COLORADO
Division of Water Resources
Department of Natural Resources
Water Division 2 – Main Office

July 10, 2019

Susan Rainey, P.E.
Deere & Ault Consultants, Inc.
600 S. Airport Rd.
Longmont, CO 80503

Subject: Lining of Stonewall Springs Quarry, Southwest Reservoir (Pueblo East Pit)
Section 35, T20S, R63W, DRMS #M2000041
Water Division 2, Water District 14

Dear Ms. Rainey:

The purpose of this letter is to approve the testing plan and leak test of the above referenced site. This site consists of one cell as shown on Figure 3 of the applicants June 20, 2019 letter known as the Stonewall Springs Southwest Reservoir (formerly Fremont Paving & Redi-Mix Pueblo East Pit).

This approval is based on a site inspection conducted by our staff on June 6, 2019 and on the information provided by you, Deere and Ault Consultants, Inc. on behalf of the applicants as described under cover letters dated May 20, 2019 and June 20, 2019 (attached). The estimated site groundwater inflow and the outflow due to pumping indicate that this site has been lined to the design standard as referenced in the August, 1999 State Engineer Guidelines for Lining Criteria for Gravel Pits. Meeting the design standard requires that all water inflows and outflows for this site must be accounted for on at least a monthly basis, by the 10th of the month following the accounting.

Please call me if you have any questions.

Sincerely,

Rachel A. Zancanella, P.E.
Assistant Division Engineer

Enclosures

CC: Steve Stratman, Water Commissioner Water Districts 14 and 15
Melissa van der Poel, Denver SEO Team 237
John Ary
Mark Morley

DEERE & AULT
CONSULTANTS, INC.

June 20, 2019

Mr. Bill W. Tyner P.E.
Division of Water Resources
310 East Abriendo Ave., Suite B
Pueblo, Colorado 81004

Re: Leak Test Plan, Stonewall Springs Quarry, Southwest Reservoir Slurry Wall; D&A Job No. CG-0183.025.00

Dear Mr. Tyner:

The required 90-day leak test for the Stonewall Springs Quarry Southwest Reservoir Slurry Wall, located near Pueblo, Colorado, is complete and we submit these findings for consideration by the State Engineer's Office (SEO). A vicinity map of the leak test site is shown on **Figure 1**. The test was performed in general accordance with the *State Engineer Guidelines for Lining Criteria for Gravel Pits*, August 1999. The leak test period occurred over 90 days between February 27, 2019 and May 27, 2019. The leak test generally followed the work plan as outlined in a letter submitted to your office by Deere and Ault Consultant (D&A) dated May 20, 2019. As you recall, you visited the site on June 6, 2019 to observe the site and discuss implementation of the leak test procedure. **Figure 2** shows the site with the flowmeter, rain gauge, dewatering ditches and sumps or ponds monitored during the leak test. **Figure 3** shows the observation wells on and near the site, and surrounding area weather stations. Our measurements and calculations demonstrate that the reservoir meets the Design Standard for allowable leakage.

ALLOWABLE LEAKAGE RATES

The allowable leakage rate for Stonewall Springs Southwest Reservoir slurry wall, as calculated by the procedure outlined in the SEO guidelines, is approximately 66.6 gallons per minute (gpm). The Performance Standard is three times the Design Standard or 199.9 gpm.

A summary of the calculations for allowable leakage are shown below:

	Length (feet)	Average Height (feet)	Area (ft^2)	Leakage Standard ($ft^3/day/ft^2$)	Design		Performance	
					Rate (ft^3/d)	Rate (gpm)	Rate (ft^3/d)	Rate (gpm)
Wall	7,464	32.6	243,326	0.03	7,300	37.9	21,901	113.8
Floor	84.6		3,685,176	0.0015	5,528	28.7	16,583	86.1
				Total	12,828	**66.6**	38,482	**199.9**

LEAK TEST PROCEDURE

The leak test procedure for the Southwest Reservoir consisted of monitoring precipitation falling at the site, water pumped out of the site, and tracking the collection of exposed surface water on the

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floor of the site. Water was pumped out of the site starting on February 27, 2019. A totalizing flow meter was used to track the volume of water pumped off site. A staff gage was installed in the main dewatering sump in the southeast corner of the site to assist in tracking changes in water storage during the leak test. The main dewatering sump collection area served as the pump location during slurry wall construction and for this leak test. Several ditches across the floor of the pit drain to this sump and remained in place throughout the duration of the leak test. The bottom of the pit is covered in sand and gravel ranging in thickness from several inches to several feet. The material was graded to facilitate drainage during the leak test. During the duration of the leak test no material was removed from the Southwest Reservoir. In general drainage was collected in the dewatering ditch along the east edge, and in the dewatering ditch bisecting the center of the site. There are two addition ponds located in the northwest corner and along the west edge where surface water was monitored during the leak test. In addition to the staff gauge located in the main sump (southeast corner), staff gauges were also installed in these two ponds.

During the leak test, field personnel from A & S Construction operated the dewatering pump and collected all monitoring data. A summary of the data collected during the leak test is attached to this letter. During the leak test period precipitation that fell at the site was measured in an on-site rain gauge. This rain gauge was not in place when the leak test started. Precipitation data was collected from three different weather stations in addition to the on-site rain gauge. These stations include a Community Collaborative Rain, Hail and Snow Network (CoCoRaHS) station located on the east side of Pueblo, Colorado Agricultural Meteorological Network (CoAgMet) station located in Avondale, and the National Oceanic and Atmospheric Administration (NOAA) station located at the Pueblo Airport. These weather stations are shown on **Figure 3**.

GRADIENT ACROSS THE CUTOFF WALL

During the leak test the average groundwater elevation outside of the slurry wall ranged from elevation 4518.6 to 4521.0. Eight monitoring wells (MH-1, MH-2, THM-1, CR24, CR6, CR10, THR10, MH-8) are installed on or around the site, as shown on **Figure 3**. The average ground water elevation was calculated using the surrounding wells except CR10 and CR24, the two wells farthest away. The wells were monitored on a bi-weekly basis during the leak test. The water elevation in the bottom of the pit was surveyed at the sump and the northwest pond. Using the surveyed elevations and the staff gauge readings, the water surface elevation in the pit during the leak test was generally elevation 4494. Based on this information the average gradient across the wall during the leak test was approximately 24 feet which is greater than the required 10 foot minimum described in the SEO guidelines.

RECORDED TEST DATA

The leak test period occurred from February 27, 2019 to May 27, 2019 for a total of 90 days. The site was monitored, and data was collected on a daily basis during the 90-day leak test. As shown on **Figure 2**, on-site equipment used to monitor conditions include a totalizing flow meter, a rain gauge, and three staff gauges. Data collected during the leak test is presented in **Table 1** and **Table 2**

SURFACE WATER

Visual observations and two drone flights were used to monitor the surface area of pooled water during the leak test. A staff gauge was installed at the main sump, in the northwest pond, and in the west pond to assist in tracking water areas. All surface water areas were monitored for increase or decrease in size and summed periodically to determine the total surface area of water. The increase or decrease in size was used to determine the change is storage portion of the mass balance equation and is described in detail in a later section of this letter. And average of total surface water area for the duration of the leak test was used in the evaporation rate detailed below. Areas of water are shown on **Figure 2** and summarized on **Table 1**.

EVAPORATION

According to the *NOAA Technical Report NWS 33, Evaporation Atlas for the Contiguous 48 United States, June 1982, Map 3 Annual Free Water Surface Evaporation (Shallow Lake)*, the Southwest Reservoir site experiences approximately 50.2 inches of evaporation per year. Gross evaporation from the total water surface area exposed during the leak test was calculated using the evaporation rates specified in the SEO guidelines adjusted for projects below elevation 6,500 feet msl, and for the time frame of this test. Using the SEO guidelines, the average evaporation rate for the surface water area of 2.59 acres during the test period was approximately 5.1 gpm, as shown on **Table 3**.

