TETRA TECH

March 3, 2023

Peter Hays
Division of Reclamation, Mining and Safety
1313 Sherman Street, Room 215
Denver, CO 80203

RE: Response to Adequacy Review Comments for Martin Marietta Materials, Inc., Windsor East Mine, File No. M-2022-042, 112c Permit Application

Dear Mr. Hays:

This letter is in response to your Adequacy Review letter, dated December 4, 2022, regarding Martin Marietta's 112c Permit Application for the Windsor East Mine (File No. M-2022-042). Please find below our responses to the Adequacy Review comments.

Comments

1. The Division state agency comments from History Colorado, Colorado Parks and Wildlife, Army Corps. of Engineers and Division of Water Resources (2). Copies of the letters are attached. Please address the comments and revise the application accordingly.

   Response
   We have prepared and sent responses to each of the referral agencies. Copies of the response letters are attached.

1.6 PUBLIC NOTICE

2. Pursuant to Rules 1.6.2(1)(d) and 1.6.5(1), please submit proof of publication in a newspaper of general circulation in the locality of the proposed mining operation.

   As you stated in your adequacy letter, "The Applicant submitted proof of publication via email to the Division on November 11, 2022. No additional response is required by the Applicant."

3. Pursuant to Rule 1.6.2(e), please submit proof of the notice to all owners of record of surface and mineral rights of the affected land and the owners of record of all land surface within 200 feet of the boundary of the affected land including all easement holders located on the affected land and within 200 feet of the boundary of the affected land. Proof of notice may be return receipts of a Certified Mailing or by proof of personal service

   As you stated in your adequacy letter, "The Applicant submitted proof of notice to the owners of record of all land surface within 200 feet via email to the Division on November 11, 2022. On November 29, 2022, the Applicant provided Division with the return receipts of the certified mailings or other documentation for all owners of record including easement owners. No additional response is required by the Applicant."

6.4 SPECIFIC EXHIBIT REQUIREMENTS – Regular 112 Operations

6.4.5. EXHIBIT E – Reclamation Plan

4. The Applicant states the site will be mined and reclaimed to create two water storage ponds and all mine walls will be re-graded with overburden material to create a compacted liner. Please submit the design specifications for the proposed clay liners in accordance with the August 1999 State Engineer Guidelines for Lining Criteria for Division review.

During the pre-operational inspection, the Applicant stated the design of the clay liner for the reservoirs would be designed prior to the construction of the liner. Please commit to providing a copy of the clay liner design as a technical revision for Division review and approval prior to the construction of the liner.

Response
A cross-section illustrating the proposed design for the liner has been incorporated into Exhibit E. In addition, Exhibit E has been revised to indicate that a copy of the clay liner design will be submitted to the Division for review and approval, through a Technical Revision process, prior to construction of the liner.

6.4.7 EXHIBIT G – Water Information

5. A copy of the review memo for the content of Exhibit G - Water Information from Eric Scott dated October 14, 2022 was sent to the Applicant on October 31, 2022. Please provide a response to the memo questions.

   Response
   Attached is a copy of a letter responding to Eric Scott's Exhibit G comments.

6. In Section 2.1 Mining Plan, the Applicant states to allow sufficient time for groundwater characterization to occur, mining is only planned to occur in the unsaturated zone until one year's worth of monitoring and groundwater sample collection has been conducted. During the pre-operational inspection, the Applicant stated the mining operations would be conducted in the saturated zone sooner than originally planned by the Applicant. Please update Exhibits D and G to describe when the mining operations will occur below the groundwater elevation.

   Response
   Exhibits D and G have been updated to explain when the mining operations will occur below the groundwater elevation. A revised copy of Exhibits D and G are attached.

7. In Section 2.2.2, the Applicant states the results of water quality sample analyses will be provided to DRMS following the baseline water quality evaluation. Please commit to providing the results of the water quality sample analysis as a technical revision for Division review and approval when available.

   Response
   Section 2.2.2 has been edited to indicate that results of the water quality sample analysis will be submitted as a Technical Revision for the Division to review and approve, when the information is available.

6.4.8 EXHIBIT H – Wildlife Information

8. Please commit to following the Pinyon Environmental, Inc. recommendations related to state-listed and special concern species in Attachment H-1 and update Exhibits C and D accordingly.

   Response
   The Pinyon Environmental, Inc. recommendations related to state-listed and special concern species in Attachment H-1 will be followed.

   We have updated Exhibits C and D accordingly.

6.4.12 EXHIBIT L – Reclamation Costs

9. The Applicant included the cost to fertilize the reclaimed land in the reclamation cost estimate. The proposed Reclamation Plan states the Applicant will follow the recommendations, if any, of the SCS. Please provide a description of the fertilization, specify types, mixtures, quantities and time of application pursuant to Rule 6.4.5(2)(f)(iii).

Response
At this time, it is not known if fertilizing will be needed. Before seeding, a soil test will be completed to determine if it is necessary so we cannot give types, mixtures, and quantities at this time. This item has been removed from the cost estimate. We had just added a little cost in case it was needed.

10. The proposed Reclamation Plan states all upland areas will be mulched with 1 ton of certified weed free straw per acre. Please include the mulching costs in the reclamation cost estimate. The Division recommends using 2 tons per acre of mulch. Please contact the SCS for a mulching rate recommendation and update Exhibits E and L accordingly.

    Response
    Seed mix and mulching rates approved for the adjacent Parsons Mine M-2009-082, called for 1 ton of certified weed free straw per acre and we just cut and pasted that seed mix and mulching recommendation into this application to be consistent. Mulch can be an issue with contaminating the aggregate when we are reclaiming in phases before all the mining is completed. Parsons Mine was permitted over 10 years ago, and we have reached out to the SCS to see if this is still the preferred mix and rates. We have not heard back from them. When they get back to us, if they have changes, we will submit a technical revision.

11. Please provide all information necessary to calculate the costs of reclamation, including the typical equipment utilized for each reclamation task, to allow the Division to calculate the cost of reclamation that would be incurred by the state.

    Response
    Equipment utilized for overburden and topsoil will be contracted out but typically is done with a scraper. Disking or Scarifying, Grass Drilling and Mulching are typically contracted out and they use agricultural tractors 200HP. Liner installation is also contracted out and the equipment used will be determined by the contractor. Our costs reflect the equipment included in the items.

6.4.13 EXHIBIT M – Other Permit and Licenses

12. Please commit to providing copies of all required and approved permits and licenses to the Division when available.

    Response
    Exhibit M has been revised to indicate that the operator will provide all required and approved permits and licenses to the Division when available. In addition, the list of permits required has been updated to eliminate the permits that are no longer required (an SPCC Plan because a fuel storage tank is no longer planned to be kept at this site and the Town of Windsor determined that a Grading, Erosion, and Sediment Control Plan will not be needed).

6.4.18 EXHIBIT R – Proof of Filing with County Clerk and Recorder

13. Please provide an affidavit or receipt indicating the date on which the revised application information required to address this adequacy letter was placed with the Weld County Clerk and Recorder for public review, pursuant to Subparagraph 1.6.2(1)(c).

    Response
    Attached is a signed affidavit indicating that these revised application information materials were placed with the Weld County Clerk and Recorder for public review.

6.4.19 EXHIBIT S – Permanent Man-made Structures

Where the affected lands are within two hundred (200) feet of any significant, valuable, and permanent man-made structures, the Applicant may either:

a. provide a notarized agreement between the Applicant and the person(s) having an interest in the structure, that the Applicant is to provide compensation for any damage to the structure; or

b. where such an agreement cannot be reached, the Applicant shall provide an appropriate engineering evaluation that demonstrates that such structure shall not be damaged by activities occurring at the mining operation; or
c. where such structure is a utility, the Applicant may supply a notarized letter, on utility letterhead, from the owner(s) of the utility that the mining and reclamation activities, as proposed, will have "no negative effect" on their utility.

The Division will require the Applicant to demonstrate they attempted to obtain notarized structure agreements with all owners of the structures within 200 feet of the affected area of the proposed mine site, pursuant to Rule 6.4.19, prior to the Division's consideration of a stability analysis.

Response
Acknowledged.

14. Please provide the Division with copies of all signed structure agreements with the owners of permanent man-made structures within 200 feet the proposed affected area boundary.

Response
Attached are copies of the signed structure agreements that Martin Marietta received back from the owners of permanent man-made structures within 200 feet the proposed affected area boundary.

15. The Applicant lists Martin Marietta Materials, Inc. as a structure owner on Exhibit C-2. Please update Exhibit S to include Martin Marietta Materials, Inc. as an owner of man-made structures within 200 feet of the affected area.

Response
Exhibit S has been updated to list Martin Marietta Materials as an owner of man-made structures within 200 feet of the affected area.

6.5 GEOTECHNICAL STABILITY EXHIBIT

16. The Division reviewed and will accept the stability analysis demonstrating the require offsets from the structures within 200 feet of the affected area of the proposed mine site if the Applicant is unable to obtain notarized structure agreements with all owners.

Response
Acknowledged.

As part of the process to permit the site through the Town of Windsor, we made some minor modifications to the mining and reclamation plan maps. As a result, revised versions of Exhibits C and F are attached. The specific changes we made included:

- Exhibit C: We added some potential water service lines (structure number 51) to sheet C-2. The City of Greeley's historic mapping shows these lines; however, the property owners that are connected to the lines indicated they do not exist as Greeley's mapping shows. The service lines would need to be potholed to locate them. This will be completed prior to mining. If the lines are found to be located where the City of Greeley's mapping shows them to be, the lines will either be relocated or Cell D will not be mined.
- Exhibit F: The reclamation topography for the water storage reservoirs was modified to incorporate more curves at the shoreline. In changing the topography, the size of the reservoirs slightly decreased. The acreage information was updated on both sheets of Exhibit F.

Thank you for your consideration. If you have any questions or need additional information, please let me know.

Sincerely,

TETRA TECH

Pamela Franch Hora

Pamela Franch Hora, AICP
Senior Planner

cc: Julie Mikulas, Martin Marietta

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TETRA TECH

March 3, 2023

Peter Hays
Eric Scott
Division of Reclamation, Mining and Safety
1313 Sherman Street, Room 215
Denver, CO 80203

RE: Martin Marietta Materials, Inc., Windsor East Mine, File No. M-2022-042, Exhibit G - Water Information Review Memo

Dear Peter Hays and Eric Scott:

This letter is in response to the Adequacy Review letter specific to Exhibit G, Water Information, dated October 31, 2022, regarding Martin Marietta's 112c Permit Application for the Windsor East Mine (File No. M-2022-042). Please find below our responses to the Adequacy Questions/Issues identified in Exhibit G.

Comments

1. What will cells B and D be backfilled with and how? The narrative implies that these areas will be as permeable as native materials and pose no impediment to GW flow when mining is completed, however if they are backfilled with wash fines, or the backfill is compacted during placement, it is much more likely that they will create a similar barrier to GW flow as the lined cells along with the same potential impacts due to mounding/shadowing.

   Response
   Cell B and D will be backfilled with overburden from the site. Martin Marietta typically contracts the work out, so depending on what they have available, it will either be a scraper or a truck and dozer placing the overburden. While the backfill material is likely to be somewhat finer grained than the gravel deposits being excavated, the material is not anticipated to represent a significant barrier to flow. It may cause some minor hydraulic mounding, but not to the extent that it will require mitigation. The potential mounding of water upgradient of cells B and D will be monitored as part of the post-mining water level program. An acknowledgement of this potential will be added to Exhibit G. If monitoring shows that hydraulic mounding is causing the water table to rise to within 4 feet of land surface resulting in the potential for surface flooding, Martin Marietta will investigate and address the issue using mitigation measures such as a perimeter drain.

2. There seems to be a great deal of uncertainty about the location of well 1472-R-R, up to and including what side of the river it is on. The location of this well should be field verified so that it can be accurately shown on the provided maps, and potential impacts be more accurately determined.

   Response
   A records search indicated that the well registered as 1472-R-R was likely installed as a replacement well on a property purchased by the Great Western leaseholder and the well inspector was not able to locate a well south of the river. Martin Marietta conducted a field search to locate this well and was unable to find an existing well. Some evidence that an irrigation supply well had been abandoned near the center pivot for the former agricultural field in the area was located on the north side of the river. As a result, Martin Marietta and Great Western believe that the well no longer exists.

3. All of the baseline GW level, flow direction data, and estimated flow mapping presented in this exhibit is derived from WL data collected from the adjacent Parsons site. However, it is stated that the measuring

point elevations for the Parsons wells were “estimated from topo maps”. Basing this kind of data presentation on “estimated” elevations from topo maps is not consistent with industry standards or the TSOP presented in the provided exhibit. For DRMS to be able to consider water level data from the Parsons site in this review, all measuring points should be surveyed to 0.01’ (and tied to the same reference elevations as the WEM wells), the historic readings recalculated, and the associated tables and figures re-created as needed.

   a. It appears that the 5 new WEM wells have been properly surveyed as the elevations are given to 0.01’, however this should be confirmed.
   b. All subsequent WL readings collected at the WEM and Parsons sites should be recorded to the nearest 0.01’, not just the nearest tenth of a foot as shown in the provided materials. This would also be consistent with the provided TSOP.

<u>*Response*</u>
The five monitoring wells in the Windsor East monitoring network are all surveyed to an accuracy of 0.01 feet of elevation. In December, the Parsons mine monitoring well network was also surveyed to the same accuracy and datum. The tables and figures provided in Exhibit G have been updated to reflect the new casing measuring point elevations.

4. Section 1.6 of the provided materials describes a “simplified model” and states that it was calibrated/verified based on observed drawdown in one well. This model is then used to predict groundwater drawdowns due to mining after one year and 5 years of dewatering at distances up to 2640 feet. DRMS will require a substantially more rigorous modelling demonstration to predict and illustrate the maximum groundwater drawdown impacts from dewatering during mining, potential impacts to nearby wells, as well as any post-mining mounding and shadowing impacts due to the construction of impermeable or low permeability mine cells. The model should provide GW drawdown/mounding contour maps based on, and verified against all available site setting and geologic information, current and historic water level data, and the predicted size and location of mining cells (for both sites).

<u>*Response*</u>
Based on subsequent conversations with the DRMS, Exhibit G will be updated to reflect that there are no registered wells owned by parties other than Great Western or Martin Marietta within 0.5 miles of the Windsor East Mine property (a letter from GWIP, the property and well owners documenting this has been included in Exhibit G as Appendix G-5). We understand that the DRMS agrees that the need for detailed modeling is therefore no longer critical because the potential for mining-induced drawdown will not result in injury to another party’s nearby well. Additionally, a study done by the United States Geological Survey (Langer and Paschke, WRI 02-4267, 2002), discussing analytical and numerical simulation of the hydrologic effects of mining aggregate in hypothetical sand-and-gravel and fractured crystalline-rock aquifers, will be referenced and attached to Exhibit G. This study illustrates that a numerical simulation of steady-state drawdown in a hypothetical sand and gravel aquifer adjacent to a river does not result in drawdown exceeding approximately 1 foot at a roughly 0.5-mile distance from the hypothetical pit.

5. Section 2.1 of the provided exhibit states that up to 5 quarters of “baseline” GW level data will be collected for the WEM site with the exception of Cell A where dewatering will commence immediately. This is based on the rationale that GW levels in that area have already been impacted by the adjacent Parsons dewatering activity. DRMS acknowledges that the historic GW regime has likely already been impacted to some extent by the adjacent Parsons site. However, based on the observations of significant GW drawdowns at distance from the Parsons site, allowing dewatering of Cell A while attempting to collect “baseline” water level data for the remainder of the WEM site will likely render that data useless as a “baseline” for later mining drawdown comparison. Dewatering or exposure of GW should not be allowed on the WEM site until the full 5 quarters of baseline data can be collected.

a. Mining below groundwater/dewatering of Cell A during collection of the 5 quarters of baseline data may also adversely impact the validity of the baseline analytical data results.

Response
Evaluation of drawdown relative to undisturbed baseline conditions in the vicinity of the Windsor East Mine property is not an issue of concern for this project because there are no water wells located within 0.5 miles of the mine that are owned by parties other than Great Western Holdings (the landowner from whom Martin Marietta is leasing the land for mining). Martin Marietta commits to collect monthly water levels for five quarters and report these to the DRMS for pseudo-background evaluation purposes. Martin Marietta acknowledges that these water level measurements will likely be partially affected by dewatering that has been occurring on the Parsons Mine property. In addition, the measurements will also likely be further influenced by the dewatering of Windsor East Cell A which is expected to begin after only three of the five quarters of water quality sampling will have been conducted. Martin Marietta does not believe that the dewatering of Cell A will have any effect on the baseline analytical data results.

6. Water Quality Parameters and rationale presented in section 2.2.1 and Table 5 are acceptable as presented with the following edits.
   a. Add CN to section 2.2.1 or sample for it.
   b. WQS for U should be 0.0168 to 0.03, not 0.02 as stated in Table 5
   c. Will any QA/QC samples be collected/run to verify field and lab procedures?
   d. I note that although there are several wells on the adjacent Parsons site, no analytical data has been presented as “background” for WEM, however, that may be a subject for another discussion.

Response
CN was added to the list of parameters for analysis and sampling to test for CN began as of November 2022. The WQS for uranium will be updated in Table 5 based on the comment above. QA/QC samples will be collected including a trip blank and a field duplicate for each sampling event.

7. Section 2.2 (as well as 2.2.2) states that “regular data collection” from the 5 new GW wells will take place, but does not specify what that means. I would suggest that WL data be collected at least monthly and analytical sampling be conducted quarterly (as stated) until the 5 quarters of baseline data have been obtained. Analytical sampling intervals after the initial 5 quarters are acceptable as presented.

Response
Exhibit G will be updated to reflect that water level measurements will be performed monthly for five quarters, and that water samples will be collected for baseline analysis quarterly, for five quarters.

8. All baseline data as well as any proposed modifications to the analyte list or sampling intervals should be submitted to DRMS as a TR for review and approval.

Response
Comment acknowledged.

9. Section 2.3 states that “in the event of a well owner compliant within 600’ of the affected area” MM will submit a report to DRMS within 30 days. DRMS does not restrict the radius of impact to 600’ and therefore will require MM to commit to reporting any complaints by well owners to DRMS within 48 hrs or less. MM will be required to initiate an investigation into the complaint immediately and submit the results to DRMS for evaluation within 30 days.

Response
Exhibit G has been amended to note that any complaints by well owners will be reported to the DRMS within 48-hours, Martin Marietta will initiate an investigation into the complaint as soon as practical, and submit the results of the investigation to the DRMS within 30 days. Language specifying the process for the

investigation, how water levels in the area will be monitored, and comparison to baseline water levels will be provided as part of the Monitoring and Mitigation Plan.

10. Section 2.3 also states that "if a well goes dry, MM will implement mitigation measures within 7 days." In the event that a well owner reports that their well has become unusable, MM will be required to implement mitigation measures immediately (as soon as practically possible). MM will concurrently commence an investigation into the status of the complaint. The results of this investigation as well as any proposed remediation or rationale for discontinuing mitigation will be submitted to DRMS for approval within 30 days.

    Response
    Martin Marietta has revised Exhibit G committing to report any complaints from well owners to the DRMS within 48-hours, initiating an investigation into the complaint as soon as practical, and submitting the results of the investigation as well as any proposed remediation or rationale for discontinuing mitigation to the DRMS within 30 days. If a well owner reports that their well has become unusable, Martin Marietta will investigate and implement mitigation measures immediately provided that the investigation indicates that mitigation measures are needed. Examples of mitigation measures such as a temporary alternative water supply sufficient to meet documented historic well production will be identified in the Monitoring and Mitigation Plan.
11. Appendix G-3: Because the analyte list and reporting levels have been identified, please identify and include the sample container type and size, preservative (if required), holding times, and analytical method to be used. This information could also be included in Table 5.

    Response
    This information has been included as part of Table 5 of Exhibit G.

12. Field forms or logbooks should be used to record GW well purging and field sampling data consistent with industry standards.

    Response
    Comment acknowledged. These practices are standard and will be followed. Exhibit G has been revised to note that field notes will be recorded as part of the field sample collection process including notes on the pre-sampling purge activities.

Thank you for your consideration. If you have any questions or need additional information, please let me know.

Sincerely,

TETRA TECH

Chris Gutmann

Christopher Gutmann, P.G. (Arizona)
Hydrogeologist

cc: Julie Mikulas, Martin Marietta
Pam Hora, Tetra Tech

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TETRA TECH

March 1, 2023

Dawn DiPrince
State Historic Preservation Officer

and
Holly McKee-Huth
Cultural Resource Information
History Colorado
1200 Broadway
Denver, CO 80203

Sent via Email to: holly.mckee@state.co.us

RE: Windsor East Mine, File No. M-2022-042 (HC#82104)

Dear Dawn DiPrince and Holly McKee-Huth:

This letter is in response to History Colorado's comment letter in response to Martin Marietta's 112c Permit Application for the Windsor East Mine (File No. M-2022-042). Below is your comment followed by Martin Marietta's response.

Comment

A search of our database indicates that no properties of historical significance included or nominated for inclusion in the state register have been recorded within the proposed permit area. Please note, as most of Colorado has not been inventoried for cultural resources, our files contain incomplete information. Consequently, there is the possibility that as yet unidentified cultural resources exist within the proposed permit area. The requirements under CRS 24-80 part 13 apply and must be followed if human remains are discovered during ground disturbing activities.

Response

Acknowledged.

Thank you for your consideration. Martin Marietta will contact you if any Cultural Resource Information/Section 106 Compliance questions should arise. If you have any questions or need additional information, please let me know.

Sincerely,

TETRA TECH

Pamela Franch Hora

Pamela Franch Hora, AICP
Senior Planner

cc: Peter S. Hays, DRMS
Julie Mikulas, Martin Marietta

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TETRA TECH

March 1, 2023

Kiel Downing
Department of the Army
Corps of Engineers, Omaha District
Denver Regulatory Office
9307 South Wadsworth Blvd
Littleton, CO 80128

RE: Section 404 of the Clean Water Act Initial Comments

Dear Kiel Downing:

This letter is in response to the Army Corps of Engineers comment letter on Martin Marietta's 112c Permit Application for the Windsor East Mine (File No. M-2022-042). The letter below details your comment followed by Martin Marietta's response.

Comments

If the activity you described would impact waters of the United States, the Denver Regulatory Office should be notified. Please include a map identifying dimensions of work in each aquatic site, the county, Township, Range and Section and the latitude and longitude of the activity in decimal degrees, along with a description of your request, to the Denver Regulatory Office mailbox located at DenverRegulatoryMailbox@usace.army.mil or contact the Denver Regulatory Office at 303-979-4120.

> *Response*
> *Martin Marietta and their consultant, Pinyon Environmental, worked with the Army Corps of Engineers and it was determined that the wetlands on the site were not jurisdictional.*

Thank you for your consideration. If you have any questions or need additional information, please let me know.

Sincerely,

TETRA TECH

Pamela Franch Hora

Pamela Franch Hora, AICP
Senior Planner

cc: Peter S. Hays, DRMS
Julie Mikulas, Martin Marietta

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TETRA TECH

March 1, 2023

Brandon B. Marette
Colorado Parks and Wildlife
6060 Broadway
Denver, CO 80216

Sent via Email to: brandon.marette@state.co.us

RE: Response to comments regarding DRMS Permit: M2022042

Dear Brandon Marette:

This letter is in response to the Colorado Parks and Wildlife (CPW) comment letter submitted to Peter Hays, DRMS via email on October 24, 2022. The email shared comments on Martin Marietta's 112c Permit Application for the Windsor East Mine (File No. M-2022-042). Below you will find the comments you submitted, followed by Martin Marietta's response.

Comments

1. This area has a well-documented Bald Eagle Nest and roosting area, which is immediately adjacent to one of the major parking lots for access on the Poudre Trail and the Poudre Learning Center.
    - Therefore, per our High Priority Habitat table, CPW recommends avoiding construction during the listed nesting (Dec 1 to July 31) and roosting seasons (Nov 15 to March 15).

    Response
    Martin Marietta is aware pf the locations of the eagle nests and roosting area and they will work with Mike Sherman as mining activity progresses.

2. There could be the potential for nesting Burrowing Owls. If prairie dog towns (active or inactive) are observed within the construction site, please avoid construction during the Burrowing Owl nesting season (March 15 to August 31).
    - If potential habitat (prairie dog towns) is observed, and the work needs to be conducted during the nesting season, please conduct a Burrowing Owl survey per this protocol.

    Response
    Martin Marietta will conduct a Burrowing Owl survey if the prairie dog towns on the site are disturbed between March 15 and August 31.

3. There could be Northern Leopard Frogs (and other Aquatic Native Species) in this stretch of the Poudre and associated tributaries, riparian areas, and adjacent uplands.
    - Therefore, please ensure there are more than sufficient stormwater BMPs to protect the Poudre from spills and/or sedimentation.

    Response
    Martin Marietta will utilize stormwater BMPs to protect the Cache la Poudre River.

Thank you for your consideration. If you have any questions or need additional information, please let me know.

Sincerely,

TETRA TECH

Pamela Franch Hora

Pamela Franch Hora, AICP
Senior Planner

cc: Peter S. Hays, DRMS
Jackson Davis, DNR jackson.davis@state.co.us
Mike Sherman, DNR mike.sherman@state.co.us
Boyd Wright, DNR boyd.wright@state.co.us
Julie Mikulas, Martin Marietta

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TETRA TECH

March 1, 2023

Ioana Comaniciu, P.E.
Division of Water Resources
1313 Sherman Street, Room 821
Denver, CO 80203

Sent via Email to: Ioana.Comaniciu@state.co.us

RE: Response to Consideration of 112c Construction Materials Reclamation Permit Application
Windsor East Mine, File No. M-2022-042
Operator: Martin Marietta Materials, Inc. - Julie Mikulas (970)-407-3631
Contact: Tetra Tech, Inc. - Pam Hora (720) 864-4507
W1/2 of Section 36, Twp 6 North, Rng 67 West, P.M., Weld County
Division 1, Water District 2

Dear Ioana Comaniciu:

This letter is in response to your letter from Division of Water Resources (DWR) Division 1 Office, Water District 2 letter dated October 24, 2022, commenting on Martin Marietta's 112c Permit Application for the Windsor East Mine (File No. M-2022-042). This letter shares your comments followed by Martin Marietta's responses.

CONDITIONS FOR APPROVAL

☒ The proposed operation will consume ground water by: ☒ evaporation, ☒ dust control, ☒ dewatering, ☒ water removed in the mined product, ☒ reclamation:
Prior to initiation of these uses of ground water, the applicant will need to obtain either a gravel pit or other type of well permit, as applicable. However, prior to obtaining a permit, an approved water supply plan or decreed plan for augmentation is required.

☒ Prior to approving a well permit, the applicant must conduct a field inspection of the site and document the locations of all wells within 600 feet of the permit area. The applicant must then obtain a waiver of objection from all well owners with wells within 600 feet of the permit area or request a hearing before the State Engineer.

Response
Acknowledged

Comment

The site is proposed to be dry mined. Dewatering trenches will be excavated around the perimeter of each mining area prior to the commencement of mining. Prior to the exposure or use of any groundwater at the site, the applicant must first obtain a well permit and a valid substitute water supply plan or decreed plan for augmentation. The applicant has indicated that they intend to obtain a substitute water supply plan for the site.

Response
Acknowledged

Comment

Water for dust control will be supplied using a 2,500 gallon water truck. The application indicates that water rights associated with the site will be used for dust control. The applicant will need to document that any water used for dust control purposes at the site is permitted or decreed for such use and be able to provide such documentation to this office upon request.

Response
Acknowledged

Comment
Stormwater will be collected in the perimeter dewatering trenches and pumped into the Cache la Poudre River. If stormwater runoff is intercepted by this mining operation and is not diverted or captured in priority, it must be released to the stream system or infiltrate into the ground within 72 hours; otherwise the operator will need to make replacements for evaporation from the surface area of the intercepted stormwater.

Response
Acknowledged

Comment
As indicated above, Cell B is proposed to be reclaimed into a stormwater detention pond. The applicant should be aware that unless the structure can meet the requirements of a “storm water detention and infiltration facility” as defined in section 37-92-602(8), C.R.S., the structure may be subject to administration by this office. The applicant should review the Division of Water Resources’ Administrative Statement Regarding the Management of Storm Water Detention Facilities and Post-Wildland Fire Facilities in Colorado, which can be found at https://dwr.colorado.gov/services/water-administration/rainwater-storm-water-graywater, to ensure that the notification, construction and operation of the proposed structure meets statutory and administrative requirements. The applicant is encouraged to use Colorado Stormwater Detention and Infiltration Facility Notification Portal, located at https://maperture.digitaldataservices.com/gvh/?viewer=cswdif to meet the notification requirements.

Response
Acknowledged

Comment
The Applicant has conducted a baseline groundwater assessment to assess potential impacts associated with the proposed sand and gravel mine. As part of the baseline groundwater assessment the applicant has constructed five monitoring wells. Monitoring well data will be used to identify changes in alluvial groundwater flow associated with mining and reclamation activities. According to the application, if the extent of groundwater changes due to mining or reclamation activities is determined to be a significant contributing factor that has or may create adverse impacts, the mining-associated impacts will be addressed to the satisfaction of the Division of Reclamation, Mining and Safety.

Response
Acknowledged

Comment
In certain areas of the South Platte River Basin, staff of DWR has observed groundwater problems that appear to be related to the lining of gravel pits located near streams, and in particular, these problems occur when multiple liners are located adjacent to each other. DWR requests that DMRS consider the siting and design of lined gravel pits to ensure that they will not individually, or cumulatively, result in impacts to the timing and quantity of groundwater flow from upgradient locations back to the stream system. In addition to impacts to property, such as flooding upgradient and reduced water levels downgradient of the liner, there are decrees of the court that specify the timing, quantity and amount of water depleted from the streams by wells and accreted to the stream through recharge operations. The installation of a gravel pit liner should not result in changes to the timing, location, and amount of such groundwater flow.

Response
Acknowledged

Thank you for your consideration. If you have any questions or need additional information, please let me know.

Sincerely,

TETRA TECH

Pamela Franch Hora

Pamela Franch Hora, AICP
Senior Planner

cc: Peter Hays, DRMS
Julie Mikulas, Martin Marietta

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TETRA TECH

March 1, 2023

Javier Vargas-Johnson, Water Resources Engineer
Division of Water Resources
1313 Sherman Street, Room 821
Denver, CO 80203

Sent via Email to: Javier.VargasJohnson@state.co.us

RE: Response to Consideration of 112c Construction Materials Reclamation Permit Application
Windsor East Mine, File No. M-2022-042
Operator: Martin Marietta Materials, Inc. - Julie Mikulas (970)-407-3631
Contact: Tetra Tech, Inc. - Pam Hora (720) 864-4507
W1/2 of Section 36, Twp 6 North, Rng 67 West, P.M., Weld County
Division 1, Water District 3

Dear Javier Vargas-Johnson:

This letter is in response to your letter from Division of Water Resources (DWR) Division 1 Office, Water District 3 letter dated October 28, 2022, commenting on Martin Marietta's 112c Permit Application for the Windsor East Mine (File No. M-2022-042). This letter shares your comments followed by Martin Marietta's responses.

CONDITIONS FOR APPROVAL

- ☒ The proposed operation will consume groundwater by: ☒ evaporation, ☒ dust control, reclamation, ☒ water removed in the mined product, ☐ processing, ☐ other.
- ☒ Prior to initiation of these uses of groundwater, the applicant will need to obtain either a gravel pit or other type of well permit, as applicable. However, prior to obtaining a permit, an approved substitute water supply plan or decreed plan for augmentation is required.
- ☒ Any stormwater runoff intercepted by this operation that is not diverted or captured in priority must be released to the stream system within 72 hours; otherwise the operator will need to make replacements for evaporation.

Response
Acknowledged

Comment

The site is proposed to be dry mined. Dewatering trenches will be excavated around the perimeter of each mining area prior to the commencement of mining. Prior to the exposure or use of any groundwater at the site, the applicant must first obtain a well permit and a valid substitute water supply plan or decreed plan for augmentation. The applicant has indicated that they intend to obtain a substitute water supply plan for the site.

Response
Acknowledged

Comment

Water for dust control will be supplied using a 2,500 gallon water truck. The application indicates that water rights associated with the site will be used for dust control. The applicant will need to document that any water used for dust control purposes at the site is permitted or decreed for such use and be able to provide such documentation to this office upon request.

Response
Acknowledged

Comment

Stormwater will be collected in the perimeter dewatering trenches and pumped into the Cache la Poudre River. If stormwater runoff is intercepted by this mining operation and is not diverted or captured in priority, it must be released to the stream system or infiltrate into the ground within 72 hours; otherwise the operator will need to make replacements for evaporation from the surface area of the intercepted stormwater.

> *Response*
> *Acknowledged*

Comment

As indicated above, Cell B is proposed to be reclaimed into a stormwater detention pond. The applicant should be aware that unless the structure can meet the requirements of a "storm water detention and infiltration facility" as defined in section 37-92-602(8), C.R.S., the structure may be subject to administration by this office. The applicant should review the Division of Water Resources' Administrative Statement Regarding the Management of Storm Water Detention Facilities and Post-Wildland Fire Facilities in Colorado, which can be found at https://dwr.colorado.gov/services/water-administration/rainwater-storm-water-graywater, to ensure that the notification, construction and operation of the proposed structure meets statutory and administrative requirements. The applicant is encouraged to use Colorado Stormwater Detention and Infiltration Facility Notification Portal, located at https://maperture.digitaldataservices.com/gvh/?viewer=cswdif to meet the notification requirements.

> *Response*
> *Acknowledged*

Comment

The Applicant has conducted a baseline groundwater assessment to assess potential impacts associated with the proposed sand and gravel mine. As part of the baseline groundwater assessment the applicant has constructed five monitoring wells. Monitoring well data will be used to identify changes in alluvial groundwater flow associated with mining and reclamation activities. According to the application, if the extent of groundwater changes due to mining or reclamation activities is determined to be a significant contributing factor that has or may create adverse impacts, the mining-associated impacts will be addressed to the satisfaction of the Division of Reclamation, Mining and Safety.

> *Response*
> *Acknowledged*

Comment

In certain areas of the South Platte River Basin, staff of DWR has observed groundwater problems that appear to be related to the lining of gravel pits located near streams, and in particular, these problems occur when multiple liners are located adjacent to each other. DWR requests that DMRS consider the siting and design of lined gravel pits to ensure that they will not individually, or cumulatively, result in impacts to the timing and quantity of groundwater flow from upgradient locations back to the stream system. In addition to impacts to property, such as flooding upgradient and reduced water levels downgradient of the liner, there are decrees of the court that specify the timing, quantity and amount of water depleted from the streams by wells and accreted to the stream through recharge operations. The installation of a gravel pit liner should not result in changes to the timing, location, and amount of such groundwater flow.

> *Response*
> *Acknowledged*

Thank you for your consideration. If you have any questions or need additional information, please let me know.

Sincerely,

TETRA TECH

Pamela Franch Hora

Pamela Franch Hora, AICP
Senior Planner

cc: Peter Hays, DRMS
Julie Mikulas, Martin Marietta

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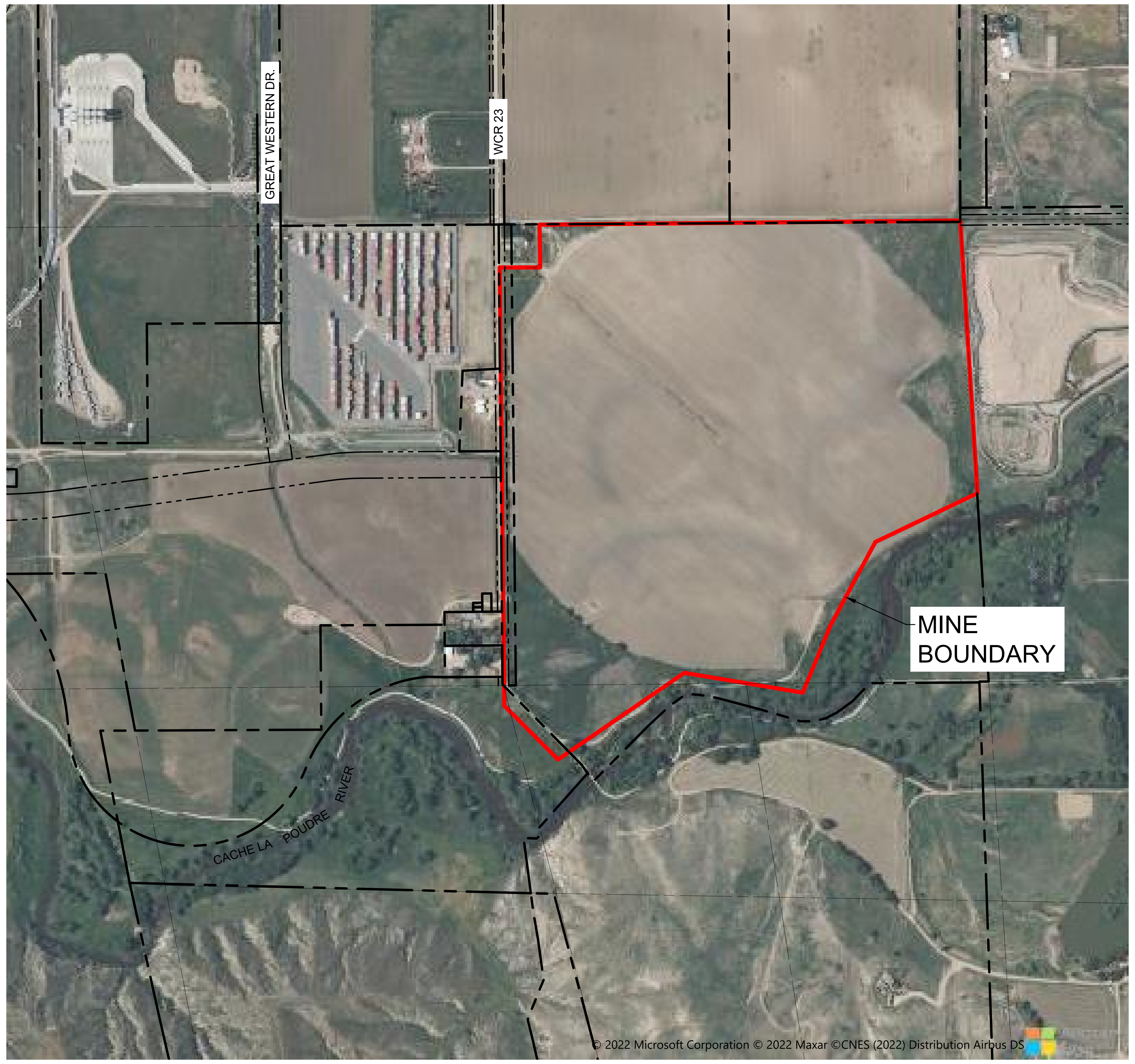

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FLOOD HAZARD LEGEND:

EFFECTIVE ZONE AE: AREA OF 1% ANNUAL CHANCE FLOOD WITH BASE FLOOD ELEVATIONS DETERMINED, AS SHOWN ON PRELIMINARY FEMA FIRM (MARCH 23, 2022)

EFFECTIVE ZONE X: AREAS OF 0.2% ANNUAL CHANCE FLOOD; AREAS OF 1% ANNUAL CHANCE FLOOD WITH AVERAGE DEPTHS OF LESS THAN 1 FOOT OR WITH DRAINAGE AREAS LESS THAN 1 SQUARE MILE; AND AREAS PROTECTED BY LEVEES FROM 1% ANNUAL CHANCE FLOOD, AS SHOWN ON PRELIMINARY FEMA FIRM (MARCH 23, 2022)

EFFECTIVE FLOODWAY: THE FLOODWAY IS THE CHANNEL OF A RIVER AND THE ADJACENT LAND AREA THAT MUST BE RESERVED IN ORDER TO DISCHARGE THE 1% ANNUAL CHANGE FLOOD WITHOUT CUMULATIVELY INCREASING THE WATER SURFACE ELEVATION MORE THAN DESIGNED HEIGHT, AS SHOWN ON PRELIMINARY FEMA FIRM (MATCH 23, 2022)

PRE-PROJECT / MINING CONDITIONS: AREA OF 1% ANNUAL CHANCE FLOODPLAIN PER TETRA TECH STUDY (NOV. 2018 OR AS REVISED)

CERTIFICATION

THIS MAP WAS PREPARED BY TETRA TECH IN COOPERATION WITH MARTIN MARIETTA MATERIALS. MARTIN MARIETTA MATERIALS WILL KEEP THE DIVISION OF RECLAMATION, MINING AND SAFETY INFORMED OF ANY CHANGES TOT HE MINING OR RECLAMATION PLANS THROUGH ANNUAL REPORTS AND FILE TECHNICAL REVISIONS OR AMENDMENT APPLICATIONS AS NECESSARY THROUGHOUT THE LIFE OF THE MINE.

Pamela Franch Hora 3/2023

PAMELA FRANCH HORA, AICP DATE

GRAVEL MINING APPLICANT / OPERATOR:

MARTIN MARIETTA MATERIALS
1800 NORTH TAFT HILL ROAD
FORT COLLINS, COLORADO 80521

SURFACE OWNERS:

GWIP LLC
252 CLAYTON ST FL 4
DENVER, COLORADO 80206-4816

PLEASE REFER TO SHEETS C-2 FOR ADJACENT PROPERTY OWNERS WITHIN 200' OF PERMIT BOUNDARY. ADJACENT PROPERTY OWNER INFORMATION WAS PROVIDED BY WELD COUNTY RECORDS.

EXISTING VEGETATION:

REPORT BY PINYON ENVIRONMENTAL, INC. PROVIDED THAT THE PROJECT AREA IS CURRENTLY USED PRIMARILY AS IRRIGATED AGRICULTURAL LAND. HABITAT TYPES INCLUDE GRASSLANDS (IRRIGATED CROPLAND) AND WETLAND AREA ON THE EAST SIDE OF THE SITE. PLEASE SEE EXHIBIT J FOR MORE VEGETATION INFORMATION.

SURVEY INFORMATION:

TOWN OF WINDSOR BENCHMARK #65

3.25" ALUMINUM CAP SET IN CONCRETE STAMPED "KING SURVEYORS WIN-KODAK-257 1997", IN THE VICINITY OF THE E, 1/4 CORNER OF SECTION 28, T6N, R67W, AT THE WEST ENTRANCE TO KODAK ROAD, 35' N. OF THE CENTER LINE OF KODAK ROAD AND 18.6' E. OF THE STOP SIGN.

ELEVATION = 4754.74 FEET (NAVD 1988 DATUM)

UTILITY INFORMATION TAKEN FROM THE GREAT WESTERN ALTA/NSPS LAND TITLE SURVEY DATED JANUARY 2, 2018 BY AZTEC CONSULTANTS, INC.

WETLAND NOTE:

WETLANDS SHOWN ON PLANS ARE PER INVESTIGATION REPORTS BY PINYON ENVIRONMENTAL, INC. DATED JULY 2022. THE ARMY CORPS OF ENGINEERS HAS DETERMINED THAT THE WETLANDS ARE NOT JURISDICTIONAL SEE EXHIBIT J-1 FOR DETERMINATION LETTER.

FLOOD HAZARD INFORMATION:

FLOODPLAIN INFORMATION IS FROM PRELIMINARY FLOOD INSURANCE RATE MAP, PANEL NO. 08123C1503F & 08123C1504F, DATED MARCH 23, 2022. A PORTION OF THIS LAND LIES WITHIN ZONE AE (SPECIAL FLOOD HAZARD AREAS INUNDATED BY THE 1% ANNUAL CHANCE FLOOD) AND REGULATORY FLOODWAY.

PERMIT BOUNDARY AND AFFECTED AREA ACREAGE:

150.3 ACRES

MINING NOTES:

1. REFER TO EXHIBITS C-2 AND C-3 FOR ADJACENT PROPERTY OWNERS, SOURCE OF SURVEY/TOPOGRAPHY, AND BENCHMARK INFORMATION.
2. AN ENGINEERING SLOPE STABILITY ANALYSIS AND SETBACK ANALYSIS HAS BEEN PERFORMED. MINING OCCURRING WITHIN 200' OF A MAN-MADE STRUCTURE NOT OWNED BY THE APPLICANT/OPERATOR HAS ADEQUATE SETBACK. THE LIMIT OF MINING EXCAVATION PER THE GEOTECHNICAL SLOPE STABILITY ANALYSIS IS SHOWN ON EXHIBIT C-3 PER THE GEOTECHNICAL SLOPE STABILITY ANALYSIS REPORT.
3. THE OPERATOR WILL USE DRY MINING TECHNIQUES AND EXCAVATE MATERIAL BY BACKHOE, BULLDOZERS, AND SIMILAR EQUIPMENT. DRY MINING WILL BE REQUIRE DISCHARGE OF WATER ASSOCIATED WITH THE CDPHE DISCHARGE PERMIT AND WILL FOLLOW THEIR RULES AND REGULATIONS.
4. TOPSOIL AND OVERBURDEN STOCKPILES SHALL BE TEMPORARILY STORED IN THE AREAS SHOWN.
5. OVERBURDEN AND TOPSOIL STOCKPILES ABOVE EXISTING GRADE, THAT ARE EXPECTED TO BE PRESENT FOR OVER 180 DAYS WILL BE VEGETATED DEPENDING ON THE SEEDING 'WINDOW" PARAMETERS FOR DRYLAND GRASS, WHICH ARE TYPICALLY BETWEEN SEPTEMBER AND APRIL.
6. STOCKPILED TOPSOIL WILL BE SEGREGATED FROM OTHER SPOIL.
7. 3H:1V, AND PLACEMENT OF 6" OF TOPSOIL ON ALL RECONSTRUCTED AREAS ABOVE THE PROPOSED HIGH WATER LEVEL OF THE FUTURE RESERVOIR; AND OTHER DISTURBED AREAS AS NECESSARY.
8. TETRA TECH INC. IS NOT RESPONSIBLE FOR SAFETY, IN, ON, OR ABOUT THE PROJECT SITE, NOR FOR COMPLIANCE BY THE APPROPRIATE PARTY OF ANY REGULATIONS THERETO.
9. A MINIMUM OF TEN (10) FEET OF CLEARANCE FROM ANY EXISTING POWERLINE OR FUTURE POWERLINE SHALL BE MAINTAINED AT ALL TIMES AS OUTLINED BY STATE STATUTES.
10. THE OPERATOR SHOULD LOCATE UTILITIES PRIOR TO MINING ACTIVITY.
11. PRIOR TO DISTURBANCE OF ANY WATERS OF THE U.S., MARTIN MARIETTA MATERIALS WILL GET APPROPRIATE APPROVALS FROM THE U.S. ARMY CORPS OF ENGINEERS.
12. NO IRRIGATION DITCHES WILL BE DISTURBED. LATERALS THAT SERVE THE PROPERTY MAY BE REMOVED.
13. GREELEY PIPELINES MUST HAVE A MINIMUM OF SIX (6) FEET OF COVER AT ALL LOCATIONS TO BE USED AS A LAND BRIDGE DURING ANY CONSTRUCTION ACTIVITIES. IF REQUIRED COVER CANNOT BE MAINTAINED OR PROPOSED LOADS ARE DETERMINED TO PRESENT A RISK OF DAMAGE TO GREELEY PIPELINE COVER, AN ENGINEERED BRIDGING SOLUTION ACCEPTABLE TO THE CITY OF GREELEY MUST BE DESIGNED AND IMPLEMENTED.
14. THE PINYON ENVIRONMENTAL, INC. RECOMMENDATIONS RELATED TO STATE-LISTED AND SPECIAL CONCERN SPECIES IN EXHIBIT H WILL BE FOLLOWED.

SHEET INDEX:

PERMIT BOUNDARY AND AFFECTED AREA LEGAL DESCRIPTION:

A PARCEL OF LAND, LOCATED IN THE WEST HALF (W1/2) OF SECTION THIRTY-SIX (36) AND THE NORTHEAST QUARTER OF THE SOUTHEAST QUARTER (NE1/4 SE1/4) OF SECTION THIRTY-FIVE (35), TOWNSHIP SIX NORTH (T.6N.), RANGE SIXTY-SEVEN WEST (R.67W.), SIXTH PRINCIPAL MERIDIAN (6TH P.M.), COUNTY OF WELD, STATE OF COLORADO, MORE PARTICULARLY DESCRIBED AS FOLLOWS:

COMMENCING AT THE NORTHWEST CORNER OF SAID SECTION 36, ASSUMING THE NORTH LINE OF THE NW1/4 OF SAID SECTION 36 AS BEARING NORTH 89°26'04" EAST WITH ALL BEARINGS CONTAINED HEREIN RELATIVE THERETO.

THENCE NORTH 89°26'04" EAST ALONG SAID NORTH LINE A DISTANCE OF 230.85 FEET TO THE POINT OF BEGINNING;

THENCE CONTINUING NORTH 89°26'04" EAST ALONG SAID NORTH LINE A DISTANCE OF 2407.28 FEET;
THENCE SOUTH 03°37'42" EAST A DISTANCE OF 1564.13 FEET;
THENCE SOUTH 64°26'59" WEST A DISTANCE OF 647.92 FEET;
THENCE SOUTH 28°13'27" WEST A DISTANCE OF 541.57 FEET;
THENCE SOUTH 22°25'04" WEST A DISTANCE OF 416.83 FEET;
THENCE NORTH 80°30'21" WEST A DISTANCE OF 687.06 FEET;
THENCE SOUTH 55°31'12" WEST A DISTANCE OF 876.63 FEET;
THENCE NORTH 45°00'06" WEST A DISTANCE OF 434.80 FEET;
THENCE NORTH 00°37'01" WEST A DISTANCE OF 2510.15 FEET;
THENCE NORTH 89°59'04" EAST A DISTANCE OF 232.05 FEET;
THENCE NORTH 00°53'25" WEST A DISTANCE OF 244.66 FEET TO THE **POINT OF BEGINNING..**

SAID DESCRIBED PARCEL OF LAND CONTAINS A TOTAL OF 6,544,695 SQ. FT. OR 150.246 ACRES, MORE OR LESS.

TETRA TECH
www.tetratech.com
351 Coffman Street, Suite 200
Longmont, CO 80501
Phone: (303) 772-5282

MARK	DATE	DESCRIPTION	BY
1	9/22/22	INITIAL SUBMITTAL	
2	3/2023	REVISED PER WINDSOR AND DRMS FEEDBACK	

MARTIN MARIETTA MATERIALS
WINDSOR EAST PERMITTING
WELD COUNTY, COLORADO

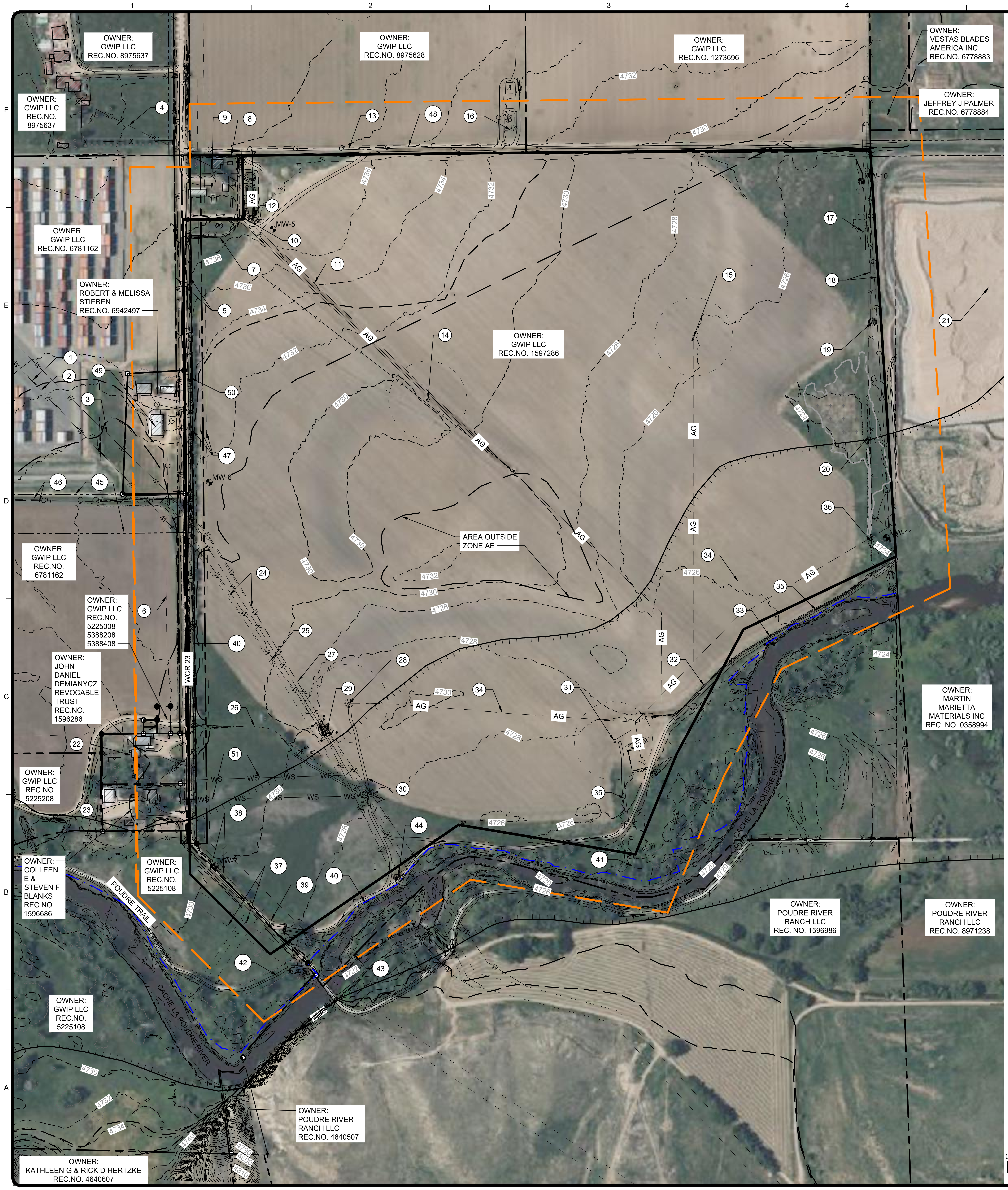
EXHIBIT C
COVER SHEET &
MINING NOTES

PROJ: 117-8741006
DESN: GH
DRWN: LAW
CHKD: PFH

C-1

3/2/2023 3:08:43 PM - C:\USERS\LAURA.WEATHERL\ACCDOCS\TETRA TECH INC\117-8741006_WINDSOREASTMINE\PROJECT FILES\CAD\SHEETFILES\C-1 EXHIBIT C COVER SHEET.DWG - WEATHERL, LAURA

Bar Measures 1 inch, otherwise drawing not to scale



5
6
7

STRUCTURES LIST

Structure ID	Structure Description	Owner
1	CL of Water Easement (Width not Specified)	City of Greeley
2	Water Line	City of Greeley
3	Water Line	City of Greeley
4	Overhead Electrical Line	Poudre Valley REA, Inc
5	Weld County Road 23 (60' ROW)	Town of Windsor
6	Pipeline ROW Grant	Associated Natural Gas (DCP Midstream)
7	Concrete Lined Lateral	GWIP, LLC
8	Concrete Lined Lateral	GWIP,LLC
9	Farmstead (House, Utility Building, 3 Small Buildings)	GWIP, LLC
10	Pipeline Easement with Abandoned Pipeline	DCP Midstream
11	Pipeline Easement with Abandoned Pipeline	DCP Midstream
12	Irrigation Pump	GWIP, LLC
13	Private Road	GWIP, LLC
14	Oil Well (State 8-36) - Plugged and Abandoned	Noble Energy
15	Oil Well (State 36-3) - Plugged and Abandoned	Noble Energy
16	Oil Equipment Inside Fence	DCP Midstream
17	Fenceline	GWIP, LLC
18	30' Pipeline Easement	DCP Lucerne 2 Plant LLC
19	Parsons Monitoring Well 12 (MW-12)	Martin Marietta Materials, Inc
20	Swale Flowline	GWIP, LLC
21	Parsons Mine	Martin Marietta Materials, Inc
22	Farmstead (House, Quonset, Outbuilding, Water Line, OHE, Septic System Leach Field)	John Daniel Demianycz Revocable Trust
23	Farmstead (House, Utility Buildings, Water Line, OHE, Sprinkler System, Septic System Tank)	Colleen E. and Steven F. Blanks
24	50' Water Pipe Easement	City of Greeley
25	Water Pipeline Easement	City of Greeley
26	Swale Flowline Lateral	GWIP, LLC
27	Water Line in 50' Easement	City of Greeley
28	Oil Well (State 7-36) - Plugged and Abandoned	Noble Energy
29	Water Valves and Appurtenant Structures	City of Greeley
30	Access Road	GWIP, LLC
31	Oil Well (State 36-5) - Plugged and Abandoned	Noble Energy
32	Swale Flowline	GWIP, LLC
33	Fenceline	GWIP, LLC
34	Gas Lines - Cut and Cleaned	DCP Midstream
35	Access Road	GWIP, LLC
36	Fenceline (to be removed)	GWIP, LLC
37	50' Water Pipe Easement	City of Greeley
38	ROW Closed to Public Access	GWIP, LLC
39	Ditch Lateral	GWIP, LLC
40	Fenceline	GWIP, LLC
41	Swale Flowline	GWIP, LLC
42	Poudre Trail in 40' Easement	Poudre River Trail Corridor, Inc.
43	Rock Structure (Side Channel)	GWIP, LLC
44	Water Meter	GWIP, LLC
45	Future Crossroads Blvd ROW	Town of Windsor
46	10' Utility Easement	GWIP, LLC
47	30' Permanent/20' Temporary Water Line Easement	City of Aurora
48	Gas Lines	DCP Midstream
49	Farmstead (Houses, Shed, Equipment Building, Water Line, OHE, Septic System)	Robert & Melissa Stieben
50	Overhead Electrical Line and Underground Fiber Optic Cable	Poudre Valley REA, Inc
51	Potential Water Service Lines*	City of Greeley

* THE EXACT LOCATIONS OF THESE WATER SERVICE LINES IS UNKNOWN. PRIOR TO MINING THEY WILL BE FIELD LOCATED. IF THE LINES ARE AS SHOWN ON THIS MAP, THE LINES WILL BE RELOCATED OR CELL D WILL NOT BE MINED.

LEGEND

PERMIT & AFFECTED AREA BOUNDARY
200' OFFSET
PROPERTY BOUNDARY
ROW LINE
SECTION LINE
EASEMENT LINE
EXISTING MAJOR CONTOUR
EXISTING MINOR CONTOUR
EXISTING ROAD EDGE
RIVERBANK
EXISTING EDGE OF WATER
EXISTING WETLAND BOUNDARY
EFFECTIVE ZONE FLOODWAY
EFFECTIVE ZONE AE
EFFECTIVE ZONE X
EXISTING BRUSH LINE
— —X— — —X— — EXISTING FENCE LINE
EXISTING SWALE
—OH— OVERHEAD ELECTRIC
— —E— — —E— — UNDERGROUND ELECTRIC
— —T— — —T— — TELEPHONE
— —G— — —G— — GAS LINE
— — AG — — GAS LINE/ CLEANED & CUT, ABANDONED IN PLACE
— —W— — —W— — WATER LINE
—FM— SANITARY SEWER FORCE MAIN
SANITARY SEWER GRAVITY MAIN
STORM SEWER
—IRR— IRRIGATION
MISCELLANEOUS PIPELINE

SECTION CORNER/ PROPERTY MONUMENTS
Ⓦ MONITORING WELL
Ⓦ WV WATER MANHOLE AND VALVE
UTILITY POLE
TEL.PED TELEPHONE PEDESTAL
Ⓢ SANITARY MANHOLE
Ⓓ STORM MANHOLE
FLARED END SECTION
EXISTING HOUSE
■MP □WP EXISTING METAL/ WOOD POST
EXISTING TREES
NON-JURISDICTIONAL WETLANDS

N

0 100' 200' 400'
SCALE: 1" = 200'

CERTIFICATION

THIS MAP WAS PREPARED BY TETRA TECH IN COOPERATION WITH MARTIN MARIETTA MATERIALS. MARTIN MARIETTA MATERIALS WILL KEEP THE DIVISION OF RECLAMATION, MINING AND SAFETY INFORMED OF ANY CHANGES TOT HE MINING OR RECLAMATION PLANS THROUGH ANNUAL REPORTS AND FILE TECHNICAL REVISIONS OR AMENDMENT APPLICATIONS AS NECESSARY THROUGHOUT THE LIFE OF THE MINE.

Pamela Franch Hora
3/2023

PAMELA FRANCH HORA, AICP
DATE

TETRA TECH
www.tetratech.com
351 Coffman Street, Suite 200
Longmont, CO 80501
Phone: (303) 772-5282

MARK	DATE	DESCRIPTION	BY
1	9/22/22	INITIAL SUBMITTAL	
2	3/2023	REVISED PER WINDSOR AND DRMS FEEDBACK	

MARTIN MARIETTA MATERIALS
WINDSOR EAST PERMITTING
WELD COUNTY, COLORADO

EXHIBIT C
PRE-MINING PLAN
EAST AREA

PROJ:	117-8741006
DESN:	GH
DRWN:	LAW
CHKD:	PFH

C-2

Bar Measures 1 inch, otherwise drawing not to scale

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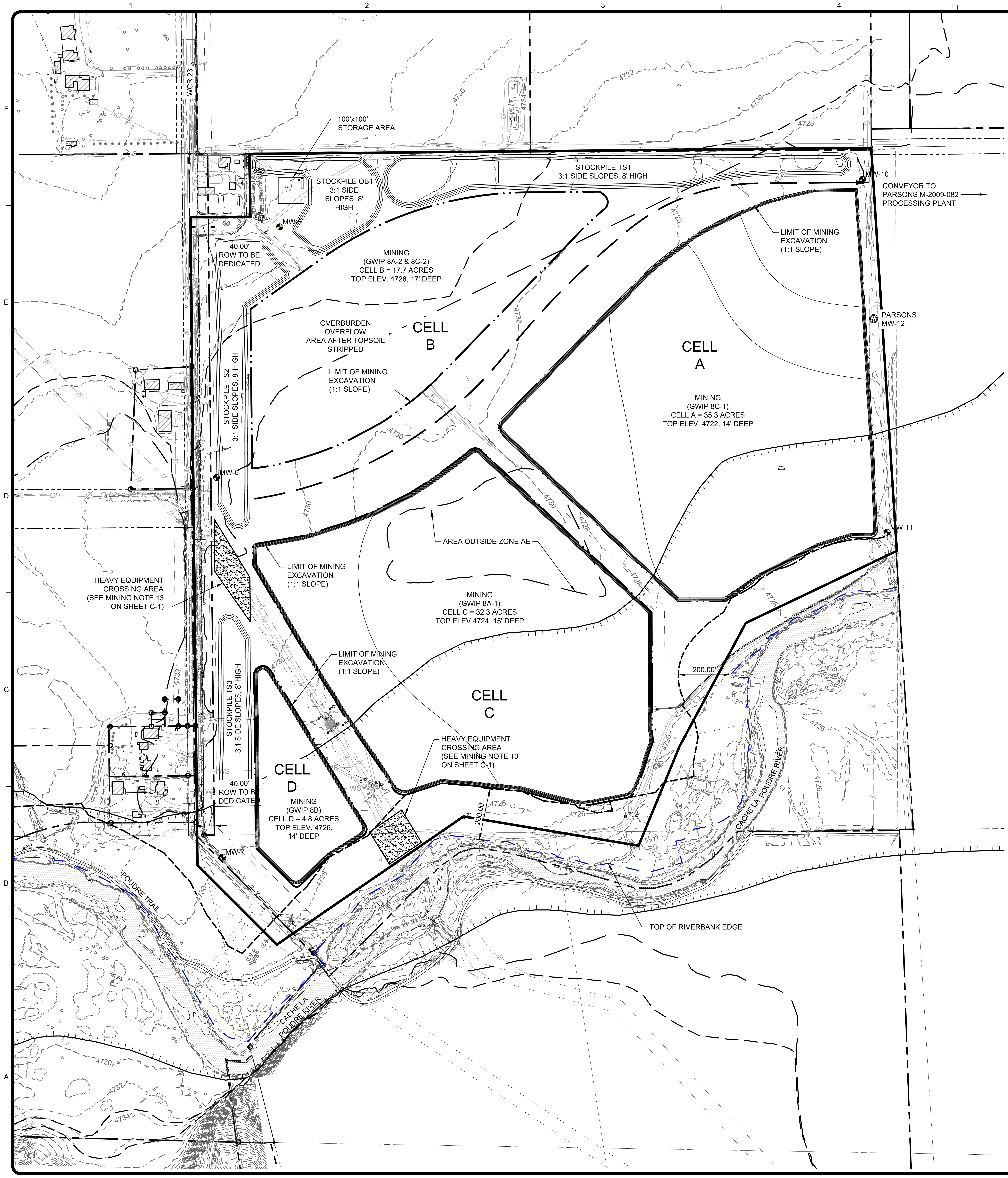
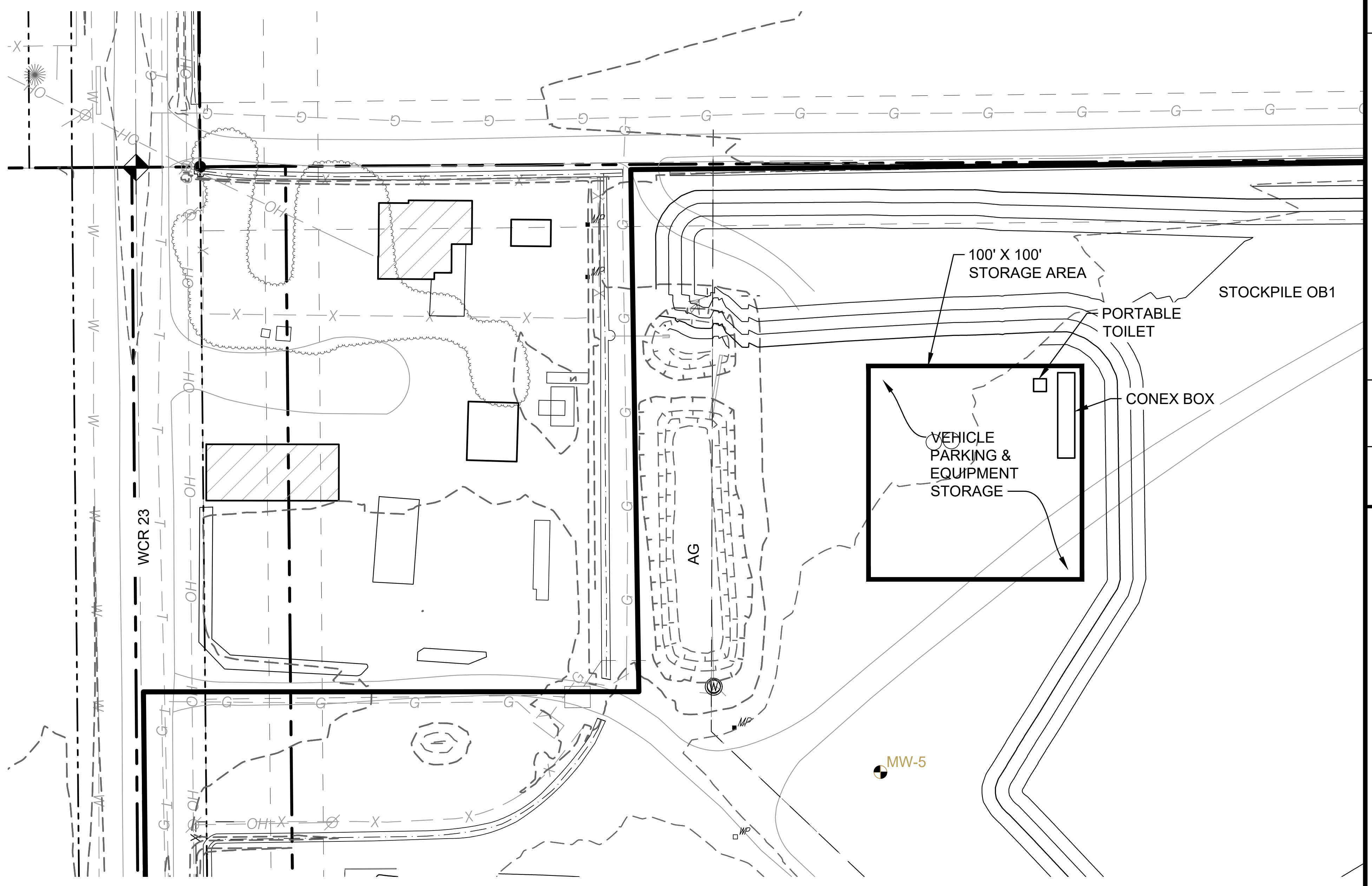


LEGEND

- PERMIT & AFFECTED AREA BOUNDARY
- LIMIT OF MINE EXCAVATION PER SLOPE STABILITY ANALYSIS
- PROPERTY BOUNDARY
- ROW LINE
- SECTION LINE
- EASEMENT LINE
- EXISTING MAJOR CONTOUR
- EXISTING MINOR CONTOUR
- EXISTING ROAD EDGE
- RIVERBANK
- 200' OFFSET FROM RIVERBANK
- EXISTING WETLAND BOUNDARY
- EFFECTIVE ZONE FLOODWAY
- EFFECTIVE ZONE AE
- EFFECTIVE ZONE X
- EXISTING EDGE OF WATER
- EXISTING BRUSH LINE
- —X— EXISTING FENCE LINE
- EXISTING SWALE
- —OH— OVERHEAD ELECTRIC
- —E— UNDERGROUND ELECTRIC
- —T— TELEPHONE
- —G— GAS LINE
- —W— WATER LINE
- —WS— WATER SERVICE
- —FM— SANITARY SEWER FORCE MAIN
- SANITARY SEWER GRAVITY MAIN
- STORM SEWER
- —IRR— IRRIGATION
- MISCELLANEOUS PIPELINE
- S1 SECTION CORNER/ PROPERTY MONUMENTS
- Ⓦ MONITORING WELL
- Ⓦ WV WATER MANHOLE AND VALVE
- Ø UTILITY POLE
- ☒ TEL.PED TELEPHONE PEDESTAL
- Ⓢ SANITARY MANHOLE
- Ⓓ STORM MANHOLE
- FLARED END SECTION
- ▨ EXISTING HOUSE
- ■MP □WP EXISTING METAL/ WOOD POST
- EXISTING TREES
- CONVEYOR



STORAGE AREA DETAIL

SCALE: 1" = 50'

N

0 100' 200' 400'

SCALE: 1" = 200'

CERTIFICATION

THIS MAP WAS PREPARED BY TETRA TECH IN COOPERATION WITH MARTIN MARIETTA MATERIALS. MARTIN MARIETTA MATERIALS WILL KEEP THE DIVISION OF RECLAMATION, MINING AND SAFETY INFORMED OF ANY CHANGES TOT HE MINING OR RECLAMATION PLANS THROUGH ANNUAL REPORTS AND FILE TECHNICAL REVISIONS OR AMENDMENT APPLICATIONS AS NECESSARY THROUGHOUT THE LIFE OF THE MINE.

Pamela Franch Hora

3/2023

PAMELA FRANCH HORA, AICP

DATE

Bar Measures 1 inch, otherwise drawing not to scale

3/2/2023 3:10:45 PM - C:\USERS\LAURA.WEATHERL\ACCDOCS\TETRA TECH INC\117-8741006_WINDSOREASTMINE\PROJECT FILES\CAD\SHEETFILES\C-3 MINING PLAN EAST SIDE.DWG - WEATHERL, LAURA

TETRA TECH
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Phone: (303) 772-5282

MARK	DATE	DESCRIPTION	BY
1	9/22/22	INITIAL SUBMITTAL	
2	3/2023	REVISED PER WINDSOR AND DRMS FEEDBACK	

MARTIN MARIETTA MATERIALS

WINDSOR EAST PERMITTING
WELD COUNTY, COLORADO

EXHIBIT C
MINING PLAN
EAST SIDE

PROJ:	117-8741006
DESN:	GH
DRWN:	LAW
CHKD:	PFH

C-3

EXHIBIT D – MINING PLAN

1.0 GENERAL

The Windsor East Mine property is located within the Town of Windsor in Weld County, Colorado. The Windsor East Mine site is on land owned by GWIP, LLC (GWIP). Martin Marietta Materials (Martin Marietta) has a lease to mine the GWIP property. The leased area is located within Parcel 08073600021, in Section 35 and 36, Township 6 North, Range 67 West of the 6th Prime Meridian. The geographic coordinates for the main entrance area are 40.450040° N, -104.851359° W. The property contains a significant commercial deposit of sand and gravel that is associated with the Cache la Poudre River. While the property is owned by GWIP, LLC, the mineral rights in the affected area are owned by the Colorado State Board of Land Commissioners.

The Windsor East Mine is 150.3 acres. The permit boundary and affected area are the same for this application. Within the site, 90.1 acres of the land will be mined, and the remaining unmined acres will be used for overburden and topsoil stockpiles, offsets from existing structures and property lines.

The permit boundary for the site was established to avoid impacting the riparian area along the Cache la Poudre River. In addition, all mining excavations will be set back a minimum of 200’ from the riverbank and then backfilled to be no closer than 400’ from the riverbank. Riverbank locations were located using GPS in June 2022 and the locations may vary over time. Offset distances are in accordance with the *Technical Review Guidelines for Gravel Mining and Water Storage Activities,* published by the Mile High Flood District in January 2013.

A wetland area was identified on the site and mapped. The US Army Corps of Engineers has determined that this is non-jurisdictional. Please see Exhibit J for the documentation. The proposed mining plan shows that Martin Marietta will mine through this area.

A Biological Resources Technical Memorandum, produced by Pinyon Environmental, Inc., provided recommendations on state-listed or special concern species that have the potential to occur or be impacted by the mine. Martin Marietta will follow the recommendations provided by Pinyon. Please see Exhibit H for the documentation.

There were oil and gas wells and flowlines through the middle of the property that were owned by Noble and DCP Midstream that are no longer used. Most of the wells have been plugged and abandoned per COGCC requirements. There is only one well left (State 8-36) for DCP to complete abandonment and the 150’ radius will be maintained until the abandonment is complete. Martin Marietta has contacted DCP Midstream and found out that all the flowlines were properly abandoned in place and Martin Marietta can remove them as they mine. Martin Marietta will contact DCP Midstream as they encounter and remove these lines so that DCP can appropriately document their removal. There is also an oil and gas flowline running north and south along the east edge of the property. Martin Marietta is working with DCP Midstream to determine what needs to be done to cross this line with conveyor and equipment.

It is estimated that the overburden will amount to approximately 676,000 cubic yards. Overburden exists to an average depth of approximately 5 feet over the entire site. All overburden and clay needed for the construction of the final reclamation will come from this site. The average depth of sand and gravel is 10 feet across the site and mining at the site is intended to progress down to bedrock.

