UNITED STATES
NUCLEAR REGULATORY COMMISSION
WASHINGTON, D.C. 20555-0001

June 13, 2017

Mr. Ken J. Peters
Senior Vice President and Chief
Nuclear Officer
Attention: Regulatory Affairs
TEX Operations Company, LLC
P.O. Box 1002
Glen Rose, TX 76043

SUBJECT: COMANCHE PEAK NUCLEAR POWER PLANT, UNITS 1 AND 2 - STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM REEVALUATION (CAC NOS. MF1099 AND MF1100)

Dear Mr. Peters:

By letter dated March 12, 2012, the U.S. Nuclear Regulatory Commission (NRC) issued a request for information pursuant to Title 10 of the *Code of Federal Regulations*, Section 50.54(f) (hereafter referred to as the 50.54(f) letter). The request was issued as part of implementing lessons learned from the accident at the Fukushima Dai-ichi nuclear power plant. Enclosure 2 to the 50.54(f) letter requested that licensees reevaluate flood-causing mechanisms using present-day methodologies and guidance. By letter dated March 12, 2013 (Agencywide Documents Access and Management System (ADAMS) Accession No. ML13074A058), Luminant Generation Company, LLC (now TEX Operations Company LLC, the licensee) responded to this request for Comanche Peak Nuclear Power Plant, Units 1 and 2. The licensee supplemented the 50.54(f) response in letters dated April 4, 2014, August 14, 2014, September 22, 2015, and February 3, 2016 (ADAMS Accession Nos. ML14100A049, ML14245A136, ML15278A306, and ML16041A029, respectively).

By letter dated February 11, 2016 (ADAMS Accession No. ML16041A228), the NRC staff sent the licensee a summary of the staff's review of the licensee's reevaluated flood-causing mechanisms. The enclosed staff assessment provides the documentation supporting the NRC staff's conclusions summarized in the letter. As stated in the letter, the reevaluated flood hazard result for local intense precipitation (LIP) and streams and rivers were not bounded by the current design-basis flood hazard. The NRC staff anticipates that the licensee will perform and document a focused evaluation for LIP and a focused evaluation or revised integrated assessment for streams and rivers.

This closes out the NRC's efforts associated with CAC No. MF1099 and MF1100.

If you have any questions, please contact me at (301) 415-1132 or e-mail at Joseph.Sebrosky@nrc.gov.

Sincerely,

Joseph M. Sebrosky, Senior Project Manager
Hazards Management Branch
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Office of Nuclear reactor Regulation

Docket Nos. 50-445 and 50-446

Enclosure:
Staff Assessment of Flood Hazard
Reevaluation Report

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STAFF ASSESSMENT BY THE OFFICE OF NUCLEAR REACTOR REGULATION

RELATED TO FLOODING HAZARD REEVALUATION REPORT

NEAR-TERM TASK FORCE RECOMMENDATION 2.1

COMANCHE PEAK NUCLEAR POWER PLANT, UNITS 1 AND 2

DOCKET NO. 50-445 AND 50-446

1.0 INTRODUCTION

By letter dated March 12, 2012 (NRC, 2012a), the U.S. Nuclear Regulatory Commission (NRC) issued a request for information to all power reactor licensees and holders of construction permits in active or deferred status, pursuant to Title 10 of the Code of Federal Regulations (10 CFR), Section 50.54(f) (hereafter referred to as the "50.54(f) letter"). The request was issued in connection with implementing lessons-learned from the 2011 accident at the Fukushima Dai-ichi nuclear power plant as documented in the "Near-Term Task Force" (NTTF) report (NRC, 2011b). Recommendation 2.1 in that document recommended that the NRC staff issue orders to all licensees to reevaluate seismic and flooding hazards for their sites against current NRC requirements and guidance. Subsequent staff requirements memoranda associated with SECY-11-0124 (NRC, 2011c) and SECY-11-0137 (NRC, 2011d), directed the NRC staff to issue requests for information to licensees pursuant to 10 CFR 50.54(f) to address this recommendation.

Enclosure 2 to the 50.54(f) letter (NRC, 2012a) requested that licensees reevaluate flood hazard for their respective sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for early site permits (ESPs) and combined licenses (COLs). The required response section of Enclosure 2 specified that NRC staff would provide a prioritization plan indicating Flooding Hazard Reevaluation Report (FHRR) deadlines for individual plants. On May 11, 2012, the NRC staff issued its prioritization of the FHRRs (NRC, 2012c).

By letter dated March 12, 2013 (Luminant, 2013a), Luminant Generation Company, LLC (Luminant) (now TEX Operations Company LLC, the licensee) provided its FHRR for Comanche Peak Nuclear Power Plant, Units 1 and 2 (Comanche Peak). By letter dated August 14, 2014, the licensee submitted FHRR Supplement 1 (Luminant, 2014b) to address a calculation error in the original FHRR (Luminant, 2013a). The NRC staff issued requests for additional information (RAIs) to the licensee by letter dated March 7, 2014 (NRC, 2014a), the licensee responded by letter dated April 4, 2014 (Luminant, 2014a). The NRC staff issued a second set of RAIs to the licensee by email dated May 4, 2015 (NRC, 2015a), the licensee responded by letter dated September 22, 2015 (Luminant, 2015).

As a result of additional communications between NRC staff and the licensee (NRC, 2016b), the licensee clarified by letter dated February 3, 2016 (Luminant, 2016), the conditions and assumptions for performing the Comanche Peak Mitigating Strategies Assessment. The NRC conducted a regulatory audit on July 6, 2015, December 10, 2015, and January 20, 2016. The NRC staff issued an Audit Summary Report summarizing additional information obtained during this audit (NRC, 2016b).

On February 11, 2016, the NRC issued an interim staff response (ISR) letter to the licensee (NRC, 2016a). The purpose of the ISR letter is to provide the flood hazard information suitable for the assessment of mitigating strategies developed in response to Order EA-12-049 (NRC, 2012b) and the additional assessments associated with NTTF Recommendation 2.1: Flooding. The ISR letter also made reference to this staff assessment, which documents the NRC staff basis and conclusions. The flood hazard mechanism values presented in the letter's enclosures match the values in this staff assessment without change or alteration.

As mentioned in the ISR letter and discussed below, the reevaluated flood hazard results for local intense precipitation (LIP) and rivers and streams are not bounded by the plant's current design basis (CDB). Consistent with the 50.54(f) letter and amended by the process outlined in COMSECY-15-0019 and Japan Lessons-Learned Division (JLD) Interim Staff Guidance (ISG) JLD-ISG-2016-01, Revision 0 (NRC, 2015b and NRC, 2016c), the NRC staff anticipates that the licensee will perform and document a focused evaluation to assess the impact of the LIP hazard on the site and evaluates and implements any necessary programmatic, procedural or plant modifications to address this hazard exceedance. The staff also anticipates the licensee will perform and document a focused evaluation or revised integrated assessment that assesses the impact flooding in streams and rivers on the site and evaluates and implements any necessary programmatic, procedural or plant modifications to address this hazard exceedance.

Additionally, for any reevaluated flood hazards that are not bounded by the plant's CDB hazard, the licensee is expected to develop flood event duration (FED) parameters and flood-related associated effects (AE) parameter to conduct the mitigating strategies assessment (MSA) and focused evaluations or revised integrated assessments.

2.0 REGULATORY BACKGROUND

2.1 Applicable Regulatory Requirements

As stated above, Enclosure 2 to the 50.54(f) letter (NRC, 2012a) requested that licensees reevaluate flood hazards for their sites using present-day methods and regulatory guidance used by the NRC staff when reviewing applications for ESPs and COLs. This section of the staff assessment describes present-day regulatory requirements that are applicable to the FHRR.

Sections 50.34(a)(1), (a)(3), (a)(4), (b)(1), (b)(2), and (b)(4), of 10 CFR describe the required content of the preliminary and final safety analysis report, including a discussion of the plant site with a particular emphasis on the site evaluation factors identified in 10 CFR Part 100. The licensee should provide in the Final Safety Analysis Report (FSAR) any pertinent information identified or developed since the submittal of the preliminary safety analysis report.

General Design Criterion 2 in Appendix A of 10 CFR Part 50 states that structures, systems, and components (SSCs) important to safety at nuclear power plants must be designed to withstand the effects of natural phenomena such as earthquakes, tornados, hurricanes, floods, tsunamis, and seiches without loss of capability to perform their intended safety functions. The design bases for these SSCs are to reflect appropriate consideration of the most severe of the natural phenomena that have been historically reported for the site and surrounding area. The design bases are also to have sufficient margin to account for the limited accuracy, quantity, and period of time in which the historical data have been accumulated.

Section 50.2 of 10 CFR defines design-bases as the information that identifies the specific functions that an SSC of a facility must perform, and the specific values or ranges of values chosen for controlling parameters as reference bounds for design, which each licensee is required to develop and maintain. These values may be (a) restraints derived from generally accepted 'state of the art' practices for achieving functional goals, or (b) requirements derived from analysis (based on calculation, experiments, or both) of the effects of a postulated accident for which an SSC must meet its functional goals.

Section 54.3 of 10 CFR defines the "current licensing basis" (CLB) as "the set of NRC requirements applicable to a specific plant and a licensee's written commitments for ensuring compliance with and operation within applicable NRC requirements and the plant-specific design basis (including all modifications and additions to such commitments over the life of the license) that are docketed and in effect." This includes 10 CFR Parts 2, 19, 20, 21, 26, 30, 40, 50, 51, 52, 54, 55, 70, 72, 73, 100, and appendices thereto; orders; license conditions; exemptions; and technical specifications as well as the plant-specific, design-basis information, as documented in the most recent final safety analysis report. The licensee's commitments made in docketed licensing correspondence that remain in effect are also considered part of the CLB.

Present-day regulations for reactor site criteria (Subpart B to 10 CFR Part 100 for site applications submitted on or after January 10, 1997) state, in part, that the physical characteristics of the site must be evaluated and site parameters established such that potential threats from such physical characteristics will pose no undue risk to the type of facility proposed to be located at the site. Factors to be considered when evaluating sites include the nature and proximity of dams and other man-related hazards (10 CFR 100.20(b)) and the physical characteristics of the site, including the hydrology (10 CFR 100.21(d)).

2.2 Enclosure 2 to the 50.54(f) Letter

Section 50.54(f) of 10 CFR states that a licensee shall at any time before expiration of its license, upon request of the Commission, submit written statements, signed under oath or affirmation, to enable the Commission to determine whether or not the license should be modified, suspended, or revoked. The 50.54(f) letter (NRC, 2012a) requested, in part, that licensees reevaluate the flood-causing mechanisms for their respective sites using present-day methodologies and regulatory guidance used by the NRC for the ESP and COL reviews.

2.2.1 Flood-Causing Mechanisms

Attachment 1 to NTTF Recommendation 2.1, Flooding (Enclosure 2 of the 50.54(f) letter) discusses flood-causing mechanisms for the licensee to address in the FHRR (NRC, 2012a). Table 2.2-1 lists the flood-causing mechanisms the licensee should consider, and the corresponding Standard Review Plan (SRP) (NRC, 2007) section(s) and applicable ISG documents containing acceptance criteria and review procedures.

