Irwin Thomas M2016-0054 TR-1, Answers to CDOT Questions

Barb Brunk <barbb@dgmllc.com> Wed, Jun 7, 2023 at 12:16 PM
To: "Lennberg - DNR, Patrick" <patrick.lennberg@state.co.us>
Cc: Landon WILHITE <landon.wilhite@holcim.com>, Wyatt WEBSTER <wyatt.webster@holcim.com>, "Bilobran - CDOT, Timothy" <timothy.bilobran@state.co.us>

Patrick,

I wanted to circle back regarding CDOT questions for this application. CDOT reached out to us when they received the Certified mail with the structure agreement.

We provided your contact information, all of the Slope Stability and Ground water info included in the DRMS records and reviewed the reports with them to answer specific questions.

We had more than one conversation and determined that the information presented addressed their concerns. CDOT did not enter into a structure agreement with the applicant.

At their request, we combined the information submitted to CDOT for review and a summary of our conversations into one Memo, so we all have a complete record of the information submitted and answers to their questions.

The attached Email from Tim Bilobran dated 6/7/2023 documents that the applicant has addressed CDOT'S questions.

I told Tim I would forward the information we provided to CDOT to you, so that it is included in the documentation for the DRMS permit.

Call with questions.

Thank you.

Barb

Barb Brunk

Resource Conservation Partners, LLC

P.O. Box 1522

Longmont, CO 80502

Fax (303)702-0585

Cell (303)775-6180

barbb@dgmllc.com

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3 attachments

From Tim Bilobran CDOT OK 6 7 2023.pdf
486K

Email to CDOT 5 12 2023.pdf
459K

M2016-0054 Irwin Thomas Mine_MEMORANDUM CDOT_ 5 12 2023.pdf
16248K

Barb Brunk

Subject: FW: Answers to CDOT Questions

From: Bilobran - CDOT, Timothy <timothy.bilobran@state.co.us>
Sent: Wednesday, June 7, 2023 11:17 AM
To: Barb Brunk <barbb@dgmllc.com>
Cc: Landon WILHITE <landon.wilhite@holcim.com>
Subject: Re: Answers to CDOT Questions

Barb,

Thank you for your patience. Both R4 Materials Lab and HQ Statewide Geotech have approved your latest round of documents. We have no further concerns with this proposal. Please feel free to show this email to other regulatory agencies as evidence of our official position.

Thanks,
Tim

On Tue, May 23, 2023 at 2:52 PM Barb Brunk <barbb@dgmllc.com> wrote:

> Tim,
> We just need to make sure CDOT is has all relevant information to answer the questions regarding slope stability as Holcim moves forward to mine the property.
> When you confirm we are on the same page I will send all to our regulator. I would like to send DRMS a complete packet including emails and information so that it is part of the record at DRMS for the application.
> The applicant is still working on final requirements prior to mining. We anticipate they will be ready to move forward soon. When you confirm we are on the same page I will send all to our regulator.
> Thank you for following up.
> Barb
>
> Barb Brunk
> **Resource Conservation Partners, LLC**
> P.O. Box 1522
> Longmont, CO 80502
> Fax (303)702-0585
> Cell (303)775-6180
> barbb@dgmllc.com
>
> ---
>
> **From:** Bilobran - CDOT, Timothy <timothy.bilobran@state.co.us>
> **Sent:** Tuesday, May 23, 2023 1:33 PM
> **To:** Barb Brunk <barbb@dgmllc.com>
> **Subject:** Re: Answers to CDOT Questions

> I promise you we haven't forgotten about this email. HQ gave the thumbs up but I'm waiting for the region materials lab to give the same thumbs up. Steve Heimmer has been on vacation. When is the drop dead date you need the answer by?
>
> Tim
>
> On Fri, May 12, 2023 at 2:08 PM Barb Brunk <barbb@dgmllc.com> wrote:
>
>> Tim,
>> Answers and clarification to follow our conversation – all included in one Memo. We started with the email response below and added clarification and summary based on our discussion. The information is combined into one response so we all have a "paper trail" to document our conversation. Based on our discussion, we believe that attached information answer's CDOT's questions and concerns. Please confirm and let me know if you need any additional information.
>> Barb
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>> ---
>>
>> **From:** Barb Brunk
>> **Sent:** Friday, April 7, 2023 4:42 PM
>> **To:** Bilobran - CDOT, Timothy <timothy.bilobran@state.co.us>; david.thomas@state.co.us; steven.heimmer@state.co.us
>> **Cc:** Landon WILHITE <landon.wilhite@holcim.com>; Wyatt WEBSTER <wyatt.webster@holcim.com>; Reggie Golden <reggieg@dgmllc.com>; Ethan Wiechert <EthanW@earth-engineering.com>; jcyork@j-tconsulting.com; Drew Golden <drewg@dgmllc.com>
>> **Subject:** FW: Answers to CDOT Questions
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>> Tim,
>> We would like to discuss any additional questions regarding Slope Stability, Slurry Wall Design and Ground Water once CDOT Staff have a chance to review the attached information and our answers to the comments as outlined below. Attached Subsurface Exploration and Slope Stability Evaluations, Ground Water Model and Slurry Wall Design and Design Report address some of the questions. Note that the Slurry Wall Design Report also includes geotechnical evaluation and slope stability analysis (Appendix A and C of the report). The slurry wall design must be reviewed and approved by DRMS prior to installation. We are thinking a direct conversation regarding the slope stability questions will help clarify the existing analysis and help us understand if CDOT needs any additional information. I sent a Zoom invite for 1:15, Wednesday, April 12 for our conversation. Our response to the comments follow the comments and are outlined below.
>>
>> - For Cells 6 and 7 specifically on the North side of HWY 119 it says that trucks will be entering HWY 119 if a conveyor system is not used. The truck route from Barb earlier showed all the traffic on the south side. Will the Northern cells be a part of the future submittal? ***Applicant Response: No mining will take place north of HWY 119 until another Technical Revision is processed through Colorado Division of Reclamation, Mining and Safety (DRMS). No direct access from the future mining area on the north side of the HWY until the access is reviewed and approved by CDOT and the City of Longmont.***
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>> - They state when they are going to reclaim it, it will become sealed or unlined ponds, what is the long-term effect on HWY 119 if it is saturated due to these ponds. ***Applicant Response: The attached Groundwater Analysis prepared by Miller Groundwater Engineering, for the south side of the HWY demonstrates impact to the water table with Mining and Reclamation, including installation of the slurry wall. The highway now sits on top of existing groundwater (see Figure 5 in the Model – existing water table is between 10 and 20' deep under the HWY ROW). Impacts on water levels are shown on Figures 8 and 9. Water level under HWY ROW will be drawn down 0 to 1 foot during mining (Figure 8) and 0 to .5 feet (Figure 9) when mining is complete. No mounding under the HWY ROW is identified in the model.***

> - We would expect this to be addressed in any analysis/report. ***Applicant Response: The attached Groundwater Evaluation prepared by Miller Groundwater Engineering includes an analysis regarding impacts of mining and reclamation for the south side of the HWY. The analysis will be updated as part of a future Technical Revision for mining and reclamation on the north side of the Hwy (Cells 6 and 7).***
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> - For the work they are intending to perform will any of it affect CDOT irrigation or drainage structures? ***Applicant Response: No. See attached Topographic map and Exhibit C-4 Mining Plan for relationship between the mining activities and CDOT improvements.***
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> 1.The geotech/stability report doesn't go into enough detail regarding the impact to our highway. It's stated that the soils were evaluated horizontally 2 times the height of the vertical cut of 25 feet or 50 feet away. Where is our road in relation to their modeling? 50 feet? ***Applicant Response: we would like to review the Slope Stability Report with CDOT Staff. No mining excavation will take place within 100 feet of the CDOT ROW. The Distance from the mining excavation on the south side of HWY 119 to the existing travel lane of roadway is approximately 125 feet (115 feet to the edge of the paved shoulder) at the closest point (the western end of Cell 1, See C-4 mining Plan). However, the proposed slurry wall will be located in the 100' mining setback along a portion of the HWY frontage. Per the attached Slurry Wall Design, the slurry wall will be located approximately 90' from the CDOT ROW and 150' from the existing roadway at the closest point (the western end of Cell 2, see sheet 1 of the design plans). Preliminary slurry wall design and the additional geotechnical evaluation completed for the slurry wall design are attached.***
>
> 2.A traffic surcharge of 250 pcf needs to be applied to represent traffic impacts along the highway if they are looking to have the edge of the mine within 200 feet. ***Applicant Response: We would like to review the Slope Stability Report with CDOT Staff. A traffic Surcharge of 250 pcf was considered as part of the slape stability analysis. See Summary and recommendations pages 5,6 and 7, Earth Engineering Consultants, LLC - 'Subsurface Exploration and Slope Stability Evaluation' report, February 7.2018 and Updated Letter dated June 28, 2022.***
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> 3.It is assumed groundwater is being pumped. What happens when mining ends and the groundwater rises? **Applicant Response:** ***Impacts on water levels are shown on Figures 8 and 9 of the Groundwater Evaluation. Water level under HWY ROW will be drawn down 0 to 1 foot during mining (Figure 8) and 0 to .5 feet (Figure 9) when reclamation is complete. No mounding under the HWY ROW was identified in the model.***
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> 5.Only the vertical cut was modeled. Are they assuming to let it fail? Are there any concerns of long-term impact or continued failure expanding beyond the initial modeled area? ***Applicant Response: We would like to review the Slope Stability Report with CDOT Staff.***
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> 6.I'm guessing the slurry wall and tunnel were pulled since they are part of the structural proposal. Otherwise, they will have to provide a geotech exploration, evaluation, and analysis for those items showing they won't impact the highway. ***Applicant Response: We do not anticipate a tunnel for conveyance of material under the HWY at this time. A slurry wall is included with the mining and reclamation on the south side of HWY 119. The slurry will be installed prior to mining Cells 2 and 3. The proposed location of the slurry wall is shown on Exhibits C-4 (Mining Plan) and Exhibit F (Reclamation Plan). Preliminary Slurry Wall Design and Design Report completed for the slurry wall are attached. Note that the Slurry Wall Design Report also includes geotechnical evaluation and slope stability analysis (Appendix A and C of the report***). ***The design for the slurry wall will be reviewed and approved by DRMS prior to installation.***
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> Thank you for coordinating CDOT review and response to the mining plans.
> Barb
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> Barb Brunk
> **Resource Conservation Partners, LLC**

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> Longmont, CO 80502
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> Cell (303)775-6180
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> --
> **Tim Bilobran**
> **Region 4 Permits Manager**
> O 970.350.2163 | C 970.302.4022 | F 970.350.2198
> **timothy.bilobran@state.co.us | codot.gov | www.cotrip.org**
> 10601 W. 10th Street, Greeley, CO 80634

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Barb Brunk

From: Barb Brunk
Sent: Friday, May 12, 2023 2:04 PM
To: 'Bilobran - CDOT, Timothy'; 'david.thomas@state.co.us'; 'steven.heimmer@state.co.us'
Cc: 'Landon WILHITE'; 'Wyatt WEBSTER'; Reggie Golden; 'Ethan Wiechert'; 'jcyork@j-tconsulting.com'; Drew Golden
Subject: RE: Answers to CDOT Questions
Attachments: M2016-0054 Irwin Thomas Mine_MEMORANDUM CDOT_ 5 12 2023.pdf

Tim,
Answers and clarification to follow our conversation – all included in one Memo. We started with the email response below and added clarification and summary based on our discussion. The information is combined into one response so we all have a "paper trail" to document our conversation. Based on our discussion, we believe that attached information answer's CDOT's questions and concerns. Please confirm and let me know if you need any additional information.
Barb

From: Barb Brunk
Sent: Friday, April 7, 2023 4:42 PM
To: Bilobran - CDOT, Timothy <timothy.bilobran@state.co.us>; david.thomas@state.co.us; steven.heimmer@state.co.us
Cc: Landon WILHITE <landon.wilhite@holcim.com>; Wyatt WEBSTER <wyatt.webster@holcim.com>; Reggie Golden <reggieg@dgmllc.com>; Ethan Wiechert <EthanW@earth-engineering.com>; jcyork@j-tconsulting.com; Drew Golden <drewg@dgmllc.com>
Subject: FW: Answers to CDOT Questions

Tim,
We would like to discuss any additional questions regarding Slope Stability, Slurry Wall Design and Ground Water once CDOT Staff have a chance to review the attached information and our answers to the comments as outlined below. Attached Subsurface Exploration and Slope Stability Evaluations, Ground Water Model and Slurry Wall Design and Design Report address some of the questions. Note that the Slurry Wall Design Report also includes geotechnical evaluation and slope stability analysis (Appendix A and C of the report). The slurry wall design must be reviewed and approved by DRMS prior to installation. We are thinking a direct conversation regarding the slope stability questions will help clarify the existing analysis and help us understand if CDOT needs any additional information. I sent a Zoom invite for 1:15, Wednesday, April 12 for our conversation. Our response to the comments follow the comments and are outlined below.

- For Cells 6 and 7 specifically on the North side of HWY 119 it says that trucks will be entering HWY 119 if a conveyor system is not used. The truck route from Barb earlier showed all the traffic on the south side. Will the Northern cells be a part of the future submittal? ***Applicant Response: No mining will take place north of HWY 119 until another Technical Revision is processed through Colorado Division of Reclamation, Mining and Safety (DRMS). No direct access from the future mining area on the north side of the HWY until the access is reviewed and approved by CDOT and the City of Longmont.***

- They state when they are going to reclaim it, it will become sealed or unlined ponds, what is the long-term effect on HWY 119 if it is saturated due to these ponds. ***Applicant Response: The attached Groundwater Analysis prepared by Miller Groundwater Engineering, for the south side of the HWY demonstrates impact to the water table with Mining and Reclamation, including installation of the slurry wall. The highway now sits on top of existing groundwater (see Figure 5 in the Model – existing water table is between 10 and 20' deep under the HWY ROW). Impacts on water levels are shown on Figures 8 and 9. Water level under HWY ROW***

will be drawn down 0 to 1 foot during mining (Figure 8) and 0 to .5 feet (Figure 9) when mining is complete. No mounding under the HWY ROW is identified in the model.

- We would expect this to be addressed in any analysis/report. ***Applicant Response: The attached Groundwater Evaluation prepared by Miller Groundwater Engineering includes an analysis regarding impacts of mining and reclamation for the south side of the HWY. The analysis will be updated as part of a future Technical Revision for mining and reclamation on the north side of the Hwy (Cells 6 and 7).***

- For the work they are intending to perform will any of it affect CDOT irrigation or drainage structures? ***Applicant Response: No. See attached Topographic map and Exhibit C-4 Mining Plan for relationship between the mining activities and CDOT improvements.***

1. The geotech/stability report doesn't go into enough detail regarding the impact to our highway. It's stated that the soils were evaluated horizontally 2 times the height of the vertical cut of 25 feet or 50 feet away. Where is our road in relation to their modeling? 50 feet? ***Applicant Response: we would like to review the Slope Stability Report with CDOT Staff. No mining excavation will take place within 100 feet of the CDOT ROW. The Distance from the mining excavation on the south side of HWY 119 to the existing travel lane of roadway is approximately 125 feet (115 feet to the edge of the paved shoulder) at the closest point (the western end of Cell 1, See C-4 mining Plan). However, the proposed slurry wall will be located in the 100' mining setback along a portion of the HWY frontage. Per the attached Slurry Wall Design, the slurry wall will be located approximately 90' from the CDOT ROW and 150' from the existing roadway at the closest point (the western end of Cell 2, see sheet 1 of the design plans). Preliminary slurry wall design and the additional geotechnical evaluation completed for the slurry wall design are attached.***

2. A traffic surcharge of 250 pcf needs to be applied to represent traffic impacts along the highway if they are looking to have the edge of the mine within 200 feet. ***Applicant Response: We would like to review the Slope Stability Report with CDOT Staff. A traffic Surcharge of 250 pcf was considered as part of the slape stability analysis. See Summary and recommendations pages 5,6 and 7, Earth Engineering Consultants, LLC - 'Subsurface Exploration and Slope Stability Evaluation' report, February 7.2018 and Updated Letter dated June 28, 2022.***
3. It is assumed groundwater is being pumped. What happens when mining ends and the groundwater rises? **Applicant Response:** ***Impacts on water levels are shown on Figures 8 and 9 of the Groundwater Evaluation. Water level under HWY ROW will be drawn down 0 to 1 foot during mining (Figure 8) and 0 to .5 feet (Figure 9) when reclamation is complete. No mounding under the HWY ROW was identified in the model.***
4. What about fully softened soil conditions where cohesion is not the deciding property? ***Applicant Response: We would like to review the Slope Stability Report with CDOT Staff.***
5. Only the vertical cut was modeled. Are they assuming to let it fail? Are there any concerns of long-term impact or continued failure expanding beyond the initial modeled area? ***Applicant Response: We would like to review the Slope Stability Report with CDOT Staff.***

6. I'm guessing the slurry wall and tunnel were pulled since they are part of the structural proposal. Otherwise, they will have to provide a geotech exploration, evaluation, and analysis for those items showing they won't impact the highway. ***Applicant Response: We do not anticipate a tunnel for conveyance of material under the HWY at this time. A slurry wall is included with the mining and reclamation on the south side of HWY 119. The slurry will be installed prior to mining Cells 2 and 3. The proposed location of the slurry wall is shown on Exhibits C-4 (Mining Plan) and Exhibit F (Reclamation Plan). Preliminary Slurry Wall Design and Design Report completed for the slurry wall are attached. Note that the Slurry Wall Design Report also includes geotechnical evaluation and slope stability analysis (Appendix A and C of the report***). ***The design for the slurry wall will be reviewed and approved by DRMS prior to installation.***

Thank you for coordinating CDOT review and response to the mining plans.

Barb

Barb Brunk
Resource Conservation Partners, LLC
P.O. Box 1522
Longmont, CO 80502
Fax (303)702-0585
Cell (303)775-6180
barbb@dgmllc.com

MEMORANDUM

TO: **Colorado Department of Transportation:** Tim Bilobran, David Thomas, Steven Heimmer
FROM: Landon Wilhite, Ethan Weichert, JC York Calvin Miller, Barb Brunk Christian Morgan, Barb Brunk
DATE: May 12, 2023
RE: Colorado Department of Transportation (CDOT) questions regarding Colorado Department of Reclamation Mining and Safety (DRMS) Irwin Thomas 112 Permit M2016-054, Technical Revision #1

This information is in response to CDOT's request to have a written document as a follow up to conversation on Wednesday, April 12, 2023 regarding gravel mining on the Irwin Thomas property adjacent to Colorado HWY 119 in Longmont, Colorado.

Holcim-WCR, Inc. has requested a Technical Revision to the Existing DRMS 112 Permit to mine sand and gravel and reclaim property adjacent to HWY 119 in Longmont. The existing 112 permit included the entire Irwin Thomas Mine. This Technical Revision (TR-1) is for the portion of the Irwin Thomas Mine located south of HWY 119. The overall goal of the TR-1 request is:

- to renumber the mining sequence,
- acknowledge installation of a slurry wall to seal the ponds on the south side of HWY 119,
- change the reclamation of Cell 1(A) from wetlands to enhanced riparian vegetation and
- reduce the mining setback from the property line 200' to 100' on the portion of the mining adjacent to HWY 119.

There is no direct access to HWY 119 from the portion of the mine located south of the HWY. All mining access to the portion of the permit area south of HWY 119 will leave the site at the intersection of North 119th Street and Quicksilver Road and will travel east on Quicksilver Road.

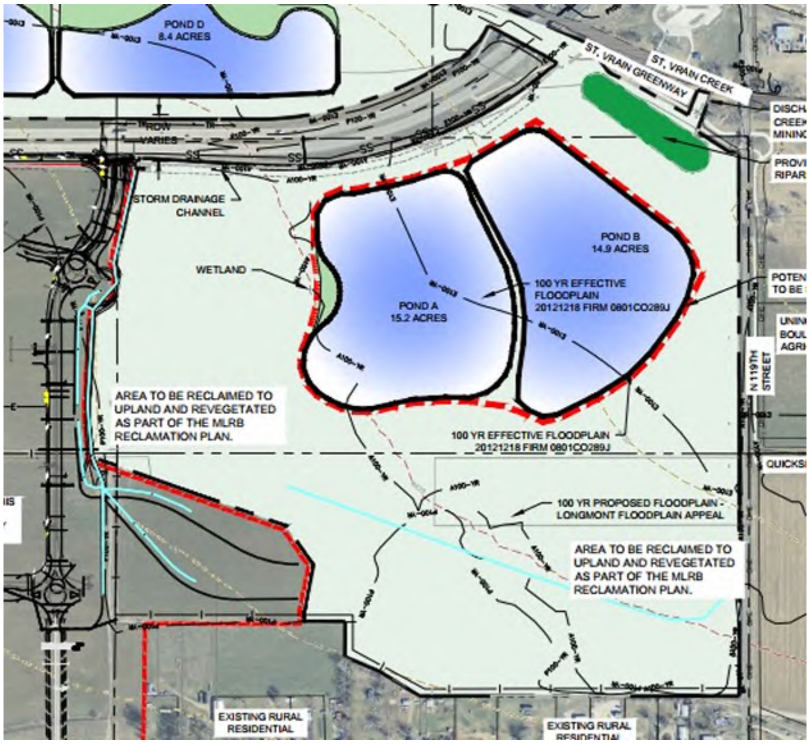
DRMS requires the applicant to enter into a structure agreement with structure owners within 200' of the permit boundary or provide a slope stability report demonstrating that structures within 200 foot of the permit boundary will not be impacted by the mining. Holcim-WCR offered to enter into a structure agreement with CDOT and provided a slope stability report demonstrating that CDOT improvements within 200' of the permit boundary will not be impacted by mining on the south side of the HWY.

Prior to any mining activity on the portions of the mine located north of HWY 119 another Technical Revision will be submitted for review and approval by the DRMS. Specific information regarding slope stability and ground water will be updated to reflect the mining activities located north of HWY 119.

The items below are specific to the questions raised by CDOT reviewers as follows:

1. For Cells 6 and 7 specifically on the North side of HWY 119 it says that trucks will be entering HWY 119 if a conveyor system is not used. The truck route from Barb earlier showed all the traffic on the south side. Will the Northern cells be a part of the future submittal?
   Applicant Response: No mining will take place north of HWY 119 until another Technical Revision is reviewed and approved by DRMS as stated above. There will be no direct access from the future mining area on the north side of the HWY until the access is reviewed and approved by CDOT and the City of Longmont. The applicant does not anticipate that a conveyor will be utilized to transport material under HWY 119. If that changes, it will be included with the review for the Technical Revision for the portion of the mine located north of HWY 119. Any future conveyor system is required to be reviewed and approved by CDOT and the City of Longmont.

2. They state when they are going to reclaim it, it will become sealed or unlined ponds, what is the long-term effect on HWY 119 if it is saturated due to these ponds.
   Applicant Response: The attached Groundwater Analysis prepared by Miller Groundwater Engineering, for the south side of the HWY, demonstrates impact to the water table with Mining and Reclamation, including installation of the slurry wall. The highway now sits on top of existing groundwater (see Figure 5 in the Model – existing water table is between 10 and 20' deep under the HWY ROW). Impacts on water levels are shown on Figures 8 and 9. The water level under HWY 119 ROW will be drawn down 0 to 1 foot during mining (Figure 8) and 0 to .5 feet (Figure 9) when mining is complete. No mounding under the HWY ROW is identified in the model. Following our discussion, Miller Groundwater Engineering prepared the attached letter dated April 13, 2023 to further clarify anticipated impacts to groundwater under HWY 119 adjacent to the mine.



   We would expect this to be addressed in any analysis/report. ***Applicant Response: There will be no unlined ponds in the portion of the mine located south of HWY 119. Reclamation for the portion of the mine located south of the HWY includes a combination of upland (created by backfilling Cells 1A, 1 ,4 and 5) , an enhanced riparian area in the portion of the site closest to St. Vrain Creek and two lined ponds.***

   The attached Groundwater Evaluation prepared by Miller Groundwater Engineering includes an analysis regarding impacts of mining and reclamation for the south side of the HWY. The impacts to groundwater both during mining and once the property is reclaimed are included in the report. Following our discussion, Miller Groundwater Engineering prepared the attached letter dated April 13, 2023 to further clarify anticipated impacts to groundwater under HWY 119 adjacent to the mine.

The applicant will prepare and submit a Technical Revision prior to mining activity on the portion of the mine north of HWY 119. The groundwater analysis will be updated as part of a future Technical Revision for mining and reclamation on the north side of the HWY (Cells 6 and 7 (Mining), Ponds c and D (Reclamation).

3. For the work they are intending to perform will any of it affect CDOT irrigation or drainage structures? ***Applicant Response: No. See attached Aerial Topographic map. All CDOT improvements are located outside the permit area south of the HWY.***

4. The geotech/stability report doesn't go into enough detail regarding the impact to our highway. It's stated that the soils were evaluated horizontally 2 times the height of the vertical cut of 25 feet or 50 feet away. Where is our road in relation to their modeling? 50 feet? ***Applicant Response: The initial Slope Stability report for this site was prepared to evaluate the "factor of safety' relative to potential slope failure for structures within 50' of a vertical mine face. The DRMS has specific guidance for this evaluation and the Slope Stability Evaluation has to demonstrate that the "factor of safety" meets or exceeds 1.5 . All mining excavation along the portion of the mine adjacent to HWY 119 will be located a minimum of 100' from the CDOT ROW. The Distance from the mining excavation on the south side of HWY 119 to the existing travel lane of roadway is approximately 125 feet (115 feet to the edge of the paved shoulder) at the closest point (the western end of Cell 1, See C-4 mining Plan). However, the proposed slurry wall will be located in the 100' mining setback along a portion of the HWY frontage. Per the attached Slurry Wall Design, the slurry wall will be located approximately 90' from the CDOT ROW and 150' from the existing roadway at the closest point (the western end of Cell 2, see sheet 1 of the design plans). Preliminary slurry wall design and the additional geotechnical evaluation completed for the slurry wall design are attached.***

5. A traffic surcharge of 250 pcf needs to be applied to represent traffic impacts along the highway if they are looking to have the edge of the mine within 200 feet. ***Applicant Response: A traffic Surcharge of 250 pcf was considered as part of the slope stability analysis. See Summary and recommendations pages 5,6 and 7, Earth Engineering Consultants, LLC - 'Subsurface Exploration and Slope Stability Evaluation' report, February 7.2018 and Updated Letter dated June 28, 2022.***

6. It is assumed groundwater is being pumped. What happens when mining ends and the groundwater rises? **Applicant Response:** ***Impacts on water levels are shown on Figures 8 and 9 of the Groundwater Evaluation. Water level under HWY ROW will be drawn down 0 to 1 foot during mining (Figure 8) and 0 to .5 feet (Figure 9) when reclamation is complete. No mounding under the HWY ROW was identified in the model. Following our discussion, Miller Groundwater Engineering prepared the attached letter dated April 13, 2023 to further clarify anticipated impacts to groundwater under HWY 119 adjacent to the mine.***

7. What about fully softened soil conditions where cohesion is not the deciding property? ***Applicant Response: ? For the following reasons, we believe the analysis by Earth Engineering Consultants accounts for fully softened conditions.***

- ***The shear strength parameters used in the analysis were determined from saturated specimens. Saturating specimens reduces the effect of apparent cohesion in unsaturated soils (seen from soil suction / negative pore air pressures).***
- ***The analyses used the residual shear strength parameters which represents the shear strength mobilized under very large strains (which are typically expected for slope stability modeling). This***

is opposed to the peak stress which reflects higher shear strength mobilized at lower strains. Fully softened conditions would occur at high strain.

- ***The subgrades consist of a relatively thin surface mantle of cohesive subgrades underlain by granular soils which extend to bedrock. Those subgrades are mostly granular. For the granular subgrades, the slope stability model used a cohesion of 0 psf. In the model, cohesion of the granular subgrades had no contribution to the mobilized shear strength.***

8. Only the vertical cut was modeled. Are they assuming to let it fail? Are there any concerns of long-term impact or continued failure expanding beyond the initial modeled area? ***Applicant Response: The initial Slope Stability report for this site was prepared to evaluate the "factor of safety' relative to potential slope failure for structures within 50' of a vertical mine face. The DRMS has specific guidance for this evaluation and the Slope Stability Evaluation has to demonstrate that the "factor of safety" meets or exceeds 1.5 . All mining excavation along the portion of the mine adjacent to HWY 119 will be located a minimum of 100' from the CDOT ROW. The report prepared by Earth Engineering Consultants was prepared with by the Client's request to model a vertical cut which is assumed to fail. The purpose was to determine the lateral distance from the vertical face to the remnant natural slope with an added factor of safety. In other words, the purpose was to determine the distance of the remnant slope from the modeled failure plus an added distance to develop an appropriate factor of safety.***

9. I'm guessing the slurry wall and tunnel were pulled since they are part of the structural proposal. Otherwise, they will have to provide a geotech exploration, evaluation, and analysis for those items showing they won't impact the highway. ***Applicant Response: We do not anticipate a tunnel for conveyance of material under the HWY at this time. A slurry wall is included with the mining and reclamation on the south side of HWY 119. The slurry will be installed prior to mining Cells 2 and 3. The proposed location of the slurry wall is shown on Exhibits C-4 (Mining Plan) and Exhibit F (Reclamation Plan). Preliminary Slurry Wall Design and Design Report completed for the slurry wall are attached. Note that the Slurry Wall Design Report also includes geotechnical evaluation and slope stability analysis (Appendix A and C of the report***). ***The design for the slurry wall will be reviewed and approved by DRMS prior to installation.***

Miller Groundwater Engineering, LLC
Consulting, Contracting, Numerical Modeling

324 Remington Street, Suite 110 Fort Collins, CO 80524 970.492.5710

April 13, 2023

Barbara Brunk
Resource Conservation Partners, LLC
P.O. Box 1522
Longmont, CO 80502

RE: Irwin Thomas gravel mine - projected groundwater level changes along Highway 119.

Dear Ms. Brunk:

Miller Groundwater Engineering is providing this letter to follow up on questions that were asked by staff of the Colorado Department of Transportation (CDOT) at our team meeting with them on April 12, 2023. CDOT asked for clarifications about potential changes in groundwater levels along Hwy 119 that are expected from gravel mining activities at the Irwin Thomas site (DRMS Permit No. M-2016-054).

In this letter, we will answer specific questions and highlight one illustration (Exhibit A). For additional background on the site, including our evaluation methods and maps of the site, please refer to our groundwater evaluation report for this site dated March 3, 2023.

(1) No direct effect on groundwater from creating ponds on the site.

The planned Mine Cells 2 and 3 are located near Hwy 119 (**Exhibit A**) and will eventually be filled with water to serve as ponds. CDOT asked if filling the ponds with water will raise the water table along and under the highway.

Answer: No. According to the mining sequence plan relayed to us by Holcim (mine operator), a slurry wall will be installed around Mine Cells 2 and 3 before they are excavated. The slurry wall's purpose is to isolate the excavation and the future ponds from the aquifer. We understand that the slurry wall will be a clay mixture placed into a vertical trench from the surface down to bedrock and keyed sufficiently into the underlying bedrock to prevent significant flow of groundwater into or out of the ponds. The underlying bedrock is expected to have low permeability and is relatively shallow at this site, so installing such a slurry wall is feasible. It is also our understanding that a leak test will likely be performed for this slurry wall.

(2) Effect from Slurry Wall and Backfilled Cells

Slurry walls placed around gravel mines can have the effect of raising the water table on their upgradient sides ("mounding") and lowering it on their down-gradient sides ("shadowing"). The same effect is also expected to occur from the mine cells that will be backfilled with fine-grained soils after mining is complete (Cells 1, 1a, 4, and 5). We constructed a groundwater model to estimate the size and extent of mounding and shadowing at this site.

Maps showing water table elevations before and after mining are included in our report dated March 3, 2023. Here we highlight Figure 9 from that report by presenting it as **Exhibit A** of this report. To construct Exhibit A, we simulated groundwater flow and water table elevations for current conditions (Figure 5 of our March report) and after mining is complete (Figure 7 of our March report). The difference in groundwater levels between the two conditions is shown via contour lines in Exhibit A.

Hwy 119 is down-gradient and cross-gradient of the slurry wall and backfilled cells. Therefore, a small <u>decrease</u> in groundwater levels is expected along Hwy 119. As shown in Exhibit A, a decrease in the range of 0.5 to 1.0 feet is projected along the highway.

A small groundwater rise is projected across Cell 1 once it is backfilled (Exhibit A). A groundwater rise was originally projected to extend west of Cell 1, which lead to the design and installation of the subsurface drain shown in Exhibit A. The purpose of that drain is to limit groundwater rising west of the mine cells. That drain was installed in Summer 2022.

<u>Notes</u>: (1) There are seasonal fluctuations in groundwater levels at this location (see Figure B-1 in Appendix B of our March report). The decrease shown in Exhibit A is relative to the level expected under comparable conditions, such as the same time of year. In other words, water levels still will go both up and down seasonally, but the levels are expected to be slightly lower in the future along and under the highway relative to a case with no mining activity. (2) As noted previously, a groundwater rise expected on the south side of the backfilled mine cells. The drawdown shown on the south side of the mine cells in Exhibit A is due to the planned installation of a subsurface drain that will be installed to prevent mounding on that side.

(3) Intermediate Mining Phases

In this report we have compared conditions from before mining to and after mining is complete. That was also the primary focus of our March report. However, in our evaluation we also simulated several intermediate stages of the mining sequence. In those stages, the cells that are outside the slurry wall would be dewatered via pumping during mining. We believe we simulated the most important mining stages, and at all stages of mining we considered, this dewatering leads to temporarily lower groundwater levels along and under Hwy 119.

(4) Summary

Gravel mining activities at the Irwin Thomas site are expected to lead to a small decrease in groundwater levels along and under Hwy 119 relative to pre-mining conditions.

(5) Standard Technical and Practical Limitations

Subsurface data is often limited in its spatial and temporal coverage, and subsurface hydraulic testing produces only approximate results. Estimates and projections about groundwater behavior therefore have inherent degrees of uncertainty. Certainty is not an expected or attainable goal. By using good, common, and accepted methods, this work provides reasonably reliable guidance for expected site groundwater behavior, but actual site performance may be different from projected and desired site performance. No guarantees or warranties are or can be provided. Furthermore, actual mining operations, including slurry wall construction, drain construction, and the drain's future maintenance, may be different than currently known or planned, and such changes and future conditions are outside the scope and control of Miller Groundwater Engineering, LLC.

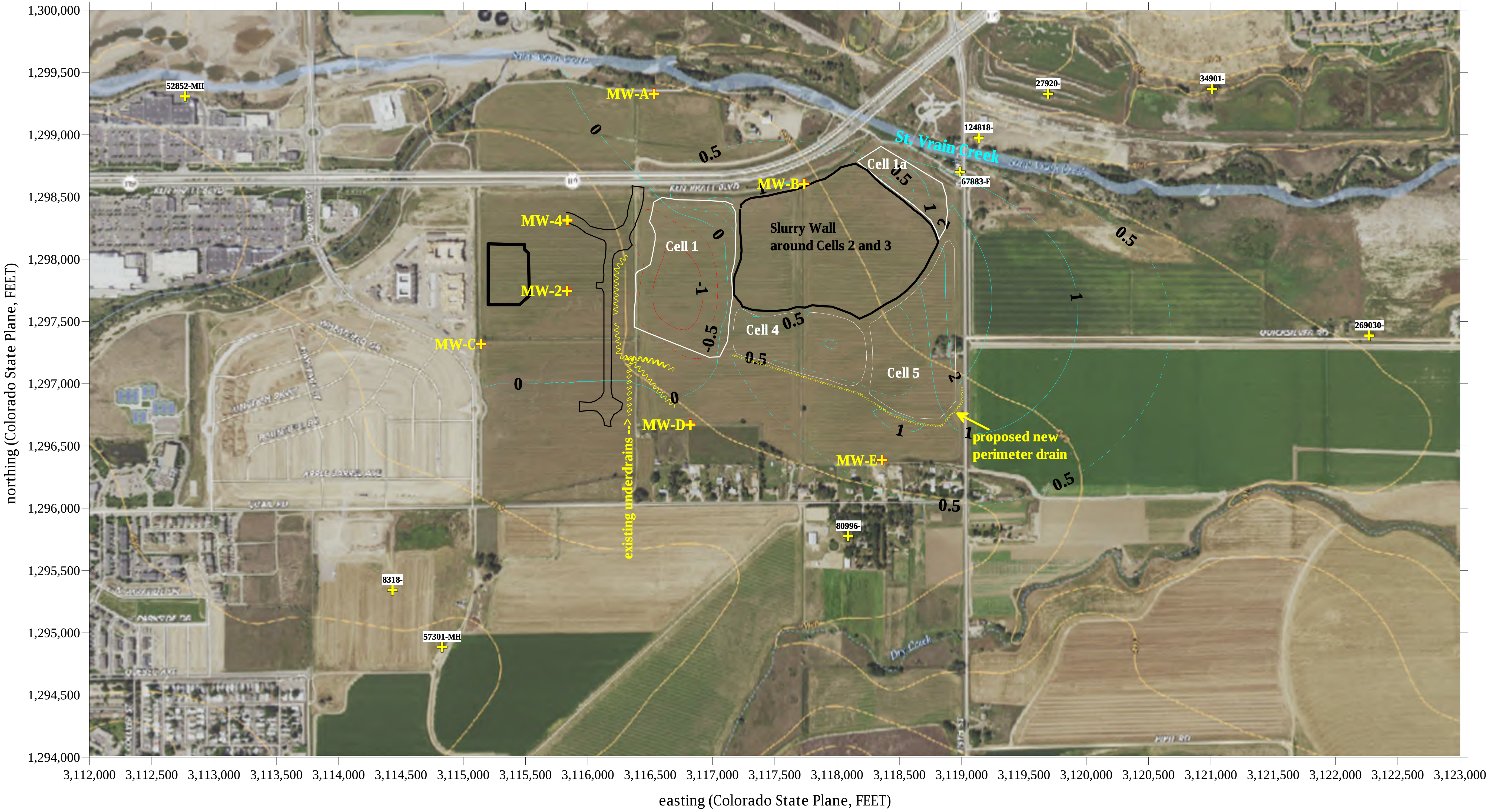
Please contact us if you would like to discuss this work further or have any further requests.

Sincerely,

Calvin Miller

Calvin Miller, PE, PhD
for Miller Groundwater Engineering, LLC

Exhibit A. Drawdown and mounding after completion of mining and site reclamation.



Notes:

(1) Elevation and drawdown contours shown in feet.

(2) A groundwater rise (when present) is shown as negative drawdown, in red.

(3) Building and roadway locations are approximate.

(4) Left Hand Creek assumed to be flowing and leaking some water.

(5) Bedrock surface interpolated between 58 on-site borings, 52 borings next-door to the west, and 22 regional off-site borings.

(6) Underdrain to west (Harvest Junction Village) assumed added circa 2017.

(7) Site underdrains based on TST plans dated June 2021.

Project: Irwin Thomas Mine, Permit No. M-2016-054, Longmont, Colorado. Task: Groundwater Evaluations.

Miller Groundwater Engineering, LLC
Consulting, Contracting, Numerical Modeling

324 Remington Street, Suite 110 Fort Collins, CO 80524 970.492.5710

March 3, 2023

Barbara Brunk
Resource Conservation Partners, LLC
P.O. Box 1522
Longmont, CO 80502

RE: Groundwater Evaluations for the Irwin Thomas Gravel Mine, Permit No. M-2016-054.

Dear Ms. Brunk:

Miller Groundwater Engineering has updated our groundwater model for the proposed Irwin Thomas Mine (DRMS Permit No. M-2016-054) and we have used the updated model to evaluate potential impacts of the mining plan on groundwater levels in the area. This letter describes our evaluation and its results.

(1) Response to Items #8 and #9 from DRMS Adequacy Review No. 1

The evaluations presented in this report address two of the items from the DRMS Adequacy Review No. 1 letter dated January 6, 2023. For reference, we are including a copy of those two items below, followed by our summary response. Our summary statement is then supported by the remainder of this report.

DRMS Item #8: In the Operator's responses, dated March 23, 2017, to the Division's Preliminary Adequacy Review the Operator provided a Hydrogeologic Evaluation of the Irwin/Thomas Mine. At the time there was limited groundwater elevation data for the site and the effects from dewatering were rough approximations. The potential effects from dewatering need to be re-assessed using the six (6) years' worth of site groundwater elevation data to verify and/or update the site assumptions of the effects of dewatering.

Response to #8: As requested, we have recently completed a reassessment of the potential effects from mine dewatering, and we used the six years of data now available for the site. In this report we are providing updated and refined projections of those mine dewatering effects.

In Summer 2020, Miller Groundwater developed an initial groundwater model of the site and the surrounding area. That 2020 model is presented in Appendix A of this report. That version of the model relied primarily on data from geotechnical borings available up through 2020, from the sources listed on Page 3 of this main report. The locations for that data are shown in

Appendix A's Figure 1. That data set included groundwater depth and bedrock depth reported at several water wells over the wider area. The legend of Appendix A's Figure 1 also notes the dates for the geotechnical data, including several geotechnical borings on-site from 2020.

For this 2023 update of the model, we reviewed six years of monthly measurements from Irwin Thomas monitoring wells MW-A, MW-B, MW-C, MW-D, and MW-E, plus 10 monthly measurements made from April 2022 to January 2023 from wells MW-2 and MW-4. (To our knowledge, there is no MW-1 or MW-3.) The locations of these seven monitoring wells are shown on Figure 1 of this main report. Depth to water plots for these wells are included as Appendix B. Figure 2 of the main report compares the observed water levels to the modeled water levels, including the updated data.

As explained in this report, we have now updated the 2020 model based on the up-to-date data set, and we revaluated dewatering and other potential mining impacts (mounding and shadowing) using the updated model. The results are presented in this report.

DRMS Item #9: In the Operator's responses, dated March 23, 2017, to the Division's Preliminary Adequacy Review the Operator provided an updated Exhibit G. In that exhibit there is brief discussion regarding the mounding and shadowing effects of a slurry wall. Please provide a groundwater model depicting the effects of installing a slurry wall and any details of mitigation measures needed to prevent injury from mounding or shadowing of groundwater as a result of installing the slurry wall. Include a discussion about the potential impacts to residential basements near the permit boundary.

Response to #9: As requested, we have developed and updated a groundwater model for the proposed mine and the surrounding area. We used the model to estimate the expected effects of mine dewatering as well as the post-mining effects of a planned slurry wall and the back-filled mine cells that will surround the slurry wall. We also considered potential impacts to residential homes with basements/crawlspaces near the mine permit boundary, plus a new commercial building nearby. Based on the results of that evaluation, and with the residential homes in mind, we propose the installation of a perimeter drain on the south side of the mine to mitigate otherwise-expected mounding on the up-gradient side of the mine cells. In this report, we provide guidance for the depth and location of the proposed perimeter drain, and we used the model to simulate groundwater conditions that would be expected with the drain in place.

The remainder of this report provides additional detail that supports the above responses.

(2) General Background Information

The location for the proposed gravel mine is south of Ken Pratt Blvd (Hwy 119), east of South Martin Street, and west of North 119th Street, in Longmont, Colorado (**Figure 1**). The primary goal of our evaluation was to estimate changes in groundwater levels in the vicinity of the mine that should be expected from the planned mining activities. The groundwater changes commonly expected from such a mine, and also expected here, are: (1) water level drawdown during mine dewatering activities, and then, once mining is complete, (2) some groundwater rise ("mounding") immediately upgradient of the mine, and (3) groundwater drawdown ("shadowing") immediately downgradient of the mine.

We initially constructed this model in Summer 2020. Our 2020 report, presenting the model's initial construction, is attached as Appendix A.

Information Relied Upon in 2020:

- EEC report, dated February 7, 2018. Subsurface Exploration and Slope Stability Evaluation, Irwin/Thomas Properties, Longmont, Colorado, EEC Project No. 1172053.
- TST, Inc. drawing dated April 2020. Irwin Thomas Preliminary/Final PUD Development Plan Amendment; for Gravel Mining. Job No. 1241.0001.02. Filename: 1241.0001 FDP PUD.
- TST, Inc. drawing dated April 2020. Mustang Preliminary Improvement Plans, Overall Grading Plan. Job No. 1241.0001.00. Filename: 0001_Overall Grading.
- Hydrogeologic Evaluation, Irwin/Thomas Mine, Division of Reclamation, Mining, and Safety Permit NO. M-2016-054, Boulder County, Colorado. Prepared for Aggregate Industries–WCR, Inc. 1687 Cole Boulevard, Suite 300, Golden, Colorado, by Blue Earth Solutions, LLC. Report dated December 2013.
- Regional aquifer and water well data from Colorado Division of Water Resources (DWR) online database (https://dwr.state.co.us/Tools/WellPermits).
- Terracon GeoReport, dated April 17, 2020. Geotechnical Engineering Report, Terracon Project No. 22195034, Terracon Consultants, Longmont, Colorado.
- Underdrain report (and associated appendices) for Harvest Junction Village, dated January 2015. Prepared for Oakwood Homes, Denver, Colorado, by Merrick & Company, Greenwood Village, Colorado; Merrick Job No. 65118260.

Additional Information Relied Upon for this 2023 Update:

- Pond Underdrain Plan. Drawings by TST, Inc., dated January 2022, of the underdrain (subsurface drain) constructed Summer 2022 to the west of the planned mine under a new stormwater detention pond.
- Photographs and video of outflow from the stormwater detention pond's underdrain taken in September 2022.
- A diagram labeled "Exhibit E – Anticipated Exploration Plan" from Terracon, dated April 11, 2022, showing the location of monitoring wells MW-2 and MW-4.
- Depth to water measurements for MW-2 and MW-4 taken in 2022, in a letter from Terracon dated January 11, 2023.
- Water level measurements, provided by client, from Irwin Thomas monitoring wells MW-A through MW-E. They were measured approximately monthly from November 2016 through January 2023. Information included coordinates for the monitoring wells (Figure 1).
- Planned mining sequence provided by client.

(3) Simulated Mining Sequence Stages

We were provided a detailed description of the planned mining sequence. That description included some potential timing overlap between phases. In our modeling simulations, we simplified the sequence to the following primary stages:

- Model Scenario 1. Cell 1 and Cell 1a dewatered. (See Figure 1 for cell locations.)
- Model Scenario 2. Cell 1 and Cell 1a dewatered during or after the slurry wall has been constructed around Cells 2 and 3.
- Model Scenario 3. Cell 1 and Cell 1a backfilled and mining taking place from within the slurry wall in Cells 2 and 3.
- Model Scenario 4. Cells 4 and 5 being dewatered and mined after the slurry wall is in place and after Cell 1 and Cell 1a have been backfilled. The period of time in which Cells 4 and 5 are both being dewatered simultaneously may be short, but we conservatively considered a period in which they were both dewatered simultaneously.
- Model Scenario 5: Post-Mining Scenario (Reclamation). Final post-mining configuration with (i) backfill in Cells 1, 1a, 4, and 5, (ii) a slurry wall around Cells 2 and 3, and (iii) a shallow perimeter drain along the south side of Cells 4 and 5. Cells 2 and 3 will not be

backfilled (they will be ponds) but the slurry wall around them is the relevant aspect for the groundwater model simulations.

We simulated each of these stages individually, and from that work we concluded that the most drawdown is expected during Model Scenario 4 (Cells 4 and 5 dewatered simultaneously) and the most mounding would be created during the final post-mining configuration if a perimeter drain were not installed. We therefore focus on those two scenarios in this report.

(4) Groundwater Model Update

We have reviewed the new water level data collected since we first constructed the model in Summer 2020. We concluded that a slight adjustment and improvement to the model's calibration was warranted due to MW-E. (See location in Figure 1.) The 2020 model was reasonably consistent with all other data, old and new, but the modeled water table was low at MW-E. We concluded it was important to have a closer fit to the data at MW-E since our initial simulations show groundwater mounding in that area, and because the water table in that area is typically shallow, and since there are houses near MW-E. The water table at MW-E is generally around 4 to 5 feet below ground surface (ft bgs) in the winter, but in the summer has sometimes risen to the range of 2 to 3 ft bgs. We created a close match between the observed and modeled water levels at MW-E by increasing seepage from Dry Creek into the aquifer.

Note: This groundwater model update, and the dewatering simulations presented herein, address Statement #8 from the DRMS Adequacy Review No. 1 letter dated January 6, 2023. The other simulations presented below—particularly Model Scenario 5---address DRMS Statement #9.

(5) Site Maps and Illustration of Model Results

Site data and model results are summarized in the following figures:

- Figure 1. Locations of planned mining cells, monitoring wells, and other site features.
- Figure 2. Model calibration plot. This is a standard plot used to assess groundwater model calibration. When modeled water levels are close to observed water levels, the data points fall close to the 45-degree line.
- Figure 3. Ground surface elevations.
- Figure 4. Depth to modeled water table from ground surface. (This is a non-seasonal approximation.) Note that the detail and seeming precision in this figure comes from subtracting an *approximate* simulated water table elevation from a detailed map of

ground surface elevations. While we expect the overall results here to be accurate, please note there could be model error at the local scale.

- Figure 5. Modeled water table under current conditions (non-seasonal approximation).
- Figure 6. Model Scenario 4: Water table with Cells 4 and 5 dewatered simultaneously.
- Figure 7. Model Scenario 5: Water table upon completion of mining and site reclamation work, including the installation of a perimeter drain along the south side of Cells 4 and 5.
- Figure 8. Model Scenario 4: Drawdown during dewatering of Cells 4 and 5. This contour map was created by subtracting the water table shown in Figure 6 from the current-conditions water table shown in Figure 5.
- Figure 9. Model Scenario 5: Drawdown and slight mounding upon completion of mining and site reclamation work, including the installation of a perimeter drain along the south side of Cells 4 and 5. This contour map was created by subtracting the water table shown in Figure 7 from the current-conditions water table shown in Figure 5.

(6) Discussion of Model Scenario 3

Not shown is Model Scenario 3 in which Cells 1 and 1a have been backfilled, a slurry wall is around Cells 2 and 3 while they are mined, and no dewatering is occurring outside of the slurry wall. Our model simulation for this scenario projects a rise of approximately 0.6 ft at MW-E, and a rise around 2.0 ft at the future Cell 4. The rise at MW-E is relatively small, but this mining phase may be in place for one to two years. Therefore, to mitigate this potential mounding, the perimeter drain that is planned for post-mining (see Section 8) will be installed prior to this phase. It will be installed in concert with the construction of the slurry wall.

(7) Discussion of Model Scenario 4

Figure 8 shows the extent of drawdown expected if Cell 4 and Cell 5 are dewatered simultaneously. At this time, we are not aware of any major concerns with this projection of drawdown. Two permitted water wells fall withing this area of influence (Figure 8). Select DWR permit information for these wells is attached as Appendix C and discussed below.

According to DWR records, Permit No. 80996-F is a domestic and stock well limited to a rate of 15 gpm. It has unique construction that likely derives its water from the alluvial aquifer but with an open borehole and pump set deep into the underlying shale bedrock. This configuration gives it a deep sump. It is our current opinion that the projected 1.4 ft drawdown at this well, combined with its low permitted rate and deep sump, is not expected to have a significant impact on this well's operations.

According to DWR records, Permit No. 67883-F is owned by the City of Longmont and is or was used as a dewatering well for an underpass that is part of the St. Vrain Greenway. DWR records suggest it is a gallery-type well using a perforated drain flowing into a sump. Since it is a dewatering well, then presumably the City would not object to additional dewatering being created by the mine.

(8) Discussion of Model Scenario 5 (Post-Mining Configuration with Perimeter Drain)

Not shown is a scenario in which we simulated post-mining reclamation conditions but without the now-proposed perimeter drain. In that case, Cells 1, 1A, 4, and 5 are backfilled and the slurry wall is in place around Cells 2 and 3. We assumed the cells will be backfilled and compacted with fine-grained materials leftover from the mining process, and therefore the backfilled cells will have a hydraulic conductivity (K) that is much lower than the K of the natural aquifer. This lower K, and the footprint of the backfilled cells relative to the width of the aquifer, and if there were no perimeter drain installed, would be expected to create a rise ("up-gradient mounding") at MW-E on the order of 2.2 ft. In the area of the former Cell 4, the rise without a drain would be on the order of 4 feet.

Considering the shallow water table at MW-E and the houses near it, a perimeter drain is proposed to mitigate this rise. As shown in Figures 7 and 9, we simulated a perimeter drain installed along the south side of Cell 4 and 5, at a depth approximately one foot below the pre-mine wintertime water table. As shown, the perimeter drain mitigates the rise described previously. Depending on the exact depth of the installation, the drain leads to either no change at MW-E over natural conditions or leads to a slight drawdown at MW-E.

It is our understanding that the houses near MW-E have occasionally experienced problems with the shallow water table, and therefore we assume a slight drawdown created by the perimeter drain would be welcomed. However, if desired, the depth of the perimeter drain could be adjusted, or its flow rate adjusted (by installing it with valves) to have a smaller or more neutral effect on water levels.

The simulated perimeter drain's invert elevation runs from 4917 ft at the southwest corner of Cell 4 to 4914 ft at the southeast corner of Cell 5. (Only the perforated portion was simulated.) That mimics the natural water table depth and gradient (as modeled), less one foot.

This general plan for the perimeter drain is recommended, and it is the mitigation plan being proposed. Certain construction details of the drain can be refined or adjusted as needed (e.g., outfall location, drain slope, modest changes in route along the edge of the future cells, etc.). In summary, our model simulation shows that a relatively shallow drain, placed at or slightly below the natural wintertime water table, at approximately 2,300 ft in length and placed along the south side of the cells, can maintain natural groundwater conditions in the aquifer after mining is complete.

Note on Role of Slurry Well: The groundwater rise simulated to occur south of the cells if no perimeter drain were installed is due primarily to the backfilled mine cells and is not due to the slurry wall. This conclusion is understandable since the slurry wall is in the middle of the fines-filled, backfilled cells. We tested this expectation with additional simulations (not shown). We simulated a scenario without the perimeter drain and without the slurry wall and with Cells 2 and 3 as open cells (i.e., ponds in communication with groundwater) and all other cells backfilled. In that case, the groundwater rise at MW-E was similar (1.9 ft vs. 2.3 ft) both with or without the slurry wall. Therefore, given that there are reports of shallow water table concerns near MW-E, the proposed perimeter drain appears to be needed even if no slurry wall were planned.

(9) Non-Seasonal Modeling Approach

These simulations were done with a steady-state model that does not consider a summertime seasonal rise. It is our current opinion that this is adequate for the purposes of this model. Our opinion is based on the observation that the scale of the seasonal rise appears to be roughly similar at MW's A through E. So, even with the rise in absolute water levels, the relative levels are roughly similar in all seasons, and this means the gradients are roughly similar as well. With a similar gradient toward the backfilled mine cells, the mounding and shadowing around the mine is expected to be roughly similar in all seasons. Based on this, the drawdown and mounding depicted in Figures 8 and 9 can be reasonably superimposed on current-conditions water levels in any season. This opinion is also based on the fact that a perimeter drain is proposed to control water levels to near or below natural levels. That drain will function in all seasons, including it naturally increasing its flow rates during a seasonal summer rise.

(10) Standard Technical and Practical Limitations

Subsurface data is often limited in its spatial and temporal coverage, and subsurface hydraulic testing produces only approximate results. Estimates and projections about groundwater behavior therefore have inherent degrees of uncertainty. Certainty is not an expected or attainable goal. By using good, common, and accepted methods, this work provides reasonably reliable guidance for expected site groundwater behavior, but actual site performance may be different from projected and desired site performance. No guarantees or warranties are or can be provided. Furthermore, actual mining operations, including drain construction and the drain's future maintenance, may be different than currently known or planned, and such changes and future conditions are outside the scope and control of Miller Groundwater Engineering, LLC.

Please contact us if you would like to discuss this work further or have any further requests. We have appreciated the opportunity to work with you on this.

