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Technical Memorandum

Prepared for: Holcim (US), Inc.

Project Title: Red Creek Quarry

Project No.: 159224-005-002

Technical Memorandum

Subject: Red Creek Quarry, Groundwater Modeling Analysis

Date: March 5, 2024

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From: Brown and Caldwell

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Limitations:

This is a draft memorandum and is not intended to be a final representation of the work done or recommendations made by Brown and Caldwell. It should not be relied upon; consult the final report.

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List of Abbreviations

AFY	acre-foot per year
BC	Brown and Caldwell
bgs	below ground surface
DRMS	Division of Reclamation, Mining & Safety
EC	existing conditions
ft/day	feet per day
gpd	gallons per day
gpm	gallons per minute
Holcim	Holcim US, Inc.
MPO	mine plan operations
RCQ	Red Creek Quarry

Section 1: Introduction

Brown and Caldwell (BC) performed groundwater flow modeling described in this report on behalf of Holcim US, Inc. (Holcim) for the Red Creek Quarry (RCQ) Portland Plant Permitting Project. This groundwater model was used to support the Division of Reclamation, Mining & Safety (DRMS) permitting by estimating the rates of groundwater entering the RCQ Mine Plan Operations (MPO) open pits. In addition, this groundwater model was used to estimate the potential impacts to Red Creek from MPO. This report describes the methods and results of the evaluation.

1.1 Model Objectives

The objectives of the modeling analysis include the following:

- Develop a simplistic groundwater flow model.
- Use the groundwater flow model to estimate rates of groundwater entering the pit in each MPO phase.
- Use the groundwater flow model to estimate potential impacts to Red Creek from MPO.

1.2 Background

RCQ (the site) is located approximately 15-miles west of Pueblo, Colorado along Highway CO-96 and encompasses approximately 3,851 acres. The mine will consist of an open-pit limestone quarry, sandstone pits and conveyor corridor to provide limestone to the Holcim Portland Plant. Figure 1 shows the RCQ site boundary, Red Creek, and locations of existing groundwater monitor wells. Red Creek flows northeast through the site and into the Arkansas River approximately two miles northeast of the site. The five monitor wells were installed in November 2021 and are screened in the Codell Sandstone. (BC, 2023)

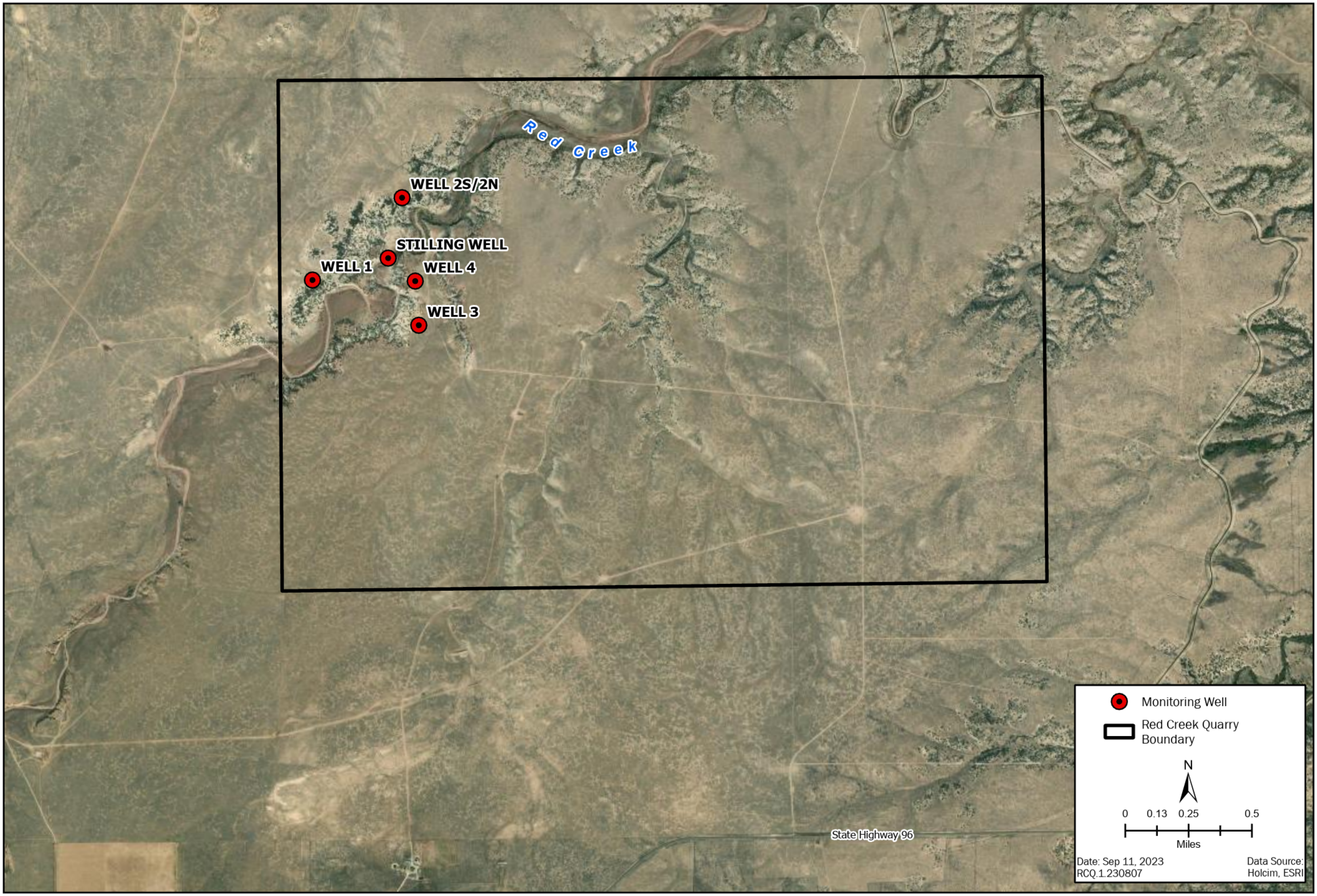

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Figure 1
Red Creek Quarry
Site Map