PRECIPITATION

Rain data was collected from three different weather stations CoCoRAHS, CoAgMet, and NOAA. The NOAA station located at Pueblo Memorial Airport showed the least amount of precipitation out of the three weather stations. Since the on-site rain gauge was not in place when leak test data collection began, the NOAA station was used for the leak test evaluation. A total of 3.59 inches of precipitation, including water equivalent in snowfall, fell on the site during the leak test period. This equates to a total precipitation flow rate value of 63.6 gpm. With only 30 percent of this value being used in the leak test flow rate calculations the precipitation component of the mass balances equation is 19.1 gpm.

PUMP DISCHARGE

During the leak test one pump was used to pump water though a totalizing flowmeter out of the slurry wall perimeter. This pump and associated flow meter were located in the southeast corner of the pit. During the leak test, the total volume of water pumped from the pit was approximately 4,431,000 gallons. This total volume over the 90-day test contributes a flow rate of 34.2 gpm to the mass balance equation. The pumping date collected during the leak test with daily calculated flow rates can be found in **Table 2**.

CHANGE IN STORAGE

Throughout the leak test the surface area of pooled water in the pit changed significantly. The southern dewatering ditch connected to the sump dried up. The central dewatering ditch reduced

in length. Miscellaneous small ponds in the center of the pit dried up until a large rain even near the end of the leak test. Using the surface area and staff gauge readings an approximate change in storage was calculated for the duration of the leak test. Since the amount of water within the pit was reduced during the test period the change in storage portion of the mass balance equation is a negative flow of 2.7 gpm.

TEST RESULTS

The mass balance equation for the Stonewall Springs Quarry Southwest Reservoir slurry wall leak test plan, as described in the letter submitted to you dated May 20, 2019 is:

$$Q_{total} = Q_{pump} + Q_{\Delta storage} + Q_{evaporation} - Q_{precipitation}$$

Based on the data collected during the 90-day leak test the mass balance equation is:

$$Q_{total} = 34.2 \text{ gpm} + (-2.7 \text{ gpm}) + 5.4 \text{ gpm} - 19.1 \text{ gpm} = 17.7 \text{ gpm}$$

As shown above, the Design Standard for unregulated seepage through the Southwest Reservoir slurry wall per the SEO guidelines is approximately 66.6 gpm. The Performance Standard for the reservoir is 199.9 gpm. The unregulated seepage inflow calculated during the 90-day leak test was approximately 17.7 gpm. Therefore, this leak test shows that the Southwest Reservoir slurry wall meets the Design Standard as defined by the SEO guidelines.

Please notify us if you need additional information or have any questions or comments regarding the analysis for this leak test.

Sincerely,

DEERE & AULT CONSULTANTS, INC.

Susan A. Rainey, P.E.
Project Manager

Attachments

cc: John Paul Ary
Mark Morley

Table 1

Southwest Reservoir Slurry Wall

Field Measurements

Date	CoCoRAHS Snow (inches)	CoCoRAHS Rain (inches)	CoAgMet Rain (inches) 38.2056° N 104.329° W	NOAA Airport Rain (inches) 38.26° N 104.51° W	NOAA Airport Snow (inches)	NOAA Airport Snow on Ground (inches)	Rain Gauge #1 (inches)	Staff Gauge (Inches)			Water Areas				
								Southeast	Northwest	West	NW Pond (ft^2)	Sump (ft^2)	W Pond (ft^2)	Misc. Ponds (ft^2)	Sum (ft^2)
02/27/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-	17,250	107,032	4,609	93,774	222,665
02/28/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/01/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/02/19	0.00	0.00	0.00	0.13	1.20	0.00	-	-	-	-					
03/03/19	2.00	0.00	0.00	0.02	0.70	2.00	-	-	-	-					
03/04/19	0.50	0.04	0.06	0.01	0.30	2.00	-	-	-	-					
03/05/19	0.00	0.00	0.00	0.00	0.00	1.00	-	-	-	-					
03/06/19	0.00	0.00	0.00	0.00	0.00	t	-	-	-	-					
03/07/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/08/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/09/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/10/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/11/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/12/19	0.00	0.02	0.03	0.02	0.00	0.00	-	-	-	-					
03/13/19	0.00	0.30	0.86	0.84	t	0.00	-	-	-	-					
03/14/19	0.00	1.15	0.00	0.00	0.00	0.00	-	-	-	-					
03/15/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/16/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/17/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/18/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/19/19	0.00	0.00	0.00	0.01	t	0.00	-	-	-	-					
03/20/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/21/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/22/19	0.00	0.00	0.26	0.10	0.00	0.00	-	-	-	-					
03/23/19	0.00	0.16	0.00	0.00	0.00	0.00	-	-	-	-					
03/24/19	0.00	0.00	0.00	t	0.00	0.00	-	-	-	-					
03/25/19	0.00	0.02	0.00	0.00	0.00	0.00	-	-	-	-					
03/26/19	0.00	0.00	0.00	0.00	0.00	0.00	-	-	-	-					
03/27/19	0.00	0.00	0.00	0.00	0.00	0.00	0	-	-	-					
03/28/19	0.00	0.00	0.00	0.00	0.00	0.00	0	-	-	-					
03/29/19	0.00	0.01	0.17	0.18	t	0.00	0	-	-	-					
03/30/19	0.00	0.16	0.02	t	t	0.00	0	-	-	-					
03/31/19	0.00	0.01	0.03	0.04	0.00	0.00	0	-	-	-					
04/01/19	0.00	0.09	0.00	0.00	0.00	0.00	0	-	-	-					
04/02/19	0.00	0.00	0.00	0.00	0.00	0.00	0	-	-	-					
04/03/19	0.00	0.00	0.00	t	0.00	0.00	0	-	-	-					
04/04/19	0.00	0.00	0.00	0.00	0.00	0.00	0	-	-	-					
04/05/19	0.00	0.00	0.00	0.00	0.00	0.00	0	-	-	-	16,917	106,963	3,000	27,737	154,617
04/06/19	0.00	0.00	0.00	0.00	0.00	0.00	0	24.0	-	-					
04/07/19	0.00	0.00	0.00	0.00	0.00	0.00	0	-	-	-					
04/08/19	0.00	0.00	0.00	0.00		0.00	0	-	-	-					
04/09/19	0.00	0.00	0.00	0.00	0.00	0.00	0	-	-	-					
04/10/19	0.00	0.00	0.00	t	t	0.00	0.01	-	-	-					

