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January 29, 2013
HAND DELIVERED

Mr. Daron Haddock
Coal Program Manager
Utah Division of Oil, Gas & Mining
1594 West North Temple
Salt Lake City, Utah 84116

RE: Revised Probable Hydrologic Consequences Genwal Resources, Inc., Crandall Canyon Mine, C/015/0032, Task ID #4206

Dear Daron:

On behalf of Genwal Resources, Inc. ("**Genwal**"), enclosed as requested in your letter dated January 16, 2013 are two clean copies of the following documents/figures for the PHC revision to Chapter 7, Crandall Canyon Mine MRP;

1. PHC Figures 1-7;
2. Appendix 7-67: Petersen Hydrologic, LLC report dated November 7, 2011, Investigation of Iron Concentrations in the Genwal Resources, Inc. Crandall Canyon Mine;
3. Appendix 7-68: Phase I and Phase 2 Toxicity Identification Evaluations for the Crandall Canyon Mine. Water & Environmental Testing, Inc.
4. Appendix 7-69: Crandall Canyon Mine Macroinvertebrate Study. JBR Environmental Consultants, Inc.;
5. Appendix 7-70: Crandall Canyon Mine Iron Treatment Facility; and
6. Appendix 7-71: Petersen Hydrologic, LLC letter report to David Hibbs dated May 11, 2012.

We previously provided the fully executed C-1 C-2 forms for this submission. Thank you for your approval of this permit change.

Very truly yours,

Denise A. Dragoo

DAD:jmc
cc: David Hibbs
Jay Marshall
J. D. Leonard
Erik Petersen

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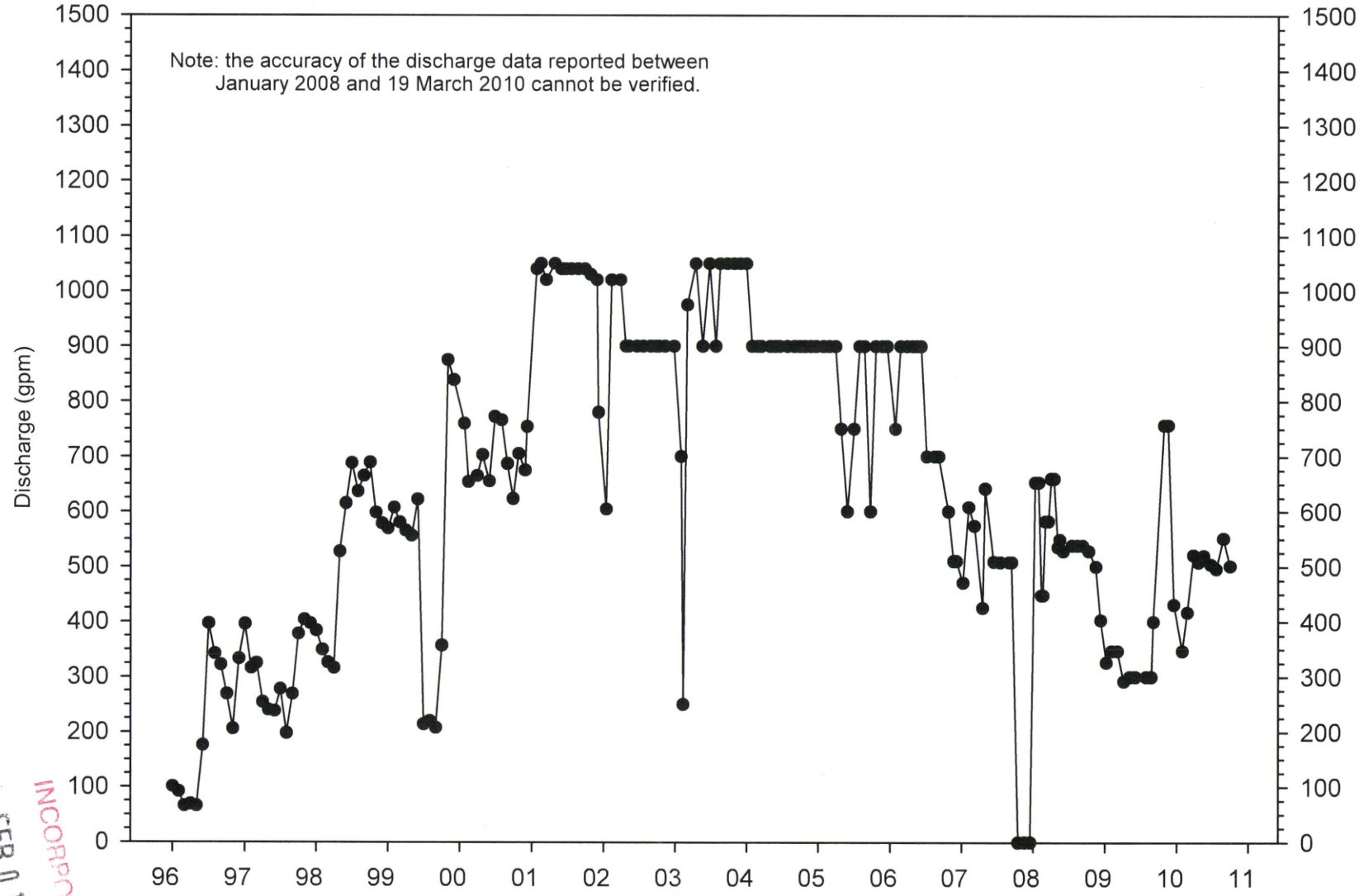

Figure PHC-1 Reported discharge for Crandall Canyon Mine (UPDES 002).

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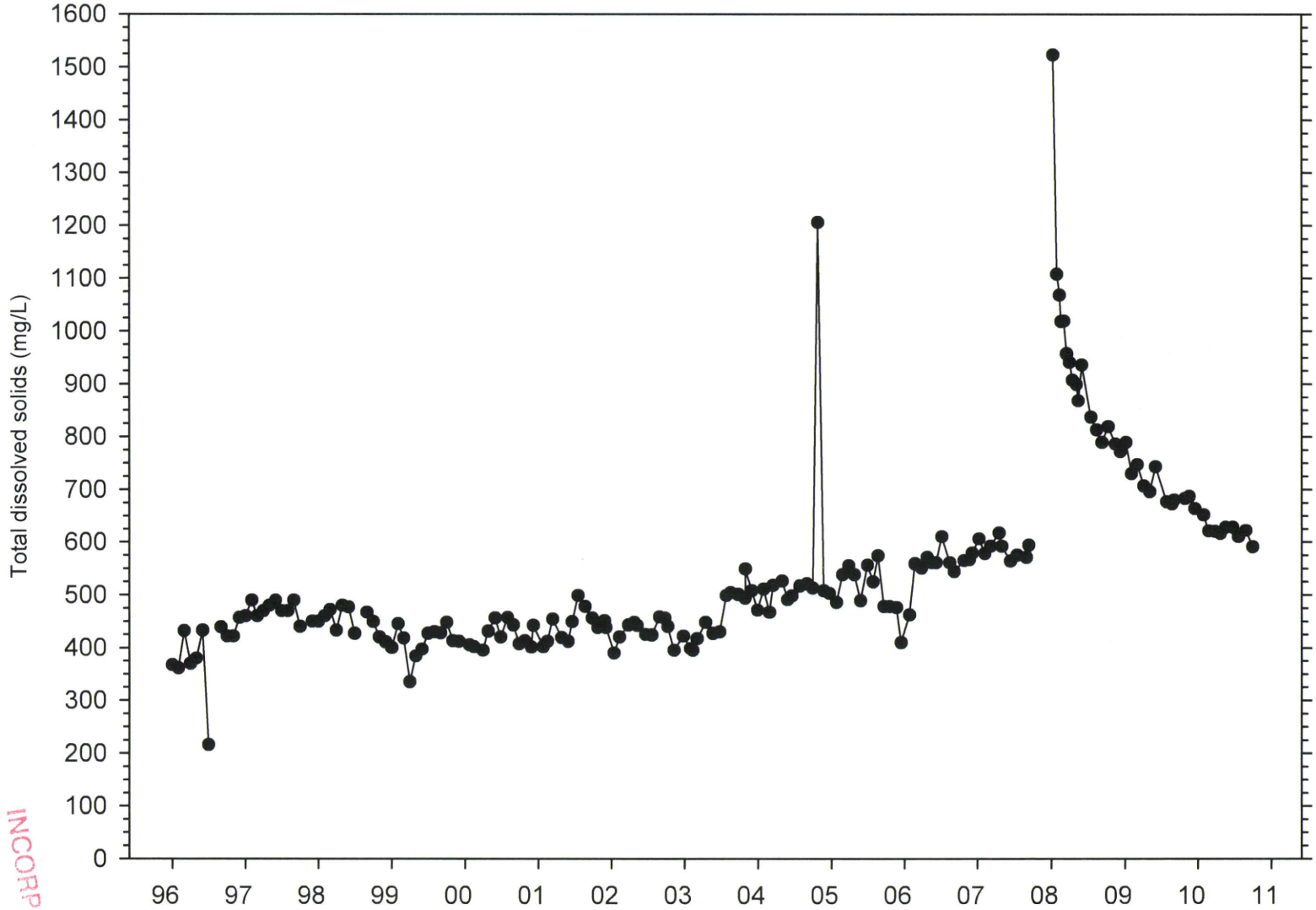

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Figure PHC-2 Total dissolved solids (TDS) concentrations of Crandall Canyon Mine discharge waters.

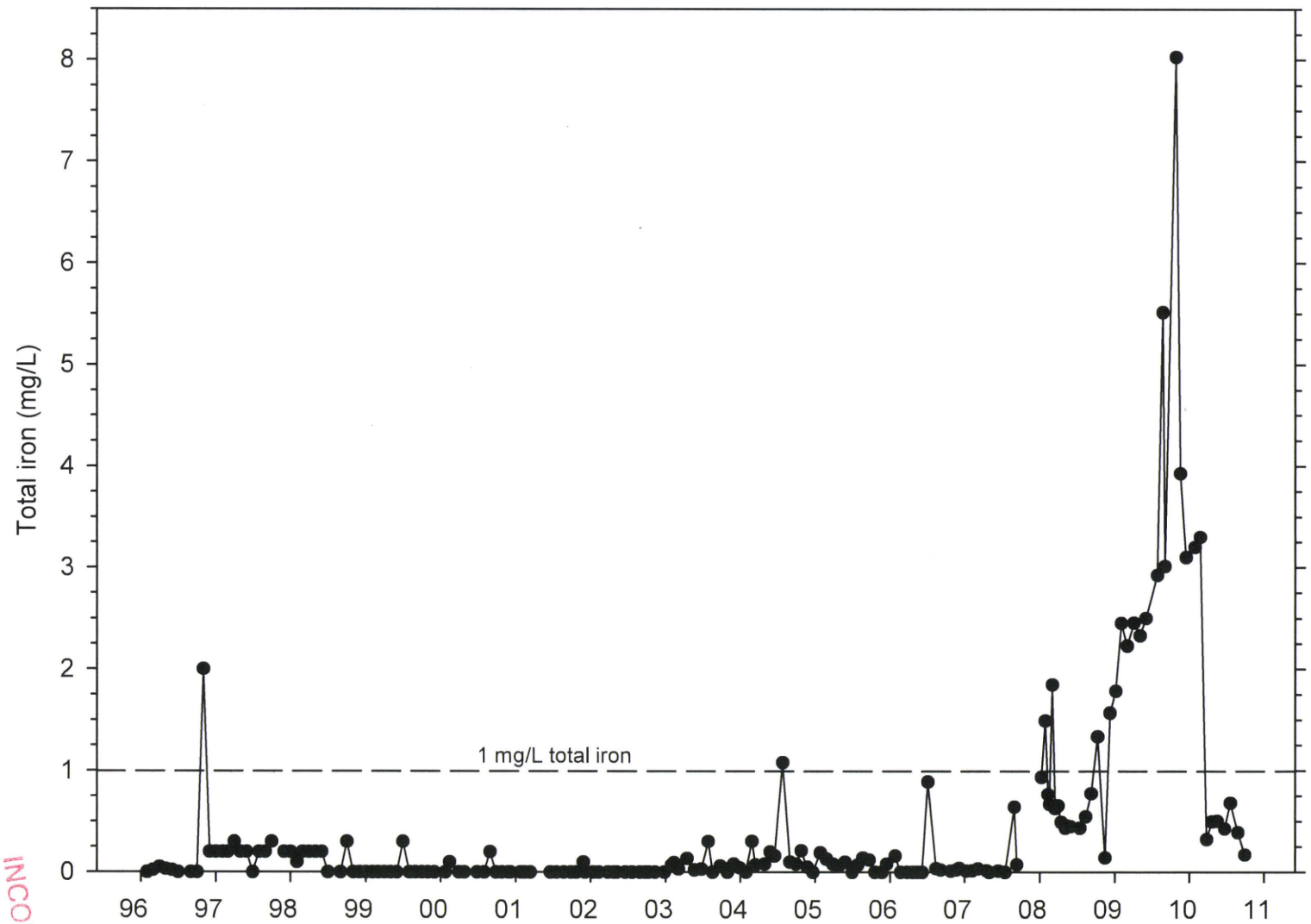

Figure PHC-3 Total iron concentrations of Crandall Canyon Mine discharge waters.

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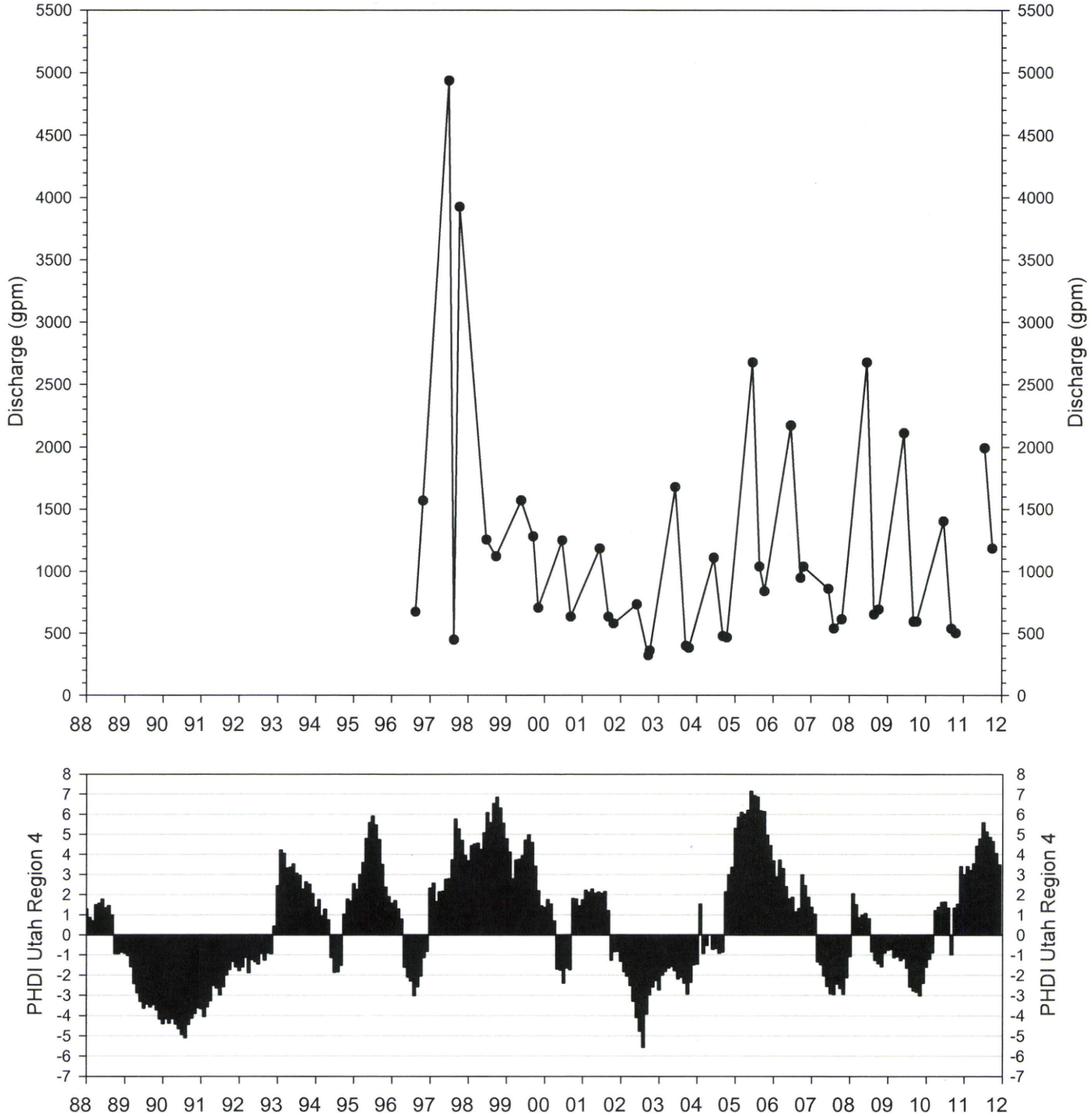

Figure PHC-6 Discharge hydrograph for Indian Creek and plot of the Palmer Hydrologic Drought Index (PHDI) for Utah Region 4.

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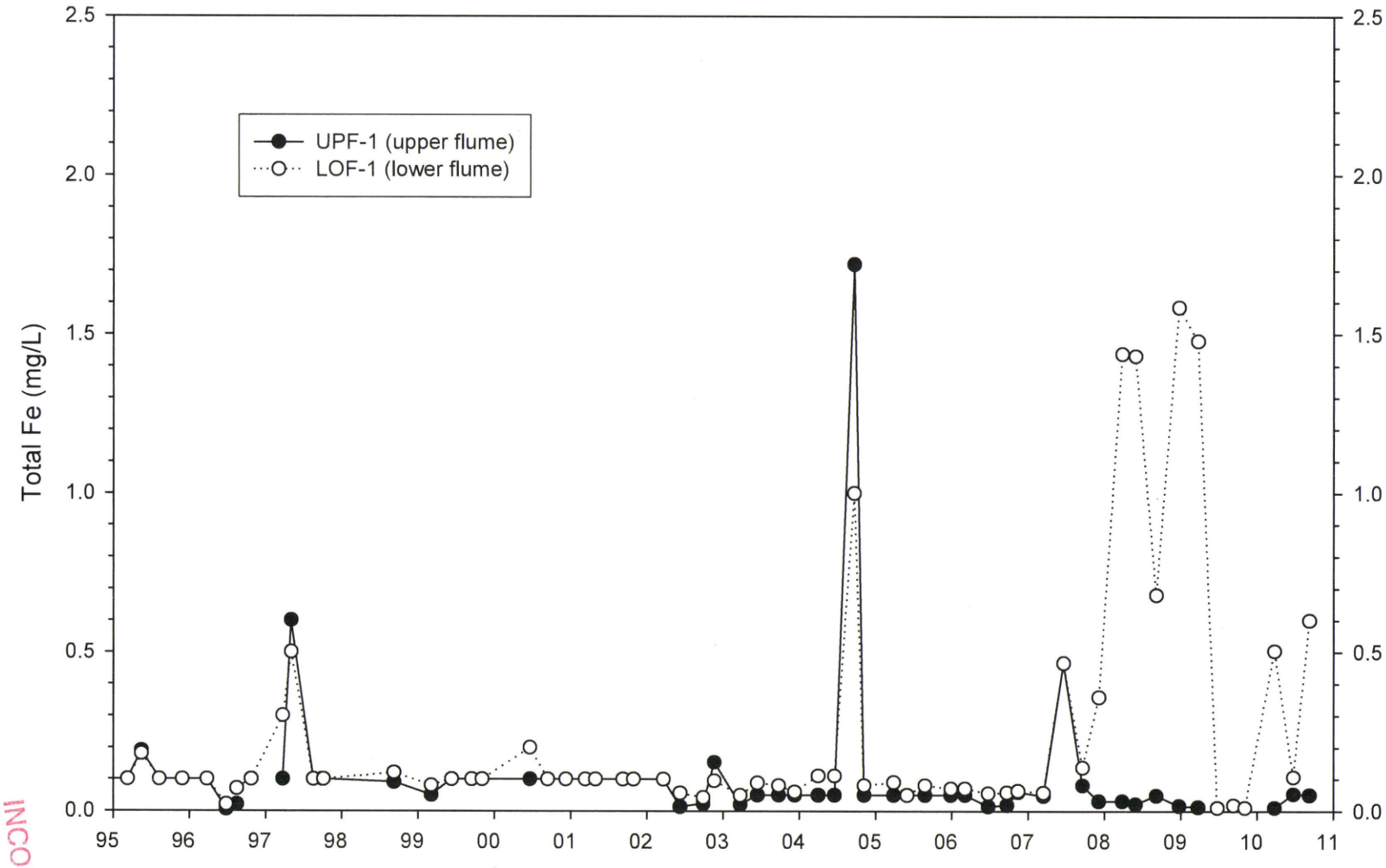

Note: for samples with non-detect laboratory results, the minimum laboratory detection limit value is plotted.

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Figure PHC-5 Total iron concentrations in Crandall Creek water as measured at the upper and lower flumes.

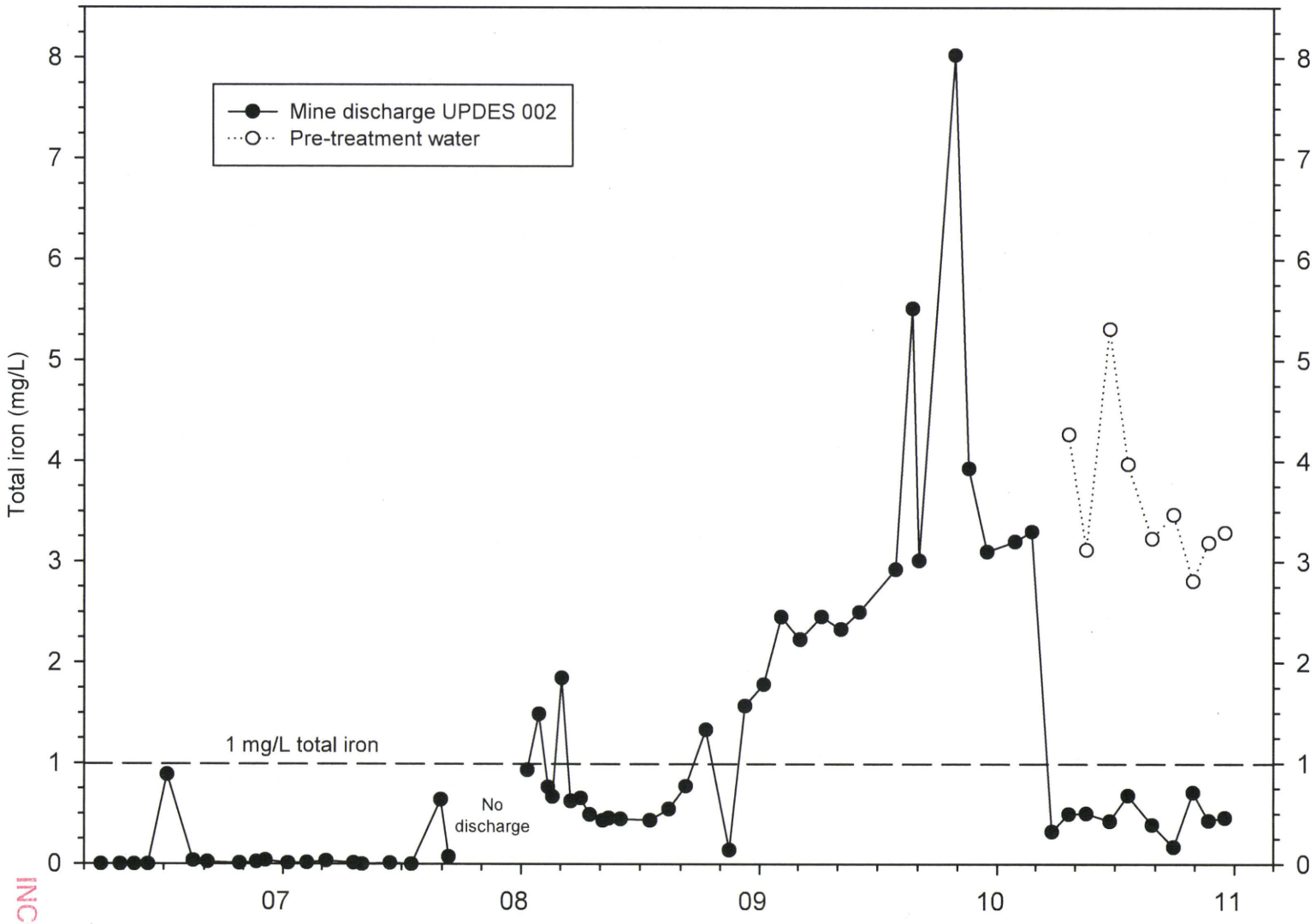

Figure PHC-4 Total iron concentrations of Crandall Canyon Mine discharge and pre-treatment water.

