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TECHNICAL MEMORANDUM

March 1, 2021

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From: Andy Kopania

Subject: **Adaptive Management Program to evaluate water quality conditions after reclamation of the CEMEX Clayton Quarry**

Impact Analysis

After mining is completed at the CEMEX Clayton Quarry, a quarry lake will form as the former mining excavation fills with water. As described in the *Hydrology and Water Quality Evaluation Report, May 2020, CEMEX Clayton Quarry, Clayton, Contra Costa County, California* (EMKO Environmental, Inc., 2020a) (referred to herein as the "May 2020 Hydrology Report"), the primary source of water for the quarry lake will be local rainfall, including rain that falls on the quarry lake and runoff that occurs from the surrounding watershed and the exposed quarry walls. As described in the May 2020 Hydrology Report, it is anticipated that it will take approximately 158 years for the quarry-lake water surface to rise to the outlet elevation of 735 feet above mean sea level (ft msl). Once the quarry lake reaches the outlet elevation, the quarry lake will have a surface area of approximately 32 acres and will hold over 8,500 acre-feet of water. The watershed around the quarry lake will consist of 17 acres of undisturbed vegetated land, 41 acres of diabase high walls, and eight acres of Knoxville Formation slopes¹. The undisturbed vegetated land is underlain by diabase. Thus, about 88 percent of the 66-acre watershed area will consist of diabase.

Due to the general lack of groundwater within the hardrock formations, the post-mining water quality in the quarry lake will primarily be affected by the leaching of the minerals from the underlying geologic formations in the runoff from the surrounding watershed.

¹ The acreages for the watershed areas are approximate and based on the best available information at the time this assessment was conducted. These values are subject to change as additional investigations are conducted and mining progresses.

To evaluate the potential for minerals within the diabase and the Knoxville Formation to leach into rainwater, leaching tests were conducted on samples collected at the Clayton Quarry. Samples of crushed diabase material from the product piles in the processing plant area and samples of native Knoxville Formation from the east rim of the quarry were obtained on March 12, 2014 and submitted to California Laboratory Services in Rancho Cordova, California. The crushed diabase sample consisted of material that had been mined and then crushed around the date the sample was collected. Thus, the 2014 sample represented a composite sample of the active mining area at that time.

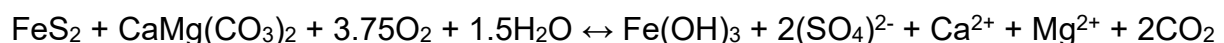
The samples were leached using deionized water following the Waste Extraction Test protocols. This type of test is commonly referred to as a DI-WET test.

The DI-WET analytical protocol uses a 10-fold dilution of the solid sample to the deionized water leaching fluid and a 48-hour contact time. Use of the DI-WET methodology with a 48-hour contact time exceeds the recommendations in the Global Acid Rock Drainage Guide (International Network for Acid Prevention, October 21, 2014), which discuss 24-hour batch tests using deionized water. The DI-WET parameters are generally applicable to evaluation of the potential for normal rainfall to leach minerals and metals from soils. The test typically involves crushing the sample to a two-millimeter grain size, which would be consistent with soil particle sizes.

However, for exposed bedrock areas such as those that would occur on the walls of the reclaimed quarry, the DI-WET test may actually provide a much greater surface area for leaching than would occur under field conditions where the storm water is running over the surface of the bedrock. Overall, the results from the DI-WET test are considered to be indicative of the effects geologic materials may have on the quality of transient waters such as rainfall runoff.

The leachate samples generated from the DI-WET extraction of the diabase and the Knoxville Formation in 2014 were analyzed for general minerals and metals (see EMKO 2020a for results). Subsequent to the 2014 sampling, observations were made of several zones within the quarry that consist of carbonate veining and minor sulfide mineralization (i.e. pyrite). Photo 1 shows a fresh exposure of the diabase with calcareous (i.e. calcite and/or dolomite) veining. Photo 2 shows a weathered surface on the diabase with apparent oxidation of the iron sulfide (pyrite) mineralization. The presence of the zones of calcareous veining and sulfide mineralization were not known in 2014.

Preliminary literature review by EMKO and CEMEX geology staff suggests that localized oxidation of the pyrite is being neutralized by the calcareous veins, such that acid rock drainage (ARD) is not occurring. However, neutralization of the oxidized pyrite may result in the formation of soluble sulfate, calcium, and magnesium in the water that passes through the mineralized zones within the diabase. The following chemical equation defines the reaction (Gomo, 2018):



The reaction indicates that oxidation of pyrite in the presence of water and limestone or dolomite results in insoluble ferric (Fe^{3+}) oxide, dissolved ions of sulfate, calcium and magnesium, and carbon dioxide. Such a reaction has the potential to result in elevated concentrations of sulfate, calcium, and magnesium along with elevated total dissolved solids (TDS) levels in the runoff water. As discussed in Attachment C, the laboratory data confirm that the acid neutralization potential was greater than the acid generation potential in all samples except for one of the altered diabase samples. However, in that one sample, the pH was neutral. Thus, the field conditions at the Clayton quarry are consistent with the above reaction, demonstrating that the carbonate veins are neutralizing any acid that may form from oxidation of the pyrite.



Photo 1. Fresh diabase surfaces showing calcareous veining (January 2, 2020).



Photo 2. Weathered diabase surfaces in quarry showing oxidation (January 2, 2020).

The rock exposures in the current walls and floor of the quarry are not the same as those that will exist once mining is completed, except for part of the west diabase highwall. This is because quarrying activity will continue to progress in the east face of the quarry to reach the design reclamation contours. Given the duration of the proposed mining activities at Clayton (anticipated until 2068), and the long timeframe after reclamation for the quarry lake to form, it is not possible with the existing data, or with data from the existing diabase exposures in the quarry, to determine the water quality in the reclaimed quarry lake and assess whether or not water quality standards would potentially be exceeded in the future. Thus, the potential for a future impact to water quality is unknown. Any potential impact can be addressed through an adaptive management strategy that includes monitoring, comparison of monitoring results with action levels, and subsequent implementation of mitigation measures if the action levels are exceeded.

Monitoring Program and Action Levels

EMKO reviewed a range of guidance documents and peer-reviewed studies to identify methods that may be applicable for assessing potential future impacts to water quality. Attachment A, below, lists the documents that were reviewed and considered. Most of the documents focus on analytical procedures and test methods while only providing general suggestions on the appropriate number of samples and sampling strategies. However, two documents do provide more specific guidance on sampling.

Chapter Nine regarding Sampling Plans in the USEPA SW-846 manual defines statistical procedures that can be used to identify the number of samples that would be appropriate to determine if a specific standard was likely to be exceeded. Use of the USEPA procedure requires some prior data to define statistical parameters such as the mean and variance of the initial data set. There are not enough measurements from the 2014 sampling to use the USEPA statistical procedures. Thus, additional sampling has been conducted in accordance with the recommendations in EMKO (2020b), as described further below.

The 2014 Global Acid Rock Drainage Guide provides guidance on sampling programs during prospecting and resource development “to evaluate the potential of a particular rock type to generate acid, neutralize acid, or leach metals” (International Network for Acid Prevention, 2014, Section 4.3.2.3). The goal of the Global Acid Rock Drainage Guide is to obtain data appropriate to prevent or minimize acid rock drainage. From the existing data at the Clayton quarry and the neutralization mechanism described above, there does not appear to be any appreciable potential for acid rock drainage to occur at Clayton quarry. However, the methods identified in the 2014 Global Acid Rock Drainage Guide are also applicable to the assessment of what elements or metals may form or be released during the acid neutralization process into the quarry lake after reclamation.