Date	CoCoRAHS Snow (inches)	CoCoRAHS Rain (inches)	CoAgMet Rain (inches) 38.2056° N 104.329° W	NOAA Airport Rain (inches) 38.26° N 104.51° W	NOAA Airport Snow (inches)	NOAA Airport Snow on Ground (inches)	Rain Gauge #1 (inches)	Staff Gauge (Inches)			Water Areas				
								Southeast	Northwest	West	NW Pond (ft^2)	Sump (ft^2)	W Pond (ft^2)	Misc. Ponds (ft^2)	Sum (ft^2)
04/11/19	0.00	0.03	0.00	0.00	0.00	0.00	0	16.0	60.0	-					
04/12/19	0.00	0.00	0.00	0.00	0.00	0.00	0	22.0	59.0	-					
04/13/19	0.00	0.00	0.00	0.01	0.00	0.00	0	-	-	-					
04/14/19	0.00	0.03	0.00	0.00	0.00	0.00	0	-	-	-					
04/15/19	0.00	0.00	0.00	0.00	0.00	0.00	0	23.5	58.0	-					
04/16/19	0.00	0.00	0.00	0.00	0.00	0.00	0	23.0	58.0	-					
04/17/19	0.00	0.00	0.01	0.02	0.00	0.00	0	22.0	57.5	34.0					
04/18/19	0.00	0.06	0.02	t	0.00	0.00	0	21.0	57.0	34.0					
04/19/19	0.00	0.00	0.00	0.00	0.00	0.00	0	20.5	56.0	31.0					
04/20/19	0.00	0.00	0.00	0.00	0.00	0.00	0	-	-	-					
04/21/19	0.00	0.00	0.00	0.00	0.00	0.00	0	-	-	-					
04/22/19	0.00	0.00	0.00	t	0.00	0.00	0	19.0	57.0	30.0					
04/23/19	0.00	0.00	0.00	t	0.00	0.00	0	19.0	55.0	33.0					
04/24/19	0.00	0.00	0.00	0.0	0.00	0.00	0	20.0	55.0	32.5					
04/25/19	0.00	0.13	0.00	0.0	0.00	0.00	0	24.0	55.0	32.0	15,580	33,875	1,494		50,949
04/26/19	0.00	0.00	0.00	0.0	0.00	0.00	0	-	-	-					
04/27/19	0.00	0.00	0.00	0.0	0.00	0.00	0	-	-	-					
04/28/19	0.00	0.00	0.00	0.0	0.00	0.00	0	-	-	-					
04/29/19	0.00	0.00	0.00	0.02	0.00	0.00	0	28.0	53.0	30.0					
04/30/19	0.00	0.08	0.07	0.02	0.00	0.00	0.01	19.0	53.0	30.0					
05/01/19	0.00	0.02	0.00	0.01	0.00	0.00	0.01	20.0	53.0	29.5					
05/02/19	0.00	0.03	0.00	t	0.00	0.00	0	14.0	53.0	29.0					
05/03/19	0.00	0.00	0.00	0.00	0.00	0.00	0	-	-	-					
05/04/19	0.00	0.00	0.00	0.00	0.00	0.00	0	-	-	-					
05/05/19	0.00	0.00	0.00	t	0.00	0.00	0	-	-	-					
05/06/19	0.00	0.00	0.00	0.02	0.00	0.00	0	14.0	51.0	28.0					
05/07/19	0.00	0.04	0.03	0.05	0.00	0.00	0.02	16.0	51.0	28.0					
05/08/19	0.00	0.06	0.07	0.04	0.00	0.00	0	15.5	51.0	28.0					
05/09/19	0.00	0.09	0.15	0.1	0.00	0.00	0.03	16.0	51.0	28.5					
05/10/19	0.00	0.08	0.00	0.00	0.00	0.00	0	14.0	50.8	28.3					
05/11/19	0.00	0.02	0.00	0.00	0.00	0.00	0	-	-	-					
05/12/19	0.00	0.0	0.00	0.00	0.00	0.00	0	-	-	-					
05/13/19	0.00	0.0	0.00	0.00	0.00	0.00	0	13.5	50.5	26.3					
05/14/19	0.00	0.0	0.00	0.00	0.00	0.00	0	13.0	50.5	26.3					
05/15/19	0.00	0.0	0.00	0.00	0.00	0.00	0	12.5	50.5	26.0	15,580	33,875	1,494		50,949
05/16/19	0.00	0.0	0.00	0.00	0.00	0.00	0	13.5	49.8	25.5					
05/17/19	0.00	0.0	0.00	0.00	0.00	0.00	0	20.5	49.0	25.5					
05/18/19	0.00	0.0	0.00	t	0.00	0.00	0	-	-	-					
05/19/19	0.00	0.0	0.00	1.35	0.00	0.00	1.80	-	-	-					
05/20/19	0.00	0.0	1.41	0.52	t	0.00	0.57	-	-	-					
05/21/19	0.00	1.96	0.60	t	t	0.00	0	-	-	-					
05/22/19	0.00	0.08	0.00	0.01	0.00	0.00	0.01	33.0	57.0	33.5	16,900	33,900	1,500	33,558	85,858
05/23/19	0.00	0.0	0.01	0.0	0.00	0.00	0	23.5	57.0	34.0					
05/24/19	0.00	0.02	0.01	0.0	0.00	0.00	0	38.0	57.0	34.0					
05/25/19	0.00	0.00	0.00	0.0	0.00	0.00	0	-	-	-					
05/26/19	0.00	0.00	0.00	0.07	0.00	0.00	0	-	-	-					
05/27/19	0.00	0.03	0.00	0.00	0.00	0.00	0	34.5	57.0	34.0					
Precipitation=	2.5	4.72	3.81	3.59			2.46								113,007

Table 2
Southwest Reservoir Slurry Wall
Pumping Field Measurements

Date	Time	Flowmeter				Comments
		Reading	Reading (gallons)	Gallons Pumped	Flow Rate (gpm)	
02/27/19	1:00 PM	49	49,000			
02/28/19	1:00 PM	96	96,000	47,000	32.6	
03/01/19	2:30 PM	145	145,000	49,000	32.0	
03/02/19	1:30 PM	187	187,000	42,000	30.4	
03/03/19	2:30 PM	223	223,000	36,000	24.0	
03/04/19	1:30 PM	256	256,000	33,000	23.9	
03/05/19	2:30 PM	294	294,000	38,000	25.3	
03/06/19	2:30 PM	335	335,000	41,000	28.5	
03/07/19	2:30 PM	388	388,000	53,000	36.8	
03/08/19	2:00 PM	433	433,000	45,000	31.9	
03/09/19	1:30 PM	471	471,000	38,000	27.0	
03/10/19	1:30 PM	503	503,000	32,000	22.2	
03/11/19	2:00 PM	533	533,000	30,000	20.4	
03/12/19	2:30 PM	563	563,000	30,000	20.4	
03/13/19	2:30 PM	951	951,000	388,000	269.4	
03/14/19	3:00 PM	1,125	1,125,000	174,000	118.4	
03/15/19	2:00 PM	1,237	1,237,000	112,000	81.2	
03/16/19	3:00 PM	1,316	1,316,000	79,000	52.7	
03/17/19	3:00 PM	1,388	1,388,000	72,000	50.0	
03/18/19	3:30 PM	1,442	1,442,000	54,000	36.7	
03/19/19	3:00 PM	1,493	1,493,000	51,000	36.2	
03/20/19	1:00 PM	1,542	1,542,000	49,000	37.1	
03/20/19	4:00 PM	1,560	1,560,000	18,000	100.0	
03/21/19	4:00 PM	1,644	1,644,000	84,000	58.3	
03/22/19	1:30 PM	1,703	1,703,000	59,000	45.7	
03/22/19	5:00 PM	1,716	1,716,000	13,000	61.9	
03/23/19	8:30 AM	1,769	1,769,000	53,000	57.0	
03/24/19	4:00 PM	1,879	1,879,000	110,000	58.2	
03/25/19	8:00 AM	1,934	1,934,000	55,000	57.3	
03/26/19	8:00 AM	2,031	2,031,000	97,000	67.4	
03/27/19	3:00 PM	2,061	2,061,000	30,000	16.1	
03/28/19	3:00 PM	2,171	2,171,000	110,000	76.4	
03/29/19	2:30 PM	2,271	2,271,000	100,000	70.9	
03/30/19	4:30 PM	2,341	2,341,000	70,000	44.9	
03/31/19	3:00 PM	2,387	2,387,000	46,000	34.1	
04/01/19	4:00 PM	2,458	2,458,000	71,000	47.3	
04/02/19	2:30 PM	2,568	2,568,000	110,000	81.5	
04/03/19	3:30 PM	2,665	2,665,000	97,000	64.7	
04/04/19	4:00 PM	2,737	2,737,000	72,000	49.0	
04/05/19	-					Plugged Pipe, No Reading
04/06/19	10:00 AM	2,790	2,790,000	53,000	21.0	
04/06/19	6:30 PM	2,826	2,826,000	36,000	70.6	
04/07/19	10:30 AM	2,882	2,882,000	56,000	58.3	
04/08/19	10:30 AM	2,925	2,925,000	43,000	29.9	
04/09/19	3:30 PM	2,974	2,974,000	49,000	28.2	
04/10/19	4:30 PM	3,023	3,023,000	49,000	32.7	
04/11/19	3:00 PM	3,064	3,064,000	41,000	30.4	