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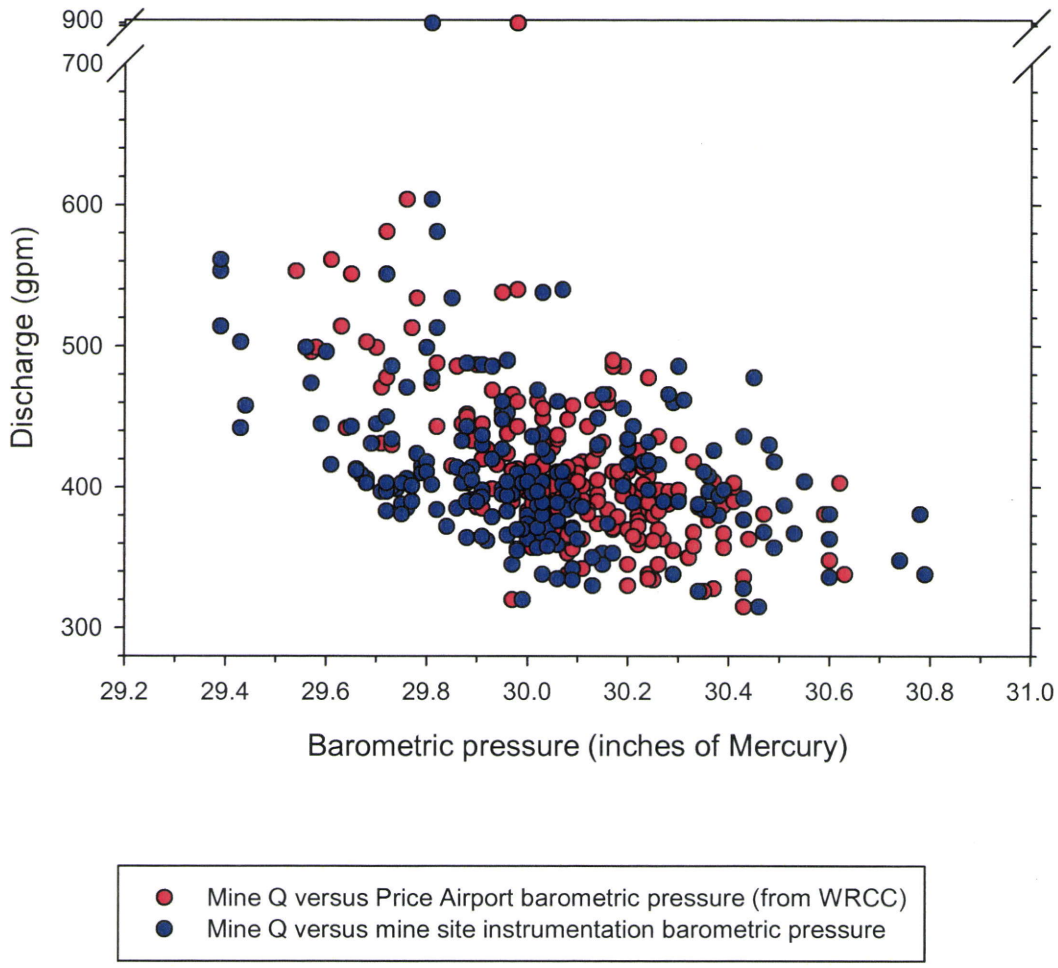

Figure PHC-7 Plot of daily discharge rate from the Crandall Canyon Mine versus barometric pressure.

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Appendix 7-67

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Investigation of Iron Concentrations in the Genwal Resources, Inc. Crandall Canyon Mine Discharge Water

7 November 2011

Genwal Resources, Inc.
Crandall Canyon Mine
East Carbon, Utah

PETERSEN HYDROLOGIC, LLC
CONSULTANTS IN HYDROGEOLOGY

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Investigation of Iron Concentrations in the Genwal Resources, Inc. Crandall Canyon Mine Discharge Water

7 November 2011

Genwal Resources, Inc.
Crandall Canyon Mine
East Carbon, Utah

Prepared by:

LICENSED PROFESSIONAL GEOLOGIST
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1.0 Introduction

The Genwal Resources Inc. Crandall Canyon Mine is located in the Wasatch Plateau coal field approximately 15 miles northwest of the town of Huntington, Utah (Figure 1). On August 6, 2007, a major event occurred near the Main West pillar section of the Crandall Canyon Mine. The Crandall Canyon Mine is in a period of approved temporary cessation. Because of the obvious unplanned nature of this event, the routing of mine waters in some portions of the mine could no longer be controlled as these areas were rendered inaccessible. On 12 September 2007 the mine pumps were shut-off and discharge of mine water to the surface ceased. During October, November, and December 2007, no mine water discharged from the Crandall Canyon Mine. Commencing in early 2008, mine water began to spill from the mine portals as portions of the sealed mine workings became filled to a topographic level that allowed gravity discharge of the mine water to the surface through the mine portals.

In early 2010, Petersen Hydrologic, LLC performed an initial investigation of iron concentrations in water discharging from the Crandall Canyon Mine. The results of our initial investigation were summarized in a letter report submitted to Mr. Dave Shaver of Genwal Resources Inc.

At the time this initial investigation was performed, iron concentrations in the mine discharge water had recently been increasing. The conclusions of our 25 February 2010 investigation are summarized as follows:

- The initial spike in TDS concentrations observed in the gravity discharge from the Crandall Canyon Mine in early 2008 was believed to be attributable to the dissolution

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of soluble minerals or other matter in inundated portions of the mine. Upon flushing of these materials from the flooded mine areas over time, the TDS concentrations of mine discharge water were at that time gradually returning to near-previous levels.

- It was our opinion that the elevated iron concentrations observed in Crandall Canyon Mine discharge waters subsequent to the commencement of gravity drainage from the mine were likely attributable to the oxidation of pyrite or other sulfide minerals in newly inundated mining areas. We believe that the Division is now in agreement with this conclusion. It should be noted that at that time of our initial consultations with the Division, it had been their opinion that the primary source of the iron in the Crandall Canyon Mine discharge water was likely from the rusting of mining machinery and other metals left underground.

- It was considered unlikely that substantially elevated iron concentrations (> 1 mg/L) [1] would persist over long periods of time in the mine discharge water. This conclusion was based on the assumption that either 1) the available pyrite in the flooded mine workings would eventually be consumed through oxidation reactions, and/or 2) the underground environment would eventually become oxygen depleted, minimizing the chemical potential for future pyrite oxidation. Consequently, prolonged discharges of mine waters with concentrations exceeding about 1 mg/L were considered unlikely. This conclusion was also based largely on 1) the fact that sustained, elevated concentrations of iron were not observed in Crandall Canyon Mine discharge water in the roughly 10 years of mine discharge prior to the mine flooding event, and 2) the concept that there is no reason to believe that any substantial change to the fundamental geochemical regime of the rocks and coals in the mine environment occurred during the August 2007 mine collapse event – other than the subsequent

[1] At the time of the previous report production, the Crandall Canyon Mine UPDES limit for total iron was 1.0 mg/L. The Utah Division of Water Quality has now assigned a total iron UPDES limit of 1.2 mg/L.

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flooding of some mine areas that had not previously been flooded with mine groundwaters when the mine pumps ceased their operation, and the emplacement of rubblized coal in mine openings in the mine collapse area.

2.0 New Hydrologic Data

Subsequent to the time of the production of our initial report, continuing routine collection of hydrologic data, including mine discharge water chemical compositions and mine discharge rate data, has occurred.

Genwal Resources, Inc. (Genwal) has continued to perform routine monitoring of mine water discharge rates and mine discharge water quality at the Crandall Canyon Mine (including sites UPDES 002 and the mine discharge water pre-treatment site. The requirements of the UPDES discharge permit specify a monthly monitoring frequency (12 per year) for the mine discharge water. Additionally, personnel from the Division collected 11 supplemental samples on a near-weekly basis during the period 10 March 2011 to 17 May 2011. During the last eight sampling events carried out by Division personnel, Genwal Resources, Inc. and Division personnel collected contemporaneous replicate samples. The mine discharge water samples (pre-treatment) were collected from a sampling manifold that is connected to the bottom of a raw mine water feed pipe at the iron treatment facility.

The Division-collected samples were analyzed by the Utah Unified State Laboratory. The Genwal samples were analyzed by an independent certified laboratory (SGS Mineral Services of Huntington, Utah). The total iron concentrations reported for the samples collected by Genwal and DOGM were generally in good agreement (although the results reported for the DOGM collected samples were always slightly lower than were the Genwal collected samples).

Samples of untreated mine discharge water were collected for laboratory analysis from a sampling port installed on a raw mine discharge water supply line at the Crandall Canyon

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Mine iron treatment facility. The sampling port is plumbed into the raw mine water discharge line such that it 'tees" from the bottom of the pipe. The port is constructed with a vertical length of pipe (projecting downward) with two gate valves installed to control the flow of water through the port. Water samples are collected from a length of flexible plastic tubing attached to the lower gate valve. While raw mine water flows continuously through the mine water discharge pipe, the attached gate valves are almost always left in the "off" position, being opened only immediately prior to the collection of water samples. A written sampling protocol was not incorporated into the sampling program.

As a part of this investigation, samples of groundwater discharging by gravity drainage from three nearby abandoned coal mines in the Wasatch Plateau coal district were collected and analyzed for iron content. The purpose of this investigation was to gain insight into whether the coal seams of the Blackhawk Formation locally support sustained, long-term discharge of groundwaters with elevated iron concentrations. The three mine sites sampled included the following:

1. Mohrland Portal (King Mine No. 2) located in Cedar Creek Canyon approximately 7 miles east of the Crandall Canyon Mine. The King Mine No. 2 was active from 1896 to 1938. Together with the King Mine, Hiawatha Mine, Blackhawk Mine, and the Miller Canyon prospects, this mining complex produced more than 51 million tons of coal.

2. Winter Quarters Mine, located in Winter Quarters Canyon approximately 16 miles north of the Crandall Canyon Mine. The Winter Quarters Mines were active from 1878 to 1940s. The total coal production has been estimated at 10.8 million tons.

3. Unnamed mine near the Joes Valley Fault in the upper Left Fork of Huntington Creek drainage approximately 4 miles north of the Crandall Canyon Mine (the period of operation and the total coal production amount is unknown).

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The nearby Huntington No. 4 Mine, located in Mill Fork Canyon approximately 2 miles south of the Crandall Canyon Mine was also inspected. The Huntington No. 4 Mine was reclaimed in the early 1980s. However, while gravity drainage of water from the reclaimed mine portal area had been observed by the author during the late 1990s, when the site was visited during late 2010, the discharge was no longer occurring.

3.0 Presentation of Data

The recent and historic discharge and water quality data from the Genwal Resources, Inc. monitoring activities at the Crandall Canyon Mine have been submitted electronically to the Division's coal water quality database. These data, which are utilized in this investigation, are freely available on the Division's internet site at: http://ogm.utah.gov/coal/edi/wqdb.htm.

A time-series plot of total iron concentration data for the Crandall Canyon Mine discharge waters are plotted on Figure 2 (For UPDES 002, Pre-Treatment Water, and Division-collected samples). A plot of the 6-month running average total iron concentrations in untreated Crandall Canyon Mine discharge water is presented in Figure 3. The 6-month running average data analysis technique for total iron concentrations in Figure 3 was implemented to simplify the analysis of longer term trends in the iron data. A 6-month running average value for a given month is obtained by calculating the average of the current month's laboratory result and the five preceding month's laboratory results. (It should be noted that during the second quarter of 2011, during which time a more frequent sampling interval was performed, the running average was calculated using the current and the five most recent data points). The running average data analysis technique typically results in a smoothed data plot which simplifies the identification of long-term trends while minimizing the noise and clutter of short-term data anomalies (such as potential sampling errors).

A plot of the monthly mine water discharge rates at the Crandall Canyon Mine is presented in Figure 4. A plot of the 6-month running average values for the mine discharge is presented in Figure 5 (the period during which there was no discharge from the mine during

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late 2007 was omitted from the running average flow rate calculation). A bar graph summarizing the average yearly mine water discharge rates are presented in Figure 6.

As mentioned by the Division in their 2 June 2011 Hydrologic Evaluation Update, several factors have complicated the performance of the mine water discharge flow measurements subsequent to the commencement of gravity mine water discharge at the Crandall Canyon Mine. (Prior to the temporary cessation of mining in 2007, flow measurements were generally performed using an in-line totalizing flow meter and are believed to be accurate). Accordingly, to independently determine the current discharge rate, an instantaneous discharge rate measurement was performed by Petersen Hydrologic, LLC on 18 October 2011. This measurement was performed at the outflow from the treatment facility to the UPDES 002 outflow point using a Marsh McBirney brand electromagnetic current velocity meter and wading rod. The result of that measurement (427 gpm) is similar to values recently reported to the Division by Genwal.

The results of the sampling of gravity mine water discharges from nearby abandoned coal mines is summarized in Table 1.

Laboratory reporting sheets are provided in the Appendix.

4.0 Discussion

As shown on Figure 2, after peaking in late 2009 and 2010, total iron concentrations in the mine discharge water have shown a gradual declining trend (see also 6-month running average plot in Figure 3). It remains our opinion that the iron in the discharge water is primarily derived from pyrite oxidation reactions in the flooded portions of the now sealed Crandall Canyon Mine. The Division is in agreement with this determination of the source of the iron (see the Division's Crandall Canyon Mine Hydrologic Evaluation Update, June 2, 2011). The observed general downward trend of the iron concentration data are consistent with our initial conclusion regarding the source of the iron and the conclusion that iron

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concentrations would decline over time. This decline is likely attributable to the combined affects of 1) chemical reactant depletion and reactant product flushing, and 2) the effects of preferential groundwater flow pathways.

The establishment of preferential groundwater flow pathways in an underground mining environment tends to enhance the effective flushing capacity of a given flow of groundwater as water is flushed continuously along the established pathways. Because of the relatively low rock/water ratio in an actively flushing preferential pathway area, there is an increased flushing potential in the actively flowing areas relative to the more stagnant, portions of the underground mine environment. In contrast, in the more stagnant portions of the underground flow regime (the "dead-end" mine entries for example) there is appreciably less movement of water passing the area, resulting in increased contact time of the stagnant water with surrounding rocks and coals and a greatly diminished potential for the transport of chemical reaction products away from the area.

In the professional experience of the author, it is not uncommon in Utah coal mines for waters gravity flowing from sealed mining areas to have appreciably better water quality characteristics (including lower iron concentrations) than do waters produced from relatively stagnant sealed areas by aggressive pumping and drawing down of pool levels. This effect is likely attributable primarily to the large differences in the rock/water ratios (See Mayo, Petersen, and Kravits, 2000) and increased residence times that exist between relatively stagnant, back-water portions of flooded mine workings and those portions of the flooded mine workings where water flow is actively occurring. In a similar way, it is likely that groundwater quality in those portions of the flooded Crandall Canyon Mine workings where preferential flow pathways to the surface have been established and active water flow conditions exist likely have improved water quality characteristics relative to the more stagnant, isolated portions of the mine.

The Division is wrong to conclude that somewhat elevated sulfate concentrations in the mine discharge water necessarily indicate that the rate of pyrite oxidation is not slowing. It is true

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that in some coal-mine geochemical regimes, the oxidation of pyrite is a dominant source of sulfate in associated mine discharge waters (and indeed, such may be the case in the Crandall Canyon Mine). However, it is not uncommon in coal mining environments that the dissolution of the evaporate minerals such as gypsum ($CaSO_4 \cdot 2H_2O$) or anhydrite ($CaSO_4$) can also be a major or principal source of sulfate in mine discharge waters. Locally in the Wasatch Plateau and adjacent areas, dissolution of other mineral species including thenardite (Na_2SO_4), mirabilite ($Na_2SO_4 \cdot 10H_2O$), and epsomite ($MgSO_4 \cdot 7H_2O$) may also be important sources of sulfate in groundwater. In the Division's analysis they incorrectly interpret Mayo, Petersen, and Kravits (2000) as stating that "*most sulfate in minewater discharge results from pyrite oxidation*". The findings of that investigation were from a case study of the Sufco Mine. In that study, while sulfide mineral oxidation was the primary source of sulfate in some portions of that mine, in other locations it was probably less significant than from the dissolution of gypsum or from other sources. The relative contribution of pyrite dissolution to sulfate concentrations described in the Journal of Hydrology paper was determined using site-specific solute and isotopic geochemical modeling (including $\delta^{34}S$ isotopic analysis). Indeed, as cited in the journal article, "Dissolution of gypsum, both native and gypsum dust previously used as rock dust, is also a significant contributor of SO_4^{2-}." Accordingly, it would not be correct to assume, as the Division did, that the modest increases in the sulfate concentrations in the Crandall Canyon Mine discharge water relative to surrounding groundwaters is wholly derived from pyrite oxidation.

As indicated in our previous report (Petersen Hydrologic, 2010), groundwater that flooded a large, sealed portion of the Skyline Mine (located about 11 miles north of the Crandall Canyon Mine) did not result in sustained discharges of mine water with elevated iron concentrations (see Figure 6 in Petersen Hydrologic (2010)). At the Skyline Mine location, fault-related groundwater inflow sources flowed into the mine workings and subsequently filled the sealed mining area by gravity flow. Upon reaching the elevation of the pumping station by gravity flow, the mine water was then pumped to the surface. After peaking in mid-2006, the iron concentrations in the mine discharge water declined gradually until

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reaching non-detect levels in mid 2009 (a period of approximately 3 years). It is noteworthy that this time frame is not inconsistent with the current trends in declining total iron concentrations at the Crandall Canyon Mine. The fact that the peak total iron concentration in the Skyline CS-14 discharge water was lower than that at the Crandall Canyon Mine may be a result of the appreciably greater magnitude of the flows encountered at the Skyline Mine location (several thousand gallons per minute at Skyline as compared to several hundred gallons per minute at Genwal – which is reflective of a considerably different rock/water ratio).

It is noteworthy that sulfate concentrations in the Crandall Canyon Mine discharge water (which ranged from 156 to 185 mg/L during the first 6 months of 2011) are not elevated relative to mine discharge waters from other Utah coal mines. Based on public information available from surrounding coal mines (UDOGM, 2011), it is evident that sulfate concentrations in mine discharge waters from surrounding coal mines that appreciably exceed 200 mg/L with total iron concentrations well below 1.2 mg/L are common. Notably, the sulfate concentration of mine water discharging from the Mohrland Portal (as monitored by the Bear Canyon Mine from 1994 to 2010; UDOGM 2011) averaged 329 mg/L, while total iron concentrations were consistently low (averaging less than 0.06 mg/L and not exceeding 0.10 mg/L). Most importantly, it should be stressed that regardless of the geochemical evolutionary pathway by which some of the sulfate in the Crandall Canyon Mine is derived, it is readily apparent that the total iron concentrations in the mine discharge water have declined appreciably in recent months (Figures 1 and 2) which is consistent with our previous projections of future declining total iron concentrations. The Division is wrong to conclude that iron concentrations have not declined and that the observed sulfate levels confirm that conclusion.

The Division's emphasis on geochemical reactions to explain the total iron content of the mine discharge is misplaced. The concentration of iron hydroxide particles in the mine discharge water at the mine mouth is largely controlled by the fluid flow regime within the mine, and not by the availability of chemical reactants or rates of reaction throughout the

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mine. The emergence of most of the iron in the discharge as solid iron hydroxide, rather than as aqueous dissolved iron species, demonstrates that the sequence of geochemical reactions discussed has largely reached its (irreversible) endpoint within the mine prior to discharge to the mine mouth. While the chemical reactions discussed at length by the Division predict that pyrite will dissolve upon contact with oxygenated water, and that a corresponding amount of solid iron hydroxide will subsequently form, they cannot predict the concentration of solid iron hydroxide in the discharge water.

The iron hydroxide particles emerge in the discharge because they are flushed from the mine workings by flowing water. Accordingly, they are only flushed from those portions of the flooded mine workings where the current velocity exceeds the settling velocity of the solid particles. If oxygenated water has reached the remainder of the flooded workings, and if pyrite is present, any iron dissolved and subsequently precipitated simply settles to the floor and does not contribute to the amount of iron reaching the surface (assuming an ample availability of oxygen as the Division asserts).

The flushing mechanism is significant because it demonstrates that only those portions of the flooded mine workings where the water current is strong enough to suspend iron hydroxide particles will contribute to observed total iron levels in the discharge (assuming a complete precipitation to ferric hydroxide in the presence of oxygenated water). Even if a large supply of unreacted pyrite exists elsewhere in the flooded workings, any iron liberated by its oxidation will not contribute to the observed iron discharge. Therefore, the Division's (unsupported) assumption that large amounts of pyrite exist in the mine has little value in predicting the extent and duration of iron-containing discharge at the mine mouth. It is more reasonable to conclude that the discharge of iron will persist only until the available precipitated iron has been flushed out of that portion of the mine where the current is swift enough to keep the particles suspended in the flow.

The Division is wrong to conclude that the recent total iron data, and in particular the single data point associated with a spike in total iron concentration observed on 27 April 2011,

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provide a scientific basis for concluding that total iron concentrations are not declining in the Crandall Canyon Mine discharge water. It is noteworthy that sharp, short-lived upward spikes in the total iron concentrations in samples from the mine discharge water have occurred periodically in the sampling history (Figure 2). However, downward spikes (relative to a more constant lower base concentration) are only rarely observed. It is my professional opinion that these upward spikes are likely a result of the inclusion of solid iron-bearing particulates in the collected water samples which elevate the measured total iron concentration above the current base (non-spike) level. This conclusion is supported by a close examination of the iron concentration data associated with a total iron spike (6.68 mg/L) that occurred on 27 April 2011 (UDOGM, 2011). When the total iron concentration was monitored only six days later (on 3 May 2011), the concentration was only 2.05 mg/L. It seems exceedingly unlikely that the bulk chemical composition of the iron concentration of the large volume of water held in the mine varied by more than 325% during that six day period. Rather, it seems much more likely that the measured spike was attributable to the inclusion of suspended iron hydroxide particulate matter in the collected water sample, which could have originated from any of several possible sources. As shown on Figure 8, for the Division to conclude that data from an anomalous single sampling event, which is bracketed both prior to and after the anomalous event by relatively constant data with a much lower total iron concentration from at least 12 monitoring events (22 laboratory analyses) over a time period of just 82 days does not seem justified.

To understand this condition, it should be remembered that the iron measured in a total iron (or total recoverable iron) analysis includes two fractions. These include 1) the iron that is present in the dissolved (filterable) form in the water, and 2) any additional iron that may be included in the water sample, which can include solid, iron-bearing particulate matter. A laboratory dissolved iron analysis measures the dissolved iron (ferrous and/or ferric ionic species) in a water sample. The dissolved iron analysis is performed by first filtering the water sample through a 0.45µm filter which removes any particles larger than 0.45µm (which would include any suspended iron hydroxide particles present in the sample), leaving only the dissolved ionic iron species in the water sample (note that the average dissolved iron

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concentration in the Crandall Canyon Mine discharge water for the first six months of 2011 is only 0.36 mg/L).

By comparison, a total iron analysis is performed on a raw water sample that includes the dissolved fraction plus any particulate matter that may be present at the time of sampling. Such matter could include dirt, rust particles from metal pipes, or suspended iron-hydroxide precipitate which is pervasive throughout the Crandall Canyon Mine discharge piping, treatment system, and sampling ports and apparatus. Prior to the performance of the total iron analysis, the contents of the sample (water and any included particulate matter) are digested under heat using a strong acid to convert solid iron-containing matter into ionic iron species that are included in the analysis. Accordingly, any iron contained in the particulate matter at the time of sampling is included in the total iron laboratory result.

