for other durations. Column 3 lists the staff's estimated PMP depths corresponding to these durations.

Table 2.4-2 Local Intense Precipitation (1-mi^2 PMP) at the Early Site Permit Site

Duration	Multiplier to 1-hour PMP depth	PMP depth in inches
5 min	0.335	6.08
15 min	0.528	9.58
30 min	0.759	13.78
1 hour	1.000	18.15
6 hours	1.493	27.10

The applicant used HMR 33 to estimate the PMP for watershed drainage into Clinton Lake; however, the current standards are HMRs 51 and 52. Section 2.4.3 of this SER describes the staff's independent PMP estimation for the watershed draining into Clinton Lake. In RAI 2.4.2-1, the staff requested that the applicant explain why it did not use these current standards and why an estimate based on HMR 33 is conservative relative to an estimate based on HMRs 51 and 52. In its response to RAI 2.4.2-1, the applicant described its method for estimating PMP values for Clinton Lake's drainage using HMR 51. The staff found that the applicant's procedure is inconsistent with the recommendations in HMR 51, which outline a detailed method for estimating PMP values for different durations for a desired drainage area.

The staff's independent estimates of 24-hour and 48-hour PMP values for the Clinton Lake watershed are 4.9 percent and 6.3 percent higher, respectively, than the applicant's PMP values derived using HMR 33 for the same durations, as reported in the SSAR. The staff concluded that the applicant did not show that PMP values estimated using HMR 33 are conservative when compared to PMP values estimated using HMR 51. Therefore, the applicant needed to provide a revised PMP estimate using the current criteria of HMR 51. This was DSER Open Item 2.4-5.

In response to DSER Open Item 2.4-5, the applicant stated, in its submission to the NRC dated April 4, 2005, that it agreed with the staff's independent estimate of PMP values obtained using the recommendations of HMR 51. The applicant noted that the PMF water surface elevations updated for HMR 51 PMP values would not change the ESP site from being considered a "dry site." However, the applicant conceded that the updated PMP values may be useful for assessing the impacts on site drainage during significant storm events. The applicant ~~also provided text for a revision to~~revised the SSAR to reflect its acceptance of the staff-estimated PMP values for the ESP site. |

~~The staff determined that a local intense precipitation value of 18.15 in. during 1 hour will be used as a site characteristic for the ESP site (see Table 2.4.14-1 of this SER). Based on the applicant's acceptance of the staff's independent estimate of PMP values at the ESP site, which were obtained using recommendations of the currently applicable HMR, the staff~~ The staff, therefore, considers Open Item 2.4-5 resolved. |

setup in DSER Permit Condition 2.4-3. However, based on the applicant's responses to DSER Open Items 2.4-1 and 2.4-2, the staff determined that the requirement of a UHS, and consequently the necessity of protecting its intake structures from flooding, is dependent on reactor design, which has not been selected at the ESP stage. Therefore, the staff determined that COL Action Item 2.4-3 is sufficient to ensure flood protection of the ESP facility's UHS intake structures, if the selected reactor design were to require one. Thus, it is not necessary to impose DSER Permit Condition 2.4-3.

SSAR Section 2.4.2 did not provide sufficient information on seismically generated seiches. In RAI 2.4.2-4, the staff requested that the applicant document any seismically induced seiches in Clinton Lake to determine whether such waves could affect the safety of the ESP site. In response to RAI 2.4.2-4, the applicant stated that it performed a search of existing literature to determine whether any seismically induced seiches had occurred in Clinton Lake or other lakes in the area. The applicant reported that seismic wave activity is extremely rare, and it did not identify any seismically induced seiche information. As an anecdotal note, the applicant stated that CPS personnel did not report any seiche activity in Clinton Lake during the magnitude 4.5 earthquake of June 2004. The staff examined the potential for seiches in Section 2.4.5 of this SER. Except for the ESP intake structures, the staff concluded that, based on the elevation of the ESP site relative to the lake and the distance of the ESP safety facilities from the shoreline (see revised SSAR Figure 1.2-4 in the attachment to RAI 2.4.1-1), seismically induced seiches did not pose a risk to the ESP site.

SSAR Section 2.4.2 did not provide sufficient information for the staff to determine whether drainage capacity at the existing grade can accommodate local intense precipitation without affecting any safety-related structures for the ESP facility. In RAI 2.4.2-5, the staff requested that the applicant demonstrate that drainage capacity at the existing grade is sufficient to accommodate local intense precipitation, or describe any active safety-related drainage systems that would be installed for the ESP facility. In response to RAI 2.4.2-5, the applicant stated that it has not yet designed site drainage at the ESP facility, since portions of this system will depend upon the reactor design selected for the ESP facility.

The applicant estimated local intense precipitation at the ESP site for a 1-hour duration to be 13.5 in. and for a 5-minute (min) duration to be 4.3 in. Table 2.4-2 of this SER shows the staff's independent estimation of local intense precipitation, which is 2 percent higher than the applicant's estimate for a 1-hour duration and 41 percent higher than its estimate for a 5-minute duration. Because of these differences, the site characteristic of local intense precipitation at the ESP site remained open. Therefore, the staff asked the applicant to address the differences between the two estimates of local intense precipitation at the ESP site for a 1-hour duration and for a 5-minute duration. This was DSER Open Item 2.4-8.

In response to DSER Open Item 2.4-8, the applicant stated, in its submission to the NRC dated April 4, 2005, that the SSAR characterizes short-term intense precipitation at the site for 1-hour and 5-minute durations on the basis of information available from the CPS USAR. The information in the CPS USAR is based on recommended procedures found in the older HMR 33. The applicant reviewed the staff's estimates of local intense precipitation for 1-hour and 5-minute durations based on the currently applicable HMR 52 and agreed with them. The applicant ~~stated that it will~~agreed with the staff's estimates and revised the text in SSAR Section 2.4.2.3 ~~to include the~~accordingly. ~~updated values.~~

The staff determined that applicant's response to DSER Open Item 2.4-8 is satisfactory, and therefore, considers DSER Open Item 2.4-8 to be resolved. The staff-estimated local intense precipitation presented in Table 2.4-2 of this SER will be included as a site characteristic for the ESP site (see Table 2.4.14-1 of this SER).

The applicant stated that a drainage system at the ESP site can be designed to handle maximum site precipitation without requiring any active components. The CP or COL applicant should demonstrate that the flooding from local intense precipitation at the ESP site can be discharged to Clinton Lake without relying on any active drainage systems that may be blocked during such an event. This is **COL Action Item 2.4-4**. The staff had planned to include this requirement as DSER Permit Condition 2.4-4. However, the staff determined that the ESP facility site grading will partially depend on the chosen reactor type, which has not been designed at the ESP stage. The staff concluded that COL Action Item 2.4-4 is sufficient to ensure the safety of the ESP facility from flooding generated by local intense precipitation. Therefore, it is not necessary to impose DSER Permit Condition 2.4-4.

2.4.2.4 Conclusions

As set forth above, the applicant provided sufficient information pertaining to identifying and evaluating floods at the site. SSAR Section 2.4.2 conforms to Section 2.4.2 of RS-002, Attachment 2, as it relates to identifying and evaluating floods at the site.

The review guidance in Section 2.4.2 of RS-002, Attachment 2, provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100. Although the applicant did not specifically address the above regulations in SSAR Section 2.4.2, the staff concludes that, by conforming to Section 2.4.2 of RS-002, Attachment 2, the applicant has met the requirements concerning floods at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c). Further, the staff finds that the applicant appropriately considered the most severe flooding that has been historically reported for the site and surrounding area, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.3 Probable Maximum Flood on Streams and Rivers

The ESP site is approximately 40.2E N latitude and 88.8E W longitude. The watershed draining into Clinton Lake is approximately 281.5 mi^2. The area of Clinton Lake is approximately 7.6 mi^2. Flooding in the watershed will lead to increased water surface elevation in Clinton Lake.

2.4.3.1 Technical Information in the Application

In SSAR Section 2.4.3.1, the applicant stated that the watershed drainage area is 296 mi^2. It developed the PMP according to procedures outlined in HMR 33. The applicant estimated a total precipitation of 25.2 in. during the 48-hour PMP storm. The 48-hour PMP storm was temporarily distributed according to guidelines in USACE, EM 1110-2-1411, "Standard Project Flood Determinations," issued March 1965. For the PMF runoff analysis, the applicant used an antecedent 48-hour ~~standard project storm (~~SPS~~)~~ equivalent to 50 percent of the PMP, followed by 3 dry days, followed by the full 48-hour PMP storm. The applicant considered the

After reviewing the conclusions of the staff's initial independent bounding analysis, the applicant elected to revise its application in order to provide the staff additional information to provide a basis for the staff's conclusions as documented in this report. In Revision 4 of the application, the applicant described its revised analysis. This new analysis did not rely on the applicant's earlier baseline calculation from the CPS USAR. The staff did not accept the applicant's initial approach as the applicant was unable to find adequate documentation of this earlier analysis.

In Revision 4 of the application, the applicant described an assessment of the PMF static flood elevation height based on a unit hydrograph analysis of the 72-hour PMP. The PMP was estimated using current National Weather Service guidance for deriving a PMP for the Clinton watershed (HMRs 51, 52, and 53). The applicant presented PMF calculations using two different synthetic unit hydrograph methods with two different conceptual watershed layouts. One conceptual layout included the lake and the two drainages associated with the Salt Creek and North Fork drainages as they enter Lake Clinton. The second conceptual layout further refined the two drainages into a total of seven sub-drainages. The applicant used the USACE Hydrologic Engineering Center (HEC) model HEC-HMS 3.0.0 computer code to estimate the variation of the lake level in response to the PMP.

The synthetic unit hydrograph method relies on estimates of lag time and precipitation losses. The applicant estimated time to peak using a relationship between drainage area and lag time developed for Illinois by the USGS (Mitchell, 1948). The applicant estimated the precipitation losses based on soil and land use data for the watershed. The most conservative estimate of hydrostatic flood elevation, due to the PMF based on results of the applicant's HEC-HMS analysis for the different synthetic unit hydrographs and conceptual layouts considered, was 709.8 ft MSL.

In Revision 4 of the application, the applicant estimated a maximum coincident wave runup of 6.4 ft based on calculations using the USACE's ACES version 1.07 code with a wind velocity of 52 mph. The applicant also estimated a probable maximum surge of 0.3 ft based on a wind velocity of 100 mph.

2.4.3.2 Regulatory Evaluation

SSAR Table 1.5-1 shows the applicant's conformance to the NRC RGs. In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to the hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

Section 2.4.3 of RS-002, Attachment 2, provides the review guidance used by the staff in evaluating this SSAR section. The acceptance criteria address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the hydrologic features of the site. The regulations in 10 CFR Parts 52 and 100 require the NRC to take into account a site's

Table 2.4-4 PMP Depth-Duration Values in Inches for the Clinton Dam Drainage Area

Clinton Lake PMP	Duration (hour)				
	6	12	24	48	72
289.2 mi^2	18.2	22.1	23.7	26.8	28.7

The staff used HMR 52 and ANSI/ANS-2.8-1992 to provide guidelines for distributing the PMP depths in time to create storm sequences during the PMP event. According to these guidelines, the staff computed incremental PMP depths corresponding to all 6-hour durations during the 72-hour PMP (column 2 of Table 2.4-5 of this SER). The staff grouped the incremental depths into three 24-hour periods in descending order (column 3 of Table 2.4-5 of this SER). The staff rearranged the PMP depths within each 24-hour group according to guidelines given by ANSI/ANS-2.8-1992 (column 4 of Table 2.4-5 of this SER). Finally, the staff rearranged column 4 according to the guidelines in ANSI/ANS-2.8-1992 to create the time distribution of the PMP storm over the Clinton Dam drainage area (column 5 of Table 2.4-5 of this SER).

Table 2.4-5 Time Distribution of PMP for the Clinton Dam Drainage Area

6-hour Period	Depth (in.)	Group No.	ANSI/ANS-2.8-1992 Rearrange	Time Distribution for PMP (in.)	Time (h)
1	18.16	1	0.79	0.79	6
2	3.95		3.95	0.79	12
3	0.79		18.16	0.79	18
4	0.79		0.79	0.79	24
5	0.79	2	0.79	0.79	30
6	0.79		0.79	3.95	36
7	0.79		0.79	18.16	42
8	0.79		0.79	0.79	48
9	0.46	3	0.46	0.46	54
10	0.46		0.46	0.46	60
11	0.46		0.46	0.46	66
12	0.46		0.46	0.46	72

The staff ~~assumed that no precipitation losses occurred in order to maximize the flood generated by the PMP storm over the Clinton Dam drainage area.~~

~~The~~independently verified the maximum hydrostatic (stillwater) elevation associated with a PMF at the ESP site. Since certain historical data (e.g., gauged inflows, observed lake elevations, etc.) were not available, multiple approaches were employed to provide a conservative basis.

The staff performed three analyses to estimate the water surface elevation of Clinton Lake near the ESP site during the PMF event. The first analysis bounded the water surface elevation by conservatively assuming no loss and instantaneous translation of the PMP into the lake. This bounding analysis was used to clearly establish that the site would remain dry. The second and third analyses refined the maximum water surface elevation estimate by relaxing some of the conservatism in the bounding analysis. These analyses were used to establish the site characteristic for the proposed ESP site intake structure and associated systems that may be placed below site grade.

The initial bounding analysis performed by staff conservatively estimated runoff by assuming that ~~the drainage~~all watershed runoff instantaneously ~~discharged to~~entered Clinton Lake. ~~Under~~In this ~~assumption, the staff estimated the runoff corresponding to all 6-hour durations~~analysis, the runoff for each 6 hour duration during the PMP (Table 2.4-5) was computed by multiplying the PMP depth~~ corresponding to that 6-hour duration~~ by the area of Clinton Dam's drainage~~ and converting the volume of runoff into discharge. Table 2.4-6 of this SER shows the PMF thus obtained for the Clinton Dam drainage area.~~

~~**Table 2.4-6 PMF into Clinton Lake**~~

~~Time (h)Runoff (in.)Runoff (cfs)60.7924853120.7924853180.7924853240.7924853300.7924696363.951242674218.16571314480.7924696540.4614472600.4614472660.4614472720.4614472~~. An infiltration loss rate of 0.0 in/hr was assumed to maximize the flood generated by the PMP storm. Based on these assumptions, runoff entering Clinton Lake had a peak discharge of 571,314 cfs.

The staff ~~estimated the PMF assuming no precipitation loss and~~assumed instantaneous translation of the inflow wave through Clinton Lake using level pool routing ~~(Linsley, et al, 1982). The staff used~~and the stage-storage curve provided by the applicant (~~see~~ SSAR ~~Figure 2~~Figure 2.~~4-12). This stage-storage curve lists spillway discharge for water surface elevations of 708 ft MSL and less. The staff extended this~~4 12). The stage-storage relationship was extended beyond~~ water surface~~ elevation ~~708 ft~~708 ft MSL ~~to that corresponding to the top of the dam at 711.8 ft MSL~~by extrapolation using the slope of the stage-storage ~~relationship at 708 ft MSL. The staff assumed that the incremental storage above water surface elevation 711.8 ft MSL was conservatively equal to that at an elevation of 711.8 ft MSL. This assumption is equivalent to a constant surface area of the lake above a water surface elevation of 711.8 ft MSL. Figure 2.4-6 of this SER shows the extended stage-storage relationship for Clinton Lake.~~

~~**Figure 2.4-6 Stage-storage relationship for Clinton Dam**~~curve.

The applicant provided the spillway rating curve for the Clinton Dam (~~see~~ SSAR ~~Figure 2~~Figure 2.~~4-12~~4 12) that listed total combined discharge from service and auxiliary spillways corresponding to water surface elevations ranging from ~~690 ft~~690 ft MSL to ~~710 ft~~710 ft MSL. The staff extended this stage-discharge relationship ~~beyond a water surface~~above elevation ~~of 710 ft~~710 ft MSL ~~to 711.8 ft MSL~~by extrapolation using the slope of the stage-discharge relationship at ~~a water surface~~ elevation of ~~710 ft MSL. The staff assumes that the whole face of Clinton Dam acts as a broad-crested weir at water surface~~710 ft MSL. At elevations above ~~that corresponding to~~ the top of the dam, ~~which is at 711.8 ft MSL. V.T. Chow (1959) gives the discharge per unit width of a broad-crested weir as $q = CH^{3/2}$, where C is a coefficient ranging from 2.67 to 3.05, and H is the height of flow passing over the weir. The staff conservatively assumed a value of 2.67 for C (a smaller value of C results in smaller discharge, thereby increasing water surface elevation in the lake) and computed the discharge over the face of Clinton Dam corresponding to water surface elevations exceeding 711.8 ft MSL. Figure 2.4-7 of this SER shows the stage-discharge relationship for Clinton Dam extended to 716 ft MSL.~~

~~**Figure 2.4-7 Stage-discharge relationship for Clinton Dam**~~

~~The staff performed~~the staff assumed that water would spill along the entire dam face; the staff used a weir equation to compute the resulting discharge.

