From: Goldmann, Elizabeth
To: Blaine, Marjorie E SPL; msvogel@fs.fed.us
Cc: Brush, Jason; Jessop, Carter; Leidy, Robert
Subject: Conference call with USFWS re: Rosemont Mine Biological Opinion
Date: Wednesday, February 26, 2014 8:55:00 AM

Dear Mindy and Marjorie

EPA has scheduled a conference call with Jean Calhoun, USFWS, and staff on March 5, 2014 at 1 pm (PT) to discuss some questions we have on the Biological Opinion for the proposed Rosemont Mine. We would like to extend the invitation to you. We will send out an agenda next week and provide call in information.

Please let me know if you can join us.

Thanks,

Elizabeth

From: Goldmann, Elizabeth
To: Kingsbury, Jamie -FS
Subject: FW: Conference call with USFWS to discuss BO for RM, call in information
Date: Wednesday, March 05, 2014 11:31:00 AM

FYI

From: Leidy, Robert
Sent: Wednesday, March 05, 2014 11:26 AM
To: Goldmann, Elizabeth; Blaine, Marjorie E SPL; Jessop, Carter; Brush, Jason; jean_calhoun@fws.gov; Douglas, Jason; Steve_Spangle@fws.gov; jupchurch01@fs.fed.us; Vogel, Mindy S -FS
Subject: RE: Conference call with USFWS to discuss BO for RM, call in information

Hello Jason and Jean,

(b)(5) Deliberative [redacted]

Best,

Rob

Robert A. Leidy, Ph.D.

U.S. Environmental Protection Agency

Wetlands Office (WTR-8)

75 Hawthorne Street

San Francisco, CA 94105

(415) 972-3463

-----Original Appointment-----
From: Goldmann, Elizabeth
Sent: Monday, March 03, 2014 12:21 PM
To: Blaine, Marjorie E SPL; Jessop, Carter; Leidy, Robert; Brush, Jason; jean_calhoun@fws.gov; Douglas, Jason; Steve_Spangle@fws.gov; jupchurch01@fs.fed.us; Vogel, Mindy S -FS
Subject: Conference call with USFWS to discuss BO for RM, call in information
When: Wednesday, March 05, 2014 1:00 PM-3:00 PM (UTC-08:00) Pacific Time (US & Canada).
Where: R9-Room-1209-20-WTR_Only/Region-9-RESTRICTED

In preparation for our meeting on Wednesday at 1 pm (PT), I am providing you with an agenda and teleconference line.

Thank you, Elizabeth

Teleconference Line:

(b) (6) [redacted]

[redacted]

Agenda:

(b) (5) Del [redacted] b5 - deliberative [redacted]

From:	Goldmann, Elizabeth
To:	jean_calhoun@fws.gov; jupchurch01@fs.fed.us
Cc:	Brush, Jason
Subject:	FW: EPA Comments dated April 9, 2014 on the Rosemont Copper Project HMMP dated April 1, 2014
Date:	Thursday, April 10, 2014 9:01:00 PM
Attachments:	EPAanalysisofRosemontHMMP.04092014.docx Attachment withheld - b5 deliberative
Importance:	High

Hi Jean and Jim

Here are EPA's comments on the Rosemont Copper Project HMMP dated April 1, 2014.

Please contact us if you have any questions.

-Elizabeth

From: Goldmann, Elizabeth
Sent: Wednesday, April 09, 2014 8:56 AM
To: 'Blaine, Marjorie E SPL'
Cc: 'David.J.Castonon@usace.army.mil'; Allen, Aaron O SPL; spencer.d.macneil@usace.army.mil; Brush, Jason
Subject: EPA Comments dated April 9, 2014 on the Rosemont Copper Project HMMP dated April 1, 2014
Importance: High

Hi Marjorie

Attached are EPA's comments on the Rosemont Copper Project HMMP dated April 1, 2014. These comments include an analysis of Sonoita Creek Ranch, South Sonoita Creek Ranch, Fullerton Ranch, the Davidson Canyon Parcels and Pantano Dam.

Please contact Rob Leidy or me if you have any questions.

Thanks, Elizabeth

(b)(5) Deliberative

From: Goldmann, Elizabeth
To: Blaine, Marjorie E SPL
Subject: FW: Rosemont Copper Project Hydrology Working Group
Date: Wednesday, June 04, 2014 9:24:00 AM
Attachments: Hydrology Working Group_final 052914.docx

Hi Marjorie

I just realized you are not on this call. I just want to make sure this is not an oversight on USFS' part.

Thanks, E.

From: Ruyle, Jennifer -FS [mailto:jruyle@fs.fed.us]
Sent: Friday, May 30, 2014 11:26 AM
To: Upchurch, Jim -FS; Kingsbury, Jamie -FS; Shafiqullah, Salek -FS; Stamer, Marc -FS; cgarrett@swca.com; mpolm@swca.com; (b) (6) [redacted]; abarclay@swca.com; Ruyle, Jennifer -FS; Calhoun, Jean; jason_douglas@fws.gov; cfsmith@usgs.gov; Vogel, Mindy S -FS; leenhout@usgs.gov; alcoes@usgs.gov; Jessop, Carter; Leidy, Robert; Goldmann, Elizabeth; Jeffrey Simms; Moore, Daniel; Kathy Arnold; blindenlaub@westlandresources.com; David Cerasale; Joyce M. Francis; Raul Vega; JWindes@azgfd.gov; Gurrieri, Joseph T -FS; Congdon, Roger D -FS
Subject: Rosemont Copper Project Hydrology Working Group

Thank you for agreeing to work with the Forest Service as a member of the group that will be taking another look at the hydro information for the Rosemont project. Attached you will find the group objectives and expectations, which will be discussed in more detail on a **conference call June 4th from 9-11 PDT**. Please dial (b) (6) [redacted]. This call is intended to (1) discuss the purpose of this group, (2) the logistics for the following two-day technical session meetings, which will be held on **June 10th and 11th from 9-4:30 PDT**, and (3) to discuss and share any information that was not included in the FEIS that should be considered at this time. The location and VTC/phone information will be provided to you during the conference call on the 4th.

Again, thank you for your cooperation and support.

Jennifer M. Ruyle
Natural Resources and Planning Staff Officer
Coronado National Forest
300 W. Congress
Tucson, AZ 85701
jruyle@fs.fed.us
O: 520.388.8351
C: 5(b) (6) [redacted]

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Hydrology Working Group

Scheduled discussions:

- June 4, 9-11 PDT: Conference call dial 8(b) (6) [redacted] 4 passcode [redacted]
- June 10-11, 9 am-4:30 PDT: In-person /Video Teleconference (location TBA)
- June 18: Potential follow-up conference call

Invited participants:

USFWS, EPA, BLM, USGS, AZGF, USFS and consultants (SWCA), Rosemont Copper and consultants

Objective:

To review the FEIS water analysis, review new information provided by various sources; identify any additional relevant new information; and discuss Groundwater/Surface Water interactions, uncertainties and context as it relates to the analysis of ground and surface water resources conducted for and disclosed in the Rosemont Copper Project FEIS.

The intent is to obtain and discuss information from participants that will aid the Forest Service in carrying out their obligation to review new information or changed conditions applicable to the water resources analysis conducted for the FEIS. However, no consensus advice or recommendations resulting from group deliberation or interaction is expected or will be solicited.

**NOTE: Any information relevant to discussions needs to be shared with all invited attendees. To allow time for review, please provide any existing information back to Melissa Polm (mpolm@swca.com) by June 6, and she will distribute to the group. We anticipate these discussions to extend through the month of June, depending on the extent and scope of the information provided.

Supplemental Information Report (SIR)

A SIR will be prepared by the Forest Service to facilitate review of the FEIS water resources analysis and discuss any new information or changed conditions that have been identified following publication of the FEIS. This document will be prepared by the Forest Service and conclusions made in this document will be the responsibility of the Forest Service.

The objective of Supplemental Information Report is:

- To review and document new information received after the FEIS was published;
- To determine whether or not the new information or changed circumstances are within the scope and range of effects considered in the original analysis;
- To determine whether a correction, supplement, or revision to the environmental document is or is not necessary.

Supplemental Biological Assessment (BA)

A Supplemental BA will be prepared by the Forest Service to integrate new information or changed conditions, both Hydrological and Biological, into the analysis of impacts to federally listed Threatened and Endangered Species. This document will begin formal consultation between the Forest Service and USFWS for the Rosemont Copper Project.

From: Goldmann, Elizabeth
To: Vogel, Mindy S -FS
Cc: Jessop, Carter
Subject: Information request on water quality data for Rosemont Mine
Date: Wednesday, September 30, 2015 2:00:00 PM

Hi Mindy,

I hope you are doing well. I was wondering if you could assist me. (b)(5) Deliberative [redacted]

Thanks,

Elizabeth

From: Goldmann, Elizabeth
To: Vogel, Mindy S -FS
Subject: RE: Information request on water quality data for Rosemont Mine
Date: Thursday, October 01, 2015 4:06:00 PM
Attachments: image001.png
image002.png
image003.png
image004.png

Thanks Mindy. I really appreciate you help.

E.

From: Vogel, Mindy S -FS [mailto:msvogel@fs.fed.us]
Sent: Thursday, October 01, 2015 4:01 PM
To: Goldmann, Elizabeth
Subject: RE: Information request on water quality data for Rosemont Mine

Hi Elizabeth.

I have tried to answer your questions below in maroon.
If you have any others, please feel free to contact me.

Thanks!

Mindy Sue Vogel
Minerals & Geology Program Manager

Forest Service
Coronado National Forest

p: 520-388-8327
c: (b) (6) [redacted] 4
f: 520-388-8305
msvogel@fs.fed.us

300 W Congress St
Tucson, AZ 85701
www.fs.fed.us

Caring for the land and serving people

From: Goldmann, Elizabeth [mailto:Goldmann.Elizabeth@epa.gov]
Sent: Wednesday, September 30, 2015 2:00 PM
To: Vogel, Mindy S -FS
Cc: Jessop, Carter
Subject: Information request on water quality data for Rosemont Mine

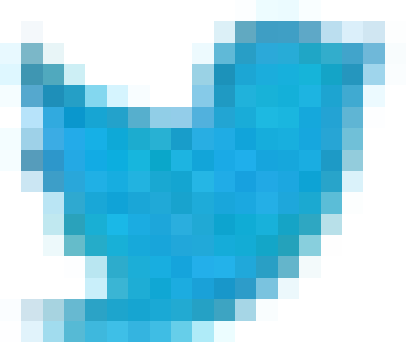
Hi Mindy,

I hope you are doing well. I was wondering if you could assist me. (b)(5) Deliberative [redacted]

(b)(5) Deliberative [redacted]

Thanks,

Elizabeth



From: Goldmann, Elizabeth
To: Julia Fonseca
Subject: RE: Rosemont Copper Project Hydrology Working Group
Date: Thursday, June 05, 2014 3:22:00 PM

Hi Julia

I forwarded your 401 comment ltr to Jennifer this morning. In addition, I inquired whether USFS invited Pima County to participate in the workgroup. ☺

-Elizabeth

From: Julia Fonseca [mailto:Julia.Fonseca@pima.gov]
Sent: Thursday, June 05, 2014 3:09 PM
To: 'Ruyle, Jennifer -FS'
Cc: 'Upchurch, Jim -FS'; 'jean_calhoun@fws.gov'; 'tshannon@blm.gov'; Goldmann, Elizabeth
Subject: RE: Rosemont Copper Project Hydrology Working Group

Hi, Jennifer,

Thank you for the invitation. I read the document and just tried to call you to understand more about what expertise you need at these meetings. We'll talk soon, I hope.

Julia Fonseca
Environmental Planning Manager

Pima County Office of Sustainability and Conservation
201 N. Stone, 6th floor
Tucson, AZ 85701
(520) 724-6460
Julia.Fonseca@pima.gov

From: Ruyle, Jennifer -FS [mailto:jruyle@fs.fed.us]
Sent: Thursday, June 05, 2014 2:57 PM
To: Julia Fonseca
Cc: Upchurch, Jim -FS; jean_calhoun@fws.gov; tshannon@blm.gov; Goldmann, Elizabeth (Goldmann.Elizabeth@epa.gov)
Subject: FW: Rosemont Copper Project Hydrology Working Group

Hi Julia,

We have decided to set up a working group to look at new information or changed conditions related to the hydrological effects of the Rosemont Copper Project, especially as they relate to ESA

listed species and habitat. As a result of a preliminary conference call, it became clear that Pima County should be part of this group. I know this is short notice, but am hoping that the County can have representatives participating. I've attached a descriptive document that sets the stage for the workshop. Please let me know if you can attend, and if I can answer any questions you may have.

Jennifer M. Ruyle
Natural Resources and Planning Staff Officer
Coronado National Forest
300 W. Congress
Tucson, AZ 85701
jruyle@fs.fed.us
O: 520.388.8351
C: (b) (6) [redacted]

From: Ruyle, Jennifer -FS
Sent: Friday, May 30, 2014 11:26 AM
To: Upchurch, Jim -FS; Kingsbury, Jamie -FS; Shafiqullah, Salek -FS; Stamer, Marc -FS; 'cgarrett@swca.com'; 'mpolm@swca.com'; (b) (6) [redacted] '; 'abarclay@swca.com'; Ruyle, Jennifer -FS; 'Calhoun, Jean'; jason_douglas@fws.gov; 'cfsmith@usgs.gov'; Vogel, Mindy S -FS; 'leenhout@usgs.gov'; 'alcoes@usgs.gov'; 'Jessop, Carter'; 'Leidy, Robert'; 'Goldmann, Elizabeth'; 'Jeffrey Simms'; 'Moore, Daniel'; 'Kathy Arnold'; 'blindenlaub@westlandresources.com'; 'David Cerasale'; 'Joyce M. Francis'; 'Raul Vega'; 'JWindes@azgfd.gov'; Gurrieri, Joseph T -FS; Congdon, Roger D -FS
Subject: Rosemont Copper Project Hydrology Working Group

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Again, thank you for your cooperation and support.

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Natural Resources and Planning Staff Officer
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300 W. Congress
Tucson, AZ 85701
jruyle@fs.fed.us
O: 520.388.8351
C: (b) (6) [redacted]

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From: Goldmann, Elizabeth
To: Ruyle, Jennifer -FS
Subject: RE: Rosemont Copper Project Hydrology Working Group
Date: Thursday, June 05, 2014 11:32:00 AM

Hi Jennifer

Did you extend participation in the hydro group to Pima County?