Red Creek Quarry
Groundwater Modeling Analysis
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1.3 Site Conceptual Leapfrog Model

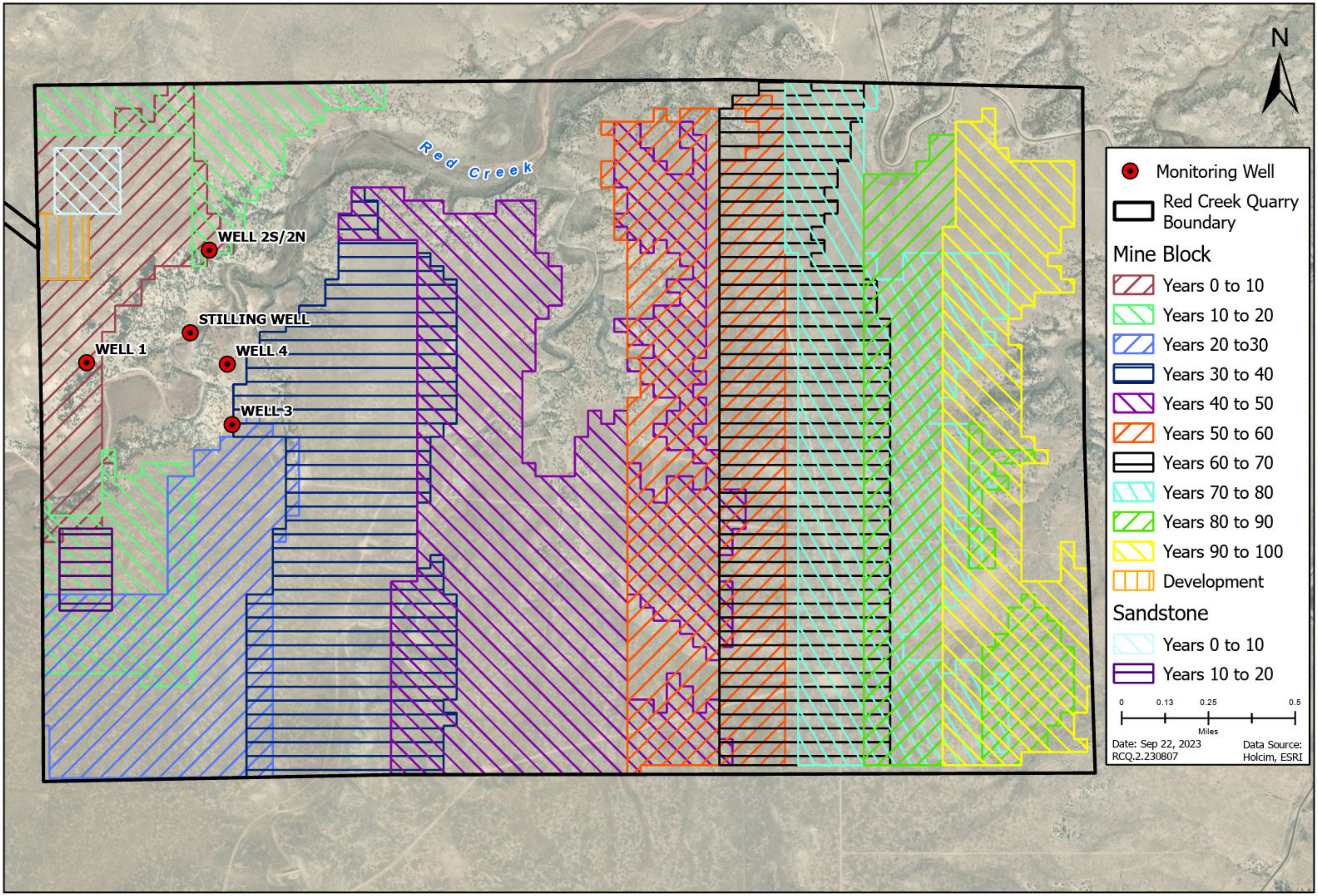
The site conceptual model was built on available data in the area and information obtained from the existing Holcim mine plan Leapfrog model. The site-specific Leapfrog geologic model includes the base Codell Sandstone, overlying Fort Hays Limestone, and additional overlying sediments. The contact between the Codell and Fort Hays dips toward the north across the site. Groundwater occurs primarily within the Codell Sandstone and within the lower portion of the Fort Hays limestone in localized areas. Sediments overlying the Fort Hays are generally unsaturated.

1.4 Mine Plan Operations

The MPO created by Holcim includes 100 years of mining broken into 10, 10-year mine blocks consisting of a continuously developing open pit with the addition of each mine block (Figure 2). The mine blocks begin in the western portion of the site and transition to the east during mining. The mine blocks in the simplistic groundwater model are represented as flat bottom pits with a single bottom elevation. The mine blocks in the groundwater model therefore do not account for elevation change of the contact between the Fort Hays and Codell, resulting in the modeled mine blocks extending into the Codell Sandstone in the southern portion of the site. In reality, mining will cease when the Fort Hays/Codell contact is encountered. The flat mine block bottom assumption likely results in a conservative (over) estimate of mining impacts to groundwater and Red Creek.

