5.19 Main Underground Cable Bank, Auxiliary Building to Intake Structure

5.19.1 Summary of Main Underground Cable Bank, Auxiliary Building to Intake Structure

Baseline information for the Main Underground Cable Bank from the Auxiliary Building to the Intake Structure is provided in Section 2.0, Site History, Description, and Baseline Condition.

The portion of the Main Underground Cable Bank system covered under this section extends from the Auxiliary Building to MH-31, which is adjacent to the southwest corner of the Intake Structure. There are two duct banks that begin at the south face of the Auxiliary Building. The two ducts turn 90° and combine into one 7-ft-wide, 3-ft-2.5-in.-deep, concrete-encased duct bank. The duct bank runs east to MH-5 in a corridor between the outside face of the Turbine Building and the Turbine Building South Switchyard. At MH-5, the ducts are split into two separate duct banks before penetrating the manhole. The ducts then turn 90° to the north and run parallel to the east face of the Service Building. Southeast of the location of fuel tank FO-10, the duct bank turns to the northeast and angles toward the Intake Structure. Adjacent to the southwest corner of the Intake Structure, the duct bank makes a final bend to the east and terminates at MH-31. The duct bank configuration transitions between MH-5 and MH-31. The size of the duct bank entering MH-31 is 4 ft 9 in. wide by 4 ft 1.5 in. deep per referenced plan data. The conduits from MH-31 feed into the west side of the Intake Structure. As discerned during field observations, MH-31 is partially filled with insulation installed on the north and south walls of the structure, which reduces the open space of the manhole to a very narrow center channel area.

5.19.2 Inputs/References Supporting the Analysis

Table 5.19-1 lists references provided by OPPD and other documents used to support HDR's analysis.

Table 5.19-1 - References for Main Underground Cable Bank, Auxiliary Building to Intake Structure

Document Title	OPPD Document Number (If applicable)	Date	Drawing No./ Page Number(s)
Underground Duct System	CE-79-3 (#60184)	12/13/2002	
Site Plan Underground Ducts – Manholes – Outdoor Lighting – Fence Grounding	11405-E-319 (#12582)	10/30/2006	
Underground Ducts & Manholes Sections & Details SH 1	11405-E-321, Sht. 1 (#12583)	7/22/2011	
Underground Ducts & Manholes Sections & Details SH 2	11405-E-321, Sht. 2 (#12584)	6/30/1973	
Underground Ducts & Manholes Sections & Details	11405-E-322, Sht. 3 (#12585)	10/30/2007	
Electrical Underground Duct Bank – Site Plan	11405-S-410 (#16581)	12/14/2004	
Foundation Plan Transformer Yard	11405-S-411 (#16582)	1/29/1975	
Naval Facilities Engineering Command, Design Manual 7.01, Soil Mechanics		9/1986	All
Incident Report Summary	CR 2011-8477	10/18/2011	All

Detailed site observations—field reports, field notes, and inspection checklists—for the Main Underground Cable Bank from the Auxiliary Building to the Intake Structure are provided in Attachment 8.

Observed performance and pertinent background data are as follows:

- OPPD assistance is required for inspection of the electrical duct bank manholes and appurtenant system components. Access to and egress from the manholes will be required by OPPD personnel to assist in the evaluation of the system.
- Water levels in the system require that manholes and appurtenant ducts be pumped dry before the interior of manholes can be inspected.
- MH-5 was opened by OPPD employees and then emptied by Thiele Geotech employees using a "Jet-Vac" on September 14, 2011. The water level prior to beginning of vacuuming activities measured 8.8 ft from the rim of the manhole. Due to the size of the vacuum storage tank, multiple trips were made to empty the manhole.
- After MH-5 was emptied, observations were made to determine whether inflow of water could be observed. No drainage into the manhole was observed during the initial 15 minutes after the manhole was emptied. Approximately 1 hour and 10 minutes later, no additional water accumulation was observed when the manhole was rechecked.
- The Aqua Dam that surrounded much of the PA crossed the Underground Cable Bank.
- The Aqua Dam failed for a short period of time because it was damaged, which allowed floodwater to enter the area inside the perimeter of the Aqua Dam. All surfaces above the Underground Cable Bank were inundated when the Aqua Dam failed.
- Equipment outside the perimeter of the replacement Aqua Dam was inundated for an extended period of time. A hole in the pavement and a void area beneath the concrete slab are north of the Security Building and east-southeast of MH-5. The hole and void area are outside the perimeter of the Aqua Dam that surrounded much of the PA. The pavement failure occurred at the intersection point of pavement jointing. The hole in the pavement is irregular-shaped and is more than 1 ft wide both in the north–south and east–west directions. The area beneath the hole was approximated as a 4-ft-diameter-by-10-in.-deep void as measured by a tape measure through the hole.
- The hole in the pavement is near the observed discharge point of a pump operated prior to the removal of the Aqua Dam. The void might be attributed to scour created by the discharge of the pump operating for an extended period of time in one place or to subsurface erosion.
- Fire Protection Cabinet FP-3C north of the Security Building and east-southeast of MH-5 is located in proximity to the pavement failure and void area discussed above. The fire hydrant was tested on September 13, 2011 (reportedly), and failed. According to OPPD operations personnel testing FP-3E during site inspections, the base of FP-3C cracked when the valve was opened. The fire hydrant was shut down, and the access cabinet was tagged out. The cause of failure was unknown at the time field observations were made..
- Concrete in the corridor that extends between the Service Building and the Intake Structure exhibits conditions that indicate distress including cracking, slab settlement, and undermining. Pavement slab settling was observed northwest of the Intake Structure and east of the abandoned acid tank. A hollow-sounding pavement area was noticed east of the Service Building truck dock. And pavement cracking was evident throughout the entire area, although most of the pavement cracking could be pre-existing conditions due the age and use of the facility.