2.2.2 Associated Effects

The licensee should incorporate and report AE per "Guidance for Performing the Integrated Assessment for External Flooding," JLD-ISG-2012-05 (NRC, 2012d), in addition to the maximum water level associated with each flood-causing mechanism. Guidance document JLD-ISG-2012-05 (NRC, 2012d) defines "flood height and associated effects" as the maximum stillwater surface elevation plus:

- Wind waves and run-up effects
- Hydrodynamic loading, including debris
- Effects caused by sediment deposition and erosion
- Concurrent site conditions, including adverse weather conditions
- Groundwater ingress
- Other pertinent factors

Combined Effect Flood

The worst flooding at a site that may result from a reasonable combination of individual flood mechanisms is sometimes referred to as a "combined effects flood." Even if some or all of the individual flood-causing mechanisms are less severe than their worst-case occurrence, their combination may still exceed the most severe flooding effects from the worst-case occurrence of any single mechanism described in the 50.54(f) letter (see SRP Section 2.4.2, "Areas of Review," (NRC, 2007)). Attachment 1 of the 50.54(f) letter describes the "combined effect flood" as defined in American National Standards Institute/American Nuclear Society (ANSI/ANS) 2.8-1992 (ANSI/ANS, 1992), as follows:

> For flood hazard associated with combined events, American Nuclear Society (ANS) 2.8-1992 provides guidance for combination of flood causing mechanisms for flood hazard at nuclear power reactor sites. In addition to those listed in the ANS guidance, additional plausible combined events should be considered on a site specific basis and should be based on the impacts of other flood causing mechanisms and the location of the site.

If two less severe mechanisms are plausibly combined per ANSI/ANS-2.8-1992 (ANSI/ANS, 1992), then the NRC staff will document and report the result as part of one of the hazard sections. An example of a situation where this may occur is flooding at a riverine site located where the river enters the ocean. For this site, storm surge and river flooding are plausible combined events and should be considered.

2.2.3 Flood Event Duration

Flood event duration was defined in JLD-ISG-2012-05 (NRC, 2012c) as the length of time during which the flood event affects the site. It begins when conditions are met for entry into a flood procedure, or with notification of an impending flood (e.g., a flood forecast or notification of dam failure), and includes preparation for the flood. It continues during the period of inundation, and ends when water recedes from the site and the plant reaches a safe and stable state that can be maintained indefinitely. Figure 2.2-1 illustrates flood event duration.

2.2.4 Actions Following the FHRR

For the sites where a reevaluated flood elevation is not bounded by the CDB flood hazard for any flood-causing mechanism, the 50.54(f) letter (NRC, 2012a) requests licensees and construction permit holders to:

- Submit an interim action plan with the FHRR documenting actions planned or already taken to address the reevaluated hazard.
- Perform an integrated assessment to: (a) evaluate the effectiveness of the CDB (i.e., flood protection and mitigation systems); (b) identify plant-specific vulnerabilities; and (c) assess the effectiveness of existing or planned systems and procedures for protecting against and mitigating consequences of flooding for the flood event duration.

If the reevaluated flood hazard is bounded by the CDB flood hazard for all flood-causing mechanisms at the site, licensees were not required to perform an integrated assessment.

COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b) outline a revised process for addressing cases in which the reevaluated flood hazard is not bounded by the plant's CDB. The revised process describes an approach in which licensees with LIP hazards exceeding their CDB flood will not be required to complete an integrated assessment, but instead will perform a focused evaluation that assesses the impact of the LIP hazard on their site and then evaluate and implement any necessary programmatic, procedural or plant modifications to address this hazard exceedance. For other flood hazard mechanisms that exceed their CDB, licensees can assess the impact of these reevaluated hazards on their site by performing either a focused evaluation or an integrated assessment (NRC, 2015b; NRC, 2016b).

3.0 <u>TECHNICAL EVALUATION</u>

The NRC staff reviewed the information provided for the flood hazard reevaluation of the Comanche Peak site. The licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews.

To provide additional information in support of the summaries and conclusions in the Comanche Peak FHRR, the licensee made several calculation packages and input/output files available to the NRC staff as attachments to the licensee's RAI response (Luminant, 2014a) and via an electronic reading room.

3.1 <u>Site Information</u>

The 50.54(f) letter included the SSCs important to safety in the scope of the hazard reevaluation. The licensee included pertinent data concerning these SSCs in the Comanche Peak FHRR. The staff reviewed and summarized this information as follows.

3.1.1 Detailed Site Information

The Comanche Peak FHRR describes the site specific information related to the flood hazard reevaluation. Unless otherwise stated, all elevations in this staff assessment are given with respect to the National Geodetic Vertical Datum of 1929 (NGVD29). The site grade at the powerblock is elevation 810 ft NGVD29. Table 3.1-1 provides the summary of controlling reevaluated flood-causing mechanisms, including associated effects, the licensee computed to be higher than the powerblock elevation.

The Comanche Peak site is located in Somervell County in north central Texas. Comanche Peak obtains its cooling water from Squaw Creek Reservoir (SCR), which was completed in 1977 by impounding Squaw Creek using the Squaw Creek Dam. The normal operating pool elevation of the SCR is 775 ft NGVD29. Additional details about the site are provided in the FHRR (Luminant, 2013a).

A location map for Comanche Peak is presented in Figure 3.1-1. The as-built site layout and topography of Comanche Peak site and vicinity is presented in Figure 3.1-2. A list of the Comanche Peak safety-related structures is provided in Table 3.1-2, and a list of design parameters found in the FSAR (Luminant, 2011) is included in Table 3.1-3. Detailed representation of structures within the Comanche Peak, Units 1 and 2, powerblock and vehicle barrier system (VBS) is presented in Figure 3.1-3. Additional details of the Comanche Peak site and plant layout are provided in the FHRR.

3.1.2 Design-Basis Flood Hazards

The CDB for Comanche Peak is described in Section 2.3 of the FHRR and are summarized by flood-causing mechanism in Table 3.1-4. The CDB states that the only safety-related structures that require flood protection are the service water intake structure (SWIS), the Electrical Building, and the Control Building. The Comanche Peak site grade elevation is at 810 ft while the probable maximum flood (PMF) water level of the SCR is calculated to be 789.7 ft, which rises to a maximum of 794.7 ft including coincident wind wave activity. The SWIS is protected from wind wave run-up on the SCR by the safe shutdown impoundment (SSI) dam. The wave run-up in the SCR at the SWIS during a PMF was estimated to be 1.6 ft, which results in a water elevation of 791.3 ft. The operating deck and safety-related equipment are located above the CDB PMF flood level, which is calculated during the PMF event within the SSI to be 790.5 ft. This leaves a freeboard of 5.5 ft within the SSI with respect to the SWIS operating deck, which is at elevation of 796.0 ft. The NRC staff reviewed the information provided and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.3 Flood-Related Changes to the Licensing Basis

Section 2.4 of the FHRR describes the flood-related changes to the licensing basis of Comanche Peak, Units 1 and 2. The licensee provided the design-basis flood elevations for Comanche Peak, Units 1 and 2 in FHRR Table 2-4 and a description of the hydrological changes to the flood elevations in FHRR Section 2.4.2. The flooding walkdown performed by the licensee identified several changes that were performed over the years in the general site drainage (Luminant, 2012). These changes include changes to catch basins, drainage basins, and partially clogged concrete swales that were obstructed with gravel and/or vegetation. The licensee indicated that these observed changes are addressed in the evaluation of the LIP event.

During the walkdown, the licensee also identified changes to the plant layout and reported the flooding impact evaluations due to changes in site layout that were not documented in the FSAR. The licensee stated that, based on field observations, the alterations to the topography are not expected to adversely affect the runoff assumed under the CDB. The licensee further stated that there were no observations that required the implementation of flood protection measures. The NRC staff reviewed the information provided and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.4 Changes to the Watershed and Local Area

Documentation of changes to the watershed is presented in Section 2.5 of the FHRR. The Comanche Peak, Units 1 and 2, site is located within the Squaw Creek watershed, which is a small tributary to the Paluxy River, which in turn is a tributary to the larger Brazos River. The licensee stated that, at the time of licensing, the Paluxy River was used to develop the basis for the hydrologic parameters of the Squaw Creek and its sub-catchments since it was an ungaged catchment at that time. The licensee also indicated that water control structures were not considered at the time of licensing. The watershed is predominantly rural and agricultural and although it has undergone land use changes over the past several years, these changes are not significant. The NRC staff reviewed the information provided in the FHRR and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.5 Current Licensing Basis Flood Protection and Pertinent Flood Mitigation Features

Under the current licensing basis, the only safety-related structures at the Comanche Peak, Units 1 and 2, site that require flood protection are the SWIS and the Electrical and Control Building (ECB). The NRC staff reviewed the information provided and determined that sufficient information was provided to be responsive to Enclosure 2 of the 50.54(f) letter.

3.1.6 Additional Site Details to Assess the Flood Hazard

The licensee stated that bathymetry data related to the site design layout and site details presented in the FHRR were used to conduct wind-wave related analysis. The site layout and design elevation contours beneath the SCR and the SSI in the vicinity of the site are presented in Figure 2-1 of the FHRR. The bathymetric information was used to derive relevant cross-section, geometry, and fetch data to evaluate wave run-up.

3.1.7 Results of Plant Walkdown Activities

The 50.54(f) letter requested that licensees plan and perform plant walkdown activities to verify that current flood protection systems are available, functional, and implementable. The 50.54(f) letter also asked the licensee to report any relevant information from the results of the plant walkdown activities (NRC, 2012a).

By letter dated November 27, 2012 (Luminant, 2012), the licensee provided the Flood Walkdown Report for Comanche Peak, Units 1 and 2. The NRC staff issued a staff assessment report on June 4, 2014, to document its review of the Flood Walkdown Report, which concluded that the licensee's implementation of the flooding walkdown methodology met the intent of the walkdown guidance (NRC, 2014b).

3.2 Local Intense Precipitation and Associated Site Drainage

The licensee reported in an update to the FHRR Supplement 1 LIP analysis, as documented in the Comanche Peak response to RAI 2-1 (Luminant, 2015) that the reevaluated flood hazard, including associated effects, for LIP and associated site drainage is based on a stillwater-surface elevation of 810.42 ft NGVD29. Following several interactions between the NRC and the licensee in response to NRC staff-identified concerns, the licensee agreed to use a modified reevaluated flood hazard elevation for LIP of 810.6 ft NGVD29 for use in the mitigating strategies assessment (Luminant, 2016 and NRC, 2016b). This flood-causing mechanism is not discussed in the licensee's CDB.

3.2.1 Probable Maximum Precipitation

Following guidance in NUREG/CR-7046 (NRC, 2011e), the licensee determined the 1-h, 1-mi^2 probable maximum precipitation (PMP) using Hydrometeorological Reports (HMR) No. 51 (National Oceanic and Atmospheric Administration (NOAA), 1978) and 52 (NOAA, 1982). The licensee used a 1-h, 1-mi^2 PMP of 19.1 in. and 6-h, 10-mi^2 PMP of 30.03 in. to create a 6-h hyetograph using 5-minute increments, with values interpolated based on values reported in Rizzo (2014a). Figure 3.2-1 shows staff's reconstruction of the licensee's LIP hyetograph.

In addition to the 6-h LIP storm encompassing the 1-h, 1-mi^2 PMP, the PMP results generated from a 72-h storm were analyzed with the use of the HMR 52 program (U. S. Army Corps of Engineers (USACE), 1987). The FHRR notes that the cumulative PMP at the site for a 72-h storm is 49.1 in. (see Section 3.2.1.1 in FHRR Supplement 1; Luminant, 2014b).