Deere & Ault Consultants, Inc. drilled 8 borings in 2017 for the property owner and Martin Marietta drilled 16 borings across the site in December 2019 with similar results. The results of these borings were used to understand the subsurface conditions across the Windsor East Mine area. Drilling logs indicate the general subsurface profile consists of approximately 3 to 9 feet of silty to clayey sand overburden, overlying approximately 6 to 17 feet of well graded gravel with varying amounts of sand and silt, overlying claystone bedrock. Groundwater was encountered at depths ranging from 4 to 7 feet in the most recent 2019 Martin Marietta borings. There is evidence that dewatering from the Parsons Mine to the east has increased the depth of the water table to 11-12 feet below the surface.

The site will be mined in four phases, called out on the Exhibit C Mining Plan map as Cells A, B, C and D. These phases are neither representative of the maximum area of disturbance nor do they limit disturbance to a particular phase.

Agricultural, industrial, residential, and mining uses surround the property.

2.0 METHODS OF MINING

The typical mining procedure for all phases will be as follows. Any areas slated for protection will be identified in the field to assure that mining operations will be set back as appropriate. The topsoil and overburden will be stripped with scrapers and stockpiled in the designated stockpile areas identified in Exhibit C. Overburden found on the site, will also be used to fill in the reclamation slopes. Overburden and topsoil reserved for reclamation will be vegetated and stabilized in accordance with Rule 3.1.9(1). Mining will expose groundwater (for details on the timing, please see Section 2.1 of Exhibit G).Prior to mining, a dewatering trench will be constructed around the perimeter of each phase. A sump hole will be created at the lowest point of each dewatering trench. The sump holes and dewatering trenches will allow sediment to settle before the water is pumped to the Cache la Poudre River using a dewatering pump in accordance with Colorado/NPDES discharge permit regulations. Pipes will be used to transport the water from the mine to the Cache la Poudre River. The location of the discharge pipes will be adjusted throughout the mining process.

When the mined alluvium is sufficiently dry, front-end loaders will excavate the material. The high wall of the mine cells will not exceed a 1:1 slope. All mined material will be deposited on conveyors which will transport the material to Martin Marietta’s existing plant site at the Parsons Mine (M-2009-082), directly east of Windsor East. No materials processing will occur at the Windsor East Mine site.

Surface water within the mine areas will drain internally. Direct precipitation falling on a mine cell is collected in the perimeter dewatering trench and pumped out. There will not be any uncontrolled releases of surface water and sediment from mining areas. Storm water collected in the open mine will be managed in accordance with Colorado/NPDES discharge permit requirements.

Water rights associated with the site will be used for dust control operations along the roads, stockpiles, transport of material and berms. The water balance discussed in Exhibit G estimates the gallons per week necessary to limit dust emissions. The water will be supplied using a 2,500-gallon water truck.

No explosives will be used to mine the site.

3.0 OVERBURDEN

Topsoil and overburden will be stripped with scrapers or a dozer and placed separately in temporary stockpiles within the permit area limits. The topsoil will be segregated and stored separately from the overburden material as required by Rule 3.1.9(1). The stockpiles will have an average height of 8 feet tall; they will have maximum 3:1 (horizontal:vertical) side slopes. The topsoil stockpiles will be protected from wind and water erosion by vegetative cover (see the Seed Mix for Upland Areas found in Exhibit E). The stockpiles will be broadcast seeded and incorporated into the weed control program. Weed control consists of chemical treatments as needed in the applicable fall and spring seasons. Topsoil and overburden stockpiles reserved for reclamation will be vegetated and stabilized in accordance with Rule 3.1.9(1).

The overburden stockpiles will be continuously rotating. Initially, a portion of a phase will be stripped, and the overburden stockpiled temporarily within the permit boundaries. Once the deposit has been mined from the stripped portion, the temporary stockpile will be removed and used for reclamation. The remaining portion of the cell will then be stripped, and the overburden will be stockpiled on the mine floor or placed immediately in the reclamation slope. No excess overburden is anticipated for this site.

4.0 COMMODITIES TO BE MINED

The primary commodity to be mined will be aggregate and a secondary commodity will be gold. Martin Marietta will supply local, county, and state governments, as well as private industry with aggregate from this facility. If gold is mined it will be used for commercial purposes.

5.0 OFFSETS

Tetra Tech prepared a Slope Stability Analysis to ensure that all existing structures will be protected based on the proposed reclamation slopes.

6.0 ROADS AND CONVEYORS

Preparation for mining for each phase will include a 15' wide gravel access road around the perimeter of the cell. Any additional short-term haul access will be constructed with 6" of native sand and gravel from the floor of the mine. These gravel roads will be removed and reclaimed as mining and reclamation is completed for each phase. These areas have been included in the permitted acreage.

All the material will be transported via conveyor from the mining cells to Martin Marietta's Parsons Mine to the east for processing. The conveyor is set on concrete block or frames. The main line will run down the future Crossroads path and feeders will be dropped into each phase we are mining and then removed before reclamation. All areas affected by the conveyors will be re-topsoiled and seeded to restore ground to the original condition.

A 10.5' wide existing road that currently connects to WCR 23 will be utilized to provide street access to this site. The location of this existing road is shown on Exhibit C, Pre-Mining Plan. It is located northwest of cell B.

7.0 MINE SCHEDULE

Depending on market conditions, the Windsor East Mine operation will process approximately 450,000 – 500,000 tons of aggregate per year. At this rate, Martin Marietta anticipates mining and reclaiming the site in approximately 8 years (about 6 years to mine and another 2 years to complete reclamation and get grasses to establish). The table outlines the anticipated mine schedule by phase. As previously stated, this schedule is just an estimate since the rate of mining and overall life of the mine is dependent upon demand and market conditions.

Phase	Mine Area (in acres)	Projected Time to Mine (in years)
Cell A	35.3	2±
Cell B	17.7	1±
Cell C	32.3	2±
Cell D	4.8	1±

8.0 PHASE OVERVIEW

The four cells in Windsor East will be mined as explained below. The following is a detailed description of Martin Marietta's plan to mine the four cells that are proposed along with an explanation of how the topsoil and overburden will be handled. Please refer to Exhibit C-3 for the locations of each mining cell, topsoil stockpile (TS#) and overburden stockpile (OB#).

1. The topsoil from Cell A will be stripped and placed on the north property line in stockpile TS1. Overburden from Cell A will be stockpiled in OB1.
2. Cell A will then be mined.
3. Topsoil from Cells B and C will be stripped and placed in stockpiles TS1, TS2, and TS3. Overburden from Cell B will remain in place and overburden from Cell C will be used to reclaim the slopes of Cell A. Any excess overburden from Cell B will be placed in stockpile OB1 or in the overburden overflow area on top of Cell B.
4. Cell C will be the second cell mined. The slopes of Cell C will be concurrently reclaimed using overburden from stockpiles OB1 and the overburden overflow area on top of Cell B.
5. Cell D topsoil will be stripped and used in reclamation of Cells A and C. Overburden from Cell D will be used in the reclamation of Cell C. Any excess overburden from Cell D will be placed in stockpile OB2.
6. Cell D will then be mined. It will then be reclaimed by backfilling it with overburden from the overburden overflow area on top of Cell B including the overburden originally left behind in Cell B.
7. Cell B will be the last cell mined, and it will be backfilled with the remaining overburden from stockpile OB1.
8. The topsoil from TS1, TS2 and TS3 will then be used to complete reclamation of Cells B and C as well as the edges of Cells A and C.

9.0 EARTHMOVING

Earthmoving is performed using a combination of mobile mining equipment including, but not limited to loaders, dozers, scrapers, backhoes, water trucks, diesel powered generators, and pumps.

EXHIBIT E – RECLAMATION PLAN

1.0 DESIGN INTENT

This site will be mined and reclaimed to create two water storage ponds that the landowner, GWIP will own and use for water storage. Water stored in the ponds will be used by GWIP to satisfy augmentation requirements. Currently, GWIP leases water from the Town of Windsor to satisfy some augmentation requirements. So, upon completion of the reservoirs, GWIP will no longer need to lease water from Windsor to meet this requirement.

Two lined water storage reservoirs surrounded by revegetated upland areas will be created by the mining and reclamation process. Native and adaptive plantings and ground covers will be used to restore and enhance all areas disturbed by mining activities that will not be within a lined water storage cell.

This reclamation plan was developed based on:

- A thorough evaluation of the environmental resources and existing conditions on and adjacent to the property;
- The context of the property relative to existing and planned land uses in the area;
- The volume, depth and configuration of the mineral resource;
- The landowners' plans for the property; and
- The rules and policies of Windsor, the Colorado Division of Mining, Reclamation and Safety and other applicable local, State and Federal agencies.

Key considerations include the following:

- The permit boundary on the south was placed outside of the Cache la Poudre riparian corridor to protect the area.
- All wetlands on the site were located and delineated. The one wetland found is being reviewed by the Corps of Engineers to determine if it is jurisdictional or not. If found to be jurisdictional, the mining plan will be adjusted to protect the wetland from disturbance.
- The 200' setback from the river will be clearly marked in the field and best management practices will be used as necessary to implement the CDPHE Storm Water Management Plan for the site.
- Maintenance activities on the site will also include a comprehensive Weed Management Plan (see attached) to limit the spread of invasive species into the riparian areas and wetlands.
- Much needed water storage reservoirs will be created on the site. The reservoirs will be lined with compacted material acceptable to construct liners that are found on the site.
- Five groundwater monitoring wells have been installed to establish pre-mining baseline water levels along with the Parsons Mine (M-2009-082) monitoring wells. The wells will be used to monitor effects from mining and provide information for mitigation of potential impacts on groundwater levels and riparian vegetation, as necessary. If levels drop below seasonal levels, dewatering water will be diverted to the areas to sustain existing vegetation to limit impacts during mining. Details of the monitoring and mitigation plans are provided in Exhibit G.

2.0 POST-MINING LAND USE

The post-mining land use, as proposed in this Reclamation Plan consists of water storage ponds surrounded by upland vegetation.

All disturbed areas will be vegetated as appropriate with a native seed mix, as recommended by the Soil Conservation Service (recommended seed mixes below). These uses are compatible with the surrounding land uses and with the Town of Windsor planning goals.

Martin Marietta will concurrently mine and reclaim this site. Reclamation, including regrading and seeding, will be completed within two to five years following the completion of mining or filling operations for each phase. The mining and reclamation will leave no high walls on the property. No acid forming or toxic materials will be used or encountered in the mining. There will be no auger holes, adits, or shafts.

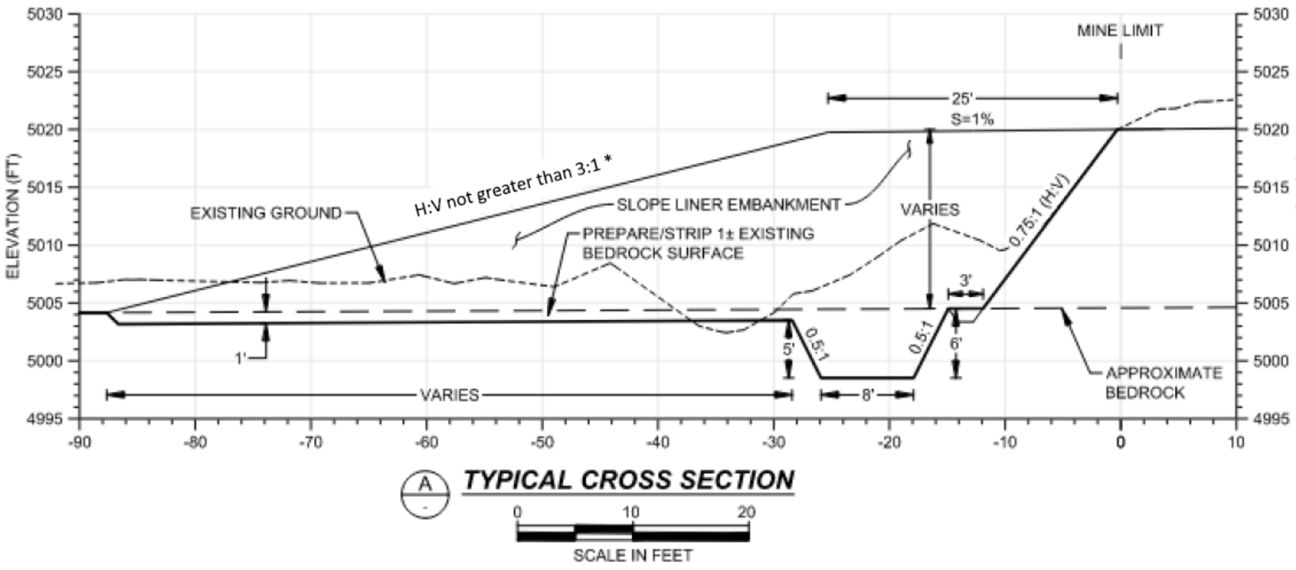
3.0 RECLAMATION MEASURES – MATERIAL HANDLING

Site reclamation measures are illustrated in Exhibit F. Reclamation of the site will include 2 water storage ponds (54.77 acres) and 35.43 acres of upland vegetation.

The ponds will be reclaimed as water storage ponds. All mine walls will be re-graded with overburden material to create a compacted liner. A cross-section of the proposed design for the liner is below.

EXAMPLE OF CLAY LINER DESIGN

Full design of each liner will be completed by a registered professional engineer as mining of the cell is completed based on soil analysis, site conditions and DRMS slope stability requirements. Full design will be submitted to the DRMS as a Technical Revision to M-2022-042.



* Slope design to be determined by PE based on soil analysis, site conditions and DRMS slope stability requirements

A copy of the clay liner design will be submitted to the Division for review and approval, through a Technical Revision process, prior to construction of the liner.

Slopes above the post-mine high water level will be 3:1 and slopes below the post-mine high water level will not exceed 3:1. Topsoil will be spread to a minimum depth of 6” over the surface of all areas outside the water storage basins that are to be revegetated as uplands.

Scrapers will be used to place the backfilled material. Using scrapers to layer the lifts at a maximum 3:1 slope ensures a stable configuration.

Reclamation quantities and costs are summarized in Exhibit L.

4.0 WATER

Overburden and mine materials will be inert and impacts to local surface water or groundwater quality are not anticipated to occur because of mining activities. Martin Marietta Materials, Inc. will comply with all applicable Colorado water laws and all applicable Federal and State water quality laws and regulations and appropriate storm water management and erosion control to protect the adjacent Cache la Poudre River and riparian vegetation.

Cell B will be backfilled above the water table leaving a 5-foot depression as defined in our lease. No stormwater will be directed to this depression, but any stormwater collected will dissipate into the ground. GWIP, LLC, the landowner, intends to use this depression as part of their stormwater detention when they develop on adjacent land and will work with Town of Windsor on their development once our reclamation permit is released. Martin Marietta is not required to install any structures as part of the depression including but not limited to headwalls, outlets, piping and forebays.

5.0 WILDLIFE

Presently, the area is used for general agriculture. There is significant habitat for many wildlife species along the river corridor which is outside our permit boundary. Please see Exhibit H (Wildlife Information) for more information pertaining to the recommendations and conclusions from the environmental report.

6.0 TOPSOILING

Topsoils in the proposed mine areas are predominantly Aquoll and Aquents, Ellicott, Colombo clay loam, Kim loam, and Nunn clay loam. All suitable soil material will be salvaged for topsoil replacement. Topsoil will be replaced, where required, in reclaimed areas at a depth of a minimum of 6 inches.

The topsoil will be segregated and stored separately from the overburden material as required by Rule 3.1.9(1). Sufficient topsoil will be stockpiled within each phase to reclaim all disturbed areas. The mine plan map depicts the location and configuration of the berms. The berms will be protected from wind and water erosion by vegetative cover if in place for more than 180 days and will be vegetated depending on the seeding “window” parameters for dryland grass, which are typically between September and April.

Soil amendments are not expected to be required due to the nature of the soils. However, topsoil samples will be subjected to agricultural testing prior to reclamation to assess fertilizer requirements. The Soil Conservation Services (SCS) will be contacted periodically throughout reclamation for soil tests. SCS soil fertilizer recommendations, if any, will be followed.

7.0 REVEGETATION

Following topsoil replacement, reseeding will be performed according to SCS recommended practices. Based on SCS guidance for other local projects having similar surficial soils, the following revegetation procedures are anticipated

- Grass seed will typically be planted in unfrozen soil between October 1 and April 30.
- Grass seed will be planted with a grass drill, or where necessary, with a broadcast seeder.
- The proposed seed mix and application rates in pounds of pure live seed per acre are described on the following pages.
- Weed control practices will be implemented as required.

The above procedures may be modified as conditions dictate. If a significant invasion of noxious weeds occurs, the area will be mowed periodically for control. Weeds will be mowed before they go to seed during the first growing season. Mechanical control will be used as a first priority. Chemical methods will be used only if no other alternative produces acceptable results.

8.0 WEED MANAGEMENT PLAN

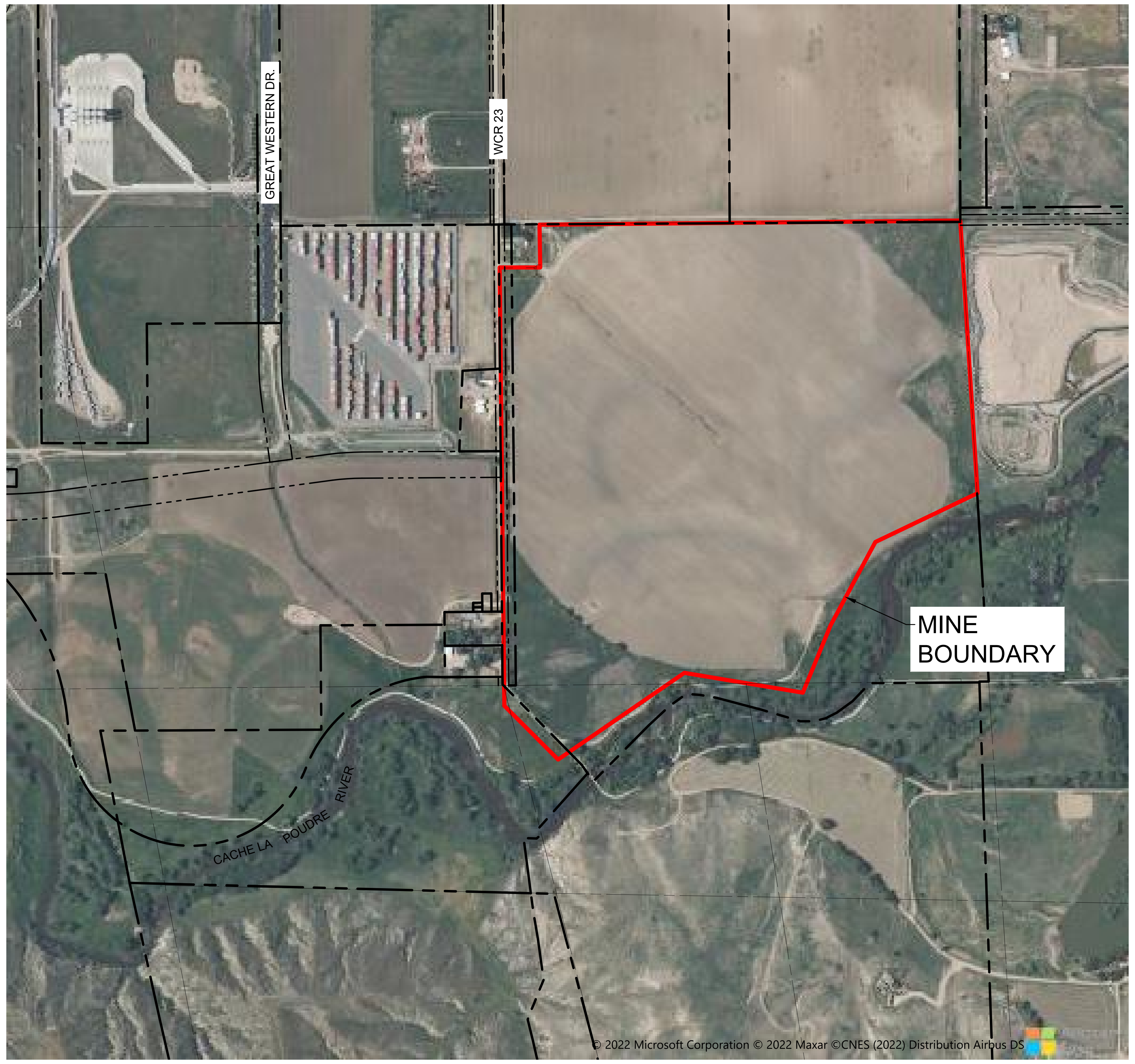
A weed management program will be undertaken to control noxious and invasive plant species and to replace those species with native and naturalized vegetation. Canada thistle (*Cirsium arvense*) and leafy spurge (*Euphorbia esula*) will be treated by a combination of mowing at regular intervals and herbicides used at the appropriate times and applications levels. Please see the attached Weed Management Plan.

9.0 SEED MIX FOR UPLAND AREAS

Common Name	Scientific Name	Variety	% of Mix	PLS Application Rate (lbs/ac)
Western Wheatgrass	Agropyron smithii	Arriba	17.0%	1.74
Sideoats Grama	Bouteloua curtipendia	Butte	17.5%	1.80
Mountain Brome	Bromus marginatus	Bromar	17.0 %	1.74
Prairie Sandreed	Calamovilfa longifolia	Goshen	1.0%	0.48
Switchgrass	Panicum virgatum	Pathfinder	7.0%	0.67
Alkali Sacaton	Sporobolus airoides		1.0%	0.10
Needle and Thread	Stipa comata		13.0%	1.29
Northern Sweetvetch	Hedysarum boreale	Timp.	10.0%	1.02
Rocky Mountain Penstemon	Penstemon strictus	Bandera	5.0%	0.46
Scarlet Globemallow	Sphaeralcea coccinea	ARS2936	3.0%	0.26
Prairie Wildrose	Rosa Arkansana		8.5%	0.87
Total lbs/ac			100%	10.43

Notes:

1. Pure Live Seed pounds per acre; rates shown are for drill seeding; double rates for broadcast seeding.
2. All upland areas will be mulched with 1 ton of certified weed free straw per acre. Mulch shall be applied within 24 hours of seeding and crimped in place.



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GRAVEL MINING APPLICANT / OPERATOR:

MARTIN MARIETTA MATERIALS
1800 NORTH TAFT HILL ROAD
FORT COLLINS, COLORADO 80521

SURFACE OWNERS:

GWIP LLC
252 CLAYTON ST FL 4
DENVER, COLORADO 80206-4816

EXISTING VEGETATION:

REPORT BY PINYON ENVIRONMENTAL, INC. PROVIDED THAT THE PROJECT AREA IS CURRENTLY USED PRIMARILY AS IRRIGATED AGRICULTURAL LAND. HABITAT TYPES INCLUDE GRASSLANDS (IRRIGATED CROPLAND) AND WETLAND AREA ON THE EAST SIDE OF THE SITE. PLEASE SEE EXHIBIT J FOR MORE VEGETATION INFORMATION.

SURVEY INFORMATION:

TOWN OF WINDSOR BENCHMARK #65

3.25" ALUMINUM CAP SET IN CONCRETE STAMPED "KING SURVEYORS WIN-KODAK-257 1997", IN THE VICINITY OF THE E, 1/4 CORNER OF SECTION 28, T6N, R67W, AT THE WEST ENTRANCE TO KODAK ROAD, 35' N. OF THE CENTER LINE OF KODAK ROAD AND 18.6' E. OF THE STOP SIGN.

ELEVATION = 4754.74 FEET (NAVD 1988 DATUM)

UTILITY INFORMATION TAKEN FROM THE GREAT WESTERN ALTA/NSPS LAND TITLE SURVEY DATED JANUARY 2, 2018 BY AZTEC CONSULTANTS, INC.

FLOOD HAZARD INFORMATION:

FLOODPLAIN INFORMATION IS FROM PRELIMINARY FLOOD INSURANCE RATE MAP, PANEL NO. 08123C1503F & 08123C1504F, DATED MARCH 23, 2022. A PORTION OF THIS LAND LIES WITHIN ZONE AE (SPECIAL FLOOD HAZARD AREAS INUNDATED BY THE 1% ANNUAL CHANCE FLOOD) AND REGULATORY FLOODWAY.

RECLAMATION AREA ACREAGE TABLE:

WATER STORAGE RESERVOIR	54.2 ACRES
UPLAND	96.1 ACRES
TOTAL	150.3 ACRES

PERMIT BOUNDARY AND AFFECTED AREA LEGAL DESCRIPTION:

A PARCEL OF LAND, LOCATED IN THE WEST HALF (W1/2) OF SECTION THIRTY-SIX (36) AND THE NORTHEAST QUARTER OF THE SOUTHEAST QUARTER (NE1/4 SE1/4) OF SECTION THIRTY-FIVE (35), TOWNSHIP SIX NORTH (T.6N.), RANGE SIXTY-SEVEN WEST (R.67W.), SIXTH PRINCIPAL MERIDIAN (6TH P.M.), COUNTY OF WELD, STATE OF COLORADO, MORE PARTICULARLY DESCRIBED
AS FOLLOWS:

COMMENCING AT THE NORTHWEST CORNER OF SAID SECTION 36, ASSUMING THE NORTH LINE OF THE NW1/4 OF SAID SECTION 36 AS BEARING NORTH 89°26'04" EAST WITH ALL BEARINGS CONTAINED HEREIN RELATIVE THERETO.

THENCE NORTH 89°26'04" EAST ALONG SAID NORTH LINE A DISTANCE OF 230.85 FEET TO THE **POINT OF BEGINNING;**

THENCE CONTINUING NORTH 89°26'04" EAST ALONG SAID NORTH LINE A DISTANCE OF 2407.28 FEET;
THENCE SOUTH 03°37'42" EAST A DISTANCE OF 1564.13 FEET;
THENCE SOUTH 64°26'59" WEST A DISTANCE OF 647.92 FEET;
THENCE SOUTH 28°13'27" WEST A DISTANCE OF 541.57 FEET;
THENCE SOUTH 22°25'04" WEST A DISTANCE OF 416.83 FEET;
THENCE NORTH 80°30'21" WEST A DISTANCE OF 687.06 FEET;
THENCE SOUTH 55°31'12" WEST A DISTANCE OF 876.63 FEET;
THENCE NORTH 45°00'06" WEST A DISTANCE OF 434.80 FEET;
THENCE NORTH 00°37'01" WEST A DISTANCE OF 2510.15 FEET;
THENCE NORTH 89°59'04" EAST A DISTANCE OF 232.05 FEET;
THENCE NORTH 00°53'25" WEST A DISTANCE OF 244.66 FEET TO THE **POINT OF BEGINNING..**

SAID DESCRIBED PARCEL OF LAND CONTAINS A TOTAL OF 6,544,695 SQ. FT. OR 150.246 ACRES, MORE OR LESS AND IS SUBJECT TO ANY EXISTING EASEMENTS AND RIGHTS OF WAY OF RECORD OR AS NOW EXISTING ON SAID DESCRIBED PARCEL OF LAND.

RECLAMATION NOTES:

1. ALL FINAL RECLAIMED RESERVOIR SIDE SLOPES SHALL BE NO STEEPER THAN 3H:1V. 6" OF TOPSOIL WILL BE PLACED ON ALL SLOPES ABOVE THE ASSUMED HIGH-WATER LINE. RE-VEGETATION SHALL USE SEED MIXES LISTED IN TABLE BELOW, OR SIMILAR ALTERNATE MIX BASED ON COMMERCIAL AVAILABILITY AT THE TIME OF RECLAMATION. ALL SUBSTITUTIONS WILL DETERMINED IN CONSULTATION WITH QUALIFIED EXPERTS, AND APPROPRIATE TO THE REGION AND SOIL REGIME.
2. HIGH WATER LINE IS APPROXIMATE BASED ON AN ASSUMED 1' FREEBOARD.
3. SEEDING WILL BE DONE DURING THE FIRST FAVORABLE SEEDING SEASON FOLLOWING TOPSOIL PLACEMENT. IT IS ANTICIPATED THAT SEEDING WILL BE DONE BETWEEN SEPTEMBER AND APRIL, UNLESS WEATHER CONDITIONS REQUIRE SEEDING OUTSIDE THESE MONTHS.
4. GRASSES ARE TO BE ESTABLISHED ABOVE THE HIGH-WATER LINE ON RESERVOIR SIDESLOPES. NEW SEEDS PLANTED INTO A COVER CROP, OR CERTIFIED WEED-FREE STRAW CRIMPED INTO TOPSOIL.

SEED MIX AND SEED MIX NOTES:

COMMON NAME	SCIENTIFIC NAME	VARIETY	% OF MIX	PLS APPLICATION RATE (LBS/AC)
WESTERN WHEATGRASS	AGROPYRON SMITHII	ARRIBA	17.0%	1.74
SIDEOATS GRAMA	BOUTELOUA CURTIPENDIA	BUTTE	17.5%	1.80
MOUNTAIN BROME	BROMUS MARGINATUS	BROME	17.0%	1.74
PRAIRIE SANDREED	CALAMOVILFA LONGIFOLIA	GOSHEN	1.0%	0.48
SWITCHGRASS	PANICUM VIRGATUM	PATHFINDER	7.0%	0.67
ALKALI SACATON	SPOROBOLUS AIROIDES		1.0%	0.10
NEEDLE AND THREAD	STIPA COMATA		13.0%	1.29
NORTHERN SWEETVETCH	HEDYSARUM BOREALE	TIMP.	10.0%	1.02
ROCKY MOUNTAIN RENSTEMON	PENSTEMON STRICTUS	BANDERA	5.0%	0.46
SCARLET GLOBEMALLOW	SPHAERALCEA COCCINEA	ARS2936	3.0%	0.26
PRAIRIE WILDROSE	ROSA ARKANSANA		8.5%	0.87
TOTAL LBS/AC			100%	10.43

CERTIFICATION

THIS MAP WAS PREPARED BY TETRA TECH IN COOPERATION WITH MARTIN MARIETTA MATERIALS. MARTIN MARIETTA MATERIALS WILL KEEP THE DIVISION OF RECLAMATION, MINING AND SAFETY INFORMED OF ANY CHANGES TOT HE MINING OR RECLAMATION PLANS THROUGH ANNUAL REPORTS AND FILE TECHNICAL REVISIONS OR AMENDMENT APPLICATIONS AS NECESSARY THROUGHOUT THE LIFE OF THE MINE.

Pamela Franch Hora
3/2023

PAMELA FRANCH HORA, AICP
DATE

SHEET INDEX:

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Phone: (303) 772-5282

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MARTIN MARIETTA MATERIALS

WINDSOR EAST PERMITTING
WELD COUNTY, COLORADO

EXHIBIT F
COVER SHEET &
RECLAMATION NOTES

PROJ: 117-8741006
DESN: GH
DRWN: LAW
CHKD: PFH

F-1

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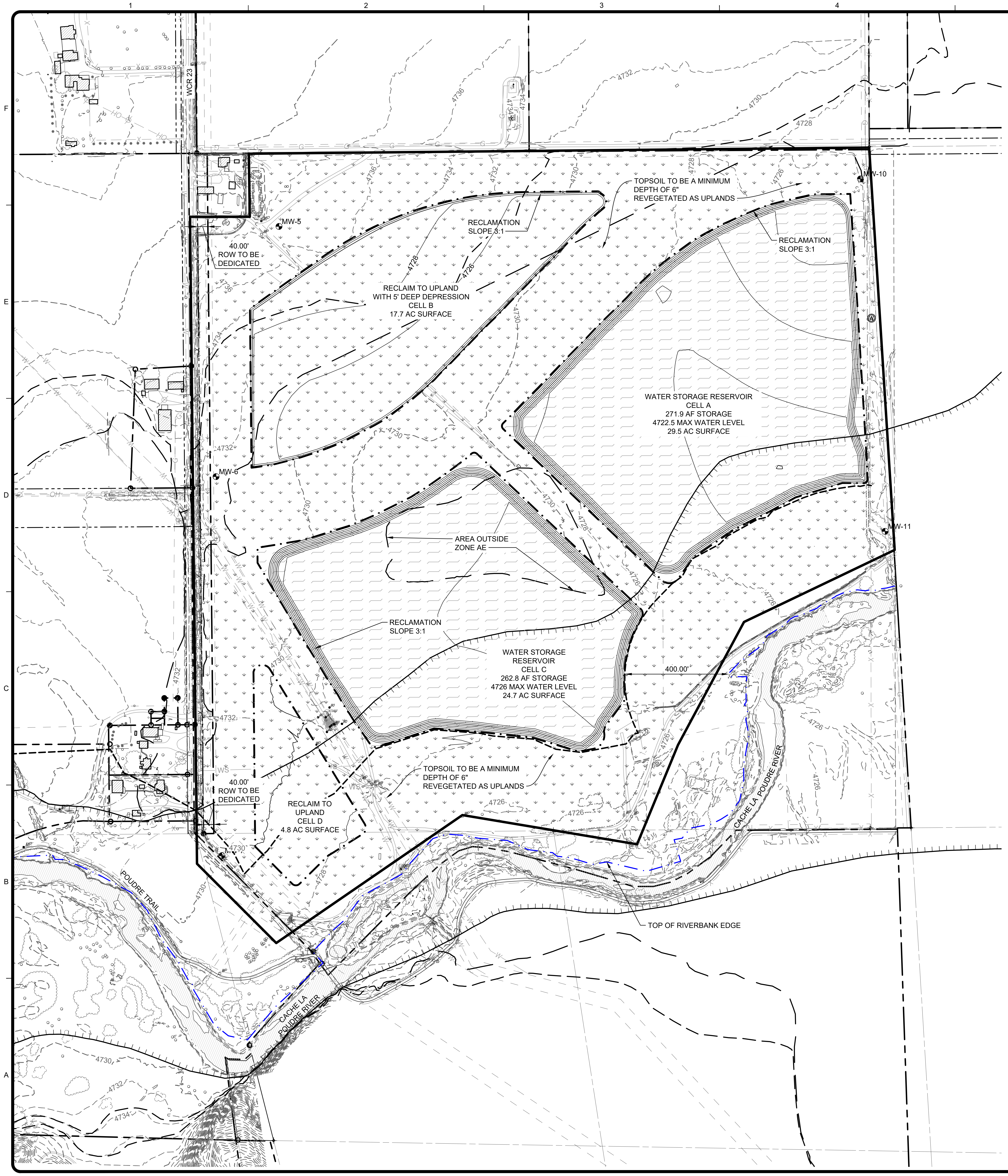

LEGEND

▬ · ▬	PERMIT & AFFECTED AREA BOUNDARY
— · —	LIMIT OF RECLAMATION
— —	PROPERTY BOUNDARY
— · · —	ROW LINE
— —	SECTION LINE
— —	EASEMENT LINE
— —	EXISTING MAJOR CONTOUR
— —	EXISTING MINOR CONTOUR
—	EXISTING ROAD EDGE
— · —	RIVERBANK
— —	400' OFFSET FROM RIVERBANK
—	EXISTING WETLAND BOUNDARY
┬┬┬	EFFECTIVE ZONE FLOODWAY
— —	EFFECTIVE ZONE AE
— —	EFFECTIVE ZONE X
· · ·	EXISTING EDGE OF WATER
~~	EXISTING BRUSH LINE
—X—	EXISTING FENCE LINE
— · —	EXISTING SWALE
—OH—	OVERHEAD ELECTRIC
—E—	UNDERGROUND ELECTRIC
—T—	TELEPHONE
—G—	GAS LINE
—W—	WATER LINE
—FM—	SANITARY SEWER FORCE MAIN
— —	SANITARY SEWER GRAVITY MAIN
—	STORM SEWER
—IRR—	IRRIGATION
—	MISCELLANEOUS PIPELINE
✦ ● S1	SECTION CORNER/ PROPERTY MONUMENTS
Ⓦ	MONITORING WELL
Ⓦ WV	WATER MANHOLE AND VALVE
⌀	UTILITY POLE
⊠ TELPED	TELEPHONE PEDESTAL
Ⓢ	SANITARY MANHOLE
Ⓢ	STORM MANHOLE
◁	FLARED END SECTION
▭	EXISTING HOUSE
■ MP ▫ WP	EXISTING METAL/ WOOD POST
● ○	EXISTING TREES
▭	RECLAIM AS UPLANDS
▨	WATER STORAGE RESERVOIR
● MW-10	MONITORING WELL LOCATION

N

0 100' 200' 400'
SCALE: 1" = 200'

CERTIFICATION

THIS MAP WAS PREPARED BY TETRA TECH IN COOPERATION WITH MARTIN MARIETTA MATERIALS. MARTIN MARIETTA MATERIALS WILL KEEP THE DIVISION OF RECLAMATION, MINING AND SAFETY INFORMED OF ANY CHANGES TOT HE MINING OR RECLAMATION PLANS THROUGH ANNUAL REPORTS AND FILE TECHNICAL REVISIONS OR AMENDMENT APPLICATIONS AS NECESSARY THROUGHOUT THE LIFE OF THE MINE.

Pamela Franch Hora 3/2023

PAMELA FRANCH HORA, AICP DATE

Bar Measures 1 inch, otherwise drawing not to scale

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MARK	DATE	DESCRIPTION	BY
1	9/22/22	INITIAL SUBMITTAL	
2	3/2023	REVISED PER WINDSOR AND DRMS FEEDBACK	

MARTIN MARIETTA MATERIALS

WINDSOR EAST PERMITTING
WELD COUNTY, COLORADO

EXHIBIT F
RECLAMATION PLAN
EAST SIDE

PROJ:	117-8741006
DESN:	GH
DRWN:	LAW
CHKD:	PFH

F-2

3/2/2023 3:12:58 PM - C:\USERS\LAURA.WEATHERL\ACCDOCS\TETRA TECH INC\117-8741006_WINDSOREASTMINE\PROJECT FILES\CAD\SHEETFILES\F-2 RECLAMATION PLAN EAST SIDE.DWG - WEATHERL, LAURA

EXHIBIT G: WATER INFORMATION

1.0 INTRODUCTION AND BACKGROUND

This Exhibit addresses the hydrologic conditions at the Windsor East Mine located in Section 36, Township 6 North, Range 67 West of the 6th Principal Meridian, Town of Windsor, Colorado (See Figure G-1), The Exhibit documents the depth and direction of groundwater flow, the nature of the subsurface geologic materials through which it flows (Figure G-2), any interactions with streams, lakes, canals or other surface water bodies in the area and the potential impacts to surrounding water users due to mining impacts.

The information in this Section is intended to satisfy the requirements outlined in Sections 3.1.6, 6.3.3, 6.3.4, and 6.4.7 of the Colorado Mined Land Reclamation Board's Construction Material Rules and Regulations.

Section 3.1.6

(1) Hydrology and Water Quality: Disturbances to the prevailing hydrologic balance of the affected land and of the surrounding area and to the quantity or quality of water in surface and groundwater systems both during and after the mining operation and during reclamation shall be minimized by measures, including, but not limited to:

> *(a) compliance with applicable Colorado water laws and regulations governing injury to existing water rights;*
>
> *(b) compliance with applicable federal and Colorado water quality laws and regulations, including statewide water quality standards and site-specific classifications and standards adopted by the Water Quality Control Commission;*
>
> *(c) compliance with applicable federal and Colorado dredge and fill requirements; and*
>
> *(d) removing temporary or large siltation structures from drainage ways after disturbed areas are revegetated and stabilized, if required by the Reclamation Plan.*

Section 6.4.7

(1) If the operation is not expected to directly affect surface or groundwater systems, a statement of that expectation shall be submitted.

This site is directly adjacent to the Cache la Poudre River. The Cache la Poudre River will be utilized for the discharge of dewatering water from each of the proposed mine cells. The presence of the river has the collateral benefit of mitigating groundwater drawdowns and associated impacts to wells east of the Site.

(2) If the operation is expected to directly affect surface or groundwater systems, the Operator/Applicant shall:

> *(a) Locate on the map (in Exhibit C) tributary water courses, wells, springs, stock water ponds, reservoirs, and ditches on the affected land and on adjacent lands where such structures may be affected by the proposed mining operations.*

Please see Exhibit C Pre-Mining Maps for the location of all tributary water courses, wells, springs, stock water ponds, reservoirs, and ditches on the affected land and on adjacent lands where such structures may be affected by the proposed mining operations.

> *(b) Identify all known aquifers*

The Windsor East site is underlain by two aquifers:

- The valley-fill deposits of the Lower Cache la Poudre River.
    - described in: Hershey, L.A. and PA. Schneider, 1972. "Geologic Map of the Lower Cache la Poudre River Basin, North-Central Colorado", USGS Miscellaneous Geologic Investigations Map I-687. (See Figure G-2)
- The Fox Hills Sandstone
    - described in: Robson, S.G. 1989, "Alluvial and Bedrock Aquifers of the Denver basin – Eastern Colorado's Dual Ground-Water Resource", USGS Water-Supply Paper 2302

(c) Submit a brief statement or plan showing how water from de-watering operations or from runoff from disturbed areas, piled material and operating surfaces will be managed to protect against pollution of either surface or groundwater (and, where applicable, control pollution in a manner that is consistent with water quality discharge permits), both during and after the operation.

The geologic conceptual model of the subsurface and groundwater was developed from the geologic map for the area and the boring logs associated with the installation of the monitoring well network at the Windsor East site and the Parsons Mine site located to the east (Figure G-3). Based on water levels measured in these wells, a groundwater level elevation map was developed (Figure G-5). Following removal and stockpiling of topsoil, each of the four cells will be dewatered and mined. Sand and gravel will be extracted using the "dry" mining method in which the water table is lowered to allow mining to be performed under drained conditions. To lower the water table, local dewatering is conducted using a perimeter drain constructed around each planned mining cell.

The dewatering system would discharge to the Cache la Poudre River. Dewatering of the mine would lower the groundwater levels to a limited extent in the surrounding alluvial aquifer and will not impact the underlying Fox Hills Sandstone aquifer. Effects on groundwater levels are projected to be limited in extent due to natural and manmade hydrologic and hydrogeologic characteristics and boundaries, principally including the transmissive nature of the alluvial aquifer, the Cache la Poudre River, and the mining operation. Figure G-6 illustrates the resulting changes to groundwater flow directions during mining and after reclamation.

The available gravel resource is anticipated to be mined for approximately 6 years; however, the rate of mining and overall life of the mine is dependent upon demand and market conditions. All material mined at Windsor East will be conveyed to Martin Marietta's adjacent Parsons Mine site for processing at the existing plant on that site.

Upon completion of mining, the reclamation plan for the mine includes the placement of compacted clay embankment liners in Mining cells A and C, while cells B and D will be backfilled with non-economic grade alluvium including topsoil, sands, and fine gravel. These cells will thereby be converted to sealed water storage reservoirs, which will be owned and used by GWIP, LLC, the landowner of the Windsor East Mine site.

Exhibit D: Pre-Mining and Mining Plan shows the location of the Affected Area and proposed mining cells. Changes to the hydrologic balance within the Affected Area will be limited to the localized dewatering associated with the excavation of the mine cells, and the minor alteration of the existing groundwater flow patterns due to the subsequent installation of compacted clay embankment liners during reclamation. Figures G-5 and G-6 show the mine cells and conceptual groundwater flows before and after the installation of the compacted clay liners.

1.1 HISTORIC USE

The Windsor East property has historically been used for agriculture. The adjacent neighbors include Martin Marietta's Parsons Mine site to the east, agricultural land with a few residences to the north and west, and the Cache la Poudre River to the south.

Based on well registration, land use besides agriculture within two miles of the site has included Eastman Kodak to the west and northwest, Front Range Energy to the northwest of the site, Joseph Energy to the northwest of the site, and Hensel Phelps Construction to the northwest of the site.

1.2 HYDROGEOLOGIC SETTING

1.2.1 Geology

The geology mapped at land surface beneath the site consists of quaternary age valley-fill deposits comprised of sand, silt, and gravel primarily (Figure G-2). The areas of higher elevation around the site are typically comprised of quaternary terrace deposits. Boring logs from installation of monitoring wells immediately east of the property were reviewed for details on the site geology. The Parsons sand and gravel mine has 12 monitoring wells on the property, including MW-12 which is the nearest to the Windsor East property, located between the Parsons property and the Windsor East property (Figure G-3). The boring logs generally indicate that the geology consists of a 10-30 ft thick layer of unconsolidated alluvial sediments overlying siltstone bedrock. The upper 4-14 feet of the alluvial sediments are typically finer-grained silts and clays and may be only partially saturated in many locations. The lower 4-20 feet of the alluvium consists of sands and gravels which are expected to be highly transmissive of shallow groundwater.

The shallow bedrock of the Fox Hills Sandstone consists of weathered, consolidated sedimentary rock varying from claystone to siltstone as observed in the boreholes advanced on the Parsons mine property to the east. In comparison to the alluvium, the weathered bedrock is expected to be several orders of magnitude less transmissive due to the consolidated, finer-grained properties. Bedrock was encountered in the boreholes advanced at the Windsor East mine property between 15 and 22 ft below ground surface (bgs), and 13ft bgs in the nearest Parsons Mine borehole (Parson MW-12).

1.2.2 Groundwater

Groundwater at the site represents a combination of water that flows through the high-permeability valley-fill alluvial deposits parallel to the Cache la Poudre River and water that infiltrates in the surrounding higher-elevation recharge areas to the north and south of the river, typically associated with the agricultural fields that dominate the land use of the area. Infiltrating water in these areas of higher elevation drains at the lower-lying erosional valleys formed by streams and rivers of the area, resulting in flow patterns that resemble a muted form of the land surface topography. The erosional valleys are typically underlain by the higher-permeability sands and gravels deposited by historic flood events and form channeled zones through which groundwater can flow more rapidly. South of the Windsor East property, the Cache la Poudre River is the surface-water feature for local groundwater discharge. Within several hundred feet of the river, groundwater flows in a direction that is near parallel to the river due to the constant interaction with the river stage within the porous sands and gravels. As a result, while groundwater beneath the site is typically slightly higher than that of the river and flows toward the river, the flow direction of groundwater flow is generally parallel to the Cache la Poudre River from west to east, at close proximity (Figure G-5). Some minor component of upward groundwater flow from the deeper bedrock may occur, but this is likely to be negligible compared to the influence of the river and the underflow within the valley-fill alluvium.

The direction of regional shallow groundwater flow is therefore toward the southeast but changing to a near easterly direction near the river. Based on water-level measurements in the monitoring wells installed at the Windsor East mine property, the water table is approximately 8-11 feet below land surface.

1.3 EXISTING AND PLANNED WELLS

1.3.1 Existing Monitoring Wells

A network of monitoring wells was installed in 2010 to characterize the groundwater conditions at the Parsons mine east of the Windsor East property (Figure G-3). The boreholes for the wells were drilled to the bedrock contact and the wells were constructed using 8-10 foot screened intervals between the water table and the bedrock contact. These wells generally show the direction of groundwater flow in an easterly direction, in equilibrium with the river water elevations, although subject to the influence of the Parsons mine cell dewatering.

1.3.2 Well Inventory

In May 2022, a well inventory of the Affected Area and adjacent areas was conducted to identify wells near the project. The inventory included a search of the State of Colorado Office of the State Engineer database of wells located within ½ mile of the Affected Area (Table 1). The well inventory identified 25 constructed wells within ½ mile of the Affected Area. Figure G-4 enclosed shows the Affected Area and the constructed well locations on file with the Colorado Division of Water Resources.

Wells located within 600 feet of the Lease Boundary

The well inventory identified two wells completed in the alluvial aquifer within 600 feet of the lease-area boundary. The first is a monitoring well (Parsons MW-12) owned by Martin Marietta (permit # 280593) associated with the Parsons mine immediately to the east of the Windsor East property. Bedrock was encountered at 13 ft bgs and water was observed at approximately 6-8 ft bgs. The second is a monitoring well owned by Hall-Irwin Corporation (permit # 277000). It was constructed in 2007 and was screened from 4 to 15 ft bgs. Bedrock was encountered at 13 ft bgs and water was observed at approximately 2 ft bgs in 2007. Monitoring holes and wells are not a concern for dewatering impacts because neither are allowed to serve as pumped sources of water.

Water supply wells located within ½ mile of the Lease Boundary

In addition to the wells identified within 600 feet of the lease boundary, the well inventory identified two residential wells, eight monitoring/observation wells, three monitoring holes, and one general purpose well completed in the alluvial aquifer within ½ mile of the lease-area boundary. Appendix G-5 provides a letter from GWIP LLC regarding the status of wells 89706-A, 113762—A, and 1472-R-R.

<u>Permit number 89706-A</u>

Domestic/Residential well (89706-A) is registered to Brett T and Mary K Lauer. It was constructed in 1977 to a depth of 32 feet. It is located slightly more than 600 feet distance from the lease boundary on the northwest corner, and approximately 1,060 feet northwest from the nearest planned mining cell. The well is 5-inch diameter PVC, screened from 17 to 32 ft bgs, and was equipped with a pump capable of 30 gpm. The driller's log indicates that water was encountered at 12 feet bgs in 1977. A 6-hr pumping test conducted in 1977 resulted in sustained pumping of 20 gpm and a pumping water level of 27 ft bgs (15 feet of drawdown, a specific capacity of 1.33 gpm/ft). Bedrock was observed at 27 ft bgs. The parcel that this well sits on is owned by GWIP LLC, the property owner for this reclamation permit application.

<u>Permit number 113762--A</u>

Domestic well (113762--A) is registered to M WaterCo LLC, although originally to Harold Long and Sons. It was constructed in 1980 to a depth of 25 feet. Water was noted at 12 ft bgs and bedrock was encountered at 20 ft bgs. A sustained pumping test of 30 gpm for 2 hours was conducted in 1980 with no recorded drawdown. It is located 1500 to 2000 feet distance from the lease boundary on the north side. A registered domestic well with a similar permit number (113762-) is associated with Harold Long and Sons Inc. The date of construction was not recorded, but the well inventory indicates that it was drilled to a depth of 30 feet, encountering bedrock at 20 ft bgs. This well shares nearly identical location and construction information (and permit number) with the well registered to M WaterCo LLC and seems to be the same well. The parcel that this well sits on is owned by GWIP LLC, the property owner for this reclamation permit application.

<u>Permit number 1472-R-R</u>

General Purpose well (1472-R-R) is registered to West Weld Ag Investors. This well was originally drilled for Allen Lamb with permit number 1472 before 1957 and listed as an irrigation well. It was replaced by well 1472-R at an unknown date to a depth of 15 ft bgs, with a 40 ft by 60 ft sump from which water was pumped at approximately 500 gpm. A permit application was received in 1981 to replace well 1472-R with a new irrigation well by West Weld Ag Investors with a proposed maximum pumping rate of 500 gpm and a planned depth of 50 ft. The registered UTM coordinates for the well indicate that it is located several hundred feet south of the Cache la Poudre river, but the description in the permit indicates that it is located 3,300 ft south of the northern edge of section 35 and 1,300 ft west of the eastern edge of section 35, and therefore may actually be located just north of the river near UTM 512260 E, 4476810 N. This location is approximately 1,200-1,300 ft west of the southwestern corner of the lease boundary, and approximately 1,500 ft from the nearest planned mining cell. A loop of the Cache la Poudre River extends between the lease area and the likely location for the well. Based on both a field and records investigation, the well listed at 1472-R-R is believed to have been located near the irrigation center pivot, and abandoned at some time in the past. The parcel that this well sits on is owned by GWIP LLC, the property owner for this reclamation permit application.

Monitoring Wells on the Adjacent Parsons Mine Property

Monitoring wells installed as part of the Parsons Mine operations were considered as part of this permit application. Twelve of the fourteen wells were installed in 2010 and the other two were installed more recently. Table 2 includes construction details and depth-to-water information. Measuring point elevations were surveyed on December 15, 2022, to the nearest 0.01 ft elevation. Appendix G-2 provides water levels measured over time for the Parsons Mine monitoring wells.

1.3.3 Site Monitoring Wells

Martin Marietta installed five monitoring wells (Figure G-3) in August 2022 to support the monitoring plan associated with the project, documenting the groundwater conditions before initiation of mining, during mining, and after mining is complete. Through the well monitoring program, the wells will serve as points at which water levels will be measured and water quality samples collected. The boreholes for each of the wells were advanced until bedrock was encountered. Lithologic logs documenting the valley-fill sediments observed and the bedrock during drilling were recorded. The monitoring wells were constructed of two-inch Schedule 40 PVC casing and screen. Silica sand was placed from approximately two feet above the top of the screen to the bottom of the borehole (bedrock). Above the silica sand, a bentonite seal was placed in the borehole annulus to restrict infiltration of surface water. Each of the monitoring wells was finished at the surface with a locking, aboveground, steel protective casing set in concrete. Table 3 provides additional details on the monitoring well installations. Appendix G-1 presents borehole logs and well completion details for the monitoring wells.

1.4 HISTORIC AND FUTURE GROUNDWATER LEVELS

Monitoring wells established at the Windsor East site in August 2022 were used to collect groundwater elevation data. This set of water level data was supplemented by water level data collected from monitoring wells on the adjacent Parsons Mine site located east of the Windsor East property. Water level data measured for the wells are included in Tables 2 and 3. Depth to water at the Windsor East site varies from 7.9 to 10.4 ft below the top of the well casing, corresponding to a range of water level elevation from 4732.14 at MW-06 to 4717.44 at MW-11. Figure G-5 presents the general direction of groundwater flow (southeast).

Since 2010, regular groundwater measurements have been collected from the 14 monitoring wells around Martin Marietta's Parsons Mine site. These wells shall hereafter be referred to as the Parsons Well Network, and are numbered MW-1 through MW-14. Appendix G-2 shows the variation in water level measurements from monitoring wells MW-1 to MW-12. Water levels measured in the Parsons well network vary from 4730 feet at MW-5 to 4690 feet above mean sea level (amsl) at MW-1 where the effects of dewatering are visible in late 2021 through 2022. Water levels are seasonally at their highest elevations in August or September following the irrigation season, and typically at their lowest elevations in February to March when irrigation has been suspended for the longest period of time. The water level at MW-12 before initiation of local dewatering in 2019 ranged from 5.8 to 7.8 ft bgs (4720.5 to 4722 ft amsl), then dropped to an average of 11.3 ft bgs (4716.7 ft amsl), a drawdown of approximately 4.6 ft. This monitoring well is located approximately 100 feet from the dewatering trench of the nearest active mining cell at the Parsons Mine, and the 4.6-foot change in water levels experienced at the Parsons Mine is expected to be representative of the drawdown that will be associated with dewatering of the mining cells at the Windsor East site.

Based on observed water levels at the Windsor East and Parsons sites, dewatering will lower water levels to within 2 feet of the top of bedrock in the immediate vicinity of each mining cell. The lowered groundwater effects will be transmitted horizontally by the gravel aquifer, reducing water levels in the surrounding area as a "cone of depression" forms around the mining cell. During mining, water in the area will flow radially toward the dewatered cells, where it will be removed using the dewatering trench drainage system and discharged into the river.

Following mining, each cell will be lined to form a hydraulically isolated reservoir. The effect of the clay liner on the groundwater within the aquifer will be the formation of a hydraulic mound upgradient of the cell where water levels will be several feet higher than under pre-mining conditions. Downgradient of the cell, the groundwater levels will be several feet lower due to a "shadow effect" behind the reservoir. These changes in groundwater levels due to the clay-lined cells are expected to have minimal effect on the groundwater in the surrounding area due to the proximity of the river adjacent to and downgradient of the lined cells. Downgradient of the lined cells, groundwater levels will reach an equilibrium with the river due to its proximity, thereby minimizing the "shadow effect".

1.5 AVAILABLE SATURATED THICKNESS

The drilling and installation of monitoring wells at the Windsor East site in August 2022 indicated that bedrock was encountered between 15 and 22.5 feet below land surface. Water levels measured on August 12, 2022, ranged from 7.9 to 10.4 feet bgs. Based on this data, the saturated thickness of aquifer present beneath the site ranges from approximately 5 to 13.5 ft (Table 3). The lowest saturated thickness was recorded in MW-11 on the eastern side of the site, which is likely showing the direct impact of dewatering activities associated with the adjacent Parsons mine.

Dewatering activities required as part of mining in the absence of a hydraulic barrier wall result in drawdown of the water table and associated decrease in saturated thickness of the alluvium. This has the potential to impact other wells nearby if the decline in water levels is sufficient to prohibit the well owner from extracting the associated water rights from the well.

Table 4 presents historic information about the variability in saturated thickness near the site and the impact from mining based on available data. Four of the monitoring wells that were installed at the Parsons Mine Site to observe water levels at the Parsons Mine site, provide evidence of the saturated thickness of alluvium nearest to the Windsor East property. Water levels measured during pre-mining and mining conditions illustrate the expected decline in saturated thickness at a distance of approximately 100 feet from the gravel mines. In particular, the Parsons Mine monitoring well MW-12 is located approximately 100 feet west of a cell that began dewatering and mining in 2019. The water level record for the well shows the range of saturated thickness for the alluvium before and during dewatering activities at this distance. MW-12 is located on the eastern edge of the Windsor East property and is therefore expected to be representative of the conditions at the site as well as of the expected impacts from dewatering during mining near the property boundary.

Before 2019, the water table was an average of 6.3 feet above the top of the bedrock at MW-12 and fluctuated over a range of approximately 1 foot above or below this average. During dewatering, the depth to water increased, and the saturated thickness decreased until it was an average of 1.7 feet above the top of the bedrock, with a variation range of approximately 1 to 1.5 feet.

Water wells completed in sand and gravel aquifers typically provide approximately 25 to 30 gallons per minute per foot of drawdown of saturated thickness in the well. Domestic wells are typically permitted for maximum pumping rates of 15 gallons per minute (gpm). As a result, less than 2 feet of saturated thickness above the pump intake is therefore likely to be required to provide the allowed pumping rates of 15 gpm. The reduction of saturated thickness of 4.6 ft at MW-12 to 1.7 ft above bedrock suggests that the potential for impact to a domestic well at this distance is likely, however, wells located further from the lease boundary will have more saturated thickness and hence will likely be able to pump the permitted rates.

1.6 HYDRAULIC IMPACTS

The hydraulic impacts associated with dewatering around the planned mine cells are expected to spread outward as a function of the aquifer properties of the alluvium, the time elapsed since dewatering began, and the distance of observation from the point of dewatering. The previous observations of the depressed water table (drawdown) due to mining at the adjacent Parsons mine (noted in the previous section) are useful for predicting the impact of the Windsor East mine. In particular, the observations at Parsons well MW-12 (located directly between a dewatered cell and the Windsor East site) represent an ideal location from which the effects of dewatering in the vicinity can be observed. As noted in Table 4, the result of dewatering at MW-12, located at a distance of approximately 100 ft from the nearest cell, resulted in drawdown of 4.6 ft. This response occurred over two years, since dewatering was variable depending on mining rates.

A water resources investigation (WRI) study performed by the United States Geological Survey (USGS) (Langer and Paschke, WRI 02-4267, 2002), explored the simulated spread of hydraulic impacts in a hypothetical situation involving the excavation of surface alluvium to bedrock (similar to most of the sand and gravel mine operations along the Front Range river corridors). Appendix G-4 shares this USGS WRI report. The study used analytical and numerical modeling of a pit near a river in a highly permeable unconfined aquifer. This study illustrated that in a hypothetical sand and gravel pit in an aquifer adjacent to a river, a numerical simulation of steady-state drawdown does not result in drawdown exceeding approximately 1 foot at a roughly 0.5-mile distance from the hypothetical pit.

There are no registered wells owned by parties other than Great Western or Martin Marietta within 0.5 miles of the Windsor East Mine property. As a result, there are no parties that are expected to be impacted as a result of either dewatering operations or subsequent development of lined ponds at the Windsor East Mine site. Therefore, detailed localized numerical modeling of hydraulic impacts has not been conducted.Additionally, there are likely mitigating factors to drawdown spread caused by dewatering. Active dewatering may stop and start at a location depending on the mining progress, the proximity of the Cache la Poudre River will provide a constant source of water mitigating drawdown impacts, and the aquifer may prove more or less transmissive depending on the location. With this understanding, the modeled spread of the hydraulic effects of dewatering suggests that the impact of the lowering of the water table during mining is unlikely to substantially affect any nearby water wells.

1.7 WATER USE

Section 6.4.7 of the Colorado Mined Land Reclamation Board's Construction Material Rules and Regulations*:*

(3) The Operator/Applicant shall provide an estimate of the project water requirements including flow rates and annual volumes for the development, mining and reclamation phases of the project.

(*4) The Operator/Applicant shall indicate the projected amount from each of the sources of water to supply the project water requirements for the mining operation and reclamation.*

Water use will be at its highest during the mining phase of the project. Mining at the site will intercept groundwater tributary to the Cache la Poudre River. Consumptive uses of groundwater at the site include evaporation from groundwater exposed to the atmosphere, water retained in material hauled off-site for processing, and water used for dust control.

Evaporative losses at the site are attributable to exposed groundwater in the dewatering trenches for each mine cell. Evaporative losses were calculated as the difference between gross evaporation and effective precipitation. The NOAA Technical Report NWS 33, Evaporation Atlas for the Contiguous 48 United States (U.S. Department of Commerce) was used to determine the site's average annual gross evaporation of 43 inches. Precipitation was obtained from the Western Regional Climate Center for the Fort Collins weather station (053005). The gross annual precipitation for this site was determined to be 15.08 inches. Effective precipitation was calculated as 70 percent of gross precipitation; thus, the average annual effective precipitation was determined to be 10.56 inches. The resulting evaporative loss rate is therefore 27.92 inches. The maximum total annual evaporative consumptive use at the site is estimated at 12-17 acre-feet, which is primarily a function of the water used for dust control (10-15 ac-ft/yr).

2.0 MONITORING AND MITIGATION PLAN

This Groundwater Monitoring and Mitigation Plan is prepared as part of Martin Marietta's application to the Colorado Division of Reclamation, Mining and Safety (DRMS) for a permit for the Windsor East Mine in Weld County, Colorado. This plan presents the methods and locations for monitoring of groundwater during gravel mining and site reclamation activities. Although adverse impacts to other local users of groundwater are not expected as a result of activities at the mine, this plan addresses how any adverse effects to groundwater would be mitigated, should they occur.

Martin Marietta will submit a Temporary Substitute Water Supply Plan to the State Engineer's Office for approval. The temporary substitute supply plan is designed to protect senior vested water rights and mitigate potential depletions of flows in adjacent waterways.

2.1 MINING PLAN

Except for Cell A, the mining plan has been designed to allow for up to five quarters worth of groundwater monitoring to occur before excavation below the water table occurs. This monitoring includes monthly water level measurements in the five monitoring wells at the Windsor East Mine site, and five quarterly water-quality sample collection events. To allow for sufficient time for groundwater characterization to occur, mining is only planned to occur in the unsaturated zone until one year's worth of monitoring and groundwater sample collection has been conducted. An exception will be made with regard to mine Cell A. This cell is the easternmost cell in the mining plan and is located within several hundred feet of the Parsons mine. As a result, water levels are already lowered in the area from Parsons dewatering. Since changes to the groundwater flow regime have already been substantially implemented, trenching and mining below the water table at Cell A with associated dewatering will begin before the five quarters of monitoring are complete. Based on the current mining schedule, mining will expose the water table after three quarters of monitoring has taken place. Following the five quarters of monitoring, dewatering trenches will be excavated around the perimeter of each remaining mine cell on a schedule determined by the mining plan.

Dewatering will occur initially adjacent to the area on the east where dewatering associated with Parsons mine has already reduced water levels (Cell A). The bottom of the trench will be maintained at or deeper than the deepest point in the excavated mine cell, thereby intercepting all groundwater before it reaches the mine cell. After collection of five quarters of groundwater monitoring, mining will gradually progress westward, with perimeter dewatering drains preceding excavation below the water table. Groundwater flow into each dewatering trench will be accumulated in connected sumps and discharged directly into the Cache la Poudre River.

Following completion of mining activities, mine cells A and C will be finished with a compacted embankment liner from material located on-site, keyed into the bedrock at the base of the mine cell, thus forming a low-permeability bathtub in the mine cell. Once finished, dewatering of the perimeter trench will cease, and the trench will be backfilled, allowing groundwater to return to a state of natural flow around the now-lined mine cell. It is expected that some minor hydraulic mounding may occur upgradient of the lined mine cell, with some "shadow effect" (decline in groundwater level) downgradient of the mine cell. Since no existing water wells have been identified downgradient between the mine and the river, the shadow effect is not anticipated to impact other users. Figure G-6 depicts the anticipated groundwater flow directions resulting from the installation of the compacted liners during reclamation.

Mine cells B and D will be backfilled with non-economic aggregate. While this material is expected to be finer-grained than the existing subsurface sands and gravels being mined, they are not expected to represent a significant barrier to flow. Some minor hydraulic mounding may occur to the northwest of each of the cells, but the effect is presumed to be localized and limited to less than 2 feet relative to the surrounding water table.

2.2 MONITORING

The monitoring plan will consist of regular data collection from the set of five monitoring wells installed around the perimeter of the Windsor East property (Figure G-3). Data collection activities will include monthly measurement of water levels in wells and quarterly sampling of water quality from wells and surface discharge locations for a minimum of five quarters. Following five quarters of background water quality sample collection and analysis, Martin Marietta will submit a summary of the water quality results to DRMS for review, and a formal request to reduce the analyte list and/or frequency for water quality sample collection, if appropriate.

2.2.1 Water Quality Parameters

Martin Marietta will collect water samples from each of the wells and discharge outflow sites and submit the samples to an analytical laboratory to determine water quality for a set of parameters. As part of this process, notes will be recorded on field forms or in a logbook documenting the activities related to sample collection including date, time, measured water level, pre-sampling well purging details, and sample collection documentation. The DRMS recommends a set of parameters for analysis for aggregate mine permitting. These include a list of dissolved metals, radiological parameters, and miscellaneous parameters which include pH and total dissolved solids (TDS). The nature of activities associated with sand and gravel mining involves excavation of large volumes of aggregate materials using industrial machinery. These activities inherently do not result in the generation or release of coliform bacteria, asbestos, chlorophenol, foaming agents, odor, or phenol compounds. They also do not result in a change in corrosivity of water, or color change. As a result, these parameters which are otherwise a part of the DRMS requirements for water quality analysis are excluded from the list of water quality parameters. Likewise, sand and gravel mining does not lead to the generation or release of gross alpha or beta and photon emitters as part of the operation. Martin Marietta acknowledges the preference on the part of DRMS to have gross alpha radiological analysis performed and will include it in the list, but will exclude beta and photon emitters from analysis. Table 5 presents the complete list of water quality parameters proposed for analysis.

2.2.2 Windsor East Monitoring Wells

The monitoring plan will consist of regular data collection from the five monitoring wells installed around the perimeter of Windsor East (Figure G-3). Monitoring data will be used to identify potential changes in alluvial groundwater flow or elevation associated with mining and reclamation activities. Baseline data collected from the monitoring program will provide a range of relative water levels associated with pre-mining groundwater conditions. Experience at other sand and gravel mine sites in similar geologic settings shows that groundwater levels tend to fluctuate between two to four feet each year; levels are highest in the summer and lowest in the winter and early spring. Martin Marietta will conduct monthly water level monitoring for the five monitoring wells around Windsor East during dewatering and until groundwater levels have recovered once dewatering ends.

Groundwater samples will be collected to document baseline water quality prior to mining, then determine whether any changes have occurred as a result of mining activities. One quarterly water quality sample for laboratory analysis will be collected during each of the five quarters of monitoring to document the baseline water quality around the mine. Based on the historical water level fluctuations observed in the wells associated with the Parsons Mine, the seasonal high and low water levels for groundwater have been evaluated. Water levels are seasonally at their highest elevations in August or September following the irrigation season, and typically at their lowest elevations in February to March when irrigation has been suspended for the longest period of time. During high groundwater levels, the sample is expected to be representative of the groundwater which flows from the agricultural fields toward the river, and during the periods of low groundwater the sample is expected to be representative of alluvial channel water flowing from the west. After five quarters, water quality sample collection will continue to be conducted twice per year while mining, with sample collection timed to be consistent with high and low groundwater levels. The results of water quality sample analysis will be provided to DRMS following the baseline water quality evaluation, and during annual reporting thereafter.

Appendix G-3 includes procedures for collecting water samples. These procedures include a process of pumping to purge standing well water, then using the pump to remove water for sample collection, then placing the water in sample bottles obtained from the analytical laboratory. At the end of purging, the pH of the water will be recorded using a handheld pH meter. Samples for dissolved constituents, primarily inorganics and metals, will first be filtered through a 0.45-micron filter to remove suspended solids. Samples will then be stored on ice in a cooler for transport and submitted for analysis of the constituents listed in Table 5 under chain-of-custody protocols.

If sufficient data is collected during the life of the mining operation, and a demonstration can be made that project impacts to the groundwater system have been minimized, Martin Marietta may request the approval of a Technical Revision to revise the water level monitoring frequency or water quality sample collection frequency at a later date.

2.2.3 Domestic and Irrigation Water Wells

No active water wells (water-supply wells) were present within 600 ft of the lease area.

2.2.4 Dewatering Discharge

Based on data collected from monitoring wells on the adjacent Parsons Mine property, the depth to groundwater fluctuates by two feet depending on the season but averages about 7 feet below ground surface. Due to the absence of large quantities of potential pollutants on site (no on-site processing or concrete or asphalt production), the mining and reclamation operations are not likely to affect groundwater quality on or off the site.

Martin Marietta's Parsons facility complies with applicable requirements in the site CDPS General Permit COG501594 for Discharges Associated with Sand and Gravel Mining and Processing. CDPHE WQCD considers stormwater runoff combined with mine dewatering water to be process water. Current discharges at the Martin Marietta Windsor East Site and Parsons Pit are permitted as process water. As such, process water discharges are subject to the process water provisions in the general permit. Martin Marietta plans to obtain a City of Windsor Grading, Erosion and Sediment Control Plan (GESCP) Permit and comply with applicable requirements as stated in the City of Windsor's Municipal Code/Ordinance Chapter 13, Article, Stormwater Quality.

2.3 MITIGATION

The available monitoring well data will be used to identify changes in alluvial groundwater flow associated with mining and reclamation activities. Baseline data collected from the monitoring program will provide a range of relative water levels associated with pre-mining groundwater conditions. These data will be utilized to evaluate the nature and extent of the change to the prevailing hydrologic balance and if necessary, provide for the development of corrective actions. Well owners in the section below refer specifically to owners of wells from which extracted water is put to beneficial use, such as water wells, irrigation wells, etc. Owners of monitoring wells are not considered well owners in this context since a change in water levels for these wells does not represent material damage.

In the event of a well owner complaint, Martin Marietta will commit to reporting any complaints received from well owners to the DRMS within 48 hours, to investigating the complaint as soon as practical, and to submitting the results to the DRMS for evaluation within 30 days.

For the investigation, the first level of response will be to review water level data from the monitoring well network and, if available, a measurement of the water level in the plaintiff's well. The information will be evaluated to determine if there is a reason to believe the plaintiff's complaint may be tied to dewatering or the lined reservoirs. If the data indicates that there is no reason to believe the plaintiff's well was impacted by dewatering or the lined reservoirs, that will conclude the action taken by Martin Marietta. If the data does not clearly show there is no impact, as a second level of response, Martin Marietta will present a contract to the well owner that requests access to the well to perform a mechanical and electrical inspection and testing of the well and associated system, e.g. pressure tank. The agreement will explain that if the problem with the well is not due to a lower water level and is instead due to a mechanical or electrical issue, the well owner will be responsible for the repairs. If the well is determined to be in good working order and the problem is due to a lower water level, then the mining-associated impacts will be addressed to the satisfaction of the DRMS. If the DRMS determines that the impact on a well for which temporary mitigation has been initiated is not a result of Martin Marietta's activities or is not solely a result of Martin Marietta's activities, Martin Marietta will reduce or cease mitigation accordingly.

In the event of a complaint that a well has become unusable, and based on the inspection results as noted above, Martin Marietta will implement mitigation measures within 7 days. Mitigation measures would include providing a temporary alternative water supply that meets the documented historic well production or need until further investigation can be conducted to determine if the well condition is due to the mining operation.

Martin Marietta will begin to implement one or more mitigation measures if mining or reclamation activity is determined to be a significant contributing factor to groundwater changes requiring mitigation.

Temporary mitigation measures may include, but are not limited to:

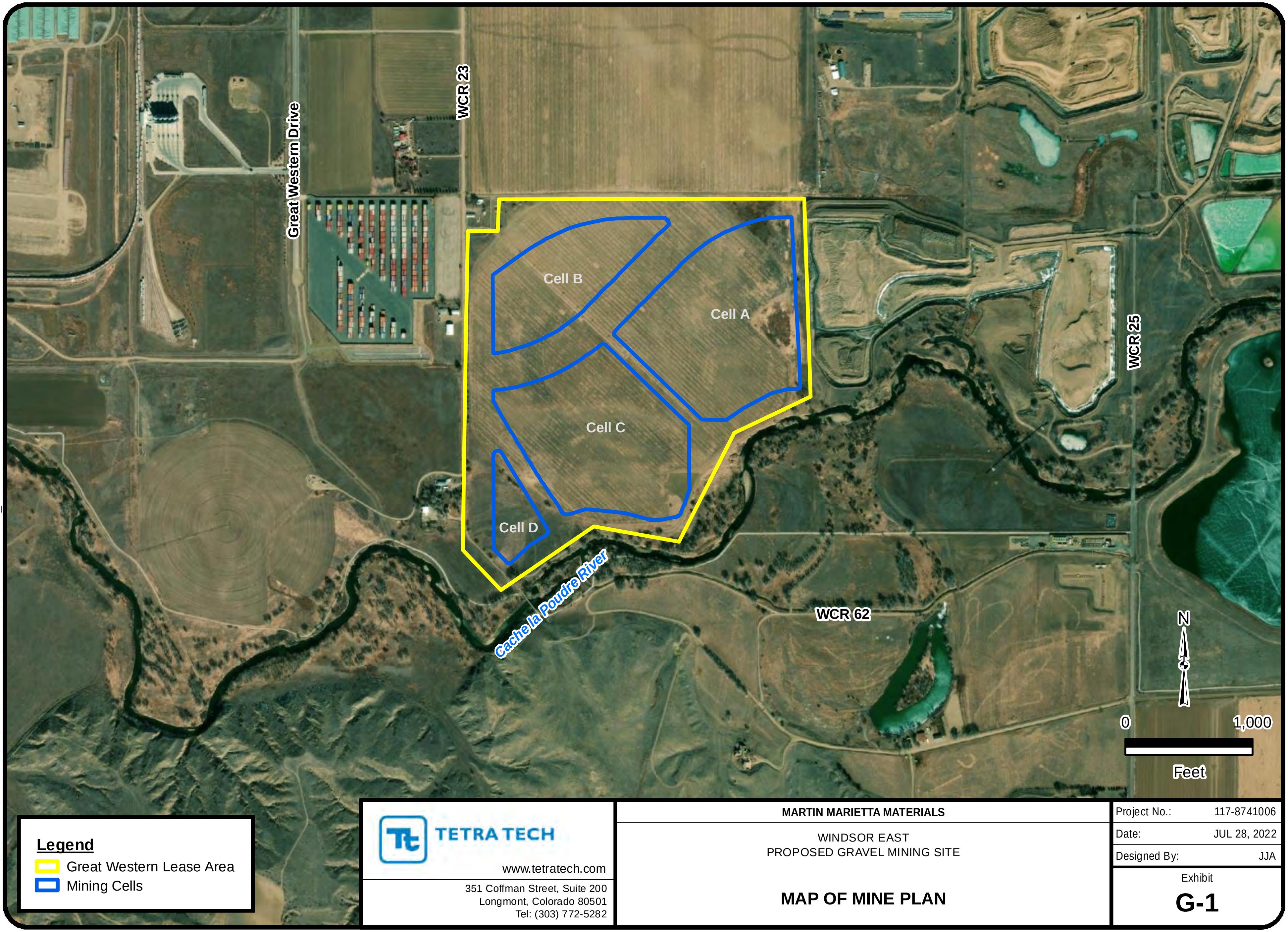
- Compensation for well owners to use their existing treated water system to replace the well production loss;
- Provision of a water tank and delivery water as necessary to meet documented historic well production or need; and
- Other means acceptable to both the well owner and Martin Marietta.

