SWCA ENVIRONMENTAL CONSULTANTS

DRAFT

Memorandum

To: File

CC:

From: Chris Garrett, SWCA

Date: July 22, 2014

Re: Refined Approach to Streamflow Predictions

In October 2013, the Coronado National Forest and Environmental Protection Agency (EPA) collaborated on a revised approach for disclosing streamflow and riparian impacts that could result from the proposed Rosemont Copper project. The resulting analysis was described in the record (SWCA 2013j)[1] and in the "Seeps, Springs, and Riparian Areas" section of Chapter 3 in the Rosemont Copper Project Final Environmental Impact Statement (FEIS).

In May 2014, the Coronado National Forest indicated their intention to reinitiate Endangered Species Act Section 7 consultation for the Rosemont Copper project based on changes to species occurrence and listings. As part of the process of preparing a Supplemental Biological Assessment for submittal to the U.S. Fish and Wildlife Service (USFWS), the Coronado National Forest is collaborating with other cooperating and federal agencies to review new information, changed conditions, or new interpretations that might be pertinent to the streamflow analysis.

The FEIS includes an analysis predicting impacts to streamflow in Upper Cienega Creek and Empire Gulch (the "FEIS approach"). A variety of new information sources have come to light during this process which allow the FEIS approach to be refined to reduce uncertainty in the analysis.

FEIS Streamflow Analysis Concept and Assumptions

The FEIS streamflow analysis involved the following: obtaining the daily streamflow data for the period 2001-2013 from a U.S. Geological Survey (USGS) streamgage on Upper Cienega Creek (09484550), converting the streamflow to depth of water using the USGS rating curve, and then statistically analyzing

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[1] SWCA Environmental Consultants. 2013j. *Review of Available Depth of Flow Information on Cienega Creek and Empire Gulch and Protocol for Estimating Impacts to Streamflow*. Memorandum to file from Chris Garrett, SWCA Environmental Consultants. Phoenix, Arizona: SWCA Environmental Consultants. October 30.

the behavior of the stream during the period of record (i.e., the average number of days dry per year). This establishes a baseline against which potential future impacts can be compared. The analysis then assumed that the same 12-year hydrograph would occur in the future, but now with additional reductions in stream depth due to groundwater drawdown from the mine. The same statistics were run for the predicted hydrograph and compared to the baseline statistics.

The predictions of future conditions were conducted for a variety of time steps and groundwater model scenarios. Time steps analyzed include 50 years, 150 years, and 1,000 years after closure of the mine. Groundwater model scenarios include the best fit results from each of three groundwater models (Tetra Tech, Montgomery, Myers), as well as the highest drawdown and lowest drawdown from any of the models (in other words, for any given time step, five different model scenarios were used to predict stream impacts).

The following is a comprehensive list of assumptions that were used to build the analysis presented in the FEIS:

- Assumes that water sources in Empire Gulch, Gardner Canyon, and Upper Cienega Creek are connected to the regional aquifer. Note that this is Forest Service policy in the absence of credible information showing no connection.
- Assumes that the results from the three groundwater models are valid and represent the best available tool for predicting groundwater impacts. This was determined by the Coronado National Forest during a prolonged peer review process, and is fully documented in the FEIS and the project record[2].
- Assumes that the uncertainty associated with the models should not preclude looking at what <u>could</u> happen if the aquifer behaves like the models predict it will. The uncertainty, however, should be fully described and acknowledged in the analysis as required under the National Environmental Policy Act (NEPA).
- Assumes that a full range of modeling scenarios should be used (i.e., use all three models, and use the high and low ends of the reported sensitivity analyses from the models).
- Assumes that the USGS streamgage data, which is collected at a v-notch weir, is representative of depth of water in the natural channel.
- In addition to analyzing when “dry” conditions occur (i.e., when flow falls to zero), the analysis also looks at how often “extremely low flow” conditions occur. This condition was defined as any depth of water in the stream channel less than 0.2 feet.
- Assumes that Gardner Canyon, Empire Gulch, and the rest of Upper Cienega Creek have identical hydrology as that which occurs at the streamgage site, and the analysis is equally applicable to all channels in the watershed. It is noted that there is a paucity of stream depth data and/or channel geometry data to truly assess the validity of this assumption.
- Assumes that there is a 1:1 linear relationship between drawdown in the aquifer and loss of water depth in the stream channel.
- Assumes that 0.1 feet is the limit of precision of the reported groundwater model results and anything less than 0.1 feet is treated as zero.
- For Upper Cienega Creek, it is recognized that there is contribution from Empire Gulch and Gardner Canyon both and that impacts to these areas could also result in less flow in Upper

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[2] See project record #047366, Process Memorandum to File, Overview of Water Resource Process, December 6, 2013

Cienega Creek. It is assumed that the contribution to flow from these areas is proportional to the area of contribution to the watershed (11% for Empire Gulch, 26% for Gardner Canyon).