The NRC staff reviewed the licensee's results for the LIP PMP values and compared them with those in HMR 52 (NOAA, 1982) and confirmed the 6-h, 1-h, and sub-hourly PMP values. The NRC staff also confirmed the HMR 52 computer program results for the 72-h PMP. The staff notes that the licensee's approach to PMP determination is consistent with current regulatory guidance and methodologies.

3.2.2 Hydrologic and Hydraulic Modeling

The licensee used USACE Hydrologic Engineering Center - Hydrologic Modeling System (HEC-HMS) software (USACE, 2010a) to evaluate runoff from the LIP event. The digital elevation model (DEM) of the site was modified by adding 5 ft along the VBS and raising areas within the foot print of buildings by 12 ft to allow for potential flow blockages and reduced storage. Various openings in the VBS were included to simulate culverts that were assumed to remain unblocked. Flow from within the power block could be conveyed through these openings or by flow over sections of the VBS (Rizzo, 2014b; Luminant, 2015).

The licensee simulated potential flood water levels within the power block protected area using the Hydrologic Engineering Center - River Analysis System (HEC-RAS) model (USACE, 2010b). Figure 3.2-2 shows a schematic of the updated HEC-RAS model for site drainage and LIP analysis. The storage areas delineated for local drainage discharge in HEC-HMS and the output hydrographs were used as input into the HEC-RAS model.

After refining the HEC-RAS LIP model, the licensee divided the site area into 66 hydrologic storage areas to represent potential flooding across the site, and calculated the area of each storage area. The storage areas were selected using digital elevation data, with confinement based on the location of the VBS, raised roads, and other topographic features (Rizzo, 2014b; Luminant, 2015). Figure 3.2-2 shows a schematic of the updated HEC-RAS model for site drainage and LIP analysis. Several reaches were included along the perimeter of the power block to simulate flow away from the site (see Figure 3.2-2). The reaches included cross-sectional elevation data with Manning's roughness coefficients ranging from 0.01 to 0.03 depending on land cover (Luminant, 2015).

The licensee described an equipment ramp below site grade, which is connected to the turbine building (TB) of Unit 2 and has an entrance on the west face of the TB located at elevation 809.3 ft NGVD29. The TB is connected to the safety-related ECB by an internal pathway at elevation 778 ft NGVD29. To assess the potential for flooding in the ECB, the TB was represented in the HEC-RAS model as a storage area with a stage volume relationship based on physical plant features. The licensee used HEC-RAS to evaluate the potential for flow into the TB using weir flow transfer and determined a maximum water surface elevation of 760.75 ft NGVD29 under the 6-h LIP event and 760.93 ft NGVD29 under the 72-h LIP event. The licensee stated that these elevations are lower than the ECB internal pathway (Luminant, 2015).

The licensee used the HEC-RAS model to simulate LIP flooding across the powerblock and compute maximum water surface elevations for each storage area. The licensee's results indicate that LIP flooding remains below the critical door elevations of 810.5 ft NGVD29, with a peak water surface elevation of 810.42 ft NGVD29 at a safety-related structure (Luminant, 2015). However, the NRC staff noted several potential issues regarding the licensee's evaluation using HEC-RAS. These issues resulted in flows that do not appropriately reflect the expected physical routing of flood water across the site. Specifically, the licensee used a quasi-2D modeling approach to address the potential for undefined flow direction with overland weirs representing the connection between adjacent catchments. A weir coefficient of 3.0 was used in the model. Rizzo (2014c) states that a weir coefficient of 3.0 "is a relatively high value for the conditions represented."

The licensee's approach accumulates water in each sub-basin until the water level exceeds a boundary weir elevation. Once the water level exceeds a point along a weir, flow transfer occurs via weir flow. Based on its review, the NRC staff determined that the quasi-2D approach allows for rapid transfer of water across sub-basins in a manner that does not reflect expected physical routing of flood waters. Moreover, the manner in which the quasi-2D approach accounts for the storage area dimensions and lumps characteristics leads to temporal and spatial flow distribution that do not reflect expected physical routing of flood waters. In addition, staff finds that a reach representing flow to the SCR from a north catchment outside the VBS presents a mechanism for flow transfer that do not reflect expected physical routing of flood waters. Specifically, the modeling of several VBS openings led to fast storage area flow transfer and allowed for water to quickly move to the model perimeter. Once at the model perimeter, water enters a dummy reach and exits from the model.

After examining the model setup and the approach used by the licensee, the NRC staff determined that the simulated flood water exits the model prematurely, resulting in water elevations that are low compared to what might be expected using an alternate modeling approach.

The staff also conducted an independent analysis using the surface water flow model FLO-2D Build No. 14.03.07 (FLO-2D, 2014) and found maximum water surface elevations to be higher than predicted by the licensee. The staff's independent analysis supported the staff's conclusions regarding the issues noted above regarding the licensee's use of the HEC-RAS model.

Based on the results of the examination of the licensee's LIP model, staff's independent analysis, and identification of the issues related to the licensee's model, the NRC staff and management held subsequent meetings as part of a regulatory audit with the licensee to determine a path forward regarding the licensee's LIP modeling approach. As a result of the discussions the staff and the licensee agreed that a higher water surface elevation of 810.6 ft

NGVD29 would be appropriate for use as the reevaluated LIP flood level (Luminant, 2016; NRC, 2016b). This water surface elevation of 810.6 ft NGVD29 is the simulated water level at the non-safety-related TB 1.

Therefore, the staff concludes that a reevaluated flood level of 810.6 ft NGVD29 is a reasonable estimate of the LIP flood hazard (NRC, 2016b; Luminant, 2016).

3.2.3 Conclusion

The staff confirmed the licensee's conclusion that the reevaluated flood hazard for LIP is not bounded by the CDB flood hazard at the Comanche Peak site. Therefore, the NRC staff expects that the licensee will submit a focused evaluation for LIP consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b).

3.3 Streams and Rivers

The licensee reevaluated flood hazard for streams and rivers is provided in FHRR Supplement 1, based on a stillwater-surface elevations that vary based on location from 792.6 to 792.7 ft NGVD29 (See Table 4.1-1 for locations). Including wind waves and run-up results in elevations that vary based on location with the maximum elevation of 795.8 ft NGVD29 (See Table 4.1-1 for locations). This flood-causing mechanism is discussed in the licensee's CDB. The CDB PMF elevation for streams and rivers is based on a stillwater-surface elevations that vary based on location from 789.7 ft to 790.5 ft NGVD29 (See Table 3.1-4 for locations). Including wind waves and run-up results in an elevations that vary based on location from 790.5 ft to 794.7 ft NGVD29 (See Table 3.1-4 for locations).

In addition, the licensee evaluated a combined effects flood scenario as part of the streams and rivers flooding. The staff reviewed the flooding hazard from streams and rivers against the relevant regulatory criteria based on present-day methodologies and regulatory guidance.

3.3.1 Probable Maximum Flood

The major hydrologic features of interest that could potentially be considered for PMF and river flooding analysis at the site are the Squaw Creek, the Paluxy River, and the Brazos River (Luminant, 2015). The licensee prepared a diagram showing the hierarchical hazard assessment (HHA) approach (Figure 3-5 of the FHRR) for river flooding analysis and performed detailed examination of the flooding potential related to the three water bodies identified. The licensee performed an initial screening of rivers, streams, and creeks in the vicinity of the site noting that most were screened from further consideration based on distance from the site or relative location and flow direction. Only Squaw Creek and the Paluxy River were retained for additional riverine flooding analysis, with the Brazos River included in the dam failure flooding analysis to evaluate the potential backwater effects at Comanche Peak (Rizzo, 2014f).

3.3.1.1 Model Domain

In order to model flooding on Squaw Creek and the Paluxy River, the licensee delineated watersheds and estimated curve numbers based on U.S. Geological Survey (USGS) land-use maps and Natural Resources Conservation Service soil type maps.

3.3.1.2 Probable Maximum Precipitation

The licensee analyzed the PMP for the Squaw Creek watershed using the HMR 52 program. The watershed boundary was represented by a series of 96 points entered into the HMR 52 input file. The licensee estimated depth-area-duration (DAD) values at the watershed centroid. Additionally, the licensee entered: the ratio of a 1-h to 6-h precipitation depths for the 20,000 mi^2 isohyet, selected an output time interval of 5 minutes for rainfall distribution, and used the default distribution (Rizzo, 2014h).

The licensee determined a critical storm area of 100 mi^2 and storm orientation of 304 degrees for the Squaw Creek watershed. The 72-h critical PMP rainfall total is 43.03 in. The 5-minute incremental PMP for the Squaw Creek watershed is shown in Figure 3.3-1. The NRC staff considers the licensee's application of the HMR 52 computer program in determining the Squaw Creek watershed PMP to be in accordance with present-day regulatory guidance.

The licensee also analyzed the PMP for the Paluxy River watershed using the HMR 52 program. The watershed boundary input consists of 100 coordinate points, and the licensee determined the DAD values for the watershed centroid. Subsequently, the critical storm area size was determined to be 450 mi^2 based on maximum precipitation on the drainage basin. The ratio of 1-h to 6-h precipitation depths for the 20,000 mi^2 isohyets and 5-minute output time interval were specified in the input file, and the default precipitation distribution was selected (Rizzo, 2014i).

For the Paluxy River PMP, the licensee determined a critical storm orientation of 300 degrees and 72-h PMP rainfall total of 36.24 in., which includes an adjustment factor of 0.99 based on the storm area and the critical storm orientation's deviation from the preferred storm orientation (Rizzo, 2014i). The 5-minute incremental PMP for the Paluxy River Watershed is shown in Figure 3.3-2. The staff concludes that the licensee's application of the HMR 52 computer program to determine the Paluxy River watershed PMP is in accordance with present-day regulatory guidance and methodology.

3.3.1.3 Hydrologic Modeling

The licensee developed HEC-HMS models to perform PMP runoff analysis using the watersheds and sub-basins delineated for PMP analysis. The hyetographs included in Figures 3.3-1 and 3.3-2 were input into the Squaw Creek and Paluxy River watershed HEC-HMS models, respectively.

The licensee calibrated the Squaw Creek HEC-HMS model to an empirical regression equation assuming a Soil Conservation Service storm type II distribution. After three calibration runs, the licensee established a Manning's roughness coefficient of 0.11 for the overbank and 0.045 for the channel (Luminant, 2015), compared with values of 0.15 and 0.15, respectively, in the FSAR for Units 3 and 4 (Luminant, 2013b). The licensee also used a Snyder basin coefficient of 0.4 and a peaking coefficient of 0.8. A total of seven scenarios were simulated in HEC-HMS based on the HHA approach (see Section 3.2.2.2.1 in FHRR Supplement 1; Luminant, 2014b).

The NRC staff issued RAI 11 and RAI 2-3 to gain further insight into the licensee's basis for using the empirically derived regression equation results for a 100-year return period flood for calibration. Specifically, staff wanted to gain further insights regarding the reason for not including potential uncertainty and sensitivity in the empirical equation or calibration to, or extrapolation beyond, the 100-year return period event. In response, the licensee stated that the 100-year return period event was used as a baseline for calibration rather than the 500-year event due to the higher confidence in the empirical relationship. Based on its independent review, the staff finds the final model parameters and the use of an empirical regression-based calibration to be reasonable.