As part of this investigation, we have specifically evaluated the 27 April 2011 total iron spike in the Crandall Canyon Mine discharge pre-treatment water sample (Figure 2). On 18 October 2011 the mine discharge pre-treatment sampling site located at the Crandall Canyon Mine iron treatment facility was visited and inspected by the author. Information regarding previous sampling procedures followed by Genwal and Division personnel during the collection of pre-treatment water samples was reviewed with Genwal personnel (Personal communication, Dana Marrelli, 2011). During this visit, a sample of the raw mine water (pre-treatment) was collected. In order to assure that as much particulate matter was flushed from the sampling port as possible, an extended purging of the sampling port was performed during this sampling event. For visual inspection of the progression and completeness of the purge, new, unpreserved plastic bottles were filled with the purge water at approximately 15-minute intervals. Sample containers filled with water from the first approximately 45 minutes of the purge were subsequently photographed (See Photograph Section of this report). Upon visual inspection, it is immediately apparent that the bottle filled with water after a purge period of approximately 15 minutes contained appreciably more suspended iron hydroxide particulate matter than did the sample collected after 30 minutes of purging. After approximately 45 minutes of purging, the collected sample contained visibly less iron

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particulate matter than did the sample collected after approximately 30 minutes of purging, though the difference was less substantial than between the first two samples.

The significance of this observation is that it clearly suggests that iron hydroxide particulates were being flushed from the sampling apparatus for at least the first ½ hour subsequent to the opening of the sampling port valve. This condition is likely related to the design of the sampling port, with the apparatus (which likely contains lots of "nooks and crannies" associated with the valves and couplings) being suspended below the larger raw water feed line. In other words, iron hydroxide particles can accumulate in this "sump" during the extended periods of time the valve is left in the "off" position. Depending on the fluid velocities, the degree of solidification or compaction of the particulate matter within the port, and the amount of iron particulate that may have accumulated since the port was last purged, it may require an appreciable amount of time for the particulate matter to be completely flushed from the sampling system. Additionally, it is possible that iron hydroxide particulate matter may accumulate in some locations within the raw water feed pipes upstream of the sampling port. While some particles may adhere to the inside of a pipe under the constant, laminar flow conditions, when the fluid dynamics in the pipe are altered by the opening of the sampling port valve (e.g. inducing turbulence) some of these particles may become dislodged and flow into the sampling port. In the absence of any written protocol, Genwal personnel have routinely collected samples of the pre-treatment water after a purge of only a few to several minutes. It is apparent that in collecting their replicate samples of mine discharge pre-treatment water, Division personnel likewise may not have allowed a sufficient purge time before collecting their samples (Personal communication, Dana Marrelli, 2011). It is interesting to note that, as indicated by Genwal personnel, it was generally the case that when the replicate samples of the pre-treatment water were collected by Genwal and the Division, the Division samples were typically collected after the Genwal sampling had been completed. Whether the additional purge time that transpired between the collection of the Genwal samples and the later collection of the Division samples contributed to the observed uniformly lower total iron concentrations determined from the Division's samples is unknown. However, it seems likely that during the 27 April 2011 replicate monitoring event,

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the purge state of the sampling port at the time of sampling was likely not complete and this condition may have resulted in the iron spike determined at the laboratory. This conclusion is based on the fact that the total iron samples from that date were collected perhaps a few minutes apart. However, the total iron concentrations measured by Genwal and the Division (6.68 mg/L and 5.0 mg/L) vary by 1.68 mg/L. The analytical laboratory utilized by Genwal (SGS Minerals Services of Huntington, Utah) reports a detection limit of 0.05 mg/L for the total iron analysis. Assuming similar accuracy in the total iron determination performed by the Utah Unified State Laboratory, then it is follows that the total iron concentrations in the two sample containers at the time of collection were not the same, and that the sample collected by the Division after the collection of Genwal's sample contained less total iron. This observation suggests the possibility that the samples collected on 27 April 2011 were likely collected prior to the complete flushing of the sampling port apparatus. Accordingly, the elevated iron concentrations measured on that date were likely associated with the inclusion of an unrepresentative amount of iron hydroxide particulate matter flushing from the sampling port, and not as a result of a spike in the total iron concentration in the Crandall Canyon mine discharge water itself (in other words, this was likely a sampling error).

While we cannot determine with certainty the causes of all of the total iron spikes that have occurred in the past, it is my professional opinion that the lack of an adequate purging of the sampling port, raw mine water feed piping, or other portions of the sampling apparatus could likely have been largely responsible for the observed spikes that have occurred while the sampling apparatus has been operative in its current condition.

It should be noted that the since March 2010 total iron concentrations of the mine discharge waters monitored at UPDES 002, which have undergone chemical treatment at the mine's iron treatment facility, have been continuously below 1 mg/L and in compliance with the UPDES permit requirements.

While it seems to be the position of the Division that extreme, unprecedented changes to the groundwater regimes at the Crandall Canyon Mine occurred as a result of the August 2007

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"catastrophic mine collapse", we do not see evidence that such is the case. This conclusion is based on the fact that:

1) The rate of discharge from the Crandall Canyon Mine at the commencement of mine water gravity discharge is essentially the same as it was just prior to the 2007 collapse event, and the gradual decline in discharge rates that began in the early 2000s (Figures 4, 5, and 6) continues, suggesting that interception of groundwater from any potential newly-fractured overlying horizons resulting from the collapse has not occurred. It is noteworthy that in down-hole videos of the emergency mine rescue drill holes in the collapse area that were reviewed by the author, it was apparent that the coal rubble present in the entryways likely originated primarily from rib bursts, while the mine roof rock appeared to be largely intact. Observations of video footage of the rock strata within the boreholes immediately overlying the coal seam likewise did not appear to have been catastrophically impacted.

2) The Division cites an MSHA report[2] indicating that the area of collapsed pillars associated with the 2007 event is on the order of 40 acres, which is not dissimilar in general scale to the size of a typical Crandall Canyon Mine longwall panel, and is much smaller than the adjacent mining areas situated immediately to both the north and south, which experienced years of longwall-related subsidence,

3) Four years of quarterly hydrologic monitoring data collected from springs and streams overlying and surrounding the area of the collapse event have not shown any pronounced changes in discharge rates, water quality characteristics, or any other observable conditions that could be attributed to the 2007 collapse event (UDOGM, 2011).

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[2] Genwal Resources, Inc. does not endorse the accuracy or the conclusions in the MSHA report referenced by the Division.

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The Division indicates in its 7 June 2010 report that in the future "the flow path of the mine-water could be easily altered and previously non-exposed areas of pyritic material could become inundated with mine water". Their conclusion is entirely speculative. While it is possible that some additional subsidence of the overburden overlying the Crandall Canyon Mine workings could occur in the future, the fact that now more than four years have transpired without the occurrence of any major ground movement seems to minimize the likelihood of such an occurrence in the future. Particularly, the potential for movement within the mine workings of a magnitude that would cause a substantial change to the topographic gradient of the mine floor, to the extent that previously dry mining areas would become flooded, seems highly unlikely.

In the findings section of their 2 June 2011 hydrologic evaluation update, the Division finds that "The Crandall Canyon Mine has been discharging for approximately 14 years. There has been no indication of diminution of flow, nor is there any indication that the flow will diminish in the foreseeable future". This conclusion is incorrect. As plotted in Figure 4, it is readily apparent that after peaking in the early 2000s, the mine discharge rate plot indicates a downward trend beginning around 2004. This trend is more readily discernable in the 6-month running average plot for mine discharge shown in Figure 5. Additionally, the yearly-average mine discharge rates plotted in Figure 6 show an obvious generally declining trend, and do not correlate with recent climatic trends. It is notable from Figure 6 that the average yearly discharge rate for 2011 (first 6 months) is less than half the average rate for 2001, clearly demonstrating the declining trend in mine water discharge rates. Although a detailed analysis of the reasons for the declining mine discharge water flow rates is beyond the scope of this investigation, the observed declines are likely the result of two main factors. These include 1) with a decrease in the mining rate or a cessation of mining activities, the potential for the underground interception and exposure of water-bearing features in the subsurface is minimized or ceases, and 2) over time it is common for discharge rates from intercepted underground water-bearing features in the Wasatch Plateau coal district to decline as the contained water is gradually drained.

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Genwal Resources personnel indicate that recent increases in the mine discharge rate seem to correlate with the passage of weather fronts or the onset of cold weather (Personal communication, Dana Marrelli, 2011). It is important to note that these flow rate changes occur even in the absence of *any* associated precipitation. This seems to suggest the likelihood that the temporary increases in mine water discharge rate are associated with barometric pressure effects acting on the underground mine pool. There is no indication that the occasionally observed increases in flow are in any way tied to any potential nearly immediate infiltration of precipitation waters into the underground mine workings.

Long-term iron discharges from coal mines in the Blackhawk Formation in Utah's Wasatch Plateau mining district are not known to occur. In order to better understand whether the coal seams of the Blackhawk Formation locally support sustained, long-term discharge of groundwaters with elevated iron concentrations (as assumed by the Division), gravity discharges from three abandoned coal mines were inspected and sampled as part of this investigation. Gravity discharge of mine groundwater has occurred from each of the three visited mines for many years. The discharge rates for these mines range from a few gallons per minute at the Winter Quarters and Left Fork mines to several hundred gallons per minute at the Mohrland Portal. Neither total nor dissolved iron concentrations at any of the three mine discharges exceeded 0.05 mg/L (Table 1). In other words, the iron concentrations in these abandoned mine discharges are at least ***24 times*** below a 1.2 mg/L UPDES limit. While this information does not does not of itself indicate when discharge of groundwater with elevated iron concentrations at the Crandall Canyon Mine will abate, it does strongly support the conclusion that the geochemical regimes in these three surrounding lower Blackhawk Formation coal mines do not support long-term discharges with elevated iron concentrations.

5.0 Projections of Likely Future Iron Concentrations

Prior to a discussion of potential future iron concentration trends at the Crandall Canyon Mine, it is important to emphasize that because the mine workings are sealed, it is not

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possible to observe physical conditions within the Crandall Canyon Mine workings. Consequently, our capability to fully characterize the underground hydrogeochemical regime is limited. However, based on the existing data set and upon our previous professional experience relating to iron geochemical behavior in underground mining environments, as part of this investigation, we have provided projections of possible future trends in iron concentrations in the Crandall Canyon Mine discharge water. It should be emphasized that the projections provided here should not be considered to be absolute predictors of future iron concentrations over time in the mine. Rather the plotted trends are provided to show reasonably plausible future trends for future iron concentrations based on the existing data and professional experience. Importantly, these trends are provided to illustrate the likely magnitude of future trends (i.e., with concentrations likely declining to levels below 1.2 mg/L within in a few years, not decades). These trends are shown graphically on Figure 7.

The first projection shown on Figure 7 (in blue) shows a mathematically calculated statistical linear regression of the pre-treatment data for the period 21 April 2010 through 18 October 2011. The linear regression line (which essentially assumes that the recent total iron concentration trends will continue into the future) intercepts the 1.2 mg/L UPDES limit at approximately mid-2012. This projection appears visually consistent with the existing historical data assuming that the declining concentration limb of the recession curve is quasi-symmetrical with the increasing limb of the curve.

It is likely that the future trend in the total iron concentration will follow an exponential decay curve. Such a decay curve was observed previously in the Crandall Canyon Mine discharge data for the total dissolved solids concentration of mine discharge water subsequent to the onset of gravity drainage (See Figure 3 of the Petersen Hydrologic (2010) report). A reasonably plausible exponential decay curve trend for total iron concentrations in the Crandall Canyon Mine discharge water is shown in green on Figure 7. The plotted exponential decay curve trend intersects the 1.2 mg/L total iron concentration line at approximately the end of 2013. Again, it should be emphasized that this projection is intended for use as a reasonable predictor of the order of future decline rates and is not

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intended as an absolute prediction of future concentrations. However, it should be noted that because the most recent total iron concentration in the mine discharge water (2.15 mg/L) is only 0.95 mg/L above the UPDES discharge limit, it would be difficult to draw a reasonable hypothetical decay curve that would intersect the 1.2 mg/L line at a time significantly further in the future than that plotted on Figure 7.

6.0 Conclusions

- It remains our opinion that the elevated iron concentrations observed in Crandall Canyon Mine discharge waters are likely attributable to the oxidation of pyrite or other sulfide minerals in flooded portions of the mine. While the minor dissolved iron fraction of the total iron present in the mine discharge water is transported in the aqueous solution, the more substantial iron hydroxide particulate fraction is transported only where the water current is sufficient to flush the solid particles to the discharge location.

- We are not aware of any special geologic conditions at the Crandall Canyon Mine that would result in probable long-term elevated concentrations of total iron in the mine discharge water. The fact that historic (pre-2007) total iron concentrations in Crandall Canyon Mine discharge waters were consistently low, even though most of the mine discharge water was historically collected from the mine floor after running considerable distances through mine longwall gob areas and elsewhere over the mine floor, does not suggest that there is any unusual iron-generating potential in the Crandall Canyon Mine geochemical environment relative to other mines in the region.

- An investigation of gravity mine-water discharges from three surrounding abandoned coal mines suggests that long-term discharges with elevated iron concentrations from the coal seams of the lower Blackhawk Formation will not occur.

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- It remains my professional opinion that the iron concentrations in the Crandall Canyon Mine discharge water will likely continue to decline over time as the necessary reactants are gradually consumed and flushed from actively flowing portions of the flooded underground mine workings. It is also my professional opinion that iron concentrations in the mine discharge water will likely not exceed the UPDES limit of 1.2 mg/L for a prolonged period of time.

- Based on the projections presented in Figure 7, it is apparent that the iron concentrations in the Crandall Canyon Mine discharge water will likely drop below 1.2 mg/L within a reasonable timeframe, likely on the order of a few years (not decades). Extrapolating a future exponential decay curve from recent trends, as shown on Figure 7, this condition could occur perhaps by the end of 2013. In my professional opinion, there is no reasonable potential for a "perpetual" discharge of mine water with elevated total iron concentrations.

- Elevated sulfate concentrations do not necessarily evidence high rates of continuing pyrite oxidation. In their 2 June 2011 findings, the Division indicates that "there is no indication that the rate of pyrite oxidation is slowing". In the general sense, this conclusion is not consistent with the total iron data that has been presented to the Division, which clearly shows a declining iron concentration in mine water since about early 2010. The Division apparently bases this conclusion largely on the sulfate concentrations of the mine discharge water (which conclusions are based at least in part on a flawed interpretation of the Mayo, Petersen, and Kravits (2000) Journal of Hydrology article). Regardless of the geochemical evolutionary pathway by which some of the sulfate in the Crandall Canyon Mine is derived, it is readily apparent that the total iron concentrations in the mine discharge water have declined appreciably in recent months, which is consistent with our previous projections of future declining total iron concentrations.

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- Iron concentrations are declining toward compliance levels. We find no basis for the Division's assertion in their 2 June 2011 finding that "iron concentrations have not declined". This conclusion appears entirely inconsistent with the data plotted in Figures 2 and 3. We vigorously disagree with this finding.

- There are no data to support an expectation of perpetual iron-containing discharge from the Crandall Canyon Mine. The Division's 2 June 2011 finding that "the available data support the likelihood of a perpetual discharge of mine water containing elevated concentrations of iron which will require treatment into the foreseeable future" seems to ignore the current trends in total iron data as plotted in Figures 2 and 3. We vigorously disagree with this finding.

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7.0 References Cited

Mayo, A.L., Petersen, E.C., Kravits, C., 2000, Chemical evolution of coal mine drainage in a non-acid producing environment, Wasatch Plateau, Ut., Journal of Hydrology 236: 1-16.

Petersen Hydrologic, LLC, 2010, Investigation of iron concentrations in mine discharge waters from the Genwal Resources, Inc. Crandall Canyon Mine, unpublished consulting letter report to Mr. Dave Shaver of Genwal Resources, Inc.

UDOGM, 2011, DOGM on-line water quality database, http://ogm.utah.gov/coal/edi/wqdb.htm

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Figure 1 Location of the Genwal Resources, Inc. Crandall Canyon Mine.

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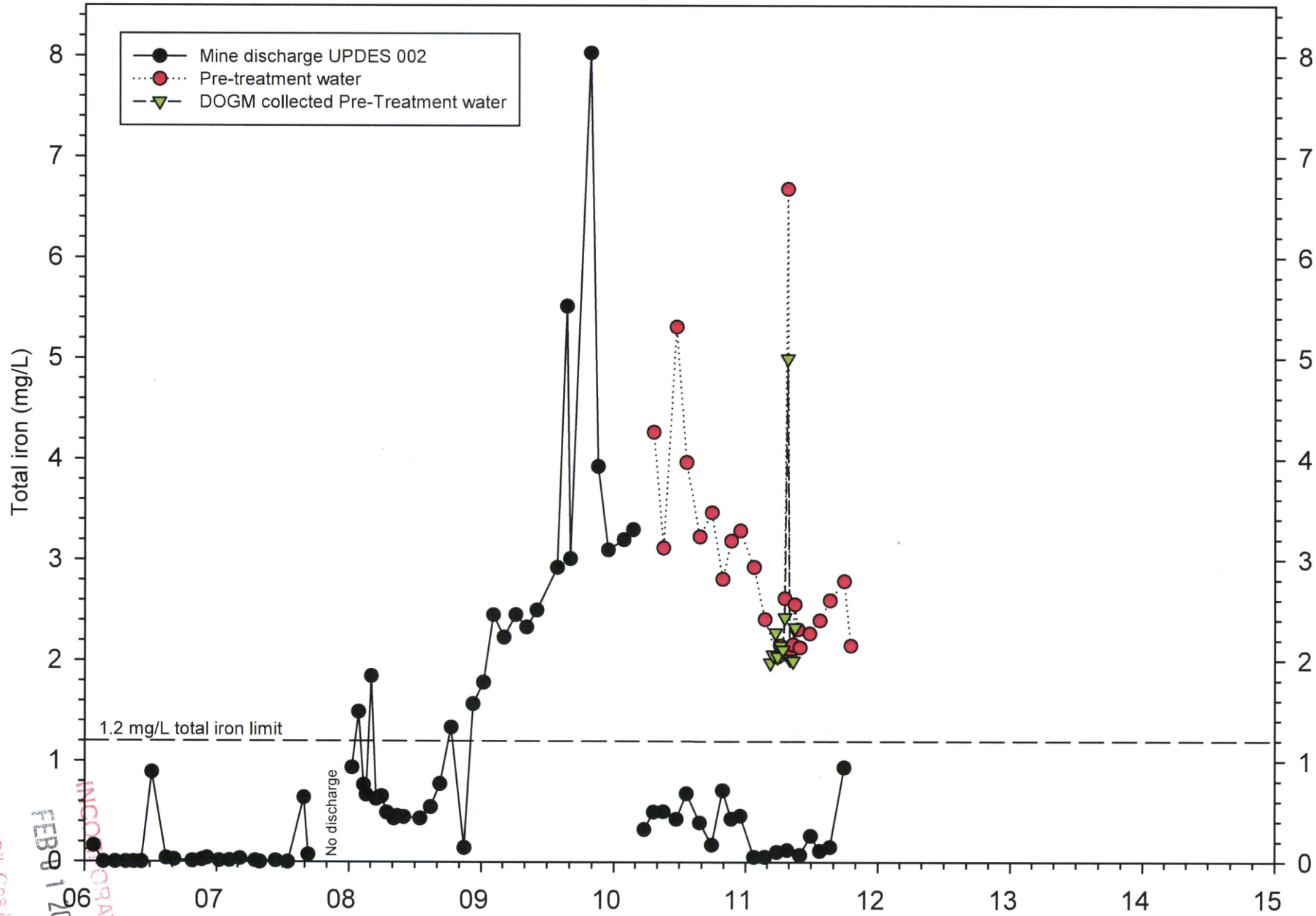

Figure 2 Plots of total iron concentrations in Crandall Canyon Mine discharge water and treated mine discharge water.

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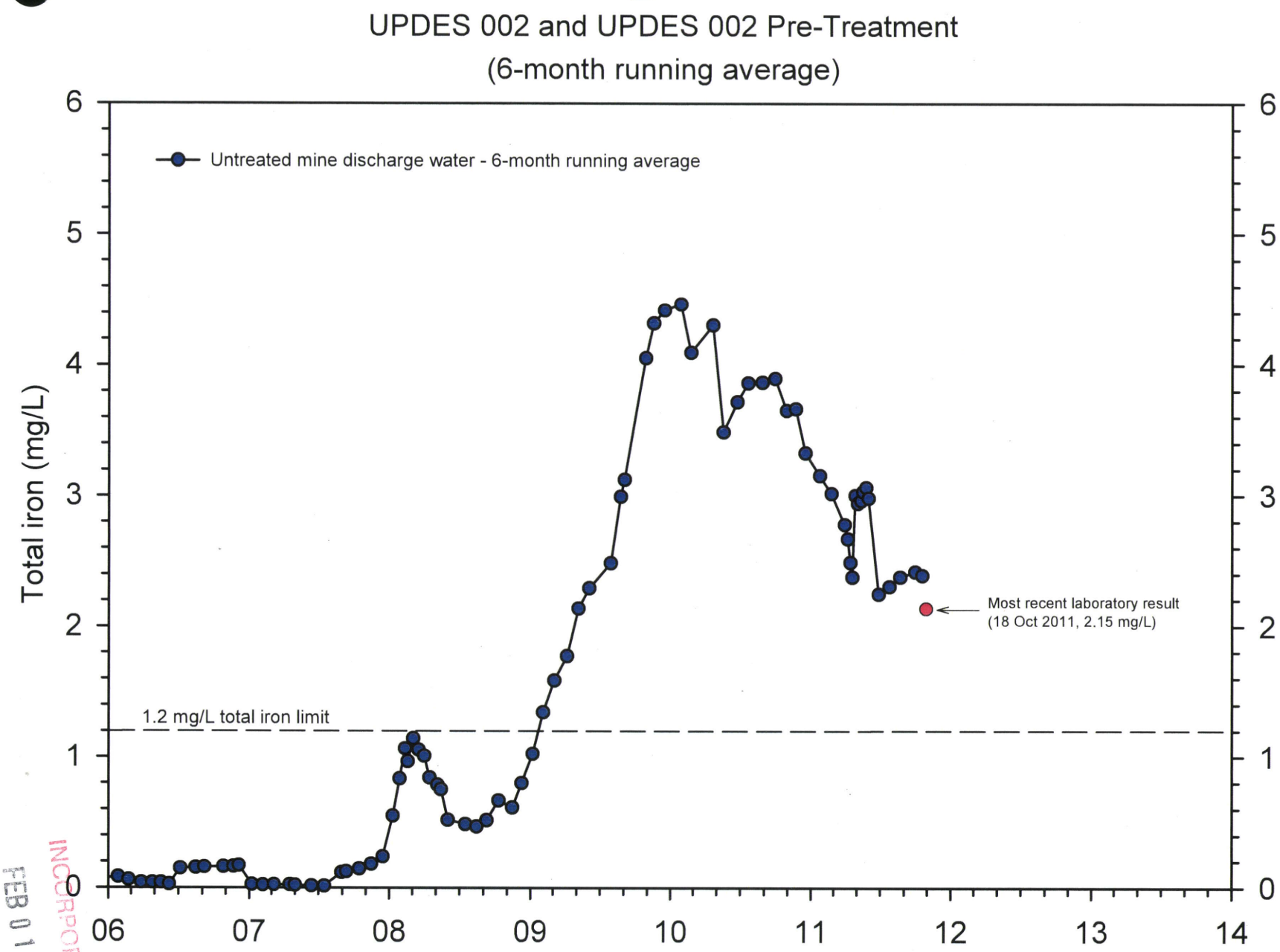

Figure 3 Plot of 6-month running average of total iron concentrations in untreated Crandall Canyon Mine discharge water.