Date	Time	Flowmeter				Comments
		Reading	Reading (gallons)	Gallons Pumped	Flow Rate (gpm)	
04/12/19	1:15 PM	3,105	3,105,000	41,000	30.7	
04/13/19	10:45 AM	3,136	3,136,000	31,000	24.0	
04/14/19	2:30 PM	3,178	3,178,000	42,000	25.2	
04/15/19	12:00 PM	3,210	3,210,000	32,000	24.8	
04/16/19	12:00 PM	3,243	3,243,000	33,000	22.9	
04/17/19	12:30 PM	3,275	3,275,000	32,000	21.8	
04/18/19	12:30 PM	3,306	3,306,000	31,000	21.5	
04/19/19	1:30 PM	3,337	3,337,000	31,000	20.7	
04/20/19	6:00 PM	3,363	3,363,000	26,000	15.2	
04/21/19	2:30 PM	3,389	3,389,000	26,000	21.1	
04/22/19	2:30 PM	3,414	3,414,000	25,000	17.4	
04/23/19	2:30 PM	3,440	3,440,000	26,000	18.1	
04/24/19	8:00 AM	3,475	3,475,000	35,000	33.3	
04/25/19	5:00 PM	3,489	3,489,000	14,000	7.1	
04/26/19	3:00 PM	3,511	3,511,000	22,000	16.7	
04/27/19	3:00 PM	3,533	3,533,000	22,000	15.3	
04/28/19	1:30 PM	3,555	3,555,000	22,000	16.3	
04/29/19	2:30 PM	3,569	3,569,000	14,000	9.3	
04/30/19	2:00 PM	3,587	3,587,000	18,000	12.8	
05/01/19	4:00 PM	3,611	3,611,000	24,000	15.4	
05/02/19	4:00 PM	3,631	3,631,000	20,000	13.9	
05/03/19	4:00 PM	3,650	3,650,000	19,000	13.2	
05/04/19	4:00 PM	3,669	3,669,000	19,000	13.2	
05/05/19	3:30 PM	3,688	3,688,000	19,000	13.5	
05/06/19	3:30 PM	3,705	3,705,000	17,000	11.8	
05/07/19	3:00 PM	3,723	3,723,000	18,000	12.8	
05/08/19	4:00 PM	3,742	3,742,000	19,000	12.7	
05/09/19	12:00 PM	3,760	3,760,000	18,000	15.0	
05/10/19	2:45 PM	3,780	3,780,000	20,000	12.5	
05/11/19	2:30 PM	3,800	3,799,500	19,500	13.7	
05/12/19	12:00 PM	3,816	3,816,000	16,500	12.8	
05/13/19	4:00 PM	3,834	3,834,000	18,000	10.7	
05/14/19	4:30 PM	3,850	3,850,000	16,000	10.9	
05/15/19	2:30 PM	3,867	3,866,500	16,500	12.5	
05/16/19	3:00 PM	3,882	3,881,500	15,000	10.2	
05/17/19	3:30 PM	3,897	3,897,000	15,500	10.5	
05/18/19	2:30 PM	3,911	3,911,000	14,000	10.1	
05/19/19	3:00 PM	3,926	3,926,000	15,000	10.2	
05/20/19	2:30 PM	3,955	3,955,000	29,000	20.6	
05/21/19	3:00 PM	4,124	4,123,500	168,500	114.6	
05/22/19	4:15 PM	4,179	4,179,000	55,500	36.6	
05/23/19	4:30 PM	4,270	4,270,000	91,000	62.5	
05/24/19	4:30 PM	4,341	4,341,000	71,000	49.3	
05/25/19	5:00 PM	4,396	4,396,000	55,000	37.4	
05/26/19	4:30 PM	4,446	4,446,000	50,000	35.5	
05/27/19	2:30 PM	4,480	4,480,000	34,000	25.8	
			Total	4,431,000		

Table 3

Southwest Reservoir Slurry Wall

90 Day Leak Test Evaporation Worksheet

Yearly Evaporation = 50.2 in/yr[1]

Average Water Surface Area = (Feb '19 to May '19) 113,007 ft²

Average Water Surface Area = (Feb '19 to May '19) 2.59 Acres

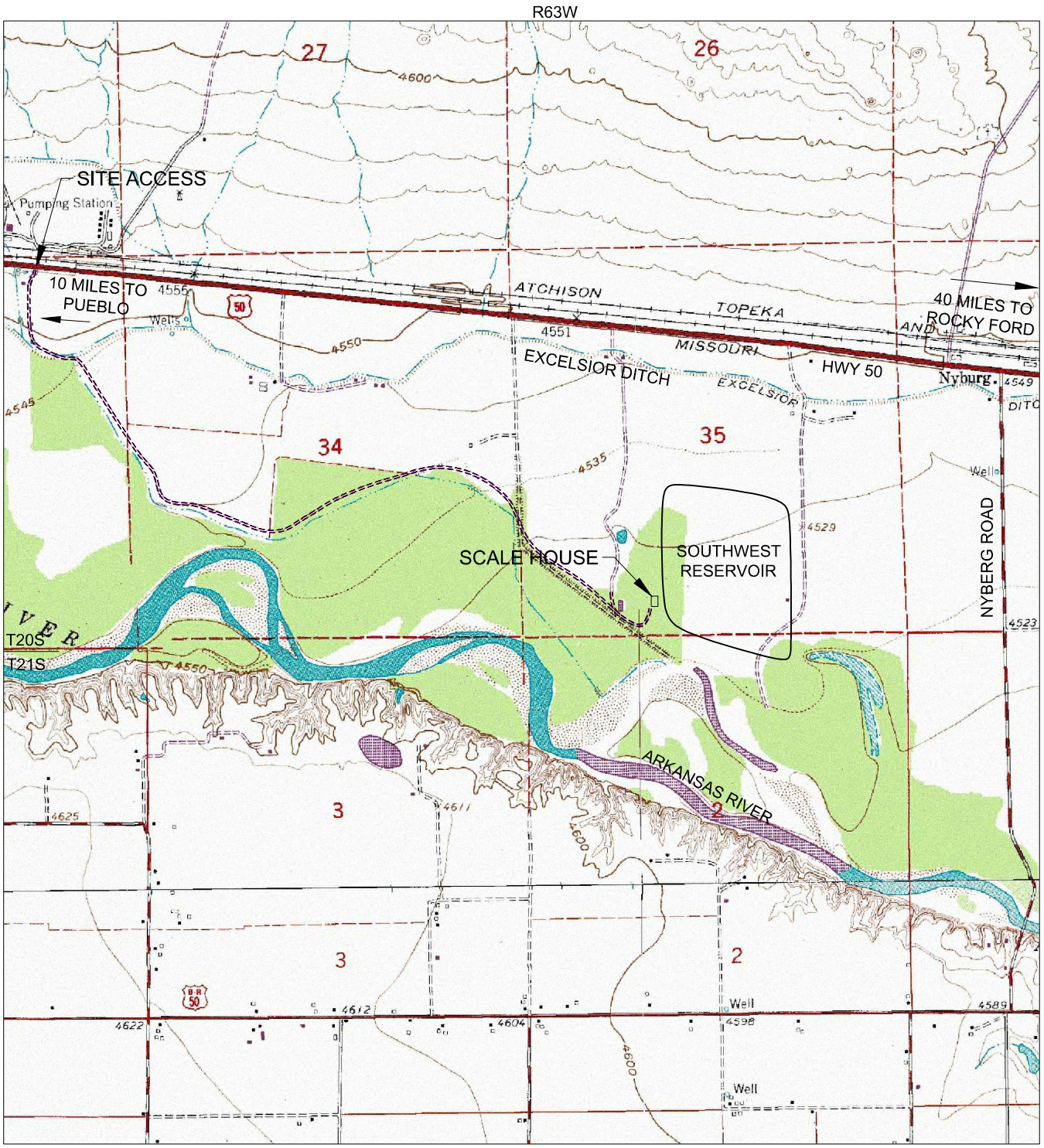
Month	Days in Month	Monthly Distribution[2] (%)	Monthly Evaporation (inches)	Monthly Evaporation Volume[3] (gal)	Monthly Evaporation Rate (gpm)	Comments
January	31	3.0	1.51	-	-	
February	28	3.5	1.76	8,841	0.219	Start of pumping (2/27)
March	31	5.5	2.76	194,502	4.357	
April	30	9.0	4.52	318,276	7.367	
May	31	12.0	6.02	369,611	8.280	End (5/27)
June	30	14.5	7.28	-	-	
July	31	15.0	7.53	-	-	
August	31	13.5	6.78	-	-	
September	30	10.0	5.02	-	-	
October	31	7.0	3.51	-	-	
November	30	4.0	2.01	-	-	
December	31	3.0	1.51	-	-	

