5.6 Independent Spent Fuel Storage Installation

5.6.1 Summary of Independent Spent Fuel Storage Installation

Baseline information for the Independent Spent Fuel Storage Installation (ISFSI) is provided in Section 2.0, Site History, Description, and Baseline Condition.

The ISFSI consists of spent fuel modules placed inside 3-ft-thick reinforced concrete shield walls and ceiling. The modules and shield walls are supported on a 2-ft-thick reinforced concrete basemat. Approach slabs are located on the plan north, south, and east sides of the basemat. The approach slabs consist of approximately 0.7-ft-thick reinforced concrete. A haul road exits at the plan northeast corner of the approach slabs and turns ninety degrees to exit toward the west. At the end of the radius, the concrete pavement ends and gravel surfacing begins.

The basemat is elevated relative to the surrounding grades to provide protection from flooding. The elevation at the surface of the basemat is about 1009.5 ft. The approach slab slopes downward away from the basemat to provide drainage. The haul road slopes downward to the surrounding grade, which is at about el. 1004 ft. Side slopes along the perimeter of the elevated area are protected from erosion with large-diameter riprap. The riprap extends from the edge of the pavement down to the toe of the slope.

An Electrical Equipment Building is located southeast of the ISFSI. A cable trench extends from the Electrical Equipment Building to the existing New Warehouse and from the Electrical Equipment Building to the spent fuel modules. The trench follows a path from the Electrical Equipment Building plan west along the plan south edge of the approach slab and then turns plan north along the plan west edge of the approach slab, where it enters the shield walls.

Two high mast light towers are located near the ISFSI. One is near the toe of the side slope along the plan south side of the ISFSI, and one is near the toe of the slope between the ISFSI and the haul road.

The basemat and approach slabs are grade supported. Site preparation prior to placement of the basemat and approach slabs included over-excavation of the existing fill. The structural backfill and structural fill consisted of crushed limestone compacted to 95 percent of the material's maximum density as determined by the modified Proctor test (ASTM D 1557) at a water content between 3 percent below and 3 percent above optimum water content.

The ISFSI—including the haul road ramp, the Electrical Equipment Building, and two high mast light towers—is surrounded by an independent security fence.

5.6.2 Inputs/References Supporting the Analysis

Table 5.6-1 lists references provided by OPPD and other documents used to support HDR's analysis.

Table 5.6-1 - References for ISFSI

Document Title	OPPD Document Number (if applicable)	Date	Page Number(s)
Geotechnical Report Independent Spent Fuel Storage Installation Fort Calhoun Station	58209-G(D)-3, Rev. 0	4/28/2004	All
Fort Calhoun Station ISFSI, Basemat Evaluation	59058-L(D)-1, Rev. 0	7/7/2004	All
Naval Facilities Engineering Command, Design Manual 7.01, Soil Mechanics		9/1986	All

Detailed site observations—field reports, field notes, and inspection checklists—for the ISFSI are provided in Attachment 8.

Observed performance and pertinent background data are as follows:

- Floodwater extended about half-way up the side slopes of the ISFSI platform.
- The Electrical Equipment Building was protected by a temporary berm constructed with sandbags, and a pump appeared to have been used for a period.
- Water stains on the Electrical Equipment Building show evidence of the structure being inundated by floodwater.
- The river bank is armored and has historically protected and stabilized the existing river bank.
- USACE reduced Missouri River Mainstem System releases to 40,000 cfs on October 2, 2011. River levels corresponding to the 40,000 cfs release rate stabilized at FCS on October 4, 2011, at about el. 995 ft.

5.6.3 Assessment Methods and Procedures

5.6.3.1 Assessment Procedures Accomplished

Assessments of the ISFSI included the following:

- A visual inspection of the grade-supported slabs and surrounding grades
- Probing of the grades around the perimeter of the structure for changes in consistency
- An assessment of collected survey data to date for indications of trends in the movement of the structure
- A review of building plans and the geotechnical report to identify possible subsurface features that might be susceptible to the PFMs

5.6.3.2 Assessment Procedures Not Completed

Assessments of the ISFSI that were not completed include the following:

- Geophysical surveys using GPR and seismic refraction to find voids (currently not planned. Other data and observations are sufficient to reach a confident conclusion.)

- Visual inspection of a portion of the precast cable trench and the grades adjacent to the Electrical Equipment Building where the sandbag temporary berm was still in place (to be completed)
- Inclinometers installed along the river bank to identify lateral movement (inclinometers are planned to be installed- Other data and observations are sufficient to reach a confident conclusion)
- Geotechnical borings to determine current soil conditions and capacities (currently not planned- Other data and observations are sufficient to reach a confident conclusion)

5.6.4 Analysis

Identified PFMs were initially reviewed as discussed in Section 3.0. The review considered the preliminary information available from OPPD data files and from initial walk-down observations. Eleven PFMs associated with five different Triggering Mechanisms were determined to be "non-credible" for all Priority 1 Structures, as discussed in Section 3.6. The remaining PFMs were carried forward as "credible." After the design review for each structure, the structure observations, and the results of available geotechnical, geophysical, and survey data were analyzed, a number of CPFMs were ruled out as discussed in Section 5.6.4.1. The CPFMs carried forward for detailed assessment are discussed in Section 5.6.4.2.

5.6.4.1 Potential Failure Modes Ruled Out Prior to the Completion of the Detailed Assessment

The ruled-out CPFMs reside in the Not Significant/High Confidence category and for clarity will not be shown in the Potential for Failure/Confidence matrix.

