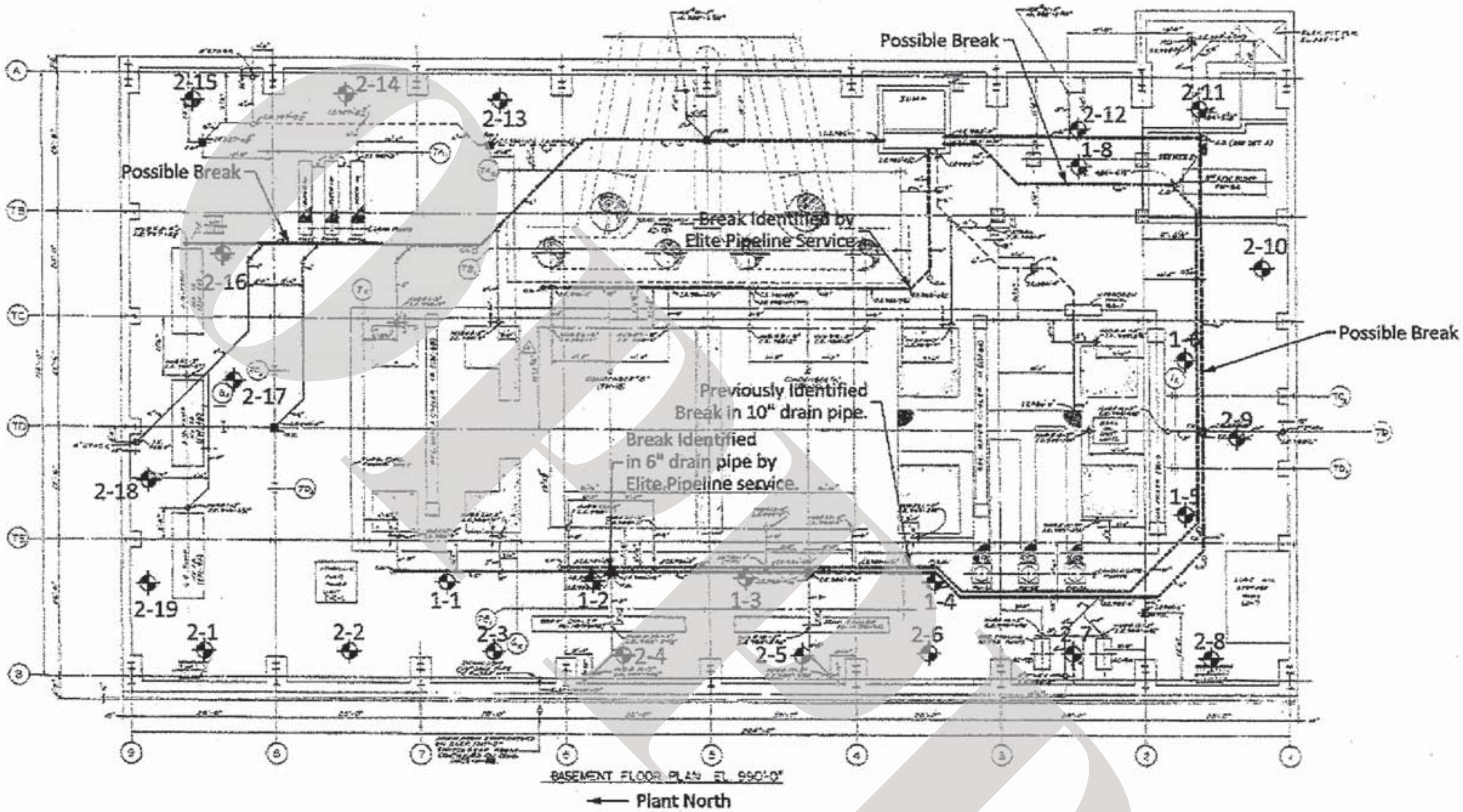

Notes:
1. Drilling locations 1-x are located near anomalies as identified in GPR analysis.
2. Drilling locations 2-x are spread along the basement perimeter for void exploration.
3. Drilling location 1-7 has been removed due to equipment conflicts.
4. Dotted lines are Asbestos Cement Pipe located below the floor.
5. Solid Lines are CISP located in the floor slab.

LEGEND
- Drilled Test Holes
- Blue = 6" Pipe
- Purple = 10" Pipe

OPPD Omaha Public Power District

Turbine Building Drilling Locations
Fort Calhoun Station

Plant and Facility Geotechnical and Structural Assessment

HDR

DATE August 2012

FIGURE 4-3

The subgrade evaluation included observation of conditions immediately below the floor slab and then field testing of the subgrade materials at each drilled location. Observations were made by HDR and Thiele Geotech. Subgrade field testing was performed by Thiele Geotech as a subcontractor to HDR, with HDR representatives present.