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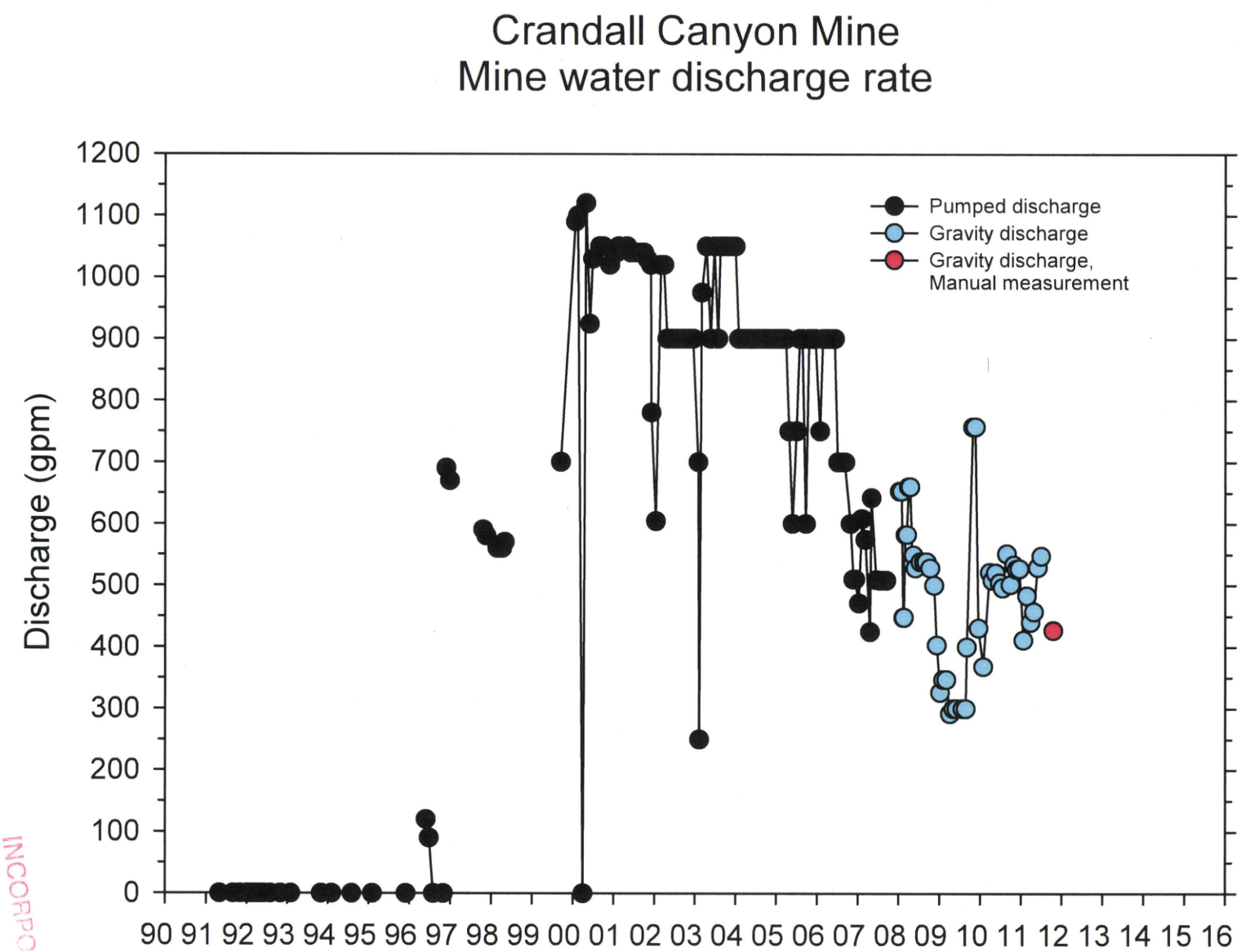

Figure 4 Plot of Crandall Canyon Mine discharge rates.

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Crandall Canyon Mine
Mine water discharge rate
(6-month running average)

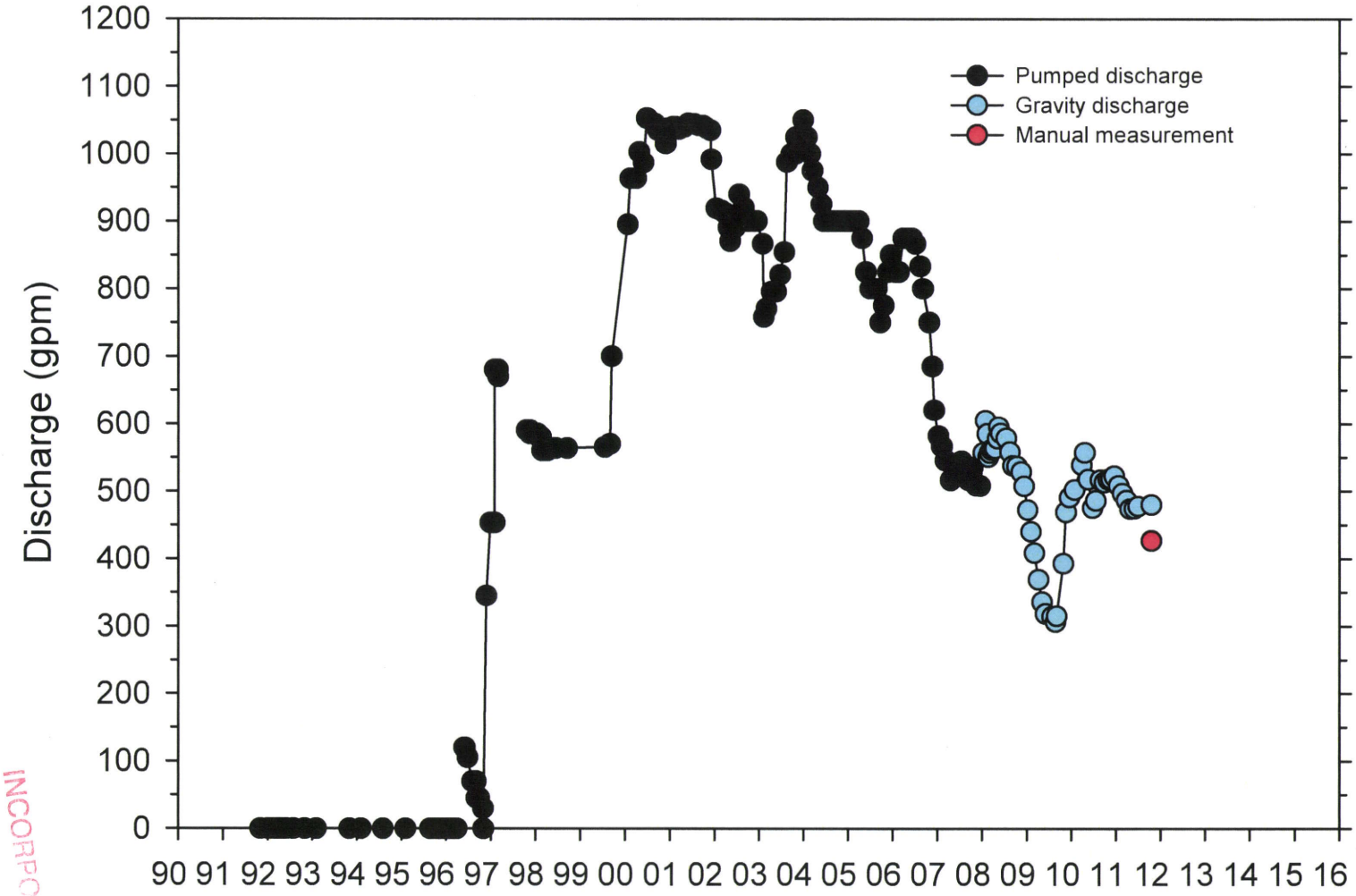

Figure 5 Plot of Crandall Canyon Mine discharge rates, 6-month running average.

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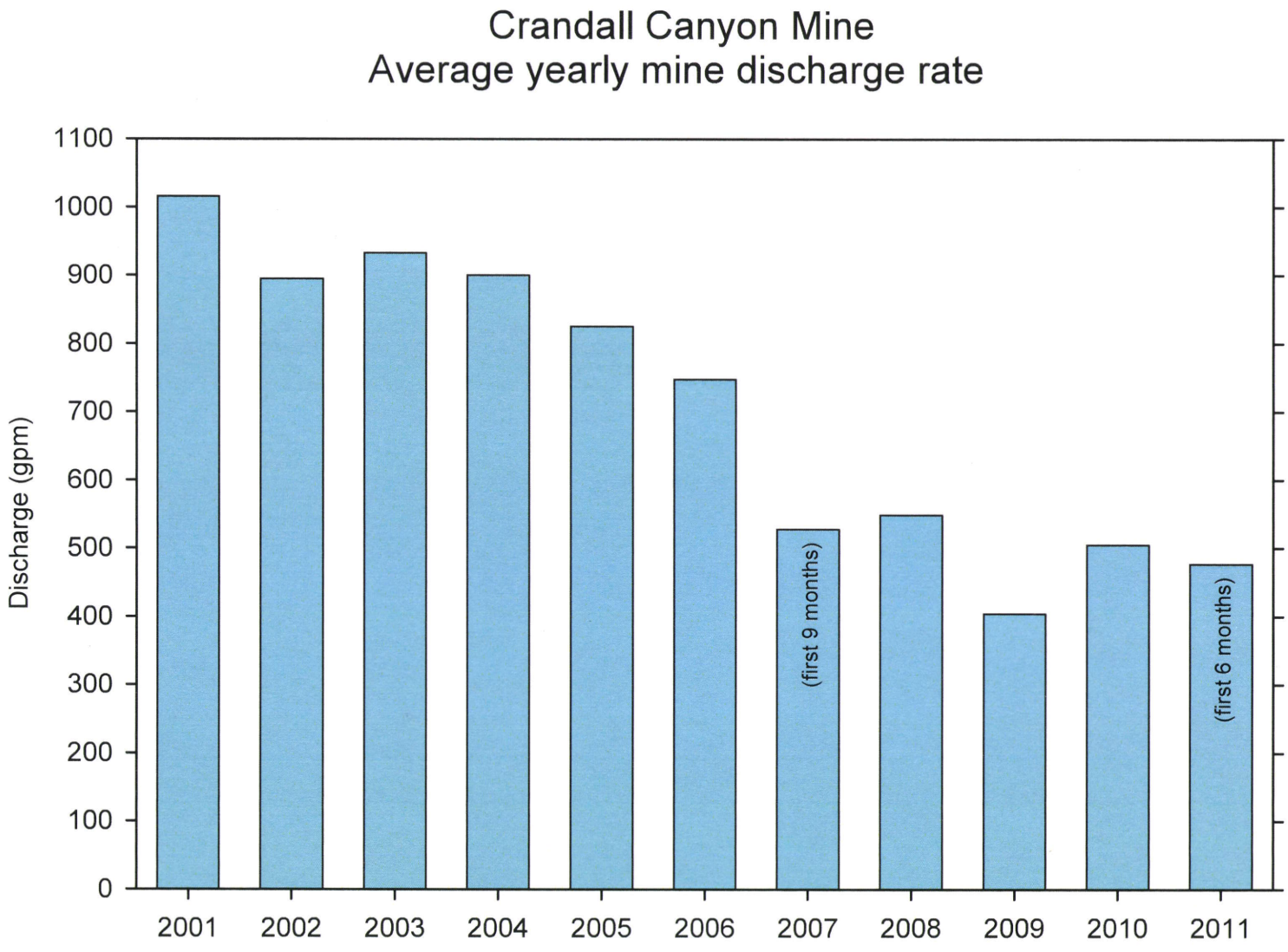

Figure 6 Average yearly mine water discharge rates for the Crandall Canyon Mine.

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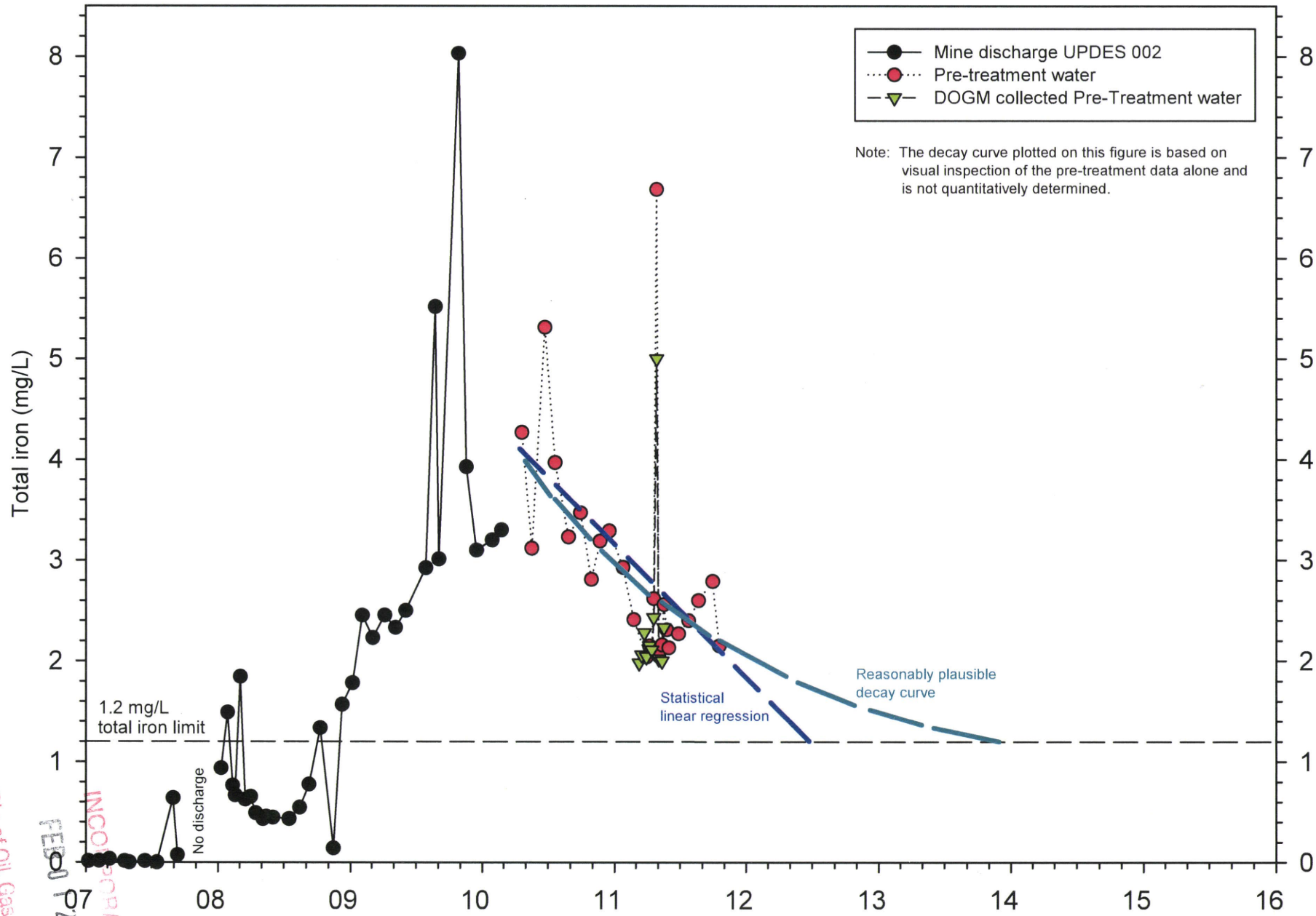

Figure 7 Possible future trends for iron concentrations in untreated mine discharge water (based on pre-treatment data).

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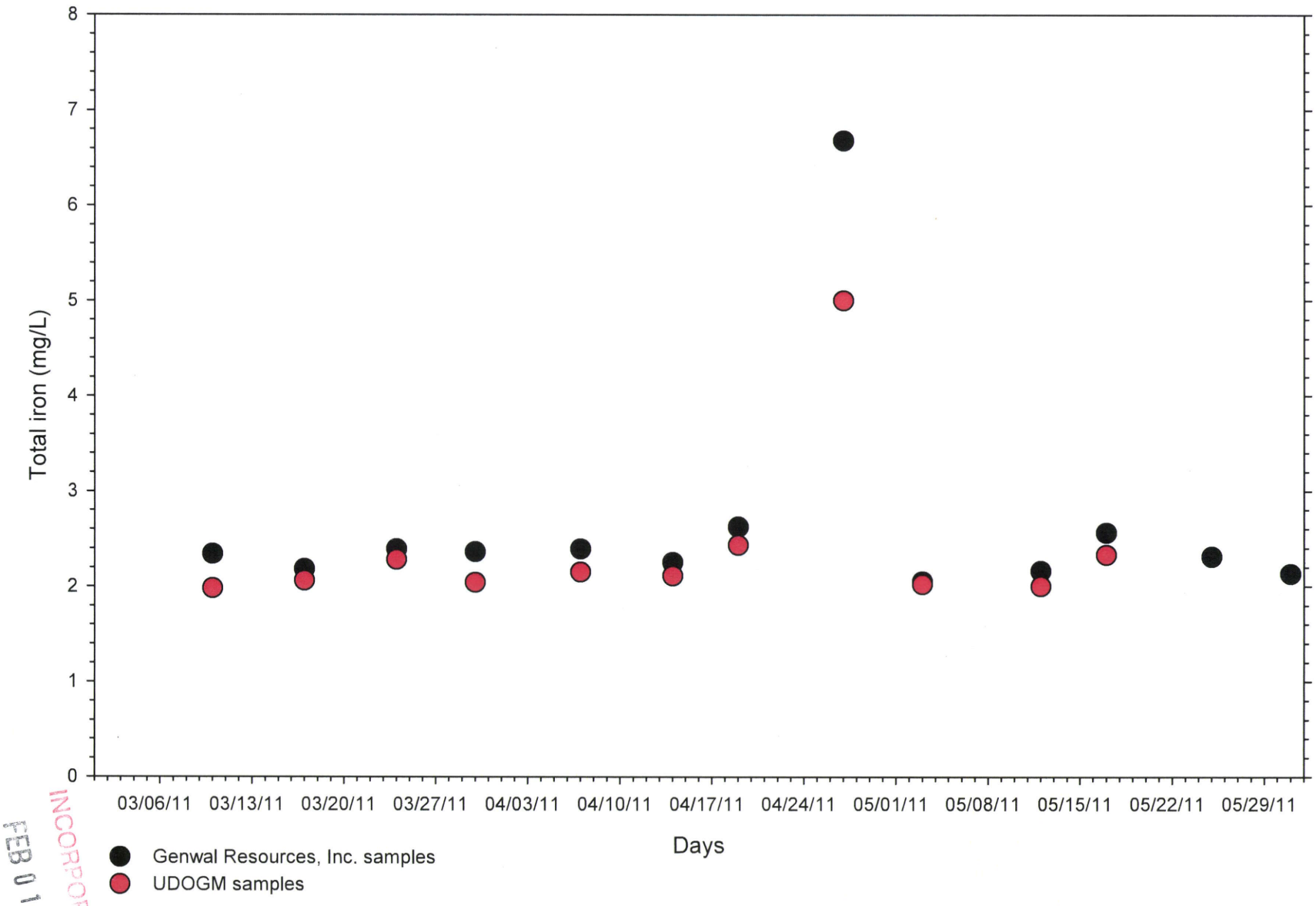

Figure 8 Measured total iron concentrations in mine discharge pre-treatment samples collected from 10 March 2011 to 31 May 2011.

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Table 1 Water quality data for gravity groundwater discharges associated with abandoned coal mines in the Wasatch Plateau coal district.

	Location	UTM, Nad 27		Sample date	T (°C)	pH S.U.	Cond. (µS/cm)	D.O. (mg/L)	Fe (d) (mg/L)	Fe (t) (mg/L)
Mohrland Portal	Sec. 8, T. 16 S., R. 8 E.	496623	4365707	23-Sep-10	12.0	7.02	1052	7.37	<0.03	0.05
Winter Quarters Mine portal	Sec. 6, T. 13 S., R. 7 E.	483785	4396466	17-Sep-10	8.5	6.65	1285	6.41	<0.03	<0.05
Joes Valley Mine spring (Left Fork Huntington)*	Sec. 2, T. 15 S., R. 6 E.	480985	4376891	20-Oct-10	10.7	8.25	528	7.75	<0.03	<0.05

* Note: The groundwater discharge observed at this location emanates near the reclaimed mine portal. However, it is not certain that this water is directly sourced from the old mine workings.

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Photographs Section

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Sampling port purged Approx. 45 Minutes

Sampling port purged Approx. 30 Minutes

Sampling port purged Approx. 15 Minutes

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Photograph 1 Raw Crandall Canyon Mine discharge water collected from sampling port on 18 October 2011.

Sampling port purged
Approx. 45 Minutes

Sampling port purged
Approx. 15 Minutes

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Photograph 2 Raw Crandall Canyon Mine discharge water collected from sampling port on 18 October 2011.

Appendix

Laboratory reporting sheets

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SGS

Analysis Report

March 07, 2011

PETERSEN HYDROLOGIC LLC
2695 NORTH 600 EAST
LEHI UT 84043

Client Sample ID:	Snell & Wilmer, LLP	Sample ID By:	Petesen Hydrologic LLC
Date Sampled:	Sep 23, 2010	Sample Taken At:	Mohrland Portal
Date Received:	Oct 4, 2010	Sample Taken By:	E. Petersen
Product Description:	WATER	Time Received:	0730
		Time Sampled:	1240

SGS Minerals Sample ID: 782-1106854-002

TESTS	RESULT	UNIT	METHOD	REPORTING LIMIT	ANALYZED DATE	ANALYZED TIME	ANALYST
METALS BY ICP							
Iron, Fe - Dissolved	<0.03	mg/L	EPA 200.7	0.030	2010-10-12	14:18:00	CM
Iron, Fe - Total	0.05	mg/L	EPA 200.7	0.050	2010-10-08	10:47:00	CM

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Lab Supervisor

Domenic Ibanez
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SGS

Analysis Report

March 07, 2011

PETERSEN HYDROLOGIC LLC
2695 NORTH 600 EAST
LEHI UT 84043

Client Sample ID:	Snell & Wilmer, LLP	Sample ID By:	Petesen Hydrologic LLC
Date Sampled:	Sep 17, 2010	Sample Taken At:	Winter Quarters Portal
Date Received:	Oct 4, 2010	Sample Taken By:	E. Petersen
Product Description:	WATER	Time Received:	0730
		Time Sampled:	1830

SGS Minerals Sample ID: 782-1106854-001

TESTS	RESULT	UNIT	METHOD	REPORTING LIMIT	ANALYZED DATE	ANALYZED TIME	ANALYST
METALS BY ICP							
Iron, Fe - Dissolved	<0.03	mg/L	EPA 200.7	0.030	2010-10-12	14:18:00	CM
Iron, Fe - Total	<0.05	mg/L	EPA 200.7	0.050	2010-10-08	10:47:00	CM

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Analysis Report

March 07, 2011

PETERSEN HYDROLOGIC LLC
2695 NORTH 600 EAST
LEHI UT 84043

Client Sample ID:	Joes Valley Mine Spring	Sample ID By:	Petesen Hydrologic LLC
Date Sampled:	Oct 20, 2010	Sample Taken At:	Joes Valley Mine Spring
Date Received:	Nov 18, 2010	Sample Taken By:	E. Petersen
Product Description:	WATER	Time Received:	1720
		Time Sampled:	1830

SGS Minerals Sample ID: 782-1106855-001

TESTS	RESULT	UNIT	METHOD	REPORTING LIMIT	ANALYZED DATE	ANALYZED TIME	ANALYST
METALS BY ICP							
Iron, Fe - Dissolved	<0.03	mg/L	EPA 200.7	0.030	2010-11-23	15:45:00	CM
Iron, Fe - Total	<0.05	mg/L	EPA 200.7	0.050	2010-11-23	12:24:00	CM

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Analysis Report

October 26, 2011

GENWAL RESOURCES INC
794 "C" CANYON ROAD
EAST CARBON UT 84520

Client Sample ID:	PRE 002	Sample ID By:	Genwal Resources Inc.
Date Sampled:	Oct 18, 2011	Sample Taken At:	PRE 002
Date Received:	Oct 19, 2011	Sample Taken By:	E.Peterson
Product Description:	WATER	Time Received:	1325
		Time Sampled:	1645
		Mine:	8

Comments: Dissolved Metals Field Filtered

SGS Minerals Sample ID: 782-1110378-001

TESTS	RESULT	UNIT	METHOD	REPORTING LIMIT	ANALYZED DATE	ANALYZED TIME	ANALYST
Sulfate, SO4	157	mg/L	EPA 300.0	1	2011-10-25	16:03:00	AL
Total Dissolved Solids	606	mg/L	SM2540-C	30	2011-10-19	14:40:00	CM
Chloride, Cl	10	mg/L	EPA 300.0	1	2011-10-25	16:03:00	AL
Alkalinity, mg CaCO3/L (pH 4.5)	381	mg/L	SM2320-B	5	2011-10-20	09:00:00	AL
Carbonate Alkalinity as CaCO3	<5	mg/L	SM2320-B	5	2011-10-20	09:00:00	AL
Bicarbonate Alkalinity as CaCO3	381	mg/L	SM2320-B	5	2011-10-20	09:00:00	AL
METALS BY ICP							
Calcium, Ca - Dissolved	96.86	mg/L	EPA 200.7	0.03	2011-10-20	15:16:00	AL
Iron, Fe - Dissolved	0.29	mg/L	EPA 200.7	0.03	2011-10-20	15:16:00	AL
Iron, Fe - Total	2.15	mg/L	EPA 200.7	0.05	2011-10-26	15:20:00	AL
Magnesium, Mg - Dissolved	54.10	mg/L	EPA 200.7	0.01	2011-10-20	15:16:00	AL
Potassium, K - Dissolved	8.24	mg/L	EPA 200.7	0.14	2011-10-20	15:16:00	AL
Sodium, Na - Dissolved	33.44	mg/L	EPA 200.7	0.09	2011-10-20	15:16:00	AL

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Appendix 7-68

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Utah American

Crandall Canyon Mine

Toxicity Identification Evaluation- 10/03/2011

Phase I Toxicity Characterization

By: Water & Environmental Testing, Inc

November 26th, 2011

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Div. of Oil, Gas & Mining

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TIE Phase I Summary Report

TIE Phase I Executive Summary
Table 1- Phase 1 Toxicity Characterization

Accelerated Test #3 10/3/2011

Chronic Fathead Minnow (1 dilution) Passed

Chronic Ceriodaphnia (5 dilution) Failed

Phase I Testing

Baseline Test
Filtration Test
Aeration Test
C-18 column
PH 6.0
PH 7.0
EDTA 3.0 mg/L
EDTA 8.0 mg/L
Thiosulfate 10 mg/L
Thiosulfate 25 mg/L

Sample Chemistries

Quality Control Charts

Fathead Minnow LC50
Fathead Minnow IC25

Ceriodaphnia dubia LC50
Ceriodaphnia dubia IC25

Chain of Custody

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W.E.T. Inc.