Table 4-5 of the 2014 Global Acid Rock Drainage Guide suggests that, as part of resource definition, static testing of five to ten representative samples is appropriate. Since this adaptive management strategy is intended to assess conditions that may occur as the diabase mineral resource at Clayton is further developed, the resource definition recommendations would be applicable since the nature of the pyrite and carbonate mineralization in the future resource are undefined at this time.

Based on the guidance discussed above, Geocon Consultants, Inc. conducted a field sampling program on October 14, 2020 to collect representative samples of Knoxville Formation, altered diabase, and unaltered diabase. Attachment B provides a summary of the field sampling procedures. Four samples of unaltered diabase were collected from locations mid-distance between areas of mineralization and veining. Four representative mineralized zones were selected in the field and samples were collected from rock exposures where both pyrite and carbonate veining were observed. In addition, one quality assurance/quality control (QA/QC) duplicate sample was collected from the diabase. Details of the sampling procedures, sample locations, and QA/QC are described in Attachment B.

The Knoxville Formation is a part of the Great Valley Sequence of Late Jurassic to Cretaceous age sedimentary rocks that were deposited in a seaway after the Coast Range Ophiolite (of which the diabase in the Clayton Quarry is a part) was emplaced. At the Clayton Quarry, the sediments making up the Knoxville Formation are unaltered and not mineralized. However, to verify that the Knoxville Formation would not contribute to acid rock drainage or other water quality concerns once mining ceases, five samples were collected from the Knoxville outcrop along the eastern side of the existing quarry in accordance with Table 4-5 of the 2014 Global Acid Rock Drainage Guide. Sample locations and methods are described in Attachment B.

The nine diabase and five Knoxville samples were submitted to a California-licensed analytical laboratory under appropriate chain-of-custody protocols. Static testing using the DI-WET test methodology was conducted on all samples to mimic rainfall conditions. The samples were also evaluated for sulfur speciation and acid-base accounting analysis, including acid generation potential, acid neutralization potential, and net generation or neutralization potential, as appropriate. This analytical program is consistent with the recommendations in Section 4.3.2.3 of the 2014 Global Acid Rock Drainage Guide. Six individual constituents exceeded their respective standards or action levels, referred to as the Regulatory Threshold in the USEPA SW-846 manual², in at least one of the 14 samples collected and analyzed:

- Arsenic from one of the Knoxville Formation samples;
- Manganese from one of the altered diabase samples;

² See Footnote 1 in Attachment C for a more detailed definition of the Regulatory Thresholds used for this analysis.

- pH from all four of the unaltered diabase samples;
- Conductivity from two of the altered diabase samples;
- Total dissolved solids (TDS) from three of the altered diabase samples; and
- Sulfate from three of the altered diabase samples.

The analytical results are discussed in more detail in Attachment C. The laboratory analytical data report is provided in Attachment D.

The data obtained from the field samples were evaluated using the USEPA SW-846 statistical procedures to determine the appropriate future quarry lake water sampling program once mining ceases and the quarry lake begins to fill with water. The statistical analysis is discussed in Attachment C. Based on that analysis, a total of four water samples, one each from four different locations, should be collected from the quarry lake each sampling round.

To facilitate reproducibility and consistency for the sampling program, four specific locations should be established once mining is completed and the quarry lake begins to fill with water. As the quarry fills with water, the locations relative to the perimeter of the lake should remain the same but will need to be moved to successively higher benches as the water level rises. To provide a reasonable distribution of sampling points, one water sample should be collected each sampling event from the following four locations in the future quarry:

1. near the outlet of the Quarry Lake;
2. along the east wall of the quarry, in an area from which either the Knoxville Formation contacts the water in the future Quarry Lake or runoff from the Knoxville Formation runs down the quarry wall into the future Quarry Lake;
3. along the diabase outcrop in the south side of the Quarry Lake; and
4. at an accessible location along the diabase high wall on the west side of the Quarry Lake.

The quarry lake water quality sampling program would begin once mining is completed and water begins to accumulate within the bottom of the excavation.

Based on seasonal changes in runoff and evaporation from the quarry lake, monitoring would be conducted twice a year, near the end of the wet season (March or April) and again near the end of the dry season (September or October). Field measurements would be conducted for the parameters listed in Table 1 at each of the four sampling locations. The field parameters listed in Table 1 are general indicators of water quality, based on Basin Plan limits and typical National Pollutant Discharge Elimination System (NPDES) requirements or geochemical conditions that could result from oxidation-reduction (redox) reactions that could affect or be caused by the sulfide mineralization.

<i>Parameter</i>	<i>Action Level</i>
pH	>8.5
Conductivity	>900 mg/L
Dissolved oxygen (DO)	<5.5 mg/L or <50% of saturation
Oxidation-reduction potential (ORP)	<0

The four quarry lake water samples would be submitted to a California-licensed analytical laboratory for analysis of the six specific constituents identified above and in Attachment C. If any of the action levels shown in Table 1 for the field data, or any of the Regulatory Thresholds defined in Attachment C for the laboratory analyses, are exceeded for two successive monitoring events, then an action plan would be developed to implement corrective measures to address the exceedances.

Corrective Measures

Specific corrective actions would depend on the nature of the underlying exceedance.

1. If pH, dissolved oxygen, or ORP levels fall outside of the limits in Table 1, aeration or mechanical circulation of the water in the quarry lake could be used to neutralize the pH and/or increase the dissolved oxygen and ORP levels.
2. If TDS or conductivity levels or individual ions or metals (i.e. sulfate, arsenic, manganese) exceed their standards, then the quarry lake water could be treated using reverse osmosis (RO) or ion-exchange prior to discharge from the quarry lake.
3. If specific areas or volumes of wall rock are identified as being problematic, the corrective measures could include removal of the rock mass or sealing off the rock mass with grout or other materials.

The corrective measures described above are established technologies that are feasible and cost-effective to implement. Additional technologies that may be developed between the time this adaptive management strategy was prepared and the time that monitoring data indicate an exceedance, if ever, could also be deployed.

It is important to note that geochemical conditions on the diabase and in the quarry lake are likely to change over time. Shortly after mining ceases, most of the diabase will be exposed to the atmosphere and intermittent seasonal precipitation. However, as the quarry lake fills, much of the exposed diabase will be permanently submerged and the exposure to available oxygen will be diminished, which would be expected to restrict oxidation of the pyrite or other sulfides, based on the chemical reaction described above. These changes are likely to have some effect on the water quality in the quarry

lake. Thus, corrective actions that may be required early in the life of the quarry lake could become unnecessary later. Likewise, if corrective actions are not necessary early on, that does not necessarily indicate they would not be needed later. It is also possible that the specific exceedances could change over time, necessitating a change in the appropriate corrective measure.

Reporting

Monitoring results would be reported to the County on an annual basis. The annual report would also describe any additional measures that have been or are planned to be taken based on the monitoring results. If the triggers described above to implement corrective measures are exceeded for two monitoring rounds, then the annual report would also describe the corrective actions that have been or are planned to be implemented under the adaptive management program.

However, if after five years of monitoring there have been no exceedances of the action levels in Table 1 and the Regulatory Thresholds defined in Attachment C, the monitoring and reporting frequency would be reduced to once every two years. If, after an additional 10 years of monitoring, there have been no exceedances of these same standards, then the monitoring and reporting frequency would be reduced to once every five years. If exceedances occur that trigger the need for corrective action, then monitoring would revert back to the original twice per year schedule, with annual reporting. If the corrective actions are successful, then subsequent monitoring and reporting frequencies would be reduced following the same schedule described above in this paragraph.

References Cited

International Network for Acid Prevention, October 21, 2014, Global Acid Rock Drainage Guide.