An exception to mining into the Codell Sandstone occurs in a planned additional smaller, deeper pit 15-feet below the top of the Codell Sandstone in Mine Block 0-10 and Mine Block 10-20 (Figure 2). Although the extent of a smaller pit into the Codell has not been explicitly defined in later Mine Plan years, it will likely occur in the southern portion of the site in all subsequent mine plan phases. Due to the flat bottom representation of the mine blocks, the model inadvertently simulates the sandstone pits since the mine block bottom elevations in subsequent MPO mine blocks following Mine Block 10-20 are at an elevation at least 15-feet below the top of the Codell Sandstone in the southern area of each mine block. Therefore, following Mine Block 10-20, the mine blocks do not require an additional smaller, deeper pit into the Codell Sandstone to be explicitly represented in the groundwater model.

As the MPO progresses, the mine blocks will be backfilled with overburden primarily consisting of the Smokey Hill Shale member of the Niobrara Formation. Figure 2 shows the location of the MPO pit as individual mine blocks as well as the two additional smaller, deeper Codell pits in the first two MPO mine blocks.



Brown AND Caldwell	DATE: Sep 22, 2023 Project No: 160041 Client: Holcim Figure ID: RCQ.2.230807	Figure 2 Red Creek Quarry MPO Mine Blocks	Red Creek Quarry, Groundwater Modeling Analysis Technical Memorandum

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Section 2: Model Construction

2.1 Modeling Codes and Discretization

Groundwater flow was simulated using MODFLOW 2005 (Harbaugh, 2005). Each MPO mine block simulates a period of 10 years of groundwater flow. The model domain was extrapolated from the Holcim mine plan Leapfrog model to approximately one mile outside of the site boundary to prevent potential boundary effects at the edges of the groundwater flow model interfering with projected MPO impacts. Figure 3 illustrates the RCQ site and the model domain extent. The grid spacing consists of a 1,000-foot by 1,000-foot grid size at the edges of the model telescopically refined to a minimum of 25-foot by 25-foot grid along Red Creek.

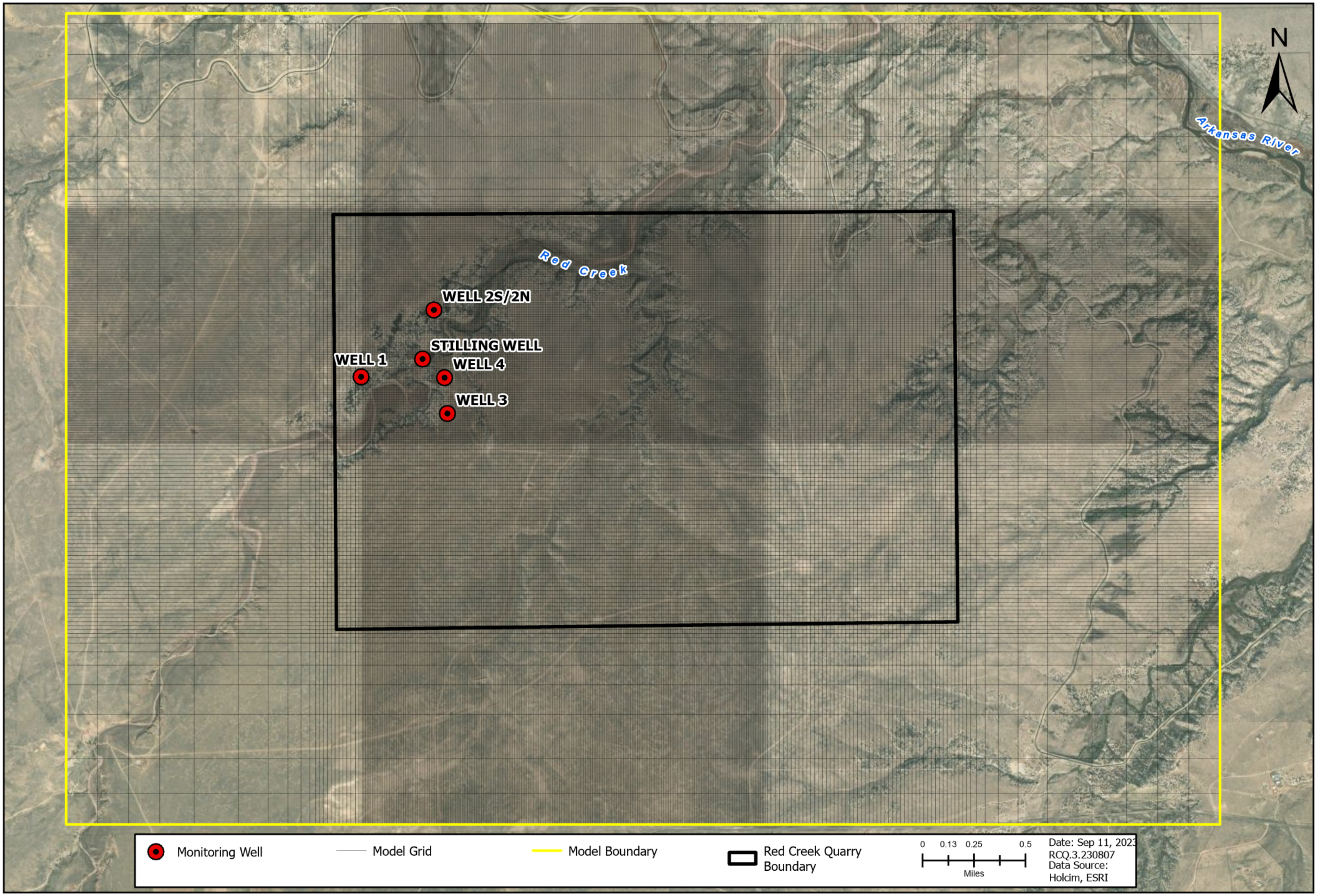

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Figure 3
Red Creek Quarry
Model Domain