Water Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801) 763-0660 FAX (801) 763 04440

November 20th, 2011

Dana Morrelli
Crandall Canyon Mine
194 North 100 West
Huntington, Utah 84528

Executive Summary

Included in the executive summary are the highlights of the Phase I testing completed on the samples collected starting 10/03/2011. Actual copies of each test and the associated data reduction have been included in the data section of this report.

Background Information

The initial failure for the Crandall Canyon Mine occurred during routine quarterly testing for the second quarter dated June 7, 2011. In this round of testing the Fathead Minnow test passed and the Ceriodaphnia test failed reproduction with an IC25 of 11.23%. The first accelerated test was conducted June 28, 2011, using Ceriodaphnia with an IC25 of 7.42% for the standard conditions and 14.67% for a CO2 atmosphere test.

The water from the mine is treated after exiting the mine, before being discharged. To identity the source of the toxicity, a sample was collected prior to treatment and one post treatment and analyzed for chronic toxicity using Ceriodaphnia. The results of these two tests showed that the toxicity was being introduced in the treatment process. Ferric chloride was being added to help precipitate iron and solids to meet the discharge permit.

Following this round of testing the chemical used for treatment was changed to aluminum sulfate. which had been used previously. Accelerated test #2 was collected September 1, 2011 and again tested using both Fathead Minnows and Ceriodaphnia. Enough sample was collected at this time to complete a Toxicity Identification Evaluation (TIE) should measurable toxicity be found. The Fathead Minnow test passed and the Ceriodaphnia test failed with an IC25 of 28.09%. The increase in the IC25 from the previous tests suggested that the change in chemical was helping the situation. In preparation for the TIE the Ceriodaphnia test was repeated to ensure that the toxicity was still present in the sample. This retest conducted on September 10, 2011 showed no measurable toxicity and without toxicity it is impossible to get beneficial data from a TIE.

A second TIE sample was collected October 3, 2011. This time the sample was collected in bladders to minimize the sample's contact with oxygen and extend the "shelf life" of the sample. Again the

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initial testing for this sample included testing with both Fathead Minnows and Ceriodaphnia. The Fathead Minnow test passed and the Ceriodaphnia test failed with an IC25 of 34.0%. A TIE was initiated on October 11, 2011 using this sample but due to poor quality food did not produce useable results. A second TIE test, using the same sample, was initiated on October 26, 2011. This round of testing showed that while there was less toxicity than in the initial test for this sample. there was still enough to give some useable results.

Summary Phase I Testing

Results of the Phase I Toxicity Characterization are shown in Table 1. The dilution series for this phase of the testing was set at 25, 50, and 100% with the number of replicates reduced from 10 to 6 as directed in the TIE guidance documents to conserve sample.

Summary of Phase I Test Results 10/7/2011

Test ID	Result IC25	TUc
Initial Test	34.0%	2.94
Baseline	56.5%	1.77
Aerated	46.41%	2.15
Filtered	86.15%	1.16
C-18	18.8%	5.3
C-18 Eluate	*	
PH 6	61.76	1.62
PH 7	>100%	1
EDTA 3 mg/L	>100%	1
EDTA 8 mg/L	>100%	1
Thiosulfate 10 mg/L	43.31%	2.30
Thiosulfate 25 mg/L	68.15%	1.47

TUc- Toxicity Unit for chronic tests.

* Test was not run as no toxicity was removed from in the C-18 test.

Conclusions from Phase I Testing

When reviewing Phase I data, the guidance documents recommend starting with the strongest indicators but include all significant tests when characterizing the toxicant. The data in Table 1. show the strongest indicators to be both EDTA test, the ph7 test and to a lessor extent the filtered test. The EDTA test suggest the toxicant to be a metal. The pH 7 test suugests a metals which

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becomes less toxic at lower pH. The 100% concentration of the pH 7 test stayed a range between 7.3 and 8.2 while the range for the baseline test stayed between 8.0 and 8.4. A reduction of toxicity associated with a change in pH suggest a metal which is more toxic at higher pH such as nickel or zinc. The filtered test collected a small amount of fine light brown powder on the filter collected on the filter. Some of the toxicant could be contained in the solids collected.

Failure of the other tests to reduce toxicity suggest that the toxicant is not an oxidizer such as chlorine, bromine or ozone. Also most likely not a non-polar organic and a reduced suspicion that it results from a surfactant or other sublateable compound nor one that can be oxidized through aeration.

An observation made in several of the Phase I tests was that in higher dilutions there was some formation of visible solids on the surface of the solutions and formation of grit on the sides and bottom of the test chambers. This would suggest that the sample is still chemically active or "unstable"and the changing environment could be contributing stress to the organisms. Stress can cause reduced reproduction and if high enough can cause mortality.

Recommended Phase II Testing

Samples have been submitted to Chemtech-Ford for analysis of total (15) and dissolved metals (4). This data will be reviewed to see if any single metals is over the expected toxic limits. Combined concentrations will also be considered. These values will be used to create mock effluents in an effort to recreate the toxicity in the original sample. The dried solids remaining on the filtered could also be analyzed for metals to determine which are prevalent in the retained solids.

The potential for stability and formation of solids could be checked by measuring the TSS of the sample then passing the sample thought a finer filter than the one used in the original test to see if additional toxicity is removed. The potential for calcium carbonate solids to precipitate out of solution can be removed by raising the pH of the sample over pH 11 and letting the solids form and settle then pouring off the supernate. The pH of the supernate is then returned to the original pH before using organisms to test for toxicity. This procedure can also remove some metals from solution.

While we finish up the phase II testing I suggest we proceed with the routine test for the fourth quarter and continue to collect extra sample to have on-hand in the event of another failure.

If you have any questions or need any additional information please feel free to give me a call at 801-763-0660, or on my cell phone at 801-360-5438.

Sincerely,

Lee Rawlings

Lee Rawlings
Laboratory Director
Water & Environmental Testing, Inc

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Crandall Canyon Mine

Reproduction average young/adult

Sample date 10/3/2011

Tests	Control	25%	50%	100%	IC25	TUc
Initial Test	16.1	16.0	9.1	0.5	34.0	2.94
Baseline #2	16.8	25	17.3	4.7	56.5	1.77
Aerated #2	16	18.8	12.2	12.5	46.41	2.15
Filtered #2	17	24.3	21.3	13.7	86.15	1.16
C-18 #2	21	13.2	14.8	6.8	18.8	5.3
PH 6 #2	27	32.2	24.5	14.7	61.76	1.62
PH 7 #2	25.3	28.2	25	21	>100	1
EDTA 3 #2	21.5	23.3	17.2	19.8	>100	1
EDTA 8 #2	18.2	23.78	24.5	17.7	>100	1
Thiosulfate 10 #2	15.7	15	10.8	3.3	43.31	2.3
Thiosulfate 25 #2	13.5	11.8	12.2	6.8	68.15	1.47

Eluate No Toxicity removed with C-18. Test not analyzed

TUc- Toxicity Unit for a chronic test.

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Accelerated Test #3 10/3/2011

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W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Cover Letter

October 28, 2011

Utah American- Crandall Canyon Mine (Accelerated Test #3)
Attn: Dana Morrelli
194 North 100 West
Huntington, Utah 84528

Dear Dana,

Enclosed is the report for the sample dated 10/03/2011. The laboratory Id assigned to these sample(s) are #8490. The sample was tested for chronic toxicity using Fathead Minnows following the procedures listed in EPA 1000.0. This report is comprised of 11 pages which include;

Cover Letter,
Chronic Whole Effluent Toxicity Reports Fathead Minnows,
Chronic Whole Effluent Toxicity Testing Data Fathead Minnows,
Chronic Whole Effluent Toxicity Chemical Report,
Data Reduction Fathead Minnows (Toxis Analysis Summary, 2 pages survival and growth)
Reference Toxicant Charts, Fathead Minnows (2 pages Survival-LC50 and Growth-IC25)
Completed Copies of the Chain of Custodies (3).

Our reports have been designed to meet requirements of National Environmental Accreditation Program. (NELAP). section 5.13. All these pages ***together*** constitute the final report, individual pages should not be removed. If copied. the report must be reconstructed in full. If you have not received any of these pages. or if you have any questions please give us a call at 801-763-0660. We look forward to doing business with you in the future.

Sincerely,

Lee Rawlings
Lab Director

QA/QC Flags: None

Comments:

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W.E.T. Inc.
Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Whole Effluent Toxicity Report

Fathead Minnows

DATE: October 28. 2011

PERMITTEE NAME: Utah American- Crandall Canyon Mine (Accelerated Test #3)

TEST *(Animal/Age)*: Fathead Minnows <24 hours

SAMPLE *(Date/Type)*: 10/03/2011 Composite

DATE/TIME TEST BEGAN: 10/04/2011 3:00 p.m.

DATE/TIME TEST COMPLETED: 10/11/2011 6:00 p.m.

TEST CONDITIONS

Fathead Minnow larvae were exposed to diluted effluent as specified by EPA 1000.0. At the end of the test period Survival and Growth were measured and compared statistically against a control to determine if Chronic Toxicity was present in the samples.

Animal Age at Test Start	24 hours.
Number of Organisms/Dilution Volume/Replicates	10 organisms/200 ml/6 replicates
Food	Fed twice daily 0.1 ml of newly hatched Brine Shrimp.
Aeration	None required.
Dissolved Oxygen	Measured Daily old/new.
Water Replacement	Renewed daily.
Temperature	25 ± 1 degree C.
Photo Period	16 hours light 8 hours dark.
pH	Measured initially and at 24 hours for each sample.
Dilution Water	Reconstituted lab water approx 200 mg/L.
Receiving Water	None Supplied
Sample Concentrations	Control, 100%.

SUMMARY

Results: X Pass Fail

There was NO significant effect on growth. (Results of Wilcoson Two-Sample Test)

There was NO significant effect of survival. (Results of Wilcoson Two-Sample Test)

Enclosed are data sheets and statistical reports.

Sincerely,

Lee Rawlings
Laboratory Director
Enclosure

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Chronic Whole Effluent Toxicity Testing

Fathead Minnows

PERMITTEE NAME: Utah American- Crandall Canyon Mine (Accelerated Test #3)

Final Mean Weight: Control 0.57 Effluent 0.59 Pass X Fail __

Percent Lethality: Control 3.3% Effluent 0.0% Pass X Fail __

Sample Type / Times and Dates

No. 1 10/03/2011 9:30 p.m.
No. 2 _____
No. 3 _____

Analyses: Times and Dates

Beginning 10/03/2011 3:00 pm
Ending 10/11/2011 6:00 pm
Initial Organism Age <24 hours

Control = 0% Effluent **Effluent Sample** = 70% Effluent **Hardness:** Reconstituted Water (if used) 200 mg/L

FATHEAD MINNOWS
Replicates

	Number of Organisms/Percent Survival						**Mean Weight after 7 days (Milligrams)**					
Sample	A	B	C	D	E	F	A	B	C	D	E	F
Control	10/100%	10/100%	9/90%	9/90%	10/100%	10/100%	0.57	0.54	0.56	0.57	0.61	0.57
Effluent	10/100%	10/100%	10/100%	10/100%	10/100%	10/100%	0.60	0.60	0.62	0.58	0.60	0.56

Physical Data - Control

Old/New	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Dissolved Oxygen	7.0	7.2/6.4	7.1/6.2	7.3/6.9	7.6/5.7	7.7/4.5	7.4/6.1	5.7
Temperature (°C)	25.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.4	25.0/24.8	25.0/24.0	24.0
pH (SU)	8.45	8.44/8.27	8.37/8.20	8.10/8.04	8.22/7.93	8.33/7.82	8.50/8.06	7.84

Physical Data - Effluent

Old/New	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
Dissolved Oxygen	8.3	7.7/6.6	8.0/6.0	8.5/6.7	8.4/4.5	9.2/5.5	8.6/6.2	5.4
Temperature (°C)	25.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.4	25.0/24.8	25.0/24.0	24.0
pH (SU)	7.71	7.70/7.81	7.63/8.29	7.60/8.17	7.68/8.06	7.70/8.12	7.62/8.12	8.12
Hardness*		472 mg/L		NA mg/L		NA mg/L		

**Testing required only on days when fresh effluent is received in the lab.*

Laboratory Director: Lee Rawlings **Laboratory:** Water & Environmental Testing, Inc.

Signature: Lee Rawlings **Date:** 10/30/11

Comments: _____

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W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Whole Effluent Toxicity Chemical Result Report

October 28, 2011

CUSTOMER NAME:
Utah American- Crandall Canyon Mine (Accelerated Test #3)
Attn: Dana Morrelli
194 North 100 West
Huntington, Utah 84528

SAMPLE DESCRIPTION:
Chemistries to go with Chronic Biomonitoring sampling began 10/03/2011

Analysis	Chronic Ceriodaphnia		
	Repl. 1	Repl. 2	Repl. 3
Log #	8490	NA	NA
Total Hardness, Recon (EPA 130.2), mg/L	176		
Total Hardness, Effluent (EPA 130.2), mg/L	472		
Ammonia, Effluent (EPA 350.2/350.3), mg/L	0.43		
Initial Chlorine Residual (EPA 330.5), mg/L	<0.05		
Final Chlorine Residual (EPA 330.5), mg/L	N/A		
Conductivity, Effluent (EPA 120.1), umhos/cm	970		
Alkalinity, Effluent (EPA 310.1), mg/L $CaCO^3$	382		
Recon Initial pH (EPA 150.1)	8.45		
After 24 hours pH (EPA 150.1)	8.27		
100% Initial pH (EPA 150.1)	7.71		
100% After 24 hours pH (EPA 150	7.81		

Reviewed: Lee Rawlings, Lab Director
Water & Environmental Testing. Inc.

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Larval Fish Growth and Survival Test-7 Day Survival

Start Date:	10/4/2011 15:00	Test ID:	GW10-11c	Sample ID:	Genwal TIE 10-11 chronic fathead
End Date:	10/11/2011 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	PP-Pimephales promelas
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	1.0000	1.0000	0.9000	0.9000	1.0000	1.0000
100	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000

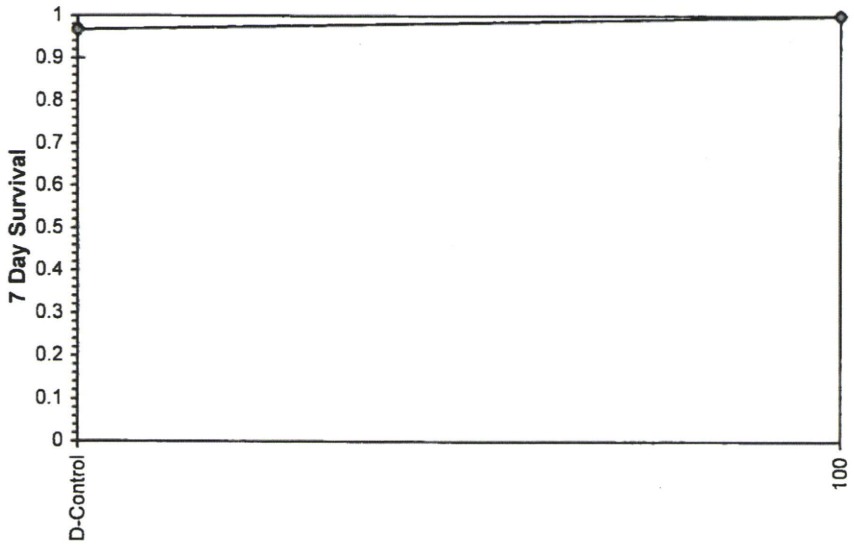
			Transform: Arcsin Square Root					Rank	1-Tailed
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical
D-Control	0.9667	1.0000	1.3577	1.2490	1.4120	6.199	6		
100	1.0000	1.0345	1.4120	1.4120	1.4120	0.000	6	45.00	28.00

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.76674	0.859	-1.1489	0.73333
Equality of variance cannot be confirmed				

Hypothesis Test (1-tail, 0.05)

Wilcoxon Two-Sample Test indicates no significant differences
Treatments vs D-Control

Dose-Response Plot



ToxCalc v5.0.32

Reviewed by:_____

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Larval Fish Growth and Survival Test-7 Day Growth

Start Date:	10/4/2011 15:00	Test ID:	GW10-11c	Sample ID:	Genwal TIE 10-11 chronic fathead
End Date:	10/11/2011 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	PP-Pimephales promelas
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	0.5680	0.5380	0.5630	0.5700	0.6120	0.5680
100	0.5950	0.5980	0.6150	0.5830	0.6020	0.5550

			Transform: Untransformed					Rank	1-Tailed
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical
D-Control	0.5698	1.0000	0.5698	0.5380	0.6120	4.186	6		
100	0.5913	1.0377	0.5913	0.5550	0.6150	3.483	6	48.00	28.00

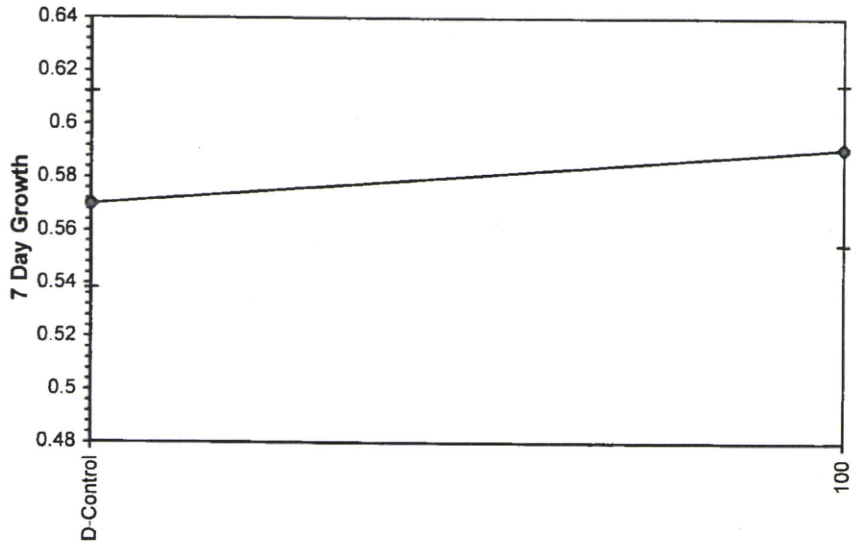
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.94762	0.859	0.09844	0.81151
F-Test indicates equal variances (p = 0.76)	1.34106	14.9394		

Hypothesis Test (1-tail, 0.05)

Wilcoxon Two-Sample Test indicates no significant differences

Treatments vs D-Control

Dose-Response Plot



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ToxCalc v5 0.32

Reviewed by:_____

W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Cover Letter

October 28, 2011

Utah American- Crandall Canyon Mine (Accelerated Test #3)
Attn: Dana Morrelli
194 North 100 West
Huntington, Utah 84528

Dear Dana,

Enclosed is the report for the sample dated 10/03/2011. The laboratory Id assigned to these sample(s) are #8490. The sample was tested for chronic toxicity using Ceriodaphnia dubia following the procedures listed in EPA 1002.0. This report is comprised of 11 pages which include;

Cover Letter,
Chronic Whole Effluent Toxicity Reports Data Ceriodaphnia dubia,
Chronic Whole Effluent Toxicity Testing Data Ceriodaphnia dubia.
Chronic Whole Effluent Toxicity Chemical Report,
Data Reduction Ceriodaphnia dubia (Toxis Analysis Summary, 2 pages survival and growth)
Reference Toxicant Charts, Ceriodaphnia dubia (2 pages Survival-LC50 and Growth-IC25)
Completed Copies of the Chain of Custodies (3).

The work represented here along with the report format have been designed to meet requirements of National Environmental Accreditation Program, (NELAP), section 5.13. All these pages ***together*** constitute the final report, individual pages should not be removed. If copied, the report must be reconstructed in full. If you have not received any of these pages, or if you have any questions please give us a call at 801-763-0660. We look forward to doing business with you in the future.

Sincerely,

Lee Rawlings
Lab Director

QA/QC Flags: None

Comments:

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W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Whole Effluent Toxicity Report

Ceriodaphnia

DATE: October 28. 2011

PERMITTEE NAME: Utah American- Crandall Canyon Mine (Accelerated Test #3)

TEST (Animal/Age): Ceriodaphnia dubia <8 hours

SAMPLE (Date/Type): 10/03/2011 Grab

DATE/TIME TEST BEGAN: 10/04/2011 3:00 p.m.

DATE/TIME TEST COMPLETED: 10/12/2011 6:00 p.m.

TEST CONDITIONS

Ceriodaphnia dubia neonates were exposed to diluted effluent as specified by EPA 1002.0. At the end of the test period Survival and Reproduction were measured and compared statistically against a control to determine if Chronic Toxicity was present in the samples.

Animal Age at Test Start	<8 hours.
Number of Organisms/Dilution Volume/Replicates	1 organism/15 ml/10 replicates.
Food	Fed daily 0.1 ml YTC and Algae.
Aeration	None required.
Dissolved Oxygen	Measured daily old/new.
Water Replacement	Renewed daily.
Temperature	25 ± 1 degree C.
Photo Period	16 hours light 8 hours dark.
pH	Measured initially and at 24 hours for each sample.
Dilution Water	Reconstituted lab water approx 100 mg/L hardness.
Receiving Water	None Received
Sample Concentrations	Control. 12. 25. 50. 75. 100%

SUMMARY

Results: Pass **X** Fail

There WAS significant effect on reproduction. (Results of Dunnett's Test)

NOEC (Reproduction) = 25 IC25 required by NPDES permit = 65.5%

LOEC (Reproduction) = 50 IC25 estimated from test data = 34.01%

There WAS significant effect on survival. (Fisher's Exact Test)

NOEC (Survival) = 50

LOEC (Survival) = 75

Enclosed are data sheets and statistical reports.

Sincerely,

Lee Rawlings
Lab Director
Enclosure

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FEB 01 2013
Div. of Oil, Gas & Mining

W.E.T. Inc.

Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Toxicity Testing

Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine (Accelerated Test #3)

Mean No. Produced: Control 16.1 12.5% 19.9 25.0% 16.0 50.0% 9.1 75.0% 2.8 100% 0.5 Pass ___ Fail X

Percent Lethality: Control 0% 12.5% 0% 25.0% 0% 50.0% 0% 75.0% 40% 100% 100% Pass ___ Fail X

Sample Type/Date: 10/03/2011 2:00 p.m.

Analyses Dates/Times Beginning 10/04/2011 3:00 p.m.
Ending 10/12/2011 6:00 p.m.

