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DIVISION OF RECLAMATION
MINING AND SAFETY

May 12, 2014

M1-2000-041

Mr. Tim Cazier
Division Of Reclamation, Mining and Safety
Department of Natural Resources
1313 Sherman Street Room 215
Denver, Colorado 80203

Dear, Tim,

Please find attached our Engineers (RJH Consultants) response to the Blue Earth Solutions hydrological assumptions. Southwest Farms, Inc. is very concerned that Staff would recommend approval based on the study that has been provided by Blue Earth to date and Staff would rather require a much more detailed analysis with proper methods. This requirement would be consistent with the requirement established in both the SWSP and the Mining Permit that the dewatering of Evans #2 not cause injury to other surrounding senior water rights as a result of these permits.

Southwest Farms, Inc. also understands that Fremont Paving and Readymix, Inc. is currently working on a detailed monitoring plan for the Amendment as been required by Staff. Southwest Farms, Inc. looks forward to receiving a copy of the monitoring plan and being able to have our Engineer respond to this criteria as well.

Also Southwest Farms, Inc. is currently working on coming to an agreement for mitigation for the depletions being caused by the current pumping and future expansion of the Evans Pit #2 with both John Paul Ary (Fremont Paving and Redimix, Inc.) and Mark Morley (Stonewall Springs Quarry/Morley Companies). We will provide you a copy for the record if and when we come to an agreement.

Sincerely,

John Sliman
Southwest Farms, Inc

May 8, 2014
Project 14109

Mr. John Sliman
Southwest Farms
1825 Chianti Court
Pueblo, CO 81001

Re: Evans Pit #2 M-2000-041
Groundwater Impacts at Southwest Farms

Dear Mr. Sliman:

We have reviewed the Hydrogeologic Evaluation that Blue Earth Solutions prepared in December 2013 for Evans Pit #2. Based on the information presented in the report, dewatering activities at the Evans Pit #2 will impact groundwater levels beyond the limits of the permit boundary and beneath Southwest Farms property. However in our opinion the dewatering impacts in the report underestimate the actual impacts and limit of dewatering influence. Our specific areas of concern are as follows:

1. **Theory of the analytical solution:** The analytical solution used by Blue Earth is based on an assumption that all the water being removed is derived from uniform recharge within the radius of influence of the dewatering. The analytical solution does not consider groundwater flow that enters the radius of influence of dewatering. We would expect that background groundwater flow would affect the shape of the zone of influence.
2. **Applicability of analytical solution to site geometry:** The analytical solution is based on an assumption that the dewatered aquifer is homogenous and the homogenous soil conditions extend significantly beyond the radius of influence. These assumptions are not valid because of the Arkansas River south of the pit, the pinch-out of alluvium against bedrock north of the pit, and the future lining of the Phase I pit. Blue Earth attempted to reconcile these geometric limitations by converting the calculated radii of influence into the qualitative zones of influence that are shown on their Figures 3, 5, and 7. However, justification is lacking for how the radii of influence were developed northwest of the pit in the vicinity of Southwest Farms property. Also, Blue Earth acknowledges that drawdown north of the pit will be greater than that predicted by the analytical solution because the alluvium pinches

9800 Mt. Pyramid Court, Suite 330
Englewood, CO 80112
www.rjh-consultants.com

303-225-4611 – phone
303-225-4615 – fax
866-900-1930 – toll free

out in this area, but they do not attempt to quantify the difference. The use of an image well could be used to evaluate this further.

3. **Accuracy of hydraulic conductivity:** In our opinion Blue Earth's development of a hydraulic conductivity value was inappropriate, and the assumed value of 480 feet per day is likely too low. Using too low of a hydraulic conductivity would underestimate the dewatering impact on groundwater levels. Our specific comments related to the developed hydraulic conductivity are as follows:

   a. Blue Earth used the Hazen formula as one of the methods to estimate hydraulic conductivity, which in our opinion is not appropriate for the site alluvium. Hazen's formula was developed for clean, uniform (C_u less than about 2) filter sands and the applicability of the method is generally limited to material with D_{10} between 0.01 and 0.3 mm. The accuracy of Hazen's formula is questionable when applied to the soils summarized in Blue Earth's Table 2. Furthermore, use of the Hazen formula requires the assumption of an empirical coefficient (C_H) that may vary over several orders of magnitude, which could result in gross inaccuracies.

   b. It appears that the Prugh graphical method for estimating hydraulic conductivity may not have been performed correctly. For example from Blue Earth's Table 2, the alluvial sample from 9.5 to 11.0 feet deep in THM-5 has D_{50} = 0.42 mm and C_u = 3.7. Blue Earth reports that the Prugh method estimated a hydraulic conductivity of 94 feet per day for this sample. Using the graphs included in Blue Earth's Appendix A, we estimated that this sample would have a hydraulic conductivity of about 2×10^{-3} m/s (567 feet per day) in a dense state and 3×10^{-3} m/s (850 feet per day) if it was at 50 percent relative density. The N-value was 7 at this sample location, which would indicate that the alluvium is loose and therefore we would expect the hydraulic conductivity to be greater than 850 feet per day. We did not evaluate if the Prugh method was applied correctly to other samples. This method does not appear to be widely published or accepted in geotechnical engineering practice, and based on the information provided by Blue Earth it may have been recently developed by a geotechnical contractor. The extent of data used to develop his relationship and the reliability of this method is unknown.

   c. We used the Kozeny-Carman equation to estimate hydraulic conductivity for the samples listed in Blue Earth's Table 2, and we estimated that the vertical hydraulic conductivity could be as high as about 830 feet per day. The horizontal hydraulic conductivity is anticipated to be higher than this as a result of anisotropy within the alluvium.

   d. Horizontal groundwater flow will be controlled by the most permeable alluvial layers, and therefore the analyses should have used a hydraulic conductivity near the upper end of the estimated values.