Long-term mitigation measures may include, but are not limited to:

- Cleaning a well to improve efficiency.
- Providing an alternative source of water or purchasing additional water to support historic well use with respect to water quantity and quality. If needed, water quality parameters will be checked in affected wells to ensure alternative sources support the historic use.
- Modifying a well to operate under lower groundwater conditions. This could include deepening existing wells or lowering the pumps. All work would be completed at Martin Marietta's expense except for replacing equipment that was non-functional prior to mining.
- If existing wells cannot be retrofitted or repaired, replace the impacted well with a new replacement well.
- Design and installation of a cistern.

If a groundwater mitigation action is required, Martin Marietta will notify the DRMS of the condition, action taken and report the results and present a plan for monitoring the mitigation.

FIGURES



Legend

🟨 Great Western Lease Area
🟦 Mining Cells

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MARTIN MARIETTA MATERIALS

WINDSOR EAST
PROPOSED GRAVEL MINING SITE

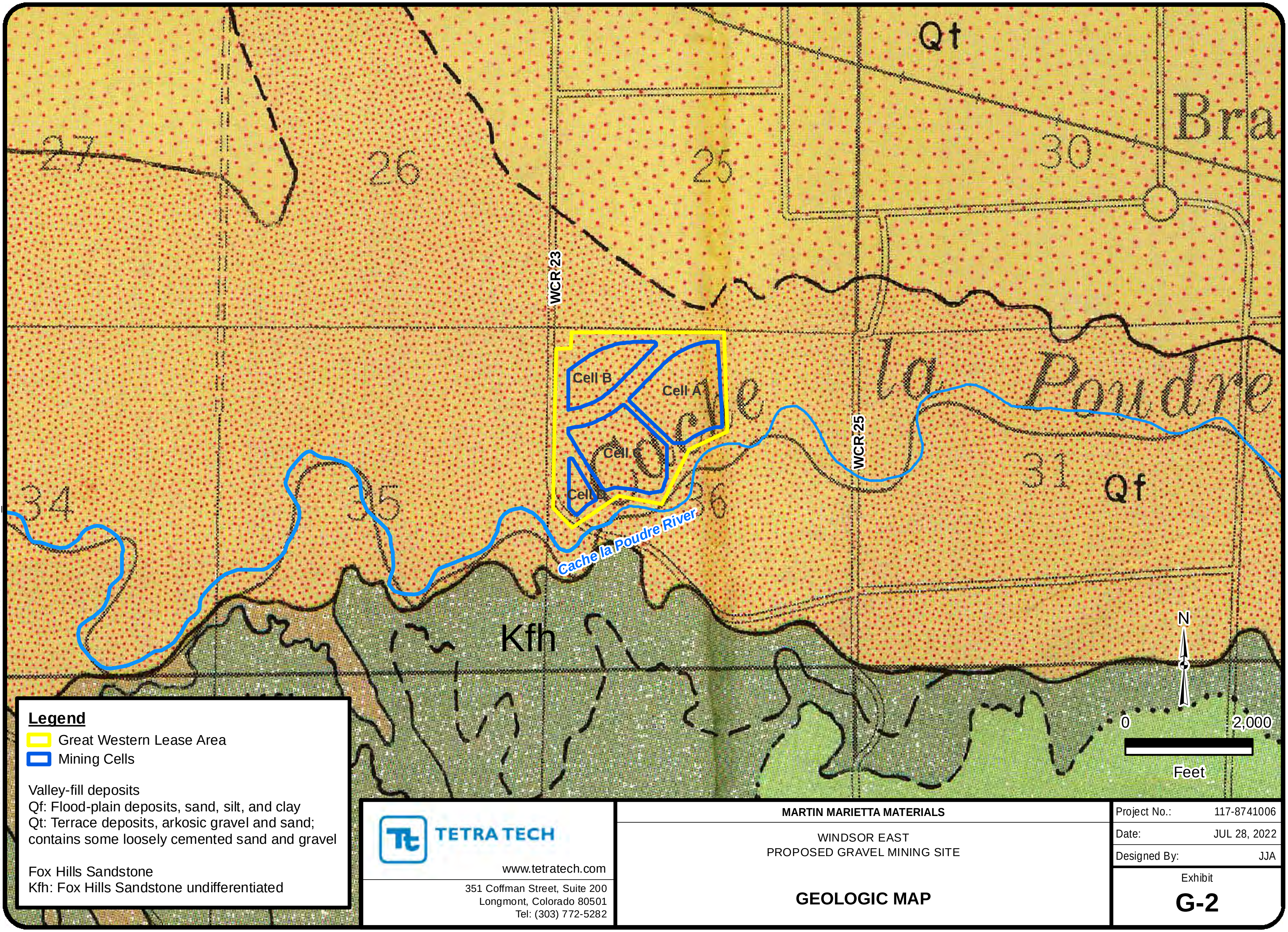
MAP OF MINE PLAN

Project No.:	117-8741006
Date:	JUL 28, 2022
Designed By:	JJA

Exhibit
G-1

7/28/2022 - O:\PROJECTS\LONGMONT\8741\117-8741006\GIS\MXD\EXHG1_MINEPLAN.MXD - JEREMY.ANDRYAUSKAS

7/28/2022 - O:\PROJECTS\LONGMONT\8741\117-8741006\GIS\MXD\EXHG2_GEOLOGICMAP.MXD - JEREMY.ANDRYAUSKAS



Legend

🟨 Great Western Lease Area
🟦 Mining Cells

Valley-fill deposits
Qf: Flood-plain deposits, sand, silt, and clay
Qt: Terrace deposits, arkosic gravel and sand; contains some loosely cemented sand and gravel

Fox Hills Sandstone
Kfh: Fox Hills Sandstone undifferentiated

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MARTIN MARIETTA MATERIALS

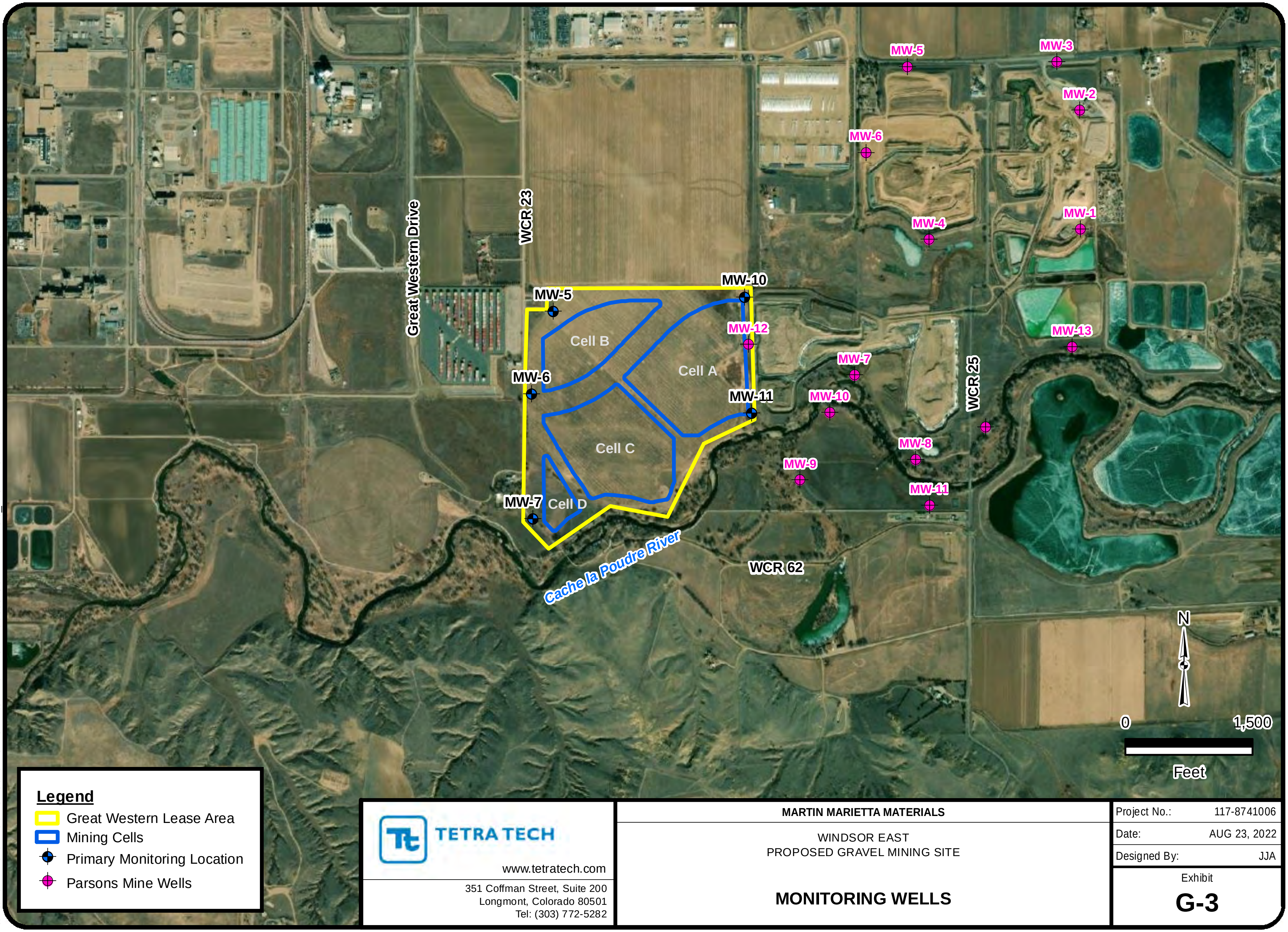
WINDSOR EAST
PROPOSED GRAVEL MINING SITE

GEOLOGIC MAP

Project No.:	117-8741006
Date:	JUL 28, 2022
Designed By:	JJA

Exhibit
G-2

8/23/2022 - O:\PROJECTS\LONGMONT\8741\117-8741006\GIS\MXD\EXHG3_MONITORINGWELLS.MXD - JEREMY.ANDRYAUSKAS



Legend

- 🟨 Great Western Lease Area
- 🟦 Mining Cells
- ⌖ Primary Monitoring Location
- ⌖ Parsons Mine Wells

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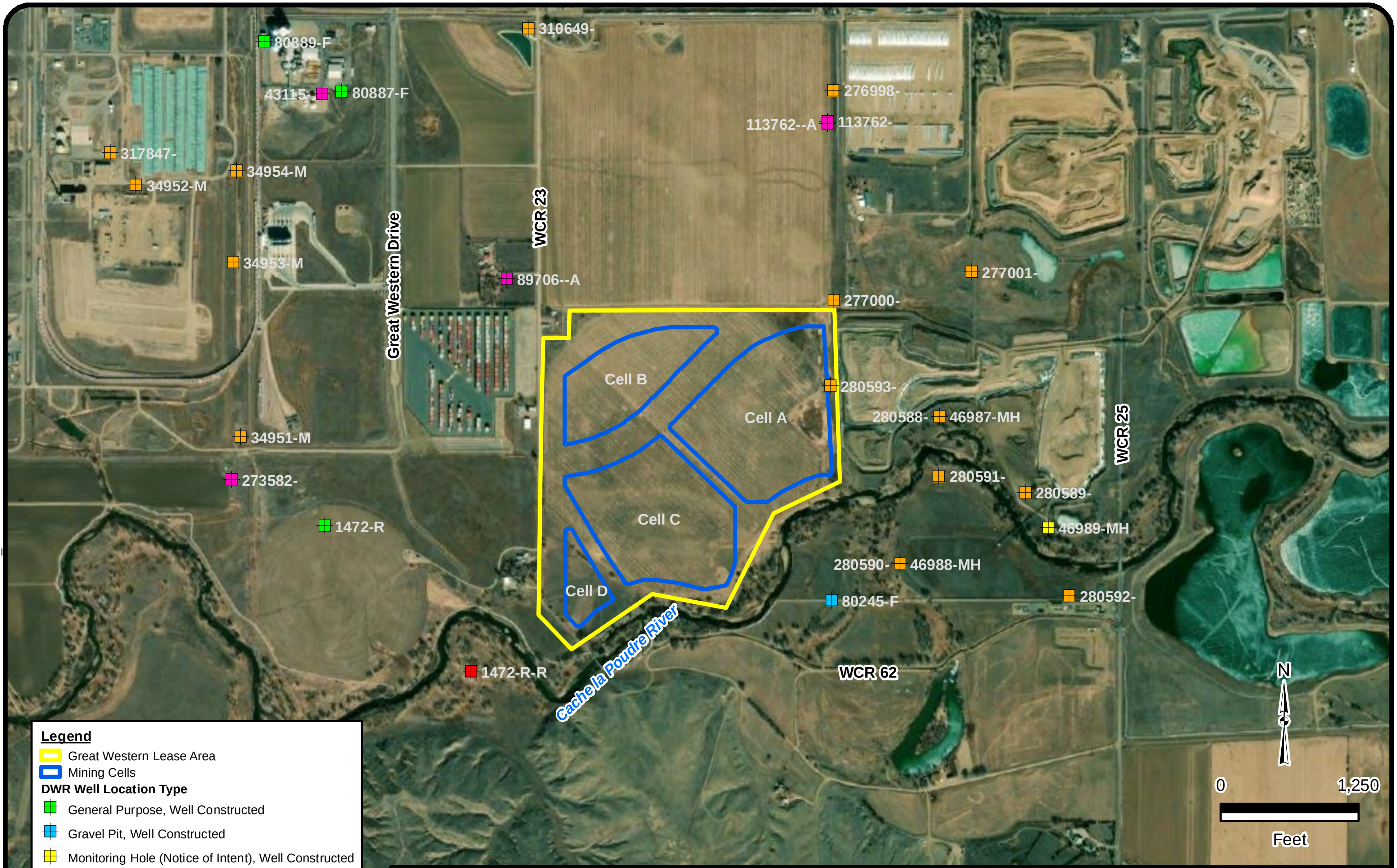
MARTIN MARIETTA MATERIALS

WINDSOR EAST
PROPOSED GRAVEL MINING SITE

MONITORING WELLS

Project No.:	117-8741006
Date:	AUG 23, 2022
Designed By:	JJA

Exhibit
G-3



Legend

- 🟨 Great Western Lease Area
- 🟦 Mining Cells

DWR Well Location Type

- 🟩 General Purpose, Well Constructed
- 🟦 Gravel Pit, Well Constructed
- 🟨 Monitoring Hole (Notice of Intent), Well Constructed
- 🟧 Monitoring/Observation, Well Constructed
- 🟪 Residential, Well Constructed
- 🟥 General Purpose, Permit Issued

Note: Search of registered wells conducted on May 24, 2022.

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MARTIN MARIETTA MATERIALS

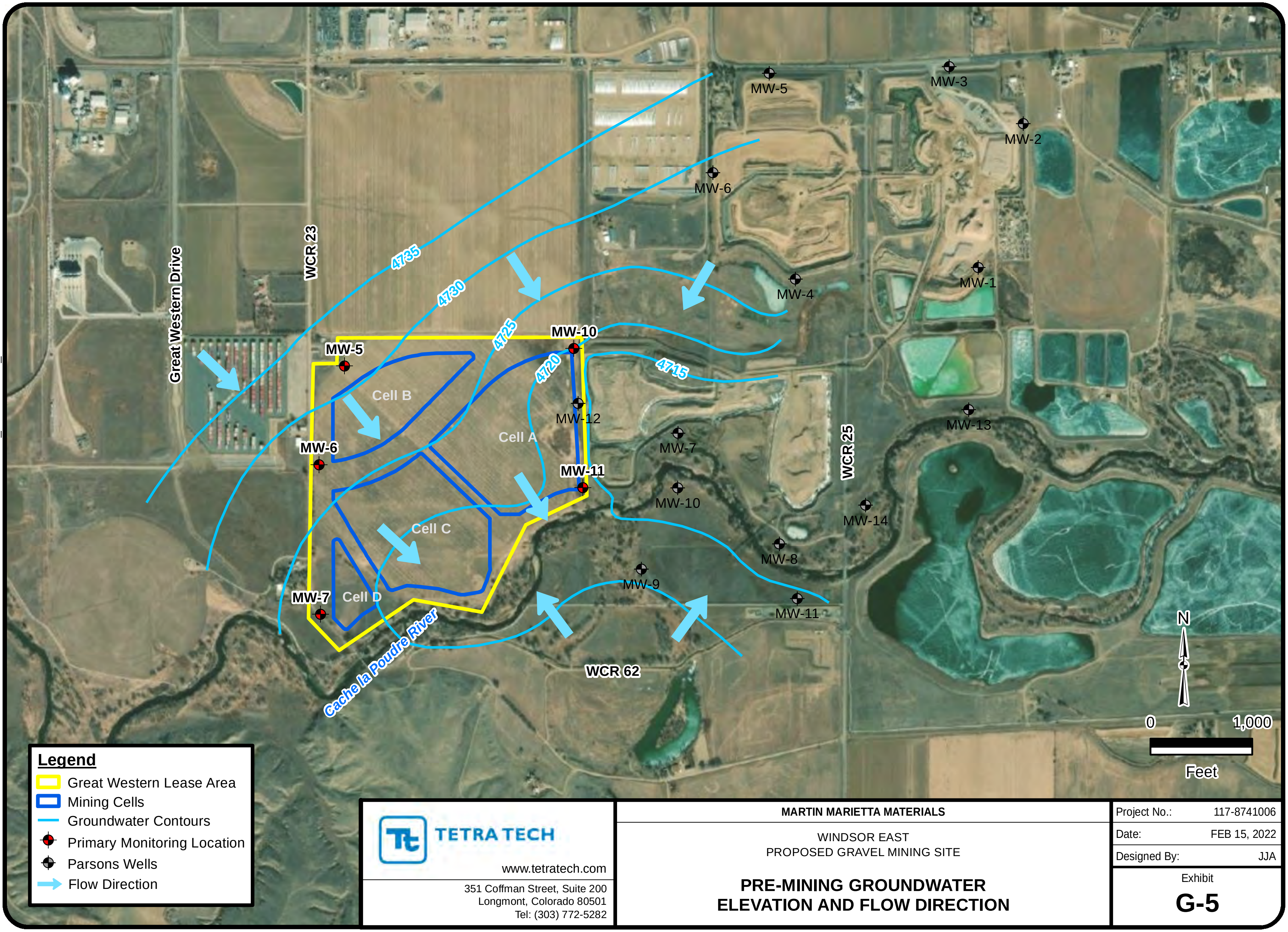
WINDSOR EAST
PROPOSED GRAVEL MINING SITE

REGISTERED WELLS WITHIN 0.5 MILES

Project No.:	117-8741006
Date:	AUG 22, 2022
Designed By:	JJA

Exhibit
G-4

8/22/2022 - O:\PROJECTS\LONGMONT\8741\117-8741006\GIS\MXD\EXHG4_REGISTEREDWELLS.MXD - JEREMY.ANDRYAUSKAS



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MARTIN MARIETTA MATERIALS

WINDSOR EAST
PROPOSED GRAVEL MINING SITE

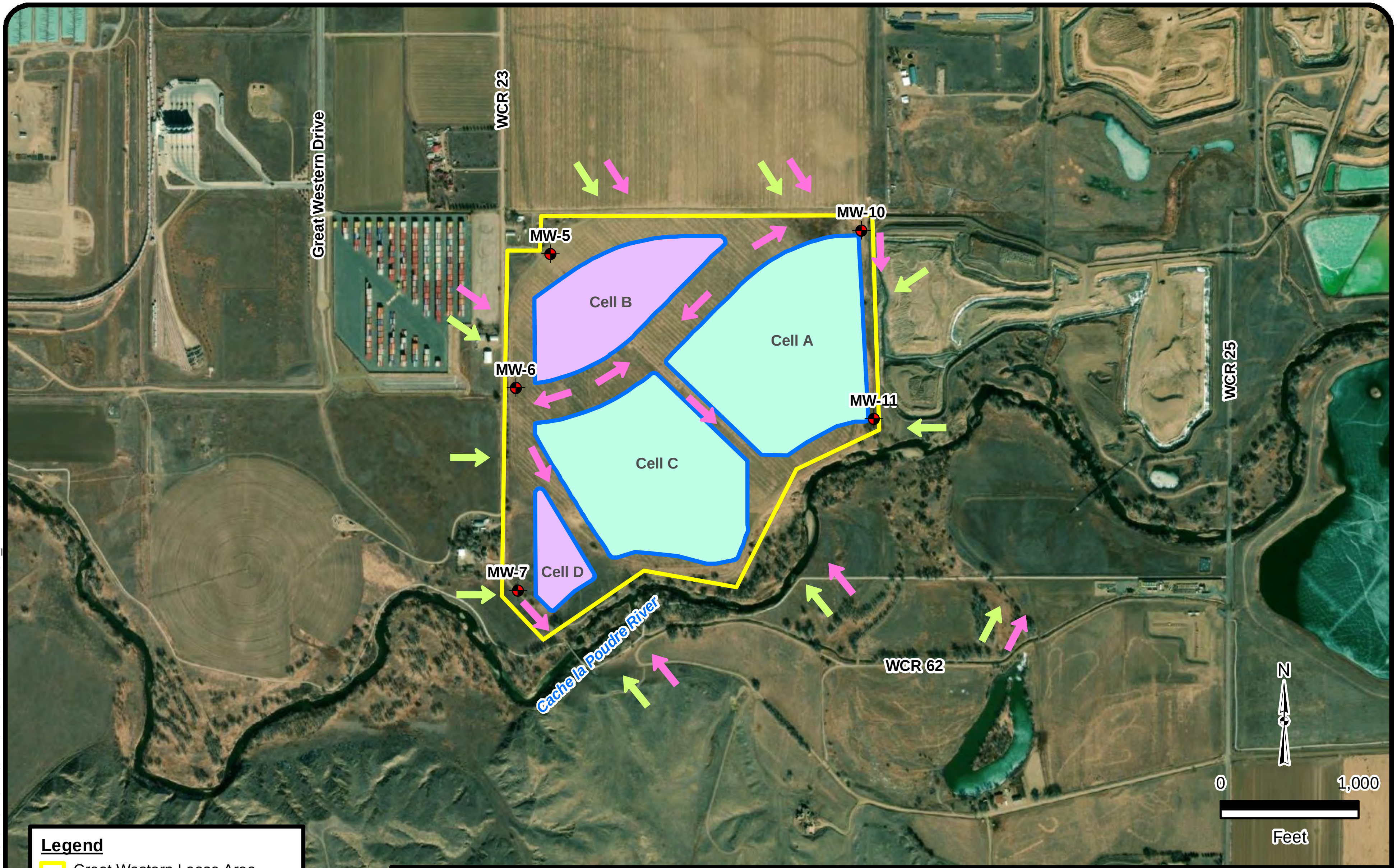
PRE-MINING GROUNDWATER ELEVATION AND FLOW DIRECTION

Project No.:	117-8741006
Date:	FEB 15, 2022
Designed By:	JJA

Exhibit

G-5

2/15/2023 - \\TT.LOCAL\IER\PROJECTS\LONGMONT\8741\117-8741006\GIS\MXD\EXHG5_PREMINING_EDIT.MXD - KATELYN.GOEN



Legend

- 🟨 Great Western Lease Area
- 🟦 Lined Mining Cell
- 🟪 Backfilled Mining Cell
- ● Primary Monitoring Location
- → Flow Direction during Mining
- → Flow Direction Post-Reclamation

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MARTIN MARIETTA MATERIALS

WINDSOR EAST
PROPOSED GRAVEL MINING SITE

GROUNDWATER FLOW DURING MINING AND POST-RECLAMATION

Project No.:	117-8741006
Date:	AUG 23, 2022
Designed By:	JJA

Exhibit
G-6

8/23/2022 - O:\PROJECTS\LONGMONT\8741\117-8741006\GIS\MXD\EXHG6_MINING-RECLAMATION.MXD - JEREMY.ANDRYAUSKAS

TABLES

Table 1. Well Inventory Search Results

Permit Number	Contact Name	Town ship	Range	Section	Q160	Q40	UTM X	UTM Y	Distance	< 600 ft ?	< 0.5 mi ?	Permit Category	Permit Issued	Construction Date	Use(s)	Elevation	Depth	Screen Top	Screen Bottom	More Info
280593-	MARTIN MARIETTA MATERIALS INC	6.0 N	67.0 W	36	NE	NW	513402.6	4477581	< 100 ft	Yes	Yes	Monitoring/Observation	5/7/2009	4/20/2007	Monitoring/Sampling	4725	14	6	14	https://dwr.state.co.us/Tools/WellPermits/3639673L
277000-	HALL-IRWIN CORPORATION	6.0 N	67.0 W	25	SE	SW	513411.5	4477818	< 100 ft	Yes	Yes	Monitoring/Observation	3/28/2008	3/1/2007	Monitoring/Sampling	4727	14	4	15	https://dwr.state.co.us/Tools/WellPermits/3627148E
89706--A	LAUER BRETT T & MARY K	6.0 N	67.0 W	26	SE	SE	512509.3	4477876	640 ft	No	Yes	Residential	4/21/1977	4/29/1977	Domestic		32	17	32	https://dwr.state.co.us/Tools/WellPermits/9065892
280591-	MARTIN MARIETTA MATERIALS INC	6.0 N	67.0 W	36	NE	SW	513702.1	4477332	900 ft	No	Yes	Monitoring/Observation	5/7/2009	4/20/2007	Monitoring/Sampling	4723	15	4	14	https://dwr.state.co.us/Tools/WellPermits/3639673J
280588-	MARTIN MARIETTA MATERIALS INC	6.0 N	67.0 W	36	NE	NW	513702.5	4477496	940 ft	No	Yes	Monitoring/Observation	5/7/2009	4/19/2007	Monitoring/Sampling	4724	16	6	14	https://dwr.state.co.us/Tools/WellPermits/3639673G
280590-	MARTIN MARIETTA MATERIALS INC	6.0 N	67.0 W	36	NE	SW	513594.4	4477089	960 ft	No	Yes	Monitoring/Observation	5/7/2009	4/20/2007	Monitoring/Sampling	4727	16	6	16	https://dwr.state.co.us/Tools/WellPermits/3639673I
1472-R-R	WEST WELD AG I	6.0 N	67.0 W	35	SE	NE	512410.1	4476792	1300 ft	No	Yes	General Purpose	4/29/1982		Irrigation					https://dwr.state.co.us/Tools/WellPermits/0221570
277001-	HALL-IRWIN CORPORATION	6.0 N	67.0 W	25	SE	SW	513792.4	4477895	1320 ft	No	Yes	Monitoring/Observation	3/28/2008	3/2/2007	Monitoring/Sampling	4724	9	4	10	https://dwr.state.co.us/Tools/WellPermits/3627148F
113762--A	M WATERCO LLC	6.0 N	67.0 W	25	SW	NE	513394.6	4478305	1700 ft	No	Yes	Residential	4/21/1980	4/28/1980	Domestic, Stock		25	12	25	https://dwr.state.co.us/Tools/WellPermits/0914278
280589-	MARTIN MARIETTA MATERIALS INC	6.0 N	67.0 W	36	NE	SE	513941.6	4477286	1750 ft	No	Yes	Monitoring/Observation	5/7/2009	4/19/2007	Monitoring/Sampling	4722	18	6	16	https://dwr.state.co.us/Tools/WellPermits/3639673H
46989-MH	PARSONS, SALLY	6.0 N	67.0 W	36	NE	SE	514004.4	4477189	1970 ft	No	Yes	Monitoring Hole (Notice of Intent)	4/17/2007	4/19/2007	Monitoring/Sampling	4722	18	6	16	https://dwr.state.co.us/Tools/WellPermits/0046989
276998-	HALL-IRWIN CORPORATION	6.0 N	67.0 W	25	SE	NW	513410.8	4478397	1980 ft	No	Yes	Monitoring/Observation	3/28/2008	3/1/2007	Monitoring/Sampling	4740	24	4	25	https://dwr.state.co.us/Tools/WellPermits/3627148C
280592-	MARTIN MARIETTA MATERIALS INC	6.0 N	67.0 W	36	NE	SE	514062.2	4477002	2300 ft	No	Yes	Monitoring/Observation	5/7/2009	4/20/2007	Monitoring/Sampling	4724	17	6	16	https://dwr.state.co.us/Tools/WellPermits/3639673K
310649-	GREAT WESTERN DEVELOPMENT CO	6.0 N	67.0 W	26	SE	NE	512567.4	4478569	2580 ft	No	Yes	Monitoring/Observation	8/22/2018	7/20/2017	Monitoring/Sampling	4758	26			https://dwr.state.co.us/Tools/WellPermits/3688007
34951-M	EASTMAN, KODAK	6.0 N	67.0 W	35	NW	NE	511773.7	4477440	2790 ft	No	No	Monitoring/Observation	4/11/1989	5/10/1989	Monitoring/Sampling		10	5	10	https://dwr.state.co.us/Tools/WellPermits/0297546O
273582-	BROE LAND ACQUISITIONS II LLC	6.0 N	67.0 W	35	NW	SE	511749.1	4477321	2800 ft	No	No	Residential	5/14/2007	12/13/2007	Commercial		32	12	32	https://dwr.state.co.us/Tools/WellPermits/3616219
80887-F	FRONT RANGE ENERGY LLC	6.0 N	67.0 W	26	SE	NW	512052.5	4478393	2880 ft	No	No	General Purpose	5/9/2017	1/23/2006	Industrial, Irrigation, Other					https://dwr.state.co.us/Tools/WellPermits/3679484A
34953-M	EASTMAN, KODAK	6.0 N	67.0 W	26	SW	SE	511752.9	4477922	2900 ft	No	No	Monitoring/Observation	4/11/1989	5/8/1989	Monitoring/Sampling		18	8	18	https://dwr.state.co.us/Tools/WellPermits/0297546Q
43115-	HENSEL PHELPS CONST	6.0 N	67.0 W	26	SE	NW	511997.7	4478388	2950 ft	No	No	Residential		9/19/1970	Domestic		29			https://dwr.state.co.us/Tools/WellPermits/9064312
34954-M	EASTMAN, KODAK	6.0 N	67.0 W	26	SW	SE	511761.9	4478175	3200 ft	No	No	Monitoring/Observation	4/11/1989	5/10/1989	Monitoring/Sampling		18	8	18	https://dwr.state.co.us/Tools/WellPermits/0297546R
80889-F	FRONT RANGE ENERGY LLC	6.0 N	67.0 W	26	SE	NW	511838.4	4478531	3690 ft	No	No	General Purpose	5/9/2017	2/1/2006	Industrial, Irrigation, Other					https://dwr.state.co.us/Tools/WellPermits/3679484C
34952-M	EASTMAN, KODAK	6.0 N	67.0 W	26	SW	SE	511484.6	4478135	3980 ft	No	No	Monitoring/Observation	4/11/1989	5/10/1989	Monitoring/Sampling		16	6	16	https://dwr.state.co.us/Tools/WellPermits/0297546P
317847-	JOSEPH ENERGY LLC	6.0 N	67.0 W	26	SW	NE	511413	4478225	4280 ft	No	No	Monitoring/Observation	7/1/2020	3/19/2020	Monitoring/Sampling	4753	13			https://dwr.state.co.us/Tools/WellPermits/10004233
34941-M	EASTMAN, KODAK	6.0 N	67.0 W	34	SE	NE	510971.7	4476873	5300 ft	No	No	Monitoring/Observation	4/11/1989	5/8/1989	Monitoring/Sampling		16	6	16	https://dwr.state.co.us/Tools/WellPermits/0297546E

Table 2. Parsons Mine Well Construction Summary

Well	Location				Land Surface	Top of	Screened
	Latitude	Longitude	Northing	Easting	Elevation (ft asl)	Casing Elevation (ft asl)	Top of screen (ft BTOC)
MW-1	40 27'09.1 N	104 49'40.2 W	1408407.20	3187071.64	4732.55	4734.88	7.2
MW-2	40 27'23.0 N	104 49'40.2 W	1409820.68	3187507.17	4739.56	4741.94	19.2
MW-3	40 27'28.6 N	104 49'43.7 W	1410378.60	3186772.58	4743.25	4745.43	20.7
MW-4	40 27'08.0 N	104 50'03.3 W	Destroyed		est 4731		4.7
MW-5	40 27'28.1 N	104 50'06.5 W	1410302.087	3185005.977	4748.44	4748.51	18.7
MW-6	40 27'18.1 N	104 50'12.9 W	1409320.737	3184458.427		4749.83	13.7
MW-7	40 26'52.2 N	104 50'14.7 W	1406761.58	3184129.57	4724.06	4726.31	5.7
MW-8	40 26'42.3 N	104 50'05.4 W	Destroyed		est 4721		6.3
MW-9	40 26'40.0 N	104 50'23.0 W	1405423.6	3183773.8	4727.01	4729.90	5.7
MW-10	40 26'47.8 N	104 50'18.5 W	1406223.77	3184126.00	4723.11	4728.27	3.7
MW-11	40 26'37.0 N	104 50'03.3 W	1405142.17	3185307.82	4724.58	4727.27	5.7
MW-12	40 26'55.8 N	104 50'30.9 W	1407046.36	3183142.78	4725.58	4728.19	5.7
MW-13	40 26'55.4 N	104 49'41.5 W	1407007.63	3186986.18	4721.13	4723.89	
MW-14	40 26'46.1 N	104 49' 54.7 W	1406061.78	3185977.16	4721.42	4723.87	

Note: Surveyed coordinates are Colorado State Plane North, US ft, NAD83.

Table 3. Windsor East Monitoring Well Construction Summary

Well	Location		Measuring Point Elevation	Screened Interval (ft BTOC)			Depth to Water		Depth to Bedrock
	Northing	Easting	Top of Casing (ft amsl)	Top of Screen	Bottom of Screen	Total Depth	Date	Measured (ft BTOC)	(ft BTOC)
MW-05	1407363.18	3180756.42	4741.04	4.0	24.0	24.0	8/12/22	8.9	22.5
MW-06	1406448.96	3180558.21	4734.84	7.0	17.0	19.0	8/12/22	7.9	16
MW-07	1405083.81	3180568.65	4733.71	6.0	16.0	17.5	8/12/22	10.4	16
MW-10	1407540.29	3183012.41	4728.44	8.0	18.0	20.0	8/12/22	8.8	16
MW-11	1406241.22	3183097.25	4727.64	6.0	16.0	20.5	8/12/22	10.2	15

Notes: amsl = above mean sea level; BTOC = Below Top of Casing
Coordinates are reported in Colorado State Plane North (US ft, NAD 83)

Table 4: Saturated Thickness and Dewatering Impacts at Parsons

Well	MW-4	MW-6	MW-7	MW-12
Pre-mining Conditions				
Minimum	5.3	7.0	4.2	5.2
Maximum	10.1	13.5	6.1	7.2
Average	7.3	8.5	5.3	6.3
Mining Conditions				
Minimum	7.0	5.9	0	1.0
Maximum	7.3	8.7	6.9	3.3
Average	7.2	6.6	1.7	1.7
Est Drawdown / Change in Saturated Thickness	0.1 ft	1.9 ft	3-5 ft	4.6 ft

Table 5. Water Quality Sampling Parameters

Parameter	Applicable Water Quality Standard Concentration	Notes and Field Filtration	Container Volume	Preservative	Hold Time
Aluminium - Dissolved	5 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Antimony - Dissolved	0.006 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Arsenic - Dissolved	0.01 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Barium - Dissolved	2.0 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Beryllium - Dissolved	0.004 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Boron - Dissolved	0.75 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Cadmium - Dissolved	0.005 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Chromium - Dissolved (CrVI)	0.1 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Cobalt - Dissolved	0.05 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Copper - Dissolved	0.2 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Cyanide - Free	0.2 mg/L		500 mL	NaOH	14 days
Fluoride - Total F	2.0 mg/L		125 mL	Temp (< 60C)	28 days
Iron - Dissolved	0.3 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Lead - Dissolved	0.05 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Lithium - Dissolved	2.5 mg/L	Filter in field (0.45 micron)	250 mL	NNO3	180 days
Manganese - Dissolved	0.05 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Mercury - Dissolved	0.002 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Molybdenum - Dissolved	0.21 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Nickel - Dissolved	0.1 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Nitrate (NO3)	10.0 mg/L as N	Filter in field (0.45 micron)	125 mL	Temp (< 60C)	28 days
Nitrite (NO2)	1.0 mg/L as N	Filter in field (0.45 micron)	125 mL	Temp (< 60C)	28 days
Nitrate+Nitrite (NO2+NO3), dissolved	10.0 mg/L as N	Filter in field (0.45 micron)			
pH	6.5 - 8.5	Measure in field	125 mL	Temp (< 60C)	<24 hrs (lab)
Selenium - Dissolved	0.02 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Silver - Dissolved	0.05 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Sulfate - Total	250 mg/L		125 mL	Temp (< 60C)	28 days
Thallium - Dissolved	0.002 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
TDS	400 mg/L	Lab Filtration	500 mL	Temp (< 60C)	7 days
Uranium - Dissolved	0.0168 to 0.03 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Vanadium - Dissolved	0.1 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Zinc - Dissolved	2 mg/L	Filter in field (0.45 micron)	250 mL	HNO3	180 days
Gross Alpha Particle Activity	15 pCi/L		1 L	HNO3	180 days
Chloride, dissolved	250 mg/L	Filter in field (0.45 micron)	125 mL	Temp (< 60C)	28 days

Notes: Detection Limit / Reporting Limit must be equivalent to the water quality standard or lower.

APPENDIX G-1

BORING LOGS AND WELL COMPLETION DIAGRAMS

WINDSOR EAST AND PARSONS MINE MONITORING WELLS

Martin Marietta Page 1 of 2

Site Name: Great Western
Site Location:
Boring Number: MW-5
Latitude: 40.4498
Date Started: 8-8-22 1303
Rig Type: CME Truck Mounted
Drilling Method: Hollow Stem Auger
Surface Elevation (Feet):
Overburden Thickness (Feet): 9.0
Boring Total Depth (Feet): 25

Logged By: Rod Preston
Longitude: -104.85053
Date Completed: 8-8-22
Drilling Contractor: Authentic Drilling
Borehole Diameter: 8.25"
Depth to Water (Feet): 7.5
Depth to Bedrock (Feet): 22.5
Backfill Type: Well Construction

13ft Accur

Depth (Feet)	Sample Interval	Grain Size (1)	Rounding (2)	Grading (3)	Time, Material Description, and Comments	Top of Groundwater
					Overburden, Silty clay, stiff, Brown	
					Dry,	
5						
						▼ 7.5
9.0						
10					Clayey sand, ~~moist~~, rig chatter, Brown, wet	
12.5			r	M	Sandy gravel, clean, wet, gravel to cobble size up to 2",	
15					rig chatter @ 17.5'	
					recovering sand, gravelly sand, wet, moderately graded	
20						
25					Bedrock-gray claystone, split spoon run for confirmat	
					18-38-50 for 3"	
					Drilled to 25' for well construction,	
					hole kept filling before pvc was	
					set	

(1) Grain Size:B=Boulder, P=Cobble, G=Gravel, S=sand, V=very, F=Fine, M=Medium, C=Coarse
(2) Rounding: R=rounded, r=subrounded, a=subangular, A=angular
(3) Grading: P=poorly graded, M=moderately graded, W=well graded, X=see description

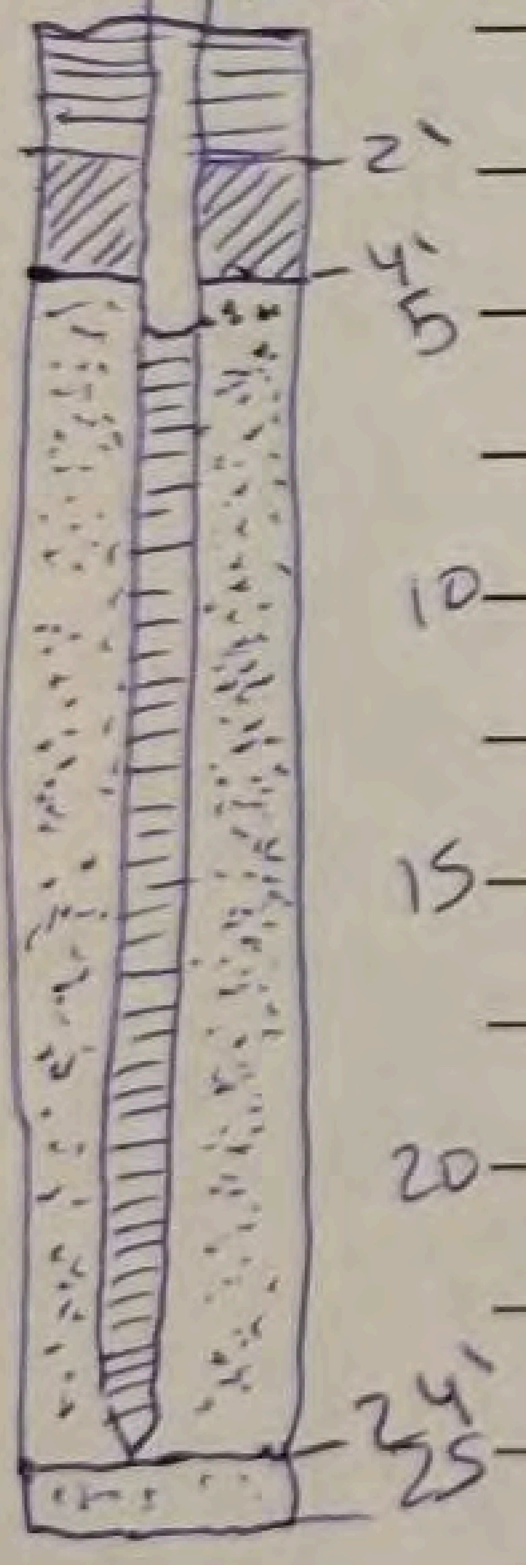
27

Martin Marietta Page 2 of 2

Site Name: Great Western
Site Location:
Boring Number: MW-05
Latitude:
Date Started: 8-8-22
Rig Type: CME Truck Mounted Rig
Drilling Method: Hollow Stem Auger
Surface Elevation (Feet):
Overburden Thickness (Feet): 9.0
Boring Total Depth (Feet): 25

Logged By: Rod Preston
Longitude:
Date Completed: 8-8-22
Drilling Contractor: Authentic Drilling
Borehole Diameter: 8.25"
Depth to Water (Feet): 7.5'
Depth to Bedrock (Feet): ~~22~~ 23.5
Backfill Type: Well construction

Depth (Feet)



Sample Interval	Grain Size (1)	Rounding (2)	Grading (3)	Time, Material Description, and Comments	Top of Groundwater
				Well Construction	
	0 -1	.5	'	~~0-2~~ 2' Cement Bentonite Grout	
	1.5	-3	'	~~2-4~~' Bentonite chip seal	
	3-	2~~5~~	'	~~4'-25~~' Sand screen	
	0-	4	'	~~0-5~~ schedule 40 riser pipe	
	4-	2	4'	~~5-25~~' -010 Slotted screen sched	40
				Materials used	
				Sand - Washed Silica Sand 10/20 50 lb bag	
				Bentonite → ~~Pure gold medium chips 50 lb~~ bag	
				crumbles → 8-20 cetco	
				Portland Cement type I/II 94 lb bag	
*	Trouble			getting well, sand filled in as we tried	to
	put filter			in, plugging the hole. ended up lifting	
	1 ft	to		get well set.	

(1) Grain Size:B=Boulder, P=Cobble, G=Gravel, S=sand, V=very, F=Fine, M=Medium, C=Coarse
(2) Rounding: R=rounded, r=subrounded, a=subangular, A=angular
(3) Grading: P=poorly graded, M=moderately graded, W=well graded, X=see description

* ran out of pure gold, used crumbles for bentonite seal

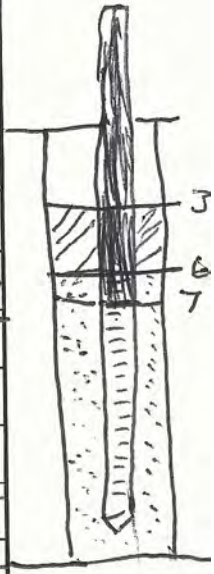
* Portland cement grout mixed with cetco 8-20 mesh granular ~~cement~~ bentonite crumbles to thicken grout

* Started setting well at 1400

Martin Marietta Page 1 of 1

Site Name: Great Western
Site Location: Pit 8 area adjacent to CO Road 23
Boring Number: MW-06
Logged By: David Bieber
Latitude: 40.44728
Longitude: -104.85126
Date Started: 8/1/2022 12:30
Date Completed: 8/1/2022 14:30
Rig Type: CME 55-300 Track
Drilling Contractor: Authentic Drilling
Drilling Method: Hollow Stem Auger
Borehole Diameter: 8 1/2 inch
Surface Elevation (Feet): 4734.839
Depth to Water (Feet): 8
Overburden Thickness (Feet): 8
Depth to Bedrock (Feet): 16 16
Boring Total Depth (Feet): 19
Backfill Type: Monitor Well

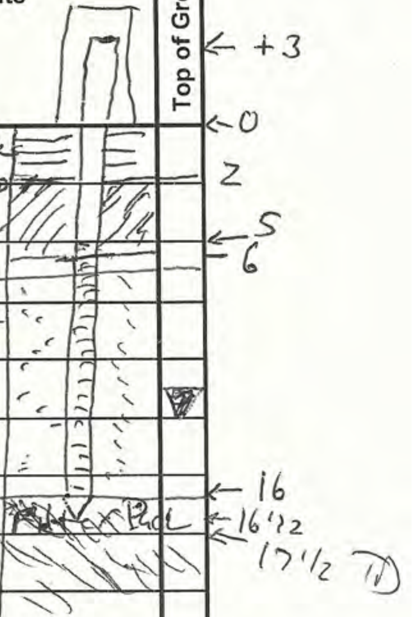
Depth (Feet)	Sample Interval	Grain Size (1)	Rounding (2)	Grading (3)	Time, Material Description, and Comments	Top of Groundwater
0					Overburden silt/clay mixture, dark grayish brown, stiff, moist, trace sand	
5						▼
8 10		vF-vC	R	W	Silty sand with gravel and cobble moderate brown, slightly firm, wet cobbles to 3 inches	
15 16					Bedrock Claystone, medium to dark gray, stiff, moist	
TD 19						
					Filter Pack 6 to 19 feet 10/20 50# x 5	
					Bentonite Chips 3 to 6 feet 50# x 2	
					Type 1/44 Cement 5% Bentonite 0 to 3 100# x 1	
					Schedule 40 PVC 0.010 screen 7 to 17 feet	
					Schedule 40 PVC Casing +3 to 7 feet	



(1) Grain Size:B=Boulder, P=Cobble, G=Gravel, S=sand, V=very, F=Fine, M=Medium, C=Coarse
(2) Rounding: R=rounded, r=subrounded, a=subangular, A=angular
(3) Grading: P=poorly graded, M=moderately graded, W=well graded, X=see description

Martin Marietta Page 1 of 1

Site Name: Great Western
Site Location: South western corner
Boring Number: GW-MW-07
Logged By: David Biebel
Latitude: 40.44353
Longitude: -104.85127
Date Started: 08/01/2022 10:00
Date Completed: 08/01/2022 12:05
Rig Type: CME55-300 Track
Drilling Contractor: Authentic Drilling
Drilling Method: Hollow Stem Auger
Borehole Diameter: 8-1/4 inch
Surface Elevation (Feet): 4733.709
Depth to Water (Feet): 12-1/2
Overburden Thickness (Feet): 7
Depth to Bedrock (Feet): 16
Boring Total Depth (Feet): 17 ½ feet
Backfill Type: Monitoring Well



Depth (Feet)	Sample Interval	Grain Size (1)	Rounding (2)	Grading (3)	Time, Material Description, and Comments	Top of Groundwater
					Overburden, silt, Light to moderate	
					Brown, slightly stiff, dry to	
5					slightly moist, trace fine sand	
7						
					Sand with some gravel, moderate	
10					reddish brown, loose, moist	
					gravel to 1 inch.	▼
					Coarsening down to sandy gravel, gravel to 1 inch	
15 / 16					Cobble lag at bottom +3"	
					Bedrock - ~~cla~~ claystone, medium gray, stiff	
20					Casing +3 to 6 feet	
					Screen 6 to 16 feet	
					well point on bottom 16 to 16½	
25					Filter Pack 5 to 17½ feet	
					~~Bentonite 2 to 5 feet~~	
					Grout 0 to 2 feet	
					2×50# Bentonite Chips (medium) Seal - ~~2×50# Bentonite Crumbles~~	
					6×50# Filter Pack - 10/20 sand	
					Casing - Sch 40 2" PVC	
					Screen - Sch 40 2" PVC .010 Slot	

Grout - 100# I/II Portland Cement with 5% Bentonite Crumbles

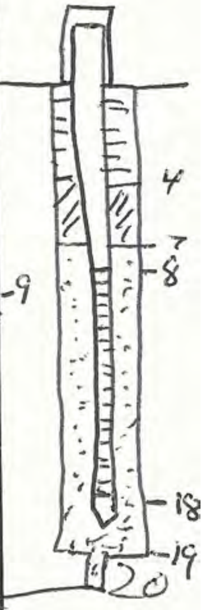
(1) Grain Size:B=Boulder, P=Cobble, G=Gravel, S=sand, V=very, F=Fine, M=Medium, C=Coarse
(2) Rounding: R=rounded, r=subrounded, a=subangular, A=angular
(3) Grading: P=poorly graded, M=moderately graded, W=well graded, X=see description

Martin Marietta

Page 1 of 1

Site Name: Great Western
Site Location: Pits 8, Northeast Corne
Boring Number: MW-10
Logged By: David Bieler
Latitude: 40.45023
Longitude: -104.84239
Date Started: 8/8/2020 0740
Date Completed: 8/8/2022 10:30 hrs
Rig Type: CME 55-300 Truck
Drilling Contractor: Authentic Drilling
Drilling Method: Hollow Stem Auger
Borehole Diameter: 8 1/2 inch
Surface Elevation (Feet):
Depth to Water (Feet): 9 feet
Overburden Thickness (Feet): 9
Depth to Bedrock (Feet): 16
Boring Total Depth (Feet): 20 ft
Backfill Type: Monitoring Well

Depth (Feet)	Sample Interval	Grain Size (1)	Rounding (2)	Grading (3)	Time, Material Description, and Comments	Top of Groundwater
0					Overburden; Clayey Silt, Dark Brown, slightly stiff, moist, sandy clay zone from 4 to 5 feet	
5					water rose to 6.15 feet	▽
9						
10					silty, Clayey Cobble zone based on rig chatter and drilling	▼
14						
15					Silt to sandy Silt, moderate Gray-Brown stiff, wet	
16					Bedrock	
20 5'@	26 30					
					4" Stickup on surface	
					Grout Type I/II Portland Cement 4 to 0 100# x 1 1/2	
					Seal Bentonite Medium Chips 7 to 4 50# x 2	
					Casing Sch 40 PVC 8 to +3	
					Screen Sch 40 PVC, .010 Slot 18 to 8	
					Filter Pack 10/20 Sand 20 to 7 50# x 9 1/4	

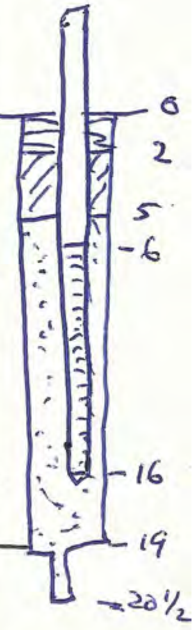


(1) Grain Size:B=Boulder, P=Cobble, G=Gravel, S=sand, V=very, F=Fine, M=Medium, C=Coarse
(2) Rounding: R=rounded, r=subrounded, a=subangular, A=angular
(3) Grading: P=poorly graded, M=moderately graded, W=well graded, X=see description

Martin Marietta Page 1 of 1

Site Name: Great Western
Site Location: Southeast side of Pit Area 8
Boring Number: MW-11
Logged By: David Bieber
Latitude: 40.44668
Longitude: -104.84212
Date Started: 8/1/2022 15:50
Date Completed: 8/1/2022 17:40
Rig Type: CME55-300 Track
Drilling Contractor: Authentic Drilling
Drilling Method: Hollow Stem Auger
Borehole Diameter: 8½ inch
Surface Elevation (Feet): 4727.636
Depth to Water (Feet): 7.4
Overburden Thickness (Feet): 7
Depth to Bedrock (Feet): 15
Boring Total Depth (Feet): 20½
Backfill Type: Monitoring Well

Depth (Feet)	Sample Interval	Grain Size (1)	Rounding (2)	Grading (3)	Time, Material Description, and Comments	Top of Groundwater	
0					Overburden, Clayey Silt, Moderate brown slightly stiff, slightly moist to moist		
5							
7			R	P	Clayey Cobbles, moderate grayish brown, stiff, moist, cobbles to 3 inches	▼	
10							
15					Weathered Bedrock, Clay, Red-Gray, stiff moist		
16					Bedrock, dark gray claystone, stiff, moist		
19 20 15-41-50 for 3"	☒						
					Filter Pack 10/20 Sand 20½ to 5 feet		50# x 6¼
					Bentonite Medium Chips 5 to 2 feet		50# x 2
					Type I/II Portland Cement 2 to 0 feet		100# x 1
					Sch 40 PVC Screen 0.010 Slot 16 to 6 feet		
					Sch 40 PVC Casing 6 feet to +3 feet		
					4" x 4" Stick Up Well Box		



(1) Grain Size: B=Boulder, P=Cobble, G=Gravel, S=sand, V=very, F=Fine, M=Medium, C=Coarse
(2) Rounding: R=rounded, r=subrounded, a=subangular, A=angular
(3) Grading: P=poorly graded, M=moderately graded, W=well graded, X=see description

Martin Marietta Page 1 of 1

Site Name: Riverbend West
Site Location: Chikuma E10
Boring Number: CH-MW05
Logged By: David Bieber
Latitude: 40.05764 15:42
Longitude: -104.84528
Date Started: 8/2/2022
Date Completed:
Rig Type: CMB 55-300
Drilling Contractor: Authentic Drilling
Drilling Method: Hollow Stem Auger
Borehole Diameter: 8 ½"
Surface Elevation (Feet):
Depth to Water (Feet): 16 Static 17.3'
Overburden Thickness (Feet): 11
Depth to Bedrock (Feet): 20
Boring Total Depth (Feet):
Backfill Type: Monitoring Well

Depth (Feet)	Sample Interval	Grain Size (1)	Rounding (2)	Grading (3)	Time, Material Description, and Comments	Top of Groundwater
0					Overburden, silt to sandy silt, moderate brown, slightly stiff, slightly moist	
5					to moist, some clay.	
10						
11					Sandy gravel, moderate reddish brown, loose, moist, gravel to	
15					1 inch Fining downward to coarse sand	▽
17					Sandy silt, moderate brown, loose to slightly stiff, wet	
20					Fining downward to silt,	20
					light brown,	
25 13 16 26					Bedrock, Claystone, dark grayish brown, stiff, wet	
					Set well on 8/3/2022	
					Set Screen 24 to 9 feet	
					Set casing 10 to +3 feet	
					Filter Pack 25½ to 8 feet	
					Bentonite 9 to 6 feet	

(1) Grain Size:B=Boulder, P=Cobble, G=Gravel, S=sand, V=very, F=Fine, M=Medium, C=Coarse
(2) Rounding: R=rounded, r=subrounded, a=subangular, A=angular
(3) Grading: P=poorly graded, M=moderately graded, W=well graded, X=see description

BOREHOLE LOG

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO LF-0538

Andy & Richard

BH NO. 1
PAGE 1 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME-75	DATE FINISH 4/18/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 16'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:

CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:

Length 2.5'
O.D. 2"
I.D. 1.7"
Material steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
0										
							Augered to 3'			
1							0 to 3.0' - Cutting - SILT AND			
							CLAY. Brown, some sand, trace			
2							roots. Moist.			
	8.25"									
3	H.S.A.				5		SS1 3' to 5'			
				19"	6					
4			SS		8		3.0' to 4.8' SILT AND CLAY. Brown			
				24"	14		stiff, little sand, little			
5	4.25" I.D.						stone up to 2-inch in diameter			
							Moist.			
6							4.8' to 5.0' NO RECOVERY			
							Augered to 9'			
7							5.0' to 9.0' - Cutting SILT AND			
							CLAY. Brown, little sand, little			
8							stone up to 2-inch in diameter			
							Moist. Rough Drilling due to stone			
9					7		SS2 9' to 11'			
			SS	10"/24"	13		9.0' to 9.8' SAND AND GRAVEL			
10							Brown med dense, little silt			

LOCATION SKETCH
Southeast of
Ettess Property
See Attached Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
60F sunny

LOG STATUS

PRELIMINARY
FINAL ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO LF-0538

BOREHOLE LOG

BH NO. 1
PAGE 2 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME 75	DATE FINISH 4/18/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 16'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES.
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other.
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
10										
							little stone up to 2" in diameter	wet		
11							9.8' to 11.0' NO RECOVERY			
							Augered to 14'			
12							11.0 to 14.0' - Cutting - SAND AND			
							GRAVEL, some silt some stone			
13	8.25" H.S.A						Rough drilling due to stone.			
14	4.25" I.D.									
				24' — 24"	5 16 25 32		SS3 14' to 16'			
15							14.0' to 15.2' - SILT, Brown			
							very stiff, some sand, wet			
16							15.2' to 16.0' - SILTSTONE, Grey			
			END OF BOREHOLE				very stiff, trace sand,			
17							lightly weathered. very moist			
							Augered to 15.5'			
18							END OF BOREHOLE At 16.0'			
19							Install monitoring well MW-1			
20										

LOCATION SKETCH
See plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
60F
Sunny

LOG STATUS.
PRELIMINARY: ____
FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

Andy & Richard

BH NO. 1
PAGE 3 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME-75	DATE FINISH 4/18/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 16'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:
CT Cuttings
[✓ SS] Split Spoon
DC Dry Core
Other
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
0							2" PVC 0.01" slotted screen			
							8' screen			
1							PUREGOLD BENTONITE COARSE			
							CHIP (3/8" to 3/4")			
2										
	8.25"						Silica Sand 10/20			
3	H.S.A									
4							Lock			
							Casing			
5	4.25"						Cap			
	I.D.						Riser -3 to 7.2' Concrete 0 to 2'			
6							Screen 7.2' - 15.2' Bentonite 2' to 6'			
							Cap 15.2'-15.5' Sand 6' to 16'			
7										
8										
9										
10										

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
60° F
Sunny

LOG STATUS:
PRELIMINARY
FINAL ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO LF-0538

BOREHOLE LOG

Andy & Richard

BH NO. 2
PAGE 1 OF 4

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME-75	DATE FINISH 4/18/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 30.3'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 14'

SAMPLE TYPES:
CT Cuttings
[✓ SS] Split Spoon
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
0										
							Augered to 4'			
1							0 to 4.0' - Cutting - SILT AND CLAY. Brown little sand, little gravel, trace roots. Moist			
2	8.25"									
3	H.S.A									
4					3		SS1 4' to 6'			
5	4.25" I.D.		SS	22" / 24"	4 6 7		4.0' to 5.8' SILT AND CLAY. Brown stiff, little sand little gravel. Damp			
6							5.8' to 6.0 NO RECOVERY			
7							Augered to 9'			
8							6.0' to 9.0' - Cutting SILT AND CLAY. Brown little sand, little gravel. Damp.			
9			SS	22" / 24'	3		SS 2 9' to 11'			
10					3		9.0' to 10.8' SILT AND CLAY. Brown Med stiff, trace sand			

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
60 F
Sunny

LOG STATUS:
PRELIMINARY: ______ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

BOREHOLE LOG

CLIENT LaTarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BH NO. 2
PAGE 2 OF 4

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME 75	DATE FINISH 4/18/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 30.3'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 14'

SAMPLE TYPES:
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
10										
					4 6		10.8' to 11' NO RECOVERY			
11										
							Augered to 14'			
12							11' to 14' - Cutting - SILT AND CLAY, Brown, trace sand			
13	8.25" H.S.A									
14	4.25" I.D.									
				16"/24"	6 12 14 21		SS 3 14' to 16'			
15							14' to 15.3' SAND AND GRAVEL, Brown, med dense, some stone up to 2-inch diameter, trace silt, trace clay, WET			
16										
17							15.3' to 16.0' NO RECOVERY			
							Augered to 19'			
18							16.0' to 19.0' SAND AND GRAVEL, Brown, some stone up to 2 inch diameter, trace silt, trace clay, WET			
19				18"/24"	15 6		SS 4 19' to 21'			
20							19.0' to 20.5' SAND AND GRAVEL Brown, med dense, some stone			

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
60 F
Sunny

LOG STATUS
PRELIMINARY ______ FINAL ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT LaFarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 2
PAGE 3 OF 4

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME 75	DATE FINISH 4/18/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 30.3'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 14'

SAMPLE TYPES:
CT Cuttings WS Wash
SS Split Spoon NX NX Core
DC Dry Core CS Continuous Sampler
Other:

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
20										
					12		up to 2-inch diameter, trace			
21					50/3"		silt, trace clay. WET.			
							20.5' to 21.0' NO RECOVERY			
22							Augered to 24'			
							21.0' to 24.0' - Cutting SAND AND			
23	8.25"						GRAVEL, Brown to redbrown,			
	H.S.A						some stones up to 2-inch			
24							diameter. WET			
	4.25" I.D.			22"/24"	22		SS 5 24' to 26'			
25					35		24.0' to 25.8' SAND AND GRAVEL,			
					40		Brown to redbrown, very dense,			
26					31		some stones up to 2-inch			
							diameter WET			
27							25.8' to 26.0' NO RECOVERY			
							Augered to 29'			
28							26.0' to 28.0' - Cutting - SAND AND			
							GRAVEL, Brown to redbrown,			
29							some stones up to 2-inch diameter			
				15"/15"	15		28.0' to 29.0' - Cutting - SILTSTONE			
30					40		Brown, little sand, trace clay. WET			
							SS 6 29' to 30.3'			

LOCATION SKETCH
See Plan

DENSITY: GRANULAR:		COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
60 F
Sunny

LOG STATUS:
PRELIMINARY ______ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 2
PAGE 4 OF 4

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME 75	DATE FINISH 4/18/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS –	TOTAL DEPTH 30.3'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 14'

SAMPLE TYPES:
CT Cuttings
SS Split Spoon
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner –
Other –

SURFACE CONDITION: Grass

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BC	HS	Core
30					50/3"		29.0' to 30.3' SILTSTONE. Brown and grey,			
31				END OF BOREHOLE			very stiff, little claystone,			
							trace sand!. Slightly weathered,			
							Very moist.			
	8.25"						Filter sand to 29.0'			
	H.S.A						Augered to 29.5'			
	4.25"						Install monitoring well MW-2			
	I.D.						2" PVC 10-foot screen			
							Cap and Lock			
							Casing			
							Riser -3' to 19.2' Concrete 0 to 2'			
							Screen 19.2' to 29.2' Bentonite chip 2' to 17'			
							Cap 29.2'-29.5' Filter Sand 17' to 29.5'			
							Bentonite 6 bags			
							Sand : 4 bags			
							Concrete 1 bag			

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-60	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
70F Sunny

LOG STATUS:
PRELIMINARY: ________ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

Andy & Richard

BH NO. 3
PAGE 1 OF 4

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME-75	DATE FINISH 4/18/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 31'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 14'

SAMPLE TYPES:
CT Cuttings
[✓ SS] Split Spoon
DC Dry Core
Other
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT)	BIT CASING	SAMP NO	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
0										
							Augered to 4'			
1							0 to 4.0' - Cutting - SILT AND CLAY			
							Brown, little sand, little gravel			
2							trace roots, Moist.			
	8.25"									
3	H.S.A.									
4							SS 1 4' to 6'			
					2		4.0 to 5.5' FINE SAND. Brown, loose,			
5	4.25" I.D.		SS	18"/24"	3		some silt, some clay. Wet			
					3		(Purged water)			
6					4		5.5' to 6.0' NO RECOVERY			
							Augered to 9'			
7							6.0' to 7.0' - Cutting - FINE SAND. Brown			
							somesilt, someclay, wet.			
8							7.0' to 9.0' - Cutting - SILT AND CLAY			
							Brown, trace sand. moist			
9							SS 2 9' to 11'			
			SS	16"/24"	6		9.0' to 10.3' - FINE TO MEDIUM SAND			
10					12		Brown, dense, some stones up			
							to 2-inch diameter. Damp			

LOCATION SKETCH
See Plan

DENSITY: GRANULAR:		COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
70F Sunny

LOG STATUS:
PRELIMINARY ________ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO LF-0538

BOREHOLE LOG

BH NO. 3
PAGE 2 OF 4

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME 75	DATE FINISH 4/18/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 31'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 14'

SAMPLE TYPES:
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other. ____
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
10					20		10.3' to 11.0' NO RECOVERY			
					25					
11							Augered to 14'			
12							11.0' to 14.0' - Cutting - SAND AND GRAVEL			
							Brown. Damp.			
13	8.25" H.S.A									
14	4.25" I.D.						SS 3 14' to 16'			
					6		14.0' to 15.3' SAND AND GRAVEL.			
15				16"/24"	6		Red brown, med dense, trace			
					8		silt. Wet.			
					7					
16							15.3' to 16.0' NO RECOVERY			
							Augered to 19'			
17							16.0 to 19.0' - Cutting - SAND AND GRAVEL, trace silt. Wet			
18										
19							SS 4 19' to 21'			
				18"/24"	8		19.0' to 20.5' SAND AND GRAVEL.			
20					30		Brown, dense, some stones up to 2-inch diameter, trace silt. Wet			

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
70 F Sunny

LOG STATUS:
PRELIMINARY: ____ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 3
PAGE 3 OF 4

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME 75	DATE FINISH 4/18/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 31'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 14'

SAMPLE TYPES:

CT Cuttings	WS Wash
SS Split Spoon	NX NX Core
DC Dry Core	CS Continuous Sampler
Other:	

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BC	HS	Core
20					50/5"		20.5' to 21.0' NO RECOVERY.			
21							Augered to 24'			
22							21.0' to 24.0' - Cutting - SAND AND GRAVEL. Brown, some			
23	8.25" H.S.A						stones up to 2-inch diameter trace silt.			
							SS 5 24' to 26'			
24	4.25" I.D.			20"/24"	25 32		24.0' to 25.7' SAND AND GRAVEL. Brown, very dense, some			
25					35 35		stones up to 2-inch diameter trace silt.			
26							25.7' to 26.0' NO RECOVERY			
27							Augered to 29'			
							26.0' to 29.0' - Cutting - SAND AND GRAVEL, some stones up to			
28							2-inch diameter, trace silt			
29							SS 6 29' to 31'			
				12"/24"	6		29.0' to 30' SILTSTONE. Grey,			
30					12		very stiff, some clay, trace sand. Lightly weathered. Wet			

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
70 F Sunny

LOG STATUS
PRELIMINARY ____ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 3
PAGE 4 OF 4

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME 75	DATE FINISH 4/18/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 31'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 14'

SAMPLE TYPES:

CT Cuttings	WS Wash
SS Split Spoon	NX NX Core
DC Dry Core	CS Continuous Sampler
Other:	

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
30					26		30.0' to 31.0' NO RECOVERY			
31					30					
			END OF BOREHOLE				Augered to 31'			
							END OF BOREHOLE			
							Monitoring well Installation			
	8.25"						2' PVC 10-foot screen			
	H.S.A						MW-3			
	4.25"									
	I.D.									
							Casing + lock			
							Cap			
							riser -3 to 20.7' Concrete 0 to 4'			
							screen 20.7' to 30.7' Bentonite chip 4' to 18.5'			
							Cap 30.7' to 31.0' Filter sand 18.5' to 31'			
							Sand 3 bags			
							Bentonite chip 6.5 bags			
							Concrete 2 bags			

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
70 F Sunny

LOG STATUS:
PRELIMINARY. ________ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

Andy & Richard

BH NO. 4
PAGE 1 OF 2

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME-75	DATE FINISH 4/18/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 13.7'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 4'

SAMPLE TYPES:
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material steel
Liner –
Other –

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
0							Augered to 4'			
1							0 to 4.0' – cutting – SILT AND CLAY			
							Brown, trace sand, trace roots			
2							Moist			
	8.25"									
3	H.S.A.									
							SS 1 4' to 6'			
4				10"	6		4.0' to 4.8' GRAVEL. Brown, med			
5	4.25"				12		dense, trace sand, trace silt,			
	I.D.			24"	12		trace clay. Wet			
6					12		4.8' to 6.0' NO RECOVERY			
							Augered to 9'			
7							6.0' to 9.0' GRAVEL. Brown, some			
							sand, some stone up to 2-inch			
8							diameter, trace silt, trace clay.			
							Wet.			
9							SS 2 9' to 11'			
				24"	5		9.0' to 11.0' SAND AND GRAVEL. Brown			
10				24"	15		to red brown, dense, trace silt			

LOCATION SKETCH	DENSITY: GRANULAR:		DENSITY: COHESIVE:		PROPORTIONS:		REMARKS/WEATHER
See Plan	0-10	Loose	0-4	Soft	0-10%	Trace	70 F Sunny
	10-30	Med Dense	4-8	Med Stiff	10-20%	Little	
	30-50	Dense	8-15	Stiff	20-35%	Some	
	>50	Very Dense	15-30	Very Stiff	35-50%	And	

LOG STATUS:
PRELIMINARY: ______ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 4
PAGE 2 OF 2

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/18/2007
EAST	RIG CME 75	DATE FINISH 4/18/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 13.7'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 4'

SAMPLE TYPES:
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT)	BIT CASING	SAMP NO	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
10					18 18					
11							Augered to 12'			
12							11.0' to 12.0' - Cutting - SILT. Brown some sand, some gravel. Wet			
				16"/20"	10 22 42 50/2"		SS3 12' to 14'			
13	8.25" H.S.A						12.0 to 13.3' SILTSTONE. Grey very stiff, trace clay. Lightly weathered. Wet			
14	4.25" I.D.		END OF BOREHOLE							
15							13.3' to 13.7' NO RECOVERY END OF Borehole			
16							Monitoring well Installation (4/19/2007) 2" PVC 7-foot screen			
17							casing and lock MW-4 cap			
18							Riser -3 to 4.7' Concrete 0 to 2' screen 4.7' to 11.7' bentonite chip 2' to 4'			
19							Cap 11.7' to 12.0' Filtersand 4.0' to 13.7'			
20										

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
70F Sunny

LOG STATUS.
PRELIMINARY. ______ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 5
PAGE 1 OF 4

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/19/2007
EAST	RIG CME 75	DATE FINISH 4/19/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 31'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 14'

SAMPLE TYPES:
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
0										
							Augered to 4'			
1							0 to 4.0' - Cutting - SILT AND CLAY.			
							Brown, little sand, little gravel			
2							trace roots. Moist.			
3	8.25" H.S.A									
4							SS 1 4' to 6'			
	4.25" I.D.			20"	4		4.0' to 5.7' SILT. Brown, med stiff,			
5					4		some sand, little clay. Moist			
				24"	4		5.7' to 6.0' NO RECOVERY			
6					4		Augered to 9'			
							6.0' to 9.0' SILT. Brown, some			
7							sand, little clay. Moist			
8										
							SS 2 9' to 11'			
9										
				20"	3		9.0' to 10.7' CLAY. Brown, little			
10				24"	4		silt, little sand. moist			

LOCATION SKETCH	DENSITY: GRANULAR:		DENSITY: COHESIVE:		PROPORTIONS:		REMARKS/WEATHER
See Plan	0-10	Loose	0-4	Soft	0-10%	Trace	50F Windy Sunny
	10-30	Med Dense	4-8	Med Stiff	10-20%	Little	
	30-50	Dense	8-15	Stiff	20-35%	Some	
	>50	Very Dense	15-30	Very Stiff	35-50%	And	

LOG STATUS

PRELIMINARY ______ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 5
PAGE 2 OF 4

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/19/2007
EAST	RIG CME 75	DATE FINISH 4/19/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS –	TOTAL DEPTH 31'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 14'

SAMPLE TYPES:
- CT Cuttings
- [✓ SS] Split Spoon
- DC Dry Core
- Other
- WS Wash
- NX NX Core
- CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner –
Other –

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
10										
					4 4		10.7' to 11.0' NO RECOVERY			
11							Augered to 14'			
12							11.0' to 14.0' - Cutting - CLAY. Brown little silt, little sand, moist			
13	8.25" H.S.A									
14	4.25" I.D.						SS 3 14' to 16'			
15				12" / 24"	8 10 7 10		14.0' to 15.0' SAND AND GRAVEL. Brown med dense, trace silt, trace clay. Wet.			
16							15.0' to 16.0' NO RECOVERY			
							Augered to 19'			
17							16.0' to 19.0' - Cutting - SAND AND GRAVEL, trace silt, trace clay. Wet.			
18										
19							SS 4 19' to 21'			
				22"/24"	12 24		19.0' to 20.8' SAND AND GRAVEL. Brown, very dense, trace silt trace clay. Wet			
20										

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
50 F Windy
Sunny

LOG STATUS
PRELIMINARY
FINAL ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 5
PAGE 3 OF 4

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/19/2007
EAST	RIG CME 75	DATE FINISH 4/19/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 31'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 14'

SAMPLE TYPES:
CT Cuttings
SS Split Spoon
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BC	HS	Core
20					32		20.8' to 21.0' NO RECOVERY			
					34					
21							Augered to 24'			
22							21.0' to 24.0' - Cutting - SAND AND GRAVEL. Brown, trace silt, trace clay. Wet			
23	8.25" H.S.A									
24	4.25" I.D.						SS 5 24' to 26'			
				22"/24"	10		24.0' to 25.8' SAND AND GRAVEL. Brown, med. dense, little silt, little clay. Wet.			
25					12					
					12					
					12					
26							25.8' to 26.0' NO RECOVERY			
							Augered to 29'			
27							26.0' to 29.0' - Cutting - SAND AND GRAVEL. Brown, little silt, little clay. wet.			
28										
29							SS 6 29' to 31'			
				14"/24"	42		29.0' to 30.2' SILTSTONE. Brown to redbrown, very stiff, trace sand, trace clay. Moderately weathered			
30					40					

LOCATION SKETCH

See Plan

DENSITY:

GRANULAR:		COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
50F Windy
Sunny

LOG STATUS
PRELIMINARY: ______
FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 5
PAGE 4 OF 4