Investigation of the subgrade below the floor slab included the following:

- Direct visual observation through the open holes with the aid of a flashlight
- Direct visual observations using a lighted, water-proof bore scope lowered through the open drill-holes
- Estimation of depth to water in each borehole using a 4-ft-long, 0.5-in.-diameter, steel-tipped fiberglass T-handle soil probe (also known as a fiberglass T-probe)
- Measurement of the floor slab thickness
- Depth to subgrade using a tape measure (to determine thickness of existing voids)

Subgrade testing consisted of DCP tests at each drilled location. Thiele Geotech used a Humboldt Model H-4219 Heavy-Duty Dual-Mass Dynamic Cone Penetrometer to perform the DCP test in accordance with ASTM D6951/D6951M, Standard Method for Use of the Dynamic Cone Penetrometer in Shallow Pavement Applications. The preferred methods of estimating density of non-cohesive soils are the SPT and CPT. However, employment of the SPT and CPT was not possible in this case due to access and space constraints in the Turbine Building basement. The data obtained from the DCP can be used to identify zones of relatively low density or softness compared to the surrounding subgrade, as stated in ASTM D6951/D6951M, Note 1. Identification of such zones is relevant to developing a comprehensive model of subgrade deterioration due to pumping and material piping.

4.1.4.2 Results

Results from the 2011 portion of the forensic investigation are summarized below. The Thiele Geotech DCP logs and HDR's DCP index plots are presented in Attachment 6A.

4.1.4.2.1 Drill-hole Results

Visual observations and measurements were made as described above. Data obtained at each drill-hole were recorded by HDR.

Floor slab thickness at the locations drilled ranged from 27 to 38 in. Construction drawings show the floor slab thickness as 31 in. These differences from the drawings may be attributed to variations during construction. Upon penetration of the slab, the hammer drill often punched through the bottom of the slab and penetrated the subgrade before the drill operator could stop the drill. For this reason, some portion of the void thickness may be attributed to the drilling method. Voids were measured at all drilling locations. Void thickness greater than or equal to 2 in. was detected below the floor slab at 16 drilled locations. Overall, void thickness ranged from 0.5 to 11 in. Voids were measured immediately after the hammer drill was extracted from the drill-hole.

The void space immediately below the slab was also measured by Thiele Geotech immediately prior to DCP testing. In many cases, the void space measured at that time was significantly less than that measured by HDR immediately following floor slab drilling. An explanation for this discrepancy is that the Thiele Geotech measurements were taken hours or even days after the initial drilling occurred, allowing the fine grained silty sand to flow into the void space. Pressurized air was noted flowing from the drill-holes at a number of the locations. Once pressure under the floor slab was released, the groundwater with fine grained silty sand was able to flow into the void space as groundwater was no longer held back by air trapped under the floor slab. In no case was evidence of silty sand encountered flowing up into the bore holes.

4.1.4.2.2 Groundwater Levels

Groundwater was measured in 11 of the borings immediately after drilling and ranged from 2.0 to 27.5 in. below the floor elevation of 990 ft immediately after floor slab drilling. Water elevations were not measured in the remaining 16 drill-hole locations due to either dry conditions, difficulty assessing an accurate water elevation due to water level fluctuation, or drill cuttings mixed with water on the drill-hole walls smearing along the fiberglass T-probe and preventing an accurate measurement. In the case of drill-hole locations 1-6 and 2-15, water flowed from the drill-hole intermittently for approximately 1 minute, and then flow ceased. These are the only two cases in which groundwater reached the floor surface. At no time did any water flow onto the floor for any extended period of time.

Figure 4-4, Turbine Building Groundwater Gradient Map, shows groundwater contours based on water level data obtained on December 9, 2011. Figure 4-4 shows a fairly consistent groundwater level with the exception of the higher gradient on the south wall. Figure 4-4 shows the groundwater gradient dropping in elevation toward the southwest corner of the Turbine Building near drill-hole locations 1-3, 1-4, and 2-6. This is consistent with the presence of significant zones of altered subgrade in this area and with previous reports (EPS report) that identify drainage pipe breaks and high flow rates in this vicinity. The combination of slightly depressed groundwater elevations and evidence of altered subgrade is evidence that subgrade piping due to pumping is occurring in this area. Groundwater contours were generated using MicroStation GeoPak DTM Tools to triangulate between the groundwater elevation points and develop a groundwater elevation surface. From this surface, the contours were generated from elevations along the triangulation lines in MicroStation. This function is within standard practices for ground surface and groundwater surface contouring.

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