April 25th, 2022 VIA EMAIL

Shawn Cross, Project Manager
KC Water
4800 East 63rd Street
Kansas City, Missouri 64130

Site Investigation – Mining Risk Report
Burns & McDonnell Project No. 125460

Dear Mr. Cross:

Please see the attached final report titled "Todd Creek Wastewater Facility Geologic Review and Mining Risk Assessment". This report provides a summary of typical mine types and conditions in the KC Metro area, as well as providing guidance regarding potential risks to siting the proposed Todd Creek WWTP on a property where subsurface mining of limestone will occur. The "Future Considerations" section of this report outlines suggested approaches to risk management for the near- and long-term use of this property for the proposed Todd Creek WWTP. These recommendations are as follows:

- Conduct vibration monitoring including acceptable particle velocity limits at the surface of the property during mining operations, and have an approach for corrective actions should particle velocities exceed established limits
- Establish a survey of the entire mine beneath the facility, once completed, with location of each pillar dimension and ceiling height documented
- Confirm the ceiling height of the mine agrees with the description provided in this report, and that the geological formations exposed in the mine generally agree with what has been described in this report
- Establish an inspection and maintenance program for the mine once mining operations have ceased
- Establish agreement on the party responsible for any remedial repairs to the mine specifically to protect the WWTP facility, should it be required

If these preventative activities are established and put into regular practice for the subject property, then the data suggests that the subject property is an appropriate site for the Todd Creek WWTP and risks to use of this property will be minimal.

Please contact me at jkeller@burnsmcd.com or 816-822-4371 if you have any questions.

Sincerely,

Jeffrey J. Keller, PE
Project Manager

STATE OF MISSOURI
JEFFREY J. KELLER
NUMBER E-2002003189
REGISTERED PROFESSIONAL ENGINEER

Keller, Jeff
Apr 25 2022 9:02 AM
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JJK/jjk

cc: Project File 125460
Shawn Cross, WSD

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Geologic Review and Mining Risk Assessment Report

Todd Creek Wastewater Treatment Facility

in

Platte County, Missouri

Kansas City, Missouri

Project No. 125460

Burns & McDonnell Engineering Company, Inc.
9400 Ward Parkway
Kansas City, MO 64114

Version: 4/21/2022

INDEX AND CERTIFICATION

KANSAS CITY, MISSOURI
TODD CREEK WASTEWATER TREATMENT FACILITY
GEOLOGIC REVIEW AND MINING RISK ASSESSMENT REPORT

REPORT INDEX

CERTIFICATION

I hereby certify, as a Professional Engineer in the State of Missouri, that the information in this document was assembled under my direct supervisory control. This report is not intended or represented to be suitable for reuse without specific verification or adaptation by the Engineer.

STATE OF MISSOURI
TYLER J. McKEE
NUMBER
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PROFESSIONAL ENGINEER

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Tyler J. McKee
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My license renewal date is December 31, 2022

Christopher J. Hoglund, R.G.
(MO #2018007069)

Date: 04/21/2022

Christopher J. Hoglund
License Number 2018007069

My license renewal date is April 30, 2023

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1.0 GENERAL

1.1 PROJECT DESCRIPTION

The City of Kansas City, Missouri is proposing to construct a new wastewater treatment plant (WWTP) near Platte City, Missouri. It is understood that Hunt Midwest will retain mining rights on the property and that the Bethany Falls Limestone Member underlying the site may be mined during and/or after construction of the new WWTP. The approximate location of the site is shown in Figure 1 below.

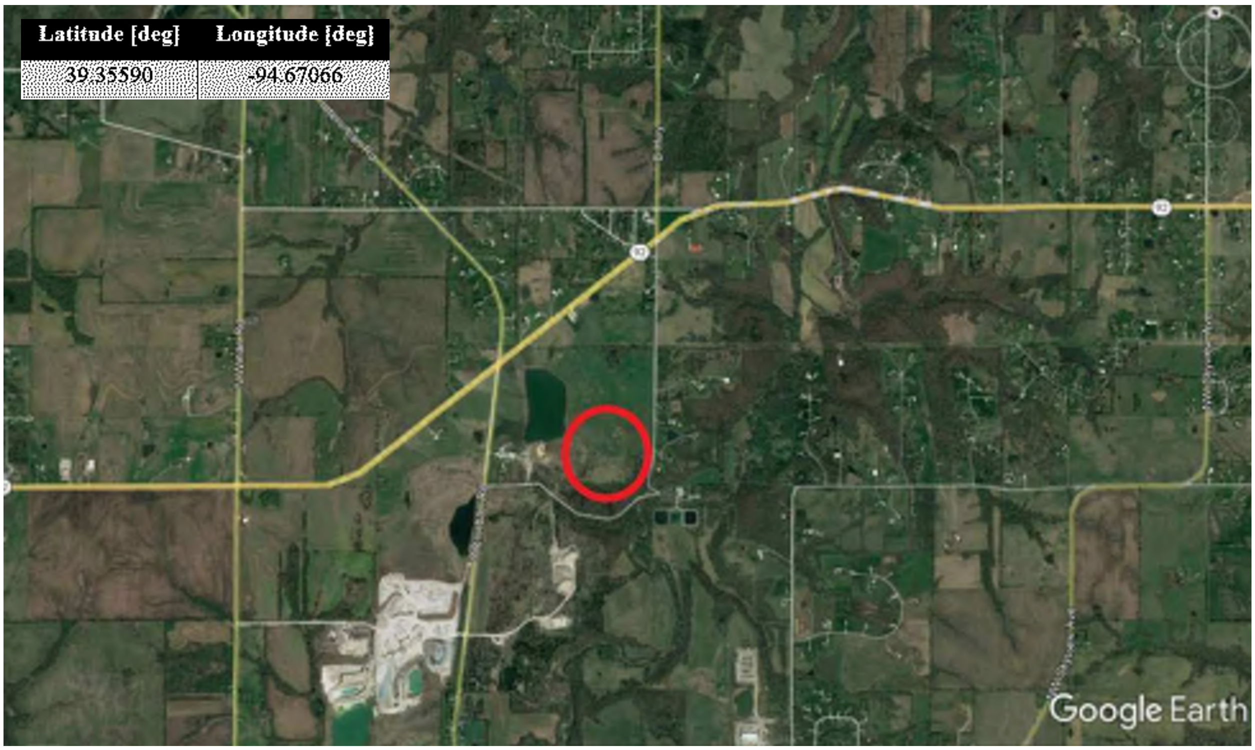

Figure 1 - Satellite Image of Site Location

1.2 PURPOSE AND SCOPE OF SERVICES

To support evaluation of the risks associated with active mining of the Bethany Falls Limestone Member during and/or after construction of the new WWTP and potential subsequent long-term effects once mining operations have ceased, Burns & McDonnell (BMcD) has reviewed available published geologic data within the vicinity of the site and publicly available mining resources to identify similarly constructed mines in the area and assess historical performance. Burns & McDonnell has also presented herein a discussion of potential mining-related factors that could impact the construction and operating performance of the new WWTP with practical mitigation/remedial options for consideration by Kansas City.