Results generated from the conservative, instantaneous translation, level pool routing ~~that resulted in~~method produced the reservoir inflow-outflow sequence shown in ~~Figure 2~~Figure 2.4-~~8~~-6 of this SER. ~~Figure 2~~Figure 2.4-~~9~~-7 of this SER shows the corresponding reservoir water surface elevations. The staff estimated ~~a~~the maximum ~~reservoir elevation~~hydrostatic (stillwater) water surface elevation using this extremely conservative and bounding approach to be 712.2 ft MSL.

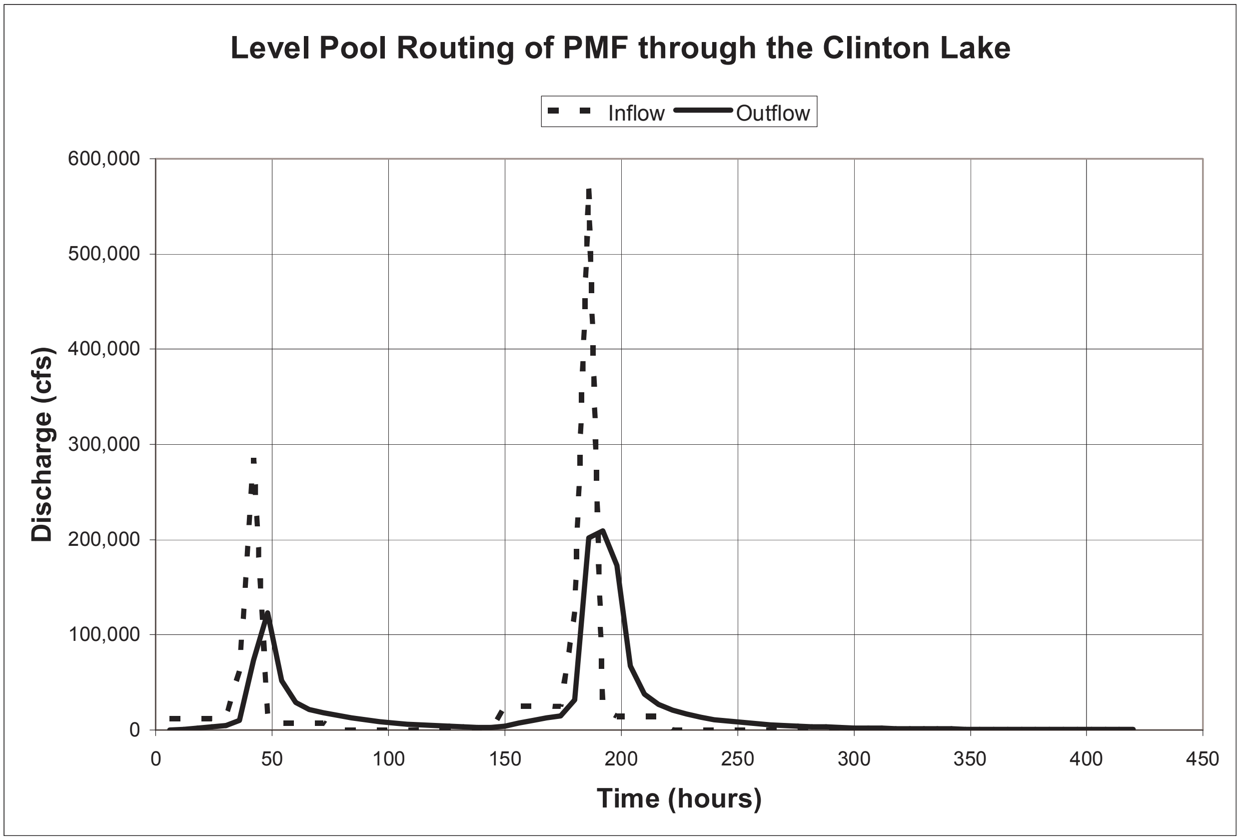

Figure 2.4-6 Inflow and Outflow from Clinton Lake during the PMF event ~~of 714.79 ft MSL.~~
calculated using the instantaneous-translation level-pool routing method

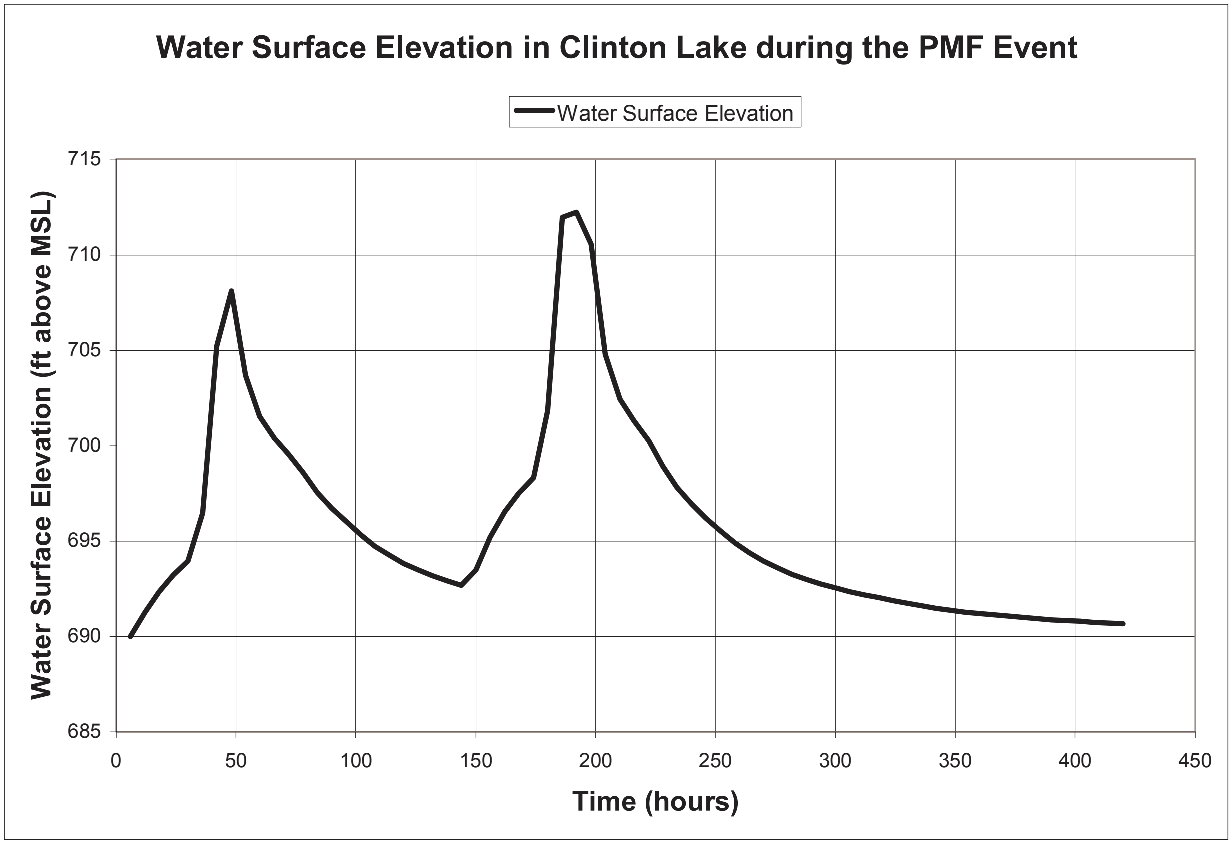

Figure 2.4-7 Water surface elevation in Clinton Lake during the PMF event calculated using the instantaneous-translation level-pool routing method

A second analysis was performed by staff using the HEC-HMS Version 3.0.0 computer code. The watershed was divided into eight sub-areas (Clinton Lake plus seven sub-basins) in the same manner as Revision 4 of the SSAR and with the following sub-areas: 1) Salt Creek headwater = 126.8 mi^2, 2) Salt Creek local area northeast = 5 mi^2, 3) Salt Creek local area northwest = 16.3 mi^2, 4) Salt Creek local area southeast = 6.2 mi^2, 5) Salt Creek local area southwest = 8.2 mi^2, 6) North Fork headwater = 111 mi^2, 7) North Fork local area = 15 mi^2, and 8) Clinton Lake area = 7.6 mi^2. The basins were connected together in the model so that outflow from the basins immediately entered the lake. This is a conservative assumption since the flow is not routed.

The Clinton Lake inflow hydrograph was estimated using the unit hydrograph approach. Synthetic unit hydrographs were developed to determine the runoff from each sub-basin area. The storm hydrograph entering Clinton Lake was computed based on two-hour unit hydrographs for each sub-basin. An antecedent storm equal in volume to 50% of the PMP, followed by three days of no rainfall, and followed by the full PMP volume (Table 2.4-5) was applied to the Clinton Lake watershed. In addition, the PMP used in the staff's analysis had a total volume of 28.7 in., which is more conservative compared to the applicant's value of 27.8 in.

One of the key parameters in the synthetic unit hydrograph method is the lag time. Values of lag times used by the applicant were based on limited published watershed data. The lag times used by the applicant and the staff ('standard lag' Table 2.4-6) in the HEC-HMS model were as follows: 1) Salt Creek headwater = 12.3 hrs, 2) Salt Creek local area northeast = 1.1 hrs, 3) Salt Creek local area northwest = 2.6 hrs, 4) Salt Creek local area southeast = 1.4 hrs, 5) Salt Creek local area southwest = 1.7 hrs, 6) North Fork headwater = 11.3 hrs, and 7) North Fork local area = 2.5 hrs. The selected lag values approximate those developed in Mitchell (1948) and the CPS USAR, although for the present analysis seven watershed sub-areas were used so corresponding values are not directly comparable. Since recent direct field data are not available, the lag time values are subjective. The staff appreciates the empirical nature of these coefficients and of the SCS method in general, which is generally not advised for use for areas larger than 2,000 ac (NOAA, 2006). To test the overall range of Clinton Lake PMF water surface elevations, the staff varied the lag time by shortening and increasing the lag time by 10 percent. Maximum Clinton Lake PMF water surface elevations are shown in Table 2.4-6 for these scenarios.

A second key parameter in the PMF computation method is the infiltration loss. The staff evaluated model sensitivity by reducing the constant loss parameter used by the applicant (0.1 in/hr) first by half (0.05 in/hr) and then eliminating infiltration altogether (0.0 in/hr loss). Computed time series of Clinton Dam outflow and Clinton Lake water surface elevation during the storm event are shown in Figure 2.4-8 and Figure 2.4-9, respectively. The maximum Clinton Lake PMF water surface elevations for this range of infiltration loss parameter values are shown in Table 2.4-6.

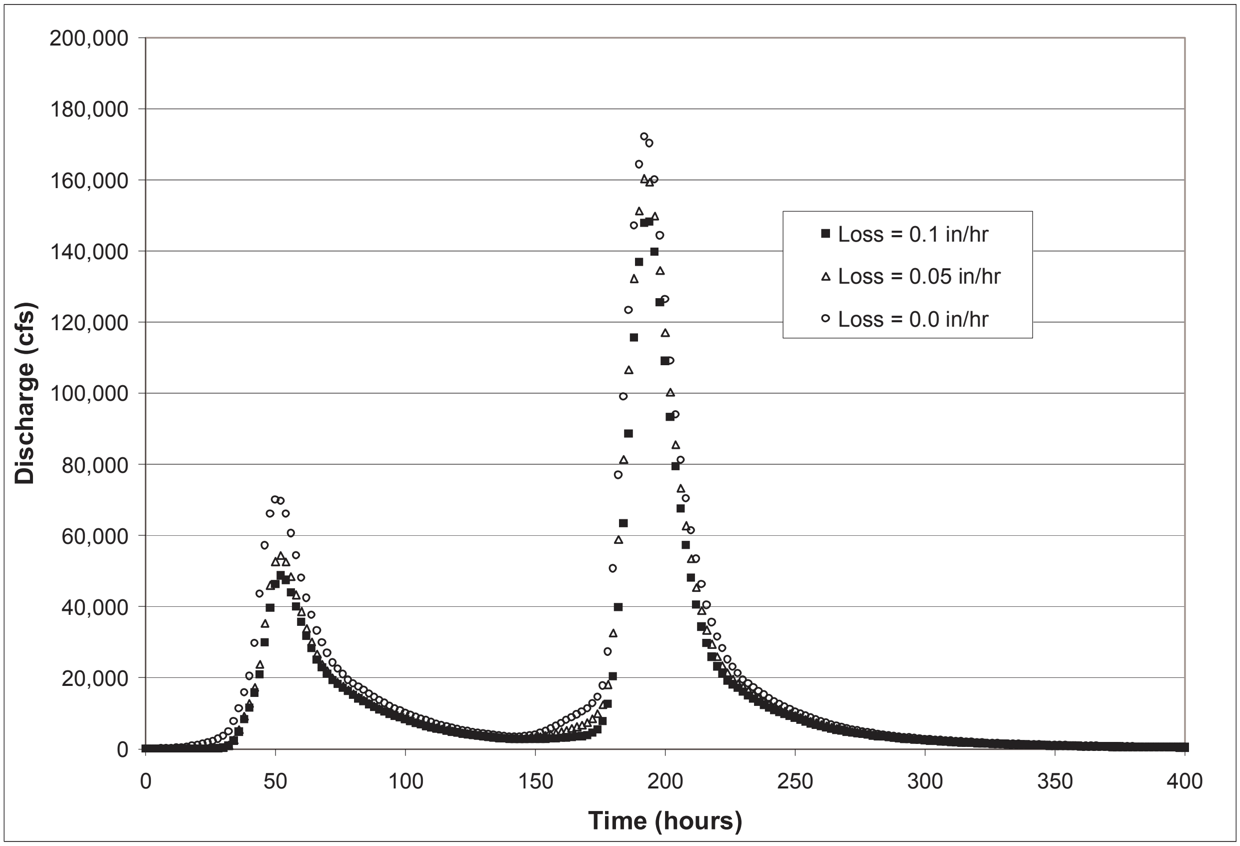

Figure 2.4-8 Inflow and Outflow Hydrographs for Clinton Lake during the PMF Event using the HEC-HMS model and the seven sub-basins + lake method

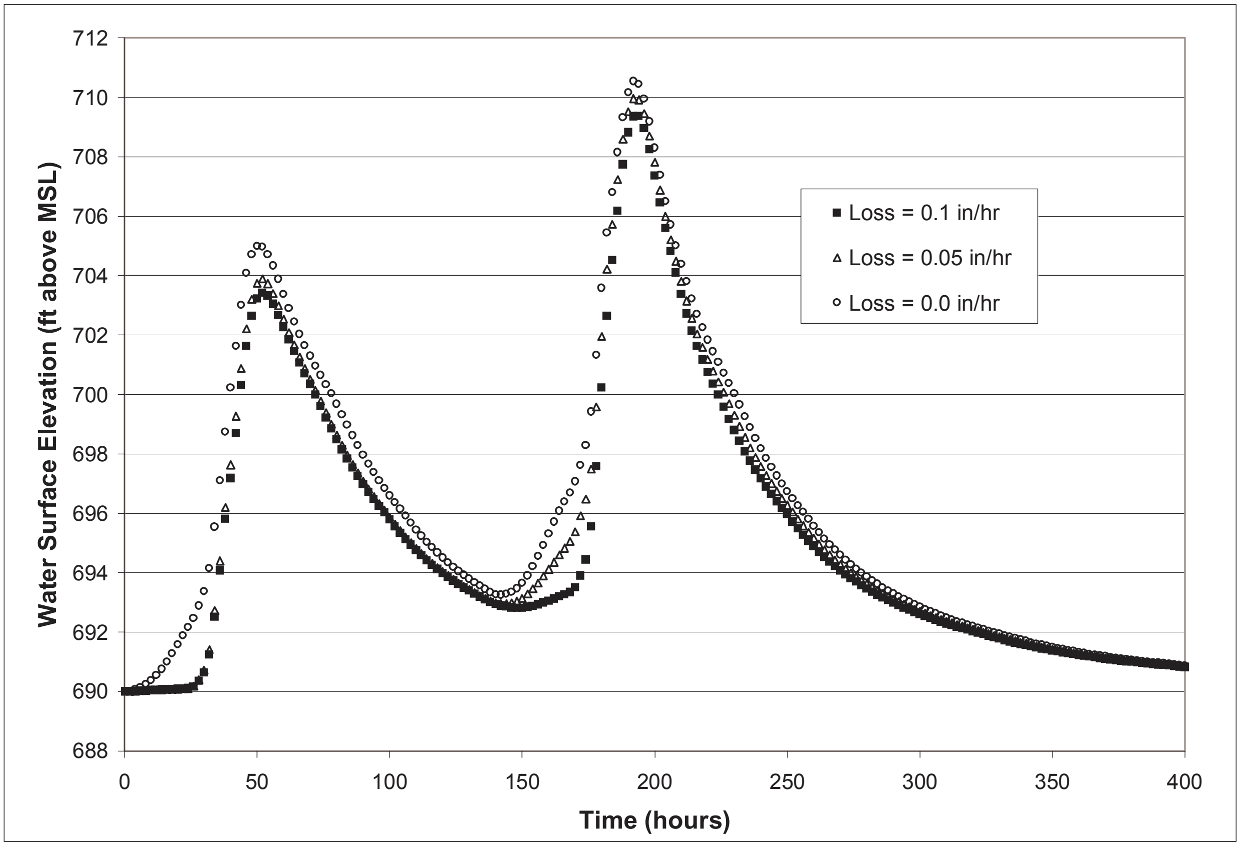

Figure 2.4-9 Water surface elevation of Clinton Lake during the PMF event using the HEC-HMS model and the seven sub-basins + lake method

The third analysis examined by staff also utilized HEC-HMS; however the watershed was divided into five sub-basins. Unit hydrographs following Mitchell (1948) and discussed in the CPS USAR were used. These unit hydrographs were made more conservative by shortening the time to peak by 33% and increasing the peak discharge by 20%. The Clinton Lake watershed was subjected to the same 50 percent PMP volume antecedent storm followed by the full PMP volume (Table 2.4-5) as the second analysis. For this analysis, the initial loss and constant loss rate were both set to zero. As in the second analysis, the routing from the five sub-basins to the Clinton Lake was instantaneous (no routing) and the PMP volume was 28.7 in.; both of which are conservative assumptions. The resulting maximum water surface elevation of Clinton Lake during the PMF was 710.6 ft MSL.