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/19/2007
EAST	RIG CME 75	DATE FINISH 4/19/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 31'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 14'

SAMPLE TYPES:

CT Cuttings	WS Wash
SS Split Spoon	NX NX Core
DC Dry Core	CS Continuous Sampler
Other	

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BC	HS	Core
-30										
					45		Wet.			
					50		30.2' to31.0' NO RECOVERY			
-31										
			END OF BOREHOLE				Augered to 29.5'			
							Add sand to 29.0'			
							End of Borehole			
	8.25"						Monitoring well Installation			
	H.S.A						2" PVC 10-foot screen			
							MW-5			
	4.25" I.D.									
							Casing and lock			
							cap			
							Riser -3 to 18.7' Concrete 0 to 3'			
							Screen 18.7' to 28.7' Bentonite chip 3' to 17'			
							Cap 28.7' to 29.0' filter sand 17' to 31.0'			
							Filter sand 4 bags			
							Bentonite 6.5 bags			
							Concrete 2 bags			

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
50F Windy
Sunny

LOC STATUS:
PRELIMINARY.
FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

Andy & Richard

BH NO. 6
PAGE 1 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/19/2007
EAST	RIG CME-75	DATE FINISH 4/19/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 25.3'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES.
CT Cuttings
[✓ SS] Split Spoon
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
0							Augered to 4'			
1							0 to 4.0' - Cutting - SILT AND CLAY Dark brown, little sand, trace roots, Moist			
2	8.25" H.S.A.									
3										
4							SS1 4' to 6'			
				19"/24"	2 2 2 2		4.0' to 5.6' CLAY. Brown, soft, little silt, little sand. Moist			
5	4.25" I.D.						5.6' to 6.0' NO RECOVERY			
6							Augered to 9'			
7							6.0' to 9.0' CLAY. Brown some sand, little silt. Moist			
8										
9							SS2 9' to 11'			
				14"/24"	3 2		9.0' to 10.2' SAND AND GRAVEL. Brown, loose, little stone up to 2-inch diameter trace silt trace clay. Wet			
10										

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
50 Windy
Sunny

LOG STATUS
PRELIMINARY: ____
FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 6
PAGE 2 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/19/2007
EAST	RIG CME 75	DATE FINISH 4/19/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 25.3'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner –
Other –

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
10					3 13		10.2' to 11.0' NO RECOVERY			
11							Augered to 14'			
12							11.0' to 14.0' - Cutting - SAND AND GRAVEL. Brown, some stones up to 2-inch diameter, trace silt, trace clay. Wet			
13	8.25" H.S.A									
14	4.25" I.D.			14"/24"	5 8 10 20		SS 3 14' to 16' 14.0' to 15.2' SAND AND GRAVEL. Brown, med dense, some stones up to 2-inch diameter, trace silt, trace clay. Wet			
15										
16							15.2' to 16.0' NO RECOVERY Augered to 19'			
17							16.0' to 19.0' - Cutting - SAND AND GRAVEL, some stones up to 2-inch diameter, trace silt, trace clay. Wet			
18										
19				14"/24"	6 8		SS 4 19' to 21'			
20							19.0' to 20.2' SAND AND GRAVEL. Brown med dense, some stones up to 2-inch diameter			

LOCATION SKETCH
See Plan

DENSITY: GRANULAR:		COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
50 Windy
Sunny

LOG STATUS
PRELIMINARY ______ FINAL ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT LaTarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 6
PAGE 3 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/19/2007
EAST	RIG CME 75	DATE FINISH 4/19/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 25.3'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES.
CT Cuttings
SS Split Spoon
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
20					20		trace silt, trace clay. Wet			
					30		20.2' to 21.0' NO RECOVERY			
21							Augered to 24'			
22							21.0' to 24.0' - Cutting - SAND AND			
	8.25"						GRAVEL. Brown, trace silt,			
23	H.S.A.						trace clay. Wet			
							SS 5 24' to 26'			
24	4.25'				10		24.0' to 25.3' SILTSTONE. Grey,			
25	I.D.				75		very stiff, little sand, trace			
	25.3'				50/3"		clay. Wet			
26				END OF BOREHOLE			END OF BOREHOLE			
							Monitoring well Installation			
							2' PVC 10 foot screen			
							MW-6			
				sand 3 bags						
				Bentonite 5 bags			Casing + Lock			
				Concrete 2 bags			cap			
							Riser -3 to 13.7' Concrete 0 to 3'			
							screen 13.7' to 23.7' Betonite chip 3' to 12'			
							clap 23.7' to 24' Filter sand 12' to 25.3'			

LOCATION SKETCH
See Plan

DENSITY: GRANULAR:		DENSITY: COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
50 F sunny
windy

LOG STATUS
PRELIMINARY: ______
FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

Andy & Richard

BH NO. 7
PAGE 1 OF 2

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/19/2007
EAST	RIG CME-75	DATE FINISH 4/19/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 16'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:
- CT Cuttings
- [✓ SS] Split Spoon
- DC Dry Core
- Other.
- WS Wash
- NX NX Core
- CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
0							Augered to 4'			
1							0 - 4.0' - Cutting - SILT AND CLAY. Dark brown, trace sand, trace rods. Moist			
2	8.25"									
3	H.S.A						SS 1 4' to 6'			
4				18"	2 2		4.0' to 5.5' CLAY. Brown, soft, some sand, trace silt. Moist			
5	4.25" I.D.			24"	2 2		5.5' to 6.0' NO RECOVERY			
6							Augered to 9'			
7							6.0' to 9.0' CLAY. Brown, some sand, trace silt, Moist			
8							SS 2 9' to 11'			
9				16"/24"	10 20		9.0' to 10.3' MEDIUM SAND. Brown dense, trace silt trace clay Wet.			
10										

LOCATION SKETCH

See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
50F Sunny
Windy

LOG STATUS:
PRELIMINARY ________ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO LF-0538

BOREHOLE LOG

BH NO. 7
PAGE 2 OF 2

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/19/2007
EAST	RIG CME 75	DATE FINISH 4/19/2007
GRD ELEV.	BITS 8.25" H.S.A. / FLUIDS –	TOTAL DEPTH 16'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner –
Other –

SURFACE CONDITION: Grass

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
10					20		10.3' to 11.0' NO RECOVERY			
					22					
11							Augered to 14'			
							11.0' to 14.0' - Cutting - CLAY.			
12							Grey, some sand, trace silt.			
							Wet			
13	8.25" H.S.A.									
							SS3 14' to 16'			
14	4.25" I.D.				12		14.0' to 15.7' CLAYSTONE. Grey.			
				20"/24"	25		very stiff, trace sand, trace			
15					27		silt. slightly weathered, very moist.			
					30		END OF BOREHOLE			
16			END OF BOREHOLE				MONITORING WELL INSTALLATION			
							2" PVC 8-foot screen			
17							MW-7			
							Casing & Lock			
18							cap			
							RISER -3 to 5.7' Concrete 0 to 2'			
19							screen 5.7' to 13.7' Bentonite 2' to 5'			
							cap 13.7' to 14.0' Filter Sand 5' to 16'			
20										

LOCATION SKETCH	DENSITY: GRANULAR:		DENSITY: COHESIVE:		PROPORTIONS:		REMARKS/WEATHER
See Plan	0-10	Loose	0-4	Soft	0-10%	Trace	50F Sunny Windy
	10-30	Med Dense	4-8	Med Stiff	10-20%	Little	
	30-50	Dense	8-15	Stiff	20-35%	Some	
	>50	Very Dense	15-30	Very Stiff	35-50%	And	

LOG STATUS:
PRELIMINARY: ____________
FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

Andy & Richard

BH NO. 8
PAGE 1 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/19/2007
EAST	RIG CME-75	DATE FINISH 4/19/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 18.3'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:
CT Cuttings
[✓ SS] Split Spoon
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
0										
							Augered to 4'			
1							0 to 4.0' - Cutting - SILT AND			
							CLAY. Dark brown. trace			
2							sand, trace roots. Moist			
	8.25"									
3	H.S.A.									
							SS 1 4' to 6'			
4					2		4.0' to 5.0' CLAY. Dark brown			
				16"	3		stiff, little sand, trace silt			
5	4.25" I.D.		SS	—	7		Moist			
				24"	9		5.0' to 5.3' SAND AND GRAVEL.			
6							Brown, med dense, trace silt. Moist			
							5.3' to 6.0' NO RECOVERY			
7							Augered to 9'			
							6.0' to 9.0' SAND AND GRAVEL			
8							Brown, some stones up to 2-inch			
							diameter, some clay. Very moist.			
9					7		SS 2 9' to 11'			
			SS	12"/24"	12		9.0' to 10.0' SAND AND GRAVEL.			
10							Brown, med dense, some stones			

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
50F Sunny
Windy

LOG STATUS:
PRELIMINARY ____ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 8
PAGE 2 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/19/2007
EAST	RIG CME 75	DATE FINISH 4/19/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 18.3'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
10										
					6		up to 2-inch diameter, trace			
					4		clay. Wet.			
11							10.0' to 11.0'. NO RECOVERY			
12							Augered to 14'			
							11.0' to 14.0' - Cutting - SAND AND			
13	8.25" H.S.A.						GRAVEL. Brown, some stones			
							up to 2-inch diameter. Wet			
14	4.25" I.D.						SS 3 14 to 16'			
			SS	18"/24"	5		14.0' to 15.5' SAND AND GRAVEL. Brown			
15					5		med. dense, some stones up to			
					10		2-inch diameter. Wet			
16					15		15.5' to 16.0' NO RECOVERY			
							Augered to 17'			
17							16.0' to 17.0' - Cutting - SAND AND			
				16"/16"	10		GRAVEL. Brown, some stone up to 2-inch diameter			
18	18.3'				30 50/4"		SS 4 17' to 19'			
			END OF		BOREHOLE		17.0' to 18.3' CLAYSTONE. Grey, very			
19							stiff, some siltstone, little sand.			
							Slightly weathered. Very moist.			
20										
							END OF BOREHOLE			

LOCATION SKETCH
See Plan

DENSITY: GRANULAR:		DENSITY: COHESIVE:		PROPORTIONS:	
0–10	Loose	0–4	Soft	0–10%	Trace
10–30	Med Dense	4–8	Med Stiff	10–20%	Little
30–50	Dense	8–15	Stiff	20–35%	Some
>50	Very Dense	15–30	Very Stiff	35–50%	And

REMARKS/WEATHER
50 F Sunny
Windy

LOG STATUS:
PRELIMINARY ______
FINAL ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 8
PAGE 3 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/19/2007
EAST	RIG CME 75	DATE FINISH 4/19/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 18.3'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
WS Wash
NX NX Core
CS Continuous Sampler
Other:

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BC	HS	Core
							Monitoring Well Installation			
							2" PVC 10-foot screen			
							MW-8			
	8.25"						casing and lock			
	H.S.A						cap			
							Riser -3 to 6.7' Concrete 0 to 2'			
	4.25'						screen 6.3' to 16.3' Bentonite Chip 2' to 5'			
	I.D.						cap 16.3' to 16.5' Filter sand 5' to 18.3'			

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
50 F Sunny
Windy

LOG STATUS
PRELIMINARY. ____________ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

Andy & Richard

BH NO. 9
PAGE 1 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/20/2007
EAST	RIG CME-75	DATE FINISH 4/20/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 16'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:

CT Cuttings	WS Wash
[✓ SS] Split Spoon	NX NX Core
DC Dry Core	CS Continuous Sampler
Other:	

SAMPLER SPECIFICATIONS:

Length 2.5'	Material steel
O.D. 2"	Liner —
I.D. 1.7"	Other —

SURFACE CONDITION: Grass

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
0										
							Augered to 4'			
1							0 to 4.0' - Cutting - SILT AND CLAY			
							Dark brown, trace sand.			
2							Moist			
3	8.25" H.S.A.									
4							SS1 4' to 6'			
			SS	16" 24"	3		4.0' to 5.3' SAND AND GRAVEL.			
5	4.25" I.D.				5		Brown, med dense, trace silt			
					7		trace clay. Moist			
6					7		5.3' to 6.0' NO RECOVERY			
							Augered to 9'			
7							6.0' to 9.0' - Cutting SAND AND			
							GRAVEL. Brown, trace silt,			
8							trace clay. Moist			
9							SS2 9' to 11'			
			SS	12" 24"	10		9.0' to 10.0' SAND AND GRAVEL.			
10					15		Brown, dense, some stone up to			
							2-inch diameter, trace silt.	Wet		

LOCATION SKETCH

See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER

50F Sunny

LOG STATUS

PRELIMINARY ____________ FINAL ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 9
PAGE 2 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/20/2007
EAST	RIG CME 75	DATE FINISH 4/20/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 16'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:
CT Cuttings
[✓ SS] Split Spoon
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT)	BIT CASING	SAMP NO	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
10					17 10		10.0' to 11.0' NO RECOVERY			
11							Augered to 14' 11.0' to 14.0' - Cutting - SAND AND GRAVEL. Brown, some stones up to 2-inch diameter			
12										
13	8.25" H.S.A									
14	4.25" I.D.						SS 3 14' to 16'			
15			SS	18"/24"	12 12 17 20		14.0' to 15.5' SILTSTONE. Grey. very stiff, trace sand, trace clay. Slightly weathered. very moist.			
16				END OF	BOREHOLE		Augered to 16' END OF BOREHOLE			
17										
18							Monitoring well Installation 2" PVC 10-foot screen MW-9			
19										
20										

LOCATION SKETCH
See Plan

DENSITY: GRANULAR:		COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
50 F Sunny

LOG STATUS
PRELIMINARY ______ FINAL ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT LaTarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 9
PAGE 3 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/20/2007
EAST	RIG CME 75	DATE FINISH 4/20/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 16'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BC	HS	Core
							Casing & Lock			
							Cap			
							Riser -3 to 5.7' Concrete 0 to 2'			
	8.25"						Screen 5.7' to 15.7' Bentonite chip 2' to 5'			
	H.S.A						Cap 15.7' to 16' Filter sand 5' to 16'			
	4.25"									
	I.D.						Concrete 1 bag			
							Sand 4 bags			
							Bentonite chip 2 bags			

LOCATION SKETCH
See Plan

DENSITY: GRANULAR:		COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
50F Sunny

LOG STATUS
PRELIMINARY. ________ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

Andy & Richard

BH NO. 10
PAGE 1 OF 2

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/20/2007
EAST	RIG CME-75	DATE FINISH 4/20/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 15.3'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 4'

SAMPLE TYPES
CT Cuttings
[✓ SS] Split Spoon
DC Dry Core
WS Wash
NX NX Core
CS Continuous Sampler
Other: ______

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
0							Augered to 4'			
1							0 to 4.0' - Cutting - CLAY. Dark			
							brown, some silt little sand			
2							trace roots. Moist			
	8.25"									
3	H.S.A									
							SS1 4' to 6'			
							4.0' to 5.3' SAND AND GRAVEL.			
4				16"	8		Brown, loose, some stones			
5	4.25"			-	4		up to 2-inch diameter, trace			
	I.D.			24"	3		silt. Wet			
6					3		5.3' to 6.0' NO RECOVERY			
							Augered to 9'			
7							6.0' to 9.0' - Cutting - SAND AND			
							GRAVEL. Brown, some stones			
8							up to 2-inch diameter, trace			
							silt. wet			
9							SS2 9' to 11'			
				18"	4		9.0' to 10.5' SAND AND GRAVEL.			
10				24"	7		Brown, loose; some stones			
							up to 2-inch diameter. wet			

LOCATION SKETCH
See Plan

DENSITY: GRANULAR:		COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER
60 F
Sunny

LOG STATUS:
PRELIMINARY: ______ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

BOREHOLE LOG

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BH NO. 10
PAGE 2 OF 2

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/20/2007
EAST	RIG CME 75	DATE FINISH 4/20/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 15.3'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 4'

SAMPLE TYPES:
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
WS Wash
NX NX Core
CS Continuous Sampler
Other:

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
10					3 15		10.5' to 11.0' NO RECOVERY			
11							Augered to 14'			
12							11.0' to 14.0' - Cutting - SAND AND GRAVEL. Brown, some silt wet			
13	8.25" H.S.A						SS3 14' to 16'			
14	4.25" I.D.			16"/16"	10 20 50/4"		14.0' to 15.3' SILTSTONE. Grey very stiff, little clay, little sand slightly weather. Very moist			
15	15.3'									
16			END OF BOREHOLE				END OF BOREHOLE			
17			Sand 4		bags		Monitoring Well Installation 2" PVC 10-foot screen			
18			Concrete		1 bag		MW-10 casing + Lock			
19			Bentonite chip		1 bag		cap Riser -3 to 3.7' Concrete 0 to 1.5'			
20							screen 3.7' to 13.7' Bentonite chip 1.5' to 3' Cap 13.7' to 14' Filter sand 3' to 15.3'			

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
60 F
Sunny

LOG STATUS
PRELIMINARY:
FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America

PROJECT LOCATION Windsor, CO

PROJECT NO. LF-0538

BOREHOLE LOG

Andy & Richard

BH NO. 11

PAGE 1 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/20/2007
EAST	RIG CME-75	DATE FINISH 4/20/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 17.3'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:

CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:

Length 2.5'
O.D. 2"
I.D. 1.7"
Material steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
0							Augered to 4'			
1							0 to 4.0' SILT AND CLAY. Dark brown, little sand, trace roots. Moist.			
2	8.25"									
3	H.S.A.						SS1 4' to 6'			
4				18"/24"	12		4.0' to 5.5' SAND AND GRAVEL. Brown, med dense, some stones up to 2-inch diameter trace silt.			
					12					
5	4.25" I.D.				17					
					20					
6							5.5' to 6.0' NO RECOVERY			
7							Augered to 9'			
							6.0' to 9.0' - Cutting - SAND AND GRAVEL. Brown, some stones up to 2-inch diameter, trace silt.			
8										
9				18"/24"	5		SS 2 9' to 11'			
10					9		9' to 10.5' SAND AND GRAVEL. Brown med dense, some stones up to			

LOCATION SKETCH

See Plan

DENSITY: GRANULAR:		DENSITY: COHESIVE:		PROPORTIONS:	
0-10	Loose	0-4	Soft	0-10%	Trace
10-30	Med Dense	4-8	Med Stiff	10-20%	Little
30-50	Dense	8-15	Stiff	20-35%	Some
>50	Very Dense	15-30	Very Stiff	35-50%	And

REMARKS/WEATHER

70 F sunny

LOG STATUS:

PRELIMINARY: ____ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 11
PAGE 2 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/20/2007
EAST	RIG CME 75	DATE FINISH 4/20/2007
GRD ELEV	BITS 8.25" H.S.A. | FLUIDS —	TOTAL DEPTH 17.3'
TOC ELEV	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:
CT Cuttings
[✓ SS Split Spoon]
DC Dry Core
Other:
WS Wash
NX NX Core
CS Continuous Sampler

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT)	BIT / CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
10					10		2-inch diameter, trace silt.			
					13		Wet			
11							Augered to 14'			
12							11.0' to 14.0' - Cutting - SAND AND			
							GRAVEL. Brown, some stones			
13	8.25"						up to 2-inch diameter, trace			
	H.S.A						silt. Wet			
14	4.25"						SS 3 14' to 16'			
	I.D.			20"	10		14.0' to 15.5' SAND AND GRAVEL.			
15				—	15		Brown med dense, little stones			
				24"	15		up to 2-inch diameter, trace			
					10		silt. Wet			
16				16"	18		15.5' to 15.7' SILTSTONE. Grey			
17	17.3'			16"	20 50/4"		stiff, little sand, moderately			
							weathered. Wet			
18			END OF BOREHOLE				15.7' to 16.0' NO RECOVERY			
							Augered to 16'.			
19							SS 4 16' to 18'			
							16.0' to 17.3' SILTSTONE. Grey very			
20							stiff, little sand, moderately			
							weathered. very moist			

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
70F Sunny

LOG STATUS
PRELIMINARY:
FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT LaTarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 11
PAGE 3 OF 3

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/20/2007
EAST	RIG CME 75	DATE FINISH 4/20/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 17.3'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:

CT Cuttings	WS Wash
SS Split Spoon	NX NX Core
DC Dry Core	CS Continuous Sampler
Other	

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

SOIL VAPOR PID ☐ FID ☐

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	BG	HS	Core
							END OF BOREHOLE			
							Monitoring Well Installation			
							2" PVC 10-foot screen			
							MW-11			
	8.25"									
	H.S.A						Casing & Lock			
							Cap			
	4.25"						Riser -3 to 5.7' Concrete 0 to 2'			
	I.D.						Screen 5.7' to 15.7' Bentonite chip 2' to 5'			
							cap 15.7' to 16' Filter Sand 5' to 17.3'			
							Concrete 1 bag			
							Bentonite chip 2 bags			
							Filter Sand 4 bags			

LOCATION SKETCH
See Plan

DENSITY:

GRANULAR:		COHESIVE:	
0-10	Loose	0-4	Soft
10-30	Med Dense	4-8	Med Stiff
30-50	Dense	8-15	Stiff
>50	Very Dense	15-30	Very Stiff

PROPORTIONS:

0-10%	Trace
10-20%	Little
20-35%	Some
35-50%	And

REMARKS/WEATHER
70F Sunny

LOG STATUS:
PRELIMINARY ______ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

Andy & Richard

BH NO. 12
PAGE 1 OF 2

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/20/2007
EAST	RIG CME-75	DATE FINISH 4/20/2007
GRD ELEV.	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 14.3'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:
- CT Cuttings
- [✓ SS] Split Spoon
- DC Dry Core
- WS Wash
- NX NX Core
- CS Continuous Sampler
- Other:

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT.)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV. FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
0							Augered to 4'			
1							0 to 4.0' - cutting - SILT AND CLAY,			
							Brown, trace sand, trace roots			
2							Moist.			
	8.25"									
3	H.S.A.									
							SS1 4' to 6'			
4				18"	1		4.0' to 5.5' FINE SAND. Brown to			
5	4.25" I.D.				2		red brown, loose, some silt,			
				24"	2		little gravel. Moist			
6					2		5.5' to 6.0' NO RECOVERY			
							Augered to 9'			
7							6.0' to 9.0' - Cutting - FINE SAND.			
							Brown to red brown, some silt,			
8							little gravel. Moist			
9							SS2 9' to 11'.			
				16"	8		9.0' to 10.3' MEDIUM SAND. Brown			
10				24"	8		med. dense, some silt, little			
							gravel. Wet.			

LOCATION SKETCH	DENSITY: GRANULAR:		DENSITY: COHESIVE:		PROPORTIONS:		REMARKS/WEATHER
See Plan	0-10	Loose	0-4	Soft	0-10%	Trace	70F Sunny
	10-30	Med Dense	4-8	Med Stiff	10-20%	Little	
	30-50	Dense	8-15	Stiff	20-35%	Some	
	>50	Very Dense	15-30	Very Stiff	35-50%	And	

LOG STATUS:
PRELIMINARY: ______ FINAL: ✓

EnviroGroup Limited
Centennial, Colorado

CLIENT Lafarge North America
PROJECT LOCATION Windsor, CO
PROJECT NO. LF-0538

BOREHOLE LOG

BH NO. 12
PAGE 2 OF 2

NORTH	DRILLER DRILLING ENGINEERS INC.	DATE START 4/20/2007
EAST	RIG CME 75	DATE FINISH 4/20/2007
GRD ELEV	BITS 8.25" H.S.A. FLUIDS —	TOTAL DEPTH 14.3'
TOC ELEV.	LOGGED BY Charoen S.	WATER DEPTH 9'

SAMPLE TYPES:

CT Cuttings	WS Wash
[✓ SS] Split Spoon	NX NX Core
DC Dry Core	CS Continuous Sampler
Other:	

SAMPLER SPECIFICATIONS:
Length 2.5'
O.D. 2"
I.D. 1.7"
Material Steel
Liner —
Other —

SURFACE CONDITION: Grass

DEPTH (FT)	BIT CASING	SAMP NO.	SAMP TYPE	RECOV FT/FT	BLOWS per 6"	SYM	SOIL/ROCK DESCRIPTION	SOIL VAPOR PID ☐ FID ☐ BG	HS	Core
10					12 16		10.3' to 11.0' NO RECOVERY Augered to 13'			
11							11.0' to 13.0' - Cutting - MEDIUM			
12							SAND, Brown, some silt, little gravel. WET			
13	8.25" H.S.A						SS 3 13' to 15'			
				SS	10 22 50/4"		13.0' to 14.3' SILTSTONE, Grey			
14	4.25" I.D.	14.3'					very stiff, little sand, little claystone. Moderately			
		END OF BOREHOLE					weathered. Very moist.			
15							Augered to 14'			
16							END OF BOREHOLE			
							MONITORING WELL INSTALLATION			
17	Sand		4 bags				2" PVC 8-foot screen			
	Bentonite		2 bags				MW-12			
18	Concrete		1 bag				Casing & Lock			
							cap			
19							Riser -3 to 5.7' Concrete 0 to 2'			
							screen 5.7' to 13.7' Bentonite chip 2' to 5'			
20							cap 13.7' - 14' Filter sand 5' to 14.3'			

LOCATION SKETCH	DENSITY: GRANULAR:		DENSITY: COHESIVE:		PROPORTIONS:		REMARKS/WEATHER
See Plan	0-10	Loose	0-4	Soft	0-10%	Trace	70F Sunny
	10-30	Med Dense	4-8	Med Stiff	10-20%	Little	
	30-50	Dense	8-15	Stiff	20-35%	Some	
	>50	Very Dense	15-30	Very Stiff	35-50%	And	

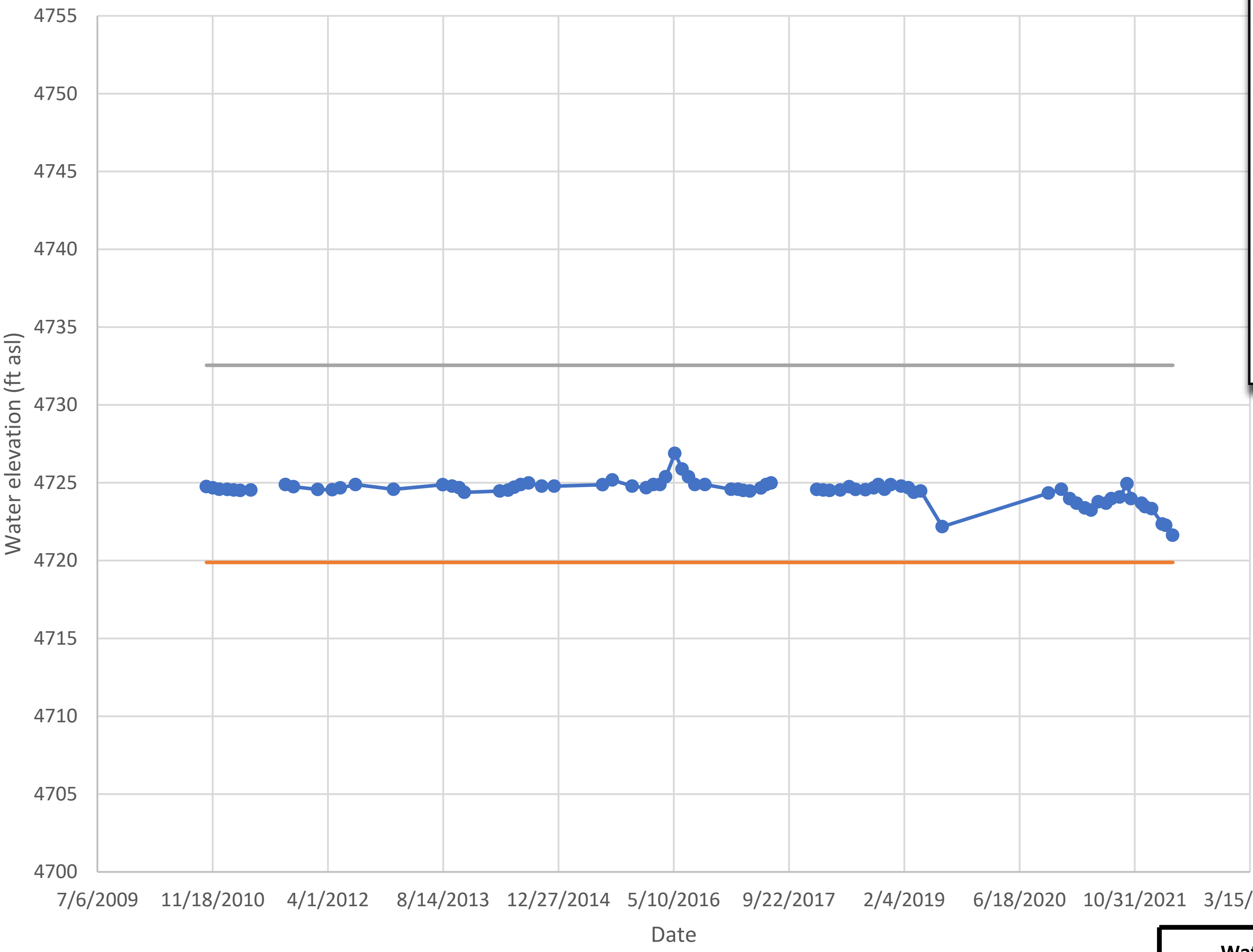
LOG STATUS:
PRELIMINARY ______ FINAL: ✓

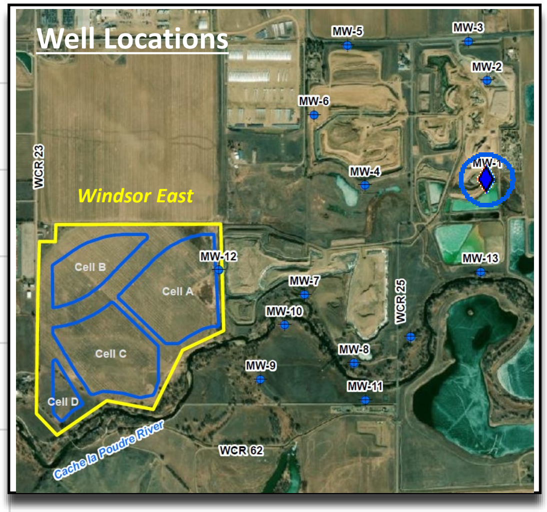
EnviroGroup Limited
Centennial, Colorado

APPENDIX G-2

WATER LEVEL ELEVATION TIME-SERIES GRAPHS (HYDROGRAPHS)

PARSONS MINE MONITORING WELLS





Land surface elevation = 4732.548 ft asl

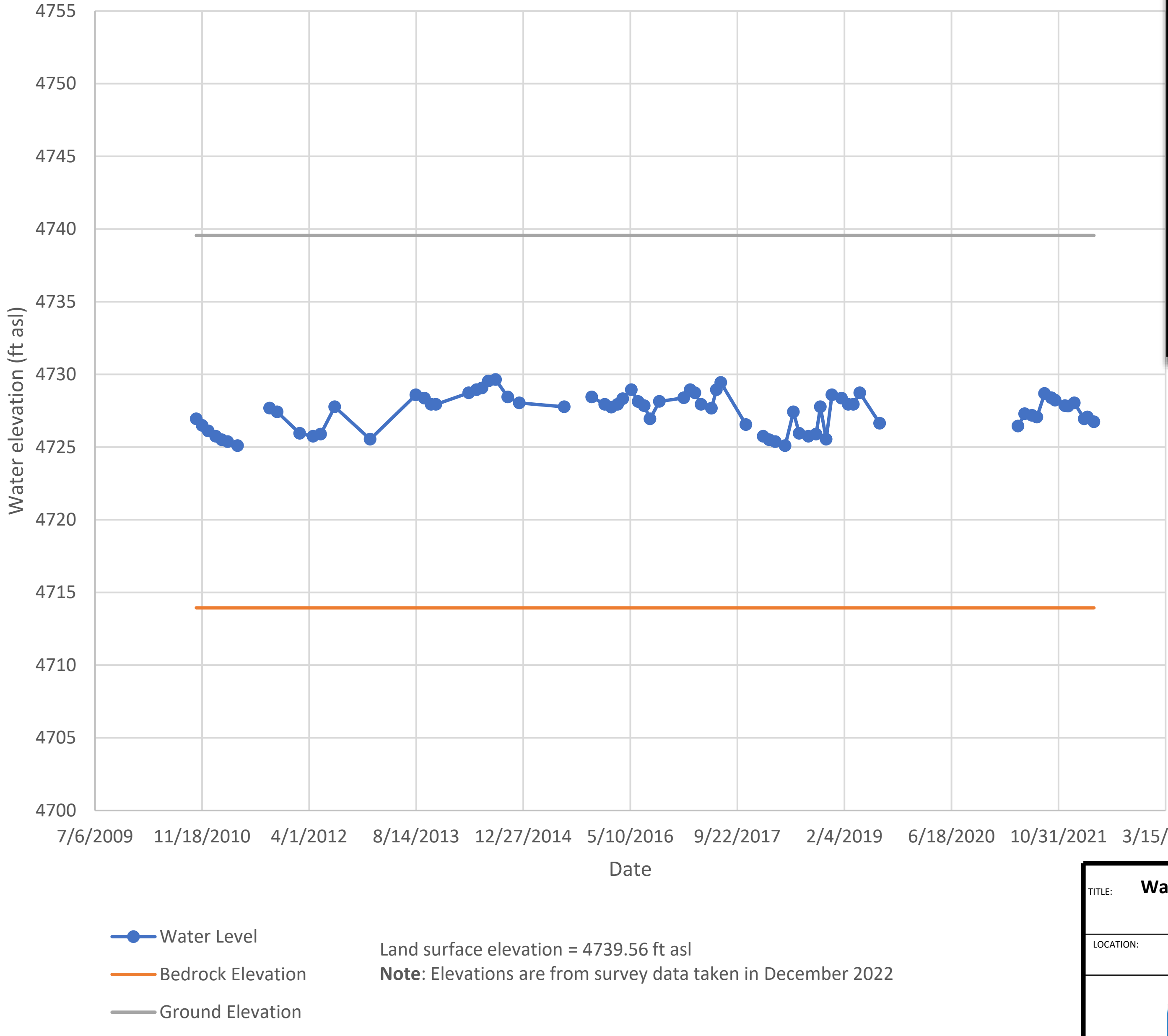
Note: Elevations are from survey data taken in December 2022

TITLE: **Water Level Elevation at Parson Monitoring Well MW-1**
MARTIN MARIETTA

LOCATION: **Windsor East Mine, Windsor, Colorado**

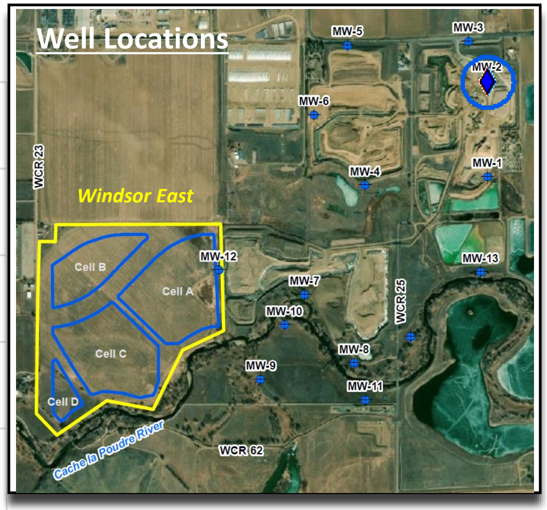
TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	G-1
PROJECT #	117-8741006	
DATE	08/01/2022	



Land surface elevation = 4739.56 ft asl

Note: Elevations are from survey data taken in December 2022

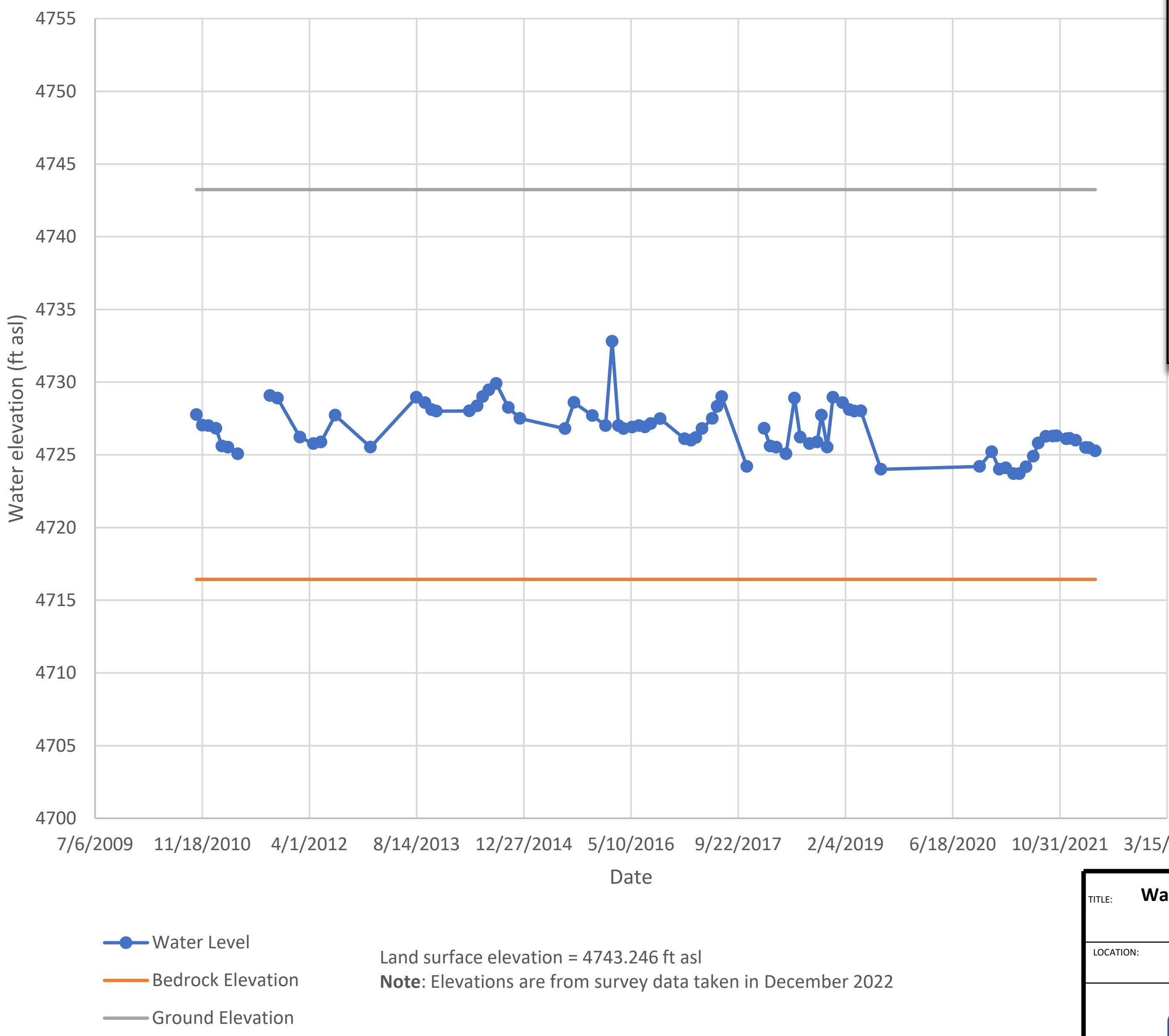


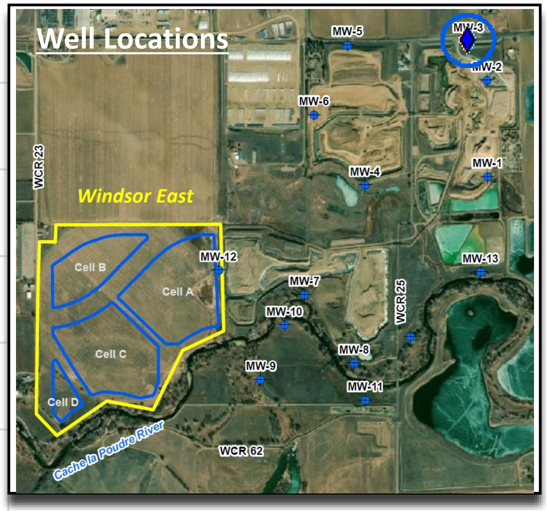
TITLE: **Water Level Elevation at Parson Monitoring Well MW-2**
MARTIN MARIETTA

LOCATION: **Windsor East Mine, Windsor, Colorado**

TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	G-2
PROJECT #	117-8741006	
DATE	08/01/2022	





Land surface elevation = 4743.246 ft asl

Note: Elevations are from survey data taken in December 2022

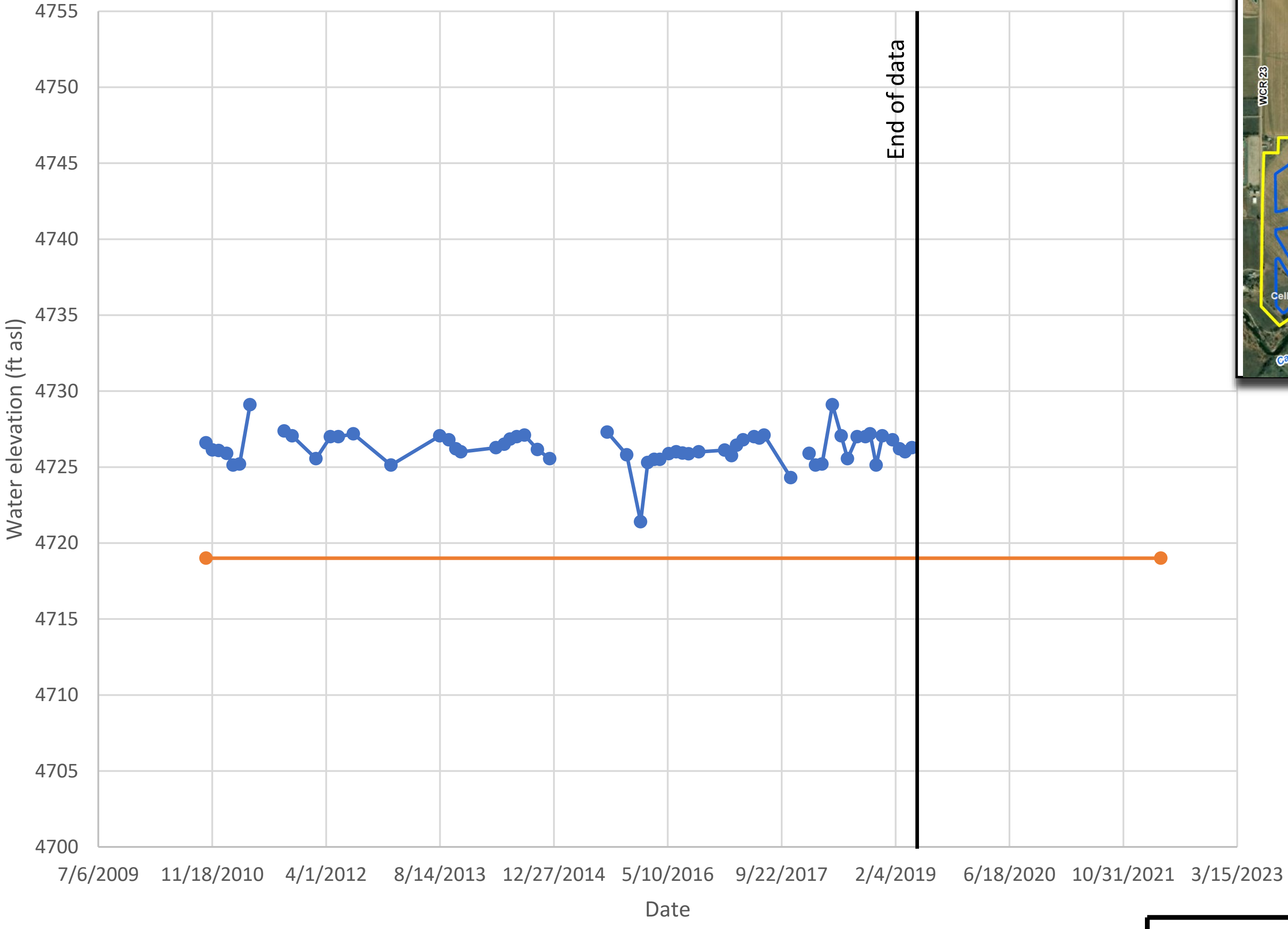
TITLE: **Water Level Elevation at Parson Monitoring Well MW-3**

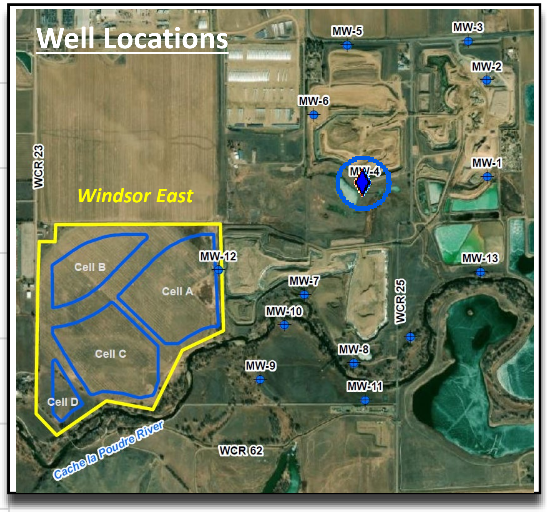
MARTIN MARIETTA

LOCATION: **Windsor East Mine, Windsor, Colorado**

TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	
PROJECT #	117-8741006	G-3
DATE	08/01/2022	





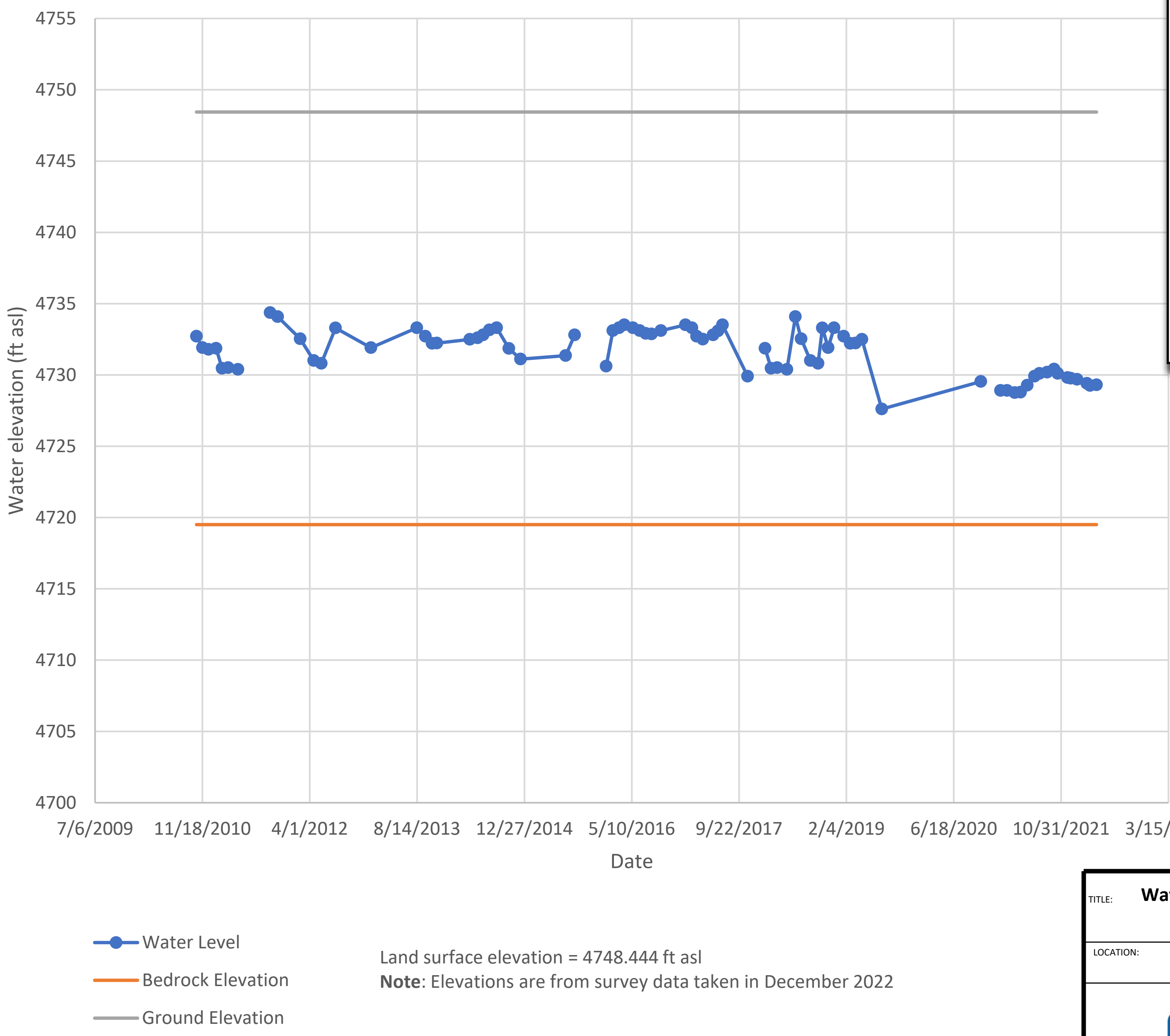
Land surface elevation = 4731 ft asl
Note: Elevations are referenced to the surface elevation provided by Martin Marietta, which is believed to be estimated from local topographic map contours. This well has since been destroyed.

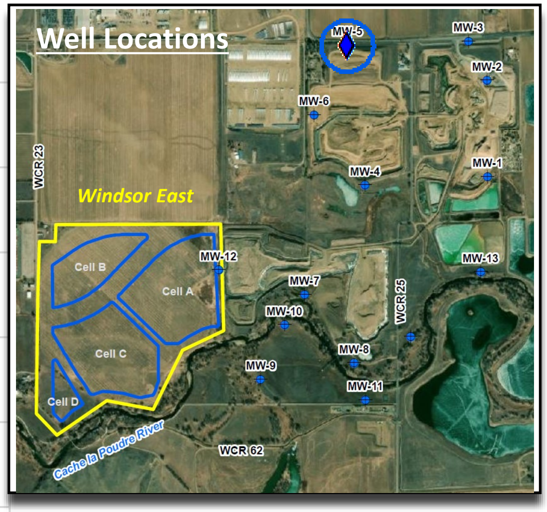
TITLE: **Water Level Elevation at Parson Monitoring Well MW-4**
MARTIN MARIETTA

LOCATION: **Windsor East Mine, Windsor, Colorado**

TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	
PROJECT #	117-8741006	G-4
DATE	08/01/2022	





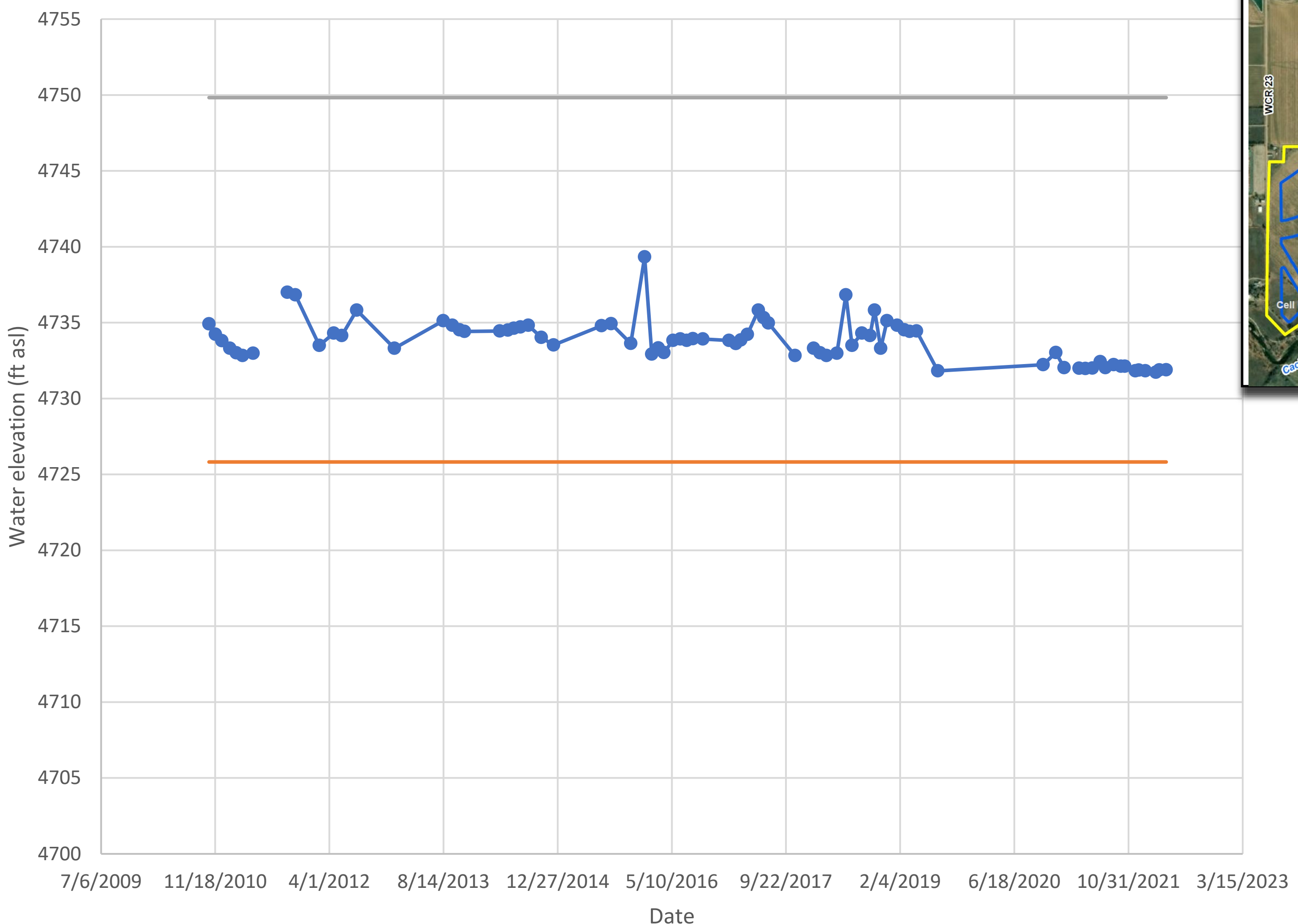
Land surface elevation = 4748.444 ft asl
Note: Elevations are from survey data taken in December 2022

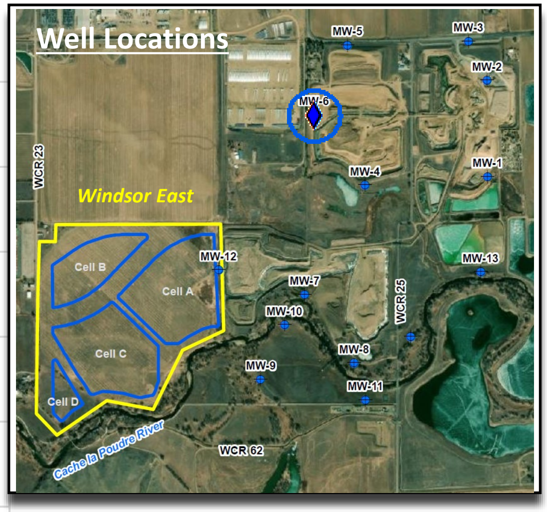
TITLE: **Water Level Elevation at Parson Monitoring Well MW-5**
MARTIN MARIETTA

LOCATION: **Windsor East Mine, Windsor, Colorado**

TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	G-5
PROJECT #	117-8741006	
DATE	08/01/2022	





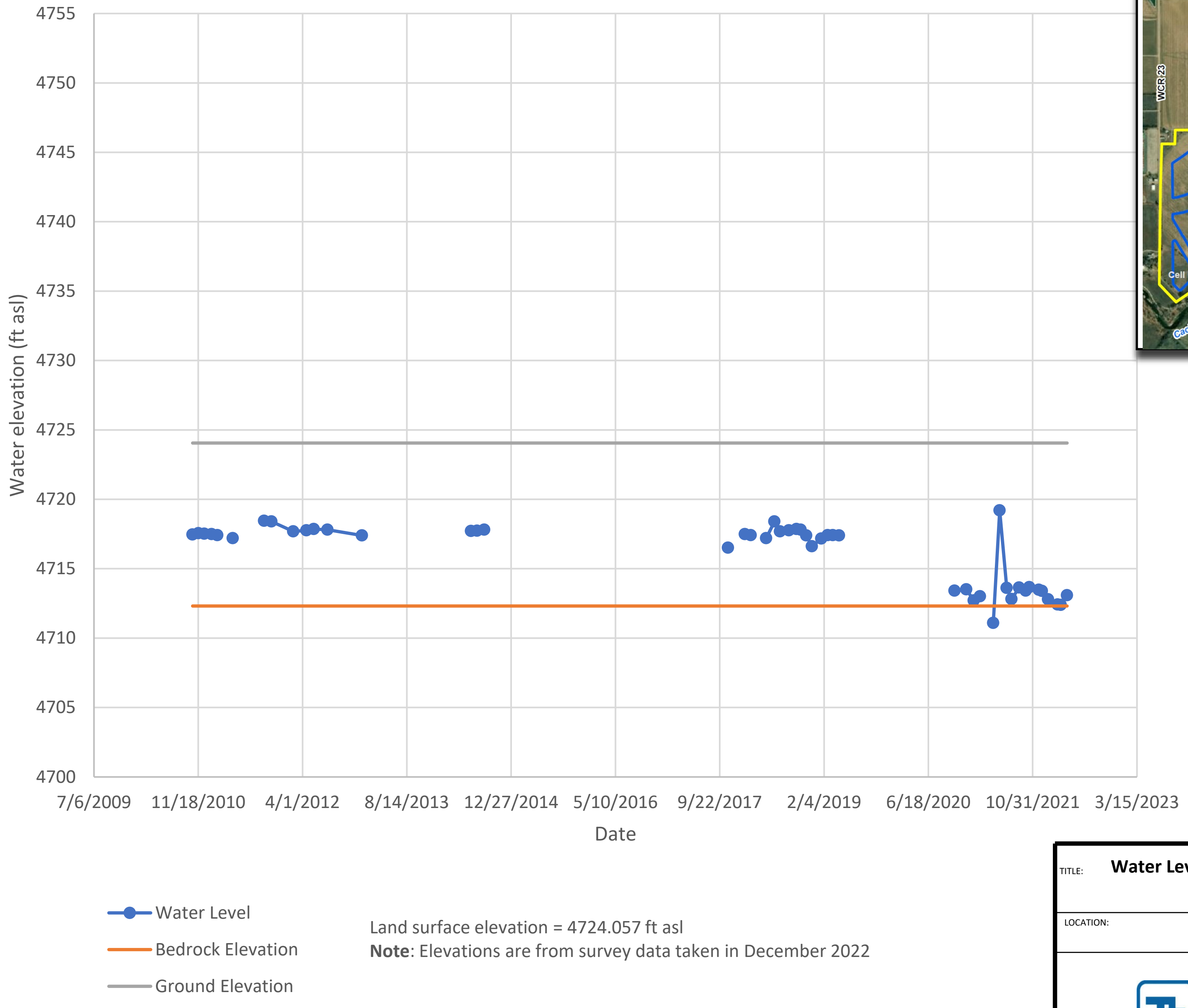
Land surface elevation = 4749.825 ft asl
Note: Elevations are from survey data taken in December 2022

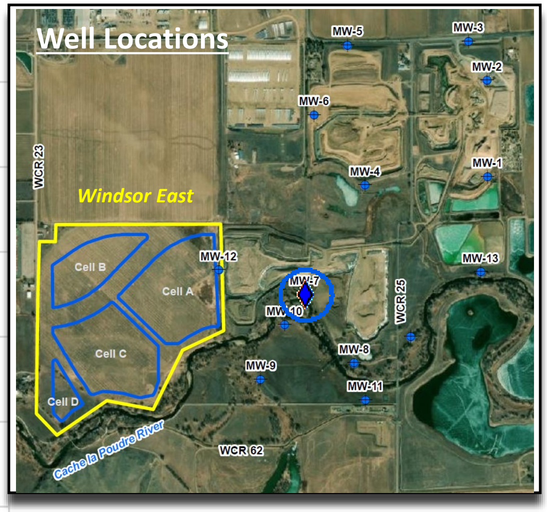
TITLE: **Water Level Elevation at Parson Monitoring Well MW-6**
MARTIN MARIETTA

LOCATION: **Windsor East Mine, Windsor, Colorado**

TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	
PROJECT #	117-8741006	G-6
DATE	08/01/2022	





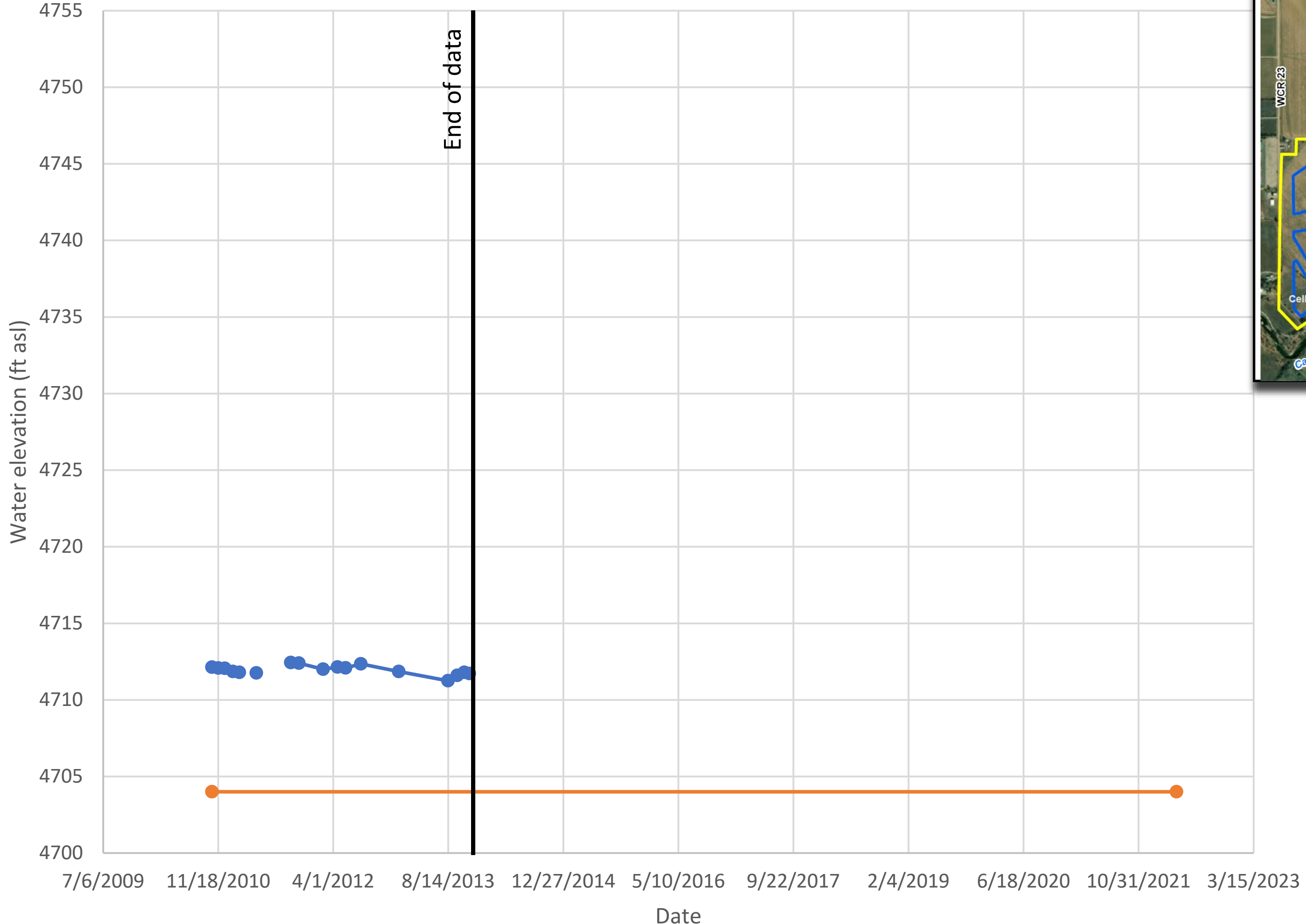
Land surface elevation = 4724.057 ft asl
Note: Elevations are from survey data taken in December 2022

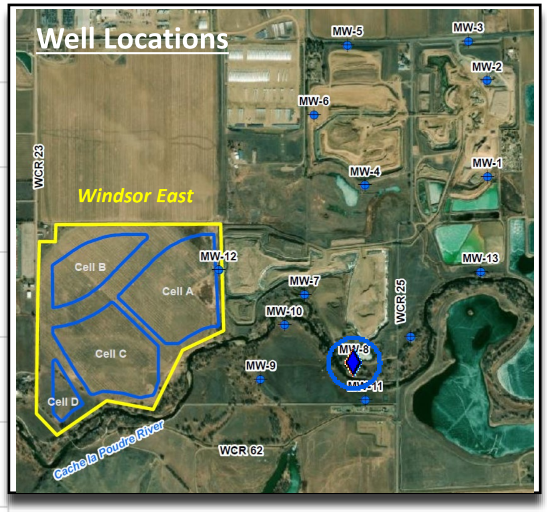
TITLE: **Water Level Elevation at Parson Monitoring Well MW-7**
MARTIN MARIETTA

LOCATION: **Windsor East Mine, Windsor, Colorado**

TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	G-7
PROJECT #	117-8741006	
DATE	08/01/2022	





Land surface elevation = 4721 ft asl

Note: Elevations are referenced to the surface elevation provided by Martin Marietta, which is believed to be estimated from local topographic map contours. This well has since been destroyed.