90 Day Test Period Evaporation Volume = 891,229 gallons

Average 90 Day Test Period Evaporation Rate = 5.06 gpm

Notes:

1) Approximated from "NOAA Technical Report NWS 33: Evaporation Atlas for the Contiguous 48 United States June 1982, Map 3"
2) From "General Guidelines for Substitute Water Supply Plans For Sand and Gravel Pits Submitted to the State Engineer Pursuant to SB 89-120 & SB 93-260"
3) Based on proportioned monthly evaporation rate times average exposed water surface area.



0 1000' 2000'

SCALE: 1" = 2000'

DEERE & AULT CONSULTANTS, INC.

Stonewall Springs-Southwest Reservoir

Vicinity Map

JOB NO.	0212.010.00	SCALE:	AS NOTED

FIGURE NO. 1

Tuesday, February 16, 2016 3:37:05 PM DRAWING: Q:\0212 Stonewall Springs\0212.010 Southwest Reservoir Slurry Wall\CAD\DAC Drawings\SW Reservoir – Cover.DWG

OVERHEAD ELECTRIC POWERLINE

ESTIMATED BEDROCK CONTOURS

NW POND

STAFF GAUGE

CONSTRUCTED EMBANKMENT

MH-8

MISC PONDS

ACTIVE MINE AREA

100 YR. FEMA FLOOD LIMITS

SOUTHWEST RESERVOIR

LENGTH: 7463.9'

AREA: 84.6 AC

STAFF GAUGE

WEST POND

℄ OF SLURRY WALL

SCALE HOUSE

MISC PONDS

CONVEYOR

STAFF GAUGE

DEWATERING TRENCHES

SUMP W/ PUMP

RAIN GAUGE

FLOW METER

DEWATERING LINE

LEGEND

- EXISTING MAJOR CONTOUR (INSIDE MINE)
- EXISTING MINOR CONTOUR (INSIDE MINE)
- EXISTING MAJOR CONTOUR (OUTSIDE MINE)
- EXISTING MINOR CONTOUR (OUTSIDE MINE)
- BEDROCK CONTOUR
- EXISTING GRAVEL ROAD
- EXISTING OVERHEAD ELECTRIC
- SECTION LINE
- 100YR FEMA FLOOD LIMITS
- WATER (DURATION OF LEAK TEST)
- WATER (TEMPORARY)

0 150' 300'

SCALE IN FEET

CONTOUR INTERVAL = 2FT

NOTE:

CONTOURS INSIDE CELL ARE DESIGN CONTOURS.

JOB NO. 0212.010.00

STONEWALL SPRINGS QUARRY

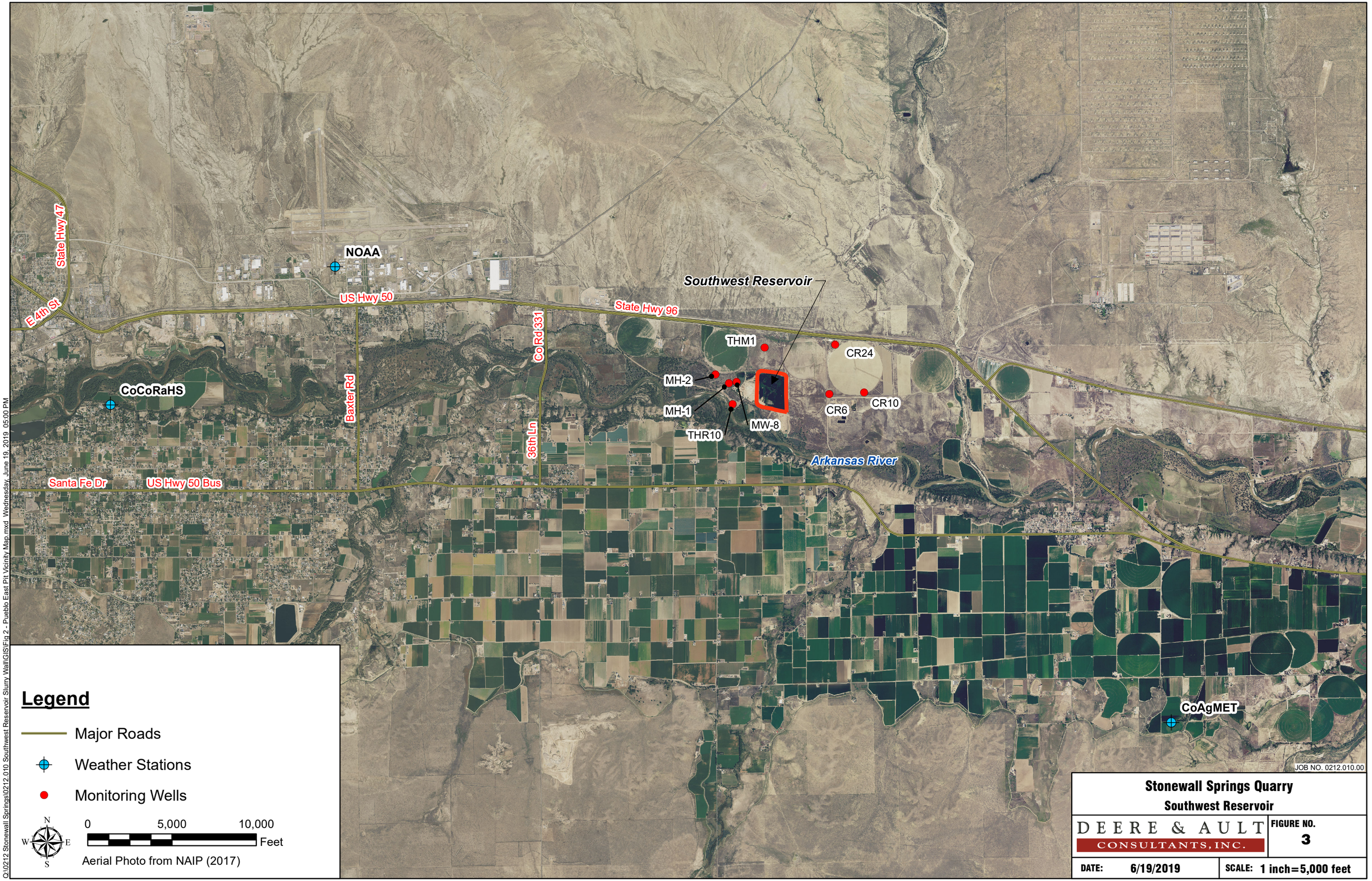
LEAK TEST

DEERE & AULT CONSULTANTS, INC.