Results from the three analyses performed by staff are summarized in Table 2.4-6. Results from the initial bounding analysis clearly establish that the site would remain dry during the PMF event. The second and third analyses were used to establish the site characteristic for the intake structures and associated safety related systems located below site grade that might be inundated. Water surface elevation results from these analysis fell within 4% of the applicant's water surface elevation value. Based upon the consistency of the results of the various analyses, the staff finds that the applicant's value of 709.8 ft MSL for the maximum hydrostatic (stillwater) water surface elevation is reasonably conservative.

Table 2.4-6 Summary of Maximum PMF Water Surface Elevations (ft MSL) at the ESP Site

Method	Constant Infiltration Loss Rates (in/hr)		
	0.0	**0.05**	**0.1**
Instantaneous Translation	712.2		
SCS with Standard Lag	710.6	710.0	709.4
Mitchell Unit Hydrograph	710.6		

Method	Lag – 10%	Standard Lag	Lag + 10%
SCS with Loss = 0.1	709.9	709.4	709.0

The influence of coincident wind wave activity would cause~~d~~ an increase in the PMF water surface elevation. The staff conservatively estimated the probable maximum windstorm (PMWS), as defined by ANSI/ANS 2.8~~-~~-1992, to be equivalent to ~~100 mph~~100 mph. This ~~windstorm~~conservative wind velocity is based upon the location of the site, which is within ~~150 miles~~150 mi of the Great Lakes. The staff estimated wave heights using the method outlined in ~~USACE, EM 1110-2-1100, Revision 1, "Coastal~~the Coastal Engineering Manual~~,"~~ ~~issued July 2003,~~ with a site-specific fetch of 1.~~2 miles~~2 mi. The resulting significant (average height of the one-third highest waves) wave height is 3.~~9 ft~~9 ft, and the 1~~-~~-percent maximum (average height of the largest ~~1 percent~~1 percent of all waves) wave height is 6.~~6 ft.~~

~~In response to RAI 2.4.3-1, the applicant stated that the presence of the ESP facility does not require that the discharge rating curve for the dam be revised and, therefore, does not require use of the SPRAT model. The applicant proposed to revise the ESP application to indicate that the hydraulic modeling, including SPRAT runs and water surface profile estimations, was performed as part of the dam design and not as part of the ESP application. The staff determined~~6 ft. Therefore, staff find that the applicant's ~~response to RAI 2.4.3-1 is satisfactory.~~

~~With respect to the effects of wind speed on PMF water level elevation, the applicant stated in response to RAI 2.4.3-2 that use of these wind speeds did not result in any safety-related issues for CPS Unit 1, since the site grade was determined to be 22.2 ft above the wave runup water surface elevation and 27.1 ft above the PMF water surface elevation, with the conclusion that the CPS plant facility could not flood under any circumstances. The staff determined that the applicant's response to RAI 2.4.3-2 is satisfactory.~~

value of 6.4 ft is reasonable.

A further increase of water surface elevation ~~resulting~~may result from storm surge, as discussed more fully in ~~Section 2~~Section 2.4.5 of this SER~~,~~. Storm surge would result~~ed~~ in an additional ~~minor~~ increase in water surface elevation of 0.~~3 ft~~3 ft. Combining the effects of PMF (elevation 709.8 ft MSL), coincident wind wave activity (6.4 ft), and storm surge (0.3 ft), the staff estimated a resulting maximum water surface elevation at the ESP site of ~~721~~716.~~7 ft~~5 ft MSL. The staff, therefore, determined that the ESP site, excluding the ESP ~~facility's~~ intake structures, is safe from flooding during a PMF event. For the ESP ~~facility's~~ intake structure~~s~~, the COL ~~or CP~~ applicant needs to design ~~them~~the intake structures to withstand the combined effects of PMF, coincident wind wave activity, and wind setup of a water surface elevation of ~~721~~716.~~7 ft~~5 ft MSL. COL Action Item 2.4-3, discussed in Section 2.4.2.3 of this SER, states this.

~~**Figure 2.4-8 Inflow and outflow hydrographs for Clinton Lake during the PMF event**~~

~~**Figure 2.4-9 Water**~~In response to RAI 2.4.3-1, the applicant stated that the presence of the ESP facility does not require that the discharge rating curve for the dam be revised and, therefore, does not require use of the SPRAT model. The applicant revised the ESP application to remove reference to the hydraulic modeling. The staff determined that the applicant's response to RAI 2.4.3-1 is satisfactory.

With respect to the effects of wind speed on PMF water level elevation, the applicant stated in response to RAI 2.4.3-2 that use of these wind speeds did not result in any safety-related issues for CPS Unit 1 since the site grade was determined to be 22.2 ft above the wave run-up water surface elevation ~~in Clinton Lake during the PMF event~~and 27.1 ft above the PMF water surface elevation. As such, the applicant determined that the CPS plant facility could not flood under any circumstances. The staff determined that the applicant's response to RAI 2.4.3-2 is satisfactory.

2.4.3.4 Conclusions

As set forth above, the applicant provided sufficient information pertaining to the identification and evaluation of PMFs on streams and rivers at the site. SSAR Section 2.4.3 conforms to Section 2.4.3 of RS-002, Attachment 2, with regard to this objective.

Section 2.4.3 of RS-002, Attachment 2, provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating PMFs on streams and rivers at the site. Although the applicant did not specifically address the above regulations in SSAR Section 2.4.3, the staff concludes that, by conforming to Section 2.4.3 of RS-002, Attachment 2, it has met the requirements to identify and evaluate PMFs on streams and rivers at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c). Further, the staff finds that the applicant considered the most severe natural phenomena that have been historically reported for the site and surrounding area in establishing the stream and river design-basis flood, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.4 Potential Dam Failures

2.4.4.1 Technical Information in the Application

In SSAR Section 2.2.4, the applicant stated that no other dams exist either upstream or downstream of Clinton Dam. The applicant also indicated that failure of Clinton Dam will not result in a loss of water from the submerged UHS pond.

2.4.4.2 Regulatory Evaluation

the service spillway when the water surface elevation in Clinton Lake exceeds its crest elevation of 690 ft MSL. Discharge over the service spillway reduces the water surface elevation in Clinton Lake, and the final increase in water surface elevation resulting from a breach of the two upstream dams is likely to be less than 3.1 ft.

The staff's estimate of maximum water surface elevation in Clinton Lake because of PMF, wind setup, and wave runup, as discussed in Section 2.4.3 of this SER, is ~~721~~716.~~7 ft~~5 ft MSL. The staff plans to include ~~721~~716.~~7 ft~~5 ft MSL as a site characteristic in any ESP that might be issued for this application. Even if the maximum water surface elevation in Clinton Lake were to be augmented by 3.1 ft because of a breach of the two upstream dams, leading to a water surface elevation of 7~~24~~19.~~8 ft~~6 ft MSL in Clinton Lake, the ESP site, located at 735 ft MSL, would be safe from flooding. Therefore, the staff determined that the applicant's response to RAI 2.4.1-3 is satisfactory.

2.4.4.4 Conclusions

As set forth above, the applicant provided sufficient information pertaining to potential dam failures at the site. SSAR Section 2.4.4 conforms to Section 2.4.4 of RS-002, Attachment 2, with regard to this objective.

Section 2.4.4 of RS-002, Attachment 2, provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to the identification and evaluation of potential dam failures at the site. Although the applicant did not specifically address the above regulations in SSAR Section 2.4.4, the staff concludes that by conforming to Section 2.4.4 of RS-002, Attachment 2, it has met the requirements for potential dam failures with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c). Further, the staff finds that the applicant has considered the most severe natural phenomena that have been historically reported for the site and surrounding area in establishing the design-basis dam failure, with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

2.4.5 Probable Maximum Surge and Seiche Flooding

The EGC ESP site is located on the shores of Clinton Lake, approximately 6 miles east of the city of Clinton in DeWitt County, in central Illinois at elevation 735 ft MSL.

2.4.5.1 Technical Information in the Application

The applicant stated in Revision 0 of SSAR ~~Section 2~~Section 2.4.5 that there are no large bodies of water near the ESP site where significant storm surges and seiche can occur. The applicant also stated that Clinton Lake is not large enough to develop surge and seiche conditions more critical than the PMF ~~conditions~~condition. In Revision 4 of the SSAR, the applicant revised their approach to provide a higher level of conservatism, and the maximum storm surge at the site was stated as 0.3 ft. This value was computed using a wind speed of 100 mph, an effective fetch of 0.8 mi, and a water depth of 40.5 ft.

2.4.5.2 Regulatory Evaluation

SSAR Table 1.5-1 demonstrates the applicant's conformance to the NRC RGs. The staff requested, in RAI 1.5-1, that the applicant provide a comprehensive listing of the NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff should use to develop its findings and conclusions related to the hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how it addresses the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

Section 2.4.5 of RS-002, Attachment 2, provides the review guidance used by the staff in evaluating this SSAR section. The applicant must meet the requirements of 10 CFR Parts 52 and 100 as they relate to evaluating the hydrologic characteristics of the site. To determine

The staff estimated the resulting seiche period to be approximately 6.8 minutes. This period is significantly shorter than meteorologically induced wave periods (e.g., synoptic storm pattern frequency and dramatic reversals in steady wind direction required for wind setup). Therefore, the staff concluded that meteorologically forced resonance is not likely. The staff also concluded that seismically induced seiche is unlikely in Clinton Lake because of the large difference between the period of oscillation resulting from seiche and that of seismically induced vibrations.

2.4.5.4 Conclusions

As set forth above, the applicant provided sufficient information pertaining to the identification and evaluation of probable maximum surge and seiche flooding at the site. SSAR Section 2.4.1 conforms to Section 2.4.5 of RS-002, Attachment 2, with regard to this objective.

Section 2.4.5 of RS-002, Attachment 2, provides that the SSAR should address the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating probable maximum surge and seiche flooding at the site. Although the applicant did not specifically address the above regulations in SSAR Section 2.4.5, the staff concludes that, by conforming to Section 2.4.5 of RS-002, Attachment 2, it has met the requirements to identify and evaluate probable maximum surge and seiche flooding at the site with respect to 10 CFR 52.17(a) and 10 CFR 100.20(c). In addition, the seismically induced flooding analysis reflects the most severe seismic event historically reported for the site and surrounding area (with sufficient margin for the limited accuracy, quantity, and period of time in which the historical data have been accumulated). In addition, the staff concludes that the applicant partially conforms to GDC 2, insofar as that analysis defines design bases for seismically induced surge and seiche.

2.4.6 Probable Maximum Tsunami Flooding

The EGC ESP site is 6 miles east of the city of Clinton, in DeWitt County, located in central Illinois. It is adjacent to Unit 1 of the CPS on the shore of Clinton Lake, an impoundment on Salt Creek. Salt Creek flows 50 miles from the Clinton Dam to its confluence with the Sangamon River. The Sangamon River, from its confluence with Salt Creek, flows 40 miles to merge with the Illinois River north of Beardstown. The Illinois River flows 90 miles from its confluence with the Sangamon River to meet the Mississippi River near Grafton. The Mississippi River flows 1172 miles from its confluence with the Illinois River to the Gulf of Mexico (NOAA, 2004). The Gulf of Mexico is the body of open water directly downstream from Clinton Lake that is subject to seismically generated tsunamis.

2.4.6.1 Technical Information in the Application

The applicant stated in Revision 0 of SSAR Section 2.4.6 that ~~“the~~"the site will not be subjected to the effects of tsunami flooding because the site is not adjacent to a coastal area.~~” The~~" In Revision 3 of the SSAR, the applicant also considered the effects of a lake tsunami caused by a hillslope failure. The applicant's analysis produced a maximum tsunami height at 0.4 ft. Based on the elevation of the ESP site, the applicant ~~considered only tsunami flooding directly associated with seismically generated waves in open water that affect coastal areas~~concluded that landslide-induced tsunamis do not pose a risk to the site.

lower flow velocity, leading to an increased potential for surface ice accumulation, particularly at locations away from the point of discharge. The applicant stated that the ice accumulation would be much thinner than the predicted normal lake accumulation because of the heat and velocity components of the ESP facility discharge. The applicant also stated that, if ice did form, it would remain on the surface, allowing unrestricted flow below the water surface. The applicant concluded that it did not expect jamming and clogging of the discharge channel because of icing.

SSAR Section 2.4.7 did not provide sufficient detail for the staff to determine if formation of ice on the lake and near the intake structure could constrain intake depth. The staff requested, in RAI 2.4.7-6, that the applicant discuss whether ice sheet formation is likely to constrain the ESP facility UHS intake depth. In response to RAI 2.4.7-6, the applicant stated that ice sheet formation in Clinton Lake will not constrain the ESP facility's UHS intake depth. The applicant stated that the thickness of ice cover is a small percentage of the intake height, and warming water used to prevent formation of frazil ice will retard the formation of an ice cover in the immediate area of the intake trash racks or screens. The applicant revised SSAR Section 2.4.7 to provide additional information on ice effects related to the ESP facility's UHS intake depth.

SSAR Section 2.4.7 provided an average thickness of an ice sheet on the surface of Clinton Lake. The staff needed to understand if such an ice sheet formation, coupled with a loss of Clinton Dam and subsequent draining of the main lake, could lead to a loss of capacity of the submerged UHS pond. The staff requested, in RAI 2.4.7-8, that the applicant describe the reduction in UHS capacity caused by a loss of Clinton Dam during periods when an ice sheet is covering the lake. In response to RAI 2.4.7-8, the applicant stated that the UHS for the ESP facility will consist of cooling towers, if the selected reactor type does not use passive emergency cooling methods. The applicant stated that Clinton Lake is used as a source of makeup water for the ESP facility's UHS cooling towers and not as a heat sink. The applicant stated that if Clinton Dam were to be lost, any surface ice would also be expected to be lost since it floats on the surface. The applicant also stated that, if this surface ice sheet were to drop to an elevation equal to the top of the submerged UHS pond, a small decrease in the capacity of the submerged UHS pond, which acts as the heat sink for CPS Unit 1, would occur. The applicant stated that during this condition, additional heat removal capacity would be available in the submerged UHS pond in the form of latent heat of fusion of ice. The applicant also stated that adequate water for makeup to the ESP facility's UHS cooling towers would be available, since the required shutdown of CPS after a dam failure would supply heat to the submerged UHS pond and convert the ice back into water.