Thanks, E.

From: Ruyle, Jennifer -FS [mailto:jruyle@fs.fed.us]
Sent: Friday, May 30, 2014 11:26 AM
To: Upchurch, Jim -FS; Kingsbury, Jamie -FS; Shafiqullah, Salek -FS; Stamer, Marc -FS; cgarrett@swca.com; mpolm@swca.com; (b) (6) [redacted]; abarclay@swca.com; Ruyle, Jennifer -FS; Calhoun, Jean; jason_douglas@fws.gov; cfsmith@usgs.gov; Vogel, Mindy S -FS; leenhout@usgs.gov; alcoes@usgs.gov; Jessop, Carter; Leidy, Robert; Goldmann, Elizabeth; Jeffrey Simms; Moore, Daniel; Kathy Arnold; blindenlaub@westlandresources.com; David Cerasale; Joyce M. Francis; Raul Vega; JWindes@azgfd.gov; Gurrieri, Joseph T -FS; Congdon, Roger D -FS
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Natural Resources and Planning Staff Officer
Coronado National Forest
300 W. Congress
Tucson, AZ 85701
jruyle@fs.fed.us
O: 520.388.8351
C: (b) (6) [redacted]

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From: Goldmann, Elizabeth
To: jruyle@fs.fed.us
Cc: Leidy, Robert; Jessop, Carter
Subject: RE: Rosemont Copper Project Hydrology Working Group
Date: Thursday, June 05, 2014 11:26:00 AM
Attachments: rs-rosemont adeq 401 certification comments.pdf

Hi Jennifer

As a follow up to our meeting yesterday, I am attaching an April 4, 2014 letter from Pima County to ADEQ regarding the State of Arizona's Draft 401 Water Quality Certification for the Rosemont Copper Project. (b)(5) Deliberative [redacted]

Thanks,

Elizabeth

From: Ruyle, Jennifer -FS [mailto:jruyle@fs.fed.us]
Sent: Friday, May 30, 2014 11:26 AM
To: Upchurch, Jim -FS; Kingsbury, Jamie -FS; Shafiqullah, Salek -FS; Stamer, Marc -FS; cgarrett@swca.com; mpolm@swca.com; (b) (6) [redacted]; abarclay@swca.com; Ruyle, Jennifer -FS; Calhoun, Jean; jason_douglas@fws.gov; cfsmith@usgs.gov; Vogel, Mindy S -FS; leenhout@usgs.gov; alcoes@usgs.gov; Jessop, Carter; Leidy, Robert; Goldmann, Elizabeth; Jeffrey Simms; Moore, Daniel; Kathy Arnold; blindenlaub@westlandresources.com; David Cerasale; Joyce M. Francis; Raul Vega; JWindes@azgfd.gov; Gurrieri, Joseph T -FS; Congdon, Roger D -FS
Subject: Rosemont Copper Project Hydrology Working Group

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Natural Resources and Planning Staff Officer
Coronado National Forest
300 W. Congress
Tucson, AZ 85701

jruyle@fs.fed.us
O: 520.388.8351
C: (b) (6) [redacted]

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COUNTY ADMINISTRATOR'S OFFICE

PIMA COUNTY GOVERNMENTAL CENTER
130 W. CONGRESS, FLOOR 10, TUCSON, AZ 85701-1317
(520) 724-8661 FAX (520) 724-8171

C.H. HUCKELBERRY
County Administrator

April 4, 2014

Robert Scalamera, Project Manager
Surface Water Section, MC5415A-1
Arizona Department of Environmental Quality
1110 West Washington Street
Phoenix, Arizona 85007

Re: **Arizona Department of Environmental Quality 401 Certification for Rosemont Copper, Public Notice 27-14AZ LTF 55425**

Dear Mr. Scalamera:

This letter presents additional consolidated comments by the Pima County Regional Flood Control District and Pima County on the Draft 401 certification for the Clean Water Act Section 404 permit for the Rosemont Copper Project. After I sent our comments to you, the Arizona Department of Environmental Quality (ADEQ) extended the comment period until April 7, 2014. ADEQ has also provided a copy of the agency's basis for the proposed certification that was not available during our previous review. Thank you for making this document available.

The additional comments provided herein largely pertain to that document, formally titled "Basis for State 401 Certification Decision, Rosemont Copper Project, ACOE Application No. SPL-2008-00816-MB". This document makes clear that ADEQ's draft certification has relied upon faulty information in the Final Environmental Impact Statement (EIS) and unsubstantiated opinions in documents that were provided by Rosemont Copper. Pima County and many others object to many of the conclusions of the Final EIS. Our previous review also found that ADEQ relied upon data and designs that no longer represent the mine as proposed to the US Army Corps of Engineers and the US Forest Service.

On behalf of Pima County and the Regional Flood Control District, I urge ADEQ to deny the 401 certification for the Rosemont Copper project.

Sincerely,

C.H. Huckelberry
County Administrator

CHH/mjk

Attachment

c. Colonel Kimberly Colloton, Los Angeles District Engineer, US Army Corps of Engineers
Jared Blumenfeld, Region IX Administrator, US Environmental Protection Agency

Additional Comments on State 401 Certification Decision – Rosemont Copper Project ACOE Application No. SPL – 2008-00816-MB

Prepared by
Evan Canfield and Akitsu Kimoto, Pima County Regional Flood Control District, and
Brian Powell and Julia Fonseca, Pima County Office of Sustainability and Conservation
On Behalf of
C. H. Huckelberry, County Administrator
130 W. Congress, Tucson, AZ 85701

Background

ADEQ has provided us their basis for 401 certification. Many of our additional comments to ADEQ restate previous concerns raised in the FEIS, because many of the findings in the Basis for State 401 Certification were supported with conclusions from the FEIS that we believe are in error. This document also presents new data and new concerns with ADEQ's basis for the certification.

Stormwater and Sediment Transport Review

We have previously described concerns with the stormwater analysis and sediment transport analysis used in the FEIS (Attachment 1), and therefore believe that the Basis for State 401 Certification is based on erroneous analysis.

<u>Summary</u>:

1.) ***Factor: Changes in loadings and the nature, persistence and potential effects of the parameter***: *Sediment Delivery/Sediment Yield (p.8).*

   a.) Previously-raised concerns: As we noted in our concerns about the FEIS there will be a reduction in sediment yield from Barrel Canyon watershed but no change in the geomorphology of the channel is expected. The FEIS only discusses annual average sediment delivery. The FEIS did not consider cumulative impacts of sediment delivery change over the active mine period and post-closure. Considering the proposed active mine life is over 20 years, the FEIS should assess long term impacts on sediment yield, delivery and channel geomorphology. County PAFEIS comments, p. 79.

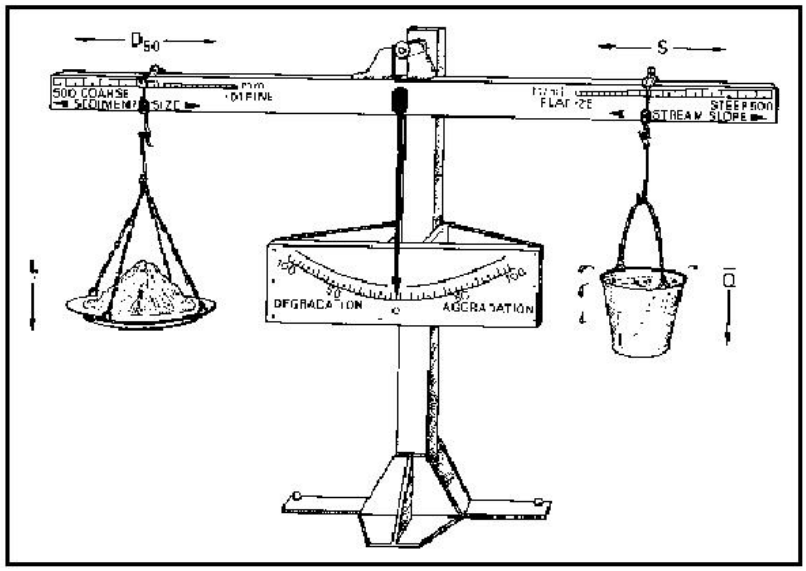
   b.) Concerns about the Patterson and Annandale 2012 assessment: The Basis for State 401 Certification cited an independent Forest Service Review (Patterson and Annandale, 2012; see Attachment 2). We have a number of concerns about this evaluation as follows:

      a. *The level of effort is not adequate to establish that removal of the sediment supply will have no downstream effects.* While this is described as a 'study,' it is in fact a summary of observations from a two-day field visit labeled a 'Technical Memorandum' which includes five page of text and no measured field data.

b. *It is not sealed by a Professional Engineer of Professional Geologist registered in the State of Arizona:* This is particularly concerning because the evaluation, because it includes no data, is essentially a statement of professional judgment.

c. *It does not consider explicitly break out current and proposed conditions in the context of sedimentation processes:* Two widely-accepted frameworks are:

   i. *The Concept that there is a relationship between sediment supply, the capability of a channel to transport that sediment (Lane's balance: Lane, 1954):*



$$Q_s \cdot D_{50} \propto Q_w \cdot S$$

Where

Q_s = *Sediment Discharge*

D_{50} = *Sediment Particle Size*

Q_w = *Streamflow*

S = *Stream Slope*

   ii. *The Concept of Sediment Transport Capacity:* Flowing water expends energy transporting sediment because sediment particles are about three times heavier than water. Therefore flowing water has more energy if it has less sediment.

d. *Existing conditions:*
    i. *Sediment transport rates are high.* We agree with the observation by Patterson and Annandale (2012) that … '*Streams such as these have extremely high sediment transport rates (for example, Reid, et al., 1998 and Greenbaum and Bergman 2006).'*
    ii. *Sediment is transported in suspension as well as bed load.* The evaluation done by Patterson and Annandale was unable to assess the importance of the suspended load in this environment because they did not evaluate conditions when water is flowing. Sediment may travel in suspension at steeper slopes (such as near the mine site) and as bed-load at shallower slopes (such as in Davidson Canyon).

    iii. *Sediment supply rates are high and expected to by higher at the mine site:* Erosion equations such as the Revised Universal Soil Loss Equation (RUSLE; Renard et al, 1991) recognize that slope steepness and higher rainfall depths and intensities erode soils. Watersheds are steep with limited cover, and erosion rates are high even though rainfall may be low (e.g. Langbein and Schumm, 1958). Patterson and Annandale continue to build on the idea that impact of the mine is proportional to the catchment area and cite previous Rosemont Reports (they note that the mine is only 13% of watershed) without looking at the sediment supply potential differences across the watershed. The deep valley fill in the Tucson basin is generated by erosion of sediment off the mountains and depositing in the valley.

    iv. *Natural and man-made grade controls exist on Barrel Creek:* Patterson and Annandale have identified some places where grade controls maintain channel grade under current conditions.

e. *Proposed Conditions:*
    i. *Sediment Supply from the mine site will be nearly eliminated.* With the proposed compliance point dams, the sediment downstream of the compliance point dams will be cut off. In the context of Lane's balance, Qs will go to nearly '0'.

f. *Effect of grade controls when sediment supply is cut off:* There are numerous examples of scour downstream of grade controls that capture sediment. A classic example is the Pantano dam on Cienega Creek, which has 10 feet of scour downstream of the dam. In the context of Lane's balance, when supply is cut off (Qs goes down), scour occurs downstream of the grade control structure. In essence this is because a natural watercourse will attempt to come into equilibrium by increasing Qs on the downstream of the dam.

While Patterson and Annandale contend that grade controls will maintain channel slope under proposed conditions where sediment supply is cut off by the mine site, it defies our observations in this area. Furthermore, we contend that the impact will be great because the current sediment supply and transport rates at the proposed mine site are extremely high.

2.) ***Factor: Reduction in available assimilative capacity***: *Reduction in runoff volume (p.9).*

   a. To reiterate our concerns about the reliance on the FEIS in assessing impacts, the FEIS shows that the Barrel Alternative results in a predicted 17.2% reduction in average annual post closure runoff volume from the watershed. ADEQ failed to assess larger impacts on runoff loss during pre-mining and active mining periods, especially during the first 10 years of active mining. The FEIS (p.424) clearly stated that the impacts during these periods are high (FEIS, p. 424 The maximum loss of runoff to the watershed occurs during the first 10 years of active mining when runoff from these areas is retained onsite and recycled as process water. During this period, the loss of runoff would vary but is likely to approach a reduction in annual average runoff of about 30 to 40 percent, compared with undeveloped baseline conditions (SWCA Environmental Consultants 2013f)). As ADEQ cited, the 17.2% reduction could result in a potential loss of assimilative capacity and potential degradation of water quality. It is not clear why there was no discussion about the larger impacts during pre- and active mining periods.

References Cited

Lane E.W. December 1954. *The importance of fluvial morphology in hydraulic engineering.* Denver, Colorado: US. Department of the Interior Bureau of Reclamation.

Langbein, W. B. and Schumm, S. A., 1958, *Yield of sediment in relation to mean annual precipitation:* Amer. Geophys. Union, Trans., v. 39, p. 1076-1 984.

Patterson, J. and G. Annandale 2012. Technical Memorandum to Chris Garrett, SWCA. Geomorphic Assessment of Barrel Creek. Golder Associates.

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Impacts of Reduced flows and Increased Total Dissolved Solids (TDS) on the Riparian Vegetation of Cienega Creek

The cottonwood/willow forest and wetlands of the Cienega Creek Natural Preserve is keystone feature of the natural environment of eastern Pima County. Unfortunately, gallery forest and wetlands are highly stressed by the current drought conditions (Powell 2013). The shallow groundwater system that these trees rely on will be further stressed by the proposed Rosemont mine, which will reduce the flows to the creek. The quality of the water being lost to the creek is also important to consider. The water is Davidson Canyon is significantly lower in total dissolved solids (TDS) as compared to the water in Cienega Creek. Lower dissolved solids are a key reason for the designation of Davidson Canyon as an Outstanding Waters (Pima Association of Governments 2005). The reduction in the amount of this higher-quality water, along with the added dissolved solids from the mining operation, could have a profound effect on the cottonwood/willow forest of Cienega Creek. This has not been analyzed or acknowledged in the 401 application. This needs to be done in light of the fact that elsewhere in southern and western Arizona, the conversion of gallery cottonwood/willow forests to tamarix-dominated sites is correlated with higher concentrations of dissolved solids and impoundment of and regulation of streams (Vandersande et. al. 2001; Shafroth et. al. 2002; Pataki et. al. 2005; Stromberg et. al. 2007). The withholding of water in the upper reaches of Barrel would constitute stream regulation.