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2.2 Model Layering

The RCQ groundwater model consists of 6 layers. Model layering was exported from the Holcim mine plan Leapfrog model. Since groundwater generally only occurs within the Codell Sandstone, all sediments overlying the Codell Sandstone were combined into one layer for input to the groundwater flow model. Layer 1 represents the combined sediments above the sandstone, determined from the Leapfrog model. Layers 2 through 5 represent the upper portion of the Codell Sandstone impacted by the MPO. Layer 6 represents the remaining, lower Codell Sandstone unaffected by the MPO. The total depth of layer 6 was determined from the Leapfrog model.

Layers 2 through 5 allow for the change in hydraulic properties of the backfilled mine blocks as the MPO progresses. Each layer in the upper portion of the Codell Sandstone is approximately 25-feet thick with the bottom of layer 5 reaching approximately 100-feet below the top of the Codell Sandstone. This depth was determined from the deepest mine block, Mine Plan 60-70, in relation to the top of the Codell Sandstone in the Leapfrog model.

2.3 Hydraulic Boundary Conditions

General Head boundary conditions were assigned along the model edges to simulate groundwater levels based on the May 2023 water table generated from static groundwater measurements at the five monitor well locations (Figure 1). The May 2023 groundwater contours were extrapolated to the model boundary to form the interpolated water table for the site. There is a measure of uncertainty in the May 2023 interpolated water table due to lack of data in the central, eastern, and southern portions of the site. Figure 1 shows the five monitor wells used for water table generation in the northwest portion of the site. Figures 4 and 5 illustrate the interpolated water table for northern and southern cross sections during pre-mining and post-mining conditions at the site. The pre-mining ground elevations in Figures 4 and 5 represent conditions prior to the Mine Block implementation. The interpolated water table shown in Figures 4 and 5 illustrates the water present in Red Creek in the northern cross section, and the groundwater present above the sandstone in the western portion of the site, seen in both the northern and southern cross sections. The interpolated water table for northern and southern cross sections during post-mining conditions at the site represent the reclaimed land surface following the completion of the final Mine Block and the completion of the reclamation activities (i.e. backfilling and grading). The interpolated water table shown in Figures 4 and 5 illustrates the water present in Red Creek in the northern cross section and the groundwater present above the sandstone, but below the ground surface in the south-western portion of the site, seen in both cross sections.

