Appendix D: Geotechnical Engineering and Geology

Mississippi River, Dubuque County, Iowa
CAP Section 14 Emergency Streambank Protection

Dubuque Forced Sewer Main

Doc Version: Draft Feasibility Report
August 2021

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FIGURES

1. PROJECT DESCRIPTION

Riverbank erosion along the right descending bank of the Mississippi River in Dubuque County, IA is threatening the structural integrity of the City of Dubuque's 42-inch forced sewer main. The sewer main transports 80% of wastewater from the City of Dubuque and failure of the sewer would be detrimental to the City. Extended periods of high water and navigation traffic have led to degradation of the existing riprap protection. Several areas throughout the project alignment have experienced severe scour resulting in the sewer main being exposed in multiple locations. If erosion continues, the sewer main could experience failure due to direct barge impacts or from collapse due to a degraded foundation. For these reasons, a proposed solution to this hazard consists of the use of riprap revetment to stabilize the slope and cover the sewer main with a minimum of 24-inches of riprap.

2. REGIONAL GEOLOGY AND PHYSIOGRAPHY

The Project is located in the Paleozoic Plateau landform region of northeastern Iowa (Figure D-1). This region is typically characterized by shallow bedrock that creates plateau-like uplands with thin loess covering and isolated patches of glacial drift. The terrain has many deep valleys created by downward erosion of streams through the rock strata. Similarly, over time the Mississippi River has eroded downward through the bedrock leaving behind steep, rocky bluffs upwards of 150 to 200 feet high in the Project area. Karstic features are common in this region though there is no evidence to suggest they are present within the Project boundaries.