FIGURE NO. 2

DATE: APRIL 2017

SCALE: AS NOTED



Legend

- Major Roads
- Weather Stations
- Monitoring Wells

0 5,000 10,000 Feet

Aerial Photo from NAIP (2017)

JOB NO. 0212.010.00

Stonewall Springs Quarry

Southwest Reservoir

DEERE & AULT CONSULTANTS, INC.

FIGURE NO. 3

DATE: 6/19/2019

SCALE: 1 inch=5,000 feet

Q:\0212 Stonewall Springs\0212.010 Southwest Reservoir Slurry Wall\GIS\Fig 2 - Pueblo East Pit Vicinity Map.mxd Wednesday, June 19, 2019 05:00 PM

DEERE & AULT
CONSULTANTS, INC.

May 20, 2019

Mr. Bill W. Tyner P.E.
Division of Water Resources
310 East Abriendo Ave., Suite B
Pueblo, Colorado 81004

Re: Leak Test Plan, Stonewall Springs Quarry, Southwest Reservoir Slurry Wall; D&A Job No. CG-0183.025.00

Dear Mr. Tyner:

This letter was prepared to outline the proposed procedure for conducting a 90-day leak test in accordance with the "*State Engineer Guidelines for Lining Criteria for Gravel Pits*," August 1999 for the Stonewall Springs Quarry Southwest Reservoir. The below grade water storage vessel was created after a mined gravel pit was lined with a soil-bentonite slurry wall around the perimeter of the mined cell. The slurry wall was designed by Deere and Ault (D&A) for the owner of the property. The Southwest Reservoir is a new proposed below grade water storage reservoir and has not been previously leak tested.

We have prepared the test procedure described here to conduct a 90-day leak test of the slurry wall. The slurry wall around the Southwest Reservoir was complete on January 23, 2019. Data collection for the leak test, as described in this letter, started February 27, 2019. Based on field observations to date, the slurry wall appears to be effective in cutting off the majority of inflow of groundwater into the gravel pit. Blank field data collection sheets are attached as **Table 1** for reference.

BACKGROUND

The Stonewall Springs Quarry Southwest Reservoir is located in Pueblo County, Colorado approximately ten miles east of the city of Pueblo. More specifically, the site is located in the South Half of Section 35, Township 20 South, Range 63 West of the 6th P.M. The Southwest Reservoir is a mined cell of the quarry located south of U.S. Highway 50, north of the Arkansas River, and one-half mile west of Nyberg Road. The slurry wall is approximately 7,464 feet long and encompasses approximately 84.6 acres east of the current mining operation. The site is accessed via the mine access road that intersects U.S. Highway 50 approximately 1/2 mile east of Devine, Colorado. A gravel road winds south and east from Highway 50 to the scale house west of the cell. **Figure 1** shows the site and surrounding area.

EXISTING SITE CONDITIONS

The Southwest Reservoir is a mined gravel cell located on the property also known as Fremont Paving and Redi-Mix, or the Pueblo East Pit. Current gravel mine operations are located to the south and west of Southwest Reservoir. The slurry wall was generally constructed through native unmined

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Longmont, CO 80503
Phone: 303-651-1468 ● Fax: 303-651-1469

alluvial soils. A section approximately 500 long in the northwest corner of the cell was mined to bedrock. To create a below grade water storage cell an earthen embankment was constructed in this section. The location of the embankment is shown on **Figure 2**. The embankment was constructed using onsite clayey soils. The slurry wall was then excavated through the embankment as the water cutoff. The bottom of the pit is covered in sand and gravel ranging in thickness from several inches to several feet. The material has been graded to facilitate drainage during the leak test and is scheduled to be removed after the leak test is complete. The bedrock encountered during slurry wall construction was firm to hard shale from the Pierre Shale Bedrock Formation.

Data that will be collected for the leak test includes: daily precipitation readings, volume of water pumped from the cell and the area of all pooled water in the cell. D&A worked with the mine operator to install all monitoring equipment necessary for the leak test. The rain gauge and totalizing flow meter are located in the southeast corner of the Southwest Reservoir. Eight monitoring wells (MH-1, MH-2, THM-1, CR24, CR6, CR10, THR10, MH-8) are installed on or around the site as shown in **Figure 3**. The groundwater elevation around the gravel pit at the start of the leak test was approximately elevation 4517. The water elevation in the bottom of the pit is between 4493 and 4495. The monitoring wells will be monitored every two weeks during the leak test to track groundwater elevation changes around the Southwest Reservoir.

LEAK TEST PLAN

The proposed testing of the slurry wall for the Southwest Reservoir will follow the procedures outlined in the publication "*State Engineer Guidelines for Lining Criteria for Gravel Pits*," August 1999, for lining gravel pits. Inflow and outflow of water at the site will be measured and recorded as required for the 90-day test period. At the end of the test period, the data will be analyzed to determine the amount of unregulated groundwater entering the cell. A summary of the findings, as well as data collected during the test will be presented in a report and submitted to the SEO for review.

The following items will be measured during the test period:

- **Observation of Surface Water**

  The surface area of the pooled water will be monitored for increase or decrease in size during the leak test. The surface area of any significant pooled water will be approximated using drone photography and visual inspection. A staff gauge has been installed at the main sump in the southeast corner, and at the pond in the northwest corner. All areas of surface water will be summed up and used as inputs in calculating evaporative loss during the test period.

- **Evaporation**

  Evaporation from any exposed water surfaces in the pit will be calculated based on procedures described in NOAA Technical Report NWS33.

- **Precipitation**

  Direct precipitation falling on the site will be measured daily by the rain gauge at the site. The nearby NOAA weather station at the airport and surrounding area CoagMet and CoCORaHS stations will be used to verify the site precipitation. These stations are shown on **Figure 3**. Any snow fall depth will be measured and converted to an equivalent rainfall value based on nearby weather station data. Precipitation falling on the ground will be incorporated into the water balance equation at a rate less than 100 percent based on an evaluation of the duration and frequency of precipitation events during the leak test period.

- **Pump Discharges**

  Water pumped from the site will be measured in gallons via a totalizing flow meters at the site. The pump will be operated as needed to pump out water from the main sump located in the southeast corner of the cell. Any pumping data collected will be used in the water balance equation for the leak test.

- **Change in Storage**

  The final grading in the bottom of the pit will follow the estimated bedrock contours, which slope from west to east. The current grading of the bottom of the cell generally follows this slope with the majority of the site draining to the east. Dewatering ditches convey this drainage to the sump and pump located in the southeast corner. As mentioned above, a staff gauge has been installed at the sump in the southeast corner, and at the pond in the northwest corner. These staff gauges will be used to monitor changes in storage for use in the water balance equation.