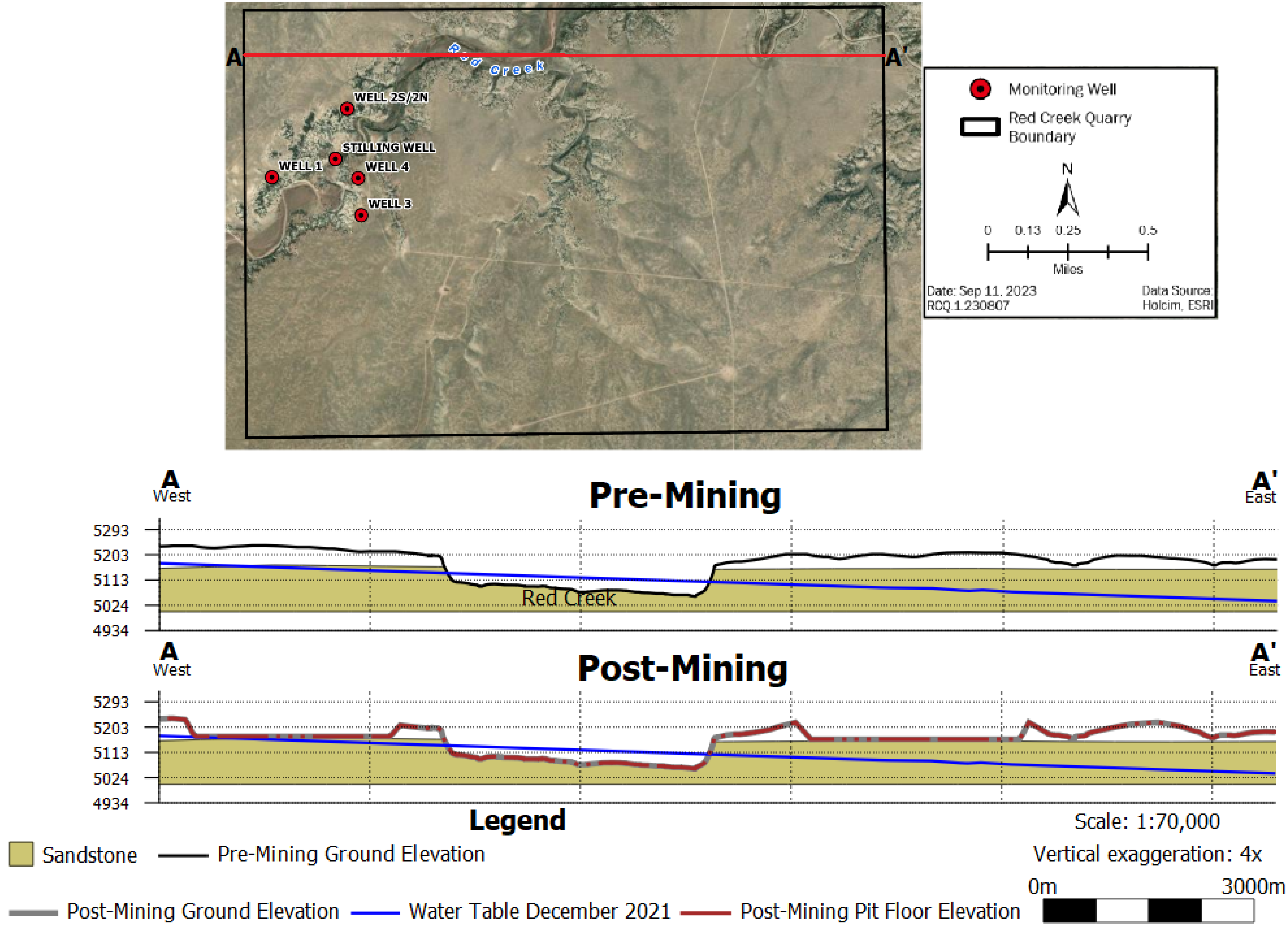

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Figure 4
Cross Section A-A'
Pre- and Post-mining

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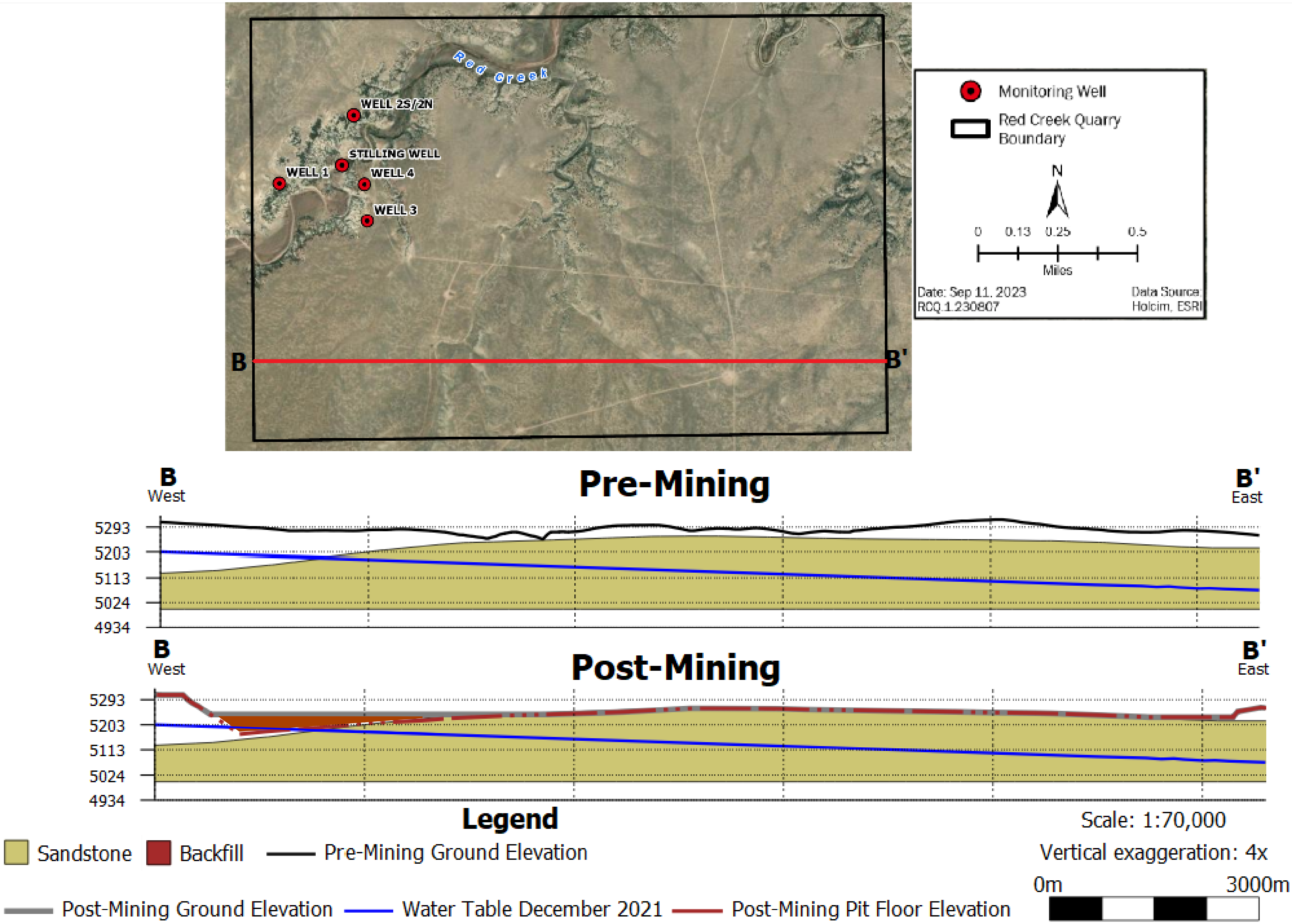

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Figure 5
Cross Section B-B'
Pre- and Post-mining

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2.4 Hydraulic Properties

Slug Testing was performed in May 2023 at groundwater monitor wells 1 through 4 completed in the Codell Sandstone (Figure 1). The hydraulic conductivity for the Codell Sandstone (layers 2 through 6) was determined from these tests to be approximately 0.011 feet per day (BC, 2023). The hydraulic properties for Layer 1 were assigned based on existing hydraulic information for the Fort Hays Limestone. Layer 1 represents the Fort Hays and all the overlying units, however, the overlying sediments are unsaturated and therefore not accounted for in the groundwater model. Hydraulic properties for layer 1 were estimated based on previous groundwater modeling efforts in the area to be 0.0054 feet per day (RGI, 1999). As the MPO progresses, the mined out areas are backfilled as discussed in Section 1.4. Due to a lack of available data regarding hydraulic properties of the overburden consisting primarily of the Smokey Hill Shale, the backfill material was estimated to have a hydraulic conductivity of 0.5 feet per day, two orders of magnitude larger than the sediments in Layer 1. Due to uncertainty of hydraulic properties of the backfill material, a model sensitivity analysis on backfill hydraulic conductivity was conducted and was not found to be a sensitive parameter during the analysis.