The Paluxy River HEC-HMS model was calibrated to match the response of the Paluxy River watershed with flow data from USGS gaging station 08091500. The resulting Manning's roughness coefficient for the main channel was 0.045, while values for the overbanks vary based on land use as described in Section 3.2.2.2.2 in FHRR Supplement 1 (Luminant, 2014b). Calibration also resulted in a Snyder basin coefficient of 1.9 and a peaking coefficient of 0.5 (Rizzo, 2014k). In accordance with the HHA approach, the licensee performed five scenarios modeled in HEC-HMS to represent variable levels of conservativeness (Luminant, 2014b).

3.3.1.4 Hydraulic Modeling

The licensee simulated PMF water levels at the Comanche Peak site using HEC-RAS. A series of cross sections were developed based on bathymetric and site survey data to represent the SCR and SSI geometry, with appurtenant features. The licensee used aerial photography to assess land coverage and determine appropriate Manning's roughness coefficients. The final values selected range from 0.016 to 0.025 for the channel and 0.08 to 0.10 for the overbank. The licensee used a contraction coefficient of 0.1 and expansion coefficient of 0.3 at normal, gradually varying cross-sections and contraction and expansion coefficients of 0.3 and 0.5, respectively, immediately upstream and downstream of rapid cross section change. The licensee modeled the SCR service spillway as an ogee weir and the emergency spillway as a broad crested weir. The estimated maximum peak stillwater flood elevation on the circulating water intake structure (CWIS) side is 792.6 ft NGVD29 on the SWIS vertical face.

3.3.1.5 Wind-wave Activity

The licensee also considered the effect of wind-wave activity coincident with the PMF. The wave setup and run-up generated by a 2-year return period wind speed were added to the PMF still water elevation. This method is consistent with the approaches outlined in NUREG/CR-7046 (NRC, 2011e). The licensee determined the wind wave activity using the USACE Coastal Engineering Manual (USACE, 2008).

The licensee determined the longest possible over-water fetches over the SCR and SSI during the PMF at critical locations of the Comanche Peak site including the CWIS on the northern edge of the plant, the SWIS embankment and vertical face on the southern edge of the plant, and either side of the SSI dam. At these locations, peak water levels for PMF with coincident wind wave run-up reported by the licensee are below the plant grade of 810 ft NGVD29, with a maximum peak elevation of 795.8 ft NGVD29 on the SWIS vertical face. Table 3-3 in FHRR Supplement 1 (Luminant, 2014b) summarizes the reevaluated water levels for stream and river flooding under existing conditions, including wave run-up, and is also discussed further in Section 4 of this staff assessment.

3.3.2 Combined Effects Flooding

As recommended by NUREG/CR-7046 (NRC, 2011e), the licensee also considered the combined effects flood resulting from baseflow measurements from USGS gages, antecedent rain equal to the 500-year event for 72-hours followed by a PMP event for 72-hours. To calculate appropriate base flows, average monthly flows were computed along the Paluxy River and Squaw Creek using USGS gages. The maximum average monthly flow for each gage was used as the base flow for conservatism. The NRC staff notes that the licensee included conservatisms in the results in accordance with present-day regulatory guidance.

The 72-h, 5-minute interval PMP hyetographs developed for stream and river flooding analysis of the Squaw Creek and Paluxy River watersheds were used as the full PMP for combined effects flooding analysis. Since the 500-year storm was assumed to be less than the 40-percent PMP, it was used as an antecedent condition in the HEC models in accordance with current regulatory guidance (NRC, 2011e). To simulate these conditions, a 72-h PMP hyetograph equivalent to the 40-percent full PMP was added prior to the full PMP and both were arranged as centered distributions.

The licensee used the HEC-HMS and HEC-RAS models used for other riverine flooding simulation, with changes made to reflect the additions from combined effects. Results of the HEC-RAS water surface elevation simulation bound other regional flooding mechanisms and are reported in Table 3-3 in FHRR Supplement 1 (Luminant, 2014b) and Section 4.0 of this staff assessment. The maximum flood level for combined events scenario with wind wave run-up on the CWIS side is 795.1 ft NGVD29.

3.3.3 Circulating Water System Flooding Analysis

The licensee also considered the potential for flooding of the Circulating Water System (CWS) while discharge valve pathways are open for maintenance. The licensee noted that flooding of the ECB via the CWS and TB cannot occur until the SCR water level exceeds 778 ft NGVD29 and the CWS discharge valve pathways located within the TB condenser pit are open for maintenance. The licensee estimated the response time required to reinstall a discharge valve to be 3 hours, precluding back-flooding. Furthermore, Section 4.3.2 in FHRR Supplement 1 notes that the analysis of river flooding, which is more limiting than the combined event flooding, resulted in the SCR water level rising from 777 ft NGVD29, when the response procedure begins, to 778 ft NGVD29 in 3.66 hours.

3.3.4 Conclusion

The staff confirmed the licensee's conclusion that the reevaluated hazard from flooding from streams and rivers is not bounded by the CDB flood hazard. Therefore, the NRC staff expects that the licensee will submit a focused evaluation for these hazards or a revised integrated assessment consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b).

3.4 Failure of Dams and Onsite Water Control/Storage Structures

The licensee demonstrated that flooding from upstream and onsite storage features is negligible and that flooding downstream of the site from flooding on other river systems does not pose a hazard to Squaw Creek Dam or the Comanche Peak site. This flood-causing mechanism is not discussed in the licensee's CDB.

3.4.1 Overtopping Dam Failure

The licensee considered dams and other water control/storage structures at the site and in the watershed surrounding the site. There are no dams upstream of the Comanche Peak site, and the only onsite structure (the SSI dam) is located just downstream of the powerblock area.

Consequently, upstream dam failure on Squaw Creek was not evaluated, and the SSI dam was only evaluated for overtopping conditions that may contribute to increased wind fetch length as described in Section 3.2.3 of FHRR Supplement 1 (Luminant, 2014b).

The licensee also considered dams along the Brazos River located above the confluence with the Paluxy River. This dam failure evaluation was based on results from the Comanche Peak Units 3 and 4 FSAR (Luminant, 2013b), which the licensee referred to as the controlling dam failure scenario. This scenario includes overtopping domino-type failures of Fort Phantom Hill, Cedar Ridge Reservoir, Morris Sheppard, and De Cordova Bend dams. The analysis considered overtopping of Lake Stamford Dam in the Cedar Reservoir Dam failure and did not account for attenuation (Luminant, 2013b). Location of dams near the Comanche Peak site is presented in Figure 3.4-1.

As determined in the Comanche Peak, Units 3 and 4 FSAR (Luminant, 2013b), a peak dam failure flow of 8,380,000 cubic feet per second (237,300 cubic meters per second) was determined for the confluence of the Paluxy and Brazos Rivers. This peak flow is associated with a water surface elevation of 768.03 ft NGVD29 at the downstream end of Squaw Creek Dam. Since this elevation is well below the Squaw Creek Dam service spillway crest elevation, dam failure flooding does not impact the Comanche Peak site. However, Section 3.2.3 in FHRR Supplement 1 states that the licensee used this maximum water surface elevation in the PMF and Combined Effects Scenario modeling as a downstream boundary condition to account for any potential backwater effects (Luminant, 2014b).

Since dam failure flooding does not present a challenge to the Comanche Peak site and the Brazos River overtopping dam failure scenario was used as input to the PMF Scenario, no maximum water surface elevation was computed for dam failure flooding at the Comanche Peak site. In addition, staff conducted independent sensitivity analysis to evaluate the dam failure assumptions, including the failure of additional dams along the Brazos River. While more severe scenarios could be considered, the licensee's approach demonstrated several conservative assumptions that allowed staff to find the licensee's overtopping dam failure evaluation and conclusions to be reasonable.

3.4.2 Seismic Dam Failure

The licensee also considered the potential for seismic dam failure effects, with a focus on the SSI dam. The SSI is formed by a portion of an inlet to the south of Comanche Peak, Units 1 and 2, which is separated from the main body of the SSI dam. The SSI dam is located downstream of safety-related structures and is a Seismic Category I rockfill dam. Even if the non-seismic SCR dam fails and rapidly drains, a minimum water level of 769.5 ft NGVD29 will be maintained by the equalization channel. The water level of the SSI is maintained by the equalization channel between the SSI and the SCR. The presence of the equalization channel ensures that the reevaluated PMF levels upstream and downstream of the SSI dam differ by only 0.03 ft (Luminant, 2014b).

The presence of the equalization channel also results in the reevaluated PMF Scenario water surface elevation differing by only 0.03 ft between the SCR and SSI. The orientation of the SSI Dam contributes to different fetch lengths on either side of the structure, leading to a maximum elevation difference of 1.87 ft under the reevaluated PMF Scenario. Therefore, seismic dam failure would not result in a higher flood hazard level compared to the hydrologic dam failure analyses considered in Sections 2.2.1.3 and 4.3.2 of FHRR Supplement 1 (Luminant, 2014b) and the staff's analysis.

3.4.3 Conclusion

The staff confirmed the licensee's conclusion that the reevaluated hazard from flooding from failure of dams and onsite water control or storage structures does not impact the site and is bounded by the CDB flood hazard. Therefore, the NRC staff determined that flooding as a result failure of dams and onsite water control or storage structures does not need to be analyzed in a focused evaluation or an additional assessment consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b).

3.5 Storm Surge

The licensee reported in its FHRR that the reevaluated hazard for storm surge does not inundate the plant site and qualitatively screened out the hazard based on the site location using the guidance of ANSI/ANS-2.8-1992 (ANSI/ANS, 1992). This flood-causing mechanism is not discussed in the licensee's CDB.

The FSARs for Units 1 and 2 (Luminant, 2011) and Units 3 and 4 (Luminant, 2013b) both conclude that flooding as a result of storm surge is not plausible. Comanche Peak is located over 250 miles from the coast. Thus, hurricanes and surges are not considered plausible flooding hazards at the site. Additionally, wind wave run-up is considered separately for regional flooding effects.

The staff confirmed the licensee's conclusion that the reevaluated hazard from flooding from storm surge does not impact the site. Therefore, the NRC staff determined that flooding as a result of storm surge does not need to be analyzed in a focused evaluation or an additional assessment consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b).

3.6 Seiche

The licensee reported in the FHRR that the reevaluated hazard for seiche does not inundate the plant site and qualitatively screened out the hazard based on the discussion of the FSAR for Comanche Peak Units 3 and 4. This flood-causing mechanism is not discussed in the licensee's CDB.

The FSARs for Units 1 and 2 (Luminant, 2011) and Units 3 and 4 (Luminant, 2013b) both conclude that flooding as a result of seiche is not plausible. The potential for meteorological seiches are not likely to occur, and seismic seiches would generate waves no more than 5 ft high in the SCR. Also, slope stability analysis performed by the licensee indicates that landslide-induced seiches are not plausible.

The NRC staff confirmed that the reevaluated hazard for flooding from seiche does not impact the site. Therefore, the NRC staff determined that the seiche flood-causing mechanism does not need to be analyzed in a focused evaluation or an integrated assessment consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b).

3.7 Tsunami

The licensee reported in its FHRR that the reevaluated hazard for tsunami does not inundate the plant site and qualitatively screened out the hazard based on an evaluation of the site location and elevation. This flood-causing mechanism is not discussed in the licensee's CDB.