Lack of Analysis on Precipitation Timing, Recharge Rates, and Climate Change

The Rosemont Mine project will impact the amount of water flowing out of Barrel Canyon and into Davidson Canyon and Cienega Creek. Because ADEQ is required to ensure that there is no degradation to the Outstanding Arizona Waters of these sites, it is incumbent on the applicant to address impacts to water quantity. In our comments on the Forest Service's FEIS, Pima County took issue with the amount of water that is predicted to be impacted (i.e., held back) by the mine. For the purposes of the 401 application, it is imperative that the analysis look not just at the amount of water being withheld, but the timing of that impact. This is important because of southern Arizona's bi-modal precipitation pattern and the scientifically established fact that groundwater recharge is influenced by the seasonality of rainfall (Ajami et. al. 2012). The picture is further complicated by climate predictions, which estimate that groundwater recharge rates could be reduced by as much as 27% by the end of this century (Serrat-Capdevila et. al. 2007). There is no analysis of these factors, yet in order to ensure that no degradation of AOW will result from the mine, this analysis is critical. This analysis would at least identify the amount of water that Rosemont Mine needs to contribute to the system to make up for losses resulting from the proposed impoundment and use of water.

Increased Temperature and Lower Dissolved Oxygen

The analysis of the impacts of the Rosemont Mine do not consider two key variables in the water quality: increased water temperature and dissolved oxygen. As has been clearly established, the retention of stormwater that contributes baseflows in Davidson and Cienega Creek will reduce Cienega Creek baseflows. Rosemont has not modeled how this will impact water temperature and dissolved oxygen in Cienega Creek. Pima County believes that surface water temperatures in Cienega Creek will increase as a result of lower flows and less shading canopy as a result of a decline in the number and/or vigor of large cottonwood trees. (The decline in cottonwood trees would reduce evapotranpiration rates and thus result in a reduction in the loss of water from Cienega Creek, but this has not been investigated either.) This is a concern from the perspective of the aquatic species in Cienega Creek and the importance of the high-quality water coming from Davidson Canyon. The amount and quality of Davidson Canyon water on aquatic plants and animals of Cienega Creek was an important factor in

Davidson being designated as an AOW. With the prospect of increased water temperatures, this can lead to lowered dissolved oxygen, which can impact fish populations, especially with loss of canopy structure (Connor et. al. 2003). These issues, including how they will change under climate change scenarios must be addressed before the permit can be issued.

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Review of Isotope Data

ADEQ has decided that "*Lower Davidson Canyon is not hydraulically connected to the regional aquifer that would be impacted by the pit dewatering."* ADEQ's reasoning is flawed.

1. ADEQ has not conducted an independent review of the primary data. ADEQ should request the primary data and conduct its own review. ADEQ should not rely on opinions of others. ADEQ cites the FEIS for its information. The FEIS and ADEQ cite Tetra Tech (2010) for its interpretations. Tetra Tech (2010) in turn presents and interprets isotope and water quality data collected by PAG (2003) and Montgomery and Associates (2009). There is no evidence that ADEQ reviewed the Montgomery and Associates (2009) report, which contains the bulk of the primary data on water quality in the mine vicinity.

2. The FEIS also cites SRK's review of Tetra Tech's interpretation, but SRK did not review the primary data either. The FEIS preparers only reviewed Tetra Tech (2010) interpretation of data collected by others. SRK (2012) relied on Tetra Tech's faulty interpretation that "*wells and springs in the upper reaches in Davidson Canyon have isotopic values indicating winter recharge from precipitation is a significant source of water (Tetra Tech 2010a). Water samples taken for Reach 2 Spring in Lower Davidson Canyon has a geochemical signature that indicates the spring water is primarily influence by summer rain: this suggest that bedrock groundwater is not a significant component of the Reach 2 Spring*."

3. Tetra Tech's interpretation, and hence ADEQ's review, is not supported by the actual isotopic work performed by Montgomery and Associates. ADEQ cites Tetra Tech's opinion as: "*Isotopic signatures of water from these two springs reflect the influence of summer precipitation, in contrast to wells in the regional aquifer which reflect the influence of winter precipitation".* Our review of primary data supports a very different conclusion about wells in the regional aquifer. Please see Table 12, result of Laboratory Analyses for Delta Oxygen-18, Deuterium, and Tritium in Groundwater and Surface Water Samples, Rosemont Area, Pima County, Arizona (Montgomery and Associates, 2009). Oxygen isotopes in wells near the mine site are heterogeneous, varying from -6.9 at RP-8 to -12.4 at RP-4B. Thus it would be incorrect to say that *wells in the regional aquifer reflect the influence of winter precipitation*. In fact, groundwater shows a wide range of of $\delta\ ^{18}0$ values. This review will demonstrate that the values reflect the influence of both winter and summer precipitation.

   This is also shown graphically on Figure 8, Graph of Deuterium Versus Delta Oxygen-18 from Wells, Springs, and Surface Water Locations, April through October 2008, Rosemont Area (Montgomery and Associates, 2009). This figure is reproduced below. Wells are crosses. Note that the well delta oxygen values range from -12 to -7 on the horizontal scale. Note also that range of values for springs (diamonds) occupies nearly the same range, excepting the singular well value at RP-4B, which is a deep well screened in the Apache Canyon Formation.

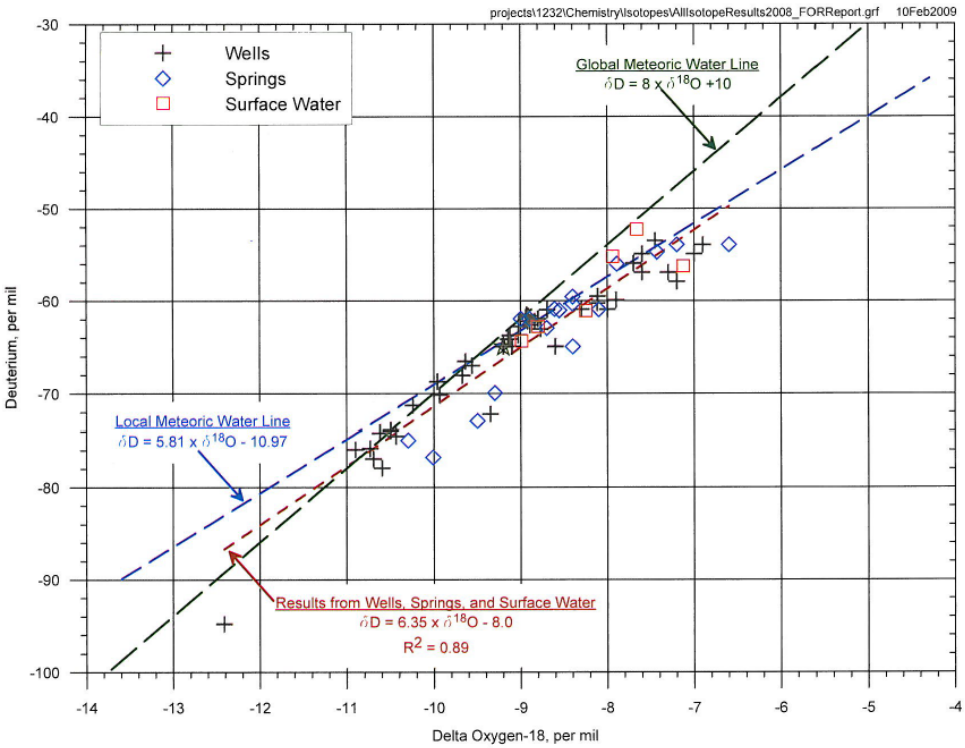

FIGURE 8. GRAPH OF DEUTERIUM VERSUS DELTA OXYGEN-18 FROM WELLS, SPRINGS, AND SURFACE WATER LOCATIONS, APRIL THROUGH OCTOBER 2008, ROSEMONT AREA

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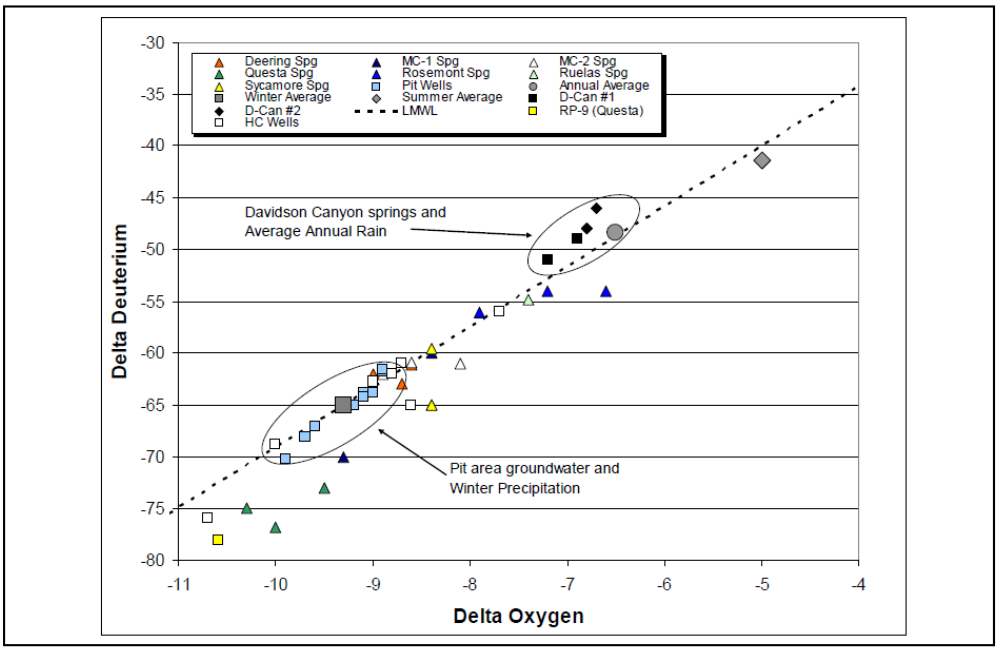
Montgomery Figure 8



Project No: 114-320869

March 2010

Figure 17
Stable isotopes in Rosemont project site ground- and surface water

Tetra Tech Figure 17

Some of these same data are shown on Figure 17 from Tetra Tech (2010), which differentiates the pit area groundwater (primarily PC well series) from other wells and springs in the mine vicinity. While it is true that the pit well data are largely grouped in the lighter oxygen values, many of Montgomery's other well and surface water data plot right along the red line calculated by Montgomery using the entire data set, suggesting that they are from the same population.

4. Referencing Montgomery's Figure 8 again, note that all of the samples, even the PC wells, plotted below the Global Meteoric Water Line. This is not disclosed by Tetra Tech, and in fact the Tetra Tech plot actually obscures this fact by plotting a dashed line that does not represent the Global Meteoric Water Line. It can be seen that the intercept of Tetra Tech's line is much lower than the Global Meteoric Water Line that Montgomery shows. The slope of the local data, and the values of the PC wells considered as a group *both show substantial influence from natural evaporation during precipitation, runoff and / or recharge*, as was noted by Montgomery and Associates in their 2009 report. Tetra Tech did not discuss Montgomery's observation of an evaporative effect, presumably because it is did not fit their preferred interpretation.

5. Tetra Tech's Figure 17 includes a data point representing winter average rainfall. This value is important because it is the principal basis for the inference that the position of the "*pit area groundwater*" on figure 17 means that *winter precipitation* is the source of the groundwater for the PC wells. Tetra Tech says that the winter average value is based on "stable isotope data for local precipitation" by Wagner (2006). Page 124 of Wagner 2006 provided several years of precipitation data from the vicinity of Cave of the Bells, in the Santa Rita mountains farther south. There were too few years in Wagner's sample to define a local meteoric water line (Dr. Chris Eastoe, personal communication).

6. Figure 8 (Montgomery and Associates 2009) also has a local meteoric water line (LMWL) derived from data provided by Dr. Chris Eastoe. In attachment 3, Dr. Eastoe presents a more robust dataset for a LMWL. LMWL's are important because they provide a basis for interpreting sample results.

7. The effects of evaporation on isotopes in rainfail at Palisades Ranger Station (Santa Catalina Mountains) is much less developed than in the lower elevation Tucson data (Attachment 3, Figures 1A and 1B). According to Dr. Eastoe, the Rosemont pit site is at about 1500 masl, and precipitation at the site most likely has stable isotope distributions (ranges, and trends on the delta D vs. delta 18O plot) between those of the Tucson and Palisades stations.

8. Dr. Eastoe plots an evaporation trend based on the Montgomery data on his Figure 1A (Attachment 3). Tetra Tech did not consider any evaporation trends in their interpretation.

9. Tetra Tech's claim that Rosemont groundwater in the PC wells represents winter recharge is not supported by the interpretation that Dr. Eastoe presents in Attachment 3. The observed values would require a mix of summer and winter rains to produce the observed values of delta -9‰ at Rosemont (the origin point of the evaporation trend plotted on Figure 1A of Attachment 3). Only values of delta -11‰, or lighter would correspond with winter precipitation (see Fig. 2, Attachment 3).

10. Tetra Tech omitted well data that did not support their hypothesis. Tetra Tech's Figure 17 omits many of the wells and spring samples that plotted closer to the PAG dataset, but retained the "pit wells" that favored Tetra Tech's interpretation. The omitted samples that plotted closer to the PAG data set included wells RP-4A and RP-3A located in areas under the waste rock and tailings landform, and Rosemont spring, which would also be covered with waste rock and tailings.

11. The major ion chemistry of wells in the Rosemont mine area as documented in Montgomery (2009) reflects multiple water sources. A map which shows major ion chemistry in the form of Stiff diagrams is reproduced without attribution to the authors as Figure 18 in Tetra Tech (2010). The map at Figure 18 shows that the vicinity of the open pit, the groundwater is calcium bicarbonate, consistent with TetraTech's interpretation (2010). There is another type of water, dominated by CaSO4 and having much higher TDS than most other wells, associated with Pit Characterization wells PC-3, PC-7, PC-6, and wells RP-7, and P-899. Thus, on the basis of major ion chemistry, water chemistry even in the pit area is seen to vary considerably.