TITLE:

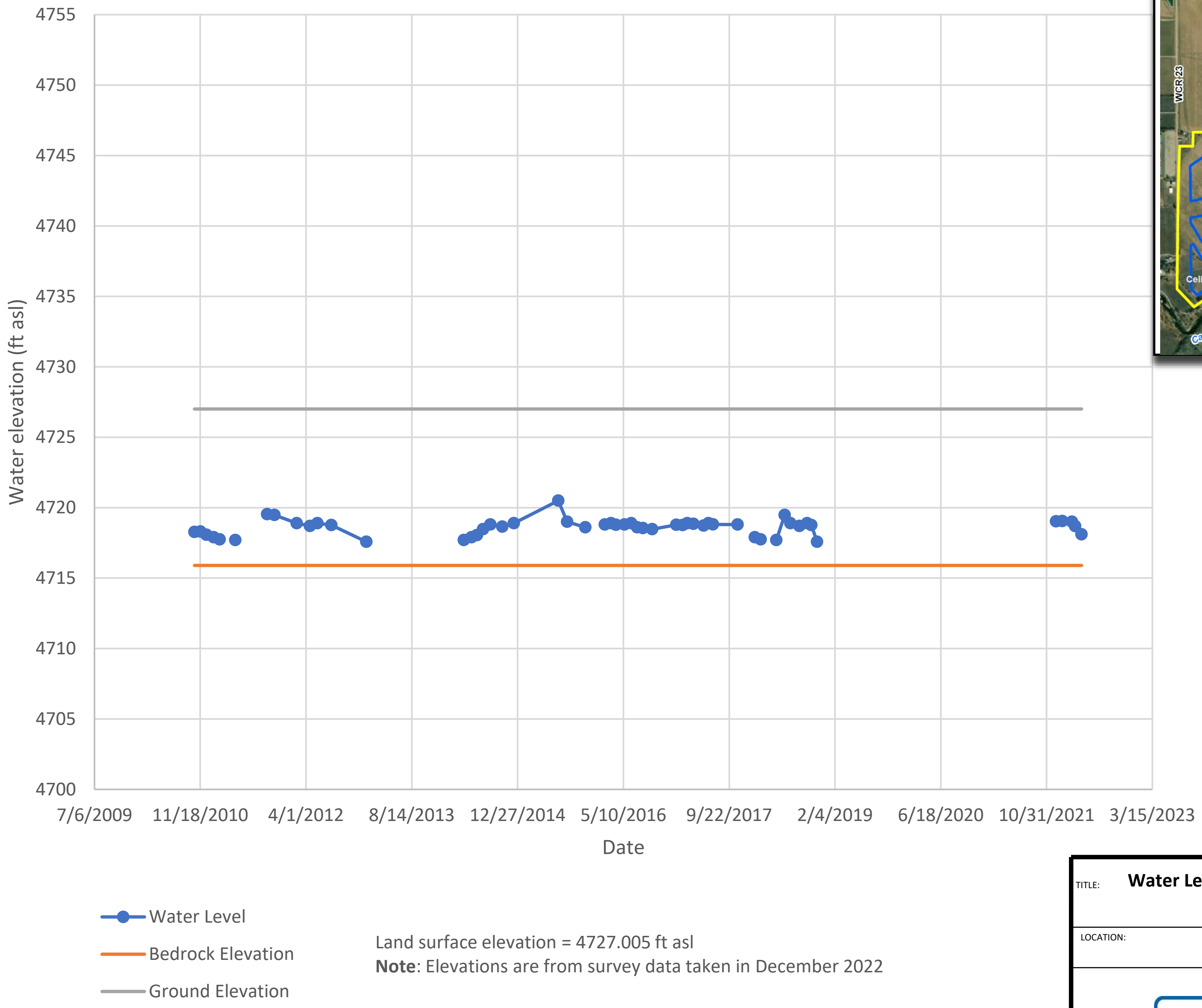
Water Level Elevation at Parson Monitoring Well MW-8
MARTIN MARIETTA

LOCATION:

Windsor East Mine, Windsor, Colorado

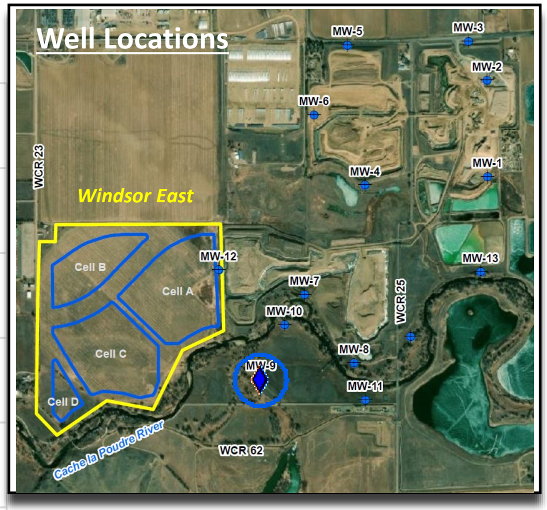
TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	
PROJECT #	117-8741006	G-8
DATE	08/01/2022	



Land surface elevation = 4727.005 ft asl

Note: Elevations are from survey data taken in December 2022

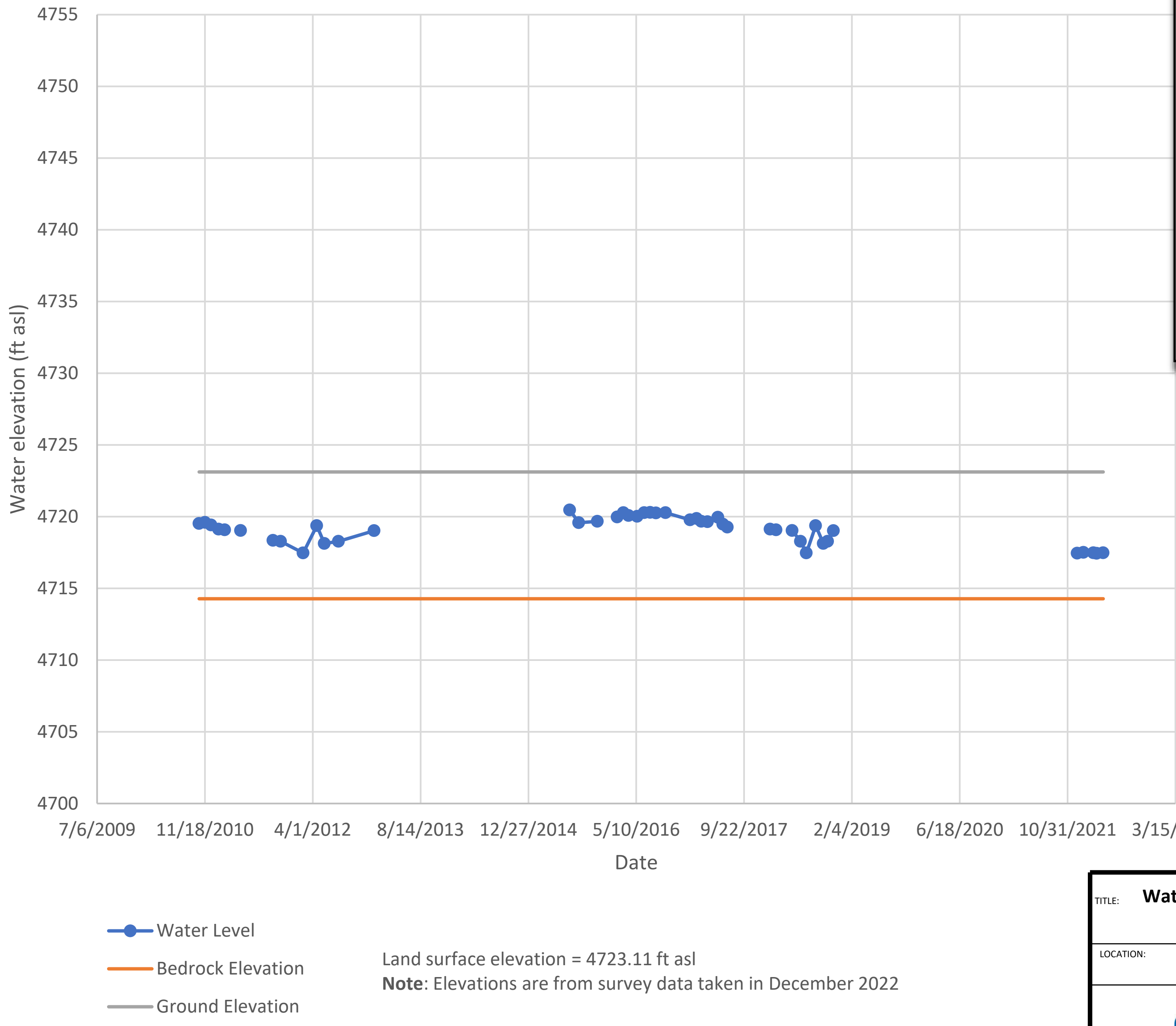


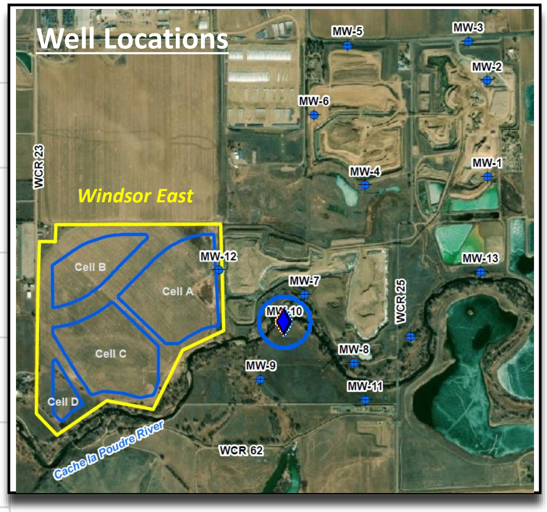
TITLE: **Water Level Elevation at Parson Monitoring Well MW-9**
MARTIN MARIETTA

LOCATION: **Windsor East Mine, Windsor, Colorado**

TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	
PROJECT #	117-8741006	G-9
DATE	08/01/2022	





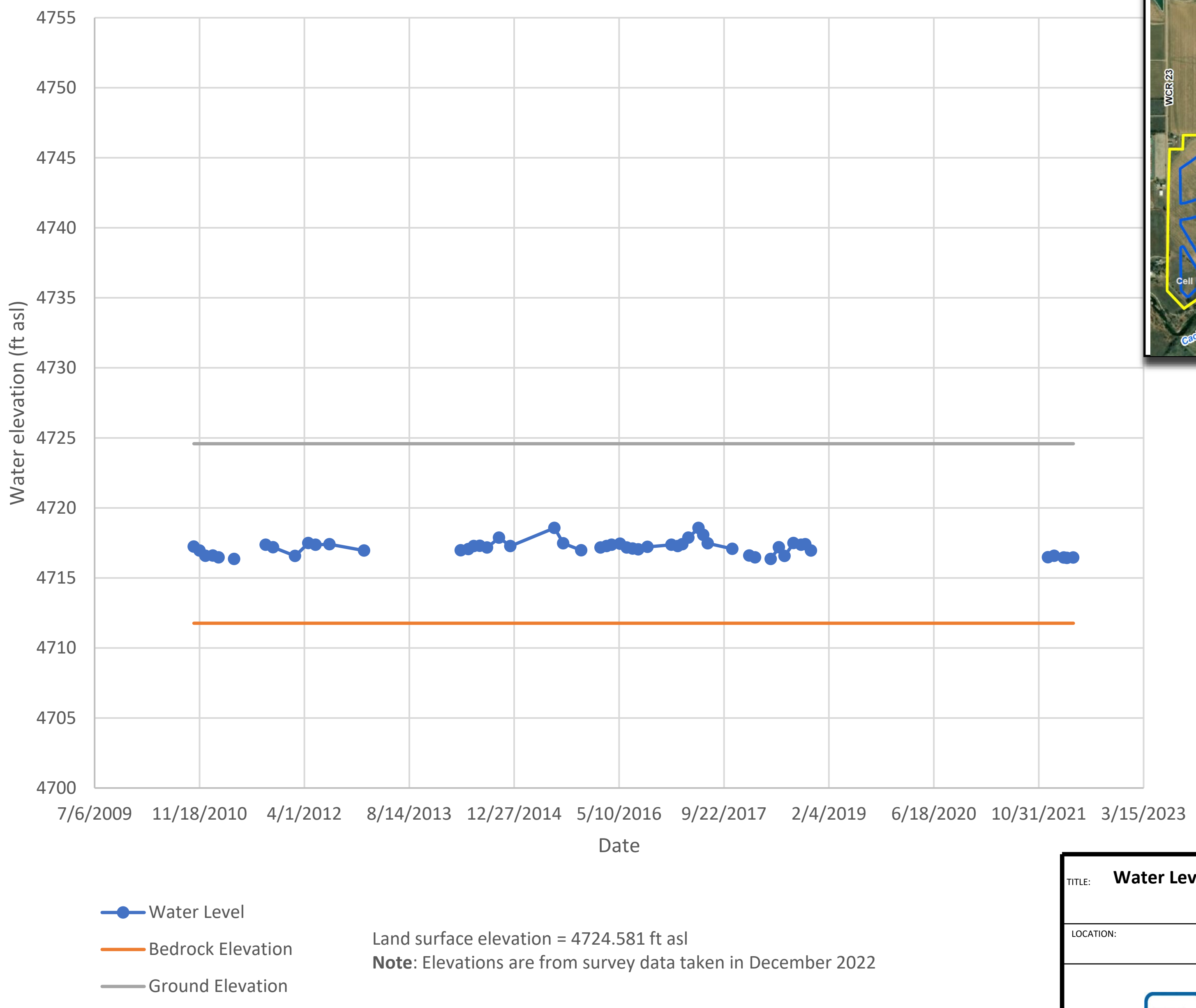
Land surface elevation = 4723.11 ft asl
Note: Elevations are from survey data taken in December 2022

TITLE: **Water Level Elevation at Parson Monitoring Well MW-10**
MARTIN MARIETTA

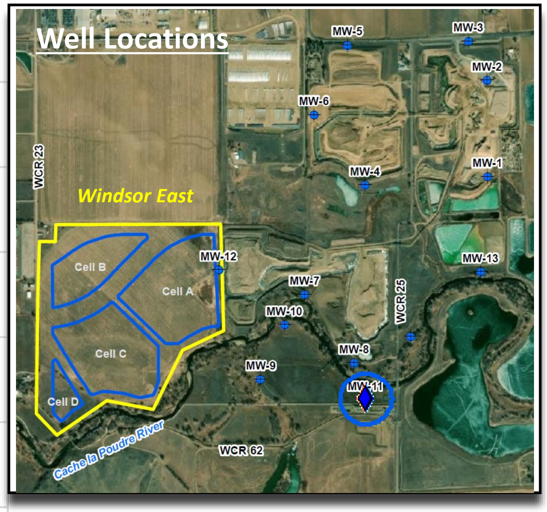
LOCATION: **Windsor East Mine, Windsor, Colorado**

TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	
PROJECT #	117-8741006	G-10
DATE	08/01/2022	



Land surface elevation = 4724.581 ft asl
Note: Elevations are from survey data taken in December 2022

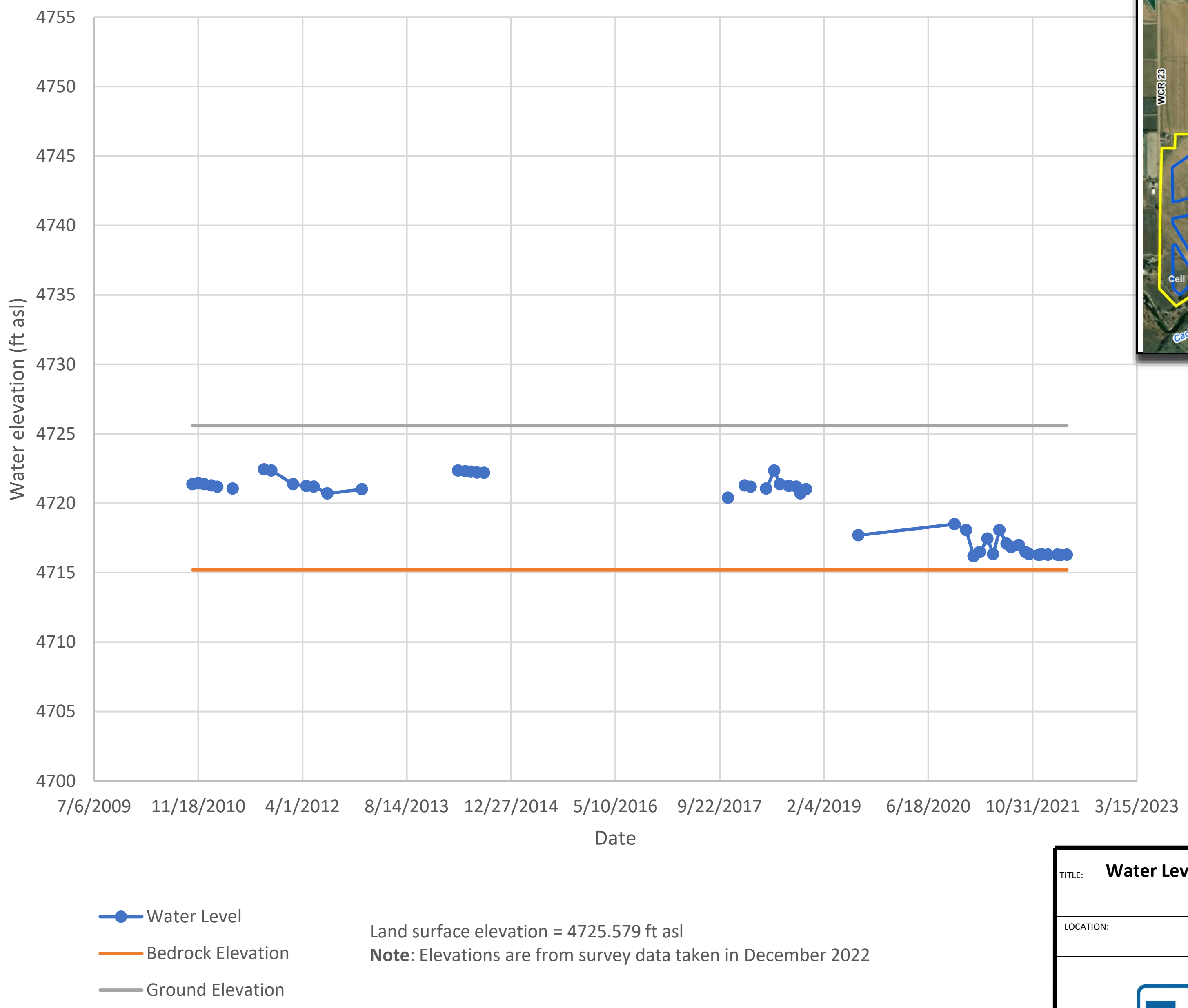


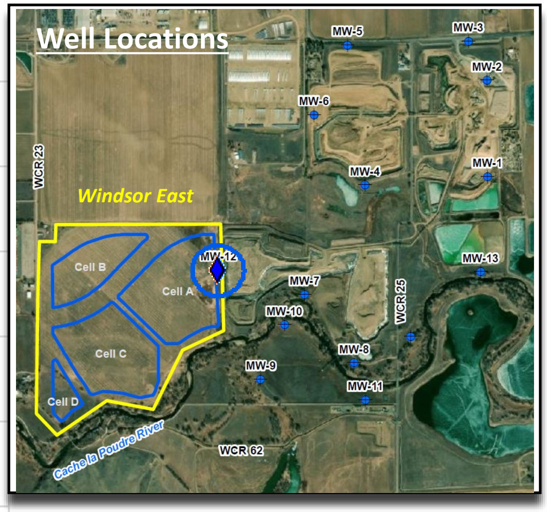
TITLE: **Water Level Elevation at Parson Monitoring Well MW-11**
MARTIN MARIETTA

LOCATION: **Windsor East Mine, Windsor, Colorado**

TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	
PROJECT #	117-8741006	G-11
DATE	08/01/2022	





Land surface elevation = 4725.579 ft asl

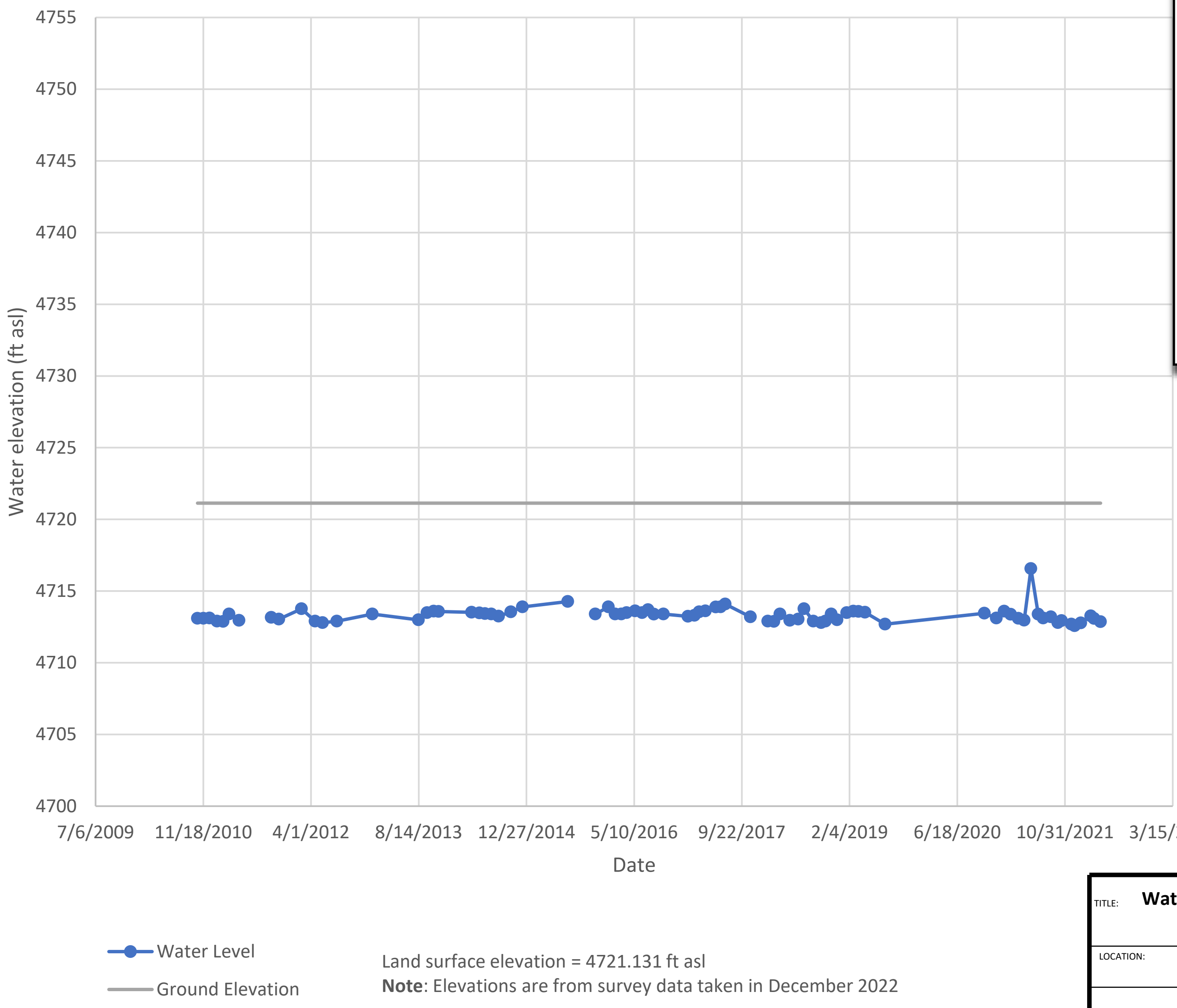
Note: Elevations are from survey data taken in December 2022

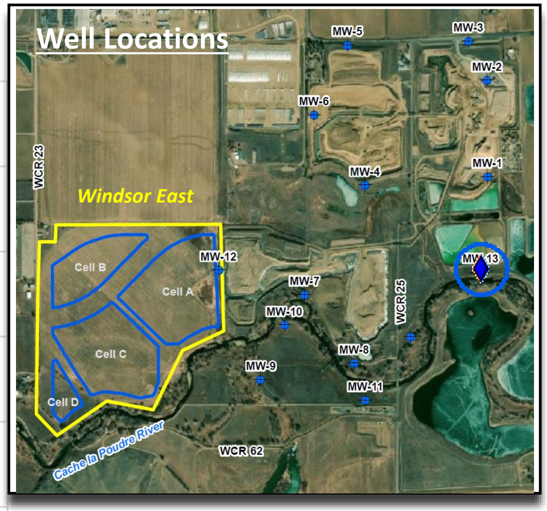
TITLE: **Water Level Elevation at Parson Monitoring Well MW-12**
MARTIN MARIETTA

LOCATION: **Windsor East Mine, Windsor, Colorado**

TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	
PROJECT #	117-8741006	G-12
DATE	08/01/2022	





Land surface elevation = 4721.131 ft asl

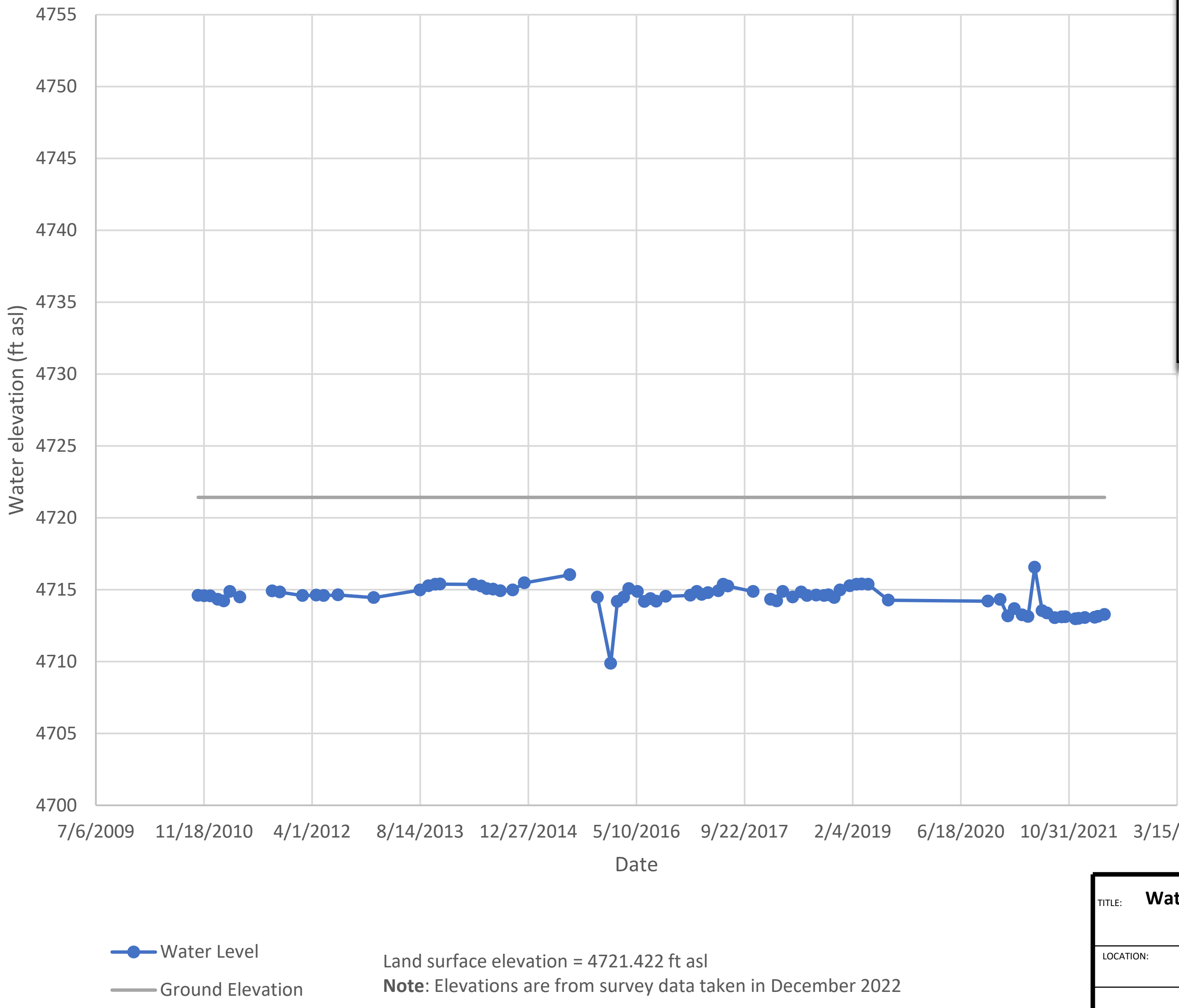
Note: Elevations are from survey data taken in December 2022

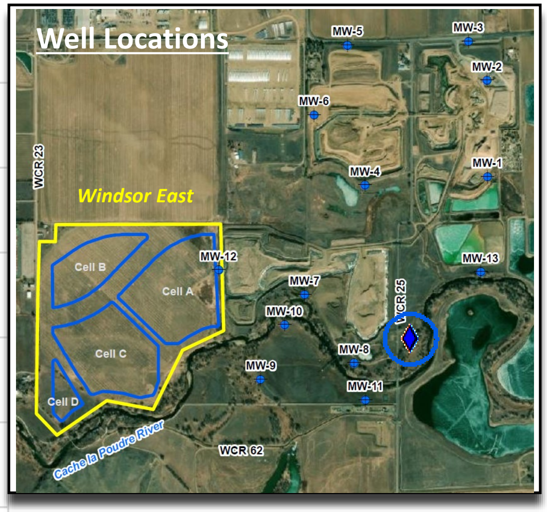
TITLE: **Water Level Elevation at Parson Monitoring Well MW-13**
MARTIN MARIETTA

LOCATION: **Windsor East Mine, Windsor, Colorado**

TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	
PROJECT #	117-8741006	G-13
DATE	08/01/2022	





Land surface elevation = 4721.422 ft asl

Note: Elevations are from survey data taken in December 2022

TITLE: **Water Level Elevation at Parson Monitoring Well MW-14**
MARTIN MARIETTA

LOCATION: **Windsor East Mine, Windsor, Colorado**

TETRA TECH

APPROVED	CG	FIGURE
DRAFTED	KG, DS	
PROJECT #	117-8741006	G-14
DATE	08/01/2022	

APPENDIX G-3

SAMPLE COLLECTION PROTOCOLS

ATTACHMENT G-3: GROUNDWATER MONITORING AND SAMPLE COLLECTION PROCEDURES

1.1 SCOPE AND APPLICATION

The purpose of this Standard Operating Procedure (SOP) is to provide guidance for determining the depth to water in a well using an electronic water level indicator. In this SOP, wells are defined as monitoring wells, piezometers, temporary well points, and potable wells. Permanent wells should be surveyed such that wells can be located and water elevations can be determined. At sites where there are multiple wells, a complete round of water level measurements should be collected site-wide prior to commencement of activities that will affect groundwater levels.

A permanent survey mark should be placed on the top of the well casing (TOC) as a reference point for groundwater level measurements. If the lip of the riser pipe/well casing is not flat, a notch can be made on the polyvinyl chloride (PVC) riser and used as the reference point. Alternatively, the reference point may be located on the top of the outer protective casing (if present). If using a measurement reference point, it must be documented in a site-specific logbook or on a field data sheet. All field personnel must be informed of the measurement reference point used to ensure the collection of consistent data.

1.2 WATER-LEVEL MONITORING

An electronic water-level indicator is used to measure the depth to water in each well. The indicator consists of a wired cable with a probe at the end. When the probe contacts water, the water completes a circuit causing the indicator to emit a sound at the surface. The water-level indicator should be turned on, then lowered until the probe emits a tone indicating contact with water. The distance from the water surface to the TOC should then be recorded using the gradational scale on the cable. The water level measurement should be recorded on a water-level monitoring field form or notebook, then the measurement should be repeated to confirm the reading. All measurements should be recorded to one hundredth (0.01) of a foot. It is important to record the date and time of each measurement along with the well identification and the depth-to-water value since water levels can vary over time. Water level measuring equipment will be cleaned of visible water and particulate matter prior to and after use at each measuring location via wiping/rinsing.

The groundwater elevation can then calculated by subtracting the depth-to-water measurement from the surveyed TOC elevation.

1.3 WATER QUALITY SAMPLE COLLECTION

The procedure for collecting a water quality sample involves the use of a pump or bailer to remove three well-volumes of water from the well to ensure that the water remaining is representative of aquifer water, then to use the pump or bailer to pass samples of water through a filter to remove suspended particles and collect the filtered sample in a bottle.

1.3.1 Well Purging

An adequate purge is normally achieved using this method by removing three well volumes of standing groundwater at relatively high flow rates prior to sampling while recording the pumping rate, discharge volume, water level and routine groundwater parameters over time. Routine groundwater parameters should include temperature, pH, and specific electrical conductance at a minimum, but may additionally include turbidity. It is assumed that stabilization of the groundwater measurements indicates the purge water is representative of ambient water from the underlying aquifer. Groundwater quality parameters are generally considered stabilized after three consecutive sets of readings do not vary by more than 10 percent (%), however the criteria for sample collection will be based on purge volume, rather than parameter stability. The time between readings (typically 5 to 10 minutes) should be chosen to ensure enough data have been collected to document the stability of parameters. If the calculated purge volume is large, measurements taken every 15 minutes may be adequate.

To calculate the volume of a well, use the following equation:

Well Volume (gallons) = πr2hk

where:

π = 3.14

r = radius of monitor well (feet)

h = height of the water column (feet). (This may be determined by subtracting the:

depth to water from the total depth of the well as measured from the same

reference point).

k = conversion factor, 7.48 gallons per cubic foot (gal/ft3)

The volume, in gallons per linear foot, for various standard monitoring well diameters (nominal):

Well diameter (inches)	2	3	4
Volume (gal/ft.)	0.1631	0.3670	0.6528

1.3.2 Sample Preservation and Containers

Groundwater samples will be collected in bottles which are chosen to be appropriate for the analysis by an analytical laboratory, and may be supplied directly by the laboratory. The analytical method specifies the type of bottle, preservative, holding time and filtering requirements for a groundwater sample. Samples should be collected, when possible, directly from the sampling device into appropriate sample containers, with an appropriate sample identification label. Record all pertinent data in a site-specific logbook and on a laboratory-supplied chain of custody (COC) record.

The samples should be placed in a cooler and maintained at less than or equal (≤) to 4 degrees Celsius (C) and protected from sunlight. Ideally, samples should be transported to the analytical laboratory within 24 hours of collection. If large numbers of samples are being collected, shipments may occur on a regular basis after consulting the analytical laboratory. In all circumstances, samples need to be analyzed before the holding time expires.

1.3.3 Sample Collection

After purging, groundwater samples may be collected using a bailer or the flow-stream from the pump. Samples collected for dissolved metals analysis require filtration. Groundwater is primarily filtered to exclude silt and other particulates from the samples that would interfere with the laboratory analysis. In-line filters (typically 0.45-micron) are used specifically for the preparation of groundwater samples for dissolved metals analysis, and for filtering large volumes of turbid groundwater. An in-line filter can be used with a peristaltic pump to transfer the sample from the original sample bottle, through the filter, and into a new sample container. The filter must be replaced between sampling locations.

The filters used in groundwater sampling are self-contained and disposable. Disposable filters are preferred and often used to reduce cross-contamination of groundwater samples. Disposable filter chambers are constructed of polypropylene material, with an inert filtering material within the housing.

The proper collection of a sample for VOC analysis requires minimal disturbance of the sample to limit volatilization. The following procedures are required to be used:

1. Open the vial, set cap in a clean place, and collect the sample. When collecting duplicate samples; collect both samples at the same time.

2. Fill the vial to almost overflowing. Do not rinse the vial, or let it excessively overflow. It needs to have a convex meniscus on the top of the vial before securing the cap.

3. Check that the cap has not been contaminated and place the cap directly over the top and screw down firmly. Do not over tighten the cap.

4. Invert the vial and tap gently. Observe vial for at least 10 seconds. If an air bubble appears, unscrew the cap and pop the bubble or refill with more sample then re-seal. Do not collect a sample with air trapped in the vial.

5. The holding time for unpreserved samples to be analyzed for VOCs is 7 or 14 days for preserved samples. Samples should be shipped or delivered to the laboratory as fast as practical in order to allow the laboratory time to analyze the samples within the holding time. Ensure that the samples are stored at ≤ 4 degrees C during transport but do not allow them to freeze.

1.3.3.1 Bailer Purging

Wells are typically purged using either pumps or bailing. Bailing is a process in which a plastic disposal bottom loading bailer with a string or thin rope attached is lowered by hand into a well, allowed to fill with water, and then retrieved. Once retrieved the water in the bailer is decanted into containers on the ground surface for subsequent disposal.

Manual bailing, or the use of dedicated or disposable bottom loading drop bailer approximating 3 feet in length and one liter storage capacity, attached by a string or rope to remove water from a small diameter well for well development and/or sampling is performed as follows:

- Open the well protector top, typically removing the protective lock and/or unbolting the cover, to access the well riser piping.
- Affix the bailer to the rope, string, or cord with a knotting technique that will ensure its permanent attachment and prevent bailer loss over the course of the purging cycle. Knots can loosen or slip when the rope becomes wet in conjunction with the application of the additional weight of the full bailer.
- Place the bailer in the well and lower it to the water table surface, slowly allowing the bailer to sink and fill with water (this avoids turbulent flow of water in the wells casing and minimizes off gassing).
- Retrieve the bailer by manually pulling the attached rope by either coiling it hand over hand or allowing it to collect onto the plastic sheeting on the ground until the bailer exits the well riser. Then grasp the bailer and decant the purge water into a bucket or other interim container. This procedure is repeated until the prescribed volume of water has been purged from the well.

1.3.3.2 Mechanical Pump Purging

Small diameter electric submersible pumps may be employed for some circumstances. Comparatively high volume pumps, such as a “Whale” or “Keck” model/brand employ a 12v battery or rechargeable power source may be used individually or in series to accommodate deep pumping situations or increase pumping volume.

Although this document does not provide a specific description for the use of each type of pump, the application and field use of a small diameter 12v pump such as a “Whale Pump” or equivalent is as follows:

- Measure the overall well depth and construct the pump with supply tubing “string” accordingly, allowing extra tubing length as necessary to accommodate discharge to storage and/or sampling containers. The electrical wire supply line should be of adequate gauge and constructed to a length sufficient to access a nearby power source. Multiple “in-line” pumps may be used in accordance with manufacturers suggested recommendations to facilitate an adequate pumping rate and volume in deep wells.

- Lower the supply tubing with attached pump(s) in the well to the desired depth, commonly near the well bottom or lower level of the screened interval. The pumping “string” can be affixed to a permanent object, typically the riser protective piping, with a small clamp to keep the pumps from contacting the bottom of the well or maintain a desired or prescribed sampling depth.

- Attached the electrical supply wires employing small clamps on the positive (+) and negative (-) battery terminal in the event a standard 12v automobile battery is utilized as power source or insert the plug to the cigarette plug-in if wired accordingly. There will be a short delay until the pumps engage and flow is actuated if wired correctly and the power source is adequate.

- As water flows from the supply tubing, place the purged water into an interim storage container, commonly a five-gallon bucket, for transport to a long term storage or staging area pending disposal analysis. The direct discharge of purged water may be warranted based on historical site findings or client direction.

- Continue with the pumping/storage/disposal routine until the desired or prescribed volume of water has been removed.

APPENDIX G-4

USGS WATER RESOURCE INVESTIGATIONS REPORT 02-4267

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Analytical and Numerical Simulation of the Steady-State Hydrologic Effects of Mining Aggregate in Hypothetical Sand-and-Gravel and Fractured Crystalline-Rock Aquifers

Water-Resources Investigations Report 02–4267

U.S. Department of the Interior
U.S. Geological Survey

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By L.R. Arnold, W.H. Langer, and S.S. Paschke

U.S. GEOLOGICAL SURVEY

Water-Resources Investigations Report 02–4267

Denver, Colorado
2003

U.S. DEPARTMENT OF THE INTERIOR
Gale A. Norton, Secretary

U.S. GEOLOGICAL SURVEY
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CONVERSION FACTORS AND ABBREVIATIONS

Multiply	By	To obtain
centimeter per year (cm/yr)	0.394	inch per year
cubic meter per day (m^3/d)	0.183	gallon per minute
meter (m)	3.281	foot
meter per day (m/d)	3.281	foot per day

Other abbreviations used in this report:

L	Length
T	Time
L/T	Length per time
L^2/T	Length squared per time

DEFINITION OF TERMS

Alluvium – Unconsolidated gravel, sand, silt, or clay deposited by streams or other moving water.

Anisotropic aquifer – Aquifer in which hydrologic properties vary with direction.

Aquifer – Water-bearing geologic material that will yield significant quantities of water to wells and springs.

Crystalline rock – General term for igneous and metamorphic rocks in contrast to sedimentary rocks.

Confined ground water – Ground water under pressure significantly greater than atmospheric because it is confined by relatively impermeable geologic materials bounding the aquifer.

Heterogeneous aquifer – Aquifer in which hydrologic properties vary by location.

Homogeneous aquifer – Aquifer in which hydrologic properties are identical at all locations.

Hydraulic conductivity – A measure of the ability of a unit area of geologic material to transmit water under a unit hydraulic gradient. It has dimensions of length per time.

Hydraulic conductance – A measure of the ability of a geologic material to transmit water per unit change of hydraulic head. It has dimensions of length squared per time.

Hydraulic head – Height of the free surface of a fluid body above a specified datum. It is a measure of the total mechanical energy per unit weight at a point in the fluid.

Isotropic aquifer – Aquifer in which hydrologic properties are independent of direction.

Saturated thickness – Thickness of that part of an aquifer in which all voids are filled with water under pressure greater than atmospheric.

Steady-state hydrologic conditions – Equilibrium conditions in which hydraulic head and flow do not change with time.

Transient hydrologic conditions – Nonequilibrium conditions in which hydraulic head and flow are time dependent.

Transmissivity – A measure of the ability of a unit width of aquifer to transmit water under a unit hydraulic gradient. It is the product of hydraulic conductivity and saturated thickness of the aquifer and has dimensions of length squared per time.

Unconfined ground water – Ground water in an aquifer with a free water table.

Analytical and Numerical Simulation of the Steady-State Hydrologic Effects of Mining Aggregate in Hypothetical Sand-and-Gravel and Fractured Crystalline-Rock Aquifers

By L.R. Arnold, W.H. Langer, *and* S.S. Paschke

Abstract

Analytical solutions and numerical models were used to predict the extent of steady-state drawdown caused by mining of aggregate below the water table in hypothetical sand-and-gravel and fractured crystalline-rock aquifers representative of hydrogeologic settings in the Front Range area of Colorado. Analytical solutions were used to predict the extent of drawdown under a wide range of hydrologic and mining conditions that assume aquifer homogeneity, isotropy, and infinite extent. Numerical ground-water flow models were used to estimate the extent of drawdown under conditions that consider heterogeneity, anisotropy, and hydrologic boundaries and to simulate complex or unusual conditions not readily simulated using analytical solutions.

Analytical simulations indicated that the drawdown radius (or distance) of influence increased as horizontal hydraulic conductivity of the aquifer, mine penetration of the water table, and mine radius increased; radius of influence decreased as aquifer recharge increased. Sensitivity analysis of analytical simulations under intermediate conditions in sand-and-gravel and fractured crystalline-rock aquifers indicated that the drawdown radius of influence was most sensitive to mine penetration of the water table and least sensitive to mine radius. Radius of influence was equally sensitive to changes in horizontal hydraulic conductivity and recharge.

Numerical simulations of pits in sand-and-gravel aquifers indicated that the area of influence in a vertically anisotropic sand-and-gravel aquifer of medium size was nearly identical to that in an isotropic aquifer of the same size. Simulated area of influence increased as aquifer size increased and aquifer boundaries were farther away from the pit, and simulated drawdown was greater near the pit when aquifer boundaries were close to the pit. Pits simulated as lined with slurry walls caused mounding to occur upgradient from the pits and drawdown to occur downgradient from the pits. Pits simulated as refilled with water and undergoing evaporative losses had little hydrologic effect on the aquifer. Numerical sensitivity analyses for simulations of pits in sand-and-gravel aquifers indicated that simulated head was most sensitive to horizontal hydraulic conductivity and the hydraulic conductance of general-head boundaries in the models. Simulated head was less sensitive to riverbed conductance and recharge and relatively insensitive to vertical hydraulic conductivity.

Numerical simulations of quarries in fractured crystalline-rock aquifers indicated that the area of influence in a horizontally anisotropic aquifer was elongated in the direction of higher horizontal hydraulic conductivity and shortened in the direction of lower horizontal hydraulic conductivity compared to area of influence in a homogeneous, isotropic aquifer. Area of influence was larger in an aquifer with ground-water flow in deep, low-permeability fractures than in a homogeneous, isotropic aquifer. Area of influence was larger for a quarry intersected by a hydraulically conductive fault zone and smaller for a quarry intersected by a low-conductivity fault zone. Numerical sensitivity analyses for simulations of quarries in fractured crystalline-rock aquifers indicated simulated head was most sensitive to variations in recharge and horizontal hydraulic conductivity, had little sensitivity to vertical hydraulic conductivity and drain cells used to simulate valleys, and was relatively insensitive to drain cells used to simulate the quarry.

INTRODUCTION

Sand, gravel, and crushed stone are the main sources of natural aggregate. During the year 2000, about 9,900 pits and quarries in the United States produced more than 2.7 billion tons of sand, gravel, and crushed stone (Bolen, 2002; Tepordei, 2002). In many places, natural aggregate lies below the water table, and the effects that mining this material may have on ground-water levels and flow directions are important concerns. The effects of mining aggregate below the water table depend upon the hydrologic properties of the aquifer system and the extent of mining, and predicting the effects of aggregate mining can be difficult because of the potentially complex and unknown nature of the ground-water system in which mining takes place.

The effects of mining can be simulated using analytical solutions or numerical models. Each method has advantages and limitations, and results can vary depending upon how the ground-water system is conceptualized and represented. Because of the uncertainties associated with predicting the hydrologic effects of aggregate mining, conflicts can occur among regulatory agencies, aggregate mining operators, and the public with regard to permitting new mines or predicting the effects of existing mines on nearby wells, wetlands, or streams.

During 2000–01, the U.S. Geological Survey, as part of the Front Range Infrastructure Resources Project (Knepper, 2002), conducted analytical and numerical simulations to study the potential hydrologic effects of mining aggregate below the water table in different hydrogeologic settings. This study seeks to provide information useful in predicting the effects of aggregate mining under various conditions and to assist in planning, managing, and regulating aggregate mine sites.

Purpose and Scope

The purposes of this report are to (1) demonstrate the potential hydrologic effects of mining aggregate below the water table under different hydrogeologic conditions, (2) compare the results of analytical and numerical simulations, and (3) evaluate the sensitivity of simulation results to parameters used in the simulations. A steady-state, one-dimensional analytical solution for ground-water flow to a quarry also is derived.

This report presents analytical and numerical simulations of the steady-state effects of mining aggregate below the water table in two hydrogeologic settings of the Front Range area of Colorado. One set of simulations used hydrogeologic conditions and mining scenarios representative of alluvial sand-and-gravel aquifers in the plains and foothills of the Front Range area. A second set of simulations used hydrogeologic conditions and mining scenarios representative of fractured crystalline-rock aquifers in the mountainous part of the Front Range area. Conceptualizations of each setting were used to provide insight into the magnitude and range of effects that may result from mining aggregate below the water table at real sites having hydrogeologic conditions similar to the conceptualizations. However, because the effects of mining at real sites depend upon site-specific hydrogeologic conditions that may differ from the conceptualizations, the effects of mining at real sites may differ from results presented here.

Analytical simulations were used to predict the extent of drawdown caused by a dewatered pit or quarry as a function of different hydrogeologic conditions (horizontal hydraulic conductivity and recharge) and mining extent (depth and radius/width) within a homogeneous, isotropic aquifer of infinite extent. Numerical simulations were used to predict the extent of drawdown caused by a dewatered pit or quarry under heterogeneous, anisotropic conditions with hydrologic boundaries and to simulate complex or unusual conditions not readily simulated using analytical solutions. Sensitivity analyses show how each parameter in the simulations affected simulation results.

Acknowledgments

Thanks are extended to Curtt Coppage of Aggregate Industries for providing access to mine sites where useful mining information was obtained. Thanks also are extended to Dan Knepper and Roger Melick of the U.S. Geological Survey for their assistance in developing the conceptualizations used in this study. Technical assistance from Ned Banta, Ken Watts, and Alan Burns of the U.S. Geological Survey was very valuable to the completion of the study and is gratefully acknowledged.

HYDROGEOLOGIC SETTINGS

The Colorado Front Range area (fig. 1) straddles the boundary of the Southern Rocky Mountains and the Colorado Piedmont section of the Great Plains in northeastern Colorado (Fenneman, 1946). The Colorado Piedmont separates the Rocky Mountains from the High Plains and contains most of the State's population. The topography of the Colorado Piedmont part of the Front Range area generally has low relief (tens of meters) in comparison to the topography of the mountainous part, which has relief of hundreds of meters.

Because of differences in topography, aspect (sun exposure), and altitude between the Colorado Piedmont and the adjacent Front Range of the Rocky Mountains, the climate of the Colorado Front Range area is varied. The climate of the Colorado Piedmont part of the Front Range area is semiarid temperate continental with average annual precipitation that varied with geographic location and ranged from about 25 to 50 cm/yr during 1961–90 (Western Regional Climate Center, 1997). Average annual pan evaporation for the same area ranged from about 140 to 180 cm/yr during 1946–55 (Robson and Banta, 1995). By contrast, the climate of the Rocky Mountain part of the Front Range area is subhumid (Fenneman, 1946) with average annual precipitation that varied with geographic location and ranged from about 40 to 65 cm/yr during 1991–2000 (Western Regional Climate Center, 1997). Average annual pan evaporation for the Rocky Mountain part of the Front Range area ranged from about 125 to 165 cm/yr during 1946–55 (Robson and Banta, 1995). The Colorado Front Range area is drained primarily by the South Platte River and its tributaries (fig. 1).

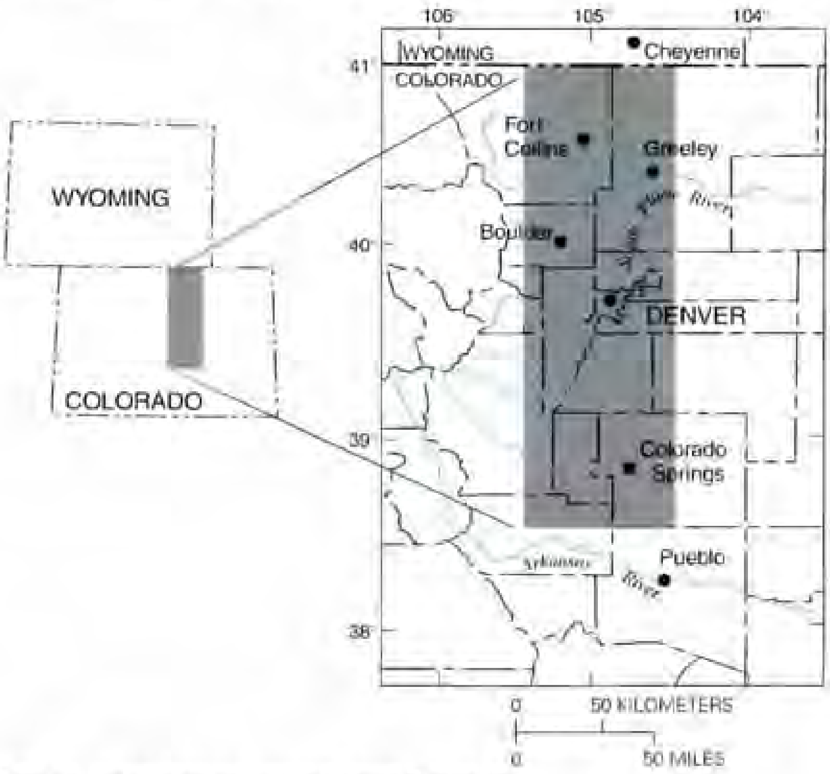


Figure 1. Index map of Colorado Front Range area.

Aggregate mining in the Colorado Front Range area takes place primarily within two distinct hydrogeologic settings: (1) alluvial sand and gravel deposits in the Colorado Piedmont and (2) fractured crystalline rock in the Rocky Mountains. About two-thirds of the aggregate in the Front Range area is sand and gravel from alluvium and about one-third is crushed stone from fractured crystalline rock (Wilburn and Langer, 2000).

Sand-and-Gravel Aquifers

Alluvial deposits in the Colorado Front Range area can be separated into four major landforms (Colton, 1978; Crosby, 1978; Trimble and Machette, 1979) (fig. 2). From highest (oldest) to lowest (youngest), the major alluvial landforms are (1) alluvial fans and pediments, (2) high dissected terraces, (3) high continuous terraces, and (4) flood plain and low terraces. Sand and gravel are mined for aggregate in each of these landforms, but because mining does not commonly penetrate the water table in alluvial fans, pediments, or high dissected terraces, only flood plains, low terraces, and high continuous terraces are represented in this study. Flood-plain, low-terrace, and high-continuous-terrace deposits are composed of clay, silt, sand, gravel, and cobbles; but sediments consist primarily of sand and gravel in areas where aggregate mining occurs. The alluvial sediments commonly are stratified, but stratification is variable.

The sand-and-gravel aquifers of flood plains, low terraces, and high continuous terraces range in width from about 700 to 9,000 m and have a saturated thickness of 0 to more than 30 m (Sheet 4 in Robson, 1996; Robson, Arnold, and Heiny, 2000a and b; Robson, Heiny, and Arnold, 2000a and b). The top of the aquifer is the water table, and the base of the aquifer is bounded by sedimentary bedrock that, on average, is 200–300 times less permeable than the alluvial sediments, which have hydraulic conductivities ranging from about 10 to 1,000 m/d (Robson, 1989; Wilson, 1965). Average water-table gradients in alluvial valleys generally range from 0.002 along

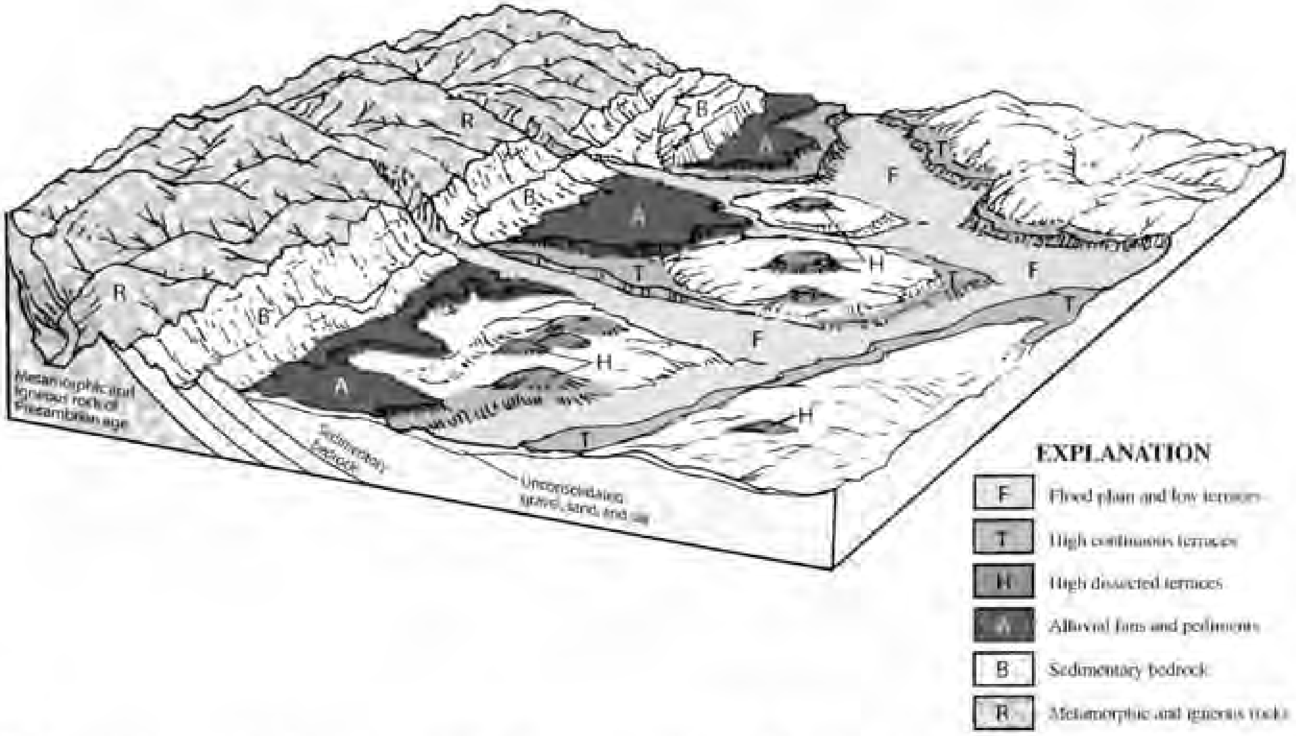


Figure 2. Alluvial and crystalline-rock landforms in the Colorado Front Range area (modified from Crosby, 1978).

downstream reaches of principal rivers to 0.007 along reaches of major tributaries nearer the mountain front (Sheet 3 in Robson, 1996; also Robson, Arnold, and Heiny, 2000a and b and Robson, Heiny, and Arnold, 2000a and b). Water-table gradients generally are steeper along hillslopes between valleys. Ground-water flow in the aquifers generally is down the valley and toward streams. Aquifer recharge is from infiltration of precipitation and irrigation or from inflow of water from adjacent alluvial aquifers or underlying bedrock aquifers (Robson and Banta, 1995). Precipitation recharge to an alluvial aquifer in the Colorado Piedmont near the Front Range has been estimated to be about 5 percent of the total annual precipitation (Buckles and Watts, 1988; Goeke, 1970). Discharge from the alluvial aquifer occurs primarily to the South Platte River and to wells (Robson and Banta, 1995).

Sand and gravel are excavated using both dry and wet mining techniques (Langer, 2001). If the excavation does not penetrate the water table, gravel is mined dry and can be extracted by using conventional earth-moving equipment such as bulldozers, front loaders, and track hoes. If the excavation penetrates the water table and the pit is mined dry, water will be pumped or otherwise removed from the pit. Water removed from the pit lowers the water table in the vicinity of the pit and may affect water levels or flow in nearby wells, wetlands, and streams. In some cases, slurry walls are constructed around the perimeter of a pit to isolate it from the surrounding aquifer. If the excavation penetrates the water table, and the pit cannot be drained, gravel may be mined wet by using draglines, clamshells, bucket and ladder, or hydraulic dredges.

Fractured Crystalline-Rock Aquifers

Precambrian metamorphic rocks (including quartzite, schist, gneiss, and amphibolite; fig. 2) and igneous rocks (including granite, granodiorite, monzonite, diorite, and pegmatite) form the mountains of the Colorado Front Range in the western part of the study area (see summaries in Colton, 1978; Trimble and Machette, 1979). Bedrock in the Front Range is broken by numerous faults that differ greatly in size, orientation, and attitude. Away from fault zones, many metamorphic and igneous rocks are hard and dense, a characteristic that makes both rock types important sources of crushed stone for use in Front Range communities. Within fault zones, the crystalline rocks are extensively fractured and faulted. Faults or fault zones may be more permeable than the surrounding rock and provide a conduit for ground-water flow, or they may be mineralized and constitute barriers to flow.

Ground water in fractured crystalline-rock aquifers is present in discrete fractures and fissures within the rock rather than in continuous, interconnected pore spaces as in sand-and-gravel aquifers. Fractured crystalline-rock aquifers may be discontinuous at a scale of a few meters or tens of meters because fractures are not locally interconnected. However, fractured crystalline-rock aquifers may be continuous at a regional scale because some local fractures may be connected to a regional fracture network. Water levels measured in wells in an area of the Front Range mountains suggest the fractured crystalline-rock aquifer is unconfined and has a high degree of hydraulic connectivity at a regional scale (Lawrence and others, 1991). The permeability and porosity of fractured crystalline-rock aquifers have been shown generally to decrease with depth (Daniel and others, 1997; Davis and Turk, 1964). In the Colorado Front Range, test data indicate the permeability of the fractured crystalline-rock aquifer tends to become exceedingly small at depths 60 to 90 m below land surface, although open fault zones may extend to greater depths (Snow, 1968). Because permeability generally decreases greatly at depth, the effective saturated thickness of the aquifer also may be 60 to 90 m or less.

The permeability of fractured crystalline-rock aquifers depends upon the spacing, aperture, and connectivity of fractures in the rock, and permeability generally is several orders of magnitude less than in unconsolidated sand and gravel deposits. Heath (1983) and Freeze and Cherry (1979) indicate hydraulic conductivity in fractured-rock aquifers generally ranges from about 0.0005 to 15 meters per day (m/d). Folger (1995) reports hydraulic conductivity ranges from about 0.002 to 1 m/d for the fractured crystalline-rock aquifer at a site in the Front Range mountains. Hydraulic conductivity of fractured crystalline-rock aquifers has been estimated to be greater beneath valleys and lesser beneath hilltops than that beneath intermediate topographic terrain, which suggests that fractures may be more numerous beneath valleys and less numerous beneath hilltops (Daniel and others, 1997). Fracture orientation may control anisotropy in fractured crystalline-rock aquifers. Water-table gradients in the fractured crystalline-rock aquifer of the

Front Range mountains generally are steep. Recharge to the fractured crystalline-rock aquifer has been estimated to range from 0 to 21 percent of precipitation with an average of 3.2 percent (Hofstra and Hall, 1975) to 10 percent (Mueller, 1979).

In the Colorado Front Range, rock quarries typically are mined dry (Langer, 2001). Although quarries may penetrate the water table, the discharge rate to quarries commonly is less than the rate of evaporation, and active dewatering measures are not needed. The quarry may drain freely. To produce aggregate, the rock is first drilled and blasted. Blasting commonly breaks the rock into pieces suitable for crushing, and the blasted material is extracted using conventional earth-moving equipment such as bulldozers, front loaders, and track hoes. Material is transported, either by truck or conveyor, from the mining face to the processing plant where it is crushed, washed, and sorted by size.

GROUND-WATER HYDRAULICS AND MATHEMATICAL METHODS

To evaluate the effects of aggregate mining on the surrounding water table, ground-water flow was simulated with analytical and numerical solutions to the ground-water flow equation. A general form of the equation describing transient (time-varying) three-dimensional ground-water flow can be written as (Konikow and Grove, 1977; McDonald and Harbaugh, 1988):

$$\frac{\partial(bK_x\frac{\partial h}{\partial x})}{\partial x}+\frac{\partial(bK_y\frac{\partial h}{\partial y})}{\partial y}+\frac{\partial(bK_z\frac{\partial h}{\partial z})}{\partial z}=S\frac{\partial h}{\partial t}+W(x,y,z,t) \qquad (1)$$

where

K_x is aquifer hydraulic conductivity in the x-direction (L^2/T),

K_y is aquifer hydraulic conductivity in the y-direction (L^2/T),

K_z is aquifer hydraulic conductivity in the z-direction (L^2/T),

b is aquifer saturated thickness (L),

h is hydraulic head (L),

S is storage coefficient (dimensionless),

W is volumetric flux per unit area from a hydrologic source or sink as a function of location and time (L/T),

x,y,z are Cartesian coordinates, and

t is time (T).

This equation assumes compressible fluid of constant density is flowing through a heterogeneous anisotropic aquifer according to Darcy's law (Fetter, 1994). It also assumes the principal axes of the hydraulic conductivity tensor are aligned with the *x*, *y*, and *z* coordinate axes, respectively (McDonald and Harbaugh, 1988). Additional details of the ground-water flow equation and its derivation can be found in numerous texts and reports (Freeze and Cherry, 1979; Lohman, 1979; Huyakorn and Pinder, 1983; McDonald and Harbaugh, 1988; Domenico and Schwartz, 1990; Anderson and Woessner, 1992; Fetter, 1994).

The ground-water flow equation can be solved for the dependent variable head (*h*) by analytical or numerical methods. Analytical solutions use algebraic methods to derive closed-form solutions to the ground-water flow equation, whereas numerical solutions use finite-difference or finite-element numerical methods to solve the ground-water flow equation. Analytical solutions to the ground-water flow equation are most useful for evaluating simplified ground-water systems and often assume a homogeneous and isotropic hydraulic-conductivity distribution, horizontal flow, and infinite horizontal extent or limited boundary conditions. Analytical methods can be useful for estimating mine inflows and drawdowns during initial stages of mine planning when site-specific data may not yet be available (Marinelli and Niccoli, 2000). The applicability of an analytical solution depends on the extent to which the real problem under consideration is consistent with the simplifying assumptions of the analytical solution. Analytical solutions that assume infinite horizontal extent can be useful in predicting drawdown in real aquifers of finite extent when aquifer boundaries lie beyond the cone of depression in the water table (area of influence) caused by the pit. When boundaries lie outside the area of influence, the aquifer within the area of influence responds as though it were of infinite extent because no boundaries are contacted. Numerical simulations are useful for evaluating more complex flow systems such as heterogeneous or anisotropic hydraulic-conductivity distributions, multiple boundary conditions, and transient conditions. Numerical methods may be required during advanced stages of mine planning when more detailed geologic and hydrologic data are available for a site (Marinelli and Niccoli, 2000). Analytical and numerical methods can be coded into computer programs to facilitate their use.

Both analytical and numerical simulation methods were used in this study to evaluate the steady-state (time-invariant) effects of mining aggregate on water-table conditions. A steady-state two-dimensional analytical solution to the ground-water flow equation by Marinelli and Niccoli (2000) and a steady-state one-dimensional analytical solution derived during this study were used to estimate the extent of drawdown around a mine in a homogeneous, isotropic aquifer of infinite extent. The U.S. Geological Survey modular ground-water model, MODFLOW–2000 (Harbaugh and others, 2000), was used to evaluate steady-state effects of aggregate mining under more complex hydrogeologic conditions.

The steady-state two-dimensional analytical solution of Marinelli and Niccoli (2000) estimates radial ground-water flow toward a circular mine pit. The analytical solution for head in the aquifer adjacent to a circular pit of radius r_p is given as:

$$h = \sqrt{h_p^{\,2} + \frac{W}{K_h}\left[r_i^{\,2}\ln\left(\frac{r}{r_p}\right) - \left(\frac{r^2 - r_p^{\,2}}{2}\right)\right]} \qquad (2)$$

where

h is saturated thickness above the pit base at r (radial distance from pit center) [L],
h_p is saturated thickness above the pit base at r_p (at the mine wall) [L],
W is distributed recharge flux [L/T],
K_h is horizontal hydraulic conductivity of surrounding geologic materials [L/T],
r_i is radius of influence (maximum extent of the cone of depression) [L],
r is radial distance from pit center [L],
r_p is effective pit radius [L] (fig. 3).

Given input values of h_p, W, K_h, r_p, and initial (premining) saturated thickness above the pit base ($h = h_o$), the radius of influence (r_i) can be determined through iteration by setting r equal to r_i. Once r_i is

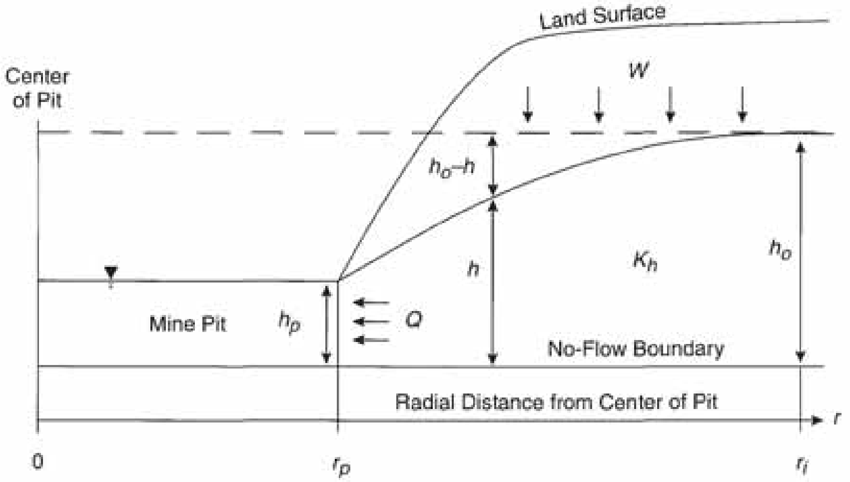


Figure 3. Conceptual diagram of the Marinelli and Niccoli analytical solution (modified from Marinelli and Niccoli, 2000).

determined, h can be calculated for any radial distance from the pit, and drawdown can be calculated as $h_o - h$. In addition, the inflow rate, Q [L^3/T], through the pit wall can be calculated as:

$$Q = W\pi(r_i^2 - r_i^2) \qquad (3)$$

The analytical solution of Marinelli and Niccoli (2000) is valid for ground-water flow systems that meet the following assumptions:

- The geologic materials are homogeneous and isotropic;
- Ground-water flow is steady state, unconfined, horizontal, radial, and axially symmetric;
- Recharge is uniformly distributed at the water table and all recharge within the radius of influence is captured by the pit;
- Pit walls are approximated as a right circular cylinder;
- The static premining water table is approximately horizontal; and
- The base of the pit is coincident with the base of the aquifer, and there is no flow through the pit bottom.

Marinelli and Niccoli (2000) also present an analytical solution for upward ground-water flow through the bottom of a pit that partially penetrates an aquifer.

However, inflow to the bottom of a pit is not considered in this report because (1) analytical solutions are used only to calculate hydraulic head at the water table, which is independent of ground-water flow through the mine bottom in the solution, (2) the bottom of aggregate mines in sand-and-gravel aquifers in the Front Range area generally are near the base of the aquifer, and (3) hydraulic conductivity of fractured crystalline-rock aquifers generally becomes exceedingly small with depth, which limits inflow to the mine bottom. For pits that do not meet these conditions, consideration of flow to the mine bottom may be important.

A steady-state, one-dimensional analytical solution is derived for ground-water flow to a mine excavated into a steep hillside such as in the mountainous part of the Front Range area. The derivation of the one-dimensional solution is similar to the Marinelli and Niccoli (2000) solution, but the mine is represented as a straight line along a hillside rather than a circular pit. The mine in this situation intercepts only the upgradient ground water within the hillside. Ground-water flow toward the mine at distance x upgradient from the mine wall can be expressed as:

$$Q = K_h h \frac{dh}{dx} \qquad (4)$$

where

Q is flow per unit length of the mine [L^2/T],
K_h is horizontal hydraulic conductivity of surrounding geologic materials [L/T],
h is saturated thickness above the mine base at distance x from the mine wall [L], and
x is distance upgradient from mine wall [L].

If all ground-water flow to the mine is assumed to originate from uniform distributed recharge (W) within the drawdown distance of influence (x_i) of the mine, then flow toward the mine also can be expressed as:

$$Q = W(x_i - x) \qquad (5)$$

Substituting equation 5 into equation 4 and integrating from the mine wall to distance x gives:

$$\frac{W}{K_h}\int_0^x (x_i - x)dx = \int_{h_m}^h hdh \qquad (6)$$

where

h_m is saturated thickness above the mine base at the mine wall [L].

Carrying out the integration leads to an analytical solution for head in the aquifer adjacent to a linear mine that is given as:

$$h = \sqrt{h_m{}^2 + \frac{W}{K_h}\left[2x_i x - x^2\right]} \qquad (7)$$

Given input values of h_m, W, K_h, and initial (premining) saturated thickness above the base of the mine ($h = h_o$), the distance of influence (x_i) can be calculated directly by setting x equal to x_i and rearranging equation 7. Once x_i is determined, h can be calculated for any distance upgradient from the mine wall, and drawdown can be calculated as $h_o - h$. In addition, the inflow rate per unit length of mine, Q [L^2/T], can be calculated as:

$$Q = Wx_i \tag{8}$$

The analytical solution for a linear mine wall is valid for ground-water flow systems that meet the following assumptions:

- The geologic materials are homogeneous and isotropic;
- Ground-water flow is steady state, unconfined, horizontal, and perpendicular to the mine wall;
- Recharge is uniformly distributed at the water table, and all recharge within the distance of influence is captured by the mine;
- The uphill mine wall is approximated as a straight line;
- The static premining water table is approximately horizontal; and
- The base of the pit is coincident with the base of the aquifer, and there is no flow through the mine bottom.

MODFLOW-2000 (Harbaugh and others, 2000) was used to estimate the steady-state extent of drawdown near a mine and ground-water inflow to a mine under conditions that consider heterogeneity, anisotropy, and boundaries. MODFLOW–2000 solves the transient ground-water flow equation by using implicit finite-difference methods and is based on a three-dimensional, block-centered, finite-difference grid. Aquifer properties can be heterogeneous and anisotropic provided the principal axes of hydraulic conductivity are aligned with the coordinate directions (Harbaugh and others, 2000; McDonald and Harbaugh, 1988), and aquifer layers can be simulated as confined, unconfined, or a combination of both (Harbaugh and others, 2000). MODFLOW–2000 can simulate several types of hydrologic sources and sinks including aquifer recharge, evapotranspiration, wells, drains, and rivers, and it can simulate either steady-state or transient conditions.

SIMULATION OF THE HYDROLOGIC EFFECTS OF MINING AGGREGATE

Two hydrogeologic settings in the Colorado Front Range area were simulated using analytical and numerical methods. The first set of simulations used conceptualizations of aggregate mining in sand-and-gravel aquifers, and the second set of simulations used conceptualizations of aggregate mining in fractured crystalline-rock aquifers. Analytical and numerical simulations were used to estimate the steady-state hydrologic effects of mining. Under steady-state conditions, discharge to a mine reaches equilibrium with the surrounding ground-water system, and the extent of drawdown caused by dewatering a mine ceases to increase. Therefore, steady-state simulations predict the maximum potential effects of mining over time. To predict short-term effects, transient (time-varying) simulations are necessary. Steady-state simulations of pits in sand-and-gravel aquifers may overpredict the effects of mining if active dewatering of the pit ceases before steady-state conditions are reached. The hydrologic effects of pits in sand-and-gravel aquifers after active dewatering ceases (pits lined with slurry walls or refilled pits undergoing evaporative losses) likely reach steady-state conditions because such pits may be left open indefinitely. The hydrologic effects of quarries in fractured crystalline-rock aquifers also likely reach steady-state conditions because quarries commonly drain without the aid of active dewatering measures (Knepper, 2002) and may be left open indefinitely. Predicting the transient hydrologic effects of mining is beyond the scope of this report.

Simulation of Pits in Sand-and-Gravel Aquifers

Definitions of input parameters for simulations of aggregate mining in sand-and-gravel aquifers were based on data reported in the literature (see "Hydrogeologic Settings"). Definitions of mining extents (area and depth) were defined based on mine footprints shown by Robson (1996) and Robson, Arnold, and Heiny (2000a and b) and Robson, Heiny, and Arnold (2000a and b) and onsite data. Intermediate parameter values and boundary conditions were used in simulations to represent average hydrogeologic conditions and mining extents. Parameter values and boundary conditions were then varied over a range of values and conditions typical for pits in sand-and-gravel aquifers to determine the potential effects of mining over a wide range of conditions. Intermediate hydraulic conductivity was defined in the simulations as 100 m/d, and intermediate recharge was defined as 0.00005 m/d, which is about 5 percent of the average annual precipitation for the Colorado Piedmont part of the Front Range area. Intermediate pit penetration of the water table was defined as 6 m, and intermediate pit radius was defined as 100 m.

Analytical Simulations and Sensitivities

The analytical solution of Marinelli and Niccoli (2000) was used to solve for the radius of influence (r_i) and saturated thickness (h) above the base of a dewatered pit in a homogeneous, isotropic sand-and-gravel aquifer of infinite extent. Horizontal hydraulic conductivity (K_h), recharge (W), initial saturated thickness above the pit base ($h = h_o$), and pit radius (r_p) were varied independently over a range of values typical for pits in sand-and-gravel aquifers in the Front Range area. By varying the parameters independently, the effects of each parameter on simulation results were evaluated, and sensitivities for parameters were calculated. Because initial saturated thickness is measured relative to the pit base, h_o also is equal to the depth to which the pit penetrates the water table. The water level in the pit was defined at the base of the pit.

Figures 4–7 show drawdown ($h_o - h$) and radius of influence measured from the pit wall ($r_i - r_p$) caused by a dewatered circular pit in a sand-and-gravel aquifer for different values of K_h (10, 100, and 1,000 m/d), W (0.000025, 0.00005, and 0.0001 m/d), h_o (4, 6, and 8 m), and r_p (25, 100, and 500 m). Results indicate radius of influence from the wall of a dewatered pit in a homogeneous, isotropic sand-and-gravel aquifer of infinite extent was 4,544 m under intermediate conditions ($K_h = 100$ m/d, $W = 0.00005$ m/d, $h_o = 6$ m, $r_p = 100$ m). Radius of influence increased as K_h, h_o, and r_p increased and as W decreased.

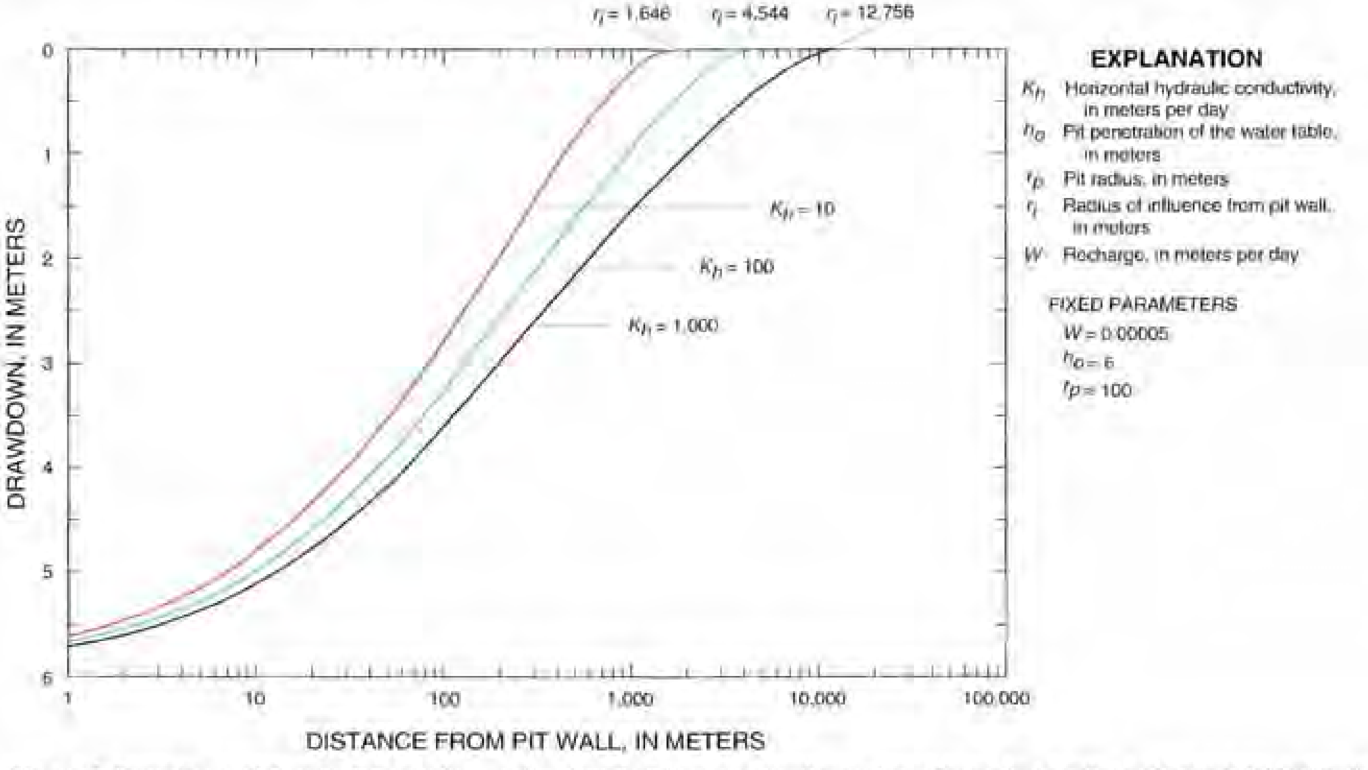


Figure 4. Drawdown relative to distance from a dewatered pit in a sand-and-gravel aquifer for three values of horizontal hydraulic conductivity, simulated by use of the Marinelli and Niccoli (2000) analytical solution.

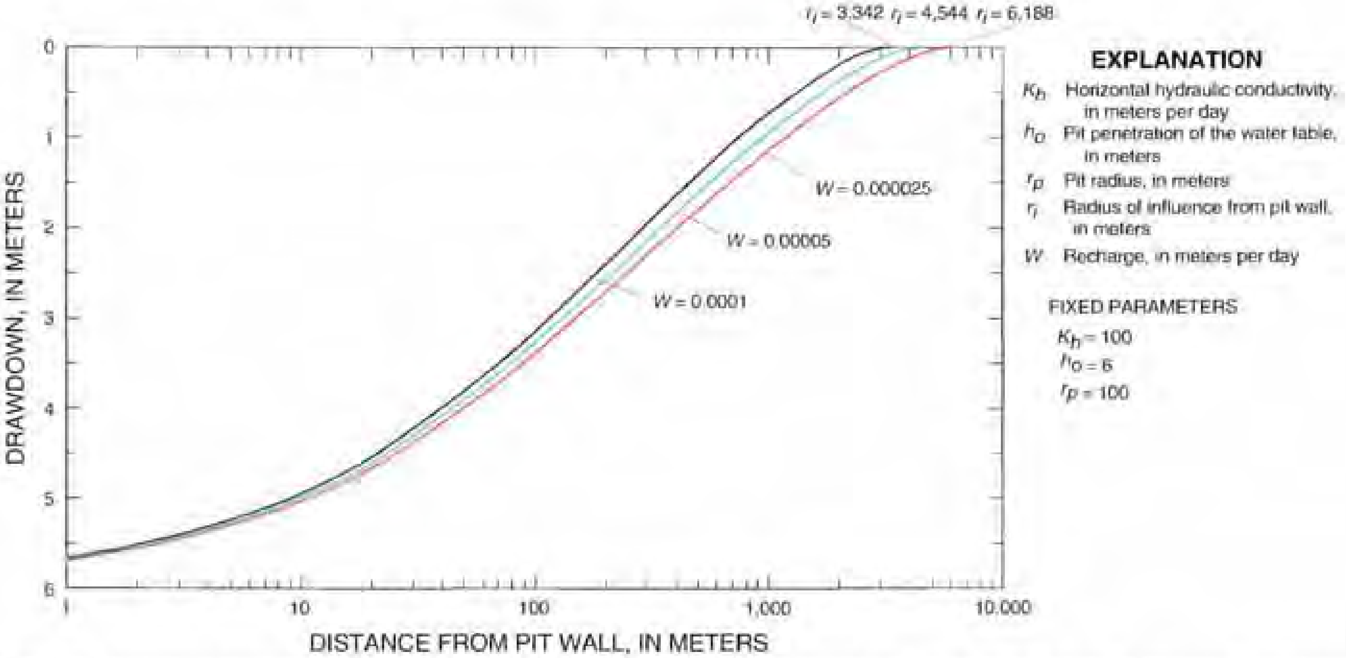


Figure 5. Drawdown relative to distance from a dewatered pit in a sand-and-gravel aquifer for three values of recharge, simulated by use of the Marinelli and Niccoli (2000) analytical solution.