- As early as 1993, excessive flow into a sump in the Turbine Building basement was observed. Subsequently, this flow was attributed to unfiltered groundwater entering breaks in drainage pipes under the Turbine Building basement floor slab.
- In 1997 a void, estimated to be approximately 10 x 8 x 1 ft, was documented below the basement floor slab in the Turbine Building. For further information see Section 5.8. A more detailed discussion of this KDI is presented in Section 4.1.
- Settlement of a column in the Maintenance Shop, north of the Turbine Building, has been documented. The Turbine Building and the Maintenance Shop are west of the corridor and associated utility alignments within the corridor.
- The fire hydrant located in FP-3E was being tested on September 13, 2011, during site investigations. No operational problems were observed during the time on site.
- OPPD operation personnel testing the fire hydrant at FP-3E were questioned about other fire hydrant tests. One such OPPD employee noted that no problems were observed for the fire hydrant at FP-3D during testing. The information on the problem at FP-3C, noted previously, was gathered at this time.

5.19.3 Assessment Methods and Procedures

5.19.3.1 Assessment Procedures Accomplished

Assessments were made by walking the cable bank alignment and observing surface features of the system (manholes) and the ground surface overlying the underground cable bank. The surface assessment included using a fiberglass T-probe to hand probe the ground surface along the utility alignments and adjacent areas to determine relative soil strength. The assessment focused on identifying conditions indicative of potential flood-related impacts or damage to the utility as follows:

- Ground surface conditions overlying and immediately adjacent to the utility and its backfilled trench including scour, subsidence or settlement, lateral spreading, piping, and heave
- Soft ground surface areas (native soil, engineered fill, or limestone gravel pavement) as determined by probing
- Water accumulations and flows in subsurface system components (manholes and concrete cable encasement pipes)
- Damage to at-grade or above-grade system features and equipment
- Variance from normal installation conditions including settled, tilted, or heaved system features and equipment
- Operation of the system and appurtenant equipment (i.e., is the system operational?)

Additional investigations were performed to further characterize the subsurface at the facility including areas where conditions indicative of potential flood-related impacts or damage were observed. These included the following non-invasive geophysical and geotechnical investigations.

- GPR. (Test reports were not available at the time of Revision 0.)
- Seismic surveys (seismic refraction and refraction micro-tremor). (Test reports were not available at the time of Revision 0.)

- Geotechnical investigations including test borings with field tests (SPT and CPT) and laboratory tests. Note that OPPD required vacuum excavation for the first 10 ft of proposed test holes to avoid utility conflicts. Test reports will therefore not address soil conditions in the upper 10 ft of site and locations where shallow utilities exist. (Test reports were not available at the time of Revision 0.)

5.19.3.2 Assessment Procedures Not Completed

Assessments of the Underground Cable Bank, Auxiliary Building to Intake Structure, that were not completed include the following:

- The interior of Underground Cable Cank manholes and connecting concrete-encased cable pipes in the PA were inspected only with visual observations that were possible from above and behind temporary safety railings. A manhole is a confined space as defined by OSHA regulations. In accordance with these regulations and OPPD FCS safety procedures, manhole entry is a permit-required confined space entry and can only be performed by appropriately trained OPPD personnel.
- No excavation to inspect underground systems and conditions was performed.
- No camera inspection of the system was completed.

5.19.4 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 5.19.4.1. The CPFMs carried forward for detailed assessment are discussed in Section 5.19.4.2.

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

All of 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
CPFM 2c – Undermined buried utilities

Reason for ruling out:

- No surface erosion was observed along the ground surface overlying the alignment of the Main Underground Cable Bank. In addition, only localized and limited surface erosion was observed on the ground surface across the facility. The Main Underground Cable Bank system is constructed at depths ranging from about 5 to 11 ft below existing ground surface and sufficiently below potential scour depths indicated by erosion features observed in other areas.

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

Reason for ruling out:

- Soil supporting and surrounding the Main Underground Cable Bank system has been previously wetted. The peak flood elevation prior to 2011 was 1003.3 ft, which occurred in 1993.

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
CPFM 10c – Additional lateral force on below-grade walls

Reasons for ruling out:

- Machine vibrations from the facility (turbine and various pumps) have historically occurred, and no indications of these CPFMs are evident.
- Pumps used on site during the flood event were insufficient to cause ground or structure vibrations sufficient to initiate soil liquefaction. Visible indications of liquefaction were not observed around the areas where the pumps were operating, and no occurrences of liquefaction were reported to HDR.
- No structure movements indicative of soil liquefaction and resultant settlement were observed; no structure cracking or lateral movements were observed.

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
CPFM 11c – Additional lateral force on below-grade walls

Reasons for ruling out:

- The structures showed no signs of distress at the time of field assessments.
- Liquefaction was not observed at the site.

Triggering Mechanism 13 – Submergence

CPFM 13a – Corrosion of underground utilities

Reason for ruling out:

- Underground utilities and structures are located below the design flood elevation for the facility. Groundwater elevations controlled by Missouri River water elevations, percolation of storm precipitation, and winter snow melt would be expected to contact underground improvements including constructed steel and concrete facility elements. As such, steel and concrete site improvements are designed to withstand the corrosive environment of groundwater and wetted soil.

Triggering Mechanism 14 – Frost Effects
CPFM 14a – Heaving, crushing, or displacement

Reasons for ruling out:

- Utility will not be adversely affected due to frost heave as long as joints remain tight.
- Manholes are founded below frost level and should not heave.
- Conditions have not been changed due to flood conditions.

5.19.4.2 Detailed Assessment of Credible Potential Failure Modes

The following CPFMs are the only CPFMs carried forward for detailed assessment for the Underground Cable Bank, Auxiliary Building to Intake Structure, as a result of the 2011 flood. This detailed assessment is provided below.

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

The Triggering Mechanism and CPFMs could occur as follows: multiple potentially connected seepage paths existed in the soil backfill at the site, including soil backfill in utility trenches, granular trench bedding, building floor drains with open/broken joints, and pre-existing defects/voids under pavement. The paths are exposed at some locations to the river floodwater (e.g., a surficial void north of the Security building). This network of seepage paths is connected to several pumping sources: the sump pit in the Turbine Building, Manhole MH-5, and a series of surface pumps inside the perimeter of the Aqua Dam. The pumps were operated for an extended period of time, maintaining a head differential on the seepage path networks. Gradient was sufficient to begin erosion of surrounding soil. Seepage is unfiltered, and erosion continues unarrested. Erosion extends out, intercepting the network of utility trenches, including the Underground Cable Bank. Voids are created under the pavement and along the utility trench walls. The potential damage includes settlement of cable bank and manholes, causing a loss of electrical connectivity.