EMKO Environmental, Inc. (EMKO), 2020a, Hydrology and Water Quality Evaluation Report, May 2020, CEMEX Clayton Quarry, Clayton, Contra Costa County, California.

EMKO, 2020b, Technical Memorandum: Initial Sampling to Support Adaptive Management Plan, Clayton Quarry, August 13, 2020.

Gomo, M., 2018, Conceptual hydrogeochemical characteristics of a calcite and dolomite acid mine drainage neutralised circumneutral groundwater system, Water Science, vol. 32, pp. 355-361, <https://www.sciencedirect.com/science/article/pii/S1110492917300036>

United States Department of Environmental Protection (USEPA), Hazardous Waste Test Methods/SW-846, Chapter Nine, Sampling Plans (<https://www.epa.gov/hw-sw846/chapter-nine-sw-846-compendium-sampling-plans>, accessed June 29, 2020).

ATTACHMENT A
Documents Reviewed and Considered

International Network for Acid Prevention, October 21, 2014, Global Acid Rock Drainage Guide.

Nevada Bureau of Land Management, Rock Characterization and Water Resources Analysis Guidance for Mining Activities.

Nevada Division of Environmental Protection (NDEP), Bureau of Mining Regulation and Reclamation, March 4, 2019, Pit-Lake Characterization Analytical Profile.

NDEP, March 22, 2019, Nevada Modified Sobek Procedure Summary.

NDEP, Bureau of Mining Regulation and Reclamation, April 12, 2019, Waste Rock, Overburden, and Ore Characterization and Evaluation.

NDEP, Pit Lake Water Quality Characterization Program, NDEP Profile III.

O2 Marine, January 25, 2019, Kirkalocka Pit Water Quality Sampling Technical Report 2018 for Adaman Resources, Western Australia, 18WAU-0038/T1800150.

United States Department of Environmental Protection (USEPA), Hazardous Waste Test Methods/SW-846, Chapter Nine, Sampling Plans (<https://www.epa.gov/hw-sw846/chapter-nine-sw-846-compendium-sampling-plans>, accessed June 29, 2020).

USEPA, December 2002, Guidance on Choosing a Sampling Design for Environmental Data Collection for Use in Developing a Quality Assurance Project Plan, EPA QA/G-5S.

Zhao, Lu Y.L., Clint D. Mccullough, Mark A. Lund, and Michelle Newport, June 2010, Mine Voids Management Strategy (III): A Monitoring Strategy for Pit Lakes and Connected Waters, Mine Water and Environment Research/Centre for Ecosystem Management Report No. 2010-02, Edith Cowan University, Perth, Western Australia.

ATTACHMENT B
Geocon Consultants, Inc. Sampling Procedures Report

ATTACHMENT C
Laboratory Data Review and Statistical Analysis

Rock samples were collected from the CEMEX Clayton Quarry and subjected to DI-WET leaching as a proxy for future water quality in the quarry lake. This testing was conducted to assist in the definition of the appropriate future water quality monitoring program as part of an adaptive management strategy.

In accordance with the August 13, 2020 sampling plan to support this Adaptive Management Program (EMKO, 2020b), 14 rock samples were collected at the Clayton Quarry on October 14, 2020. Five samples were collected from the Knoxville Formation outcrop along the east side of the quarry. Four samples and one duplicate sample of altered diabase were collected from three different quarry benches below an elevation of 735 feet. Four samples of unaltered diabase were collected from two different benches between the altered diabase samples. A summary of the field sampling procedures is provided in the technical memorandum from Geocon Consultants, Inc. (Geocon, 2021) provided as Attachment B to the Adaptive Management Program. Maps and field photographs documenting the sampling locations are also provided in Attachment B.

Tables C-1, C-2, and C-3 provide a summary of the laboratory analytical results for metals, acid-base accounting and sulfur parameters, and general mineral constituents, respectively. As indicated in Tables C-1 through C-3, six constituents exceeded their applicable Regulatory Threshold¹ (RT) in the DI-WET leachate from at least one of the samples collected. These six constituents are:

- Arsenic from one of the Knoxville Formation samples
- Manganese from one of the altered diabase samples;
- pH in the saturated paste² from all four of the unaltered diabase samples;
- Conductivity from two of the altered diabase samples;
- Total dissolved solids (TDS) from three of the altered diabase samples; and

1 The Regulatory Thresholds considered in this analysis are the primary and secondary maximum contaminant levels (MCLs) for drinking water, as reported by the California State Water Resources Control Board (SWRCB, 2021, A Compilation of Water Quality Goals, accessed January 13, 2021 https://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/#db_instructions). The MCLs for the detected constituents are also typically equivalent to Basin Plan water quality standards and NPDES discharge limits.

2 The saturated paste pH was used for this assessment because it is more representative of the conditions that will exist in the geologic formations that are in direct contact with the water in the Quarry Lake (i.e. the water that accumulates in the Quarry Lake will saturate the fractures and void spaces within the adjacent diabase and Knoxville Formation).

- Sulfate from three of the altered diabase samples.

The acid-base potential evaluation indicated that the acid neutralization potential was greater than the acid generation potential in all samples except for one of the altered diabase samples (sample BENCH 2 A1 – see Table C-2). Despite the slight negative acid-base potential in BENCH 2 A1, the leaching pH and saturated paste pH values of 6.4 and 6.8 are within the RT and do not indicate the potential for the generation of acid rock drainage. As discussed further below, pH will be part of the monitoring program for the reclaimed Quarry Lake, which will allow for the assessment and subsequent mitigation of any potential for acid pH issues.

An initial statistical evaluation of the sampling results for the six parameters listed above indicates that the data for five of the six parameters (i.e. all but pH) are not normally distributed, as illustrated by the strongly skewed data distributions shown on Figures C-1A and C-2A. As indicated by the green highlighted cells in Table C-4, for these constituents, the standard deviation is typically much higher than the mean. The primary reason for the non-normal distribution of the data is the large range of values, with most of the results clustered at low concentrations, or non-detectable values, and the few RT exceedances being as many as three orders of magnitude greater. The USEPA SW-846 evaluation methodology assumes that the data approximate a normal distribution. To accommodate the USEPA SW-846 approach, the data were transformed using the base-10 logarithm. Figures C-2A and C-2B compare the distribution of the manganese laboratory results and the log-transformed manganese data. As illustrated on Figure C-2A, the laboratory reported results cluster at very low concentrations, with a long tail to the right for the single RT exceedance. Figure C-2B shows that the log-transformed manganese data better approximate a normal distribution. Figures C-3A and C-3B provide a similar comparison of the TDS data for the laboratory reported and log-transformed values.

Table C-4 provides a summary of the laboratory data for all six parameters that exceed their respective RTs and the log-transformed values for each parameter except pH. In Table C-4, values reported as not detected (ND) are shown at one-half of the method detection limit (MDL). Typically, ND values would be shown at one-half of the practical quantitation limit (PQL), also known as the laboratory reporting limit (RL). However, due to the prevalence of B-flagged data, where the laboratory was able to approximate values between the MDL and PQL, use of one-half of the PQL would over-estimate the mean and other statistical parameters.

Table C-4 also shows the mean and standard deviations for each parameter, along with the RT. Values of the standard deviation that exceed the mean are highlighted in green on Table C-4. Note that for values below one, the log transformation results in negative values. The presence of negative values does not affect the evaluation, however, because the log-transformed RTs for those constituents are also negative. In addition, the USEPA SW-846 calculations are based on the square of the difference

between the RT and the average, and on the square of the standard deviation, which eliminates negative values.