Dilution Water Hardness: Provo River Water Approx. 200 mg/L. **Organism Type/Age:** Ceriodaphnia dubia <8 hours

CERIODAPHNIA

Total Number of Young Produced in Three Broods ("D" = dead)

Replicates

Sample	A	B	C	D	E	F	G	H	I	J	Mean # Produced
Control	23	21	22	11	20	8	13	19	17	7	16.1
12.5	23	17	14	17	21	19	23	23	27	15	19.9
25.0	11	27	17	8	18	18	18	12	19	12	16.0
50.0	10	7	10	15	12	4	8	11	8	6	9.1
75.0	8	6	0D	0D	4	4	0D	3	3	0D	2.8
100	1D	0D	0D	0D	0D	4D	0D	0D	0D	0D	0.5

Concentration (mg/L)

Max/Min	Control	12.5	25.0	50.0	75.0	100
Dissolved Oxygen	8.0/6.7	8.5/6.7	8.6/6.7	8.7/6.9	9.2/7.0	9.3/7.1
Temperature (°C)	25.2/24.0	25.2/24.0	25.2/24.0	25.2/24.0	25.2/24.0	25.2/24.0
pH	8.56/8.09	8.59/7.98	8.66/7.90	8.67/7.75	8.58/7.64	8.49/7.61

Dilution Water (Average) Hardness: 212 mg/L **Alkalinity:** 166 mg/L **Conductivity:** 450 umhos/cm

Laboratory Director: Lee Rawlings **Laboratory:** Water & Environmental Testing, Inc

Signature: Lee Rawlings **Date:** 10/30/11

Comments:

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Div. of Oil, Gas & Mining

Ceriodaphnia Survival and Reproduction Test-7 Day Survival

Start Date:	10/4/2011 15:00	Test ID:	GW10-11c	Sample ID:	GW 10-11 chronic cero
End Date:	10/12/2011 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

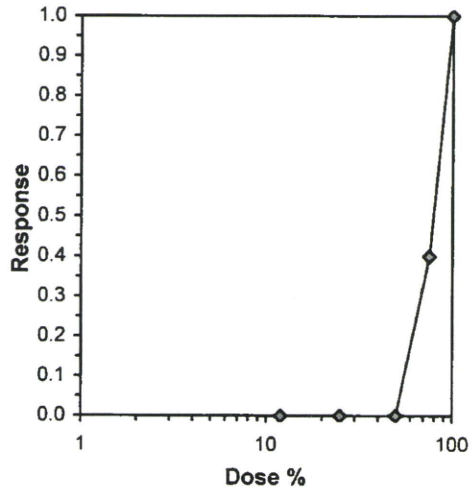
Conc-%	1	2	3	4	5	6	7	8	9	10
D-Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
12	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
75	1.0000	1.0000	0.0000	0.0000	1.0000	1.0000	0.0000	1.0000	1.0000	0.0000
100	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000

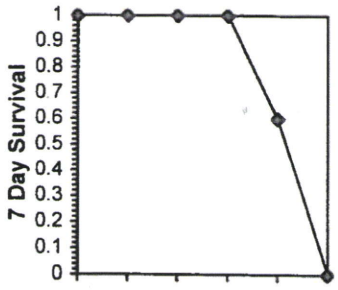
Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Number Resp	Total Number
D-Control	1.0000	1.0000	0	10	10	10			0	10
12	1.0000	1.0000	0	10	10	10	1.0000	0.0500	0	10
25	1.0000	1.0000	0	10	10	10	1.0000	0.0500	0	10
50	1.0000	1.0000	0	10	10	10	1.0000	0.0500	0	10
*75	0.6000	0.6000	4	6	10	10	0.0433	0.0500	4	10
100	0.0000	0.0000	10	0	10	10			10	10

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	50	75	61.2372	2
Treatments vs D-Control				

Trimmed Spearman-Karber

Trim Level	EC50	95% CL	
0.0%	75.392	67.716	83.938
5.0%	75.874	67.291	85.553
10.0%	76.354	66.540	87.617
20.0%	77.295	63.481	94.115
Auto-0.0%	75.392	67.716	83.938





ToxCalc v5.0 32

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Reviewed by:_____

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/4/2011 15:00	Test ID:	GW10-11c	Sample ID:	GW 10-11 chronic cero
End Date:	10/12/2011 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6	7	8	9	10
D-Control	23.000	21.000	22.000	11.000	20.000	8.000	13.000	19.000	17.000	7.000
12	23.000	17.000	14.000	17.000	21.000	19.000	23.000	23.000	27.000	15.000
25	11.000	27.000	17.000	8.000	18.000	18.000	18.000	12.000	19.000	12.000
50	10.000	7.000	10.000	15.000	12.000	4.000	8.000	11.000	8.000	6.000
75	8.000	6.000	0.000	0.000	4.000	4.000	0.000	3.000	3.000	0.000
100	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

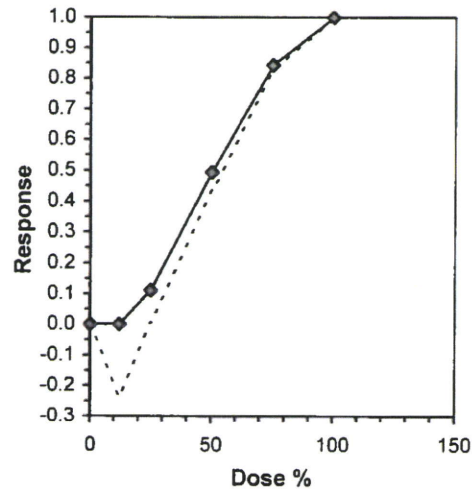
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	16.100	1.0000	16.100	7.000	23.000	36.740	10				18.000	1.0000
12	19.900	1.2360	19.900	14.000	27.000	20.982	10	-1.902	2.223	4.442	18.000	1.0000
25	16.000	0.9938	16.000	8.000	27.000	33.850	10	0.050	2.223	4.442	16.000	0.8889
*50	9.100	0.5652	9.100	4.000	15.000	34.924	10	3.503	2.223	4.442	9.100	0.5056
*75	2.800	0.1739	2.800	0.000	8.000	100.734	10	6.656	2.223	4.442	2.800	0.1556
100	0.000	0.0000	0.000	0.000	0.000	0.000	10				0.000	0.0000

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.98098	0.947	0.03666	-0.1579
Bartlett's Test indicates equal variances (p = 0.15)	6.81316	13.2767		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	25	50	35.3553	4	4.44247	0.27593	463.07	19.9622	1.9E-10	4, 45
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL		Skew
IC05	17.850	5.268	13.728	27.848	0.4277
IC10	23.700	5.111	15.920	30.696	0.0595
IC15	27.536	5.014	17.975	33.718	-0.1458
IC20	30.797	5.005	19.968	37.030	-0.3007
IC25	34.058	4.951	22.050	40.310	-0.4936
IC40	43.841	4.174	35.636	51.753	-0.4197
IC50	50.397	3.536	43.657	57.706	-0.0163



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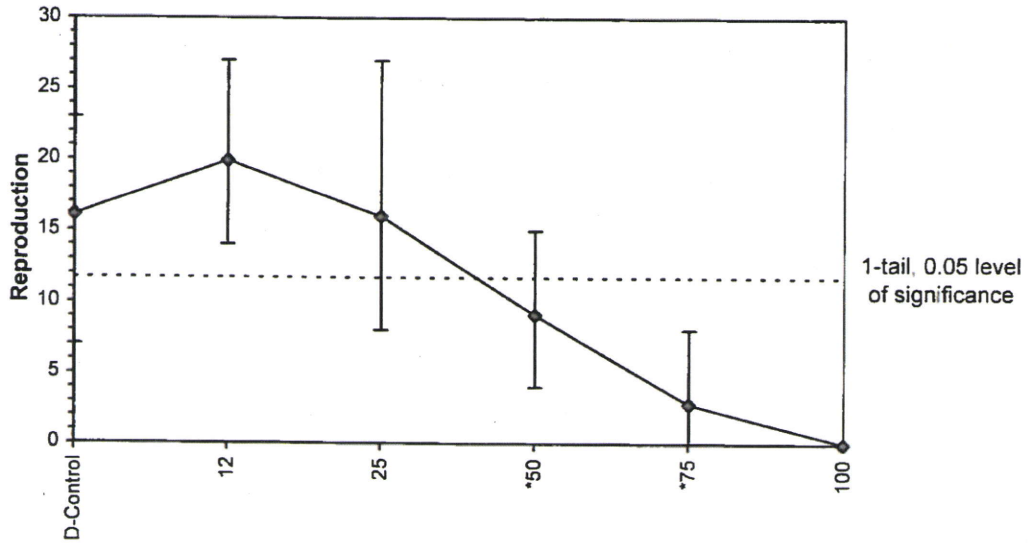
ToxCalc v5.0.32

Reviewed by:_____

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/4/2011 15:00	Test ID:	GW10-11c	Sample ID:	GW 10-11 chronic cero
End Date:	10/12/2011 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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Phase I Characterization Testing

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Chronic Toxicity Testing
Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase I- Baseline Test

TIE sample made by compositing samples collected: 10/3/2011

Analyses Dates/Times Beginning 10/26/2011 10:45 p.m Ending 11/3/2011 11:00 p.m **IC25 Estimated from Test:** 56.50%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia
Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	16	8	19	24	30	4	16.8	0%
25.0%	28	21	29	15	29	28	25.0	0%
50.0%	10	30	26	13	8	17	17.3	0%
100%	2	0	4	8	8	6	4.7	0%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
DO New/Old	6.9	7.0/6.8	6.5/7.5	6.6/6.4	6.5/6.4	6.6/6.1	6.8/6.2	7.1/6.6	6.5
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.28	8.20/8.30	8.00/8.25	8.14/8.15	8.24/8016	8.31/8.16	8.29/8.18	7.54/8.04	8.30

Physical Data- 25%

DO New/Old	7.0	6.8/7.2	7.6/6.6	7.0/6.4	6.8/6.3	6.6/6.0	6.9/5.9	7.4/6.6	6.9
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.19	8.12/8.38	8.10/8.36	8.08/8.31	8.27/8.33	8.24/8.29	8.23/8.31	8.23/8.31	8.47

Physical Data - 50%

DO New/Old	7.1	7.3/6.9	7.7/6.7	6.9/6.3	6.8/6.4	6.5/6.2	6.8/5.4	7.4/6.9	6.4
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.07	8.10/8.40	8.15/8.38	8.05/8.40	8.18/8.39	8.21/8.38	8.14/8.39	7.96/8.32	8.53

Physical Data - 100%

DO New/Old	7.3	7.5/6.9	7.7/6.8	7.1/6.6	7.0/6.6	6.6/6.2	7.0/5.9	7.7/6.9	6.6
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.04	8.10/8.31	8.24/8.28	7.97/8.25	8.15/8.26	8.16/8.26	8.06/8.31	7.84/8.17	8.40

Comments: Some fine solids formed on the surface of the 100% on days 3 & 4. with grit forming on the inside of the test chamber on most days.
LC50 estimated at >100%.

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 22:45	Test ID:	GenTIEB	Sample ID:	Genwal TIE Baseline Chronic Cero
End Date:	11/3/2011 23:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	16.000	8.000	19.000	24.000	30.000	4.000
25	28.000	21.000	29.000	15.000	29.000	28.000
50	10.000	30.000	26.000	13.000	8.000	17.000
100	2.000	0.000	4.000	8.000	8.000	6.000

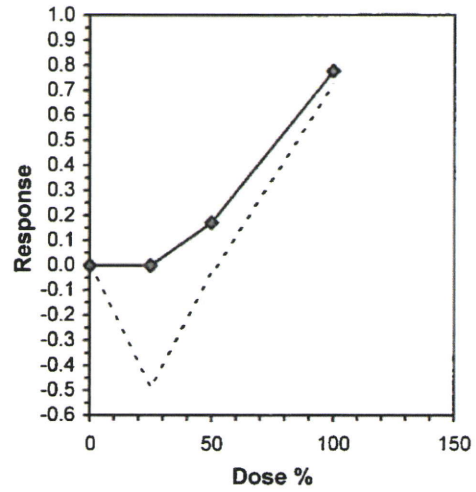
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	16.833	1.0000	16.833	4.000	30.000	57.770	6				20.917	1.0000
25	25.000	1.4851	25.000	15.000	29.000	23.048	6	-1.918	2.190	9.324	20.917	1.0000
50	17.333	1.0297	17.333	8.000	30.000	51.300	6	-0.117	2.190	9.324	17.333	0.8287
*100	4.667	0.2772	4.667	0.000	8.000	69.985	6	2.858	2.190	9.324	4.667	0.2231

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.97279	0.916	0.04748	-0.4081
Bartlett's Test indicates equal variances (p = 0.14)	5.51238	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	50	100	70.7107	2	9.32359	0.55388	423.819	54.375	0.00122	3, 20
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	32.297	10.045	24.696	64.209	0.6910
IC10	39.593	9.908	24.565	65.918	0.3194
IC15	46.890	9.659	24.618	67.627	0.0495
IC20	52.368	9.471	25.399	70.245	-0.1543
IC25	56.497	9.394	27.130	73.538	-0.3131
IC40	68.882	9.254	31.664	83.418	-0.8545
IC50	77.138	8.619	34.687	90.622	-1.2650



ToxCalc v5.0.32

Reviewed by:_____

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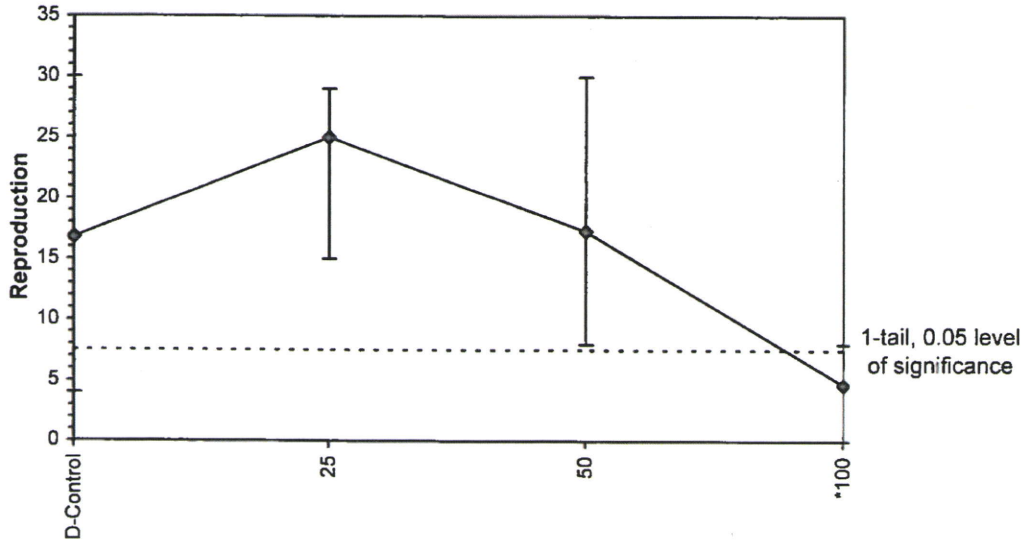
Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 22:45	Test ID:	GenTIEB	Sample ID:	Genwal TIE Baseline Chronic Cero
End Date:	11/3/2011 23:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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ToxCalc v5.0.32

Reviewed by:_____

Chronic Toxicity Testing
Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase I- Aerated

TIE sample made by compositing samples collected: 10/3/2011

Analyses Dates/Times Beginning 10/26/2011 10:45 p.m Ending 11/3/2011 11:10 p.m **IC25 Estimated from Test:** 46.41%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia
Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	17	16	20	20	15	8	16.0	0%
25.0%	21	16	16	19	24	17	18.8	0%
50.0%	25	4	12	10	15	7	12.2	0%
100%	18	0	22	19	11	5	12.5	0%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
DO New/Old	7.0	7.1/6.9	7.7/6.7	6.8/6.5	6.8/6.4	6.6/5.9	6.9/6.0	7.2/6.7	6.1
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.8	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.31	8.28/8.31	8.25/8.27	8.16/8.19	8.32/8.15	8.26/8.17	8.30/8.17	7.86/8.07	8.34

Physical Data- 25%

DO New/Old	7.0	7.4/7.0	7.7/6.8	6.9/6.6	6.8/6.3	6.6/6.3	6.9/5.5	7.4/6.5	5.9
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.25	8.24/8.32	8.26/8.35	8.05/8.29	8.30/8.26	8.26/8.29	8.28/8.20	8.09/8.17	8.44

Physical Data - 50%

DO New/Old	7.0	7.4/6.9	7.7/6.8	7.0/6.5	6.8/6.2	6.6/6.3	6.8/5.1	7.2/6.8	5.8
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.21	8.20/8.34	8.18/8.41	7.96/8.36	8.23/8.33	8.23/8.41	8.23/8.37	8.06/8.28	8.51

Physical Data - 100%

DO New/Old	7.2	7.4/6.8	7.8/6.9	6.9/6.6	6.6/6.4	6.5/6.5	6.7/5.9	7.7/6.7	6.4
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.6	25.0/24.0	24.2
Ph New/Old	8.12	8.15/8.34	8.17/8.36	7.88/8.35	8.06/8.32	8.07/8.30	8.06/8.33	7.96/8.18	8.39

Comments: Grit forming on the inside of the test chamber on most days. LC50 estimated at >100%.

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 22:45	Test ID:	GenTIEA	Sample ID:	Genwal TIE Aerated Chronic Cero
End Date:	11/3/2011 23:10	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	17.000	16.000	20.000	20.000	15.000	8.000
25	21.000	16.000	16.000	19.000	24.000	17.000
50	25.000	4.000	12.000	10.000	15.000	7.000
100	18.000	0.000	22.000	19.000	11.000	5.000

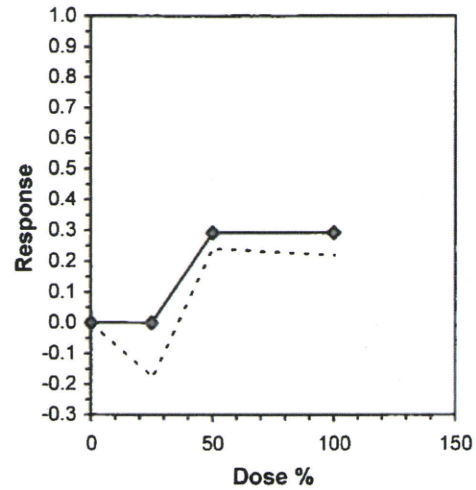
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	16.000	1.0000	16.000	8.000	20.000	27.670	6				17.417	1.0000
25	18.833	1.1771	18.833	16.000	24.000	16.930	6	-0.777	2.190	7.983	17.417	1.0000
50	12.167	0.7604	12.167	4.000	25.000	60.492	6	1.052	2.190	7.983	12.333	0.7081
100	12.500	0.7813	12.500	0.000	22.000	69.513	6	0.960	2.190	7.983	12.333	0.7081

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.98886	0.916	0.01767	0.15065
Bartlett's Test indicates equal variances (p = 0.16)	5.21762	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	7.98258	0.49891	59.8194	39.8583	0.24485	3, 20
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	29.283			
IC10	33.566			
IC15	37.848			
IC20	42.131			
IC25	46.414			
IC40	>100			
IC50	>100			



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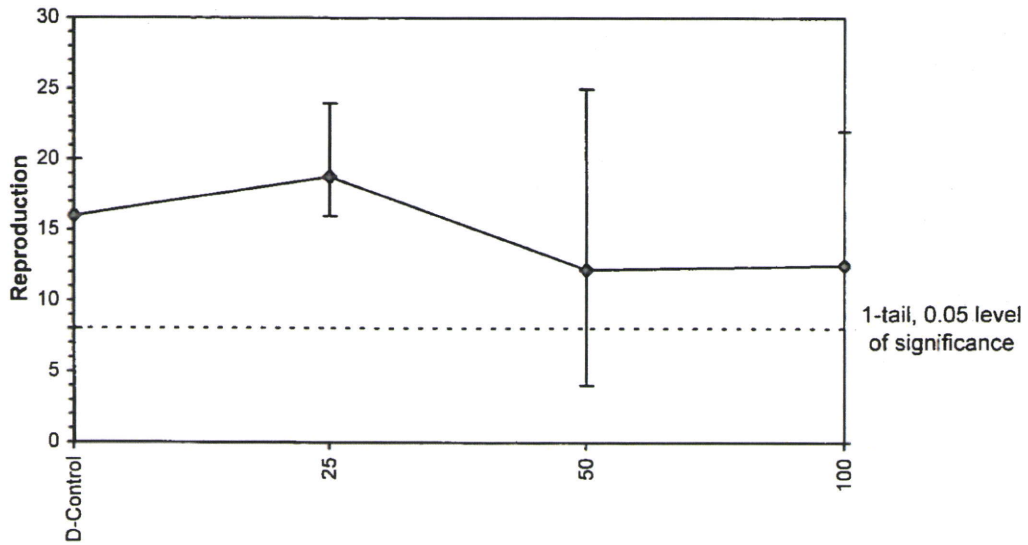
Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 22:45	Test ID:	GenTIEA	Sample ID:	Genwal TIE Aerated Chronic Cero
End Date:	11/3/2011 23:10	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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ToxCalc v5.0.32

Reviewed by:_____

Chronic Toxicity Testing
Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase I- Filtered

TIE sample made by compositing samples collected: 10/3/2011

Analyses Dates/Times Beginning 10/26/2011 11:00 p.m Ending 11/3/2011 11:20 p.m **IC25 Estimated from Test:** 86.15%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia
Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	16	8	16	23	20	19	17.0	0%
25.0%	18	28	24	26	24	26	24.3	0%
50.0%	20	21	25	26	21	15	21.3	0%
100%	16	14	17	19	11D	5D	13.7	33%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
DO New/Old	7.0	7.4/6.8	7.6/6.7	6.9/6.4	6.8/6.3	6.7/6.3	6.9/6.2	7.1/6.8	6.4
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.28	8.30/8.24	8.28/8.26	8.24/8.15	8.33/8.17	8.32/8.19	8.29/8.26	8.14/8.05	8.40

Physical Data- 25%

DO New/Old	7.3	7.4/6.9	7.8/6.9	7.0/6.5	6.8/6.3	6.6/6.3	7.0/6.4	7.3/6.8	6.0
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.17	8.18/8.37	8.15/8.39	8.13/8.31	8.24/8.29	8.29/8.31	8.27/8.39	8.13/8.19	8.44

Physical Data - 50%

DO New/Old	7.3	7.6/6.9	7.9/6.9	7.0/6.5	6.8/6.4	6.7/6.3	6.9/6.6	7.3/6.9	6.0
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.06	8.07/8.38	8.05/8.42	8.06/8.41	8.23/8.41	8.24/8.41	8.27/8.53	8.06/8.33	8.53

Physical Data - 100%

DO New/Old	7.4	7.5/7.0	7.7/7.0	7.3/6.4	6.9/6.5	6.4/6.4	6.8/6.6	7.7/7.0	6.5
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.03	8.05/8.27	8.08/8.28	8.00/8.30	8.13/8.35	8.17/8.33	8.14/8.36	7.97/8.23	8.35

Comments: Grit forming on the inside of the test chamber on most days. LC50 estimated at >100%.