- Further, a “binary” system of flow contribution was used, in which flow contribution to Upper Cienega Creek from each of these areas is either present or not, and that contribution ceases from these areas when a certain depth is reached. The analysis assumed a trigger that reaching a depth of 0.3 feet in Empire Gulch or Gardner Canyon would “turn off” the flow from these areas to Upper Cienega Creek.
- Because there is no aquifer drawdown to speak of in Lower Cienega Creek, and no further streamgage data available in Lower Cienega Creek anywhere upstream of Pantano Dam, the analysis assumes that flow impacts will migrate downstream, and that Lower Cienega Creek will react identically as Upper Cienega Creek.
- The word “dry” was used in the FEIS to indicate a condition of zero flow; it is recognized that standing water may still be present in the channel under these conditions, and in fact this is readily demonstrable during the period of May/June 2010 when no streamflow occurred at the streamgage, yet miles of stream channel remained wet based on BLM wet/dry mapping.

Major Criticisms of FEIS Approach and Strategy to Address Criticisms

Several major criticisms have been raised regarding the FEIS approach. These include the following:

- A criticism was raised that the word “dry” to describe a condition of zero streamflow is not appropriate, as water still remains in the channel. Based on wet/dry mapping data obtained from BLM that were not available at the time the FEIS was written, this is clearly a valid criticism. To address this criticism, the refined analysis will not use the term “days dry”, but instead will use the term “days with no flow”. To be clear, this refined analysis only is pertinent to the presence or absence of flowing water, and is not able to predict the presence or absence of standing water in the channel.

- A criticism was raised that the 1:1 relationship is not supported, and has a major influence on the results. SWCA has prepared a sensitivity analysis to examine this parameter[3] and found that the assumption does a have a major influence on the predicted outcomes. While much discussion occurred during a technical meeting on June 10-11, 2014 about whether a 1:1 relationship between aquifer drawdown and change in stream depth is appropriate, a clear consensus was not reached..

  Meanwhile, information and data recently obtained from BLM include paired measurements of groundwater levels from piezometers and measured streamflow, both on Upper Cienega Creek (above Gardner Canyon) and Empire Gulch. In addition, other near-stream water level measurements are available that can be paired with measured streamflow at the USGS stream gage on Upper Cienega Creek. These data were not available at the time the FEIS was written. Using these data, an empirical relationship can be established directly between aquifer water level change and change in streamflow. This allows the 1:1 assumption to be completely removed from the analysis and remove uncertainty associated with that assumption.

- A criticism was raised that the conditions at the Upper Cienega Creek streamgage were applied to all other points in the watershed, including Gardner Canyon and Empire Gulch, without basis. This

[3] SWCA 2014. Draft Memorandum - Sensitivity Analysis for FEIS Streamflow Impact Assessment. June 6, 2014.

was necessary as no other measured data were known to be available elsewhere in the watershed. As noted, now that additional data have come to light on Upper Cienega Creek and Empire Gulch, the analysis can be expanded to incorporate that site-specific data and remove this assumption from the analysis.

Refined Approach to Streamflow Impacts

The refined approach is similar to that used in the FEIS, but with several important changes.

- A measured hydrograph is statistically analyzed to establish baseline statistics of how many "days with no flow" and "extremely low flow days" occur on average. The assumption is made that this same hydrograph—superimposed with any mine impacts—would occur again in the future. This remains the same as the approach in the FEIS. **Change to analysis**: instead of solely using the USGS gage on Upper Cienega Creek, the analysis now uses the USGS gage, a BLM measurement location on Upper Cienega Creek above the Gardner Canyon confluence, and a BLM measurement location on Upper Empire Gulch.

- The predictions of future conditions are conducted for a variety of time steps and groundwater model scenarios. Time steps analyzed include 50 years, 150 years, and 1,000 years after closure of the mine. Groundwater model scenarios include the best fit results from each of three groundwater models (Tetra Tech, Montgomery, Myers), as well as the highest drawdown and lowest drawdown from any of the models (in other words, for any given time step, five different model scenarios are used to predict stream impacts). **There is no change to this step in the analysis.**

- These model predictions of drawdown in the aquifer are then translated to reductions in streamflow using empirical relationships established by analysis of paired water level/streamflow measurements. **Change to analysis:** this step replaces the use of the 1:1 relationship and replaces any need to translate streamflow measurements into stream depth.

The following assumptions remain for the analysis:

- The analysis still assumes that water sources in Empire Gulch, Gardner Canyon, and Upper Cienega Creek are connected to the regional aquifer.
- The analysis still assumes that the results from the three groundwater models are valid and represent the best available tool for predicting groundwater impacts.
- The analysis still assumes that the uncertainty associated with the models should not preclude looking at what could happen if the aquifer behaves like the models predict it will.
- The analysis still assumes that all reasonable modeling scenarios should be used.
- "Extremely low flow conditions" are no longer defined as any depth of water in the stream channel less than 0.2 feet, but are instead defined as a flow threshold (described in more detail below).
- The analysis no longer assumes that Gardner Canyon, Empire Gulch, and the rest of Upper Cienega Creek have identical hydrology as that which occurs at the USGS streamgage site, as there are now three different locations (two on Upper Cienega Creek and one on Empire Gulch) at which to analyze impacts. Gardner Canyon still does not have any direct measurements of

streamflow, but the BLM measurement location on Upper Cienega Creek is near the confluence with Gardner Canyon and has been assumed to match this location.