The FHRR states that both the FSAR for Units 1 and 2 (Luminant, 2011) and Units 3 and 4 (Luminant, 2013b) conclude that Comanche Peak would not be impacted from a tsunami on the Gulf of Mexico due to its location more than 250 miles inland and elevation of over 800 ft NGVD29. The licensee also stated that landslide and seismic waves are not plausible for the SCR due to sufficient slope stability and a lack of tectonic or non-tectonic geologic and seismic concerns. The licensee also stated that NRC guidance indicates that if regional screening identifies that the site region is not subject to tsunamis, no further analysis for tsunami hazard is required

The NRC staff confirmed that the reevaluated hazard for flooding from tsunami does not impact the site. Therefore, the NRC staff determined that the tsunami flood-causing mechanism does not need to be analyzed in a focused evaluation or an integrated assessment consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b).

3.8 Ice-Induced Flooding

The licensee reported in its FHRR that the reevaluated hazard for ice-induced flooding does not inundate the plant site and screened out the hazard based on evaluation of historical water and air temperature records. This flood-causing mechanism is not discussed in the licensee's CDB.

The licensee stated that Comanche Peak's location in a temperate climate prevents the formation of significant ice thickness on lakes, streams, and rivers. Additionally, the lowest water temperature recorded at USGS Station 11856 along the Brazos River was 39.0 degrees Fahrenheit (°F) in 1970. The lowest water temperature at Station 11555 along Squaw Creek was 41.9 °F in 1982. The licensee also assessed the potential ice thickness using USACE methods (USACE, 2004). The licensee calculated a maximum ice thickness of 7 inches as a function of the accumulated freezing-degree days and a thermal expansion coefficient. This is considered minimal and would not impact any safety-related facilities.

The staff confirmed the licensee's conclusion that the reevaluated hazard from ice-induced flooding does not impact the site. Therefore, the NRC staff determined that ice-induced flooding does not need to be analyzed in a focused evaluation or an integrated assessment consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b).

3.9 Channel Migrations or Diversions

The licensee reported in its FHRR that the reevaluated hazard for channel migrations or diversions does not inundate the plant site and screened out the hazard based on a qualitative assessment. This flood-causing mechanism is not discussed in the licensee's CDB.

The licensee stated in its FHRR that both the FSARs for Units 1 and 2 (Luminant, 2011) and Units 3 and 4 (Luminant, 2013b) conclude that the potential for flooding due to channel migrations or diversions is not plausible. The FSAR for Units 1 and 2 (Luminant, 2011) indicates that diversion of water from the Squaw Creek watershed is not plausible and no evidence exists to suggest any historical or potential diversions or realignments of Squaw Creek or the Brazos River. Additionally, no steep or unstable slopes exist in the areas that could contribute to landslide cutoffs or diversions.

The licensee also stated that the SCR is largely situated on limestone making it relatively impermeable and free of sinkholes. Thus, the reservoir is unlikely to lose water through its base or via other means. The regional characteristics of the geothermal, volcanic, or seismic activity also supports the conclusion that channel diversion is not a potential hazard at Comanche Peak.

The staff confirmed the licensee's conclusion that the reevaluated hazard from flooding from channel migrations or diversions does not impact the site. Therefore, the NRC staff determined that flooding as a result of channel migrations or diversions does not need to be analyzed in a focused evaluation or an additional assessment consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b).

4.0 INTEGRATED ASSESSMENT AND ASSOCIATED HAZARD DATA

4.1 Reevaluated Flood Elevation for Hazards Not Bounded by the CDB

Section 3 documents the staff's review of the licensee's flood hazard water elevation results. Table 4.1-1 contains the maximum flood elevation results, including wind waves and run-up effects, for flood mechanisms not bounded by the CDB. The staff agrees with the licensee's conclusion that LIP and flooding from streams and rivers are not bounded by the CDB. Consistent with the process and guidance discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b), the NRC staff anticipates the licensee will submit a focused evaluation for LIP and associated site drainage. For the streams and rivers flood-causing mechanisms, the NRC staff anticipates the licensee will perform additional assessments of plant response, either a focused evaluation or an integrated assessment, as discussed in COMSECY-15-0019 (NRC, 2015b) and JLD-ISG-2016-01, Revision 0 (NRC, 2016b).

4.2 Flood Event Duration for Hazards Not Bounded by the CDB

The staff reviewed information provided in the licensee's 50.54(f) responses (Luminant, 2014a, 2014b, and 2015) regarding the FED parameters needed to perform additional assessments of plant response for flood hazards not bounded by the CDB. Subsequent to these submittals the licensee provided the FED parameters in a letter dated February 9, 2017 (Luminant, 2017). The FED parameters can be found in Table 4.2-1 and were reviewed by the staff as documented in a staff assessment dated May 9, 2017 (NRC, 2017).

4.3 Associated Effects for Hazards Not Bounded by the CDB

The NRC staff reviewed information provided in the licensee's 50.54(f) responses (Luminant, 2014a, 2014b, 2015) regarding the AE parameters needed to perform the additional assessments of plant response for flood hazards not bounded by the CDB. The AE parameters directly related to maximum total water elevation, such as waves and run-up, are presented in Table 4.1-1. Subsequent to the 2014 and 2015 FHRR submittals discussed above, the licensee provided AE parameters in a letter dated February 9, 2017 (Luminant, 2017). The AE parameters can be found in Table 4.3-1 and were reviewed by the staff as documented in a staff assessment dated May 9, 2017 (NRC, 2017).

4.4 Conclusion

Based upon the preceding analysis, NRC staff confirmed that the reevaluated flood hazard information defined in Section 4.1 is appropriate input to the additional assessments of plant response as described in the 50.54(f) letter and COMSECY-15-0019, "Mitigation Strategies and Flooding Hazard Reevaluation Action Plan" (NRC, 2015b). The licensee's FED parameters and applicable flood AE parameters were reviewed by the staff in a separate staff assessment (NRC, 2017).

5.0 CONCLUSION

The NRC staff has reviewed the information provided for the reevaluated flood-causing mechanisms of Comanche Peak Nuclear Power Plant, Units 1 and 2. Based on its review of available information provided in the licensee's 50.54(f) response (Luminant, 2015), the staff concludes that the licensee conducted the hazard reevaluation using present-day methodologies and regulatory guidance used by the NRC staff in connection with ESP and COL reviews.

Based upon the preceding analysis, the NRC staff confirmed that the licensee responded appropriately to Enclosure 2, Required Response 2, of the 50.54(f) letter, dated March 12, 2012. In reaching this determination, staff confirmed the licensee's conclusions that: (a) the reevaluated flood hazard results for LIP, and flooding in streams in rivers are not bounded by the CDB flood hazard; (b) a focused evaluation of plant response will be performed for LIP and a focused evaluation or integrated assessment will be performed for flooding in streams and rivers; and (c) the reevaluated flood-causing mechanism information is appropriate input to additional assessments of plant response, as described in the 50.54(f) letter (NRC, 2012a), COMSECY-15-0019 (NRC, 2015b), JLD-ISG-2012-01, Revision 1 (NRC, 2016a), and JLD-ISG-2016-01, Revision 0 (NRC, 2016c).

6.0 REFERENCES

Notes: ADAMS Accession Nos. refers to documents available through NRC's Agencywide Documents Access and Management System (ADAMS). Publicly-available ADAMS documents may be accessed through http: /www.nrc.gov/reading-rm adams.html.

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Table 2.2-1. Flood-Causing Mechanisms and Corresponding Guidance

Flood-Causing Mechanism	SRP Section(s) and JLD-ISG
Local Intense Precipitation and Associated Drainage	SRP 2.4.2 SRP 2.4.3
Streams and Rivers	SRP 2.4.2 SRP 2.4.3
Failure of Dams and Onsite Water Control/Storage Structures	SRP 2.4.4 JLD-ISG-2013-01
Storm Surge	SRP 2.4.5 JLD-ISG-2012-06
Seiche	SRP 2.4.5 JLD-ISG-2012-06
Tsunami	SRP 2.4.6 JLD-ISG-2012-06
Ice-Induced	SRP 2.4.7
Channel Migrations or Diversions	SRP 2.4.9

SRP is the Standard Review Plan for the Review of Safety Analysis Reports for Nuclear Power Plants: LWR Edition (NRC, 2007)

JLD-ISG-2012-06 is the "Guidance for Performing a Tsunami, Surge, or Seiche Hazard Assessment" (NRC, 2013a)

JLD-ISG-2013-01 is the "Guidance for Assessment of Flooding Hazards Due to Dam Failure" (NRC, 2013b)

Table 3.1-1. Summary of Controlling Flood-Causing Mechanisms

Reevaluated Flood-Causing Mechanisms and Associated Effects that May Exceed the Powerblock Elevation 810 ft (NGVD29)[1]	ELEVATION (NGVD29)
Local Intense Precipitation and Associated Drainage	810.6 ft

[1]Flood height and associated effects as defined in JLD-ISG-2012-05.

Table 3.1-2. List of Safety-Related Structures and Elevations (adapted from FHRR Table 2-2)

Structures, Systems, and Components (SSCs)	Elevation (NGVD29)
Auxiliary Building	810.0 ft
Reactor Building (Each Unit)	810.0 ft
Electrical and Control Building (ECB)	810.0 ft
Safeguards Building (Each Unit)	810.0 ft
Diesel Building (Each Unit)	810.0 ft
Fuel Building	810.0 ft
Service Water Intake Structure	796.0 ft
Condensate Storage Tank (Each Unit)	810.0 ft
Reactor Makeup Water Storage Tank (Each Unit)	810.0 ft
Refueling Water Storage Tank (Each Unit)	810.0 ft

Table 3.1-3. Design Parameters in the FSAR (adapted from FHRR Table 2-3)

Design Parameters	Value
Plant Grade Level (all SSCs except Service Water Intake Structure)	810 ft NGVD29
Elevation of Service Water Intake Structure	796 ft NGVD29
Lowest Elevation of Exterior Entrances to any Safety-Related Structures	810.5 ft NGVD29
Probable Maximum Precipitation	39.1 in. (48 hour PMP)
Category 1 Roof Uniform Maximum Design Depth	8 in.
Onsite Drainage System Design Rainfall	6 in. (in one hour) / 7.5 in. (in two hours)
Maximum SCR Water Level at the Site Including Wave Run-up	794.7 ft NGVD29
Maximum Water Level at the Squaw Creek Dam Including Wave Run-up	793.7 ft NGVD29
Maximum Water Level at the Safe Shutdown Impoundment Dam Including Wave Run-up (SCR Side of SSI Dam)	791.3 ft NGVD29
Annual Mean Temperature	66 °F

Table 3.1-4. Current Design Basis Flood Hazards

Flooding Mechanism	Stillwater Elevation (NGVD29)	Associated Effects	CDB Flood Elevation (NGVD29)	Reference
Local Intense Precipitation and Associated Drainage	Not included	Not included	Not included	FHRR Supplement 1 Table 3-3
Streams and Rivers *Upstream of Squaw Creek Reservoir Dam* *Within Squaw Creek Reservoir at the Safe Shutdown Impoundment Dam* *Within Safe Shutdown Impoundment*	 789.7 ft 789.7 ft 790.5 ft	 5.0 ft 1.6 ft N/A	 794.7 ft 791.3 ft 790.5 ft	FHRR Supplement 1 Table 3-3
Failure of Dams and Onsite Water Control/Storage Structures	Not Applicable	Not Applicable	Not Applicable	FHRR Supplement 1 Table 3-3
Storm Surge	Not Applicable	Not Applicable	Not Applicable	FHRR Supplement 1 Table 3-3
Seiche	Not Applicable	Not Applicable	Not Applicable	FHRR Supplement 1 Table 3-3
Tsunami	Not Applicable	Not Applicable	Not Applicable	FHRR Supplement 1 Table 3-3
Ice-Induced	Not Applicable	Not Applicable	Not Applicable	FHRR Supplement 1 Table 3-3
Channel Migrations or Diversions	Not Applicable	Not Applicable	Not Applicable	FHRR Supplement 1 Table 3-3