For the SW-846 procedure, the mean (\bar{x}) and the standard deviation (s) of the sample set are calculated. The value delta (Δ) is then calculated by subtracting the mean from the RT:

$$\Delta = RT - \bar{x}.$$

Then, using the t value for $n-1$ degrees of freedom from Table 9-2 of SW-846, the number of water samples (N) to collect from the future Quarry Lake to evaluate whether a constituent exceeds its water-quality RT is defined as:

$$N = (t^2 \times s^2) / \Delta^2.$$

The calculations are summarized in Table 4 for each constituent based on 14 samples and 13 degrees of freedom ($n-1$).

The appropriate number of water samples, N , to collect from the future Quarry Lake for each sampling round for each constituent are shown at the bottom of Table C-4. N ranges from 0.66 for arsenic to 3.38 for pH. In general, the N values shown in Table C-4 should be increased to the next highest whole number. Thus, the appropriate number of samples for arsenic and manganese is one, the appropriate number of samples for conductivity and TDS is two, the appropriate number of samples for sulfate is three, and the appropriate number of samples for pH is four.

To provide a consistent and easily implementable water quality monitoring program, it is recommended that the number of samples be the same for each constituent for each monitoring round. Thus, four water samples should be collected each sampling event and analyzed for the six constituents identified in Table C-4. To facilitate reproducibility and consistency for the sampling program, four specific locations should be established once mining is completed and the Quarry Lake begins to fill with water. Thus, for each sampling round, a single water sample would be collected from each of the four established sampling locations. As the quarry fills with water, the locations relative to the perimeter of the lake should remain the same but will need to be moved to successively higher benches as the water level rises. To provide a reasonable distribution of sampling points, one water sample should be collected each sampling event from each the following four locations:

1. near the outlet of the Quarry Lake;
2. along the east wall of the quarry, in an area from which either the Knoxville Formation contacts the water in the future Quarry Lake or runoff from the Knoxville Formation runs down the quarry wall into the future Quarry Lake;
3. along the diabase outcrop in the south side of the Quarry Lake; and

4. at an accessible location along the diabase high wall on the west side of the Quarry Lake.

Due to the substantial variation in rainfall and hydrologic conditions between the wet and dry seasons, it is recommended that one sampling event be conducted near the end of the wet season (March or April) each year and that a second sampling event be conducted near the end of the dry season (September or October) each year.

TABLE C-1
Metals Results from DI-WET Extraction
Wall Rock Samples Collected on October 14, 2020
CEMEX Clayton Quarry

KNOXVILLE FORMATION SAMPLES										
ANALYTE	UNITS	KXF1	KXF2	KXF3	KXF4	KXF5	MDL	PQL	RT	
Aluminum (WET DI)	mg/L	0.093 B	0.216 B	0.232 B	ND	0.818	0.05	0.25	1	
Antimony (WET DI)	mg/L	0.00101 B	0.00085 B	0.00105 B	0.00151 B	0.00283	0.0004	0.002	0.006	
Arsenic (WET DI)	mg/L	0.0031	0.00307	0.00507	0.00181	0.02	0.0002	0.001	0.01	
Barium (WET DI)	mg/L	ND	ND	ND	ND	ND	0.007	0.035	1	
Beryllium (WET DI)	mg/L	ND	ND	ND	ND	ND	0.00008	0.00025	0.004	
Boron (WET DI)	mg/L	0.051 B	0.042 B	0.043 B	0.053 B	0.253	0.02	0.1	1	
Cadmium (WET DI)	mg/L	ND	ND	ND	ND	ND	0.00005	0.00025	0.005	
Calcium (WET DI)	mg/L	9.08	7.94	7.27	22.3	0.17 B	0.1	0.5		
Chromium (WET DI)	mg/L	ND	ND	ND	ND	ND	0.01	0.05	0.05	
Cobalt (WET DI)	mg/L	ND	ND	ND	ND	ND	0.01	0.05		
Copper (WET DI)	mg/L	ND	ND	ND	ND	ND	0.01	0.05	1.3	
Iron (WET DI)	mg/L	ND	0.105 B	0.101 B	ND	0.29	0.06	0.15	0.3	
Lead (WET DI)	mg/L	ND	ND	ND	ND	ND	0.03	0.15	0.015	
Magnesium (WET DI)	mg/L	2.85	2.54	1.49	1.72	ND	0.2	1		
Manganese (WET DI)	mg/L	ND	ND	ND	ND	ND	0.01	0.05	0.05	
Mercury (WET DI)	mg/L	ND	ND	ND	ND	ND	0.0002	0.001	0.002	
Molybdenum (WET DI)	mg/L	ND	ND	ND	ND	ND	0.02	0.1		
Nickel (WET DI)	mg/L	ND	ND	ND	ND	ND	0.008	0.04	0.1	
Potassium (WET DI)	mg/L	1.52	1.27	1.19	1.37	ND	0.2	1		
Selenium (WET DI)	mg/L	0.00271	0.00195	0.00123	0.00471	0.0068	0.0001	0.00025	0.05	
Silver (WET DI)	mg/L	ND	ND	ND	ND	ND	0.01	0.025	0.1	
Sodium (WET DI)	mg/L	5.76	5.12	5.97	7.16	45.1	0.2	1		
Thallium (WET DI)	mg/L	ND	ND	ND	ND	ND	0.0001	0.0005	0.002	
Vanadium (WET DI)	mg/L	0.015 B	0.017 B	0.029	ND	0.132	0.01	0.025		
Zinc (WET DI)	mg/L	ND	ND	ND	ND	ND	0.02	0.05	5	
ALTERED DIABASE SAMPLES										
ANALYTE	UNITS	BENCH 1 A1	BENCH 1 A2	BENCH 2 A1	BENCH 2 A2	BENCH 3 A1	MDL	PQL	RT	
Aluminum (WET DI)	mg/L	ND	0.076 B	ND	0.083 B	0.075 B	0.05	0.25	1	
Antimony (WET DI)	mg/L	ND	ND	ND	ND	ND	0.0004	0.002	0.006	
Arsenic (WET DI)	mg/L	ND	ND	ND	ND	ND	0.0002	0.001	0.01	
Barium (WET DI)	mg/L	ND	ND	ND	ND	ND	0.007	0.035	1	
Beryllium (WET DI)	mg/L	ND	ND	ND	ND	ND	0.00008	0.00025	0.004	
Boron (WET DI)	mg/L	0.024 B	ND	ND	ND	ND	0.02	0.1	1	
Cadmium (WET DI)	mg/L	ND	ND	ND	ND	ND	0.00005	0.00025	0.005	
Calcium (WET DI)	mg/L	490	81.4	109	11.9	530	0.1	0.5		
Chromium (WET DI)	mg/L	ND	ND	ND	ND	ND	0.01	0.05	0.05	
Cobalt (WET DI)	mg/L	ND	ND	ND	ND	ND	0.01	0.05		
Copper (WET DI)	mg/L	ND	ND	ND	ND	ND	0.01	0.05	1.3	
Iron (WET DI)	mg/L	ND	ND	ND	0.062 B	ND	0.06	0.15	0.3	
Lead (WET DI)	mg/L	ND	ND	ND	ND	ND	0.03	0.15	0.015	
Magnesium (WET DI)	mg/L	9.99	18.2	20.9	9.58	10.6	0.2	1		
Manganese (WET DI)	mg/L	0.028 B	0.015 B	0.334	0.011 B	0.019 B	0.01	0.05	0.05	
Mercury (WET DI)	mg/L	ND	ND	ND	ND	ND	0.0002	0.001	0.002	
Molybdenum (WET DI)	mg/L	ND	ND	ND	ND	ND	0.02	0.1		
Nickel (WET DI)	mg/L	ND	ND	ND	ND	ND	0.008	0.04	0.1	
Potassium (WET DI)	mg/L	ND	ND	ND	ND	ND	0.2	1		
Selenium (WET DI)	mg/L	0.00199	0.00016 B	0.0003	0.00011 B	0.00014 B	0.0001	0.00025	0.05	
Silver (WET DI)	mg/L	ND	ND	ND	ND	ND	0.01	0.025	0.1	
Sodium (WET DI)	mg/L	4.03	4.72	5.12	5.9	0.29 B	0.2	1		
Thallium (WET DI)	mg/L	ND	ND	ND	ND	ND	0.0001	0.0005	0.002	
Vanadium (WET DI)	mg/L	ND	ND	ND	ND	ND	0.01	0.025		
Zinc (WET DI)	mg/L	ND	ND	ND	ND	ND	0.02	0.05	5	
UNALTERED DIABASE SAMPLES										
ANALYTE	UNITS	BENCH 1 U1	BENCH 1 U2	BENCH 2 U1	BENCH 2 U2		MDL	PQL	RT	
Aluminum (WET DI)	mg/L	0.321	0.199 B	0.233 B	0.29		0.05	0.25	1	
Antimony (WET DI)	mg/L	ND	ND	0.0005 B	0.0005 B		0.0004	0.002	0.006	
Arsenic (WET DI)	mg/L	0.0004 B	ND	0.00035 B	0.00073 B		0.0002	0.001	0.01	
Barium (WET DI)	mg/L	ND	ND	ND	ND		0.007	0.035	1	
Beryllium (WET DI)	mg/L	ND	ND	ND	ND		0.00008	0.00025	0.004	
Boron (WET DI)	mg/L	ND	0.02 B	ND	ND		0.02	0.1	1	
Cadmium (WET DI)	mg/L	ND	ND	ND	ND		0.00005	0.00025	0.005	
Calcium (WET DI)	mg/L	7.12	12.2	7.49	7.24		0.1	0.5		
Chromium (WET DI)	mg/L	ND	ND	ND	ND		0.01	0.05	0.05	
Cobalt (WET DI)	mg/L	ND	ND	ND	ND		0.01	0.05		
Copper (WET DI)	mg/L	ND	ND	ND	ND		0.01	0.05	1.3	
Iron (WET DI)	mg/L	0.124 B	ND	0.134 B	0.156		0.06	0.15	0.3	
Lead (WET DI)	mg/L	ND	ND	ND	ND		0.03	0.15	0.015	
Magnesium (WET DI)	mg/L	2.4	3.17	3.25	3.23		0.2	1		
Manganese (WET DI)	mg/L	ND	ND	ND	ND		0.01	0.05	0.05	
Mercury (WET DI)	mg/L	ND	ND	ND	ND		0.0002	0.001	0.002	
Molybdenum (WET DI)	mg/L	ND	ND	ND	ND		0.02	0.1		
Nickel (WET DI)	mg/L	ND	ND	ND	ND		0.008	0.04	0.1	
Potassium (WET DI)	mg/L	0.21 B	ND	0.47 B	0.72 B		0.2	1		
Selenium (WET DI)	mg/L	0.00027	0.00028	ND	ND		0.0001	0.00025	0.05	
Silver (WET DI)	mg/L	ND	ND	ND	ND		0.01	0.025	0.1	
Sodium (WET DI)	mg/L	5.06	5.63	4.57	7.52		0.2	1		
Thallium (WET DI)	mg/L	ND	ND	ND	ND		0.0001	0.0005	0.002	
Vanadium (WET DI)	mg/L	0.018 B	0.012 B	ND	ND		0.01	0.025		
Zinc (WET DI)	mg/L	ND	ND	ND	ND		0.02	0.05	5	