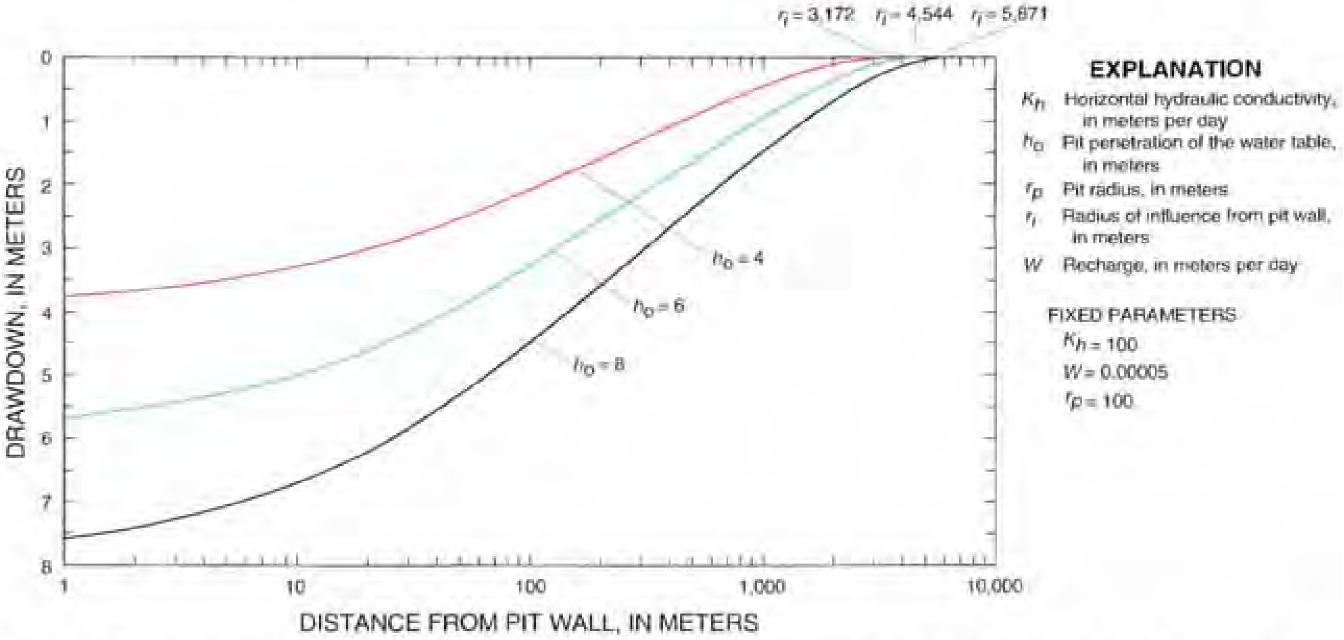


Figure 6. Drawdown relative to distance from a dewatered pit in a sand-and-gravel aquifer for three values of pit peneration of the water table, simulated by use of the Marinelli and Niccoli (2000) analytical solution.

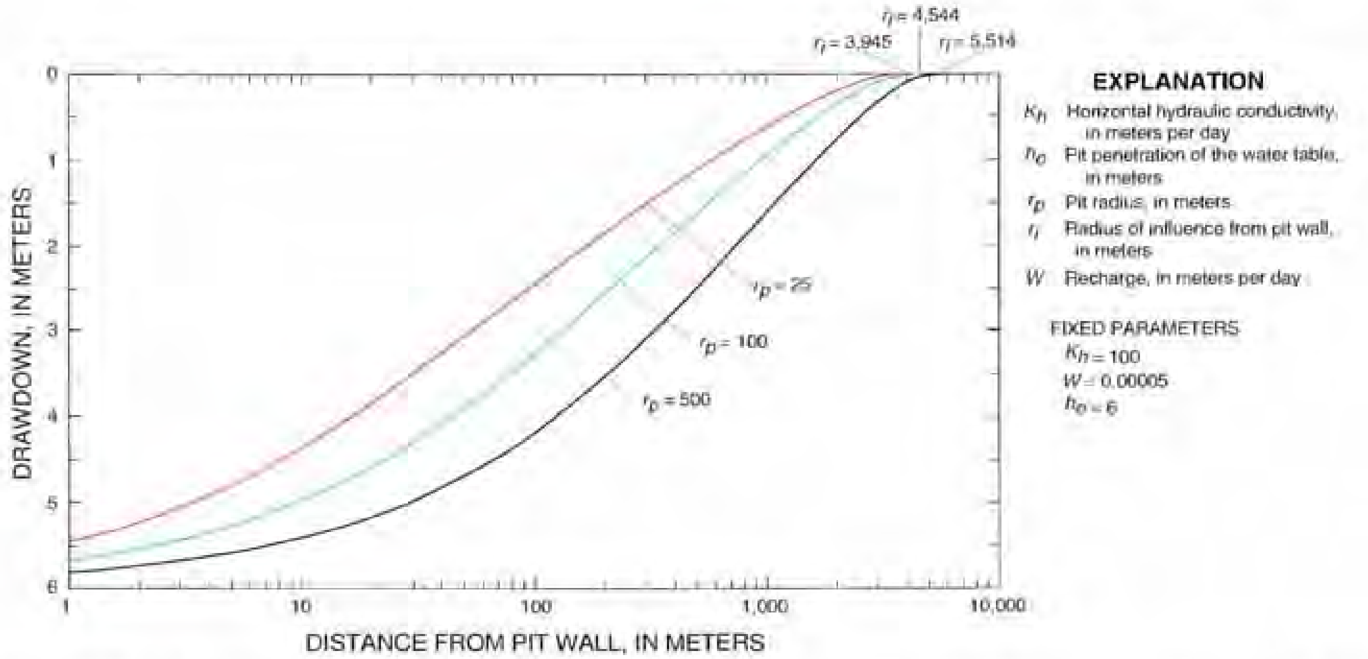


Figure 7. Drawdown relative to distance from a dewatered pit in a sand-and-gravel aquifer for three values of pit radius, simulated by use of the Marinelli and Niccoli (2000) analytical solution.

One-percent scaled sensitivities were calculated for each parameter used in the analytical solution of Marinelli and Niccoli (2000) to determine the effect of each parameter on simulation results under intermediate conditions. One-percent scaled sensitivities, $1ss_{ij}$ are calculated as (Hill, 1998):

$$1ss_{ij} = \frac{\partial y_i'}{\partial b_j}\frac{b_j}{100} \qquad (9)$$

where

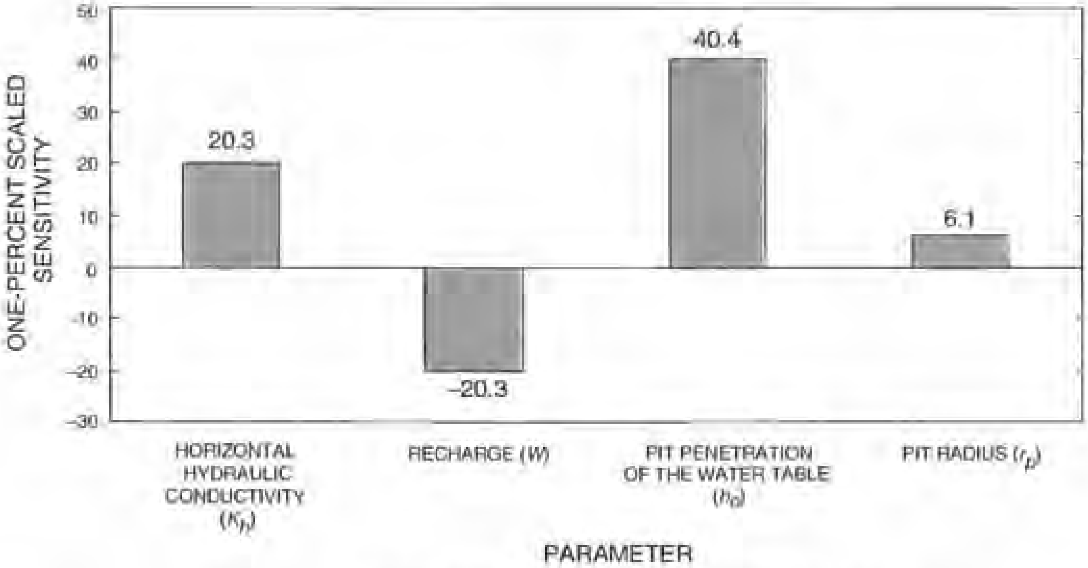
y'_i is the simulated value associated with the ith observation;

b_j is the jth estimated parameter;

$\frac{\partial y'}{\partial b_j}$ is the sensitivity of the simulated value associated with the ith observation with respect to the jth parameter and is evaluated at $\underline{b}$; and

$\underline{b}$ is a vector that contains the parameter values at which the sensitivities are evaluated.

In this application, y_i' is the radius of influence, and b_j is the parameter (K_h, W, h_o, or r_p) for which sensitivity is calculated. Resulting sensitivities have units of meters and are the change in radius of influence caused by a 1-percent change in the parameter value. Parameters with high sensitivities affect simulated radius of influence more than parameters with low sensitivities. Therefore, parameters with high sensitivities may be more important to accurately define than parameters with low sensitivities at real sites with conditions similar to those in the analytical simulations. Because one-percent scaled sensitivities depend upon the parameter values at which they are evaluated, sensitivity results will be different for different hydrogeologic conditions and mining extents. Results of analytical sensitivity analysis (fig. 8) under intermediate conditions (K_h = 100 m/d, W = 0.00005 m/d, h_o = 6 m, r_p = 100 m) indicate radius of influence was most sensitive to changes in pit penetration of the water table and least sensitive to changes in pit radius. Radius of influence was equally sensitive to changes in horizontal hydraulic conductivity and recharge; however, the parameters had opposite effects on



Sensitivities indicate change in radius of influence, in meters, caused by a 1-percent change in parameter value

Figure 8. One-percent scaled sensitivities for parameters in the analytical solution of Marinelli and Niccoli (2000), calculated for a pit in a sand-and-gravel aquifer under intermediate conditions (K_h = 100 m/d, W = 0.00005 m/d, h_o = 6 m, r_p = 100 m).

simulation results because they are inversely correlated in the analytical solution. Radius of influence increased as horizontal hydraulic conductivity increased and as recharge decreased.

Numerical Simulations

MODFLOW–2000 (Harbaugh and others, 2000) was used to compute (1) hydraulic heads in a hypothetical sand-and-gravel aquifer under steady-state, premining conditions, (2) steady-state drawdown caused by a dewatered pit in the sand-and-gravel aquifer under different hydrogeologic conditions, and (3) inflow to the pit under different hydrogeologic conditions. In addition, the observation and sensitivity capabilities (Hill and others, 2000) of MODFLOW–2000 were used to compute sensitivities for simulation input parameters. Because simulations are of hypothetical aquifers, model calibration was not necessary. However, generalized aquifer data from real sites were used to guide development of simulated premining conditions. Six numerical simulations of the hydrologic effects of mining aggregate in hypothetical sand-and-gravel aquifers are presented as follows:

Simulation 1–The hydrologic effects of a dewatered pit in a medium-sized (about 2,500-m wide) alluvial valley under homogeneous and isotropic conditions are simulated. Comparison of simulation 1 to analytical simulation results shows the effects of boundary conditions.

Simulation 2–The hydrologic effects of a dewatered pit in a medium-sized alluvial valley under homogeneous but anisotropic conditions are simulated. Comparison of simulation 2 to simulation 1 shows the effects of vertical anisotropy.

Simulation 3–The hydrologic effects of a dewatered pit in a large (about 5,000-m wide) alluvial valley under homogeneous and isotropic conditions are simulated. Comparison of simulation 3 to simulation 1 shows the effects of increasing aquifer size and changing boundary conditions.

Simulation 4–The hydrologic effects of a dewatered pit in a small (about 1,200-m wide) alluvial valley under homogeneous and isotropic conditions are simulated. Comparison of simulation 4 to simulation 1 shows the effects of decreasing aquifer size and changing boundary conditions.

Simulation 5–The hydrologic effects of five closely spaced pits lined with slurry walls in a medium-sized homogeneous, isotropic sand-and-gravel aquifer are simulated.

Simulation 6–The hydrologic effects of five closely spaced, water-filled pits undergoing evaporative losses in a medium-sized homogeneous, isotropic sand-and-gravel aquifer are simulated.

Simulation 1–Pit in a medium-sized, homogeneous, isotropic aquifer

Simulation 1 shows the potential hydrologic effects of dewatering a pit in a medium-sized alluvial valley. The simulation uses the intermediate values of horizontal hydraulic conductivity, recharge, and pit width from the analytical simulations, but a shallow pit is simulated so that water-table penetration is constant among all numerical simulations, including simulation 4 (pit in a small sand-and-gravel aquifer), which is too shallow for the intermediate penetration depth.

Model design

A sand-and-gravel aquifer is represented using two layers in the numerical model (fig. 9). Layer 1 (top layer) is 6 m thick with about 2 to 5 m of saturated thickness. Layer 2 (bottom layer) is 2 m thick and is fully saturated. Both layers are simulated as convertible, which allows hydraulic head to be computed for either confined or unconfined conditions. Total premining saturated thickness near the pit is about 6 m. The model grid has 35 rows and 80 columns (fig. 10) with a cell size of 50 m × 50 m near the pit and 100 m × 100 m at a distance 600 m from the pit. The alluvial valley represented by the model is 7,000 m long and about 2,500 m wide, which is representative of medium-sized alluvial valleys in the Front Range area. Hydraulic gradient is about 0.005 along the length of the valley. Horizontal hydraulic conductivity in both layers is 100 m/d, and vertical hydraulic conductivity is equal to horizontal hydraulic conductivity.

Boundary conditions

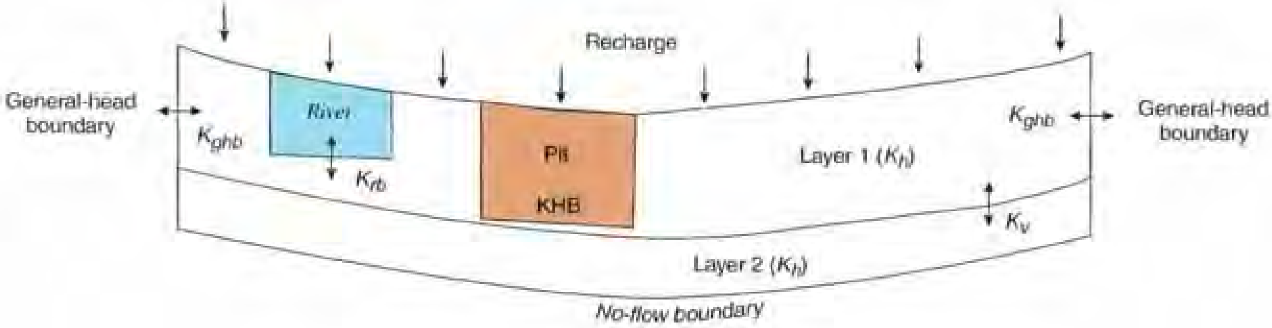
The upgradient and downgradient ends of the valley are simulated as constant-head boundaries. The sides of the valley are simulated as general-head boundaries to simulate inflow to the model from a thin part of the alluvial aquifer beyond the boundaries of the valley. General-head boundaries are defined to simulate flow through a saturated thickness of 2.5 m under a gradient about twice that of the downvalley gradient. General-head boundaries also are defined using a hydraulic conductivity value of 10 m/d to simulate finer grained and somewhat less permeable material at the valley edges. The aquifer base is simulated as a no-flow boundary at the bedrock surface. A specified-flux boundary with a value of 0.00005 m/d is used to simulate areal recharge from precipitation.

Water flow between the river and the aquifer is simulated by using the River package of MODFLOW–2000. Definition of riverbed conductance is based on a river 10 m wide with a stage 4 m above the base of the aquifer and a riverbed 1 m thick with a hydraulic conductivity value of 1 m/d. The pit is simulated in layer 1 as a 200-m wide square with a water-table penetration of 4 m by using the Flow and Head Boundary package (Leake and Lilly, 1997) of MODFLOW–2000. Initial heads in the pit cells are set to match those of the steady-state conditions of the premining aquifer, and final heads for the pit cells are set 4 m below the water table to simulate drawdown in the dewatered pit. Horizontal and vertical hydraulic conductivity of pit cells is increased by a factor of 1,000 to represent the open area of the pit where sand and gravel were removed.

Results and comparison to analytical simulation

The simulated steady-state premining distribution of hydraulic head in the aquifer is shown in figure 11*a*, and steady-state drawdown near a dewatered pit in the aquifer is shown in figure 11*b*. Steady-state drawdown computed using the analytical solution of Marinelli and Niccoli (2000) for a dewatered pit in a homogeneous, isotropic sand-and-gravel aquifer of infinite extent is shown in figure 11*c*. Results of the analytical simulation were computed using the same input values of horizontal hydraulic conductivity, recharge, pit penetration of the water table, and pit radius as the numerical simulation.

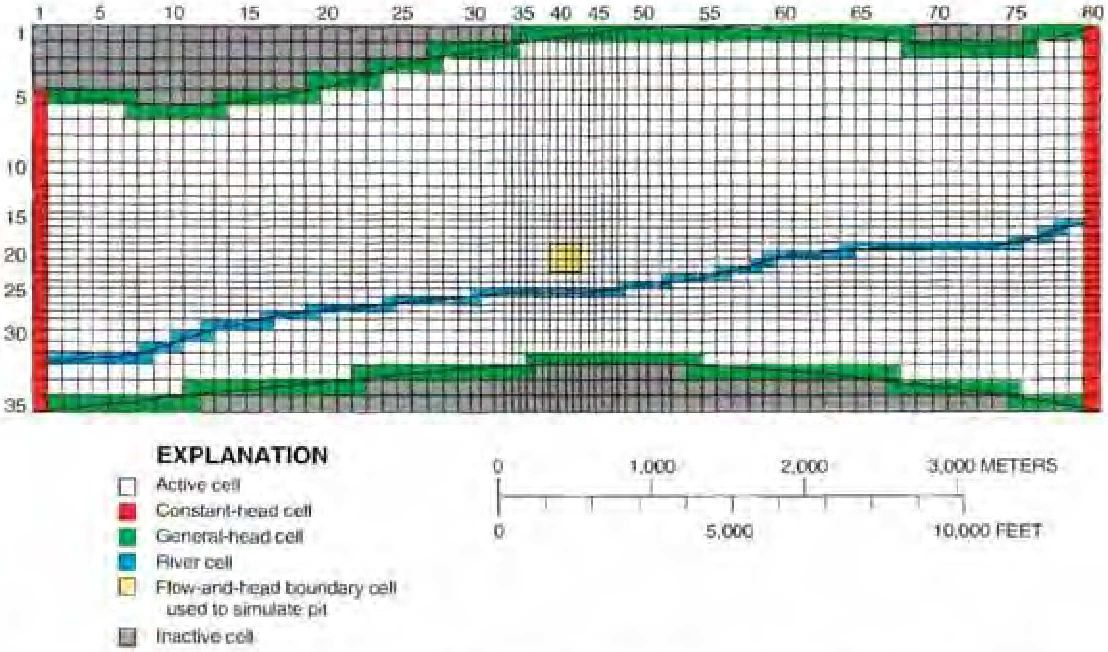
Lines of equal drawdown computed by the analytical simulation are concentric circles centered around the pit, and area of influence computed by the analytical simulation (defined by the limit of 0.1 m drawdown) has a radius of 3,187 m, measured from the pit center. Lines of equal drawdown computed by the numerical simulation are asymmetrical because of boundary effects, and area of influence computed by the numerical simulation (also defined by the limit of 0.1 m drawdown) has a maximum extent of about 3,200 m, measured from the pit center. Area of influence in the numerical simulation is smaller in general than in the analytical simulation because ground-water flow to the pit in the numerical simulation is contributed by many sources, including precipitation, river leakage, and inflow from constant-head and general-head boundaries, whereas ground-water flow to the pit



EXPLANATION

K_h = Horizontal hydraulic conductivity of layers 1 and 2
K_v = Vertical hydraulic conductivity of layers 1 and 2
K_{ghb} = Hydraulic conductance controlling flow between external source and aquifer
K_{rb} = Hydraulic conductance controlling flow between river and aquifer
KHB = Flow-and-head boundary

Figure 9. Conceptual diagram for numerical simulation 1 (pit in a hypothetical, medium-sized sand-and-gravel aquifer under homogeneous and isotropic conditions.



EXPLANATION

☐ Active cell
🟥 Constant-head cell
🟩 General-head cell
🟦 River cell
🟨 Flow-and-head boundary cell used to simulate pit
▨ Inactive cell

Figure 10. Finite-difference grid and boundary conditions for numerical simulation 1 (pit in a hypothetical, medium-sized sand-and-gravel aquifer under homogeneous and isotropic conditions).

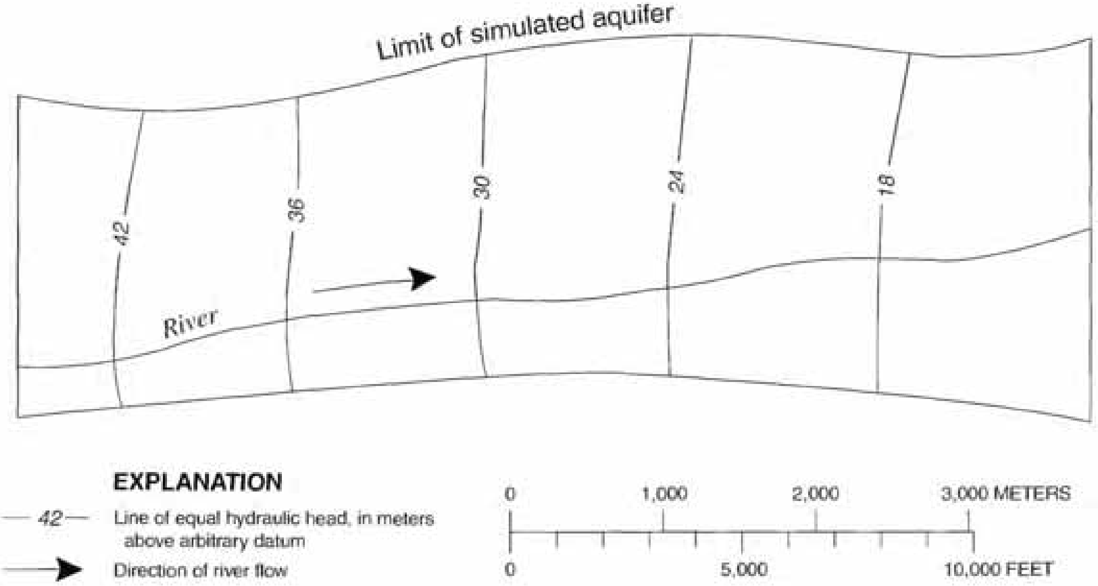


Figure 11*a*. Numerical simulation 1– Steady-state premining distribution of hydraulic head in a hypothetical, medium-sized sand-and-gravel aquifer under homogeneous and isotropic conditions.

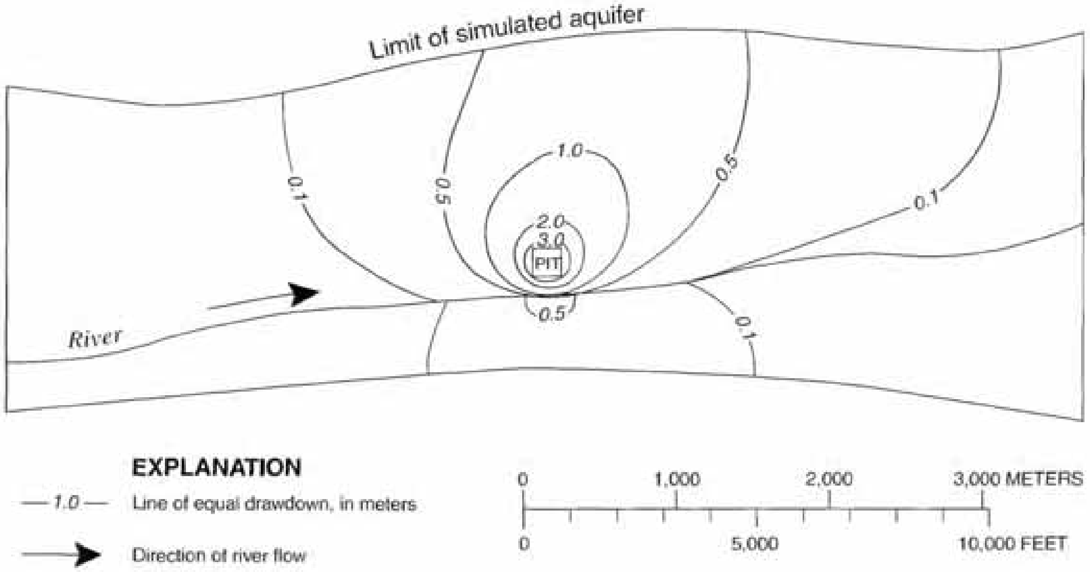


Figure 11*b*. Numerical simulation 1–Steady-state drawdown caused by a dewatered pit in a hypothetical, medium-sized sand-and-gravel aquifer under homogeneous and isotropic conditions.

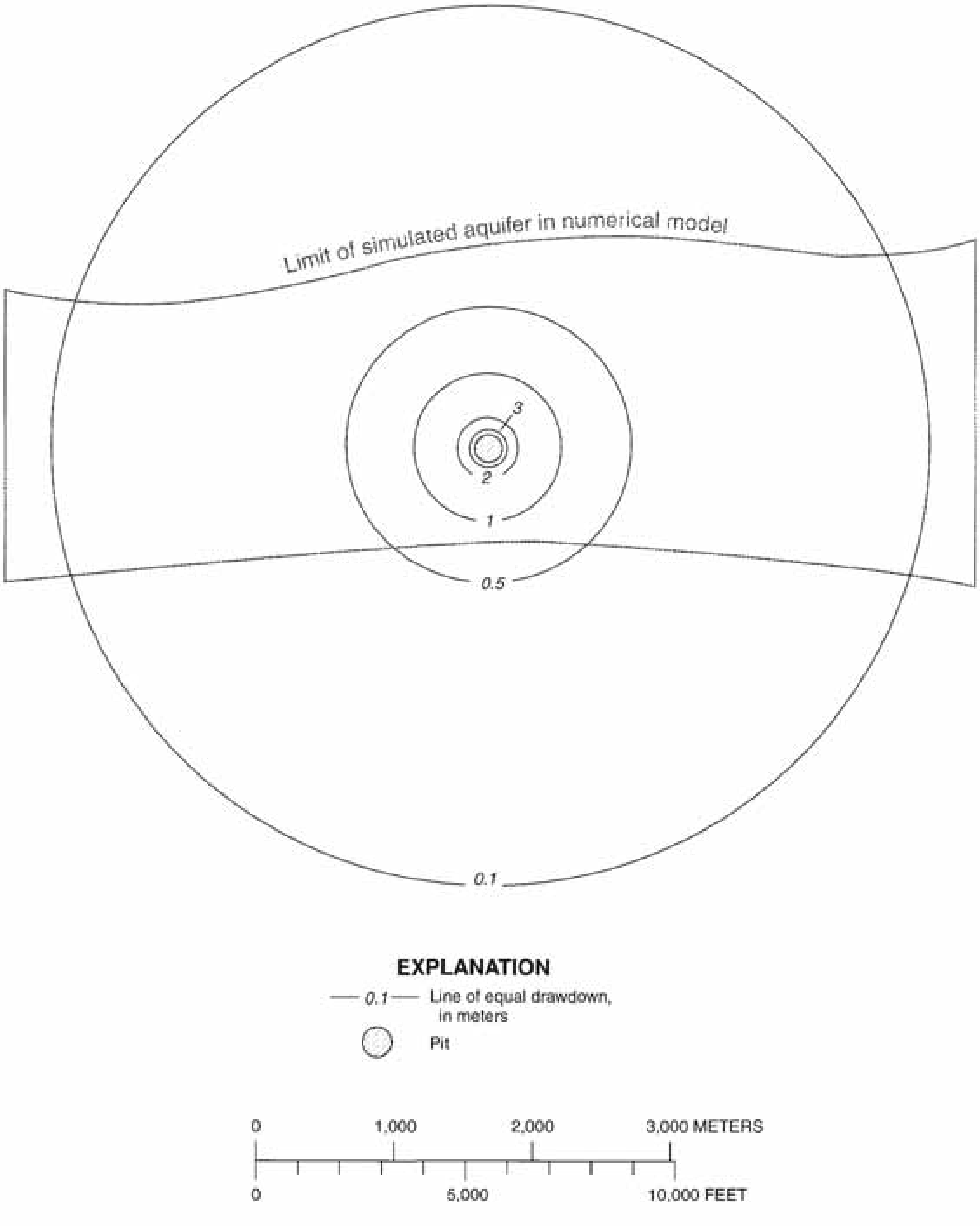


Figure 11*c*. Steady-state drawdown caused by a dewatered pit in a homogeneous, isotropic sand-and-gravel aquifer of infinite extent, simulated by use of the Marinelli and Niccoli (2000) analytical solution.

in the analytical simulation is contributed only by distributed recharge from precipitation.

Drawdown in the area between the pit and the river in the numerical simulation is less than drawdown in the analytical simulation because the river in the numerical simulation acts as a recharge boundary and maintains hydraulic head in the aquifer near premining levels at the river. Although the river contributes flow to the pit and acts as a recharge boundary in the numerical simulation, some drawdown (0.1 m) does occur across the river because ground water flows to the pit through the underlying aquifer in layer 2. Drawdown away from the river in the numerical simulation is greater than drawdown in the analytical simulation because the area of influence in the numerical simulation contacts the boundary of the aquifer, which limits flow to the area of influence and causes hydraulic head to drop more substantially.

Under premining conditions, the largest component of recharge is from inflow at the upgradient end of the aquifer, and the second largest component of recharge is from inflow along the sides of the aquifer. Precipitation is a relatively small component of recharge, and river leakage to the aquifer is the smallest component. Discharge at the downgradient end of the aquifer under premining conditions is similar in magnitude to discharge to the river. The complete ground-water budget for premining conditions in simulation 1 is shown in table 1, and the complete ground-water budget for the effects of the dewatered pit in simulation 1 is shown in table 2. The ground-water budgets give an accounting of recharge to the aquifer and discharge from the aquifer. Values given in the tables indicate total volumetric fluxes for each category. Recharge to the aquifer includes (1) ground-water inflow from the constant-head boundary at the upgradient end of the aquifer, (2) ground-water inflow from general-head boundaries along the sides of the aquifer, (3) river leakage to the aquifer, and (4) distributed recharge from precipitation. Discharge from the aquifer includes (1) ground-water outflow to the constant-head boundary at the downgradient end of the aquifer, (2) ground-water discharge to the river,

Table 1. Steady-state ground-water budget for six numerical simulations of premining conditions in hypothetical sand-and-gravel aquifers

[All values are in cubic meters per day; totals reflect sum of all rounded individual components; --, not computed]

Budget component	Simulation 1	Simulation 2	Simulation 3	Simulation 4	Simulation 5	Simulation 6
Recharge to aquifer						
Ground-water inflow from constant-head boundary at upgradient end of aquifer	6,928	6,928	24,748	2,019	6,929	6,929
Ground-water inflow from general-head boundaries along sides of aquifer	3,966	3,966	7,551	--	3,966	3,966
River leakage to aquifer	271	270	1,067	705	271	271
Precipitation recharge	749	749	1,599	404	749	749
Total	11,914	11,913	34,965	3,128	11,915	11,915
Discharge from aquifer						
Ground-water outflow to constant-head boundary at downgradient end of aquifer	6,650	6,650	28,374	2,352	6,649	6,649
Ground-water discharge to river	5,264	5,263	6,577	777	5,265	5,265
Total	11,914	11,913	34,951	3,129	11,914	11,914
Recharge – Discharge	0	0	14	–1	1	1

Model simulations:

1. Medium-sized, homogeneous, isotropic aquifer.
2. Medium-sized, homogeneous, vertically anisotropic aquifer.
3. Large, homogeneous, isotropic aquifer.
4. Small, homogeneous, isotropic aquifer.
5. Medium-sized, homogeneous, isotropic aquifer.
6. Medium-sized, homogeneous, isotropic aquifer.

Table 2. Steady-state ground-water budget for six numerical simulations of the effects of mining aggregate in hypothetical sand-and-gravel aquifers

[All values are in cubic meters per day: totals reflect sum of all rounded individual components: --, not computed]

Budget component	Simulation 1	Simulation 2	Simulation 3	Simulation 4	Simulation 5	Simulation 6
Recharge to aquifer						
Ground-water inflow from constant-head boundary at upgradient end of aquifer	6,937	6,937	25,532	2,019	6,921	6,933
Ground-water inflow from general-head boundaries along sides of aquifer	4,043	4,043	7,684	--	3,956	3,975
River leakage to aquifer	4,652	4,639	18,541	3,608	328	587
Precipitation recharge	747	747	1,597	402	739	749
Total	16,379	16,366	53,354	6,029	11,944	12,244
Discharge from aquifer						
Ground-water outflow to constant-head boundary at downgradient end of aquifer	6,505	6,504	27,253	2,338	6,653	6,662
Ground-water discharge to river	3,135	3,132	1,634	432	5,292	5,403
Ground-water discharge to actively dewatered pit	6,740	6,730	24,500	3,260	--	--
Cumulative evaporative losses at pits	--	--	--	--	--	680
Total	16,380	16,366	53,387	6,030	11,945	12,745
Recharge – Discharge	–1	0	–33	–1	–1	–501

Model simulations:

1. Pit in medium-sized, homogeneous, isotropic aquifer.
2. Pit in medium-sized, homogeneous, vertically anisotropic aquifer.
3. Pit in large, homogeneous, isotropic aquifer.
4. Pit in small, homogeneous, isotropic aquifer.
5. Five pits lined with slurry walls in medium-sized, homogeneous, isotropic aquifer.
6. Five water-filled pits undergoing evaporative losses in medium-sized, homogeneous, isotropic aquifer.

and (3) ground-water discharge to the pit under conditions of active mining.

Under conditions of active mining, when the pit is dewatered, inflow from the upgradient end and the sides of the aquifer is slightly greater than under premining conditions because drawdown caused by the pit increases the hydraulic gradient in the area between the pit and the upgradient end and sides of the aquifer. Recharge from precipitation is nearly unchanged between premining and active mining conditions. The slight difference in precipitation recharge between the two simulations likely is due to cells going dry during the rewetting process for unconfined conditions in the active mining simulation. River leakage to the aquifer is much greater under active mining conditions than under premining conditions because drawdown caused by the pit reverses the hydraulic gradient in the area between the pit and the river, which causes water to flow from the river to the aquifer. The largest component of discharge under active mining conditions is ground-water discharge to the pit. Outflow to the downgradient end of the aquifer under active mining conditions is somewhat less than under premining conditions because drawdown caused by the pit decreases the hydraulic gradient in the area between the pit and the down-gradient end of the aquifer. Ground-water discharge to the river under active mining conditions is less than under premining conditions because drawdown caused by the pit intercepts ground water that, under premining conditions, flows to the river.

Simulation 2–Pit in a medium-sized, homogeneous aquifer with vertical anisotropy

Simulation 2 shows the effect vertical anisotropy may have on steady-state drawdown near a dewatered pit in a medium-sized (about 2,500 m wide) alluvial valley. Simulation 2 is identical to simulation 1 except vertical hydraulic conductivity is uniformly set to a value equal to one-tenth the horizontal hydraulic conductivity. Simulation 2 represents a system in which lithologic stratification of the sand-and-gravel aquifer has produced vertical anisotropy.

The simulated steady-state premining distribution of hydraulic head in the anisotropic aquifer (fig. 12*a*) and steady-state drawdown near a dewatered pit in the anisotropic aquifer (fig. 12*b*) are nearly identical to those in the isotropic aquifer of simulation 1. The premining ground-water budget (table 1) for simulation 2 also is nearly identical to that of simulation 1. The active mining ground-water budget (table 2) for simulation 2 differs only slightly from that of simulation 1. River leakage to the aquifer, ground-water discharge to the river, and ground-water discharge to the pit under active mining conditions are slightly less in simulation 2 than in simulation 1 because the lower vertical hydraulic conductivity of simulation 2 reduces flow between the layers and, therefore, reduces exchange of water with the river and inflow to the pit bottom.

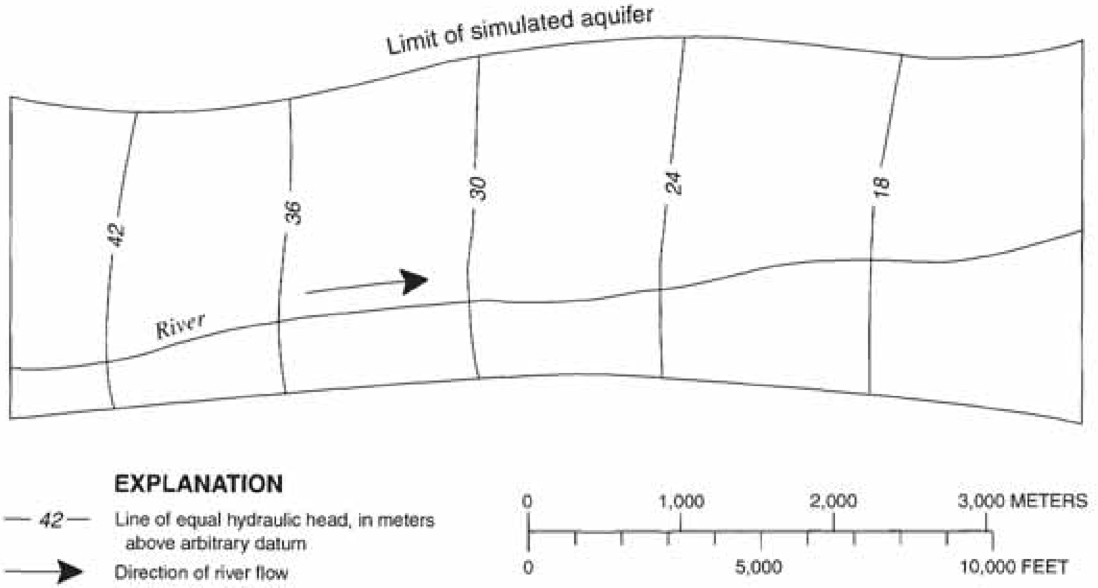


Figure 12*a*. Numerical simulation 2–Steady-state premining distribution of hydraulic head in a hypothetical, medium-sized sand-and-gravel aquifer under homogeneous and vertically anisotropic conditions.

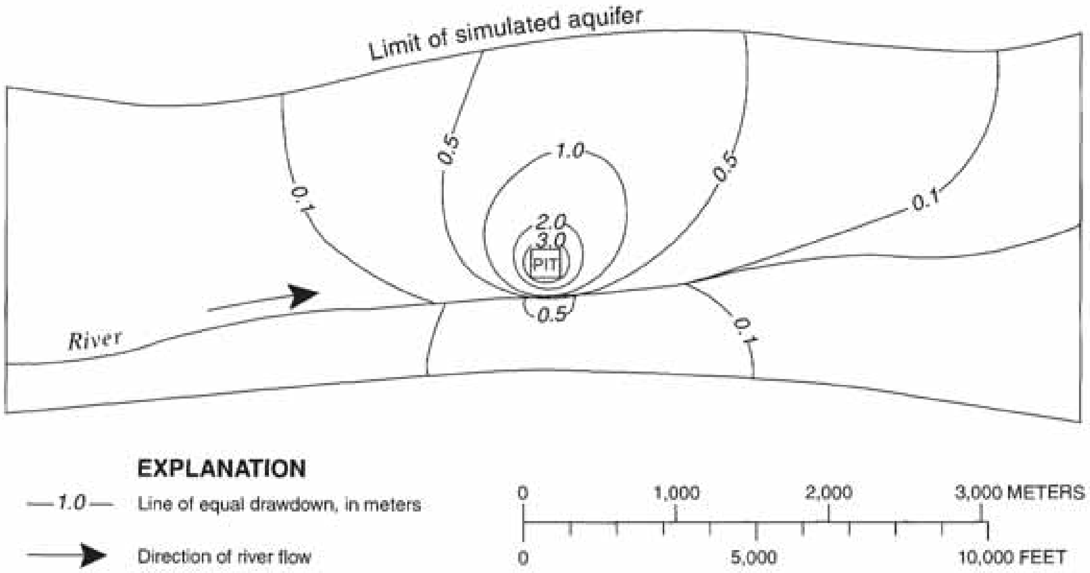


Figure 12*b*. Numerical simulation 2–Steady-state drawdown caused by a dewatered pit in a hypothetical, medium-sized sand-and-gravel aquifer under homogeneous and vertically anisotropic conditions.

Simulation 3–Pit in a large, homogeneous, isotropic aquifer

Simulation 3 shows the potential hydrologic effects of dewatering a pit in a large alluvial valley. Simulation 3 is similar to simulation 1 except the alluvial valley in which mining occurs is deeper and wider, and the hydraulic conductance of the general-head boundaries and river are larger. The simulation represents a valley 7,000 m long and about 5,000 m wide. Layer 1 is 6 m thick with about 3 to 5 m of saturated thickness. Layer 2 is 16 m thick and is fully saturated. Total premining saturated thickness near the pit is about 20 m. The premining steady-state hydraulic gradient is about 0.003, which is typical of gradients in larger alluvial valleys in the Front Range area. Grid spacing and number of columns in the model are the same as in simulation 1, but 25 rows were added to accommodate the greater valley width.

To simulate a greater amount of inflow to the larger valley, the hydraulic conductance of general-head boundaries along the valley sides in simulation 3 is approximately double that of simulation 1. Similarly, the hydraulic conductance of the riverbed is doubled to simulate a larger river with a greater capacity to exchange flow with the aquifer.

The simulated steady-state premining distribution of hydraulic head in the large aquifer is shown in figure 13*a*, and steady-state drawdown near a dewatered pit in the large aquifer is shown in figure 13*b*. Area of influence in simulation 3 has a maximum extent (measured from pit center) of about 4,350 m. Area of influence in simulation 3 is larger and more symmetrical than in simulation 1. Area of influence is larger in simulation 3 because the greater aquifer thickness and riverbed conductance allow more ground water to flow to the pit, which must then be removed to maintain drawdown at the pit. As more

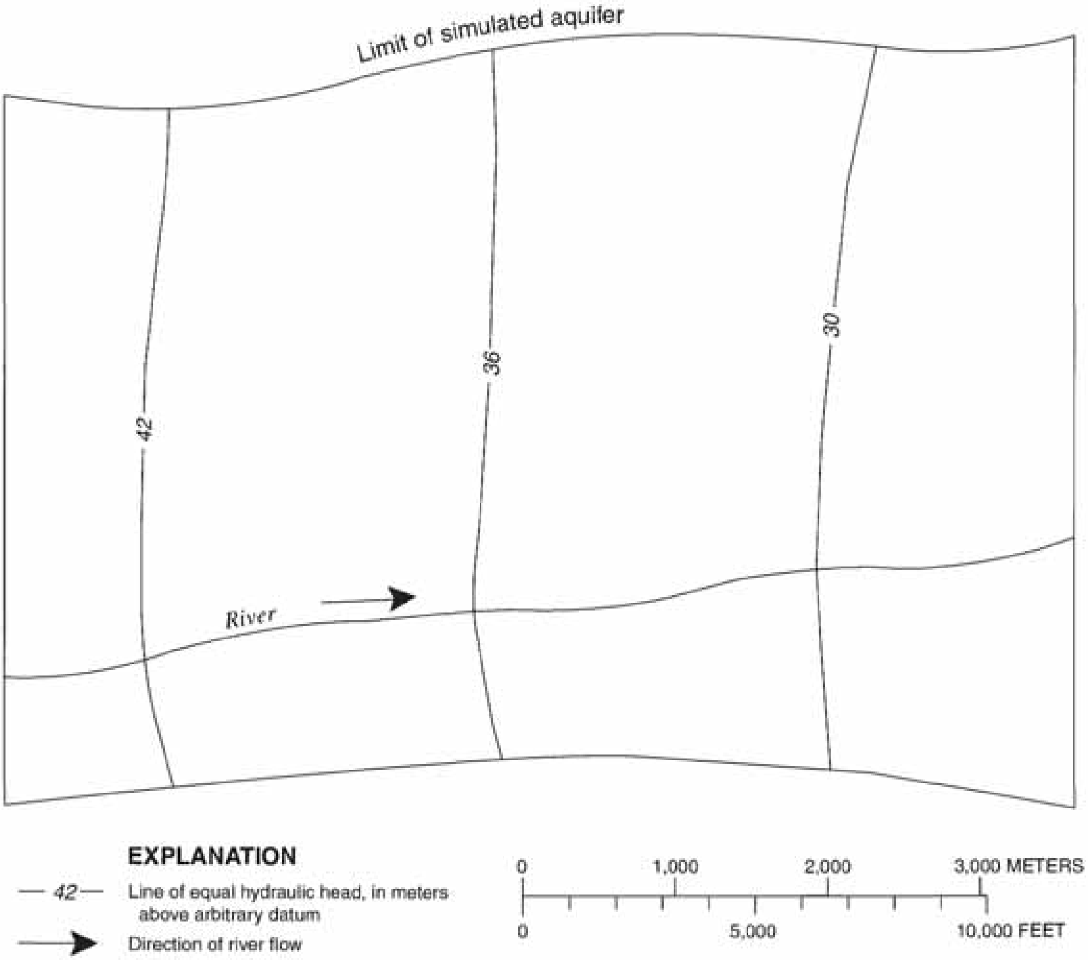


Figure 13*a*. Numerical simulation 3–Steady-state premining distribution of hydraulic head in a hypothetical, large sand-and-gravel aquifer under homogeneous and isotropic conditions.

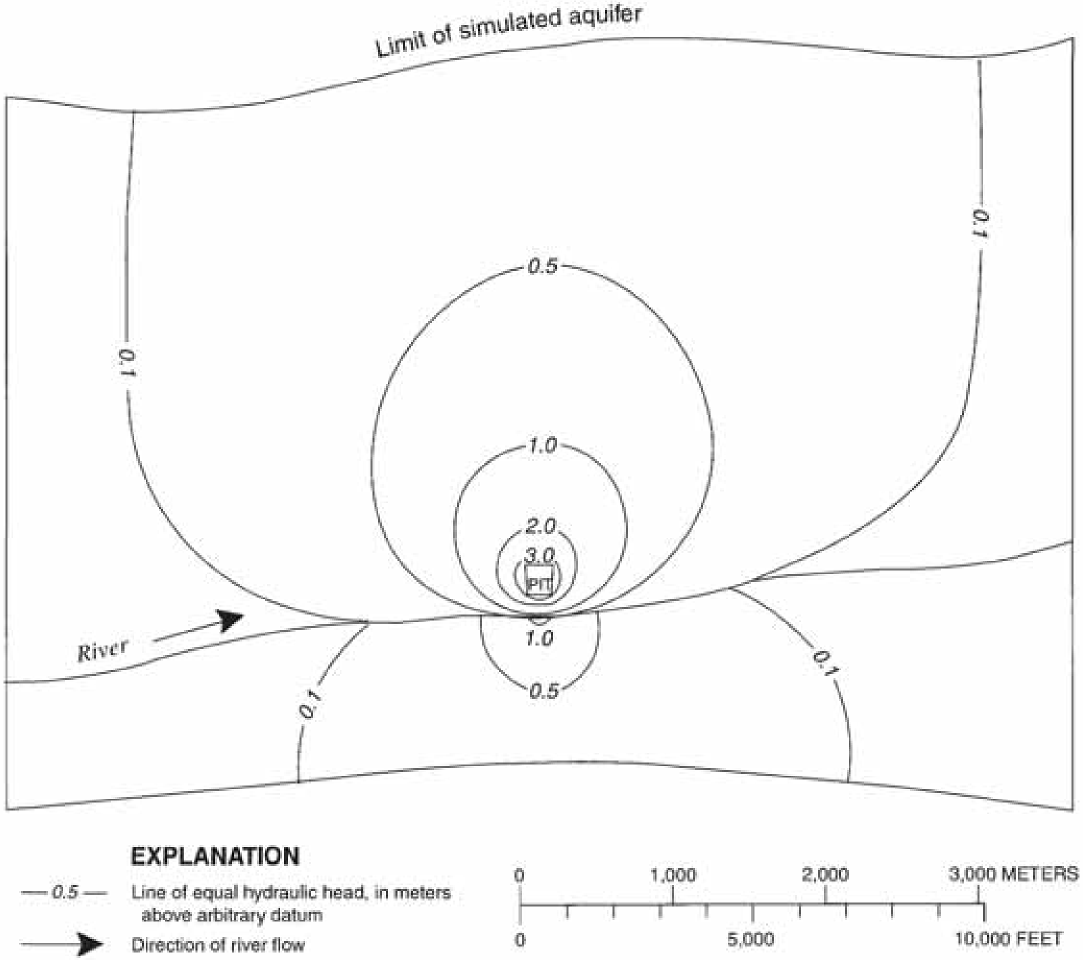


Figure 13*b*. Numerical simulation 3–Steady-state drawdown caused by a dewatered pit in a hypothetical, large sand-and-gravel aquifer under homogeneous and isotropic conditions.

water is removed, the effects of drawdown at the pit occur farther away. Area of influence in simulation 3 is more symmetrical than that in simulation 1 because aquifer boundaries are farther from the pit and, therefore, have less effect on the shape of the area of influence. The shape of the area of influence in simulation 3 is more like that of the infinite aquifer simulated using the analytical solution. Drawdown across the river in simulation 3 is greater than in simulation 1 because flow to the pit is greater and the bottom layer of the aquifer in simulation 3 is thicker, which allows the pit to draw more ground water from across the river.

With the exception of ground-water discharge to the river under active mining conditions (table 2), flow for all ground-water budget components under premining and active mining conditions (tables 1 and 2) in simulation 3 is larger than in simulation 1 because the aquifer in simulation 3 is larger and has higher conductances for the general-head boundaries and riverbed. Ground-water discharge to the river under active mining conditions is less than that in simulation 1 because the larger area of influence in simulation 3 reduces the area where ground water can flow to the river.

Simulation 4–Pit in a small, homogeneous, isotropic aquifer

Simulation 4 shows the potential hydrologic effects of dewatering a pit in a small alluvial valley. Simulation 4 is similar to simulation 1 except the width of the alluvial valley in which mining occurs is smaller, no-flow boundaries are used along the sides of the valley, and the conductance term of the riverbed is smaller. The simulation represents a valley 7,000 m long and about 1,200 m wide. Layer 1 is 4 m thick with about 1 to 3 m of saturated thickness. Layer 2 is 2 m thick and is fully saturated. Total premining saturated thickness near the pit is about 4 m. Because the aquifer in simulation 4 is shallow, the base of the pit occurs in model layer 2 rather than layer 1. The steady-state premining hydraulic gradient is similar to that of simulation 1. Grid spacing and number of columns in the model are the same as in simulation 1, but only 24 rows are needed to represent the smaller valley width. No-flow boundaries are used along the sides of the model to simulate an alluvial valley incised into bedrock with no ground-water inflow to the sides of the valley. Riverbed conductance is decreased by a factor of 2 to simulate a smaller capacity river flowing in the valley.

The simulated steady-state premining distribution of hydraulic head in the small aquifer is shown in figure 14*a*, and steady-state drawdown near a dewatered pit in the small aquifer is shown in figure 14*b*. Area of influence in simulation 4 has a maximum extent (measured from pit center) of about 2,050 m. Area of influence in simulation 4 is smaller than that in simulation 1, but drawdown generally is greater because the sides of the aquifer are closer to the pit, and the no-flow boundaries do not contribute ground-water inflow to the aquifer as do the general-head boundaries in simulation 1. Drawdown across the river in simulation 4 is similar to that in simulation 1.

Flow for all ground-water budget components in simulation 4 (tables 1 and 2), except river leakage to the aquifer under premining conditions (table 1), is smaller than in simulation 1 because the aquifer in simulation 4 is smaller and the riverbed has smaller hydraulic conductance than in simulation 1. River leakage to the aquifer under premining conditions in simulation 4 is larger than in simulation 1 because the no-flow boundaries along the sides of the aquifer in simulation 4 do not contribute flow to the aquifer,

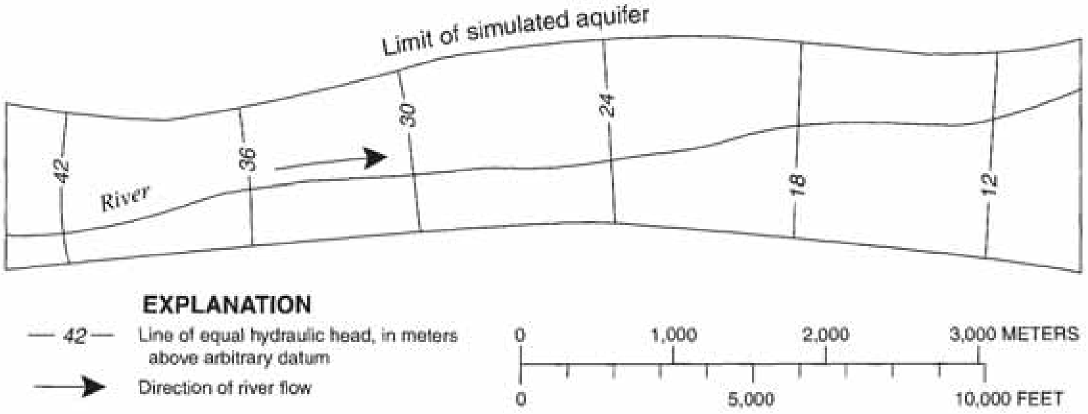


Figure 14*a*. Numerical simulation 4 –Steady-state premining distribution of hydraulic head in a hypothetical, small sand-and-gravel aquifer under homogeneous and isotropic conditions.

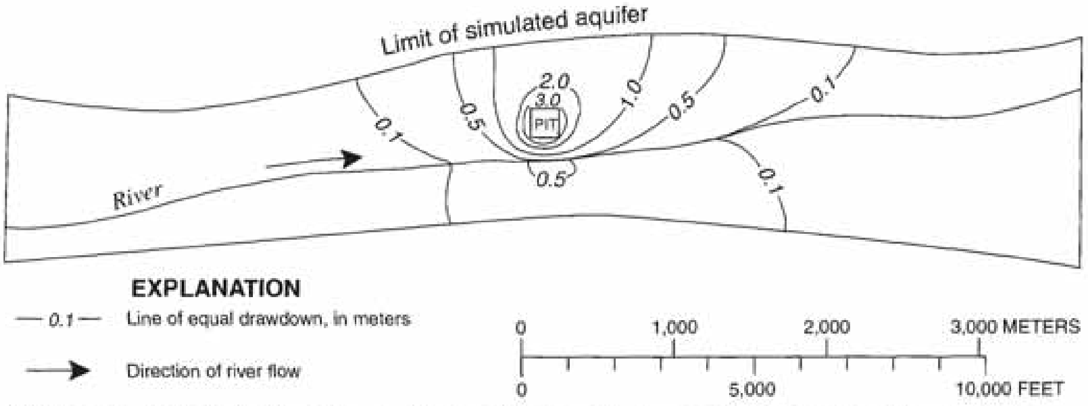


Figure 14*b*. Numerical simulation 4 –Steady-state drawdown caused by a dewatered pit in a hypothetical, small sand-and-gravel aquifer under homogeneous and isotropic conditions.

which causes the ground-water gradient between the sides of the aquifer and the river to be flatter and the water table to be lower than the river in places.

Simulation 5–Five pits lined with slurry walls in a medium-sized, homogeneous, isotropic aquifer

A slurry wall sometimes is installed around a pit to isolate it from ground water while mining continues or after mining ceases. Simulation 5 shows the potential cumulative effect of five closely spaced pits lined with slurry walls in a medium-sized (about 2,500 m wide) alluvial valley. Simulation 5 is similar to simulation 1 except five medium-sized pits are simulated simultaneously, and the area of grid refinement near the pits was enlarged to encompass five pits rather than one. The revised model grid has 35 rows and 90 columns with a cell size of 50 m × 50 m near the pits and a cell size of 100 m × 100 m at a distance of 500 m to 650 m from the pits. The five pits in simulation 5 are placed 100 m apart. Pits lined with slurry walls are simulated by using inactive cells at pit locations, thereby simulating no-flow barriers at the edges of the pits where slurry walls would be present. Simulating the slurry walls as no-flow barriers maximizes the hydrologic effects of the pit on the aquifer.

The simulated steady-state premining distribution of hydraulic head in the aquifer in simulation 5 is the same as in simulation 1 (fig. 11*a*), and steady-state drawdown near the pits in simulation 5 is shown in figure 15. Drawdown near the pits is complex and ranges from about –0.5 m to 0.3 m. Drawdown is negative upgradient from the pits, which indicates ground water is mounding against the impermeable slurry walls. Drawdown is positive downgradient from the pits, which indicates the pits have a shadow effect on ground-water flow. The extent of upgradient mounding (defined by the limit of –0.1-m drawdown) is about 2,200 m wide, and the extent of downgradient drawdown (defined by the limit of 0.1-m drawdown) is about 400 m wide. Ground-water levels across the river are not significantly affected by the pits in simulation 5.

The premining ground-water budget (table 1) of simulation 5 is nearly identical to that of simulation 1. Slight differences between the two simulations likely are due to the larger area of grid refinement in simulation 5. Recharge to the aquifer from precipitation (table 2) under active mining conditions is slightly less than in simulation 1 because inactive cells used to simulate lined pits do not contribute flow to the aquifer. Recharge from all other ground-water budget components and discharge to all ground-water budget components are greater than in simulation 1 because active pit dewatering is not simulated.

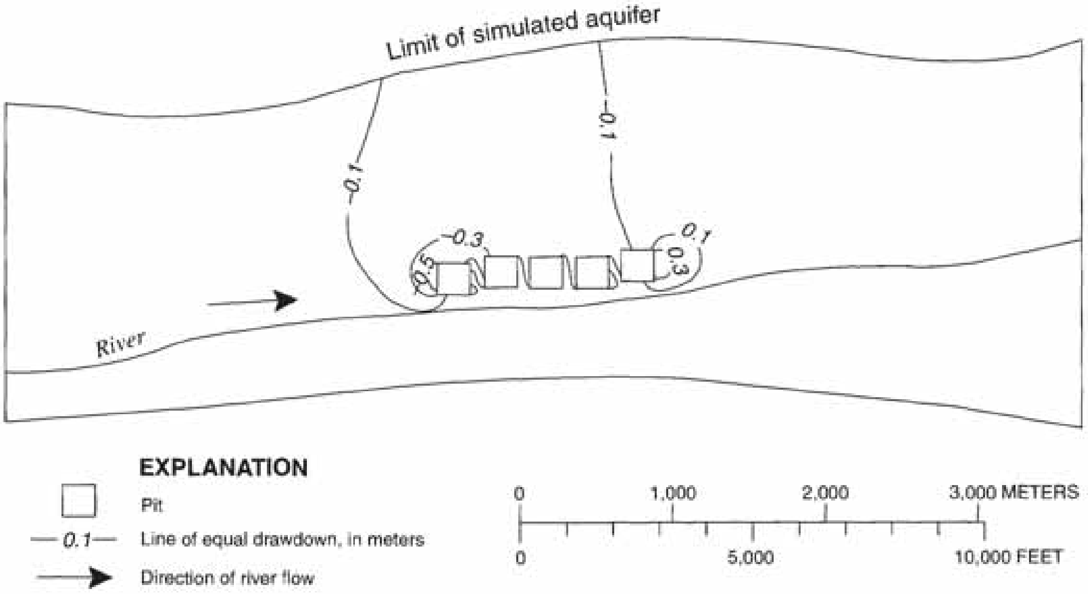


Figure 15. Numerical simulation 5–Steady-state drawdown caused by five closely spaced pits lined with slurry walls in a hypothetical, medium-sized sand-and-gravel aquifer under homogeneous and isotropic conditions.

Simulation 6–Five pits undergoing evaporative losses in a medium-sized, homogeneous, isotropic aquifer

Once mining is completed, aggregate pits may be refilled with water and used as water-storage reservoirs or for environmental or recreational purposes. Simulation 6 shows the potential cumulative effect of evaporative losses from five pits after refilling with water in a medium-sized (about 2,500 m wide) alluvial valley. Simulation 6 is the same as simulation 5 except cells at the pit locations are active (no slurry walls) and have horizontal and vertical hydraulic conductivity values 1,000 times greater than the surrounding aquifer material to simulate the open area of the pits. Using the MODFLOW–2000 Well package, evaporative losses are simulated as constant discharge from pit cells at a rate of 0.0034 m/d, which is approximately equal to average annual pan evaporation minus average annual precipitation for the Colorado Piedmont part of the Front Range area (see "Hydrogeologic Settings").

The simulated steady-state premining distribution of hydraulic head in the aquifer is the same as that of simulation 1 (fig. 11*a*), and steady-state drawdown caused by evaporation from the pits is shown in figure 16. To separate the effects of pit evaporation from the hydraulic effects of open pits in the aquifer, drawdown is calculated relative to initial steady-state post-mining conditions, rather than premining conditions. Drawdown near the pits is less than 0.1 m at all locations in simulation 6. For illustrative purposes, the limit of 0.05-m drawdown is shown in figure 16, but this area of influence is not comparable to other simulations, which have areas of influence defined by the limit of 0.1-m drawdown.

The premining ground-water budget (table 1) of simulation 6 is nearly identical to that of simulation 1. Slight differences between the two simulations likely are due to the larger area of grid refinement in simulation 6. Total evaporative loss from the pits is 680 m^3/d (table 2). The hydrologic effects of pits in simulation 6 are small because evaporative discharge from refilled pits is small compared to the overall ground-water budget for the aquifer.

Numerical Sensitivity Analysis

Composite scaled sensitivities were calculated for each simulation input parameter by using the Parameter Sensitivity with Observations mode (Hill and others, 2000) of MODFLOW–2000. Composite scaled sensitivities are dimensionless quantities that provide information about the importance of each input parameter to calculations of simulated equivalents (head or flow) at specific locations (observations) and indicate the amount of information that observations contain for the estimation of a parameter (Hill, 1998). The actual value of sensitivity for each

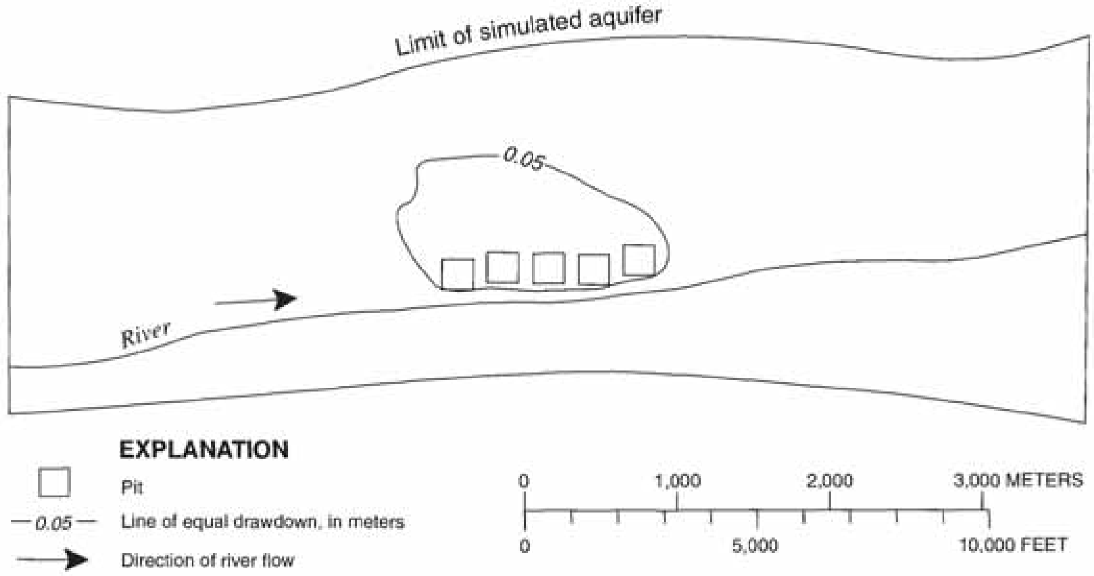


Figure 16. Numerical simulation 6–Steady-state drawdown caused by five closely spaced, water-filled pits undergoing evaporative losses in a hypothetical, medium-sized sand-and-gravel aquifer under homogeneous and isotropic conditions.

parameter is less meaningful than the relative magnitude of the value compared to the sensitivities for other parameters. Parameters with high sensitivities affect simulated equivalents more than parameters with low sensitivities, and high sensitivities indicate that available observations provide much information on which parameters can be estimated. In this report, composite scaled sensitivities indicate the sensitivity of simulated head to variations in parameter values. The sensitivity of simulated flow to variations in parameter values was not calculated because changes in head (drawdown and area of influence) are the primary quantities of interest in the study.

Sensitivities of simulated head were calculated for each parameter by using hypothetical observations distributed evenly throughout the numerical model domain. Twenty-six observations were used to calculate sensitivities in simulations 1, 2, 5, and 6 (medium-sized alluvial valley); 52 observations were used to calculate sensitivities in simulation 3 (large alluvial valley); and 20 observations were used to calculate sensitivities in simulation 4 (small alluvial valley). Observation locations are shown in figure 17. The use of hypothetical head observations does not affect simulation results, but the observations are necessary to generate composite scaled sensitivities using MODFLOW–2000.

Composite scaled sensitivities depend on model construction and observation locations and are, therefore, unique to each model. However, because observations are distributed evenly throughout the hypothetical aquifers, composite scaled sensitivities describe the approximate overall sensitivity of simulated head to each parameter and may indicate which parameters are most critical to define at real sites having conditions similar to those of the hypothetical aquifers. Parameters with high sensitivities may be more important to accurately define for predictions of mining effects than parameters with low sensitivities. Results of sensitivity analysis for simulation 1 are shown in figure 18. Results of sensitivity analyses for all sand-and-gravel aquifer simulations are shown in table 3.

Results of the sensitivity analyses indicate simulated head was most sensitive to variations in horizontal hydraulic conductivity in every simulation except simulation 6 (five pits undergoing evaporative losses), in which simulated head was most sensitive to variations in the hydraulic conductance term of the general-head boundaries. In all simulations except simulation 6 and simulation 4 (no general-head boundaries present), the sensitivity for general-head boundary conductance was second only to that for horizontal hydraulic conductivity and was similar in magnitude to that of horizontal hydraulic conductivity. Similarly, the sensitivities for riverbed conductance and recharge were similar in magnitude to each other in all simulations except simulations 3 and 4, but the sensitivities were relatively small compared to those for horizontal hydraulic conductivity and general-head boundary conductance. Simulated head was relatively insensitive to vertical hydraulic conductivity in all simulations.

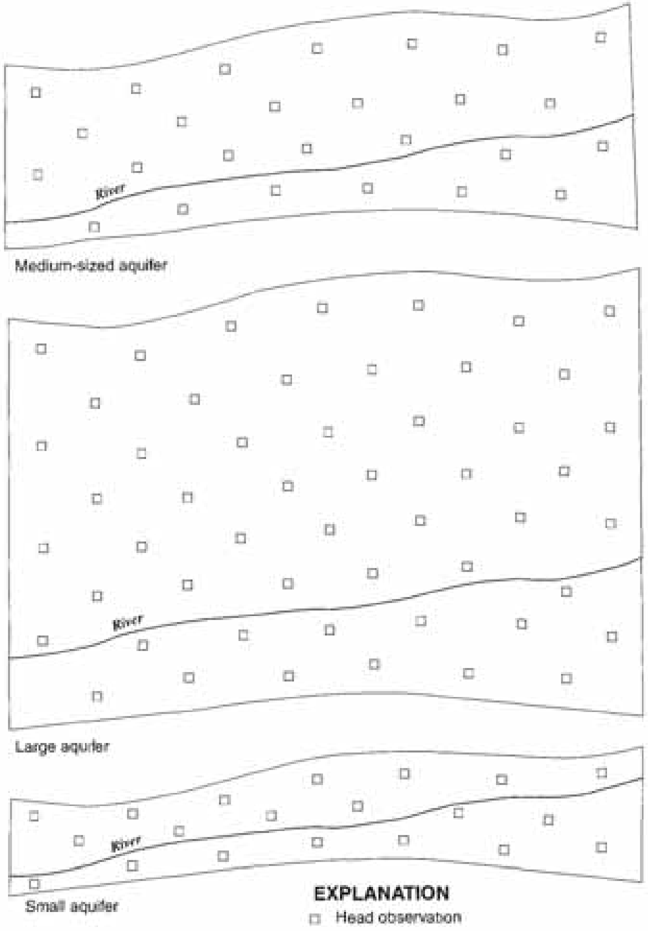


Figure 17. Location of hypothetical head observations used to calculate composite scaled sensitivities for numerical simulations of the hydrologic effects of mining aggregate in sand-and-gravel aquifers.

For simulations of a real gravel pit or quarry, it would be important to include hydrologic observations of both hydraulic head and flow data for simulation

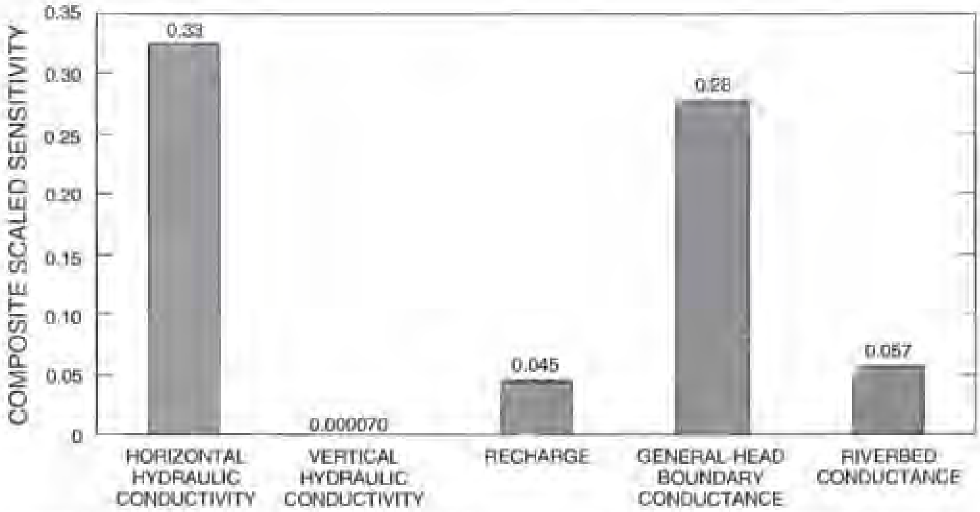


Figure 18. Composite scaled sensitivities for parameters in numerical simulation 1 (pit in a hypothetical, medium-sized sand-and-gravel aquifer under homogeneous and isotropic conditions.

Table 3. Composite scaled sensitivities for parameters used in six numerical simulations of the effects of mining aggregate in hypothetical sand-and-gravel aquifers

[—, not applicable]

Simulation	Parameter				
	Horizontal hydraulic conductivity	Vertical hydraulic conductivity	Recharge	General-head boundary conductance	Riverbed conductance
1	0.33	0.000070	0.045	0.28	0.057
2	0.33	0.00069	0.045	0.28	0.057
3	0.33	0.0034	0.044	0.23	0.10
4	0.12	0.000056	0.024	—	0.10
5	0.29	0.000042	0.051	0.29	0.069
6	0.25	0.000077	0.043	0.26	0.064

Model simulations:

1. Pit in medium-sized, homogeneous, isotropic aquifer.
2. Pit in medium-sized, homogeneous, vertically anisotropic aquifer.
3. Pit in large, homogeneous, isotropic aquifer.
4. Pit in small, homogeneous, isotropic aquifer.
5. Five pits lined with slurry walls in medium-sized, homogeneous, isotropic aquifer.
6. Five water-filled pits undergoing evaporative losses in medium-sized, homogeneous, isotopic aquifer.

calibration (Hill, 1998). Hydraulic head data alone often do not provide enough information to break the inverse correlation between the hydraulic conductivity and recharge parameters and therefore obtain a unique solution to the ground-water flow equation (Hill, 1998). Streamflow or pit-discharge measurements provide a measure of ground-water discharge from an aquifer, and such flow measurements would be important to include when simulating actual gravel pits or quarries. Anderman and others (1996) present a detailed analysis of different types of hydrologic observations and their importance in ground-water flow simulations.

Simulation of Quarries in Fractured Crystalline-Rock Aquifers

Definitions of input parameters for simulations of aggregate mining in fractured crystalline-rock aquifers were based on data reported in the literature (see "Hydrogeologic Settings"). Definitions of mining extents (area and depth) were based on mine permit information, site data, and quarry footprints shown on U.S. Geological Survey 1:50,000 County Maps. Intermediate parameter values and boundary conditions were used in the simulations to represent average hydrogeologic conditions and mining extents. Parameter values and boundary conditions were then varied over a range of values and conditions typical for quarries in fractured crystalline-rock aquifers to determine the potential effects of mining over a wide range of conditions. Intermediate hydraulic conductivity was defined in the simulations as 0.01 m/d, and intermediate recharge was defined as 0.0001 m/d, which is about 7 percent of average annual precipitation for the Rocky Mountain part of the Colorado Front Range area. Intermediate quarry penetration of the water table was defined as 50 m, and intermediate quarry radius was defined as 200 m.

Analytical Simulations and Sensitivities

Two analytical solutions were used to simulate the effects of mining aggregate in a fractured crystalline-rock aquifer. The analytical solution of Marinelli and Niccoli (2000) was used to solve for the radius of influence (r_i) and saturated thickness (h) above the base of a dewatered circular quarry in a homogeneous, isotropic, fractured crystalline-rock aquifer of infinite extent. Equation 7 was used to solve for the distance of influence (x_i) and saturated thickness (h) above the base of a dewatered linear quarry in a homogeneous, isotropic, fractured crystalline-rock aquifer of infinite extent. Horizontal hydraulic conductivity (K_h), recharge (W), initial saturated thickness above the quarry base ($h = h_o$), and quarry radius (r_p, circular quarry only) were varied independently over a range of values typical for quarries in fractured crystalline-rock aquifers in the Front Range area. By varying the parameters independently, the effects of each parameter on simulation results were evaluated, and sensitivities for parameters were calculated. Because initial saturated thickness is measured relative to the quarry base, h_o also is equal to the depth to which the quarry penetrates the water table. The water level in the quarry was defined at the base of the quarry.

Figures 19–22 show drawdown ($h_o - h$) and radius of influence measured from the quarry wall ($r_i - r_p$) caused by a dewatered circular quarry in a fractured crystalline-rock aquifer for different values of K_h (0.0001, 0.01, and 1 m/d), W (0.000025, 0.0001, and 0.0004 m/d), h_o (20, 50, and 80 m), and r_p (100, 200, and 400 m). Figures 23–25 show drawdown and distance of influence (x_i) caused by a dewatered linear quarry in a fractured crystalline-rock aquifer for the same values of K_h, W, and h_o. Results indicate radius of influence from the wall of a dewatered circular quarry in a homogeneous, isotropic fractured crystalline-rock aquifer of infinite extent was 411 m under intermediate conditions ($K_h = 0.01$ m/d, $W = 0.0001$ m/d, $h_o = 50$ m, $r_p = 200$ m). Distance of influence from the wall of a dewatered linear quarry under the same conditions was 500 m. Radius (or distance) of influence increased as K_h, h_o, and r_p (circular quarry only) increased and as W decreased.

Equation 9 was used to calculate 1-percent scaled sensitivities (see "Analytical Simulations and Sensitivities" under "Simulation of Pits in Sand-and-Gravel Aquifers") for each parameter used in the analytical solutions of Marinelli and Niccoli (2000) and equation 7 to determine the effect of each parameter on simulation results under intermediate conditions. Resulting sensitivities have units of meters and are the change in radius or distance of influence caused by a 1-percent change in the parameter value.

Results of analytical sensitivity analysis under intermediate conditions ($K_h = 0.01$ m/d, $W = 0.0001$ m/d, $h_o = 50$ m, $r_p = 200$ m) are shown in figure 26 for a circular quarry and in figure 27 for a linear quarry.