Table 4.1-1. Reevaluated Flood Hazards for Flood-Causing Mechanisms Not Bounded by the CDB

Flood-Causing Mechanism	Stillwater Elevation, (NGVD29)	Waves/Run-up	Reevaluated Flood Hazard (NGVD29)	Reference
Local Intense Precipitation and Associated Drainage	810.6 ft	Minimal	810.6 ft	FHRR Supplement 1 (Luminant, 2014b); Table 2-1-3 in Luminant, 2015; and Luminant 2016
Streams and Rivers				
PMF Scenario + Wave run-up on Cooling Water Intake Structure Side	792.6 ft	2.3 ft	794.9 ft	
PMF Scenario + Wave run-up on Safe Shutdown Impoundment Dam From Squaw Creek Reservoir Side	792.7 ft	1.9 ft	794.6 ft	
PMF Scenario + Wave Run-up on Safe Shutdown Impoundment Dam from Safe Shutdown Impoundment Side	792.7 ft	1.5 ft	794.2 ft	FHRR Supplement 1 Table 3-3 (Luminant, 2014b)
PMF Scenario + Wave Run-up on Service Water Intake Structure Embankment	792.7 ft	0.6 ft	793.3 ft	
PMF Scenario+ Wave Run-up on Service Water Intake Structure Vertical Face	792.7 ft	3.1 ft	795.8 ft	

Table 4.2-1. Flood Event Duration for Flood-Causing Mechanisms Not Bounded by the CDB

Flood-Causing Mechanism	Time Available for Preparation for Flood Event	Duration of Inundation of Site	Time for Water to Recede from Site
Local Intense Precipitation and Associated Drainage	Minimal (use of NEI 15-05 (NEI, 2015), as needed)	6.7 hours (Non-safety-related Turbine Building) 0.4 hours (Safety-Related Buildings)	minimal
Streams and Rivers [1]	Not Applicable	Not Applicable	Not Applicable

1. The FED parameters for the streams and rivers flood-causing mechanism are not applicable because the plant site would not be inundated by this flooding mechanism.

Table 4.3-1 **ASSOCIATED EFFECTS PARAMETERS FOR FLOOD-CAUSING MECHANISMS NOT BOUNDED BY THE CURRENT DESIGN BASIS**

Associated Effects Parameter	Local Intense Precipitation and Associated Drainage	Streams and Rivers (1)
Hydrodynamic loading at plant grade	Minimal(2)	Not Applicable
Debris loading at plant grade	Minimal	Not Applicable
Sediment loading at plant grade	Minimal	Not Applicable
Sediment deposition and erosion	Minimal	Not Applicable
Concurrent conditions, including adverse weather - Winds	Minimal	Not Applicable
Groundwater ingress	793/810.6 ft.(2)	Not Applicable
Other pertinent factors (e.g., waterborne projectiles)	Minimal	Not Applicable

1. The AE parameters for the streams and rivers flood-causing mechanism are not applicable because the plant site would not be inundated by this flooding mechanism.

2. The licensee reported in its MSA that the maximum groundwater elevations of 793 ft. MSL at the SWIS and 810.6 ft. MSL at other plant buildings for the LIP flood-causing mechanism, but determined the rate of hydrostatic load increase due to LIP-induced groundwater level increase would be minimal and within the design margin for the buildings (Luminant, 2017).

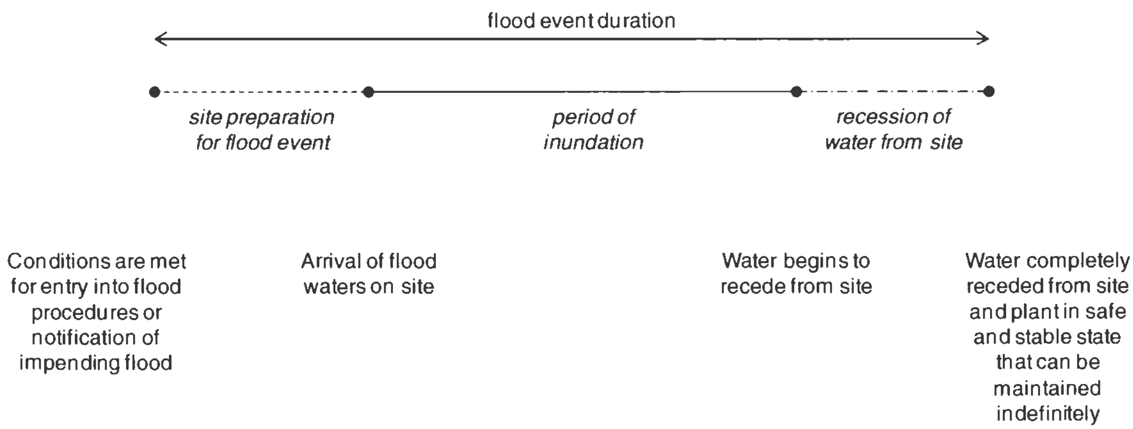


Figure 2.2-1 Flood Event Duration (NRC JLD-ISG-2012-05, Figure 6)

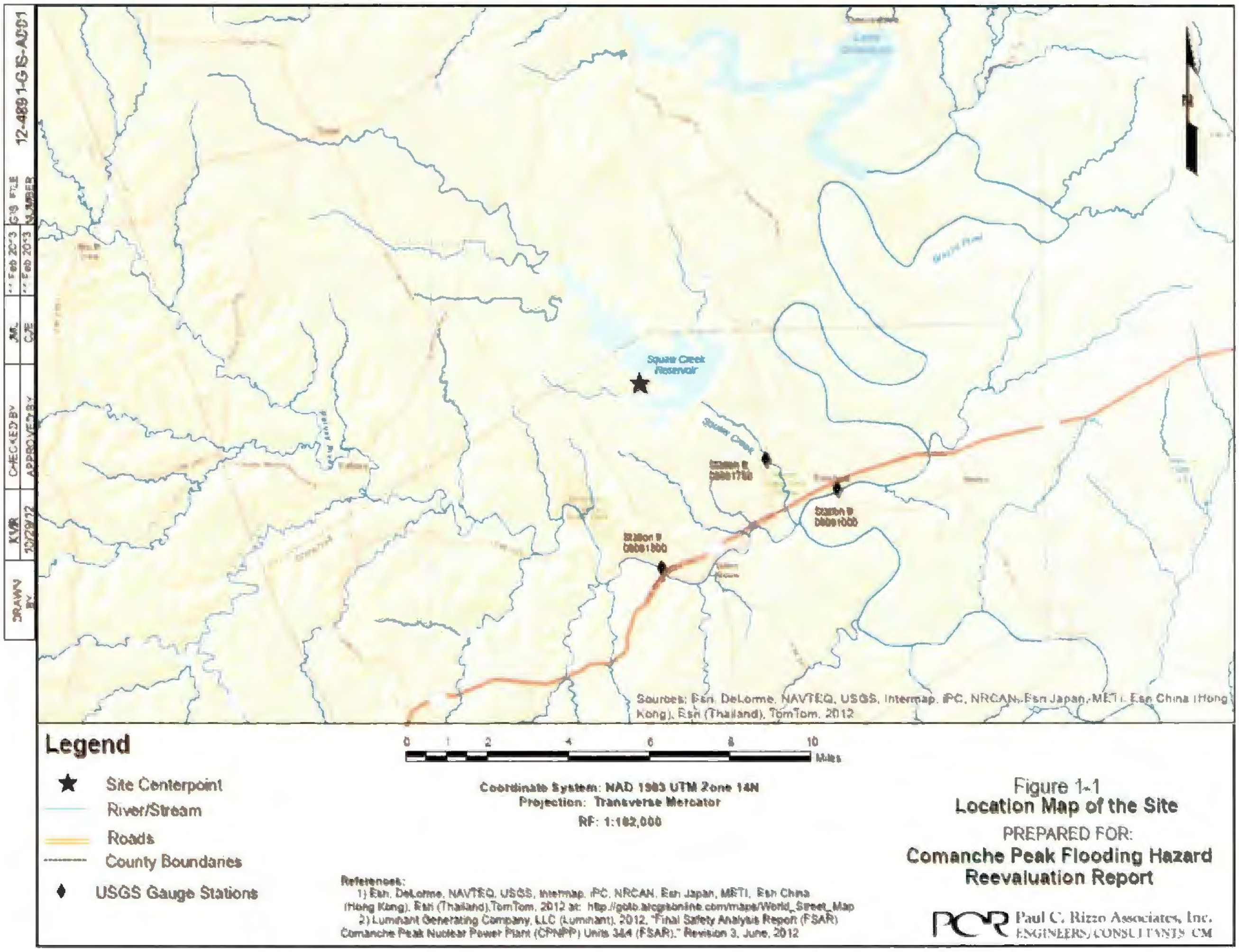


Figure 3.1-1: Local Map of the Comanche Peak Units 1 and 2 Site (adapted from FHRR Figure 1-1)

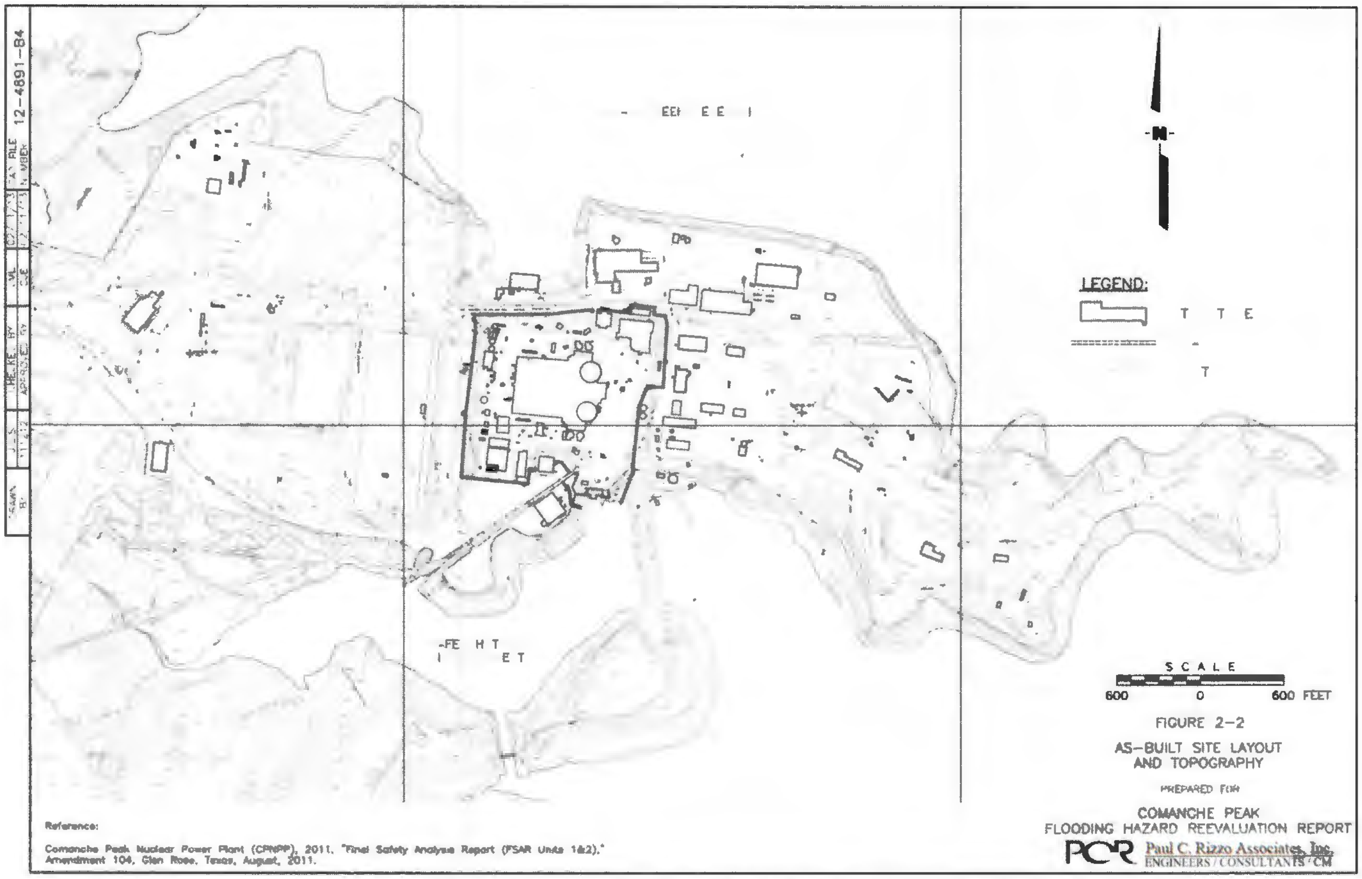


Figure 3.1-2: As-built Site Layout and Topography of the Comanche Peak, Units 1 and 2 Site (adapted from FHRR Figure 2-2)