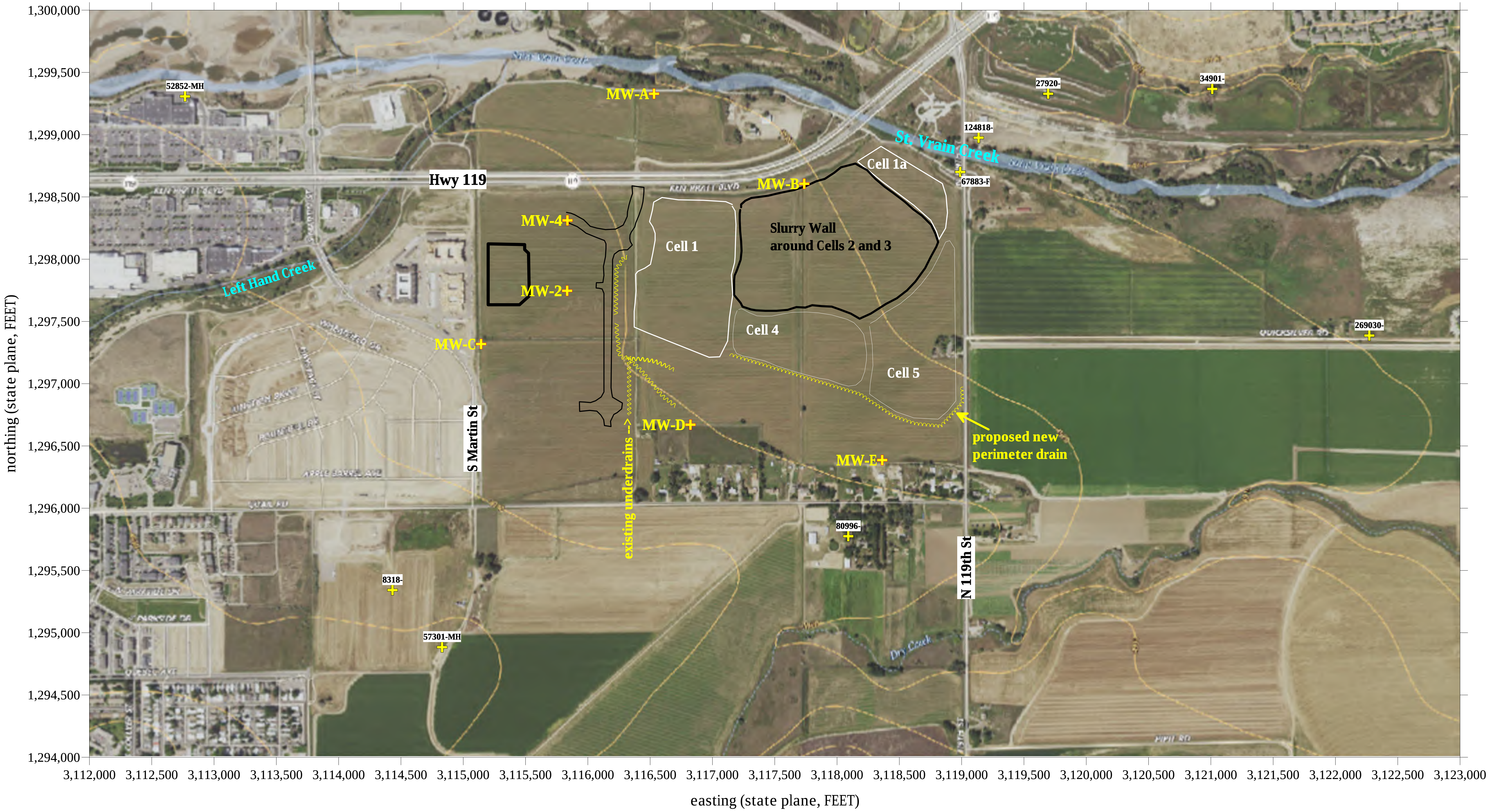
Sincerely,

Calvin Miller

Calvin Miller, PE, PhD
for Miller Groundwater Engineering, LLC

COLORADO LICENSED PROFESSIONAL ENGINEER
CALVIN D. MILLER
39929
Calvin Miller
3-3-23

Figure 1. Locations of planned mining cells, monitoring wells, and other site features.



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Notes:

(1) Site building and roadway locations are approximate.

(2) Site underdrains based on TST plans dated January 2022.

Project: Irwin Thomas Mine, Permit No. M-2016-054, Longmont, Colorado. Task: Groundwater Evaluations.

Miller Groundwater Engineering, LLC

Figure 2. Groundwater model calibration plot, updated with newest field data and the 2023 recalibrated model.

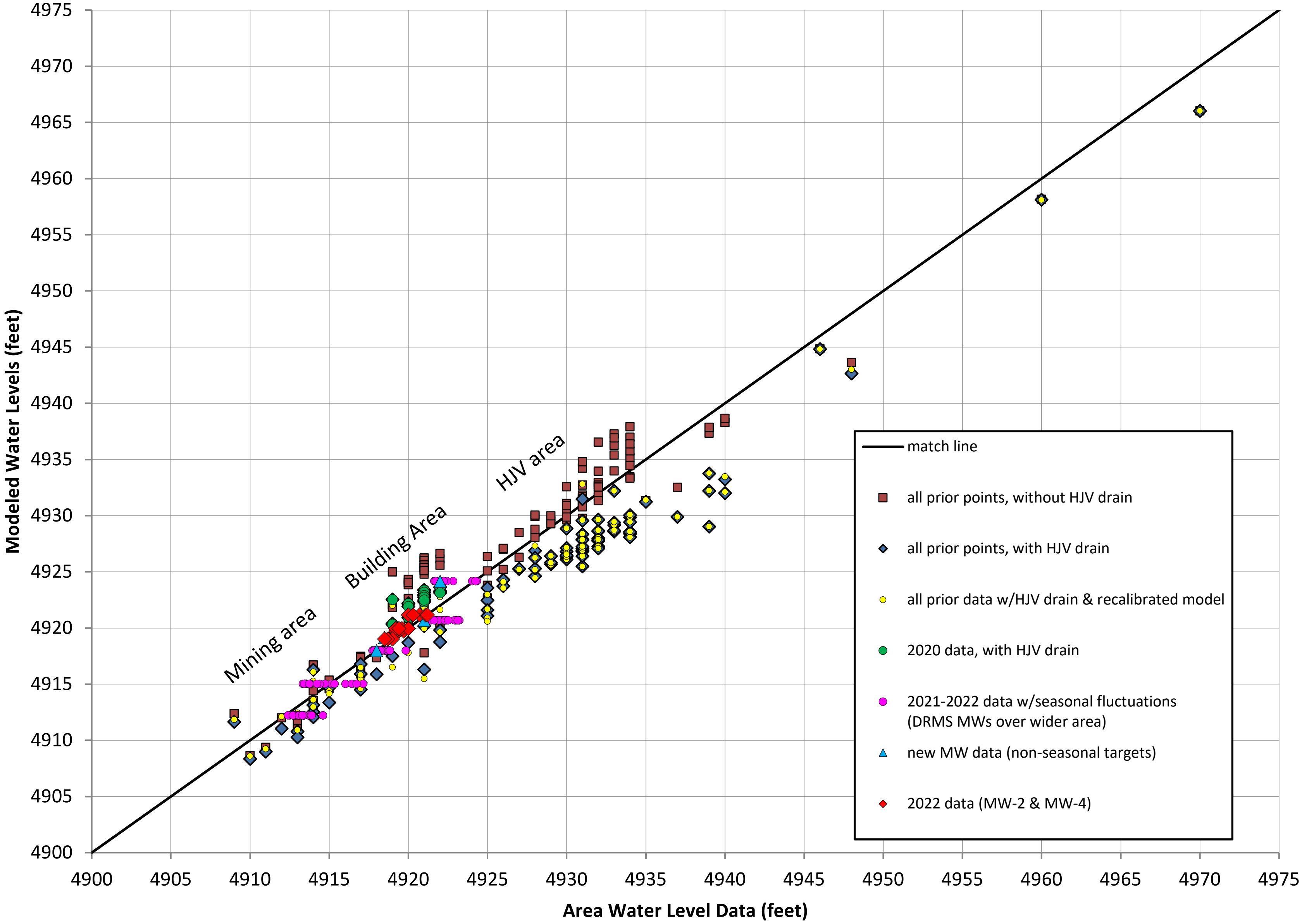
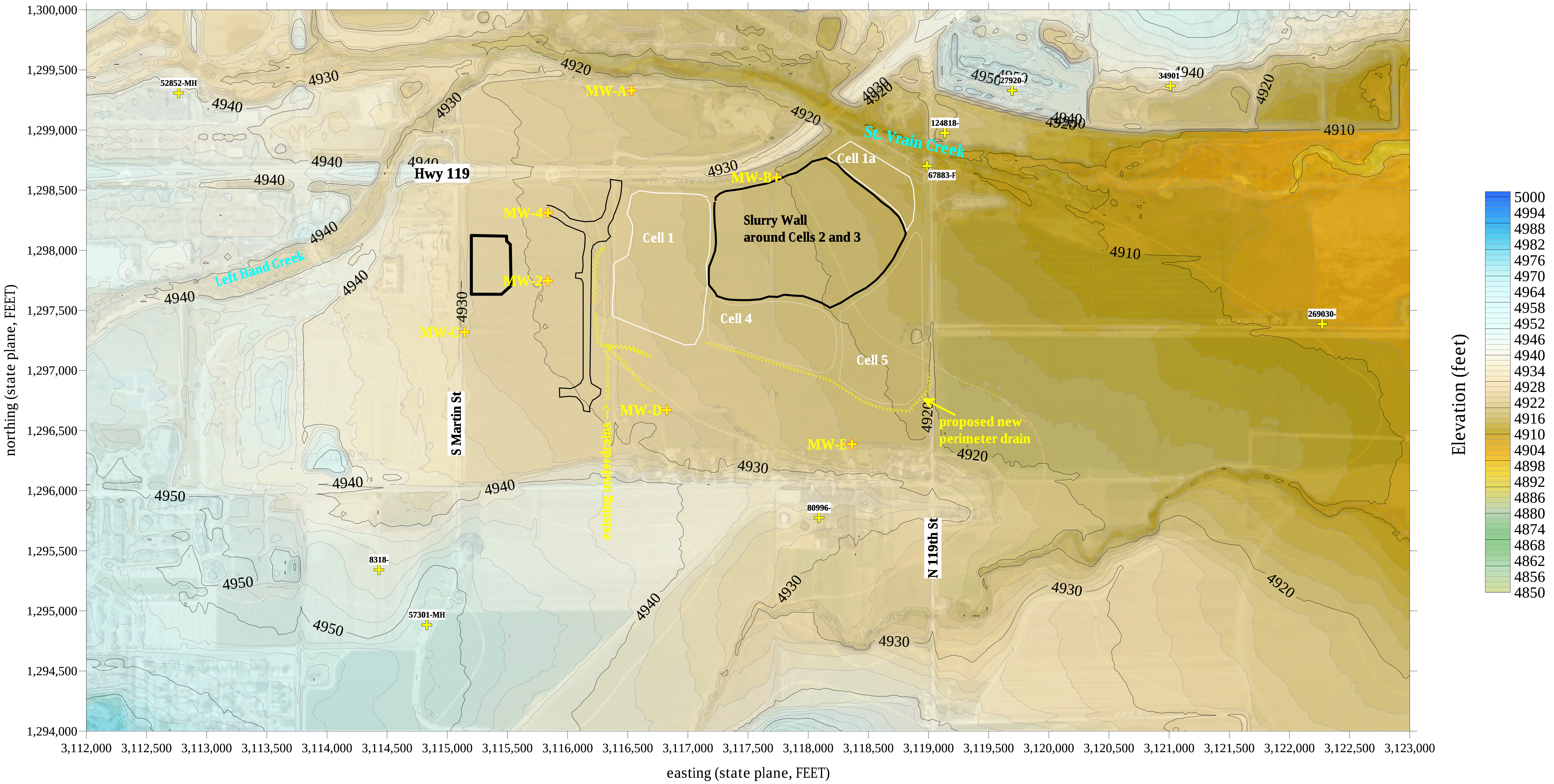


Figure 3. Ground surface elevation.



Notes:
(1) Site building and roadway locations are approximate.
(2) Site underdrains based on TST plans dated January 2022.
(3) Elevations given in feet.

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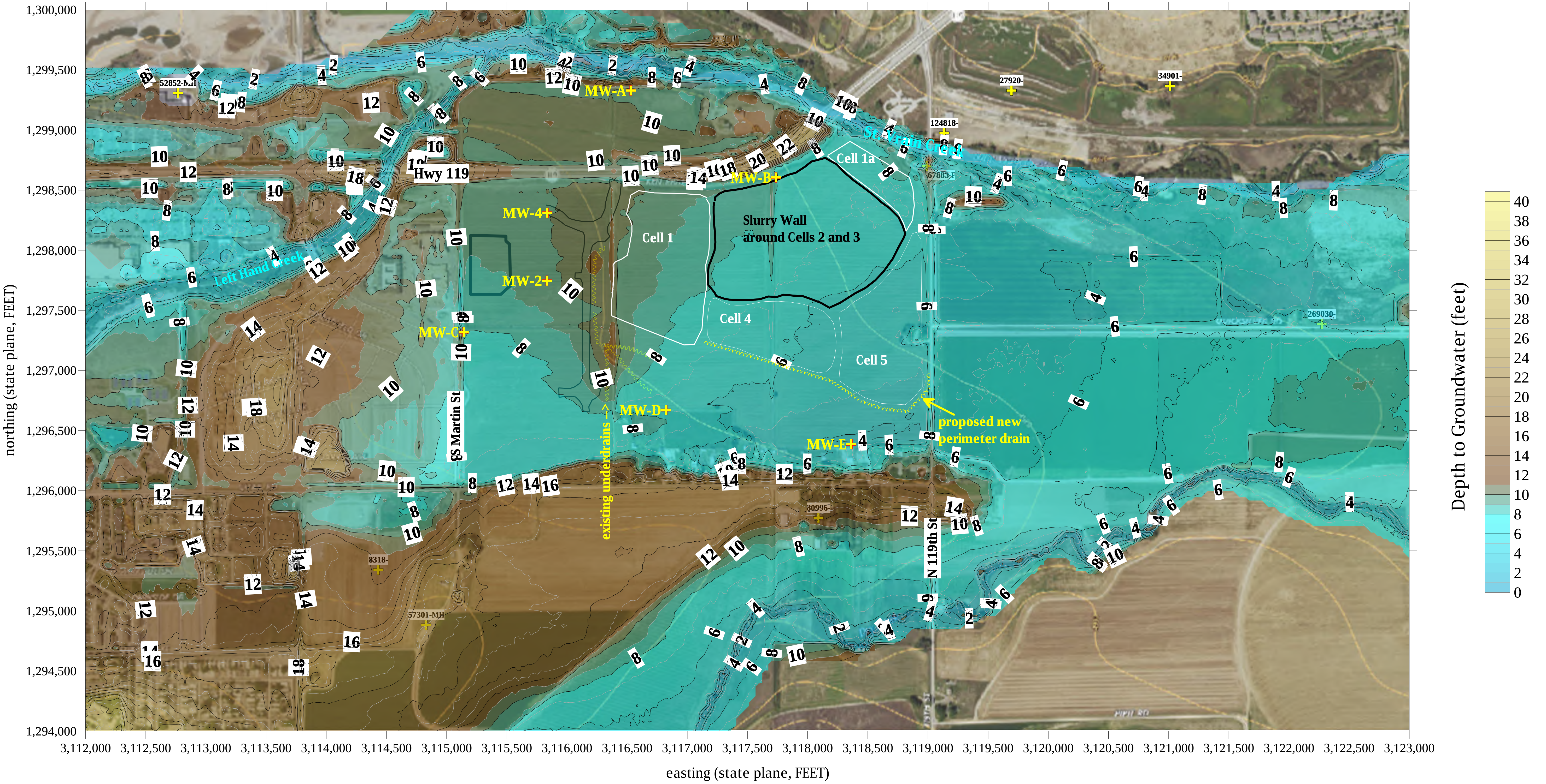
Figure 4. Depth to groundwater (non-seasonal approximation).



Notes:
(1) Site building and roadway locations are approximate.
(2) Site underdrains based on TST plans dated January 2022.
(3) Elevations given in feet.

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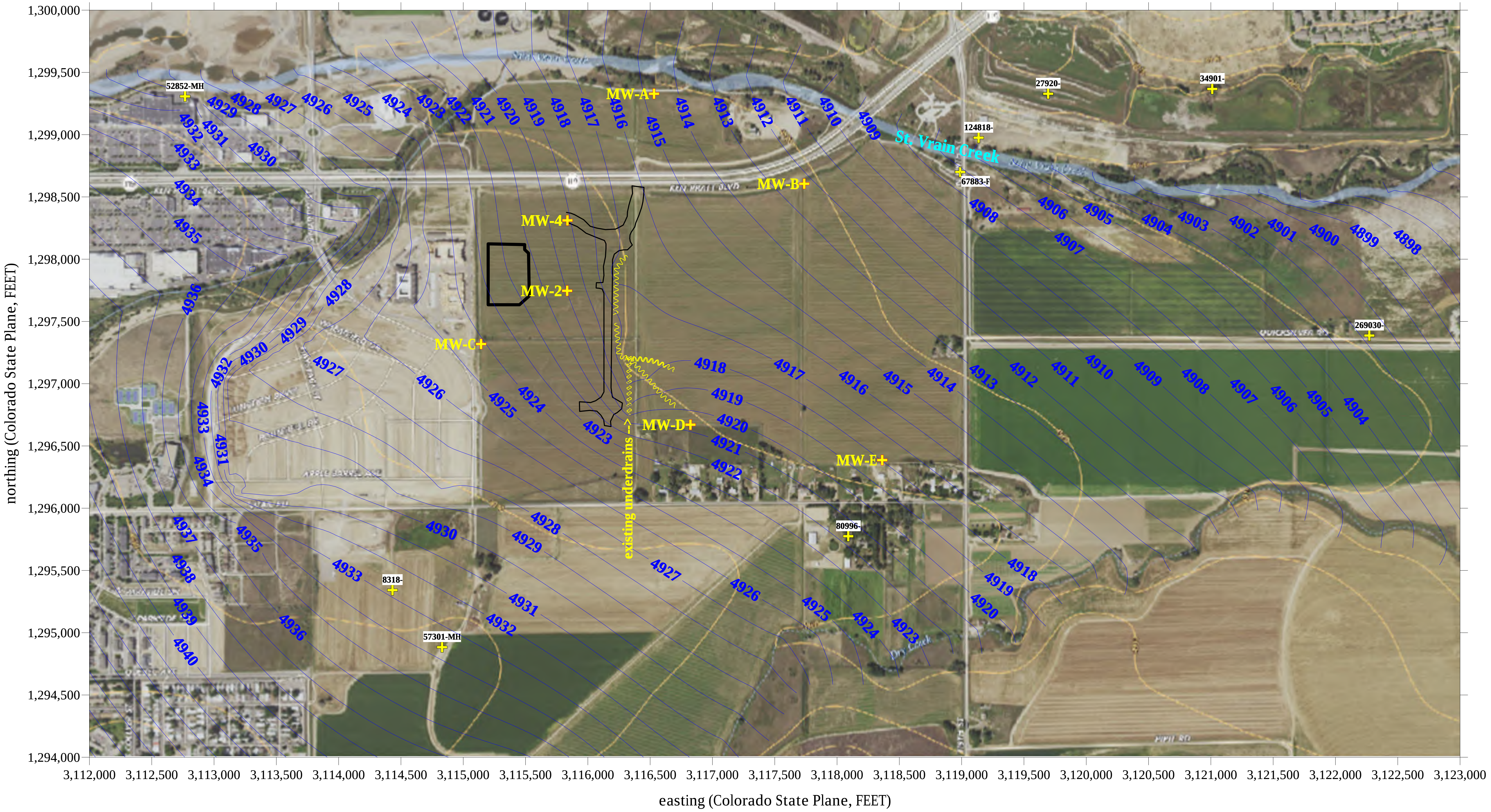
Project: **Irwin Thomas Mine, Permit No. M-2016-054, Longmont, Colorado.** **Task**: **Groundwater Evaluations.**

Miller Groundwater Engineering, LLC

Figure 5. Modeled water table under current conditions.



Notes:
(1) Elevation and drawdown contours shown in feet.
(2) A groundwater rise (when present) is shown as negative drawdown, in red.
(3) Building and roadway locations are approximate.
(4) Left Hand Creek assumed to be flowing and leaking some water.
(5) Bedrock surface interpolated between 58 on-site borings, 52 borings next-door to the west, and 22 regional off-site borings.
(6) Underdrain to west (Harvest Junction Village) assumed added circa 2017.
(7) Site underdrains based on TST plans dated June 2021.

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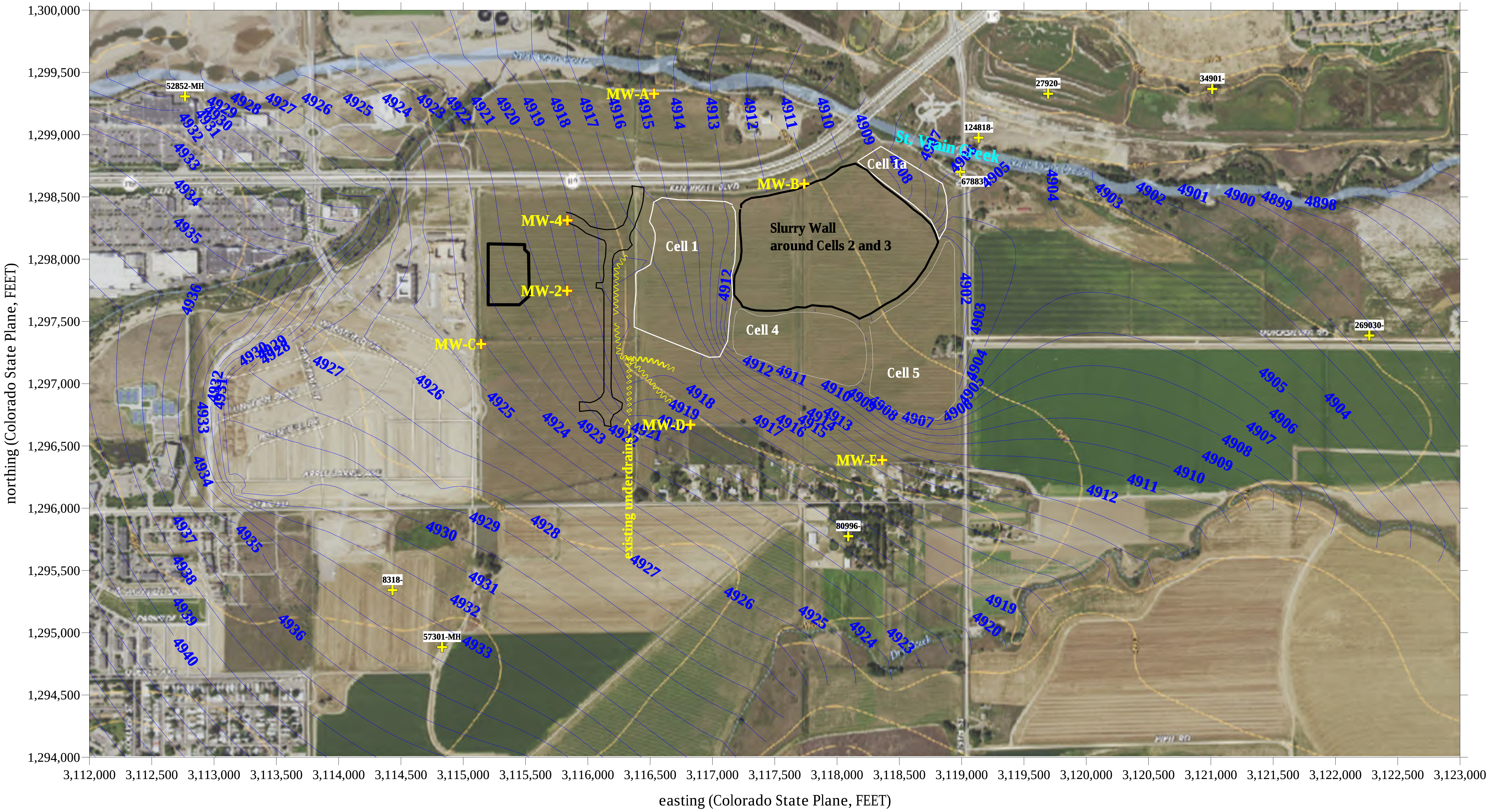
Figure 6. Model Scenario 4: Water table with backfilled cells, slurry wall, and Cells 4 and 5 being dewatered.



Notes:
(1) Elevation and drawdown contours shown in feet.
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(6) Underdrain to west (Harvest Junction Village) assumed added circa 2017.
(7) Site underdrains based on TST plans dated June 2021.

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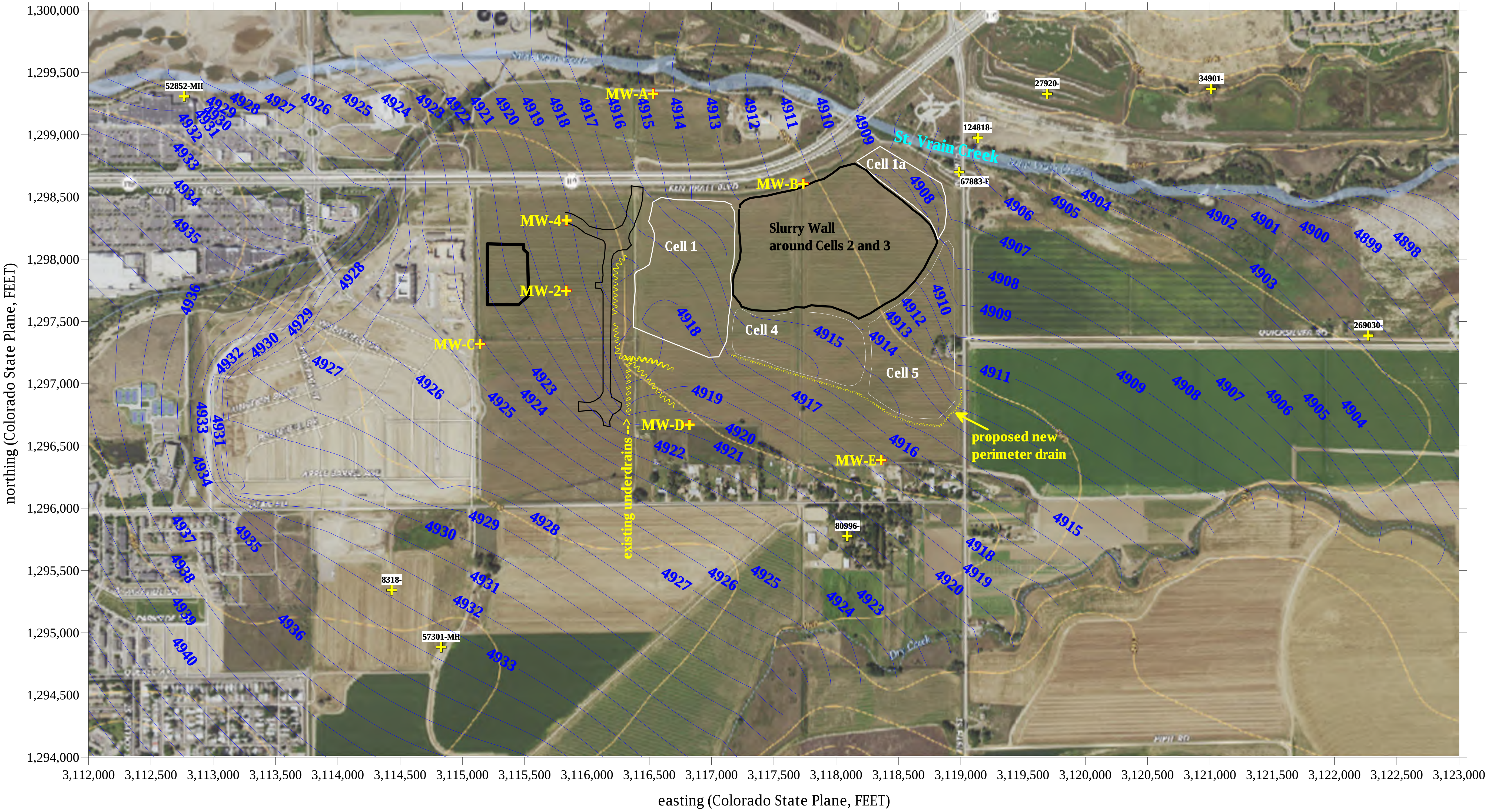
Figure 7. Model Scenario 5: Water table after completion of mining and site reclamation.



Notes:
(1) Elevation and drawdown contours shown in feet.
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(6) Underdrain to west (Harvest Junction Village) assumed added circa 2017.
(7) Site underdrains based on TST plans dated June 2021.

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Figure 8. Model Scenario 4: Drawdown and mounding with backfilled cells, slurry wall, and Cells 4 and 5 being dewatered.

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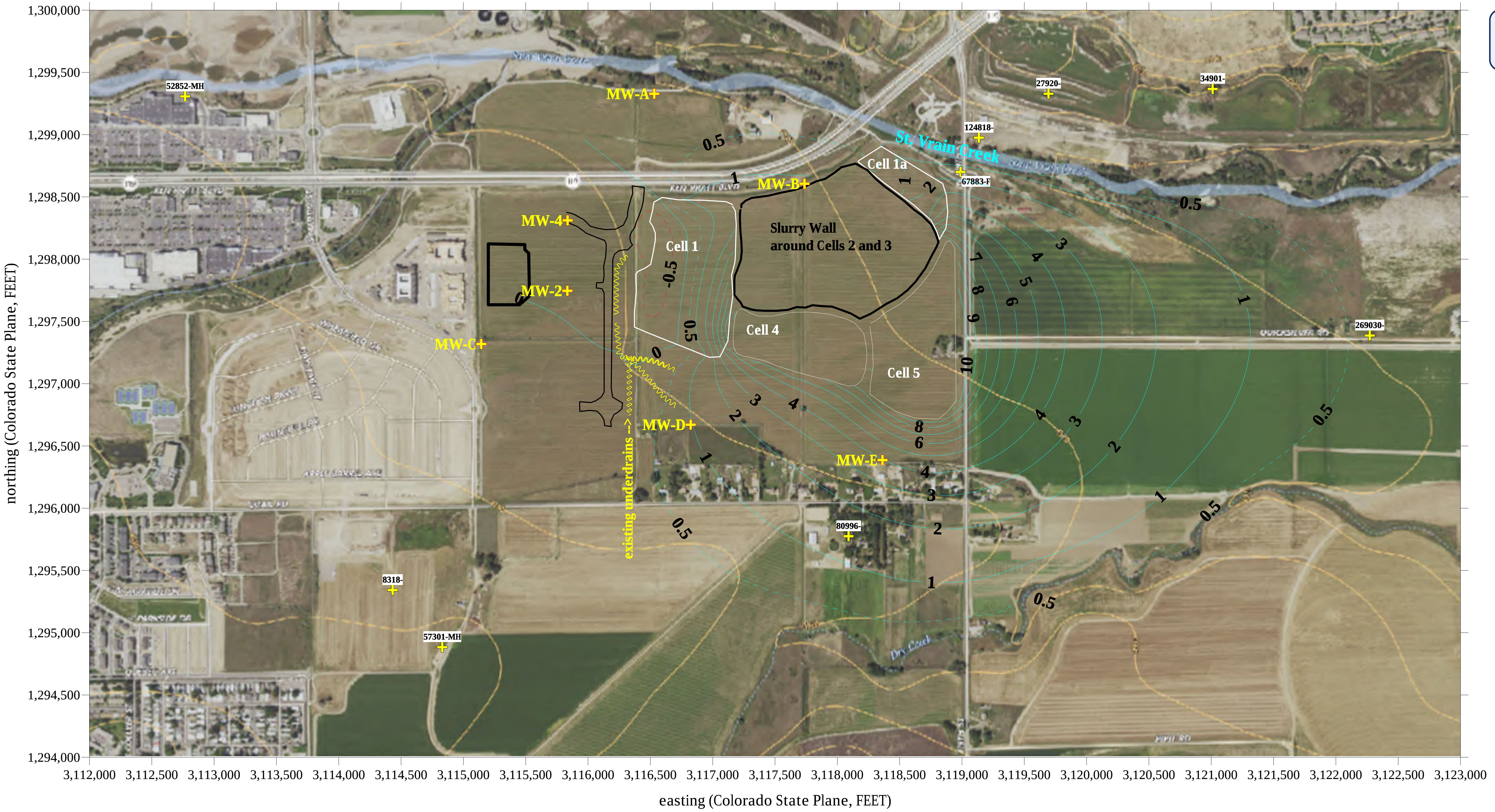

easting (Colorado State Plane, FEET)

Notes:
(1) Elevation and drawdown contours shown in feet.
(2) A groundwater rise (when present) is shown as negative drawdown, in red.
(3) Building and roadway locations are approximate.
(4) Left Hand Creek assumed to be flowing and leaking some water.
(5) Bedrock surface interpolated between 58 on-site borings, 52 borings next-door to the west, and 22 regional off-site borings.
(6) Underdrain to west (Harvest Junction Village) assumed added circa 2017.
(7) Site underdrains based on TST plans dated June 2021.

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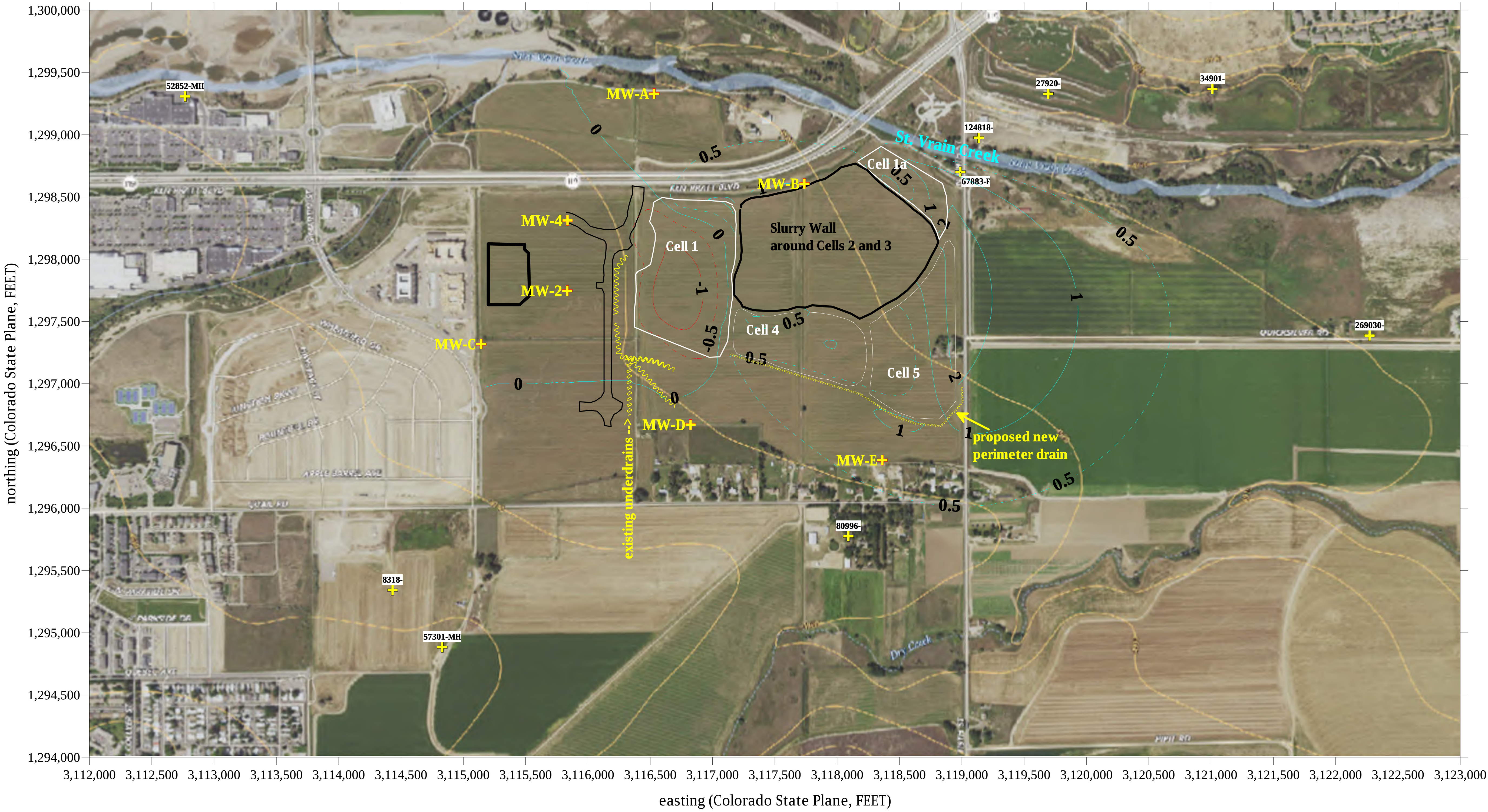
Figure 9. Model Scenario 5: Drawdown and mounding after completion of mining and site reclamation.



/ProjectMustang/mapping/F____.srf 2/21/2023

<u>Notes</u>:
(1) Elevation and drawdown contours shown in feet.
(2) A groundwater rise (when present) is shown as negative drawdown, in red.
(3) Building and roadway locations are approximate.
(4) Left Hand Creek assumed to be flowing and leaking some water.
(5) Bedrock surface interpolated between 58 on-site borings, 52 borings next-door to the west, and 22 regional off-site borings.
(6) Underdrain to west (Harvest Junction Village) assumed added circa 2017.
(7) Site underdrains based on TST plans dated June 2021.

Appendix A

Groundwater model development (2020 Groundwater model report).

Miller Groundwater Engineering, LLC
Consulting, Contracting, Numerical Modeling

324 Remington Street, Suite 110 Fort Collins, CO 80524 970.492.5710

July 22, 2020

Donald N. Taranto, P.E.
TST, Inc. Consulting Engineers
748 Whalers Way
Suite 200
Fort Collins, CO 80525

RE: **Project Mustang,** Longmont, Colorado – Results of Groundwater Drawdown Evaluation

Dear Mr. Taranto:

This letter report presents results from the groundwater evaluation that Miller Groundwater Engineering, LLC, was asked to provide for a confidential building development in Longmont, Colorado. The development has been referred to as "Project Mustang".

The primary goal of our work was to estimate the scale of change in groundwater levels ("drawdown") that should be expected across the development in the future due to dewatering for gravel mining that is planned to take place immediately east and north of the site. The project location is south of Ken Pratt Blvd (aka Hwy 119) and east of South Martin Street, in Longmont, Colorado (**Figure 1**).

Information Relied Upon

- EEC report, dated February 7, 2018. Subsurface Exploration and Slope Stability Evaluation, Irwin/Thomas Properties, Longmont, Colorado, EEC Project No. 1172053.
- TST, Inc. drawing dated April 2020. Irwin Thomas Preliminary/Final PUD Development Plan Amendment; for Gravel Mining. Job No. 1241.0001.02. Filename: 1241.0001 FDP PUD.
- TST, Inc. drawing dated April 2020. Mustang Preliminary Improvement Plans, Overall Grading Plan. Job No. 1241.0001.00. Filename: 0001_Overall Grading.
- Hydrogeologic Evaluation, Irwin/Thomas Mine, Division of Reclamation, Mining, and Safety Permit NO. M-2016-054, Boulder County, Colorado. Prepared for Aggregate Industries–WCR, Inc. 1687 Cole Boulevard, Suite 300, Golden, Colorado, by Blue Earth Solutions, LLC. Report dated December 2013.
- Regional aquifer and water well data from Colorado Division of Water Resources (DWR) online database (https://dwr.state.co.us/Tools/WellPermits).
- Terracon GeoReport, dated April 17, 2020. Geotechnical Engineering Report, Terracon Project No. 22195034, Terracon Consultants, Longmont, Colorado.
- Underdrain report (and associated appendices) for Harvest Junction Village, dated January 2015. Prepared for Oakwood Homes, Denver, Colorado, by Merrick & Company, Greenwood Village, Colorado; Merrick Job No. 65118260.

Hydrogeologic Setting

The shallow groundwater at the site lies in and flows through an alluvial (stream-deposited) aquifer, composed primarily of sand and gravel, that is associated with the Saint Vrain River and Left Hand Creek. The area outlined in **Figure 1** corresponds fairly closely with the lateral (north and south) extents of the saturated alluvium. Based on borings at the property and the planned gravel mine area, the depth to bedrock ranges from 12 to 20 feet below ground surface (ft bgs). The top few feet of soil at the property has been described in the geotechnical reports as sandy lean clay, but we could leave that out of this analysis and include only on the deeper sandy aquifer since the water table was typically in the deeper sands and gravels. Depth to groundwater at site borings ranged from 2.5 to 12 ft bgs. Saturated thickness of the aquifer at the site appears to range from 2 to 17 ft. Below the sand and gravel alluvium is a regional bedrock material (sandstone and claystone) which, relative to the sand, can be considered as impermeable for this evaluation. At the lateral edges of the aquifer (to the north and south here) the aquifer becomes thin as the bedrock is more shallow. In essence, the aquifer lies in a buried subsurface valley which was eroded into the bedrock and filled with sand and gravel (and some silts) deposited by the surface streams.

Based on our experience, it is very likely that the Saint Vrain River has a strong hydraulic connection with the aquifer and is therefore a strong hydrogeologic boundary to the aquifer to the north of the project. We have included it as such in our analysis. And to the west (**Figure 1**), we have assumed Left Hand Creek is a weaker boundary, but that it too is a boundary to some degree. A cursory review of aerial photos suggests that Left Hand Creek does typically have water in it at this location. To the south, we have assumed Dry Creek is a weak boundary, and we do not know if it typically has water in it. Since Dry Creek is at the south edge of the analysis area (and where we have a relatively clear no-flow boundary) we don't expect our results to be strongly sensitive to our assumptions about Dry Creek.

Evaluation Method

We constructed a numerical groundwater model of the site and vicinity using the USGS's MODFLOW-2000 groundwater modeling code. A MODFLOW model was an effective tool for evaluating drawdown at this site since the model was able to account for the effect of nearby streams, nearby subsurface drains, unconfined aquifer behavior, and the location and spatial footprint of the various gravel mine cells. The model also was a useful tool for organizing available site data and accounting for spatial factors such as the ground, water table, and underlying bedrock surfaces each having variable elevations and slopes across the study area.

Model Construction

We constructed the model with a single computational layer representing the alluvial aquifer. The upper model surface represents the ground surface, which we created using USGS digital topo files. The lower model surface represents the top of the regional bedrock which we created by interpolating drilling log information from 22 regional wells selected from the DWR database, plus 58 geotechnical borings located onsite across the development and the planned gravel mine areas, and an additional 52 geotechnical borings from the property located to the west of the Mustang property. Additional details can be provided about these surfaces and other features of model construction upon request.

The lower left-hand corner of the model is at Colorado State Plane coordinates 3,106,000 ft east, 1,289,400 ft north, with the grid covering an area 21,000 ft east to west and 11,000 ft north to south (**Figure 1**). We used a uniform and regular model that has with 50 x 50 ft cells. The north model boundary is aligned approximately with the Saint Vrain River and the south boundary extends south past Dry Creek. Much of the areas north of the river and south of Dry Creek are outside of the main aquifer alluvium and were therefore deactivated in the model, thereby making the river and Dry Creek the effective north and south boundaries of the model. (We deactivated some additional aquifer areas in those regions since the creek and river would significantly bound the simulated groundwater behavior.) The location of the east model boundary coincides with the confluence of Dry Creek and the Saint Vrain River. The west model boundary was placed to be far away from the target area and also at a location where, to the southwest, Left Hand Creek and Dry Creek are close to each other, thereby making Left Hand Creek a natural hydrologic boundary to the west and southwest of the site.

Aquifer hydraulic conductivity (K) for most of the model domain was set to be spatially uniform at K = 100 ft/day. That is reasonable as a mid-range value for this part of the St. Vrain alluvium based on the materials encountered and based on specific capacity test information in the DWR well permits. It is also consistent with the value used in the Blue Earth Solutions (2013) report and with calibrated model values used in the Harvest Junction Village (HJV) underdrain design reports (see the 2014 model report within in the overall 2015 HJV report). We did include one area with lower K (20 ft/day) on the west one-third of the HJV property based on similar lower-K zones being used in HJV's calibrated groundwater model and based that zone improving water level calibration in our model to the HJV water level data.

Model Calibration and Model Versions

We compiled groundwater level targets from seven area water wells in the DWR database plus 55 onsite geotechnical borings and 53 HJV geotechnical borings (**Figure 1**). In reviewing that data, we noticed that water levels in the January 2020 data were distinctly lower than comparable locations in the August 2009 and June 2013 data sets. We initially assumed this was a seasonal difference (which is common in irrigated areas in Colorado) and therefore calibrated two versions of the model, one for higher water level conditions and one for lower conditions. Calibration for each model version was achieved by adjusting stream profiles, net aquifer recharge (0.5 inch/yr in final model), and stream leakage. We sent draft results from those two models to the project team on June 4 and June 6, 2020.

It was later brought to our attention that a large subsurface drain ("underdrain") system was installed at the Harvest Junction Village (HJV) development, located to the west of the Mustang property, circa 2017. Based on this new information, we then revised the high water level model to include this underdrain. We also included geotechnical boring data from the HJV report to slightly adjust the bedrock elevations in the HJV area. Adding the HJV drain improved our model's calibration at the planned building location: the pre-drain (pre-2017) simulation calibrated reasonably well to the higher water levels from the older borings, and then—by adding the HJV underdrains to the model with no other changes—the model calibrated reasonably well to the data from the more recent borings at the property, particularly the January 2020 borings at the planned building location. A calibration plot is presented in **Figure 2**.

Drawdown Projections

To represent the gravel mine dewatering operations, we lowered the groundwater level at each mine cell to within about one foot of the bedrock elevation. Due to seepage-face effects, this reasonably approximates dewatering the pit completely dry to bedrock. We ran some simulations with just the closest cells dewatered, and some with all cells dewatered simultaneously. The drawdown at the Mustang Property (building and roadway area) was similar under both cases, so for the projections presented herein we have used the simulations in which we dewatered just the cells closest to the project (the most important cells for impacts).

Figures 3 and 4 show the simulated water table before and after the addition of the HJV underdrain to the west of the project.

Figure 5 shows the simulated water table while dewatering gravel mine cells 1, 6, and 7.

Figure 6 shows the simulated water table drawdown (in feet) caused by the mine dewatering combined with the HJV underdrain. The drawdown in this figure is computed relative to the pre-drain water levels and therefore *represents drawdown from past conditions to future conditions*. As shown, about 4 ft of drawdown is expected on the east half of the building and 3 ft on the west half of the building. Drawdown at the roadway, very close to the mine pit, ranges from 5 to 8 ft, depending on location.

Figure 7 again shows the simulated water table drawdown (in feet) caused by the same mine dewatering, but this drawdown is computed relative to the post-drain water levels. This figure *represents gravel-mine drawdown relative to "current" conditions* with the HJV drain drawdown already in effect and not included. In other words, this is additional drawdown caused by only the mine. As shown, in this case the new drawdown is expected to be about 1 to 2 ft at the building and 4 to 6 ft at the roadway.

We were asked to provide drawdown estimates so that geotechnical engineers on the project team could assess risk to structures from potential ground subsidence that might be caused by the gravel mine lowering groundwater levels across the development. We have provided these two different drawdown maps (Figures 6 and 7) since it is not clear to us if the relevant drawdown would be only relative to current conditions (**Figure 7**) or to recent past (2017) conditions (**Figure 6**). Please note also that if the HJV underdrain happens to be less effective than we have modeled, then the actual dewatering drawdown relative to current conditions could lie in between the values shown in Figures 6 and 7. We do not expect that to be the case, because adding the HJV underdrain to the model better-matched observed levels at the planned building area, but it may be a possibility.

Sensitivity Analysis

We have not conducted a sensitivity analysis with this model because, in our experience, these drawdown projections will be fairly similar under reasonable ranges of alternative *K* values and also under reasonable variations in initial water table elevations. *To be clear, the simulated* <u>*pumping rate*</u> *required to dewater a mine cell will certainly be sensitive to different assumed K values and to higher and lower initial water levels*, but the <u>drawdown</u> profile away from the water level fixed at the mine pit is typically similar within reasonable variations in *K*. Similarly, changes in water levels (drawdown) caused by new pumping are typically not strongly sensitive to the initial water level conditions as long as initial aquifer saturated thickness is roughly similar in both cases. Furthermore, the drawdown projections from this final model (with drain) were roughly similar to projections from the initial two versions of this model (high-season and low-season, both for pre-2017 drain installation). For these all reasons, we did not see a need to perform formal sensitivity simulations.

Groundwater Monitoring

We were asked to recommend locations for potential long-term groundwater level monitoring. Please note that we are not fully aware of the context and potential use of that monitoring data, but we assume the purpose may be to track groundwater fluctuations near the building caused by the dewatering operations. If that is the purpose, then we suggest four monitoring wells (MWs) be placed in an east-to-west line across the area of interest. For example: (i) place the first MW at the east edge of the development very close to the pit (i.e., near planned roadway, on what we assume is the east side of the planned parking lot), (ii) place the second MW about halfway between the building and the roadway, (iii) place the third one close to the east side of the building, and (iv) place the fourth one close to the west side of the building. An ideal plan might place an additional (fifth) MW further away to the south, at a right angle to that east-west line. That additional MW would serve to monitor "background" fluctuations that might occur separate of the gravel mine dewatering. However, we expect that the fourth MW (west side of building) likely could also serve that purpose as the background monitor. We would be happy to refine these recommendations, upon request, if we learn more about the intended purpose of the monitoring.

Other Potential Uses of this Groundwater Model

Gravel mine cells/pits are commonly lined with clay, either before, during, or after mining is complete, to prevent groundwater inflow. We understand that two of these cells may be lined in the future. Since these mine cells typically reach to bedrock, these liners can, in effect, create a localized subsurface dam. The liner therefore creates a moderate rise of groundwater on the up-gradient side and moderate decline (a "shadow") on the down-gradient side. Similarly, an open pit that is not lined (and fills with water) may create a small decline on its up-gradient side and small rise on its down-gradient side, since groundwater flows through the cell and the cell flattens the natural gradient around it. At this site, the rise (mounding) would be on the west and south sides of the planned pits, toward the planned building and parking lot areas. If that future rise is of interest, this model could be easily used to provide projections of mounding and shadowing around the future cells.

Standard Technical and Practical Limitations

Subsurface data is often limited in its spatial and temporal coverage, and subsurface hydraulic testing produces only approximate results. Estimates and projections about groundwater behavior therefore have inherent and unavoidable uncertainties. No one can provide certainty. By using good, common, and accepted methods, this work provides reasonably reliable guidance for expected site groundwater behavior, but client has acknowledged that actual site performance may be different from projected site performance. Furthermore, actual mining operations may be different than currently known or planned and such changes are outside our scope and control.

Please contact us if you would like to discuss this work further or have any further requests. We have appreciated the opportunity to work with you on this.

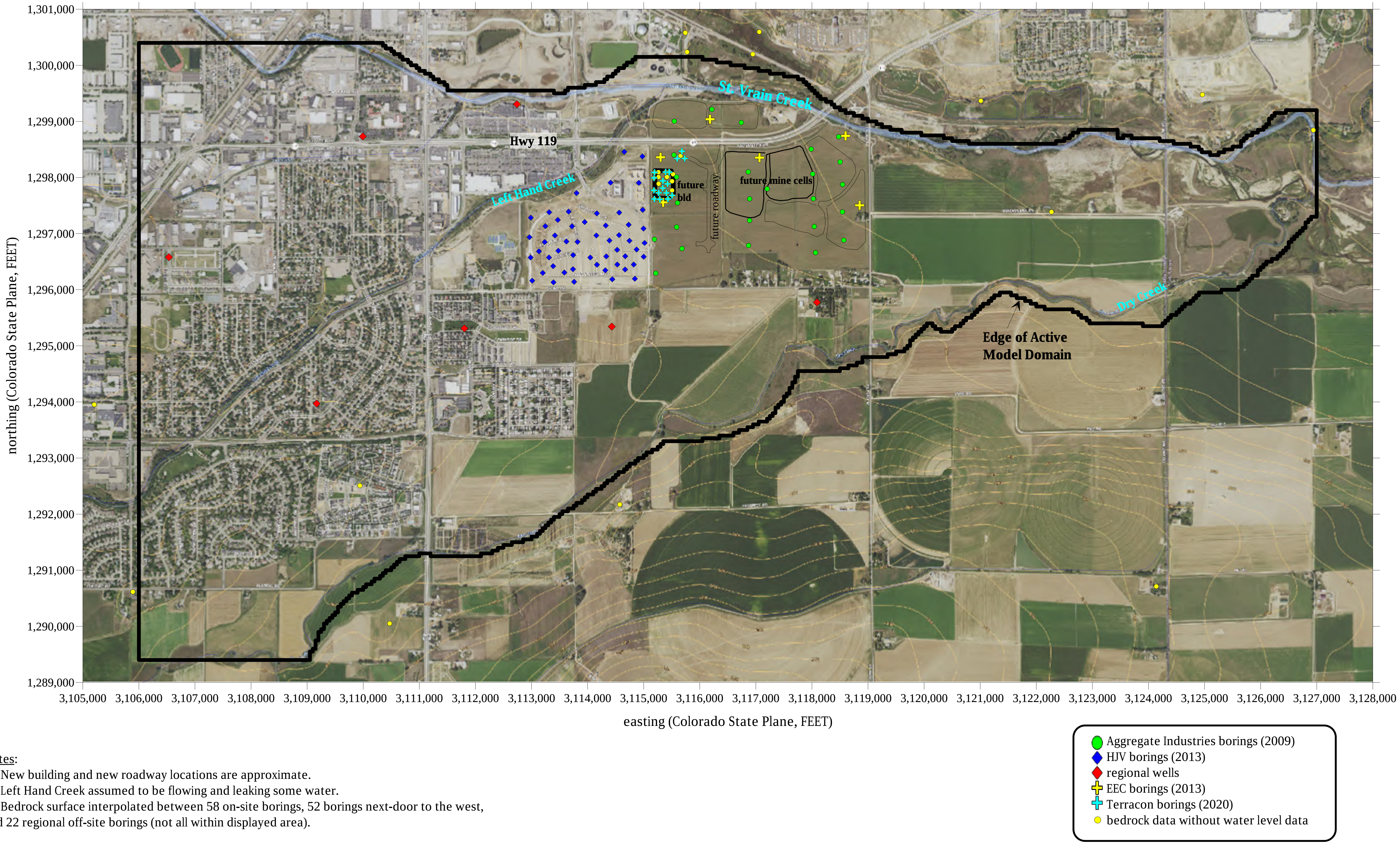
Sincerely,

Calvin Miller

Calvin Miller, PE, PhD
for Miller Groundwater Engineering, LLC

COLORADO LICENSED PROFESSIONAL ENGINEER
CALVIN D. MILLER
39929
Calvin Miller
4 2020

Figure 1. Model domain and location of water level and/or bedrock elevation data points.



Notes:
(1) New building and new roadway locations are approximate.
(2) Left Hand Creek assumed to be flowing and leaking some water.
(3) Bedrock surface interpolated between 58 on-site borings, 52 borings next-door to the west, and 22 regional off-site borings (not all within displayed area).

/ProjectMustang/mapping/ModelGridFigure.srf 7/21/2020

Project: Mustang Property, Longmont, Colorado. Report: Results of groundwater drawdown evaluation.

Miller Groundwater Engineering, LLC

Figure 2. Water level calibration plot.