Below are field observations and data that support the likelihood of these CPFMs:

- MH-5 was pumped for the duration of flooding to remove water entering into the manhole. Known water sources included ducts from MH-31 and ducts running to the Auxiliary Building. This created a head differential.
- The flow of water into MH-5 was observed on multiple field visits. Sources of the water were not documented.
- Sediment deposits (and fish) were observed in the bottom the MH-5 when it was emptied on September 14, 2011. The sediment could be an indication of piping and subsurface erosion.

- The area inside the perimeter of the Aqua Dam was pumped dry, creating a hydrostatic head condition between the areas inside and outside the perimeter of the Aqua Dam. The area inside the perimeter of the Aqua Dam was pumped from several locations, creating points toward which underground piping and subsurface flows would tend to flow.
- A void area and potential piping location was observed beneath the concrete slab just north of the Security Building and east-southeast of MH-5.
- Based on a conversation with the OPPD operations employee testing FP-3E on September 13, 2011, fire hydrant FP-3C, located northeast of the Security Building, was tested that day and failed. According to the OPPD operations employee, the base of FP-3C cracked when the valve was opened. The fire hydrant was shut down, and the access cabinet was tagged out. The cause of failure was unknown at the time field observations were made.
- Pavement distress was observed along the driveway corridor between the Intake Structure and the Service Building. The area north of where the duct bank crosses the corridor includes observed slab settlement and undermining (as evidenced by hollow-sounding pavement areas).
- The Turbine Building sump pit was pumped continually during the flood event. The five pipes connected to this sump pit are floor drain and condensate system flush drain pipes. Because this is a floor drain system, no infiltration of groundwater should occur in the system. The infiltration of groundwater into the system indicates an open flow path of some sort.

Below are field observations and data that indicate these CPFMs are unlikely:

- Sediment and fish were observed in the bottom of MH-5 when it was emptied on September 14, 2011. Sediment accumulations and small fish at the bottom of MH-5 might not be associated with these CPFMs. The manhole was uncovered when the Aqua Dam failed and the area was inundated. Sediment and fish could have been transported into the manhole with floodwater.
- The observed hole in the pavement, north of the Security Building, could have been developed by outflow from the surface pumps and might not be associated with these CPFMs. Temporary surface pumps were pumping water back into the river with hoses placed over the Aqua Dam. One of the discharge points was near the observed hole. Concentrated discharge flow might have eroded pavement and created the observed hole.
- Subsurface erosion paths are limited between the Intake Structure and the Service Building. The top of the Circulation Tunnel extends to el. 1002.5 ft. Pavement grades in the area are in the range of el. ±1004 ft. Thus, for a large section of the corridor between the Intake Structure and Service Building, the only possible subsurface flow path is directly beneath the pavement slab.
- Any void spaces created by subsurface erosion will have to be significant to create conditions to cause the duct bank to fail, and settlement would be visible from the surface.
- Observed subsurface damage indicators or known instances of damage in the corridor are not located immediately adjacent to the Main Underground Cable Bank.

Below are data gaps (data still required to assess these CPFMs):

- GPR data (Task completed, awaiting reports). The occurrence and extent of subsurface erosion is not known at this time.
- Seismic survey (refraction/tomography and ReMi).

The following table describes observed distress indicators and factors that would increase the risk associated with these CPFMs and factors that would make these CPFMs less likely.

Adverse (Degradation/Direct Floodwater Impact More Likely)	Favorable (Degradation/Direct Floodwater Impact Less Likely)
A hole in the pavement with a void space underneath was observed north of the Security Building and east of MH-5. This location was outside the perimeter of the Aqua Dam and might be a void developed due to subsurface erosion.	The observed hole in the pavement with a void space underneath could have been developed by outflow from the surface pumps and might not be associated with these CPFMs. Temporary surface pumps were pumping water back over the Aqua Dam. One of the pump discharge points was near the observed hole (see Attachment 5, General Field Reports, FR 118). Concentrated discharge flow could have created the observed hole.
MH-5 was pumped continually during the time the site was flooded.	
Monitoring well data seems to indicate a cone of influence around the facility that might be attributable to the subsurface drainage flowing to the Turbine Building sump	
Data Gaps: • GPR data are not available at the time of Revision 0 to assist in determining possible void areas at the facility.	

Conclusion

Significance

Potential for Degradation/Direct Floodwater Impact

MH-5 was continually pumped during the flood event, creating a point of head differential that created a potential direct path along the electrical duct bank for subsurface erosion. In addition, areas of pavement distress were observed in the corridor between the Intake Structure and the Service Building that might be tied to MH-5 pumping. Thus, a direct potential source for subsurface erosion is linked to the system, and potential indicators of subsurface erosion are located in the region of the duct bank alignment.

The Turbine Building sump, associated with KDI #1 (see Section 4.1), also creates a potential subsurface erosion path that could affect the electrical bank where it is located closest to the facility. Groundwater monitoring well readings seem to indicate that there is a zone of influence that can be attributed to drawdown from a deep source such as the Turbine Building sump. Due to high groundwater conditions, high head conditions created the potential for increased subsurface erosion to points of zero pressure (i.e., pumped locations) during the 2011 flood.

The potential for degradation is considered high.

Implication

The Underground Cable Bank is a structural entity. The cables in the duct bank are flexible, and some minor deflection can be tolerated. Small signs of distress due to this CPFM might be noticeable to experienced OPPD employees who work installing cables. A large-scale failure of the duct bank and shearing of the cables would likely only be possible in the case of a very large void. Large underground voids usually present surface indications of underground distress. Therefore, the implication of degradation for these CPFMs is low.

Confidence

Information on the duct bank is limited to inspection information gathered from observations made along the duct bank alignment and visual observations made through the tops of MH-5 and MH-31. Detailed information was not available from an inside inspection of the manholes or from information provided by OPPD employees. Therefore, the confidence in the above assessment is low. "Low Confidence" indicates that additional information and studies are required to increase the confidence in the above findings.

Summary

For CPFMs 3a and 3c, as discussed above, the combined consideration of the potential for degradation and the implications of that degradation to the system puts it in the "significant" category. As discussed above, the potential for degradation is composed of two parts. The potential for subsurface erosion appears to be high based on flood-induced conditions and data regarding the Turbine Building sump and MH-5. However, the potential for subsurface erosion to impact the underground duct bank to a point of failure without visible signs of distress prior to failure of the system appears to be low. The data currently collected are not sufficient to rule out this CPFM. Therefore, the confidence in the above assessment is low, which means more data or inspections might be necessary to draw a conclusion.