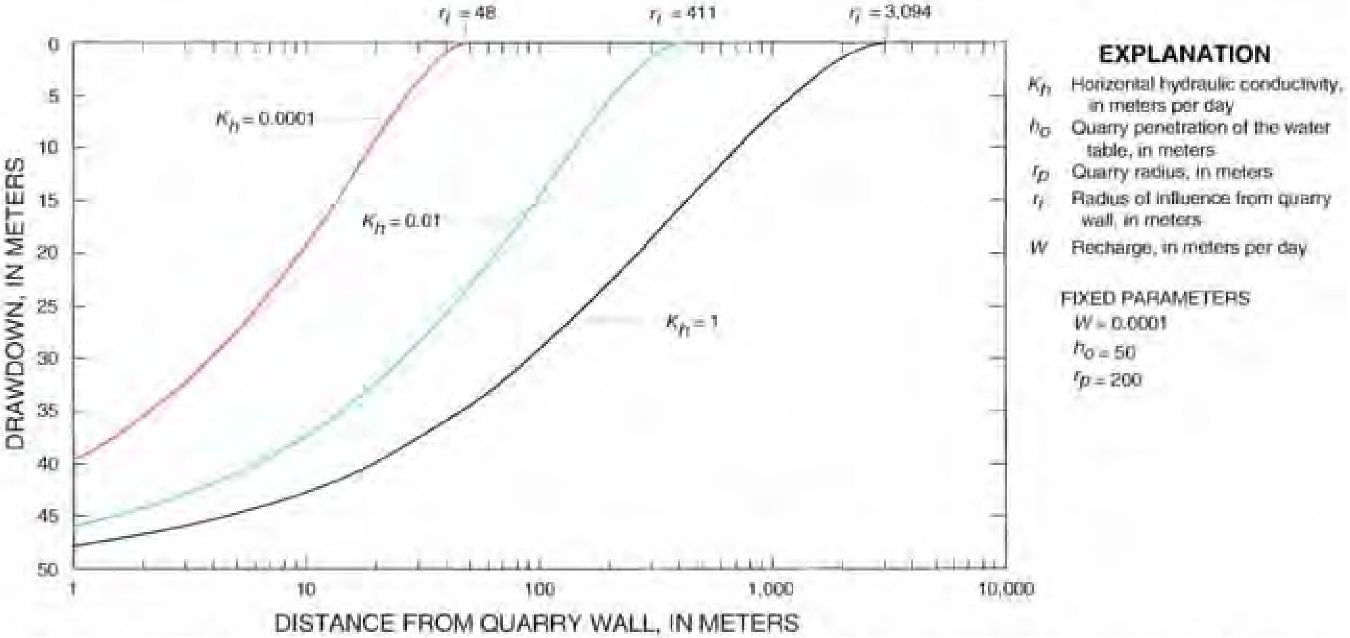


Figure 19. Drawdown relative to distance from a dewatered circular quarry in a fractured crystalline-rock aquifer for three values of horizontal hydraulic conductivity, simulated by use of the Marinelli and Niccoli (2000) analytical solution.

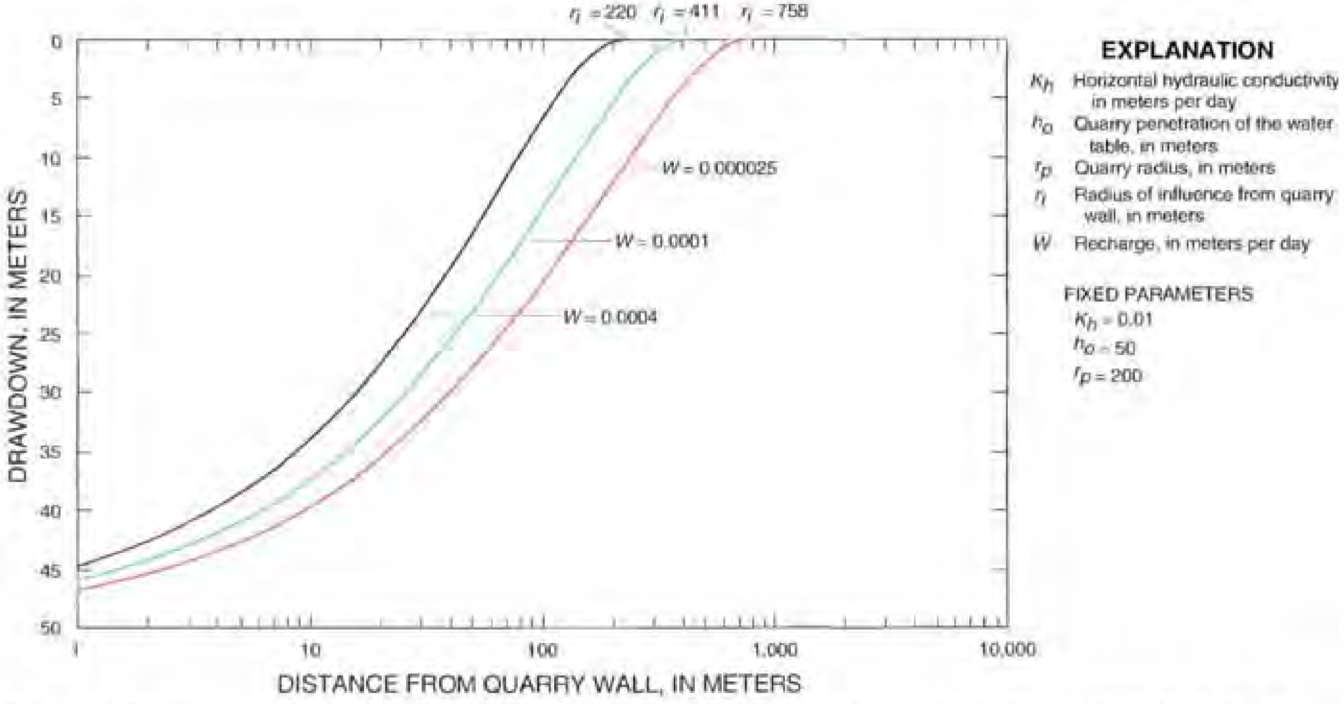


Figure 20. Drawdown relative to distance from a dewatered circular quarry in a fractured crystalline-rock aquifer for three values of recharge, simulated by use of the Marinelli and Niccoli (2000) analytical solution.

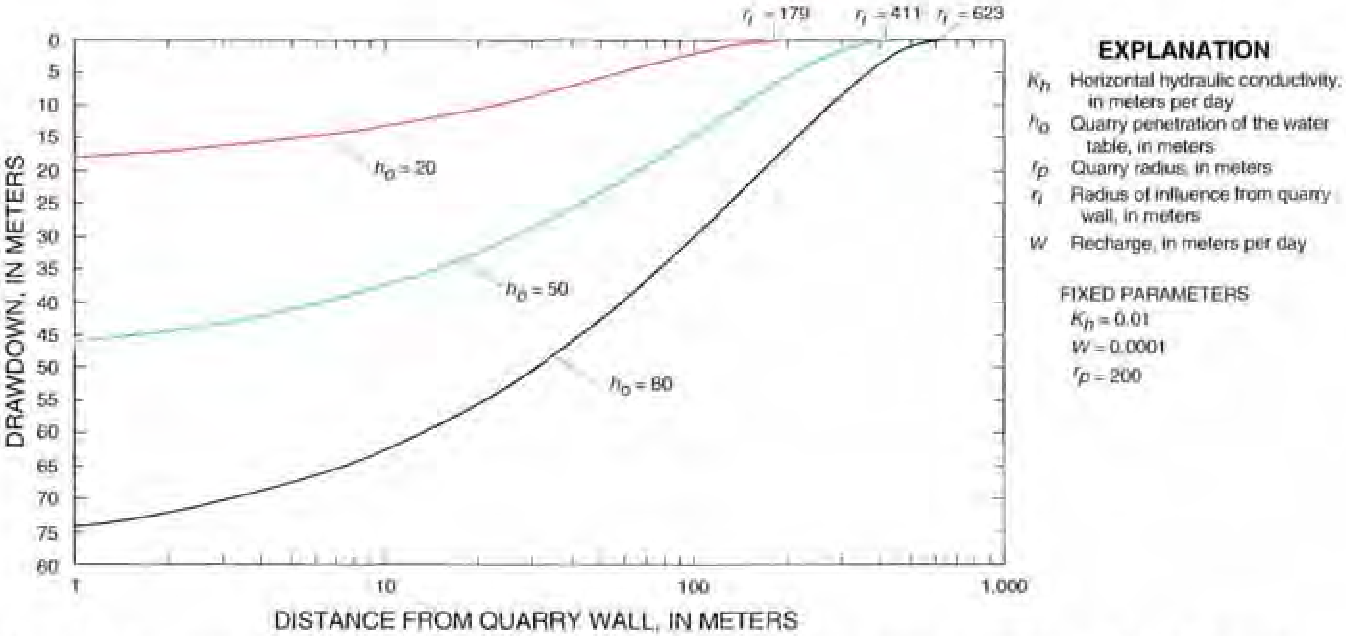


Figure 21. Drawdown relative to distance from a dewatered circular quarry in a fractured crystalline-rock aquifer for three values of quarry penetration of the water table, simulated by use of the Marinelli and Niccoli (2000) analytical solution.

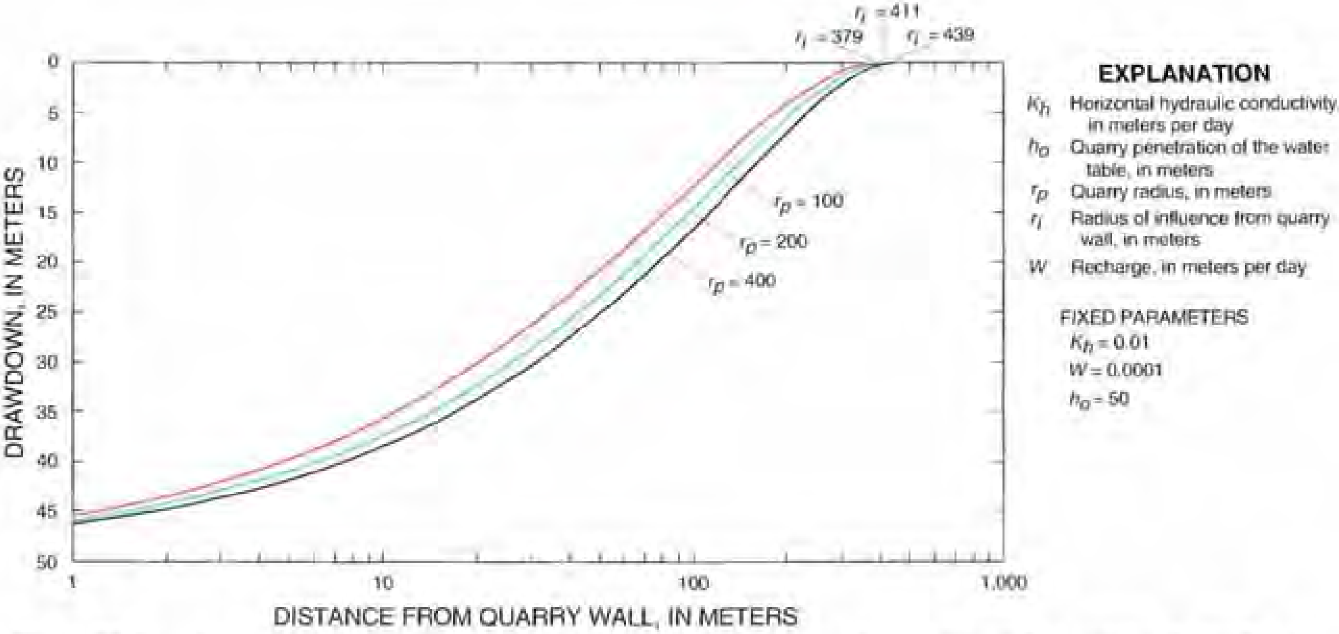


Figure 22. Drawdown relative to distance from a dewatered circular quarry in a fractured crystalline-rock aquifer for three values of quarry radius, simulated by use of the Marinelli and Niccoli (2000) analytical solution.

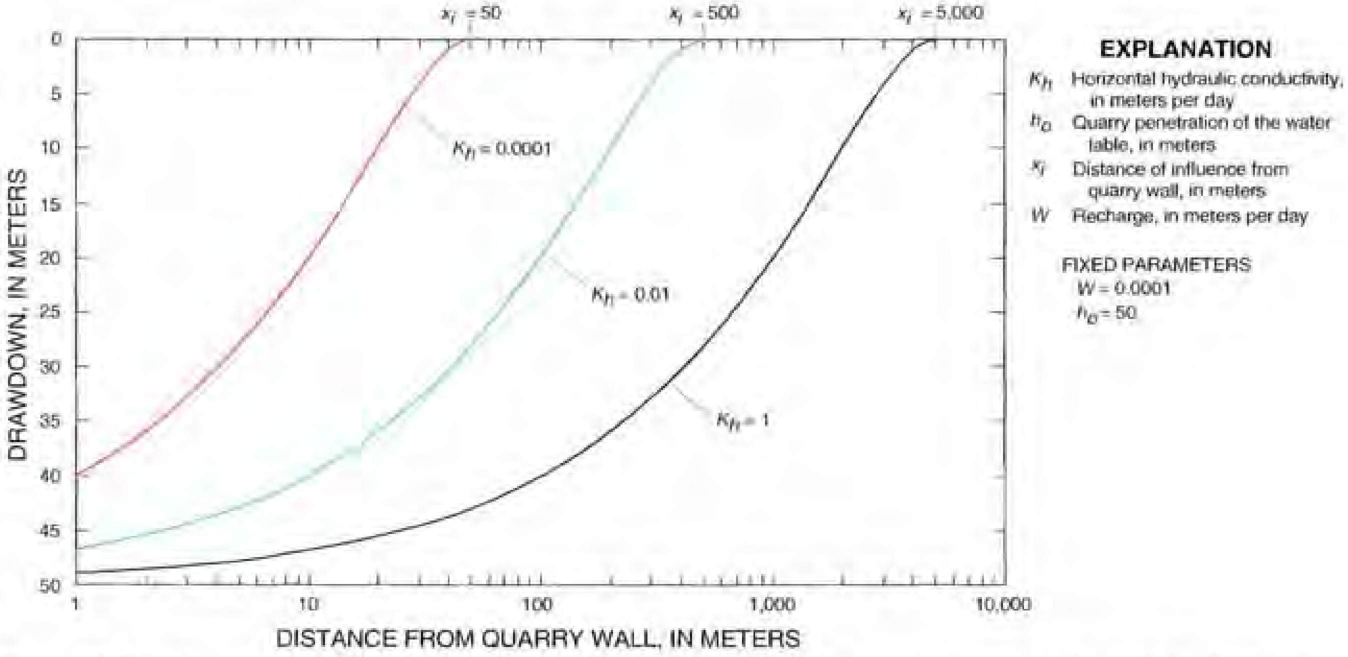


Figure 23. Drawdown relative to distance from a dewatered linear quarry in a fractured crystalline-rock aquifer for three values of quarry penetration of the water table, simulated by use of equation 7.

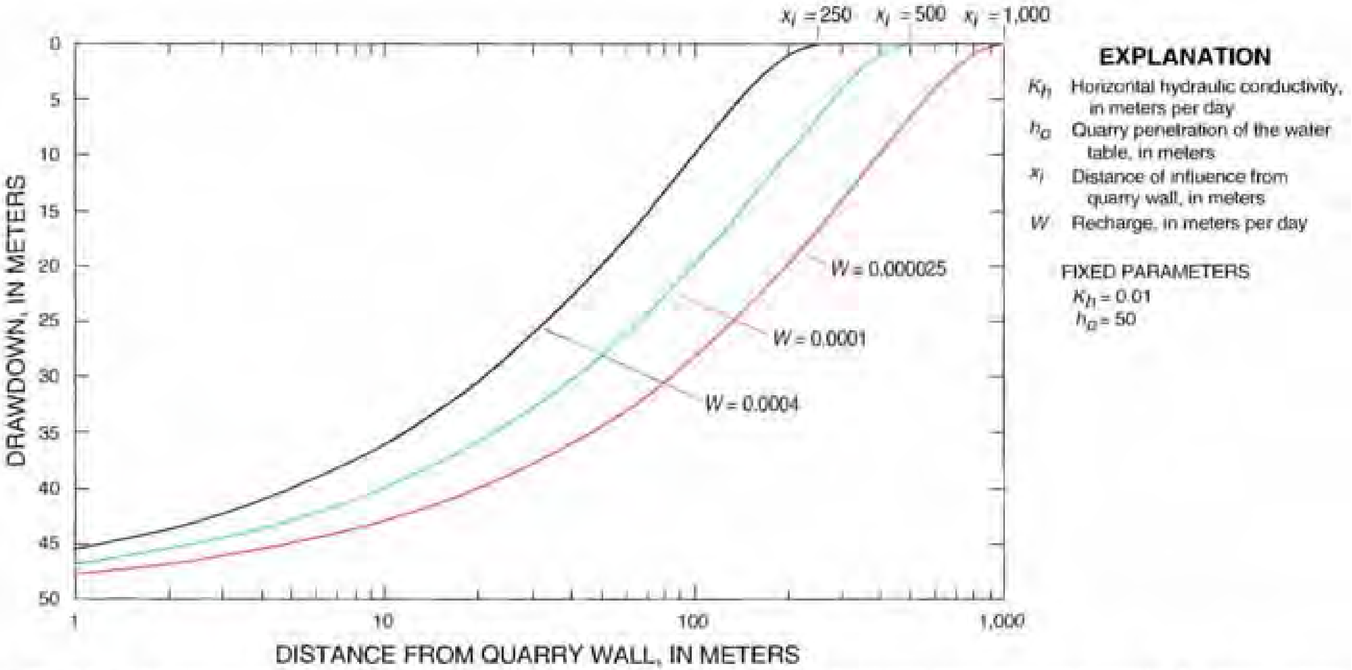


Figure 24. Drawdown relative to distance from a dewatered linear quarry in a fractured crystalline-rock aquifer for three values of recharge, simulated by use of equation 7.

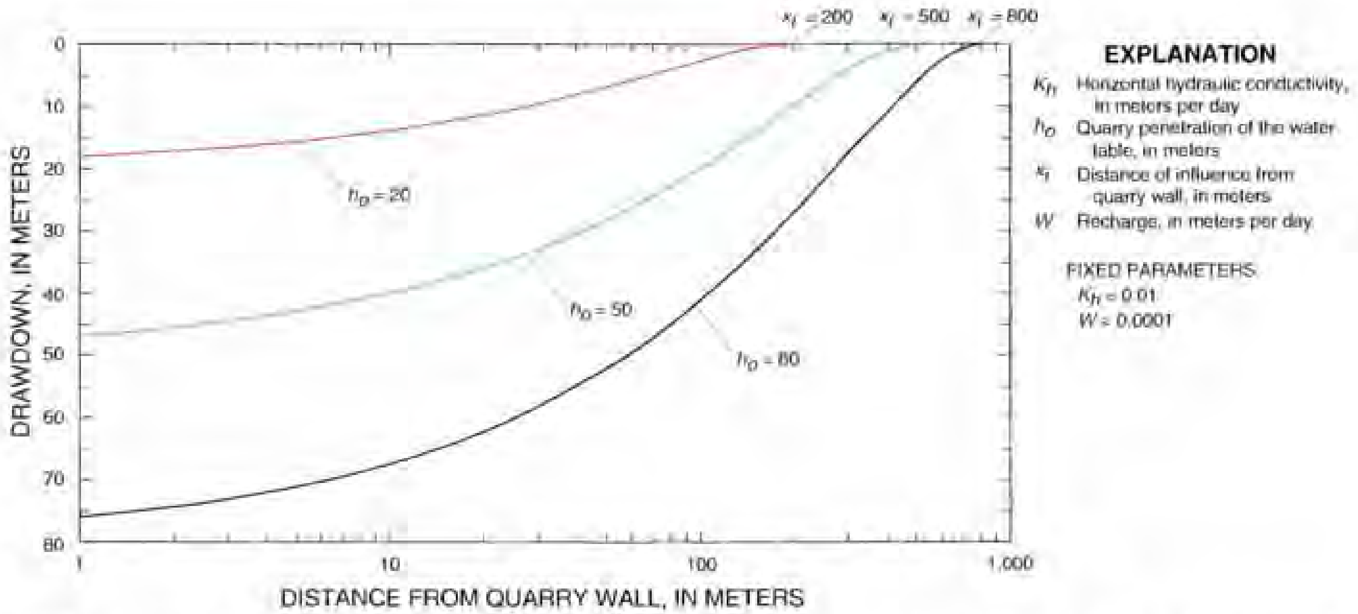


Figure 25. Drawdown relative to distance from a dewatered linear quarry in a fractured crystalline-rock aquifer for three values of quarry penetration of the water table, simulated by use of equation 7.

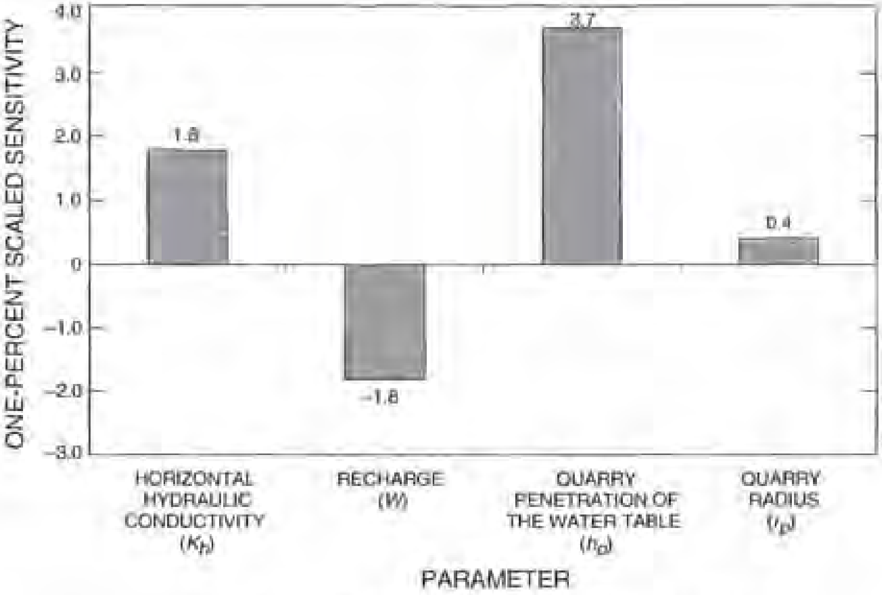
Results indicate that radius or distance of influence was most sensitive to changes in quarry penetration of the water table and least sensitive to changes in quarry radius (circular quarry only). Radius of influence was equally sensitive to changes in horizontal hydraulic conductivity and recharge. However, the parameters had opposite effects on simulation results because they are inversely correlated in the analytical solution. Radius (or distance) of influence increased as horizontal hydraulic conductivity increased and as recharge decreased.

Numerical Simulations

MODFLOW–2000 (Harbaugh and others, 2000) was used to compute (1) hydraulic heads in a hypothetical fractured crystalline-rock aquifer under steady-state, premining conditions, (2) steady-state drawdown caused by a dewatered quarry in the fractured crystalline-rock aquifer under different hydrogeologic conditions, and (3) inflow to the quarry under different hydrogeologic conditions. In addition, the observation and sensitivity capabilities (Hill and others, 2000) of MODFLOW–2000 were used to compute sensitivities for simulation input parameters. Although MODFLOW–2000 is designed to simulate ground-water flow in a porous medium, such as a sand-and-gravel aquifer, the code also was used in this study to simulate the effects of mining in a fractured crystalline-rock aquifer because it is well documented, well supported, and has been successfully applied to other fractured-rock settings (Tiedeman and others, 1997; Daniel and others, 1997; Long and others, 1982). Because simulations are of hypothetical aquifers, model calibration was not necessary. However, generalized aquifer data from real sites were used to guide development of simulated premining conditions. Six numerical simulations of the hydrologic effects of mining aggregate in hypothetical fractured crystalline-rock aquifers are presented as follows:

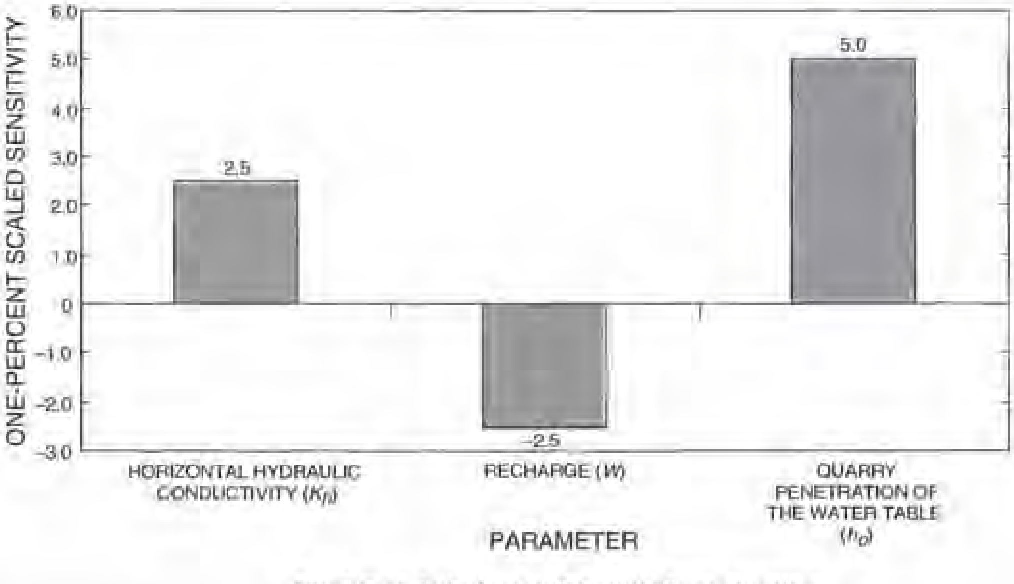
Simulation 7–The hydrologic effects of a dewatered quarry in a homogeneous and isotropic fractured crystalline-rock aquifer are simulated. Comparison of simulation 7 to analytical simulation results shows the effects of boundary conditions.

Simulation 8–The hydrologic effects of a dewatered quarry in a homogeneous but horizontally anisotropic, fractured crystalline-rock aquifer are simulated.



Sensitivities indicate change in radius of influence, in meters, caused by a 1-percent change in parameter value

Figure 26. One-percent scaled sensitivities for parameters in the analytical solution of Marinelli and Niccoli (2000), calculated for a circular quarry in a fractured crystalline-rock aquifer under intermediate conditions ($K_h = 0.01$ m/d, $W = 0.0001$ m/d, $h_o = 50$ m, $r_p = 200$ m).



Sensitivities indicate change in distance of influence, in meters, caused by a 1-percent change in parameter value

Figure 27. One-percent scaled sensitivities for parameters in equation 7, calculated for a linear quarry in a fractured crystalline-rock aquifer under intermediate conditions ($K_h = 0.01$ m/d, $W = 0.0001$ m/d, $h_o = 50$ m).

Comparison of simulation 8 to simulation 7 shows the effects of horizontal anisotropy.

Simulation 9–The hydrologic effects of a dewatered quarry in a fractured crystalline-rock aquifer with three hydraulic conductivity zones are simulated. Comparison of simulation 9 to simulation 7 shows the effects of lateral variations of hydraulic conductivity.

Simulation 10–The hydrologic effects of a dewatered quarry in a fractured crystalline-rock aquifer with ground-water flow in deep, low-permeability fractures are simulated. Comparison of simulation 10 to simulation 7 shows the effects of adding a layer of low hydraulic conductivity to the bottom of the model.

Simulation 11–The hydrologic effects of a dewatered quarry intersected by a hydraulically conductive fault zone in a homogeneous and isotropic fractured crystalline-rock aquifer are simulated. Comparison of simulation 11 to simulation 7 shows the effects of a fault zone that provides a conduit for ground-water flow.

Simulation 12–The hydrologic effects of a dewatered quarry intersected by a low-conductivity fault zone in a homogeneous and isotropic fractured crystalline-rock aquifer are simulated. Comparison of simulation 12 to simulation 7 shows the effects of a fault zone that forms a barrier to ground-water flow.

Simulation 7–Quarry in a homogeneous, isotropic aquifer

Simulation 7 shows the potential hydrologic effects of a dewatered quarry in a homogeneous and isotropic fractured crystalline-rock aquifer. The simulation uses the intermediate values of horizontal hydraulic conductivity, recharge, quarry depth, and quarry width from the analytical simulations to facilitate comparison between the simulations.

Model design

A fractured crystalline-rock aquifer is represented using one layer with a thickness of 100 m and a horizontal hydraulic conductivity of 0.01 m/d (fig. 28). Vertical hydraulic conductivity is not considered because the model has only one layer. Saturated thickness in the vicinity of the quarry ranges from about 75 to 100 m. The aquifer is simulated as convertible, which allows hydraulic head to be computed for either confined or unconfined conditions. The model grid has 34 rows and 31 columns with a cell size of 100 m × 100 m near the pit and 200 m × 200 m at a distance 1,000 m from the quarry (fig. 29). The model domain is 4,800 m by 5,200 m. The hydraulic gradient is about 0.1 in the vicinity of the quarry.

Boundary conditions

The left side of the aquifer (fig. 29) is simulated as a no-flow boundary to represent a ground-water divide coincident with hilltops along a major topographic high. The top and bottom edges of the aquifer (map-view) also are simulated as no-flow boundaries and are assumed far enough from the quarry that their influence on simulation results was negligible. The right side of the aquifer is simulated as a constant-head boundary to represent a large stream flowing along the bottom of a prominent valley. The aquifer base is simulated as a no-flow boundary at a depth 100 m below land surface to represent the depth below which fracture permeability is assumed negligible. A specified-flux boundary with a value of 0.0001 m/d is used to simulate areal recharge from precipitation.

Valleys in the model domain are simulated as drains by using the Drain package of MODFLOW-2000. The hydraulic conductance of drains is defined based on a valley 30-m wide with a 3-m thick layer of valley-bottom sediments having a hydraulic conductivity of 1 m/d. The use of drains in the mountain valleys was important to obtaining a realistic steady-state distribution of hydraulic head in the aquifer under premining conditions. The quarry is simulated as a 400 m wide square with truncated corners at the upgradient wall and a maximum water-table penetration of 50 m. The quarry also is simulated as a drain by using the Drain package of MODFLOW–2000 because ground-water inflow to quarries in fractured crystalline-rock aquifers commonly is slow enough that active dewatering measures are not needed (Knepper, 2002) and because the quarries commonly are cut into steep hillsides where the water table may not be penetrated by all parts of the quarry.

Results and comparison to analytical simulation

The simulated steady-state premining distribution of hydraulic head in the aquifer is shown in figure 30*a*, and steady-state drawdown near a dewatered quarry in the aquifer is shown in figure 30*b*. Steady-state drawdown computed using the analytical solution of Marinelli and Niccoli (2000) for a dewatered quarry in a homogeneous, isotropic fractured

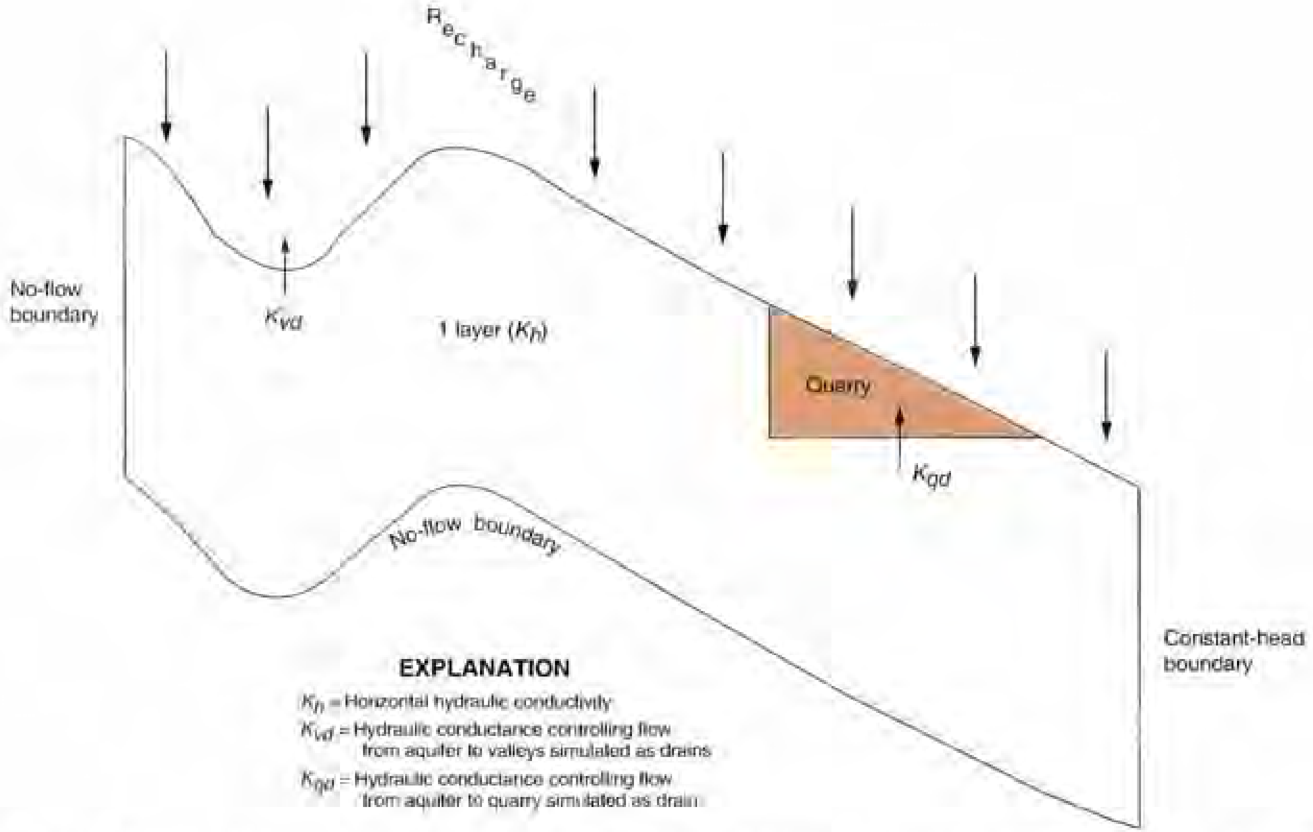


Figure 28. Conceptual diagram for numerical simulation 7 (quarry in a hypothetical fractured crystalline-rock aquifer under homogeneous and isotropic conditions).

crystalline-rock aquifer of infinite extent is shown in figure 30*c*. Results of the analytical simulation were computed using the same values of horizontal hydraulic conductivity, recharge, pit penetration of the water table, and pit radius as the numerical simulation.

Lines of equal drawdown computed by the analytical simulation occur as concentric circles centered around the quarry, and area of influence computed by the analytical simulation (defined by limit of 1-m drawdown) has a radius of 513 m, measured from the quarry center. Lines of equal drawdown computed by the numerical simulation are asymmetrical because of boundary effects. Area of influence (defined by limit of 1-m drawdown) computed by the numerical simulation has a maximum extent of about 1,300 m, measured from the quarry center. Area of influence in the numerical simulation is larger than in the analytical simulation because saturated thickness near the quarry in the numerical simulation is greater, which increases aquifer transmissivity. Area of influence increases as aquifer transmissivity increases. Drawdown in the numerical simulation is centered around the upgradient wall of the quarry because the quarry is excavated into a water table with a steep gradient. Because the base of the simulated quarry is level, the upgradient wall of the quarry penetrates the water table to a greater degree than the downgradient wall. Valleys simulated as drains in the numerical simulation affect the shape of area of influence, but area of influence extends across the valley nearest the quarry.

The complete ground-water budget for premining conditions in simulation 7 is shown in table 4, and the complete ground-water budget for the effects of the dewatered quarry in simulation 7 is shown in table 5. The ground-water budgets give an accounting of recharge to the aquifer and discharge from the aquifer. Values given in the tables indicate total volumetric fluxes for all cells of a given type. Recharge to the aquifer includes ground-water inflow from the

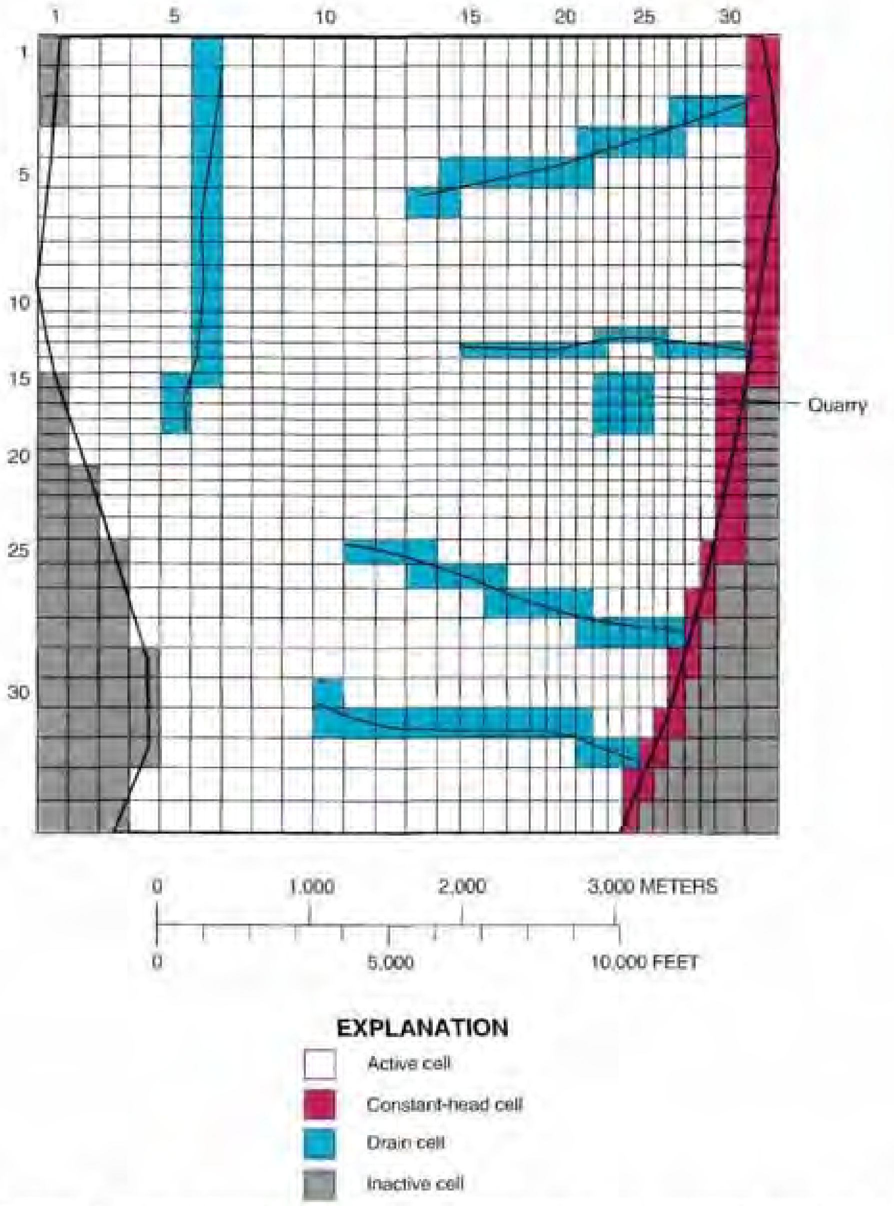


Figure 29. Finite-difference grid and boundary conditions for numerical simulation 7 (quarry in a hypothetical fractured crystalline-rock aquifer under homogeneous and isotropic conditions).

constant-head boundary and distributed recharge from precipitation. Discharge from the aquifer includes (1) ground-water outflow to the constant-head boundary, (2) ground-water discharge to valleys simulated as drains, and (3) ground-water discharge to the quarry under conditions of active mining.

Under premining conditions, nearly all recharge is from precipitation. Very little recharge is contributed by the constant-head boundary because the boundary occurs along the downgradient edge of the model. Most discharge from the aquifer under premining conditions occurs to valleys simulated as drains, but discharge to the constant-head boundary also is significant. Under conditions of active mining, when the quarry is dewatered, recharge is nearly identical to premining conditions, but discharge to valleys and the constant-head boundary is less because the quarry intercepts ground water that, under premining conditions, flows to the valleys and the constant-head boundary. Discharge to the quarry in simulation 7 is much less than discharge to the pit in simulation 1 because the hydraulic conductivity of the fractured crystalline-rock aquifer is much less than that of the sand-and-gravel aquifer.

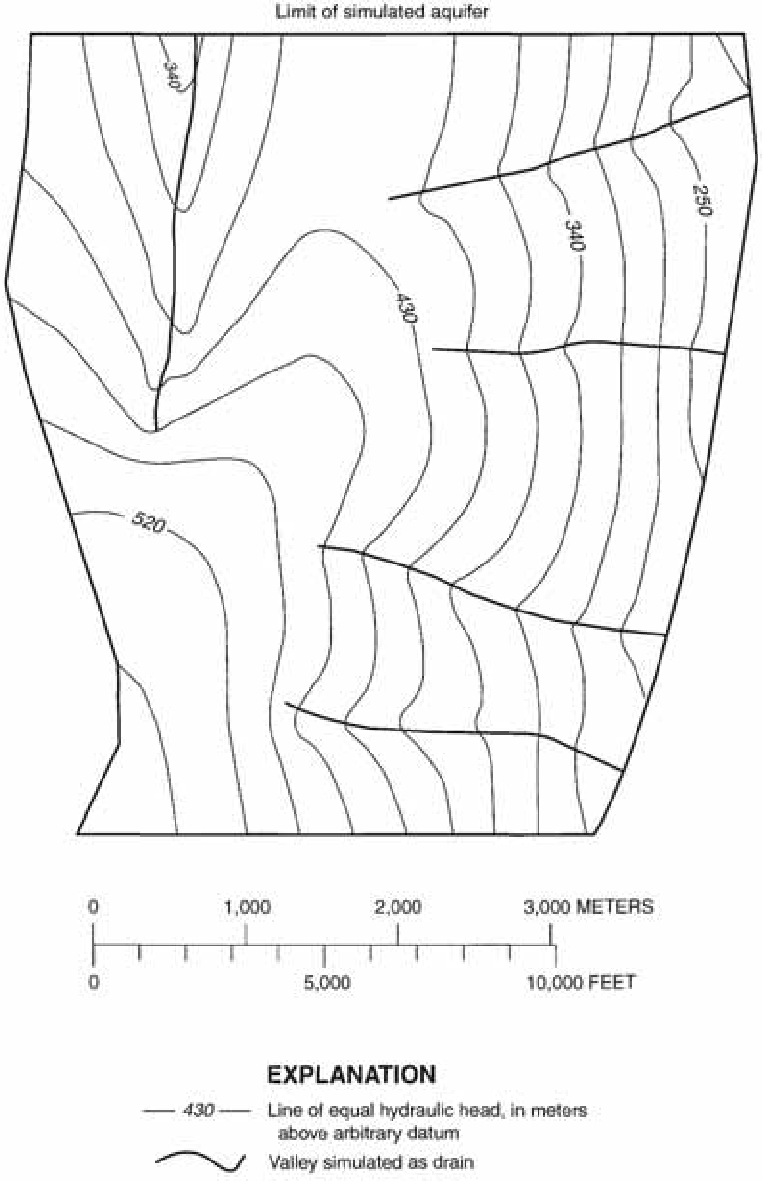


Figure 30*a*. Numerical simulation 7–Steady-state premining distribution of hydraulic head in a hypothetical fractured crystalline-rock aquifer under homogeneous and isotropic conditions.

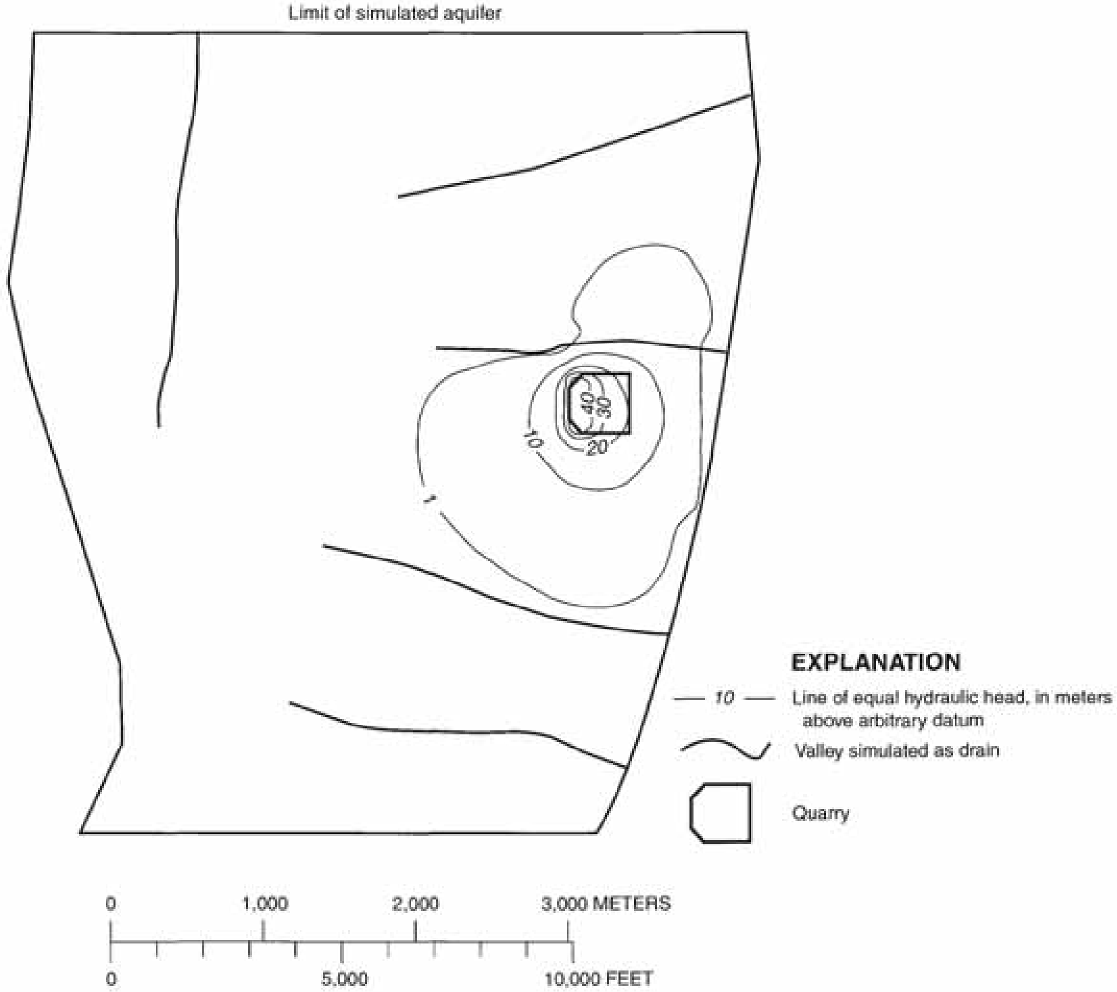


Figure 30*b*. Numerical simulation 7–Steady-state drawdown caused by a dewatered quarry in a hypothetical fractured crystalline-rock aquifer under homogeneous and isotropic conditions.

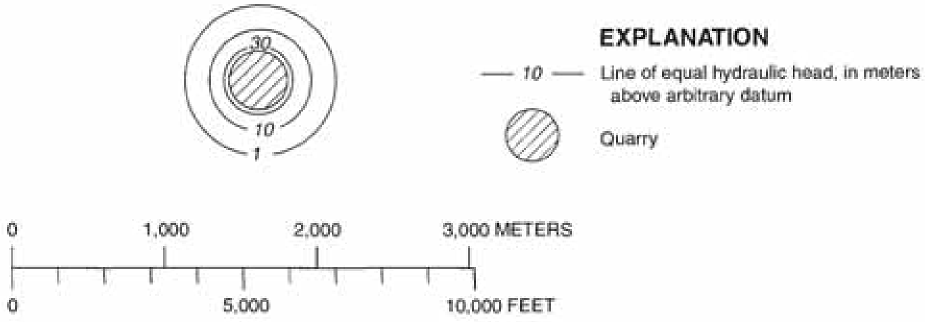


Figure 30*c*. Steady-state drawdown caused by a dewatered quarry in a homogeneous, isotropic, fractured crystalline-rock aquifer of infinite extent, simulated by use of the Marinelli and Niccoli (2000) analytical solution.

Simulation 8–Quarry in a homogeneous aquifer with horizontal anisotropy

Simulation 8 shows the effects horizontal anisotropy may have on steady-state drawdown near a quarry. Simulation 8 is identical to simulation 7 except hydraulic conductivity along columns in the model is assigned a value three times greater than the hydraulic conductivity along rows. Hydraulic conductivity along rows is 0.01 m/d as in simulation 7. Simulation 8 represents a system in which fracture permeability in one horizontal coordinate direction is greater than that in another coordinate direction.

The simulated steady-state premining distribution of hydraulic head in the aquifer is shown in figure 31*a*, and steady-state drawdown near a dewatered quarry in the anisotropic aquifer is shown in figure 31*b*. Premining hydraulic head in simulation 8 generally is slightly lower than in simulation 7 because the increased hydraulic conductivity along columns in simulation 8 increases discharge to valleys, which lowers the water table. The water table of simulation 8

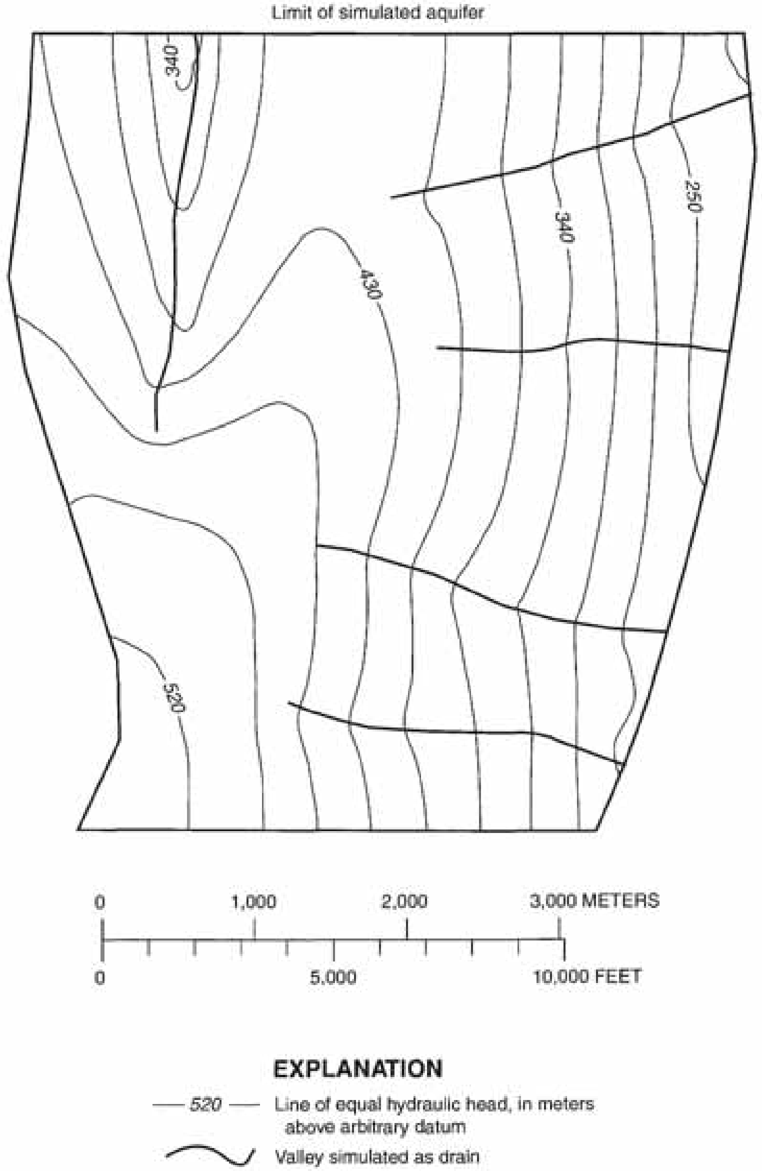


Figure 31*a*. Numerical simulation 8–Steady-state premining distribution of hydraulic head in a hypothetical fractured crystalline-rock aquifer under homogeneous and horizontally anisotropic conditions.

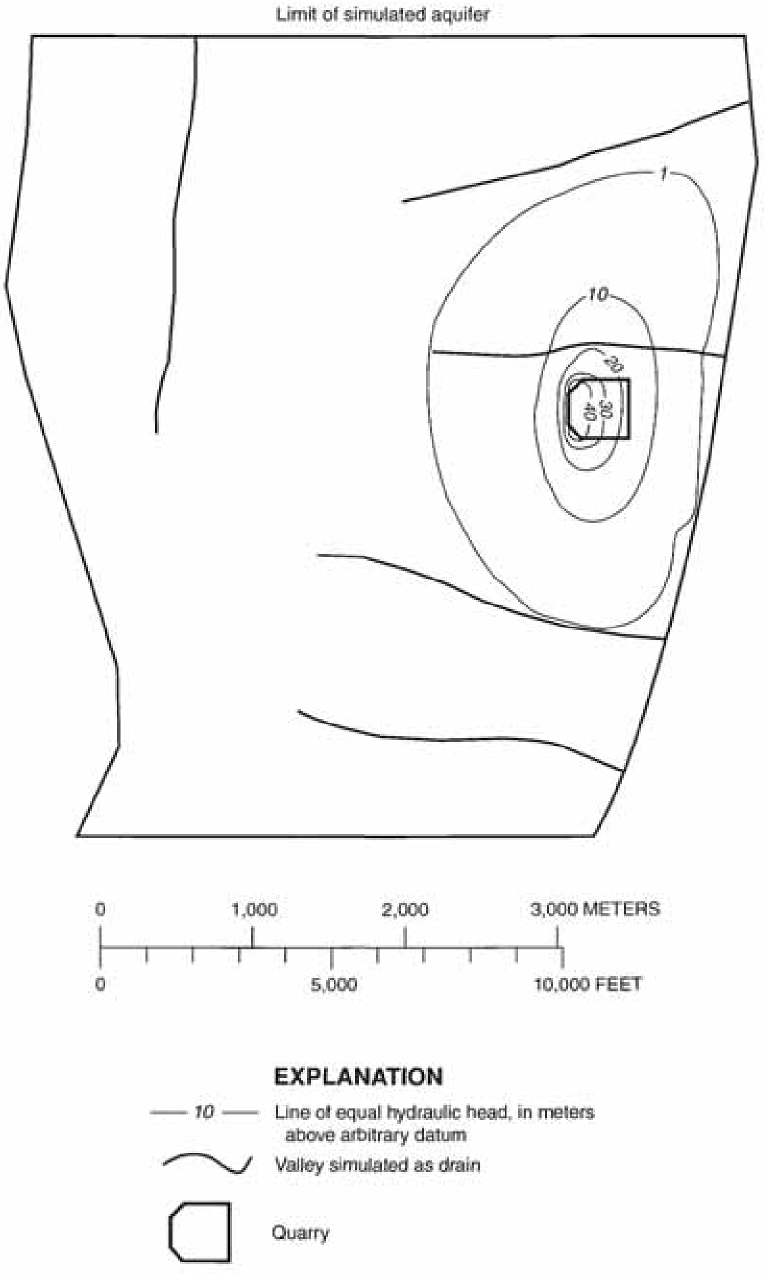


Figure 31*b*. Numerical simulation 8–Steady-state drawdown caused by a dewatered quarry in a hypothetical fractured crystalline-rock aquifer under homogeneous and horizontally anisotropic conditions.

is mostly below the elevation of the valley nearest the quarry; consequently, the valley has less effect on the quarry area of influence than in simulation 7. Area of influence in simulation 8 has a maximum extent (measured from the quarry center) of about 1,600 m and is elongated in the direction of greater hydraulic conductivity along columns because area of influence increases with increasing hydraulic conductivity. Area of influence along rows is similar to that of simulation 7 because hydraulic conductivity along rows is the same for both simulations.

Ground-water inflow from the constant-head boundary is larger and outflow to the constant-head boundary is smaller under premining conditions (table 4) in simulation 8 than in simulation 7 because the lower water table of simulation 8 causes the hydraulic gradient between the aquifer and boundary to be less. Discharge to valleys simulated as drains under premining conditions in simulation 8 is larger than in simulation 7 because the greater hydraulic conductivity along columns increases ground-water flow to the valleys. The ground-water budget for simulation 8 under active mining conditions (table 5) is similar to that for premining conditions except the quarry intercepts some ground water that, under premining conditions, flows to valleys. Ground-water discharge to the quarry is greater in simulation 8 than in simulation 7 because the greater hydraulic conductivity along columns increases ground-water flow to the quarry.

Simulation 9–Quarry in an aquifer with lateral variations of hydraulic conductivity

Simulation 9 shows the effects lateral variations of hydraulic conductivity may have on steady-state drawdown near a dewatered quarry. Simulation 9 is the same as simulation 7 except the model domain is divided into three zones with each having a different horizontal hydraulic conductivity (fig. 32*a*). Hilltops are assigned a horizontal hydraulic conductivity value of 0.005 m/d to represent relatively unweathered crystalline rock with fewer fractures at the core of mountains. Major valleys are assigned a horizontal hydraulic conductivity value of 0.05 m/d to represent areas where streams have incised into more highly fractured rock. The area between hilltops and major valleys is assigned a horizontal hydraulic conductivity value of 0.01 m/d as in simulation 7. Hydraulic conductivity is homogeneous and isotropic within each zone.

The simulated steady-state premining distribution of hydraulic head in the aquifer is shown in figure 32*a*, and steady-state drawdown near a dewatered quarry in the aquifer is shown in figure 32*b*. The lower horizontal hydraulic conductivity of hilltops in simulation 9 causes hydraulic head to be higher and the water table to be steeper beneath hilltops than in simulation 7. Similarly, higher horizontal hydraulic conductivity along major valleys in simulation 9 causes hydraulic head to be lower and the water table to be flatter beneath major valleys than in simulation 7. Area of influence in simulation 9 has a maximum

Table 4. Steady-state ground-water budget for six numerical simulations of premining conditions in hypothetical fractured crystalline-rock aquifers

[All values are in cubic meters per day; totals reflect sum of all rounded individual components]

Budget component	Simulation 7	Simulation 8	Simulation 9	Simulation 10	Simulation 11	Simulation 12
			Recharge to aquifer			
Ground-water inflow from constant-head boundary	4	14	39	4	4	4
Precipitation recharge	2,151	2,151	2,151	2,151	2,151	2,151
Total	2,155	2,165	2,190	2,155	2,155	2,155
			Discharge from aquifer			
Ground-water outflow to constant-head boundary	580	438	890	600	620	551
Ground-water discharge to valleys simulated as drains	1,575	1,726	1,299	1,555	1,534	1,603
Total	2,155	2,164	2,189	2,155	2,154	2,154
Recharge – Discharge	0	1	1	0	1	1

Model simulations:

7. Homogeneous, isotropic aquifer.
8. Homogeneous, horizontally anisotropic aquifer.
9. Aquifer with lateral variations of hydraulic conductivity.
10. Aquifer with ground-water flow in deep, low-permeability fractures.
11. Aquifer with a fault zone that acts as a conduit for ground-water flow.
12. Aquifer with a fault zone that acts as a barrier to ground-water flow.

Table 5. Steady-state ground-water budget for six numerical simulations of the effects of mining aggregate in hypothetical fractured crystalline-rock aquifers

[All values are in cubic meters per day; totals reflect sum of all rounded individual components]

Budget component	Simulation 7	Simulation 8	Simulation 9	Simulation 10	Simulation 11	Simulation 12
			Recharge to aquifer			
Ground-water inflow from constant-head boundary	4	14	40	4	4	4
Precipitation recharge	2,151	2,151	2,151	2,151	2,151	2,151
Total	2,155	2,165	2,191	2,155	2,155	2,155
			Discharge from aquifer			
Ground-water outflow to constant-head boundary	540	438	842	558	550	529
Ground-water discharge to valleys simulated as drains	1,504	1,587	1,258	1,483	1,456	1,531
Ground-water discharge to quarry	109	139	91	115	149	94
Total	2,153	2,164	2,191	2,156	2,155	2,154
Recharge –Discharge	2	1	0	–1	0	1

Model simulations:

7. Quarry in a homogeneous, isotropic aquifer.
8. Quarry in a homogeneous, horizontally anisotropic aquifer.
9. Quarry in an aquifer with lateral variations of hydraulic conductivity.
10. Quarry in an aquifer with ground-water flow in deep, low-permeability fractures.
11. Quarry intersected by a fault zone that acts as a conduit for flow.
12. Quarry intersected by a fault zone that acts as a barrier to ground-water flow.

extent (measured from quarry center) of about 1,100 m. Area of influence in simulation 9 is smaller than in simulation 7 because the lower horizontal hydraulic conductivity of hilltops reduces the area of influence upgradient from the quarry, and the higher horizontal hydraulic conductivity of the major valley along the right side of the model domain increases the effects of the constant-head boundary, thereby reducing area of influence downgradient from the quarry.

Ground-water inflow from the constant-head boundary and outflow to the constant-head boundary under premining conditions (table 4) in simulation 9 is greater than in simulation 7 because the higher horizontal hydraulic conductivity of the major valley along the constant-head boundary facilitates ground-water flow between the boundary and the aquifer. Discharge to valleys under premining conditions in simulation 9 is less than in simulation 7 because the water table in the vicinity of valleys simulated as drains in simulation 9 is lower than in simulation 7. The ground-water budget for simulation 9 under active mining conditions (table 5) is similar to that for premining conditions except the quarry intercepts some ground water that, under premining conditions, flows to valleys and the constant-head boundary. Ground-water discharge to the quarry in simulation 9 is less than in simulation 7 because saturated thickness near the quarry in simulation 9 is less and aquifer transmissivity is smaller.

Simulation 10–Quarry in an aquifer with ground-water flow in deep, low-permeability fractures

Simulation 10 shows the effects adding a model layer to simulate ground-water flow in deep, low-permeability fractures may have on steady-state drawdown near a dewatered quarry. Simulation 10 is similar to simulation 7 except a second layer is added. As in simulation 7, the top layer (layer 1) is 100 m thick with a horizontal hydraulic conductivity of 0.01 m/d. The new layer (layer 2) underlies layer 1 and is 50 m thick with a horizontal hydraulic conduc-

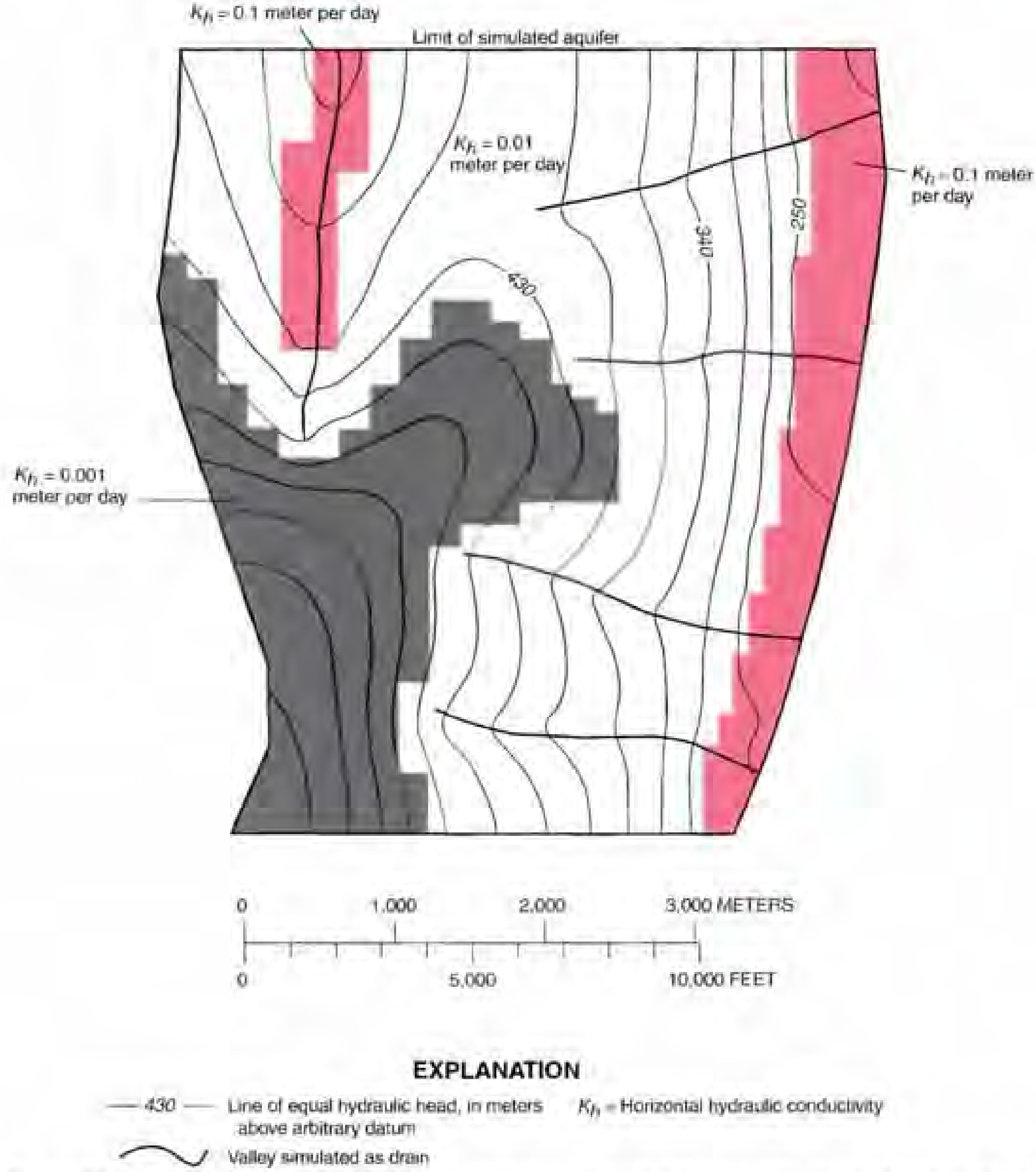


Figure 32*a*. Numerical simulation 9–Steady-state premining distribution of hydraulic head in a hypothetical fractured crystalline-rock aquifer with lateral variations of hydraulic conductivity.

tivity of 0.001 m/d. Vertical hydraulic conductivity is set equal to horizontal hydraulic conductivity in each layer.

The simulated steady-state premining distribution of hydraulic head in the aquifer is shown in figure 33*a*, and steady-state drawdown near a dewatered quarry in the aquifer is shown in figure 33*b*. Area of influence in simulation 10 has a maximum extent (measured from quarry center) of about 1,300 m, which is the same as in simulation 7. However, area of influence across the valley nearest the quarry is larger in simulation 10 than in simulation 7 because the aquifer represented by two layers in simulation 10 is thicker and has higher transmissivity. Because horizontal and vertical hydraulic conductivity in layer 2 are an order of magnitude lower than in layer 1, the additional thickness created by adding layer 2 has only a small effect on transmissivity and, consequently, on area of influence.

Recharge to the aquifer under premining conditions (table 4) in simulation 10 is identical to that in simulation 7. Discharge to the constant-head boundary is slightly larger under premining conditions in simulation 10 than in simulation 7 because saturated thickness adjacent to the constant-head boundary is greater in simulation 10. Discharge to valleys under premining conditions in simulation 10 is smaller than in simulation 7 because the water table is slightly lower in simulation 10. The ground-water budget for simulation 10 under active mining conditions (table 5) is similar to that for premining conditions except the quarry intercepts some ground water that, under premining conditions, flows to valleys and the constant-head boundary. Ground-water discharge to the quarry in simulation 10 is greater than in simulation 7 because the saturated thickness near the quarry in simulation 10 is greater, which causes aquifer transmissivity to be larger.

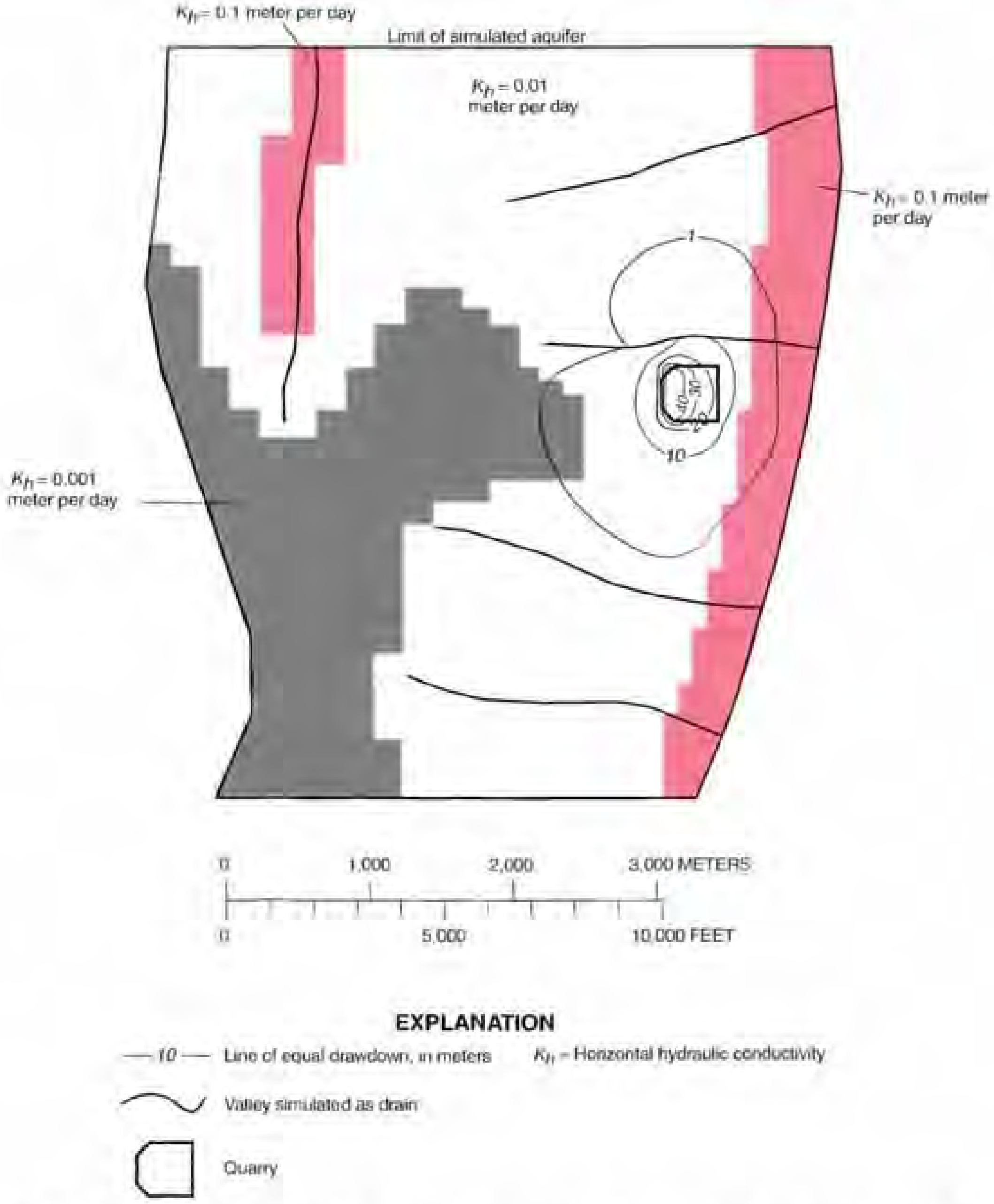


Figure 32*b*. Numerical simulation 9–Steady-state drawdown caused by a dewatered quarry in a hypothetical fractured crystalline-rock aquifer with lateral variations of hydraulic conductivity.

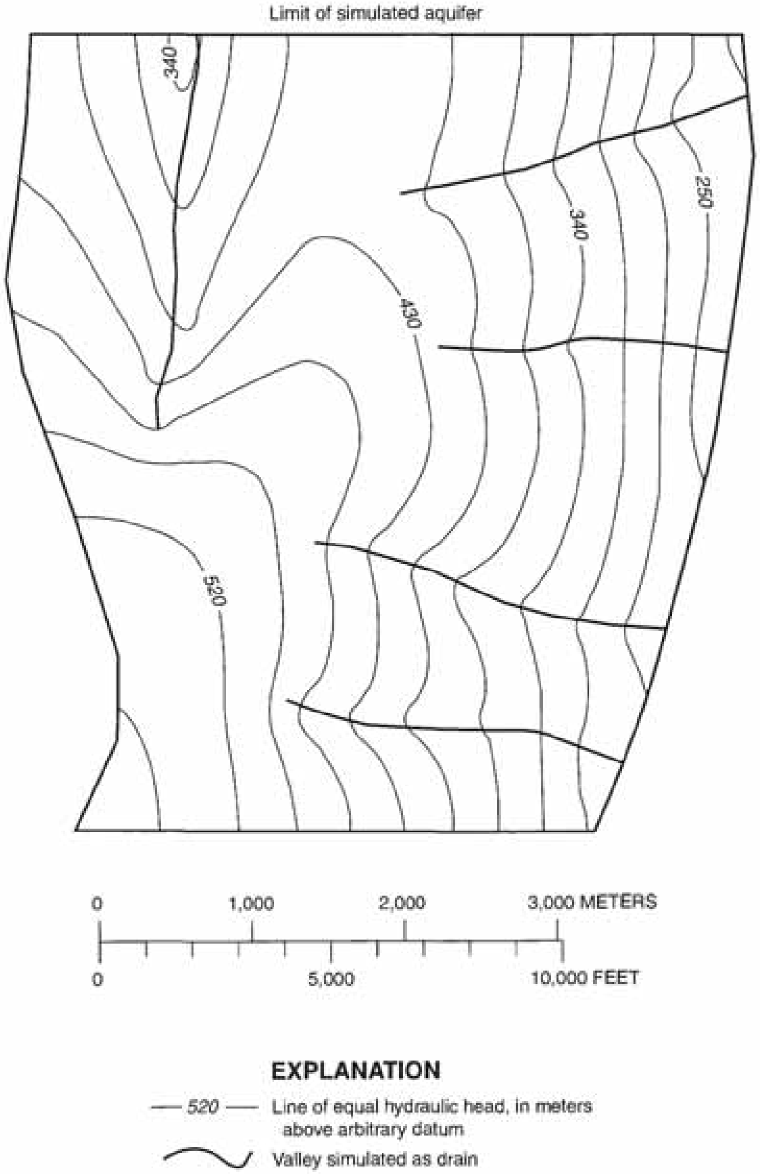


Figure 33*a*. Numerical simulation 10–Steady-state premining distribution of hydraulic head in a hypothetical fractured crystalline-rock aquifer with ground-water flow in deep, low-permeability fractures.

Simulation 11–Quarry intersected by a hydraulically conductive fault zone

Simulation 11 shows the effects a hydraulically conductive fault or fault zone may have on steady-state drawdown around a dewatered quarry. Simulation 11 is similar to simulation 7 except a fault zone having a horizontal hydraulic conductivity of 0.1 m/d intersects the quarry.