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:00	Test ID:	GenTIEF	Sample ID:	Genwal TIE Filtered Chronic Cero
End Date:	11/3/2011 23:20	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	16.000	8.000	16.000	23.000	20.000	19.000
25	18.000	28.000	24.000	26.000	24.000	26.000
50	20.000	21.000	25.000	26.000	21.000	15.000
100	16.000	14.000	17.000	19.000	11.000	5.000

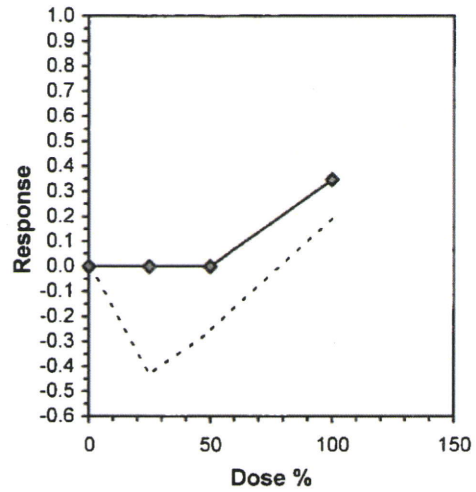
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	17.000	1.0000	17.000	8.000	23.000	30.224	6				20.889	1.0000
25	24.333	1.4314	24.333	18.000	28.000	14.157	6	-2.854	2.190	5.626	20.889	1.0000
50	21.333	1.2549	21.333	15.000	26.000	18.435	6	-1.687	2.190	5.626	20.889	1.0000
100	13.667	0.8039	13.667	5.000	19.000	36.925	6	1.297	2.190	5.626	13.667	0.6543

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.91824	0.916	-0.8296	0.12359
Bartlett's Test indicates equal variances (p = 0.80)	1.01341	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	5.62621	0.33095	132.611	19.8	0.00261	3, 20
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	57.231	6.962	23.547	64.421	-1.6245
IC10	64.462	6.915	34.595	82.041	-0.7835
IC15	71.692	8.306	46.999	98.591	0.2120
IC20	78.923				
IC25	86.154				
IC40	>100				
IC50	>100				



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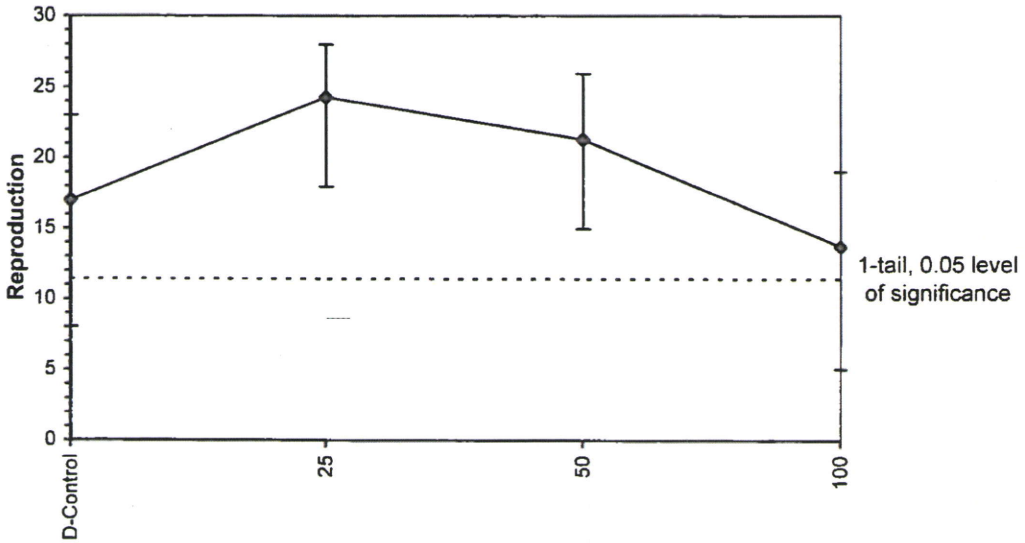
 ToxCalc v5.0.32 Reviewed by:_____

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:00	Test ID:	GenTIEF	Sample ID:	Genwal TIE Filtered Chronic Cero
End Date:	11/3/2011 23:20	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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Chronic Toxicity Testing
Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase I- C-18

TIE sample made by compositing samples collected: 10/3/2011

Analyses Dates/Times Beginning 10/26/2011 11:00 p.m Ending 11/3/2011 11:30 p.m **IC25 Estimated from Test:** 18.8%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia
Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	21	21	27	28	12	17	21.0	0%
25.0%	8	17	12	11D	14	17	13.2	17%
50.0%	13	25	21	13	22	6	14.8	0%
100%	3D	15	5	5D	9	4D	6.8	50%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
DO New/Old	7.2	7.4/6.9	7.8/6.9	6.8/6.4	6.8/6.3	6.6/6.1	6.9/6.1	7.2/6.6	6.3
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.23	8.18/8.24	8.14/8.24	8.12/8.17	8.28/8.16	8.21/8.16	8.28/8.22	8.15/8.04	8.37

Physical Data- 25%

DO New/Old	7.3	7.5/6.9	7.9/7.0	7.0/6.4	6.8/6.4	6.6/6.4	6.8/6.4	7.2/6.7	6.1
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.25	8.20/8.35	8.17/8.39	8.18/8.32	8.33/8.31	8.29/8.30	8.28/8.39	8.15/8.19	8.50

Physical Data - 50%

DO New/Old	7.3	7.5/6.9	8.0/6.8	7.0/6.4	6.7/6.5	6.6/6.3	6.9/6.4	7.3/6.8	6.0
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.24	8.22/8.39	8.18/8.44	8.19/8.42	8.30/8.44	8.28/8.41	8.30/8.51	8.12/8.32	8.53

Physical Data - 100%

DO New/Old	7.1	7.2/6.9	7.9/7.0	7.0/6.5	6.6/6.3	6.5/6.5	6.7/6.4	7.3/6.9	6.6
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.18	8.15/8.33	8.09/8.32	8.09/8.31	8.08/8.36	8.18/8.34	8.15/8.39	8.10/8.26	8.43

Comments: Grit forming on the inside of the test chamber on most days. LC50 estimated at 100%.

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:00	Test ID:	GenTIEC	Sample ID:	Genwal TIE C-18 Chronic Cero
End Date:	11/3/2011 23:30	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	21.000	21.000	27.000	28.000	12.000	17.000
25	8.000	17.000	12.000	11.000	14.000	17.000
50	13.000	25.000	21.000	13.000	11.000	6.000
100	3.000	15.000	5.000	5.000	9.000	4.000

			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	21.000	1.0000	21.000	12.000	28.000	28.730	6				21.000	1.0000
*25	13.167	0.6270	13.167	8.000	17.000	26.924	6	2.505	2.190	6.847	14.000	0.6667
50	14.833	0.7063	14.833	6.000	25.000	46.788	6	1.972	2.190	6.847	14.000	0.6667
*100	6.833	0.3254	6.833	3.000	15.000	65.718	6	4.531	2.190	6.847	6.833	0.3254

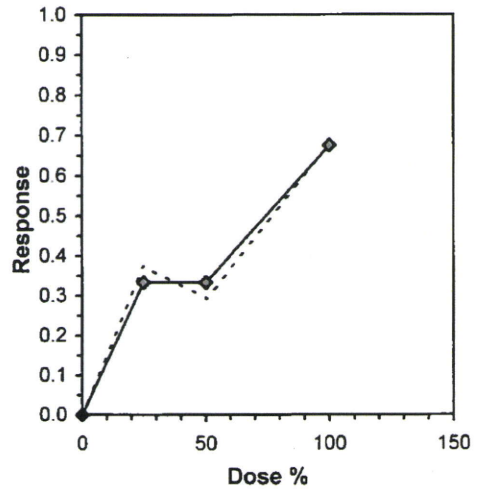
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.96036	0.916	0.26537	-0.4034
Bartlett's Test indicates equal variances (p = 0.50)	2.35129	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	50	100	70.7107	2	6.84703	0.32605	203.486	29.325	0.0022	3, 20
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05*	3.750	6.438	2.083	25.877	5.9501
IC10*	7.500	9.061	4.166	75.591	4.0642
IC15*	11.250	10.401	6.249	81.327	3.2856
IC20*	15.000	13.816	8.332	85.495	2.0663
IC25*	18.750	17.336	10.415	92.018	1.1307
IC40	59.767				
IC50	74.419				

* indicates IC estimate less than the lowest concentration



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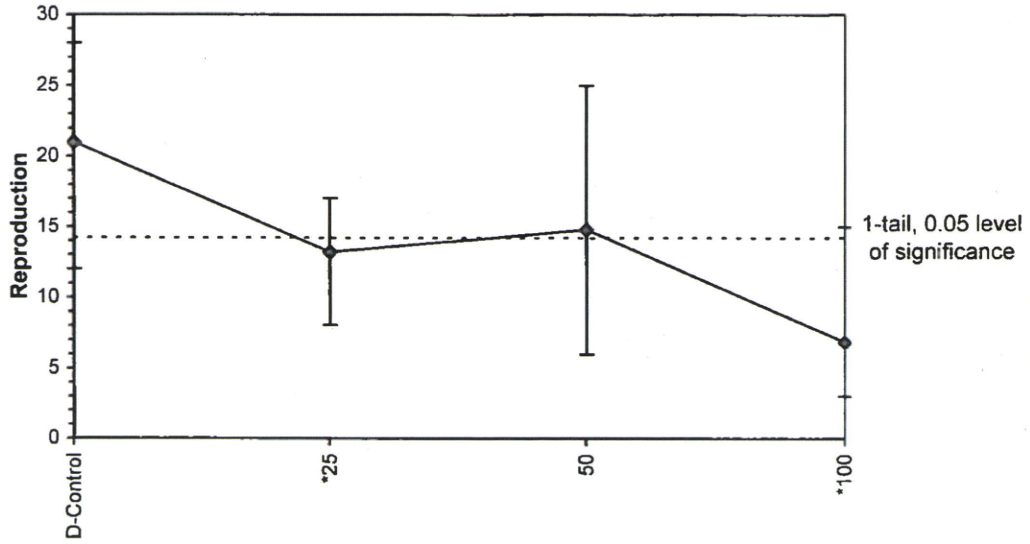
Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:00	Test ID:	GenTIEC	Sample ID:	Genwal TIE C-18 Chronic Cero
End Date:	11/3/2011 23:30	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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Chronic Toxicity Testing
Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase I- PH 6

TIE sample made by compositing samples collected: 10/3/2011

Analyses Dates/Times Beginning 10/26/2011 11:15 p.m Ending 11/3/2011 11:40 p.m **IC25 Estimated from Test:** 61.76%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia
Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	32	29	28	23	22	28	27.0	0%
25.0%	22	35	33	36	35	32	32.2	0%
50.0%	21	28	29	21	24	24	24.5	0%
100%	16	22	7	14	16	13	14.7	0%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
DO New/Old	6.9	7.2/6.9	7.3/6.9	6.8/6.4	6.7/6.3	6.6/6.2	6.7/6.3	7.2/6.8	6.3
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	6.00	6.01/6.09	5.97/6.04	5.98/6.06	6.15/6.05	6.04/6.01	6.06/6.06	5.98/6.06	6.06

Physical Data- 25%

DO New/Old	6.9	7.2/6.8	7.4/7.1	6.8/6.6	6.7/6.4	6.7/6.3	7.0/6.5	7.3/7.0	6.3
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	6.25	6.20/6.31	8.18/6.44	6.24/6.44	6.30/6.49	6.31/6.49	6.31/6.47	6.19/6.47	6.48

Physical Data - 50%

DO New/Old	7.1	7.3/6.8	7.3/7.0	6.7/6.6	6.7/6.4	6.6/6.5	7.1/6.7	7.1/7.0	6.3
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	6.39	6.41/6.79	6.43/6.88	6.39/6.78	6.50/6.74	6.52/6.92	6.50/6.85	6.44/6.84	6.90

Physical Data - 100%

DO New/Old	7.4	7.2/6.7	7.7/7.1	7.1/6.6	6.8/6.5	6.8/6.3	7.1/6.6	7.6/7.1	6.5
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	6.62	6.64/7.13	6.68/7.01	6.66/7.51	6.80/7.47	6.92/7.64	6.79/7.69	6.63/7.66	8.09

Comments: Grit forming on the inside of the test chamber on most days. LC50 estimated at >100%.

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:15	Test ID:	GenTIE6	Sample ID:	Genwal TIE ph6 Chronic Cero
End Date:	11/3/2011 23:40	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	32.000	29.000	28.000	23.000	22.000	28.000
25	22.000	35.000	33.000	36.000	35.000	32.000
50	21.000	28.000	29.000	21.000	24.000	24.000
100	16.000	22.000	7.000	14.000	16.000	13.000

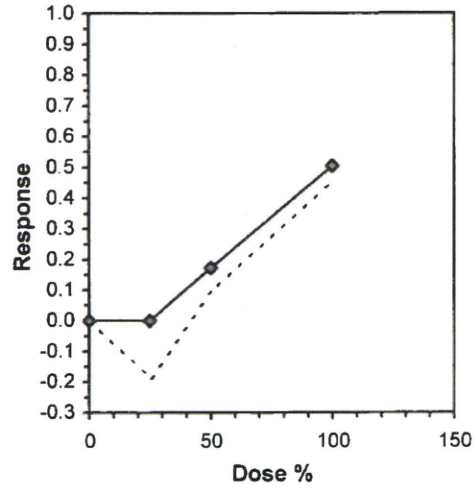
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	27.000	1.0000	27.000	22.000	32.000	14.055	6				29.583	1.0000
25	32.167	1.1914	32.167	22.000	36.000	16.144	6	-2.043	2.190	5.538	29.583	1.0000
50	24.500	0.9074	24.500	21.000	29.000	13.841	6	0.989	2.190	5.538	24.500	0.8282
*100	14.667	0.5432	14.667	7.000	22.000	33.309	6	4.877	2.190	5.538	14.667	0.4958

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.96285	0.916	-0.7038	0.57758
Bartlett's Test indicates equal variances (p = 0.78)	1.10542	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	50	100	70.7107	2	5.53791	0.20511	323.389	19.1833	1.1E-05	3, 20
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	32.275	5.279	28.518	62.773	1.7837
IC10	39.549	6.002	32.112	67.058	1.1519
IC15	46.824	6.368	35.667	72.640	0.7885
IC20	54.237	6.712	39.306	76.620	0.5057
IC25	61.758	7.039	42.777	84.072	0.1977
IC40	84.322				
IC50	99.364				



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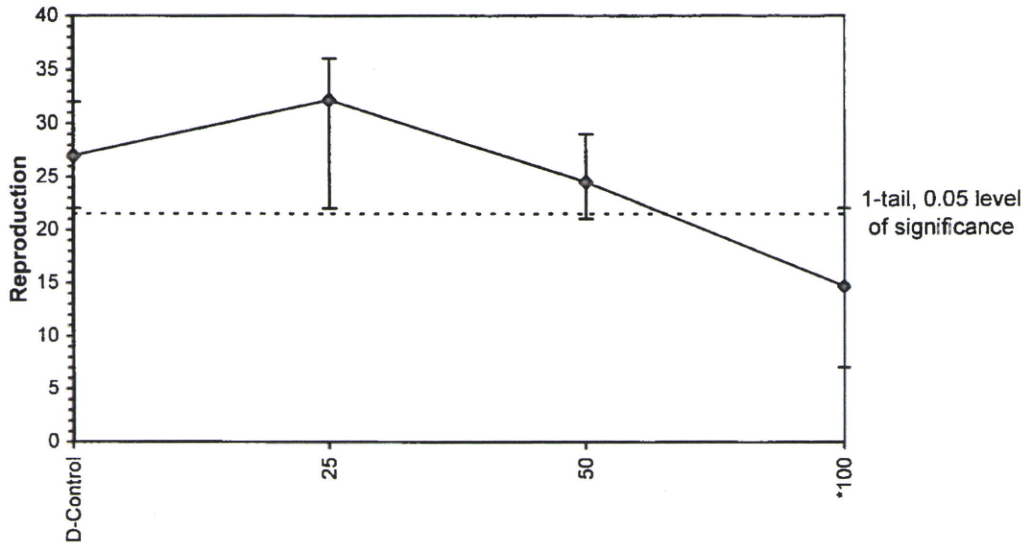
Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:15	Test ID:	GenTIE6	Sample ID:	Genwal TIE ph6 Chronic Cero
End Date:	11/3/2011 23:40	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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Chronic Toxicity Testing
Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase I- PH 7

TIE sample made by compositing samples collected: 10/3/2011

Analyses Dates/Times Beginning 10/26/2011 11:15 p.m Ending 11/3/2011 11:40 p.m **IC25 Estimated from Test:** >100%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia
Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	22	26	21	27	28	28	25.3	0%
25.0%	34	27	24	26	32	26	28.2	0%
50.0%	22	25	26	23	31	23	25.0	0%
100%	23	22	13	21	27	20	21.0	0%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
DO New/Old	7.3	7.3/6.8	7.1/7.1	6.7/6.5	6.6/6.4	6.6/6.2	6.8/6.7	7.0/6.9	6.2
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	7.48	7.23/8.18	7.29/8.37	7.35/7.71	7.38/7.69	7.43/7.66	7.45/7.72	7.30/7.60	7.80

Physical Data- 25%

DO New/Old	7.1	7.3/6.8	7.2/7.1	6.8/6.5	6.6/6.3	6.5/6.4	6.6/6.6	7.2/6.9	6.1
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	7.46	7.40/8.10	7.34/8.19	7.37/7.98	7.46/7.89	7.44/7.85	7.50/7.95	7.33/7.83	8.07

Physical Data - 50%

DO New/Old	7.0	7.1/6.8	7.3/7.0	6.9/6.6	6.7/6.4	6.6/6.4	6.8/6.5	7.2/7.0	6.2
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	7.38	7.37/8.03	7.39/8.00	7.43/8.13	7.51/8.06	7.52/8.02	7.61/8.19	7.43/8.00	8.26

Physical Data - 100%

DO New/Old	6.8	7.4/6.9	7.6/7.0	6.9/6.7	6.7/6.6	6.6/6.4	6.9/6.6	7.3/7.0	6.3
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	7.34	7.35/7.80	7.41/7.79	7.52/8.37	7.59/8.29	7.59/8.33	7.63/8.41	7.48/8.26	8.35

Comments: LC50 estimated at >100%.

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:15	Test ID:	GenTIE7	Sample ID:	Genwal TIE ph7 Chronic Cero
End Date:	11/3/2011 23:50	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	22.000	26.000	21.000	27.000	28.000	28.000
25	34.000	27.000	24.000	26.000	32.000	26.000
50	22.000	25.000	26.000	23.000	31.000	23.000
100	23.000	22.000	13.000	21.000	27.000	20.000

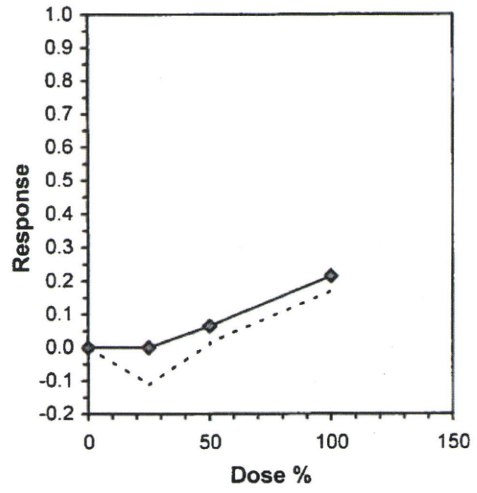
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	25.333	1.0000	25.333	21.000	28.000	12.145	6				26.750	1.0000
25	28.167	1.1118	28.167	24.000	34.000	13.917	6	-1.302	2.190	4.766	26.750	1.0000
50	25.000	0.9868	25.000	22.000	31.000	13.145	6	0.153	2.190	4.766	25.000	0.9346
100	21.000	0.8289	21.000	13.000	27.000	21.925	6	1.991	2.190	4.766	21.000	0.7850

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.9722	0.916	-0.0317	-0.0592
Bartlett's Test indicates equal variances (p = 0.82)	0.93134	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	4.76601	0.18813	52.1528	14.2083	0.02956	3, 20
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	44.107			
IC10	61.563			
IC15	78.281			
IC20	95.000			
IC25	>100			
IC40	>100			
IC50	>100			



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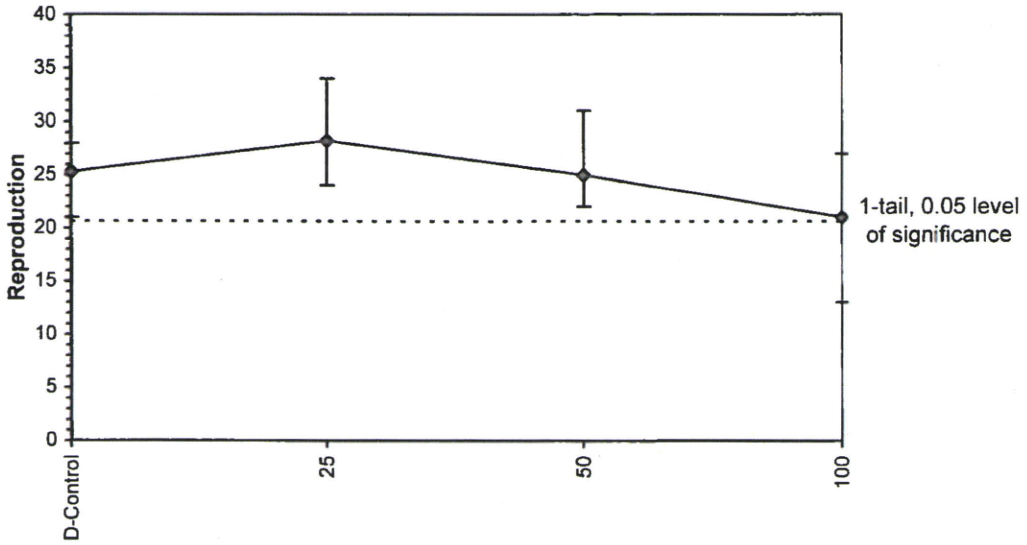
 ToxCalc v5.0.32 Reviewed by: _____

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:15	Test ID:	GenTIE7	Sample ID:	Genwal TIE ph7 Chronic Cero
End Date:	11/3/2011 23:50	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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Chronic Toxicity Testing

Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase I- EDTA 3 mg/L

TIE sample made by compositing samples collected: 10/3/2011

Analyses Dates/Times Beginning 10/26/2011 11:25 p.m Ending 11/3/2011 12:00 p.m **IC25 Estimated from Test:** >100%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia

Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	24	0D	21	25	33	26	21.5	17%
25.0%	26	26	13	22	35	18	23.3	0%
50.0%	24	11	7	12	23	26	17.2	0%
100%	13	22	24	15	26	19	19.8	0%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
DO New/Old	7.0	7.2/6.9	7.2/7.1	6.7/6.7	6.9/6.5	6.6/6.4	7.0/6.6	7.1/6.8	6.4
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	7.80	7.79/8.25	7.74/8.28	7.75/8.17	7.86/8.21	7.86/8.19	7.89/8.29	7.77/8.06	8.39

Physical Data- 25%

DO New/Old	7.0	7.2/6.9	7.2/7.1	6.8/6.6	6.8/6.6	6.7/6.7	6.9/6.9	7.3/7.0	6.4
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.01	7.96/8.39	7.89/8.44	7.91/8.37	8.02/8.36	8.07/8.36	8.05/8.48	7.82/8.23	8.53

Physical Data - 50%

DO New/Old	7.2	7.2/6.9	7.3/7.3	6.9/6.7	6.8/6.7	6.7/6.8	7.0/6.9	7.3/7.4	6.4
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	7.94	7.92/8.37	7.89/8.40	7.95/8.44	8.09/8.47	8.13/8.43	8.13/8.52	7.90/8.36	8.51

Physical Data - 100%

DO New/Old	7.3	7.1/6.8	7.3/7.5	6.9/6.6	6.9/6.8	6.7/6.8	7.0/7.0	7.3/7.3	6.4
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	7.93	7.91/8.38	7.89/8.35	7.94/8.26	8.03/8.28	8.12/8.28	8.09/8.33	7.96/8.21	8.41

Comments: LC50 estimated at >100%.