Triggering Mechanism 3 – Subsurface Erosion/Piping

CPFM 3d – Undermining and settlement of shallow foundation/slab (due to river drawdown)

CPFM 3f – Undermined buried utilities (due to river drawdown)

This CPFM is similar to CPFMs 3a and 3c, but instead of pumping, the gradient is created by rapidly receding river level.

The Triggering Mechanism and CPFMs could then occur as follows: river level drops faster than pore water pressure in the soil foundation can dissipate. A gradient is created that moves water and soil into existing defects and enlarges voids along the cable bank and through the soil toward the river via piping features or networks. Other consequences include damage to adjacent structures such as the Fire Protection System Piping, the Raw Water Piping, and the Trenwa.

Below are field observations and data that support the likelihood of these CPFMs:

- Field observation of the river bank has not been completed since the river release rate stabilized at 40,000 cfs at FCS on October 4, 2011. The nearest utility installations have not been observed on a regular basis to inspect for developing conditions or distress indicators.

Below are field observations and data or site conditions that indicate these CPFMs are unlikely:

- 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.
- The Main Underground Cable Bank is offset from the river bank. This offset reduces the likelihood that rapid drawdown and related subsurface piping to the river bank will impact the Main Underground Cable Bank.
- Soils in the area of the Main Underground Cable Bank and to the east are backfill materials that were placed and compacted during construction of site improvements and therefore would be expected to be less susceptible to rapid drawdown impacts.
- Void spaces created by subsurface erosion would have to be significant to create conditions to cause the duct bank to fail.

Below are data gaps (data still required to assess these CPFMs):

- Inspection of the riverbank following drawdown to normal river elevations.
- Geophysical surveys (GPR, seismic refraction and refraction micro-tremor) in the PA. (Test reports were not available at the time of Revision 0.)
- Geotechnical test borings in the PA. Note that OPPD required vacuum excavation for the first 10 ft of proposed test holes to avoid utility conflicts. Therefore, test reports will not show soil conditions in the upper 10 ft of test boring logs. (Test reports were not available at the time of Revision 0.)

The following table describes observed distress indicators and factors that would increase the risk associated with these CPFMs and factors that would make these CPFMs less likely.

Adverse (Degradation/Direct Floodwater Impact More Likely)	Favorable (Degradation/Direct Floodwater Impact Less Likely)
Floodwater inundated the site for an extended period of time and totally saturated site soils.	The existing river bank is protect and armored. No history of river bank failure has been noted at the site due to past flood events.
	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 the FCS on October 4, 2011.
Data Gaps: • Inspection of the riverbank following drawdown to normal river elevations	

Conclusion

Significance

Potential for Degradation/Direct Floodwater Impact

The installation of the Main Underground Cable Bank system nearest the river bank is MH-31, located at the southwest corner of the Intake Structure. The structure is located on the west side of the structure, and a direct connection from the manhole to the river bank is not possible.

The river bank is armored and has historically protected and stabilized the existing river bank. The potential for degradation is reduced due to these improvements.

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 the FCS on October 4, 2011. Groundwater levels had thus started to stabilize between the termination of drawdown reduction and the time of Revision 0. The potential for development of subsurface erosion due to river drawdown decreases with the time due to stabilization between groundwater elevations and river elevations. The potential for these CPFMs thus decreases with time as long as subsurface erosion has not instigated and created a flow path that will be subject to future impacts.

As groundwater elevations and river elevations stabilize, the head potential between the two conditions will decrease, and the possibility of subsurface erosion will also decrease correspondingly. In addition, the stabilized river embankment reduces the likelihood of these CPFMs.

Overall, the potential for degradation is considered low for these CPFMs.

Implication

The Main Underground Cable Bank is a structural entity. The cables in the duct bank are flexible, and some minor deflection can be tolerated. Small signs of distress due to this CPFM might be noticeable to experienced OPPD employees who work installing cables. A large-scale failure of the duct bank and shearing of the cables would likely only be possible in the case of a very large void. Large underground voids usually present surface indications of underground distress. Therefore, the implication of degradation for these CPFMs is low.

Confidence

Data are not available to make a determination on subsurface erosion due to river drawdown. Time between the termination of the steady reduction of dam release rates and the most current time without indications of subsurface erosion does not decrease the likelihood that damage is not present. Thus, confidence with the assessment is low.

Summary

For CPFMs 3d and 3f, as discussed above, the combined consideration of the potential for degradation and the implications of that degradation to the system put it in the "not significant" category. As discussed, the potential for degradation is considered low because the potential for highly elevated groundwater elevations versus river elevations is unlikely due to stabilized river levels, structural soil backfill on the site, and the protected nature of the existing bank. The data currently collected are not sufficient to rule out these CPFMs. Therefore, the confidence in the above assessment is low, which means more data or continued monitoring and inspections might be necessary to make a final assessment.

Triggering Mechanism 4 – Hydrostatic Lateral Loading (water loading on structures)

CPFM 4c – Wall failure in flexure
CPFM 4d – Wall failure in shear
CPFM 4e – Excess deflection

The Triggering Mechanism and CPFMs could occur as follows: water level rises and imposes additional unbalanced lateral pressure on manhole walls, exceeding shear or flexure capacity of the wall and/or causing excessive deflection or failure. Alternatively, the wall transfers the load to supporting elements, overloading them. The supporting elements fail, allowing below-grade walls to fail. These CPFMs are credible only for possible degradation to Manhole MH-5. The remainder of the system is non-structural (a poured concrete encasement with no walls, floors, or roof structures) or was not exposed to hydrostatic loading beyond design standards (MH-31 was flooded and therefore balanced with regard to hydrostatic loading).

Below are field observations and data that support the likelihood of these CPFMs:

- MH-5 was pumped for the duration of flooding to remove water coming in from duct banks extending between the Auxiliary Building and MH-31. Floodwater outside the perimeter of the Aqua Dam was above grade and possibly created a hydraulic head condition greater than the design standard for underground structures (i.e., hydraulic loading to the ground surface).