4. **Estimation of recharge:** In our opinion Blue Earth's development of recharge was inappropriate and likely overestimated aquifer recharge. Using too high of a

recharge value would underestimate the dewatering impact on groundwater levels. Our specific comments related to the developed recharge are as follows:

a. Recharge was crudely estimated and it does not appear that the entire water budget was considered. A more thorough evaluation of the water budget would have estimated recharge by equating inflow and outflow near the root zone in a form similar to:

Precipitation + Irrigation = Soil Evaporation + Plant Evapotranspiration + Runoff + Recharge

Blue Earth assumed that total inflow was 32 inches per year and recharge was 12.4 inches per year. This would only leave 19.6 inches per year that would be available for soil evaporation, plant evapotranspiration, and runoff. Blue Earth's water budget does not provide the recommended 32 inches per year for crops in the Arkansas River Valley. In our opinion, a more rigorous evaluation of the water budget needs to be performed to estimate recharge. It is possible that there could be negligible aquifer recharge from irrigation if water is effectively applied to keep moisture within the root zone.

b. To compensate for the inaccuracies of their water budget analysis, Blue Earth assumed that 20 percent of precipitation and 50 percent of irrigation contributes to aquifer recharge; however, supporting data was not included to justify these values. According to Colorado State University Fact Sheet No. 4.718 included in Blue Earth's Appendix A, center pivot irrigation systems are 80 percent efficient. Underestimating the irrigation efficiency would result in recharge being overestimated.

c. Blue Earth did not evaluate the sensitivity of the radius of influence to changes in recharge. We would expect the radius of influence to increase during periods of lesser recharge.

5. **Miscellaneous comments:** We also have the following comments about inaccuracies and omissions within the Blue Earth evaluation that need to be clarified:

a. Appendix A shows that Deere and Ault drilled 22 borings, but only eight borings are included in Blue Earth's Table 1 and Figure 2. Where were the other borings located relative to the site?

b. Blue Earth's text says the overburden is 2 to 3 feet thick, but the boring logs show that the overburden is commonly 10 feet thick or more. Less aquifer recharge is anticipated to occur through a greater thickness of low-permeability overburden. Less recharge would result in the analytical solution underestimating dewatering impacts on groundwater levels.

c. Blue Earth's text and gradation test results characterize the alluvium as clayey sand and clayey sand with gravel. What classification system was used? The gradation test results included in their report all have less than 5 percent fines and therefore the alluvium would not classify as clayey sand using the Unified Soil Classification System (USCS, ASTM D 2487). In our opinion, proper

characterization and classification of the alluvium is important for the estimation of hydraulic conductivity.

d. Gradation test results are included in Blue Earth's Appendix A for samples from boring THM-15; however, the location of this boring is not provided and these samples were not used to develop hydraulic conductivity of the alluvium. The alluvial samples from THM-15 had lower fines contents than the samples from THM-5 and THM-16, and therefore could possibly have higher hydraulic conductivity than the evaluated samples.

e. Additional detail needs to be provided about how the groundwater contours shown on Blue Earth's Figure 2 were developed. Also, what extent of the pit was being dewatered at the time that Deere and Ault performed their drilling in 2006? Boring THM-1 is located about 1,300 feet outside of the permit boundary and the measured groundwater level was about 2.5 feet below the regional gradient. The groundwater levels in most of the other borings shown on Blue Earth's Figure 2 correspond well with the groundwater contours, and therefore it does not appear that the low groundwater level in THM-1 is the result of seasonal fluctuations.

f. Blue Earth did not attempt to calibrate their analytical solution to observed groundwater levels and pumping rates at the current pit.

Blue Earth's evaluation shows that dewatering of Evans Pit #2 will impact groundwater levels beneath Southwest Farms property beyond the limits of the permit boundary. We have also identified several shortcomings in Blue Earth's evaluation that would cause the severity of groundwater impacts to be underestimated. Because of these deficiencies in the Blue Earth evaluation, it is our opinion that additional analyses need to be performed to evaluate how dewatering of Evans Pit #2 will impact the surrounding groundwater levels. Also, more rigorous analyses need to be performed to evaluate the hydraulic conductivity of the alluvium and the aquifer recharge rate.

Please contact me if you have any comments or questions.

Sincerely,

RJH CONSULTANTS, INC

Robert J. Huzjak, P.E.
President

RJH/jmm

John Sliman
Southwest Farms, Inc
1825 Chianti Ct
Pueblo, CO 81001

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Tim Cazier
Division of Reclamation, Mining
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Department of Natural Resources
1313 Sherman St., Room 215
Denver CO 80203

80203224965