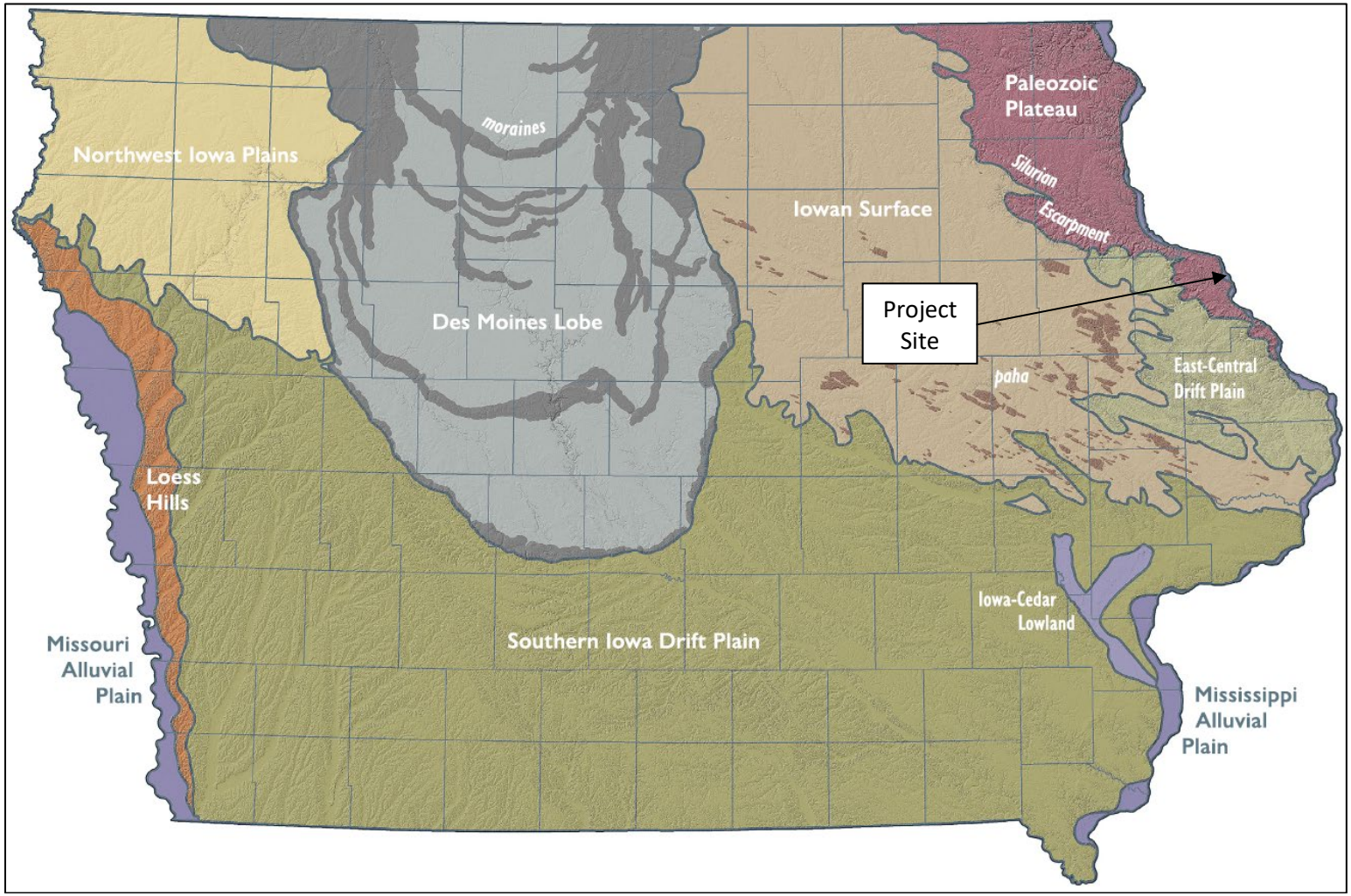

Figure D-1: Map of the Landform Regions of Iowa

2.1. Topography. The gorge of the Mississippi River has steep and bluff-like walls with a broad, flat bottom. The main channel in this area acts as a meandering stream but has braided stream features when flowing through and around the existing wooded islands.

The Project site lies on the outside curve of a stream meander just south of the City of Dubuque. The natural cut bank is a steep, rocky bluff approximately 200 feet high. However, a riprap lined earthen fill railroad embankment runs parallel with the bottom of the bluff and now takes the brunt of the river's erosive forces. The railroad embankment, which also contains the 42-inch sewer main on the river side of the tracks, generally has a 1.5H:1V slope. A typical photo of the project site can be seen in Figure D-2. Cross-sections created based on LiDAR and hydrographic surveys indicate a near vertical slope in some locations of up to 8 feet. These vertical slopes appear to be due to erosion at and just below the water line, but a lack of hydrographic survey data immediately at the shoreline could cause misleading interpretations of the existing conditions.

Based on hydrographic survey data, the river bottom gradually slopes down to a maximum depth of 35 feet in the channel from normal pool (EL 595), though this is in excess of 300 feet from the shoreline. Cross-sections throughout the project site, which extend 150 feet into the river from the centerline of the sewer main, show a maximum depth of about 20 feet (EL 575).

Figure D-2: Typical Photograph of Project Site

2.2. Geology. Soil borings specific to the Project area are not available. However, the U.S. Department of Agriculture (USDA) Web Soil Survey places the Project area primarily in the Nordness-Rock outcrop complex (Figure D-3). The Nordness soil series generally consists of silt loam and silty clay loam. The Project's location in and adjacent to the Mississippi River means most of the soil and sediments in the subsurface likely include typical alluvial materials consisting of sands, silts, clays, and gravel from glacial outwash of late Wisconsin age. Due to the Project's proximity to adjacent steep, rocky bluffs it is likely that larger rocky debris like cobbles and boulders exists in the subsurface soils as well.

Figure D-3: From NRCS Soil Map – Dubuque County, Iowa

According to the Iowa DNR Bedrock Geology of Northern Iowa Map (Figure D-4), the Project site is underlain by Ordovician Age bedrock of the Galena Group and Platteville Formation (Upper/Middle Ordovician) as well as the Prairie Du Chien Group (Lower Ordovician). Similar to the soil information, there is a lack of bedrock data specific to the Project area. The nearest

borings to the site that provide a glimpse into the possible bedrock conditions were selected from the Iowa Geological Survey's (IGS) GeoSam website, a database of well and boring logs around the state. In selecting representative borings, ones were sought which were in similar proximity to the steep rock cliffs and sampling the same elevations present at the Project site.