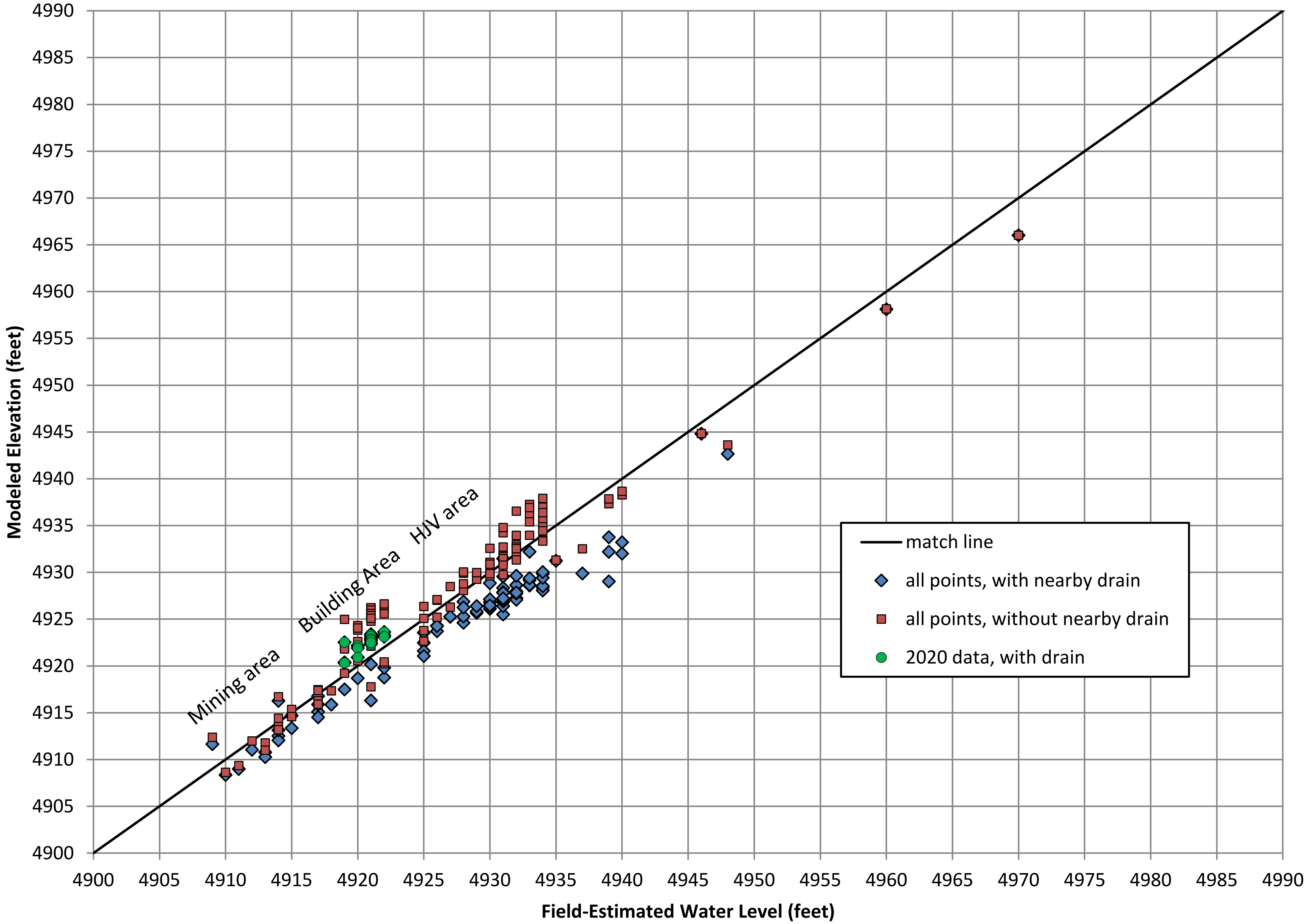
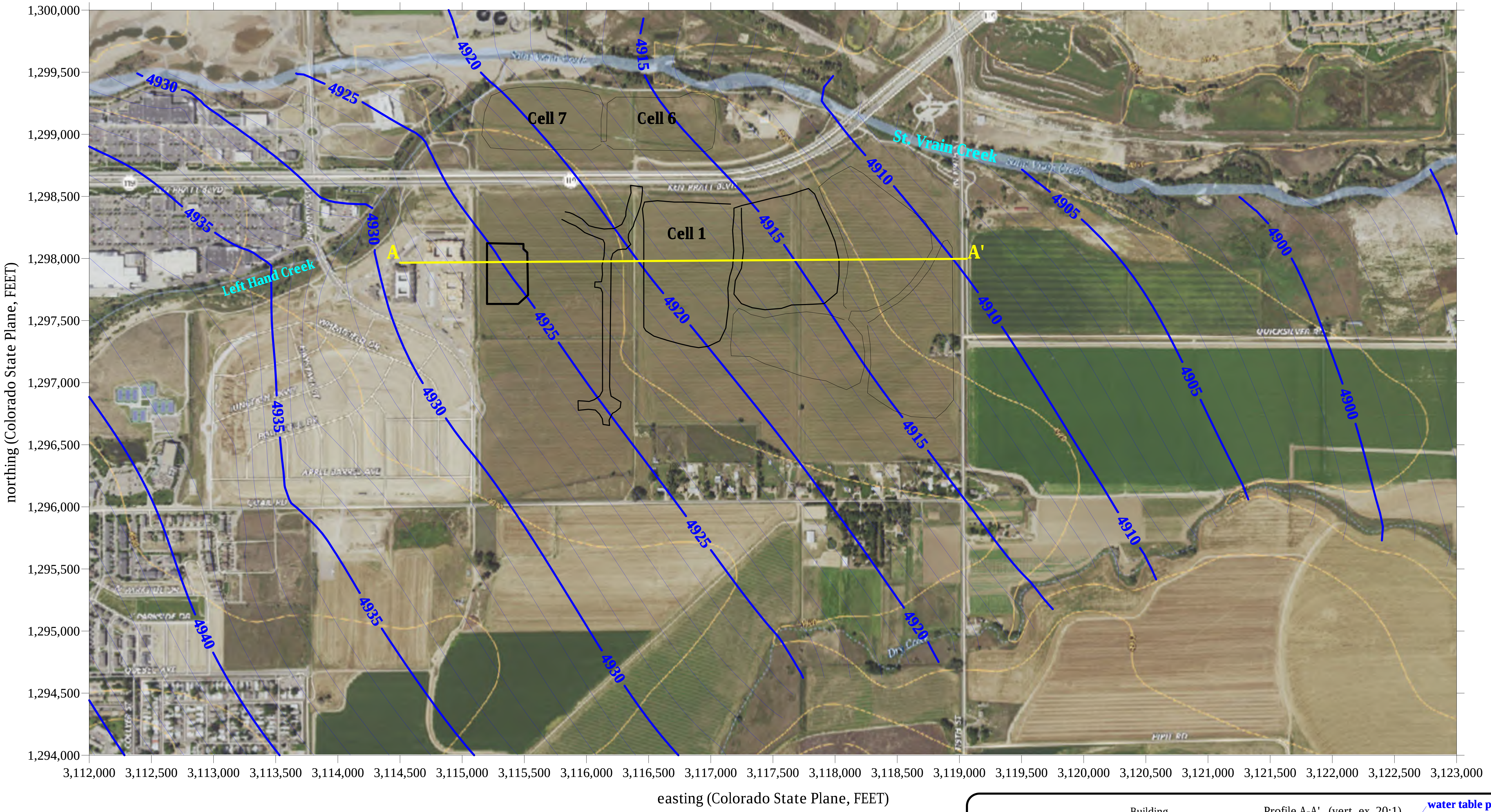
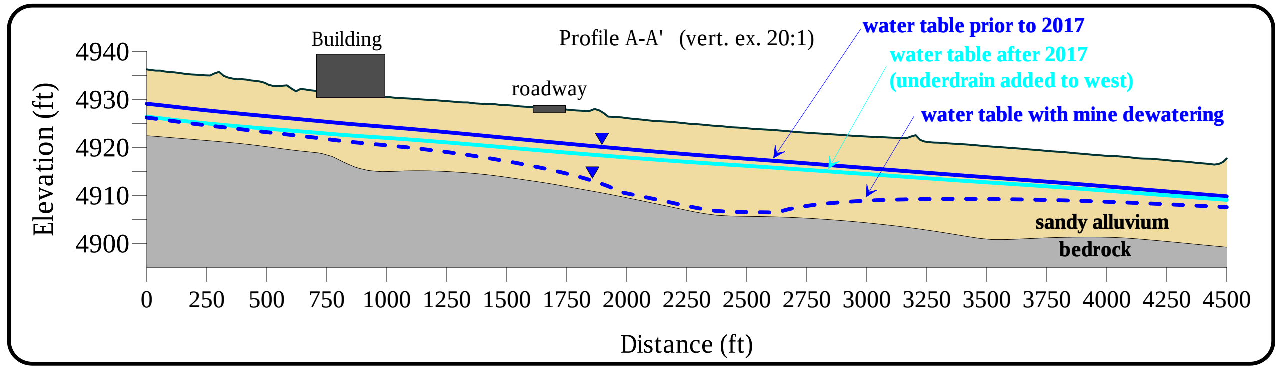


Figure 3. Simulated water table for pre-2017 conditions.





Notes:

(1) New building and new roadway locations are approximate.

(2) Left Hand Creek assumed to be flowing and leaking some water.

(3) Bedrock surface interpolated between 58 on-site borings, 52 borings next-door to the west, and 22 regional off-site borings.

(4) Elevation contours shown in feet.

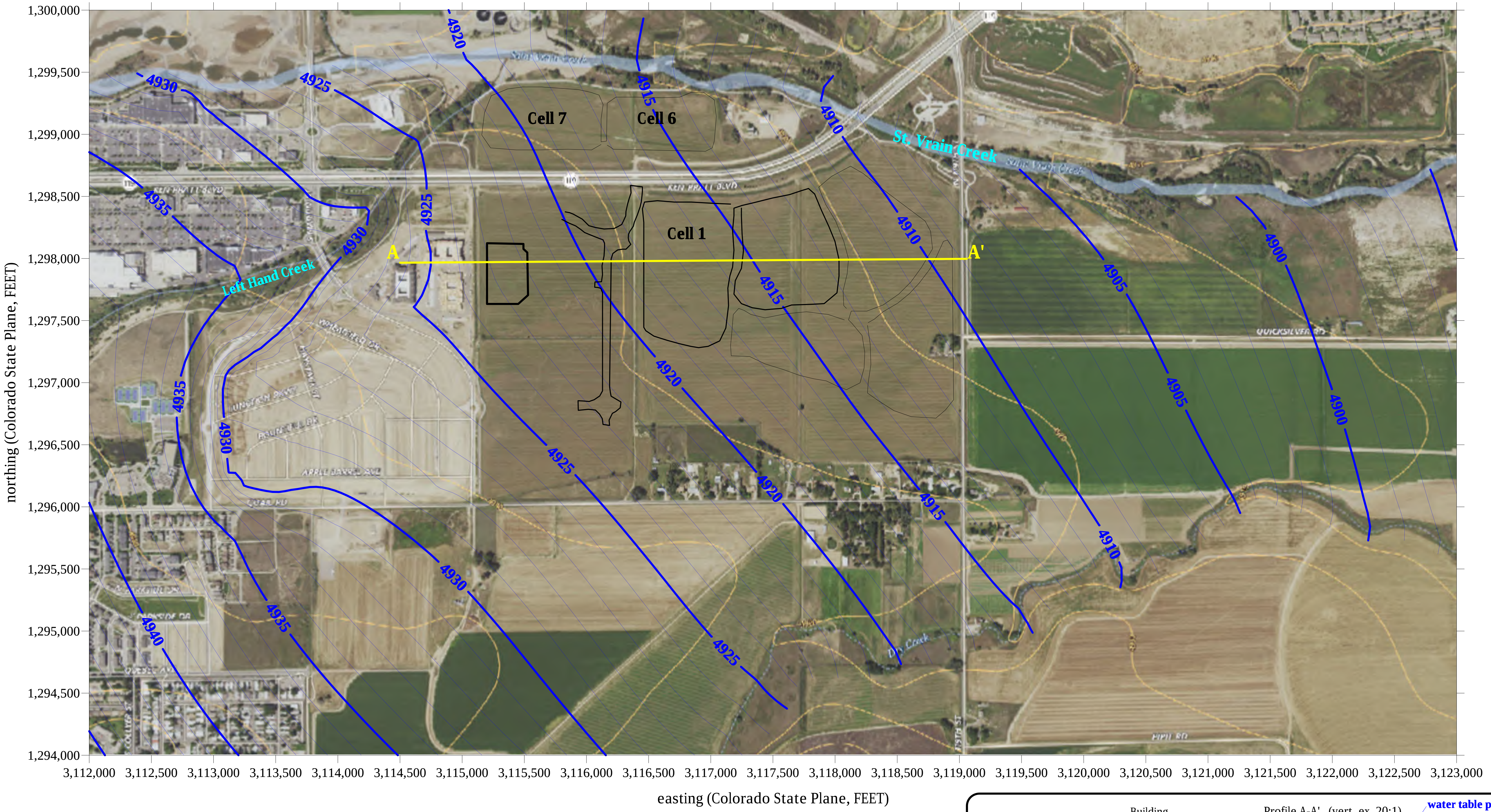
(5) new underdrain to west (Harvest Junction Village) assumed added circa 2017.

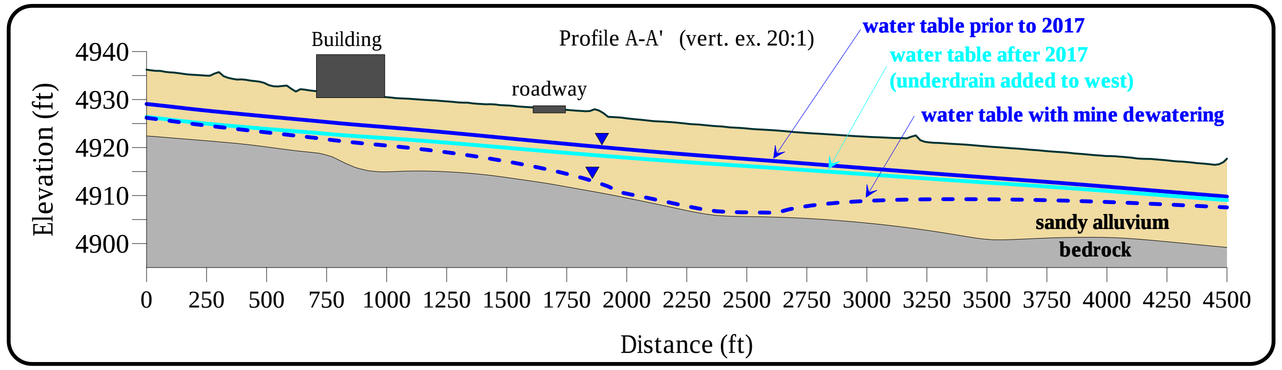
/ProjectMustang/mapping/OutputMaps-M7.srf 6/17/2020

Project: Mustang Property, Longmont, Colorado. Report: gravel pit drawdown evaluation - results review (updated June 17, 2020)

Miller Groundwater Engineering, LLC

Figure 4. Simulated water table for current conditions (i.e., after underdrain installed in neighborhood on west side).

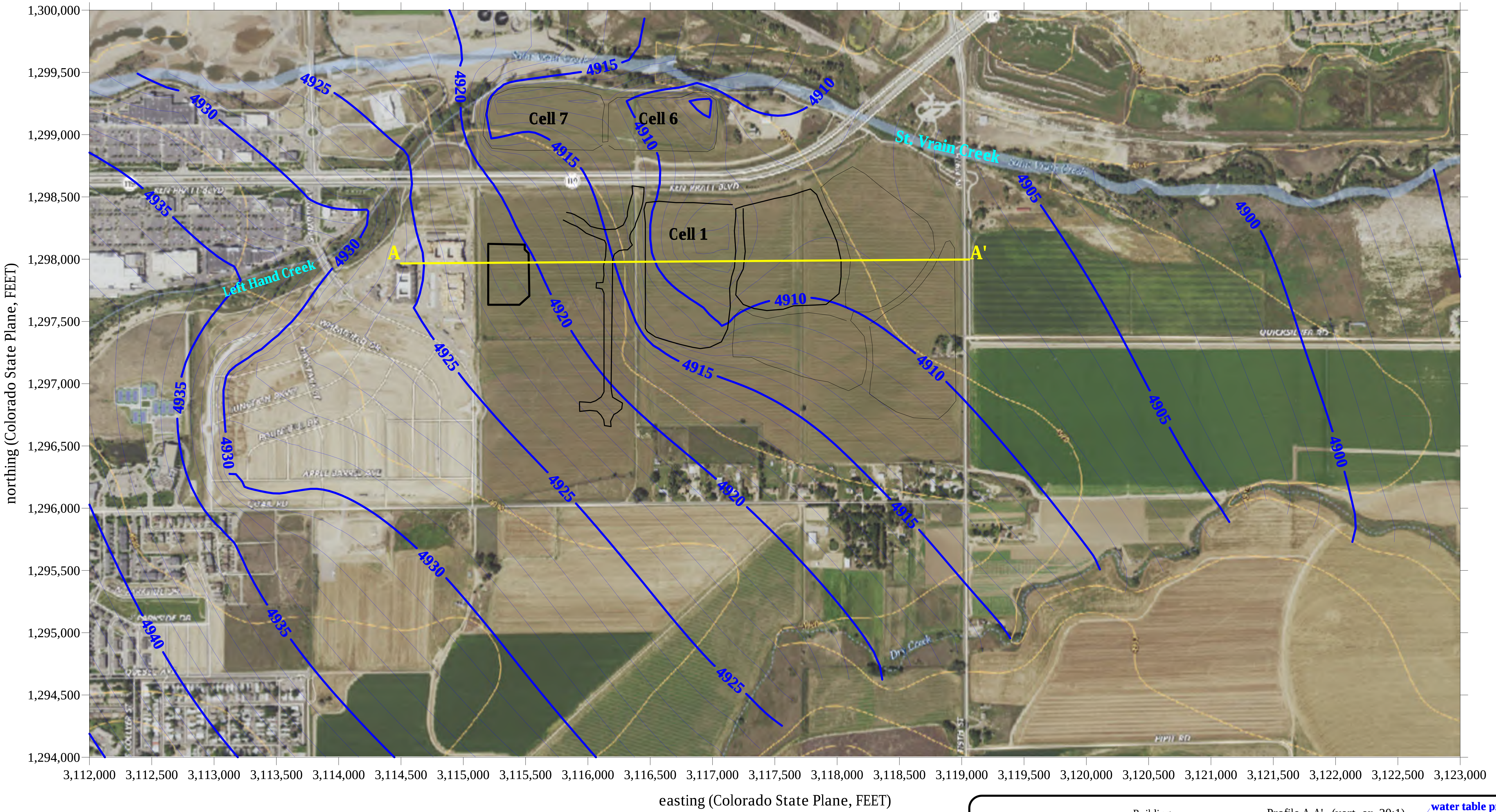


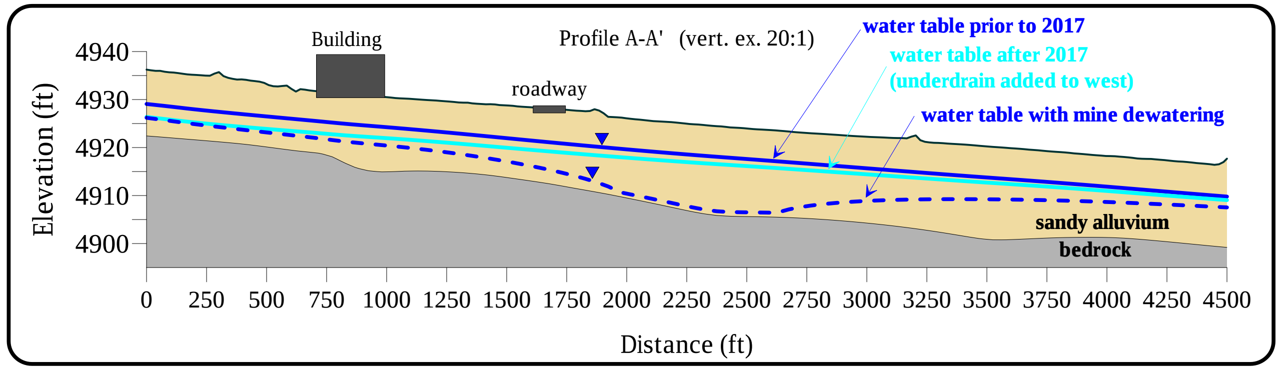


/ProjectMustang/mapping/OutputMaps-M7.srf 6/17/2020

Notes:
(1) New building and new roadway locations are approximate.
(2) Left Hand Creek assumed to be flowing and leaking some water.
(3) Bedrock surface interpolated between 58 on-site borings, 52 borings next-door to the west, and 22 regional off-site borings.
(4) Elevation contours shown in feet.
(5) new underdrain to west (Harvest Junction Village) assumed added circa 2017.

Figure 5. Simulated water table while dewatering mine cells 1, 6, and 7.





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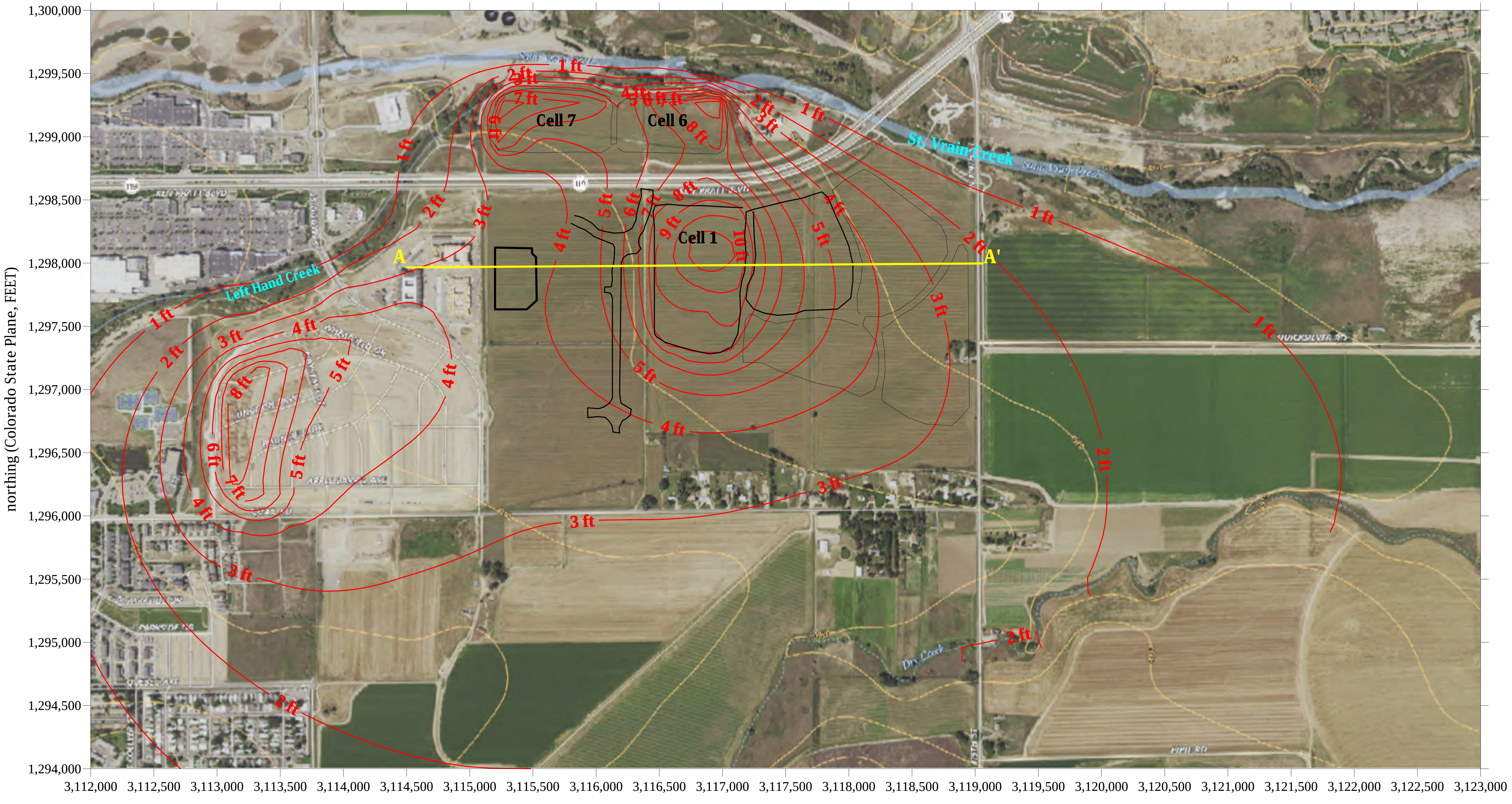
(4) Elevation contours shown in feet.
(5) new underdrain to west (Harvest Junction Village) assumed added circa 2017.

/ProjectMustang/mapping/OutputMaps-M7.srf 6/17/2020

Figure 6. Simulated drawdown with mine dewatering (Cells 1, 6, and 7) relative to pre-2017 water levels.



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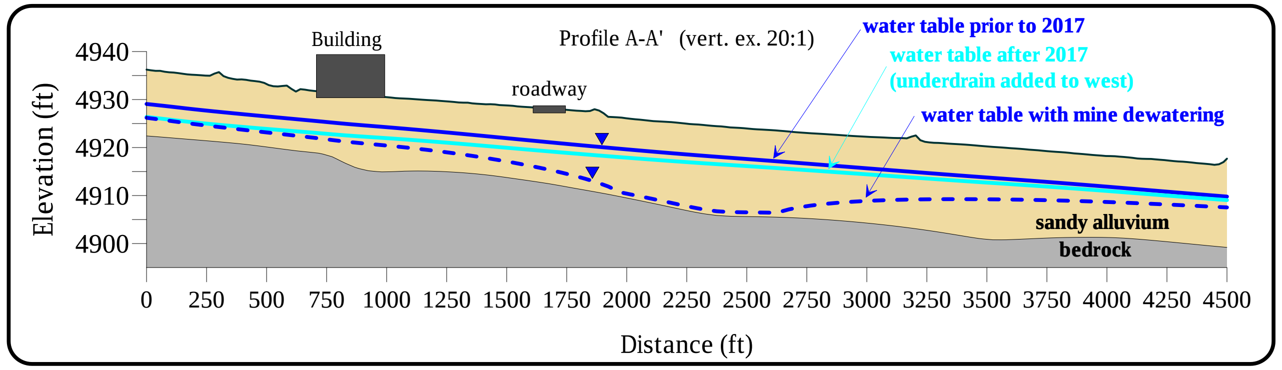
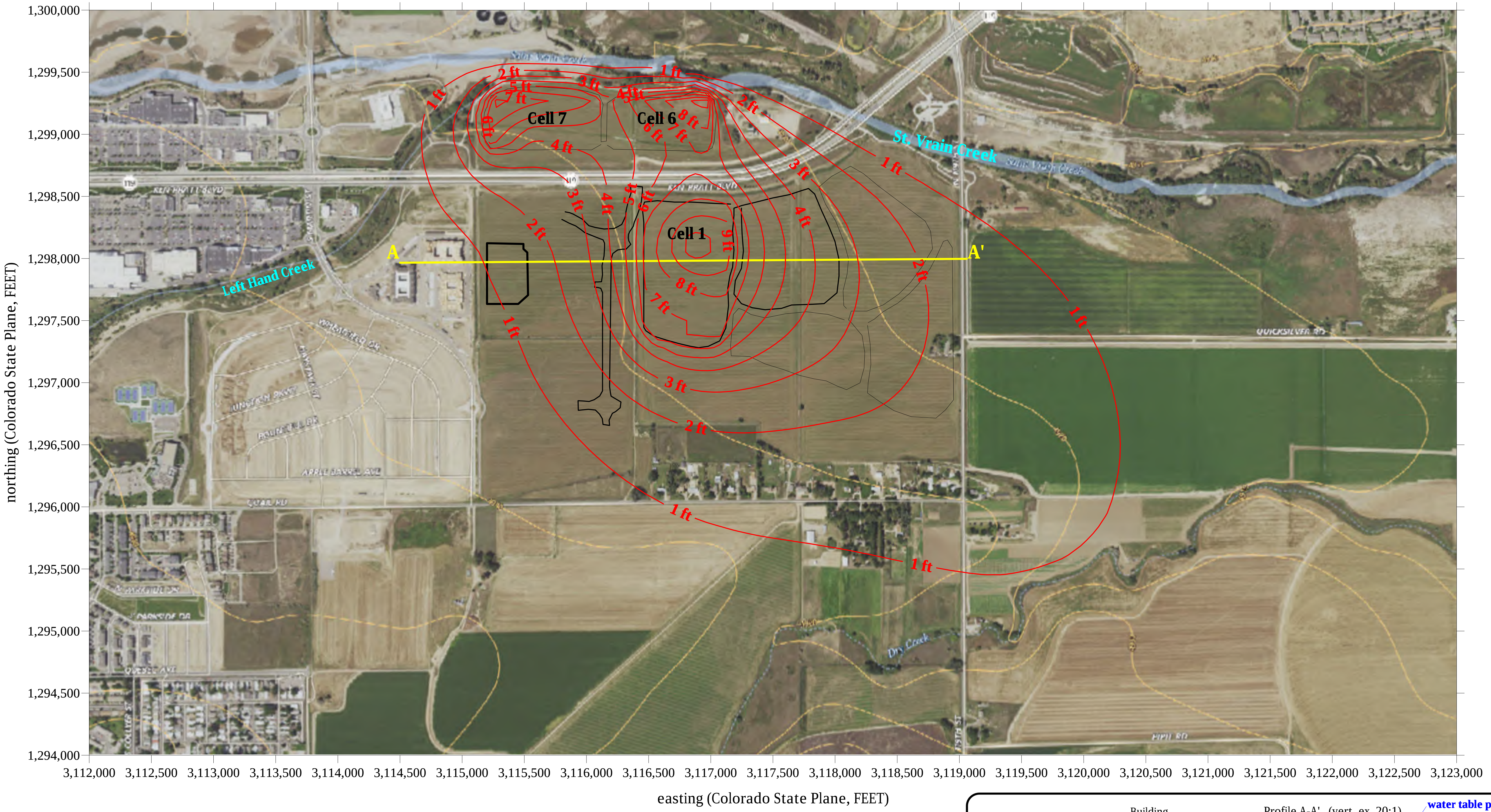
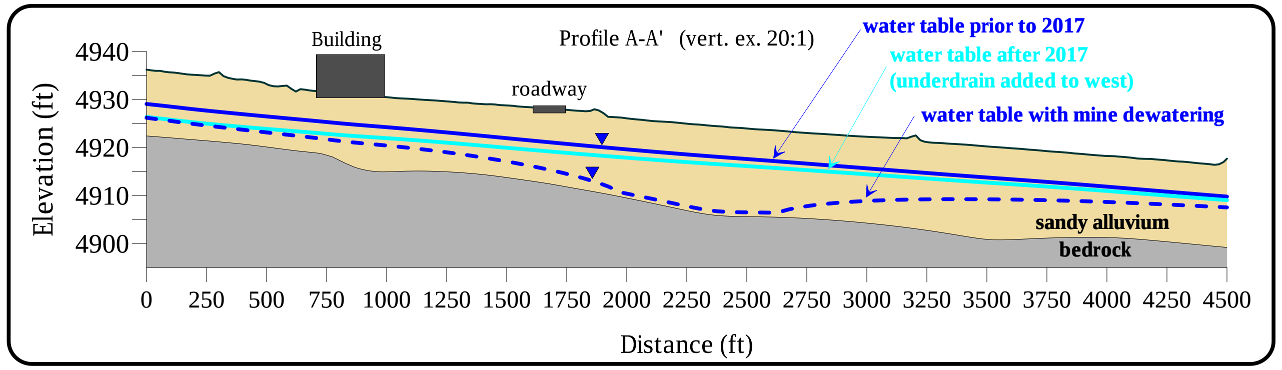


Project: Mustang Property, Longmont, Colorado. Report: gravel pit drawdown evaluation - results review (updated June 17, 2020)

Miller Groundwater Engineering, LLC

Figure 7. Simulated drawdown with mine dewatering (Cells 1, 6, and 7) relative to recent (post-2017) water levels.





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/ProjectMustang/mapping/OutputMaps-M7.srf 6/17/2020

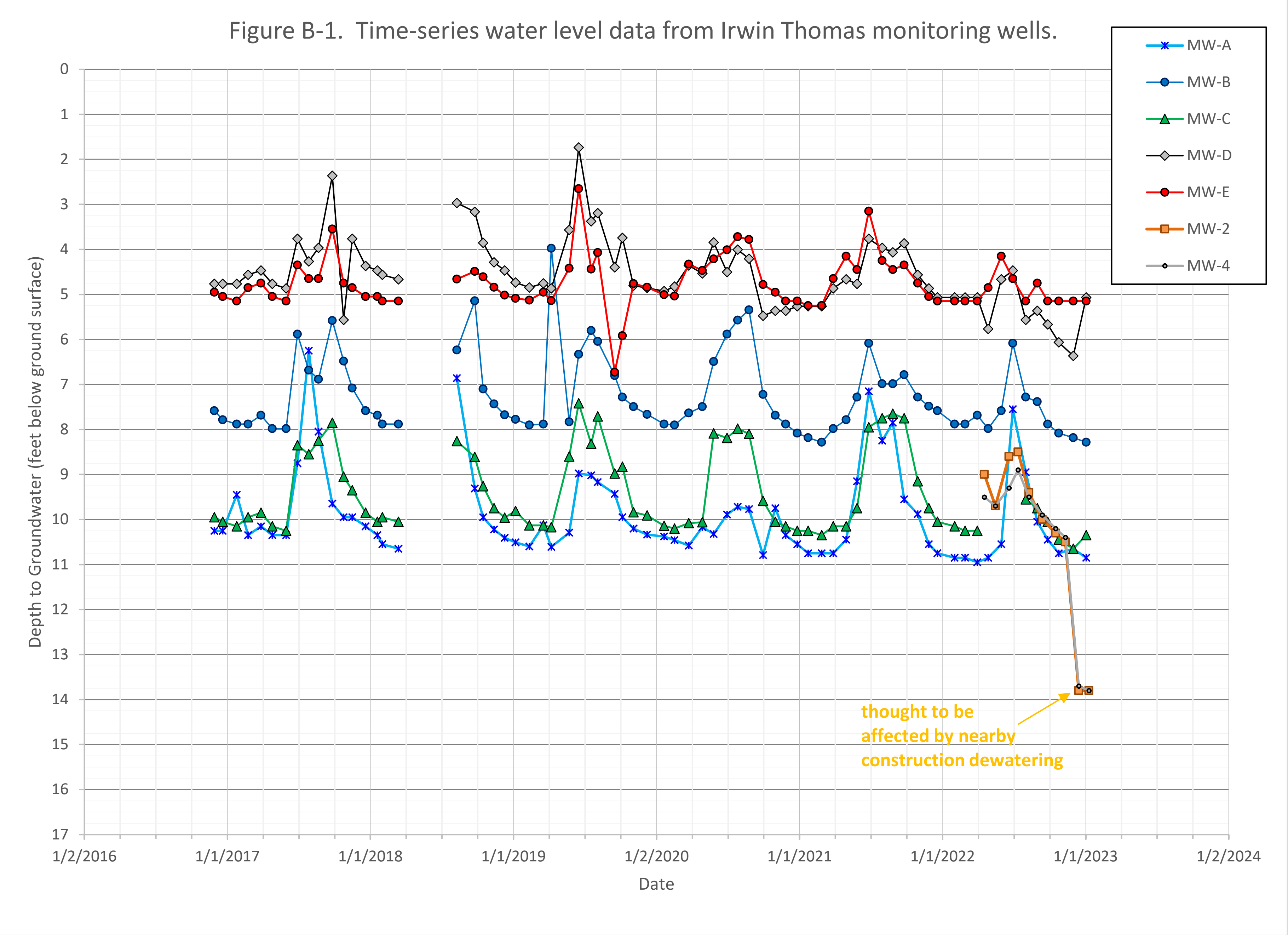
Project: **Mustang Property, Longmont, Colorado.** **Report**: **gravel pit drawdown evaluation - results review (updated June 17, 2020)**

Miller Groundwater Engineering, LLC

Appendix B

Time-Series Water Level Data for the Site

Figure B-1. Time-series water level data from Irwin Thomas monitoring wells.



Appendix C-1

Select permit information for nearby water well: Permit No. 80996-F

WRJ-25-74

U

THIS FORM MUST BE SUBMITTED PRIOR TO THE EXPIRATION OF THE PERMIT. TYPE OR PRINT IN BLACK INK. COPY OF ACCEPTED STATEMENT MAILED ON REQUEST.

COLORADO DIVISION OF WATER RESOURCES

300 Columbine Bldg., 1845 Sherman St.
Denver, Colorado 80203

RECEIVED
JUN 5 '78
WATER RESOURCES
STATE ENGINEER
COLO.

STATE OF COLORADO
COUNTY OF Boulder } SS.

AFFIDAVIT

X STATEMENT OF BENEFICIAL USE OF GROUND WATER
___ AMENDMENT OF EXISTING RECORD

PERMIT NUMBER 80996[redacted]

LOCATION OF WELL

County Boulder
NE ¼ of the NE ¼, Section 14
Twp. 2 N (N OR S), Rng. 69 W (E OR W), 6 P.M.

THE AFFIANT(S) ARNOLD & JOSEPHINE READ whose mailing address is 11774 Quail Rd
City Longmont Colo (STATE) 80501 (ZIP)

being duly sworn upon oath, deposes and says that he (they) is (are) the owner(s) of the well described hereon; the well is located as described above, at distances of 250 feet from the North (NORTH OR SOUTH) section line and 940 feet from the East (EAST OR WEST) section line; water from this well was first applied to a beneficial use for the purpose(s) described herein on the 1 day of May, 1978; the maximum sustained pumping rate of the well is 15 gallons per minute, the pumping rate claimed hereby is 12 gallons per minute; the total depth of the well is 300 feet; the average annual amount of water to be diverted is 2 acre-feet; for which claim is hereby made for Domestic, Livestock & IRRIGATION (1 acre) purpose(s); the legal description of the land on which the water from this well is used is a part of NE¼, NE¼ Sec 14 T.2N R.69W, 6th pm which totals ONE acres and which is illustrated on the map on the reverse side of this form; that this well was completed in compliance with the permit approved therefor; this statement of beneficial use of ground water is filed in compliance with law; he (they) has (have) read the statements made hereon; knows the content thereof; and that the same are true of his (their) knowledge.

Signature(s)

Subscribed and sworn to before me on this 2nd day of ~~Ap~~ June, 1978

My Commission expires: 7-23-79
(SEAL)

Connie L. Warren
NOTARY PUBLIC

his name only notarized by myself.

ACCEPTED FOR FILING BY THE STATE ENGINEER OF COLORADO PURSUANT TO THE FOLLOWING CONDITIONS:

FOR OFFICE USE ONLY

Court Case No. ______
Prior. ______ Mo. ______ Day ______ Yr. ______
Div. 1 Cty. 07
Sec. ______ ¼, ______ ¼, ______ ¼,
Well Use 3
Dist. 05 Basin ______ Man. Dis. ______

DATE ______ STATE ENGINEER ______ BY ______

Well drilled by Western Star Lic. No. 976

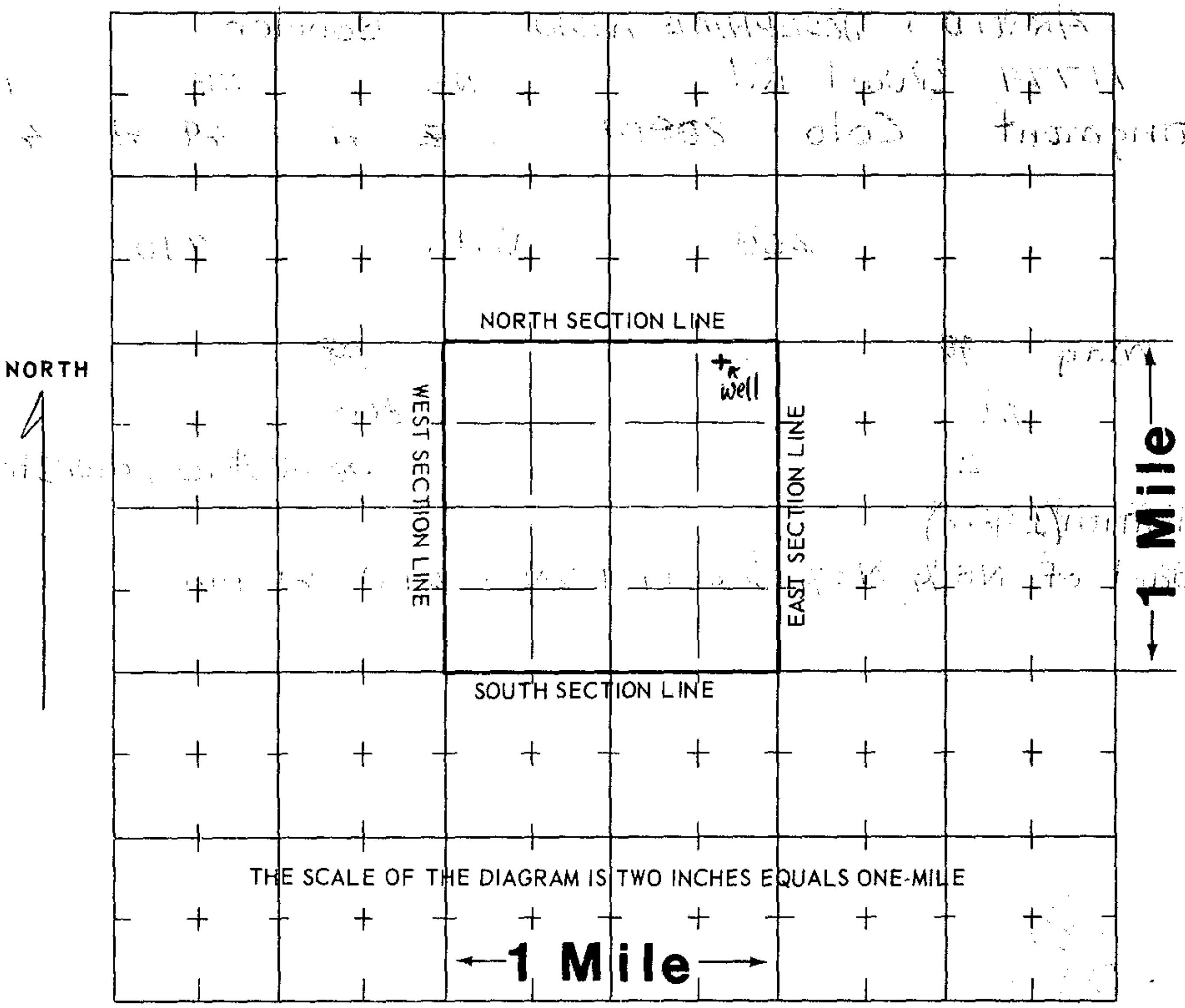
Pump installed by ARNOLD READ Lic. No. Owner

Meter Serial No. N/A ☐ Flow Meter Date Installed

Owner of land on which water is being used ARNOLD & JOSEPHINE READ

THE LOCATION OF THE WELL MUST BE SHOWN AND THE AREA ON WHICH THE WATER IS USED MUST BE SHADED OR CROSS-HATCHED ON THE DIAGRAM BELOW.

This diagram represents nine (9) sections. Use the **CENTER SQUARE** (one section) to indicate the location of the well, if possible.



WATER EQUIVALENTS TABLE (Rounded Figures)

An acre-foot covers 1 acre of land 1 foot deep.
1 cubic foot per second (cfs) . . . 449 gallons per minute (gpm).
1 acre-foot . . . 43,560 cubic feet . . . 325,900 gallons.
1,000 gpm pumped continuously for one day produces 4.42 acre-feet.
100 gpm pumped continuously for one year produces 160 acre-feet.

WRJ-25-74

THIS FORM MUST BE SUBMITTED PRIOR TO THE EXPIRATION OF THE PERMIT. TYPE OR PRINT IN BLACK INK. COPY OF ACCEPTED STATEMENT MAILED ON REQUEST.

COLORADO DIVISION OF WATER RESOURCES

300 Columbine Bldg., 1845 Sherman St.
Denver, Colorado 80203

RECEIVED
SEP 12 '75
WATER RESOURCES
STATE ENGINEER
COLO.

STATE OF COLORADO
COUNTY OF BOULDER } SS.

AFFIDAVIT

____ STATEMENT OF BENEFICIAL USE OF GROUND WATER
____ AMENDMENT OF EXISTING RECORD
xx LATE REGISTRATION

PERMIT NUMBER 80996

LOCATION OF WELL

County Boulder
NE ¼ of the NE ¼, Section 14
Twp. 2 N (N OR S), Rng. 69 W (E OR W), 6th P.M.

THE AFFIANT(S) Arnold & Josephine Read
whose mailing address is 3265 Euclid Ave.
City Boulder, Colorado (STATE) 80303 (ZIP)

being duly sworn upon oath, deposes and says that he (they) is (are) the owner(s) of the well described hereon; the well is located as described above, at distances of 100 feet from the NORTH (NORTH OR SOUTH) section line and 940 feet from the EAST (EAST OR WEST) section line; water from this well was first applied to a beneficial use for the purpose(s) described herein on the ____ day of March, 1935; the maximum sustained pumping rate of the well is 25 gallons per minute, the pumping rate claimed hereby is 15 gallons per minute; the total depth of the well is 25 feet; the average annual amount of water to be diverted is 2 acre-feet; for which claim is hereby made for domestic & livestock purpose(s); the legal description of the land on which the water from this well is used is a part of NE¼, NE¼ Sec. 14, T. 2N, R. 69W, 6th P.M. which totals one acres and which is *illustrated on the map on the reverse side of this form; that this well was completed in compliance* with the permit approved therefor; this statement of beneficial use of ground water is filed in compliance with law; he (they) has (have) read the statements made hereon; knows the content thereof; and that the same are true of his (their) knowledge.

Signature(s) Josephine J. Read

64297 63656

Subscribed and sworn to before me on this 11th day of September, 1975
My Commission expires: My Commission expires July 14, 1979
(SEAL)
NOTARY PUBLIC

ACCEPTED FOR FILING BY THE STATE ENGINEER OF COLORADO PURSUANT TO THE FOLLOWING CONDITIONS: (OVER)

FOR OFFICE USE ONLY

Court Case No. ____
Prior. ____ Mo. ____ Day ____ Yr. ____
Div. ____ Cty. ____
Sec. ____ ____ ¼, ____ ¼, ____ ¼,
Well Use ____ ____ ____ ____
Dist. ____ Basin ____ Man. Dis. ____,

SEP 22 1975
DATE

Bruce E. DeBrine Dep.
STATE ENGINEER

BY

Well drilled by ✓ Ralph Sawdey Lic. No. ✓ NA

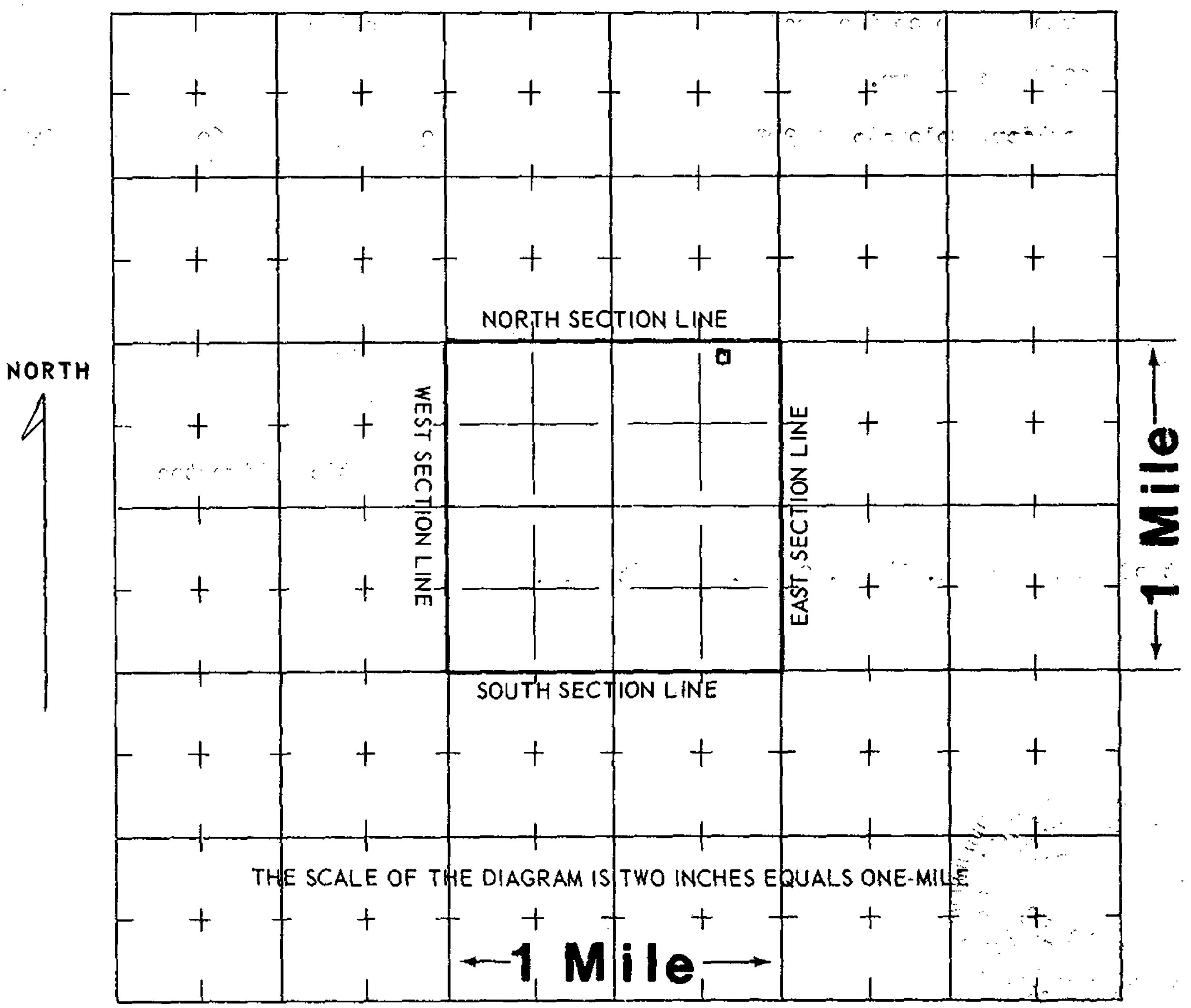
Pump installed by ✓ Ralph Sawdey Lic. No. ✓ NA

Meter Serial No. NA ☐ Flow Meter Date Installed NA

Owner of land on which water is being used ✓ Arnold and Josephine Read

THE LOCATION OF THE WELL MUST BE SHOWN AND THE AREA ON WHICH THE WATER IS USED MUST BE SHADED OR CROSS-HATCHED ON THE DIAGRAM BELOW.

This diagram represents nine (9) sections. Use the **CENTER SQUARE** (one section) to indicate the location of the well, if possible.



WATER EQUIVALENTS TABLE (Rounded Figures)

An acre-foot covers 1 acre of land 1 foot deep.
1 cubic foot per second (cfs) . . . 449 gallons per minute (gpm).
1 acre-foot . . . 43,560 cubic feet . . . 325,900 gallons.
1,000 gpm pumped continuously for one day produces 4.42 acre-feet.
100 gpm pumped continuously for one year produces 160 acre-feet.

WRJ-26-72

THIS FORM MUST BE SUBMITTED WITHIN 60 DAYS OF COMPLETION OF THE WORK DESCRIBED HEREON. TYPE OR PRINT IN BLACK INK.

COLORADO DIVISION OF WATER RESOURCES

300 Columbine Bldg., 1845 Sherman St.
Denver, Colorado 80203

RECEIVED
JAN 12 '78
WATER RESOURCES
STATE ENGINEER
COLO.

WELL COMPLETION AND PUMP INSTALLATION REPORT

PERMIT NUMBER 80996A

WELL OWNER Arnold Reed

ADDRESS 3265 Euclid, Boulder, Colorado

DATE COMPLETED October 26, , 19 77

NE ¼ of the NE ¼ of Sec. 14 ,

T. 2 N , R. 69 W , 6 P.M.

HOLE DIAMETER

8 in. from 0 to 20 ft.

6 in. from 20 to 300 ft.

in. from to ft.

DRILLING METHOD cable tool

CASING RECORD: Plain Casing

Size 6 5/8 & kind steel from +1 to 20 ft.

Size OPEN & kind from 20 to 300 ft.

Size & kind from to ft.

Perforated Casing

Size 6 5/8 & kind steel from 20 to 26 ft.

Size & kind from to ft.

Size & kind from to ft.

GROUTING RECORD

Material cement

Intervals 10-20

Placement Method poured

GRAVEL PACK: Size

Interval

TEST DATA

Date Tested October 26 , 1977

Static Water Level Prior to Test 12 ft.

Type of Test Pump Balor

Length of Test 2 hours

Sustained Yield (Metered) 15 GPM

Final Pumping Water Level 50'

WELL LOG

From	To	Type and Color of Material	Water Loc.
0	21	sand, gravel, brown	
21	24	" " "	*
24	50	shale, gray	
50	75	" blue	
75	200	" gray	
200	300	" gray	

TOTAL DEPTH 300'

Use additional pages necessary to complete log.

PUMP INSTALLATION REPORT

Pump Make ____________________

Type ____________________

Powered by ____________________ HP ______

Pump Serial No. ____________________

Motor Serial No. ____________________

Date Installed ____________________

Pump Intake Depth ____________________

Remarks ____________________

____

WELL TEST DATA WITH PERMANENT PUMP

Date Tested ____________________

Static Water Level Prior to Test ____________________

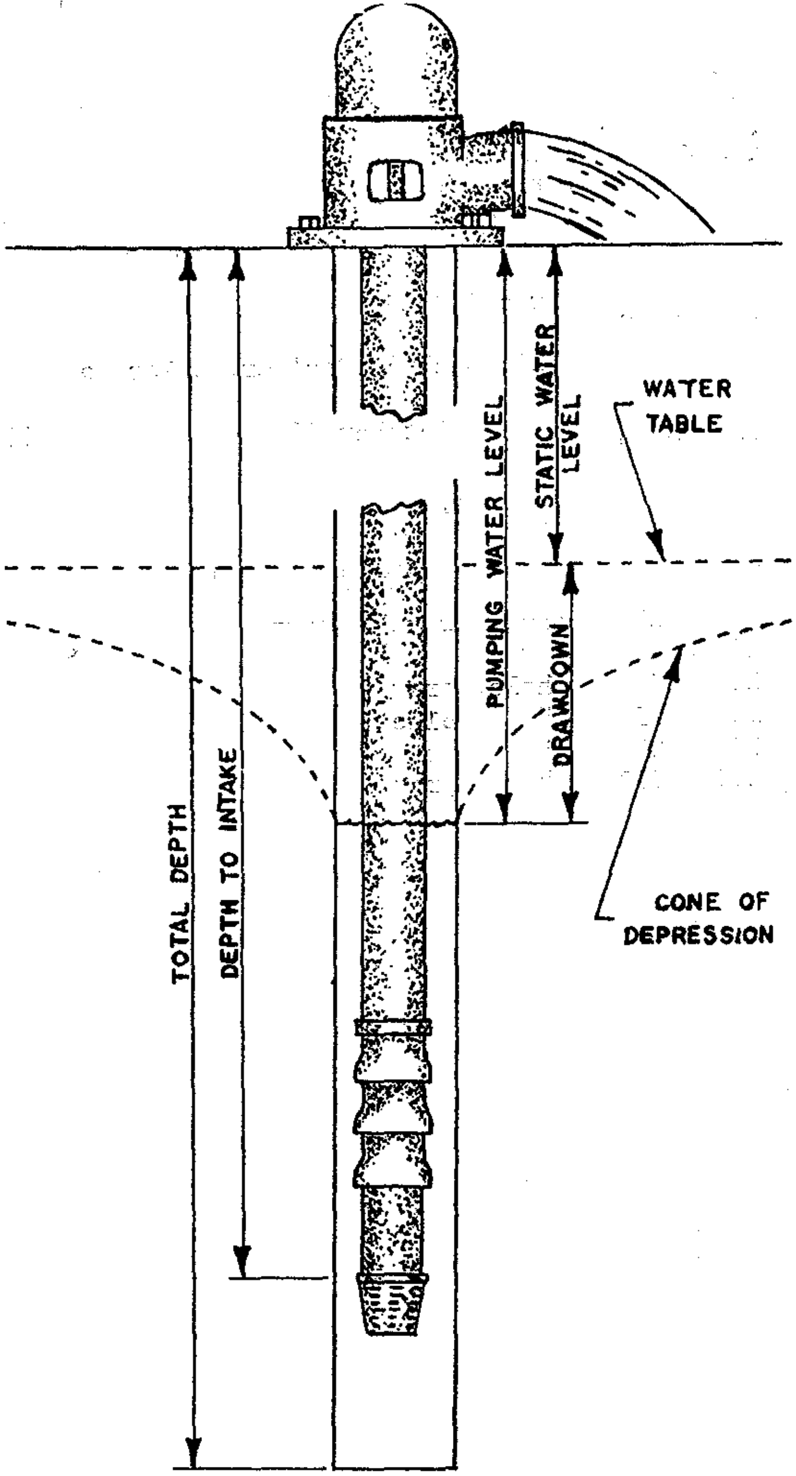
Length of Test ____________________ Hours

Sustained yield (Metered) ____________________ GPM

Pumping Water Level ____________________

Remarks ____________________

____



CONTRACTORS STATEMENT

The undersigned, being duly sworn upon oath, deposes and says that he is the contractor of the well or pump installation described hereon; that he has read the statement made hereon; knows the content thereof, and that the same is true of his own knowledge.

Signature Paul ____________________ License No. 976

State of Colorado, County of Denver SS

Subscribed and sworn to before me this 12 day of January, 19 78.

My Commission expires: My Commission Expires Feb. 22, 1981, 19 ____.

Notary Public Robert W. Boose

FORM TO BE MADE OUT IN QUADRUPLICATE: WHITE FORM must be an original copy on both sides and signed. WHITE AND GREEN copies must be filed with the State Engineer. PINK COPY is for the Owner and YELLOW COPY is for the Driller.