    Note also that the east of the pit, the groundwater is mix of calcium bicarbonate, sodium bicarbonate, and calcium sulfate type waters (Montgomery and Associates 2009). There is also a zone of Na-rich bicarbonate waters that runs NE along the axis of Barrel Canyon from HC2B NE through HV-1 and the RP-2 series.

12. Turning now to the Davidson surface flows, Tetra Tech fails to plot or discuss the sample results shown on Montgomery's Table 12 for lower Davidson Canyon Wash**. This sample has a $\delta^{18}0$ value equal to -9**. This is similar to the pit wells and the so-called winter precipitation. Thus, Tetra Tech's interpretation regarding the character of Davidson spring **is not supported by the only sample which was contemporaneous with the well data to which it is compared.** No explanation is offered in the Tetra Tech report for this omission.

13. While ignoring contemporaneous Montgomery data that does not support their hypothesis, Tetra Tech included PAG 2003 data for Davidson. Below I have plotted the PAG data by hand on Montgomery's graph above for convenience. The line defined PAG's 2003 Davidson samples plots is within the trend line defined by Rosemont area groundwater. It does not plot below the trend line, with a flatter slope, which is what you would expect if the Davidson discharges were "local springs".

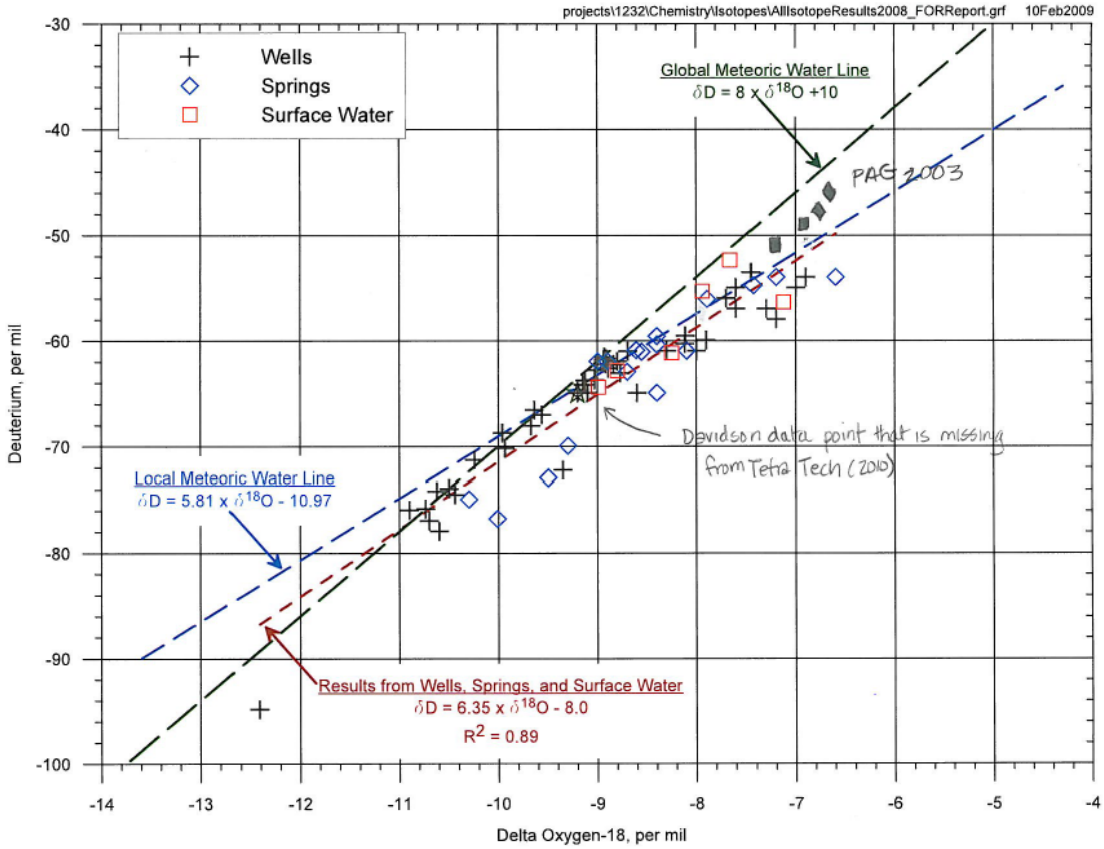


FIGURE 8. GRAPH OF DEUTERIUM VERSUS DELTA OXYGEN-18 FROM WELLS, SPRINGS, AND SURFACE WATER LOCATIONS, APRIL THROUGH OCTOBER 2008, ROSEMONT AREA

PAG 2003 DATA PLOTTED BY HAND

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14. Tetra Tech's interpretation ignored variability in dates for Davidson surface water samples they do include. The PAG isotope data were collected at a different time, June 2002 and May 2003 from Montgomery's Davidson Canyon sample Tetra Tech makes no explanation regarding sources of variability between PAG and Montgomery data, because they omitted the Montgomery data.

15. Even PAG (2003) noted that "*the stable isotope data for Davidson Canyon base flows varied markedly between the Davidson #1 and Davidson #2 sample points. Davidson #1 is farther upstream and reflects a higher-elevation water source than Davidson #2.*"

16. Montgomery collected their surface water sample in October 2008 at a location close to the confluence of Cienega Creek, near PAG's Davidson #2 site. This downstream site and collection date showed evidence for a mix of high elevation and low elevation runoff by virtue of its position within the trend line defined in red by the rest of the Rosemont data set. This can be seen by the position of the Davidson data point relative to other Rosemont area wells on the annotated graph above. The penciled arrow indicates the position of the 2008 Davidson sample, which plots in a very different location than the PAG values for Davidson samples, but solidly along the same trend.

17. During the term of PAG's study, Cienega Creek had consistently lighter delta 018 values than either of the two Davidson Canyon sites. During the term of Montgomery's study, Davidson had higher delta 018 values than either upper or lower Cienega Creek. Montgomery's data for Cienega Creek is not plotted, nor discussed by Tetra Tech. We can expect there to be year-to-year variation in values observed in spring flows, but Tetra Tech's interpretation obscures this phenomenon.

18. ADEQ's proposition that "*Lower Davidson Canyon is not hydraulically connected to the regional aquifer that would be impacted by the pit dewatering"* fails to address many of the direct and indirect effects of the dredge and fill activities related to the 404 permit. Pit dewatering is only one mine-related activity to be considered in making a determination regarding impacts upon Davidson Canyon water availability. Another significant impact is the alteration of transmission losses and thus recharge processes through the diversion, capture and impoundment of surface flows. ADEQ has not considered this in their basis for the anti-degradation finding. Another is the clearing and grubbing of soil above the bedrock—how will that affect transmission losses and recharge? How will recharge be affected by filling of entire valleys with waste rock and tailings? Given that these activities are directly related to the Section 404 permit, it is imperative that ADEQ consider the effects of these activities on infiltration losses. Another issue is how changes in the groundwater gradients induced by the pit lake (as opposed to *pit dewatering*) over time may alter the direction of underflow toward Davidson Canyon.

19. Pit dewatering strategies have changed since Tetra Tech (2010) and the FEIS failed to recognize this. New data show that pit dewatering can not be accomplished with wells. Rosemont will have to install costly drains in the Willow Canyon and basin fill in order to dig the pit. *" CNI recommends groundwater modeling to determine the anticipated horizontal drain spacing for dewatering approximately 100 to 200 feet behind the slope face. Because of the low conductivity values, a relatively tight spacing will be required resulting in a high cost to depressurize the [south] slope…..Because of the low hydraulic conductivities determined from pump tests mentioned previously, CNI did not consider a reduction in the phreatic surface level with the use of depressurization from vertical pumping wells."* Nicholas, Standridge and Pratt, 20 July 2012, p.3.

In conclusion, ADEQ erred by not conducting an independent review of the primary data sets, instead relying on the interpretations of others. Tetra Tech cherry-picked data to support their conclusion, ignored complexity, and over-extended the information to the regional aquifer. The isotopic data support an interpretation that there are multiple sources of recharge in the mine vicinity, and these occur at different elevations. ADEQ cannot conclude on the basis of the isotope data that construction of the mine will not interfere with one or more of these recharge locations and mechanisms. ADEQ also failed to consider effects on recharge, other than pit dewatering. ADEQ basis also relied on Tetra Tech's evaluation of the old mine design to draw its conclusions. Finally, pit dewatering will occur by means that have not been evaluated by either Tetra Tech (2010) or ADEQ.

ADEQ should request the primary data sources and evaluate effects of discharge of dredging the waters of the US of their native soil and filling the Waters of the US. These dredge and fill activities will affect recharge processes that result from mountain front and stream-bed infiltration processes at a variety of locations. ADEQ should rely on the same dataset as the Corps; in order to do that, ADEQ must request

additional information from the applicant, because the applicant has provided incomplete and outdated information to ADEQ, as indicated in our previous letter of comment about this certification.

References

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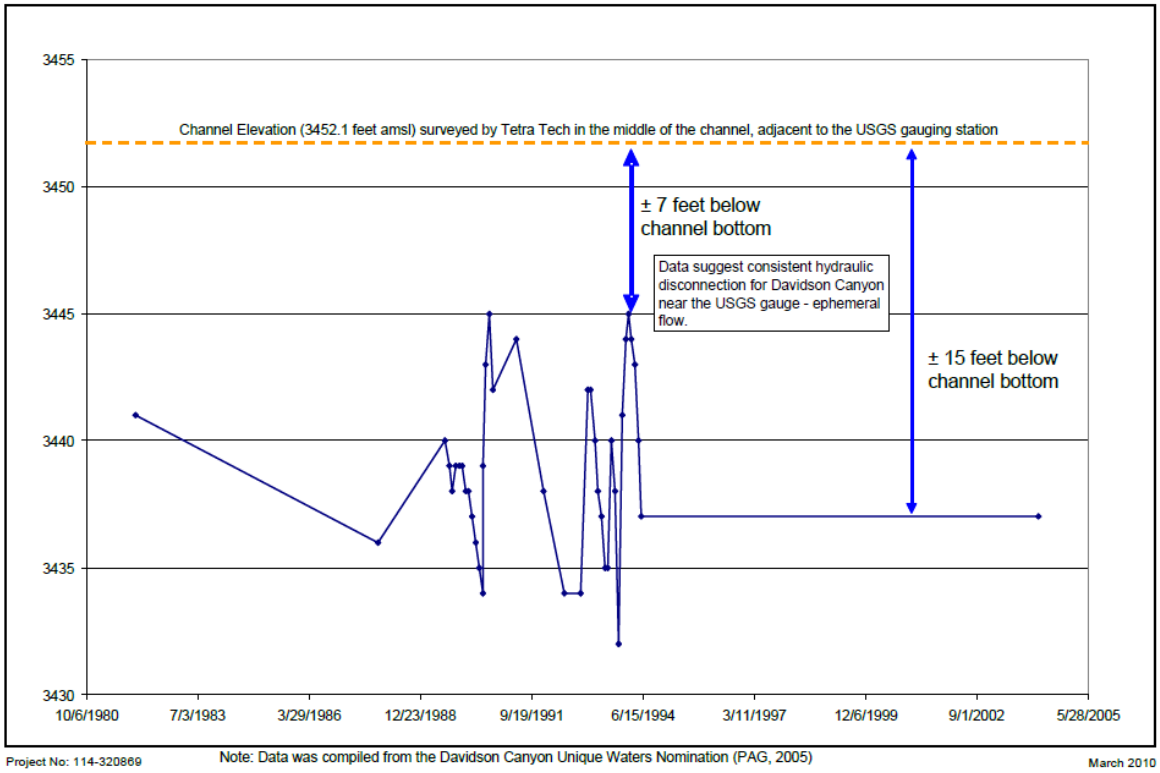
Review of Assumptions regarding Regional vs Local Springs

On page 12, ADEQ's basis also relies on Tetra Tech's 2010 report that concludes that springs along Davidson Canyon are not likely connected to the regional aquifer because they have gone dry during the past few years, "*rather than being supported by perennial flow, as would be expected from a regional groundwater source (FEIS page 535)*."

It is not logical to assume that springs connected with the regional water table would not decline during times of drought or lack of recharge. Although perennial springs are likely to be fed by regional aquifer, it does not follow that a non-perennial spring is NOT related to the regional aquifer. In some areas, groundwater observations indicate that there have been declines in the regional aquifer, therefore cessation of flow at a nearby spring WOULD BE CONSISTENT with a connection to a regional aquifer.

With respect to Davidson Canyon, Tetra Tech presents PAG well observations at a well located near the OAW reach:



Project No: 114-320869 Note: Data was compiled from the Davidson Canyon Unique Waters Nomination (PAG, 2005) March 2010

Figure 5
Pima County Well Hydrograph

Tetra Tech misrepresents the PAG (2005) data by plotting a line connecting individual observations separated by years. Tetra Tech further misrepresents the data by adding a text box on the graph interpreting the time between 1994 and 2005 as data suggesting a hydraulic disconnection, when it actually represents a data gap in the cited report (PAG 2005).

During the data gap shown on Figure 5 (1994-2005), Pima County obtained observations of flow and absence of flow from Sky Island Alliance. The observations were made at locations of animals tracks observed in the Davidson Canyon stream bed from the Interstate 10 bridge to 1.5 miles south. This reach includes Davidson adjacent to the County well mentioned above. During 2002-2005, there was either damp soil, running water, or standing water on 12 of 26 (46%) of the Sky Island sampling occasions. These observations were made during the 2002-2006 drought.

Damp	6
Dry	14
Running Water	3
Standing water	3

The well is located downstream and outside reach 2. Observations of groundwater levels at the well do not represent conditions at the reach 2 spring. The 2005 PAG report identifies several reaches of Davidson Canyon as having perennial and intermittent flow based on PAG observations, independent of the Sky Island Alliance data.

Seepage to Waters of the US and Seepage Monitoring

Page 5 and 6 of ADEQ's Basis refers to the potential for seepage from the waste rock and tailings piles to Waters of US. Pima County and Pima County Regional Flood Control District have objected to the inadequacy of the EIS with respect to seepage and seepage monitoring. The Forest Service is the process of reviewing objections. One objection is that the FEIS modeling of waste rock seepage is faulty. Another objection is that FEIS ignores the high probability of preferential seepage flow in the tailings and waste rock piles. A third objection is that the FEIS waste rock seepage monitoring plan will not result in adequate seepage impact evaluation .