2.5 Groundwater Recharge and Storage

Recharge from precipitation is assumed to be negligible due to laterally extensive shale units in the unsaturated zone within the model domain. Aerial recharge may occur in fault zones within the limestone; however, due to lack of available data, aerial recharge was estimated based on historical reports for the area (USGS, 1985; USGS, 1987). Specific storage was estimated from slug testing preformed in May 2023 as discussed in Section 2.4 (BC, 2023).

2.6 Red Creek

Red Creek was divided into 11 reaches for the groundwater flow model as illustrated in Figure 6 to allow for calibration to observed flow conditions and evaluation of potential impacts from MPO. Red Creek was represented as a drain for the purposes of the groundwater flow model, allowing the rate of groundwater flow into Red Creek for each reach to be evaluated. Groundwater flow rates for each reach of Red Creek provides a comparison point between initial conditions and potential MPO influences.

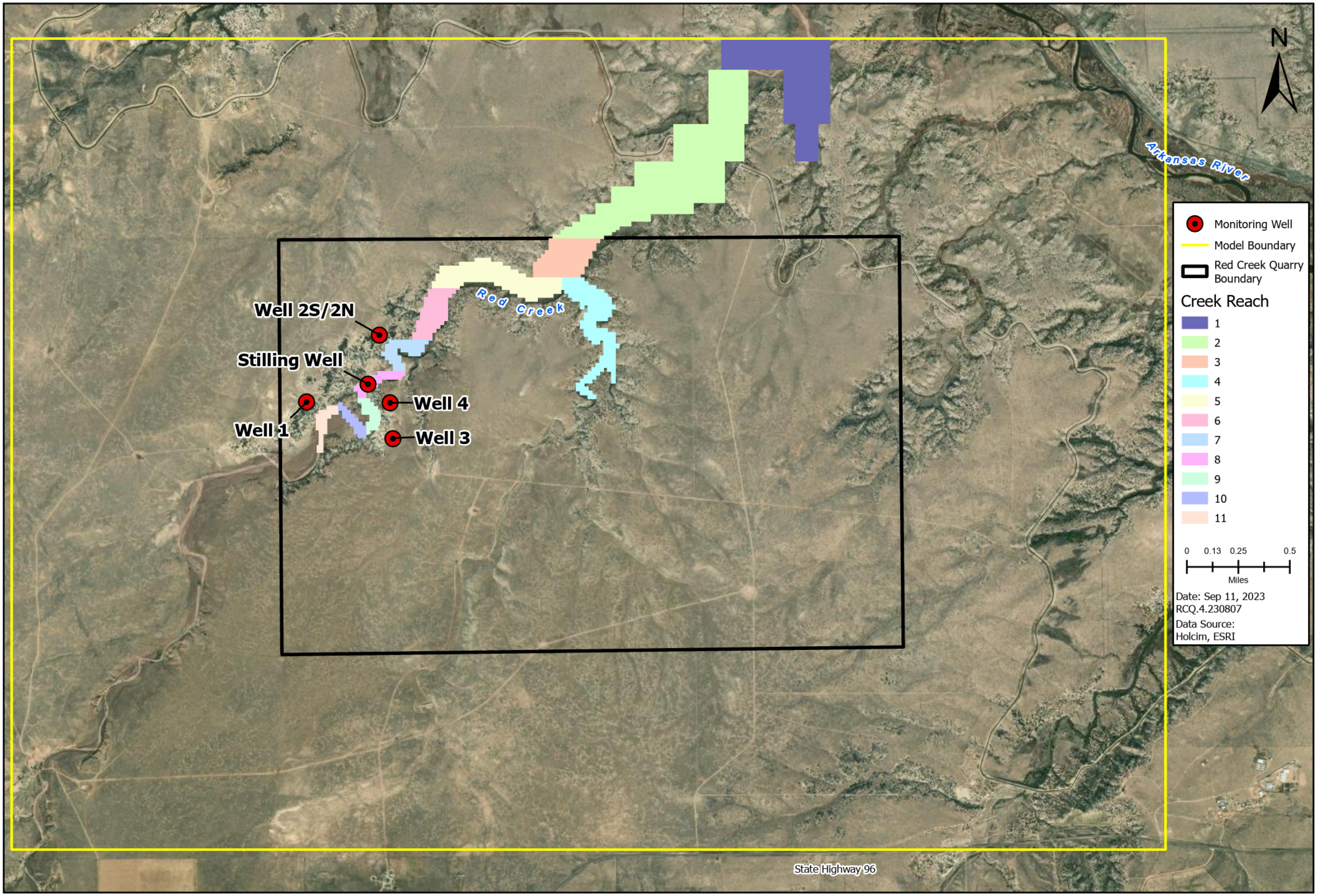

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Figure 6
Red Creek Reaches
Groundwater Flow Model

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2.7 MPO Mine Blocks

As discussed in Section 1.4, the MPO is divided into 10, 10-year mine blocks incorporating a new open, flat bottom elevation mine block. Each mine block is represented as a drain in the groundwater flow model. This allows for the rate of groundwater in to be estimated for each mine block. As the MPO progresses, previous mine blocks are replaced with an updated hydraulic conductivity to represent backfill material, as discussed in Section 2.4.