WRJ-5-74

COLORADO DIVISION OF WATER RESOURCES
101 Columbine Bldg., 1845 Sherman St., Denver, Colorado 80203

RECEIVED
SEP 12 '75
WATER RESOURCES
STATE ENGINEER
COLO

SEP 1975
RECEIVED
WATER RESOURCES
STATE ENGINEER
COLO

Previously Received 8-19-75

PERMIT APPLICATION FORM

Application must be complete where applicable. Type or print in BLACK INK. No overstrikes or erasures unless initialed.

FOR:
☐ A PERMIT TO USE GROUND WATER
☒ A PERMIT TO CONSTRUCT A WELL
☒ A PERMIT TO INSTALL A PUMP
☒ REPLACEMENT FOR NO.
☐ OTHER

(1) APPLICANT - mailing address

NAME Arnold and Josephine Read
STREET 3265 Euclid Ave.
CITY Boulder, Colorado (State) 80303 (Zip)
TELEPHONE NO. 442-0427

(2) LOCATION OF PROPOSED WELL

County Boulder
NE ¼ of the NE ¼, Section 14
Twp. 2 N, Rng. 69 W, 6th P.M.

(3) WATER USE AND WELL DATA

Proposed maximum pumping rate (gpm) 15
Average annual amount of ground water to be appropriated (acre-feet): 2
Number of acres to be irrigated: 1
Proposed total depth (feet): 65
Aquifer ground water is to be obtained from:
Owner's well designation #1

GROUND WATER TO BE USED FOR:

☐ HOUSEHOLD USE ONLY - no irrigation (0)
☒ DOMESTIC (1)
☒ LIVESTOCK (2)
☐ COMMERCIAL (4)
☐ INDUSTRIAL (5)
☐ IRRIGATION (6)
☐ MUNICIPAL (8)
☐ OTHER (9)

(4) DRILLER

Name Marshall Drilling
Street 741 Collyer Street
City Longmont, Colorado (State) 80501 (Zip)
Telephone No. 776-2620 Lic. No. 84

FOR OFFICE USE ONLY: DO NOT WRITE IN THIS COLUMN

Receipt No. 63656 / 64297
Basin Dist.

CONDITIONS OF APPROVAL

This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of the permit does not assure the applicant that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.

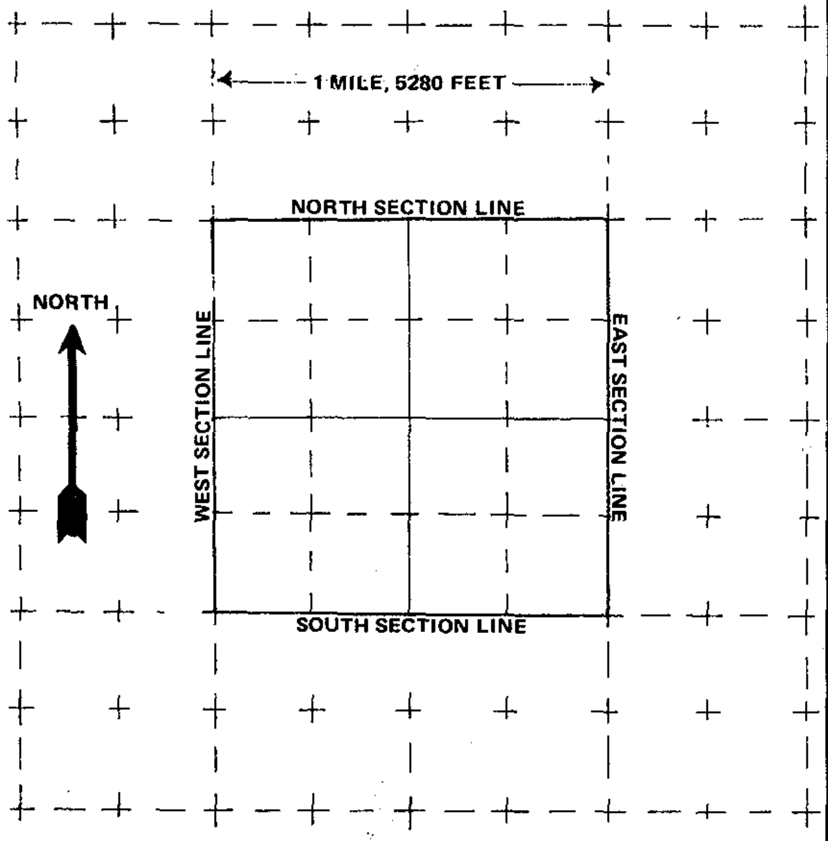
APPROVED AS A REPLACEMENT OF WELL NO. 80996 THE EXISTING WELL MUST BE PLUGGED AND ABANDONED ACCORDING TO THE REVISED AND AMENDED RULES AND REGULATIONS FOR WATER WELL AND PUMP INSTALLATION CONTRACTORS. THE ENCLOSED AFFIDAVIT MUST BE SUBMITTED WITHIN SIXTY (60) DAYS AFTER THE CONSTRUCTION OF THE NEW WELL, AFFIRMING THAT WELL NO. 80996 WAS PLUGGED AND ABANDONED.

PERMIT EXPIRATION EXTENDED ONE YEAR TO SEPTEMBER 22, 1978. APPROVED BY: RGH

APPLICATION APPROVED

PERMIT NUMBER 80996-A
DATE ISSUED SEP 22 1975
EXPIRATION DATE SEP 22 1977
Bruce E. DeBrine
Deputy (STATE ENGINEER)
BY
I.D. 1-05 COUNTY 07

(5) THE LOCATION OF THE PROPOSED WELL and the area on which the water will be used must be indicated on the diagram below. Use the CENTER SECTION (1 section, 640 acres) for the well location.



The scale of the diagram is 2 inches = 1 mile
Each small square represents 40 acres.

WATER EQUIVALENTS TABLE (Rounded Figures)

An acre-foot covers 1 acre of land 1 foot deep
1 cubic foot per second (cfs) . . . 449 gallons per minute (gpm)
A family of 5 will require approximately 1 acre-foot of water per year.
1 acre-foot . . . 43,560 cubic feet . . . 325,900 gallons.
1,000 gpm pumped continuously for one day produces 4.42 acre-feet.

(6) THE WELL MUST BE LOCATED BELOW by distances from section lines.

✓ 200 ft. from ✓ North (north or south) sec. line

✓ 940 ft. from ✓ East (east or west) sec. line

LOT ______ BLOCK ______ FILING # ______

SUBDIVISION ______

(7) TRACT ON WHICH WELL WILL BE LOCATED Owner: ✓ A. Read

No. of acres ✓ 10 . Will this be the only well on this tract? ✓ ~~No~~ Yes

(8) PROPOSED CASING PROGRAM

Plain Casing

✓ 5 in. from ✓ 0 1' above ft. to ✓ 25 ft.

______ in. from ______ ft. to ______ ft.

Perforated casing

✓ 5 in. from ✓ 25 ft. to ✓ 65 ft.

______ in. from ______ ft. to ______ ft.

(9) FOR REPLACEMENT WELLS give distance and direction from old well and plans for plugging it:

✓100 ft south
✓Fill with gravel 5 ft above
✓water table then compacted
✓earth to ground level

(10) LAND ON WHICH GROUND WATER WILL BE USED:

Owner(s): ✓ Arnold E. Read Josephine R. Read No. of acres: ✓ 10

Legal description: ______

(11) DETAILED DESCRIPTION of the use of ground water: Household use and domestic wells must indicate type of disposal system to be used.

Domestic and Livestock
Septic tank and Leach field

(12) OTHER WATER RIGHTS used on this land, including wells.

Type or right	Used for (purpose)	Description of land on which used
✓ 16.5 Acre-feet Rice Ditch	Irrigation	✓ Farm Land

(13) THE APPLICANT(S) STATE(S) THAT THE INFORMATION SET FORTH HEREON IS TRUE TO THE BEST OF HIS KNOWLEDGE.

X
SIGNATURE OF APPLICANT(S)

Use additional sheets of paper if more space is required.

RICHARD D. LAMM
Governor

C.J. KUIPER
State Engineer

DIVISION OF WATER RESOURCES

Department of Natural Resources
1313 Sherman Street - Room 818
Denver, Colorado 80203
Administration (303) 892-3581
Ground Water (303) 892-3587

September 21, 1977

Mr. Paul Balbin
Western Star Drilling Company
Sugarloaf Star Route
Boulder, CO 80302

RE: Well Permit No. 80996-A

Dear Mr. Balbin:

Your request for an extension of time to construct the proposed well and put the water from it to beneficial use has been received and reviewed.

You are hereby given notice that an extension of one year to September 22, 1978, has been approved by the State Engineer and a copy of the extended permit is enclosed. Please be advised that additional extensions may not be approved.

If you have questions regarding this matter, please contact this office.

Very truly yours,

Reiner G. Haubold
Water Resources Engineer
Ground Water Section

RGH/DJA:ew
Encl.

Appendix C-2

Select permit information for nearby water well: Permit No. 67883-F

FORM NO.
GWS-31
04/2005

WELL CONSTRUCTION AND TEST REPORT

STATE OF COLORADO, OFFICE OF THE STATE ENGINEER
1313 Sherman St., Room 818, Denver, CO 80203
Phone – Info (303) 866-3587 Main (303) 866-3581
Fax (303) 866-3589 http://www.water.state.co.us

For Office Use Only

RECEIVED
NOV 09 2009
WATER RESOURCES
STATE ENGINEER
COLO.

1. **WELL PERMIT NUMBER:** 67883-F

2. **WELL OWNER INFORMATION**

NAME OF WELL OWNER: City of Longmont
MAILING ADDRESS: 385 Kimbark Street
CITY: Longmont STATE: CO ZIP CODE: 80501
TELEPHONE NUMBER: (303) 651 - 8330

3. WELL LOCATION AS DRILLED: SE 1/4, NE 1/4, Sec. 11, Twp. 2 ☒ N or ☐ S, Range 69 ☐ E or ☒ W
DISTANCES FROM SEC. LINES: 2571 ft. from ☒ N or ☐ S section line and 47 ft. from ☒ E or ☐ W section line.
SUBDIVISION: ______, LOT ____, BLOCK ____, FILING (UNIT) ____
Optional GPS Location: GPS Unit must use the following settings: Format must be **UTM**, Units must be **meters**, Datum must be **NAD83**, Unit must be set to **true N**, ☐ Zone 12 or ☐ Zone 13
Owner's Well Designation: ______
Easting: ______
Northing: ______
STREET ADDRESS AT WELL LOCATION: 9762 N. 119th St. Longmont, CO 8050

4. GROUND SURFACE ELEVATION 4913 feet DRILLING METHOD Open Excavation
DATE COMPLETED 7/16/2009 TOTAL DEPTH 16 feet DEPTH COMPLETED 16 feet

5. GEOLOGIC LOG:

Depth	Type	Grain Size	Color	Water Loc.
0-16	Sand & Gravel	3"-	Tan	8'2"

Remarks: ______

6. HOLE DIAM (in.) From (ft) To (ft)
N/A

7. PLAIN CASING:

OD (in) Kind Wall Size (in) From (ft) To (ft)
See Attached Drawings

PERFORATED CASING: Screen Slot Size (in): ____

8. FILTER PACK:
Material See Attached
Size Drawings
Interval

9. PACKER PLACEMENT:
Type See Attached Drawings
Depth

10. GROUTING RECORD

Material Amount Density Interval Placement
See Attached Drawings

11. DISINFECTION: Type HTH Amt. Used 1lb

12. WELL TEST DATA: ☐ Check box if Test Data is submitted on Form Number GWS 39 Supplemental Well Test.

TESTING METHOD Submersible
Static Level 8'2" ft. Date/Time measured: 9/8/2009, Production Rate 201 gpm.
Pumping Level 13'1" ft. Date/Time measured 9/8/2009, Test Length (hrs) 30 min.
Remarks:

13. I have read the statements made herein and know the contents thereof, and they are true to my knowledge. This document is signed and certified in accordance with Rule 17.4 of the Water Well Construction Rules, 2 CCR 402-2. [The filing of a document that contains false statements is a violation of section 37-91-108(1)(e), C.R.S., and is punishable by fines up to $5000 and/or revocation of the contracting license.]

Company Name: Crall & Bowes, Inc.
Phone: (303)772-7290
License Number: 857
Mailing Address: 1877 Vista View Drive, Longmont, CO 80504
Signature: Glenn Clement
Print Name and Title: Glenn Clement Special Consultant To Crall & Bowes
Date: 9-11-09

3636843

STATE OF COLORADO

BOARD OF EXAMINERS OF WATER WELL CONSTRUCTION AND PUMP INSTALLATION CONTRACTORS
Division of Water Resources

1313 Sherman Street, Room 818
Denver, CO 80203
Phone (303) 866-3581
FAX (303) 866-3589

http://www.water.state.co.us/boe

Bill Ritter, Jr.
Governor

Harris D. Sherman
Executive Director, DN

Dick Wolfe, P.E.
Secretary

RECEIVED
NOV 09 2009
WATER RESOURCES
STATE ENGINEER
COLO.

1876

February 6, 2009

RECEIVED
FEB 13 2009
Loris and Associates, Inc.

FILE COPY

City of Longmont
385 Kimbark Street
Longmont, Colorado 80501

RE: Request for Approval of Plans for Construction of a Gallery-Type Dewatering Well, Permit Application Receipt No. 3636843, SE ¼, NE ¼, Section 11, Township 2 North, Range 69 West, Sixth P.M., Boulder County.

Request No: 2009-008A

A request for approval of plans for the construction of a gallery-type dewatering well to be used as an underdrain system to control shallow ground water beneath a proposed underpass for the St. Vrain Greenway was submitted by Loris and Associates, Inc., along with well permit application receipt number 3636843 on January 28, 2009. The request has been reviewed for the Board of Examiners of Water Well Construction and Pump Installation Contractors. The request is specifically for approval of plans to construct a gallery-type dewatering well as required by Rule 10.4.12.

Pursuant to Rules 10.4.12 and 18, and the authority granted by the Board, the construction plans are approved subject to the following conditions:

1. The well construction shall be in accordance with the Water Well Construction Rules except those Rules for which a variance is granted herein. Unless written approval for a modification to this variance is obtained, all conditions and requirements of this variance approval shall be satisfied, or the entire variance shall be void, and all standards of the Construction Rules applicable.
2. The gallery-type well shall be constructed in accordance with the plans and diagrams submitted with the permit application, except as modified herein.
3. Discharge from the dewatering gallery must be in accordance with the well permit.
4. Water from the dewatering well shall not be used for human consumption, or for any other purpose not specifically approved by well permit.
5. The well must be constructed by a licensed water well construction contractor or by the owner with equipment both owned and operated by the owner.
6. The Well Construction and Test Report (Form GWS-31) must be completed and filed within 60 days of completion of the well and the Pump Installation and Test Report

(Form GWS-32) must be submitted within 60 days of installation of pumping equipment.

Owner and contractors are also advised that Rule 6.6 of the Construction Rules requires that the construction comply with any federal, state, county, municipal or local government laws, regulations or codes that are more stringent than these Rules, including distance requirements from sources of contaminants, or contain standards not covered by these Rules.

Approval of this request does not relieve the owner of potential responsibility or liability in the event contamination of the water source results from construction, nor does the grantor assume any responsibility or liability should contamination occur.

If you have any questions, please contact this office.

Sincerely,

Michael P Schaubs, P.G.
Senior Geologist, Geotechnical Services Branch
Division of Water Resources

cc: Well Permit File
Loris and Associates

Form No.
GWS-25

OFFICE OF THE STATE ENGINEER
COLORADO DIVISION OF WATER RESOURCES

818 Centennial Bldg., 1313 Sherman St., Denver, Colorado 80203
(303) 866-3581

FILE COPY

LIC

WELL PERMIT NUMBER 67883 -F -
DIV. 1 WD 6 DES. BASIN MD

APPLICANT

RECEIVED
NOV 09 2009
WATER RES...
STATE ENGINEER
COLO.

CITY OF LONGMONT
385 KIMBARK STREET
LONGMONT, CO 80501-

(303) 651-8330

APPROVED WELL LOCATION
BOULDER COUNTY
SE 1/4 NE 1/4 Section 11
Township 2 N Range 69 W Sixth P.M.

DISTANCES FROM SECTION LINES
2571 Ft. from North Section Line
47 Ft. from East Section Line

UTM COORDINATES (Meters,Zone:13,NAD83)
Easting: Northing:

PERMIT TO CONSTRUCT A WELL

ISSUANCE OF THIS PERMIT DOES NOT CONFER A WATER RIGHT

CONDITIONS OF APPROVAL

1) This well shall be used in such a way as to cause no material injury to existing water rights. The issuance of this permit does not assure the applicant that no injury will occur to another vested water right or preclude another owner of a vested water right from seeking relief in a civil court action.
2) The construction of this well shall be in compliance with the Water Well Construction Rules 2 CCR 402-2, unless approval of a variance has been granted by the State Board of Examiners of Water Well Construction and Pump Installation Contractors in accordance with Rule 18.
3) Approved pursuant to CRS 37-90-137(2) for the construction of a dewatering well (underdrain system) to withdraw ground water from Saint Vrain Creek which is tributary to the South Platte River. The underdrain system will be used to control shallow ground water beneath a proposed underpass for the Saint Vrain Greenway.
4) The well shall be constructed and maintained in accordance with variance no. 2009-008A, granted by the Board of Examiners of Water Well Construction and Pump Installation Contractors on February 6, 2009.
5) All ground water diverted must be discharged to Saint Vrain Creek without consumptive use or evaporative losses.
6) The owner shall mark the well in a conspicuous place with well permit number(s), name of the aquifer, and court case number(s) as appropriate. The owner shall take necessary means and precautions to preserve these markings.
7) This well shall be constructed at least 600 feet from any existing well, completed in the same aquifer, that is not owned by the applicant.
8) This well shall be constructed not more than 200 feet from the location specified on this permit.
9) This well is subject to administration by the Division Engineer in accordance with applicable decrees, statutes, rules, and regulations.

02.09.2009
I.O.C.

APPROVED
IDC

Dick Wolfe
State Engineer

By

Receipt No. 3636843

DATE ISSUED 02-09-2009

EXPIRATION DATE 02-09-2010

REVISIONS

BY	DATE	DESCRIPTION

DRAWN RLF

CHECKED MAT

DESIGNED RLF

FILENAME 001_Topo Exhibit

MUSTANG

AERIAL TOPO EXHIBIT

TST

TST, INC.
CONSULTING ENGINEERS
748 Whalers Way
Suite 200 Fort Collins
Colorado 80525
Phone: 970.226.0557

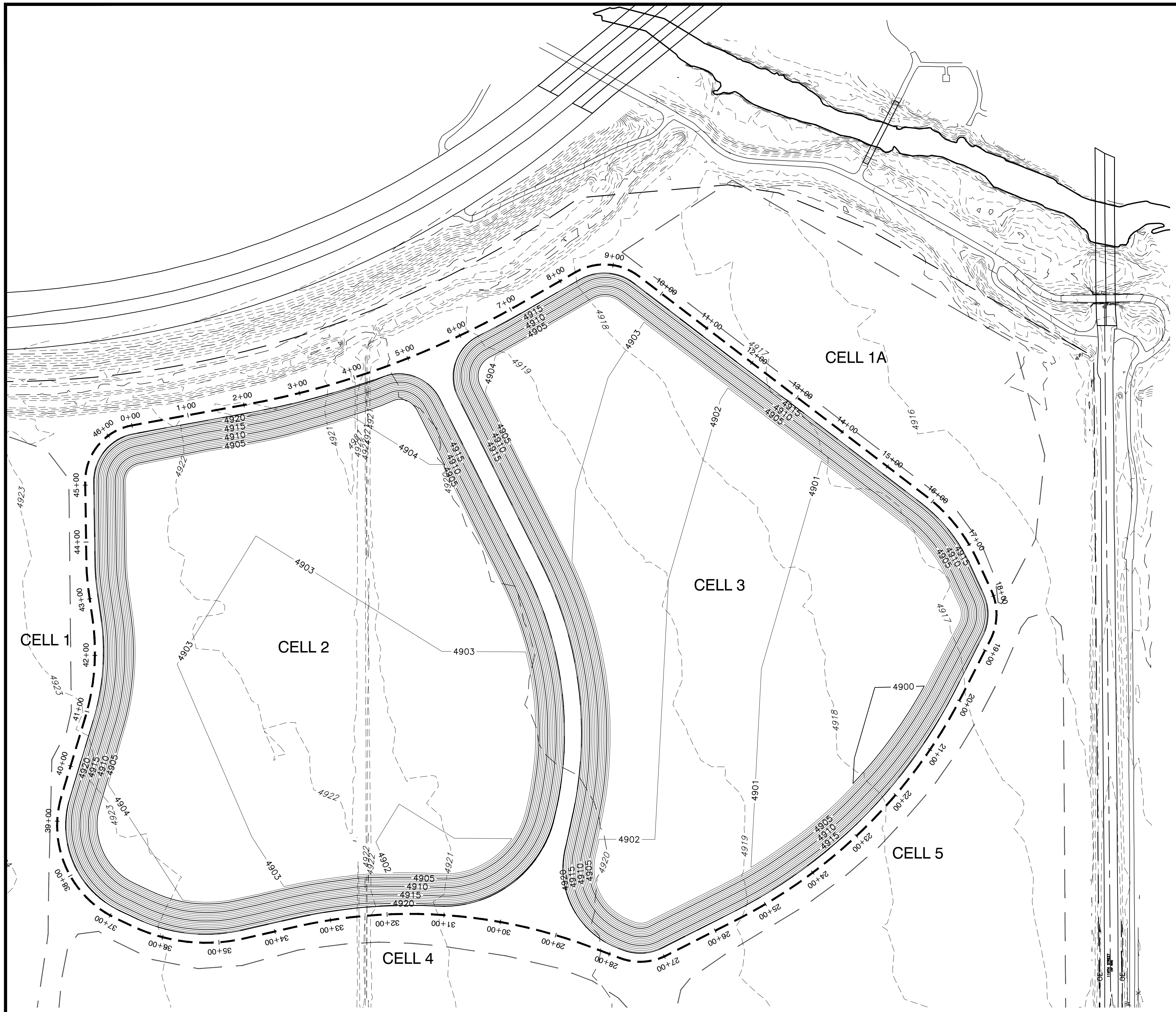
JOB NO. 1241.0001.00

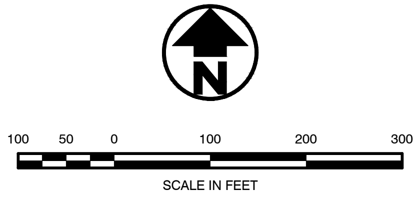
SCALE 1" = 150'

DATE JANUARY 2020

SHEET 1 of 1

P:\22012 NCC AI Slurry Wall Irwin Thomas Property\Drawings\Plan Sheets\Slurry Wall\JT-Irwin-Slurry.dwg, 1 Horizontal Control Plan, 4/7/2023 2:09:06 PM





J&T Consulting, Inc.

305 Denver Avenue - Suite D
Fort Lupton, CO 80621
Ph: 303-857-6222 Fax: 303-857-6224
www.j-tconsulting.com

Irwin-Thomas Slurry Wall

Horizontal Control Plan

Northern Colorado Constructors

REVISIONS

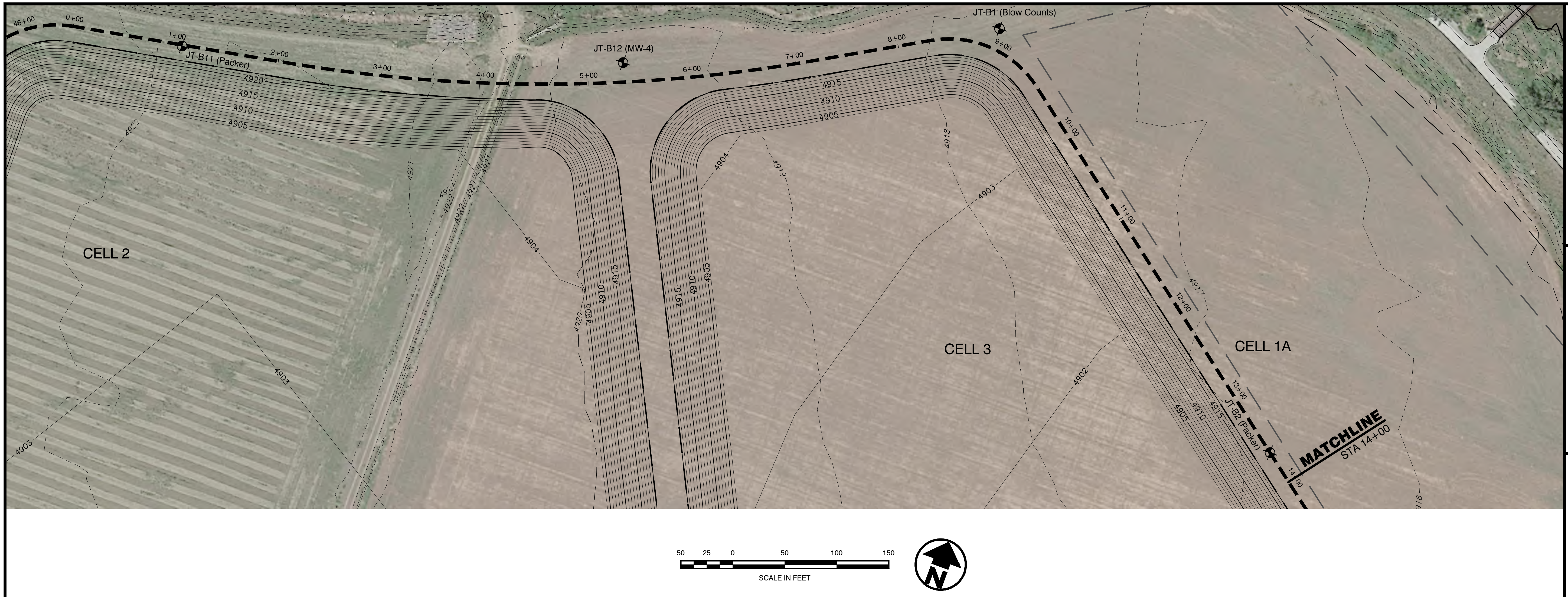
No	Date	By	Chk	Description

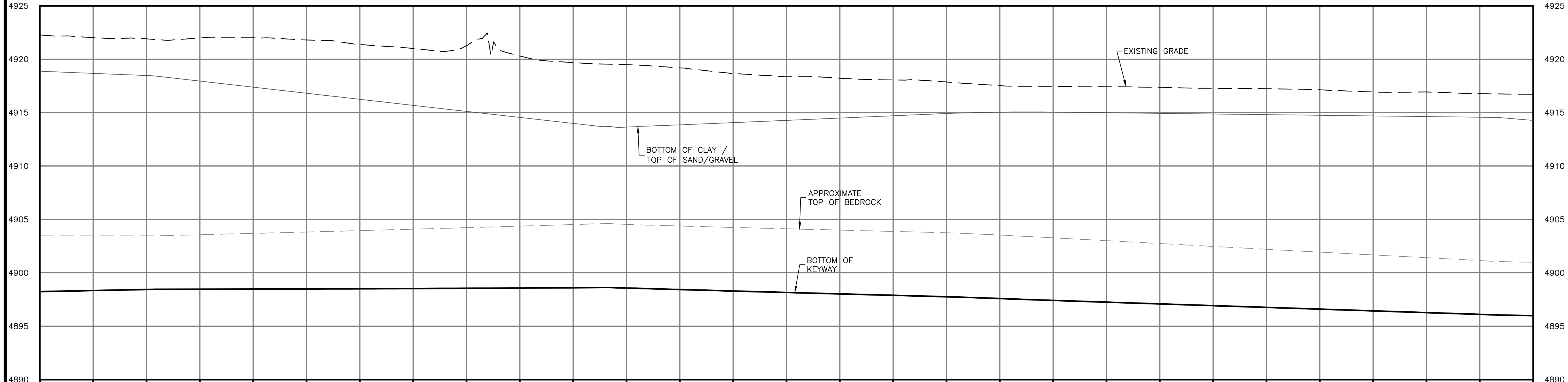
PRELIMINARY

Job #	22012
Date	3.31.23
Drawn By	TPY
Designed By	TPY
Checked By	JCY
File	JT-Irwin-Slurry.dwg
Scale	As Shown

Sheet: 1 Of: 6

P:\22012 NCC AI Slurry Wall Irwin Thomas Property\Drawings\Plan Sheets\Slurry Wall\JT-Irwin-Slurry.dwg, 2 Slurry Wall Plan & Profile Sta 0+00 to 1400, 3/31/2023 11:55:27 AM





Station	Existing	Top Bedrock	Bot Keyway	SW Depth
0+00	4922.28	4903.45	4898.24	24.04
0+50	4922.03	4903.45	4898.34	23.69
1+00	4921.91	4903.45	4898.44	23.47
1+50	4921.99	4903.56	4898.46	23.53
2+00	4922.06	4903.69	4898.47	23.58
2+50	4921.80	4903.82	4898.49	23.32
3+00	4921.37	4903.95	4898.50	22.87
3+50	4921.02	4904.08	4898.52	22.49
4+00	4921.27	4904.22	4898.55	22.72
4+50	4920.31	4904.37	4898.57	21.74
5+00	4919.69	4904.52	4898.60	21.08
5+50	4919.49	4904.54	4898.57	20.92
6+00	4919.19	4904.38	4898.43	20.76
6+50	4918.67	4904.25	4898.29	20.38
7+00	4918.36	4904.12	4898.16	20.20
7+50	4918.23	4904.00	4898.02	20.20
8+00	4918.06	4903.87	4897.89	20.17
8+50	4917.87	4903.74	4897.76	20.11
9+00	4917.53	4903.54	4897.59	19.94
9+50	4917.47	4903.27	4897.41	20.06
10+00	4917.42	4903.01	4897.25	20.17
10+50	4917.38	4902.74	4897.09	20.29
11+00	4917.28	4902.47	4896.92	20.36
11+50	4917.24	4902.21	4896.76	20.48
12+00	4917.13	4901.94	4896.59	20.54
12+50	4916.94	4901.67	4896.43	20.51
13+00	4916.93	4901.41	4896.27	20.66
13+50	4916.78	4901.14	4896.10	20.68
14+00	4916.72	4900.98	4895.98	20.73

J&T Consulting, Inc.

305 Denver Avenue - Suite D
Fort Lupton, CO 80621
Ph: 303-857-6222 Fax: 303-857-6224
www.j-tconsulting.com

Irwin-Thomas Slurry Wall

Slurry Wall Plan & Profile
Sta 0+00 To 1400

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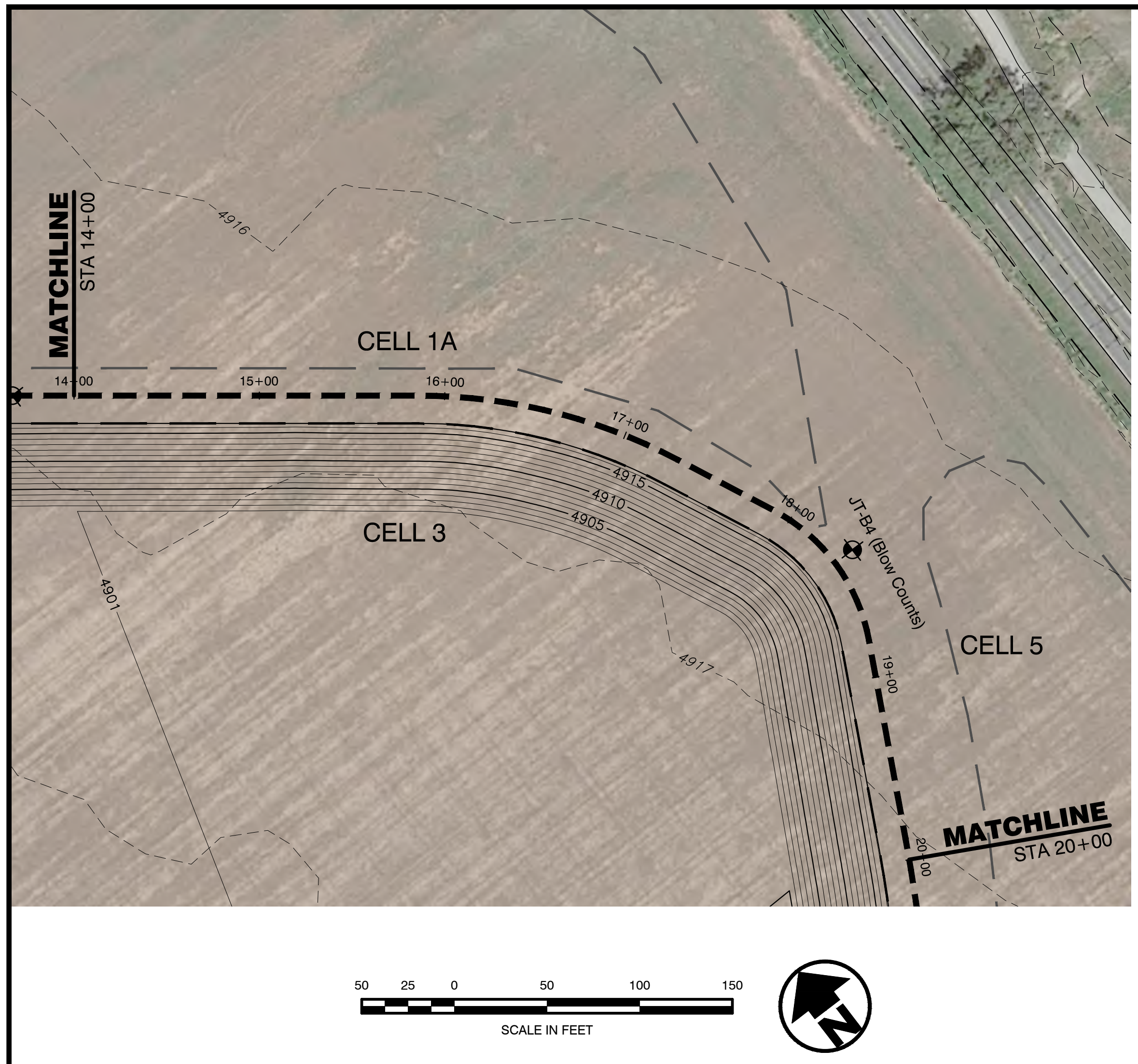

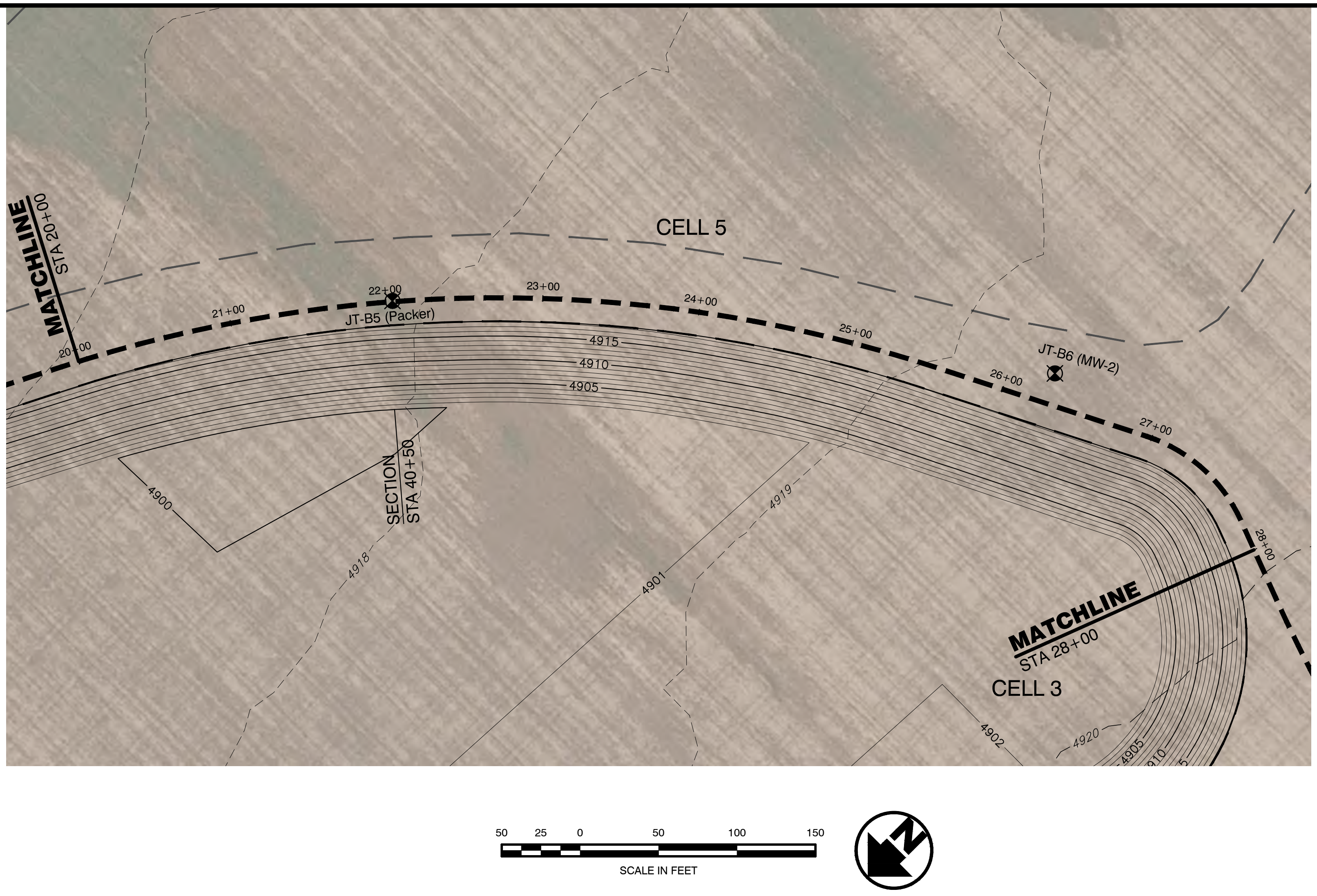

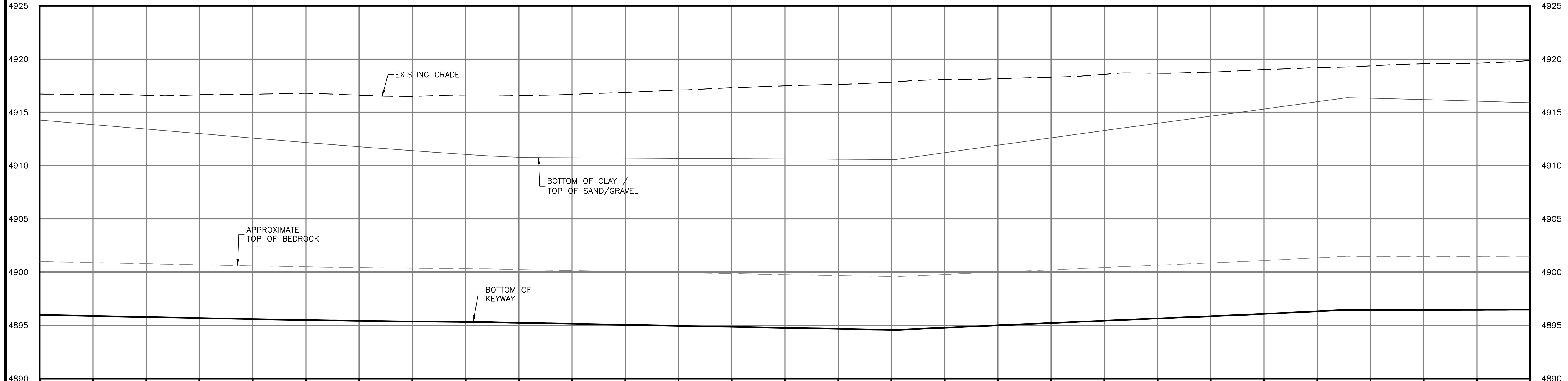

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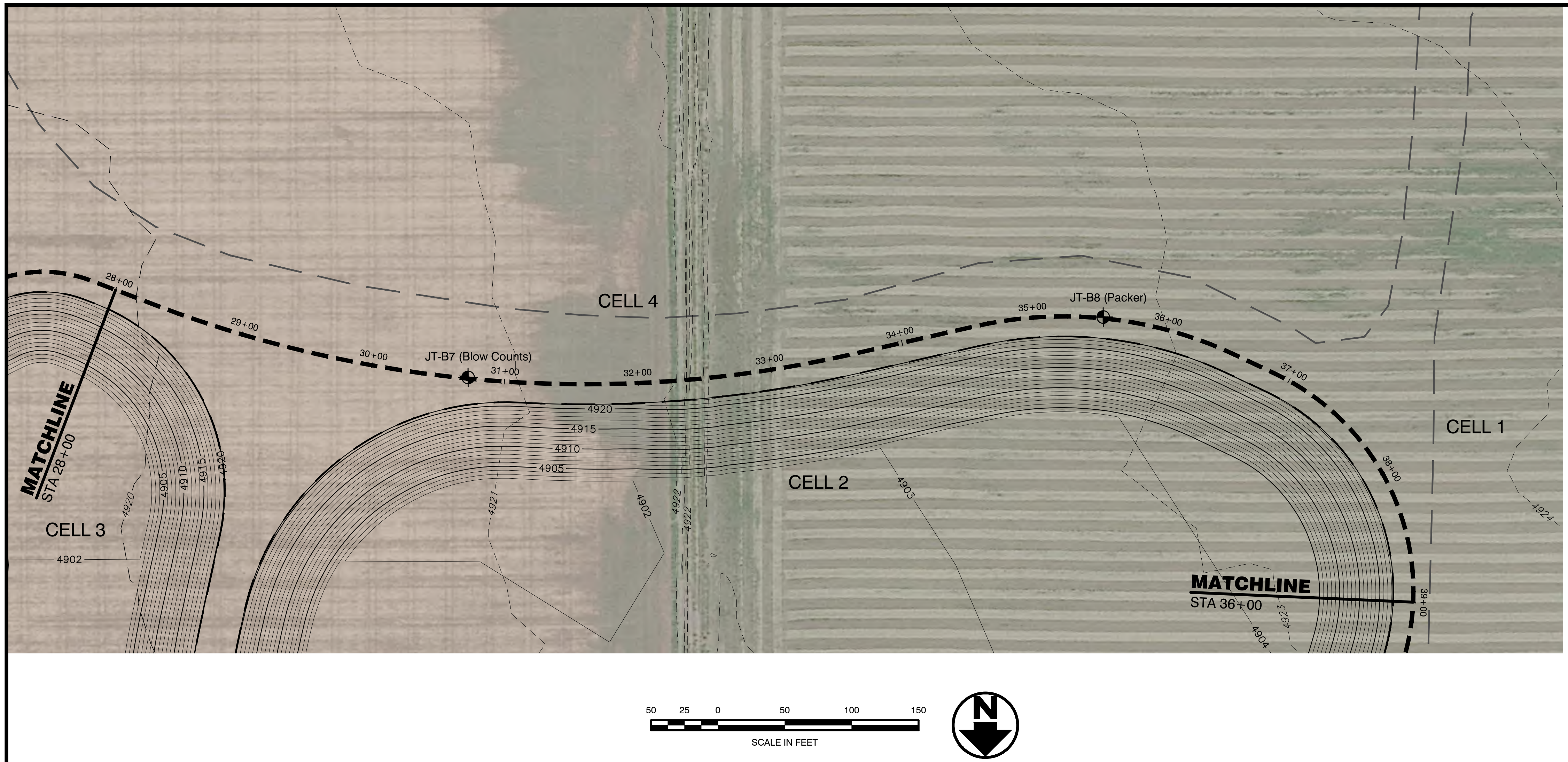

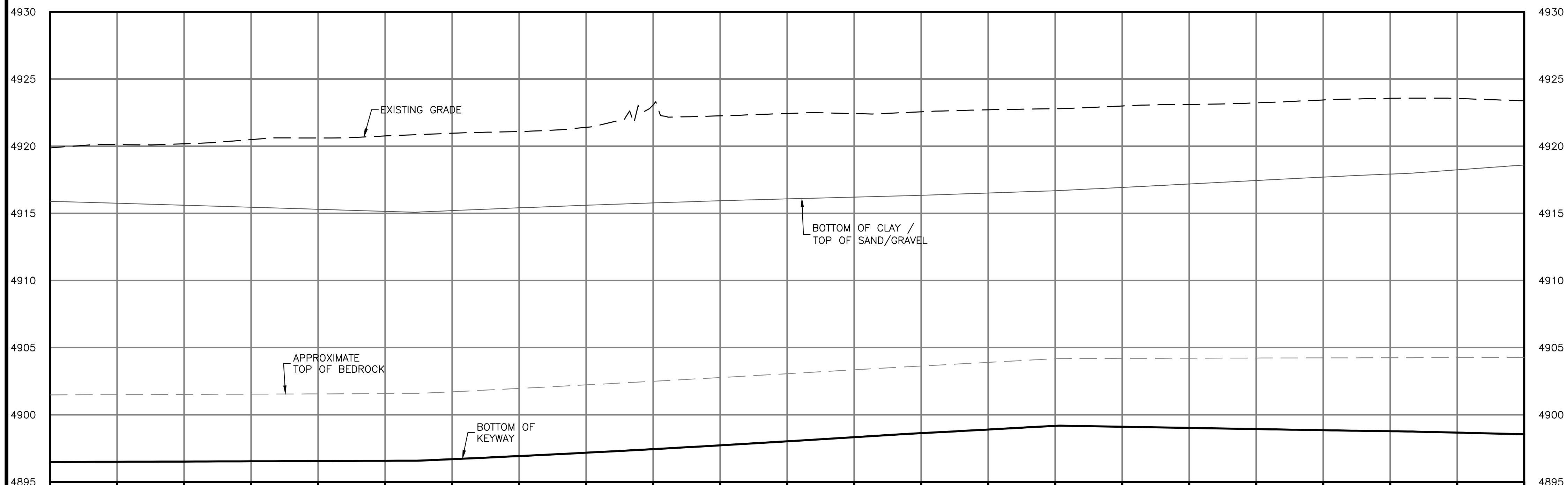

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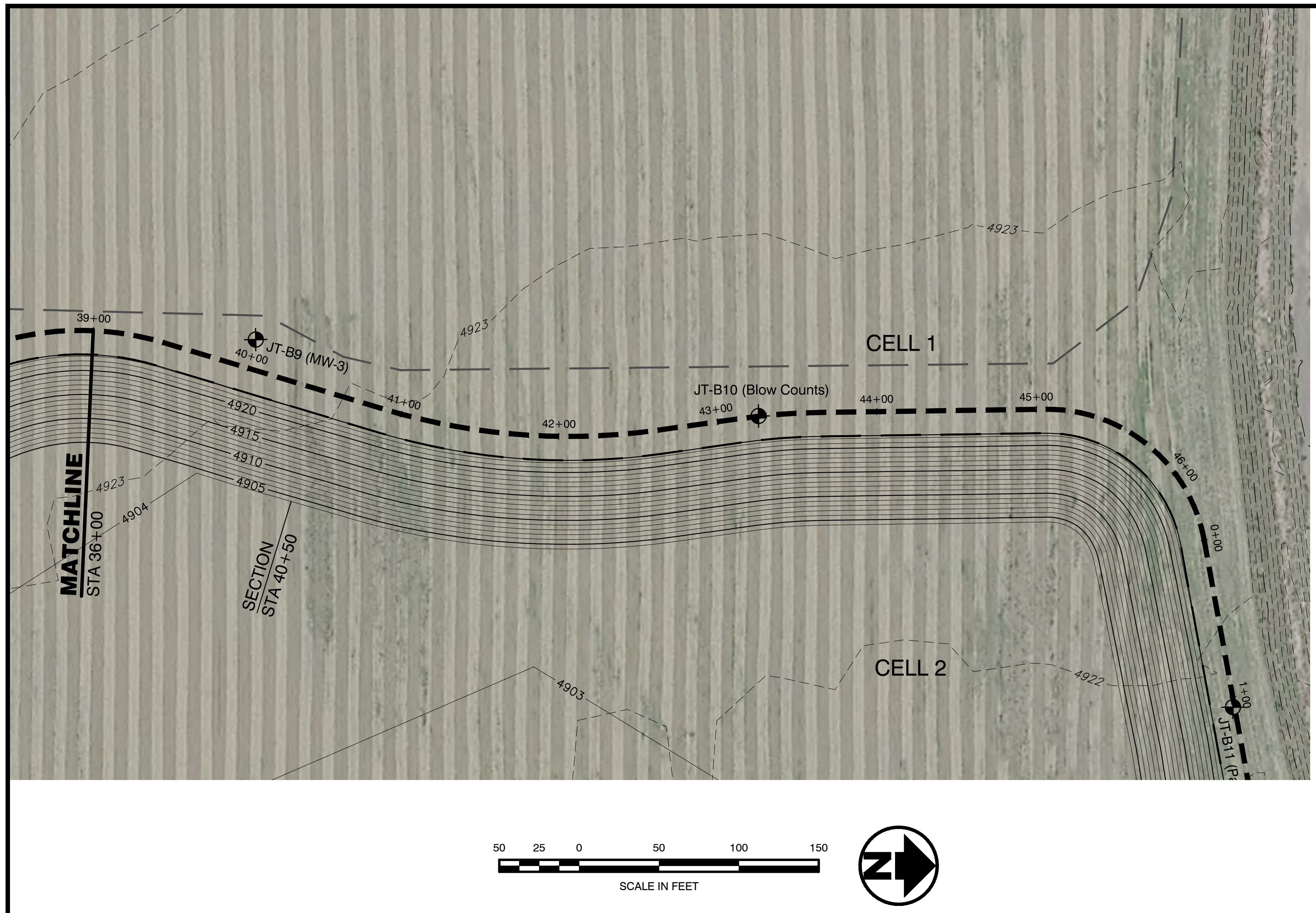

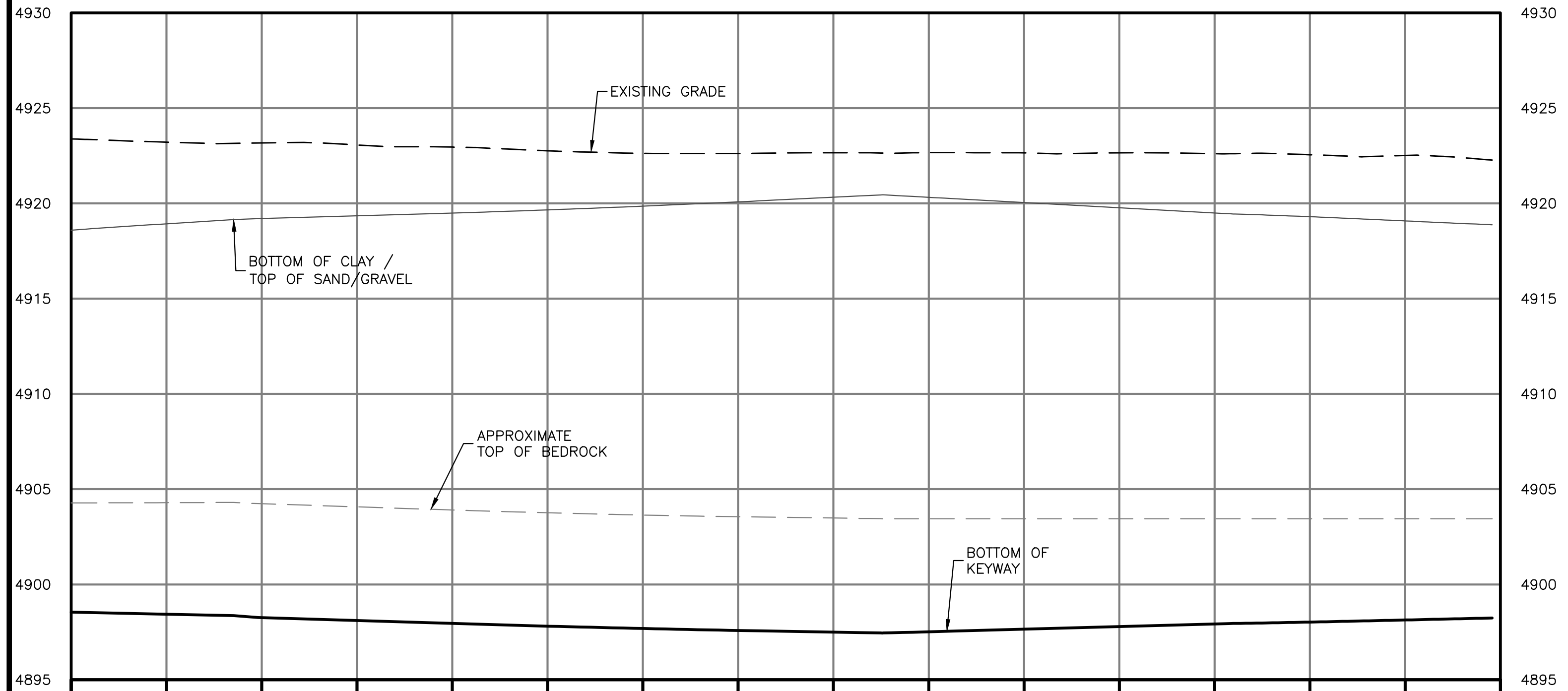

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41+00	4922.96	4903.91	4897.95	25.01
41+50	4922.76	4903.76	4897.81	24.95
42+00	4922.62	4903.64	4897.69	24.94
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46+50				

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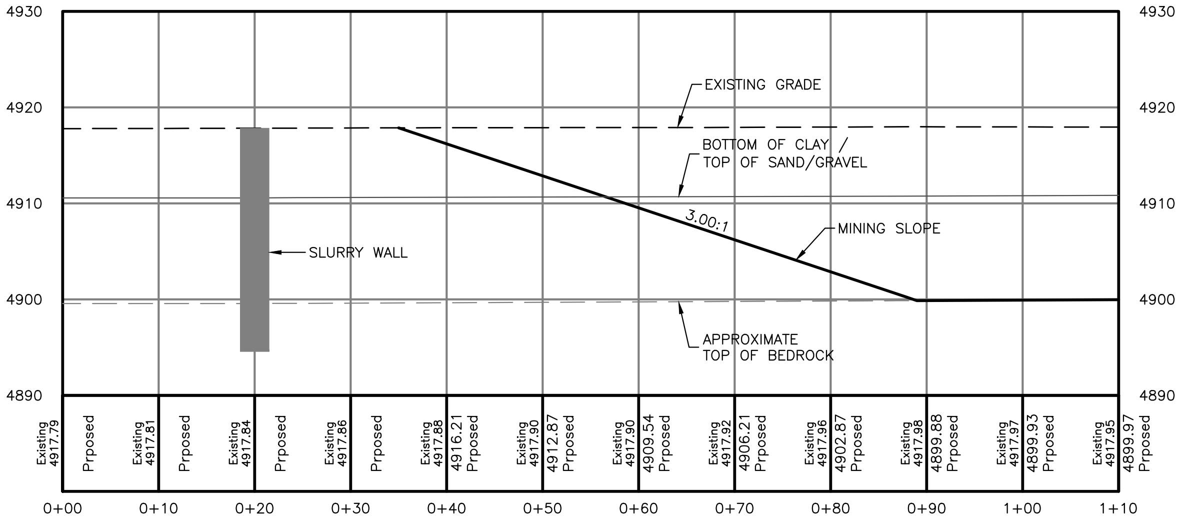
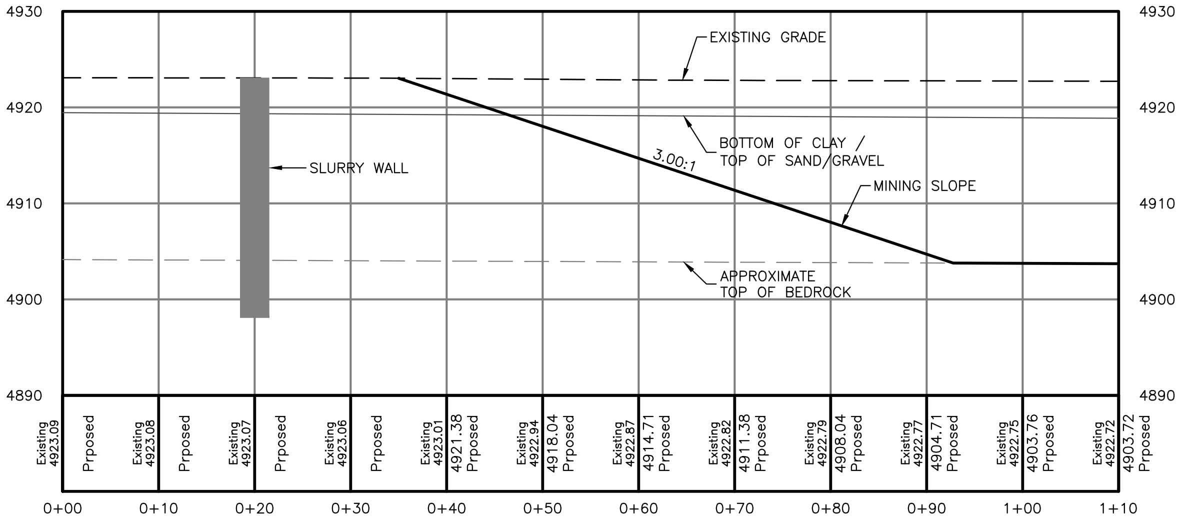


CROSS-SECTION STA 22+00

SCALE 1" = 10'



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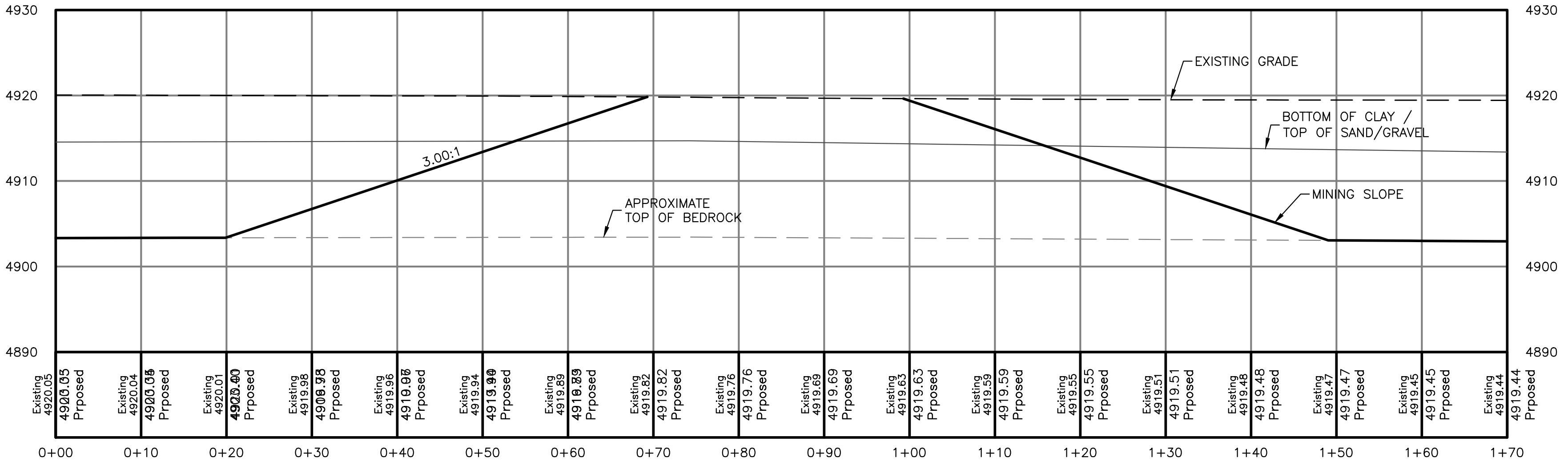

BERM CROSS-SECTION

SCALE 1" = 10'

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Cross-Sections

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CMT TECHNICAL SERVICES

GEOTECHNICAL STUDY

Irwin-Thomas Slurry Wall Design
Longmont, Colorado

Prepared for:

J.C. York, P.E.
J&T Consulting, Inc.
305 Denver Avenue, Suite D
Fort Lupton, CO 80621

Project No. 22.3059.A
February 17, 2023

Colorado Regional Office: 7108 South Alton Way, Building B • Centennial, CO 80112
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CMT TECHNICAL SERVICES

GEOTECHNICAL STUDY

Irwin-Thomas Slurry Wall Design
Longmont, Colorado

Prepared for:

J.C. York, P.E.
J&T Consulting, Inc.
305 Denver Avenue, Suite D
Fort Lupton, CO 80621

Project No. 22.3059.A
February 17, 2023

Prepared by:

Jonathan A Crystal

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COMMON ABBREVIATIONS

AASHTO	**American Association of State Highway and Transportation Officials**
ABC	**aggregate base course**
ACI	**American Concrete Institute**
ADA	**Americans with Disabilities Act**
ADSC	**Association of Drilled Contractors**
AI	**Asphalt Institute**
APM	**asphalt paving material**
ASCE	**American Society of Civil Engineers**
ASTM	**American Society for Testing and Materials**
AWWA	**American Water Works Association**
bgs	**below ground surface**
CDOT	**Colorado Department of Transportation**
CBR	**California Bearing Ratio**
CSEO	**Colorado State Engineers Office**
CFR	**Code of Federal Regulations**
cfs	**cubic feet per second**
CGS	**Colorado Geological Survey**
CKD	**cement of kiln dust stabilized subgrade**
cms	**centimeters per second**
CMU	**concrete masonry unit**
CTB	**cement treated base course**
deg	**degree**
EDLA	**equivalent daily load application**
e_m	**edge moisture variation distance**
EPS	**expanded polystyrene**
ESAL	**equivalent single axle loads**
f’c	**specified compressive strength of concrete at the age of 28 days**
F_a	**seismic site coefficient**
FHWA	**Federal Highway Administration**
FS	**factor of safety**
F_v	**seismic site coefficient**
GSA	**global stability analysis**
GVW	**gross vehicle weight**
IBC	**International Building Code**
ICC-ES	**International Code Council Evaluation Services, Inc.**
IRC	**International Residential Code**
kip	**1,000 pounds-force**
km	**kilometer**
LTS	**lime treated subgrade**
MDD	**maximum dry density**
mg/L	**milligrams per liter**
MGPEC	**Metropolitan Government Pavement Engineers Council**
mm	**millimeter**
Mr	**resilient modulus**
MSE	**mechanically stabilized earth**
mV	**millivolts**

NAPA	**National Asphalt Pavement Association**
N_{DESIGN}	**design gyrations**
OSHA	**Occupational Safety and Health Administration**
OMC	**optimum moisture content**
OWTS	**onsite wastewater treatment system**
PCA	**Portland Cement Association**
PCC	**portland cement concrete**
pcf	**pounds per cubic foot**
pci	**pounds per cubic inch**
pH	**power of hydrogen**
psf	**pounds per square foot**
psi	**pounds per square inch**
PT	**post-tension**
RAP	**recycled asphalt pavement**
ROW	**right of way**
S_s	**mapped spectral accelerations for short periods**
UBC	**Uniform Building Code**
USGS	**United States Geological Survey**

Important Information about This

Geotechnical-Engineering Report

Subsurface problems are a principal cause of construction delays, cost overruns, claims, and disputes.