In Revision 2 of the SSAR, the applicant stated that ice thickness calculations were carried out for the period 1902 through 2001. The applicant reported that the average ice sheet thickness over this period was 16.2 in. and that the maximum was 27.0 in. during 1977-78 winter. The applicant used accumulated freezing degree-days (AFDD) data from USACE Engineering Research and Development Center (ERDC) at the Cold Regions Research and Engineering Laboratory (CRREL) and the approach as described by ERDC/CRREL Technical Note 04-3. The applicant used a value of 0.8 for the ice cover condition coefficient. The applicant stated that the average AFDD was 409.9 with a maximum of 1141.5 (in Fahrenheit degree days) .

The applicant stated in Revision 2 of the SSAR that the openings of ESP intake structure will extend vertically from the water surface elevation to approximately 669 ft MSL, providing a vertical opening of about 21 ft when the Clinton Lake water surface elevation is at a normal pool level of 690 ft MSL. An ice sheet, equal in thickness to the maximum estimated ice-sheet thickness of 27.0 in., would potentially block only a small portion of the intake opening, leaving approximately 18.75 ft of vertical opening for water intake with initial lake water surface elevation at 690 ft MSL before ice formation, and a vertical opening of 5.75 ft if the initial lake water surface elevation were at the minimum of 677 ft MSL. The applicant stated that this vertical opening, combined with a normal horizontal dimension of the opening for an intake structure, would still be adequate for intake water requirements of the ESP plant.

The applicant stated in Revision 2 of the SSAR that no ice currently forms in the discharge channel with the CPS in operation, which discharges about 445,000 gpm of warm cooling water during winter months. The applicant reported that the capacity of the discharge canal at a flow velocity of 1.5 fps is 1,372,000 gpm, which will not be exceeded with the addition of approximately 12,000 gpm of warm blowdown water from the proposed ESP facility.

The applicant stated that there is some possibility of ice formation in the discharge channel if the ESP facility is operated alone and the CPS is offline, since the warm water discharge to the canal would be reduced to only 12,000 gpm. However, the applicant stated that any such ice would be thin, remain only on the surface, and not restrict flow in the discharge canal.

In Revision 2 of the SSAR, the applicant included a description of formation of frazil and anchor ice. The applicant stated that the current CPS facility water intake is designed to avoid obstruction from surface ice and accumulation of frazil ice by recirculating warm cooling water via a warming line back into the inlet to the screen house. The applicant noted that the warming line is designed to maintain a minimum water temperature of 40 °F during winter at the intake. The applicant reported that the CPS has not encountered a problem due to frazil ice accumulation on intake facilities.

The applicant stated in Revision 2 of the SSAR that a means to prevent the formation of frazil ice at the intake for essential service water cooling tower make-up would be provided, such as a warming line from the hot side of the cooling towers back to the intake. The applicant stated that the design of these features would support the operation of the ESP facility independent of the CPS facility.

The applicant estimated that approximately 326 ac-ft of liquid water would be displace by a 27.0 in ice sheet settling down on the UHS pond in the event of complete loss of the main dam. The applicant also estimated that an excess capacity of 395 ac-ft is normally available. Since the evaporation of water from the pond would be negligible in presence of complete ice cover, the applicant estimated that the net change would result in essentially the same excess capacity of liquid water in the UHS pond. If the main dam failure occurs with maximum ice thickness on the lake and the CPS facility not in operation, the UHS water normally reserved for CPS shutdown would also be available to the ESP facility. The applicant concluded that the UHS liquid water capacity is sufficient to support the combined emergency operation of CPS and the ESP facilities.

2.4.7.2 Regulatory Evaluation

The staff prepared a stage-discharge relationship from available gauge heights for peak streamflow at the Rowell gauge using data from the period before the construction of Clinton Dam. Figure 2.4-12 of this SER shows this stage-discharge relationship. Using this relationship, the staff estimated a stage of 22.8 ft corresponding to a discharge of 7500 cfs, and an ice-jam-induced stage increase of 2.0 ft. If an ice-jam-induced flood were to augment the PMF, the maximum expected water surface elevation in Clinton Lake would be 7~~23~~18.~~7 ft~~5 ft MSL.

The staff estimated the all-season PMP depth for Clinton Lake's drainage area in Section 2.4.3 of this SER using HMRs 51 and 52 and ANSI/ANS-2.8-1992. The 48-hour PMP depth was 26.8 in. and the 72-hour PMP depth was 28.7 in. The National Weather Service's current HMRs do not provide a method to estimate a monthly PMP for areas exceeding 10 mi^2. Methods for estimating a monthly PMP appear in HMR 33, but the current HMRs (i.e., HMRs 51 and 52) supersede that report. The staff independently confirmed that the 48-hour winter PMP depth is less than the all-season 48-hour PMP depth. The staff's estimate of the all-season PMP using the current HMRs is greater than the applicant's winter and all-season PMP. The staff concluded that a flood generated by a winter PMP and augmented by an ice-jam flood would be less critical than the all-season PMF.

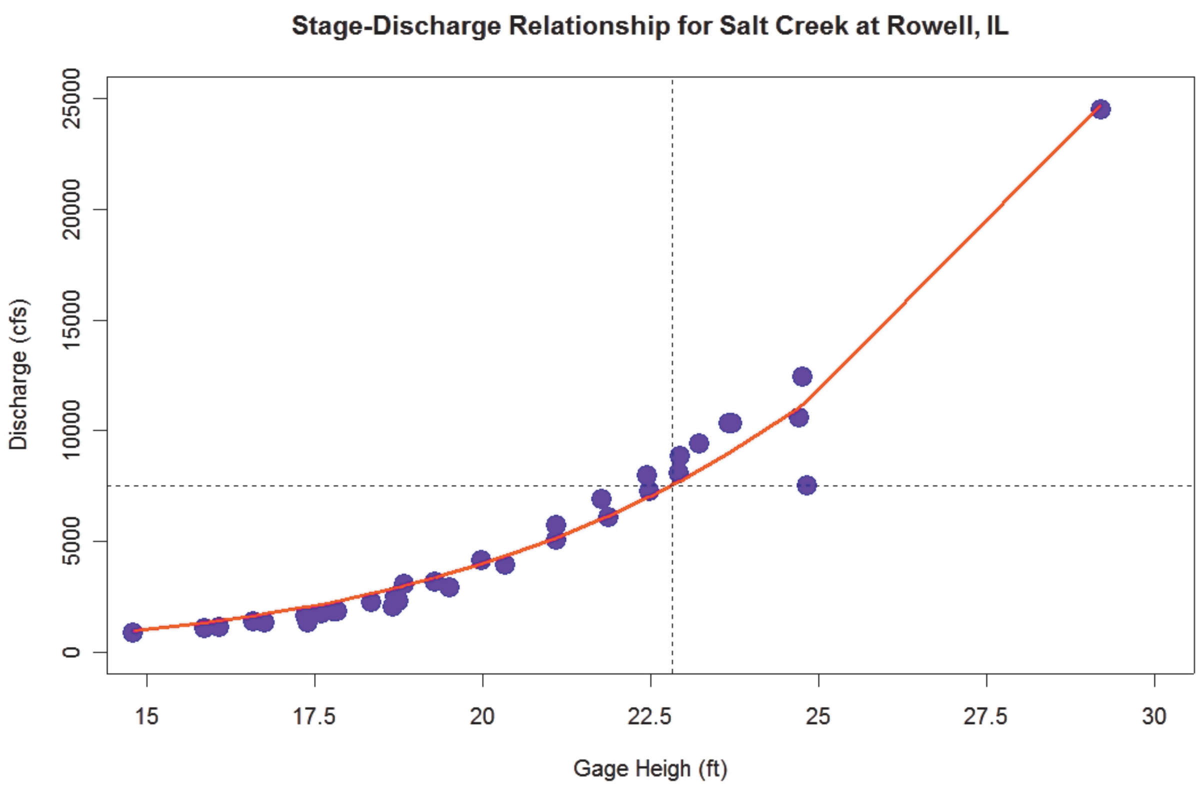

Figure 2.4-12 Stage-discharge relationship for Salt Creek at Rowell, IL

The staff independently estimated the likely surface ice thickness that might form near the intake structures. During this estimation, the staff used mean daily air temperatures recorded at the Decatur, Illinois, meteorologic station. Maximum and minimum daily air temperatures at accumulated freezing degree-days) from that determined by the staff in its previous assessment.

The staff determined that there are two major differences in the revised ice-thickness procedure presented by the applicant in its response to DSER Open Item 2.4-9 as compared to the staff's previous procedure used in the DSER. The first difference is that the applicant used the estimation equation in USACE (2002), whereas the staff used Assur's 1956 equation in its DSER review. The second difference is that the applicant estimated the maximum accumulated freezing degree-days starting from an estimated freezeup onset date, whereas the staff used a fixed December 1 freezeup date in its DSER review. These two differences are discussed in detail below.

Ice Thickness Estimation Equation

Assur's ice-thickness estimation equation, which the staff used in the DSER, was published in 1956. The USACE (2002) estimation equation is more recent than Assur's estimation equation, although both equations estimate an ice thickness that is proportional to the square root of accumulated freezing degree-days. The difference between the two methods arises from the use of different coefficients of proportionality. Assur's equation applies a constant of proportionality of ($1.06 \times \alpha$), with different values for α recommended for ice sheets covered with moderate snow (α ranging from 0.65 to 0.75) and for ice sheets not covered with snow (α ranging from 0.85 to 0.9). Assur suggested a theoretical maximum value of 1.0 for α. The USACE (2002) equation applies a constant of proportionality α, only. The recommended value of α under windy, snow-free lake conditions is 0.8 and that under average lake conditions, in the presence of a snow cover, ranges from 0.5 to 0.7. Assur's equation is more conservative than the USACE (2002) equation because of the differences in the recommended values of α and the presence of 1.06 multiplier in Assur's equation. The staff used the most conservative α (equal to 0.9) recommended by Assur in the DSER review, which implies an ice sheet not covered with snow. For similar conditions, USACE (2002) recommends a maximum α of 0.8. Therefore, use of Assur's equation would yield an ice thickness 19 percent larger than that derived from the USACE (2002) equation for the same accumulated freezing degree-days.

The applicant stated in its response to DSER Open Item 2.4-9 that the USACE (2002) equation was more accurate because it was a refinement on the earlier method based on additional study. The staff's review of USACE (2002) did not provide any substantiation of this statement. The applicant did not provide any other reference that describes this refinement to enable the staff to assess the accuracy of the USACE (2002) equation in relation to Assur's equation. The applicant also stated that both ice-thickness estimation equations likely overestimate the ice thickness, but did not provide any references to substantiate this statement.

The staff contacted researchers at the USACE ~~Cold Regions Research and Engineering Laboratory (~~CRREL~~)~~ to determine the currently accepted standard for estimating ice thickness. Based on email communication with CRREL, the staff determined that USACE (2002) is the currently accepted standard for design ice engineering. Based on the above review, the staff determined that the USACE (2002) equation is acceptable for estimating the ice thickness in Clinton Lake and other safety-related water storage reservoirs, should any be required by the selected ESP plant reactor type.

During the conversation with Dr. Hopkins, the staff also became aware of a power plant that discharges warm water, run through its condenser, into Monona Lake. The staff's further investigation revealed that Madison Gas and Electric owns and operates Blount Station, which was constructed in 1902 with a maximum generating capacity of 200 megawatts (MW) (see http://www.mge.com/about/electric/blount.htm). Although more details of the Blount Station discharge are not available, the staff concluded that Monona Lake is not an appropriate lake to compare to Clinton Lake in terms of freezeup for two reasons. First, the warm water discharged from Blount Station into Monona Lake has some influence on its freezeup dates, particularly since 1902, affecting any estimation of freezeup dates under natural conditions using the observed freezeup of Monona Lake since 1902. An inspection of the time series of duration of ice cover (created by the Wisconsin State Climatology Office) on Monona Lake for the winters from 1851 to 2005 revealed a significant drop in the duration of ice cover immediately after construction of the Blount Station in 1902 (see http://www.aos.wisc.edu/%7Esco/lakes/monona-dur.gif), reflecting the effect of the power plant discharge on the freezing characteristics of the lake. Second, Monona Lake is significantly deeper (27 ft) than Clinton Lake (15 ft). Based on these reasons, the staff determined that the applicant's conclusion that Clinton Lake's freezeup is similar to that of Monona Lake is not appropriate.

The staff obtained freezeup data for lakes in the vicinity of Clinton Lake from the National Snow and Ice Data Center, but could not locate a lake with characteristics similar to those of Clinton Lake for an independent verification of the freezeup dates the applicant used in its analysis. Based on the characteristics of Monona Lake, accounting for the fact that its freezeup in winter is affected by discharge form Blount Station, the staff determined that it is not overly conservative to assume a freezeup date of December 1 for Clinton Lake. In years not affected by the Blount Station discharge, Monona Lake froze as early as November 22.

Based on the above review, the staff determined that ice thickness in Clinton Lake should be determined using a conservative freezeup date of December 1 and the USACE (2002) estimation equation. The staff's revised its estimate of maximum ice thickness in Clinton Lake to 26.4 in. as shown below.

$$h_i = \alpha \cdot \sqrt{AFDD} = 0.8 \times \sqrt{1086.5} = 26.4\, in$$

Based on the above review, the staff had planned to include a maximum ice thickness of 26.4 in. as a site characteristic in any ESP that may be issued for this site.

Subsequent to discussions with the applicant over concerns that December 1 may be too conservative (i.e., early in the winter season) for initiation of freeze-up, the staff reviewed USACE technical note ERDC/CRREL TN-04-3, "Methods to estimate River Ice Thickness Based on Meteorological Data" by K.D. White. This technical note recommends that freezing degree days (FDD) and ~~accumulated freezing degree days (~~AFDD~~)~~ be calculated starting October 1 of each water year. The technical note mentions that AFDD do not begin accumulating until the first sustained period of cold temperatures, and that the "zero AFDD" point be assigned to a day in late fall or early winter when the AFDD curve goes from a negative to a consistently positive slope.

The staff obtained AFDD data from ~~U.S. Army Engineering Research and Development Center (~~ERDC~~)~~ located in Hanover, New Hampshire. ERDC calculated AFDD data based on mean daily air temperature recorded at the National Weather Service station in Decatur, Illinois, for water years 1902 to 2000. According to USACE (E-mail correspondence between Rajiv Prasad and Carrie M. Vuyovich), AFDD on any day of the winter season, $AFDD_n$, represents the accumulated difference between freezing and the average daily temperature for the previous *n* days. The accumulation process starts each fall before the average daily temperature has fallen below freezing. ERDC starts calculation of AFDD on August 1 of each year and the calculation ends July 31 of the following year. AFDD graph through a winter can show multiple peaks. Early in the winter, AFDD graph can also fall to zero during warm spells.

The staff extracted the "zero AFDD" date for each water year during 1902-2000 corresponding to maximum AFDD values. The "zero AFDD" date corresponding to maximum AFDD for water years on record varied from November 16 to March 5, with 14 percent falling in November, 60 percent in December, 21 percent in January, four percent in February, and one percent in March. Fifteen percent of "zero AFDD" dates preceded December 1. The staff determined that winter of water year 1978 (calendar years 1977-1978) was the coldest on record with a maximum AFDD of 1141.5 EF (Figure 2.4-14 below). The "zero AFDD" day for this year was November 25, 1977. The maximum AFDD occurred on March 10, 1978. The staff revised their estimate of maximum ice thickness in Clinton Lake to 27.0 in as shown below.

$$h_i = \alpha \cdot \sqrt{AFDD} = 0.8 \times \sqrt{1141.5} = 27.0 in$$

The applicant also stated that the available water quantities are expected to maintain the lake water surface elevation at or above the CPS minimum lake elevation of 677 ft MSL with both the existing CPS unit and the proposed ESP facility in operation.

The staff requested, in RAI 2.4.8-4, that the applicant describe how it estimated the UHS capacity loss resulting from sediment or debris during extreme events. In response to RAI 2.4.8-4, the applicant stated that the ESP facility would use the safety-related cooling tower(s) as the UHS, if one were to be required, and would use the CPS submerged UHS pond only as a source of makeup water. For this reason, sediment or debris does not directly affect the ESP facility's UHS.

The applicant stated that, according to soil surveys of Illinois, early spring rains in areas where soil is exposed because of farming can cause extensive erosion when the soil surface is partially frozen leading to greater runoff. The applicant stated that the highest 24-hour PMP occurs in the summer and fall (June through September), with the monthly PMP value ranging from 24.4 to 31.2 in. The applicant reasoned that the occurrence of the PMP would not be coincident with the conditions for maximum runoff.