ALLOWABLE LEAKAGE

The allowable leakage rate conforming to the Design Standard criteria defined by the guidelines is 0.03 $feet^3/day/feet^2$ for the perimeter liner surrounding the reservoir and 0.0015 $feet^3/day/feet^2$ for the floor of the reservoir. The allowable leakage for Design and Performance Standards has been calculated below. The allowable leakage for Southwest Reservoir is based on the following dimensions:

- Length of the as-constructed slurry wall is approximately 7,464 linear feet
- The weighted average of the liner height is approximately 32.6 feet
- The floor area of the pit is approximately 84.6 acres, or 3,685,176 $feet^2$

Design Standard for Stonewall Springs Quarry Southwest Reservoir

Q_{design} = $Q_{design\ wall} + Q_{design\ floor}$

Q_{design} = (7,464 feet x 32.6 feet x 0.03 $feet^3/day/feet^2$) + (3,685,176 $feet^2$ x 0.0015 $feet^3/day/feet^2$)

Q_{design} = 7,300 $feet^3/day$ + 5,528 $feet^3/day$ = 12,828 $feet^3/day$ = 66.6 gpm

Performance Standard for Stonewall Springs Southwest Reservoir

The performance standard is three times the design standard:

$Q_{performance}$ = 3 x 12,828 feet^3/day = 38,484 feet^3/day
$Q_{performance}$ = 199.9 gpm

Water Balance

To meet the criteria outlined in the guidelines for a lined gravel cell, the leak test must demonstrate that the steady state condition for design or performance standard is:

Q_{design} = 66.6 gpm $\geq Q_{pump} + Q_{\Delta storage} + Q_{evaporation} - Q_{precipitation}$
$Q_{performance}$ = 199.9 gpm $\geq Q_{pump} + Q_{\Delta storage} + Q_{evaporation} - Q_{precipitation}$

The facilities and measuring equipment described here is in place and actively being monitored. Once you have reviewed the attached information please contact me if you have any questions or comments. If you would like to meet on site please let me know your availability and we will schedule a time. The 90-day data collection period will end on May 27, 2019 and results will be submitted shortly thereafter.

Sincerely,

DEERE & AULT CONSULTANTS, INC.

Susan A. Rainey, P.E.
Project Manager

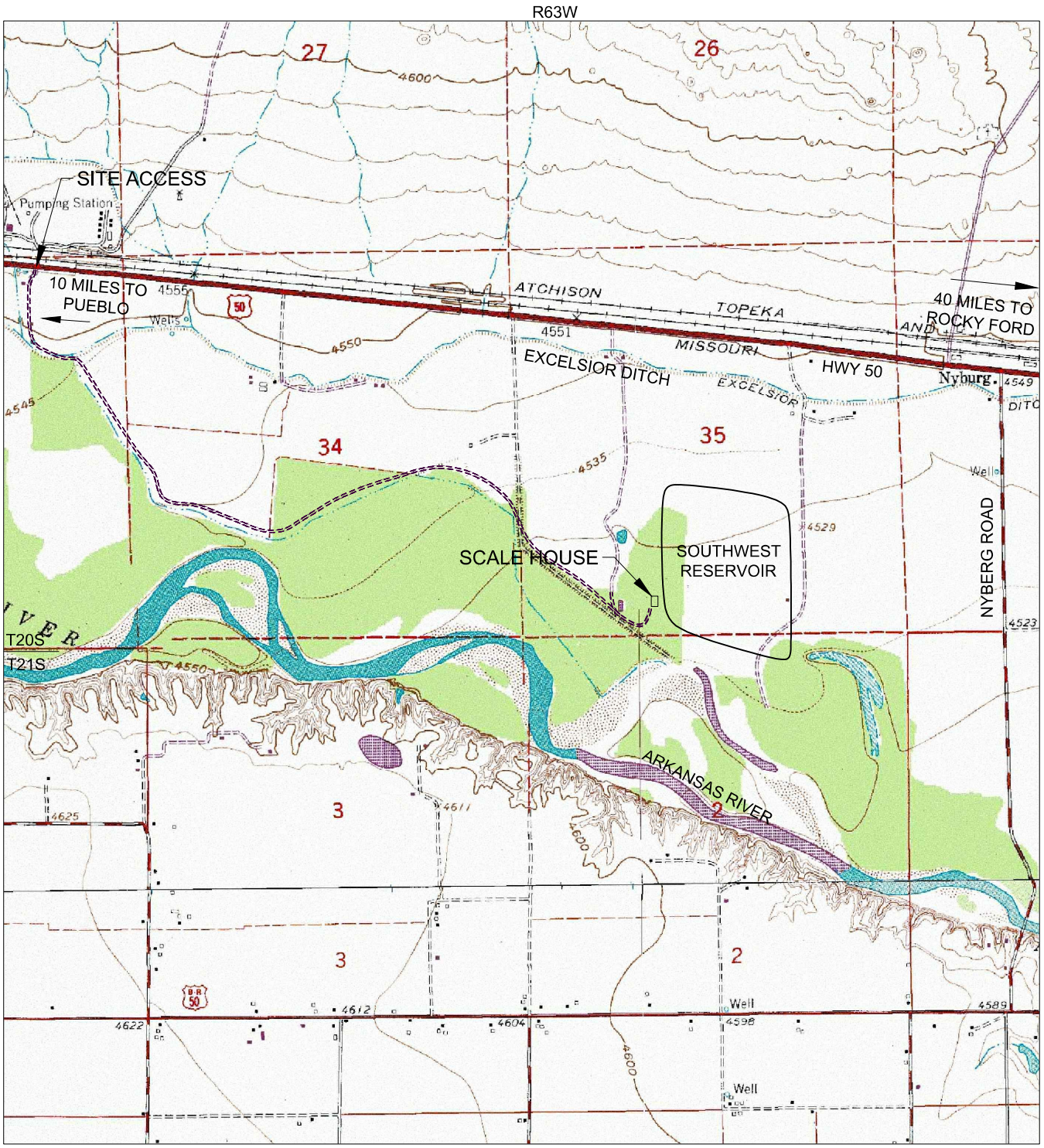
Attachments

cc: John Paul Ary
Mark Morley

Q:\0183 Fremont Paving & Red-Mix\025 Stonewall Springs SW Slurry Wall Construction\Leak Test\Stonewall Springs SW Leak Test Plan.ltr.docx

Table 1
Southwest Reservoir Slurry Wall
Leak Test
Field Measurements

Date	Temp (°F)	Rain Gauge (inches)	Snow Fall (inches)	Staff Gauge	Flowmeter Reading	Time	Photo 1	Photo 2	Photo 3	Photo 4	Reading Done By
							check mark if photo taken from each corner				



0 1000' 2000'

SCALE: 1" = 2000'

DEERE & AULT CONSULTANTS, INC.