While you cannot eliminate all such risks, you can manage them. The following information is provided to help.

The Geoprofessional Business Association (GBA) has prepared this advisory to help you – assumedly a client representative – interpret and apply this geotechnical-engineering report as effectively as possible. In that way, you can benefit from a lowered exposure to problems associated with subsurface conditions at project sites and development of them that, for decades, have been a principal cause of construction delays, cost overruns, claims, and disputes. If you have questions or want more information about any of the issues discussed herein, contact your GBA-member geotechnical engineer. Active engagement in GBA exposes geotechnical engineers to a wide array of risk-confrontation techniques that can be of genuine benefit for everyone involved with a construction project.

Understand the Geotechnical-Engineering Services Provided for this Report

Geotechnical-engineering services typically include the planning, collection, interpretation, and analysis of exploratory data from widely spaced borings and/or test pits. Field data are combined with results from laboratory tests of soil and rock samples obtained from field exploration (if applicable), observations made during site reconnaissance, and historical information to form one or more models of the expected subsurface conditions beneath the site. Local geology and alterations of the site surface and subsurface by previous and proposed construction are also important considerations. Geotechnical engineers apply their engineering training, experience, and judgment to adapt the requirements of the prospective project to the subsurface model(s). Estimates are made of the subsurface conditions that will likely be exposed during construction as well as the expected performance of foundations and other structures being planned and/or affected by construction activities.

The culmination of these geotechnical-engineering services is typically a geotechnical-engineering report providing the data obtained, a discussion of the subsurface model(s), the engineering and geologic engineering assessments and analyses made, and the recommendations developed to satisfy the given requirements of the project. These reports may be titled investigations, explorations, studies, assessments, or evaluations. Regardless of the title used, the geotechnical-engineering report is an engineering interpretation of the subsurface conditions within the context of the project and does not represent a close examination, systematic inquiry, or thorough investigation of all site and subsurface conditions.

Geotechnical-Engineering Services are Performed for Specific Purposes, Persons, and Projects, and At Specific Times

Geotechnical engineers structure their services to meet the specific needs, goals, and risk management preferences of their clients. A geotechnical-engineering study conducted for a given civil engineer will not likely meet the needs of a civil-works constructor or even a different civil engineer. Because each geotechnical-engineering study is unique, each geotechnical-engineering report is unique, prepared *solely* for the client.

Likewise, geotechnical-engineering services are performed for a specific project and purpose. For example, it is unlikely that a geotechnical-engineering study for a refrigerated warehouse will be the same as one prepared for a parking garage; and a few borings drilled during a preliminary study to evaluate site feasibility will not be adequate to develop geotechnical design recommendations for the project.

Do not rely on this report if your geotechnical engineer prepared it:

- for a different client;
- for a different project or purpose;
- for a different site (that may or may not include all or a portion of the original site); or
- before important events occurred at the site or adjacent to it; e.g., man-made events like construction or environmental remediation, or natural events like floods, droughts, earthquakes, or groundwater fluctuations.

Note, too, the reliability of a geotechnical-engineering report can be affected by the passage of time, because of factors like changed subsurface conditions; new or modified codes, standards, or regulations; or new techniques or tools. *If you are the least bit uncertain* about the continued reliability of this report, contact your geotechnical engineer before applying the recommendations in it. A minor amount of additional testing or analysis after the passage of time – if any is required at all – could prevent major problems.

Read this Report in Full

Costly problems have occurred because those relying on a geotechnical-engineering report did not read the report in its entirety. Do not rely on an executive summary. Do not read selective elements only. *Read and refer to the report in full.*

You Need to Inform Your Geotechnical Engineer About Change

Your geotechnical engineer considered unique, project-specific factors when developing the scope of study behind this report and developing the confirmation-dependent recommendations the report conveys. Typical changes that could erode the reliability of this report include those that affect:

- the site's size or shape;
- the elevation, configuration, location, orientation, function or weight of the proposed structure and the desired performance criteria;
- the composition of the design team; or
- project ownership.

As a general rule, *always* inform your geotechnical engineer of project or site changes – even minor ones – and request an assessment of their impact. *The geotechnical engineer who prepared this report cannot accept* *responsibility or liability for problems that arise because the geotechnical engineer was not informed about developments the engineer otherwise would have considered.*

Most of the "Findings" Related in This Report Are Professional Opinions

Before construction begins, geotechnical engineers explore a site's subsurface using various sampling and testing procedures. *Geotechnical engineers can observe actual subsurface conditions only at those specific locations where sampling and testing is performed.* The data derived from that sampling and testing were reviewed by your geotechnical engineer, who then applied professional judgement to form opinions about subsurface conditions throughout the site. Actual sitewide-subsurface conditions may differ – maybe significantly – from those indicated in this report. Confront that risk by retaining your geotechnical engineer to serve on the design team through project completion to obtain informed guidance quickly, whenever needed.

This Report's Recommendations Are Confirmation-Dependent

The recommendations included in this report – including any options or alternatives – are confirmation-dependent. In other words, they are not final, because the geotechnical engineer who developed them relied heavily on judgement and opinion to do so. Your geotechnical engineer can finalize the recommendations *only after observing actual subsurface conditions* exposed during construction. If through observation your geotechnical engineer confirms that the conditions assumed to exist actually do exist, the recommendations can be relied upon, assuming no other changes have occurred. *The geotechnical engineer who prepared this report cannot assume responsibility or liability for confirmation-dependent recommendations if you fail to retain that engineer to perform construction observation.*

This Report Could Be Misinterpreted

Other design professionals' misinterpretation of geotechnical-engineering reports has resulted in costly problems. Confront that risk by having your geotechnical engineer serve as a continuing member of the design team, to:

- confer with other design-team members;
- help develop specifications;
- review pertinent elements of other design professionals' plans and specifications; and
- be available whenever geotechnical-engineering guidance is needed.

You should also confront the risk of constructors misinterpreting this report. Do so by retaining your geotechnical engineer to participate in prebid and preconstruction conferences and to perform construction-phase observations.

Give Constructors a Complete Report and Guidance

Some owners and design professionals mistakenly believe they can shift unanticipated-subsurface-conditions liability to constructors by limiting the information they provide for bid preparation. To help prevent the costly, contentious problems this practice has caused, include the complete geotechnical-engineering report, along with any attachments or appendices, with your contract documents, *but be certain to note conspicuously that you've included the material for information purposes only.* To avoid misunderstanding, you may also want to note that "informational purposes" means constructors have no right to rely on the interpretations, opinions, conclusions, or recommendations in the report. Be certain that constructors know they may learn about specific project requirements, including options selected from the report, *only* from the design drawings and specifications. Remind constructors that they may perform their own studies if they want to, and *be sure to allow enough time* to permit them to do so. Only then might you be in a position to give constructors the information available to you, while requiring them to at least share some of the financial responsibilities stemming from unanticipated conditions. Conducting prebid and preconstruction conferences can also be valuable in this respect.

Read Responsibility Provisions Closely

Some client representatives, design professionals, and constructors do not realize that geotechnical engineering is far less exact than other engineering disciplines. This happens in part because soil and rock on project sites are typically heterogeneous and not manufactured materials with well-defined engineering properties like steel and concrete. That lack of understanding has nurtured unrealistic expectations that have resulted in disappointments, delays, cost overruns, claims, and disputes. To confront that risk, geotechnical engineers commonly include explanatory provisions in their reports. Sometimes labeled "limitations," many of these provisions indicate where geotechnical engineers' responsibilities begin and end, to help others recognize their own responsibilities and risks. *Read these provisions closely.* Ask questions. Your geotechnical engineer should respond fully and frankly.

Geoenvironmental Concerns Are Not Covered

The personnel, equipment, and techniques used to perform an environmental study – e.g., a "phase-one" or "phase-two" environmental site assessment – differ significantly from those used to perform a geotechnical-engineering study. For that reason, a geotechnical-engineering report does not usually provide environmental findings, conclusions, or recommendations; e.g., about the likelihood of encountering underground storage tanks or regulated contaminants. *Unanticipated subsurface environmental problems have led to project failures.* If you have not obtained your own environmental information about the project site, ask your geotechnical consultant for a recommendation on how to find environmental risk-management guidance.

Obtain Professional Assistance to Deal with Moisture Infiltration and Mold

While your geotechnical engineer may have addressed groundwater, water infiltration, or similar issues in this report, the engineer's services were not designed, conducted, or intended to prevent migration of moisture – including water vapor – from the soil through building slabs and walls and into the building interior, where it can cause mold growth and material-performance deficiencies. Accordingly, ***proper implementation of the geotechnical engineer's recommendations will not of itself be sufficient to prevent moisture infiltration. Confront the risk of moisture infiltration*** by including building-envelope or mold specialists on the design team. ***Geotechnical engineers are not building-envelope or mold specialists.***

GBA GEOPROFESSIONAL BUSINESS ASSOCIATION

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1. INTRODUCTION

CMT Technical Services - Colorado (CMT) performed a geotechnical study of the proposed Irwin-Thomas slurry wall site located immediately east of Longmont, Colorado. The purpose of the project is to dewater the site and allow construction aggregate mining. The resulting pit will be used later for raw water storage upon mining completion. CMT performed the study to evaluate the geotechnical conditions underlying the site to provide design criteria for site development, slurry wall design and construction, and address other pertinent geotechnical issues. Factual data gathered during the field and laboratory work is summarized in Figures 1 and 2 and Appendices A through C. Opinions and recommendations presented in this report are based on the data generated during this field investigation, laboratory testing, and CMT's experience.

2. PROJECT DESCRIPTION

CMT understands the proposed slurry wall will surround a future construction aggregate mining pit comprised of two cells with an unexcavated dividing embankment left between them. The wall will be about 4,700 feet in total length, surrounding the two cells together, with a total area of about 30 acres. The two cells will hold an estimated total 312.7 acre-feet of water at the maximum pond surface, considering 3 feet of freeboard. CMT used a water discharge rate equivalent to about 1 foot per day for rapid drawdown, which is the typical upper limit of discharge used for reservoir design.

3. EXISTING CONDITIONS

The project site is an estimated 41 acres in area, trapezoidal in perimeter shape, and located in the northeastern quarter of the southeastern quarter of Section 11, Township 2 North, Range 69 West in Boulder County, Colorado. More specifically, the site is in the southwestern quadrant of the Ken Pratt Boulevard and 119th Street intersection, east of Longmont, Colorado. The site is located within a vacant area, understood to have been under cultivation as recent as 2020. Due to the configuration of the proposed pit, only Ken Pratt Boulevard ROW borders the site on its northern side. Some vacant land borders the site between the site and the St. Vrain River to the site's northeast and 119th Street to the site's east. Vacant land borders the site on its southern and western sides.

Topography of the project area is relatively flat and slopes down to the east with an estimated 7 feet of relief across the project's extent. Vegetation observed at the time of CMT's field exploration consisted of a moderate growth of native grasses and wheat stubble. A manmade drainage channel parallels the site's northern side along the Ken Pratt ROW. The city's wastewater treatment plant, with aeration ponds, and the confluence of Left Hand Creek with the St. Vrain River are about 2/3 of a mile northwest of the site. No other bodies of water were noted within 2/3 of a mile of the site at the time of CMT's field exploration. Concrete paved hiking trails are located in the area between the site and the St. Vrain River. No bedrock outcrops were noted onsite at the time of CMT's field exploration.

4. SUBSURFACE EXPLORATION

Twelve borings were drilled at locations indicated on the boring location plan presented on Figure 2 to depths of about 20 to 35 feet below existing grades. One of the borings was drilled away from the eastern side of the slurry wall alignment near 119th Street for a monitoring well. The borings were advanced using a CME 55 truck mounted drill rig equipped with a 7-1/2 inch outside diameter, continuous flight, hollow stem auger and NX wireline coring equipment. Eight borings were drilled with no sampling until bedrock contact, where driven samples were taken of the bedrock. The remaining four borings were sampled at designated intervals using a modified California sampler driven into the soil. The bedrock was cored about 15 feet using an NX wireline core barrel and drill steel. Descriptions of drilling, sampling, and Packer testing procedures are presented in Appendix A. Penetration test results, coring results, and sampling locations are presented on individual boring logs in Appendix A, along with photographs of the core.

After coring completion, CMT tested the bedrock's in situ permeability using the Packer test method, from which the permeability was calculated. NX coring and Packer testing were performed in Borings B-2, B-5, B-8, and B-11. Results of the Packer tests are summarized as geometric means in Table 4.1 and on the individual boring logs in Appendix A.

TABLE 4.1 Summary of Packer Test Results

Boring	Interval Tested		Average Hydraulic Conductivity* (cm/s)
	Depth (feet)	Elevation (feet)	
B-2	31 to 35	4885.5 to 4881.5	0.00
	27 to 35	4889.5 to 4881.5	7.3E-04
	23 to 35	4893.5 to 4881.5	5.0E-04
B-5	31 to 35	4886.5 to 4882.5	0.00
	27 to 35	4890.5 to 4882.5	0.00
	23 to 35	4897.5 to 4882.5	4.0E-04
B-8	31 to 35	4891.5 to 4887.5	0.00
	27 to 35	4895.5 to 4887.5	0.00
	23 to 35	4899.5 to 4887.5	1.4E-03
B-11	31 to 35	4891.0 to 4887.0	0.00
	27 to 35	4895.0 to 48878.0	0.00
	23 to 35	4899.0 to 4887.0	8.7E-04

* 0.00 indicates no water loss recorded during Packer testing.

Groundwater monitoring wells were constructed in Borings B-3, B-6, B-9, and B-12. Monitoring well completion details are shown on the individual borings logs presented in Appendix A.

5. LABORATORY TESTING

CMT's field staff returned the samples to its laboratory where a professional engineer visually classified the samples and assigned appropriate testing to specific samples to evaluate pertinent engineering properties. Laboratory tests performed are presented in Table 5.1. Appendix B presents a summary of laboratory test results and detailed test results.

TABLE 5.1. Laboratory Testing Performed

Laboratory Test	Number of Tests	Remarks
Gradation	7	Grain size distribution for classification
Atterberg limits	7	Plasticity for classification
Natural moisture content and dry density	5	Evaluate the materials' in situ conditions
Unconfined compression	2	Evaluate the bedrock shear strength.
Water soluble sulfate content	4	Evaluate the sulfate's potential to react with lime bearing materials

6. SUBSURFACE CONDITIONS

Madole[1] maps the site as underlain predominantly by upper Pleistocene and lower Holocene Post-Broadway alluvium comprised of silty sand overlying clast supported gravel. A relatively small area in the northeastern corner of the site is mapped as upper and middle Holocene Valley floor alluvium consisting of poorly sorted silty clayey sand.

CMT's borings encountered about 2 to 7 feet sandy clay at the surface in all borings. Granular soil consisting of interbedded zones of gravel with varying percentages of silt, clay, and sand; and sand with varying percentages of silt, clay, and gravel extending to depths of about 14 to 19 feet. Shale bedrock was encountered below the soil extending to the remaining depths explored of about 20 to 35 feet.

The borings encountered groundwater in all but one of the borings at depths of 7 to 14 feet during drilling. Groundwater was measured in the monitoring wells set in B-3, B-6, B-9, and B-12 at depths of about 8, 6-1/2, 8-1/2, and 8 feet. A more complete description of the subsurface material and groundwater is shown on the individual boring logs presented in Appendix A.

These observations represent conditions at the time of field exploration and may not be indicative of other times or other locations. Groundwater can be expected to fluctuate with variations in seasons, weather conditions, river levels, and changes in nearby farming water application.

7. ANALYSIS

CMT analyzed the stability of the proposed reservoir slopes using GeoStudio 2021R.3 software by GeoSlope, Inc. GeoStudio is a fully integrated software that allows multiple analyses to use the same data. In this case, it allows (constant property of the software, it **allows** in all cases) both steady state and transient seepage to be performed and slope stability analysis to use the results from each for porewater effects on the slope.

7.1 CONFIGURATION

The depth of excavation will not vary considerably over the pit, so slope heights will be very similar along the slurry wall alignment. The sections at stations (Sta) 22+00 and 42+50 were selected as the excavation at these locations represents the likely maximum depth of excavation in the mining pit. In addition, their stratigraphy's suggested a maximum thickness of clay at Sta 22+00 and

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[1] Madole, R.F., Geologic Map of the Longmont Quadrangle, Boulder and Weld Counties, Colorado, United States Geologic Survey, Department of the Interior, 2016.

minimum thickness of clay at Sta 42+50. Cell 2 will have an average crest elevation of about 4,919 feet and Cell 3 will have an average crest height of about 4,916. Both cells are planned to maintain 3 feet of freeboard at maximum water storage surface. The estimated cell depths will be about 14 and 13 feet for Cells 2 and 3, respectively. The interior slope is planned for 3:1, horizontal to vertical, for both cells. The slurry wall centerline will be about 15 feet away from the excavation crest. CMT anticipates the slurry wall will be about 3 feet wide and keyed into competent shale bedrock at least 1 foot, which is estimated to be about 4 to 5 feet below the bedrock contact.

7.2 SEEPAGE

Steady state seepage of the empty reservoir was analyzed to evaluate conformance with the design standard portion of the leakage requirements contained in the Colorado State Engineer's Office (CSEO) *State Engineer Guidelines for Lining Criteria of Gravel Pits* (August 1999). These guidelines contain both design standards and performance standards, with the maximum allowable groundwater inflow from the perimeter and bottom of a lined gravel pit. These standards are shown in Table 7.1.

TABLE 7.1. CSE Guidelines for Maximum Allowable Inflow

Location	Design Standard	Performance Standard
Pit perimeter	0.03 $ft^3/day/ft^2$	0.09 $ft^3/day/ft^2$
Pit bottom	0.0015 $ft^3/day/ft^2$	0.0030 $ft^3/day/ft^2$

For sand and gravel, hydraulic conductivity values were calculated empirically based on Sherard, et al.[2], using gradation analyses results. Clay hydraulic conductivity was based on Cedergren[3]. Hydraulic conductivity values for bedrock were based on Packer test results performed in Borings B-2, B-5, B-8, and B-11. The design hydraulic conductivity for the slurry cutoff wall material is 1E-07 cm/sec (3.28E-09 ft/sec), which was used in the analysis. Presumptive ratios of horizontal to vertical hydraulic conductivity for each material were assigned as found in a United States Army Corps of Engineers/California Department of Water Resources (USACE/CA DWR) guidance document.

A summary of the hydraulic properties used in CMT's analysis is shown in Table 7.2.

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[2] Sherard, J.L., Dunnigan, L.P., Talbot, J.R., Basic Properties of Sand and Gravel Filters, Journal of Geotechnical Engineering, Vol 110, No. 6, June 1984; American Society of Civil Engineers, Geotechnical Engineering Division.

[3] Cedergren, H.R., Seepage, Drainage, and Flow Nets, 3rd Edition, John Wiley & Sons, 1989.

TABLE 7.2. Material Properties - Seepage

Material	Hydraulic Conductivity	
	ft/sec	K_y/K_x
Clay	9.12E-09	1.0
Sand with gravel	4.60E-05	1.0
Gravel with sand	2.90E-03	1.0
Weathered bedrock	1.31E-05	0.1
Bedrock	3.28E-09	0.1
Slurry wall	3.28E-09	1.0

Analysis included both steady state seepage when empty and rapid drawdown (transient) of the pools. A drawdown rate of about 1 foot per day was used for rapid drawdown analysis. This drawdown rate is roughly equivalent to an average discharge rate of about 6 cfs over the maximum storage depth. The actual drawdown rates in feet per day increase with depth due to the reduced ponding area. In transient analysis, the critical stability zone is typically between one-half and two-thirds the depth. Although the actual drawdown rate will be greater at that depth, the values used are considered sufficiently conservative for this analysis through the critical zone.

7.3 STABILITY

The unit weight, cohesion, and friction angles of the material encountered are estimated values based on published literature, test results, and CMT’s experience in the area.

TABLE 7.3. Material Properties - Stability

Material	Unit Weight (pcf)	Friction Angle Φ (degrees)	Cohesion c (psf)
Clay	120	25	50
Sand with gravel	125	33	10
Gravel with sand	130	35	10
Weathered bedrock	135	0	3,000
Bedrock	140	0	5,000
Slurry wall	110	15	0

7.4 STABILITY AND SEEPAGE RESULTS

CMT analyzed the sections at approximately Sta 22+00 and Sta 42+50 for seepage and stability, as described previously. The model for Sta 22+00 was based on Boring B-5, which was at the section station, and exhibited about 7 feet of clay at the surface and granular soil from below the surface clay to bedrock contact. The model for Sta 42+50 was based on Boring B-10, nearest the section station, which exhibited about 2 feet of clay at the surface and granular soil directly underlying the clay extending to bedrock contact.

7.4.1 Seepage

CMT analyzed the excavation sections considering steady state seepage, while empty for both stability and seepage inflow from groundwater. The section was analyzed for rapid drawdown considering 1 foot of drawdown a day, typically considered the practical upper limit of typical dam design. The rate is equivalent to about 6 cfs. The empty steady state seepage results averaged over the slope height to evaluate inflow are presented in Table 7.4.

TABLE 7.4. Empty Steady State Flux

Station	Face Location	Flux ($ft^3/sec/ft^2$)	Flux ($ft^3/day/ft^2$)
22+00	Slope	4.27E-11	3.69E-06
	Bottom	4.96E-08	4.29E-03
42+50	Slope	2.27E-12	1.96E-07
	Bottom	3.69E-08	3.19E-03
CSEO Design	Slope		3.00E-02
	Bottom		1.50E-03

The seepage analysis for the empty condition indicated the slope flux of the full slope height is well below the CSEO requirement. The seepage analysis also indicates potential flow into the reservoir, only marginally greater than the CSEO design requirements. CMT opines the results evaluated together compare favorably with the CSEO design requirements.

7.4.2 Stability

Results of CMT's stability analyses are presented in Table 7.5 and include the CSEO requirements. Printouts of critical failure surfaces for each evaluation are presented in Appendix C.

TABLE 7.5. Stability Analyses Results

Section Station	Analysis	Factor of Safety		Required Factor of Safety
		Block	Circular	
22+00	Empty, steady state	2.21	2.18	1.5
	Transient	1.91	1.87	1.2*
42+50	Empty, steady state	2.32	2.33	1.5
	Transient	2.09	2.03	1.2*

* Lowest factor of safety of all time steps.

8. SLURRY WALL RECOMMENDATIONS

The bedrock is considered very fractured from its contact to a depth of about 2 to 5 feet. The slurry wall should penetrate the bedrock to a depth sufficient to embed in the competent bedrock below the fractured zone. In CMT's opinion, this penetration should be at least 1 foot into competent bedrock, making total penetration from bedrock contact up to 6 feet, or more.

9. GEOTECHNICAL RISK

The concept of risk is an important aspect of any geotechnical study. The primary reason for this is that the analytical methods used by geotechnical engineers are generally empirical and must be tempered by engineering judgment and experience, therefore, the solutions or recommendations presented in any geotechnical study should not be considered risk free, and more importantly, are not a guarantee that the interaction between the soil and the proposed construction will perform as predicted, desired, or intended. The engineering recommendations presented in the preceding sections constitute CMT's best estimate of those measures that are necessary to help the slurry wall perform in a satisfactory manner based on the information generated during this study, training, and experience in working with these conditions.

10. LIMITATIONS

This document has been prepared as an instrument of service for the exclusive use of J&T Consulting, Inc. for the specific application to the project as discussed herein and has been prepared in accordance with geotechnical engineering practices generally accepted in the state of Colorado at the date of its preparation. No warranties, either expressed or implied, are intended or made. This document should not be assumed to contain information for other parties or other purposes.

The findings of this study are valid as of the date its preparation. Changes in the conditions of a property can occur with the passage of time, whether due to natural processes or the works of people on this or adjacent properties. Standards of practice evolve in engineering and changes in applicable or appropriate standards may occur, whether they result from legislation or the broadening of knowledge. Accordingly, the findings of this study may be invalidated wholly or partially by changes outside of CMT's control, therefore, this study is subject to review and should not be relied upon without such review after a period of 3 years.

In the event changes, including but not limited to, the nature, type, design, size, elevation, or location of the project or project elements as outlined in this report are made, the conclusions and recommendations contained in this report shall not be considered valid unless CMT reviews the changes and either confirms or modifies the conclusions of this report in writing.

CMT should be retained to review final plans and specifications that are developed for proposed construction to judge whether the recommendations presented in this report and any addenda have been appropriately interpreted and incorporated in the project plans and specifications as intended.

The exploration locations for this study were selected to obtain a reasonably accurate depiction of underground conditions for design purposes. Variations from the soil conditions encountered are possible. These variations may necessitate modifications to CMT's design recommendations; therefore, CMT should be retained to observe subsurface conditions, as exposed, to evaluate whether they are consistent with the conditions encountered during CMT's exploration and that the recommendations of this study remain valid. If parties other than CMT perform these observations and judgements, they must accept responsibility to judge whether the recommendations in this report remain appropriate. At a minimum, CMT should be retained during construction to observe slurry wall construction.

CMT's scope of services for this report did not include either specifically, or by implication, any environmental assessment of the site or identification of contaminated or hazardous material or conditions.

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BACKGROUND IMAGE FROM GOOGLE EARTH

PROJECT NO:	22.3059		
PROJECT NAME:	Irwin-Thomas Slurry Wall Design		
DRAWN BY:	JBE	CHECKED BY:	JAC2
DWG DATE:	01.18.23	REV. DATE:	--

FIGURE 1
Vicinity Map

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

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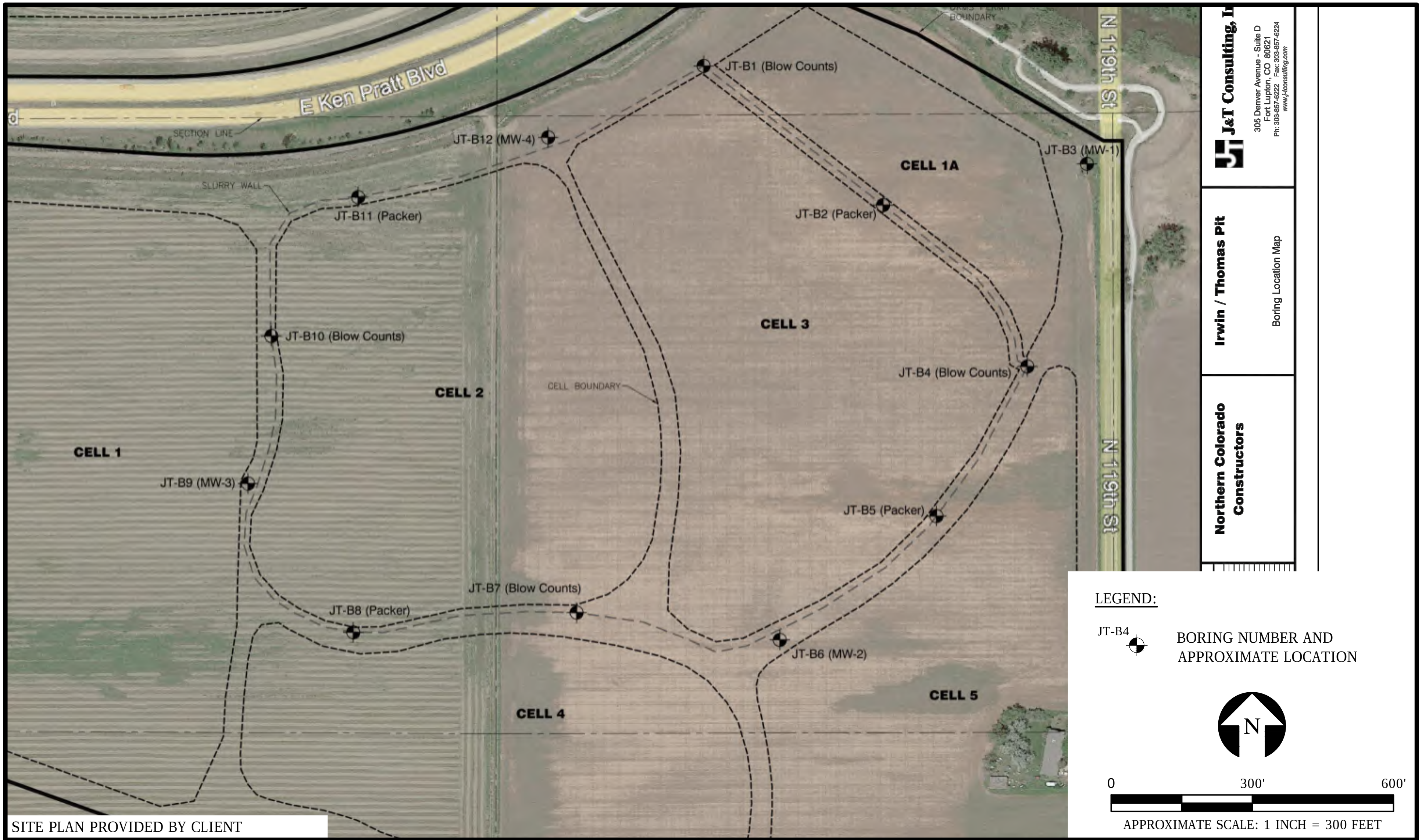


PROJECT NO:	22.3059		
PROJECT NAME:	Irwin-Thomas Slurry Wall Design		
DRAWN BY:	JBE	CHECKED BY:	JAC2
DWG DATE:	01.18.23	REV. DATE:	--

FIGURE 2
Site Plan and Boring Locations

CESARE, INC.
Geotechnical Engineers & Construction Materials Consultants

CMT TECHNICAL SERVICES

APPENDIX A

Field Exploration

FIELD EXPLORATION

Samples of the subsoil were obtained using modified California and standard split spoon samplers. Modified California and standard split spoon samplers were driven into the soil by dropping a 140 pound hammer through a free fall of 30 inches. The modified California sampler is a 2-1/2 inch outside diameter by 2 inch inside diameter device lined with brass tubes. The split spoon sampler is a 2 inch outside diameter by 1-3/8 inch inside diameter device. The procedure to drive these samplers into the soil and to record the number of blows required to do so is known as a penetration test. The number of blows required for the sampler to penetrate 12 inches gives an indication of the relative stiffness of cohesive soil, relative density of non-cohesive soil, and relative hardness of sedimentary bedrock material encountered. Locations of sampling and penetration test results are presented on the boring logs contained in this appendix.

Bedrock cores were obtained using NX wireline coring equipment. Wireline coring equipment consists of drill steel and a core barrel comprised of an inner and outer barrel. The drill steel is thin walled pipe, 5 to 10 foot lengths, threaded at both ends, and connected, as necessary, to reach coring depths. The NX core barrel consists of an outer barrel of larger diameter than the drill steel with a cutting edge on the bottom that cuts an annular space 3 inches in outside diameter and 1-7/8 inches inside diameter. The inner barrel is a split metal tube held stationary inside the outer barrel and holds the core sample as it is cut from the rock mass. The inner core barrel is retrieved from the outer core barrel by a thin cable attached to it without removing the outer barrel. During coring, the recovered core was continuously logged, wrapped in plastic tubing, and stored in partitioned core boxes. Photographs of the cores are presented in this appendix.

After coring completion, Packer testing was performed on the bedrock in selected borings to evaluate the in situ permeability. The Packer test consists of sealing the cored hole perimeter with a single inflatable rubber Packer at a specific depth and pumping water through a pipe extending through the Packer into the open cored hole below. The procedure begins at the boring’s bottommost cored interval, then raising the Packer unit in 4 to 5 foot intervals with permeability testing completed at each interval. During test pumping, CMT recorded the flow into the interval in gallons, the time interval pumped in minutes, the pumping pressure, and the volume meter elevation. Based on these measurements, CMT calculated the permeability. Packer testing was performed in Borings B-2, B-5, B-8, and B-11. Results of the Packer tests are summarized in Table 4.1 in the report and included on the detailed logs in this appendix.

CMT installed temporary monitoring wells in Borings B-3, B-6, B-9, and B-12. Groundwater level measurements within the temporary monitoring wells are presented on the boring logs in this appendix. Groundwater can be expected to fluctuate with variations in seasons, drainage, site vegetation, irrigation, or weather conditions.

Monitoring wells were constructed using 2 inch diameter PVC pipe consisting of a slotted screen interval placed in the water bearing strata and a continuous solid interval above the screen extending to the ground surface. Refer to the boring logs for well completion details specific to each boring.

Silica sand was typically placed from the base or several feet below the base of the slotted pipe to about 1 foot above the slotted pipe interval and a bentonite seal placed above that. The bentonite seal was a minimum of about 3 feet thick. Cement bentonite grout was placed above the seal extending to near ground surface level. The monitor well pipe terminates below the ground surface and is covered with a protective flush mount steel cover surrounded by a concrete apron around the flush mount steel cover at the ground surface.

Temporary monitoring wells must be abandoned within 18 months of installation in accordance with the State of Colorado's Division of Water Resources abandonment requirements, unless the wells are permitted as permanent monitoring wells. If requested by the Client, CMT can assist with well abandonment and/or the process of converting the monitoring wells from temporary to permanent.

PROJECT NAME	Irwin-Thomas Slurry Wall Design	PROJECT NUMBER	22.3059	**B-1**
BORING LOCATION	9+00, 20L	BORING ELEVATION	4917.6ft.	
DRILLING COMPANY/RIG	Dakota Drilling/CME-55	CMTTS REP.	J. Edwards	
DRILLING METHOD	7"in. Diameter HSA	DATE STARTED	12/20/2022	
HAMMER SYSTEM	140 lb hammer rope and cathead	DATE COMPLETED	12/20/2022	Page 1 of 1

DEPTH (ft)	NATURAL MOISTURE CONTENT (%)	FINES (%)	LL-PL-PI	BLOW COUNT	SAMPLE DRIVE	SAMPLE BULK	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	Water Level and Depth of Cave (ft)
								4915.1	CLAY, sandy, with gravel to 1" diameter, slightly moist, dark brown.	2.5	
								4913.6	SAND, poorly graded, with gravel to 1" diameter, moist, light brown.	4	
5	0.1	9	NV-NV-NP	46/18	☒			4903.6	GRAVEL, well graded, with silt and sand, occasional to with cobbles, dense to very dense, slightly moist to wet, brown.	14	
											▼
10				76/11	☒						
15				111/17	☒			4897.6	SHALE, with fine sand, very hard, slightly moist to moist, gray.	20	
20				50/1							

Boring terminated at 20.08 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

▽# WATER LEVEL # DAYS AFTER DRILLING

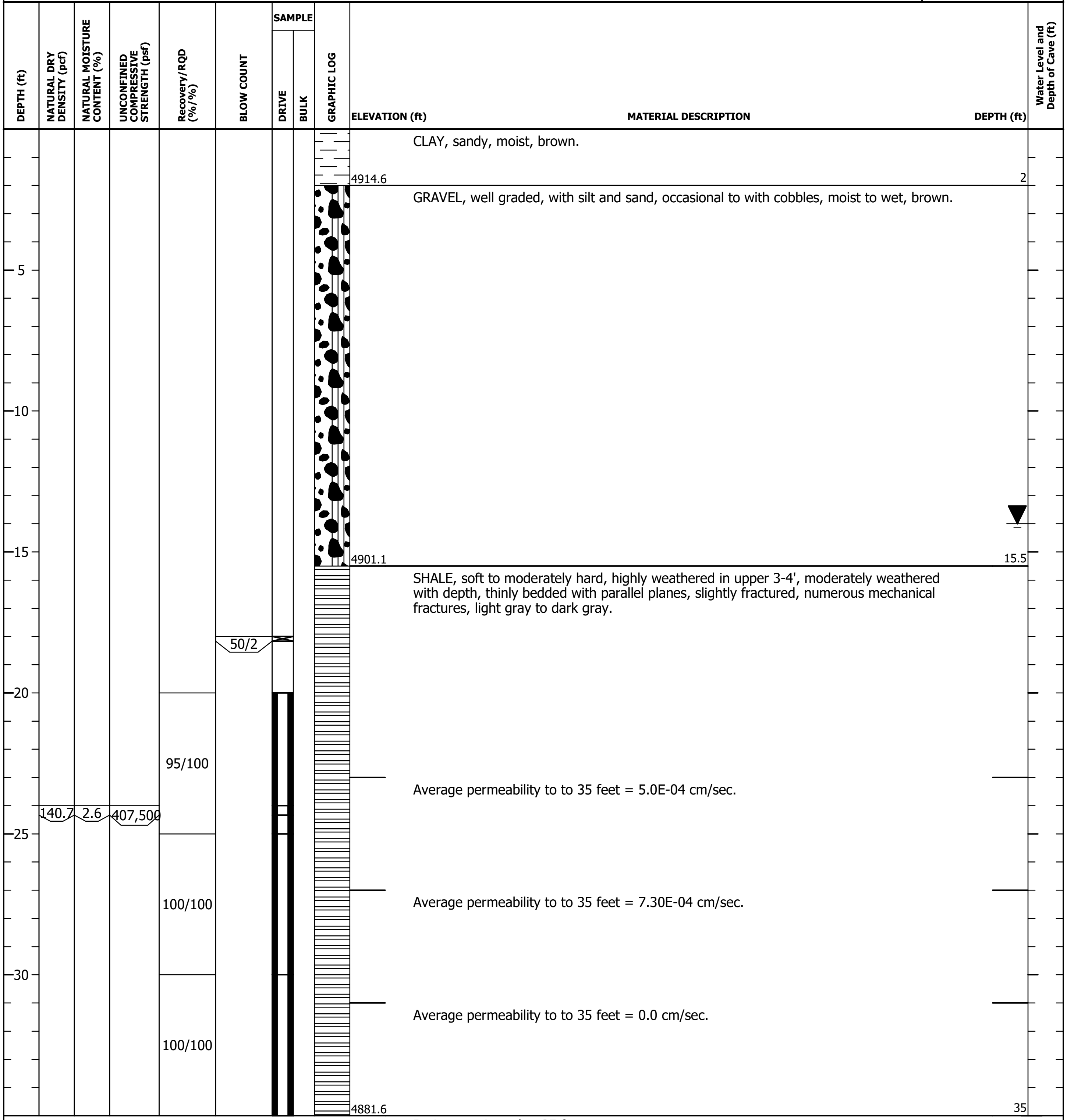
→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

☒ SPLIT SPOON

CMT TECHNICAL SERVICES

PROJECT NAME	Irwin-Thomas Slurry Wall Design	PROJECT NUMBER	22.3059	**B-2**
BORING LOCATION	13+70	BORING ELEVATION	4916.6ft.	
DRILLING COMPANY/RIG	Dakota Drilling/D-120	CMTTS REP.	J. Edwards	
DRILLING METHOD	7"in. Diameter HSA and NX Wireline Core	DATE STARTED	12/8/2022	
HAMMER SYSTEM	140 lb hammer rope and cathead	DATE COMPLETED	12/8/2022	Page 1 of 1



ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)
	CLAY, sandy, moist, brown.	
4914.6		2
	GRAVEL, well graded, with silt and sand, occasional to with cobbles, moist to wet, brown.	
4901.1		15.5
	SHALE, soft to moderately hard, highly weathered in upper 3-4', moderately weathered with depth, thinly bedded with parallel planes, slightly fractured, numerous mechanical fractures, light gray to dark gray.	
	Average permeability to to 35 feet = 5.0E-04 cm/sec.	
	Average permeability to to 35 feet = 7.30E-04 cm/sec.	
	Average permeability to to 35 feet = 0.0 cm/sec.	
4881.6		35

Boring terminated at 35 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

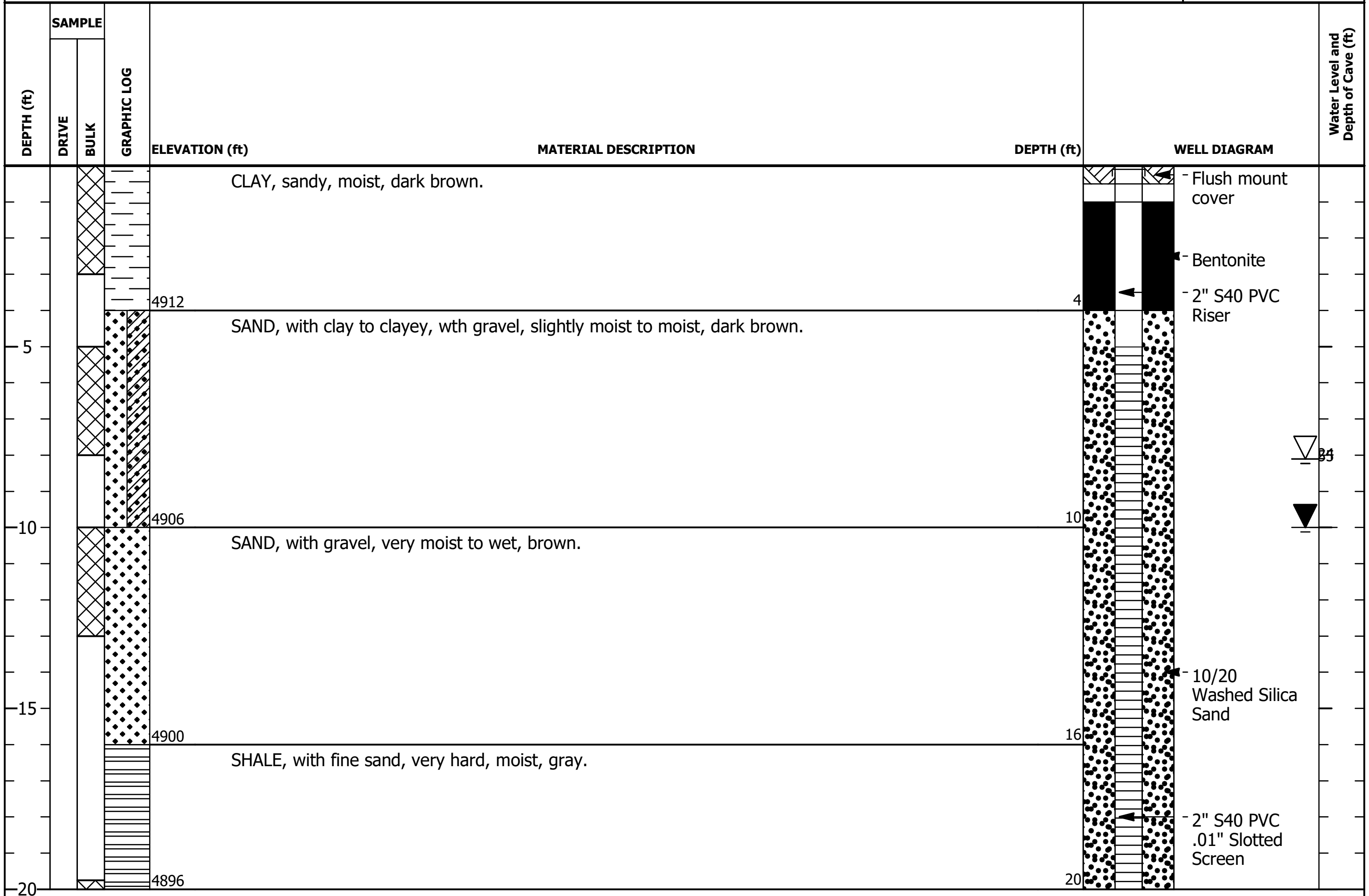
↑ DEPTH OF REFUSAL

☒ SPLIT SPOON

▮ ROCK CORE

CMT TECHNICAL SERVICES

PROJECT NAME	Irwin-Thomas Slurry Wall Design	PROJECT NUMBER	22.3059	B-3/ MW-1
BORING LOCATION	16+25, 165L	BORING ELEVATION	4916ft.	
DRILLING COMPANY/RIG	Dakota Drilling/CME-55	CMTTS REP.	J. Edwards	
DRILLING METHOD	7"in. Diameter HSA	DATE STARTED	12/19/2022	
HAMMER SYSTEM	140 lb hammer rope and cathead	DATE COMPLETED	12/19/2022	



ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)
	CLAY, sandy, moist, dark brown.	
4912		4
	SAND, with clay to clayey, wth gravel, slightly moist to moist, dark brown.	
4906		10
	SAND, with gravel, very moist to wet, brown.	
4900		16
	SHALE, with fine sand, very hard, moist, gray.	
4896		20

Boring terminated at 20 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

☒ BULK SAMPLE

▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

CMT TECHNICAL SERVICES

PROJECT NAME	Irwin=Thomas Slurry Wall Design	PROJECT NUMBER	22.3059	**B-4**
BORING LOCATION	18+30, 10L	BORING ELEVATION	4916.3ft.	
DRILLING COMPANY/RIG	Dakota Drilling/CME-55	CMTTS REP.	J. Edwards	
DRILLING METHOD	7"in. Diameter HSA	DATE STARTED	12/20/2022	
HAMMER SYSTEM	140 lb hammer rope and cathead	DATE COMPLETED	12/20/2022	Page 1 of 1

DEPTH (ft)	NATURAL MOISTURE CONTENT (%)	FINES (%)	LL-PL-PI	BLOW COUNT	SAMPLE DRIVE	SAMPLE BULK	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	Water Level and Depth of Cave (ft)
								4914.3	CLAY, sandy, moist, dark brown.	2	
								4910.8	CLAY, sandy, stiff to very stiff, slightly moist to moist, dark brown; INTERLAYERED WITH: SAND, silty, medium dense, very moist, light brown.	5.5	
5	8.5	8	NV-NV-NP	28/18	☒						
											▼
10				36/18	☒						
15				75/18	☒			4900.3	SAND, poorly graded, with silt and gravel, with cobbles from 12' to 16', medium dense to very dense, moist to wet, brown.	16	
20				50/5	☒			4895.88	SHALE, with fine sand, very hard, moist, gray.	20.42	

Boring terminated at 20.42 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

☒ SPLIT SPOON

CMT TECHNICAL SERVICES

PROJECT NAME	Irwin-Thomas Slurry Wall Design	PROJECT NUMBER	22.3059	**B-5**
BORING LOCATION	22+00	BORING ELEVATION	4917.6ft.	
DRILLING COMPANY/RIG	Dakota Drilling/D-120	CMTTS REP.	J. Edwards	
DRILLING METHOD	7"in. Diameter HSA and NX Wireline Core	DATE STARTED	12/9/2022	
HAMMER SYSTEM	140 lb hammer rope and cathead	DATE COMPLETED	12/9/2022	Page 1 of 1

DEPTH (ft)	NATURAL DRY DENSITY (pcf)	NATURAL MOISTURE CONTENT (%)	Recovery/RQD (%/%)	BLOW COUNT	SAMPLE DRIVE	SAMPLE BULK	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	Water Level and Depth of Cave (ft)
									CLAY, sandy, slightly moist to moist, brown to dark brown.		
5											
								4910.6	SAND, poorly graded, with gravel, moist to wet, brown.	7	
10											
											▼
15											
								4899.6	SHALE, soft to moderately hard, highly weathered to 3-4', moderately weathered below, planar/parallel bedding planes banded to thin, slightly fractured, numerous mechanical fractures, light gray to dark gray	18	
20				50/5	☒						
			75/47								
	137.5	4.6							Average permeability to to 35 feet = 4.0E-4 cm/sec.		
25											
			100/100						Average permeability to to 35 feet = 0.0 cm/sec.		
	143.1	2.3									
30											
			100/100						Average permeability to to 35 feet = 0.0 cm/sec.		
								4882.6		35	

Boring terminated at 35 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

☒ SPLIT SPOON

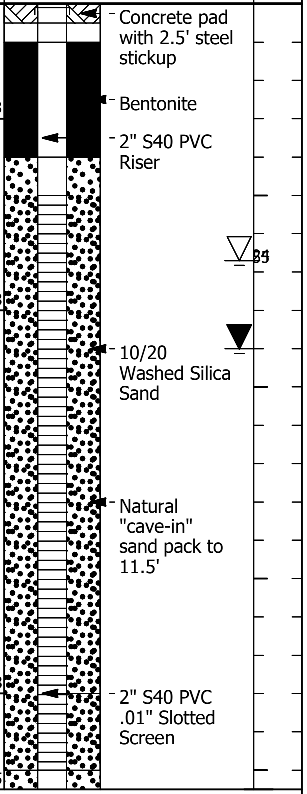
▮ ROCK CORE

CMT TECHNICAL SERVICES

PROJECT NAME	Irwin-Thomas Slurry Wall Design	PROJECT NUMBER	22.3059	**B-6/ MW-2**
BORING LOCATION	26+30, 40L	BORING ELEVATION	4919.4ft.	
DRILLING COMPANY/RIG	Dakota Drilling/CME-55	CMTTS REP.	J. Edwards	
DRILLING METHOD	7"in. Diameter HSA	DATE STARTED	12/19/2022	
HAMMER SYSTEM	140 lb hammer rope and cathead	DATE COMPLETED	12/19/2022	

DEPTH (ft)	NATURAL MOISTURE CONTENT (%)	FINES (%)	LL-PL-PI	BLOW COUNT	SAMPLE DRIVE	SAMPLE BULK	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)
						☒	4916.4	CLAY, sandy, slightrly moist to moist, dark brown.	3
5	1.7	13	NV-NV-NP			☒	4911.4	SAND, silty, with gravel to 1" diameter, moist, brown.	8
10						☒		GRAVEL, well graded, with silt and sand, moist to wet, brown.	
15							4901.4		18
20				50/6	☒		4898.9	SHALE, with fine sand, very hard, moist, gray.	20.5

Boring terminated at 20.5 feet



LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

☒ BULK SAMPLE

☒ SPLIT SPOON

CMT TECHNICAL SERVICES

PROJECT NAME	Irwin-Thomas Slurry Wall Design	PROJECT NUMBER	22.3059
BORING LOCATION	30+70	BORING ELEVATION	4920.6ft.
DRILLING COMPANY/RIG	Dakota Drilling/CME-55	CMTTS REP.	J. Edwards
DRILLING METHOD	7"in. Diameter HSA	DATE STARTED	12/20/2022
HAMMER SYSTEM	140 lb hammer rope and cathead	DATE COMPLETED	12/20/2022