The applicant stated that the design of the CPS UHS pond considered four failure modes:

(1) loss of cooling water inventory because of its displacement by alluvial flow slides into the UHS

(2) loss of the service water system because of blockage of the service water pump intakes from unstable soil flow blocking or entering the intake structure

(3) loss of UHS circulation pattern because of local slides producing dams or dikes across the circulation channel

(4) loss of UHS water as a result of the UHS dam or its flanks breaching because of a combination of seismic loading, liquefaction, and washout

The applicant stated that, in addition to the storage requirements for cooling purposes and fire water supply, the submerged UHS pond was designed to account for sedimentation. The design of the submerged UHS pond considered sediment inflow from liquefaction and an associated loss in capacity of 221 ac-ft, fire water storage capacity of 3 ac-ft, minimum cooling water capacity of 590 ac-ft required to meet the 95 EF shutdown service water inlet temperature, and loss in capacity of 35 ac-ft from sedimentation resulting from a 100-year flood.

In Revision 4 of the SSAR, the applicant stated that the probable maximum flood water surface elevation is 709.8 ft MSL. The applicant also stated that any overtopping wave would only produce a spray because of riprap placed on the upstream face of the dam. The applicant stated that the downstream face of the dam is protected against gully erosion by grass and therefore, any overtopping resulting in spray on the downstream face is not expected to result in significant damage to the dam.

2.4.8.2 Regulatory Evaluation

Acceptance criteria for this section are based on meeting the requirements of 10 CFR Parts 52 and 100 as they relate to identifying and evaluating the hydrologic features of the site.

Compliance with 10 CFR 52.17(a) and 10 CFR 100.20(c) requires consideration of the site's physical characteristics (including seismology, meteorology, geology, and hydrology) when determining its acceptability for a nuclear power reactor. To satisfy the hydrologic requirements of 10 CFR Parts 52 and 100, the applicant's safety assessment should contain a description of cooling water canals and reservoirs for a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site. The applicant should include details in its analysis of cooling water canals and reservoirs sufficient to evaluate the site's acceptability and to assess the potential for those characteristics to influence the design of SSCs important to safety for a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site. Meeting this requirement provides reasonable assurance that the capacities of cooling water canals and reservoirs are adequate.

In those cases for which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. The applicant can develop a PPE for a single type of facility or a group of candidate facilities by selecting the limiting values of parameters. Important PPE parameters for safety assessment described in SSAR Section 2.4 include, but are not limited to, cooling needs (e.g., adverse local meteorological conditions, high ambient temperature).

2.4.8.3 Technical Evaluation

The staff visually inspected the site during the site safety analysis visit on May 11, 2004. The staff determined that the SSAR accurately describes the intakes, discharge canals, outfalls, and reservoirs near the ESP site.

The applicant stated in SSAR Section 2.4.8.1 that the ESP facility would use cooling tower(s) for the normal cooling of the power plant. In addition, the applicant stated in SSAR Section 2.4.8.1 that the UHS system for the ESP facility might also use cooling tower(s). In the same section, the applicant stated that a lake drawdown analysis, to be performed at the design stage, would indicate whether a load reduction to the ESP facility, or a wet/dry hybrid cooling tower system, might be necessary to maintain water surface elevation in Clinton Lake at or above 677 ft MSL during a 100-year drought.

According to the PPE table (SSAR Table 1.4-1, item 3.3.9), average makeup water for the UHS system with mechanical draft cooling tower(s) is 555 gpm. This makeup water flow is equivalent to a volume of 73.6 ac-ft over a 30-day period. The staff estimated that applying a 33-percent factor for blowdown, and an overall 20-percent margin, the 30-day makeup water needed for the ESP facility's UHS system would be 73.6 x 1.33 x 1.2 = 117.4 ac-ft. The staff's estimate was considerably different from the applicant's estimate of 87 ac-ft. The staff

In RAI 2.4.9-1, the staff requested the applicant to reference studies related to the geological features or other characteristics that preclude any likelihood of channel diversion upstream of the ESP site. In response to RAI 2.4.9-1, the applicant stated that it performed a study of geological features and other characteristics related to the potential for channel diversion upstream of the ESP site specifically for the ESP application. The applicant indicated that this site-specific examination did not rely on any previously published studies other than topographic maps. The applicant further stated that its examination of the topographic maps of Salt Creek and the North Fork of Salt Creek did not reveal evidence of natural channel diversions, such as oxbow lakes or broad, well-developed floodplains.

The applicant stated that the creeks and streams in the watershed generally occur in well-defined valleys. Any diversion of water out of these valleys into an adjacent drainage basin would require sufficient energy to overcome the topography and cut a new drainage channel. The applicant stated that, based on the physical characteristics of the drainage area and the creek system, it is unlikely that a potential, naturally occurring channel diversion would shift water out of the Clinton Lake watershed. ~~The applicant also stated that it would revise SSAR Section 2.4.9 to add this~~In Revision 4 of the SSAR, the applicant added information to reflect the above clarification.

2.4.9.2 Regulatory Evaluation

SSAR Table 1.5-1 shows the applicant's conformance to the NRC RGs. In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to the hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

The staff used the review guidance provided in Section 2.4.9 of RS-002, Attachment 2, to evaluate this SSAR section. These acceptance criteria relate to 10 CFR Parts 52 and 100, insofar as they require that the site evaluation consider the hydrologic characteristics of the site. The regulations at 10 CFR 52.17(a), 10 CFR 100.20(c), and 10 CFR 100.21(d) require that the NRC take into account the physical characteristics of the site (including seismology, meteorology, geology, and hydrology) when determining the acceptability of a site for a nuclear reactor.

Channel diversion or realignment poses the potential for flooding or for an adverse effect on the supply of cooling water for a nuclear power plant(s) of a specified type (or falling within a PPE) that might be constructed on the proposed site. Therefore, it is one physical characteristic that must be evaluated pursuant to 10 CFR 100.21(d). The consideration of the 10 CFR 100.21(d) criteria in this evaluation provides reasonable assurance that the effects of flooding caused by channel diversion resulting from severe natural phenomena would pose no undue risk to the type of facility proposed for the site.

In response to RAI 2.4.10-1, the applicant stated that the CPS USAR considered the 40-mph overland wind speed to act on the PMF water surface elevation. The applicant also stated that the design of the circulating water screenhouse for the CPS Unit 1 considered a 48-mph overland wind speed coincident with the PMF water surface elevation. The applicant noted that use of these design wind speeds did not result in any safety issues and concluded that the CPS plant would not flood under any circumstances. The applicant also stated that the ESP site is considered to be a dry site, consistent with Condition 3 of Section 2.4.3 of RS-002, Attachment 2. The applicant further stated that the operation of the ESP facility would not impact the potential for flooding at the existing dam or at the plant site. Therefore, the applicant concluded that the calculation of wave runup effects on PMF water surface elevations is inconsequential. The applicant stated that the ESP analyses retained the design wind speeds to be consistent with the previously completed CPS USAR analyses.

The applicant stated that a review of the more recent ANSI/ANS-2.8-1992 information indicated that a wind speed of somewhat greater magnitude (i.e., 52 mph) is more appropriate for estimating wave runup height coincident with PMF water surface elevation. The applicant provided a revision to SSAR Sections 2.4.3.6 and 2.4.10 in the RAI response, using a wind speed of 52 mph.

In Revision 4 of the SSAR, the applicant stated that the maximum hydrostatic PMF water surface elevation is 709.8 ft MSL and, combined with other effects, the maximum water level of Clinton Lake near the ESP facility is 716.5 ft MSL. The applicant noted that the ESP facility grade is approximately 19 ft above the maximum combined effects elevation and 25 ft above the hydrostatic PMF elevation. The applicant stated that the only safety-related equipment below these elevations is the new ESP intake structure, which would be designed with adequate flooding protection.

2.4.10.2 Regulatory Evaluation

As required by 10 CFR 100.20(c), the PMF must be estimated using historical data. Meeting this requirement provides reasonable assurance that the effects of flooding or a loss of flooding protection, resulting from severe natural phenomena, would pose no undue risk to the type of facility proposed for the site.

In those cases for which a reactor design is not specified, the ESP applicant may instead provide a PPE to characterize a facility or facilities for comparison with the hydrologic characteristics of the site. A PPE can be developed for a single type of facility or a group of candidate facilities by selecting the limiting values of the relevant parameters.

To determine whether the applicant met the requirements of 10 CFR Parts 52 and 100, as they relate to flooding protection, the staff used the following specific criteria:

- The applicability (potential adverse effects) of a loss of flooding protection should be described.

- Historical incidents of shore erosion and flooding damage should be discussed.

The applicant stated that the reliability of the submerged UHS pond to provide a supply of water during drought conditions is enhanced by the location of the pond with respect to the adjacent ground water table. The applicant stated that, because the pond is normally submerged in Clinton Lake and the normal water surface elevation sets the base level for the adjacent ground water during low flow or loss of the main dam, water stored in upstream alluvium would replenish water in the submerged UHS pond. The applicant further stated that the Salt Creek watershed would also provide a source of water for long-term cooling following loss of the Clinton Lake dam. The applicant estimated that the watershed can supply 400 gpm at the minimum mean daily flow and 16,150 gpm at the minimum mean monthly flow. The required makeup flow to the ESP facility's UHS cooling tower(s) during normal operation would be 250 gpm and would bound the requirement after shutdown was achieved.

The applicant stated that it monitors the submerged UHS pond for sediment accumulation periodically and after a major flood passes through Clinton Lake. The applicant stated that, after the ESP facility is constructed, it might reduce the allowable sediment accumulation in the submerged UHS pond.

In Revision 2 of the SSAR, the applicant described an assessment similar to the one described above in order to determine the amount of cooling water available during drought periods. The applicant stated that the excess available water on an annual average basis after satisfying CPS consumptive demand is 1,300 ac-ft/month (9,500 gpm) during the 100-year drought event and 2,000 ac-ft/month (15,100 gpm) during the 50-year drought event.

2.4.11.2 Regulatory Evaluation

SSAR Table 1.5-1 shows the applicant's conformance to the NRC RGs. In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to the hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

Acceptance criteria for this section relate to the following regulations and criteria:

- 10 CFR Parts 52 and 100 require that hydrologic characteristics be considered in the evaluation of the site.

- 10 CFR 100.23 requires, in part, that siting factors to be evaluated must include the cooling water supply.

The regulations in 10 CFR Parts 52 and 100 require, in part, that the evaluation of a nuclear power plant site consider hydrologic characteristics. To satisfy the requirements of 10 CFR Parts 52 and 100, the applicant's SSAR should describe the surface and subsurface hydrological characteristics of the site and region. In particular, the UHS for the cooling water

RAI 2.4.1-1, to provide locations for the proposed ESP facility. Section 2.4.1.1 of this SER discusses the applicant's response to the RAI.

No changes were made in Section 2.4.13 in Revision 4 of the application.

2.4.12.2 Regulatory Evaluation

SSAR Table 1.5-1 shows the applicant's conformance to the NRC RGs. In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to the hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff reviewed this portion of the application for conformance with the applicable regulations and considered the corresponding regulatory guidance, as identified below.

Acceptance criteria for this section relate to the following regulations and criteria:

- 10 CFR Parts 52 and 100 require that the site evaluation consider hydrologic characteristics.

- 10 CFR 100.23 sets forth the criteria to determine the suitability of design bases for a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site with respect to the seismic characteristics of the site. It also requires that the adequacy of the cooling water supply for emergency and long-term shutdown decay heat removal be ensured, taking into account information concerning the physical, including hydrological, properties of the materials underlying the site.

As specified in 10 CFR 100.20(c), the site's physical characteristics (including seismology, meteorology, geology, and hydrology) must be considered when determining its acceptability for a nuclear power reactor.

As required by 10 CFR 100.20(c)(3), the applicant must address factors important to hydrological radionuclide transport using onsite measurements. To satisfy the hydrologic requirements of 10 CFR Part 100, the staff's review of the applicant's safety assessment should verify the description of ground water conditions at the proposed site, as well as how those conditions could be affected by the construction and operation of a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the site. Meeting this requirement provides reasonable assurance that ground water at or near a proposed site will not be significantly affected by the release of radioactive effluents from a plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site.

The regulation at 10 CFR 100.23 requires that geologic and seismic factors be considered when determining the suitability of the site and the acceptability of the design for each nuclear power plant. In particular, 10 CFR 100.23(d)(4) requires that the physical properties of materials underlying the site be considered when designing a system to supply cooling water

In the two paragraphs comprising SSAR Section 2.4.12, the applicant stated that it is extremely unlikely that effluents can move out of facilities containing liquid radioactive wastes because of the high water table elevation. The applicant's position is that the high water table results in an inward-directed hydraulic gradient that would allow ground water into the facility but not out of the facility.

The applicant identified the closest surface water withdrawal for drinking water purposes to be 2452 miles downstream at Alton, Illinois.

In Revision 4 of SSAR Section 2.4.12, the applicant states that the issue of a possible groundwater pathway for liquid effluents will be reviewed at the COL stage.

2.4.13.2 Regulatory Evaluation

SSAR Table 1.5-1 shows the applicant's conformance to the NRC RGs. In RAI 1.5-1, the staff asked the applicant to provide a comprehensive listing of NRC regulations applicable to its ESP SSAR. In its response to this RAI, the applicant indicated that RS-002, Attachment 2, identifies the NRC regulations applicable to its ESP SSAR. Section 2.4 of RS-002, Attachment 2, describes the methods of review and the applicable acceptance criteria that the staff uses to develop its findings and conclusions related to the hydrologic aspects of site characterization for an ESP. Although the applicant did not indicate how the individual sections of SSAR Section 2.4 address the hydrology-related site suitability criteria in RS-002, Attachment 2, the staff reviewed this portion of the application for conformance with the applicable regulations, and considered the corresponding regulatory guidance, as identified below.

Acceptance criteria for this section relate to the following regulations and criteria:

- 10 CFR Parts 52 and 100, as they relate to the evaluation of a site's hydrologic characteristics with respect to the consequences of the escape of radioactive material from the facility

Compliance with 10 CFR Parts 52 and 100 requires that local geological and hydrological characteristics be considered when determining the acceptability of a nuclear power plant site. The geological and hydrological characteristics of the site may have a bearing on the potential consequences of radioactive materials escaping from a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site. The applicant should plan for special precautions if a reactor(s) were to be located at a site where a significant quantity of radioactive effluent could accidentally flow into nearby streams or rivers or find ready access to underground water tables.

These criteria apply to Section 2.4.13 of RS-002, Attachment 2, because the reviewer evaluates site hydrologic characteristics with respect to the potential consequences of radioactive materials escaping from a nuclear power plant(s) of specified type (or falling within a PPE) that might be constructed on the proposed site. The staff reviews radionuclide transport characteristics of the ground water and surface water environments with respect to accidental releases to ensure that current and future users of ground water and surface water are not adversely affected by an accidental release of radioactive materials. RGs 1.113, Revision 1, “Estimating Aquatic Dispersion of Effluents from Accidental and Routine Reactor Releases for the Purpose of Implementing Appendix I,” issued April 1977, and 4.4, “Reporting Procedure for

Table 2.4-7 Staff's Proposed Site Characteristics Related to Hydrology

SITE CHARACTERISTIC	VALUE
Proposed Facility Boundaries	Figure 2.4-15
Site Grade	735 ft MSL
Highest Ground Water Elevation	733.5 ft MSL
Flood Elevation721.7Probable Maximum Flood (PMF) maximum hydrostatic water surface elevation	709.8 ft MSL
Coincident Wind Wave Activity (to add to the PMF water surface elevation)	6.4 ft
Storm Surge (to add to the PMF water surface elevation)	0.3 ft
Combined Effects Maximum Water Surface Elevation	716.5 ft MSL
Local Intense Precipitation	18.15 in. during 1 hour
Lake Surface Icing	27.0 in.
Maximum Cumulative Degree-Days	1141.5 in Fahrenheit
Frazil and Anchor Ice	The ESP site is subject to frazil and anchor ice formation.

WordPerfect Document Compare Summary

Original document: C:\Documents and Settings\jps1\Desktop\OLD\Section 2_5__original.wpd
Revised document: @PFDesktop\New1\Section 2_5_new1.wpd
Deletions are shown with the following attributes and color:
~~Strikeout~~, Blue RGB(0,0,255).
Deleted text is shown as full text.
Insertions are shown with the following attributes and color:
Double Underline, Redline, Red RGB(255,0,0).

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2.5.1.1 Technical Information in the Application

2.5.1.1.1 Regional Geology

SSAR Section 2.5.1.1 summarizes the regional geologic history and structural geology, with an emphasis on the Quaternary Period. Section 2.2 of SSAR Appendix A provides additional detail on the regional (1) physiography, (2) stratigraphy, and (3) structural geology. In addition, Section 2.1 of SSAR Appendix B provides a description of the regional (1) tectonic setting, (2) tectonic features, (3) prehistoric earthquakes, and (4) seismic sources. Finally, Attachment 1 to SSAR Appendix B describes the applicant's regional paleoliquefaction investigations. The applicant concluded that the ESP site is one of the most geologically stable areas in the United States and that the geologic conditions at the ESP site are the same as those at the CPS site.