MDL = Method Detection Limit

PQL = Practical Quantitation Limit

ND = Not detected above the PQL

B = Concentration detected at a value between the MDL and PQL. Reported value is an estimated quantity.

RT = Regulatory Threshold, equivalent to primary or secondary maximum contaminant level, based on:

SWRCB, 2021, A Compilation of Water Quality Goals, accessed January 13, 2021

https://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/#db_instructions

0.334 = Highlighted results exceed the RT

TABLE C-2

Acid-Base Accounting and Sulfur Parameter Results
Wall Rock Samples Collected on October 14, 2020
CEMEX Clayton Quarry

KNOXVILLE FORMATION SAMPLES									
ANALYTE	UNITS	KXF1	KXF2	KXF3	KXF4	KXF5	MDL	PQL	RT
Acid Generation Potential (calc on Sulfur t	t CaCO3/Kt	14.1	7.5	6.88	11.9	11.9	0.31	3.1	
Acid Neutralization Potential (calc)	t CaCO3/Kt	20	19	21	17	15	1	5	
Acid-Base Potential (calc on Sulfur total)	t CaCO3/Kt	5.9	11.5	14.1	5.1	3.1			>0
Neutralization Potential as CaCO3	%	2	1.9	2.1	1.7	1.5	0.1	0.5	
pH	units	8.5	8.7	8.9	8.4	9.8	0.1	0.1	
pH, Saturated Paste	units	7.6	7.8	7.9	7.8	8.4	0.1	0.1	6.5 - 8.5
Sulfur HCl Residue	%	0.4	0.2	0.19	0.35	0.35	0.01	0.1	
Sulfur HNO3 Residue	%	0.01 B	ND	ND	ND	ND	0.01	0.1	
Sulfur Organic Residual	%	0.01 B	ND	ND	ND	ND	0.01	0.1	
Sulfur Pyritic Sulfide	%	0.39	0.2	0.19	0.35	0.35	0.01	0.1	
Sulfur Sulfate	%	0.05 B	0.04 B	0.03 B	0.03 B	0.03 B	0.01	0.1	
Sulfur Total	%	0.45	0.24	0.22	0.38	0.38	0.01	0.1	
Temperature	C	21.5	21.5	21.5	21.5	21.5	0.1	0.1	
Total Sulfur minus Sulfate	%	0.4	0.2	0.19	0.35	0.35	0.01	0.1	
ALTERED DIABASE SAMPLES									
ANALYTE	UNITS	BENCH 1 A1	BENCH 1 A2	BENCH 2 A1	BENCH 2 A2	BENCH 3 A1	MDL	PQL	RT
Acid Generation Potential (calc on Sulfur t	t CaCO3/Kt	84.4	32.5	28.8	12.5	16.9	0.31	3.1	
Acid Neutralization Potential (calc)	t CaCO3/Kt	420	34	13	15	714	1	5	
Acid-Base Potential (calc on Sulfur total)	t CaCO3/Kt	336	1.5	-15.8	2.5	697			>0
Neutralization Potential as CaCO3	%	42	3.4	1.3	1.5	71.4	0.1	0.5	
pH	units	7.6	8.1	6.4	7.9	7.8	0.1	0.1	
pH, Saturated Paste	units	6.9	7.8	6.8	7.9	7.3	0.1	0.1	6.5 - 8.5
Sulfur HCl Residue	%	1.62	0.64	0.58	0.22	0.26	0.01	0.1	
Sulfur HNO3 Residue	%	ND	ND	ND	ND	ND	0.01	0.1	
Sulfur Organic Residual	%	ND	ND	ND	ND	ND	0.01	0.1	
Sulfur Pyritic Sulfide	%	1.62	0.64	0.58	0.22	0.26	0.01	0.1	
Sulfur Sulfate	%	1.08	0.4	0.34	0.18	0.28	0.01	0.1	
Sulfur Total	%	2.7	1.04	0.92	0.4	0.54	0.01	0.1	
Temperature	C	21.5	21.5	21.5	21.5	21.5	0.1	0.1	
Total Sulfur minus Sulfate	%	1.62	0.64	0.58	0.22	0.26	0.01	0.1	
UNALTERED DIABASE SAMPLES									
ANALYTE	UNITS	BENCH 1 U1	BENCH 1 U2	BENCH 2 U1	BENCH 2 U2		MDL	PQL	RT
Acid Generation Potential (calc on Sulfur t	t CaCO3/Kt	1.88 B	5.31		0.63 B		0.31	3.1	
Acid Neutralization Potential (calc)	t CaCO3/Kt	13	19	15	18		1	5	
Acid-Base Potential (calc on Sulfur total)	t CaCO3/Kt	11.1	13.7	15	17.4				>0
Neutralization Potential as CaCO3	%	1.3	1.9	1.5	1.8		0.1	0.5	
pH	units	9.1	9.1	9	9.1		0.1	0.1	
pH, Saturated Paste	units	8.9	9	8.8	8.9		0.1	0.1	6.5 - 8.5
Sulfur HCl Residue	%	0.03 B	0.13	ND	0.01 B		0.01	0.1	
Sulfur HNO3 Residue	%	ND	ND	ND	ND		0.01	0.1	
Sulfur Organic Residual	%	ND	ND	ND	ND		0.01	0.1	
Sulfur Pyritic Sulfide	%	0.03 B	0.13	ND	0.01 B		0.01	0.1	
Sulfur Sulfate	%	0.03 B	0.04 B	ND	0.01 B		0.01	0.1	
Sulfur Total	%	0.06 B	0.17	ND	0.02 B		0.01	0.1	
Temperature	C	21.5	21.5	21.5	21.5		0.1	0.1	
Total Sulfur minus Sulfate	%	0.03 B	0.13	ND	0.01 B		0.01	0.1	