* * * * *

2.0 GEOLOGY

2.1 GENERAL

2.2 GEOLOGIC PROFILE

The Site is located midway in a 150-mile-wide band of outcropping Pennsylvanian-aged bedrock exposed at the surface that extends in a north-south direction through western Missouri and eastern Kansas (Figure 2). The Pennsylvanian-aged bedrock beds exhibit a very gentle prevailing dip to the west-northwest and are comprised of strata that are part of the lower Missourian Series, one of five series in the Pennsylvanian System. The lower Missourian Series is subdivided into three groups (from top to bottom); the Lansing, Pleasanton, and Kansas City Groups. The Kansas City Group is further subdivided from top to bottom into the Zarah, Linn, and Bronson Subgroups (Parizek, E.J. & Gentile, R.J, 1965). The geologic units of interest for this discussion focuses on the strata from the Bronson Subgroup of the Kansas City Group. An idealized geologic column illustrating the stratigraphy of Kansas City Geology is presented in Figure 3.

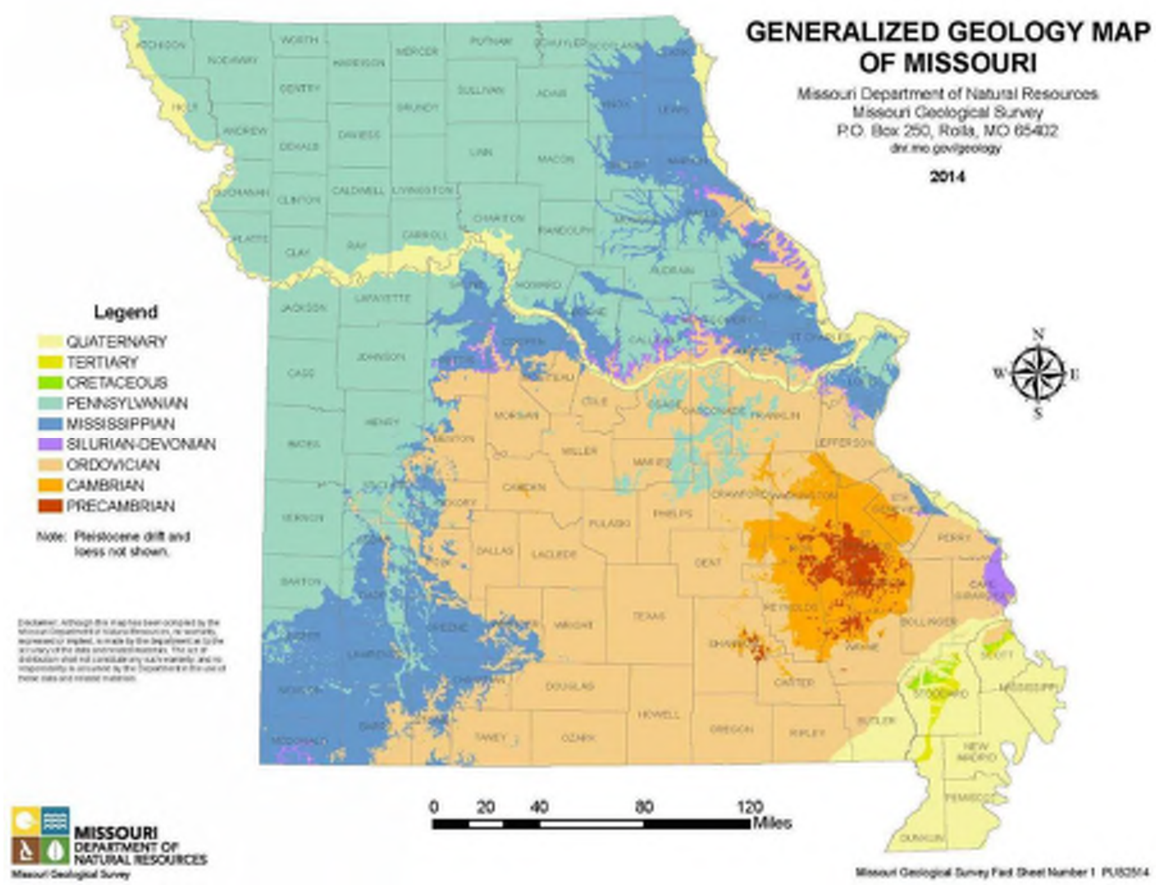

Figure 2 - Generalized Geologic Map of Missouri (MDNR, 2014)

Underground mining of the Bethany Falls Limestone typically consist of undisturbed roof strata in the upper Bethany Falls Limestone, underlying the Galesburg Shale, Stark Shale, and the Winterset Limestone Members, sequentially from bottom to top.

The upper portion of the Bethany Falls Limestone Member is composed of a limestone with flaser/wavy bedding colloquially known as "Peanut rock." The flaser/wavy bedding is a result of deposition in a tidal environment with either high energy or reworking tidal floor sediments. The Peanut rock appears rounded, irregular, and fragmented and is generally much weaker than the rest of the underlying Bethany Falls Limestone Member, when encountered, especially when wetted.

Above the Peanut rock is the greenish-grey Galesburg Shale Member. Similar to the Peanut Rock, the Galesburg Shale Member appears to have formed during a relatively turbulent depositional environment, resulting in irregularities and weak zones called 'potholes' in the formation, which are likely attributed to scouring in ancient streams and rivers. Also similar to the Peanut rock member, the Galesburg Shale is considered a relatively weak structural geologic unit.

The Stark Shale Member is typically encountered overlying the Galesburg Shale Member. The Stark Shale Member is usually easily identifiable compared to the other members, being black in color, rich in pyrite, and cut by closely-spaced vertical fractures. The Stark Shale Member is typically strong enough to withstand an initial domeout when the weaker rocks slake and fall from the roof of the mine (ceiling spall), but domeout of the Stark Shale Member usually follows the weaker underlying rocks after being exposed in the roof of the mine after several years (Parker, 1987).