<u>Objection: The modeling of waste rock seepage is faulty.</u>

The EIS must justify the parameters used and complete a sensitivity analysis of the parameters to demonstrate that the results of the seepage modeling are feasible; this is especially needed since there is no data to calibrate to. They must also justify ignoring preferential flow paths through the waste rock. The mine facility seepage analysis predicts there will be essentially no seepage through waste rock facilities, a result that is simply not feasible. The modeling used parameters in which the conductivity for relatively dry rock is six orders of magnitude less than when saturated. These parameters would allow a wetting front to move through unsaturated waste rock only very slowly; even most of a large event would be stored in the top few feet. After the storm ends, the close proximity of most of the seepage to the ground surface would allow the water to be evaporated away because evaporation would quickly establish an upward matric potential gradient.

The EIS repeats this error, which affects the quality of the organic constituent analyses. It does not seem reasonable that infiltration from waste rock be close to zero because natural recharge in this area is not zero. Blasted waste rock is almost certainly more conductive than the in-situ rock. It is also unlikely that the onefoot thick cover will result in less infiltration than the natural soil and vegetation regime.

Similarly, it is not reasonable for the seepage through a leach pad to cease. Leach pads are designed to conduct flow. All water that gets through the cover will become seepage. Based on experience, the long-term seepage through heaps in more arid climates in Nevada do not approach rates as experience has shown that waste rock dumps in much drier climates will have seepage.

These three comments refer to the estimates of infiltration through waste rock, which have been estimated to be near zero. These comments had been made without reviewing the waste rock seepage study.

The modeling is effectively water balance modeling among layers in the facility, with [f]low between layers controlled by unsaturated flow equations, or saturated in areas where saturation occurs. Unsaturated flow modeling solves the equations of soil physics, most specifically the flow equation relating the matric potential gradient to the conductivity,

which varies as a function of matric potential. Unsaturated flow is toward the lower matric potential which occurs at the point where the media is drier, all other conditions being equal. When saturated the equation becomes Darcy's law and the matric potential gradient becomes the head gradient. Matric potential becomes negative as soil dries, so during dry conditions water from depth can be drawn to the surface and evaporated in a process known as exfiltration.

Tetra Tech utilized a two-dimensional variably saturated flow model, VADOSE/W, for this simulation (Tetra Tech 2010c, p. 20). The code solves the flow equations using a finite element routine. Two-dimensional means flow in a vertical cross section. Tetra Tech emphasizes that it "can simulate heterogeneous material, and can account for changes in material conditions due to compaction and underlying alluvial and/or bedrock formations" (Id.). This simply means that different model elements may be defined by different material property parameters and that those parameters can represent any material including compacted waste rock. The modeling presented in this Tetra Tech study is strictly based on conceptual flow models for the various materials because there are no data to which to calibrate. Material parameters depend on textbook or smallscale test values. The predicted values are not verified in any way to previously observed data.

The model simulates precipitation and evaporation, using various sequences of climate data for the simulations. Climate data provides the daily precipitation, temperature, wind speed, and evaporation. Using data from the Nogales site (Tetra Tech 2010c, p. 21) is not unreasonable, but the scenario using average daily values is not representative. TT states that the average conditions "dataset has small amounts of precipitation everyday because of the averaging of many years of data" (Id.) and call this "conservative". In a response to a review memorandum, TT (2011) responded that "[t]he average conditions dataset, as noted in previous memos, has precipitation nearly every day of the year. This is not likely to occur in Arizona, but would be a worst case scenario. Water is more likely to readily infiltrate into a facility if the upper surface is wet, so considering a climate conditions with a small amount of precipitation each day would produce such a condition and provide a result of the worst case infiltration" (TT, 2011, p. 2, emphasis added). Tetra Tech apparently considers this to be conservative, but the evaporation likely exceeds precipitation most days so there would rarely be an excess of precipitation to infiltrate. Even during winter, average precipitation may exceed the average evaporation by only a small amount, but the model would accumulate moisture in the top layers. This modeled soil moisture may just be stored and later evaporated as conditions warm and dry in the spring. Infiltration through the surface zone would occur when moist antecedent conditions precede a large daily rainfall; this type of situation which would result in seepage has been ignored in the Tetra Tech study. This is not uncommon during late winter or spring snow melt and subsequent spring showers.

The mine development periods and reclamation scenarios simulated are reasonable (TT, p. 22). Whether the parameters used for the scenarios were proper remains a question.

Tetra Tech discusses steady state modeling as a means of determining starting moisture concentrations for the transient simulations (Tetra Tech 2010c, p 37). In a system that should be event driven, steady state should never be approached, much less achieved.

The assumed parameters for the waste rock control the seepage through the waste rock facilities. The so-called permeability reported by Tetra Tech is actually saturated hydraulic conductivity (K). The values are very high, but the unsaturated values decrease very rapidly.

The figures showing the relationship of conductivity with matric suction and moisture with matric suction are poorly labeled. For example, Illustration 5.6 shows the relations for run-of-mine (ROM) rock, with saturated K equal to 174 ft/hr; the matric suction on the conductivity graph does not obviously match the axis for the moisture content, and does not have labels. Even the conductivity axis does not have labels for ROM rock.

Considering Ill 5.7 for semi-consolidated rock, the conductivity decreases over five orders of magnitude from saturated to dry (moisture 0.4 to 0.05). At the beginning of a storm with dry antecedent conditions, infiltrating precipitation increases the moisture content which increases the effective conductivity. As noted, the parameters for the surface ROM layer are hard to read, but dry (moisture about 0.16), the conductivity is significantly less than 174 ft/hr. Assuming no runoff, the ROM would rapidly saturate at a wetting front. Because of the low conductivity the wetting front would advance very slowly with conditions above the front being saturated. This means that significant amounts of ROM above a wetting front would be saturated. According to Ill 5.6, the difference between saturated and dry moisture content is the difference between 0.27 and 0.18, or about 0.09. Using these numbers, a three-inch infiltration event would be completely stored in just 33 inches of initially dry ROM, based on the available porosity between 0.18 and 0.27 being 0.09. The modeling assumes that it completely fills. Once the infiltration event ends, water would continue to seep downward, drawn by gravity and a negative matric potential. However, evaporation would begin at the upper end and, as the surface soil dries, a negative matric potential would develop on the surface and begin to counter the downward movement of the stored water.

The example just given allows the soil above the wetting front to become saturated because of the large difference in effective conductivity at the wetting front, which keeps the water close enough to the ground surface for evaporation to begin to quickly remove the water after the precipitation event ends. During summer, when the larger short duration events are most likely, the daily potential evaporation is as much as half an inch per day which means that most of the precipitation stored in upper layers of the waste rock would quickly evaporate; it is clear why the modeling does not simulate deeper seepage of water.

The figures showing water content through a model cross-section are clear (Ill 5.15 and 5.16). Near the surface, the moisture content is about 0.1 which increases initially with depth to about 0.14 but then decreases to 0.04 in the consolidated zone. This moisture content is less than the lowest moisture content presented in Illustration 5.8 for consolidated material, so the accuracy of the data is questionable. Clearly the effective conductivity at that moisture is 10-7 ft/hr (2.4x10-6 ft/d), an almost negligible conductivity.

The effective gradient due to high negative matric potential may be significantly higher than 1. Even at 1000, the water would move only about 2.4x10-3 feet in a day. These numbers should make clear why the model does not simulate seepage through the waste rock. The small amount of moisture below the unconsolidated ROM can be simulated to move only very slowly. These numbers suggest that increasing the moisture available significantly would not result in substantial differences in moisture content at depth, meaning that whether the model considers runoff accumulating at a location is irrelevant.

Many of the water balance figures, such as Illustrations 5.12 and 5.14, show precipitation entering the system and evaporation leaving the system; because the evaporation exceeds the precipitation, water leaves storage so that the moisture content decreases. These figures present a year's results, but

presumably the waste rock would just become drier with time and evaporation would have to approach precipitation as stored water available to evaporate would dissipate. The figures also demonstrate that the model simulate almost no runoff.

The modeling does not account for preferential flow which can allow flow to move quickly through the piled waste rock. A preferential flow path in a waste rock dump is a pathway of larger pore spaces through which groundwater flow tends to funnel; it is similar to flow through fractures in in-situ bedrock. By ignoring preferential flow, the model underestimates seepage through any of the mine components, although waste rock would likely be most heterogeneous.

Tetra Tech's mention of preferential flow (TT, p. 20) refers to the fact that hydraulic conductivity for unsaturated flow varies with moisture content; different materials are preferentially more conductive at different moisture contents. More flow occurs through clay at low matric potential than through coarser sand because the sand is actually drier. The curves in TT Figure 5.5 may apply in a given facility but they would not apply at the same point (due to differing soil types at each point) so the flow cannot transition from on to the other.

The FEIS reports results from modeling seepage through waste rock dumps that are unreasonably low. This is because the modeler used unrealistic unsaturated parameters and used climate data from the wrong location.

The FEIS responded to comments by having Rosemont consider additional scenarios. The scenarios had to do with the length of simulation but with inappropriate climate values the antecedent conditions were never wet enough to allow additional seepage beyond the surface. The FEIS did not amend or address the fact that the precipitation data was wrong and the ET data was from Tucson. The presence of seepage through waste rock all over the country including in areas much drier than Rosemont demonstrates that seepage can occur.

The FEIS also does not respond to the comment about the wrong hydraulic parameters for the soil – specifically that the unsaturated conductivity was incredibly low which prevented any water entry to the waste. The FEIS did not address these problems or have Rosemont test the sensitivity of the waste rock parameters in their model

Conclusion and Recommendations

- **The EIS must present data justifying the conductivity parameters.** It is not reasonable for ROM rock with saturated K = 170 ft/hr to only allow seepage to move a few feet before being removed by exfiltration.
- **The study should be redone to include a sensitivity analysis.**

If the conductivity for high matric potential rock is set higher and there is still no seepage, then the EIS may be able to conclude there is no seepage. Otherwise, the results of this seepage study are simply uncalibrated estimates based on very unrealistic parameters.

<u>Objection: The FEIS ignores the high probability of preferential seepage flow in the tailings and waste rock piles</u>

The DEIS must justify the parameters used and complete a sensitivity analysis of the parameters to

demonstrate that the results of the seepage modeling are feasible; this is especially needed since there is no data to calibrate to. They must also justify ignoring preferential flow paths through the waste rock. The mine facility seepage analysis predicts there will be essentially no seepage through waste rock facilities, a result that is simply not feasible. The modeling used parameters in which the conductivity for relatively dry rock is six orders of magnitude less than when saturated. These parameters would allow a wetting front to move through unsaturated waste rock only very slowly; even most of a large event would be stored in the top few feet. After the storm ends, the close proximity of most of the seepage to the ground surface would allow the water to be evaporated away because evaporation would quickly establish an upward matric potential gradient.

The modeling does not account for preferential flow which can allow flow to move quickly through the piled waste rock. A preferential flow path in a waste rock dump is a pathway of larger pore spaces through which groundwater flow tends to funnel; it is similar to flow through fractures in in-situ bedrock. By ignoring preferential flow, the model underestimates seepage through any of the mine components, although waste rock would likely be most heterogeneous.

> Tetra Tech's mention of preferential flow (TT, p. 20) refers to the fact that hydraulic conductivity for unsaturated flow varies with moisture content; different materials are preferentially more conductive at different moisture contents. More flow occurs through clay at low matric potential than through coarser sand because the sand is actually drier. The curves in TT Figure 5.5 may apply in a given facility but they would not apply at the same point (due to differing soil types at each point) so the flow cannot transition from on to the other.
>
> FEIS claims that seepage would not be concentrated but would rather be spread across the entire area of the facility. The FS rejects good science and observations at literally every waste rock seep showing that seepage discharges from a point, not spread around the base of the facility.
>
> Preferential flow would cause seepage through waste rock (and tails) to reach the ground surface at concentrated locations rather than spread over the entire area of the facility. This is unaccounted for in the modeling and the FEIS in general. Because preferential flow has the potential to significantly impact downstream waters and habitats, the models should be re-run to account for this phenomenon.

<u>Objection: The FEIS waste rock seepage monitoring plan will not result in adequate seepage impact evaluation .</u>

The monitoring plan calls for two points to be monitored for moisture content. The waste rock dumps cover a large area, but the FEIS suggests there will be no seepage. Objection 7 deals with the high probability of preferential flow in the piles, which means that actual seepage will likely be concentrated. The mitigation plan in the FEIS calls for monitoring seepage in just two locations. Because preferential flowpaths could develop almost anywhere, there is little chance that the proposed monitoring will actually detect seepage if it occurs.

ADEQ's Basis states that "should the seepage reach surface waters, an individual AZPDES permit would be required and discharges would have to meet the appropriate surface water quality standards individual antidegradation." However, neither ADEQ nor Forest Service have provided for monitoring to

detect seepage that has reached surface waters, except if the seepage reaches the compliance point dams. ADEQ should require detection and reporting of any inadevertently created surface water features created in and around the mine site upstream of the Barrel Canyon compliance dam. Detections should trigger monitoring to assure that any unplanned water bodies are meeting state water quality standards.

Attachment 1

Objections Related to Stormwater Management

Throughout the EIS process, the County has commented on the issue of stormwater management at the Rosemont site and the impacts of the proposed management methods on downstream waters, both above-ground and below. The County continues to believe that the impacts on those waters will be substantially greater than predicted in the FEIS.