Regional Physiography. The applicant described the regional physiography in Section 2.2.1 of SSAR Appendix A. The ESP site is located in the Till Plains section of the Central Lowland physiographic province. The terrain in central Illinois is typical of the province and consists of undulating, low-relief topography formed by the glacial drift cover, which ranges in thickness from a few tens of feet to several hundreds of feet. The applicant stated that much of the Till Plains section is characterized by landforms of low, commonly arcuate ridges, called moraines, interspersed with relatively flat intermorainal areas. The development of postglacial streams has led to the dissection of the glacial drift mantle and in some areas ~~postglacial~~ bedrock is exposed; however, there are no bedrock exposures near the site area.

Regional Geologic History and Stratigraphy. The applicant described the Quaternary geologic history and stratigraphy in SSAR Section 2.5.1.1 and Section 2.2.2 of SSAR Appendix A. During the Quaternary (mainly Pleistocene time), continental glaciation left widespread glacial deposits in the regional area. There were four major episodes of glaciation in the region, which from the youngest to the oldest are the Wisconsinan, Illinoian, Kansan, and Nebraskan. Wisconsinan deposits are found throughout the ESP site, and Illinoian deposits are present beyond the limit of Wisconsinan deposits in northern and central Illinois. Kansan- and Nebraskan-age glacial deposits are present at the surface and in the subsurface in areas of Iowa, Missouri, and part of western and east-central Illinois. These Quaternary deposits consist predominantly of glacial or glacial-derived sediments of glacial till, outwash, loess (a windblown silt), and glacialacustrine deposits, as well as alluvium.

Regional Structural Geology. The applicant described the structural geology in SSAR Section 2.5.1.1 and Section 2.2.3 of SSAR Appendix A. The Quaternary glacial deposits in the region are underlain by thick sequences of gently dipping Paleozoic sedimentary rocks. The bedrock surface throughout Illinois is of Paleozoic age, and the Paleozoic rocks are relatively thicker at the centers of the structural basins, such as the Illinois basin. During Paleozoic sedimentation, several discontinuations of regional importance occurred because of the widespread advances and retreats of the Paleozoic seas across the interior of North America. At a depth of about 2,000 to 13,000 ft below the ground surface, the basement complex of the Precambrian igneous and metamorphic rocks underlies the Paleozoic rocks. Throughout the Paleozoic era, the area underwent intermittent slow subsidence and gentle uplift, which resulted in broad regional geologic basins of gently dipping sedimentary rocks and intervening broad arches or highs. Locally, folds and faults are superimposed on this pattern.

Regional Tectonic Setting. The applicant described the tectonic setting in Section 2.1.1 of SSAR Appendix B. The ESP site is located within the Illinois basin in the stable continental region (SCR) of the North American craton. The Illinois basin is a spoon-shaped depression, covering parts of Illinois, Indiana, and Kentucky. The basin is bounded on the north by the Wisconsin arch, on the east by the Kankakee and Cincinnati arches, on the south by the Mississippi embayment, and on the west by the Ozark dome and Mississippi River arch. The east-west-trending Rough Creek-Shawneetown fault system divides the Illinois basin into two unequal parts. The northern part of the Illinois basin is larger but shallower, a typical cratonic depression with basement elevations ranging from approximately 2,950 ft below sea level in the northern part of the basin to 14,100 ft below sea level in southeastern Indiana. In the northern part of the basin, Paleozoic sedimentary strata overlie the Proterozoic-age basement rocks of the Eastern Granite-Rhyolite Province. The southern part of the Illinois basin is relatively smaller but deeper, with about 23,000 ft of Paleozoic sedimentary rocks. The southern part of the basin is underlain by portions of the Reelfoot rift and Rough Creek graben, which is a rift system that formed during late Precambrian to middle Cambrian time (800 to 500 million years ago (mya)).

The applicant stated that the ESP site lies within a compressive midplate stress province characterized by a relatively uniform compressive stress field with a maximum horizontal stress oriented northeast to east-northeast. However, within this relatively uniform stress field, the applicant cited recent studies that show a geographic shift from an east-west maximum horizontal compressive stress at the latitude of the New Madrid seismic zone (NMSZ) to a stress that trends just north of east in southern Illinois and Indiana.

Regional Tectonic Features. Section 2.1.2 of SSAR Appendix B describes the major geologic structures (folds, faults, and lineaments) in the region surrounding the ESP site as follows:

- folds
  - La Salle anticlinorium
  - Peru monocline
  - D~~o~~u Quoin monocline
  - Louden anticline
  - Waterloo-Dupo anticline
  - Farmington anticline-Avon block
  - Peoria folds
- faults
  - Sandwich fault zone
  - Plum River fault zone
  - Centralia fault zone
  - Rend Lake fault zone
  - Cap au Gres faulted flexure
  - St. Louis fault
  - Eureka-House Springs structure
  - Ste Genevieve fault zone
  - Simms Mountain fault system
  - Bodenschatz-Lick fault system

Folds

The regional folds that the applicant considered to be potential Quaternary features are the (1) Peru monocline, (2) D~~o~~u Quoin monocline, (3) Waterloo-Dupo anticline, and (4) Farmington anticline-Avon block.

The Peru monocline is a 65-mile-long northwest trending fold belt in which the rocks dip steeply to the southwest into the Illinois basin. The distance between the Peru monocline and the ESP site is about 50 to 55 miles. Three earthquakes occurring in September 1972 (body wave magnitude (m_b) 4.6), September 1999 (m_b 3.5), and possibly May 1881 (magnitude unknown) are assumed to be related to this structure, and, as such, the applicant concluded that the Peru monocline may be a reactivated Paleozoic structure.

The D~~o~~u Quoin monocline, which is located about 90 to 100 miles south of the ESP site, is a north-south trending structure, which warps Paleozoic strata downwards on its eastern flank. Normal faults of the Dowell and Centralia fault zones are coincident with the dipping flank of the D~~o~~u Quoin monocline. The applicant cited research that postulates that the Centralia fault zone represents extensional activation of the basement structure beneath the D~~o~~u Quoin monocline, and these two structures may connect at depth. The D~~o~~u Quoin monocline and related Centralia fault zone are considered as a potential source for an earthquake that produced middle Holocene paleoliquefaction features in southwestern Illinois and southeastern Missouri.

The Waterloo-Dupo anticline, which is located about 130 miles southwest of the ESP site, is a north-northwest-trending, asymmetrical anticline that may be a southern continuation of the Cap au Gres faulted monocline, located in Missouri and Illinois. The applicant stated that the Waterloo-Dupo anticline may be the seismic source for the paleoliquefaction features in eastern Missouri.

The Farmington anticline-Avon block is a broad (as much as 12 miles wide), northwest-trending, low-relief structure. Weak to moderate seismicity is clustered around this structure, which is located about 170 miles south of the ESP site.

Faults

The regional faults and fault zones that the applicant considered to be potential Quaternary features are the (1) Centralia fault zone, (2) St. Louis fault, (3) Ste Genevieve fault zone, (4) WVFS, and (5) FAFC.

The Centralia fault zone is a north-trending structure zone, composed of normal faults that dip 70E to 75E toward the west, with a consistent displacement of 100 to 160 ft for strata from the upper Mississippian to Ordovician periods. The fault zone is located about 100 miles south of the ESP site. The applicant stated that earthquakes with strike-slip focal mechanisms located near the structural axis of the Centralia fault are probably associated with the D~~o~~u Quoin monocline.

The St. Louis fault, which is located about 130 miles from the ESP site, is a northeast-trending fault located along the border between Missouri and Illinois. The applicant cited recent studies which show that the St. Louis fault (1) appears to offset the Waterloo-Dupo anticline in the right-lateral sense, and (2) is considered as a possible candidate for the paleoearthquake features

Based on historical accounts and geologic evidence, geologists have postulated that the December 16, 1811, earthquake occurred primarily along the BA, which is the southernmost fault segment. Similarly, geologists have concluded that the causative fault for the January 23, 1812, earthquake is along the NN fault segment, and the February 7, 1812, earthquake occurred on the RF, which connects the two other fault zones through the stepover region.

Geologists have determined the maximum earthquake potential of the NMSZ based largely on the analysis of damage-intensity data and liquefaction features from the 1811–1812 earthquake sequence. The applicant found that recent analyses favor lower magnitudes (7.5 to 8.0) for the NMSZ, suggesting that site effects and population distribution biased earlier interpretations, which postulated higher magnitudes (7.8 to 8.4). To determine the recurrence interval for the maximum earthquakes in the NMSZ, geologists have used paleoliquefaction studies and the evaluation of fault-related deformation along the Reelfoot scarp. The applicant cited paleoliquefaction events with dates of AD 1450 ± 150, AD 900 ± 100, AD 490 ± 50, AD 300 ± 200, and BC 1370 ± 970, based on its review of the literature. As such, the applicant concluded that the occurrence interval of a New Madrid-type earthquake may have been as short as 200 years or as long as 800 years, with an average of about 500 years.

Wabash Valley/Southern Illinois Seismic Zone

The WVSZ is located in southeastern Illinois and southwestern Indiana to the northeast of the NMSZ. The WVSZ is a zone of moderate seismicity, with the strongest event (moment magnitude (M_w) 5.4) occurring in 1968 in southern Illinois. Other notable recent events occurring in the WVSZ include a magnitude 5.~~1~~0 earthquake near Lawrenceville, Illinois, in 1987 and a magnitude 4.~~8~~5 earthquake in 2002 near Evansville, Indiana. Much larger earthquakes have occurred in the WVSZ during the past 10,000 years. The applicant cited research that demonstrates, based on paleoliquefaction data, the existence of repeated large-magnitude (M_w 7.0 to 7.8) earthquakes in the Wabash Valley region. The applicant stated that the causative structure for these earthquakes may be basement thrust faults beneath the Illinois basin that coincide with an area of broad flexure in the CGL. The location of the 1968 M_w 5.4 earthquake in southern Illinois supports this hypothesis. Figure 2.5.1-4, reproduced from Figure 2.1-14 in SSAR Appendix B, shows the historical seismicity and estimated centers of the large prehistoric earthquakes in the WVSZ.

The applicant stated that the maximum-magnitude distribution for the WVSZ is based on the analysis of paleoliquefaction features in the vicinity of the lower Wabash Valley of southern Illinois and Indiana. The applicant cited research showing that the largest paleoearthquake occurred ~~6011~~6101 ± 200 years ago with an estimated M_w range between 7.0 to 7.5. The next largest earthquake occurred 12,000 ± 1,000 years ago with an estimated magnitude between 7.1 to 7.3. Both of these earthquakes occurred close to one another in the lower Wabash Valley of Indiana and Illinois.

Central Illinois Basin/Background Source

In addition to the NMSZ and WVSZ, evidence from recent paleoliquefaction studies and seismic reflection data show that significant earthquakes may occur in parts of the central Illinois basin where there are no obvious folds or faults at the surface. The applicant stated that the location, size, and recurrence of such events are not well constrained by available data. However, because of the paleoliquefaction evidence, the applicant has developed a background source zone for this region. The central Illinois basin/background source covers the area to the west and north of the WVSZ and encompasses the ESP site. The applicant stated that one or two prehistoric earthquakes may have occurred near Springfield, Illinois, approximately 3~~0~~5 miles southwest of the ESP site (see SER Figure 2.5.1-4 above) between about 5900 to 7400 years ago. These earthquakes were apparently large enough to generate liquefaction features, with magnitude estimates ranging between 6.2 and 6.8. The applicant was unable to associate the Springfield earthquakes with any known geologic structure or local seismic activity. In addition to the Springfield events, the applicant stated that additional liquefaction features were discovered further south near the confluence of the Shoal Creek and Kaskaskia River~~ in Clinton, Illinois~~. The estimated magnitude and date for this event is about 6.0 and 5700 before present (BP).

To further characterize the seismic potential of the central Illinois basin/background source, the applicant investigated the banks of several streams (Sangamon River, Salt Creek, ~~Sugar Creek, Kickapoo Creek, Deer~~North Fork of Salt Creek, and ~~Lake Fork~~the Mackinaw River) near the ESP site for evidence of liquefaction features resulting from strong ground motion. These paleoliquefaction investigations are described in Attachment 1 to SSAR Appendix B. Figure 2.5.1-5, reproduced from Figure B-1-6 in Attachment 1 to SSAR Appendix B, shows the streams that the applicant surveyed during its paleoliquefaction reconnaissance.

Although the applicant discovered some small liquefaction features, which suggest possible local seismic sources, the applicant stated that these features could also be related to more distant sources, such as the WVSZ or NMSZ. The applicant concluded by stating the following:

> Given the low rate of historical seismicity in this region, the apparent long recurrence between events suggested by the paleoliquefaction data, and the lack of clearly defined seismogenic structures close to the inferred energy centers, it is unlikely that distinct seismic sources can be defined for these paleoliquefaction events.

For the central Illinois basin/background source, the applicant stated that the results of its paleoliquefaction investigations show that there have not been repeated moderate to large events, comparable to the magnitude (M) 6.2 to 6.8 Springfield earthquake in the vicinity of the ESP site, in the ~~past 2 million~~late Holocene time (approximately 6 to 7 thousand years). However, because of the uncertainty in the paleoliquefaction data, the applicant stated that the range in maximum magnitude assigned to a random earthquake in the background source should include events comparable to that estimated for the Springfield earthquake.

In RAI 2.5.2-6, the staff asked the applicant to explain its selected paleoliquefaction study area along the streams near the ESP site. Specifically, the staff asked the applicant why it did not examine the streams northwest and southeast of the site as part of its study. In response, the applicant stated that it selected its study area to supplement previous liquefaction studies along portions of the Sangamon River, portions of Salt Creek, and similar drainages west and northwest of the site. SER Section 2.5.1.3.1 provides further detail on the applicant's response to RAI 2.5.2-6 and the staff's evaluation of the applicant's response.

In RAI 2.5.1-4, the staff asked the applicant to provide better annotated photographs of the liquefaction features found along the Salt Creek. In response, the applicant provided photographs that clearly indicate the locations of the sand dikes. In RAI 2.5.1-5, the staff asked the applicant to substantiate the reliability of its methods to determine the size and location of paleoearthquakes based on liquefaction features. In response, the applicant demonstrated how it used the paleoliquefaction data and analyses to characterize the regional and local seismic potential of these paleoearthquake centers. SER Section 2.5.1.3.1 provides further detail on the applicant's response to RAIs 2.5.1-4 and 2.5.1-5 as well as the staff's evaluation of these responses.

2.5.1.1.2 Site Geology

SSAR Section 2.5.1.2 summarizes the local geologic history and structural geology, with an emphasis on the Quaternary Period. Section 2.2 of SSAR Appendix A provides additional detail on the local (1) physiography, (2) stratigraphy, and (3) structural geology. In addition, Chapter 5 of SSAR Appendix A provides a description of the site ground water conditions and other geologic considerations, such as potential topographic depressions caused by karst terrain and mine subsidence. Chapter 5 of SSAR Appendix A also describes regional natural gas production and oil fields, ground water springs, landslides, and the overall geologic suitability.

Site Physiography. The ESP site lies within the Bloomington Ridged Plain physiographic subsection of the Till Plains physiographic section in Central Illinois. The site is located in an upland area ground moraine that is dissected by the Salt Creek and the North Fork of the Salt Creek. The local relief of the uplands is about 10 ft, except near the drainage ways, and the average elevation of the uplands is approximately 740 ft above mean sea level (msl). The applicant concluded that the physiography of the ESP site is the same as that of the CPS site.

Site Stratigraphy. The ESP site is located a few miles inside the extent of the Wisconsinan glaciation. The surface deposits in the upland site area consist of a thin layer of loess (silt with some fine sand) over glacial till. Other stratigraphic units beneath the glacial till include organic silt, under which lie glacial till deposits of the Illinoian Stage and pre-Illinoian Stage. Bedrock in the vicinity of the ESP site is from the Bond and Modesto formations, which generally consist of alternating bands of limestone, shale, siltstone, sandstone, and some coal seams. At the base of the Bond formation is a layer of limestone, which corresponds to the top of the Modesto formation (495 ft above msl). The applicant concluded that the site stratigraphy across the ESP and CPS sites is very similar in terms of soil consistency and layering. The primary difference between the two sites is that the depth to bedrock is approximately 50 ft deeper at the ESP site than at the CPS site.