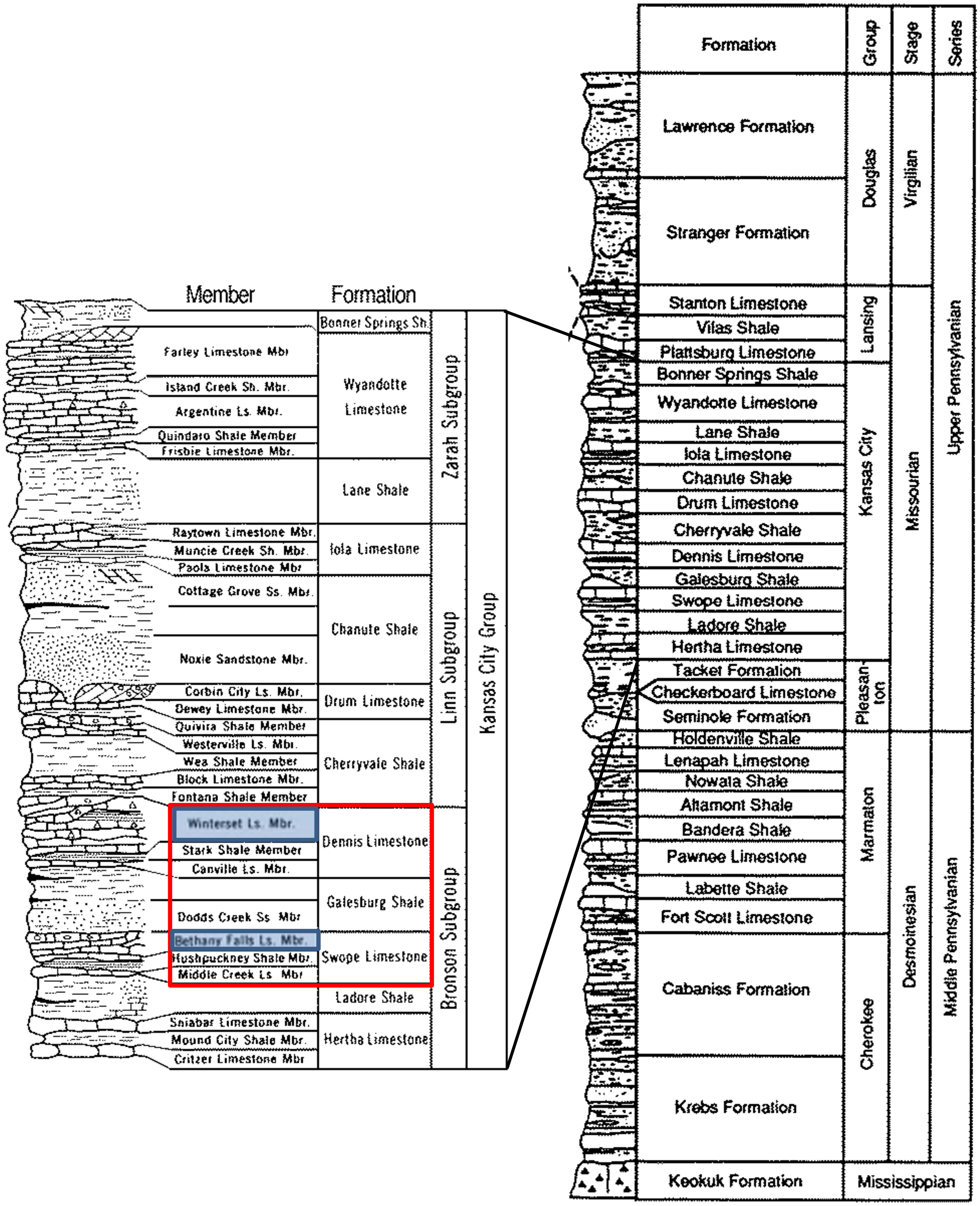

Figure 3 –Kansas City Group Geologic Column (KGS, 2010)

2.3 UNDERGROUND LIMESTONE MINES IN KANSAS CITY AREA

Most underground limestone mines in northwest Missouri target two Pennsylvanian rock units, the Bethany Fall Limestone Member of the Swope Limestone Formation and the Amazonia Limestone Member of the Lawrence Formation. A third unit, the Argentine Limestone Member of the Wyandotte Limestone Formation, is mined nearby in Kansas. In some mines the Winterset Limestone Member of the Dennis Limestone Formation is also mined, but these are exceptions, because Bethany Falls limestone mines generally rely on the Winterset Limestone for roof support. The Amazonian, Argentine, and Winterset Limestone units are all younger and overly the Bethany Falls Limestone.

Most roofs of underground mines in Bethany Falls Limestone have an overburden sequence that includes at least 6 to 8 feet of the upper Bethany Falls Limestone, the entire Galesburg Shale Formation and Stark Shale Member, and at least half, but preferably all, of the Winterset Limestone Member. The presence of these overlying geologic units and a soil cover minimum of 8 to 10 feet generally ensure an underground mine roof between approximately 40 to 50 feet thick (Whitfield, 1981).

Limestone extracted from underground mines is a common practice in the Kansas City area with records dating back to at least the 1950's (United States Geological Survey [USGS], 2022; Missouri Department of Natural Resources [MDNR], 2022; Whitfield, 1981). While numerous records of underground limestone mines exist, limited information pertaining to their construction, status, or condition is available in the public domain. The USGS offers a web-based Geographic Information Systems (GIS) repository (USGS, 2022) of active and historic mines with grades A through E. The assigned grades correspond to available information, with grade "A" being the most information available and grade "E" being the least. Of the mines identified in Platte and Clay counties in Missouri, only grades D and E mines were available with orange markers identifying mines with grade D and gray markers identifying mines with grade E (Figure 4).

The Missouri Department of Natural Resources (MDNR, 2022) offers a tabulated Missouri Mine Map Repository, however, most of the regional mine map information in the repository is available for purchase only. Of the records shown for limestone mines in Platte, Clay, Ray, and Jackson counties from the MDNR Mine Map Repository, similar or more extensive information is publicly available from the USGS GIS repository.