- The analysis still assumes that 0.1 feet is the limit of precision of the reported groundwater model results and anything less than 0.1 feet is treated as zero.
- For Upper Cienega Creek, the analysis still recognizes that there is contribution from both Empire Gulch and Gardner Canyon and that impacts to these areas could also result in less flow in Upper Cienega Creek. It is still assumed that the contribution to flow from these areas is proportional to the area of contribution to the watershed (11% for Empire Gulch, 26% for Gardner Canyon). However, with the additional measurement locations the method of estimating this contribution has changed (described in more detail below).

Selection of Criteria to Designate "Extremely Low Flow" Conditions

In the FEIS, the condition of "extremely low flow" was defined as anything less than 0.2 feet of stream depth. This was selected because 0.2 feet of stream depth very rarely occurs at the USGS stream gage, and even summer low flows tend to stay above this threshold.

A similar approach is taken for the refined analysis, with "extremely low flow" conditions defined by the lowest flow that is observed at each measurement location. These are as follows:

- Empire Gulch[4]. Period of record from June 2007 – November 2013, with 50 streamflow measurements. Lowest flow observed (June 2012) = 6 gallons per minute (gpm).

- Upper Cienega Creek (BLM)[5]. Period of record from April 2006 – November 2013, with 46 streamflow measurements. Lowest flow observed (October 2009) = 36 gpm.

- Upper Cienega Creek (USGS)[6]. Period of record from 2001-2013. Typical lowest flow observed during May/June = 0.15 cubic feet per second = 67 gpm.

Contribution from Gardner Canyon and Empire Gulch

Previously, a "binary" system of estimating contribution from Gardner Canyon and Empire Gulch was used, whereas input from these tributaries was cut off when a certain threshold was reached. A similar approach is used for the refined analysis, but with different thresholds based on streamflow instead of stream depth. As before, the thresholds are based on the most critical time of year—May/June. It is during this time frame when additional reductions in streamflow due to the loss of Empire Gulch or Gardner Canyon are most likely to result in zero flow conditions at the USGS streamgage location.

The Upper Cienega Creek (USGS) location receives water from both Empire Gulch and Gardner Canyon. Based on watershed area, it is estimated that 11% of the flow at the USGS streamgage location is from Empire Gulch and 26% is from Gardner Canyon. There are no direct measurement points in lower Empire Gulch or in Gardner Canyon, so each of these areas must be handled with an assumption.

Empire Gulch Contribution

[4] This location is in Upper Empire Gulch, near the ranch headquarters and Upper Empire Gulch springs.
[5] This location is just above the confluence of Gardner Canyon and Upper Cienega Creek.
[6] USGS Streamgage 09484550, Cienega Creek near Sonoita

This analysis assumes that flow in lower Empire Gulch can be modeled on the measurements from upper Empire Gulch. It should be noted that Upper Empire Gulch and Lower Empire Gulch appear to be hydrologically separate and not necessarily similar, based on wet/dry mapping. As observed in upper Empire Gulch, the flow during the summer months ranges from 6 to 20 gpm. Therefore any drawdown sufficient to reduce flow by at least 6 gpm has the potential to halt contribution from Empire Gulch. A 6 gpm change in streamflow corresponds to a drawdown of 0.5 feet (see next section for the correlation between drawdown and streamflow in upper Empire Gulch).

However, the drawdown measurement point most pertinent to lower Empire Gulch is not the "Upper Empire Gulch Spring" measurement point (see Figures 54-58 in the FEIS). The drawdown measurement point closest to lower Empire Gulch is that for the Cienega Creek/Gardner Canyon confluence. Therefore any drawdown greater than 0.5 feet at this location is assumed to extinguish flow from Empire Gulch, and if so an additional 11% reduction in flow is applied to the Upper Cienega Creek (USGS) location.

Gardner Canyon Contribution

This analysis assumes that Gardner Canyon can be modeled on the measurements from the Upper Cienega Creek (BLM) location. As observed at the Upper Cienega Creek (BLM) location, the flow during the summer months ranges from roughly 49 to 86 gpm. Therefore any drawdown sufficient to reduce flow by at least 49 gpm has the potential to halt contribution from Gardner Canyon. A 49 gpm change in streamflow corresponds to a drawdown of 0.4 feet (see next section for the correlation between drawdown and streamflow at the Upper Cienega Creek (BLM) location).

Any drawdown greater than 0.4 feet at the Cienega Creek/Gardner Canyon confluence is assumed to extinguish flow from Gardner Canyon, and if so an additional 26% reduction in flow is applied to the Upper Cienega Creek (USGS) location.

Empirical Relationship Between Streamflow and Aquifer Drawdown

Upper Empire Gulch (BLM Measurement Location)

Streamflow has been manually measured on Upper Empire Gulch from June 2007 to November 2013, with 50 streamflow measurements taken. A piezometer was installed approximately 100 meters from the streamflow measurement location and water levels have been measured using a pressure transducer from February 2012 through October 2013 (20 months). There are a total of 21 paired streamflow/water level measurements.