Below are field observations and data that indicate these CPFMs are unlikely:

- No movement or distress of MH-5 concrete cover was observed.
- After pumping MH-5 dry on September 14, 2011, no visible water inflow was noted over a 1 hour and 10 minute time period.

Below are data gaps (observations and data still required to assess these CPFMs):

- Visual inspection and photographs of the inside of MH-5.
- Visual inspection of the inside of MH-31 was not made. Insulation on the sides of the manhole prevents access and visual inspection.
- Basis of design/design assumptions for the manhole vault.

The following table describes observed distress indicators and factors that would increase the risk associated with these CPFMs and factors that would make these CPFMs less likely.

Adverse (Degradation/Direct Floodwater Impact More Likely)	Favorable (Degradation/Direct Floodwater Impact Less Likely)
MH-5 was continually pumped during the time the site was flooded.	Manhole structures and underground utilities are designed for groundwater conditions and forces.
Ground was saturated when the Aqua Dam was in place.	No leakage was noted after observing MH-5 get pumped dry with high groundwater conditions still existing.
Data Gaps: • Visual inspection and photographs of the inside of MH-5 • Visual inspection of the inside of MH-31	

Conclusion

Significance

Potential for Degradation/Direct Floodwater Impact

Indicators for initiation of CPFMs 4c, 4d, and 4e on only the MH-5 element of the Main Underground Cable Bank have been observed. These include continual pumping from Manhole MH-5 and floodwater elevations above the ground surface outside the perimeter of the Aqua Dam, resulting in hydraulic head conditions greater than the design standard for MH-5. However, MH-5 is designed for high groundwater conditions and forces. The possible additional forces related to about 3 ft of additional head from floodwater outside the perimeter of the Aqua Dam are not believed to be sufficient to cause degradation of MH-5 due to these CPFMs. In addition, following pumping MH-5 dry on September 14, 2011, no visible water inflow was noted over a 1 hour and 10 minute time period. Therefore, the potential for degradation to the Main Underground Cable Bank system due to CPFMs 4c, 4d, and 4e is low.

Implication

As stated, a couple of CPFM 4c, 4d, and 4e indicators have been observed supporting low (or unlikely) potential for degradation to the MH-5 element of the Main Underground Cable Bank system. The occurrence of CPFMs 4c, 4d, and 4e on a large scale could result in degradation of MH-5, including wall failure in flexure, shear, or deflection. For degradation from these CPFMs to impact service (i.e., damage that renders electrical cables carried by the system inoperable), degradation would need to result in complete failure of supporting elements of MH-5 and this is not deemed likely. Therefore, the implication of degradation for these CPFMs is low.

Confidence

Currently, evidence supporting possible degradation of the MH-5 element of the Main Underground Cable Bank system is based on possible forces that are not supported by visual observations of physical site conditions as discussed above. Geophysical reports including information obtained through geophysical surveys completed at or in the vicinity of the MH-5 element of the Main Underground Cable Bank system were not available at the time of Revision 0. Therefore, the confidence in the above assessment is low. "Low confidence" indicates that additional information and studies are required to increase the confidence in the above findings.

Summary

For CPFMs 4c, 4d, and 4e, as discussed above, the combined consideration of the potential for degradation and the implications of that degradation to the system puts it in the "not significant" category. The data currently collected are not sufficient to rule out or confirm these CPFMs, and more data or continued monitoring and inspections might be necessary to draw a conclusion.

Triggering Mechanism 6 – Buoyancy, Uplift Forces on Structures

CPFM 6b – Cracked slab, loss of structural support
CPFM 6c – Displaced structure/broken connections

The Triggering Mechanism and CPFMs could occur as follows: water level rises and water is pumped from MH-5, causing an uplift force. This uplift force exceeds the weight of the structure, causing structure slabs to crack and buckle. Additional damage could include structure displacement and broken utility connections.

Below are field observations and data that support the likelihood of these CPFMs:

- MH-5 was pumped for the duration of flooding to remove water coming in from duct banks extending between the Auxiliary Building and MH-31 and possible other sources. This created a head differential.
- Water levels outside the perimeter of the Aqua Dam created hydrostatic uplift forces on MH-5 while it was being pumped that were potentially greater than the hydrostatic forces that the manhole was designed to resist.

Below are field observations and data that indicate these CPFMs are unlikely:

- No movement or distress of MH-5 concrete cover was observed.
- After MH-5 was emptied, observations were made to determine whether inflow of water could be observed. No drainage into the manhole was observed during the initial 15 minutes after the manhole was emptied. One hour and 10 minutes later, no additional water accumulation was observed.

Below are data gaps (observations and data still required to assess these CPFMs):

- Visual inspection and photographs of the inside of MH-5.
- Visual inspection of the inside of MH-31 was not and cannot be made. Insulation on the sides of the manhole prevents access and visual inspection.
- Basis of design data for the system are unknown.

The following table describes observed distress indicators and factors that would increase the risk associated with these CPFMs and factors that would make these CPFMs less likely.

Adverse (Degradation/Direct Floodwater Impact More Likely)	Favorable (Degradation/Direct Floodwater Impact Less Likely)
	No indications of upward displacement were observed in the field.
	A steel pipe extension above the manhole access opening and stacked sandbags around the manhole extension added ballast to the top of the structure that offset the effects of increased buoyancy on the structure.
Data Gaps: • Visual inspection and photographs of the inside of MH-5 • Visual inspection of the inside of MH-31	

Conclusion

Significance

Potential for Degradation/Direct Floodwater Impact

MH-5 was located inside the perimeter of the Aqua Dam and was pumped continually during the flood event. High water levels existed outside the perimeter of the Aqua Dam, creating a hydraulic head condition. Paving in the corridor inside the perimeter of the Aqua Dam created a barrier that prevented the water from equalizing on the area inside the perimeter of the Aqua Dam. The confined water potentially transmitted uplift forces to structures inside the perimeter of the Aqua Dam, including MH-5, which was pumped during the same time as the high hydrostatic forces. The potential for degradation due to flood conditions was increased above design norms. The potential for buoyancy forces and chances of degradation were offset by the weight of sandbags and other materials on top of the manhole. Overall, the potential for degradation is considered low for these CPFMs.