Comments filed by the County include:

a. The reduction of flows to downstream during the first 10 years of operations will put the offsite riparian areas at risk. County PAFEIS comments, p. 68.

b. Cumulative impacts of the reduction of storm flows downstream of the project site have not been evaluated. The FEIS focuses on the changes in either annual runoff or storm peak flow but ignored the cumulative impacts over the 20 years active mining life. Long-term, cumulative impacts of the reduction of flow from the project site on Davidson Canyon and Cienega Creek need to be evaluated. County PAFEIS comments, p. 73.

c. The impacts of mining activities on sediment transport could change over time during the active mine life and after the closure. The FEIS reported that the reach of Davidson Canyon is currently a sediment transport-limited system. However, with a reduction in sediment load from the project area over time, it is possible that loose sediment is washed out and as a result the sediment transport system could be changed. The changes in sediment balance could affect the fluvial geomorphology of the Davidson Canyon and Cienega Creek. Appropriate sediment transport analysis is necessary to estimate long-term impacts of mining activities on channel geomorphology, vegetation and fluvial system of the "Potential Waters of the United States". Cumulative impacts of possible changes in sediment transport system on "Potential Waters of the United States" over time should be disclosed. County PAFEIS comments, p. 78.

d. The FEIS acknowledged that there will be a reduction in sediment yield from Barrel Canyon watershed but no change in the geomorphology of the channel is expected. The FEIS only discusses about annual average sediment delivery. The FEIS did not consider cumulative impacts of sediment delivery change over the active mine period and post-closure. Considering the proposed active mine life is over 20 years, the FEIS should assess long term impacts on sediment yield, delivery and channel geomorphology. County PAFEIS comments, p. 79.

e. The FEIS acknowledges that the modification of stormwater peak flows and volume is important in multiple aspects. However, the FEIS does not include any plans to address possible issues resulting from the modification of storm flow. For example, what would happen if the reduction of runoff volume significantly affects Davidson Canyon and Cienega Creek? The FEIS lacks a "backup" plan. Please explain what actions would be taken when problems are identified. County AFEIS comments, p.72.

f. The FEIS acknowledges that some water sources would be impacted (p.31, L.30). However, the FEIS did not clearly explain who would be responsible of addressing issues. Please cite a responsible party to address potential issues, threat to health and natural resources and explain how to address issues when identified. County PAFEIS comments, p.73.

g. How will the monitoring data be used? What would happen if the monitoring data shows problems? The FIES should explain what actions would be taken when a problem arises. County PAFEIS comments, p. 73.

h. What action would be taken if monitoring data shows the impacts to surface water quality in the Davidson Canyon during active period and post-closure? County PAFEIS comments, p. 79.

i. How long will the Rosemont Copper fund USGS to monitor the flow after the closure? The monitoring should continue after the closure to assess the mitigation effectiveness. County PAFEIS comments, p. 73.

j. The analysis of downstream water volume effects on Davidson Canyon and Cienega Creek is flawed, because *Predicting Regulatory (100-yr) Hydrology and Average Annual Runoff Downstream of the Rosemont Copper Project* (Zeller, 2011a) ignores the fact that greater rainfall occurs higher on the high elevations like the mine site, and will contribute more water to downstream areas than low elevation watersheds. By assuming that all areas contribute runoff equally underestimates the impact the mine site will have on surface water and riparian habitat in Davidson Canyon and Cienega Creek. Therefore, Rosemont should revise the analysis to more accurately reflect the effect the differences in rainfall depths on downstream runoff and its impact on riparian habitat. County PAFEIS comments, p. 68.

k. The recognition that fires occur in the project area, that the largest burn areas have occurred since 2005 and that fires can dramatically impact the hydrologic regime should include a plan to address these concerns. There is no acknowledgment of associated hazards which occur in post-fire conditions including gullying/erosion and debris flows which could impact drainage infrastructure both during operations and post closure. There are many examples of gullying and post fire debris flows, including the Schultz fire that occurred near Flagstaff in 2010. Therefore, PAEIS does not offer a plan to address a likely hazard to occur in the project area during the operations and post-closure of the mine (i.e. fire and the associated flooding and debris flow hazard) and it should. County PAFEIS comments, p. 68.

l. *The method used to estimate erosion is not appropriate to evaluate the impact of mining alternatives and is far below industry standards.* While Rosemont's consultant, Tetra Tech, has justified their use of the PSIAC method (Tetra Tech, August 18, 2011, comment 2), the two studies cited by Tetra Tech (Rasely, 1991; Renard *and Stone* 1982 [Tetra-Tech neglected to mention the co-author Stone]), clearly state that the PSIAC method is inappropriate for site level assessment. County PAFEIS comments, p. 80.

m. The PAEIS erroneously states that Pima County recommends the PC-Hydro model for determining peak flows. Instead, RFCD Tech Policy 015 describes which hydrologic model should be used in different situations, and Tech Policy 018 describes how these models should be applied. County PAFEIS comments, p 67.

n. Because of the need to reassess the hydrologic information provided in the DEIS, a Supplemented Environmental Impact Statement (SEIS) should be provided that includes the following studies:

1.) *Evaluation of the impact of mine on habitat in Davidson Canyon – An Outstanding Water of the State of Arizona.* Because the DEIS describes an approach that captures rainfall on the mine site, and limits downstream discharge, the impact of this approach on downstream resources should be evaluated, especially in light of the fact that Davidson Canyon is an Outstanding Water of the State of Arizona.

2.) *Hydrologic evaluation that uses 'critical' storms and approved hydrologic methods to design structures for peak flow rates.* Design should adopt the FEMA criteria for flood peak determination rather than use 24-hr storms. In Pima County, these are peak from

Intensity-Duration curves, such as used in PC Hydro, and shorter duration high intensity rainfall events, such as 3-hr storms.

3.) *Hydrologic values that consider longer-term storm durations (1-week) for volume design.* Because recent events have shown that rainfall over several days can cause flooding and overwhelm ponds, a more critical (and conservative) evaluation of the hydrology used to design volume control is required.

County DEIS comment, No. 386.

o. Hydrologic evaluation that uses 'critical' storms and approved hydrologic methods to design structures for peak flow rates. Design should adopt the FEMA Criteria for flood peak determination rather than use 24-hr storms. In Pima County, these are peak from Intensity-Duration curves, such as used in PC Hydro, and shorter duration high intensity rainfall events, such as 3-hr storms. County DEIS comment, No. 63.

p. The Forest recognizes the ephemeral stormwater flow from the project area would change, primarily as a result of the retention of water at the project site. Although the FEIS acknowledged that several cooperating agencies expressed concerns of the amount of water removed and a resulting serious impact to downstream riparian resources, the FEIS did not evaluate how the water removal could impact downstream riparian resources over time (pre-mining, active mining and postclosure periods). Please disclose cumulative impacts of the reduction of storm water to riparian vegetation, channel geomorphology and groundwater drawdown. County PAFEIS comment, p. 71.

<u>Objection 1. Impacts on outstanding Arizona Waters for all mining life phases (especially first 10 years) not disclosed.</u>

The FEIS states that "the only potential effect on the Outstanding Arizona Waters in Lower Davidson Canyon and Lower Cienega Creek would be the result of a decrease in runoff that would occur because portions of the Davidson Canyon watershed would be cut off in perpetuity by the mine site. This reduction in ephemeral flow is estimated to be 4.3 to 11.5 percent in lower Davidson Canyon." In comment reference "a", above, the County points out that these flow reductions will put the riparian habitat at risk. However, the FEIS never discusses the resulting impacts. It focuses only on the "post-closure" conditions. As mentioned above, during first 10 years active mining phases, estimated runoff reduction from Barrel Canyon is significant. FEIS should disclose the impacts on Outstanding Arizona Waters for different phases by using estimated runoff during that period. Failure to disclose and analyze these impacts is contrary to the Forest Service's charge under NEPA.

<u>Objection 2. Cumulative impacts on downstream riparian and water resources, Davidson Canyon, and Cienega Creek not fully disclosed.</u>

As pointed out in comment reference "b", above, the FEIS fails to assess cumulative impacts of the runoff reduction (it focuses only on the post-closure condition) on downstream riparian and water resources and Outstanding Arizona Waters. These impacts are not fully analyzed in "Cumulative Effects" section in the FEIS. The FEIS should assess cumulative impacts of runoff reductions from the active mining period to the post-closure. Failure to disclose and analyze these impacts is contrary to the Forest Service's charge under NEPA.

Objection 3. Long-term impacts of reduction of sediment yield have not been fully disclosed.

The FEIS does not address the two comments referenced in “c” and “d”, above. The impacts of mining activities on sediment transport could change over time during the active mine life and after the closure. The FEIS's statement of "As a whole, these changes are unlikely to be significant when assessed in the context of the watershed as a whole." is not reasonable without long-term analysis for all phases of mining life. Long-term and cumulative impacts of the reduction of sediment yield on Arizona Outstanding Waters should be analyzed. Failure to disclose and analyze these impacts is contrary to the Forest Service’s charge under NEPA.

Objection 4. There is no explanation about possible actions to be taken to restore damages of downstream water and riparian resources.

There is no question that the Rosemont mine will impact downstream and riparian resources. However, as pointed out in referenced comments “e”, “f”, “g”, and “h”, above, the FEIS and draft ROD lack any discussion of what step will be taken to address these impacts when they become apparent. The FEIS should identify contingency mitigation steps for likely impacts and the ROD should include obligations to implement the mitigation measures when impacts become apparent.

Objection 5. Unclear description of the storm water monitoring plan.

As pointed out in referenced comment “i”, above, there must be a plan for post-closure monitoring to ensure that mitigation efforts are effective. The FEIS and draft ROD fail to fully explain how this monitoring will be funded. It is critical that post-closure monitoring occurs and that the responsible funding source be identified in the ROD.

Objection 6. The FEIS underestimates the reduction of Surface Water and Impacts to Outstanding Waters of the State of Arizona

Referenced comment “j”, above, identifies flaws in the methods of estimating impacts to Surface Water and Impacts to Outstanding Waters of the State of Arizona. Appropriate runoff volume calculation is important. The potential reduction of average annual runoff losses for Davidson Canyon are calculated based on the reduction of area only, but we know that runoff is derived from rainfall and more rain occurs at higher altitudes, such as the mine site.

The analysis of downstream water volume effects on Davidson Canyon and Cienega Creek is flawed, because *Predicting Regulatory (100-yr) Hydrology and Average Annual Runoff Downstream of the Rosemont Copper Project* (Zeller, 2011a) ignores the fact that greater rainfall occurs higher on the high elevations like the mine site, and will contribute more water to downstream areas than low elevation watersheds.

This indicates that the impacts on Outstanding Arizona Waters are underestimated. Reduction of annual post-closure runoff volume will be larger. The FEIS fails to properly address the County’s flow estimates and, as a result, fails to fully identify the significant environmental impacts and potential mitigation steps, as required by NEPA regulations.

Objection 7.The FEIS does not consider risk from the likelihood of post-fire sediment impacts.

Comment reference “k”, above, points out that the mine area has a significant potential for fire impacts. A fire could substantially impact stormwater management systems related to the mine and cause them to fail. The FEIS fails, despite the County comment, to adequately consider fire impacts on stormwater

flows and quality and potential steps to mitigate those impacts. This failure is contrary to the NEPA obligation to identify significant environmental impacts and means to mitigate those impacts.

Objection 8. The method used to estimate erosion is not appropriate to evaluate the impact of mining alternatives (as determined by the developers of the methods themselves) and is far below industry standards.

In referenced comment “l”, above, the County explained that the erosion estimating model, the PSIAC method, is inappropriate for use in scenarios like the Rosemont. This viewpoint is consistent with prior statements by the models’ author. Despite this knowledge that the model developer does not recommend the model for this purpose, the model continues to be a basis for the FEIS analysis of erosion impacts. Use of inappropriate models is arbitrary and capricious.

Objection 9. The Hydrologic Analysis is Inadequate and the Report Misrepresents the Hydrologic Analysis performed

Pima County clearly stated that the consultant should consider the results of a 3-hr storm (comment reference “n”), which was never done, and the FEIS implies that Pima County's concerns were addressed in the analysis they did, while they were not. In referenced comment “m”, above, Pima County reiterated that the consultant erroneously stated that Pima County recommends the PC Hydro model for determining peak flows, and stated that Pima County has technical policies 15 and 18 that describe which models should be used for which application.

The FEIS inaccurately states that the methods presented in the 'Golder Model (p. 402)' (assumed to be Baxter and Patterson, 2012) follows the methods 'prescribed' by Pima County in the 01-12-12 comment letter. Referenced comment “o”, above, specifically states that modeling should consider 'shorter duration high intensity rainfall events, such as 3-hr storms.' These were not included in any analysis we have seen supporting the surface water evaluation. Use of improper data and modeling for EIS purposes is arbitrary and capricious.

Objection 10. Potential impacts on downstream riparian and water resources for all phases of mine life are not fully disclosed

In comment reference “p”, above, the County points to a lack of disclosure regarding stormwater impacts to downstream riparian and water resources during earlier phases of the mine life. The estimated reduction of annual runoff flow volume to downstream is 30-40% during pre-mining and active mining phases (SWCA, 2013). This substantial reduction of runoff to downstream could significantly affect downstream riparian and water resources. Although the potential impacts of the runoff reduction are briefly discussed in "Seeps, Springs and Riparian Areas", the FEIS only focused on the post-closure 17% reduction and did not fully analyzed the runoff reduction impacts on downstream vegetation and water resources for all phases of mine life. This failure is contrary to the NEPA obligation to identify significant environmental impacts and means to mitigate those impacts.

Attachment 2

TECHNICAL MEMORANDUM

Date:	July 18, 2012	**Project No.:**	093-81962.0007
To:	Chris Garrett, P. HGW.	**Company:**	SWCA Environmental Consultants
From:	Jennifer Patterson and George Annandale	**Email:**	JMPatterson@Golder.com GAnnandale@Golder.com

RE: GEOMORPHIC ASSESSMENT OF BARREL CREEK

Golder Associates Inc. (Golder) was requested to conduct a qualitative geomorphic assessment of Barrel Creek. The goal was to determine the current geomorphic condition and develop an opinion on potential geomorphic changes that could occur with the development of the Rosemont Mine. This letter presents observations from the fieldwork and opinions on potential geomorphic changes that might result due to proposed development of Rosemont Mine.

1.0 INTRODUCTION

Barrel Creek is an ephemeral arroyo located about 25 miles southwest of Tucson (Figure 1). Historic downcutting is evidenced by relatively high banks that are near vertical. This cross-sectional geometry is typical for streams in the arid and semi-arid West. Water flows in the creek only after local precipitation events occur within the watershed. The average annual precipitation estimated at the Rosemont Mine site is 17 inches (USFS 2011). The majority of the precipitation falls during the monsoon period from early July to late August. During the monsoon period, intense thunderstorms build in the late afternoon causing heavy precipitation and flash floods. Streams such as these have extremely high sediment transport rates (for example, Reid, et al., 1998 and Greenbaum and Bergman 2006).

2.0 FIELD OBSERVATIONS

Ms. Jennifer Patterson and Dr. George Annandale conducted a field assessment of Barrel Creek from the headwaters to the confluence with Davidson Canyon on May 1 and 2, 2012. Photographic documentation of the site is recorded from upstream to downstream in the Photographs section below. The photographs illustrate the typical observations from the site.