A linear regression analysis was conducted on these 21 measurements (see Attachment A). The results of the linear regression are summarized below:

Table 1. Linear Regression Results for Upper Empire Gulch	
Number of points (n)	21
Full Regression Equation (y = streamflow, x = water level)	y = 10.9x - 20
R^2	0.709
Standard error of regression (S)	4.3 gpm

Specific Drawdown/Streamflow Relationship	10.9 gpm per 1 foot change in water level
95% Probability Range	7.6 – 14.3 gpm per 1 foot change in water level
80% Probability Range	8.8 – 13.0 gpm per 1 foot change in water level

Upper Cienega Creek above Gardner Canyon (BLM Measurement Location)

Streamflow has been manually measured on Upper Cienega Creek above the Gardner Canyon confluence from April 2006 to November 2013, with 46 streamflow measurements taken. A piezometer was installed approximately 6 meters from the streamflow measurement location and water levels have been measured using a pressure transducer from February 2012 to October 2013 (20 months). There are a total of 19 paired streamflow/water level measurements.

A linear regression analysis was conducted on these 19 measurements (see Attachment B). The results of the linear regression are summarized below:

Table 2. Linear Regression Results for Upper Cienega Creek above Gardner Canyon	
Number of points (n)	19
Full Regression Equation (y = streamflow, x = water level)	y = 117.8x - 375
R^2	0.588
Standard error of regression (S)	21.4 gpm
Specific Drawdown/Streamflow Relationship	117.8 gpm per 1 foot change in water level
95% Probability Range	67.3 – 168.3 gpm per 1 foot change in water level
80% Probability Range	85.9 – 149.7 gpm per 1 foot change in water level

Upper Cienega Creek at USGS Streamgage Station

Daily streamflow measurements have been taken at the USGS streamgage station from 2001 to 2013. No peizometers or highly detailed water level measurements were found near the streamgage; the nearest well with a reasonable coverage of water levels was the “Frog Well” located approximately 784 meters distant from the gage, but still close to the stream channel. The “Frog Well” has water level measurements available periodically between April 2011 and June 2013 (26 months), for a total of 21 total water level measurements. There are a total of 21 paired streamflow/water level measurements.

A linear regression analysis was conducted on these 21 measurements (see Attachment C). The results of the linear regression are summarized below:

Table 3. Linear Regression Results for Upper Cienega Creek at USGS Streamgage	
Number of points (n)	21
Full Regression Equation (y = streamflow, x = water level)	y = -189.0x + 7220
R^2	0.455
Standard error of regression (S)	108.9 gpm
Specific Drawdown/Streamflow Relationship	189 gpm per 1 foot change in water level
95% Probability Range	89.6 – 288.5 gpm per 1 foot change in water level
80% Probability Range	126.0 – 252.1 gpm per 1 foot change in water level

Predicted Streamflow Impacts

Upper Empire Gulch (BLM Measurement Location)

Predictions based on the Upper Empire Gulch hydrograph are included as Attachment D. The analysis was conducted for the best-fit regression (10.9 gpm reduction in streamflow per foot of water level change), as well as the 80% confidence interval (85.9 – 149.7 gpm/foot). Analysis was also conducted based on the modeled reduction in Empire Gulch streamflow recently provided[7].

A summary of predicted "days with zero flow" for Upper Empire Gulch is shown in Table 4. A summary of predicted "days with extremely low flow" for Upper Empire Gulch is shown in Table 5. A summary of the predicted flow status (i.e., perennial, intermittent, ephemeral) is shown in Table 6. The previous results from the published FEIS analysis are also included in these tables.

Compared to the previous FEIS analysis, the results are similar but not quite as severe.

- In the near-term (50 years after mine closure), Upper Empire Gulch remains perennial in 4 out of 5 scenarios, and intermittent in 1 scenario. Previously the analysis indicated a wider range (perennial in 3 scenarios, intermittent in 1 scenario, ephemeral in 1 scenario).
- In the long-term (150 years after mine closure), Upper Empire Gulch remains perennial in 3 out of 5 scenarios, intermittent in 1 scenario, and ephemeral in 1 scenario. Previously the analysis indicated a similar range, but more severe impacts (perennial in 1 scenario, intermittent in 2 scenarios, ephemeral in 2 scenarios).
- In the long-term (1,000 years after mine closure), Upper Empire Gulch is intermittent (2 out of 5 scenarios) or ephemeral (3 out of 5 scenarios). Previously the analysis indicated a more severe impact, with Empire Gulch being ephemeral in 5 out of 5 scenarios.

Upper Cienega Creek (BLM measurement location above Gardner Canyon)

Predictions based on the Upper Cienega Creek BLM hydrograph are included as Attachment E. The analysis was conducted for the best-fit regression (118 gpm reduction in streamflow per foot of water level change), as well as the 80% confidence interval (85.9 – 149.7 gpm/foot). Analysis was also conducted based on the modeled reduction in Upper Cienega Creek streamflow recently provided.

A summary of predicted "days with zero flow" for Upper Cienega Creek is shown in Table 4. A summary of predicted "days with extremely low flow" for Upper Cienega Creek is shown in Table 5. A summary of the predicted flow status (i.e., perennial, intermittent, ephemeral) is shown in Table 6. This area was not specifically analyzed in the FEIS analysis, but would have been similar to the analysis made for Gardner Canyon, which is also included in these tables.

Compared to the previous FEIS analysis, the results are similar but not quite as severe.

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[7] Hydro-Logic, LLC. Simulated Empire Gulch Spring Discharge and Stream Flows based on the Tetra Tech (2010) Groundwater Flow Model. June 27, 2014.