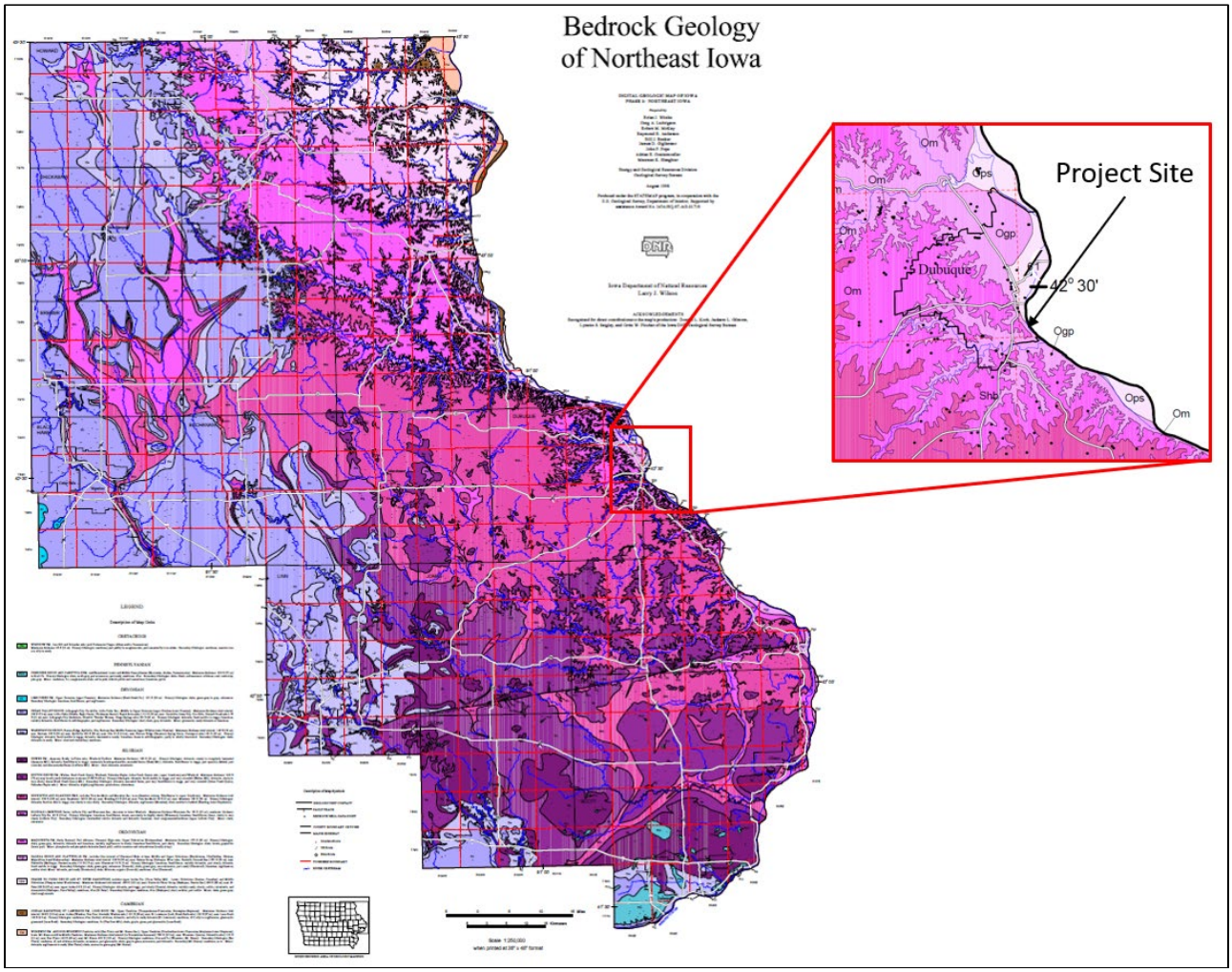

Figure D-4: IA DNR Map of the Bedrock Geology of Northeast Iowa

Three total borings were selected that met the above criteria (Figure D-5). Two borings (#109 and #762) are approximately 0.6 and 2.0 miles upstream of the Project site, respectively. One boring (#9491) is roughly in line with the downstream end of the Project site but approximately 0.2 miles inland in an old stream valley. All three of the boring logs describe an Ordovician aged dolomite as the uppermost bedrock consistent with the Iowa DNR map previously mentioned. The geologic unit differs between all three, but this is not unexpected as depth to bedrock is different in all three borings. Boring #109 indicates that an arenaceous (sandy), cherty dolomite of the lower Ordovician Prairie du Chien Group is the uppermost bedrock unit. The top elevation of the boring is EL 608 and shows the top of bedrock 70 feet deep (EL 538). So, bedrock in this area would be approximately 57 feet below normal pool. Boring #762

designates a dolomitic limestone of the middle Ordovician Platteville Formation as the bedrock unit which was first encountered. The top elevation of the boring is EL 618 and shows the top of bedrock 125 feet deep (EL 493). So, bedrock in this area would be approximately 102 feet below normal pool. Boring #9491 specifies a cherty dolomite of the upper Ordovician Galena Group as the shallowest rock layer. The top elevation of the boring is EL 605 and shows the top of bedrock 35 feet deep (EL 570). So, bedrock in this area would be approximately 25 feet below normal pool. Using flat pool as a baseline, depth to bedrock in the Project area would range between 25 – 125 feet. It should be noted that the two borings upstream of the Project site are a greater distance from the rocky bluff which may result in deeper bedrock in those locations. Depth to bedrock within the Project boundaries could range between just a few feet to dozens of feet deep.