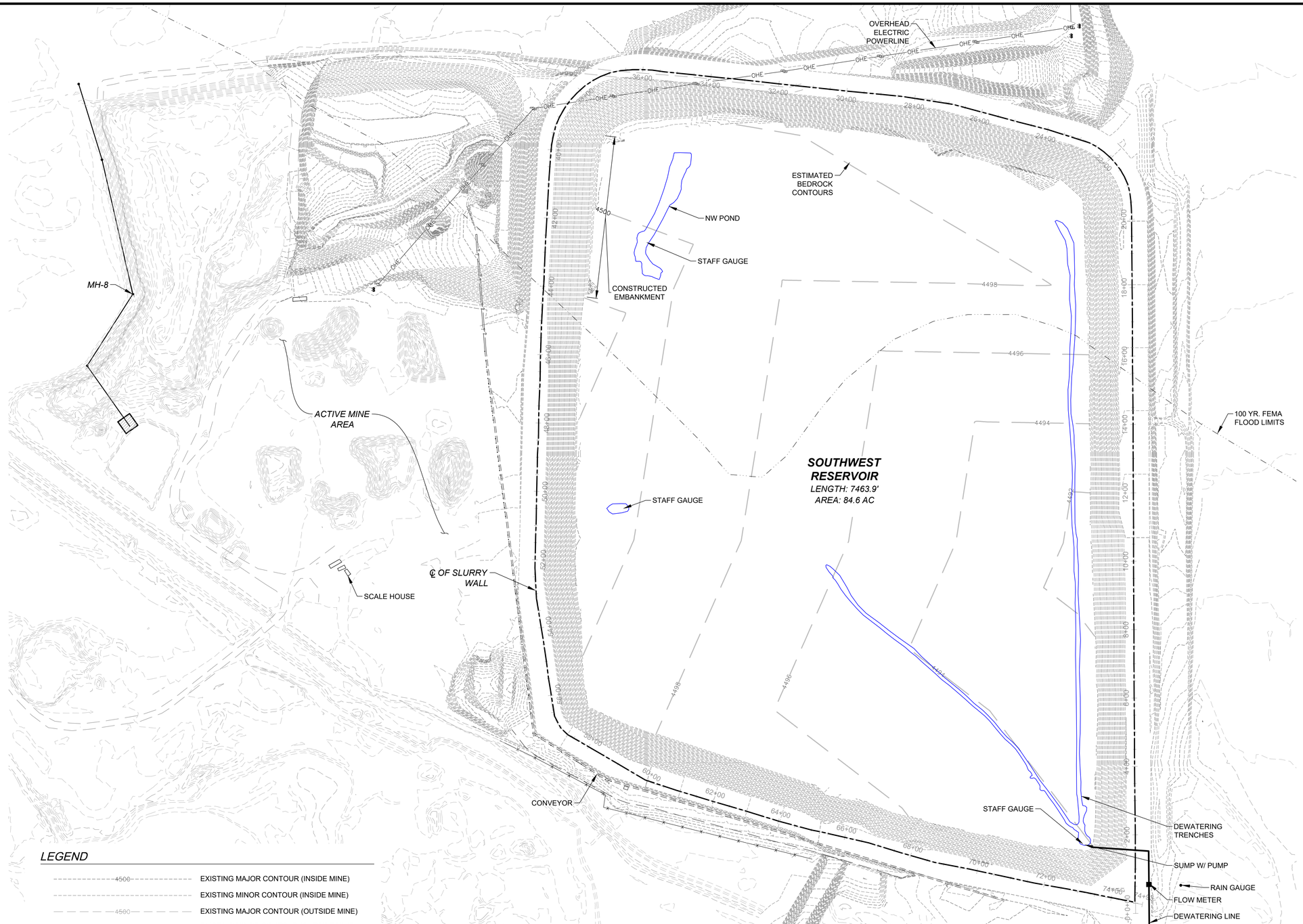
Stonewall Springs-Southwest Reservoir

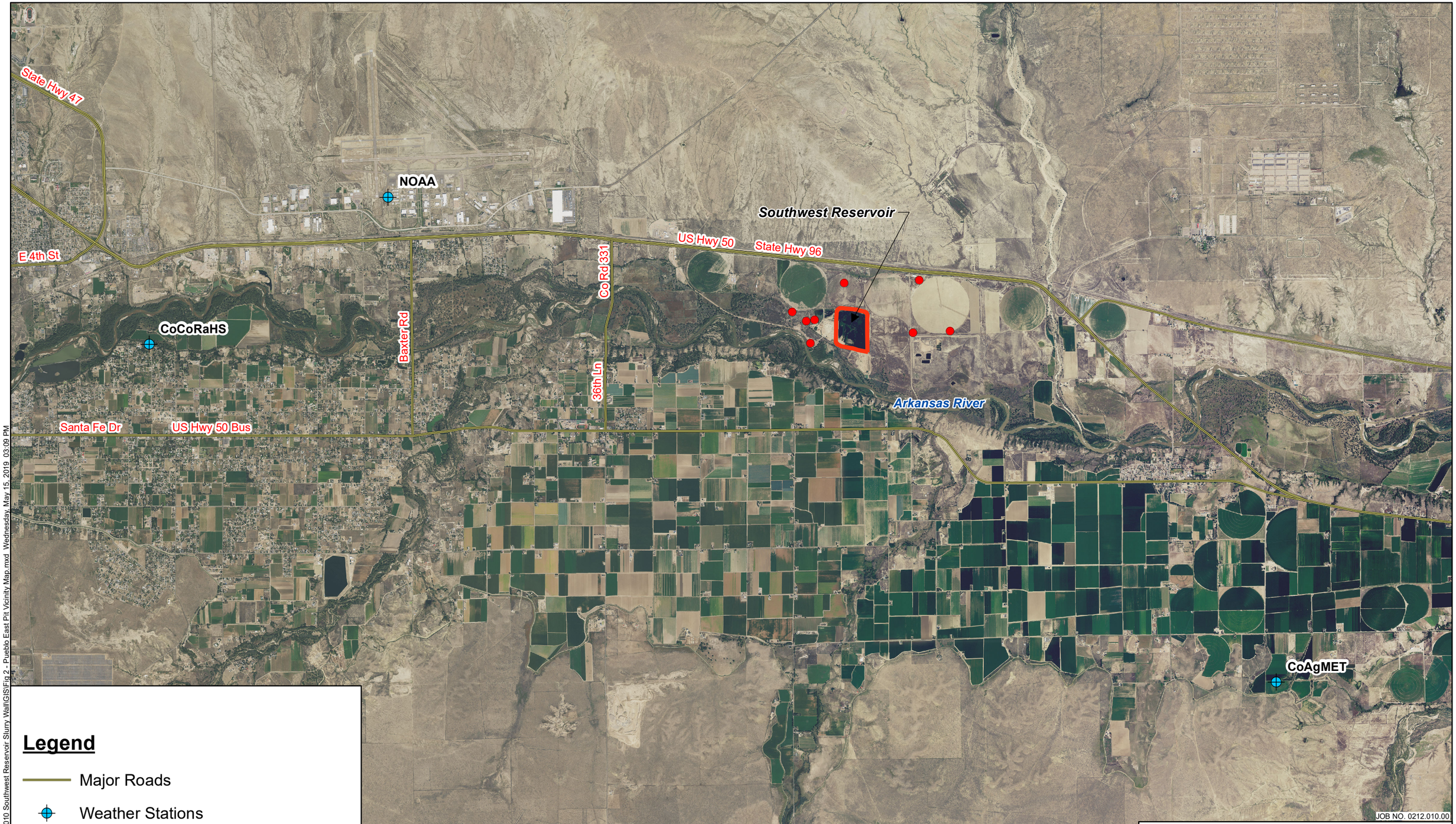
Vicinity Map

JOB NO.	0212.010.00	SCALE:	AS NOTED

FIGURE NO. 1

Tuesday, February 16, 2016 3:37:05 PM DRAWING: Q:\0212 Stonewall Springs\0212.010 Southwest Reservoir Slurry Wall\CAD\DAC Drawings\SW Reservoir – Cover.DWG





Legend

- Major Roads
- Weather Stations
- Monitoring Wells

N W E S

0 5,000 10,000 Feet

Aerial Photo from NAIP (2017)

JOB NO. 0212.010.00

Stonewall Springs Quarry

Southwest Reservoir

DEERE & AULT CONSULTANTS, INC.

FIGURE NO. 3

DATE: 5/15/2019

SCALE: 1 inch=5,000 feet

Q:\0212 Stonewall Springs\0212.010 Southwest Reservoir Slurry Wall\GIS\Fig 2 - Pueblo East Pit Vicinity Map.mxd Wednesday, May 15, 2019 03:09 PM