- In the near-term (50 years after mine closure), Upper Cienega Creek above Gardner Canyon remains perennial in all scenarios. This was identical to the previous analysis (for Gardner Canyon).
- In the long-term (150 years after mine closure), Upper Cienega Creek above Gardner Canyon remains perennial in 4 out of 5 scenarios, and becomes intermittent in 1 scenario. This is identical to the previous analysis (for Gardner Canyon).
- In the long-term (1,000 years after mine closure), Upper Cienega Creek above Gardner Canyon is perennial (3 out of 5 scenarios) or intermittent (2 out of 5 scenarios). Previously the analysis indicated a more severe impact, with Gardner Canyon being perennial under 2 scenarios, intermittent under 1 scenario, and ephemeral under 2 scenarios.

Upper Cienega Creek (USGS Streamgage Location)

Predictions based on the Upper Cienega Creek USGS hydrograph are included as Attachment F. The analysis was conducted for the best-fit regression (189 gpm reduction in streamflow per foot of water level change), as well as the 80% confidence interval (125 - 252 gpm/foot). Analysis was also conducted based on the modeled reduction in Upper Cienega Creek streamflow recently provided.

A summary of predicted "days with zero flow" for Upper Cienega Creek is shown in Table 4. A summary of predicted "days with extremely low flow" for Upper Cienega Creek is shown in Table 5. A summary of the predicted flow status (i.e., perennial, intermittent, ephemeral) is shown in Table 6. The previous results from the published FEIS analysis are also included in these tables.

Compared to the previous FEIS analysis, the results are similar but not quite as severe.

- In the near-term (50 years after mine closure), Upper Cienega Creek at the USGS gage remains perennial in all scenarios. This was identical to the previous analysis.
- In the long-term (150 years after mine closure), Upper Cienega Creek at the USGS gage remains perennial in all scenarios. Previously the analysis indicated a more severe impact, with Upper Cienega Creek perennial under 3 scenarios and intermittent under 2 scenarios.
- In the long-term (1,000 years after mine closure), Upper Cienega Creek at the USGS gage is perennial (3 out of 5 scenarios) or intermittent (2 out of 5 scenarios). Previously the analysis indicated a more severe impact, with Upper Cienega Creek being perennial under 2 scenarios, intermittent under 1 scenario, and ephemeral under 2 scenarios.

Results from 80% Confidence Intervals

The 80% confidence interval for the empirical streamflow/drawdown relationship was also modeled to determine how predicted results would differ within that range. Overall, the range had relatively little effect on the overall predictions. The most variation was observed with the Upper Empire Gulch predictions, which indicate a higher likelihood of becoming ephemeral at 1,000 years if the entire range were considered, rather than just the best-fit empirical relationship.

Table 1. Summary of Refined FEIS Analysis - Number of Days with Zero Flow

	Current	50 Years					150 Years					1000 Years				
		Low	Best-Fit	Best-Fit	Best-Fit	High	Low	Best-Fit	Best-Fit	Best-Fit	High	Low	Best-Fit	Best-Fit	Best-Fit	High
Empire Gulch	0	0	0	0	0	168	0	0	0	299	365	285	336	365	365	365
Empire Gulch-80% Confidence Low End of Range	0	0	0	0	0	110	0	0	0	226	365	190	307	336	365	365
Empire Gulch-80% Confidence High End of Range	0	0	0	0	7	234	0	0	0	336	365	307	365	365	365	365
Empire Gulch - Modeled Streamflow Reduction (Note model was for different location from hydrograph)	0			0					0					22		
Upper Cienega Creek above Gardner Canyon	0	0	0	0	0	0	0	0	0	0	111	0	0	16	183	183
Upper Cienega Creek above Gardner Canyon – 80% Confidence Low End of Range	0	0	0	0	0	0	0	0	0	0	16	0	0	0	103	103
Upper Cienega Creek above Gardner Canyon – 80% Confidence High End of Range	0	0	0	0	0	0	0	0	0	16	183	0	0	103	286	286
Upper Cienega Creek above Gardner Canyon – Modeled Streamflow Reduction	0			0					0					0		
Upper Cienega Creek at USGS Streamgage	2	2	2	2	3	3	2	3	3	4	23	3	3	9	42	42
Upper Cienega Creek at USGS Streamgage – 80% Confidence Low End of Range	2	2	2	2	3	3	2	3	3	3	6	3	3	3	13	13
Upper Cienega Creek at USGS Streamgage – 80% Confidence High End of Range	2	2	2	2	3	3	2	3	3	9	48	3	3	20	88	88
Upper Cienega Creek at USGS Streamgage – Modeled Streamflow Reduction	2			2					3					3		
FEIS Predictions for Comparison																
Empire Gulch	3	3	3	4	283	361	3	32	32	363	365	363	364	365	365	365
Upper Cienega Creek	3	3	3	3	3	4	3	3	3	32	313	3	3	125	351	351
Gardner Canyon	3	3	3	3	3	3	3	3	3	4	146	3	3	283	363	363

Table 2. Summary of Refined FEIS Analysis - Number of Days with Zero Flow or Extremely Low Flow