MDL = Method Detection Limit

PQL = Practical Quantitation Limit

ND = Not detected above the PQL

B = Concentration detected at a value between the MDL and PQL. Reported value is an estimated quantity.

RT = Regulatory Threshold, equivalent to primary or secondary maximum contaminant level, based on:

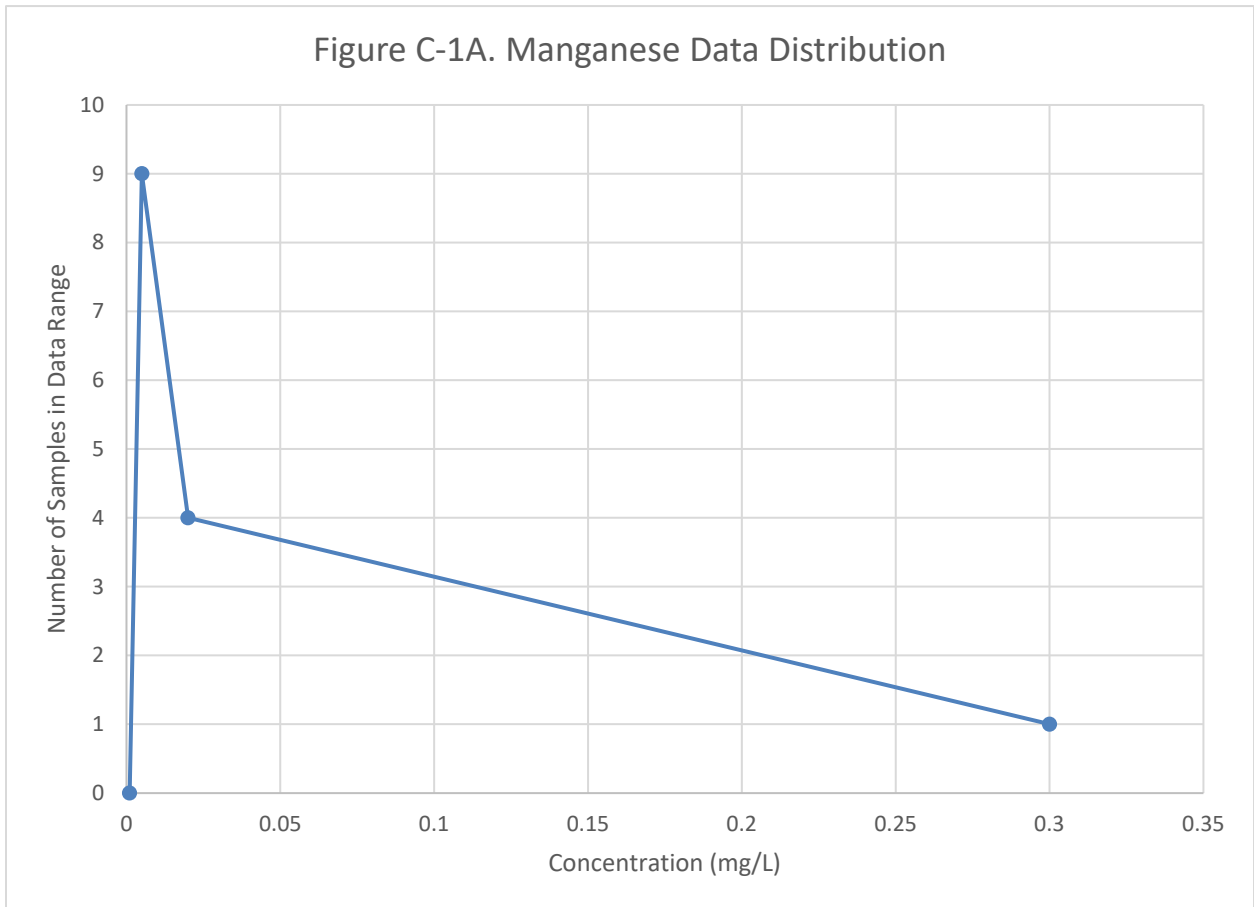
SWRCB, 2021, A Compilation of Water Quality Goals, accessed January 13, 2021