B-7

Page 1 of 1

DEPTH (ft)	NATURAL MOISTURE CONTENT (%)	FINES (%)	LL-PL-PI	BLOW COUNT	SAMPLE DRIVE	SAMPLE BULK	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	Water Level and Depth of Cave (ft)
									CLAY, sandy, stiff to very stiffmedium dense, moist, dark brown.		
5				46/12	☒			4915.1		5.5	
									SAND, silty, with gravell, with cobbles from 15' to 19', dense to very dense, very moist to wet, brown.		▼
10				52/18	☒						
15	7.9	12	NV-NV-NP	109/18	☒						
								4901.6		19	
									SHALE, with fine sand, cemented at 23', very hard, moist, gray.		
20				50/6	☒						
								4897.6		23	
				50/0					Boring terminated at 23 feet		↑

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

☒ SPLIT SPOON

▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

CMT TECHNICAL SERVICES

PROJECT NAME	Irwin-Thomas Slurry Wall Design	PROJECT NUMBER	22.3059
BORING LOCATION	35+50	BORING ELEVATION	4922.7ft.
DRILLING COMPANY/RIG	Dakota Drilling/D-120	CMTTS REP.	K. McNally
DRILLING METHOD	7"in. Diameter HSA and NX Wireline Core	DATE STARTED	1/4/2023
HAMMER SYSTEM	140 lb hammer rope and cathead	DATE COMPLETED	1/4/2023

B-8

Page 1 of 1

DEPTH (ft)	NATURAL DRY DENSITY (pcf)	NATURAL MOISTURE CONTENT (%)	UNCONFINED COMPRESSIVE STRENGTH (psf)	Recovery/RQD (%/%)	BLOW COUNT	SAMPLE DRIVE	SAMPLE BULK	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	Water Level and Depth of Cave (ft)
0–6								4916.7	CLAY, sandy, moist, brown to dark brown.	6	
6–18.5								4904.2	SAND, with silt and gravel, moist, brown.	18.5	▼ (10)
20					50/5	☒			SHALE, soft to moderately hard, highly weathered to 3-4', moderately weathered below, planar/parallel bedding planes banded to thin, slightly fractured, numerous mechanical fractures, light gray to dark gray		
20–25	139.8	4.9	172,875	75/42		▌			Average permeability to to 35 feet = 1.4E-3 cm/sec.		
25–30				100/82.5		▌			Average permeability to to 35 feet = 0.0 cm/sec.		
30–35				100/100		▌		4887.7	Average permeability to to 35 feet = 0.0 cm/sec.	35	

Boring terminated at 35 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

☒ SPLIT SPOON

▌ ROCK CORE

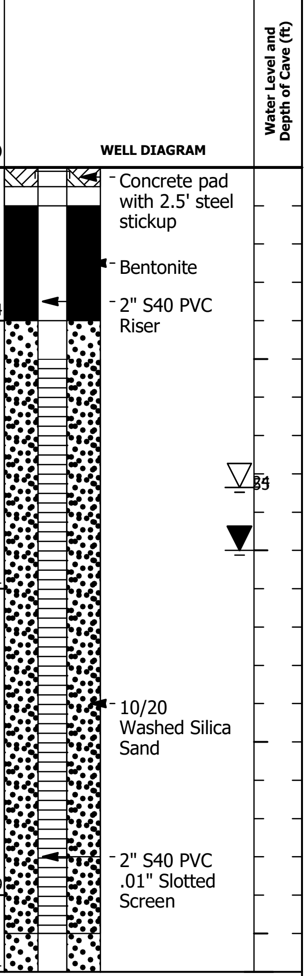
CMT TECHNICAL SERVICES

PROJECT NAME	Irwin-Thomas Slurry Wall Design	PROJECT NUMBER	22.3059
BORING LOCATION	40+00, 20L	BORING ELEVATION	4923.3ft.
DRILLING COMPANY/RIG	Dakota Drilling/CME-55	CMTTS REP.	J. Edwards
DRILLING METHOD	7"in. Diameter HSA	DATE STARTED	12/19/2022
HAMMER SYSTEM	140 lb hammer rope and cathead	DATE COMPLETED	12/19/2022

B-9/ MW-3

DEPTH (ft)	NATURAL MOISTURE CONTENT (%)	FINES (%)	LL-PL-PI	BLOW COUNT	SAMPLE DRIVE	SAMPLE BULK	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)
0–4						☒	4919.3	CLAY, sandy, moist, brown.	4
4–11						☒	4912.3	SAND, poorly graded, with gravel to 1" diameter, moist, brown.	11
10–15	15.7	28	NV-NV-NP			☒			
11–19							4904.3	SAND, silty, occasional gravel, wet, dark brown.	19
19–21				83/12	☒		4902.3	SHALE, with fine sand, very hard, moist, gray.	21

Boring terminated at 21 feet



LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

☒ BULK SAMPLE

☒ SPLIT SPOON

CMT TECHNICAL SERVICES

PROJECT NAME	Irwin-Thomas Slurry Wall Design	PROJECT NUMBER	22.3059	**B-10**
BORING LOCATION	43+25	BORING ELEVATION	4922.5ft.	
DRILLING COMPANY/RIG	Dakota Drilling/CME-55	CMTTS REP.	J. Edwards	
DRILLING METHOD	7"in. Diameter HSA	DATE STARTED	12/20/2022	
HAMMER SYSTEM	140 lb hammer rope and cathead	DATE COMPLETED	12/20/2022	Page 1 of 1

DEPTH (ft)	NATURAL MOISTURE CONTENT (%)	FINES (%)	LL-PL-PI	BLOW COUNT	SAMPLE DRIVE	SAMPLE BULK	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	Water Level and Depth of Cave (ft)
								4920.5	CLAY, sandy, moist, dark brown.	2	
								4917.5	SAND, with clay and gravel, slightly moist, light brown.	5	
5	3.3	5	NV-NV-NP	80/18	☒			4903.5	GRAVEL, well graded, with sand, dense to very dense, moist to wet, brown.	19	
											▼
10				68/18	☒						
15				80/12	☒						
								4897.08	SHALE, with fine sand, very hard, moist, gray.	25.42	
20				50/5	☒						
25				50/5	☒						

Boring terminated at 25.42 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

↑ DEPTH OF REFUSAL

☒ SPLIT SPOON

CMT TECHNICAL SERVICES

PROJECT NAME	Irwin-Thomas Slurry Wall Design	PROJECT NUMBER	22.3059
BORING LOCATION	1+05	BORING ELEVATION	4922ft.
DRILLING COMPANY/RIG	Dakota Drilling/D-120	CMTTS REP.	K. McNally
DRILLING METHOD	7"in. Diameter HSA and NX Wireline Core	DATE STARTED	1/3/2023
HAMMER SYSTEM	140 lb hammer rope and cathead	DATE COMPLETED	1/3/2023

B-11

Page 1 of 1

DEPTH (ft)	NATURAL DRY DENSITY (pcf)	NATURAL MOISTURE CONTENT (%)	Recovery/RQD (%/%)	BLOW COUNT	SAMPLE DRIVE	SAMPLE BULK	GRAPHIC LOG	ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)	Water Level and Depth of Cave (ft)
									CLAY, sandy, slightly moist, brown to dark brown.		
								4918.5		3.5	
									SAND, with silt and gravel, moist to wet, brown.		
5											
10											▼
15											
								4903.5		18.5	
									SHALE, soft to moderately hard, highly weathered to 3-4', moderately weathered to depth, planar/parallel bedding planes banded to thin, slightly to moderately fractured, numerous mechanical fractures, light gray to dark gray		
20				50/5	☒						
			78/40		▮						
									Average permeability to to 35 feet = 8.7E-4 cm/sec.		
	130.3	6.2									
25											
			95/83		▮				Average permeability to to 35 feet = 0.0 cm/sec.		
30											
			97/87		▮				Average permeability to to 35 feet = 0.0 cm/sec.		
								4887		35	

Boring terminated at 35 feet

LEGEND

▼ WATER LEVEL AT TIME OF DRILLING

▽# WATER LEVEL # DAYS AFTER DRILLING

→# DEPTH OF CAVE # DAYS AFTER DRILLING

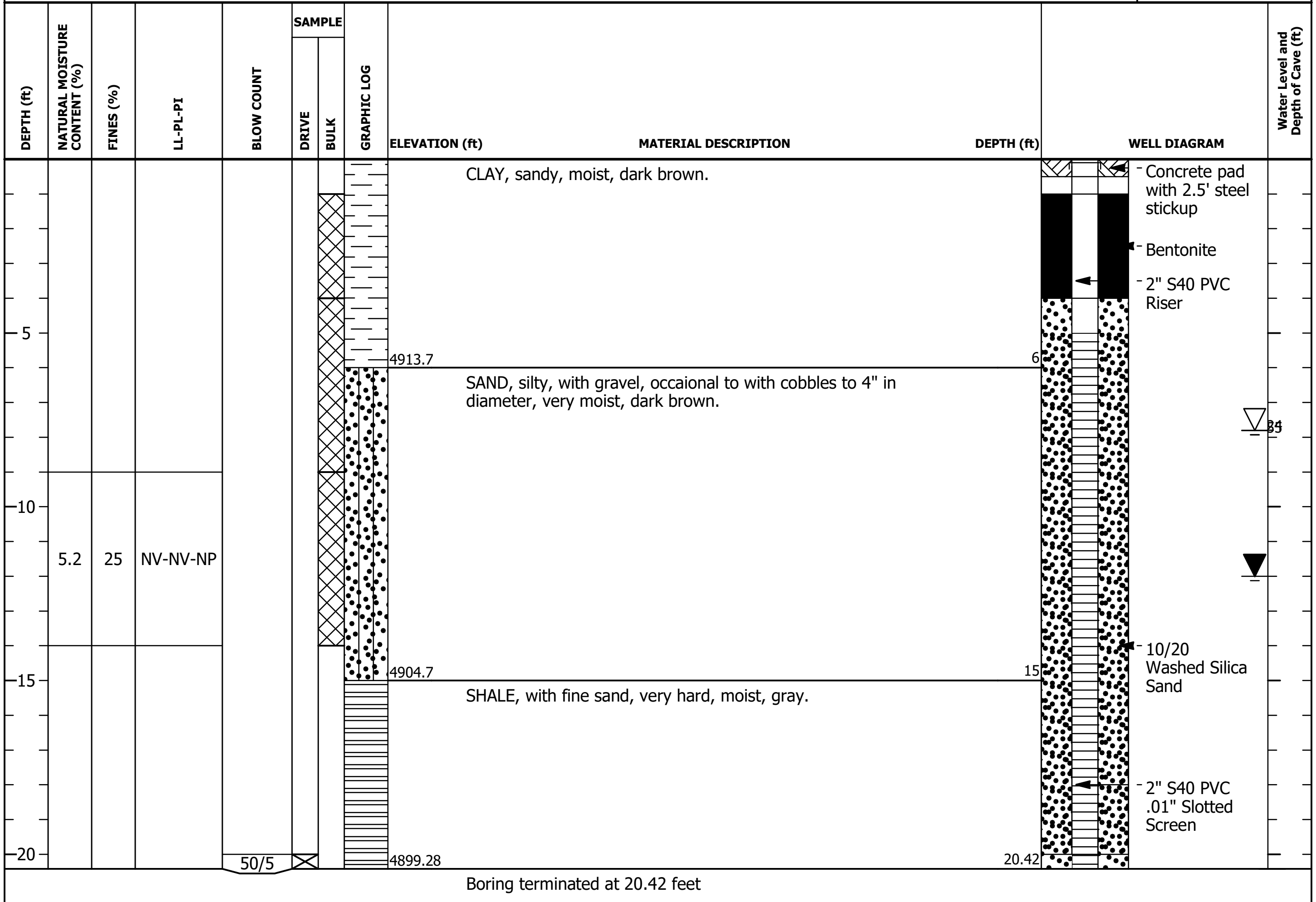
↑ DEPTH OF REFUSAL

☒ SPLIT SPOON

▮ ROCK CORE

CMT TECHNICAL SERVICES

PROJECT NAME	Irwin-Thomas Slurry Wall Design	PROJECT NUMBER	22.3059	B-12/ MW-4
BORING LOCATION	5+30, 20L	BORING ELEVATION	4919.7ft.	
DRILLING COMPANY/RIG	Dakota Drilling/CME-55	CMTTS REP.	J. Edwards	
DRILLING METHOD	7"in. Diameter HSA	DATE STARTED	12/19/2022	
HAMMER SYSTEM	140 lb hammer rope and cathead	DATE COMPLETED	12/19/2022	



DEPTH (ft)	NATURAL MOISTURE CONTENT (%)	FINES (%)	LL-PL-PI	BLOW COUNT
9–14	5.2	25	NV-NV-NP	
20				50/5

ELEVATION (ft)	MATERIAL DESCRIPTION	DEPTH (ft)
	CLAY, sandy, moist, dark brown.	
4913.7	SAND, silty, with gravel, occaional to with cobbles to 4" in diameter, very moist, dark brown.	6
4904.7	SHALE, with fine sand, very hard, moist, gray.	15
4899.28		20.42

Boring terminated at 20.42 feet

LEGEND

▼	WATER LEVEL AT TIME OF DRILLING	☒	BULK SAMPLE
▽#	WATER LEVEL # DAYS AFTER DRILLING	☒	SPLIT SPOON
→#	DEPTH OF CAVE # DAYS AFTER DRILLING		
↑	DEPTH OF REFUSAL		

CMT TECHNICAL SERVICES

Photo 1. Boring B-2 at 20 to 21 feet.

Photo 2. Boring B-2 at 21 to 22 feet.

Photo 3. Boring B-2 at 22 to 23 feet.

Photo 4. Boring B-2 at 23 to 24 feet.

Photo 5. Boring B-2 at 24 to 25 feet.

Photo 6. Boring B-2 at 25 to 26 feet.

Photo 7. Boring B-2 at 26 to 27 feet.

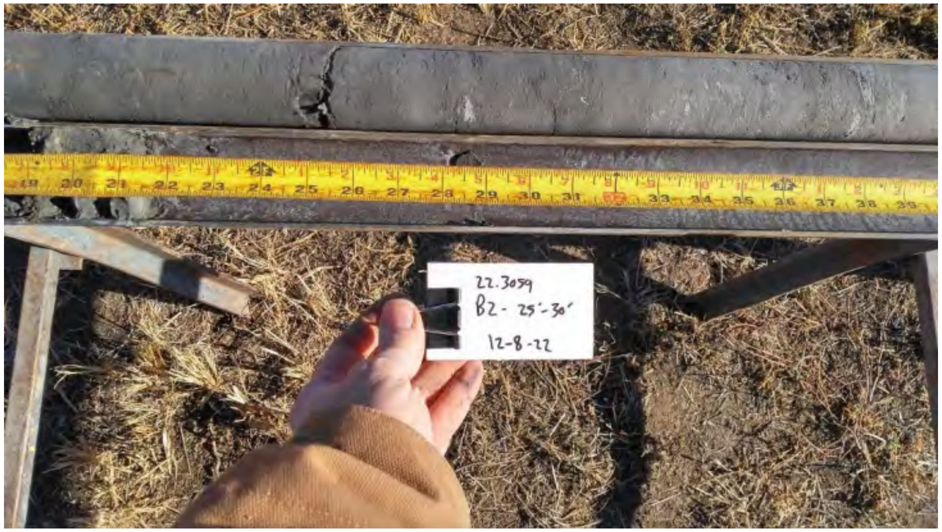


Photo 8. Boring B-2 at 27 to 28 feet.

Photo 9. Boring B-2 at 28 to 29 feet.

Photo 10. Boring B-2 at 29 to 30 feet.

Photo 11. Boring B-2 at 30 to 31 feet.

Photo 12. Boring B-2 at 31 to 32 feet.

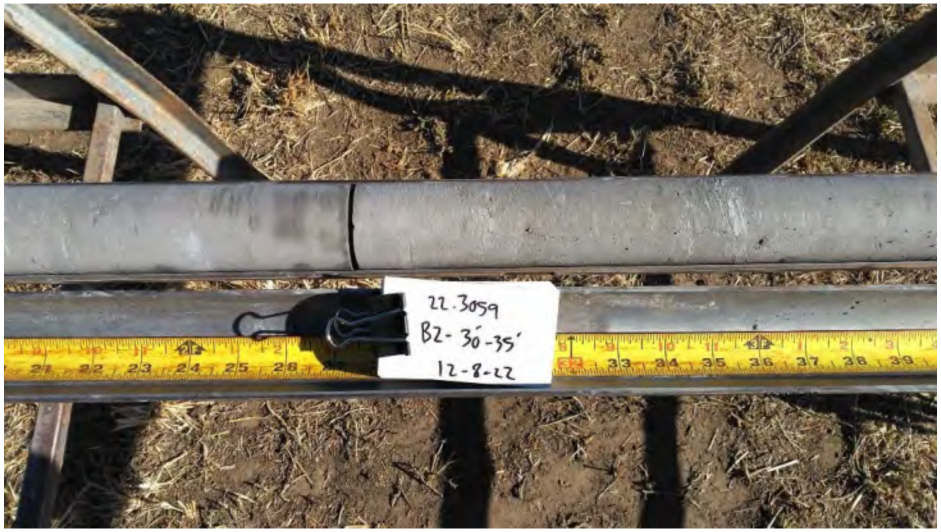


Photo 13. Boring B-2 at 32 to 33 feet.

Photo 14. Boring B-2 at 33 to 34 feet.

Photo 15. Boring B-2 at 34 to 35 feet.

Photo 16. Boring B-5 at 20 to 21 feet.

Photo 17. Boring B-5 at 21 to 22 feet.

Photo 18. Boring B-5 at 22 to 23 feet.

Photo 19. Boring B-5 at 23 to 24 feet.

Photo 20. Boring B-5 at 25 to 26 feet.

Photo 21. Boring B-5 at 26 to 27 feet.

Photo 22. Boring B-5 at 27 to 28 feet.

Photo 23. Boring B-5 at 28 to 29 feet.

Photo 24. Boring B-5 at 29 to 30 feet.

Photo 25. Boring B-5 at 30 to 31 feet.

Photo 26. Boring B-5 at 31 to 32 feet.

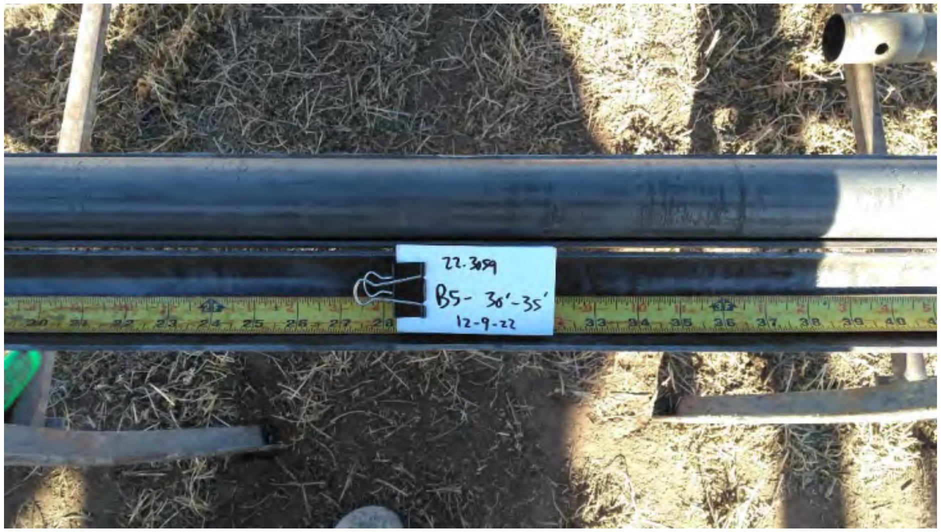


Photo 27. Boring B-5 at 32 to 33 feet.

Photo 28. Boring B-5 at 33 to 34 feet.

Photo 29. Boring B-5 at 34 to 35 feet.

Photo 30. Boring B-8 at 20 to 21 feet.

Photo 31. Boring B-8 at 21 to 22 feet.

Photo 32. Boring B-8 at 22 to 23 feet.

Photo 33. Boring B-8 at 23 to 24 feet.

Photo 34. Boring B-8 at 25 to 26 feet.

Photo 35. Boring B-8 at 26 to 27 feet.

Photo 36. Boring B-8 at 27 to 28 feet.

Photo 37. Boring B-8 at 28 to 29 feet.

Photo 38. Boring B-8 at 29 to 30 feet.

Photo 39. Boring B-8 at 30 to 31 feet.

Photo 40. Boring B-8 at 31 to 32 feet.

Photo 41. Boring B-8 at 32 to 33 feet.

Photo 42. Boring B-8 at 33 to 34 feet.

Photo 43. Boring B-8 at 34 to 35 feet.

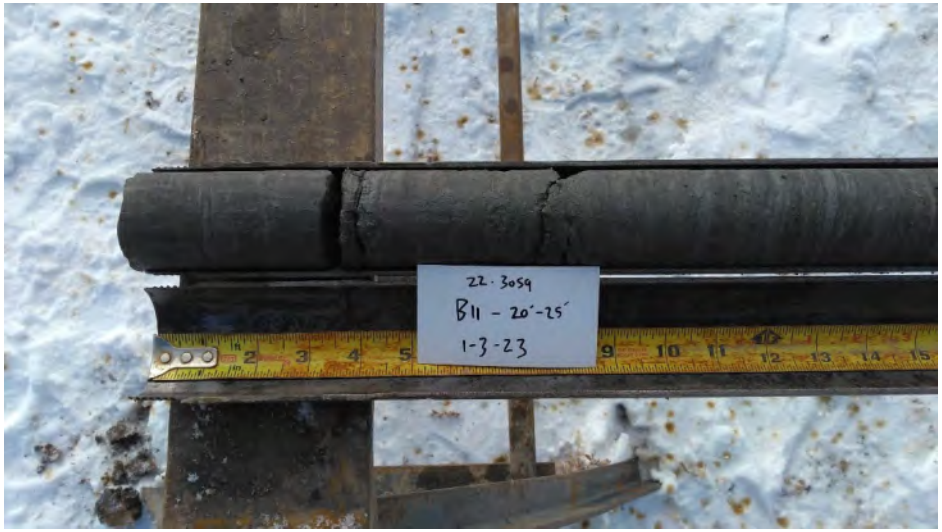


Photo 44. Boring B-11 at 20 to 21 feet.

Photo 45. Boring B-11 at 21 to 22 feet.

Photo 46. Boring B-11 at 22 to 23 feet.

Photo 47. Boring B-11 at 23 to 24 feet.

Photo 48. Boring B-11 at 25 to 26 feet.

Photo 49. Boring B-11 at 26 to 27 feet.

Photo 50. Boring B-11 at 27 to 28 feet.

Photo 51. Boring B-11 at 28 to 29 feet.

Photo 52. Boring B-11 at 29 to 30 feet.

Photo 53. Boring B-11 at 30 to 31 feet. *Depth interval in photo is incorrect.*

Photo 54. Boring B-11 at 31 to 32 feet. *Depth interval in photo is incorrect.*

Photo 55. Boring B-11 at 32 to 33 feet. *Depth interval in photo is incorrect.*

Photo 56. Boring B-11 at 33 to 34 feet. *Depth interval in photo is incorrect.*

Photo 57. Boring B-11 at 34 to 35 feet. *Depth interval in photo is incorrect.*

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APPENDIX B

Laboratory Testing

LABORATORY TESTING

Unconfined compressive strength testing was performed to evaluate undrained shear strength of the bedrock. The testing was performed on core samples collected using NX rock coring technique.

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SUMMARY OF LABORATORY TEST RESULTS

Irwin-Thomas Slurry Wall Design
Project No. 22.3059

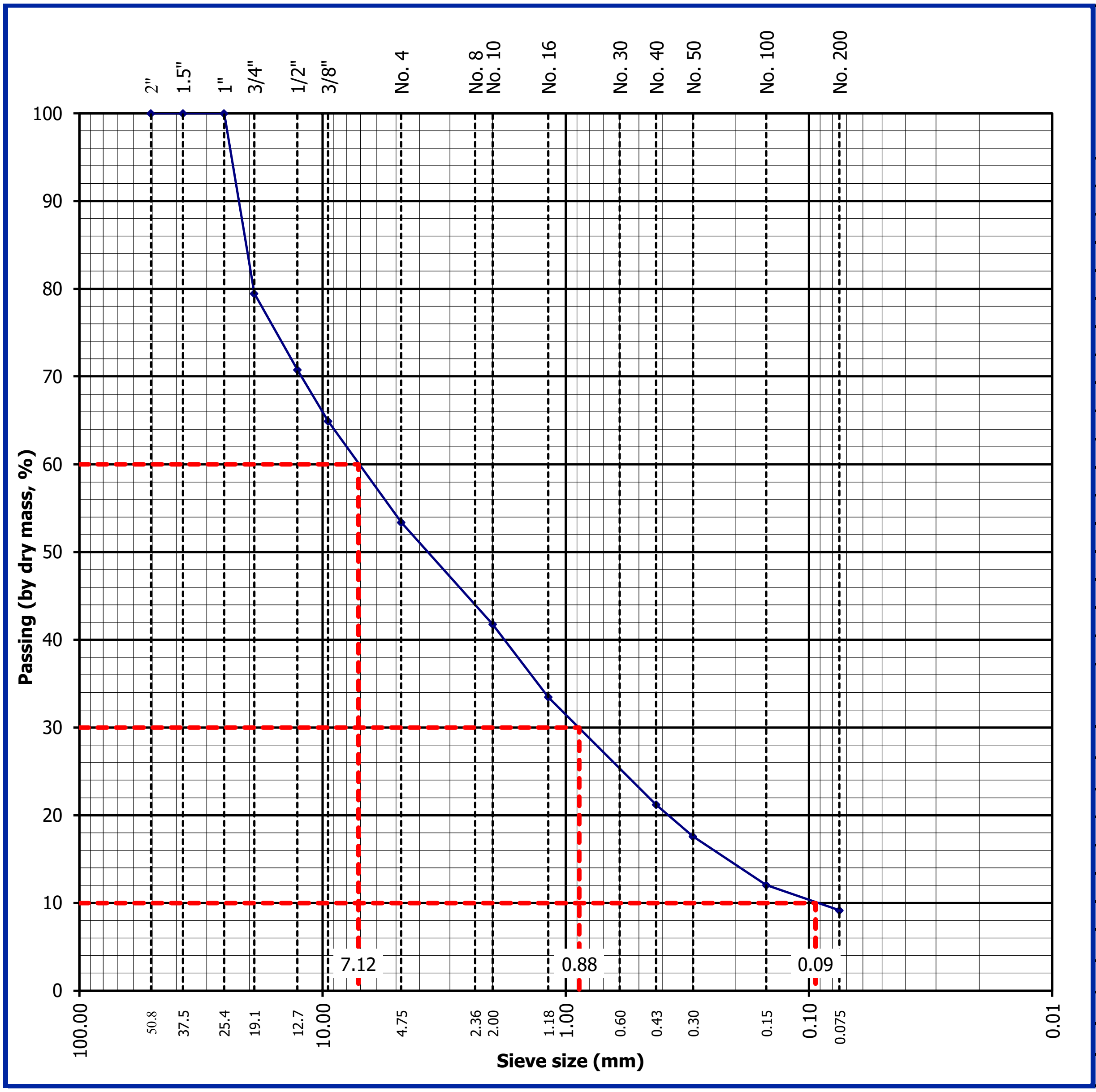
Sample Location					Gradation			Atterberg Limits			
Boring	Depth (feet)	Natural Dry Density (pcf)	Natural Moisture Content (%)	Water Soluble Sulfates (%)	Gravel (%)	Sand (%)	Silt/ Clay (%)	Liquid Limit (%)	Plasticity Index (%)	Unconfined Compression (psf)	Material Type
B-1	5		0.1		47	44	9	NV	NP		GRAVEL, well graded, with silt and sand (GW-GM,A-1-a)
B-2	24 to 25	140.7	2.6							407,500	SHALE
B-3	0 to 3			0.00							CLAY, sandy (CL, A-6)
B-4	5		8.5		35	57	8	NV	NP		SAND, poorly graded, with silt and gravel (SP-SM, A-1-a)
B-5	23 to 24	137.5	4.6								SHALE
B-5	28	143.1	2.3								SHALE
B-6	0 to 3			0.07							CLAY, sandy (CL, A-6)
B-6	5 to 10		1.7		24	63	13	NV	NP		SAND, silty, with gravel (SM, A-1-b)
B-7	15		7.9		39	49	12	NV	NP		SAND, silty, with gravel (SM, A-1-b)
B-8	23	139.8	4.9							172,875	SHALE
B-9	0 to 5			0.40							CLAY, sandy (CL, A-6)
B-9	10 to 15		15.7		12	60	28	NV	NP		SAND, silty (SM, A-2-4)
B-10	5		3.3		58	37	5	NV	NP		GRAVEL, well graded, with sand (GW,A-1-a)
B-11	24	130.3	6.2								SHALE
B-12	1 to 4			0.00							CLAY, sandy (CL, A-6)
B-12	9 TO 14		5.2		35	40	25	NV	NP		SAND, silty, with gravel (SM, A-1-b)

GRADATION PLOT - SOIL AND AGGREGATE

Project number 22.3059
Project name Irwin-Thomas Slurry Wall Design
Lab ID number F222340
Sample location B-1 at 5 feet
Visual description GRAVEL, with silt and sand, brown

Date December 29, 2022
Technician B. Keith/L. Glenn
Reviewer G. Hoyos

AASHTO M145 Classification				**Soaking Method**	
				Procedure	**Method**
Classification	**A-1-a**	**Group Index**	**0**	AASHTO T11	
Unified Soil Classification System (ASTM D2487)				ASTM D1140	**A**
(GW-GM)	**Well graded gravel with silt and sand**			Specimen soaking time (min)	**1,440**

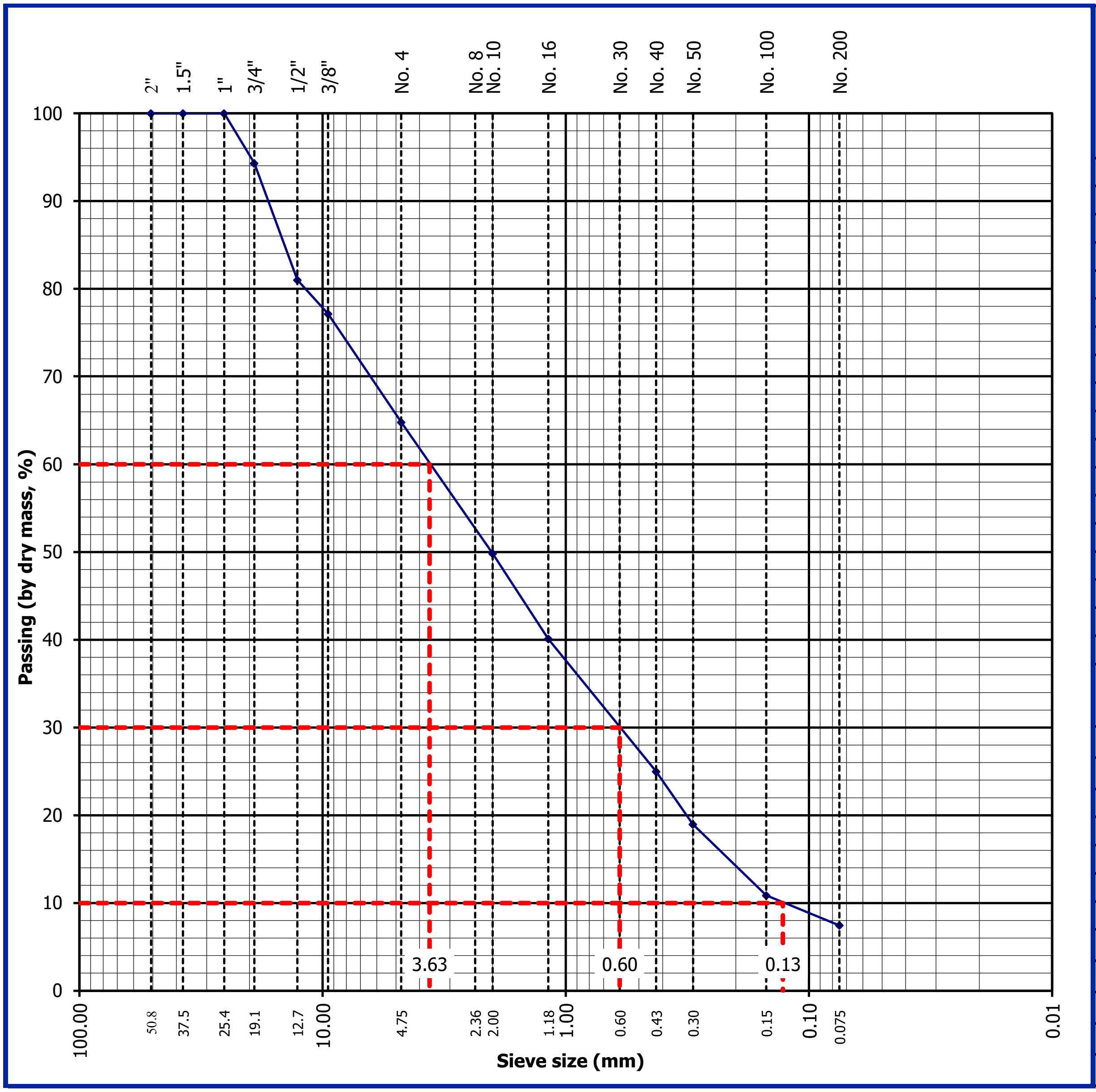


Sieve Size	**Passing (%)**
2"	
1.5"	
1"	100
3/4"	79
1/2"	71
3/8"	65
#4	53
#8	
#10	42
#16	33
#30	
#40	21
#50	18
#100	12
#200	9.2
Moisture (M) and Density (D)	
M (%)	0.1
D (pcf)	
LL	NV
PL	NP
PI	NP
D_{60}	7.12
D_{30}	0.88
D_{10}	0.09
Cu	**75.79**
Cc	**1.16**

GRADATION PLOT - SOIL AND AGGREGATE

Project number	22.3059	Date	December 29, 2022
Project name	Irwin-Thomas Slurry Wall Design	Technician	B. Keith/L. Glenn
Lab ID number	F222343	Reviewer	G. Hoyos
Sample location	B-4 at 5 feet		
Visual description	SAND, with silt and gravel, brown		

AASHTO M145 Classification				Soaking Method	
				Procedure	**Method**
Classification	**A-1-a**	**Group Index**	**0**	AASHTO T11	
Unified Soil Classification System (ASTM D2487)				ASTM D1140	**A**
(SP-SM)	**Poorly graded sand with silt and gravel**			Specimen soaking time (min)	**60**



Sieve Size	Passing (%)
2"	
1.5"	
1"	100
3/4"	94
1/2"	81
3/8"	77
#4	65
#8	
#10	50
#16	40
#30	
#40	25
#50	19
#100	11
#200	7.5

Moisture (M) and Density (D)	
M (%)	8.5
D (pcf)	
LL	NV
PL	NP
PI	NP
D_{60}	3.63
D_{30}	0.60
D_{10}	0.13
Cu	**28.36**
Cc	**0.77**

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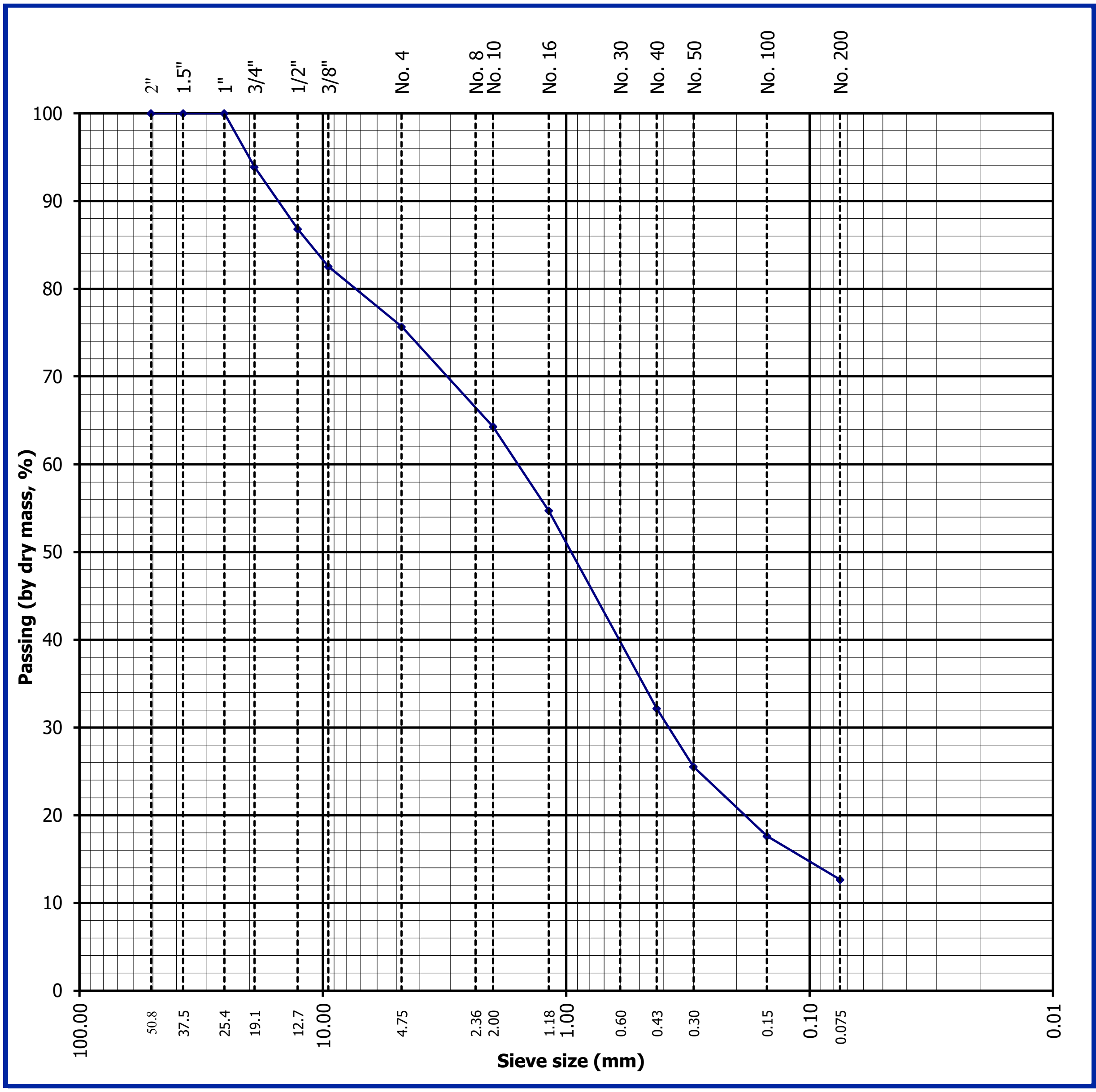
AASHTO ACCREDITED

GRADATION PLOT - SOIL AND AGGREGATE

Project number	22.3059	Date	December 29, 2022
Project name	Irwin-Thomas Slurry Wall Design	Technician	B. Keith/L. Glenn
Lab ID number	F222346	Reviewer	G. Hoyos
Sample location	B-6 at 5 to 10 feet		
Visual description	SAND, silty, with gravel, brown		

AASHTO M145 Classification				**Soaking Method**	
				Procedure	**Method**
Classification	**A-1-b**	**Group Index**	**0**	AASHTO T11	
Unified Soil Classification System (ASTM D2487)				ASTM D1140	**A**
(SM)	**Silty sand with gravel**			Specimen soaking time (min)	**120**



Sieve Size	**Passing (%)**
2"	
1.5"	
1"	100
3/4"	94
1/2"	87
3/8"	83
#4	76
#8	
#10	64
#16	55
#30	
#40	32
#50	26
#100	18
#200	12.7

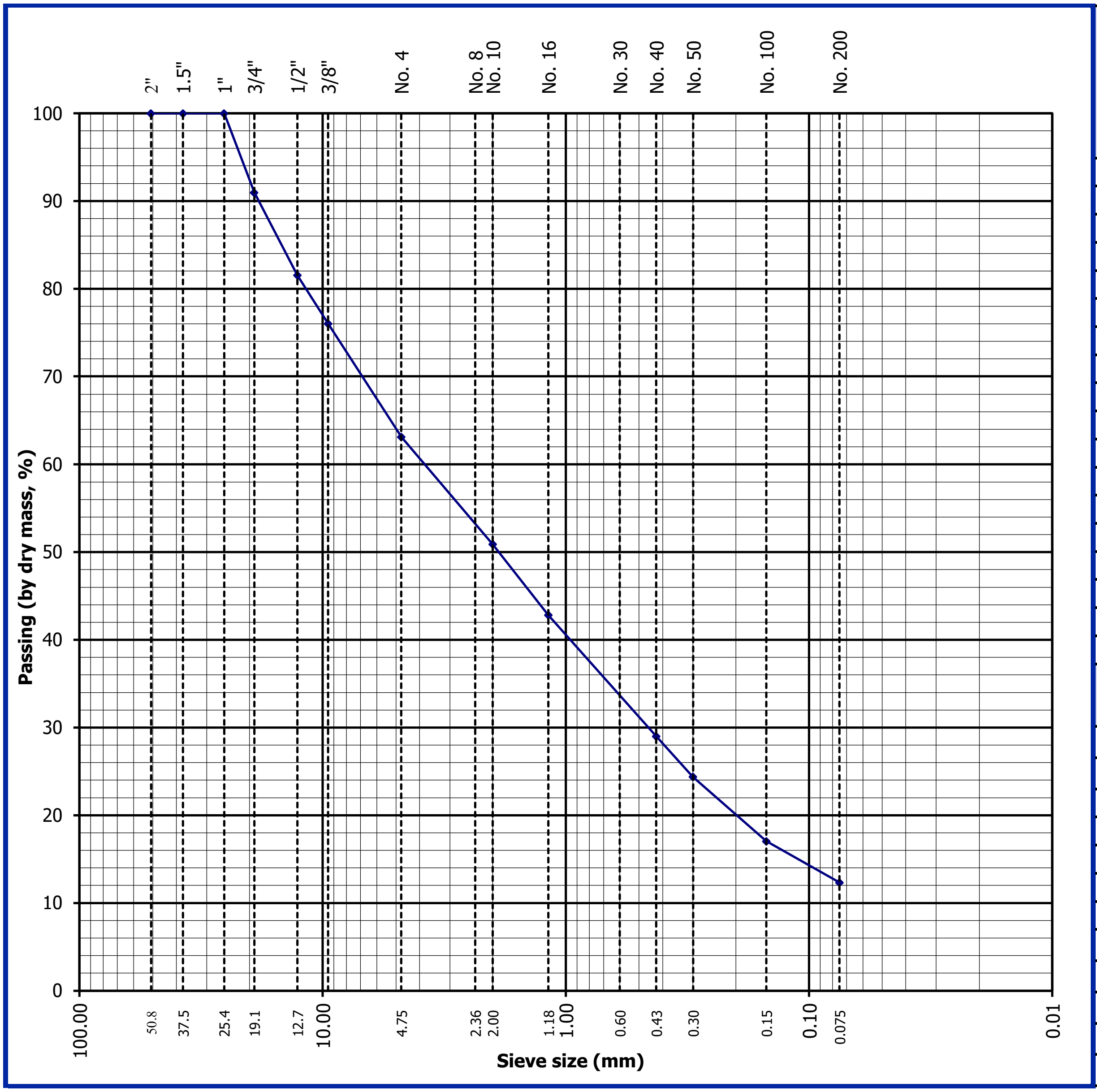
Moisture (M) and Density (D)	
M (%)	1.7
D (pcf)	
LL	NV
PL	NP
PI	NP
D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

CMT TECHNICAL SERVICES

GRADATION PLOT - SOIL AND AGGREGATE

Project number	22.3059	Date	December 29, 2022
Project name	Irwin-Thomas Slurry Wall Design	Technician	B. Keith/L. Glenn
Lab ID number	F222347	Reviewer	G. Hoyos
Sample location	B-7 at 15 feet		
Visual description	SAND, silty, with gravel, brown		

				Soaking Method	
AASHTO M145 Classification				**Procedure**	**Method**
Classification	**A-1-b**	**Group Index**	**0**	AASHTO T11	
Unified Soil Classification System (ASTM D2487)				ASTM D1140	**A**
(SM)	**Silty sand with gravel**			Specimen soaking time (min)	**1,646**



Sieve Size	**Passing (%)**
2"	
1.5"	
1"	100
3/4"	91
1/2"	82
3/8"	76
#4	63
#8	
#10	51
#16	43
#30	
#40	29
#50	24
#100	17
#200	12.3

Moisture (M) and Density (D)	
M (%)	7.9
D (pcf)	
LL	NV
PL	NP
PI	NP
D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

CMT TECHNICAL SERVICES

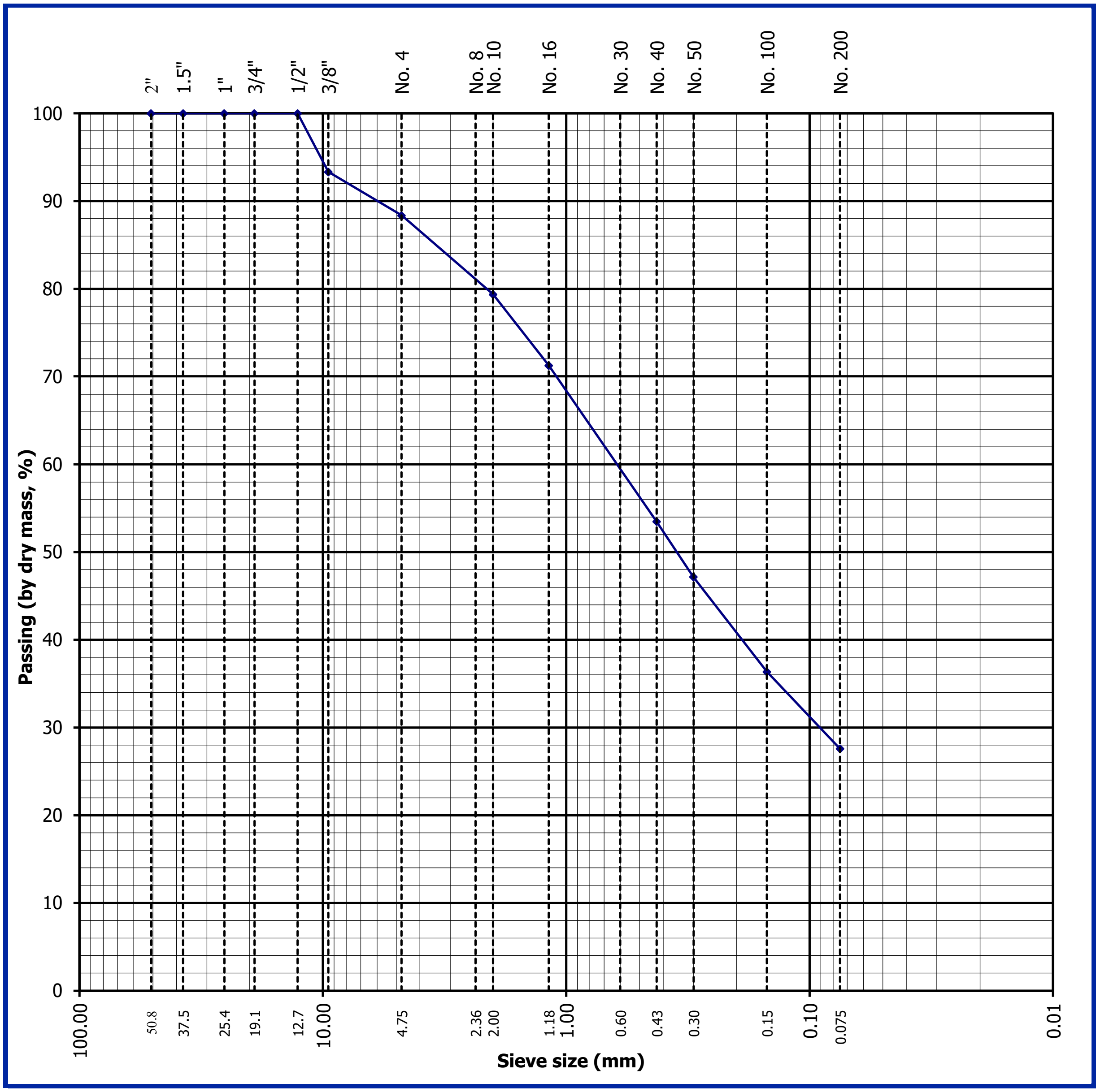
AASHTO ACCREDITED

GRADATION PLOT - SOIL AND AGGREGATE

Project number 22.3059
Project name Irwin-Thomas Slurry Wall Design
Lab ID number F222349
Sample location B-9 at 10 to 15 feet
Visual description SAND, silty, brown

Date December 30, 2023
Technician B. Keith/L. Glenn
Reviewer G. Hoyos

AASHTO M145 Classification				**Soaking Method**	
				Procedure	**Method**
Classification	**A-2-4**	**Group Index**	**0**	AASHTO T11	
Unified Soil Classification System (ASTM D2487)				ASTM D1140	**A**
(SM)	**Silty sand**			Specimen soaking time (min)	**1,440**



Sieve Size	**Passing (%)**
2"	
1.5"	
1"	
3/4"	
1/2"	100
3/8"	93
#4	88
#8	
#10	79
#16	71
#30	
#40	53
#50	47
#100	36
#200	27.6

Moisture (M) and Density (D)	
M (%)	15.7
D (pcf)	

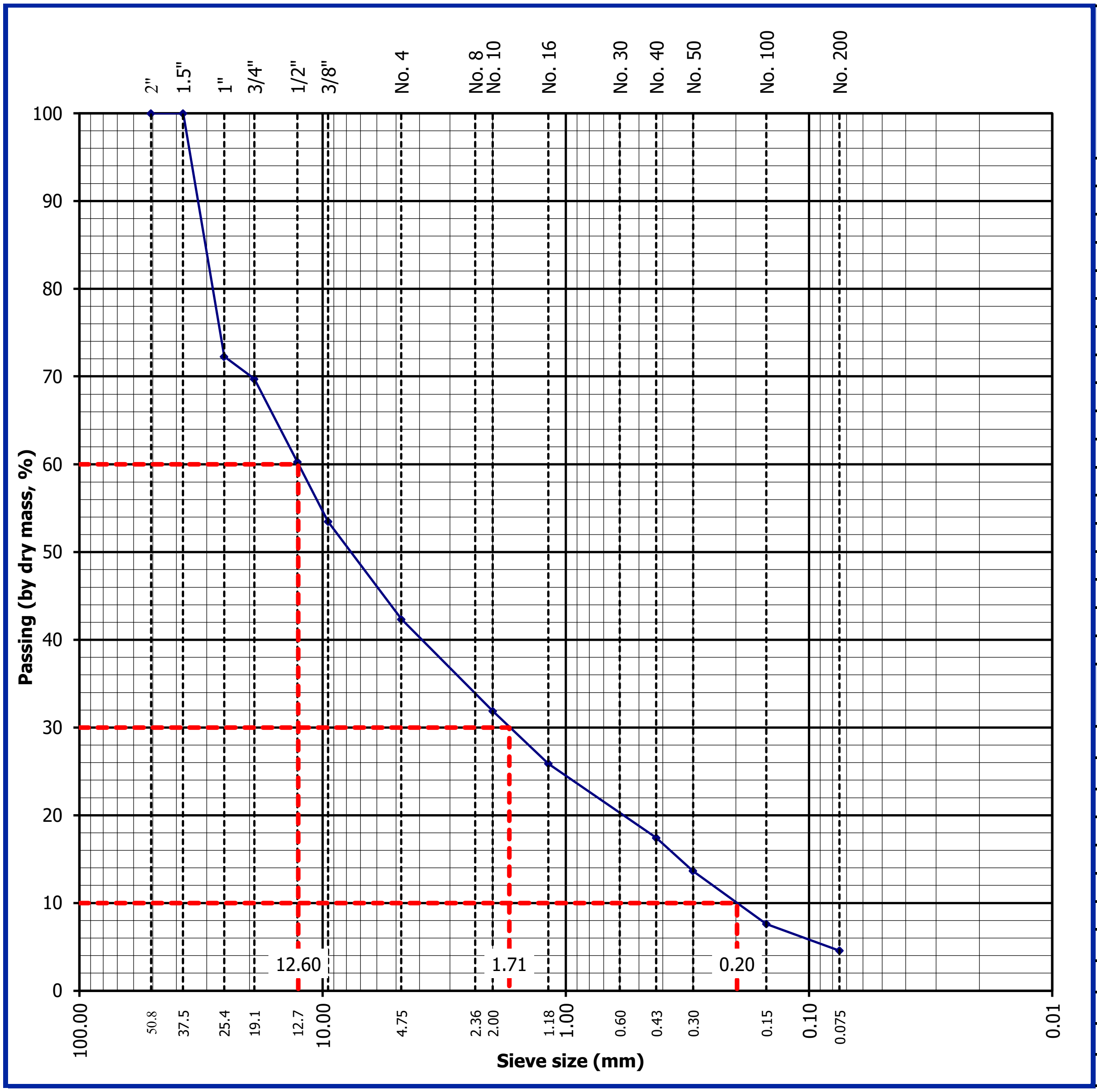
LL	NV
PL	NP
PI	NP

D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

GRADATION PLOT - SOIL AND AGGREGATE

Project number	22.3059	Date	December 30, 2023
Project name	Irwin-Thomas Slurry Wall Design	Technician	B. Keith/L. Glenn
Lab ID number	F222350	Reviewer	G. Hoyos
Sample location	B-10 at 5 feet		
Visual description	GRAVEL, with sand, brown		

AASHTO M145 Classification				**Soaking Method**	
				Procedure	**Method**
Classification	**A-1-a**	**Group Index**	**0**	AASHTO T11	
Unified Soil Classification System (ASTM D2487)				ASTM D1140	**A**
(GW)	**Well graded gravel with sand**			Specimen soaking time (min)	**240**



Sieve Size	**Passing (%)**
2"	
1.5"	100
1"	72
3/4"	70
1/2"	60
3/8"	53
#4	42
#8	
#10	32
#16	26
#30	
#40	17
#50	14
#100	8
#200	4.6
Moisture (M) and Density (D)	
M (%)	3.3
D (pcf)	
LL	NV
PL	NP
PI	NP
D_{60}	12.60
D_{30}	1.71
D_{10}	0.20
Cu	**63.64**
Cc	**1.17**

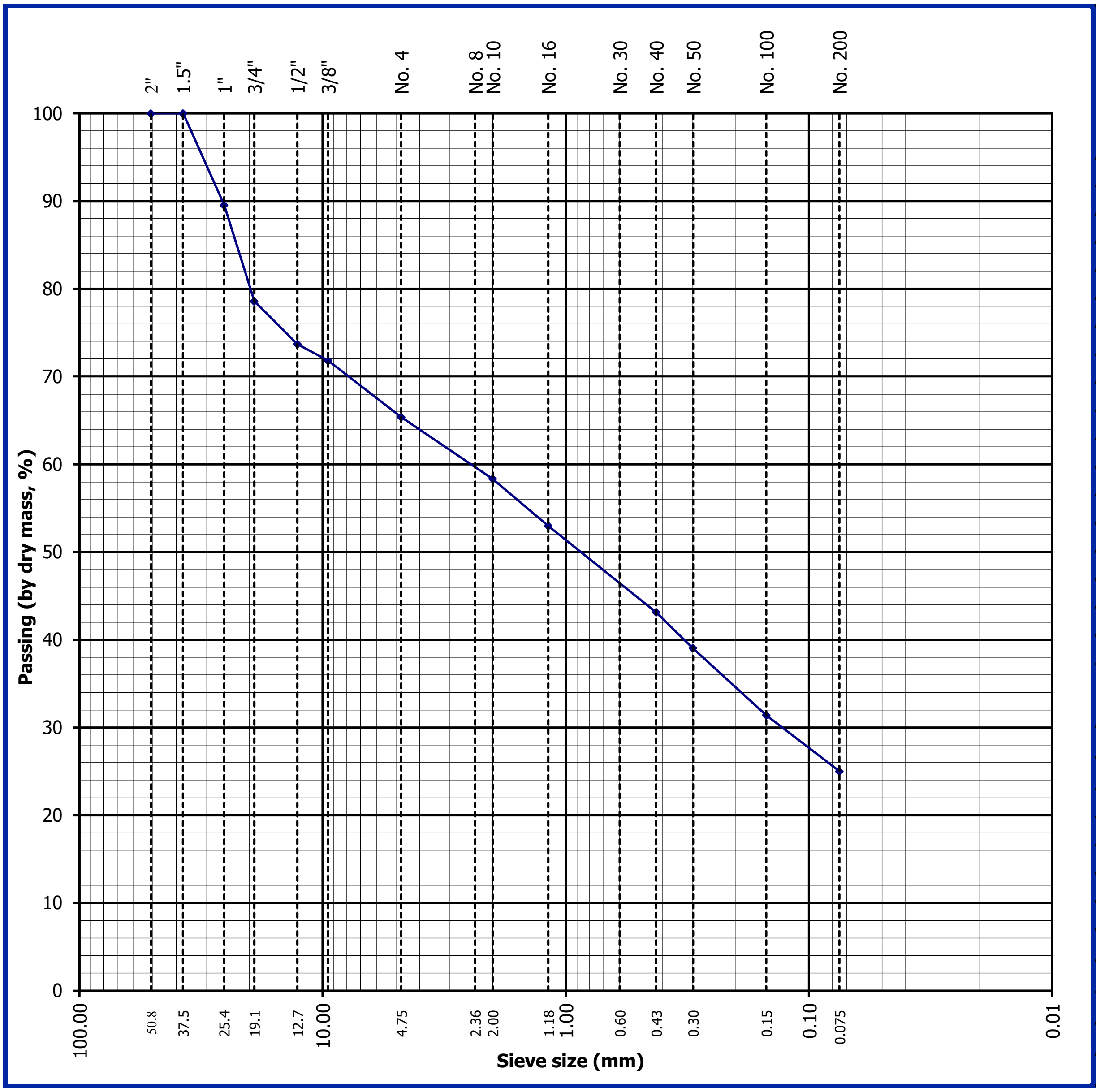
CMT TECHNICAL SERVICES

AASHTO ACCREDITED

GRADATION PLOT - SOIL AND AGGREGATE

Project number	22.3059	Date	December 30, 2022
Project name	Irwin-Thomas Slurry Wall Design	Technician	B. Keith
Lab ID number	F222352	Reviewer	G. Hoyos
Sample location	B-12 at 9 to 14 feet		
Visual description	SAND, silty with gravel, brown		