	Current	50 Years					150 Years					1000 Years				
		Low	Best-Fit	Best-Fit	Best-Fit	High	Low	Best-Fit	Best-Fit	Best-Fit	High	Low	Best-Fit	Best-Fit	Best-Fit	High
Empire Gulch	0	0	0	15	22	285	7	22	22	336	365	329	365	365	365	365
Empire Gulch-80% Confidence Low End of Range	0	0	0	7	22	197	7	15	15	299	365	292	336	365	365	365
Empire Gulch-80% Confidence High End of Range	0	0	0	15	58	307	7	22	22	350	365	336	365	365	365	365
Empire Gulch - Modeled Streamflow Reduction (Note model was for different location from hydrograph)	0			0					22					95		
Upper Cienega Creek above Gardner Canyon	0	0	0	0	8	103	0	95	95	159	278	95	95	183	333	333
Upper Cienega Creek above Gardner Canyon – 80% Confidence Low End of Range	0	0	0	0	8	95	0	24	24	111	190	24	24	127	270	270
Upper Cienega Creek above Gardner Canyon – 80% Confidence High End of Range	0	0	0	0	16	119	0	103	103	183	333	103	103	270	333	333
Upper Cienega Creek above Gardner Canyon – Modeled Streamflow Reduction	0			0					8					71		
Upper Cienega Creek at USGS Streamgage	6	6	6	6	11	25	6	20	20	38	106	20	20	93	143	143
Upper Cienega Creek at USGS Streamgage – 80% Confidence Low End of Range	6	6	6	6	9	18	6	16	16	25	68	16	16	68	106	106
Upper Cienega Creek at USGS Streamgage – 80% Confidence High End of Range	6	6	6	6	11	35	6	25	25	55	133	25	25	117	172	172
Upper Cienega Creek at USGS Streamgage – Modeled Streamflow Reduction	6			6					11					23		
FEIS Predictions for Comparison																
Empire Gulch	4	4	4	146	352	362	4	283	283	364	365	363	364	365	365	365
Upper Cienega Creek	4	4	4	4	4	146	4	88	88	283	352	88	88	339	354	354
Gardner Canyon	4	4	4	4	4	88	4	4	32	146	349	4	4	352	363	363

Table 3. Summary of Refined FEIS Analysis – Flow Status

	Current	50 Years					150 Years					1000 Years				
		Low	Best-Fit	Best-Fit	Best-Fit	High	Low	Best-Fit	Best-Fit	Best-Fit	High	Low	Best-Fit	Best-Fit	Best-Fit	High
Empire Gulch	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Perennial	Perennial	Perennial	Intermittent	Ephemeral	Intermittent	Intermittent	Ephemeral	Ephemeral	Ephemeral
Empire Gulch-80% Confidence Low End of Range	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Perennial	Perennial	Perennial	Intermittent	Ephemeral	Intermittent	Intermittent	Intermittent	Ephemeral	Ephemeral
Empire Gulch-80% Confidence High End of Range	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Perennial	Perennial	Perennial	Intermittent	Ephemeral	Intermittent	Ephemeral	Ephemeral	Ephemeral	Ephemeral
Empire Gulch - Modeled Streamflow Reduction (Note model was for different location from hydrograph)	Perennial		Perennial					Perennial					Perennial			
Upper Cienega Creek above Gardner Canyon	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Perennial	Perennial	Perennial	Intermittent	Intermittent
Upper Cienega Creek above Gardner Canyon – 80% Confidence Low End of Range	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Intermittent
Upper Cienega Creek above Gardner Canyon – 80% Confidence High End of Range	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Perennial	Perennial	Intermittent	Intermittent	Intermittent
Upper Cienega Creek above Gardner Canyon – Modeled Streamflow Reduction	Perennial		Perennial					Perennial					Perennial			
Upper Cienega Creek at USGS Streamgage	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Intermittent
Upper Cienega Creek at USGS Streamgage – 80% Confidence Low End of Range	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial
Upper Cienega Creek at USGS Streamgage – 80% Confidence High End of Range	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Perennial	Perennial	Perennial	Intermittent	Intermittent
Upper Cienega Creek at USGS Streamgage – Modeled Streamflow Reduction	Perennial		Perennial					Perennial					Perennial			

FEIS Predictions for Comparison

	Current	50 Years Low	50 Years Best-Fit	50 Years Best-Fit	50 Years Best-Fit	50 Years High	150 Years Low	150 Years Best-Fit	150 Years Best-Fit	150 Years Best-Fit	150 Years High	1000 Years Low	1000 Years Best-Fit	1000 Years Best-Fit	1000 Years Best-Fit	1000 Years High
Empire Gulch	Perennial	Perennial	Perennial	Perennial	Intermittent	Ephemeral	Perennial	Intermittent	Intermittent	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral	Ephemeral
Upper Cienega Creek	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Intermittent	Perennial	Perennial	Intermittent	Ephemeral	Ephemeral
Gardner Canyon	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Perennial	Intermittent	Perennial	Perennial	Intermittent	Ephemeral	Ephemeral

SUMMARY OUTPUT

Regression Statistics	
Multiple R	0.842005
R Square	0.708973
Adjusted R	0.693656
Standard E	4.299415
Observatio	21

ANOVA

	df	*SS*	*MS*	*F*	*ignificance F*
Regression	1	855.5952	855.5952	46.286	1.7E-06
Residual	19	351.2143	18.48497		
Total	20	1206.81			