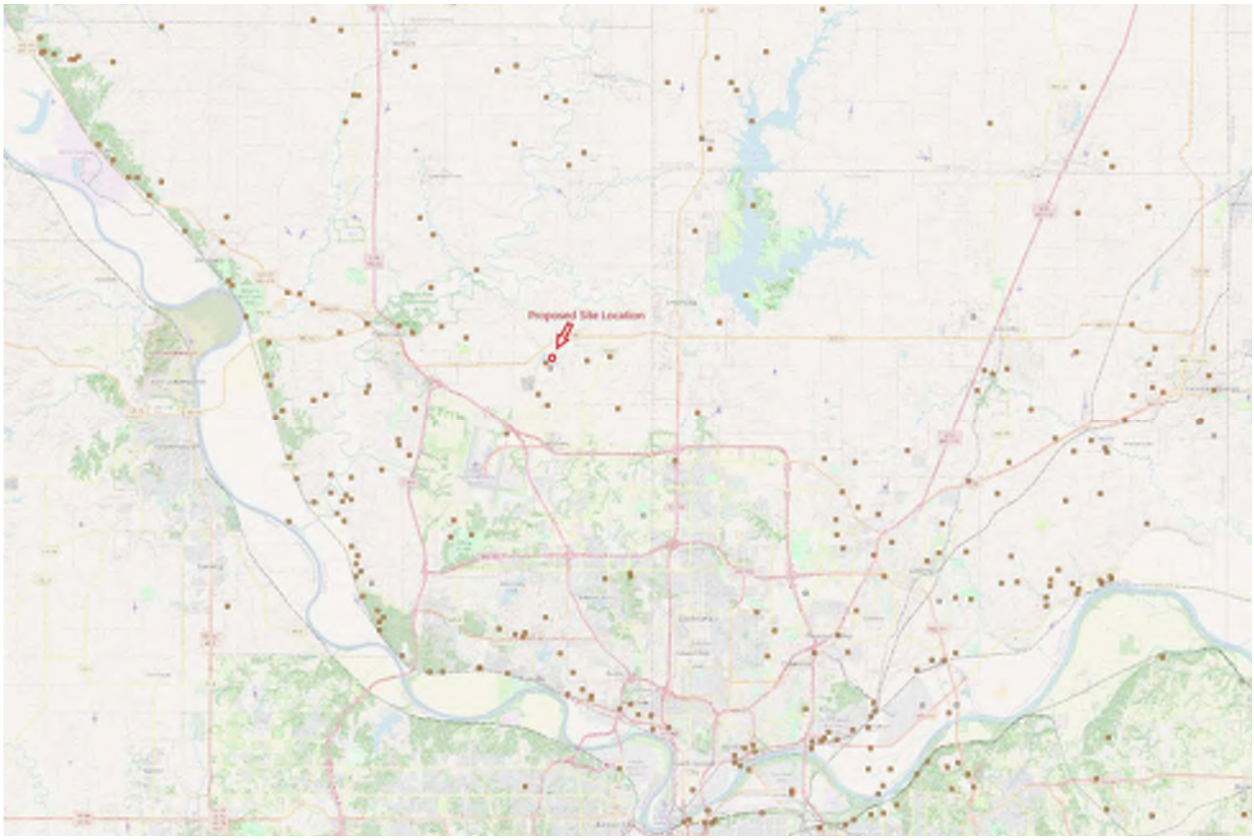

Figure 4 - Active and Historic Mines in Platte and Clay Counties (USGS, 2022)

The MDNR performed an assessment of underground mines in a report entitled *Underground Space Resources in Missouri* (Whitfield, 1981). While the number of mines identified and investigated are a fraction of those identified in the USGS repository, the MDNR report offers more information in the way of mine status, condition, and historical performance. The MDNR report includes mines across the state of Missouri, but only undeveloped mines within the Bethany Falls Limestone Member in the areas of Platte, Clay, Ray, and Jackson counties are presented for discussion in this report. A map of both developed and undeveloped mines in the area (Figure 5) with available data and remarks presented in Table 1. Developed mines are repurposed for secondary use once mining is complete – oftentimes for use as temperature-controlled storage or office space. It is understood from discussions with Hunt Midwest, that no secondary use or development of the mine located under the proposed footprint of the WWTP is anticipated. Therefore, only evaluations of undeveloped mines in the Bethany Falls Limestone Member were included for discussion herein.

It is understood from discussions with Hunt Midwest, the dimensions for the proposed mine will have roof thickness ranging between 250 and 300 feet and ceiling heights of 14 feet beneath the footprint of the proposed WWTWP. It is also understood that the uppermost 3.5 ft to 4 feet portion of Bethany Falls limestone will remain unmined to serve as the mine ceiling and a 0.5 to 1 feet thick layer of Bethany Falls limestone will serve as the mine floor. Historical mine data for similar undeveloped Bethany Falls mines presented in Table 1 include mines with roof thicknesses ranging between 10 to 100 feet and ceiling heights ranging between 7 and 30 feet (Whitfield, 1981). The effect of greater roof thickness in the proposed mining operation suggests a lower likelihood of surface impacts caused by roof instability, as well as additional time to enact remedial measures in the mine should a progressive roof failure occur.

Based on review of the MDNR report, 23 undeveloped mines were identified within the Platte, Clay, Ray, and Jackson counties, however, no mine information was readily available for Platte County. Of the 23 undeveloped mines presented, 6 were evaluated to have pillars or ceilings in poor or moderate to poor conditions. Eight of the mines were found to have floors in poor conditions. For the scope of this report, only the mines with poor pillars or ceiling conditions will be evaluated/discussed as those will be the governing instability issues that would most likely have the potential to result in subsidence at the ground surface that could impact the construction and operating performance of the new WWTP.

Roof thickness in the mines presented in Table 1 range between 10 feet and 100 feet, with about 30% of the mines having roof thicknesses between 15 and 30 feet. The remainder of the mines generally had thicker roof sections. Roughly 25% to 30% of mines with 15 to 30 feet roof thickness and mines with greater than 30 feet roof thickness were identified as having poor pillar or ceiling conditions. Since the percentage of mines having poor pillar and ceiling conditions are comparable between both groups of mines, it is difficult to identify how much improvement is afforded by increasing roof thickness from this data alone. Additionally, it should be noted, that the data provides limited resolution for the roof thickness with most of the undeveloped mines reported to have a range of roof thicknesses. Therefore, the precise roof thickness in the identified undeveloped mines with poor pillar and ceiling conditions where roof collapse/instability were reported cannot be determined/evaluated.

Ceiling heights in the undeveloped mines presented in Table 1 range between 7 to 30 feet. Of the mines with ceiling height data, roughly 40% of the mines had ceiling heights less than 13 feet while the remainder generally had ceiling heights greater than 13 feet. About 45% of the mines with ceilings greater than 13 feet had pillars or ceilings in poor conditions, while roughly 20% of the mines with ceilings less than 13 feet were identified has having pillars or ceilings in poor conditions.

Given the limited specifics regarding where instability was reported within the mines themselves, it is difficult to identify the specific causes of reported instability. However, of the 6 mines having pillars and ceilings in poor condition, 5 mines were noted as being inactive or no longer actively quarried. It is impossible to know how long the mines have been inactive from the information provided, but it is reasonable to conclude that one of the primary contributors to poor pillar and ceiling conditions is inadequate inspection and maintenance.