Each mine block begins with the previous mine block's ending groundwater heads. The first mine block utilizes the steady-state Existing Conditions (EC) groundwater heads. If the bottom elevation of a mine block is above the interpolated water table, no groundwater will enter the pit during the phase.

Section 3: Simulation Results

3.1 Calibration to Existing Conditions

The steady-state simulated groundwater elevation contours for the EC groundwater flow model are shown in Figure 7. The EC model was calibrated against groundwater elevations measured in site wells in May 2023 and visual Red Creek flow observations from December 2022. Due to the limited aerial extent of the site monitor wells, there is a measure of uncertainty introduced with the interpolated water table due to lack of measured groundwater data in the central, southern, and eastern portions of the site. Groundwater flow is generally to the northeast towards the Arkansas River.

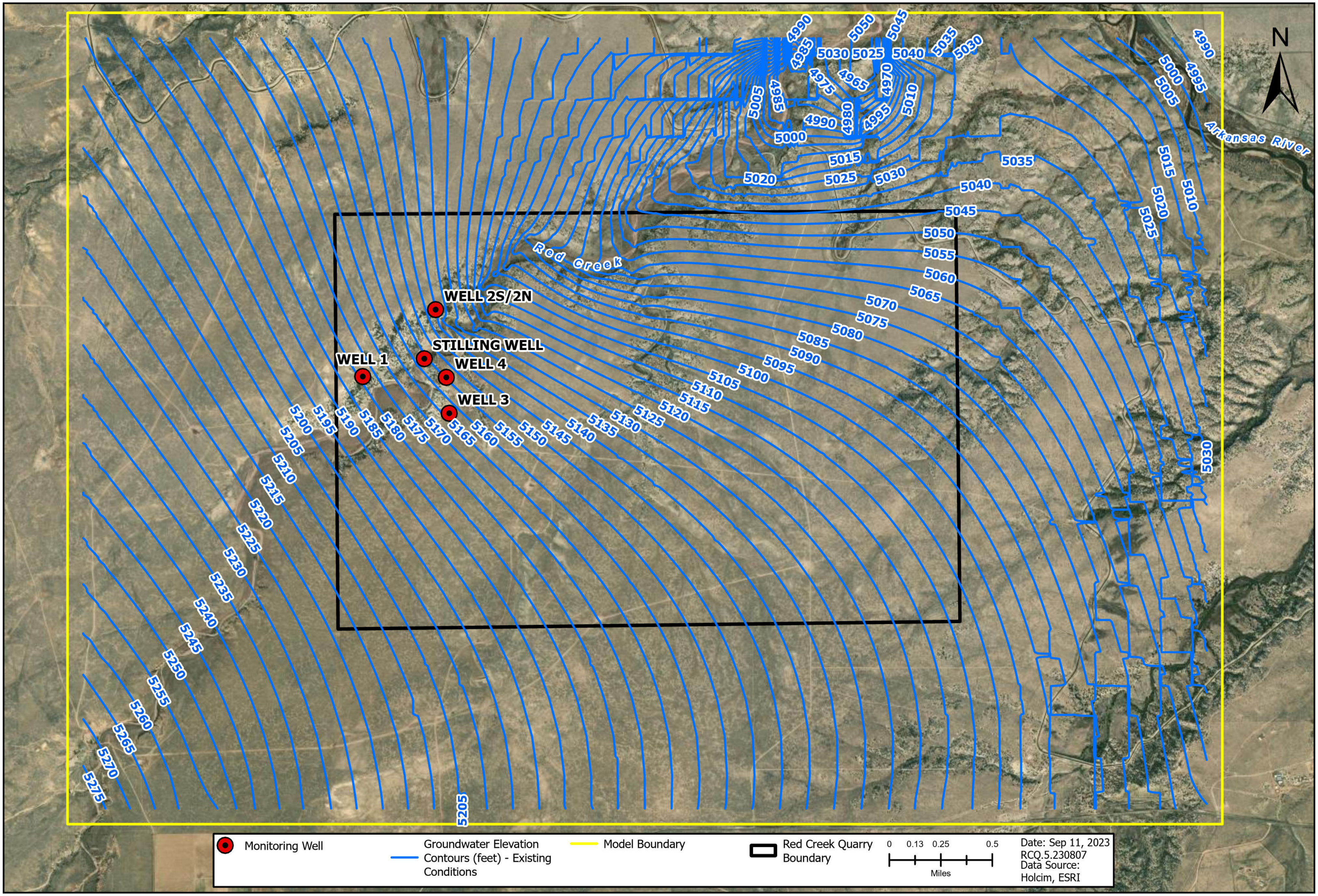

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Figure 7
Existing Conditions Simulated
Groundwater Elevation Contours

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Visual field observations were conducted on Red Creek in December 2022. The steady-state EC model was also calibrated to the visual observations of flow conditions in Red Creek.

Table 1 shows the December 2022 field observations compared to the EC model projections. Reaches that were dry in December 2022 are also seen to be dry in the EC model results. In reaches that have minimal surface water present in December 2022 (reaches 7 and 8), there is less water present in the EC model results than compared to reaches with surface water present (reaches 5 and 6) (Table 1). Reach 1 is located at the model boundary closer to the Arkansas River and receives some boundary effects, contributing to a higher rate of groundwater entering the creek (Figure 6, Table 1).