Implication

Underground structures are normally designed for groundwater conditions and will experience buoyancy forces. In addition, a sandbag installation on top of MH-5 and a pipe extension connected to the manhole opening that extended above the hydrostatic head conditions helped weigh down the structure and offset buoyancy induced by flood conditions. No indications of movement or distress were noted from surface observations. Because groundwater levels have dropped with river drawdown, the implication of degradation related to these CPFMs occurring is considered low.

Confidence

As discussed above, the potential for degradation is considered low because the potential for impacts due to buoyancy is no longer a factor. Since no apparent distress was noted and none is expected due to the groundwater elevations at the present time, confidence in the assessment results is high.

Summary

For CPFMs 6b and 6c, as discussed above, the combined consideration of the potential for degradation and the implications of that degradation to the system puts it in the "not significant" category. As discussed above, the potential for degradation is considered low because the potential for buoyancy impacts from flood conditions no longer exists. Confidence in the above assessment is high.

Triggering Mechanism 12 – Rapid Drawdown

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

The Triggering Mechanism and CPFMs could occur as follows: the river level drops faster than pore water pressure in the soil can dissipate. The saturated soil is elevated above the dropping river level. The sloped bank of the river provides no lateral pressure support for the saturated soil. At some point there is insufficient support on the river side to support the saturated soils. At that point, the soils experience slope movements or even failure. Generally, slope failures associated with rapid drawdown are relatively localized and shallow in nature; however, deeper failures can occur.

The river stage level has dropped and stabilized at a level corresponding to the nominal normal river level at 40,000 cfs as of October 4, 2011. At the time of Revision 0, the groundwater levels had not yet stabilized to nominal normal levels. Therefore, it is possible that new distress indicators could still develop. Field observation of the river bank area has not been performed since the river level has dropped.

The following table describes observed distress indicators and other data that would increase or decrease the potential for degradation associated with these CPFMs for the Underground Cable Bank, Auxiliary Building to Intake Structure.

Adverse (Degradation/Direct Floodwater Impact More Likely)	Favorable (Degradation/Direct Floodwater Impact Less Likely)
The Main Underground Cable Bank is in close proximity to the river.	No distress was observed at the time of HDR's site inspection.
Elevated saturated soils and elevated flood levels provided a water source.	

Data Gaps:

- Observations of the riverbank following drawdown to nominal normal river elevations
- Geophysical investigation data to address any observed concerns
- Inclinometer readings that will provide an indication of slope movement

Conclusion

Significance

Potential for Degradation/Direct Floodwater Impact

The river stage level has dropped and stabilized at a level corresponding to the nominal normal river level at 40,000 cfs as of October 4, 2011. Rapid drawdown has been controlled, and continued river drawdown is not expected to occur at a rate that would initiate this CPFM. The potential for degradation for this CPFM is considered low.

Implication

The occurrence of this CPFM on a large scale could negatively impact the integrity of the cables in the trench. No distress has been observed during site inspections, however. Therefore, the implication of the potential degradation for these CPFMs is low.

Confidence

Although no distress has been observed to date, the river bank has not been inspected for signs of degradation and slope failure. Therefore, the confidence for these CPFMs is low.

Summary

For CPFMs 12a and 12b, as discussed above, the combined consideration of the potential for degradation and the implications of that degradation to a structure of this type puts it in the "not significant" category. The river bank has not been inspected for signs of degradation and slope failure; therefore, these CPFMS cannot be ruled out, and the confidence is low, which means continued monitoring and inspections might be necessary to draw a conclusion.

5.19.5 Results and Conclusions

The CPFMs evaluated for the Main Underground Cable Bank, Auxiliary Building to Intake Structure, are presented in the following matrix, which shows the rating for the estimated significance and the level of confidence in the evaluation.

	Low Confidence (Insufficient Data)	High Confidence (Sufficient Data)
Potential for Failure **Significant**	CPFM 3a CPFM 3c	
Potential for Failure **Not Significant**	CPFM 3d CPFM 3f CPFM 4c CPFM 4d CPFM 4e CPFM 12a CPFM 12b	CPFM 6b CPFM 6c

5.19.6 Recommended Actions

Certain actions are recommended for the Main Underground Cable Bank, Auxiliary Building to MH-31, to address CPFMs 3a, 3c, 3d, 3f, 4c, 4d, 4e, 6a, and 6b. These actions are discussed, separately as appropriate, in the following paragraphs.

The following actions are recommended to address CPFMs 3a, 3c, 3d, and 3f:

- Further forensic investigations and physical modifications are recommended to address CPFMs 3a and 3c for the Main Underground Cable Bank. These CPFMs are associated with unfiltered flow of groundwater into the Turbine Building basement drain piping system (KDI #1). These recommendations are described in detail in Section 4.1.
- CPFMs 3a, 3c, 3d, and 3f are associated with the distress in and near the Paved Access Area between the Service Building and the Intake Structure (KDI #2). These recommendations are described in detail in Section 4.2.

The following actions are recommended to address the CPFMs listed:

- Continued monitoring is recommended to include a continuation of the elevation surveys of the previously identified targets on this structure and surrounding the site. The purpose is to monitor for signs of structure distress and movement or changes in soil conditions around the structure. The results of this monitoring will be used to increase the confidence in the assessment results. Elevation surveys should be performed weekly for 4 weeks and biweekly until December 31, 2011. At the time of Revision 0, groundwater levels had not yet stabilized to nominal normal levels. Therefore, it is possible that new distress indicators could still develop. If new distress indicators are observed before December 31, 2011, appropriate HDR personnel should be notified immediately to determine whether an immediate inspection or assessment should be conducted. Observation of new distress indicators might result in a modification of the recommendations for this structure.
- Inspect the interior of MH-5, including walls, floor, cover, joints, and duct bank penetrations. Obtain photographic record of conditions.
- Inspect the interior of MH-31 as practical.
- Have OPPD initiate a procedure to monitor for problems during cable-pulling operations. Unusual/non-typical conditions encountered or noted during cable pulling operations should be documented, reported, and evaluated for additional investigation, as appropriate (i.e., if strong resistance is encountered during cable pulling, then consider video camera inspection of the problem and adjacent ducts.)
- Perform a detailed analysis of the pavement subgrade and trench alignments if the pavement in the corridor between the Intake Structure and the Service Building is replaced.
- Perform detailed geophysical analysis (GPR and/or seismic surveys) of the system subgrade and trench alignments if failure is suspected or if adjacent/nearby site improvements indicate failure due to subsurface erosion or piping.
- Review geophysical and geotechnical reports to evaluate the data as they pertain to the Underground Cable Bank.
- Observe the river bank for signs of degradation and slope failure.