	Coefficients	*andard Errc*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*ower 80.0%*	*Jpper 80.0%*
Intercept	-20.0001	5.625755	-3.55509	0.002114	-31.7749	-8.22522	-27.4695	-12.5306
X Variable :	10.91834	1.604841	6.803382	1.7E-06	7.559373	14.27731	8.787551	13.04913

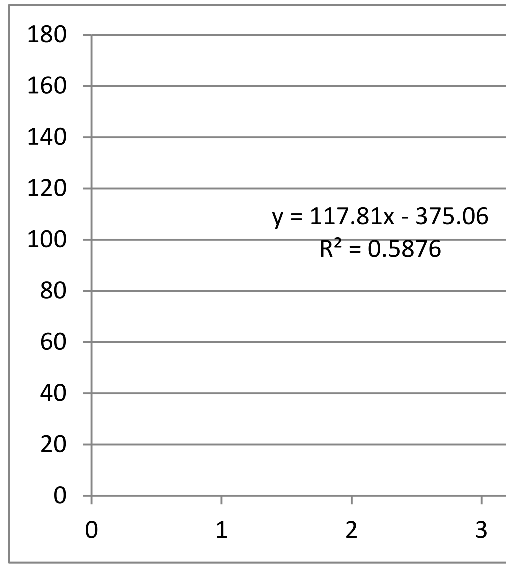
RESIDUAL OUTPUT

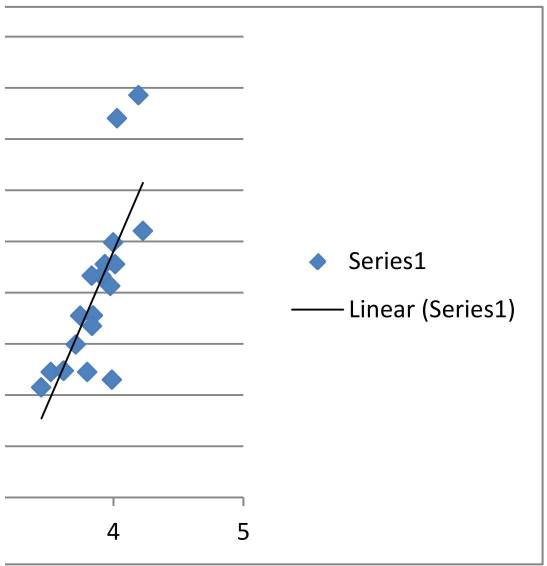
Observation	*Predicted Y*	*Residuals*	*ıdard Residuals*
1	25.881	-5.881	-1.40339
2	27.52857	10.47143	2.498819
3	25.07522	-2.07522	-0.49521
4	18.87469	-6.87469	-1.64052
5	10.92942	-4.92942	-1.17632
6	10.00791	-1.00791	-0.24052
7	8.192188	3.807812	0.908666
8	12.31168	0.688321	0.164256
9	11.83891	3.161085	0.754336
10	19.06904	-3.06904	-0.73237
11	21.16536	-0.16536	-0.03946
12	23.58268	6.417316	1.531378
13	25.32962	-3.32962	-0.79455
14	26.38324	0.616761	0.147179
15	24.94529	0.054707	0.013055
16	17.51536	-3.01536	-0.71956
17	10.93269	-2.93269	-0.69983
18	11.8007	2.1993	0.524823
19	10.60187	4.398134	1.049536
20	15.47145	0.528553	0.12613
21	15.0631	0.936899	0.223574

PROBABILITY OUTPUT

Percentile	*Y*
2.380952	6
7.142857	8
11.90476	9
16.66667	12
21.42857	12
26.19048	13
30.95238	14
35.71429	14.5
40.47619	15
45.2381	15
50	16
54.7619	16
59.52381	16
64.28571	20
69.04762	21
73.80952	22
78.57143	23
83.33333	25
88.09524	27
92.85714	30
97.61905	38

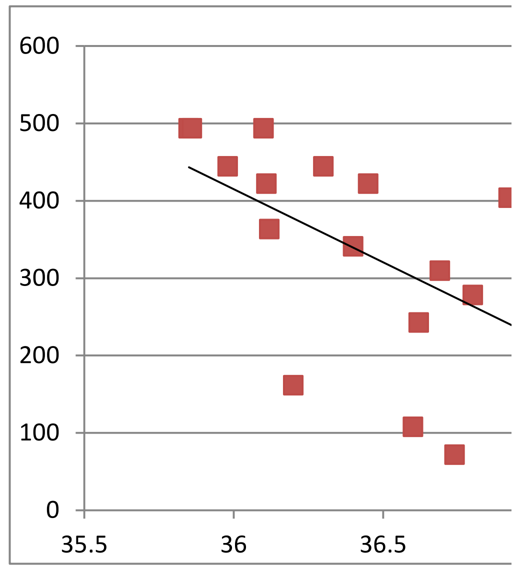
			BLM Flow	Piezo Level
2/16/2012	11:30	2/16/12 11:30	157	4.1923
3/20/2012	10:30	3/20/12 10:30	104	4.2263
5/16/2012	10:00	5/16/12 10:00	148	4.0283
6/14/2012	8:30	6/14/12 8:30	49	3.7983
7/17/2012	11:00	7/17/12 11:00	46	3.9885
9/20/2012	10:00	9/20/12 10:00	49	3.5181
10/17/2012	11:00	10/17/12 11:00	43	3.4459
11/27/2012	10:30	11/27/12 10:30	71	3.8427
12/17/2012	10:45	12/17/12 10:45	86.6	3.9075
1/24/2013	11:22	1/24/13 11:22	91.1	3.9349
2/22/2013	11:30	2/22/13 11:30	99.6	3.9979
3/19/2013	10:15	3/19/13 10:15	91.1	4.0135
4/10/2013	10:15	4/10/13 10:15	82.6	3.9765
5/15/2013	10:36	5/15/13 10:36	59.7	3.7108
6/10/2013	8:30	6/10/13 8:30	49.4	3.6153
7/19/2013	8:15	7/19/13 8:15	66.9	3.8362
8/19/2013	8:30	8/19/13 8:30	49.4	3.6187
9/17/2013	9.15	9/26/13 3:36	70.9	3.7448
10/25/2013	10:00	10/25/13 10:00	86.6	3.8333