Recharge to the aquifer under premining conditions (table 4) in simulation 11 is identical to that in simulation 7. Discharge to the constant-head boundary is slightly larger under premining conditions in simulation 11 than in simulation 7 because the hydraulically conductive fault zone increases ground-water flow to the boundary. Discharge to valleys under premining conditions in simulation 11 is smaller than in simulation 7 because the water table is slightly lower beneath the valley nearest the fault zone in simulation 11. The ground-water budget for simulation 11 under active mining conditions (table 5) is similar to that for premining conditions except the quarry intercepts some ground water that, under premining conditions, flows to valleys and the constant-head boundary. Ground-water discharge to the quarry in simulation 11 is greater than in simulation 7 because the hydraulically conductive fault zone increases ground-water flow to the quarry. The simulated steady-state premining distribution of hydraulic head in the aquifer is shown in figure 34*a*, and steady-state drawdown near a dewatered quarry intersected by a hydraulically conductive fault zone is shown in figure 34*b*. Premining hydraulic head in simulation 11 is slightly lower along and upgradient of the fault zone compared to simulation 7 because the fault zone facilitates ground-water flow along the fault. Area of influence in simulation 11 extends along the fault zone and has a maximum extent (measured from quarry center) of about 1,600 m. Area of influence in simulation 11 is larger than in simulation 7 because area of influence increases as hydraulic conductivity increases.

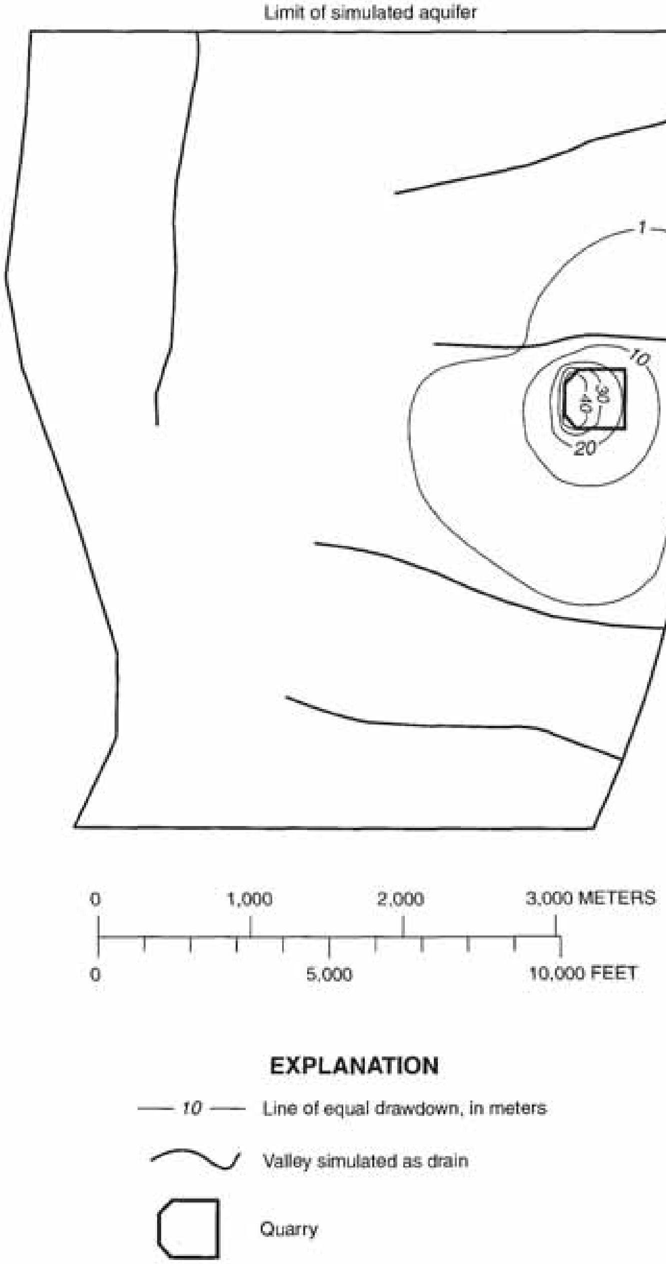
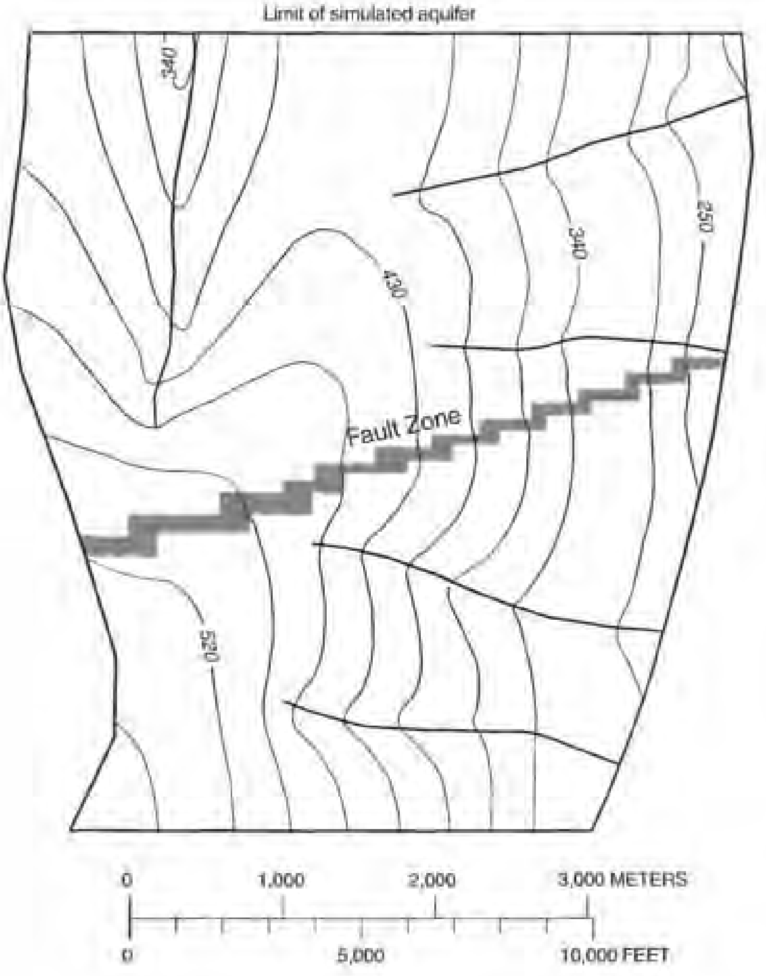


Figure 33*b*. Numerical simulation 10–Steady-state drawdown caused by a dewatered quarry in a hypothetical fractured crystalline-rock aquifer with ground-water flow in deep, low-permeability fractures.



EXPLANATION

— 430 — Line of equal hydraulic head, in meters above arbitrary datum

〰 Valley simulated as drain

Figure 34*a*. Numerical simulation 11–Steady-state premining distribution of hydraulic head in a hypothetical fractured crystalline-rock aquifer with a hydraulically conductive fault zone.

Simulation 12–Quarry intersected by a low-conductivity fault zone

Simulation 12 shows the effects a low-conductivity fault or fault zone may have on steady-state drawdown around a quarry. Simulation 12 is identical to simulation 11 except the fault zone has a horizontal hydraulic conductivity of 0.001 m/d.

The simulated steady-state premining distribution of hydraulic head in the aquifer is shown in figure 35*a*, and steady-state drawdown near a dewatered quarry intersected by a low-conductivity fault zone is shown in figure 35*b*. Premining hydraulic head in simulation 12 is slightly higher along and upgradient of the fault zone compared to simulation 7 because the fault zone impedes ground-water flow from upgradient areas to downgradient areas. Area of influence in simulation 12 has a maximum extent (measured from quarry center) of about 1,300 m, and area of influence in simulation 12 is smaller than in simulation 7 because the fault zone decreases ground-water flow to the quarry.

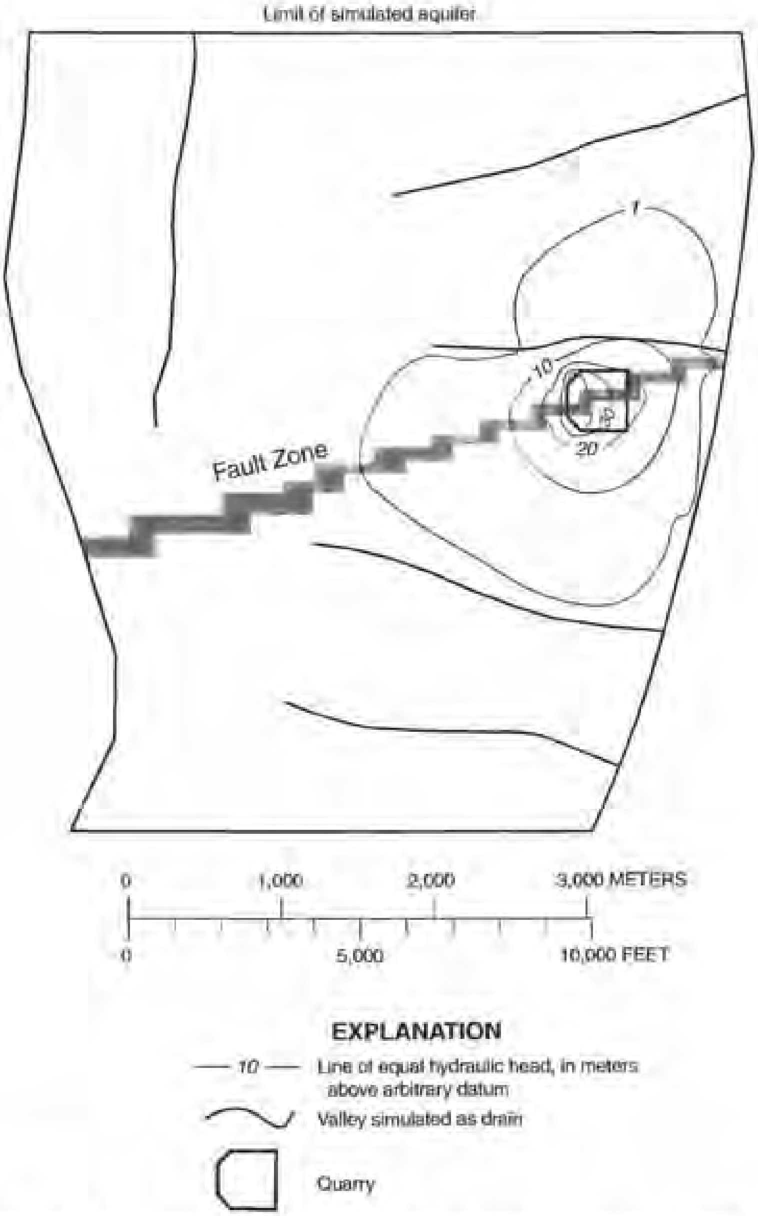


Figure 34*b*. Numerical simulation 11–Steady-state drawdown caused by a dewatered quarry intersected by a hydraulically conductive fault zone in a hypothetical fractured crystalline-rock aquifer.

Recharge to the aquifer under premining conditions (table 4) in simulation 12 is identical to that in simulation 7. Discharge to the constant-head boundary is slightly smaller under premining conditions in simulation 12 than in simulation 7 because the low-conductivity fault zone decreases ground-water flow to the boundary. Discharge to valleys under premining conditions in simulation 12 is larger than in simulation 7 because the water table is higher beneath the valley nearest the fault zone in simulation 12. The ground-water budget for simulation 12 under active mining conditions (table 5) is similar to that for premining conditions except the quarry intercepts some ground water that, under premining conditions, flows to valleys and the constant-head boundary. Ground-water discharge to the quarry in simulation 12 is less than in simulation 7 because the low-conductivity fault zone decreases ground-water flow to the quarry.

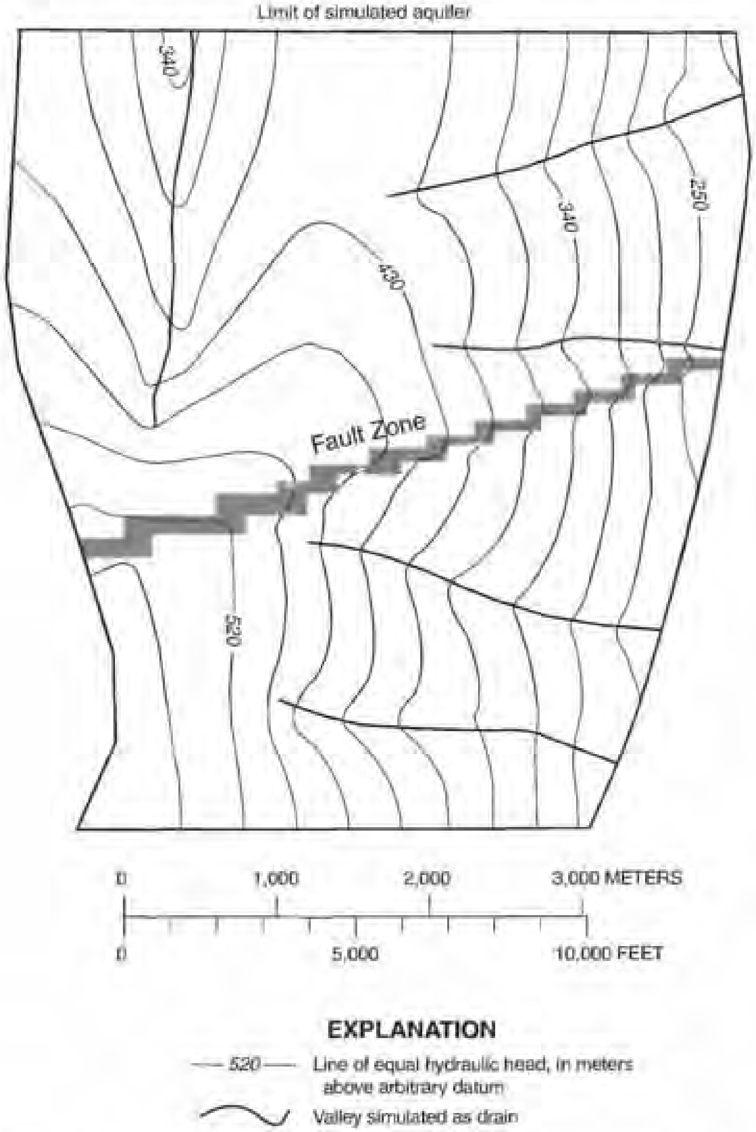


Figure 35a. Numerical simulation 12–Steady-state premining distribution of hydraulic head in a hypothetical fractured crystalline-rock aquifer with a low-conductivity fault zone.

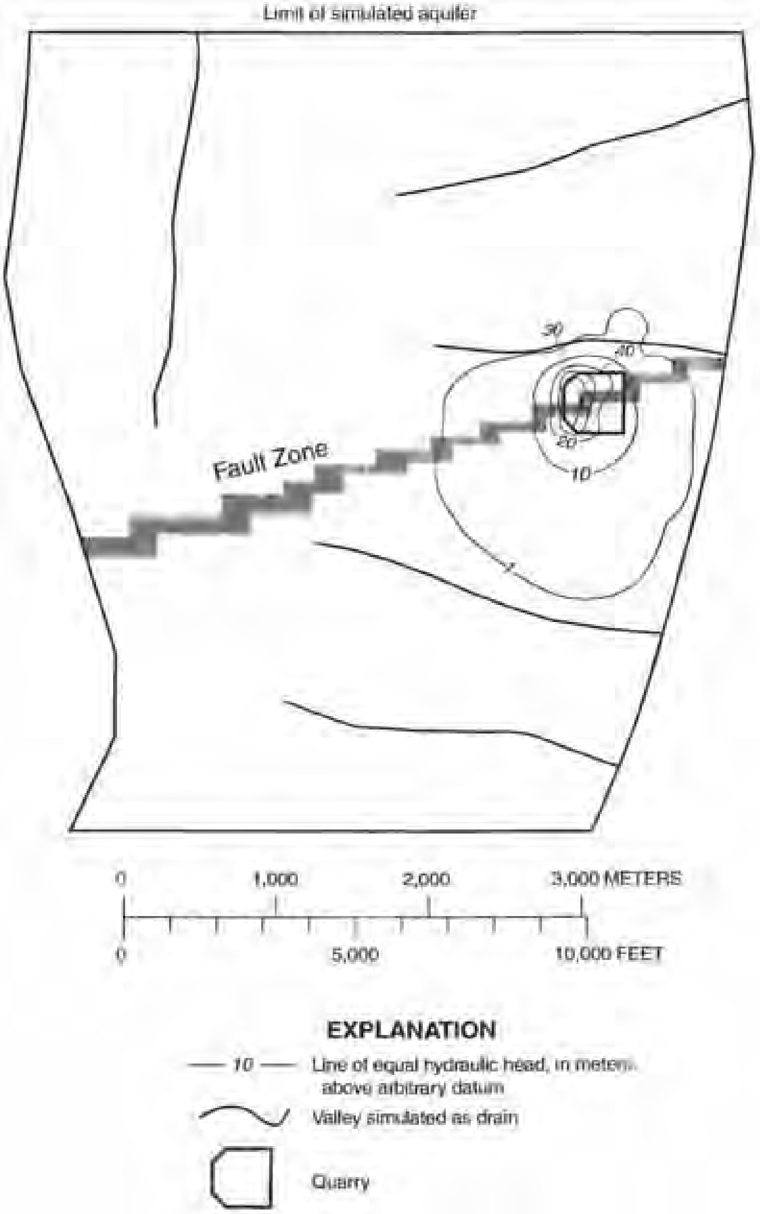


Figure 35b. Numerical simulation 12–Steady-state drawdown caused by a dewatered quarry intersected by a low-conductivity fault zone in a hypothetical fractured crystalline-rock aquifer.

Numerical Sensitivity Analysis

Composite scaled sensitivities (see "Numerical Sensitivity Analysis" under "Simulation of Pits in Sand-and-Gravel Aquifers") were calculated for each model parameter by using the Parameter Sensitivity with Observations mode (Hill and others, 2000) of MODFLOW–2000. Sensitivities were calculated for each parameter by using 27 hypothetical head observations distributed evenly throughout the numerical model domain as shown in figure 36. Sensitivity analysis results for simulation 7 are shown in figure 37, and sensitivity analysis results for all simulations in fractured crystalline rock are shown in table 6.

Sensitivity analyses results indicate simulated hydraulic head was most sensitive to recharge and horizontal hydraulic conductivity in every simulation. In simulations 7 and 8, the sensitivities for recharge and horizontal hydraulic conductivity were almost equal. However, in simulations 9, 10, 11, and 12, more than one horizontal hydraulic-conductivity parameter was used, and the sensitivity for recharge was greater than that for any individual horizontal hydraulic-conductivity parameter. In simulation 9 (quarry in an aquifer with lateral variations of hydraulic conductivity), sensitivity for horizontal hydraulic conductivity was greatest for hilltops (low hydraulic conductivity) and least for valleys (high hydraulic conductivity). In simulation 10 (quarry in an aquifer represented by two model layers, one of which simulates ground-water flow in deep, low-permeability fractures), the sensitivity for horizontal hydraulic conductivity in layer 2 was much less than that in layer 1. In simulations 11 and 12 (quarry intersected

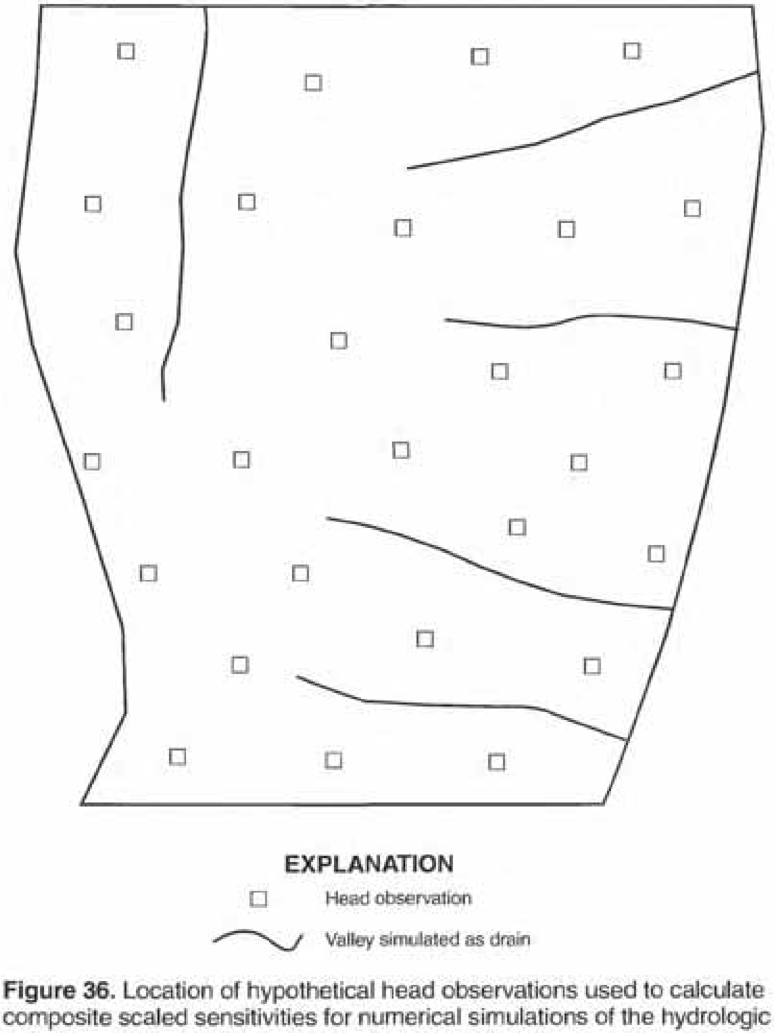


Figure 36. Location of hypothetical head observations used to calculate composite scaled sensitivities for numerical simulations of the hydrologic effects of mining aggregate in fractured crystalline-rock aquifers.

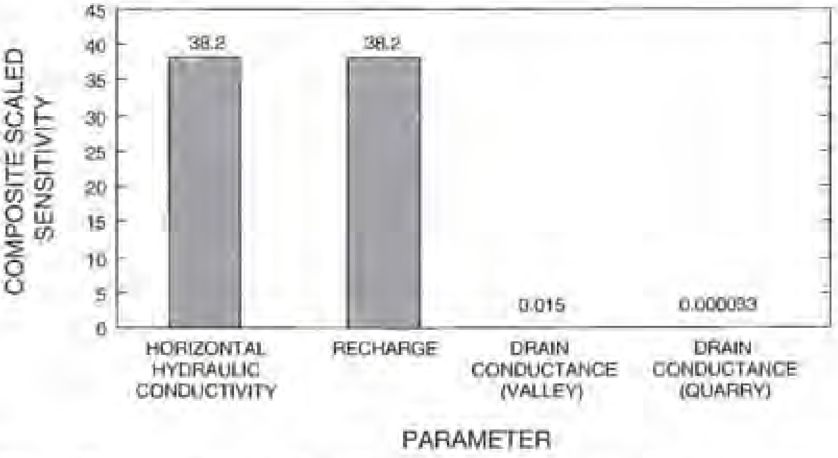


Figure 37. Composite scaled sensitivities for parameters in numerical simulation 7 (quarry in a fractured crystalline-rock aquifer under homogeneous and isotropic conditions).

Table 6. Composite scaled sensitivities for parameters used in six numerical simulations of the effects of mining aggregate in hypothetical fractured crystalline-rock aquifers

[--, not applicable]

Simulation	Parameter									
	Horizontal hydraulic conductivity (Layer 1)	Horizontal hydraulic conductivity (Layer 2)	Horizontal hydraulic conductivity (Hilltops)	Horizontal hydraulic conductivity (Valleys)	Horizontal hydraulic conductivity (Fault)	Vertical hydraulic conductivity (Layer 1)	Vertical hydraulic conductivity (Layer 2)	Recharge	Drain conductance (Valleys)	Drain conductance (Quarry)
7	38.2	--	--	--	--	--	--	38.2	0.015	0.000033
8	27.8	--	--	--	--	--	--	27.8	0.018	0.000031
9	24.6	--	32.6	3.5	--	--	--	52.0	0.015	0.000011
10	34.9	1.8	--	--	--	0.0055	0.032	36.7	0.014	0.000038
11	34.1	--	--	--	2.9	--	--	36.2	0.014	0.000143
12	38.6	--	--	--	1.2	--	--	39.3	0.015	0.000036

Model simulations:

7. Quarry in a homogeneous, isotropic aquifer.
8. Quarry in a homogeneous, horizontally anisotropic aquifer.
9. Quarry in an aquifer with lateral variations of hydraulic conductivity.
10. Quarry in an aquifer with ground-water flow in deep, low-permeability fractures.
11. Quarry intersected by a fault zone that acts as a conduit for ground-water flow.
12. Quarry intersected by a fault zone that acts as a barrier to ground-water flow.

by a fault zone), the sensitivity for horizontal hydraulic conductivity of the fault zone was small compared to the sensitivity for horizontal hydraulic conductivity of the surrounding rock. In all simulations, simulated head had little sensitivity to the hydraulic conductance of drain cells used to simulate valleys, and simulated head was relatively insensitive to the conductance of drain cells used to simulate the quarry. The sensitivity for vertical hydraulic conductivity could only be calculated for simulation 10, which had more than one model layer. Simulated head in simulation 10 had little sensitivity to vertical hydraulic conductivity in both layers.

SUMMARY AND CONCLUSIONS

Analytical solutions and numerical models were used to predict the extent of drawdown caused by mining aggregate below the water table in hypothetical sand-and-gravel and fractured crystalline-rock aquifers representative of hydrogeologic settings in the Front Range area of Colorado. A steady-state, two-dimensional analytical solution derived by Marinelli and Niccoli was used to predict the extent of drawdown caused by a circular pit or quarry in a homogeneous, isotropic sand-and-gravel or fractured crystalline-rock aquifer, respectively, of infinite extent. A similar, one-dimensional analytical solution derived during this study was used to predict the extent of drawdown caused by a linear quarry in a homogeneous, isotropic fractured crystalline-rock aquifer of infinite extent. Parameters used in the analytical solutions were varied independently over a range of values to simulate the effects of mining over a wide range of conditions. Results of analytical simulations indicate radius of influence was about 4,500 m for a circular pit in a sand-and-gravel aquifer under intermediate conditions. Radius of influence was about 400 m for a circular quarry in a fractured crystalline-rock aquifer under intermediate conditions, and distance of influence was 500 m for a linear quarry in a fractured crystalline-rock aquifer under the same conditions. Radius (or distance) of influence increased as horizontal hydraulic conductivity, mine penetration of the water table, and mine radius increased and as recharge decreased. One-percent sensitivities were calculated for each parameter in the analytical solutions to evaluate the influence of each parameter on simulation results. Results of analytical sensitivity analyses under intermediate conditions in sand-and-gravel and fractured crystalline-rock aquifers indicate radius of influence was most sensitive to mine penetration of the water table and least sensitive to mine radius. Radius of influence was equally sensitive to horizontal hydraulic conductivity and recharge, but the parameters had opposite effects on simulation because they are inversely correlated in the ground-water flow equation.

Numerical ground-water flow models were used to predict the extent of drawdown caused by a pit or quarry under conditions that consider heterogeneity, anisotropy, and boundaries and to simulate complex or unusual conditions that were not readily simulated by using analytical solutions. Six numerical simulations were presented for the effects of mining in sand-and-gravel aquifers, and six numerical simulations were presented for the effects of mining in fractured crystalline-rock aquifers.

Numerical simulations in sand-and-gravel aquifers predicted the hydrologic effects of mining in a homogeneous, vertically anisotropic aquifer of medium size and in homogeneous, isotropic aquifers of different sizes with different boundary conditions. Numerical simulations in sand-and-gravel aquifers also predicted the hydrologic effects of pits lined with slurry walls and the effects of pits that have been refilled with water and are undergoing evaporative losses. Drawdown caused by a pit in a medium-sized sand-and-gravel aquifer under homogeneous and isotropic conditions (simulation 1) was compared to drawdown simulated using an analytical solution. Area of influence in the numerical simulation was smaller than in the analytical simulation because of boundary effects and additional sources of recharge in the numerical simulation. Area of influence for a pit in a medium-sized sand-and-gravel aquifer under homogeneous but vertically anisotropic conditions (simulation 2) was nearly identical to that in simulation 1. Area of influence for a pit in a large sand-and-gravel aquifer under homogeneous and isotropic conditions (simulation 3) was larger and more symmetrical than that in simulation 1 because more water discharges to the pit and aquifer boundaries were farther away from the pit. Area of influence was smaller and drawdown was greater for a pit in a small, hydraulically isolated sand-and-gravel aquifer under homogeneous and isotropic conditions (simulation 4) because aquifer boundaries were closer to the pit and no recharge was contributed by general-head boundaries. Pits lined with impermeable slurry walls in a medium-sized sand-and-gravel aquifer under homogeneous and isotropic conditions (simulation 5) caused mounding to occur upgradient from the pits and drawdown to occur downgradient from the pits. Pits refilled with water after mining and undergoing evaporative losses in a medium-sized sand-and-gravel aquifer under homogeneous and isotropic conditions (simulation 6) had little hydrologic effect on the aquifer because discharge from the refilled pits was small compared to the overall ground-water budget.

Numerical simulations in fractured crystalline-rock aquifers predicted the hydrologic effects of mining in a homogeneous, isotropic aquifer and in heterogeneous, anisotropic aquifers. Drawdown caused by a quarry in a homogeneous, isotropic fractured crystalline-rock aquifer (simulation 7) was compared to drawdown simulated using analytical solutions. Area of influence in the numerical simulation was larger than in the analytical simulation because aquifer transmissivity in the numerical simulation was greater. Area of influence for a quarry in a homogeneous, horizontally anisotropic fractured crystalline-rock aquifer (simulation 8) was elongated in the direction of greater hydraulic conductivity. Area of influence for a quarry in a fractured crystalline-rock aquifer with lateral variations of hydraulic conductivity (simulation 9) was smaller than in simulation 7 because zones of low horizontal hydraulic conductivity beneath hilltops in simulation 9 limited expansion of the area of influence upgradient from the quarry, and zones of high horizontal hydraulic conductivity along the major valley represented as a constant-head boundary caused heads downgradient from the quarry to be maintained near premining levels. Area of influence for a quarry in a fractured crystalline-rock aquifer with ground-water flow in deep, low-permeability fractures (simulation 10) was larger than in simulation 7 because the thicker aquifer in simulation 10 increased aquifer transmissivity. Area of influence for a quarry intersected by a hydraulically conductive fault zone in a fractured crystalline-rock aquifer (simulation 11) was larger than in simulation 7 because the fault zone increased ground-water flow to the quarry. Area of influence for a quarry intersected by a low-conductivity fault zone in a fractured crystalline-rock aquifer (simulation 12) was smaller than in simulation 7 because the fault zone decreased ground-water flow to the quarry.

Composite scaled sensitivities were calculated for each parameter used in the numerical models to evaluate the influence of each parameter on simulated hydraulic head. Numerical sensitivity analysis results for sand-and-gravel aquifer simulations indicated simulated head was most sensitive to horizontal hydraulic conductivity and the hydraulic conductance of general-head boundaries. Simulated head in the sand-and-gravel aquifers was less sensitive to riverbed conductance and recharge, and simulated head was relatively insensitive to vertical hydraulic conductivity. Numerical sensitivity analysis results for fractured crystalline-rock aquifer simulations indicated simulated head was most sensitive to variations in recharge and horizontal hydraulic conductivity. Simulated head in the fractured crystalline-rock aquifers had little sensitivity to vertical hydraulic conductivity and the hydraulic conductance of drain cells used to simulate valleys. Simulated head was relatively insensitive to the hydraulic conductance of drain cells used to simulate quarries.

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APPENDIX G-5

GWIP LLC Letter re: Wells with Permit Nos. 113762, 1472 and 89706

GREAT WESTERN INDUSTRIAL PARK

Dean Brown
Phone: (303) 398-4575
dbrown@broe.com

February 20, 2023

Via U.S. Mail and Email
(julie.mikulas@martinmarietta.com)

Julie Mikulas
Martin Marietta Materials
1800 N Taft Hill Road
Fort Collins, CO 80534

Re: GWIP Wells with Permit Nos. 113762 and 1472

Dear Julie,

Per your request, we have investigated the ownership, well permitting and use (or non-use as it turns out) of the wells with Permit Nos. 113762, 1472 and 89706, located in the Great Western Industrial Park. All three wells are located on land owned by GWIP, LLC ("GWIP") and, as appurtenances to said property, the wells themselves are owned by GWIP.

Although the well with Permit No. 113762 is permitted for domestic and livestock watering use, the well is not used for domestic purposes and there is no longer a residence able to utilize said well. The well is actually not being used for any purpose and there are no plans to revive use of the well. If the well is ever used again, it will not be used for domestic purposes.

The well with Permit No. 1472 is permitted for irrigation use only. Under Colorado law, for the well to be used for irrigation purposes, it would need to be augmented. The well is not augmented; and it is not being used. There are no plans to revive use of the well. If the well is ever used again, it will not be used for domestic purposes.

The well with Permit No. 89706 is permitted for domestic use and irrigation of one (1) acre. The well is not used for domestic purposes. The residence that once used the well is being served domestic potable water by the City of Greeley. The well in the future will not be used for domestic purposes.

Please let me know if you need anything else.

GWIP, LLC,
A Colorado limited liability company

By: Dean Brown

EXHIBIT L - RECLAMATION COSTS

During the life of mine, 150 acres will be disturbed by the mining activities and approximately 54.7 acres of that will be water surface once reclamation is completed leaving 95.6 acres to be topsoiled and seeded. This site will be mined and reclaimed concurrently to limit the number of times that overburden is handled.

The spreadsheet below represents the estimated cost for the Division to reclaim the Windsor East Mine, based on the point in time in the mining schedule where reclamation cost will be the highest. This will occur when Cell A is lined, Cell C is mined out but not lined, Cell B has had the topsoil removed and Cell D is mined out. At this point there will be an estimated 117 acres of disturbance.

ITEM	UNIT	COST PER UNIT	# OF UNITS	TOTAL COST
Earthmoving and Revegetation				
Overburden Replacement	Cubic Yard	$1.75	489,000	$855,750.00
Topsoil Replacement	Cubic Yard	$1.75	68,600	$120,050.00
Disking or Scarifying	Acre	$28.50	96	$2,724.60
Grass Seed Mix	Acre	$40.00	96	$3,840.00
Drill Grass Seed Mix	Acre	$18.00	96	$1,728.00
Mulch Application	Acre	$300.00	96	$28,800.00
Dewatering	Lump Sum	$10,000.00	1	$10,000.00
Liner Installation Cell C				
Mob, Bonding, and Ins	Lump Sum	$150,000.00	1	$150,000.00
Backfill 200-400' along river	Cubic Yard	$2.20	115,000	$253,000.00
Foundation Excavation	Cubic Yard	$3.50	18,000	$63,000.00
Slope Liner Embankment	Cubic Yard	$2.20	90,000	$198,000.00
Reservoir Bottom Grading	Lump Sum	$40,000.00	1	$40,000.00
TOTAL DIRECT RECLAMATION COSTS				**$1,726,892.60**
Overhead & Profit				
Public Liability Insurance			0.0155	$26,766.84
Contractor Performance Bond			0.0155	$26,766.84
Contractor Profit			0.1000	$172,689.26
DRMS Project Administration Expense			0.0500	$86,344.63
TOTAL INDIRECT RECLAMATION COST				**$312,567.56**
TOTAL PERFORMANCE BOND AMOUNT				**$2,039,460**

EXHIBIT M: OTHER PERMITS AND LICENSES

Marin Marietta will provide all required and approved permits and licenses to the DRMS, when available.

The following is a list of permits and licenses that Martin Marietta currently knows will be required prior to mining.

Town of Windsor

Conditional Use Grant and Site Plan application

Flood Hazard Development Permit

Colorado Department of Public Health and Environment

Fugitive Air Permit 15WE1438F including the Parsons Mine

Air Permit 21WE0692 Crusher at Parsons Mine

Air Permit 19WE0182 Screen at Parsons Mine

Air Permit 19WE0183 Screen at Parsons Mine

CDPS Sand and Gravel Mining and Processing Discharge Permit COG501594 including the Parsons Mine

EXHIBIT R – PROOF OF FILING WITH WELD COUNTY CLERK TO THE BOARD

Enclosed please find receipt as proof of filing that the additional information provided to the DRMS in response to the Adequacy Review 1 comments were placed with the Weld County Clerk to the Board for public review pursuant to Rule 1.6.2(1)(c).

Martin Marietta

Julie Mikulas
Regional Land Manager

March 3, 2023

Weld County Clerk to the Board's Office
1150 O Street
Greeley, CO 80631

RE: Notice of Application for a Mined Land Reclamation Permit (M-2022-042), County Copy of Public Notice Documents

To Whom It May Concern:

Enclosed are revised pages for the 112(c) application to the Colorado Division of Reclamation, Mining and Safety for our Windsor East Mine that were delivered to you on September 22, 2022 and October 6, 2022. Copies of these rervised pages are being delivered to you pursuant to 34-32.5-112(9)(a), C.R.S., as amended. The revised pages should be made available for public review along with the application that was delivered on September 23, 2022 and the revisions on October 6, 2022 until the permit has been approved by the Division of Reclamation, Mining and Safety.

Please acknowledge receipt of the public notice documents by signing below.

Sincerely,

Julie Mikulas

Julie Mikulas
Regional Land Manager

RECEIVED THIS ____ DAY OF ________________ 2023.

Weld County Clerk to the Board

By: ______________________________

Name: ______________________________

Title: ______________________________

RECEIVED
MAR 03 2023
WELD COUNTY
COMMISSIONERS

Rocky Mountain Division – Northern Office
1800 N Taft Hill Road, Fort Collins, CO 80534
julie.mikulas@martinmarietta.com
www.martinmarietta.com

EXHIBIT S – PERMANENT MAN-MADE STRUCTURE AGREEMENTS

The table, below, provides a list of the owners of man-made structures within 200 feet of the affected area along with information about when the structure owner was sent a structure agreement and if the structure agreement was signed and returned.

Structure Owners within 200 feet of the affected area

Owner	Address	City, ST Zip	Date Agreement Sent	Notarized Agreement received
Robert & Melissa Stieben (parcel previously owned by 3W Properties, LLC)	PO Box 363	Timnath, CO 80547	14-Oct 2022	yes
City of Aurora	15151 E. Alameda Parkway	Aurora, CO 80012	13-Sep 2022	no
City of Greeley	1000 10th St	Greeley, CO 80631	13-Sep 2022	yes
Colleen and Steven Blanks	30523 County Road 23	Greeley CO, 80631	13-Sep 2022	yes
DCP Lucerne 2 Plant LLC	3026 4th Ave	Greeley, CO 80631	13-Sep 2022	yes
DCP Midstream	3026 4th Ave	Greeley, CO 80631	13-Sep 2022	yes
GWIP, LLC	252 Clayton Street, 4th Floor	Denver, CO 80206	13-Sep 2022	yes
John Daniel Demianycz Revocable Trust	PO Box 147	Windsor, CO 80550	13-Sep 2022	yes
Martin Marietta Materials, Inc.	C/O Baden Tax Management PO Box 8040	Fort Wayne, IN 46898	N/A	N/A
Noble Energy/Chevron USA Inc	2115 117th Ave	Greeley, CO 80634	13-Sep 2022	no
Poudre River Trail Corridor	321 N 16th Ave	Greeley, CO 80631	13-Sep 2022	no
Poudre Valley REA, Inc	7649 REA Parkway	Fort Collins, CO 80528	13-Sep 2022	yes
Town of Windsor	301 Walnut Street	Windsor, CO 80550	13-Sep 2022	yes

Copies of the signed structure agreements we have received are attached to this document.

NOTARIZED STRUCTURE AGREEMENTS

Steven & Colleen Blanks

STRUCTURE AGREEMENT

This letter has been provided to you as the owner of a structure on or within 200 feet of a proposed mine site. The State of Colorado, Division of Reclamation, Mining and Safety ("Division") requires that where a mining operation may adversely affect the stability of any significant, valuable and permanent man-made structure located within 200 feet of the affected land, the Applicant shall either:

a) Provide a notarized agreement between the Applicant and the Person(s) having an interest in the structure, that the Applicant is to provide compensation for any damages to the structure; or

b) Where an agreement cannot be reached, the Applicant shall provide an appropriate engineering evaluation that demonstrates that such structure shall not be damaged by activities occurring at the mining operation; or

c) Where such structure is a utility, the Applicant may supply a notarized letter, on utility letterhead, from the owner(s) of the utility that the mining and reclamation activities, as proposed, will have "no negative effect" on their utility. (*Construction Materials Rule 6.3.12 and Rule 6.4.19 & Hard Rock/Metal Mining Rule 6.3.12 and Rule 6.4.20)*

The Colorado Mined Land Reclamation Board ("Board") has determined that this form, if properly executed, represents an agreement that complies with Construction Materials Rule 6.3.12(a), Rule 6.4.19(a), and C.R.S. 34-32.5-115(4)(e) and with Hard Rock/Metal Mining Rule 6.3.12(a), Rule 6.4.20(a), and C.R.S. 34-32-115(4)(d). This form is for the sole purpose of ensuring compliance with the Rules and Regulations and shall not make the Board or Division a necessary party to any private civil lawsuit to enforce the terms of the agreement or create any enforcement obligations in the Board or the Division.

The following structures are located on or within 200 feet of the proposed affected area:

1. House (1782 SF)
2. Water Line
3. Overhead Electric Line
4. Sprinkler System
5. Septic System Tank
6. Driveway
7. Historic rock root cellar building

CERTIFICATION

The Applicant, Martin Marietta Materials, Inc., represented by H. Abbott Lawrence as West Division President, does hereby certify that Steven and Colleen Blanks (structure owner) shall be compensated for any damage from the proposed mining operation to the above listed structure(s) located on or within 200 feet of the proposed affected area described within Exhibit A, of the Reclamation Permit Application for Windsor East Mine.

This form has been approved by the Colorado Mined Land Reclamation Board pursuant to its authority under the Colorado Land Reclamation Act for the Extraction of Construction Materials and the Colorado Mined Land Reclamation Act for Hard Rock, Metal, and Designated Mining Operations. Any alteration or modification to this form shall result in voiding this form.

NOTARY FOR PERMIT APPLICANT

ACKNOWLEGED BY: H. Abbott Lawrence

Applicant: Martin Marietta Materials, Inc. Representative Name: H. Abbott Lawrence

Date: 1-4-2023 Title: West Division President

STATE OF Colorado)
) ss.
COUNTY OF Jefferson)

The foregoing was acknowledged before me this 4th day of January, 2023, by

H. Abbott Lawrence as West Division President of Martin Marietta Materials, Inc.

Julie M Mikulas
Notary Public

My Commission Expires: May 30, 2024

JULIE M MIKULAS
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19964009323
MY COMMISSION EXPIRES MAY 30, 2024

NOTARY FOR STRUCTURE OWNER

ACKNOWLEGED BY: Steven & Colleen Blanks

Structure Owner: Steve Blanks Name: Steven F. Blanks

Colleen Blanks Colleen Blanks

Date: 1/4/2023 Title: Owners

STATE OF Colorado)

) ss.

COUNTY OF Weld)

The foregoing was acknowledged before me this 4th day of December, 2023, by Steven Blanks & Colleen Blanks as Owners of __________.

Julie M Mikulas My Commission Expires: 5-30-2024

Notary Public

JULIE M MIKULAS
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19964009323
MY COMMISSION EXPIRES MAY 30, 2024

DCP Lucerne

STRUCTURE AGREEMENT

This letter has been provided to you as the owner of a structure on or within 200 feet of a proposed mine site. The State of Colorado, Division of Reclamation, Mining and Safety ("Division") requires that where a mining operation may adversely affect the stability of any significant, valuable and permanent man-made structure located within 200 feet of the affected land, the Applicant shall either:

a) Provide a notarized agreement between the Applicant and the Person(s) having an interest in the structure, that the Applicant is to provide compensation for any damages to the structure; or

b) Where an agreement cannot be reached, the Applicant shall provide an appropriate engineering evaluation that demonstrates that such structure shall not be damaged by activities occurring at the mining operation; or

c) Where such structure is a utility, the Applicant may supply a notarized letter, on utility letterhead, from the owner(s) of the utility that the mining and reclamation activities, as proposed, will have "no negative effect" on their utility. (*Construction Materials Rule 6.3.12 and Rule 6.4.19 & Hard Rock/Metal Mining Rule 6.3.12 and Rule 6.4.20)*

The Colorado Mined Land Reclamation Board ("Board") has determined that this form, if properly executed, represents an agreement that complies with Construction Materials Rule 6.3.12(a), Rule 6.4.19(a), and C.R.S. 34-32.5-115(4)(e) and with Hard Rock/Metal Mining Rule 6.3.12(a), Rule 6.4.20(a), and C.R.S. 34-32-115(4)(d). This form is for the sole purpose of ensuring compliance with the Rules and Regulations and shall not make the Board or Division a necessary party to any private civil lawsuit to enforce the terms of the agreement or create any enforcement obligations in the Board or the Division.

The following structures are located on or within 200 feet of the proposed affected area:

1. 30' Pipeline Easement

CERTIFICATION

The Applicant, Martin Marietta Materials, Inc., represented by H. Abbott Lawrence as West Division President, does hereby certify that DCP Lucerne 2 Plant LLC (structure owner) shall be compensated for any damage from the proposed mining operation to the above listed structure(s) located on or within 200 feet of the proposed affected area described within Exhibit A, of the Reclamation Permit Application for Windsor East Mine.

This form has been approved by the Colorado Mined Land Reclamation Board pursuant to its authority under the Colorado Land Reclamation Act for the Extraction of Construction Materials and the Colorado Mined Land Reclamation Act for Hard Rock, Metal, and Designated Mining Operations. Any alteration or modification to this form shall result in voiding this form.

NOTARY FOR PERMIT APPLICANT

ACKNOWLEGED BY: H. Abbott Lawrence

Applicant: Martin Marietta Materials, Inc. Representative Name: H. Abbott Lawrence

Date: 12/23/22 Title: West Division President

STATE OF Colorado)
) ss.
COUNTY OF Jefferson)

The foregoing was acknowledged before me this 23 day of December, 20 22 by

H. Abbott Lawrence as West Division President of Martin Marietta Materials, Inc.

Julie M Mikulas
Notary Public

My Commission Expires: May 30, 2024

JULIE M MIKULAS
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19964009323
MY COMMISSION EXPIRES MAY 30, 2024

NOTARY FOR STRUCTURE OWNER

ACKNOWLEGED BY: __________

Structure Owner: DCP Lucerne 2 Plant LLC Name: __________

Date: 9/20/2022 Title: Attorney In Fact

STATE OF Colorado)
) ss.
COUNTY OF Weld)

The foregoing was acknowledged before me this 20th day of September, 2022, by Lewis D. Hagenlock as Attorney-In-Fact of DCP Lucerne 2 Plant LLC

Lorri Ann Carlson My Commission Expires: 3-2-2025
Notary Public

LORRI ANN CARLSON
Notary Public
State of Colorado
Notary ID # 20054008501
My Commission Expires 03-02-2025

DCP

STRUCTURE AGREEMENT

This letter has been provided to you as the owner of a structure on or within 200 feet of a proposed mine site. The State of Colorado, Division of Reclamation, Mining and Safety ("Division") requires that where a mining operation may adversely affect the stability of any significant, valuable and permanent man-made structure located within 200 feet of the affected land, the Applicant shall either:

a) Provide a notarized agreement between the Applicant and the Person(s) having an interest in the structure, that the Applicant is to provide compensation for any damages to the structure; or

b) Where an agreement cannot be reached, the Applicant shall provide an appropriate engineering evaluation that demonstrates that such structure shall not be damaged by activities occurring at the mining operation; or

c) Where such structure is a utility, the Applicant may supply a notarized letter, on utility letterhead, from the owner(s) of the utility that the mining and reclamation activities, as proposed, will have "no negative effect" on their utility. (*Construction Materials Rule 6.3.12 and Rule 6.4.19 & Hard Rock/Metal Mining Rule 6.3.12 and Rule 6.4.20)*

The Colorado Mined Land Reclamation Board ("Board") has determined that this form, if properly executed, represents an agreement that complies with Construction Materials Rule 6.3.12(a), Rule 6.4.19(a), and C.R.S. 34-32.5-115(4)(e) and with Hard Rock/Metal Mining Rule 6.3.12(a), Rule 6.4.20(a), and C.R.S. 34-32-115(4)(d). This form is for the sole purpose of ensuring compliance with the Rules and Regulations and shall not make the Board or Division a necessary party to any private civil lawsuit to enforce the terms of the agreement or create any enforcement obligations in the Board or the Division.

The following structures are located on or within 200 feet of the proposed affected area:

1. Pipeline Easement with Abandoned Pipeline (2)
2. Oil Equipment Inside Fence
3. Gas Lines – Cut and Cleaned
4. Gas Lines
5. Pipeline ROW Grant

CERTIFICATION

The Applicant, Martin Marietta Materials, Inc., represented by H. Abbott Lawrence as West Division President, does hereby certify that DCP Midstream (structure owner) shall be compensated for any damage from the proposed mining operation to the above listed structure(s) located on or within 200 feet of the proposed affected area described within Exhibit A, of the Reclamation Permit Application for Windsor East Mine.

This form has been approved by the Colorado Mined Land Reclamation Board pursuant to its authority under the Colorado Land Reclamation Act for the Extraction of Construction Materials and the Colorado Mined Land Reclamation Act for Hard Rock, Metal, and Designated Mining Operations. Any alteration or modification to this form shall result in voiding this form.

NOTARY FOR PERMIT APPLICANT

ACKNOWLEGED BY: H. Abbott Lawrence

Applicant: Martin Marietta Materials, Inc. Representative Name: H. Abbott Lawrence

Date: 12/23/2022 Title: West Division President

STATE OF Colorado)
) ss.
COUNTY OF Jefferson)

The foregoing was acknowledged before me this 23 day of December, 2022, by

H. Abbott Lawrence as West Division President of Martin Marietta Materials, Inc.

Julie M Mikulas
Notary Public

My Commission Expires: May 30, 2024

JULIE M MIKULAS
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19964009323
MY COMMISSION EXPIRES MAY 30, 2024

NOTARY FOR STRUCTURE OWNER

ACKNOWLEGED BY: ______________________

Structure Owner: DCP Operating Company, LP F/K/A DCP Midstream Name: ______________________

Date: 9/20/2022 Title: Attorney In Fact

STATE OF Colorado)
) ss.
COUNTY OF Weld)

The foregoing was acknowledged before me this 20th day of September, 2022, by Lewis D. Hagenlock as Attorney-In-Fact of DCP Operating Company, LP

Lorri Ann Carlson My Commission Expires: 3-2-2025
Notary Public

LORRI ANN CARLSON
Notary Public
State of Colorado
Notary ID # 20054008501
My Commission Expires 03-02-2025

John Daniel Demianycz

STRUCTURE AGREEMENT

This letter has been provided to you as the owner of a structure on or within 200 feet of a proposed mine site. The State of Colorado, Division of Reclamation, Mining and Safety ("Division") requires that where a mining operation may adversely affect the stability of any significant, valuable and permanent man-made structure located within 200 feet of the affected land, the Applicant shall either:

a) Provide a notarized agreement between the Applicant and the Person(s) having an interest in the structure, that the Applicant is to provide compensation for any damages to the structure; or

b) Where an agreement cannot be reached, the Applicant shall provide an appropriate engineering evaluation that demonstrates that such structure shall not be damaged by activities occurring at the mining operation; or

c) Where such structure is a utility, the Applicant may supply a notarized letter, on utility letterhead, from the owner(s) of the utility that the mining and reclamation activities, as proposed, will have "no negative effect" on their utility. (*Construction Materials Rule 6.3.12 and Rule 6.4.19 & Hard Rock/Metal Mining Rule 6.3.12 and Rule 6.4.20)*

The Colorado Mined Land Reclamation Board ("Board") has determined that this form, if properly executed, represents an agreement that complies with Construction Materials Rule 6.3.12(a), Rule 6.4.19(a), and C.R.S. 34-32.5-115(4)(e) and with Hard Rock/Metal Mining Rule 6.3.12(a), Rule 6.4.20(a), and C.R.S. 34-32-115(4)(d). This form is for the sole purpose of ensuring compliance with the Rules and Regulations and shall not make the Board or Division a necessary party to any private civil lawsuit to enforce the terms of the agreement or create any enforcement obligations in the Board or the Division.

The following structures are located on or within 200 feet of the proposed affected area:

1. House (1270 SF)
2. Quonset (2520 SF)
3. Outbuilding
4. Water Line
5. Overhead Electric Line
6. Septic System Leach Field
7. Driveway

CERTIFICATION

The Applicant, Martin Marietta Materials, Inc., represented by H. Abbott Lawrence as West Division President, does hereby certify that the John Daniel Demianycz Revocable Trust (structure owner) shall be compensated for any damage from the proposed mining operation to the above listed structure(s) located on or within 200 feet of the proposed affected area described within Exhibit A, of the Reclamation Permit Application for Windsor East Mine.

This form has been approved by the Colorado Mined Land Reclamation Board pursuant to its authority under the Colorado Land Reclamation Act for the Extraction of Construction Materials and the Colorado Mined Land Reclamation Act for Hard Rock, Metal, and Designated Mining Operations. Any alteration or modification to this form shall result in voiding this form.

NOTARY FOR PERMIT APPLICANT

ACKNOWLEDGED BY: H. Abbott Lawrence

Applicant: Martin Marietta Materials, Inc. Representative Name: H. Abbott Lawrence

Date: 12/23/22 Title: West Division President

STATE OF Colorado)

) ss.

COUNTY OF Jefferson)

The foregoing was acknowledged before me this 23 day of December, 2022 by

H. Abbott Lawrence as West Division President of Martin Marietta Materials, Inc.

Julie M Mikulas
Notary Public

My Commission Expires: May 30, 2024

JULIE M MIKULAS
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19964009323
MY COMMISSION EXPIRES MAY 30, 2024

NOTARY FOR STRUCTURE OWNER

ACKNOWLEGED BY: Elaine Schlotthauer

Structure Owner: John Daniel Demianycz Trust Name: John Daniel Demianycz

Date: October 3, 2022 Title: Trustee

STATE OF Colorado)

) ss.

COUNTY OF Weld)

The foregoing was acknowledged before me this 3 day of October, 2022, by John Daniel Demianycz as trustee of John Daniel Demianycz Trust

El Sch My Commission Expires: 8-27-2026

Notary Public

ELAINE SCHLOTTHAUER
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 20024027381
MY COMMISSION EXPIRES 08-27-2026

City of Greeley

STRUCTURE AGREEMENT

This letter has been provided to you as the owner of a structure on or within 200 feet of a proposed mine site. The State of Colorado, Division of Reclamation, Mining and Safety ("Division") requires that where a mining operation may adversely affect the stability of any significant, valuable and permanent man-made structure located within 200 feet of the affected land, the Applicant shall either:

a) Provide a notarized agreement between the Applicant and the Person(s) having an interest in the structure, that the Applicant is to provide compensation for any damages to the structure; or

b) Where an agreement cannot be reached, the Applicant shall provide an appropriate engineering evaluation that demonstrates that such structure shall not be damaged by activities occurring at the mining operation; or

c) Where such structure is a utility, the Applicant may supply a notarized letter, on utility letterhead, from the owner(s) of the utility that the mining and reclamation activities, as proposed, will have "no negative effect" on their utility. (*Construction Materials Rule 6.3.12 and Rule 6.4.19 & Hard Rock/Metal Mining Rule 6.3.12 and Rule 6.4.20)*

The Colorado Mined Land Reclamation Board ("Board") has determined that this form, if properly executed, represents an agreement that complies with Construction Materials Rule 6.3.12(a), Rule 6.4.19(a), and C.R.S. 34-32.5-115(4)(e) and with Hard Rock/Metal Mining Rule 6.3.12(a), Rule 6.4.20(a), and C.R.S. 34-32-115(4)(d). This form is for the sole purpose of ensuring compliance with the Rules and Regulations and shall not make the Board or Division a necessary party to any private civil lawsuit to enforce the terms of the agreement or create any enforcement obligations in the Board or the Division.

The following structures are or may be located on or within 200 feet of the proposed affected area:

1. Centerline of Water Easement (Width Not Specified)
2. Water Line (2)
3. 50' Water Pipe Easement
4. Water Pipeline Easement
5. Water Line in 50' Easement
6. Water Valves and Appurtenant Structures
7. 50' Water Pipe Easement
8. Potential water service pipelines (Initial investigations indicate these pipelines from homes west of WCR 23 do not exist, as shown on the City of Greeley's utility mapping; however, prior to mining Cell D, Martin Marietta will perform field locates and if they are found, the service pipelines will either be relocated or mining will not occur in Cell D.)

CERTIFICATION

The Applicant, Martin Marietta Materials, Inc., represented by H. Abbott Lawrence as West Division President, does hereby certify that the City of Greeley (structure owner) shall be compensated for any damage from the proposed mining operation to the above listed structure(s) located on or within 200 feet of the proposed affected area described within Exhibit A, of the Reclamation Permit Application for Windsor East Mine.

This form has been approved by the Colorado Mined Land Reclamation Board pursuant to its authority under the Colorado Land Reclamation Act for the Extraction of Construction Materials and the Colorado Mined Land Reclamation Act for Hard Rock, Metal, and Designated Mining Operations. Any alteration or modification to this form shall result in voiding this form.

NOTARY FOR PERMIT APPLICANT

ACKNOWLEGED BY: H. Abbott Lawrence

Applicant: Martin Marietta Materials, Inc. Representative Name: H. Abbott Lawrence

Date: 1-19-2023 Title: West Division President

STATE OF Colorado)
) ss.
COUNTY OF Jefferson)

The foregoing was acknowledged before me this 19th day of January, 2023, by

H. Abbott Lawrence as West Division President of Martin Marietta Materials, Inc.

Julie M Mikulas
Notary Public

My Commission Expires: May 30, 2024

JULIE M MIKULAS
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19964009323
MY COMMISSION EXPIRES MAY 30, 2024

NOTARY FOR STRUCTURE OWNER

ACKNOWLEGED BY:

Structure Owner: City of Greeley Name: Adam Prior

Date: 1/11/2023 Title: Chief Engineer

STATE OF CO)

) ss.

COUNTY OF Weld)

The foregoing was acknowledged before me this 11th day of January, 2023 by Adam Prior as Chief Engineer of City of Greeley Water & Sewer Dept.

Crystal Sanchez My Commission Expires: March 4, 2024

Notary Public

CRYSTAL SANCHEZ
NOTARY PUBLIC
STATE OF COLORADO
Notary ID 20204008831
My Commission Expires March 04, 2024

GWIP

STRUCTURE AGREEMENT

This letter has been provided to you as the owner of a structure on or within 200 feet of a proposed mine site. The State of Colorado, Division of Reclamation, Mining and Safety ("Division") requires that where a mining operation may adversely affect the stability of any significant, valuable and permanent man-made structure located within 200 feet of the affected land, the Applicant shall either:

a) Provide a notarized agreement between the Applicant and the Person(s) having an interest in the structure, that the Applicant is to provide compensation for any damages to the structure; or

b) Where an agreement cannot be reached, the Applicant shall provide an appropriate engineering evaluation that demonstrates that such structure shall not be damaged by activities occurring at the mining operation; or

c) Where such structure is a utility, the Applicant may supply a notarized letter, on utility letterhead, from the owner(s) of the utility that the mining and reclamation activities, as proposed, will have "no negative effect" on their utility. (*Construction Materials Rule 6.3.12 and Rule 6.4.19 & Hard Rock/Metal Mining Rule 6.3.12 and Rule 6.4.20)*

The Colorado Mined Land Reclamation Board ("Board") has determined that this form, if properly executed, represents an agreement that complies with Construction Materials Rule 6.3.12(a), Rule 6.4.19(a), and C.R.S. 34-32.5-115(4)(e) and with Hard Rock/Metal Mining Rule 6.3.12(a), Rule 6.4.20(a), and C.R.S. 34-32-115(4)(d). This form is for the sole purpose of ensuring compliance with the Rules and Regulations and shall not make the Board or Division a necessary party to any private civil lawsuit to enforce the terms of the agreement or create any enforcement obligations in the Board or the Division.

The following structures are located on or within 200 feet of the proposed affected area:

1. Concrete Lined Lateral (2)
2. House (1309 SF)
3. Utility Building (1440 SF)
4. Small Buildings (3) (1348 SF)
5. Irrigation Pump
6. Private Road
7. Fenceline (4)
8. Swale Flowline (3) - some to be removed per mine plan
9. Swale Flowline Lateral – to be removed per mine plan
10. Access Road (2)
11. ROW Closed to Public Access
12. Ditch Lateral
13. Water Meter
14. 10' Utility Easement
15. Rock Structure (Side Channel)

CERTIFICATION

The Applicant, Martin Marietta Materials, Inc., represented by H. Abbott Lawrence as West Division President, does hereby certify that GWIP, LLC (structure owner) shall be compensated for any damage from the proposed mining operation to the above listed structure(s) located on or within 200 feet of the proposed affected area described within Exhibit A, of the Reclamation Permit Application for Windsor East Mine.

This form has been approved by the Colorado Mined Land Reclamation Board pursuant to its authority under the Colorado Land Reclamation Act for the Extraction of Construction Materials and the Colorado Mined Land Reclamation Act for Hard Rock, Metal, and Designated Mining Operations. Any alteration or modification to this form shall result in voiding this form.

NOTARY FOR PERMIT APPLICANT

ACKNOWLEGED BY: H. Abbott Lawrence

Applicant: Martin Marietta Materials, Inc. Representative Name: H. Abbott Lawrence

Date: 12/23/22 Title: West Division President

STATE OF Colorado)
) ss.
COUNTY OF Jefferson)

The foregoing was acknowledged before me this 23 day of December, 20 22, by

H. Abbott Lawrence as West Division President of Martin Marietta Materials, Inc.

Julie M Mikulas
Notary Public

My Commission Expires: May 30, 2024

JULIE M MIKULAS
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19964009323
MY COMMISSION EXPIRES MAY 30, 2024

NOTARY FOR STRUCTURE OWNER

ACKNOWLEGED BY: __________

Structure Owner: GWIP, LLC Name: DEAN A. BROWN

Date: 10/2/2022 Title: ~~SV~~ AGENT

STATE OF Colorado)

) ss.

COUNTY OF WELD)

The foregoing was acknowledged before me this 2 day of OCTOBER, 2022, by DEAN Brown as SVP of ID.

__________ My Commission Expires: 7/8/2024

Notary Public

BRETT T. RUDER
Notary Public
State of Colorado
Notary ID # 20084009621
My Commission Expires 07-08-2024

PVREA

STRUCTURE AGREEMENT

This letter has been provided to you as the owner of a structure on or within 200 feet of a proposed mine site. The State of Colorado, Division of Reclamation, Mining and Safety ("Division") requires that where a mining operation may adversely affect the stability of any significant, valuable and permanent man-made structure located within 200 feet of the affected land, the Applicant shall either:

a) Provide a notarized agreement between the Applicant and the Person(s) having an interest in the structure, that the Applicant is to provide compensation for any damages to the structure; or

b) Where an agreement cannot be reached, the Applicant shall provide an appropriate engineering evaluation that demonstrates that such structure shall not be damaged by activities occurring at the mining operation; or

c) Where such structure is a utility, the Applicant may supply a notarized letter, on utility letterhead, from the owner(s) of the utility that the mining and reclamation activities, as proposed, will have "no negative effect" on their utility. (*Construction Materials Rule 6.3.12 and Rule 6.4.19 & Hard Rock/Metal Mining Rule 6.3.12 and Rule 6.4.20)*

The Colorado Mined Land Reclamation Board ("Board") has determined that this form, if properly executed, represents an agreement that complies with Construction Materials Rule 6.3.12(a), Rule 6.4.19(a), and C.R.S. 34-32.5-115(4)(e) and with Hard Rock/Metal Mining Rule 6.3.12(a), Rule 6.4.20(a), and C.R.S. 34-32-115(4)(d). This form is for the sole purpose of ensuring compliance with the Rules and Regulations and shall not make the Board or Division a necessary party to any private civil lawsuit to enforce the terms of the agreement or create any enforcement obligations in the Board or the Division.

The following structures are located on or within 200 feet of the proposed affected area:

1. Overhead Electric Line
2. Overhead Electric Line and Underground Fiber Optic Cable

CERTIFICATION

The Applicant, Martin Marietta Materials, Inc., represented by H. Abbott Lawrence as West Division President, does hereby certify that Poudre Valley REA (structure owner) shall be compensated for any damage from the proposed mining operation to the above listed structure(s) located on or within 200 feet of the proposed affected area described within Exhibit A, of the Reclamation Permit Application for Windsor East Mine.

This form has been approved by the Colorado Mined Land Reclamation Board pursuant to its authority under the Colorado Land Reclamation Act for the Extraction of Construction Materials and the Colorado Mined Land Reclamation Act for Hard Rock, Metal, and Designated Mining Operations. Any alteration or modification to this form shall result in voiding this form.

NOTARY FOR PERMIT APPLICANT

ACKNOWLEGED BY: H. Abbott Lawrence

Applicant: Martin Marietta Materials, Inc. Representative Name: H. Abbott Lawrence

Date: 12/23/22 Title: West Division President

STATE OF Colorado)
) ss.
COUNTY OF Jefferson)

The foregoing was acknowledged before me this 23 day of December, 2022 by

H. Abbott Lawrence as West Division President of Martin Marietta Materials, Inc.

Julie M Mikulas
Notary Public

My Commission Expires: May 30, 2024

JULIE M MIKULAS
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19964009323
MY COMMISSION EXPIRES MAY 30, 2024

NOTARY FOR STRUCTURE OWNER

ACKNOWLEDGED BY: ______________________

Structure Owner: Poudre Valley REA, Inc Name: John Bauerfind

Date: 12/22/22 Title: VP / COO

STATE OF Colorado)
) ss.
COUNTY OF Larimer)

The foregoing was acknowledged before me this 22 day of December, 2022, by John Bauerfind as VP/COO of Poudre Valley REA, Inc.

______________________ My Commission Expires: 05/29/2024
Notary Public

CASSANDRA MARIE HAYES
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 20204018925
MY COMMISSION EXPIRES MAY 29, 2024

Robert Greg + Melissa Stieben

STRUCTURE AGREEMENT

This letter has been provided to you as the owner of a structure on or within 200 feet of a proposed mine site. The State of Colorado, Division of Reclamation, Mining and Safety ("Division") requires that where a mining operation may adversely affect the stability of any significant, valuable and permanent man-made structure located within 200 feet of the affected land, the Applicant shall either:

a) Provide a notarized agreement between the Applicant and the Person(s) having an interest in the structure, that the Applicant is to provide compensation for any damages to the structure; or

b) Where an agreement cannot be reached, the Applicant shall provide an appropriate engineering evaluation that demonstrates that such structure shall not be damaged by activities occurring at the mining operation; or

c) Where such structure is a utility, the Applicant may supply a notarized letter, on utility letterhead, from the owner(s) of the utility that the mining and reclamation activities, as proposed, will have "no negative effect" on their utility. (*Construction Materials Rule 6.3.12 and Rule 6.4.19 & Hard Rock/Metal Mining Rule 6.3.12 and Rule 6.4.20)*

The Colorado Mined Land Reclamation Board ("Board") has determined that this form, if properly executed, represents an agreement that complies with Construction Materials Rule 6.3.12(a), Rule 6.4.19(a), and C.R.S. 34-32.5-115(4)(e) and with Hard Rock/Metal Mining Rule 6.3.12(a), Rule 6.4.20(a), and C.R.S. 34-32-115(4)(d). This form is for the sole purpose of ensuring compliance with the Rules and Regulations and shall not make the Board or Division a necessary party to any private civil lawsuit to enforce the terms of the agreement or create any enforcement obligations in the Board or the Division.

The following structures are located on or within 200 feet of the proposed affected area:

1. House (3170 SF)
2. House (560 SF)
3. Shed (495 SF)
4. Equipment Building (960 SF)
5. Water Line
6. Overhead Electric Line
7. Septic System
8. Driveway

CERTIFICATION

The Applicant, Martin Marietta Materials, Inc., represented by H. Abbott Lawrence as West Division President, does hereby certify that Robert Greg & Melissa Stieben * ~~3W Properties, LLC~~ (structure owner) shall be compensated for any damage from the proposed mining operation to the above listed structure(s) located on or within 200 feet of the proposed affected area described within Exhibit A, of the Reclamation Permit Application for Windsor East Mine.

This form has been approved by the Colorado Mined Land Reclamation Board pursuant to its authority under the Colorado Land Reclamation Act for the Extraction of Construction Materials and the Colorado Mined Land Reclamation Act for Hard Rock, Metal, and Designated Mining Operations. Any alteration or modification to this form shall result in voiding this form.

* Robert Greg & Melissa Stieben bought property from 3W Properties, LLC on 10/14/2022

NOTARY FOR PERMIT APPLICANT

ACKNOWLEGED BY: H. Abbott Lawrence

Applicant: Martin Marietta Materials, Inc. Representative Name: H. Abbott Lawrence

Date: 12/14/2022

Title: West Division President

STATE OF Colorado)
) ss.
COUNTY OF Jefferson)

The foregoing was acknowledged before me this 14th day of December, 20 22 by

H. Abbott Lawrence as West Division President of Martin Marietta Materials, Inc.

Julie M Mikulas
Notary Public

My Commission Expires: May 30, 2024

JULIE M MIKULAS
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19964009323
MY COMMISSION EXPIRES MAY 30, 2024

NOTARY FOR STRUCTURE OWNER

ACKNOWLEGED BY: Greg Stieben

Structure Owner: Robert Greg & Name: Melissa Stieben

Date: 12/13/2022 Title: Owner

STATE OF Colorado)

) ss.

COUNTY OF Weld)

The foregoing was acknowledged before me this 13 day of December, 2022, by Robert Greg Stieben as owner of 30801 County Rd 23.

Julie M Mikulas My Commission Expires: 5/30/2024

Notary Public

JULIE M MIKULAS
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19964009323
MY COMMISSION EXPIRES MAY 30, 2024

Return copy to
35106 County Rd 13
Windsor, CO 80550

Windsor

STRUCTURE AGREEMENT

This letter has been provided to you as the owner of a structure on or within 200 feet of a proposed mine site. The State of Colorado, Division of Reclamation, Mining and Safety ("Division") requires that where a mining operation may adversely affect the stability of any significant, valuable and permanent man-made structure located within 200 feet of the affected land, the Applicant shall either:

a) Provide a notarized agreement between the Applicant and the Person(s) having an interest in the structure, that the Applicant is to provide compensation for any damages to the structure; or

b) Where an agreement cannot be reached, the Applicant shall provide an appropriate engineering evaluation that demonstrates that such structure shall not be damaged by activities occurring at the mining operation; or

c) Where such structure is a utility, the Applicant may supply a notarized letter, on utility letterhead, from the owner(s) of the utility that the mining and reclamation activities, as proposed, will have "no negative effect" on their utility. (*Construction Materials Rule 6.3.12 and Rule 6.4.19 & Hard Rock/Metal Mining Rule 6.3.12 and Rule 6.4.20)*

The Colorado Mined Land Reclamation Board ("Board") has determined that this form, if properly executed, represents an agreement that complies with Construction Materials Rule 6.3.12(a), Rule 6.4.19(a), and C.R.S. 34-32.5-115(4)(e) and with Hard Rock/Metal Mining Rule 6.3.12(a), Rule 6.4.20(a), and C.R.S. 34-32-115(4)(d). This form is for the sole purpose of ensuring compliance with the Rules and Regulations and shall not make the Board or Division a necessary party to any private civil lawsuit to enforce the terms of the agreement or create any enforcement obligations in the Board or the Division.

The following structures are located on or within 200 feet of the proposed affected area:

1. Weld County Road 23 (60' ROW)
2. Future Crossroads Boulevard ROW

CERTIFICATION

The Applicant, Martin Marietta Materials, Inc., represented by H. Abbott Lawrence as West Division President, does hereby certify that the Town of Windsor (structure owner) shall be compensated for any damage from the proposed mining operation to the above listed structure(s) located on or within 200 feet of the proposed affected area described within Exhibit A, of the Reclamation Permit Application for Windsor East Mine.

This form has been approved by the Colorado Mined Land Reclamation Board pursuant to its authority under the Colorado Land Reclamation Act for the Extraction of Construction Materials and the Colorado Mined Land Reclamation Act for Hard Rock, Metal, and Designated Mining Operations. Any alteration or modification to this form shall result in voiding this form.

NOTARY FOR PERMIT APPLICANT

ACKNOWLEGED BY: H. Abbott Lawrence

Applicant: Martin Marietta Materials, Inc. Representative Name: H. Abbott Lawrence

Date: 12/23/22 Title: West Division President

STATE OF Colorado)
) ss.
COUNTY OF Jefferson)

The foregoing was acknowledged before me this 23 day of December, 20 22 by

H. Abbott Lawrence as West Division President of Martin Marietta Materials, Inc.

Julie M Mikulas
Notary Public

My Commission Expires: May 30, 2024

JULIE M MIKULAS
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 19964009323
MY COMMISSION EXPIRES MAY 30, 2024

NOTARY FOR STRUCTURE OWNER

ACKNOWLEGED BY: ____________

Structure Owner: Town of Windsor Name: Shane Hale

Date: 9/22/22 Title: Town Manager

STATE OF COLORADO)

) ss.

COUNTY OF WELD)

The foregoing was acknowledged before me this 22 day of SEPTEMBER 2022, by Shane Hale as Town Manager of Town of Windsor.

Christine Martin My Commission Expires: NOVEMBER 29, 2024

Notary Public

CHRISTINE MARTIN
NOTARY PUBLIC
STATE OF COLORADO
NOTARY ID 20164045063
MY COMMISSION EXPIRES NOVEMBER 29, 2024

STATE OF COLORADO

Hays - DNR, Peter <peter.hays@state.co.us>

Windsor East Adequacy Review 1 Response (M-2022-042)

Hora, Pam <Pam.Hora@tetratech.com> Fri, Mar 3, 2023 at 1:12 PM
To: "Peter Hays (peter.hays@state.co.us)" <peter.hays@state.co.us>, Eric Scott <eric.scott@state.co.us>
Cc: Julie Mikulas <Julie.Mikulas@martinmarietta.com>

Hi Peter,

I am sending you a link to our Adequacy Review 1 Response documents for Windsor East Mine (M-2022-042). Eric, I'm also including you on this email since you had prepared a letter with comments specific to Exhibit G.

🗀 2023 03 03 Adequacy Review 1 Resubmittal Package

If you have any questions or need any other information, please let me or Julie know.

Thank you,

Pam Hora

Pamela Franch Hora, AICP | Senior Planner / Longmont Operations Manager

Pronouns: she, her, hers
Direct **+1 (720) 864-4507** | Business **+1 (303) 772-5282** | Mobile **+1 (720) 201-1073** | pam.hora@tetratech.com

Tetra Tech | *Leading with Science®* | ECS
351 Coffman Street, Suite 200 | Longmont, CO 80501 | tetratech.com

TETRA TECH