5.19.7 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.

5.19.7.1 Additional Data Available

The following additional data were available for the Main Underground Cable Bank for Revisions 1 and 2 of this Assessment Report:

- Results of KDI #1 forensic investigation (see Section 4.1)
- Results of KDI #2 forensic investigation (see Section 4.2)
- Additional groundwater monitoring well and river stage level data from OPPD
- Field observations of the river bank (see Section 5.25)
- Results of FWD investigation by AET (see Attachment 6B)

- Results of geophysical investigation by Geotechnology (see Attachment 6C)
- Results of geotechnical investigation by Thiele Geotech (see Attachment 6A)
- Data obtained from inclinometers by Thiele Geotech (see Attachment 6A)
- Results of continued survey by LRA (see Attachment 6E)
- Inspection reports for MH-5 and MH-31

5.19.7.2 Additional Analysis

The following analysis of additional data was conducted for the Main Underground Cable Bank:

- Groundwater monitoring well and river stage level data from OPPD

  Data show that the river and groundwater have returned to nominal normal levels.

- Field observations of river bank

  No significance distress from the 2011 flood was observed.

- Results of FWD investigation by AET

  FWD and associated GPR testing performed in the Paved Access Area identified anomalies such as soft clay and broken pavement. Additional ground truthing of the investigation results were performed as part of the KDI #2 additional investigations.

- Results of geophysical investigation report by Geotechnology

  Seismic refraction and seismic ReMi tests performed around the outside perimeter of the power block as part of KDI #2 identified deep anomalies that could be gravel, soft clay, loose sand, or possibly voids.

- Results of geotechnical investigation by Thiele Geotech

  Six test borings were drilled, with continuous sampling of the soil encountered, to ground truth the Geotechnology seismic investigation results as part of the KDI #2 forensic investigation. Test bore holes were located to penetrate the deep anomalies identified in the seismic investigation. The test boring data did not show any piping voids or very soft/very loose conditions that might be indicative of subsurface erosion/piping or related material loss or movement.

  All of the SPT and CPT test results conducted for this Assessment Report were compared to similar data from numerous other geotechnical investigations that have been conducted on the FCS site in previous years. This comparison did not identify substantial changes to the soil strength and stiffness over that time period. SPT and CPT test results were not performed in the top 10 ft to protect existing utilities.

  Data from inclinometers to date compared to the original baseline measurements have not exceeded the accuracy range of the inclinometers. Therefore, deformation at the monitored locations since the installation of the instrumentation has not occurred.

- 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.

- Results of inspection report by OPPD for MH-5

  The results of the inspection indicate no apparent damages caused by 2011 flooding.

- Results of inspection report by OPPD for MH-31 (CR 2011-8477)

  Pictures of exposed concrete surfaces did not show indications of significant cracks or damage to the concrete walls and floor. Steel conduit support framing members were extremely corroded. The corrosion damage was generated of years and was not related to the 2011 flood.

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

Significance

Potential for Degradation/Direct Floodwater Impact

Except for Turbine Building sump, conditions inductive to subsurface erosion no longer exist due to present site and flood conditions. Site pumping sources have been removed, and high groundwater conditions no longer exist. The potential for these CPFMs to occur only exists in conjunction with KDI #1. Some conditions produced by subsurface erosion might still exist from site pumping sources. Areas identified by forensic investigations with indications of subsoil or subsurface issues have been addressed for further investigation and repair as necessary. Recommended actions in conjunction with KDI #2 address a majority of the areas in question as part of the Paved Access Area. Therefore, with known issues being addressed and further investigated by OPPD, the implication of the potential degradation due to these CPFMs is low.

Implication

The Main Underground Cable Bank is a structural entity. The cables in the duct bank are flexible, and some minor deflection can be tolerated. Small signs of distress due to these CPFMs might be noticeable to experienced OPPD employees who work installing cables. A large-scale failure of the duct bank and shearing of the cables would likely only be possible in the case of a very large void. Large underground voids usually present surface indications of underground distress. Therefore, the implication is low.

Confidence

With investigations and repairs associated with KDI #1 and #2 handling known issues, and contingencies for expanding investigations and repairs as needed and directed by geotechnical inspectors, confidence in addressing issues associated with this CPFM is high.

Summary

Forensic test results received since the issuance of the Rev 0 report have narrowed and defined probable areas impacted by these CPFMs. Recommended actions associated with the results of the forensic reports and site inspections will address known problem areas and will allow the direction and expansion of proposed investigations or repairs as necessary. The combined consideration of the potential for degradation and the implications to that structure or system puts it in the "not-significant" category.

Triggering Mechanism 3 – Subsurface Erosion/Piping

CPFM 3d – Undermining and settlement of shallow foundation/slab (due to river drawdown)

CPFM 3f – Undermined buried utilities (due to river drawdown)

Significance

Potential for Degradation/Direct Floodwater Impact

Based on groundwater monitoring data taken in conjunction with river drawdown and on a continuing weekly basis, groundwater levels have been dropping at a rate that closely follows the river drawdown rate. Thus, the differential head necessary to create subsurface erosion due to river drawdown has not occurred. The area most conducive to creating these CPFMs is nearest the river. River bank inspections made since the issuance of the Rev 0 report show no indications of these CPFMs. The Paved Access Area between the Intake Structure and the Service Building is the developed area nearest the river bank and includes most of the utility services that are critical to the operation of the facility. Recommended actions in association with KDI #2 will address issues that are encountered in the area. This will include instances of subsoil erosion that could have been induced (however unlikely) by river drawdown. The potential for degradation for this CPFM to occur is considered low.

Implication

The Main Underground Cable Bank is a structural entity. The cables in the duct bank are flexible and some minor deflection can be tolerated. Small signs of distress due to these CPFMs might be noticeable to experienced OPPD employees who work installing cables. A large-scale failure of the duct bank and shearing of the cables would likely only be possible in the case of a very large void. Large underground voids usually present surface indications of underground distress. Therefore, the implication is low.

Confidence

With groundwater data indicating the absence of a high head condition and the instigation of recommendations associated with KDI #2, confidence in the assessment associated with this CPFM is high.