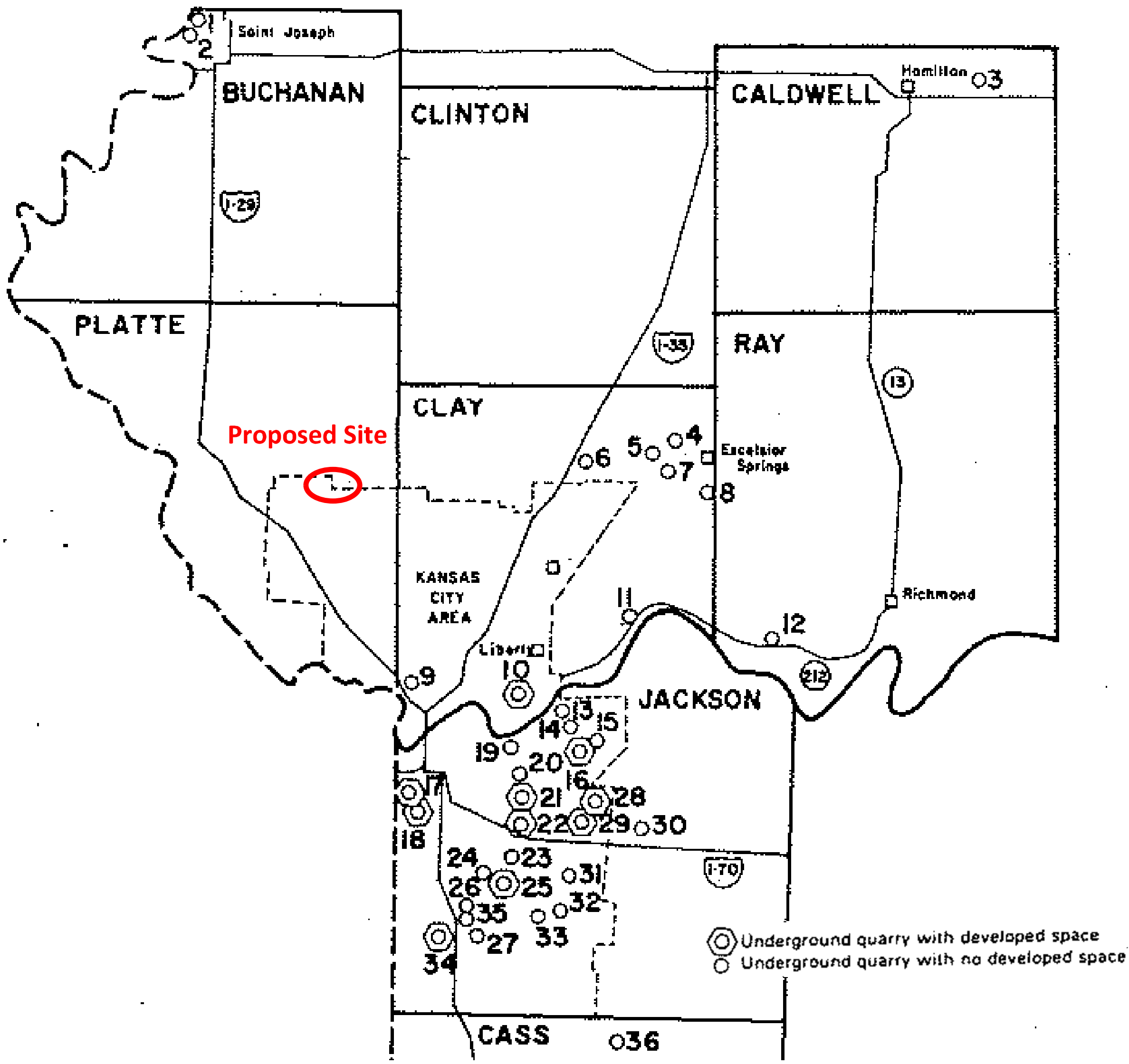

Figure 5 - Locations of underground mines in Northwest Missouri (Whitfield, 1981)

Table 1 - Mine Inspection Summary (For mines located in Platte, Clay, Ray and Jackson Counties) (Whitfield, 1981)

Site No.	Formation Mined	Approx. Mine Size (acres)	Roof Thickness (feet)	Ceiling Height (feet)	Floor Cond.	Pillar Cond.	Additional Remarks
4	Bethany Falls	10	20+	F-M (13)	M	F	Shale floors; flooded in some places. Local ceiling collapse near north entrance. Appears to be in generally stable condition.
5	Bethany Falls	-	-	-	-	-	Near south side of Rock Hollow Dam. Abandoned for years; all entrances sealed. Natives say quarry was as large as the Clay County Highway quarry (Site No. 4).
6	Bethany Falls	3	15-20	F (7-10)	M-P	F	Floors shale, muddy: portions flooded. Thick layer of Bethany Falls left in place for roof rock. Appears in stable condition.
7	Bethany Falls	3-5	15	M-P (13-15)	M	M	Inactive for years; used as cattle shelter. Several acres of ceiling collapse. Enlarged ceiling joints near entrance. Floors shale, muddy; portions covered by trash and ceiling spall.
8	Bethany Falls	4-6	30	F (12)	M-P	F	On wooded hillside along East Fork Fishing River. Inactive for years. Floors shale, muddy; portions flooded. Ceilings and pillars look stable. Poor entrance road.
9	Bethany Falls	70	30-100	F-M (13)	M	F	At base of bluff on Missouri River flood plain, near north Kansas City. Two steep inclined entranceways provide access to quarry. Floors shale and limestone.
10	Bethany Falls	300+	50-80	F-M (±15)	F	F	At large quarry complex spread along the base of a bluff along the Missouri River flood plain. Large segments of these room-and-pillar quarries developed into office and warehouse space. According to owner, there are over 250 acres of usable underground space. Some localized ceiling collapse on the west side of the quarry.
11	Bethany Falls	70	60-80	M-P (13-18)	F-M Shale	F	Large inactive quarry on bluff along Missouri River flood plain. Underground quarry comprises two distinct north and south areas separated by a large open-pit quarry. Some local ceiling collapse in rear of south quarry, possibly from robbing of ceiling rock. Several large ceiling cracks parallel to quarry face, near entrances. Access to quarry by steep gravel road in poor condition. Railroad track near base of bluff. The north quarry appears in better condition than south quarry. Piles of waste rock pushed in front of entrances.
12	Bethany Falls	10	80	M-P (12-13)	M Shale	F	On bluff along Missouri River flood plain. Underground quarry comprises two separate areas separated by open-pit quarry. According to operator, north area unusable because of unstable ceiling conditions. South area has localized ceiling collapse and several ceiling cracks.
13	Bethany Falls	300±	-	13-30	-	-	Operator uses underground quarry for workshop, warehouse, and clinker storage. Denied entrance to quarry; information in-house reports and surface examination. Access by railroad and paved road.
14	Bethany Falls	10	30	F-M (12-13)	F-M	F	Scattered complex of underground quarries. Those north of Courtney Road flooded, with areas of ceiling collapse; those south of Courtney Road in