Site Structural Geology. The ESP site is located in a tectonically stable area of North America. The applicant stated that although the ESP site is within several miles of structural features, there is no evidence of surface faulting at the site or the area surrounding the site within a 25-mile radius. In addition, the applicant stated that no evidence of faulting was observed ~~from aerial photographs, satellite imagery, geophysical studies, boreholes, or excavations~~based on interpretations of borehole data at the ESP and CPS sites, excavations for CPS, or during geologic reconnaissance for this study. The applicant found that although differences in bedrock unit elevations can be attributed to structural deformation, the relatively flat-lying and undeformed Pleistocene drift overlying the bedrock demonstrates that the stresses that would have been responsible for the deformation have been inactive since at least ~~pre-Pleistocene~~Illinoian time (~~about 2 mya~~~ 185 to 128 ka). The applicant concluded that its understanding of the CPS and ESP site structural geology and geologic history has not changed since the geology work done for the CPS site.

Site Ground Water Conditions. The applicant found that the ground water elevations at the ESP site are consistent with those of the CPS site. As indicated by the ESP site piezometers, the ground water generally exists in a perched water table condition a few feet below the ground surface in the shallow Wisconsinan till soils. A downward gradient of about 20 ft in the ground water elevation was observed by the applicant across the ESP site. SSAR Section 2.4.13.2, "Sources," presents a detailed discussion of the hydrogeologic conditions at the ESP site.

Other Geologic Conditions. Chapter 5 of SSAR Appendix A covers additional geologic conditions that the applicant investigated as part of its ESP application. These additional geologic conditions include (1) karst terrain, (2) mine subsidence, (3) natural gas production and oil fields, (4) ground water springs, (5) landslides, and (6) overall geologic suitability.

Karst terrain includes topographic depressions (sinkholes), caves, large springs, fluted rocks, blind valleys, and swallow holes that develop in areas of high rock solubility and permeability. These features have the potential to affect the foundation support for buildings and other

Central Illinois Basin/Background Source Zone—Maximum Magnitude Distribution

The applicant stated that evidence from recent paleoliquefaction studies suggests that significant earthquakes may occur in parts of the central Illinois basin where there are no obvious surface faults or folds. The location, size, and recurrence of these earthquakes are not well constrained by available data. One known earthquake is the M 6.2 to 6.8 prehistoric Springfield earthquake, located approximately 30 miles to the southwest of the ESP site. At present, the moderate-size prehistoric earthquakes in the central Illinois basin cannot be associated clearly with any known geologic structure, and no seismicity trends have been observed for this region. The applicant stated that paleoliquefaction evidence suggests that there may have been additional moderate-magnitude events in central and southern Illinois, such as the Shoal Creek earthquake which occurred about 5700 years BP. In addition to a literature review, the applicant conducted its own field reconnaissance north and east of the ESP site. Some paleoliquefaction features were discovered, but the applicant stated that the data are too limited to provide a basis for estimating the size or location of the event or events. The applicant also concluded that there have not been repeated moderate to large events (comparable to the Springfield earthquake) in the vicinity of the ESP site in the latest Pleistocene to Holocene time (~~10~~6,000 to 7,000 years BP). A study of earthquakes in SCRs conducted by EPRI in 1994 (Johnston, et al., 1994) specifically addresses the problem of defining a maximum magnitude for regions that are characterized by the rare occurrence of maximum earthquakes and the lack of recognized surface expression or well-defined seismicity patterns associated with seismic sources, typical conditions over much of the CEUS. The 1994 EPRI study developed worldwide databases that could be used for assessments of maximum magnitudes for seismic sources in the CEUS. Using the database and method found in the 1994 EPRI study, the applicant developed the following maximum magnitude range for earthquakes in the central Illinois basin background source—M 6.2 (0.4), M 6.4 (0.3), M 6.6 (0.2), and M 6.8 (0.1).

In RAI 2.5.2-4, the staff asked the applicant to provide further detail and justification regarding its use of the 1994 EPRI study and accompanying worldwide database of earthquakes. Specifically, the staff requested the applicant to explain why its maximum magnitude for central Illinois should not be set at 6.8 since the two largest SCR earthquakes from nonextended crust are the Accra, Ghana, earthquake of 1862 (M 6.75 ± 0.35) and the Meeberrie, Western Australia, earthquake of 1941 (M 6.78 ± 0.25). In its response to RAI 2.5.2-4, the applicant stated that the method developed by the 1994 EPRI study does not start from the assumption that all SCR domains have the same maximum magnitude potential. Instead it assumes that there are characteristics that control the maximum size of an earthquake that can occur in an individual SCR domain, and these characteristics vary from domain to domain. SER Section 2.5.2.3.3 provides further detail on the applicant's response to RAI 2.5.2-4 as well as the staff's evaluation of the applicant's response.

Ground Motion Attenuation. The original EPRI-SOG study used three attenuation relationships, developed in the mid-1980s. Since the completion of the EPRI-SOG study, estimating ground motions in the CEUS has been the focus of considerable research. Following the guidance provided in NUREG/CR-6372, "Recommendations for Probabilistic Seismic Hazard Analysis: Guidance on Uncertainty and Use of Experts," prepared by the Senior Seismic Hazard Analysis Committee, EPRI completed in 2003 a study to characterize the distribution of ground motion prediction in the CEUS (EPRI 1008910, "CEUS Ground Motion Project: Model Development

- Use updated attenuation models.

After implementing the above adjustments to the seismic source characterizations and ground motion models, the applicant concluded that the resulting seismic hazard curves are generally higher for the ESP site. The applicant implemented each of the above adjustments individually and then made comparisons with the earlier EPRI-SOG hazard curves for the ESP site. In addition, the applicant implemented each of the above adjustments simultaneously and made similar comparisons. For both cases, the applicant considered the change in the seismic hazard levels to be significant enough to perform an updated PSHA for the ESP site.

2.5.2.1.4 Maximum Earthquake Potential

SSAR Section 2.5.2.4 presents the maximum earthquake potential for the ESP site in terms of the controlling earthquake magnitudes and distances. The applicant determined the low- and high-frequency controlling earthquakes by deaggregating the PSHA results at selected probability levels. Before determining the controlling earthquakes, the applicant updated the original EPRI-SOG PSHA using the seismic source zone adjustments and new ground motion modeling described above in the previous SER subsection.

PSHA Results. The applicant performed the PSHA by combining the hazard from the EPRI-SOG seismic sources (with updated maximum magnitude distributions) with the hazard from the New Madrid characteristic earthquake sources. The applicant assumed that the characteristic earthquake ruptures on the New Madrid faults rupture along the entire length of the fault, and the closest approach of the fault to the ESP site was used as the distance to the rupture. In addition, the applicant assumed that the characteristic earthquakes occurring on the central New Madrid faults rupture as clustered events or as a sequence within a short time period relative to the return period for the events.

The applicant performed PSHA calculations for peak ground acceleration (PGA) and spectral acceleration at frequencies of 25, 10, 5, 2.5, 1, and 0.5 Hz. Following the guidance provided in RG 1.165, the PSHA calculations were performed assuming generic hard rock site conditions (i.e., a shear- (S-) wave velocity of 9~~3~~200 ft/s). The actual local site characteristics are incorporated in the calculation of the SSE spectrum, which uses the hard rock PSHA hazard results as the starting point. To compare the relative contribution of each of the dominant seismic source zones to the total hazard, the applicant computed PSHA results for the central Illinois basin background source, Wabash Valley, and New Madrid individually. At low ground motion levels, the distant Wabash Valley and New Madrid characteristic earthquakes produce the highest hazard. As the ground motion level increases, the local central Illinois background source becomes the dominant contributor to the hazard for high-frequency ground motions.

Controlling Earthquakes. To determine the low- and high-frequency controlling earthquakes for the ESP site, the applicant followed the procedure outlined in Appendix C to RG 1.165. This procedure involves the deaggregation of the PSHA results at a target probability level to determine the controlling earthquake in terms of a magnitude and source-to-site distance. The applicant chose to perform the deaggregation of the mean 10^{-4} and 10^{-5} PSHA hazard results. The low- and high-frequency controlling earthquakes are shown below in Table 2.5.2-1.

2.5.2.1.5 Seismic Wave Transmission Characteristics of the Site

SSAR Section 2.5.2.5 describes the method used by the applicant to develop the site free-field ground motion spectrum. The hazard curves from the PSHA are defined for generic hard rock conditions. According to the applicant, these hard rock conditions exist at the ESP site at a depth of several thousand feet or more below the ground surface. To determine the free-field ground motion, the applicant (1) developed soil/rock profile models for the ESP site, (2) selected seed earthquake time histories, and (3) performed the final site response analysis.

ESP Profile Model. The soil profile model used by the applicant for its site response analysis is shown in SSAR Figure 2.5-3. The profile consists of a thin layer of loess underlain by interbedded glacial tills and lacustrine (lake) deposits of Quaternary age to a depth of nearly 300 ft. For the 310-ft soil column at the ESP site, the applicant used the S-wave velocity (V_s) values from its ESP geophysical surveys, which are described in SER Section 2.5.4.1.4. SER Figure 2.5.4-5 shows the compressional- (P-) wave velocity (V_p) and V_s for each of the different soil layers to a depth of about 300 ft below the ground surface. As described in SER Section 2.5.4.1.2, the applicant conducted cyclic testing of the ESP site soils to determine the variation in soil shear strain modulus and material damping ratio with shearing strain amplitude. Based on the dynamic test results, the applicant selected appropriate shear modulus and damping curves for the ESP site.

As a result of the large range in S-wave velocities for some of the soil layers (Table 5-2 in SSAR Appendix A) and the differences in standard penetration test (SPT) blowcount values for ESP borings B1 and B4 compared to those of B2 and B3, the staff in RAI 2.5.4-4 requested that the applicant justify the appropriateness of using a single “average” soil column for the site response analyses rather than including a number of different base-case soil columns. In response to RAI 2.5.4-4, the applicant stated that it modeled the variations in S-wave velocity and SPT blowcounts by statistically creating a large number of profiles, or realizations, and conducting the site response analyses using these profiles. SER Section 2.5.2.3.5 provides further detail on the applicant’s response to RAI 2.5.4-4 as well as the staff’s evaluation of the applicant’s response.

At a depth of approximately 300 ft is the top of the bedrock, which consists of limestone, shale, sandstone, siltstone, and a single 1-ft-thick interval of coal. The bedrock is of Pennsylvanian age. The applicant characterized the dynamic properties of this soil/bedrock profile during field and laboratory testing. These dynamic properties consisted of S-wave velocity data to a depth of 310 ft and a set of shear modulus reduction and damping data obtained from samples taken from boreholes drilled at the ESP site. Since the V_s at a depth of 310 ft below the ESP site is about 4000 ft/s, the applicant used nearby deep borehole V_p measurements to estimate the bedrock V_s profile. The applicant assumed V_p/V_s ratios of 1.73 and 2, which correspond to depths of 1900 ft and 3000 ft to reach the hard rock value of V_s = 9~~3~~200 ft/s. In addition, for the sedimentary rocks below a depth of 310 ft, the applicant assumed a linear behavior during earthquake shaking. The damping values used by the applicant for the sedimentary rocks vary from 3.3 percent at depths ranging from 310 to 400 ft to 1.8 percent for rocks at a depth of 1200 to 1900 ft.

Once the applicant determined the appropriate soil and rock dynamic properties, it modeled the variability present in the site data by randomizing the soil and rock S-wave velocity profiles, soil

$$SSE = UHRS_{10^{-4}} \times DF \qquad (2.5.2\text{-}1)$$

where

$$DF = \mathbf{Max}(DF_1, DF_2)$$

and

$$DF_1 = 1.0$$

$$DF_2 = 0.6(A_R)^{0.8}$$

The amplitude ratio, A_R, is given by the ratio of 10^{-5} UHRS and 10^{-4} UHRS spectral accelerations for each spectral frequency. As shown in the above equations, the minimum value of DF for each spectral frequency is 1.0, which implies that the SSE will be equivalent to the 10^{-4} UHRS or higher, depending on the amplitude ratio. Table 2.5.2-3 shows the applicant's computation of the horizontal SSE using the two UHRS spectra and the DF for a select number of spectral frequency values.

Table 2.5.2-3 Computation of the Horizontal SSE Spectrum for the ESP Site

Spectral Frequency (Hz)	10^{-4} Mean UHRS (g)	10^{-5} Mean UHRS (g)	DF_2	DF	Horiz. SSE (g)
0.1	0.0129	0.0412	1.519	1.511	0.0196
0.5	0.1400	0.4160	1.434	1.434	0.2007
1.0	0.2970	0.8020	1.328	1.328	0.3945
2.5	0.6382	1.2561	1.031	1.031	0.6582
5.0	0.6570	1.2149	0.981	1.600	0.6570
10.0	0.5864	1.1065	0.997	1.079	0.6002
20.0	0.4599	0.7862	0.921	1.000	0.4599
50.0	0.3200	0.5791	0.914	1.000	0.~~3647~~3200
100.0 (PGA)	0.2660	0.4895	0.977	1.000	0.2660

Figure 2.5.2-6 shows the soil surface 10^{-4} (green line) and 10^{-5} (red line) mean UHRS and the applicant's performance-based SSE spectrum (black line). As shown in Figure 2.5.2-6 and above in Table 2.5.2-3, the final performance-based SSE is approximately equivalent to the 10^{-4} UHRS for spectral frequencies above 2.5 Hz.

For each simulation, the depth and the Joyner-Boore distance were used to compute the corresponding point source distance. The median ground motion for the given magnitude and point source distance were then computed using the Frankel et al. (1996) and Atkinson and Boore (1995) relationships. The resulting simulated data sets were then fit with an appropriate functional form to provide ground motion relationships in terms of moment magnitude and Joyner-Boore distance consistent with the other relationships in Clusters 1 and 2.

In Open Item 2.5.2-1, the staff requested further clarification regarding the EPRI study's distance conversion process. In response, the applicant provided a detailed description of the distance conversion process used in the EPRI CEUS ground motion model. Specifically, the staff asked for clarification on the process used to convert Joyner-Boore distance to hypocentral distance so that the two attenuation relationships based on hypocentral distance can be combined with the relationships based on Joyner-Boore distance. In response, the applicant provided a detailed description of the distance-conversion process for the two attenuation relationships (Atkinson and Boore, 1995; and Frankel et al., 1996). The staff's review of the distance-conversion process determined that the EPRI (2003) implementation process provides a smooth variation with distance and results in somewhat higher median ground motions only at very small values of Joyner-Boore distance. Therefore, the staff considers Open Item 2.5.2-1 to be resolved.

The ESP applicant for the North Anna, Virginia, site also used the EPRI 2003 ground motion study for its PSHA. Many of the staff's RAIs and the open item related to the updated EPRI CEUS ground motion modeling are described in Section 2.5.2 of the staff's final SER for North Anna (ADAMS Accession No. ML051610246). After reviewing the North Anna ESP applicant's responses to the staff's RAIs and open item, the staff concluded that Dominion had adequately resolved each of the staff's concerns with regard to the development by EPRI of new ground motion models for the CEUS.

2.5.2.3.4 Maximum Earthquake Potential

The staff focused its review of SSAR Section 2.5.2.4 on the ESP site controlling earthquakes determined by the applicant after completion of its PSHA. The applicant determined the low- and high-frequency controlling earthquakes by deaggregating the PSHA results at selected probability levels. Before determining the controlling earthquakes, the applicant updated the original EPRI-SOG PSHA using the seismic source zone adjustments and new ground motion modeling described above in the previous SER subsection.

PSHA Results. The applicant performed PSHA calculations for PGA and spectral acceleration at frequencies of 25, 10, 5, 2.5, 1, and 0.5 Hz. Following the guidance provided in RG 1.165, the PSHA calculations were performed assuming generic hard rock site conditions (i.e., an S-wave velocity of 9~~3~~200 ft/s). The actual local site characteristics are incorporated in the calculation of the SSE spectrum, which uses the hard rock PSHA hazard results as the starting point.

Controlling Earthquakes. To determine the low- and high-frequency controlling earthquakes for the ESP site, the applicant followed the procedure outlined in Appendix C to RG 1.165. This procedure involves the deaggregation of the PSHA results at a target probability level to deaggregation earthquake magnitudes and distances adequately characterized the local and regional seismic hazard for the ESP site. The three deaggregation earthquakes corresponding to each controlling earthquake represent lower, middle, and higher magnitude earthquakes appropriate for the ESP site. Specifically, the lower magnitude deaggregation earthquake (M = 5.7–6.0 at R = 11–15 km (9 mi)) corresponds to a local earthquake occurring in the central Illinois source zone, the middle magnitude deaggregation earthquake (M = 6.7–6.9 at R = 140–166 km (103 mi)) corresponds to an earthquake in the Wabash Valley-southern Illinois region, and the upper magnitude deaggregation earthquake (M 7.2–7.4 at R = 375–381 km (237 mi)) corresponds to a New Madrid earthquake.