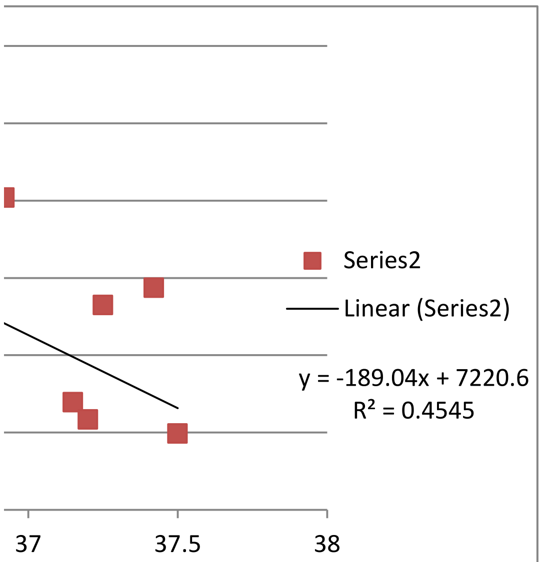




4
5
Series1
Linear (Series1)

		Frog Well Level	USGS Flow	GPM
4/27/2011	12:04	36.69	0.69	309.7134
5/18/2011	10:50	36.8	0.62	278.2932
7/18/2011	12:45	37.5	0.22	98.7492
9/21/2011	11:13	37.25	0.59	264.8274
10/28/2011	9:28	37.42	0.64	287.2704
11/29/2011	10:09	36.92	0.9	403.974
2/6/2012	8:32	36.45	0.94	421.9284
2/29/2012	10:30	36.3	0.99	444.3714
3/29/2012	14:36	36.1	1.1	493.746
4/18/2012	13:56	36.12	0.81	363.5766
5/23/2012	16:33	36.6	0.24	107.7264
7/3/2012	11:15	37.15	0.31	139.1466
8/14/2012	10:38	37.2	0.26	116.7036
11/1/2012	13:02	36.62	0.54	242.3844
12/18/2012	12:41	36.4	0.76	341.1336
1/30/2013	13:04	36.11	0.94	421.9284
3/1/2013	10:26	35.98	0.99	444.3714
29-Mar	10:10	35.85	1.1	493.746
4/11/2013	12:57	35.86	1.1	493.746
5/22/2013	14:05	36.2	0.36	161.5896
6/20/2013	12:46	36.74	0.16	71.8176




Series2
Linear (Series2)
y = -189.04x + 7220.6
R² = 0.4545
37
37.5
38

Summary of Refined FEIS Analysis - Number of Days with Zero Flow or Extremely Low Flow

	Current	50 Years				
		Low	Best-Fit	Best-Fit	Best-Fit	High
Empire Gulch-BLM	0	0	0	15	22	285
Empire Gulch-80% Low	0	0	0	7	22	197
Empire Gulch-80% High	0	0	0	15	58	307
EG - Modeled (Wrong locat	0			0		
UCC-BLM	0	0	0	0	8	103
UCC-BLM-80% Low	0	0	0	0	8	95
UCC-BLM-80% High	0	0	0	0	16	119
UCC-BLM-Modeled	0			0		
UCC-USGS	6	6	6	6	11	25
UCC-USGS-80% Low	6	6	6	6	9	18
UCC-USGS-80% High	6	6	6	6	11	35
UCC-USGS-Modeled	6			6		
FEIS Predictions for Comparison						
EG	4	4	4	146	352	362
UCC	4	4	4	4	4	146
Gardner Canyon	4	4	4	4	4	88

150 Years						
Low	Best-Fit	Best-Fit	Best-Fit	High	Low	Best-Fit
7	22	22	336	365	329	365
7	15	15	299	365	292	336
7	22	22	350	365	336	365
		22				
0	95	95	159	278	95	95
0	24	24	111	190	24	24
0	103	103	183	333	103	103
		8				
6	20	20	38	106	20	20
6	16	16	25	68	16	16
6	25	25	55	133	25	25
		11				
4	283	283	364	365	363	364
4	88	88	283	352	88	88
4	4	32	146	349	4	4

1000 Years		
Best-Fit	Best-Fit	High
365	365	365
365	365	365
365	365	365
95		
183	333	333
127	270	270
270	333	333
71		
93	143	143
68	106	106
117	172	172
23		
365	365	365
339	354	354
352	363	363