Site No.	Formation Mined	Approx. Mine Size (acres)	Roof Thickness (feet)	Ceiling Height (feet)	Floor Cond.	Pillar Cond.	Additional Remarks
							better condition. Evaluations for Site 14 for quarries south of Courtney Road. Site adjacent to active open-pit quarry.
15	Bethany Falls	1	50	F (15)	F	-	Belongs to asphalt plant. Underground area small; used for shop, generator room, and conveyer belt.
19	Bethany Falls	20-25	100	F-P	M-P	M	At base of bluff along Missouri River flood plain. Inactive for years. No improvements. Ceiling has joints and local ceiling collapse. Access road in poor condition, but railroad tracks nearby. At entrance, floor composed of shale. Mine interior not examined.
20	Bethany Falls	80+	20-90	F-M (15-18)	M-P	F	Near I-435. Inactive for years. No improvements. Shale floor; portions covered by shallow water. Numerous widely scattered entrances along base of bluff along the Blue River. Many entrances littered with trash. Interior of quarry not examined.
23	Bethany Falls	35	15-50	M-P (12)	M-P	F-M	Inactive for years. Several areas of ceiling collapse extend upward to land surface. Floor is shale, muddy at entrance, but dry further back in quarry; local areas covered by ceiling collapse. Entrances sealed by large concrete blocks.
24	Bethany Falls	3-4	30-40	F (12-15)	F	F	Inactive for years. Owner intends to improve underground space for equipment storage. Adjacent to railroad tracks. Access road to be improved.
26	Bethany Falls	2	25-40	F (12-15)	M-P	F	Small, unimproved underground area. Interior very damp, floors consist of muddy shale. Some stored equipment, but quarry less used for storage now than in the past.
27	Bethany Falls	400±	75-100	F-M (12)	F-M	F	Large without improved space. Local areas of ceiling collapse at rear. Quarry work almost finished.
30	Bethany Falls	80+	-	-	-	-	Not permitted to examine mine. According to owner, underground space in favorable condition. Underground space to be prepared for leasing in near future.
31	Bethany Falls	100±	20-50	F	F-M	F	A large quarry of 100± acres and a small quarry of 2 acres. Quarrying almost finished in large quarry. Small quarry will be enlarged by future quarrying. Currently no plan to improve underground space.
32	Bethany Falls	2	10-40	F-M (15)	M-P	F	Small, unimproved quarry formerly used to store fruit. Very damp inside. Floors are muddy shale. Poor access road. Nearby railroad, but no spur rail or docking facilities.
33	Bethany Falls	250±	40-90	F-M (12)	F-M	F	Large, active quarry without improved space. Good road access; eventually will have access to railroad facilities. Mining will continue for several years.
35	Bethany Falls	2	10-15	P	P	F-M	Inactive for years. Floors flooded and covered by rock fall from ceiling. Entrances blocked except for small crawl space near ceiling.

F = Favorable condition M = Moderate Conditions P = Poor Condition

* * * * *

3.0 RISK EFFECTS OF MINING

3.1 DURING MINING OPERATIONS

3.1.1 Structural Impacts

Safe blasting criteria were developed for residential structures (Figure 6) by the United States Bureau of Mines (Sisking, D.D. et. al., 1989). The criteria establishes a particle velocity limit for a given frequency of vibration to reduce the risk of damage to plaster or drywall. Between 4 and 12 Hz, a particle velocity limit of 0.5 inches per second (in/sec) is recommended for plaster construction and 0.75 in/sec is suggested for drywall construction. Greater than 40 Hz, the particle velocity limit is increased to 2 in/sec. At intermediate frequencies, the particle velocity limits are linearly interpolated between the two constant limits. The vibration levels for structural damage are significantly greater (Section 3.1.2) than the safe blasting limits shown in Figure 6.

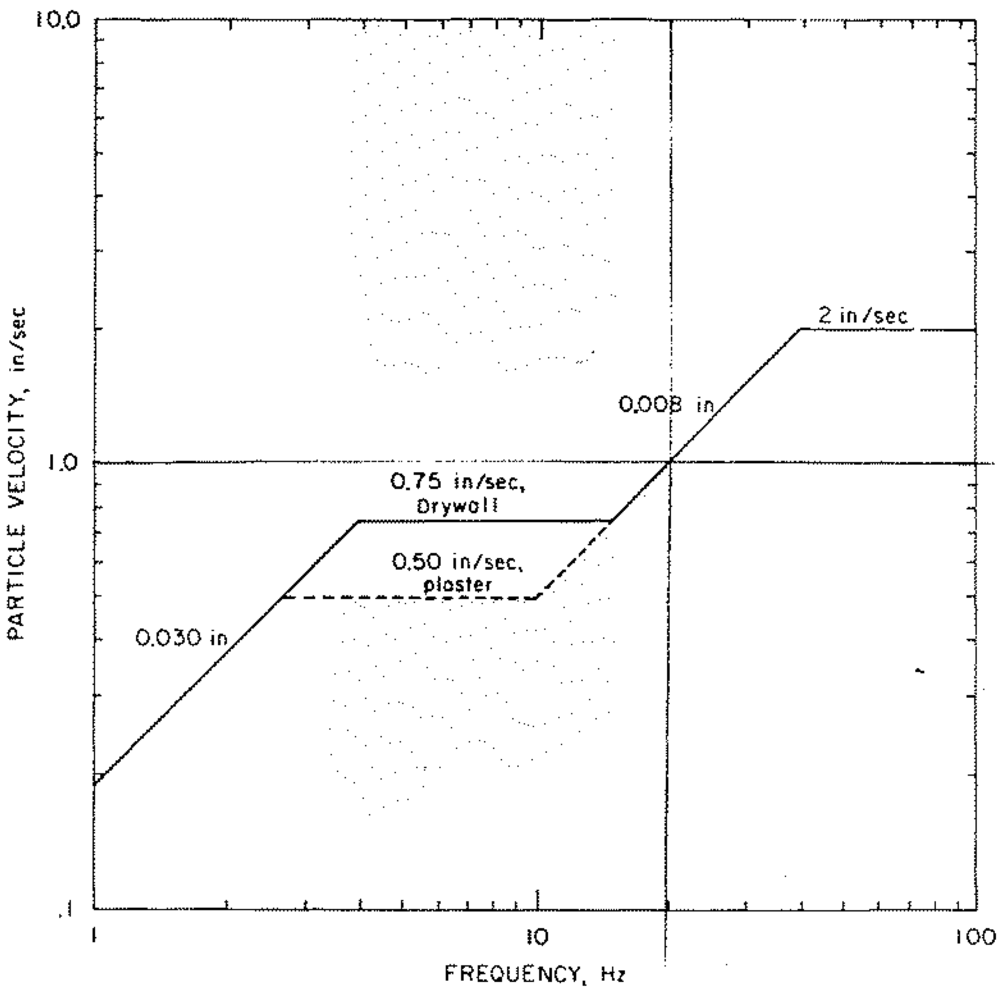

Figure 6 -Safe levels of blasting vibration for houses using a combination of velocity and displacement (U.S. Bureau of Mines, 1989)

Per discussions with Hunt Midwest, it is understood that particle velocity limits for plaster construction suggested in Figure 6 often govern blasting practices and that Hunt Midwest will maintain a particle velocity value lower than the most restrictive limits identified during blasting/mining operations. It is the opinion of Burns & McDonnell that Kansas City establish similar or operationally appropriate vibration monitoring program during contract discussions for purchase of the property with agreed upon particle velocity limits.