AASHTO M145 Classification				Soaking Method	
				Procedure	**Method**
Classification	**A-1-b**	**Group Index**	**0**	AASHTO T11	
Unified Soil Classification System (ASTM D2487)				ASTM D1140	**A**
(SM)	**Silty sand with gravel**			Specimen soaking time (min)	**120**



Sieve Size	**Passing (%)**
2"	
1.5"	100
1"	90
3/4"	79
1/2"	74
3/8"	72
#4	65
#8	
#10	58
#16	53
#30	
#40	43
#50	39
#100	31
#200	25.0

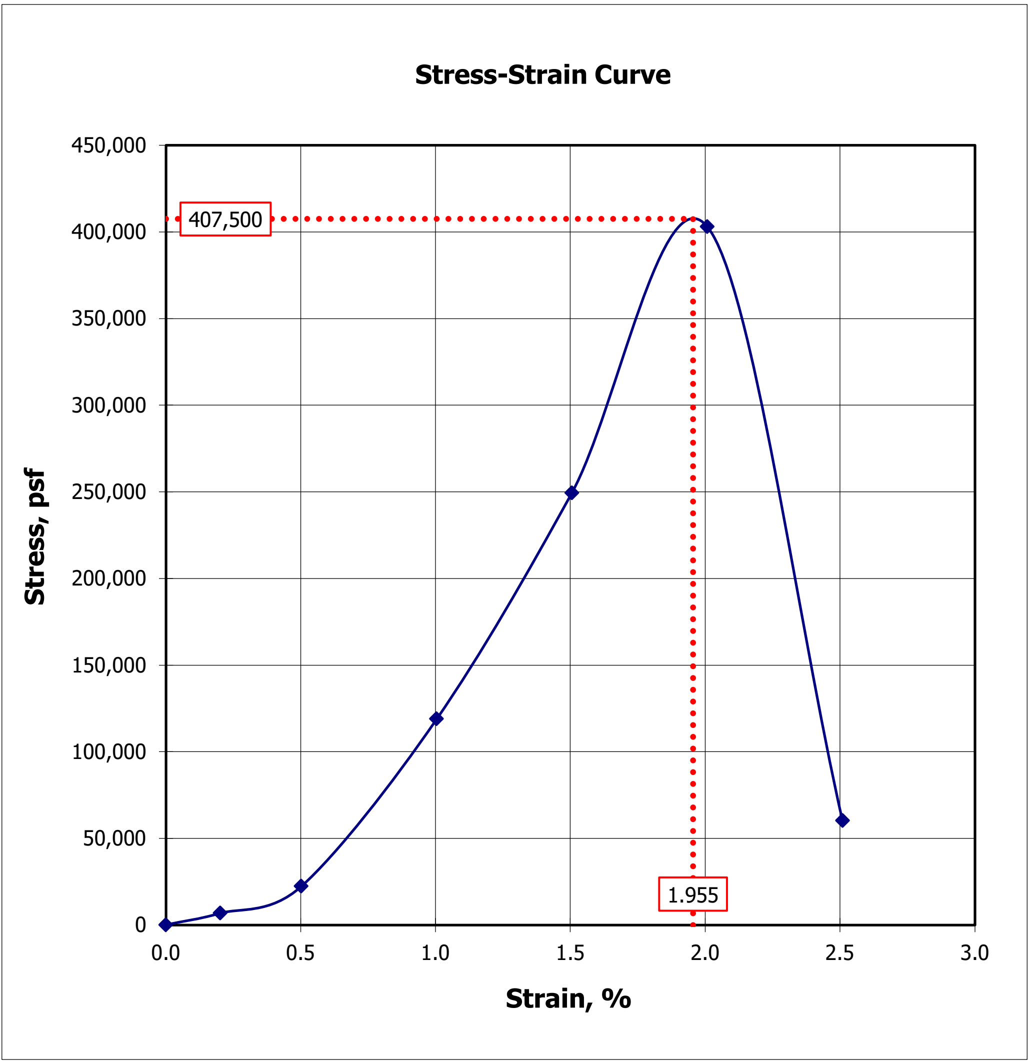
Moisture (M) and Density (D)	
M (%)	5.2
D (pcf)	
LL	NV
PL	NP
PI	NP
D_{60}	
D_{30}	
D_{10}	
Cu	
Cc	

UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOIL (ASTM D2166)

Project No.:	22.3059			Hole:	B-2
Project Name:	Irwin-Thomas Slurry Wall Design			Depth:	24 to 25 feet
Date:	8-Jan-23	Lab Tech:	G. Hoyos	Visual Description of Sample:	
Lab ID:	F222341	Checked By:	G. Hoyos	SHALE, gray	

Unconfined Compressive Strength (q_u):	**407,500**	**psf**	**Density (pcf):**	140.7
Shear Strength (S_u):	**203,750**	**psf**	**Moisture:**	2.6

Axial Strain (%)	Axial Stress (psf)
0.0	42.3
0.2	6,856.0
0.5	22,346.3
1.0	118,910.6
1.5	249,315.5
2.0	403,086.3
2.5	60,173.9

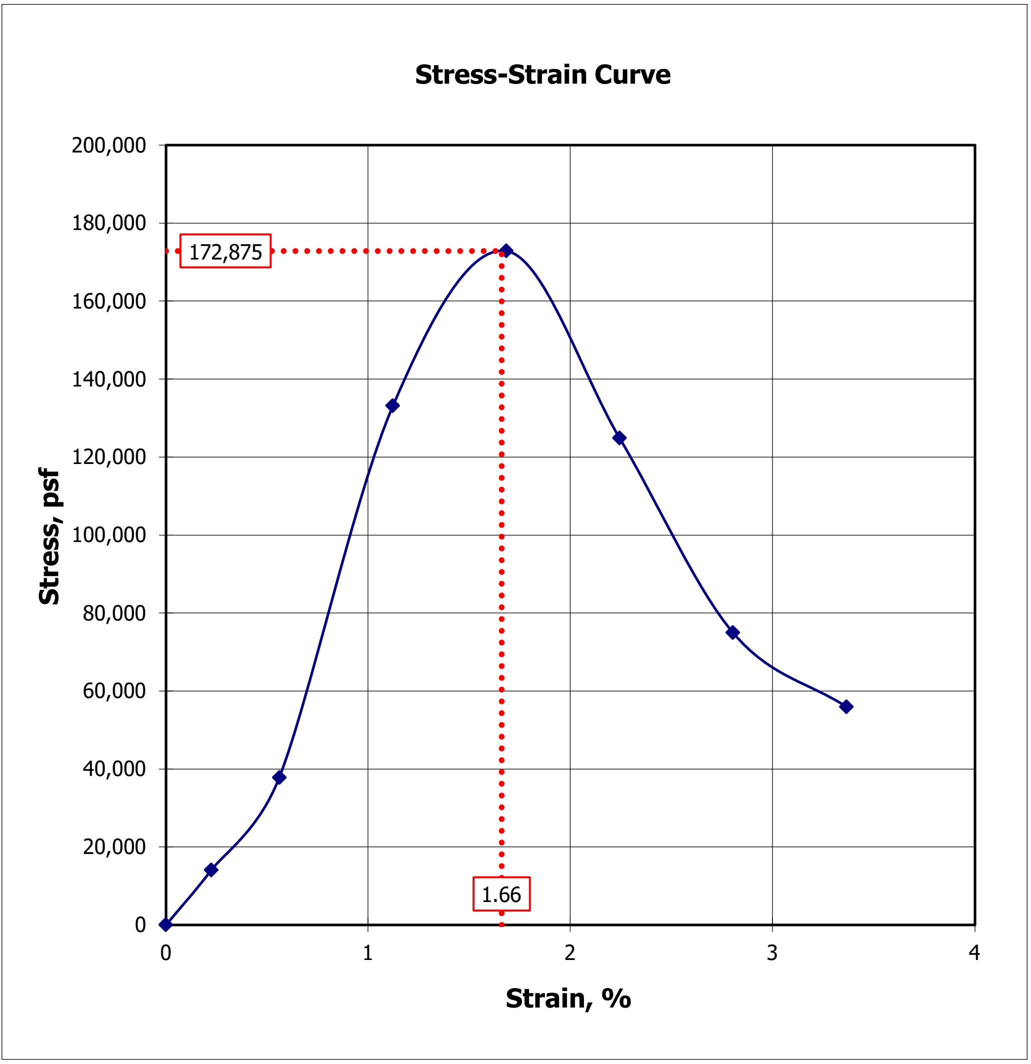


UNCONFINED COMPRESSIVE STRENGTH OF COHESIVE SOIL (ASTM D2166)

Project No.:	22.3059			Hole:	B-8
Project Name:	Irwin-Thomas Slurry Wall Design			Depth:	23 feet
Date:	January 11, 2023	Lab Tech:	K. McNally	Visual Description of Sample:	
Lab ID:	F232022	Checked By:	G. Hoyos	SHALE, gray	

Unconfined Compressive Strength (q_u):	**172,875**	**psf**	**Density (pcf):**	139.8
Shear Strength (S_u):	**86,438**	**psf**	**Moisture:**	4.9

Axial Strain (%)	**Axial Stress (psf)**
0.0	0.0
0.2	14,065.3
0.6	37,801.1
1.1	133,123.7
1.7	172,857.9
2.2	124,903.9
2.8	74,922.9
3.4	55,919.0

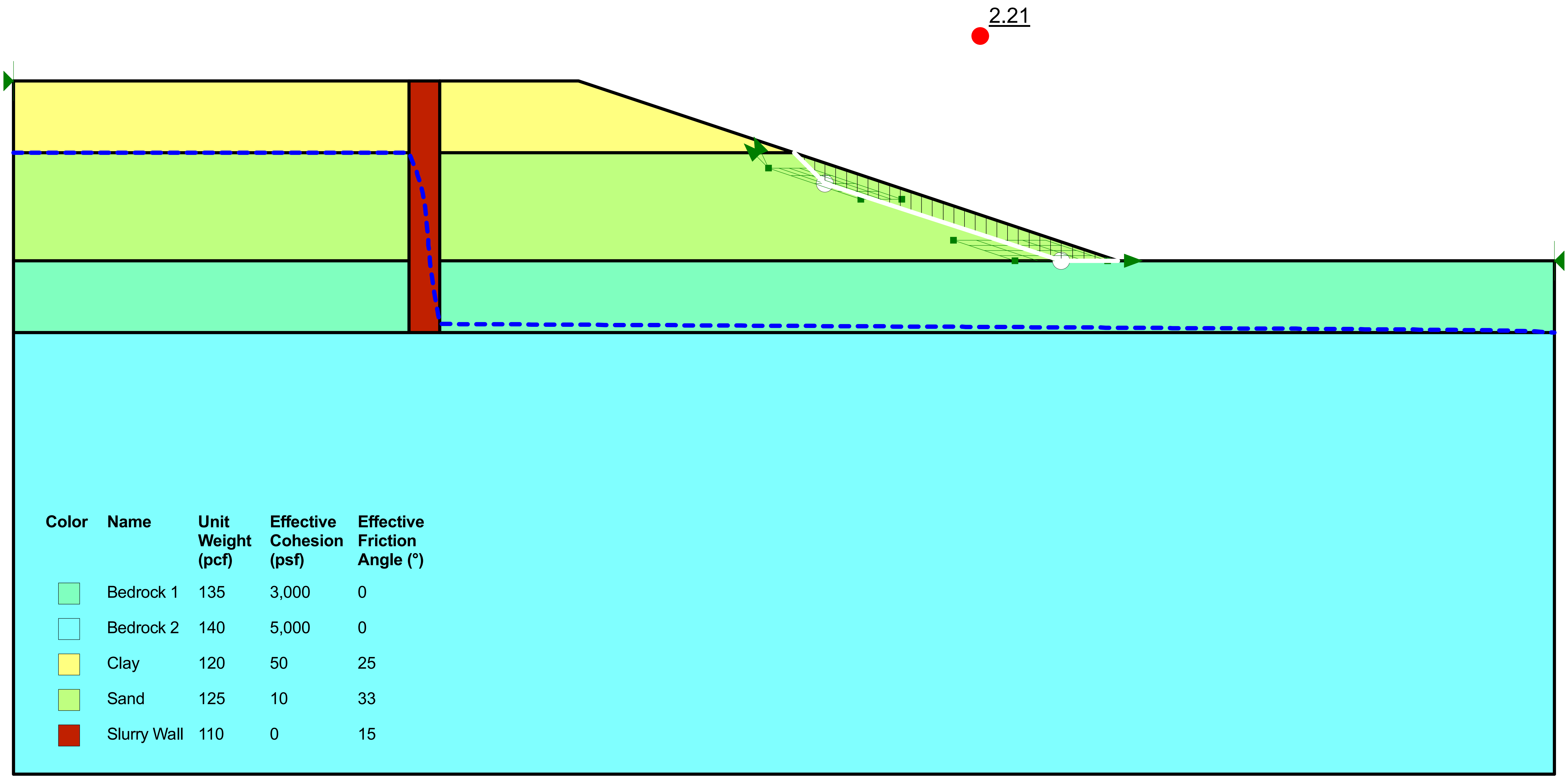


APPENDIX C

Slope Stability Analyses Results

CMT TECHNICAL SERVICES

Irwin-Thomas Slurry Wall
Project No. 22.3059



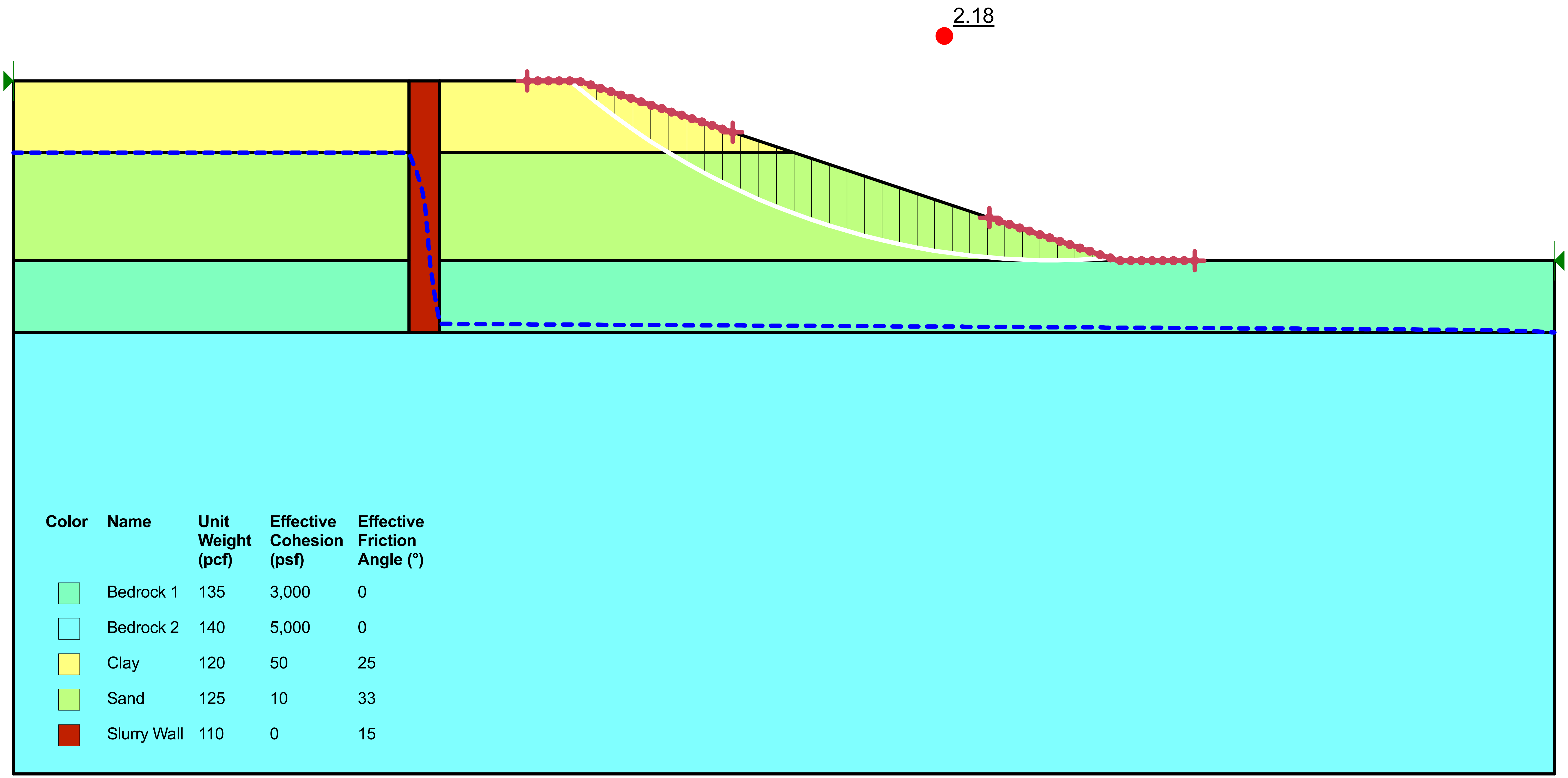
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟩	Bedrock 1	135	3,000	0
🟦	Bedrock 2	140	5,000	0
🟨	Clay	120	50	25
🟩	Sand	125	10	33
🟥	Slurry Wall	110	0	15

Station 22+00

Steady State Seepage, Empty

Block Failure, Critical Failure Surface

Irwin-Thomas Slurry Wall
Project No. 22.3059



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟩	Bedrock 1	135	3,000	0
🟦	Bedrock 2	140	5,000	0
🟨	Clay	120	50	25
🟩	Sand	125	10	33
🟥	Slurry Wall	110	0	15

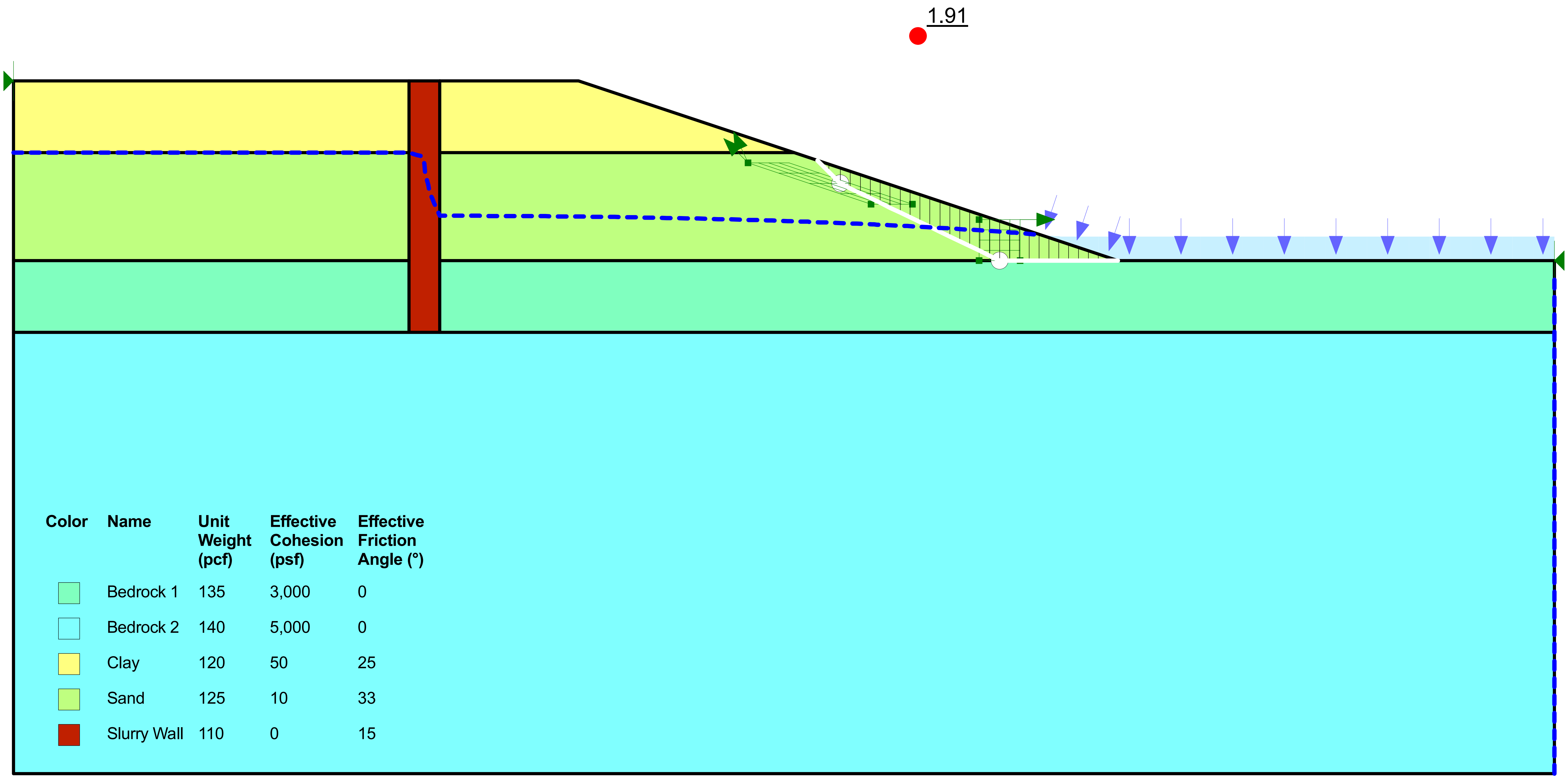
Station 22+00

Steady State Seepage, Empty

Circular Failure, Critical Failure Surface

CMT TECHNICAL SERVICES

Irwin-Thomas Slurry Wall
Project No. 22.3059



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟩	Bedrock 1	135	3,000	0
🟦	Bedrock 2	140	5,000	0
🟨	Clay	120	50	25
🟩	Sand	125	10	33
🟥	Slurry Wall	110	0	15

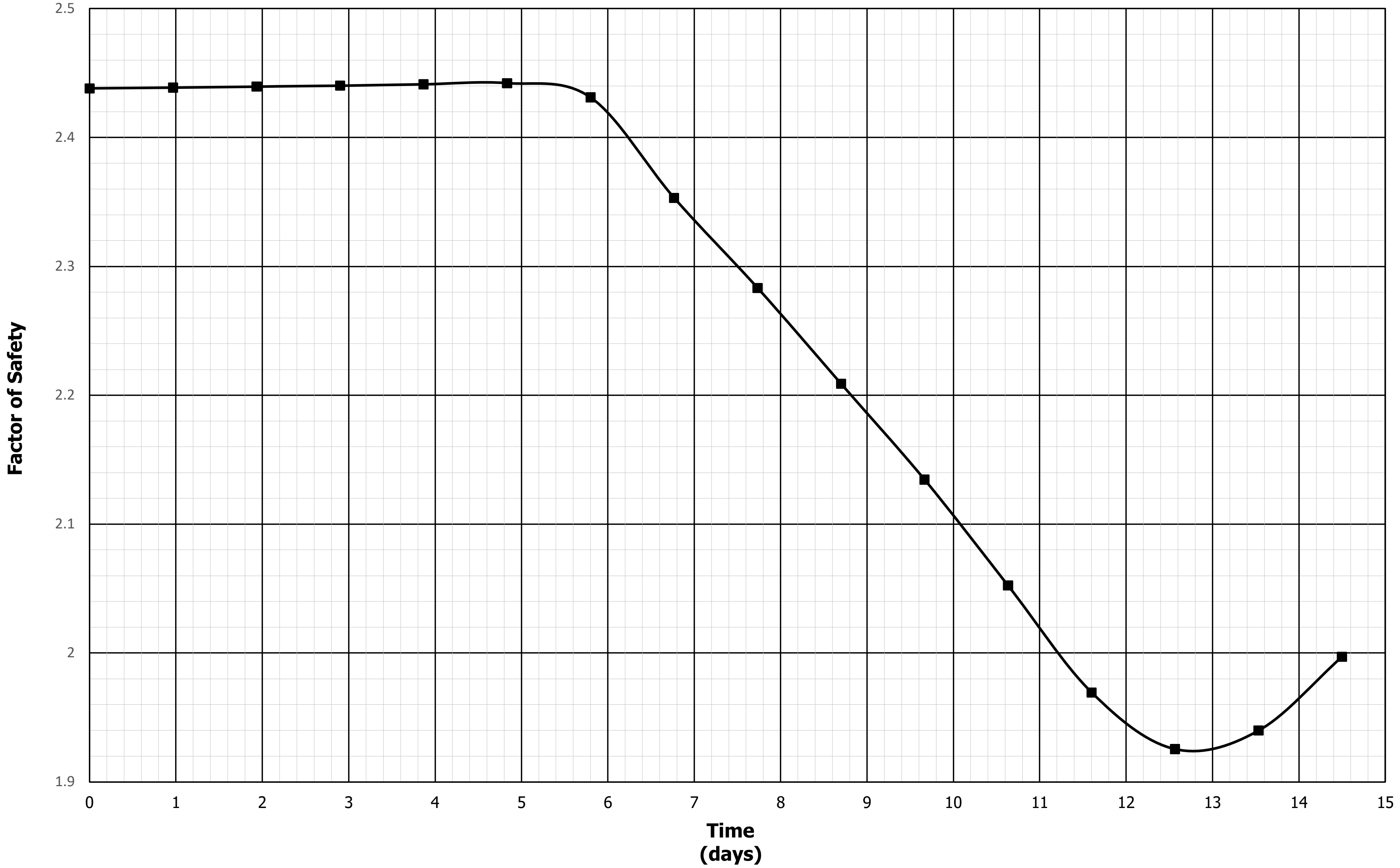
Station 22+00

Trnasient Seepage, Time Step 13

Block Failure, Lowest Critical Failure Surface of All Time Steps

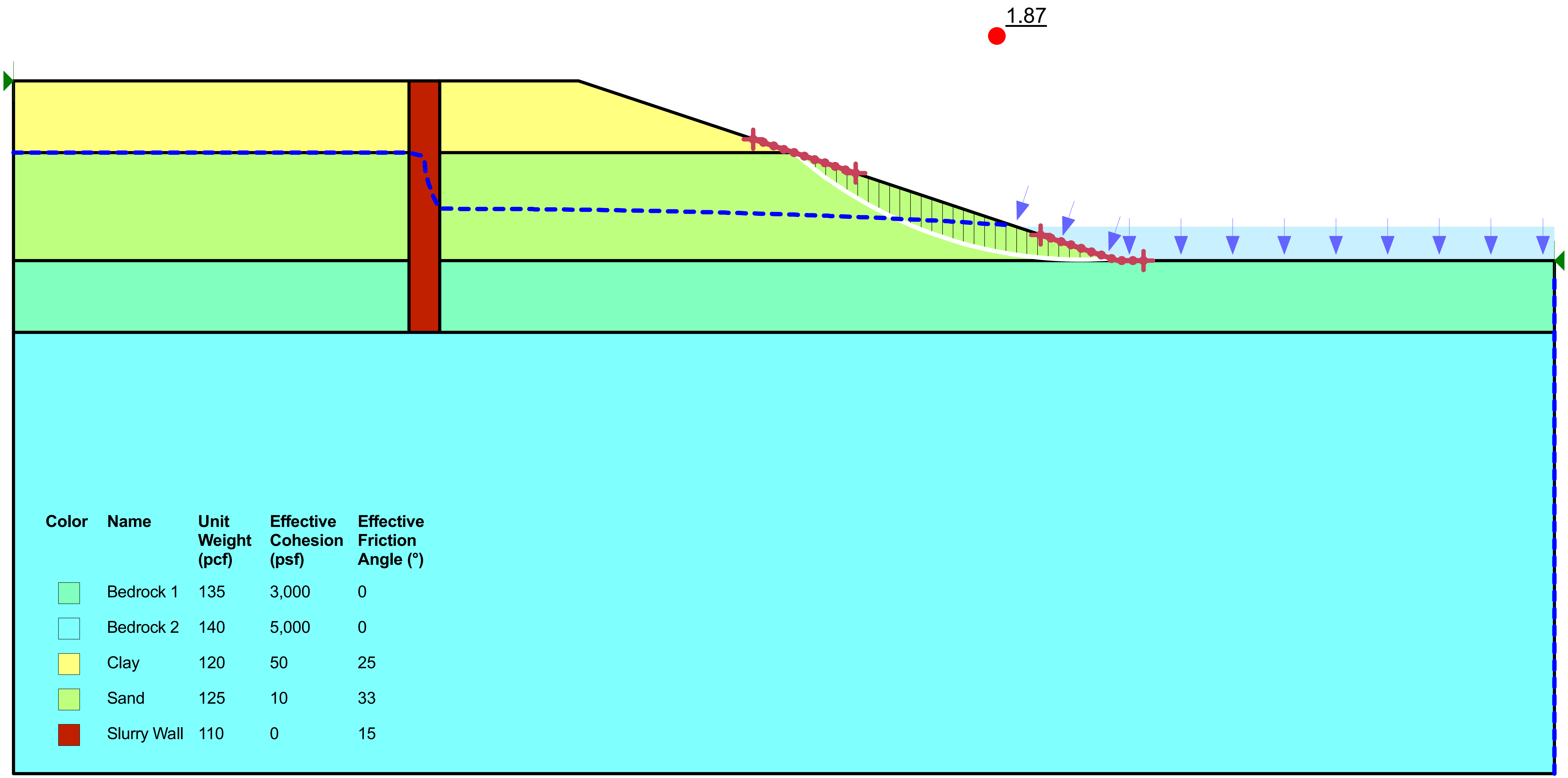
CMT TECHNICAL SERVICES

Irwin-Thomas Slurry Wall Design
Project No. 22.3059
Station 22+00
Rapid Drawdown
Block Stability Analysis
Time vs Factor of Safety



CMT TECHNICAL SERVICES

Irwin-Thomas Slurry Wall
Project No. 22.3059



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟩	Bedrock 1	135	3,000	0
🟦	Bedrock 2	140	5,000	0
🟨	Clay	120	50	25
🟩	Sand	125	10	33
🟥	Slurry Wall	110	0	15

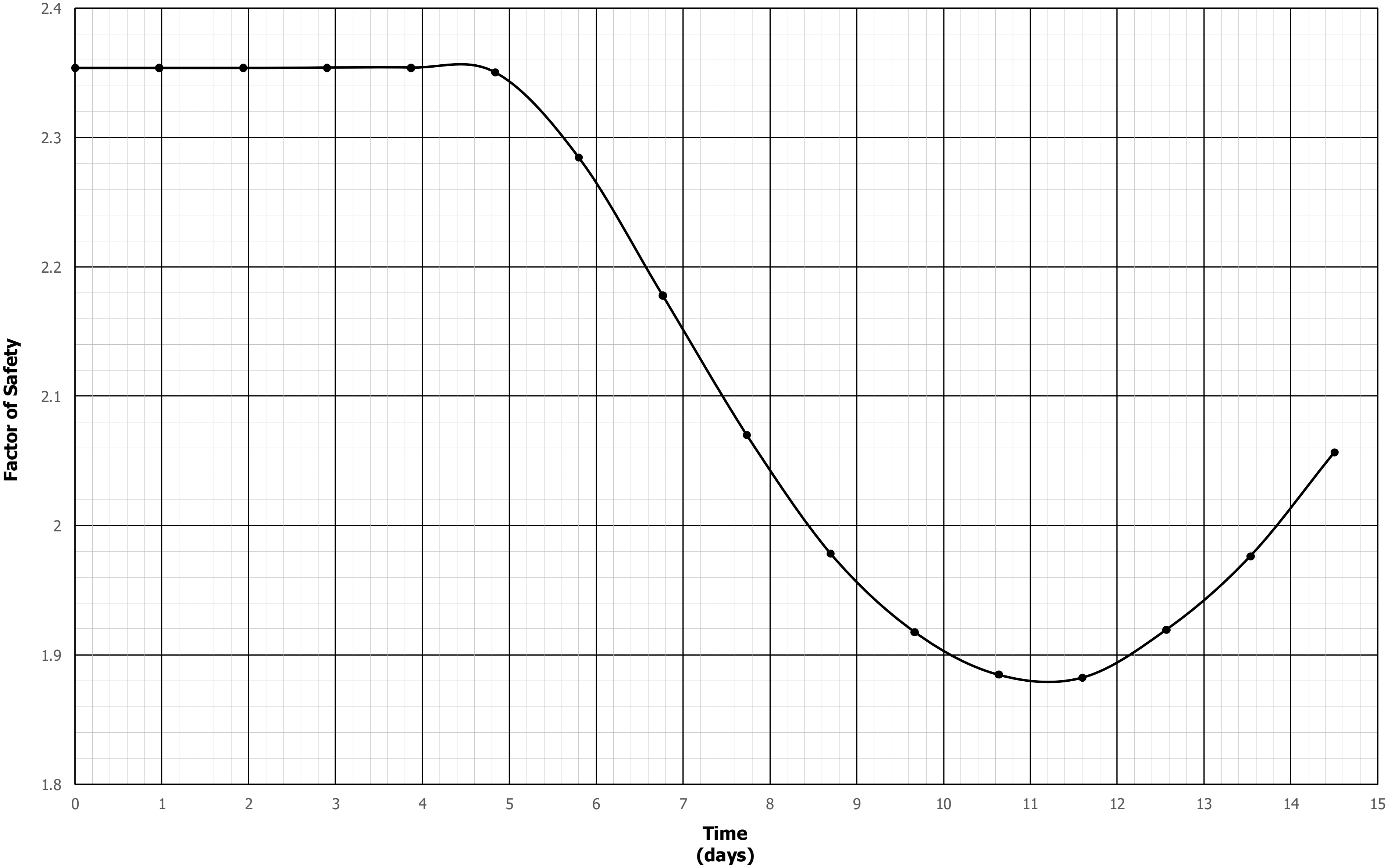
Station 22+00

Transient Seepage, Time Step 12

Circular Failure, Lowest Critical Failure Surface of All Time Steps

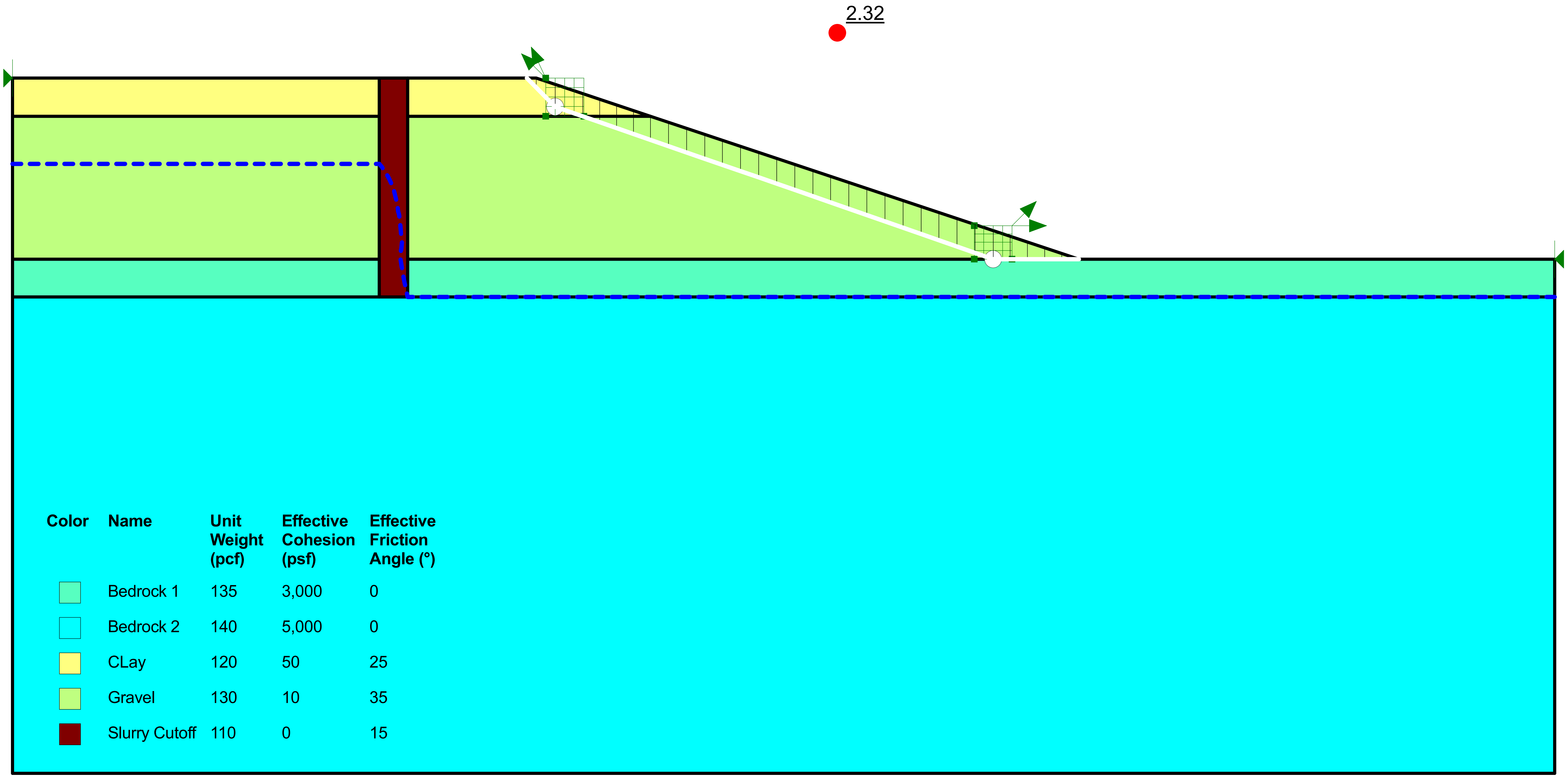
CMT TECHNICAL SERVICES

Irwin-Thomas Slurry Wall Design
Project No. 22.3059
Station 22+00
Rapid Drawdown
Circular Slope Stability Analysis
Time vs Factor of Safety



CMT TECHNICAL SERVICES

Irwin-Thomas Slurry Wall
Project No. 22.3059



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟩	Bedrock 1	135	3,000	0
🟦	Bedrock 2	140	5,000	0
🟨	CLay	120	50	25
🟩	Gravel	130	10	35
🟥	Slurry Cutoff	110	0	15

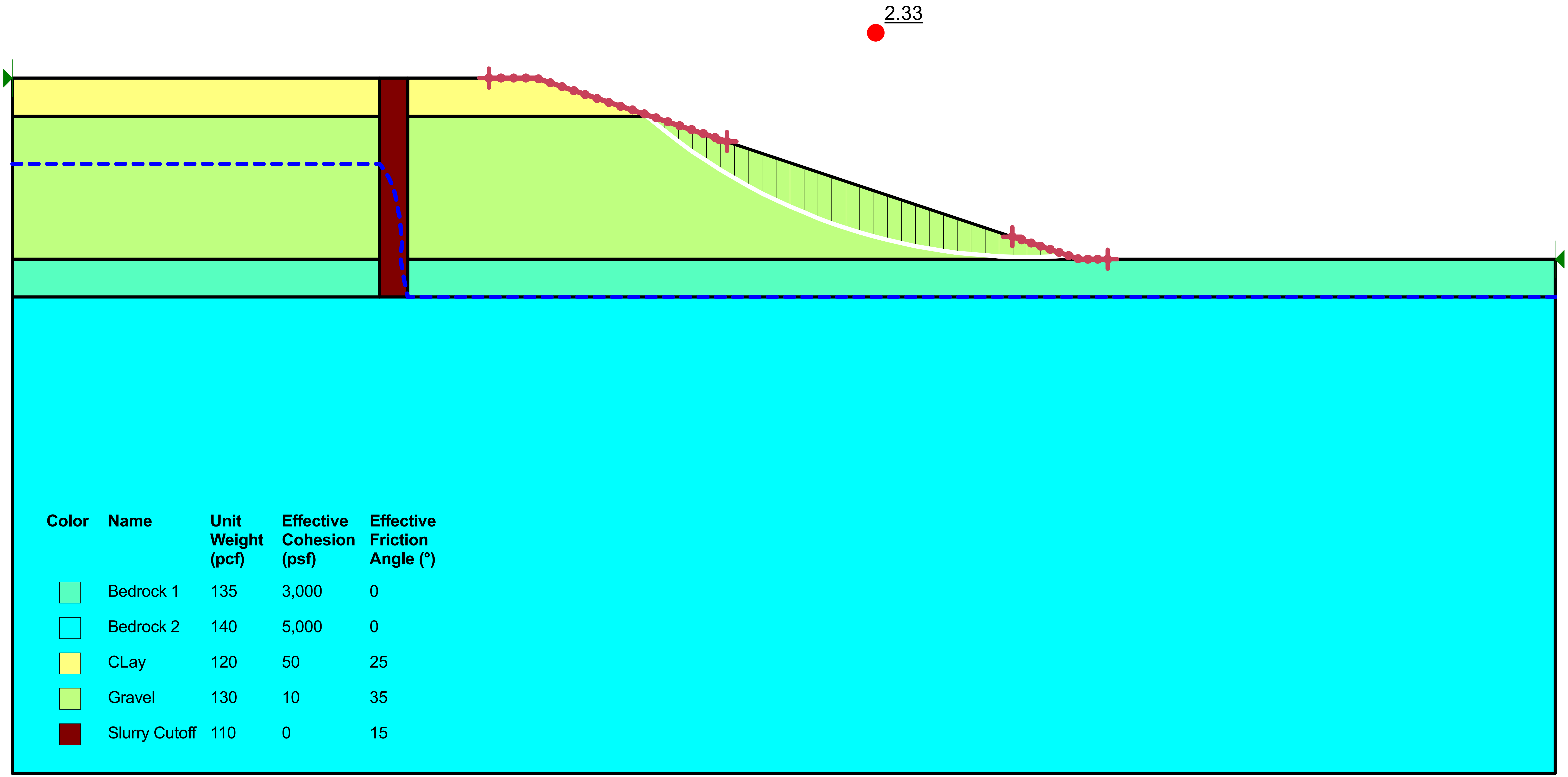
Station 42+50

Steady State Seepage, Empty

Block Failure, Critical Failure Surface

CMT TECHNICAL SERVICES

Irwin-Thomas Slurry Wall
Project No. 22.3059



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟩	Bedrock 1	135	3,000	0
🟦	Bedrock 2	140	5,000	0
🟨	CLay	120	50	25
🟩	Gravel	130	10	35
🟥	Slurry Cutoff	110	0	15

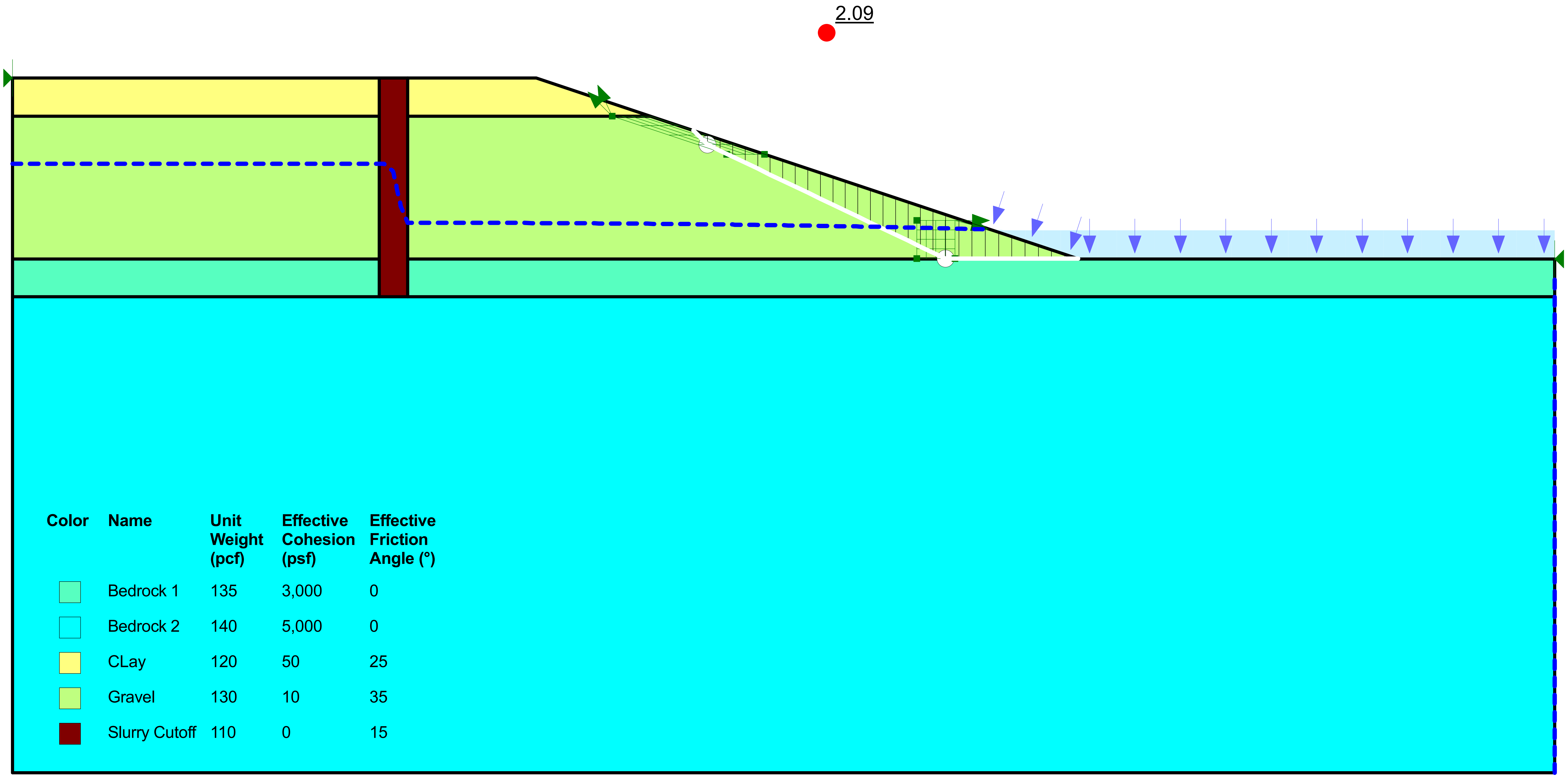
Station 42+50

Steady State Seepage, Empty

Circular Failure, Critical Failure Surface

CMT TECHNICAL SERVICES

Irwin-Thomas Slurry Wall
Project No. 22.3059



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟩	Bedrock 1	135	3,000	0
🟦	Bedrock 2	140	5,000	0
🟨	CLay	120	50	25
🟩	Gravel	130	10	35
🟥	Slurry Cutoff	110	0	15

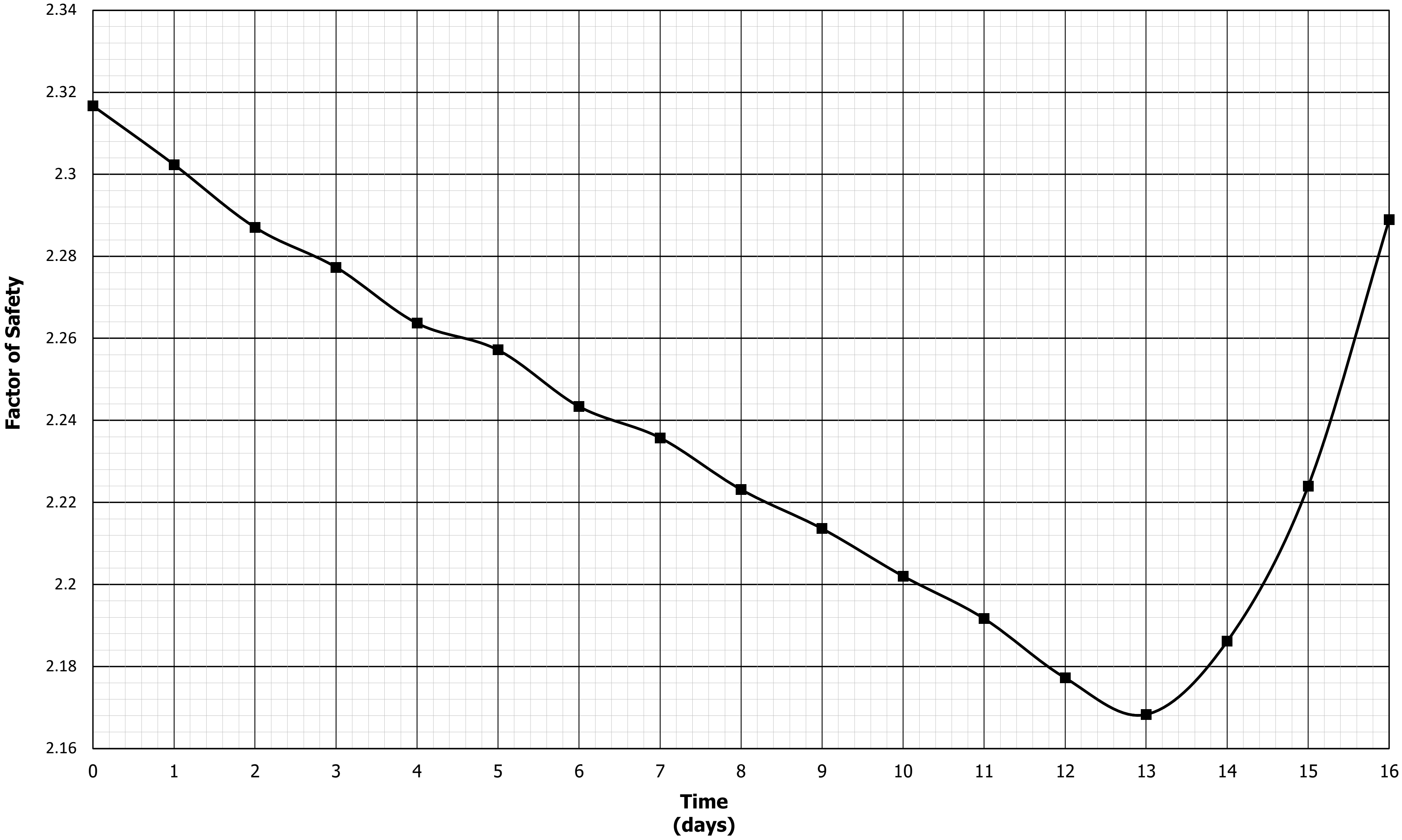
Station 42+50

Transient Seepage, Time Step 13

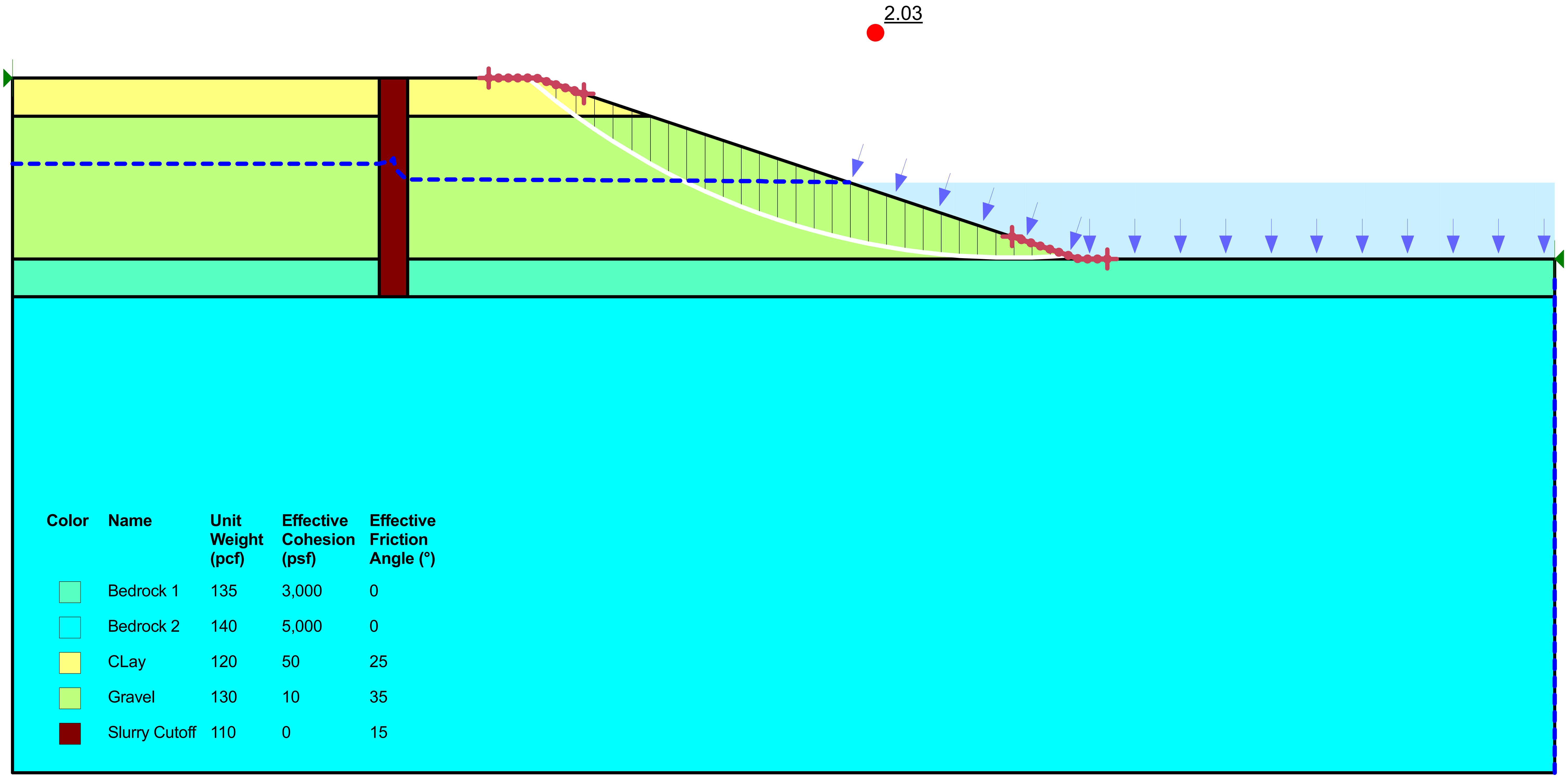
Block Failure, Lowest Critical Failure Surface of All Time Steps

CMT TECHNICAL SERVICES

Irwin-Thomas Slurry Wall Design
Project No. 22.3059
Station 42+50
Rapid Drawdown
Block Slope Stability Analysis
Time vs Factor of Safety



Irwin-Thomas Slurry Wall
Project No. 22.3059



Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
🟩	Bedrock 1	135	3,000	0
🟦	Bedrock 2	140	5,000	0
🟨	CLay	120	50	25
🟩	Gravel	130	10	35
🟥	Slurry Cutoff	110	0	15

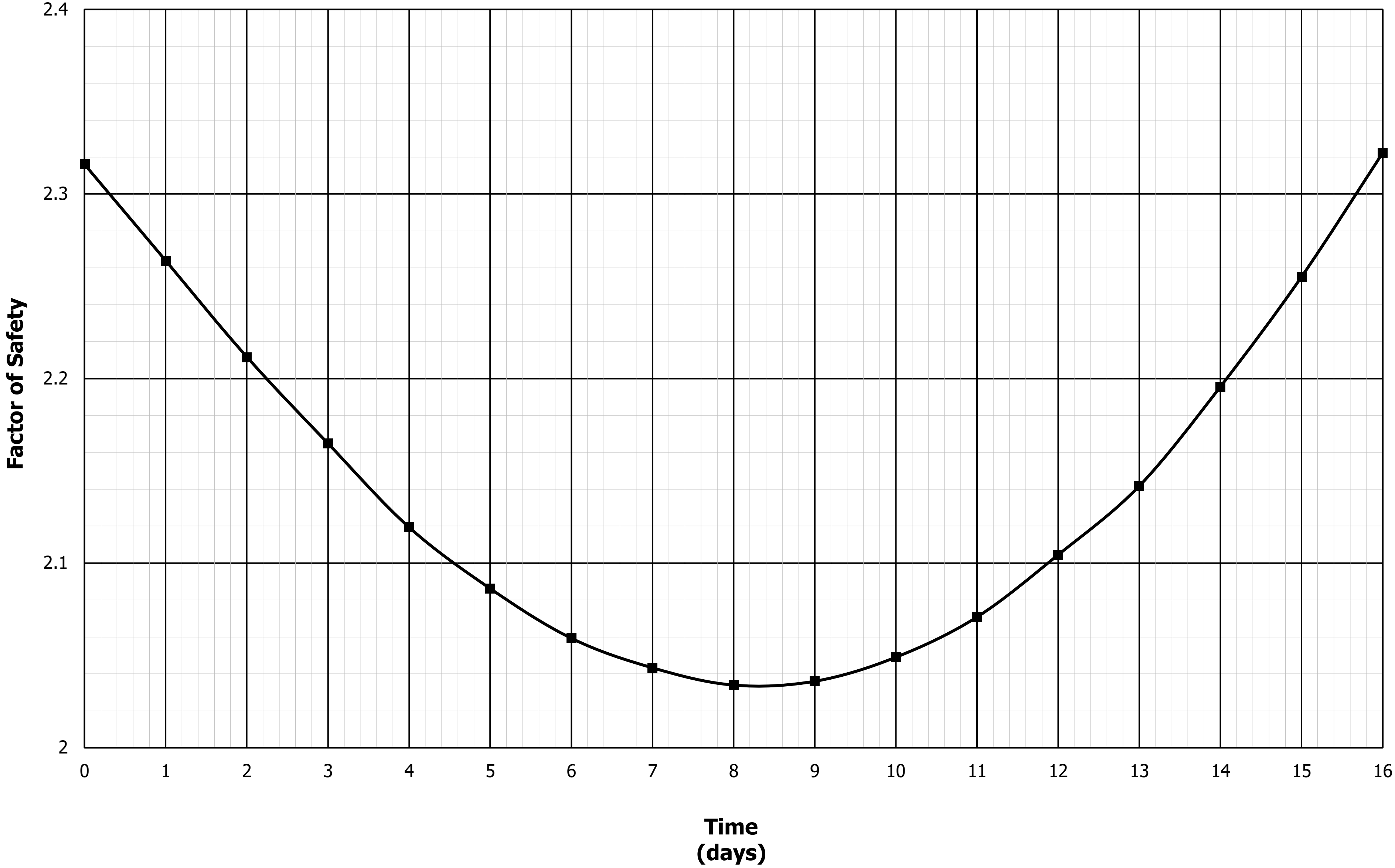
Station 42+50

Transient Seepage, Time Step 8

Circular Failure, Lowest Critical Failure Surface of All Time Steps

CMT TECHNICAL SERVICES

Irwin-Thomas Slurry Wall Design
Project No. 22.3059
Station 42+50
Rapid Drawdown
Circular Slope Stability Analysis
Time vs Factor of Safety



Subsurface Exploration and Slope Stability Evaluations

EARTH ENGINEERING
CONSULTANTS, LLC

June 28, 2022

Holcim
1687 Cole Boulevard, Suite 300
Golden, Colorado 80401

Attn: Mr. Paul Conrad (paul.conrad@holcim.com)

Re: Subsurface Exploration and Slope Stability Evaluation - Supplemental Report #2
Irwin/Thomas Properties
Longmont, Colorado
EEC Project No. 1172053

Mr. Conrad:

As requested, Earth Engineering Consultants, LLC (EEC) submitted to your attention a report (EEC project number 1172053, dated February 7, 2018) which provided the results of a subsurface exploration and slope stability analysis of slopes that may develop as part of the open pit mining operation planned at the referenced site (February 7 Report). At this time, we have been requested to provide a response to your request for information you submitted to our attention (via email) on April 13, 2022. Outlined below is the submitted requests for information, followed by our responses. Note the submitted question may be rephrased for clarity.