Table 1. Red Creek Existing Conditions

Creek Reach	December 2022 Visual Creek Observation	EC Model –May 2023 GW table - Rate of groundwater added to stream (ft^3/day)
1	Unknown	1854
2	Unknown	646
3	Dry	66
4	Unknown	51
5	Surface Water Present	230
6	Surface Water Present	136
7	Minimal Surface Water Present	47
8	Start of Surface Water	9
9	Dry	0
10	Dry	0
11	Dry	0

3.2 Projected MPO Mine Block Groundwater Accumulation

The transient groundwater flow model for each mine block estimates the rate of groundwater entering each mine block during the 10-year period as discussed in Section 2.7. Table 2 summarizes the projected rate of groundwater entering each mine block. As mentioned in Section 1.4, the first two mine blocks have an additional defined smaller, deeper pit 15-feet into the Codell Sandstone. This is represented in Table 2 for Mine Block 0 to 10 and Mine Block 10 to 20. Subsequent mine blocks are at least 15-feet below the top of the Codell Sandstone in the southern portions of each mine block and therefore do not require the additional area be modeled explicitly.

If the elevation of a mine block bottom is above the interpolated water table, the mine block will have no simulated groundwater flow in and will be dry. Mine blocks following Mine Block 20 to 30 are seen to have no groundwater entering the pit floor due to the elevations of the mine block being above the interpolated water table (Table 2). These mine blocks are located in the central, southern, and eastern portions of the site where the interpolated water table has the greatest uncertainty due to lack of monitor wells (Figure 2). The main portion of Mine Block 10 to 20 has an elevation above the water table and is therefore dry, but the additional deeper sandstone pit has an elevation below the water table and thus has a rate of groundwater entering the pit (Table 2). The greatest rate of groundwater entering a mine block is seen in Mine Block 20 to 30 (Table 2).

Table 2. Red Creek Quarry Mine Block Groundwater Rates Model Results			
Mine Block	Rate of Groundwater Entering Mine Block		
	(ft^3/day)	(gpm)	(acre-feet/year)
0 to 10	440.75	2.29	3.69
0 to 10 deep sandstone	1326.69	6.89	11.12
10 to 20	0	0	0
10 to 20 deep sandstone	3134.09	16.28	26.26
20 to 30	8742.07	45.41	73.25
30 to 40	0	0	0
40 to 50	0	0	0
50 to 60	0	0	0
60 to 70	0	0	0
70 to 80	0	0	0
80 to 90	0	0	0
90 to 100	0	0	0

3.3 Projected MPO Mine Block Creek Influence

To evaluate the potential impact of each mine block on Red Creek, the rate of groundwater in for each Red Creek reach during every mine block was compared to the EC model results. Table 3 illustrates the comparison between every mine block and each Red Creek reach with the EC model results. Projected flow rates are for comparison purposes only.

There were no reaches in Red Creek that became dry during the MPO. There was also no significant decrease in any of the Red Creek reaches at any point during the MPO. These comparisons suggest that the mine blocks will not influence Red Creek.

Table 3. Red Creek Quarry Mine Block Influence on Red Creek Model Results											
Stream Reach	1	2	3	4	5	6	7	8	9	10	11
Mine Block	Rate of Groundwater Entering Stream (ft^3/day)										
Existing Conditions	1854	646	66	51	230	136	47	9	0	0	0
0 to 10	1852	640	64	50	229	136	47	8	0	0	0
10 to 20	1851	640	64	49	229	135	47	8	0	0	0
20 to 30	1851	640	64	49	229	136	47	8	0	0	0
30 to 40	1852	640	64	49	229	136	47	8	0	0	0
40 to 50	1851	640	64	49	229	135	46	9	0	0	0
50 to 60	1852	640	64	49	229	135	46	8	0	0	0

Table 3. Red Creek Quarry Mine Block Influence on Red Creek Model Results											
Stream Reach	1	2	3	4	5	6	7	8	9	10	11
Mine Block	Rate of Groundwater Entering Stream (ft^3/day)										
60 to 70	1851	640	64	48	229	135	46	9	0	0	0
70 to 80	1852	640	64	49	228	134	46	9	0	0	0
80 to 90	1851	640	64	50	228	135	46	8	0	0	0
90 to 100	1852	640	64	49	228	134	46	9	0	0	0

Section 4: Summary and Conclusions

Groundwater flow modeling was conducted to assess potential groundwater flow impacts from the mine blocks. The rate of groundwater entering the mine blocks increased from Mine Block 0-10 through Mine Block 20-30. Following Mine Block 20-30 the MPO pit floor elevations are above the interpolated water table and are therefore dry. The evaluation of the MPO impacts to Red Creek suggested no significant influence to the creek.

Section 5: Recommendations for Model Improvements

The model results discussed represent a simplistic assessment for the MPO influence on groundwater in RCQ. To improve model predictions, it is recommended to implement additional groundwater monitor wells throughout the site as mining progresses into Mine Block 20-30. This will allow for a more robust set of measured groundwater data for the interpolated water table. Additional groundwater monitor wells located in the central, southern, and eastern portions of the site can be implemented throughout the MPO process to better assess the groundwater at the site.

Section 6: Limitations

This document was prepared solely for Holcim (US), Inc. in accordance with professional standards at the time the services were performed and in accordance with the contract between the Holcim (US), Inc. and Brown and Caldwell dated July 17, 2023. This document is governed by the specific scope of work authorized by Holcim (US), Inc.; it is not intended to be relied upon by any other party except for regulatory authorities contemplated by the scope of work. We have relied on information or instructions provided by the Holcim (US), Inc. and other parties and, unless otherwise expressly indicated, have made no independent investigation as to the validity, completeness, or accuracy of such information.

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