3.1.2 Human Sensitivity Impacts

There is an additional vibration perceptibility risk to plant occupants depending on the particle velocity, duration, and time of day due to the blast-induced vibrations from mining activity. Human perception of events of varying durations are illustrated in Figure 7 below. It should be noted that participants used to develop these relationships were inclusive to a test program and that one could conclude the sensitivities to vibrations will vary somewhat from person-to-person, environment-to-environment, and geologic setting, however, the relationship is useful as a reference target.

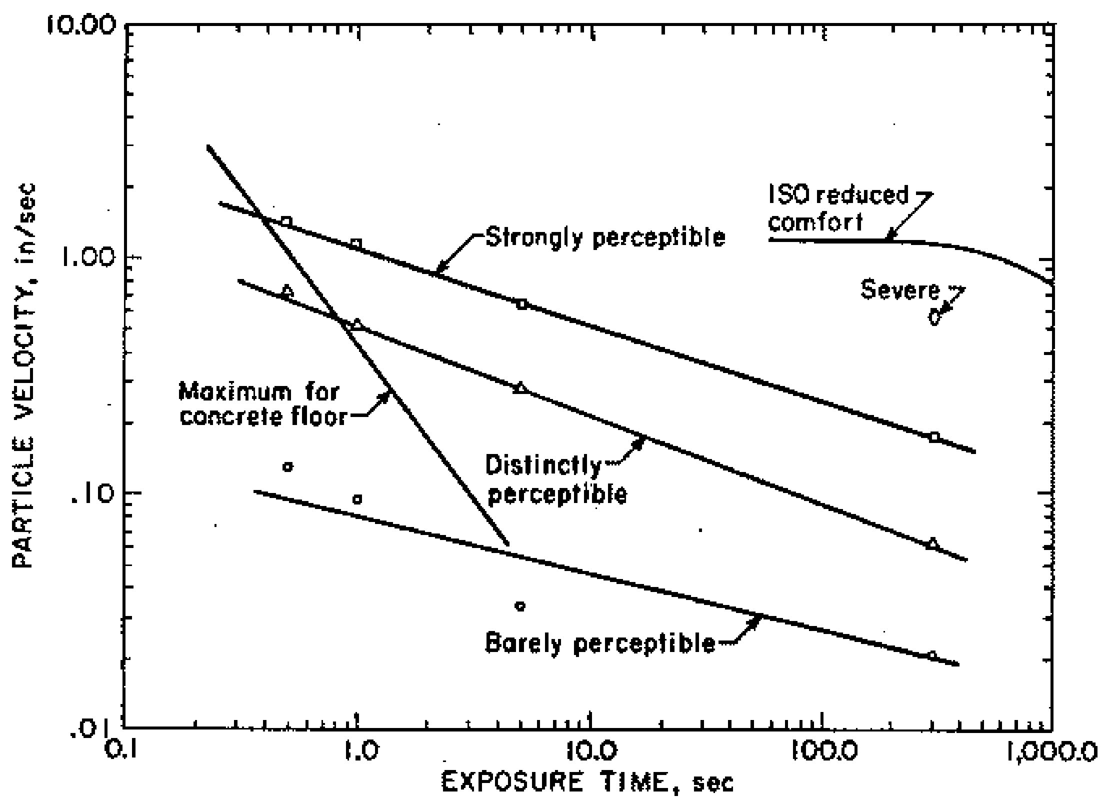

Figure 7 - Human Response to Vibrations of Various Durations, summary. (US Bureau of Mines, 1989)

Per discussions with Hunt Midwest, it is understood that typical operating practices limit blasting to a 1-hour window each day. Usually this is performed between 5pm and 6pm and is limited to a duration of a few seconds for each blast. It is the opinion of Burns & McDonnell that Kansas City establish similar or operationally appropriate blasting and vibration limitations during contract negotiations and that a site-specific program be developed with vibration monitoring instrumentation to calibrate the effects of observed particle velocities on plant personnel and notification procedures be developed for blasting, routine mining operations, and emergencies.

3.2 POST-MINING MAINTENANCE

During mining, rock that has been protected for millions of years is subjected to different atmospheric, humidity, moisture content, and stress conditions that can adversely affect the integrity of the exposed bedrock shales and limestones. Over time, exposing the bedrock to these different conditions can accelerate weathering or instability in the structural elements of the bedrock mine and present themselves as pillar instability, roof instability, and/or floor heave. While structural instability observed in a mine may not immediately (or ever) result in subsidence at the ground surface, it can be one of the few early indicators of an elevated risk scenario.

3.2.1 Special Inspections

The simplest way to reduce the risk of long-term effects to the construction and operational performance of the wastewater treatment facility is to perform routine special inspections of the mine both during mining and after mining activities have been completed. Types of inspections may include installation of monuments on the mine floor, pillars, and ceiling for regular measurement, obtaining updated map of mine showing mining extent and active/inactive areas, walking both active and inactive areas of the mine for visual observation of mined spaces, and that any mitigation/remediation systems in-place within the mine are functioning as intended. Routine inspections of the mining operations and mined space can identify changes between routine inspections that may provide a good indication of any developments that may warrant more frequent inspection or corrective/remedial action. Mining inspections should be performed and/or accompanied by a qualified personnel. It is the opinion of Burns & McDonnell that Kansas City establish parties responsible for mining inspections and reporting both during mining and after mining is completed.

Pillar stability – The width to height ratio is a very important factor in pillar stability. Either reductions in width or increases in pillar height can affect pillar stability. The original room-and-pillar designs can offer stable conditions during and post-mining activities, however, if domeouts (slaking/falling of bedrock from roof resulting in roof/ceiling spall on mine floor) occur near pillars (increasing pillar height) or slaking of the pillars or weathering of exposed shale (decreasing pillar width) occurs, the support pillars can become unstable over time. As the pillars W:H ratio decrease, they will continue to become overstressed until they eventually offer no support to the roof, effectively transferring the load to adjacent pillars, perpetuating the process. Once the process of domeouts or slaking of pillars begins, the process will not stop unless remedial actions are taken. It is understood per discussions with Hunt Midwest, that the proposed mine is anticipated to be constructed with 40 ft long x 40 ft wide pillars with 30 ft rooms, in accordance with the specifications provided by Hunt Midwest's mining engineer based on construction of similar underground mines developed by Hunt Midwest in the Bethany Falls Limestone Member.

Roof stability – Damage from blasting, irregular bedding planes, or 'potholes' identified in the bedrock roof can create weak planes, which unchecked, may initiate a domeout in the roof structure of the mine. These planes typically present themselves as gaps in the ceiling rock (hanging slabs or feather edges) and/or fresh detritus ceiling spall onto the mine floor. The Winterset Limestone Member acts an excellent mine roof in most instances and usually serves as the last line of defense to keep collapses from propagating to the ground surface. The thickness and structural integrity of the Winterset Limestone Member combined with the thickness of overburden soils overlying the Winterset Limestone Member typically governs whether a domeout will propagate to the ground surface or not.