Summary

For CPFMs 3d and 3f, as discussed above, the combined consideration of the potential for degradation and the implications to that structure or system puts it in the "not-significant category" in the assessment matrix.

Triggering Mechanism 4 – Hydrostatic Lateral Loading (water loading on structures)

CPFM 4c – Wall failure in flexure
CPFM 4d – Wall failure in shear
CPFM 4e – Excess deflection

Significance

Potential for Degradation/Direct Floodwater Impact

Based on groundwater monitoring data taken in conjunction with river drawdown and on a continuing weekly basis, groundwater levels have been dropping at a rate that closely follows the river drawdown rate. Thus, hydrostatic loading conditions due to the flood no longer exist, and the structures are designed for normal groundwater conditions. The structure most susceptible to these CPFMs would have been MH-5. From visual external inspection of the manhole, no indications of these CPFMs were apparent. The potential for degradation due to these CPFMs having occurred is low since hydrostatic loads above those of standard design conditions were limited. The manhole is intact, appears structurally sound, and showed no signs of leakage at the time of previous inspections. Internal inspections of MH-5 did not reveal significant degradation due to the 2011 flood. Thus, the potential for degradation due to these CPFMs is considered low.

Implication

As stated, a couple of CPFM 4c, 4d, and 4e indicators have been observed supporting low (or unlikely) potential for degradation to the MH-5 element of the Main Underground Cable Bank system. The occurrence of CPFMs 4c, 4d, and 4e on a large scale could result in degradation of MH-5 including wall failure in flexure, shear, or deflection. For degradation from these CPFMs to impact service (i.e., damage that renders electrical cables carried by the system inoperable), degradation would need to result in complete failure of supporting elements of MH-5, and this is not deemed likely. Therefore, the implication of degradation for these CPFMs is low.

Confidence

Groundwater levels based on recent monitoring well readings are now down to an elevation near or below the base of MH-5. Confidence is high that no additional impacts due to flooding conditions will occur based on groundwater elevations and on inspections of MH-5 that indicate the structure is sound.

<u>Summary</u>

For CPFMs 4c through 4e, as discussed above, the combined consideration of the potential for degradation and the implications to that structure or system puts it in the "not-significant category" in the assessment matrix.

Triggering Mechanism 12 – Rapid Drawdown

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

The groundwater monitoring well data and river level data indicate that excess pore pressures due to river drawdown had generally dissipated by about October 14, 2011. Field observations of the river bank on October 20, 2011, did not identify deformation of the river bank that could be attributed to slope failure or lateral spreading. Therefore, neither slope failure nor lateral spreading occurred due to the 2011 flood.

5.19.7.3 Revised Results and Recommendations

The CPFMs evaluated for the Main Underground Cable Bank from the Auxiliary Building to the Intake Structure are presented in the following matrix, which shows the rating for the estimated significance and the level of confidence in the evaluation.

CPFMs 3a and 3c for the Main Underground Cable Bank from the Auxiliary Building to the Intake Structure are associated with KDI #1. Section 4.1 and 8.3 presents the results of additional forensic investigation that was conducted to ascertain whether these CPFMs could be ruled out. The results of the additional forensic investigations show that if the recommendations for physical modifications in KDI #1 are implemented, these CPFMs are ruled out. Therefore, these CPFMs are moved to the quadrant of the matrix representing "No Further Action Recommended Related to the 2011 Flood."

CPFMs 3d and 3f for the Main Underground Cable Bank from the Auxiliary Building to the Intake Structure are associated with KDI #2. Section 4.2 presents the results of additional forensic investigation that was conducted to ascertain whether these CPFMs could be ruled out. The results of the additional forensic investigation show that these CPFMs are ruled out. Therefore, these CPFMs are moved to the quadrant of the matrix representing "No Further Action Recommended Related to the 2011 Flood."

CPFMs 4c, 4d, and 4e for the Main Underground Cable Bank from the Auxiliary Building to the Intake Structure are not associated with KDIs. Groundwater monitoring data have been gathered since the Revision 0 report and indicate groundwater levels have dropped below a level that can hydrostatically load the system and create these CPFMs. Impacts due to the effects of pumping and high hydrostatic head conditions were assessed by internal inspection of MH-5. The internal assessment of MH-5 found no indications of flood damage, and the results of the additional forensic investigation show that these CPFMs are ruled out based on present site conditions. Therefore, these CPFMs move to the quadrant of the matrix representing "No Further Action Recommended Related to the 2011 Flood."

CPFMs 12a and 12b for the Main Underground Cable Bank from the Auxiliary Building to the Intake Structure are not associated with KDIs. River bank inspections have been made, and groundwater monitoring data have been gathered since the Revision 0 report. The results of the additional forensic investigation show that these CPFMs are ruled out. Therefore, these CPFMs will be moved to the quadrant of the matrix representing "No Further Action Recommended Related to the 2011 Flood."

	Low Confidence (Insufficient Data)	High Confidence (Sufficient Data)
Potential for Failure **Significant**		
Potential for Failure **Not Significant**		CPFM 3a CPFM 3c CPFM 3d CPFM 3f CPFM 4c CPFM 4d CPFM 4e CPFM 6b CPFM 6c CPFM 12a CPFM 12b

5.19.7.4 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 Main Underground Cable Bank from the Auxiliary Building to the Intake Structure other than CPFMs 3a, 3c, 3d, 3f, 4c, 4d, 4e, 6b, 6c, 12a, and 12b had been ruled out prior to Revision 1, because CPFMs 4c, 4d, 4e, 6b, 6c, 12a, and 12b have been ruled out as a result of the Revision 1 findings, because CPFMs 3d and 3f were ruled out by the results of the KDI #2 investigations, and because CPFMs 3a and 3c will be ruled out when the physical modifications recommended for KDI #1 in Section 4.1 and 8.3 are implemented, no Triggering Mechanisms and their associated PFMs will remain credible for the Main Underground Cable Bank from the Auxiliary Building to the Intake Structure. HDR has concluded that the geotechnical and structural impacts of the 2011 Missouri River flood will be mitigated by the implementation of the physical modifications recommended in this Assessment Report. Therefore, after the implementation of the recommended physical modifications, the potential for failure of this structure due to the flood will not be significant.