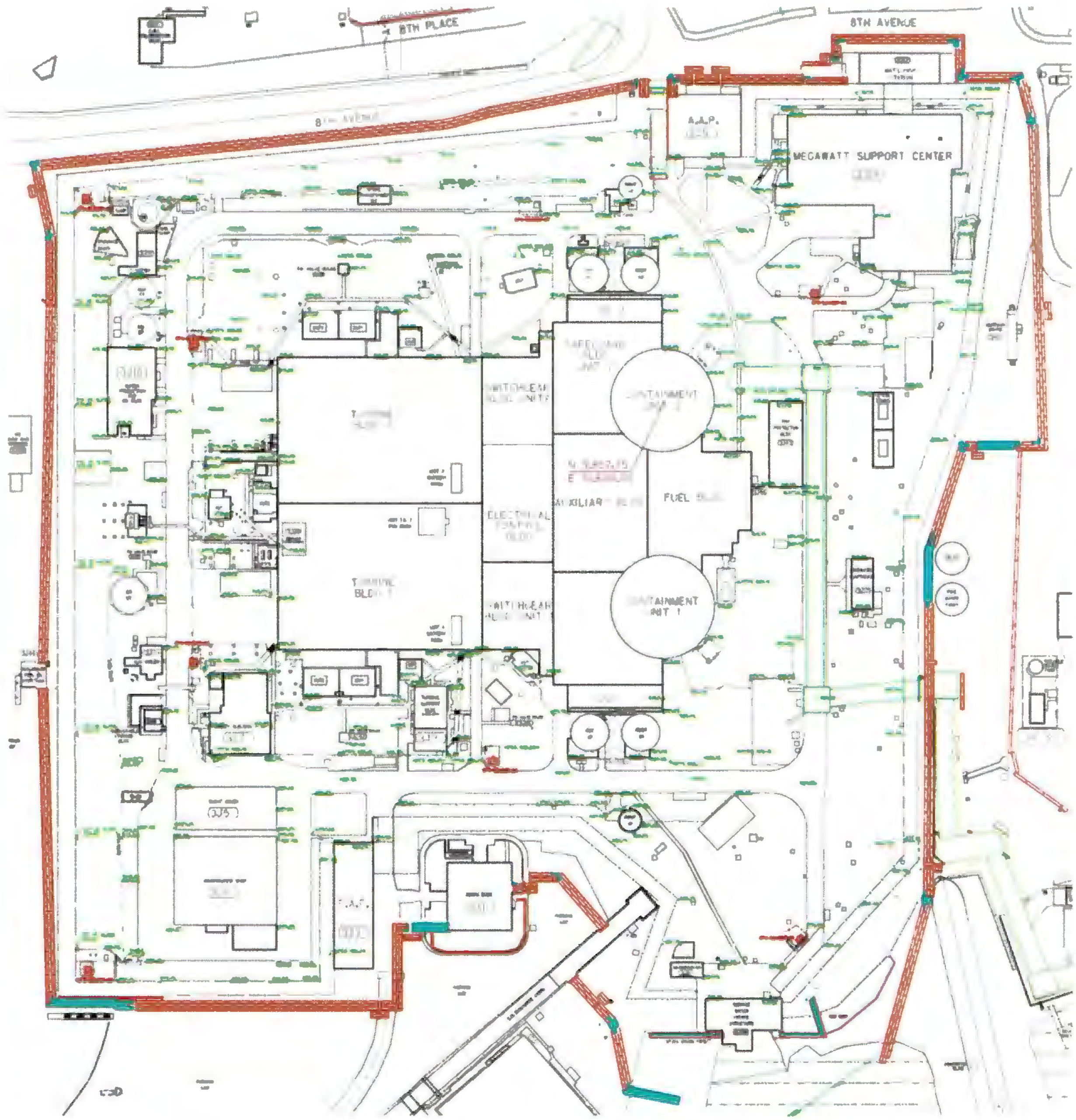


Figure 3.1-3: Site Layout of the Comanche Peak Units 1 and 2 Site within the Vehicle Barrier System (adapted from Luminant 2014a, Enclosure 5)

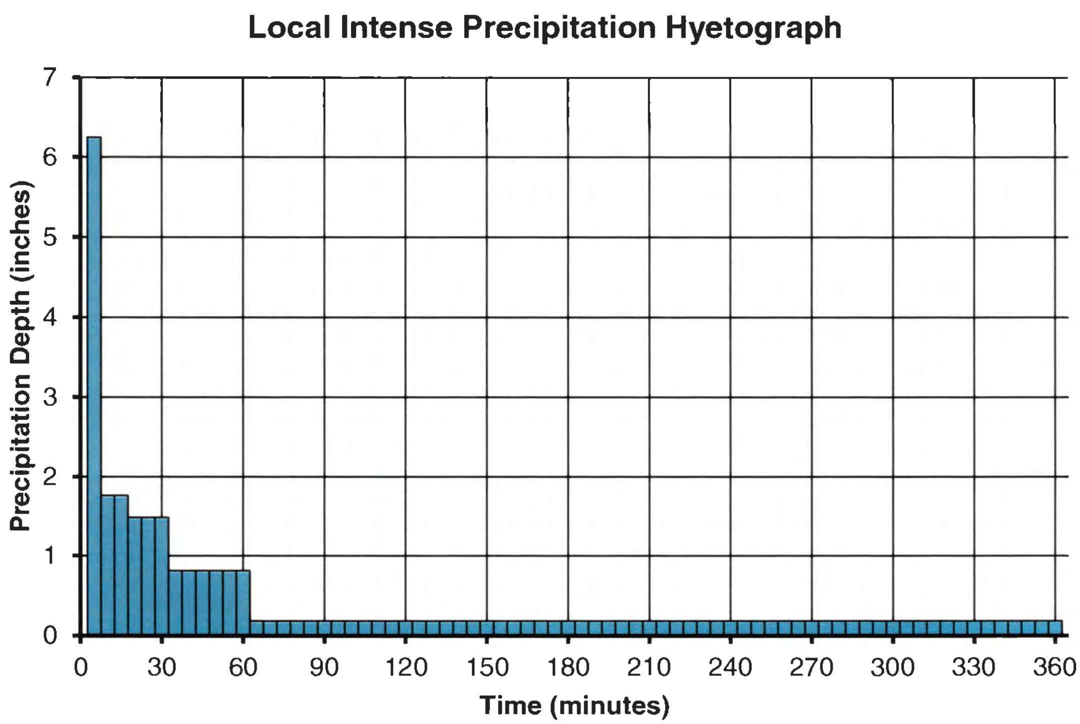


Figure 3.2-1: Local Intense Precipitation Hyetograph (Staff's reconstruction of licensee's hyetograph data found in Rizzo, 2014a)

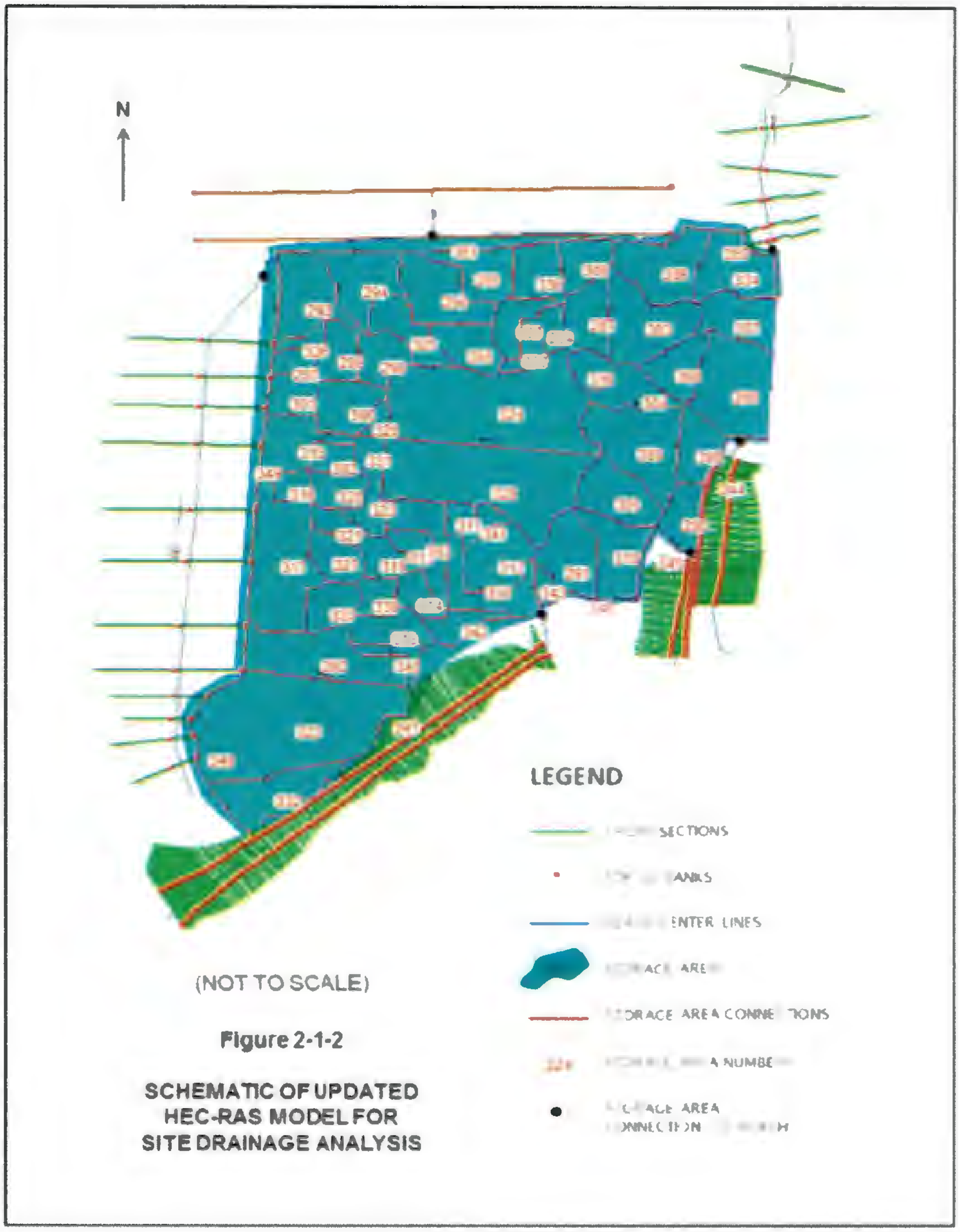


Figure 3.2-2: Schematic of Updated HEC-RAS Model for Site Drainage and LIP Analysis (Adapted from Luminant, 2015, Figure 2-1-2)