https://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/#db_instructions

8.9 =

Highlighted results exceed the RT

TABLE C-3											
General Mineral Constituent Results from DI-WET Extraction											
Wall Rock Samples Collected on October 14, 2020											
CEMEX Clayton Quarry											
KNOXVILLE FORMATION SAMPLES											
ANALYTE	UNITS	KXF1	KXF2	KXF3	KXF4	KXF5	MDL	PQL	RT		
Bicarbonate as CaCO3	mg/L	28.9	30.2	28.7	27.8	52.9		2	20		
Carbonate as CaCO3	mg/L	ND	ND	ND	ND	31.9		2	20		
Chloride (WET DI)	mg/L	0.8 B	0.6 B	0.81 B	1.45 B	3.12		0.5	2	250	
Conductivity @25C (WET-DI)	umhos/cm	108	86	76	177	202		1	10	900	
Fluoride (WET DI)	mg/L	0.3 B	0.3 B	0.3 B	ND	0.1 B		0.2	0.7	2	
Hardness as CaCO3 (WET-DI)	mg/L	34	30	24	63	0.424 B		0.2	5		
Hydroxide as CaCO3	mg/L	ND	ND	ND	ND	ND		2	20		
Nitrate as N (WET-DI)	mg/L	0.09 BH	0.04 BH	0.03 BH	0.03 BH	0.05 BH		0.02	0.1	10	
Nitrate/Nitrite as N (WET DI)	mg/L	0.093 BH	0.037 BH	0.029 BH	0.028 BH	0.052 BH		0.02	0.1		
Nitrite as N (WET DI)	mg/L	ND	H	ND	H	H	ND	H	0.01	0.05	1
Residue, Filterable (TDS) @180C (WET DI)	mg/L	66	52	52	104	120		20	40	500	
Sulfate (WET DI)	mg/L	22 B	ND	ND	50	ND		20	50	250	
Total Alkalinity	mg/L	28.9		28.7	27.8	84.8		2	20		
ALTERED DIABASE SAMPLES											
ANALYTE	UNITS	BENCH 1 A1	BENCH 1 A2	BENCH 2 A1	BENCH 2 A2	BENCH 3 A1	MDL	PQL	RT		
Bicarbonate as CaCO3	mg/L	72.3	38.8	20.3	14.8 B	37.8		2	20		
Carbonate as CaCO3	mg/L	ND	ND	ND	ND	ND		2	20		
Chloride (WET DI)	mg/L	1.61 B	5.21	2.34	1.74 B	0.64 B		0.5	2	250	
Conductivity @25C (WET-DI)	umhos/cm	1770	522	650	177	1810		1	10	900	
Fluoride (WET DI)	mg/L	ND	ND	ND	0.2 B	ND		0.2	0.7	2	
Hardness as CaCO3 (WET-DI)	mg/L	1260	278	358	69	1370		0.2	5		
Hydroxide as CaCO3	mg/L	ND	ND	ND	ND	ND		2	20		
Nitrate as N (WET-DI)	mg/L	0.45 H	0.06 BH	0.04 BH	0.04 BH	0.09 BH		0.02	0.1	10	
Nitrate/Nitrite as N (WET DI)	mg/L	0.451 H	0.055 BH	0.044 BH	0.037 BH	0.086 BH		0.02	0.1		
Nitrite as N (WET DI)	mg/L	ND	H	ND	H	ND	H	ND	H	0.01	0.05
Residue, Filterable (TDS) @180C (WET DI)	mg/L	1910	390	528	102	2020		20	40	500	
Sulfate (WET DI)	mg/L	1170	238	351	65	1300		20	50	250	
Total Alkalinity	mg/L	72.3	38.8	20.3	14.8 B	37.8		2	20		
UNALTERED DIABASE SAMPLES											
ANALYTE	UNITS	BENCH 1 U1	BENCH 1 U2	BENCH 2 U1	BENCH 2 U2		MDL	PQL	RT		
Bicarbonate as CaCO3	mg/L	21.8	25.4	18.1 B	25.3			2	20		
Carbonate as CaCO3	mg/L	ND	ND	ND	ND			2	20		
Chloride (WET DI)	mg/L	1.12 B	2.28	1.47 B	1.5 B			0.5	2	250	
Conductivity @25C (WET-DI)	umhos/cm	90	121	95	105			1	10	900	
Fluoride (WET DI)	mg/L	ND	ND	0.2 B	0.3 B			0.2	0.7	2	
Hardness as CaCO3 (WET-DI)	mg/L	28	44	32	31			0.2	5		
Hydroxide as CaCO3	mg/L	ND	ND	ND	ND			2	20		
Nitrate as N (WET-DI)	mg/L	0.24 H	0.34 H	0.91 H	1.3 H			0.02	0.1	10	
Nitrate/Nitrite as N (WET DI)	mg/L	0.244 H	0.338 H	0.925 H	1.32 H			0.02	0.1		
Nitrite as N (WET DI)	mg/L	ND	H	ND	H	0.014 BH	0.018 BH		0.01	0.05	1
Residue, Filterable (TDS) @180C (WET DI)	mg/L	54	78	60	66			20	40	500	
Sulfate (WET DI)	mg/L	22 B	35 B	29 B	27 B			20	50	250	
Total Alkalinity	mg/L	21.8	25.4	18.1 B	25.3			2	20		
MDL = Method Detection Limit											
PQL = Practical Quantitation Limit											
ND = Not detected above the PQL											
B = Concentration detected at a value between the MDL and PQL. Reported value is an estimated quantity.											
H = Hold time exceeded											
RT = Regulatory Threshold, equivalent to primary or secondary maximum contaminant level, based on:											
SWRCB, 2021, A Compilation of Water Quality Goals, accessed January 13, 2021											
https://www.waterboards.ca.gov/water_issues/programs/water_quality_goals/#db_instructions											
1170 =	Highlighted results exceed the RT										