3.2.2 Remedial Options

Should inspections and monitoring identify signs of distress or structural instability within the mine, remedial actions may need to be implemented to stabilize portions of the mine. During both mining operations and when mining is completed, remedial activities may need to be implemented, routinely inspected, and maintained to address potential concerns/risks associated with the integrity of the mine.

Pillar Stability - If slaking or signs of pillar instability is observed during routine visual inspections or mining operations, the following are common remedial options to prevent complete loss of pillar support.

> **Mechanical Anchorage -**If a large slab of the pillar appears to be breaking away at a joint, rock bolts, grouted bolts, or resin bolts may be installed to restrain the slab with the pillar to prevent decreasing the width to height ratio of the pillar and limit further exposure/degradation of the pillar. Additionally, depending on the type of anchorage system, routine inspections may be warranted to assess structural competency and the effectiveness of the remedy. Steel anchors have a tendency to corrode in this particular geologic section of the Kansas City Group.

Pillar Wrap and Shotcrete – If too many cracks appear in a pillar that mechanical anchorage is not the best option or if exposed shale seams in the pillar are weathering/slaking, the pillar can be wrapped tightly with wire ropes to help hold shape and limit decreasing the width to height ratio of the pillar further. Additionally, the pillar may be sprayed with gunite or shotcrete to help protect the pillar and wires from further exposure and degradation. Routine inspections may be warranted to assess structural competency and the effectiveness of the remedy.

Roof Stability –

Mechanical Anchorage – If movement is detected in the mine ceiling or a hanging slab is identified underlying a stable zone of rock, mechanical anchors may be used to arrest further movement of the ceiling. These are advantageous as they don't utilize any of the mine footprint to stabilize the ceiling. The drawback is that a stable bedrock zone must be identified above the ceiling to establish a suitable bond zone to anchor into.. If not anchored properly, the anchored section of ceiling will continue to move, just collectively in a larger unit instead of individual strata. Additionally, depending on the type of anchorage system, routine inspections may be warranted to assess structural competency and the effectiveness of the remedy. Steel anchors have a tendency to corrode in this particular section of the Kansas City Group.

Support system – Similarly, in certain cases, if movement of a monolithic slab is detected in the mine ceiling, but the mine is no longer active or in use, floor-to-ceiling support systems may be used to limit additional movements. These support systems can vary from timber poles to steel or concrete support systems. Routine inspections may be warranted to assess structural competency and the effectiveness of the remedy.

Backfilling – In extreme instances where domeouts have occurred to the base of the Winterset Limestone Member or in overlying strata, a backfilling program may be needed to restrain further collapses from propagating to the ground surface. Backfilling can also be performed via several scenarios, but the principle method is primarily to infill the area under the domeout with compacted inorganic materials. Some previously employed fill materials have included limestone fines, bottom ash, or fly ash coal combustion residual. This will help to support the pillar system, infill the void space, and depending on the degree of compaction achieved, afford some stress redistribution from the adjacent pillars. Routine inspections may be warranted to assess structural competency and the effectiveness of the remedy.

Mine Flooding –

Dewatering – If groundwater/water table is known to occur above the mined area, dewatering pumps may be installed and positioned outside of the footprint of the mine to lower groundwater table below mined area. If groundwater enters the mine and poses a potential risk for mine instability then dewatering within the mine will be performed. Management and disposal (may require treatment) of pumped groundwater will likely be needed. Routine inspections may be warranted to assess dewatering competency and the effectiveness of the remedy.

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4.0 FUTURE CONSIDERATIONS

Per discussions with Hunt Midwest, it is understood the proposed underground mine will have an anticipated roof thickness between 250 to 300 feet with 40 feet by 40 feet pillars and 30 feet rooms and that the uppermost 3.5 ft to 4.0 ft of the Bethany Falls Limestone will remain unmined to serve as the mine ceiling and a 0.5 to 1.0 ft thick layer of Bethany Falls Limestone will serve as the mine floor, per their mining engineer's design and specification based on construction of similar mines developed by Hunt Midwest in the Bethany Falls Limestone Member. The floor-to-ceiling height is expected to be 14 feet. The proposed mine dimensions are comparable to the publicly available data reviewed and discussed herein (USGS, 2022; MDNR, 2022; Whitfield, 1981). The primary indicator of poor mine performance historically appears to be inadequate inspection, maintenance, and corrective action.

During land purchase contract negotiations between Kansas City and Hunt Midwest, it is the opinion of Burns & McDonnell that terms and conditions be developed for the following items and ownership of the associated risks be identified:

1. Finalization of mining schedule/completion of mining operations.
2. Vibration monitoring program and acceptable particle velocity limits established considering both structural damage and human perceptibility.
    a. Corrective actions will be required should observed particle velocities exceed established limits.
3. Develop notification system during mining operations for blasting, routine mining operations, and emergencies; including emergency action plan.
4. Inspection, maintenance, and remedial program of mine during mining and once mining activities have ceased.
    a. Establish ownership and access rights to mined space.
    b. Establish party responsible for periodic mine inspections.
    c. Responsible party for maintenance and remedial repairs.
    d. Provide a survey of the entire mine beneath the subject property, mapping locations of each pillar, pillar dimension, ceiling height, inspection monuments, and any remedial actions implemented.
    e. Provide record/documentation of location and type of any remedial actions implemented in the mine.

The modes of failure described herein generally present themselves locally within a limited area of the mine. As such, remedial activities would likely only be required in localized portions of the mine and not necessarily warrant remediation of the entire mine. While the inherent risk still exists, implementation of the measures detailed above should result in a limiting of potential vibrations observed during mining operations and provide a route to successfully manage the risk of damage to or operational losses at the WWTP facility as a result of mining activities. To further characterize risk factors and refine the risk assessment presented herein specific to this Project, further study is suggested upon acquisition of property rights.

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5.0 LIMITATIONS

This Report was prepared solely for the client, under the terms of the contract. The analysis by Engineer was based on information as qualified in the Report, including information provided by Kansas City and discussions between Hunt Midwest and Kansas City, which was relied upon. Any conclusions or recommendations are provided solely as opinions of Burns & McDonnell. The Report shall only be provided and considered in its entirety, and only for the purpose originally intended in the Statement of Work, and subject to the limitations of remedies as provided in the contract. The Report shall not be utilized or relied upon by any third-party. Client shall waive and release, and otherwise indemnify, defend, and hold Engineering harmless for any use or misuse of this Report for any purpose other than as it was intended, including any claims against Engineer by third parties arising or related to this Report.

This Report is intended to identify and discuss some of the effects and risks associated with the construction and operations of the proposed WWTP and not offer commentary on what may be considered acceptable levels of risk for the WWTP.

All work performed in completion of this Report to be submitted to the Client will be prepared, checked, and reviewed in accordance with the Burns & McDonnell Quality Program, as stated in the QC Manual (Chapter 10 of the Burns & McDonnell corporate Policies and Procedures) and the Report Preparation Guide (Chapter 13 of the Burns & McDonnell corporate Policies and Procedures).

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