> Question 1: At the time the February 7 Report was prepared, the Pre-Mining Map prepared by Blue Earth Solution, dated September 2016, indicated a mining boundary setback from permit boundary along Ken Pratte Boulevard of at least 200 feet. A current Pre-Mining Map prepared by TST, dated March 2022, indicates that setback of at least 100 feet. Is the referenced minimum 100-foot setback acceptable to maintain the required the minimum factor of safety?

> Response: In our opinion, a minimum setback of 100 feet of the mining boundary from the permit boundary near Ken Pratte Boulevard right-of-way would maintain an acceptable factor of safety of at least 1.5 as indicated for static slope stability for Critical Structures (based on the conditions described in our February 7 Report, including maximum mining depths of 25 feet below ground surface). This assumes a relatively flat backslope and no stockpile or other surcharges at the ground surface between the mining and permit boundaries. Note the minimum factors of safety and definitions of Non-Critical Structures and Critical Structures, are based on Colorado Division of Reclamation, Mining and Safety, *Proposed Slope Stability/Geotechnical Analysis Policy for The Mined Land Reclamation Board*, dated May 16, 2018; that specification should be reviewed for completeness. If the factors of safety required vary from those specifications, this report should be reviewed by EEC and revised as necessary.

We trust the information provided in this letter provides the necessary information you requested; however, if additional information is needed, or if we can be of further service to you in any other way, please do not hesitate to contact us.

Very truly yours,
Earth Engineering Consultants, LLC

COLORADO LICENSED PROFESSIONAL ENGINEER
ETHAN PATRICK WIECHERT
40838
6/28/22

Ethan P. Wiechert, P.E.
Senior Project Engineer

EEC
EARTH ENGINEERING
CONSULTANTS, LLC

February 7, 2018

Aggregate Industries (US) Inc.
1687 Cole Blvd, Suite 300
Golden, Colorado 80401

Attn: Mr. Joel Bolduc (joel.bolduc@aggregate-us.com)

Re: Subsurface Exploration and Slope Stability Evaluation
Irwin/Thomas Properties
Longmont, Colorado
EEC Project No. 1172053

Mr. Bolduc:

Enclosed, herein, are the results of the subsurface exploration and geotechnical engineering services completed by Earth Engineering Consultants, LLC (EEC) personnel for the referenced project. The purpose of this exploration was to develop subsurface information for stability evaluation of slopes that would develop during the open pit mining operation planned at the referenced properties. This exploration and evaluation was carried out in general accordance with our proposal dated October 30, 2017.

INTRODUCTION

We understand open-pit mining is planned on the approximate 258-acre Irwin/Thomas properties in Longmont, Colorado. The open-pit mine would generally operate to obtain useable aggregates with mining extending to depths not to exceed approximately 25 feet below ground surface. The mining operations would propose near vertical cuts at the mining boundaries with the top of the cut slope maintaining a minimum setback of two times the cut depth to the surrounding permit boundary. We understand the open pit would maintain dewatering trenches at the base of the cut to dewater the pit and prevent water seepage into the open cut slopes.

EXPLORATION AND TESTING PROCEDURES

To obtain information of the existing subsurface conditions, six (6) test borings extending to depths of approximately 23 to 25 feet below present site grades were advanced at preselected locations across the permit area. The boring locations were established in the field by EEC personnel by pacing and estimating angles from identifiable site references. The approximate locations of the completed test borings are indicated on the attached boring location diagram. The locations of the test borings should be considered accurate only to the degree implied by the methods used to make the field measurements. Individual boring logs and a diagram indicating the approximate boring locations are included with this report.

The borings were completed using a truck mounted, CME-55 drill rig equipped with a hydraulic head employed in drilling and sampling operations. The boreholes were advanced using 4¼-inch inside diameter hollow stem continuous flight augers. Samples of the subsurface materials encountered were obtained using split barrel and California barrel sampling procedures in general accordance with ASTM Specifications D1586 and D3550, respectively, and directly from the auger.

In the split barrel and California barrel sampling procedures, standard sampling spoons are driven into the ground by means of a 140-pound hammer falling a distance of 30 inches. The number of blows required to advance the split barrel and California barrel samplers is recorded and is used to estimate the in-situ relative density of cohesionless soils and, to a lesser degree of accuracy, the consistency of cohesive soils. In the California barrel sampling procedure, relatively intact samples are recovered in removable brass liners. All samples obtained in the field were sealed and returned to our laboratory for further examination, classification and testing.

Laboratory moisture content tests were completed on each of the recovered samples. Atterberg limits and washed sieve analysis tests were completed on selected samples to evaluate the quantity and plasticity of fines in the subgrades. Direct shear tests were carried out on remolded samples to evaluate the shear strength parameters of the subgrades. Results of the completed laboratory tests are indicated on the attached boring logs and summary sheets.

As part of the testing program, all samples were examined in the laboratory and classified in general accordance with the attached General Notes and the Unified Soil Classification System, based on the soil's texture, plasticity and grain size distribution. The estimated group symbol for the Unified Soil Classification System is indicated on the boring logs and a brief description of that classification system is included with this report. Classification of the bedrock was based on visual and tactual observation of disturbed samples and auger cuttings. Coring and/or petrographic analysis may reveal other rock types.

SITE AND SUBSURFACE CONDITIONS

The Irwin/Thomas property generally includes an area which extends from SH 119 south to Quail Road and from North 119th Street approximately 3/4 of a mile to the west (proposed mining area (MA)1). The property also includes an area which extends north from SH 119 approximately 1/3 of a mile. The MA1 property south of the highway is relatively flat and gently slopes down to the north and east. The Irwin/Thomas site north of the highway is bisected north and south by the Saint Vrain River and properties both north and south of the river gently slope to the river. The proposed MA2 is south of the river and MA3 and MA4 are north of the river. This exploration and evaluation only includes the proposed MA1 and MA2 properties. The properties are mostly covered with sparse vegetation. Photographs of the site taken during our exploration and are included with this report.

EEC personnel were on site during the drilling operations to evaluate the subsurface conditions encountered and direct the drilling activities. Field logs prepared by EEC site personnel were based on visual and tactual observation of auger cuttings and disturbed samples. The boring logs included with this report may contain modifications to the field logs based on results of laboratory testing and engineering evaluation. Based on results of the field boring and laboratory testing, subsurface conditions can be generalized as follows.

Approximately 4 to 6 inches of topsoil and vegetation was encountered at the surface of the boring locations. The topsoil and vegetation was underlain by brown sandy clay which extended to depths of approximately 3 to 8 feet below ground surface. The sandy clay soils were moderately to highly plastic, and stiff to very stiff. The sandy clay soils were underlain by sand and gravel with various amounts of silt and apparent cobbles which extended to depths of approximately 13 to 18 feet below ground surface. The sands and gravels were medium dense to dense and becoming dense to very dense with depth. The sands and gravels were underlain by moderately hard to hard sandstone, siltstone, and claystone bedrock which extended to the bottom of the test borings which were terminated at depths of approximately 23 to 25 feet below ground surface.

The stratification boundaries indicated on the boring logs represent the approximate locations of changes in soil and rock types; in-situ, the transition of materials may be gradual and indistinct.

Groundwater

Observations were made while drilling and after completion of borings to detect the presence and depth to groundwater. During drilling operations, groundwater was encountered at depths ranging from 7 to 11 feet below ground surface. Approximately three days after drilling, groundwater was measured at depths ranging from approximately 4 to 11 feet below ground surface. After the last groundwater level measurement, the boreholes were backfilled.

Fluctuations in groundwater levels can occur over time depending on variations in hydrologic conditions and other conditions not apparent at the time of this report. In addition, zones of perched and/or trapped water may be encountered at times throughout the year in more permeable areas within the subgrade materials. Perched water is commonly observed in more permeable soils above lower permeability bedrock.

Physical Characteristics of Subgrades

Site materials encountered generally consisted of sandy clay underlain by sands and gravels with various amounts of silts and apparent cobbles. The physical properties of the materials encountered in the borings are summarized in the following sections. Note that changes in materials and physical properties of those materials may vary from boring location to boring location. The parameters outlined below do not include any safety factors.

Sandy Clay

Selected samples of the sandy clay were tested for Atterberg limits, washed sieve analysis unconfined compression (estimated using a calibrated hand penetrometer), and direct shear tests.

The results of the laboratory testing are attached with this report and/or shown on the attached boring logs.

In summary, the sandy clay soils were moderately to highly plastic with liquid limits ranging from 32 to 57% with plastic indices ranging from 15 to 40%. Unconfined compression testing was estimated in the range of 3,000 to 7,000 psf. Direct shear testing indicated a peak friction angle of 29.6° and cohesion of 794 psf, and a residual friction angle of 28.3° and cohesion of 624 psf.

Sands and Gravels

The sands and gravels were tested in the laboratory for plasticity, grain size distribution, and shear strength parameters. In general, the sands and gravels were well graded to poorly graded and contained various amounts of silt. Direct shear testing indicated a peak friction angle of 38.4° and cohesion of 949 psf, and a residual friction angle of 33.1° and cohesion of 424 psf.

ANALYSIS AND RECOMMENDATIONS

The stability of two proposed sections were evaluated at your request. Section 1 included a surcharge from a stockpile of overburden materials (6-foot tall and 3:1 (horizontal to vertical) slopes) with a setback of at least 20 feet from the cut face. Section 2 included a surcharge from a roadway setback of at least 50 feet from the cut face. The analyses assumed a maximum 25-foot excavation depth which would extend to bedrock, continuous dewatering to the base of the excavation, no surcharges other than that indicated on the analyses, and vertical cut faces. Based on the subsurface conditions encountered and the geometry of the proposed excavations, stability analyses were carried out to determine (1) the probable location of the failure surface, (2) the distance from the cut face to a safety factor of approximately 1.3, and (3) the distance from the cut face to a safety factor of approximately 1.5.

The stability analyses were evaluated using Morgenstern-Price method of slices modeled in SlopeW software provided by GeoStudio. Porewater pressures were modeled using SeepW software. Soil parameters used in the analyses were obtained from the conditions observed, the results of laboratory testing, and/or estimated from available geotechnical information. Shear strength parameters used for the sandy clay soils included a friction angle of 28° and cohesion of

500 psf; cohesion was neglected for the stockpile soils. For the sands and gravels, a friction angle of 33° and no cohesion was used. The shear strength parameters were conservatively reduced from those determined in the laboratory to account for some variation in the subgrades and, for the case of the soil stockpiles, the loss of apparent cohesion due to disturbing the soils when building the stockpiles. The results of the slope stability analyses are summarized in Table 1 below. The results for Section 1 are shown in Figures 1 through 3 with the results for Section 2 shown in Figures 4 through 6.

Table 1: Summary of Slope Stability Results

Section	Description of Geometry	(1) Distance from Cut to Top of Likely Failure Surface	(2) Distance from Cut to Factor of Safety ≈ 1.3	(3) Distance from Cut to Factor of Safety ≈ 1.5
1	Includes Stockpile	29 feet	52 feet	58 feet
2	Includes Roadway	24 feet	41 feet	50 feet

A minimum factor of safety of 1.3 to 1.5 is generally considered acceptable for slope stability of permanent improvements. Higher factors of safety would be developed with greater distances from the cut face.

GENERAL COMMENTS

The analysis and recommendations presented in this report are based upon the data obtained from the soil borings performed at the indicated locations and from any other information discussed in this report. This report does not reflect any variations which may occur between borings or across the site. The nature and extent of such variations may not become evident until further exploration or construction. If variations appear evident, it will be necessary to re-evaluate the recommendations of this report.

It is recommended that the geotechnical engineer be retained to review the plans and specifications so comments can be made regarding the interpretation and implementation of our geotechnical recommendations in the design and specifications. It is further recommended that the geotechnical engineer be retained for testing and observations during earthwork construction phases to help determine that the design requirements are fulfilled.

This report has been prepared for the exclusive use of Aggregate Industries and Blue Earth Solutions for specific application to the project discussed and has been prepared in accordance with generally accepted geotechnical engineering practices. No warranty, express or implied, is made. In the event that any changes in the nature, design, or location of the project as outlined in this report are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and the conclusions of this report are modified or verified in writing by the geotechnical engineer.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report, or if we can be of further service to you in any other way, please do not hesitate to contact us.

Very truly yours,
Earth Engineering Consultants, LLC

COLORADO LICENSED PROFESSIONAL ENGINEER
ETHAN PATRICK WIECHERT
40638
2/7/18

Ethan P. Wiechert, P.E.
Senior Geotechnical Engineer

Reviewed by: David A. Richer, P.E.
Senior Geotechnical Engineer

cc: Blue Earth Solutions - Bill Schenderlein (bill@blueearthsolutions.net)

DRILLING AND EXPLORATION

DRILLING & SAMPLING SYMBOLS:

SS: Split Spoon - 13/8" I.D., 2" O.D., unless otherwise noted
ST: Thin-Walled Tube - 2" O.D., unless otherwise noted
R: Ring Barrel Sampler - 2.42" I.D., 3" O.D. unless otherwise noted
PA: Power Auger
HA: Hand Auger
DB: Diamond Bit = 4", N, B
AS: Auger Sample
HS: Hollow Stem Auger

PS: Piston Sample
WS: Wash Sample

FT: Fish Tail Bit
RB: Rock Bit
BS: Bulk Sample
PM: Pressure Meter
WB: Wash Bore

Standard "N" Penetration: Blows per foot of a 140 pound hammer falling 30 inches on a 2-inch O.D. split spoon, except where noted.

WATER LEVEL MEASUREMENT SYMBOLS:

WL : Water Level
WCI: Wet Cave in
DCI: Dry Cave in
AB : After Boring

WS : While Sampling
WD : While Drilling
BCR: Before Casing Removal
ACR: After Casting Removal

Water levels indicated on the boring logs are the levels measured in the borings at the time indicated. In pervious soils, the indicated levels may reflect the location of ground water. In low permeability soils, the accurate determination of ground water levels is not possible with only short term observations.

DESCRIPTIVE SOIL CLASSIFICATION

Soil Classification is based on the Unified Soil Classification system and the ASTM Designations D-2488. Coarse Grained Soils have move than 50% of their dry weight retained on a #200 sieve; they are described as: boulders, cobbles, gravel or sand. Fine Grained Soils have less than 50% of their dry weight retained on a #200 sieve; they are described as : clays, if they are plastic, and silts if they are slightly plastic or non-plastic. Major constituents may be added as modifiers and minor constituents may be added according to the relative proportions based on grain size. In addition to gradation, coarse grained soils are defined on the basis of their relative in-place density and fine grained soils on the basis of their consistency. Example: Lean clay with sand, trace gravel, stiff (CL); silty sand, trace gravel, medium dense (SM).

CONSISTENCY OF FINE-GRAINED SOILS

Unconfined Compressive Strength, Qu, psf	Consistency
< 500	Very Soft
500 - 1,000	Soft
1,001 - 2,000	Medium
2,001 - 4,000	Stiff
4,001 - 8,000	Very Stiff
8,001 - 16,000	Very Hard

RELATIVE DENSITY OF COARSE-GRAINED SOILS:

N-Blows/ft	Relative Density
0-3	Very Loose
4-9	Loose
10-29	Medium Dense
30-49	Dense
50-80	Very Dense
80 +	Extremely Dense

PHYSICAL PROPERTIES OF BEDROCK

DEGREE OF WEATHERING:

Slight	Slight decomposition of parent material on joints. May be color change.
Moderate	Some decomposition and color change throughout.
High	Rock highly decomposed, may be extremely broken.

HARDNESS AND DEGREE OF CEMENTATION:

Limestone and Dolomite:

Hard	Difficult to scratch with knife.
Moderately	Can be scratched easily with knife.
Hard	Cannot be scratched with fingernail.
Soft	Can be scratched with fingernail.

Shale, Siltstone and Claystone:

Hard	Can be scratched easily with knife, cannot be scratched with fingernail.
Moderately Hard	Can be scratched with fingernail.
Soft	Can be easily dented but not molded with fingers.

Sandstone and Conglomerate:

Well Cemented	Capable of scratching a knife blade.
Cemented	Can be scratched with knife.
Poorly Cemented	Can be broken apart easily with fingers.

EEC

UNIFIED SOIL CLASSIFICATION SYSTEM

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests					Soil Classification	
					Group Symbol	Group Name
Coarse - Grained Soils more than 50% retained on No. 200 sieve	Gravels more than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5% fines	$Cu \geq 4$ and $1 < Cc \leq 3^{E}$		GW	Well-graded gravel ^{F}
			$Cu < 4$ and/or $1 > Cc > 3^{E}$		GP	Poorly-graded gravel ^{F}
		Gravels with Fines more than 12% fines	Fines classify as ML or MH		GM	Silty gravel ^{G,H}
			Fines Classify as CL or CH		GC	Clayey Gravel ^{F,G,H}
	Sands 50% or more coarse fraction passes No. 4 sieve	Clean Sands Less than 5% fines	$Cu \geq 6$ and $1 < Cc \leq 3^{E}$		SW	Well-graded sand ^{I}
			$Cu < 6$ and/or $1 > Cc > 3^{E}$		SP	Poorly-graded sand ^{I}
		Sands with Fines more than 12% fines	Fines classify as ML or MH		SM	Silty sand ^{G,H,I}
			Fines classify as CL or CH		SC	Clayey sand ^{G,H,I}
Fine-Grained Soils 50% or more passes the No. 200 sieve	Silts and Clays Liquid Limit less than 50	inorganic	PI>7 and plots on or above "A" Line		CL	Lean clay ^{K,L,M}
			PI<4 or plots below "A" Line		ML	Silt ^{K,L,M}
		organic	Liquid Limit - oven dried	<0.75	OL	Organic clay ^{K,L,M,N}
			Liquid Limit - not dried			Organic silt ^{K,L,M,O}
	Silts and Clays Liquid Limit 50 or more	inorganic	PI plots on or above "A" Line		CH	Fat clay ^{K,L,M}
			PI plots below "A" Line		MH	Elastic Silt ^{K,L,M}
		organic	Liquid Limit - oven dried	<0.75	OH	Organic clay ^{K,L,M,P}
			Liquid Limit - not dried			Organic silt ^{K,L,M,O}
Highly organic soils		Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in (75-mm) sieve

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12% fines required dual symbols:

GW-GM	well graded gravel with silt
GW-GC	well-graded gravel with clay
GP-GM	poorly-graded gravel with silt
GP-GC	poorly-graded gravel with clay

[D] Sands with 5 to 12% fines require dual symbols

SW-SM	well-graded sand with silt
SW-SC	well-graded sand with clay
SP-SM	poorly graded sand with silt
SP-SC	poorly graded sand with clay

[E] $Cu = D_{60}/D_{10} \quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥15% sand, add "with sand" to

[G] If fines classify as CL-ML, use dual symbol GC-CM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name

[I] If soil contains >15% gravel, add "with gravel" to group name

[J] If Atterberg limits plots shaded area, soil is a CL-ML, Silty clay

[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel", whichever is predominant

[L] If soil contains ≥ 30% plus No 200 predominantly sand, add "sandy" to group name

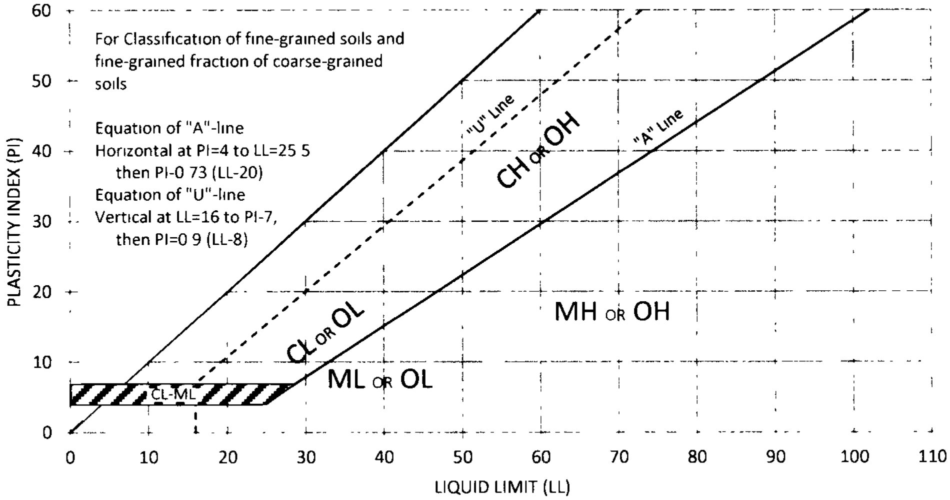
[M] If soil contains ≥30% plus No 200 predominantly gravel, add "gravelly" to group name.

[N] PI≥4 and plots on or above "A" line.

[O] PI≤4 or plots below "A" line.

[P] PI plots on or above "A" line

[Q] PI plots below "A" line



Boring Location Diagram
Irwin/Thomas Properties
Longmont, Colorado
EEC Project #: 1172053 Date: November 2017


PHOTO # 1


PHOTO # 2

IRWIN/THOMAS PROPERTIES
LONGMONT, COLORADO
EEC PROJECT NO. 1172053
NOVEMBER 2017

PHOTO # 3

PHOTO # 4


PHOTO # 5


PHOTO # 6

IRWIN/THOMAS PROPERTIES

LONGMONT, COLORADO

PROJECT NO: 1172053	LOG OF BORING B-1 *SHEET 1 OF 1*		DATE: JUNE 2013	
RIG TYPE: CME55			WATER DEPTH	
FOREMAN: DG	START DATE	11/6/2017	WHILE DRILLING	7.5'
AUGER TYPE: 4-1/4" HSA	FINISH DATE	11/6/2017	AFTER DRILLING	N/A
SPT HAMMER: AUTOMATIC	SURFACE ELEV	N/A	11/9/2017	6.0'

SOIL DESCRIPTION	TYPE	D (FEET)	N (BLOWS/FT)	QU (PSF)	MC (%)	DD (PCF)	A-LIMITS LL	A-LIMITS PI	-200 (%)	SWELL PRESSURE	SWELL % @ 500 PSF
SPARSE VEGETATION &TOPSOIL											
		1									
SANDY LEAN CLAY (CL) brown		2									
		3									
POORLY GRADED SAND with SILT (SP - SM) brown		4									
medium dense with gravel and apparent cobbles	CS	5	19	–	2.3	106.6					
		6									
		7									
		8									
		9									
	SS	10	22	–	11.0		17	NP	7.6		
		11									
		12									
		13									
SANDSTONE / SILTSTONE / CLAYSTONE		14									
gray weathered to moderately hard	CS	15	30	9000+	14.0	120.5					
		16									
		17									
		18									
		19									
		20									
		21									
		22									
		23									
BOTTOM OF BORING DEPTH 23.0'		24									
		25									

IRWIN/THOMAS PROPERTIES

LONGMONT, COLORADO

PROJECT NO: 1172053	**LOG OF BORING B-2** *SHEET 1 OF 1*		**DATE: JUNE 2013**	
RIG TYPE: CME55			**WATER DEPTH**	
FOREMAN: DG	**START DATE**	**11/6/2017**	**WHILE DRILLING**	**7.0'**
AUGER TYPE: 4-1/4" HSA	**FINISH DATE**	**11/6/2017**	**AFTER DRILLING**	**N/A**
SPT HAMMER: AUTOMATIC	**SURFACE ELEV**	**N/A**	**11/9/2017**	**4.4'**

SOIL DESCRIPTION	**TYPE**	**D (FEET)**	**N (BLOWS/FT)**	**QU (PSF)**	**MC (%)**	**DD (PCF)**	**A-LIMITS LL**	**PI**	**-200 (%)**	**SWELL PRESSURE**	**% @ 500 PSF**
VEGETATION & TOPSOIL											
		1									
SANDY LEAN to FAT CLAY (CL to CH) brown		2									
stiff		3									
		4									
	CS	**5**	**11**	**3000**	**18.0**		**57**	**40**	**65.6**		
POORLY GRADED SAND with SILT (SP - SM) brown		6									
medium dense to very dense with gravel and apparent cobbles		7									
		8									
with cobbles		9									
	SS	**10**	**35**	--	**12.0**						
		11									
		12									
		13									
		14									
	CS	**15**	**62**	–	**15.7**	**112.3**					
		16									
		17									
		18									
SANDSTONE / SILTSTONE / CLAYSTONE gray		19									
moderately hard	SS	**20**	**50**	**4000**	**20.7**						
		21									
		22									
		23									
		24									
	CS	**25**	**50/6"**	**9000+**	**32.1**	**100.9**					
BOTTOM OF BORING DEPTH 25 0'											

IRWIN/THOMAS PROPERTIES

LONGMONT, COLORADO

PROJECT NO: 1172053	**LOG OF BORING B-3** *SHEET 1 OF 1*		**DATE: JUNE 2013**		
RIG TYPE: CME55			**WATER DEPTH**		
FOREMAN: DG	**START DATE**	**11/6/2017**	**WHILE DRILLING**	**7.5'**	
AUGER TYPE: 4-1/4" HSA	**FINISH DATE**	**11/6/2017**	**AFTER DRILLING**	**N/A**	
SPT HAMMER: AUTOMATIC	**SURFACE ELEV**	**N/A**	**11/9/2017**	**6.5'**	

SOIL DESCRIPTION	**TYPE**	**D (FEET)**	**N (BLOWS/FT)**	**QU (PSF)**	**MC (%)**	**DD (PCF)**	**A-LIMITS LL**	**A-LIMITS PI**	**-200 (%)**	**SWELL PRESSURE**	**SWELL % @ 500 PSF**
VEGETATION & TOPSOIL											
		1									
SANDY LEAN CLAY (CL) brown		2									
		3									
		4									
POORLY GRADED SAND with SILT (SP - SM) brown medium dense to very dense with gravel and apparent cobbles	CS	**5**	**9**	**2500**	**6.3**	**98.1**	**21**	**NP**	**14.1**		
		6									
		7									
		8									
		9									
	SS	**10**	**34**	**--**	**11.0**		**NL**	**NP**	**8.9**		
		11									
		12									
		13									
		14									
	CS	**15**	**50/10.5"**	**--**	**8.7**	**126.2**					
		16									
		17									
		18									
SANDSTONE / SILTSTONE / CLAYSTONE gray moderately hard to hard		19									
	SS	**20**	**50/11"**	**7000**	**16.0**						
		21									
		22									
		23									
		24									
	CS	**25**	**50/4.5"**	**9000+**	**10.9**	**127.4**					
BOTTOM OF BORING DEPTH 25 0'											

Earth Engineering Consultants, LLC

IRWIN/THOMAS PROPERTIES

LONGMONT, COLORADO

PROJECT NO: 1172053	**LOG OF BORING B-4** *SHEET 1 OF 1*		**DATE: JUNE 2013**	
RIG TYPE: CME55			**WATER DEPTH**	
FOREMAN: DG	**START DATE**	**11/6/2017**	**WHILE DRILLING**	**10.0'**
AUGER TYPE: 4-1/4" HSA	**FINISH DATE**	**11/6/2017**	**AFTER DRILLING**	**N/A**
SPT HAMMER: AUTOMATIC	**SURFACE ELEV**	**N/A**	**11/9/2017**	**11.0'**

SOIL DESCRIPTION	**TYPE**	**D (FEET)**	**N (BLOWS/FT)**	**QU (PSF)**	**MC (%)**	**DD (PCF)**	**A-LIMITS LL**	**PI**	**-200 (%)**	**SWELL PRESSURE**	**% @ 500 PSF**
VEGETATION & TOPSOIL											
		1									
SANDY LEAN CLAY (CL) brown		2									
		3									
		4									
WELL GRADED SAND (SW) brown medium dense with gravel	SS	**5**	**13**	**–**	**5.4**						
		6									
		7									
		8									
		9									
	CS	**10**	**18**	**--**	**5.2**	**123.4**	**NL**	**NP**	**5.0**		
		11									
		12									
		13									
		14									
SANDSTONE / SILTSTONE / CLAYSTONE gray moderately hard to hard	SS	**15**	**50/9"**	**8000**	**14.5**						
		16									
		17									
		18									
		19									
	CS	**20**	**50/6.5"**	**9000+**	**10.2**	**123.8**					
		21									
		22									
		23									
		24									
	SS	**25**	**50/3.5"**	**–**	**21.5**						
BOTTOM OF BORING DEPTH 25.5'											

IRWIN/THOMAS PROPERTIES

LONGMONT, COLORADO

PROJECT NO: 1172053	LOG OF BORING B-5		DATE: JUNE 2013	
RIG TYPE: CME55	*SHEET 1 OF 1*		WATER DEPTH	
FOREMAN: DG	START DATE	11/6/2017	WHILE DRILLING	9.0'
AUGER TYPE: 4-1/4" HSA	FINISH DATE	11/6/2017	AFTER DRILLING	N/A
SPT HAMMER: AUTOMATIC	SURFACE ELEV	N/A	11/9/2017	9.4'

SOIL DESCRIPTION	TYPE	D (FEET)	N (BLOWS/FT)	QU (PSF)	MC (%)	DD (PCF)	A-LIMITS LL	A-LIMITS PI	-200 (%)	SWELL PRESSURE	SWELL % @ 500 PSF
VEGETATION & TOPSOIL											
		1									
SANDY LEAN CLAY (CL)		2									
brown / rust											
very stiff		3									
		4									
	CS	5	8	7000	11.1	97.9	32	15	54.4		
		6									
		7									
		8									
POORLY GRADED SAND with SILT (SP - SM)		9									
brown											
medium dense to dense	SS	10	19	--	9.7						
with gravel											
		11									
		12									
		13									
		14									
	CS	15	39	--	14.5						
SANDSTONE / SILTSTONE / CLAYSTONE		16									
gray											
moderately hard to hard		17									
		18									
		19									
	SS	20	50/4"	5500	13.5						
		21									
		22									
		23									
		24									
	CS	25	50/3"	8000	8.8	113.5					
BOTTOM OF BORING DEPTH 25.0'											

IRWIN/THOMAS PROPERTIES
LONGMONT, COLORADO

PROJECT NO: 1172053	**LOG OF BORING B-6**	**DATE:** JUNE 2013	
RIG TYPE: CME55	*SHEET 1 OF 1*	**WATER DEPTH**	
FOREMAN: DG	**START DATE** 11/6/2017	**WHILE DRILLING**	11.0'
AUGER TYPE: 4-1/4" HSA	**FINISH DATE** 11/6/2017	**AFTER DRILLING**	N/A
SPT HAMMER: AUTOMATIC	**SURFACE ELEV** N/A	11/9/2017	10.0'

SOIL DESCRIPTION		D	N	QU	MC	DD	A-LIMITS		-200	SWELL	
	TYPE	(FEET)	(BLOWS/FT)	(PSF)	(%)	(PCF)	LL	PI	(%)	PRESSURE	% @ 500 PSF
VEGETATION & TOPSOIL											
		1									
SANDY LEAN CLAY (CL)		2									
brown											
		3									
POORLY GRADED SAND (SP)		4									
brown / gray / rust											
loose to very dense	CS	5	7	–	1.3	90.1	NL	NP	3.4		
		6									
with gravel and apparent cobbles		7									
		8									
		9									
	SS	10	48	–	8.0						
		11									
		12									
		13									
		14									
with silt											
	CS	15	50/10"	–	6.0	134.9	22	NP	7.0		
		16									
SANDSTONE / SILTSTONE / CLAYSTONE		17									
gray											
moderately hard to hard		18									
		19									
	SS	20	50/8"	3000	17.8						
		21									
		22									
		23									
		24									
	CS	25	50/3"	9000+	12.9	123.6					
BOTTOM OF BORING DEPTH 25 0'											

EARTH ENGINEERING CONSULTANTS, LLC

SUMMARY OF SIEVE ANALYSIS TEST RESULTS

Project: Irwin/Thomas Properties **Project No.:** 1172053

Location: Longmont, Colorado **Date** November 2017

						Washed Sieve Analysis (ASTM Specifications C117 and C136)					
Sieve No.	**B-1 at 9'**	**B-3 at 4'**	**B-3 at 9'**	**B-4 at 9**	**B-5 at 4'**	**B-6 at 4'**	**B-6 at 14'**	**B-1 thru B-3 Overburden**	**B-4 thru B-6 Overburden**	**B-1 thru B-3 Sand and Gravel**	**B-4 thru B-6 Sand and Gravel**
3"	100	100	100	100	100	100	100	100	100	100	100
2"	100	100	100	100	100	100	100	100	100	97	100
1 1/2"	100	100	100	100	100	100	100	100	100	94	98
1"	84	100	93	79	100	100	72	100	100	83	96
3/4"	75	100	79	69	100	100	67	99	100	76	88
1/2"	67	97	71	58	100	100	55	98	100	68	75
3/8"	63	95	68	51	100	100	51	98	100	65	68
No. 4	57	91	59	41	100	100	45	96	99	58	60
No. 8	48	82	49	34	100	95	40	94	97	51	52
No. 10	47	77	47	32	100	91	38	93	97	49	50
No. 16	40	67	39	27	99	70	32	90	95	42	44
No. 30	30	52	28	21	98	29	22	85	92	32	35
No. 40	25	45	24	18	96	15	19	82	90	28	31
No. 50	20	36	19	15	93	9	16	80	87	24	27
No. 100	12	20	13	8	76	5	10	71	80	18	21
No. 200	7 6	14 1	8 9	5 0	54 4	3 4	7 2	59 3	67 7	14 0	15 2
						Atterberg Limits (ASTM Specification D4318)					
Liquid Limit	17	21	NL	NL	32	NL	22	28	32	21	22
Plastic Limit	NP	NP	NP	NP	17	NP	NP	19	17	NP	15
Plasticity Index	NP	NP	NP	NP	15	NP	NP	10	15	NP	7

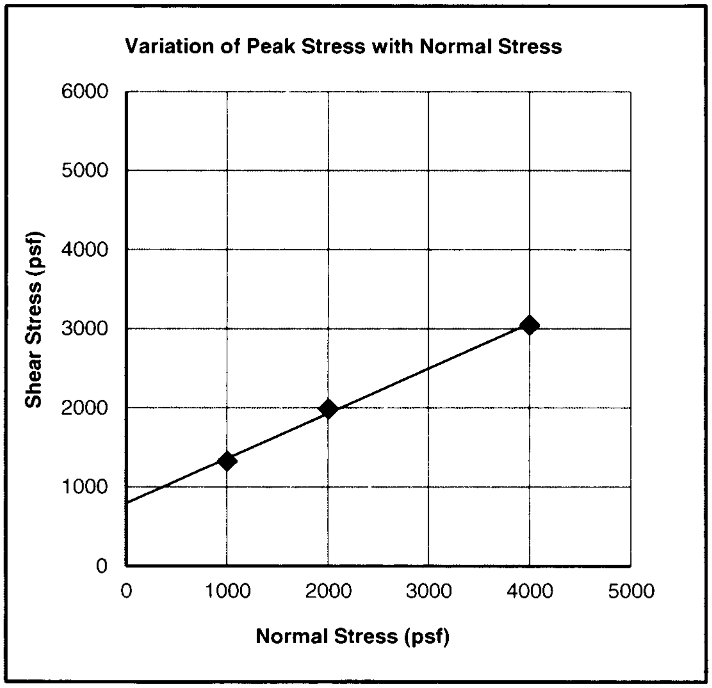
USCS	SP-SM	SM	SP-SM	SW	CL	SP	SP-SM	CL	CL	SP-SM	SP-SM

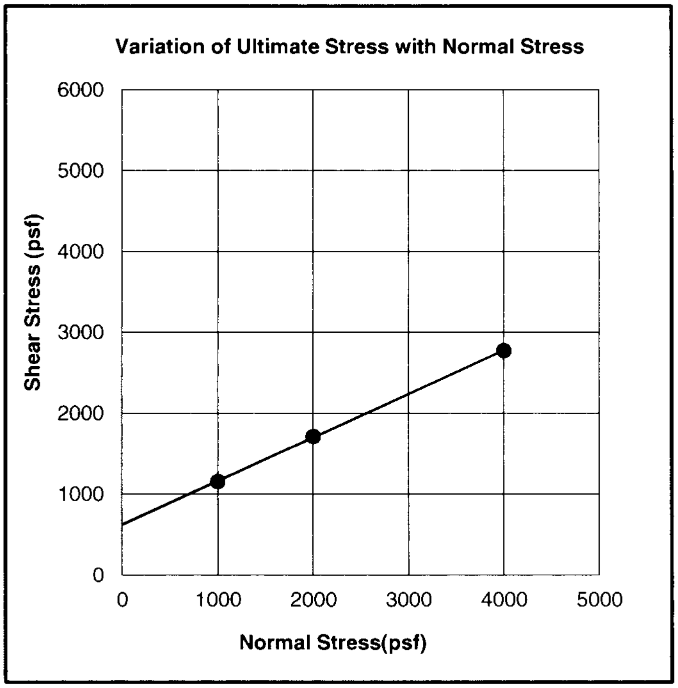
EARTH ENGINEERING CONSULTANTS, LLC
DIRECT SHEAR TEST REPORT
ASTM D3080

CLIENT: Aggregate Industries
PROJECT: Irwin/Thomas Properties
PROJECT NO. 1172053
SAMPLE LOCATION: B-1 through B-3, Overburden
SOIL CLASSIFICATION: Sandy Lean Clay (CL)

SAMPLE NO.	NORMAL STRESS (PSF)	ULTIMATE SHEAR STRESS (PSF)	PEAK SHEAR STRESS (PSF)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
1	1000	1152	1325	16.7	94.2
2	2000	1715	1986	17.5	93.4
3	4000	2771	3047	16.5	94.3

	FRICTION ANGLE (ϕ)	COHESION (psf)
PEAK	29.6	794
ULTIMATE	28.3	624



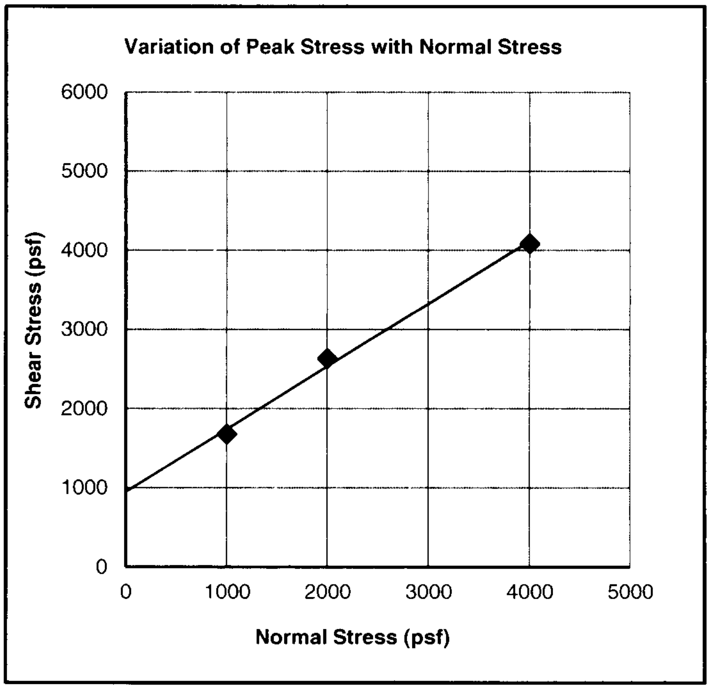


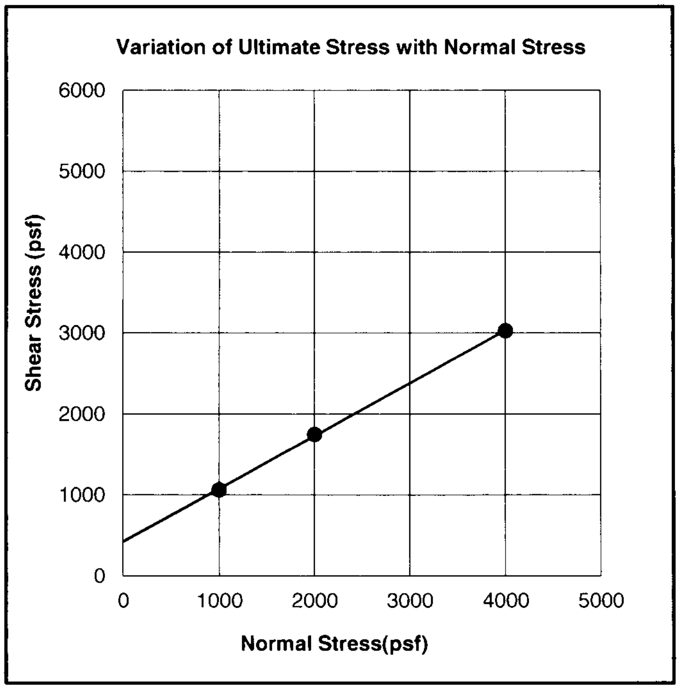
EARTH ENGINEERING CONSULTANTS, LLC
DIRECT SHEAR TEST REPORT
ASTM D3080

CLIENT:	Aggregate Industries
PROJECT:	Irwin/Thomas Properties
PROJECT NO.	1172053
SAMPLE LOCATION:	B-4 through B-6, Sand and Gravel Zone
SOIL CLASSIFICATION:	Poorly Graded Sand with Silt and Gravel (SP-GP)

SAMPLE NO.	NORMAL STRESS (PSF)	ULTIMATE SHEAR STRESS (PSF)	PEAK SHEAR STRESS (PSF)	MOISTURE CONTENT (%)	DRY DENSITY (PCF)
1	1000	1064	1677	11.6	108.7
2	2000	1748	2631	11.0	109.2
3	4000	3027	4087	9.2	113.5

	FRICTION ANGLE (ϕ)	COHESION (psf)
PEAK	38.4	949
ULTIMATE	33.1	424


Variation of Peak Stress with Normal Stress


Variation of Ultimate Stress with Normal Stress

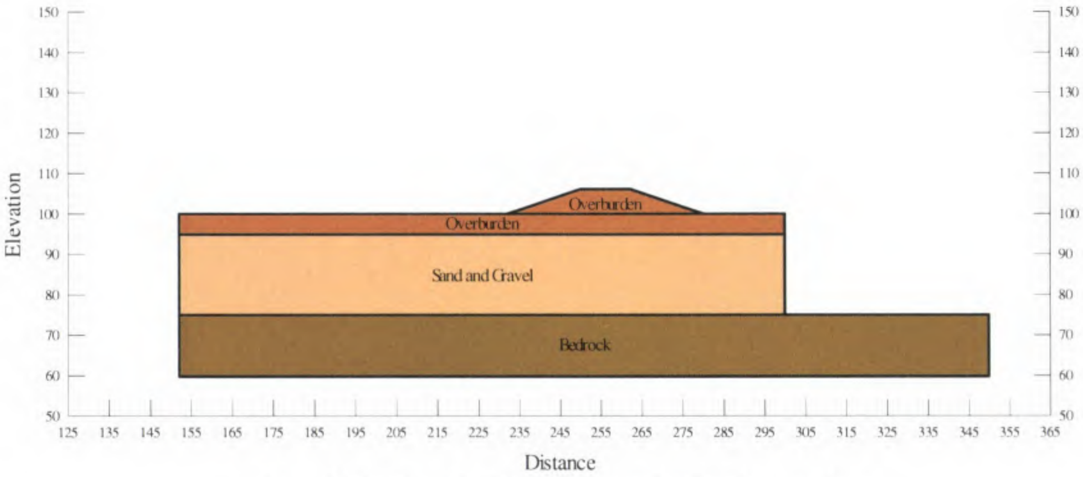


Figure 1: Section 1 – Geometry and subsurface section.

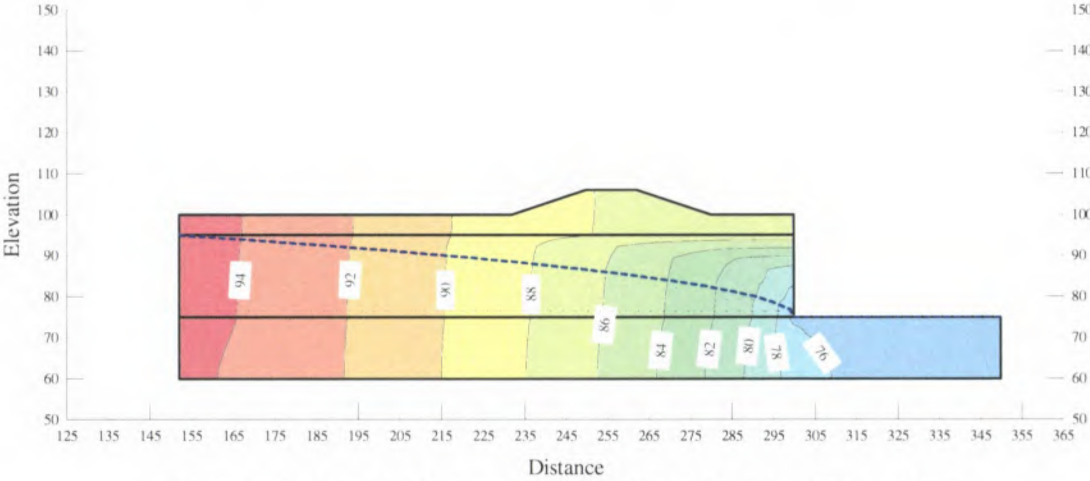


Figure 2: Section 1 – Flow path and total head distribution in section.

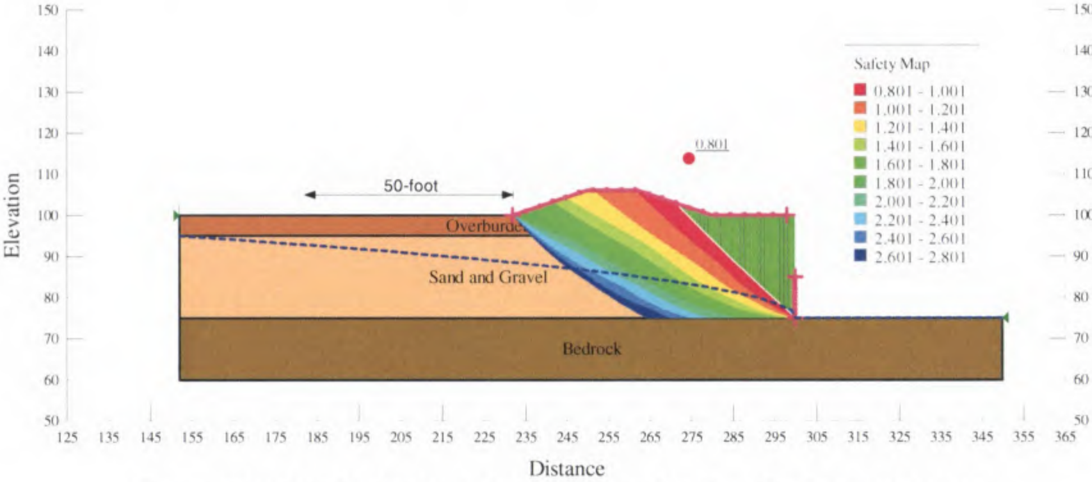


Figure 3: Section 1 – Critical slip surface with factor of safety distribution.

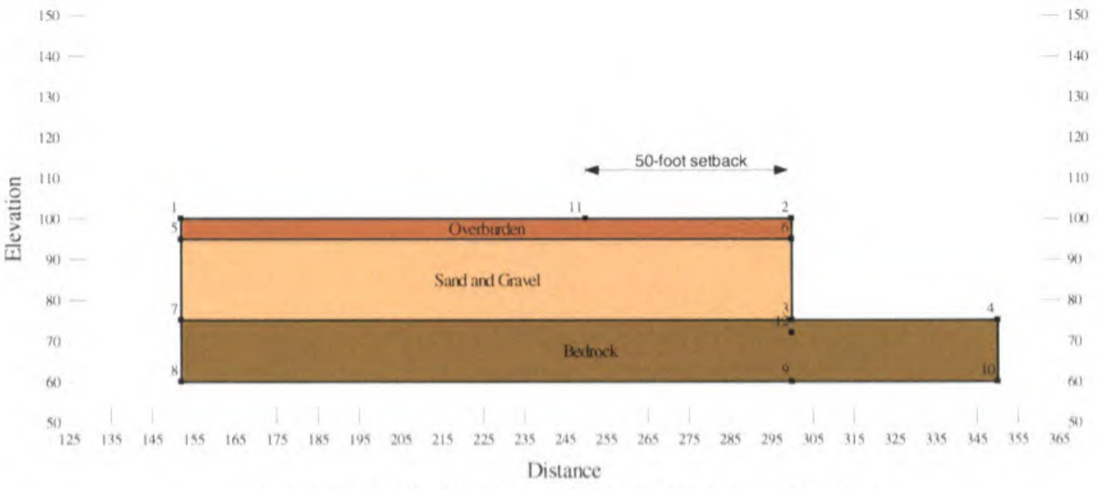


Figure 4: Section 2 – Geometry and subsurface section.

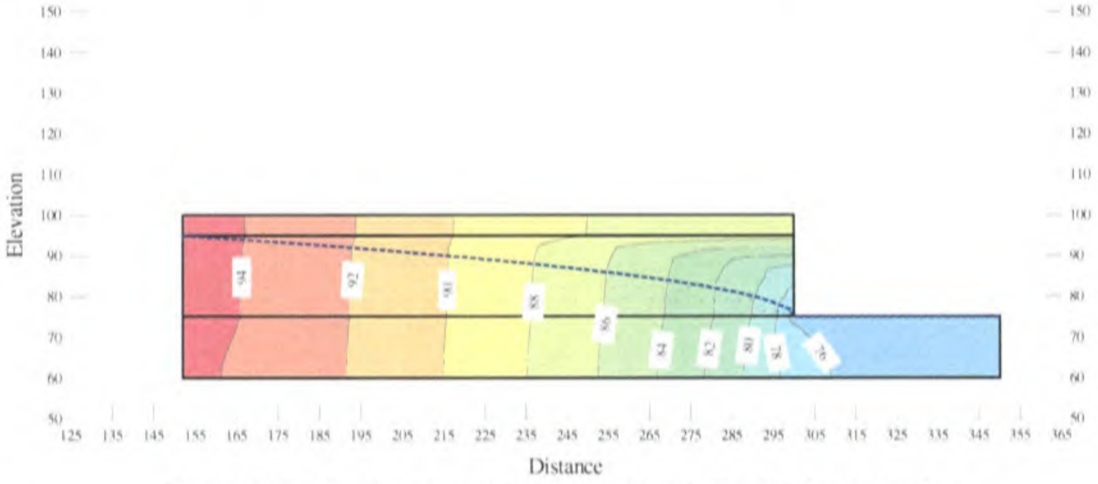


Figure 5: Section 2 – Flow path and total head distribution in section.

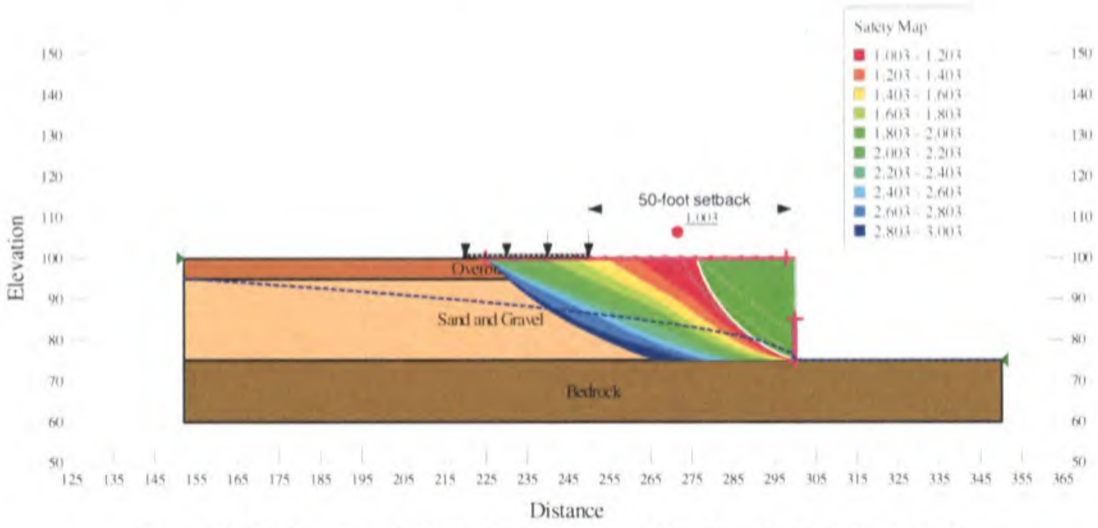


Figure 6: Section 2 – Critical slip surface with factor of safety distribution.