Triggering Mechanism 2 – Surface Erosion
CPFM 2a – Undermining shallow foundation/slab/surfaces

Reasons for ruling out:

- Slabs were never inundated with floodwater.
- Surface erosion near the ISFSI was not observed during the field assessment.

Triggering Mechanism 2 – Surface Erosion
CPFM 2c – Undermined buried utilities

Reason for ruling out:

- Surface erosion near the ISFSI was not observed during the field assessment.

Triggering Mechanism 3 – Subsurface Erosion/Piping
CPFM 3a – Undermining and settlement of shallow foundation/slab/surfaces (due to pumping)

Reason for ruling out:

- The basemat and slabs are supported on 10 ft of crushed limestone, which would require higher water velocities to erode than inflow due to pumping can produce.

Triggering Mechanism 3 – Subsurface Erosion/Piping
CPFM 3c – Undermined buried utilities (due to pumping)

Reason for ruling out:

- Distress that can be attributed to the CPFM was not observed during the field assessments.

Triggering Mechanism 3 – Subsurface Erosion/Piping
CPFM 3d – Undermining and settlement of shallow foundation/slab (due to river drawdown)

Reason for ruling out:

- The ISFSI is a sufficient distance from the river to be outside the zone of influence for this CPFM.

Triggering Mechanism 3 – Subsurface Erosion/Piping
CPFM 3f – Undermined buried utilities (due to river drawdown)

Reason for ruling out:

- The ISFSI is a sufficient distance from the river to be outside the zone of influence for this CPFM.

Triggering Mechanism 7 – Soil Collapse (first time wetting)
CPFM 7a – Cracked slab, differential settlement of shallow foundation, loss of structural support
CPFM 7b – Displaced structure/broken connections
CPFM 7c – General site settlement

Reasons for ruling out:

- Visual observations during the assessments did not identify settlement of the site during the field assessment.
- Compacted crushed limestone below the basemat, approach slabs, and haul road does not collapse when wetted.
- Site fills were previously wetted. The peak flood elevation prior to 2011 was documented in 1993 as 1003.3 ft, which would indicate that the soils below and surrounding the building had been saturated at this time.

Triggering Mechanism 10 – Machine/Vibration-Induced Liquefaction
CPFM 10a – Cracked slab, differential settlement of shallow foundation, loss of structural support
CPFM 10b – Displaced structure/broken connections

Reasons for ruling out:

- ISFSI is not subjected to machines or vibrations that could induce liquefaction.
- Liquefaction was not observed at the site during the field assessment.

Triggering Mechanism 11 – Loss of Soil Strength due to Static Liquefaction or Upward Seepage

CPFM 11a – Cracked slab, differential settlement of shallow foundation, loss of structural support

CPFM 11b – Displaced structure/broken connections

Reason for ruling out:

- Liquefaction was not observed at the site during the field assessment.

Triggering Mechanism 12 – Rapid Drawdown

CPFM 12a – River bank slope failure and undermining surrounding structures

CPFM 12b – Lateral spreading

Reasons for ruling out:

- The ISFSI is a sufficient distance from the river to be outside the zone of influence for this PFM.
- Slope failure was not observed at the site.
- River stage level has dropped and stabilized as of October 4, 2011.

5.6.5 Results and Conclusions

Possible CPFMs for the ISFSI have been ruled out above. Therefore, there are no CPFMs related to the 2011 flood event that are applicable to the ISFSI.

5.6.6 Recommended Actions

No further actions are recommended for the ISFSI.

5.6.7 Updates Since Revision 0

Revision 0 of this Assessment Report was submitted to OPPD on October 14, 2011. Revision 0 presented the results of preliminary assessments for each Priority 1 Structure. These assessments were incomplete in Revision 0 because the forensic investigation and/or monitoring for most of the Priority 1 Structures was not completed by the submittal date. This revision of this Assessment Report includes the results of additional forensic investigation and monitoring to date for this structure as described below.

5.6.7.1 Additional Data Available

The following additional data were available for the ISFSI for Revisions 1 and 2 of this Assessment Report:

- Results of continued survey by LRA (see Attachment 6E).
- A visual inspection of the cable trench at the grades adjacent to the Electrical Equipment building was observed with no signs of distress.

5.6.7.2 Additional Analysis

The following analysis of additional data was conducted for the ISFSI:

- Results of continued survey by LRA.

  Survey data to date compared to the original baseline surveys have not exceeded the accuracy range of the surveying equipment. Therefore, deformation at the monitored locations, since the survey baseline was shot, has not occurred.

5.6.7.3 Conclusions

In the assessment of the FCS Structures, the first step was to develop a list of all Triggering Mechanisms and PFMs that could have occurred due to the prolonged inundation of the FCS site during the 2011 Missouri River flood and could have negatively impacted these structures. The next step was to use data from various investigations, including systematic observation of the structures over time, either to eliminate the Triggering Mechanisms and PFMs from the list or to recommend further investigation and/or physical modifications to remove them from the list for any particular structure. Because all CPFMs for the ISFSI have been ruled out, no Triggering Mechanisms and their associated PFMs remain credible for the ISFSI. Therefore, HDR has concluded that the 2011 Missouri River flood did not impact the geotechnical and structural integrity of the ISFSI because the potential for failure of this structure due to the flood is not significant.