Two important, geomorphic observations were made during the field visit. The first is that the system is sediment-transport limited. The second is that there is bedrock grade control within the creek upstream of the confluence with Davidson Canyon. Each of these observations is detailed below.

2.1 Sediment-transport Limited

When evaluating the potential impacts for a system, one should consider whether the system is sediment-supply limited or sediment-transport limited. Sediment-supply limited means that the river is transporting as much sediment as is available. The riverbed in a sediment-supply limited system will be composed of

Golder Associates Inc.
44 Union Boulevard, Suite 300
Lakewood, CO 80228 USA
Tel: (303) 980-0540 Fax: (303) 985-2080 www.golder.com

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an armor layer that is transported only during relatively high flows or the bed may be composed of bedrock. An extreme example of sediment-supply limited is “hungry water” that can occur downstream of a dam.

Sediment-transport limited is the exact opposite. There is more sediment in the system than the river can transport during normal or even flood-flow conditions. The sediment-transport limited system is common in ephemeral streams, because of the flashy nature of these systems. A large precipitation event will create a pulse of water flowing down the creek. On the rising limb of the hydrograph, the water picks up more and larger particles of sediment and transports them downstream. However, the hydrograph is short. Typical hydrographs contain multiple peaks due to slugs of precipitation from different areas of the watershed (Reid, et al., 1996). The sediment is dropped out of suspension on the falling limb of the hydrograph. Sediment is transported downstream, but it is deposited a relatively short distance from the source. In a sediment-transport limited system, the bed material will be poorly sorted (i.e., all gradations are present). The bed material will be loose, and an armor layer will not be present (Hassan, et al., 2005).

Barrel Creek is a classic example of a sediment-transport limited system. It is ephemeral, which means that the water only flows occasionally and usually after a precipitation event. The flashy nature of the flows means that sediment is not transported on a regular basis. The bed is composed of a thick layer of unconsolidated sands, gravels, and cobbles. These types of sediment are readily transported during any significant flows within the creek, but the transport stops as quickly as it starts.

Evidence observed in the field confirming that Barrel Creek is a sediment-transport limited system includes the following:

- Deep, unconsolidated, poorly sorted bed material
- Angular particles
- Localized erosion that is not propagating upstream
- Deposited materials on top of bedrock and under bridge

The deep, unconsolidated, poorly sorted bed material also indicates that the system is dropping particles out of suspension in a relatively short time. If the tail of the hydrograph were long, the bed materials would be sorted with coarser material underlying the fine-grained sands. However, the material is just dropped out of suspension at roughly the same time as the water infiltrates into the substrate and quickly disappears. It is deep and unconsolidated, which indicates that it is readily transported with any significant flow. The system has the materials ready to be transported, but it is transport-limited because it is ephemeral.

The angular particles in the bed material indicate that the sediment is not being transported for long distances or for long periods of time. When sediment is transported, it rubs against the bed, bank, and other suspended particles. This will make each grain smoother and rounded. The presence of angular gravels and cobbles indicates that the system is only transporting materials for short times.

Localized erosion was observed in the field in a few locations (for example Photographs 8 and 12). However, this erosion is not propagating upstream. If the system were actively down cutting, the apron on the downstream side of the Barrel Creek Bridge would be severely undercut. But instead, there is a small drop indicating that sediment is not being actively eroded.

The loose sands being deposited on top of bedrock (Photograph 19) and under the bridge (Photograph 11) illustrate the deposition of material at the falling limb of the hydrograph. The grain size is small enough to be transported during any significant flow event. The system is sediment-transport limited.

2.2 Downstream Grade Controls

The second critical geomorphic observations made in the field are the downstream grade controls. A grade control is a critical component of a stream, because it limits the extent of any potential change in the stream gradient. The schematic in Figure 2 illustrates how a grade control limits the extent of erosion both upstream and downstream of the structure. The grade control will stop any upstream migration of head cuts. The grade control acts as a pivot point for the gradient of a river, so erosion upstream of the grade control is also limited.

During the field investigation, two grade controls were identified, as follows:

- Bridge at Barrel Creek (Photograph 9)
- Bedrock across river bottom (Photograph 23)

The upstream grade control is the bridge at Barrel Creek; it is a man-made structure. Because it is man-made, there is the potential that this structure may fail at some time in the future. The downstream grade control is made of bedrock that is erosion resistant, so it will continue to control the stream gradient for an extremely long time. These structures control the hydraulic gradient and therefore the stream power of the creek. The grade controls will limit the erosion capacity of the stream (Figure 2) and a control on depositional processes.

3.0 GEOMORPHIC IMPLICATIONS FOR DEVELOPMENT IN WATERSHED

Concerns have been expressed about the potential impact of the development of the proposed Rosemont Mine on the geomorphology of Barrel Creek and Davidson Canyon. Degradation of these channels, should it occur, could potentially affect the Outstanding Waters of Arizona located in lower Davidson

Canyon. The geomorphologic investigation that was conducted addresses this concern, indicating that the proposed mine development will have no significant impact on the geomorphology of either Barrel Creek or Davidson Canyon.

The geomorphology of fluvial systems is largely dependent on three factors: i.e., water flow, sediment characteristics and availability, and the geometry of stream channels. The justification for stating that the mine will not have a significant impact on Barrel Creek and Davidson Canyon can be formulated in terms of these three variables:

3.1 Sediment

- The area affected by the mine is roughly equal to about 13% of the entire catchment area upstream of the Outstanding Waters of Arizona, located in Davidson Creek (SWCA 2012). Changes in sediment load and runoff from such a small portion of the entire catchment will not have a significant impact on the fluvial geomorphology of the stream system.
- In the worst case, it is estimated that the impact of the mine on total sediment load upstream of the Outstanding Waters of Arizona will amount to a reduction of about 4% (SWCA 2012). This difference between current and predicted sediment load is within the statistical noise of the fluvial system. An estimated change of about a couple percent is therefore deemed insignificant.
- Abundant availability of loose sediment on the surface of the catchment surrounding Barrel Creek and Davidson Canyon will continue to supply directly sediment to the streams during rainstorm events, regardless of the presence of the mine. The amount of sediment thus supplied is greater than what the flowing water can carry, characterizing the transport-limited nature of the stream system.

3.2 Geometry

- The natural grade control that is characteristic of the stream system prevents riverbed degradation and will maintain the sediment transport capacity of the flowing water, regardless of the planned mine development. Maintaining the sediment transport capacity at historic levels and not significantly altering the sediment load to the stream will retain the current geomorphologic character of Barrel Creek and Davidson Canyon, regardless of mine development.

3.3 Water Flow

- It is uncommon for the catchment of Barrel Creek and Davidson Canyon to be subjected to large storm events covering the entire area. Instead, convective storms of limited size occur over portions of the catchment when it rains. The scattered nature of such storm events results in generation of sediment supply from diverse locations in the catchment at different points in time. It rarely happens that sediment would be generated simultaneously from the entire catchment. The nature of sediment supply based on the isolated nature of storms will remain and not be significantly impacted by the mine.
- The transport-limited nature of Barrel Creek and Davidson Canyon explains the non-degrading nature of the stream system. The nature of the stream system will remain unchanged because the change in sediment supply due to the presence of the mine is insignificant, and the sediment transport capacity of the water will essentially remain the same due to the presence of naturally occurring grade control features. It is therefore

reasonable to expect that the creek will not degrade; particularly not near the Outstanding Waters of Arizona in Davidson Canyon and beyond. The creek will remain in a state of quasi-equilibrium; expected from a semi-arid, ephemeral stream.

4.0 REFERENCES

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Attachment 3

Comments on the interpretation of isotope data at Rosemont

C.J. Eastoe

Prepared for Julia Fonseca, April 4, 2014

Abbreviations

TT = Tetratech

ELM = E.L. Montgomery and Associates

LMWL = Local Meteoric Water Line

GMWL = Global Meteoric Water Line

masl = meters above sea level

Local Meteoric Water Line at Rosemont

Figure 8 of ELM (2009) shows a LMWL with a slope of 5.8. This is based on data I provided at the request of ELM, but as I remember it is a relatively small subset of the total data set we have for Tucson, 740 masl (Fig. 1A). A longer-term view of the data suggests that LMWLs vary from year to year (Wright, 2001). In the long term, there are two lines in Tucson. For $\delta^{18}O < -7$ ‰, the line has a slope of 7.6 and closely approximates the GMWL. For $\delta^{18}O > -3$ ‰, a second line emerges, with slope of 4.6. This is a typical evaporation trend. The intersection of the two lines occurs near $\delta^{18}O = -5.5$ ‰.

These lines can be compared with data for Palisades Ranger Station, 2420 masl (Wright, 2001, and unpublished data; Fig. 1B). The data form a trend of slope near 8 (compare the GMWL), with a suggestion of an evaporation trend at $\delta^{18}O > -5$ ‰, but the evaporation effect is much less developed than in the Tucson data. Together, the two plots imply that the evaporation line in Tucson results from the falling of rain through dry, hot air at low elevations, an effect that diminishes in importance towards to mountain tops. The Rosemont pit site is at about 1500 masl, and precipitation at the site most likely has stable isotope distributions (ranges, and trends on the δD vs. $\delta^{18}O$ plot) between those of the Tucson and Palisades stations.

Recharge seasonality at Rosemont

The data for the Tucson and Palisades stations, weighted for precipitation amount, are the basis of the altitude dependence lines shown in Fig. 2. These lines represent long-term precipitation records; altitude effects from year to year are variable (Eastoe and Dettman, submitted). This figure can be used in the following way: a spring discharging at 1500 masl, for instance, yields

water that fell as precipitation between 1500 masl and the crest of the local topography. For groundwater that represents mixing of recharge over several years, and undergoes minimal evaporation prior to recharge, the diagram provides constraints on the seasonality of recharge in the catchment of the spring. If such groundwater had a $\delta^{18}O$ value of -5 ‰ at 1500 masl near Rosemont, predominant summer recharge would be indicated. For a $\delta^{18}O$ value of -9 ‰, combined summer and winter recharge would be indicated, and for -10‰, predominant winter recharge.

The isotope data for springs and wells in ELM's Figure 8 have been interpreted by ELM (2009) as a linear trend approximating a LMWL, the latter probably an inadequate estimate of the true LMWL(s) as suggested above. An alternative interpretation is that the data compose two trends: for $\delta^{18}O$ values < -9.5 ‰, a trend close to the GMWL for least evaporated samples, and for $\delta^{18}O$ values > -9.0‰, an evaporation trend of slope near 5 (Fig. 1A).

If the isotopic variation in precipitation in the Santa Rita Mountains resembles that in Tucson and the Santa Catalina Mountains, the intersection point near -9.5‰ does not reflect evaporation of falling rain. An alternative explanation for the isotope data is that infiltration of surface water with original (as precipitation) $\delta^{18}O$ values of -9.0 to -11.0‰ predominates. For -9‰, the recharge corresponds to mixed summer and winter precipitation, and for -11‰, to winter precipitation (Fig. 2). Infiltration of water that fell as rain with $\delta^{18}O$ values of long term average near -9.5 ‰ is common, accounting for more than half of the groundwater data points in ELM's Fig. 8. Evaporation of surface water prior to infiltration is also common, and evaporated versions of precipitation having $\delta^{18}O$ values of -9.0 to -14.0‰ are present in the data set. Precipitation with $\delta^{18}O$ > -9‰ does not appear contribute to recharge in a detectable quantity.

The outlying data point with $\delta^{18}O$ = -12.4‰ cannot be explained by average winter recharge either on the ridge above Rosemont pit, or in the high elevations of the Santa Rite Mountains. This sample has a ^{14}C content of 16 pMC, (ELM, 2009) and appears to represent precipitation from a period of cooler, wetter climate.

Davidson Canyon subflow

In TT's Fig. 17 (TT, 2010), four data points from springs in the bed of Davidson Canyon plot with $\delta^{18}O$ values near -7‰. An extra data point, not plotted, is listed in ELM's Table 12, and has $\delta^{18}O$ = -9‰. It is understood that these samples were collected with the aim of obtaining a long-term average for the isotope composition of Davidson Canyon subflow. The presence of a variation of more than 2‰ in such samples over a short period of time suggests that the

isotopes in the subflow groundwater respond to variations in isotopes in precipitation at a timescale corresponding to individual precipitation events or seasons. Using these data as an indication of the characteristic seasonality of recharge in the Davidson Canyon watershed constitutes an over-interpretation of a small data set for an incompletely understood groundwater system. In particular, the data point omitted from TT's Fig. 8 leaves open the possibility that groundwater abundant in the area of the Rosemont pit can contribute to Davidson Canyon subflow.

Figure Captions

1. A. Plot of δD vs. $\delta^{18}O$ for individual rain events at the University of Arizona station, central Tucson. Data in near the inflection point have been omitted to enable determination of trend lines. The red trend line is the evaporation trend for groundwater at Rosemont (cf. ELM's Fig. 8). B. Plot of δD vs. $\delta^{18}O$ for individual rain events at the Palisades ranger station, Santa Catalina Mountains.
2. Plot of elevation vs. $\delta^{18}O$, with altitude3 dependences of $\delta^{18}O$ based on data from the University of Arizona and Palisades stations. Elongate rectangles indicate altitude ranges in the Rosemont area. Other rectangles indicate isotope data ranges for springs in the altitude range show.

References

Eastoe, C.J., and Dettman, D.L., Isotope-amount and isotope-altitude effects in hydrologic and climate reconstructions: implications of some long-term data sets for precipitation. Submitted Feb. 2014 to *Quaternary Research*.