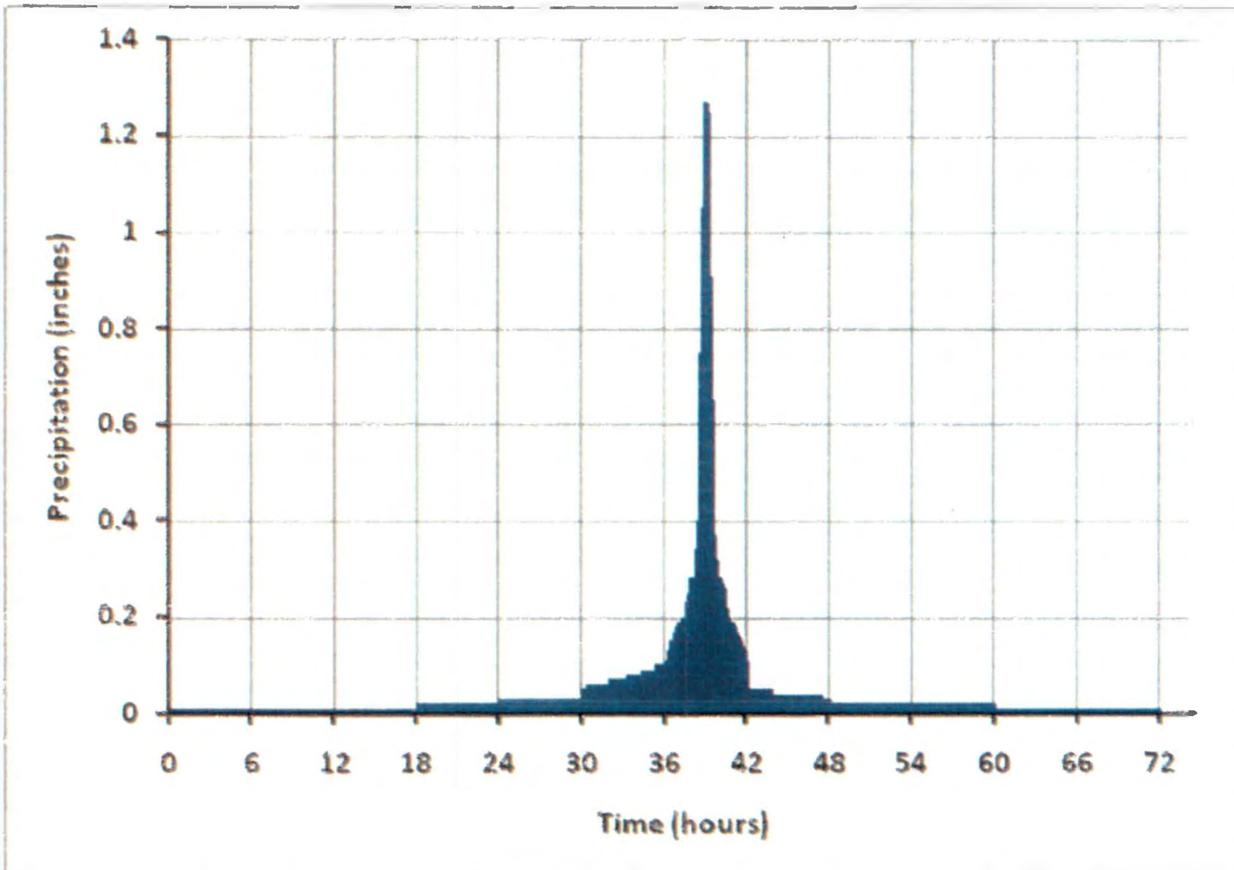


Figure 3.3-1: 5-minute Incremental PMP for Squaw Creek Watershed (FHRR Figure 3-7)

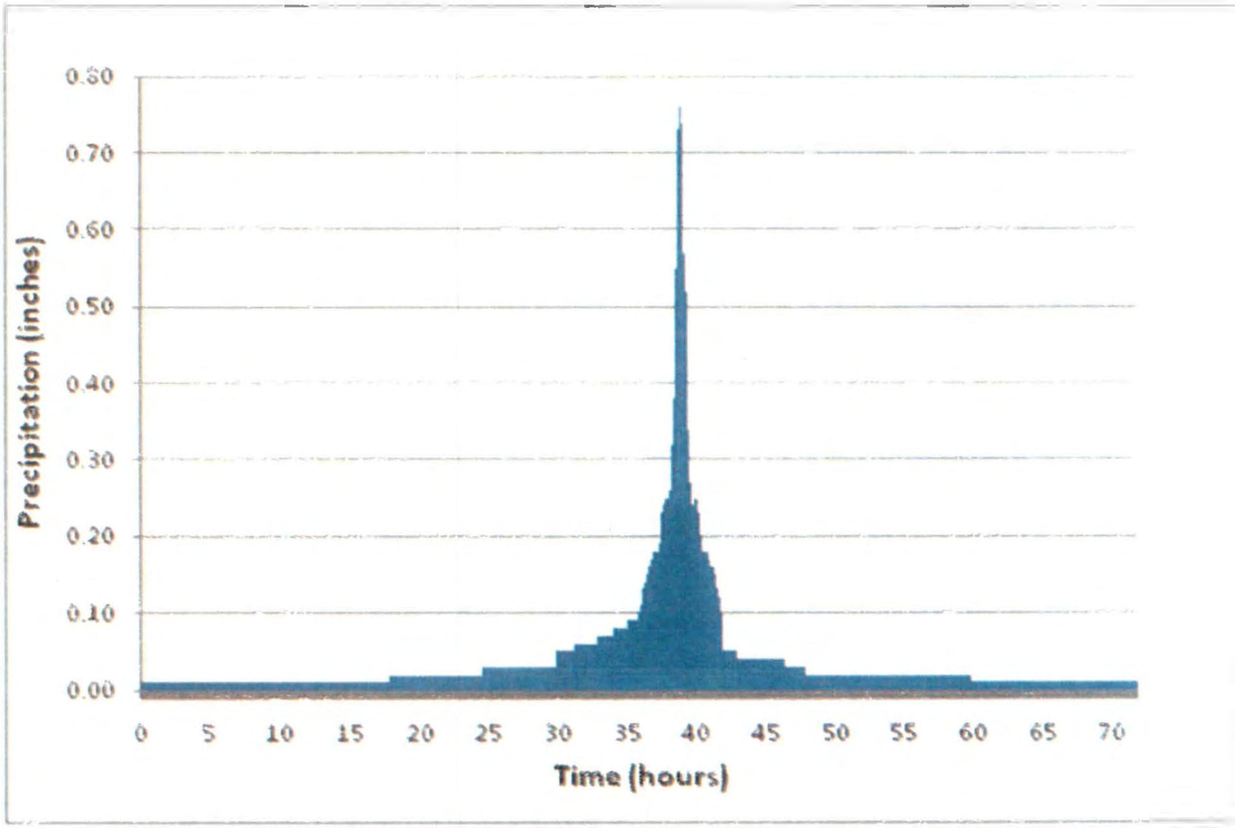
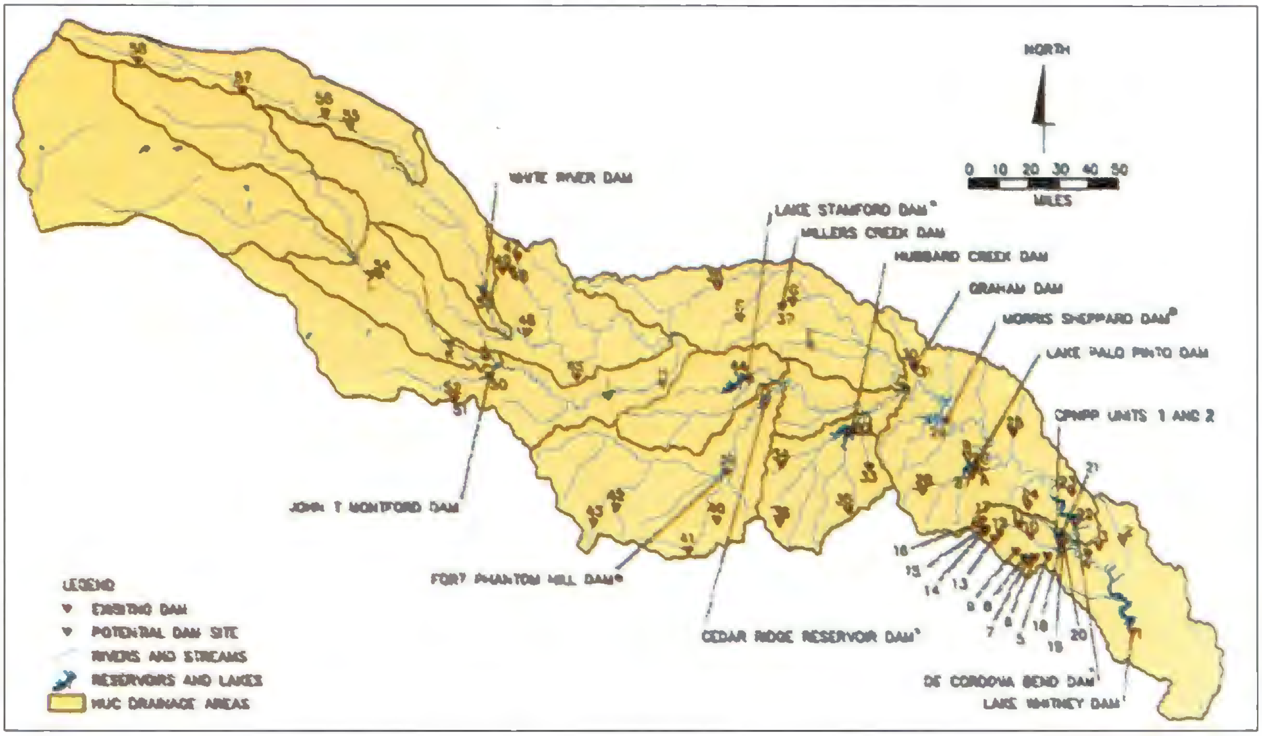


Figure 3.3-2: 5-minute incremental PMP for Paluxy River Watershed (FHRR Figure 3-7)



Source FHRR Figure 3-13

Figure 3.4-1. Location of Dams near the CPNPP Site

Figure 3.4-1: Location of dams near the Comanche Peak site (adapted from FHRR Figure 3-13)

COMANCHE PEAK NUCLEAR POWER PLANT, UNITS 1 AND 2 - STAFF ASSESSMENT OF RESPONSE TO 10 CFR 50.54(f) INFORMATION REQUEST – FLOOD-CAUSING MECHANISM REEVALUATION DATED JUNE 13, 2017

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