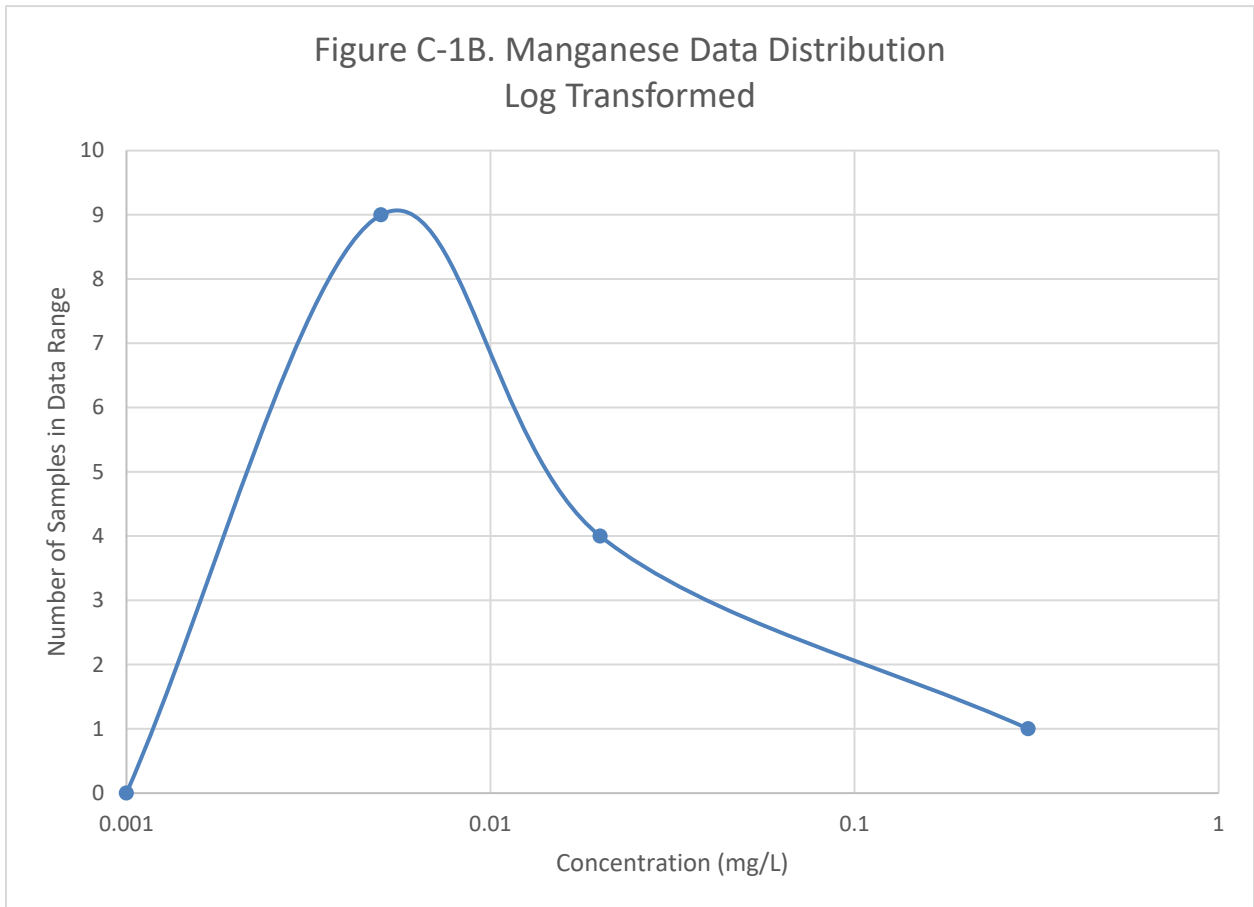


Figure C-2A. TDS Data Distribution

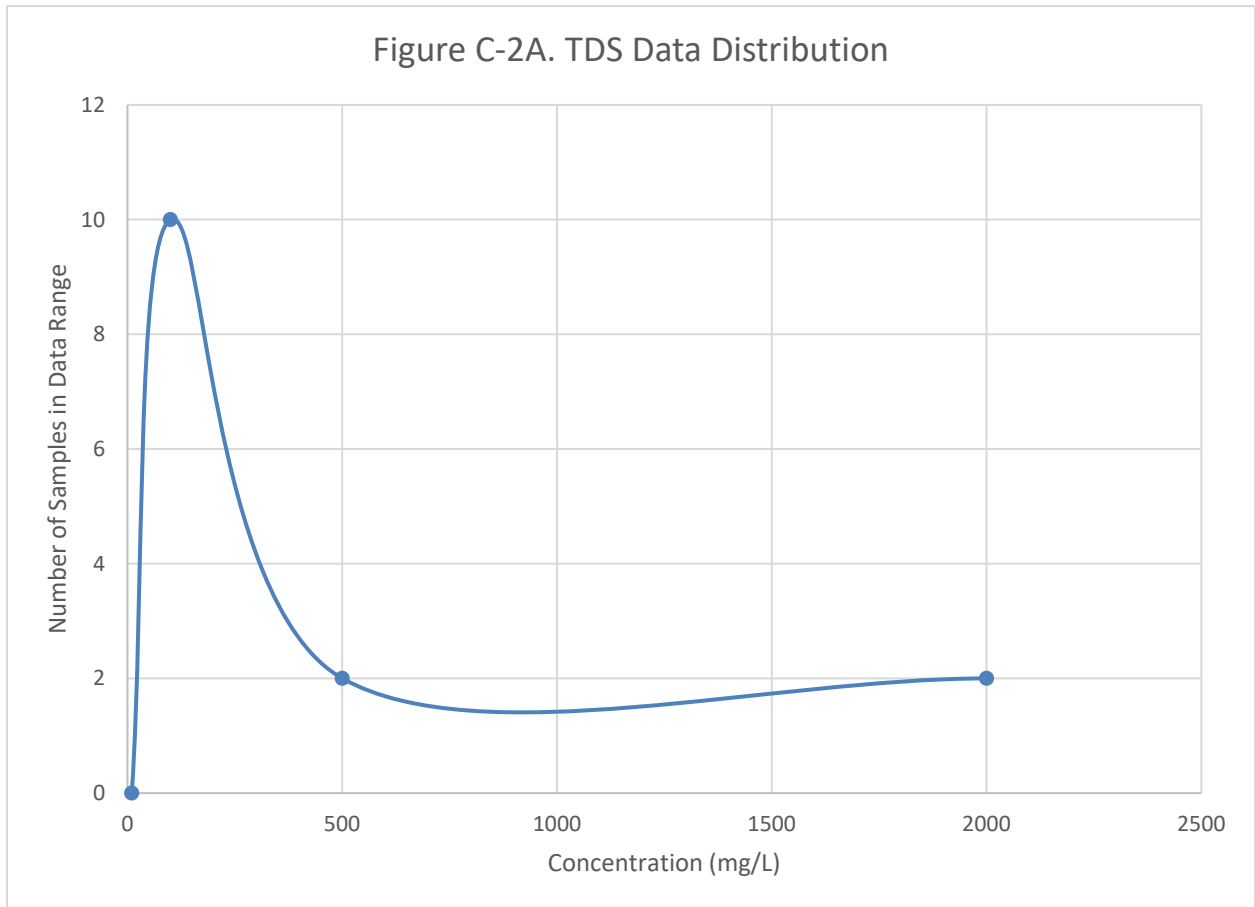
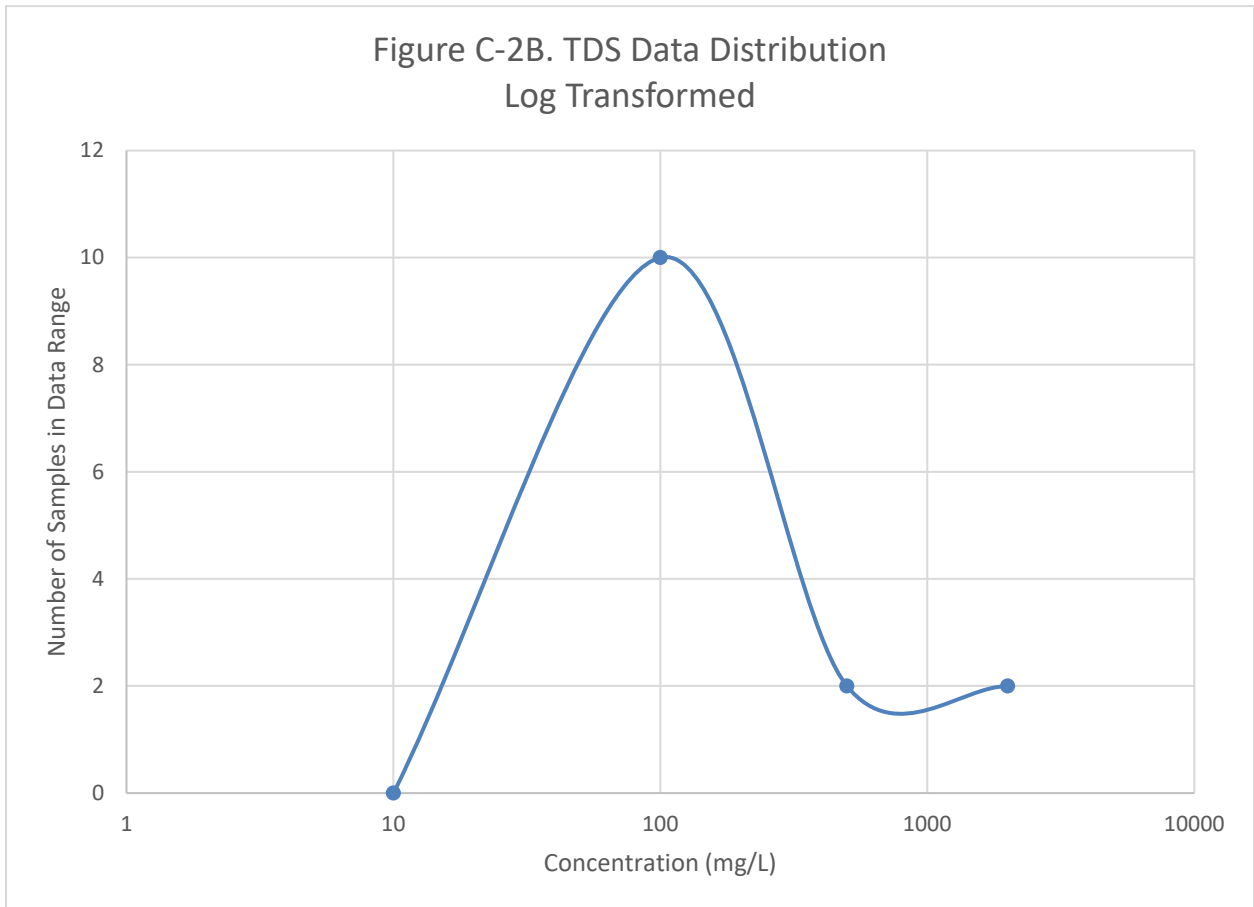


Figure C-2B. TDS Data Distribution
Log Transformed



ATTACHMENT D
Laboratory Analytical Report