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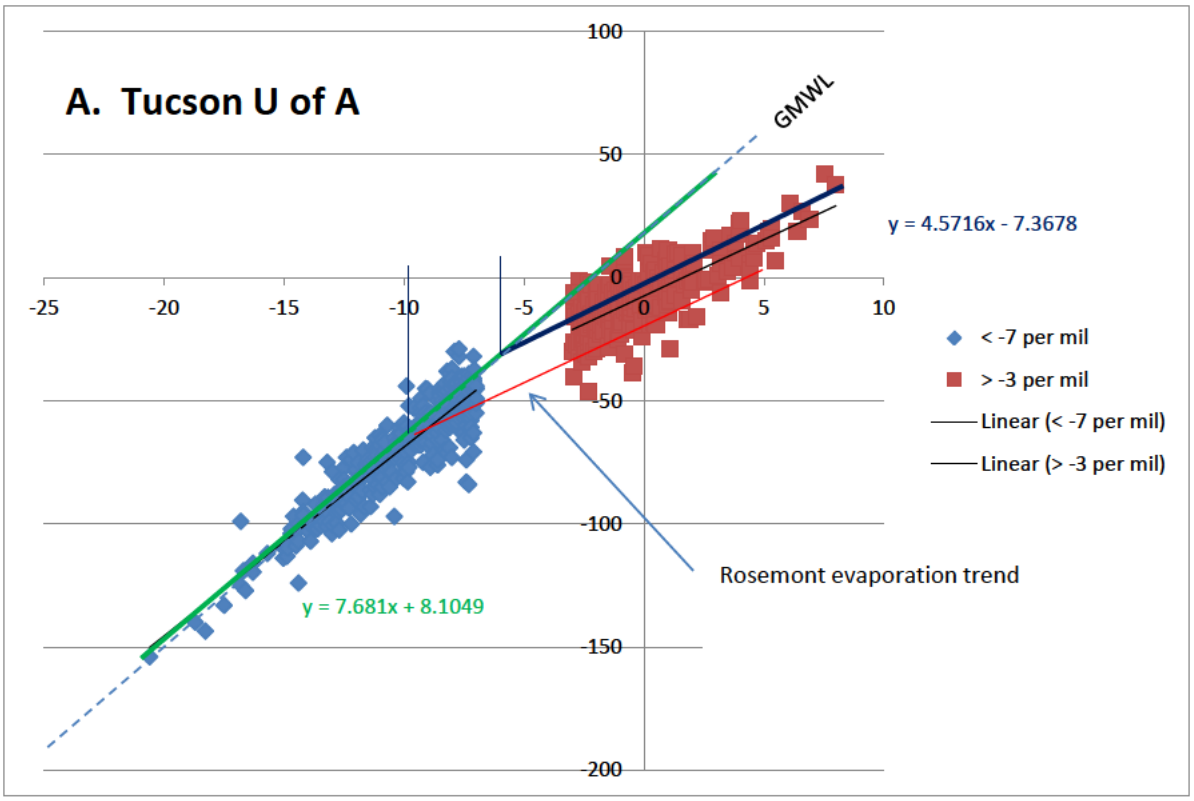
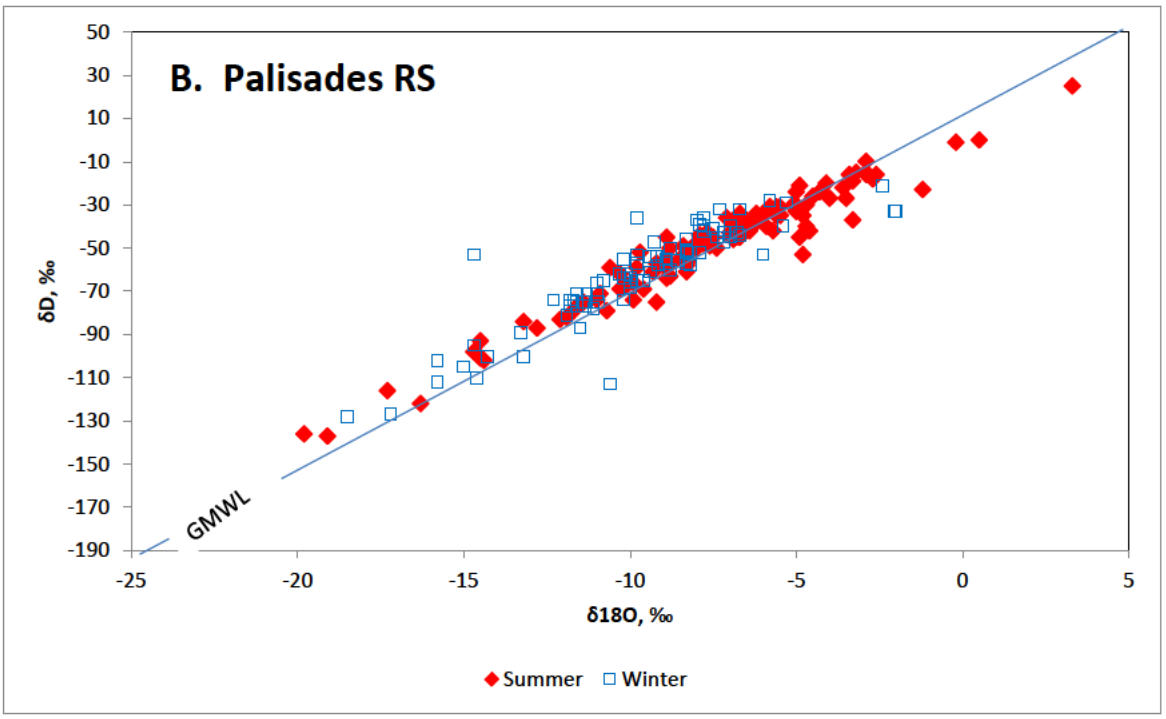
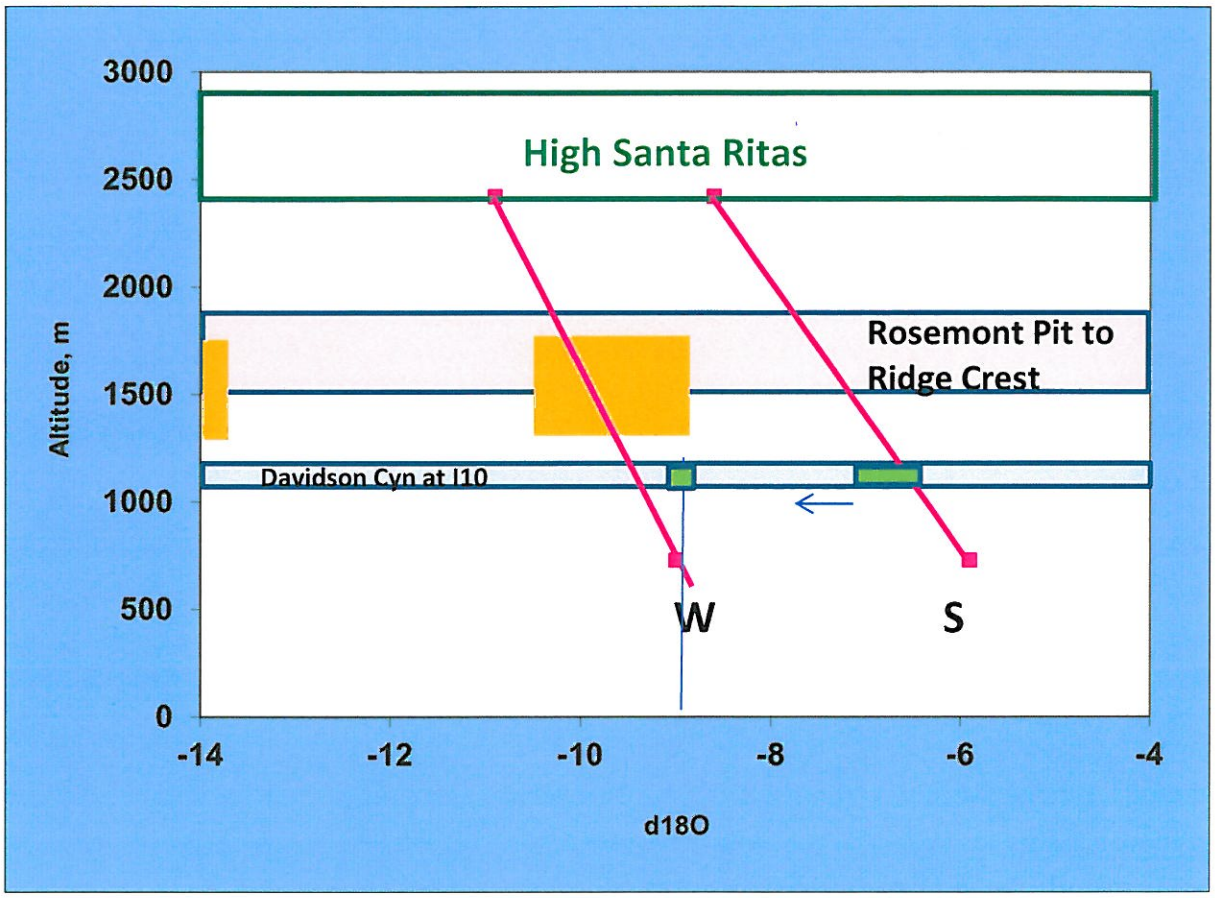
Wright, W.E. 2001. *δD and $\delta^{18}O$ in mixed conifer systems in the U.S. Southwest: The potential of $\delta^{18}O$ in* Pinus ponderosa *tree rings as a natural environmental recorder*. Ph.D. diss,

Department of Geosciences, The University of Arizona, Tucson, Arizona, 328 p.

This calculation omits 6 summer outliers







Springs and wells, Rosemont
Base flow in Davidson Cyn at I10
← Possible evaporation shift
Altitude dependences from Sta. Catalinas

From: Goldmann, Elizabeth
To: Ruyle, Jennifer -FS
Subject: RE: Rosemont Copper Project Hydrology Working Group
Date: Thursday, June 12, 2014 1:13:00 PM

Hi Jennifer

The meetings on June 10 and 11 were attended by Dr. Robert Leidy and Carter Jessop.

Jane Diamond, Kathy Goforth, Jason Brush and Carter Jessop attended the meeting yesterday afternoon.

From: Ruyle, Jennifer -FS [mailto:jruyle@fs.fed.us]
Sent: Thursday, June 12, 2014 11:54 AM
To: Goldmann, Elizabeth
Subject: RE: Rosemont Copper Project Hydrology Working Group

Hi Elizabeth, can you send me the names of all from your office who attended the meetings on June 10th and 11th, including the meeting with Rosemont yesterday afternoon?

From: Goldmann, Elizabeth [mailto:Goldmann.Elizabeth@epa.gov]
Sent: Thursday, June 05, 2014 11:32 AM
To: Ruyle, Jennifer -FS
Subject: RE: Rosemont Copper Project Hydrology Working Group

Hi Jennifer

Did you extend participation in the hydro group to Pima County?

Thanks, E.

From: Ruyle, Jennifer -FS [mailto:jruyle@fs.fed.us]
Sent: Friday, May 30, 2014 11:26 AM
To: Upchurch, Jim -FS; Kingsbury, Jamie -FS; Shafiqullah, Salek -FS; Stamer, Marc -FS; cgarrett@swca.com; mpolm@swca.com; (b) (6) [redacted]; abarclay@swca.com; Ruyle, Jennifer -FS; Calhoun, Jean; jason_douglas@fws.gov; cfsmith@usgs.gov; Vogel, Mindy S -FS; leenhout@usgs.gov; alcoes@usgs.gov; Jessop, Carter; Leidy, Robert; Goldmann, Elizabeth; Jeffrey Simms; Moore, Daniel; Kathy Arnold; blindenlaub@westlandresources.com; David Cerasale; Joyce M. Francis; Raul Vega; JWindes@azgfd.gov; Gurrieri, Joseph T -FS; Congdon, Roger D -FS
Subject: Rosemont Copper Project Hydrology Working Group

Thank you for agreeing to work with the Forest Service as a member of the group that will be taking another look at the hydro information for the Rosemont project. Attached you will find the group objectives and expectations, which will be discussed in more detail on a **conference call June 4th from 9-11 PDT**. Please dial (b) (6) [redacted] with passcode [redacted] This call is intended to (1) discuss the purpose of this group, (2) the logistics for the following two-day technical session

meetings, which will be held on **June 10th and 11th from 9-4:30 PDT**, and (3) to discuss and share any information that was not included in the FEIS that should be considered at this time. The location and VTC/phone information will be provided to you during the conference call on the 4th.

Again, thank you for your cooperation and support.

Jennifer M. Ruyle
Natural Resources and Planning Staff Officer
Coronado National Forest
300 W. Congress
Tucson, AZ 85701
jruyle@fs.fed.us
O: 520.388.8351
C: 5(b) (6)[redacted]

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From: Goldmann, Elizabeth
To: Vogel, Mindy S -FS
Subject: RE: quick question on stormwater quality data
Date: Tuesday, November 03, 2015 9:00:00 AM
Attachments: image001.png
image002.png
image003.png
image004.png

Thank you Mindy!

From: Vogel, Mindy S -FS [mailto:msvogel@fs.fed.us]
Sent: Monday, November 02, 2015 3:07 PM
To: Goldmann, Elizabeth <Goldmann.Elizabeth@epa.gov>
Cc: Jessop, Carter <JESSOP.CARTER@EPA.GOV>
Subject: RE: quick question on stormwater quality data

Hi Elizabeth,

[redacted]
Subject to USFS consultation - see RCM.USFS.1 consult extract
[redacted]

Hope this helps. Please let me know if you have any other questions.

Mindy Sue Vogel
Minerals & Geology Program Manager

Forest Service
Coronado National Forest

p: 520-388-8327
(b) (6) [redacted]
f: 520-388-8305
msvogel@fs.fed.us

300 W Congress St
Tucson, AZ 85701
www.fs.fed.us

Caring for the land and serving people

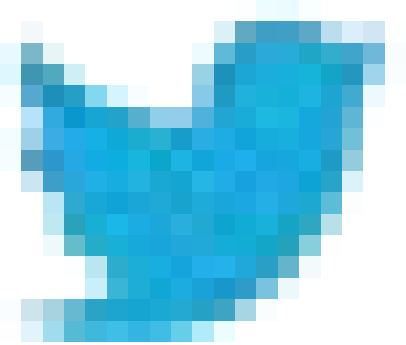
From: Goldmann, Elizabeth [mailto:Goldmann.Elizabeth@epa.gov]
Sent: Friday, October 30, 2015 1:51 PM
To: Vogel, Mindy S -FS
Cc: Jessop, Carter
Subject: quick question on stormwater quality data

Hi Mindy

I hope you are doing well. I (b)(5) Deliberative [redacted]

[redacted]

Thanks, Elizabeth



From: Goldmann, Elizabeth
To: Vogel, Mindy S -FS
Cc: Jessop, Carter
Subject: quick question on stormwater quality data
Date: Friday, October 30, 2015 1:50:00 PM

Hi Mindy

I hope you are doing well. I (b)(5) Deliberative [redacted]

[redacted]

Thanks, Elizabeth