Figure D-5. Location of Borings Used for Bedrock Description

2.3. Site Hydrogeology. Subsurface information related to groundwater elevations and flow does not exist for this site. However, groundwater does not appear to be causing a migration of material downslope and is not likely a main contributor of erosion or bank instability at the site.

2.4. Seismic Risk and Earthquake History. Project performance with respect to earthquake loading was not assessed. The project area is located in one of the least seismically active places in the United States.

3. SUBSURFACE INVESTIGATION

Subsurface investigation is limited to existing data (as described in Section D.2). Additional exploration and/or testing is not required at this time given the scope of the project.

4. GEOTECHNICAL DESIGN

4.1. Design Section. Design is not part of the feasibility study. More details will be provided during the design phase of this project.

4.2. Foundation. As stated previously, the foundation materials likely to be encountered along the river channel are clays, silts, sands, and gravels, with lesser amounts of clay. Larger rocks may also be present along the river channel. Clearing of topsoil, vegetation, concrete scour protection, and downed trees/debris along the bank may be necessary prior to placement of rock.

4.3. Seepage. Soils in the project area are predominantly permeable coarse-grained materials that are conducive to seepage; however, the main concern with seepage is the migration of foundation materials through the riprap section. A well graded stone gradation with appropriately sized bedding stone will be used to prevent the migration of foundation soils through the riprap.

4.4. Slope Stability. The railroad embankment generally has a 1.5H:1V slope. Cross-sections indicate a near vertical slope in some locations of up to 8 feet. These vertical slopes appear to be due to erosion at and just below the water line, but a lack of hydrographic survey data immediately at the shoreline could cause misleading interpretations of the existing conditions. While no major sloughing of the bank is visible above the water surface, it is likely that some movement has occurred below the water surface due to the erosion noted above. The erosion indicates that stone protection at that elevation is missing which could lead to increased material loss and risk of slope instability.
Analyses for slope stability were not performed for this project. Stability of existing slopes will be increased by placement of new bedding stone and riprap on the embankment including areas displaying increasing amounts of erosion at a slope of 2H:1V.

4.5. Consolidation Settlement. A settlement analysis was not performed for this project. Settlement of this project is expected to be minimal due to the site stratigraphy being primarily

coarse-grained materials and having been loaded for many years.

5. EROSION PROTECTION

5.1. Riprap. According to calculations by the Rock Island District's Hydrology and Hydraulics (H&H) section in Appendix A, it was determined that an Iowa Department of Transportation (IADOT) riprap gradation Class E (250-pound top-size) or higher is required for the Project site. IADOT Class C (450-pound top-size) riprap is recommended. IADOT Class C riprap is preferred over IADOT Class A (400-pound top-size) riprap since Section 4130.02.A of the *IADOT Standard Specifications for Highway and Bridge Construction* stipulates that Class A revetment stones "are to have at least one flat face with one dimension at least 15 inches". It is preferred that riprap has a more equidimensional blocky shape to aid in interlock of individual stones. The additional mass of the Class C stone over the Class E stone will provide an extra degree of protection and resistance from the river's erosive forces and prop wash from parked tows extending the life of the project.

The riprap should be placed at a minimum thickness of 24-inches. As noted above, the Project site will consist of a 2H:1V slope which differs from the 3H:1V slope of the riprapped levee slope just upstream. A smooth transition will be required from the shallower levee slope to the steeper Project slope to avoid inducing any eddy currents that could lead to scour and erosion of the embankment.

Based on cross-sections, erosion below the water line is occurring above where the toe of the riprap revetment will be. For this reason, a weighted toe will not be required.

If necessary, areas of greater erosion may be backfilled with unprocessed quarry-run stone to achieve the required 2H:1V slope before placement of bedding stone and riprap.

5.2. Bedding Material. The majority of the Class C riprap will be underlain by 6-inches of bedding stone consisting of IADOT Gradation 3 aggregate. The Class C riprap which will be placed on top of the 42-inch sewer main will be underlain by 12-inches of IADOT Gradation 3 aggregate to ensure riprap stones do not make direct contact with the sewer main.

5.3. Fill Sources. The Rock Island District Geotechnical Branch maintains an updated list of pre-approved quarries to be used as stone sources on USACE projects. A PDF version of this list is located on the Rock Island District's public website and will be provided in the final contract specifications.

6. REFERENCES

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