To determine the final site response, the applicant used the program SHAKE to compute the site amplification function for each of the deaggregation earthquakes. The applicant paired the 60 randomized velocity profiles with the 60 sets of randomized shear modulus and damping curves (i.e., one velocity profile with one set of modulus reduction and damping curves). To obtain a site amplification function, the applicant divided the response spectrum from the computed surface motion by the response spectrum from the input hard rock motion. The applicant then computed the arithmetic mean of these 60 individual response spectral ratios to define the mean amplification function for each deaggregation earthquake.

The results of the applicant's site response analysis show that the ESP site subsurface amplifies the input hard rock motion over the fairly wide frequency range of 0.5 to 10 Hz, with the maximum amplification of 3.3 at a frequency of 1.7 Hz. The final site amplification function for each controlling earthquake represents the weighted average of the amplification functions for the associated deaggregation earthquakes. The weights (see SER Table 2.5.2-2) represent the relative contribution of earthquakes represented by the deaggregation earthquakes to the hazard at the appropriate spectral frequency and hazard level. The applicant determined the final soil surface spectra for the ESP site by scaling the rock controlling earthquake spectra by the mean site amplification functions.

In summary, the staff concludes that based on its review of SSAR Section 2.5.2.5, as described above, the applicant's site response analysis adequately incorporates the effects of the local site properties and their uncertainties into the determination of the ESP free-field ~~DRS~~SSE, as required by 10 CFR 100.23.

2.5.2.3.6 Safe-Shutdown Earthquake

The staff focused its review of SSAR Section 2.5.2.6 on the method used by the applicant to determine the SSE ground motion spectra (horizontal and vertical) for the ESP site. Rather than developing the SSE as recommended by RG 1.165, the applicant used a new method called the performance-based approach. The performance-based approach, which is described in ASCE/SEI Standard 43-05, sets a target of a mean annual frequency of 10^{-5} of unacceptable performance of Category I nuclear SSCs as a result of seismically initiated events. This safety performance target, P_{FT}, is based on assuming (1) a target 10^{-4} mean annual risk of core damage from all accident initiators and (2) that seismic initiators contribute about 10 percent of the risk of core damage posed by all accident initiators. To determine the SSE that achieves the annual performance goal of 10^{-5}, the performance-based approach scales the site-specific mean 10^{-4} UHRS, determined in the previous section, by a DF. The equations for the SSE and DF are provided in SER Section 2.5.2.1.6. As shown previously in Table 2.5.2-3, a DF is results of its application to the EGC ESP site. To determine the appropriateness of the target 10^{-5} annual performance goal and performance-based approach for the EGC ESP site, the staff reviewed the applicant's final SSE to ensure that it adequately reflects the regional and local seismic hazards surrounding the ESP site.

As shown previously in SER Section 2.5.2.1.6, the final SSE using the performance-based approach is calculated by multiplying the DF and 10^{-4} surface UHRS. Since, by definition, the DF is at least 1.0, the final SSE ground motion spectrum will be at least the 10^{-4} UHRS and higher, depending on the value of the amplitude ratio (A_R) for the 10^{-4} and 10^{-5} hazard curves. For the EGC ESP site, the DF values from 2.5 to 100 Hz are very close to 1.0, implying that the final SSE, while meeting the target 10^{-5} annual performance goal, is close to the 10^{-4} surface UHRS. This result is shown by Figure 2.5.2-6 in SER Section 2.5.2.1.6, which shows the 10^{-4} and 10^{-5} surface UHRS along with the final SSE.

The high-frequency and low-frequency controlling earthquakes that provide the largest contribution to these two hazard levels (10^{-4} and 10^{-5}) for the ESP site were shown previously in SER Section 2.5.2.1.4. This table is repeated below for convenience.

Table 2.5.2-7 High- and Low-Frequency Controlling Earthquakes

Hazard	Magnitude (m_b)	Distance
Mean 10^{-4} High Frequency (5 and 10 Hz)	6.5	83 km (52 mi)
Mean 10^{-4} Low Frequency (1 and 2.5 Hz)	7.2	320 km (199 mi)
Mean 10^{-5} High Frequency (5 and 10 Hz)	6.2	24 km (15 mi)
Mean 10^{-5} Low Frequency (1 and 2.5 Hz)	7.2	320 km (199 mi)

Because the performance-based SSE is close to the 10^{-4} surface UHRS, the corresponding controlling earthquakes for the ESP site are mM_{bw} 6.5 at 83 km (52 mi) (high frequency) and m_b 7.2 at 320 km (199 mi) (low frequency). These two earthquakes correspond to events in the WVSZ and NMSZ, respectively. Both of these events are somewhat distant from the ESP site. In contrast, the mean 10^{-5} high-frequency controlling earthquake (m_b 6.2 at 24 km (15 mi)) represents a local earthquake from the central Illinois seismic zone.

The seismic hazard for the central Illinois basin/background source zone, which encompasses the ESP site, is dominated by the Springfield earthquake. Paleoliquefaction studies in the area have found evidence that one or, more likely, two prehistoric earthquakes occurred 5900 to 7400 years ago near Springfield, Illinois, approximately 37 mi southwest of the ESP site (McNulty and Obermeier, 1999). These earthquakes were large enough to generate liquefaction features, with magnitude estimates ranging between 6.2 and 6.8 for the larger event and at least 5.5 for the second event. In addition to the Springfield events, geologists have discovered paleoliquefaction features further south near Shoal Creek. The estimated

To characterize the seismic hazards for the ESP site, including the controlling earthquake magnitudes and distances, the applicant used the guidance provided in RG 1.165. SER Sections 2.5.2.1 through 2.5.2.5 fully describe the results of this characterization. The applicant departed from RG 1.165 in the use of the performance-based approach for the ESP site to determine the final SSE. The staff has determined, as described above in Section 2.5.2.3.6.1, that the performance-based approach used by the applicant results in an SSE that is adequately conservative based on SCDF values of about 1×10^{-6}/yr. In addition, based on its review of the applicant's response to Open Item 2.5.2-4, the staff concludes that the SSE adequately represents both the regional and local seismic hazards for the ESP site. This conclusion is based on the applicant's comparison of the estimated ground motion from the largest known prehistoric local event (Springfield earthquake) and the $UHRS_{10-4}$, which is slightly smaller than the SSE. This comparison shows that the SSE envelops the best estimates for the ground motion from the most severe local event. Therefore, the staff considers Open Item 2.5.2-4 to be resolved.

2.5.2.3.6.3 Vertical Safe-Shutdown Earthquake

To compute the vertical SSE, the applicant used the V/H response spectral ratios provided in NUREG/CR-6728. The V/H response spectral ratios given in NUREG/CR-6728 are CEUS hard rock site conditions and depend on the PGA value of the horizontal SSE spectrum. For the ESP site, the V/H ratios used by the applicant are based on having a PGA less than 0.5g. The vertical SSE spectrum is given by multiplying the horizontal SSE spectrum by the V/H ratios. The applicant also considered the effects of the ESP site soil conditions on the vertical ground motions by using ground motion models that provide vertical motions for soil conditions. The applicant used a magnitude 6.4 earthquake at source-to-site distance of 15 km (9 mi) as input to the ground motion models. This magnitude and distance roughly correspond to the high-frequency controlling earthquake.

To verify the adequacy of the V/H SSE ratios used by the applicant, the staff evaluated both the V/H ratios provided in NUREG/CR-6728 and the applicant's consideration of the local site effects on the vertical ground motions. The V/H ratios provided in NUREG/CR-6728 take into account the effects of magnitude, source distance, and local site conditions and are based on earthquake strong motion data. Previous regulatory guidance (RG 1.60 and NUREG/CR-0098) recommended that the V/H ratio be fixed at 2/3 independent of ground motion frequency, earthquake magnitude, distance, and local site conditions. To incorporate the effect of the local site conditions on the vertical ground motions, the applicant used a magnitude 6.4 at a source-to-site distance of 15 km. Based on its review of the V/H ratios provided in NUREG/CR-6728 and the applicant's use of a representative local controlling earthquake, the staff concludes that the V/H ratios used by the applicant are adequate for the EGC ESP site. The staff notes that for higher frequencies (20 Hz and above), the vertical SSE is larger than the horizontal SSE.

2.5.2.3.6.4 Design Response Spectrum

In SSAR Section 3.4.1.4.3, the applicant compared the horizontal performance-based SSE for the ESP site with the RG 1.60 DRS anchored to a PGA of 0.3g at 33 Hz, which is the DRS used by many of the current reactor designs. The applicant noted that the ESP SSE is lower than the RG 1.60 DRS except at frequencies between 1~~6~~5 and ~~50~~65 Hz. However, after applying the high-frequency reduction factors recommended in a 1993 EPRI study, the ESP SSE is the staff reviewed the applicant's conclusions concerning the association of earthquakes with capable tectonic sources, the ages of most deformation, the relationship of local area tectonic structures to regional tectonic structures, the characterization of capable tectonic sources, the designation of zones of Quaternary deformation, and the potential for surface tectonic deformation.

As a result of its geologic investigations, the applicant found no potential for surface faulting or fold deformation at the ESP site. In addition, the applicant was unable to associate any of the historically reported earthquakes within 25 miles of the site with local geologic structures. Rather than characterizing the seismic potential of the known geologic folds and faults in the region, the applicant used the EPRI-SOG seismic hazard study, which groups these potential sources into large areal seismic source zones. The EPRI-SOG seismic hazard study is endorsed by RG 1.165 as an acceptable method for evaluating the seismic hazard for CEUS sites. The staff concurs with the applicant's characterization of the regional and local seismic sources as broad areal source zones. Within these source zones, earthquakes are modeled as occurring over a large area as part of the applicant's PSHA. The ESP site is located within the Illinois basin/background seismic source zone.

To search for evidence of nearby prehistoric earthquakes, the applicant conducted extensive paleoliquefaction investigations along the banks of several streams near the ESP site. The applicant found only a small number of paleoliquefaction features and concluded that there is insufficient information to estimate a location or magnitude for the prehistoric earthquake which caused these features. The staff concurs with the applicant's conclusion that the results of these paleoliquefaction investigations imply that no repeated moderate to large earthquakes comparable to the Springfield earthquake (M 6.2 to 6.8) occurred in the site vicinity during the past ~~2000~~6,700 to 7,000 years.

Based on its review of SSAR Section 2.5.3, as well as the supporting information in Chapter 5 of SSAR Appendix B, the staff concludes that the applicant adequately investigated the potential for surface faulting in the site area as required by 10 CFR 100.23. The staff concludes that the applicant performed extensive field investigations and concurs with the applicant's conclusion that there are no capable faults within the site area. The applicant noted that folds within the La Salle anticlinorium do lie within 25 miles of the site; however, the staff concurs with the applicant's statement that there is no evidence for tectonic surface deformation that is associated with this series of anticlines. Based on its site visit and its review of SSAR Section 2.5.3, as set forth above, the staff concurs with the applicant's conclusion that there are no capable tectonic sources within 25 miles of the site that would cause surface deformation in the site area.

2.5.3.4 Conclusions

In its review of the geological and seismological aspects of the ESP site, the staff considered the pertinent information gathered by the applicant during the regional and site-specific geological, seismological, and geophysical investigations. As a result of this review, described above, the staff concludes that the applicant performed its investigations in accordance with 10 CFR 100.23 and RG 1.165 and provided an adequate basis to establish that no capable tectonic sources exist in the site vicinity that would cause surface deformation in the site area. The staff concludes that the site is suitable from the perspective of tectonic surface deformation the ground surface. Above 60 ft, the applicant found several layers where the FOS is less than 1.1, indicating that these layers are susceptible to liquefaction. RG 1.198 states that soil elements with an FOS less than or equal to 1.1 "would achieve conditions wherein soil liquefaction should be considered to have been triggered." However, the applicant stated that these soils (susceptible to liquefaction) will "need to be excavated and replaced or improved for settlement considerations, thereby mitigating any liquefaction potential." Therefore, the applicant concluded that liquefaction is not a design consideration for the ESP site.

In RAI 2.5.4-6, the staff asked the applicant to provide a sample liquefaction analysis from one of its four borehole locations and to clearly show how it determined the FOS for the different soil layers. In addition, the staff asked the applicant to describe the methods that it might use to mitigate the potential for liquefaction and to describe the extent of the liquefiable soils over the ESP site area. In response to RAI 2.5.4-6, the applicant provided a sample calculation for borehole B-1 at the 38.5-ft depth interval. In addition, the applicant described the methods (other than removal and replacement) that it may use to mitigate the potential for liquefaction. The applicant stated that it encountered noncohesive soils in its soil borings, but that not all of these noncohesive soils are considered liquefiable. SER Section 2.5.4.3.8 provides a complete description of the applicant's response to RAI 2.5.4-6 and the staff's evaluation of this response.

For the CPS site, the licensee used a different method to assess the potential for liquefaction. Instead of using the empirical blowcount procedure, the licensee used cyclic triaxial testing to determine the soil shearing resistance. To determine the shearing stresses induced by seismic loading, the licensee used the SSE ground motion. Using this method, the licensee found an FOS greater than 2.0, and, therefore, liquefaction was not an issue for the CPS site.

2.5.4.1.9 Earthquake Design Basis

SSAR Section 2.5.4 describes the development of the SSE ~~DRS~~ground motion for which the applicant used the performance-based approach, described in ASCE/SEI Standard 43-05. Section 2.5.2.1.6 of this SER describes the applicant's use of the performance-based approach to develop the SSE response spectrum for the ESP site.

2.5.4.1.10 Static Stability

The applicant did not estimate the bearing capacity, settlement, or lateral earth pressures for the ESP site, since it has not selected a nuclear power plant design. The applicant stated that each generating system has different footprint sizes, depths of embedment, and effective weights, and these variables will affect the determination of bearing pressures, settlement, and lateral earth pressures. For this reason, the applicant deferred the determination of static stability to the COL stage.

Using the licensee's evaluation of static stability for the CPS site, the applicant stated that it expected high allowable bearing values and low compressibility for the ESP site because of the similarity in soil conditions between the two sites. Based on the bearing capacity values given in the CPS USAR, which range from 39.9 to 60.6 tsf, the applicant established the minimum site characteristic value for bearing pressures at the ESP site at 25 tsf. Net foundation pressures for the Category I structures at the CPS site are less than 2.5 tsf.

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2.4 - Hydrology		
Hydrology		
Proposed Facility Boundaries	Appendix A, Figure 1 (FSER Figure 2.4.14) shows the proposed facility boundary	ESP site boundary map
Site Grade	735 ft MSL	Finished plant grade at the ESP site
Highest Ground Water Elevation	733.5 ft MSL	The maximum elevation of ground water at the ESP site
Probable Maximum Flood E(PMF) elevation	72109.78 ft MSL	The maximum flood levelhydrostatic water surface elevation at the ESP site
Coincident Wind Wave Activity	6.4 ft	Increment of change in water surface elevation due to wind waves
Storm Surge	0.3 ft	Increment of change in water surface elevation due to storm surge
Combined Effects Maximum Water Surface Elevation	716.5 ft MSL	Sum of hydrostatic water surface elevation, wind wave activity, and storm surge. Maximum water surface elevation at the ESP site.
Local Intense Precipitation	18.15 in during 1 hour	Maximum potential rainfall at the immediate ESP site
Lake Surface Icing	27 in	Ice sheet thickness at Clinton Lake (based on maximum cumulative degree-days below freezing)
Maximum Cumulative Degree-Days	1141.5 in Fahrenheit	A measure of severity of winter weather conditions conducive to ice formation

WordPerfect Document Compare Summary

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Appendix B

Chronology of Early Site Permit Application for the EGC ESP Site

This appendix lists all correspondence between the Exelon Generation Company, LLC (EGC), and the U.S. Nuclear Regulatory Commission regarding the EGC early site permit application through February 16, 2006, with the exception of legal filings related to the hearing. Source: Agencywide Document Access and Management System (ADAMS).

Revisions to the EGC Early Stie Permit Application

Revision	Date	Accession Number
0	September 25, 2003	ML032721596
1	November 23, 2005	ML053420053
2	January 10, 2006	ML060460043
3	March 3, 2006	ML060950511
4	April 14, 2006	MLXXXXXXXXX

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[2]Data provided by the Illinois State Climatologist's Office, a part of the Illinois State Water Survey (ISWS) located in Champaign, Peoria, Carbondale, and Chicago, Illinois, and on the web at www.sws.uiuc.edu/atmos/statecli.

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