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:25	Test ID:	GenTIEE3	Sample ID:	Genwal TIE EDTA 3 Chronic Cero
End Date:		Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	24.000	0.000	21.000	25.000	33.000	26.000
25	26.000	26.000	13.000	22.000	35.000	18.000
50	24.000	11.000	7.000	12.000	23.000	26.000
100	13.000	22.000	24.000	15.000	26.000	19.000

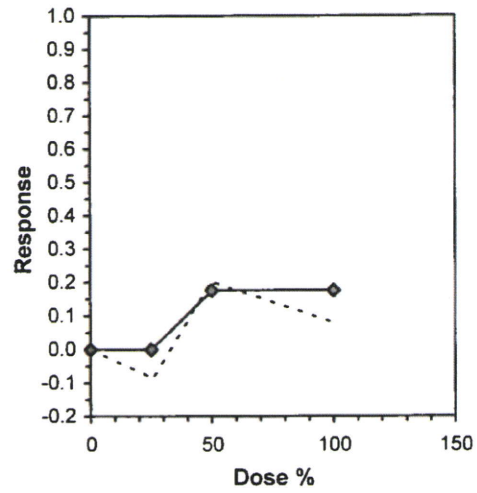
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	21.500	1.0000	21.500	0.000	33.000	52.354	6				22.417	1.0000
25	23.333	1.0853	23.333	13.000	35.000	32.489	6	-0.382	2.190	10.497	22.417	1.0000
50	17.167	0.7984	17.167	7.000	26.000	47.097	6	0.904	2.190	10.497	18.500	0.8253
100	19.833	0.9225	19.833	13.000	26.000	25.792	6	0.348	2.190	10.497	18.500	0.8253

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.947	0.916	-0.8414	1.11354
Bartlett's Test indicates equal variances (p = 0.43)	2.74408	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	100	>100		1	10.4972	0.48824	41.1528	68.925	0.6243	3, 20
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	32.154			
IC10	39.309			
IC15	46.463			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



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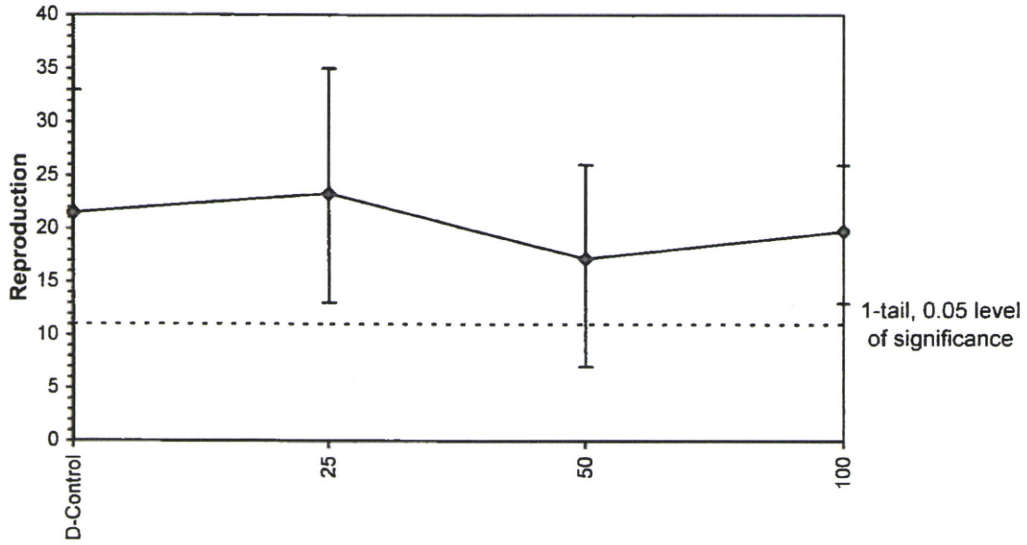
Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:25	Test ID:	GenTIEE3	Sample ID:	Genwal TIE EDTA 3 Chronic Cero
End Date:		Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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 ToxCalc v5.0.32 Reviewed by:_____

Chronic Toxicity Testing

Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase I- EDTA 8 mg/L

TIE sample made by compositing samples collected: 10/3/2011

Analyses Dates/Times Beginning 10/26/2011 11:25 p.m Ending 11/3/2011 12:10 p.m **IC25 Estimated from Test:** >100%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia

Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	22	24	21	10	21	11	18.2	0%
25.0%	23	30	10	26	27	26	23.7	0%
50.0%	24	27	27	20	26	23	24.5	0%
100%	9	16	18	20	18	25	17.7	0%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
DO New/Old	7.0	7.2/6.8	7.0/7.0	6.9/6.5	6.8/6.6	6.7/6.2	7.0/6.7	7.2/7.0	6.4
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.11	8.08/8.25	8.00/8.23	8.07/8.18	8.18/8.09	8.19/8.13	8.15/8.21	7.93/8.15	8.42

Physical Data- 25%

DO New/Old	7.0	7.2/6.8	7.1/7.1	6.9/6.7	6.8/6.6	6.7/6.5	7.0/6.5	7.3/7.1	6.4
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.03	8.00/8.32	7.96/8.41	8.07/8.34	8.11/8.33	8.11/8.33	8.16/8.44	7.92/8.28	8.53

Physical Data - 50%

DO New/Old	7.2	7.4/6.9	7.3/7.1	6.9/6.4	6.8/6.7	6.6/6.6	6.9/6.8	7.4/7.2	6.4
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	7.95	7.94/8.39	7.93/8.40	8.02/8.41	8.07/8.43	8.09/8.44	8.17/8.50	7.89/8.37	8.51

Physical Data - 100%

DO New/Old	7.2	7.4/6.8	7.3/7.3	7.0/6.6	6.8/6.8	6.7/6.7	7.0/6.9	7.5/7.2	6.4
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	7.91	7.93/8.32	7.96/8.35	7.96/8.27	8.04/8.25	8.10/8.31	8.07/8.32	7.89/8.23	8.42

Comments: LC50 estimated at >100%.

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:25	Test ID:	GenTIEE8	Sample ID:	Genwal TIE EDTA 8 Chronic Cero
End Date:		Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	22.000	24.000	21.000	10.000	21.000	11.000
25	23.000	30.000	10.000	26.000	27.000	26.000
50	24.000	27.000	27.000	20.000	26.000	23.000
100	9.000	16.000	18.000	20.000	18.000	25.000

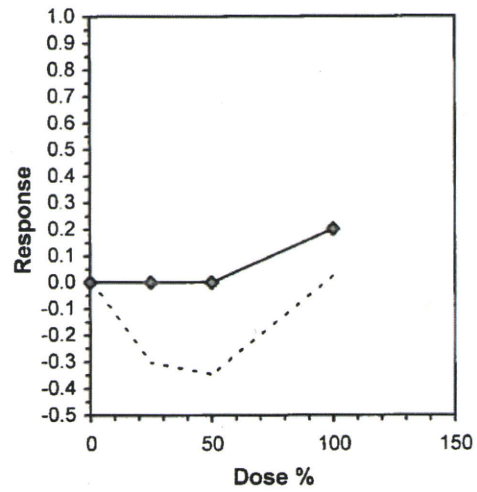
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
D-Control	18.167	1.0000	18.167	10.000	24.000	33.286	6			22.111	1.0000
25	23.667	1.3028	23.667	10.000	30.000	29.838	6	50.50	26.00	22.111	1.0000
50	24.500	1.3486	24.500	20.000	27.000	11.178	6	51.50	26.00	22.111	1.0000
100	17.667	0.9725	17.667	9.000	25.000	29.665	6	35.00	26.00	17.667	0.7990

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.90043	0.916	-1.1046	0.96996
Bartlett's Test indicates equal variances (p = 0.29)	3.76071	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs D-Control				

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	62.438			
IC10	74.875			
IC15	87.313			
IC20	99.750			
IC25	>100			
IC40	>100			
IC50	>100			



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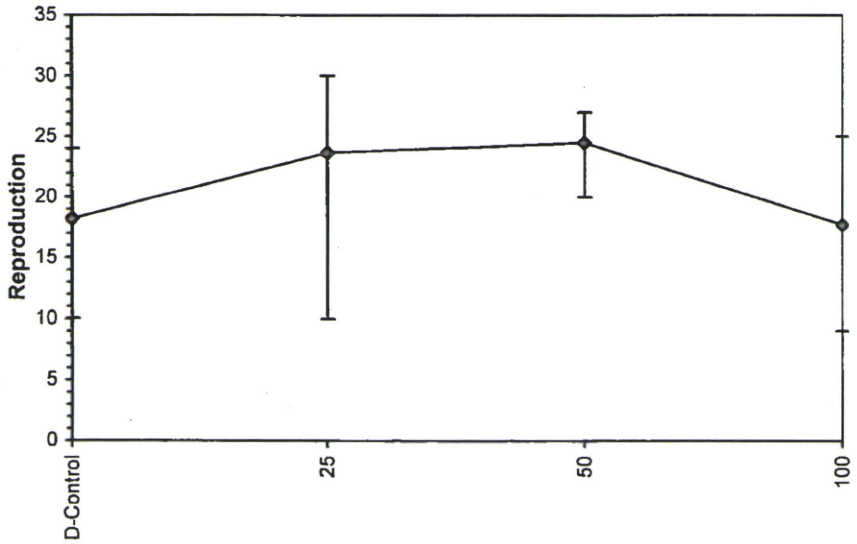
 ToxCalc v5.0.32 Reviewed by: ____

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:25	Test ID:	GenTIEE8	Sample ID:	Genwal TIE EDTA 8 Chronic Cero
End Date:		Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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ToxCalc v5.0.32

Reviewed by._____

Chronic Toxicity Testing

Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase I- Thiosulfate 10 mg/L

TIE sample made by compositing samples collected: 10/3/2011

Analyses Dates/Times Beginning 10/26/2011 11:40 p.m Ending 11/3/2011 12:20 p.m **IC25 Estimated from Test:** 43.31%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia

Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	17	16	19	13	14	15	15.7	0%
25.0%	10	14	11	18	17	20	15.0	0%
50.0%	12	11	5D	10	16	12	10.8	0%
100%	3	9	0	4	2	2	3.3	0%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
DO New/Old	6.9	7.2/6.8	7.0/7.1	6.8/6.7	6.8/6.6	6.9/6.3	7.0/6.4	7.3/7.0	6.3
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.23	8.24/8.36	8.26/8.38	8.20/8.11	8.30/8.18	8.29/8.22	8.27/8.28	815/8.06	8.41

Physical Data- 25%

DO New/Old	7.1	7.2/6.9	7.0/7.3	6.6/6.8	6.7/6.7	6.7/6.5	7.0/6.7	7.0/7.1	6.3
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.12	8.09/8.45	8.07/8.48	8.07/8.35	8.21/8.39	8.29/8.36	8.22/8.47	8.04/8.28	8.52

Physical Data - 50%

DO New/Old	7.2	7.3/6.9	7.1/7.4	6.9/6.6	6.8/6.8	6.7/6.6	6.9/6.9	7.4/7.2	6.3
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.06	8.07/8.35	8.05/8.37	8.04/8.38	8.14/8.44	8.24/8.45	8.19/8.50	7.99/8.38	8.41

Physical Data - 100%

DO New/Old	7.3	7.4/7.0	7.5/7.4	6.9/6.8	6.9/6.9	6.7/6.8	7.0/6.9	7.5/7.4	6.5
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.00	7.95/8.32	7.90/8.34	8.03/8.23	8.12/8.24	8.14/8.27	8.07/8.32	7.97/8.21	8.38

Comments: Grit forming on the inside of the test chamber on most days. LC50 estimated at >100%.

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:40	Test ID:	GenTIEt10	Sample ID:	Genwal TIE Thiosulfate 10 Chronic Cer
End Date:		Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	17.000	16.000	19.000	13.000	14.000	15.000
25	10.000	14.000	11.000	18.000	17.000	20.000
50	12.000	11.000	5.000	10.000	16.000	12.000
100	3.000	9.000	0.000	4.000	2.000	2.000

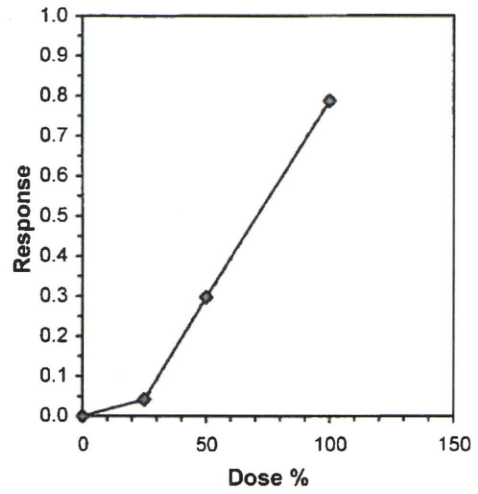
			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	15.667	1.0000	15.667	13.000	19.000	13.789	6				15.667	1.0000
25	15.000	0.9574	15.000	10.000	20.000	26.667	6	0.352	2.190	4.142	15.000	0.9574
*50	11.000	0.7021	11.000	5.000	16.000	32.525	6	2.467	2.190	4.142	11.000	0.7021
*100	3.333	0.2128	3.333	0.000	9.000	92.304	6	6.520	2.190	4.142	3.333	0.2128

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.97804	0.916	0.05988	-0.2756
Bartlett's Test indicates equal variances (p = 0.62)	1.76843	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	25	50	35.3553	4	4.14239	0.26441	192.611	10.7333	6.8E-06	3, 20
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05	25.729	9.452	0.000	35.724	-0.5958
IC10	30.625	8.957	0.000	52.705	-0.5566
IC15	35.521	9.026	2.791	60.320	-0.4500
IC20	40.417	9.071	7.193	63.513	-0.4295
IC25	45.313	8.866	11.595	66.618	-0.5139
IC40	60.435	8.037	35.571	79.071	-0.1150
IC50	70.652	7.720	44.800	88.540	-0.1095



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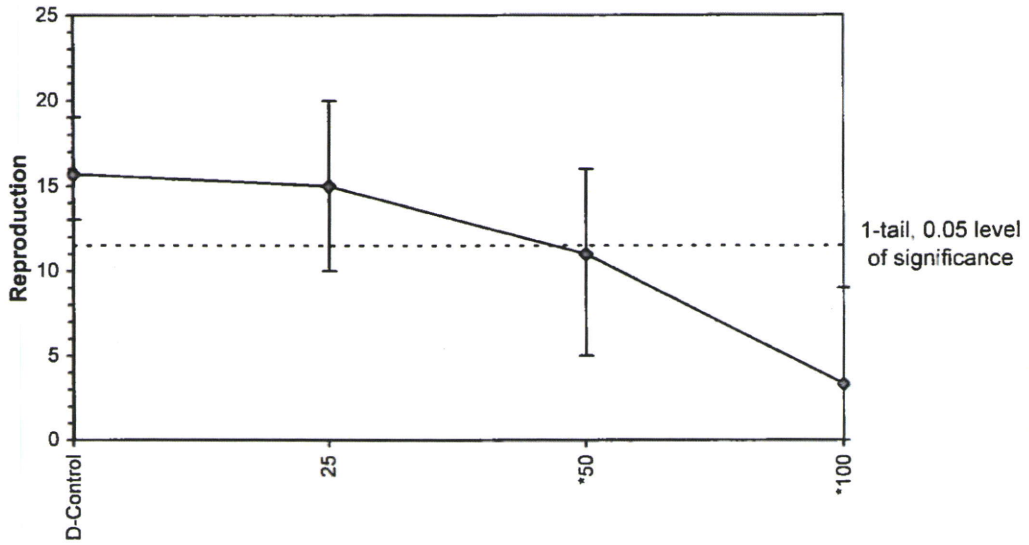
Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:40	Test ID:	GenTIEt10	Sample ID:	Genwal TIE Thiosulfate 10 Chronic Cer
End Date:		Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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Chronic Toxicity Testing
Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase I- Thiosulfate 25 mg/L

TIE sample made by compositing samples collected: 10/3/2011

Analyses Dates/Times Beginning 10/26/2011 11:40 p.m Ending 11/3/2011 12:30 p.m **IC25 Estimated from Test:** 68.15%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia
Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	12	11	16	16	12	14	13.5	0%
25.0%	11	13	15	9	9	14	11.8	0%
50.0%	14	9	15	9	15	11	12.2	0%
100%	5	9	9	10	3	5	6.8	0%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
DO New/Old	6.9	7.2/6.9	7.0/7.2	6.7/6.7	6.9/6.5	6.8/6.4	7.0/6.5	6.9/7.3	6.2
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.28	8.26/8.39	8.24/8.41	8.24/8.16	8.35/8.17	8.26/8.17	8.28/8.26	8.15/8.18	8.33

Physical Data- 25%

DO New/Old	7.1	7.1/6.9	7.2/7.2	6.7/6.8	6.8/6.7	6.8/6.8	7.0/6.7	7.1/7.2	6.3
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.18	8.12/8.45	8.08/8.49	8.12/8.38	8.18/8.39	8.19/8.37	8.21/8.48	8.01/8.36	8.51

Physical Data - 50%

DO New/Old	7.2	7.2/6.9	7.3/7.2	7.0/6.8	6.9/6.7	6.7/6.8	7.0/6.6	7.3/7.1	6.3
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.07	8.05/8.39	8.00/8.37	8.06/8.42	8.13/8.46	8.19/8.37	8.23/8.50	7.97/8.31	8.42

Physical Data - 100%

DO New/Old	7.2	7.5/6.9	7.4/7.4	7.2/6.8	6.8/6.8	6.7/6.8	6.9/6.6	7.5/7.2	6.4
Temp New/Old	24.2	25.0/24.4	25.0/24.4	25.0/24.4	25.0/24.6	25.0/24.6	25.0/24.8	25.0/24.0	24.2
Ph New/Old	8.01	7.97/8.37	7.95/8.35	7.94/8.25	8.09/8.24	8.11/8.27	8.13/8.23	7.95/8.16	8.38

Comments: Grit forming on the inside of the test chamber on most days. LC50 estimated at >100%.

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:40	Test ID:	GenTIEt25	Sample ID:	Genwal TIE Thiosulfate 25 Chronic Cer
End Date:		Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	12.000	11.000	16.000	16.000	12.000	14.000
25	11.000	13.000	15.000	9.000	9.000	14.000
50	14.000	9.000	15.000	9.000	15.000	11.000
100	5.000	9.000	9.000	10.000	3.000	5.000

			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
D-Control	13.500	1.0000	13.500	11.000	16.000	16.059	6			13.500	1.0000
25	11.833	0.8765	11.833	9.000	15.000	21.655	6	32.00	26.00	12.000	0.8889
50	12.167	0.9012	12.167	9.000	15.000	23.488	6	33.00	26.00	12.000	0.8889
*100	6.833	0.5062	6.833	3.000	10.000	41.821	6	21.00	26.00	6.833	0.5062

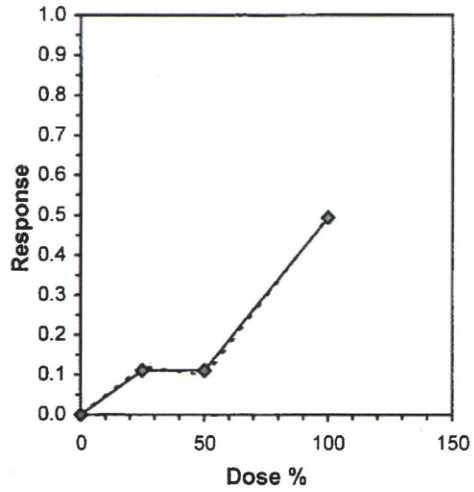
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.88009	0.916	-0.076	-1.698
Bartlett's Test indicates equal variances (p = 0.93)	0.4449	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	50	100	70.7107	2
Treatments vs D-Control				

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05*	11.250	17.164	2.971	79.003	1.0290
IC10*	22.500	18.376	5.941	83.006	-0.0082
IC15	55.081	16.761	0.000	76.343	-0.7685
IC20	61.613	13.990	3.576	85.658	-1.2518
IC25	68.145	10.652	31.950	96.716	-0.7489
IC40	87.742				
IC50	>100				

* indicates IC estimate less than the lowest concentration



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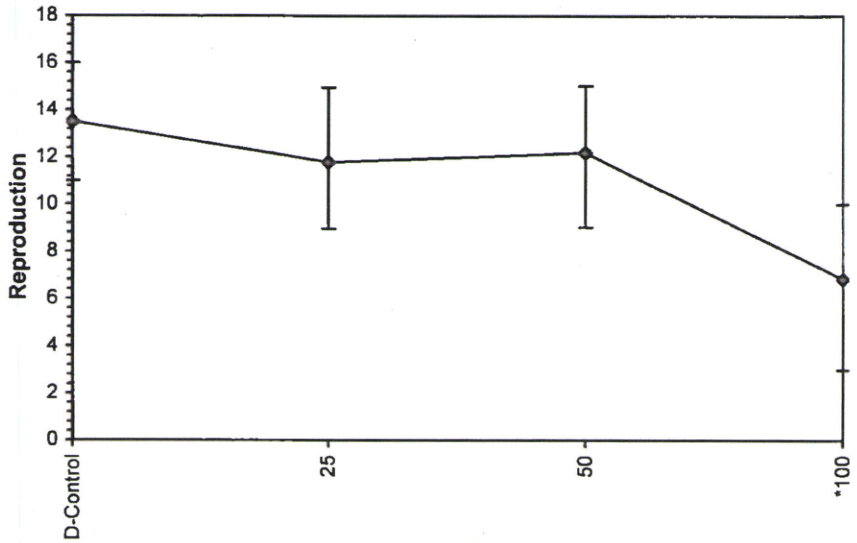
Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	10/26/2011 23:40	Test ID:	GenTIEt25	Sample ID:	Genwal TIE Thiosulfate 25 Chronic Cer
End Date:		Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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Sample Chemistries

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W.E.T. Inc.

ater & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Whole Effluent Toxicity Chemical Result Report

October 28, 2011

CUSTOMER NAME:
Utah American- Crandall Canyon Mine (Accelerated Test #3)
Attn: Dana Morrelli
194 North 100 West
Huntington, Utah 84528

SAMPLE DESCRIPTION:
Chemistries to go with Chronic Toxicity Test sampled on 10/03/2011.

Analysis	Test Results		
	Repl. 1	Repl. 2	Repl. 3
Log #	8490	NA	NA
Total Hardness, Recon (EPA 130.2), mg/L	176		
Total Hardness, Effluent (EPA 130.2), mg/L	472		
Ammonia, Effluent (EPA 350.2/350.3), mg/L	0.43		
Initial Chlorine Residual (EPA 330.5), mg/L	<0.05		
Final Chlorine Residual (EPA 330.5), mg/L	N/A		
Conductivity, Effluent (EPA 120.1), umhos/cm	970		
Alkalinity, Effluent (EPA 310.1), mg/L $CaCO^3$	382		
Recon Initial pH (EPA 150.1)	8.45		
After 24 hours pH (EPA 150.1)	8.27		
100% Initial pH (EPA 150.1)	7.71		
100% After 24 hours pH (EPA 150.1)	7.81		

Reviewed: Lee Rawlings. Lab Director
Water & Environmental Testing, Inc.

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Quality Control Charts

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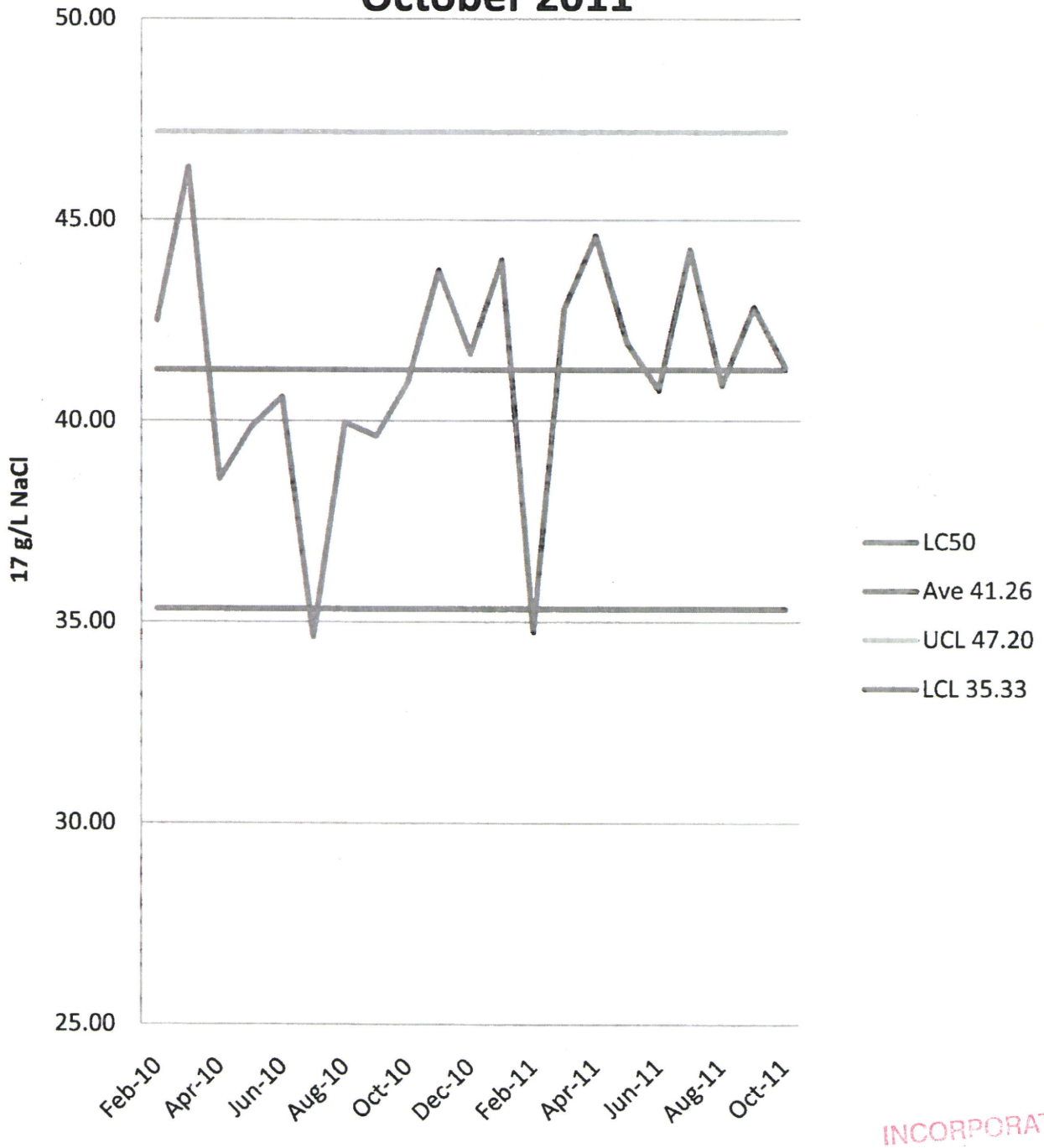
Reference Toxicant Control Chart
Chronic Fathead Minnow LC50
October 2011



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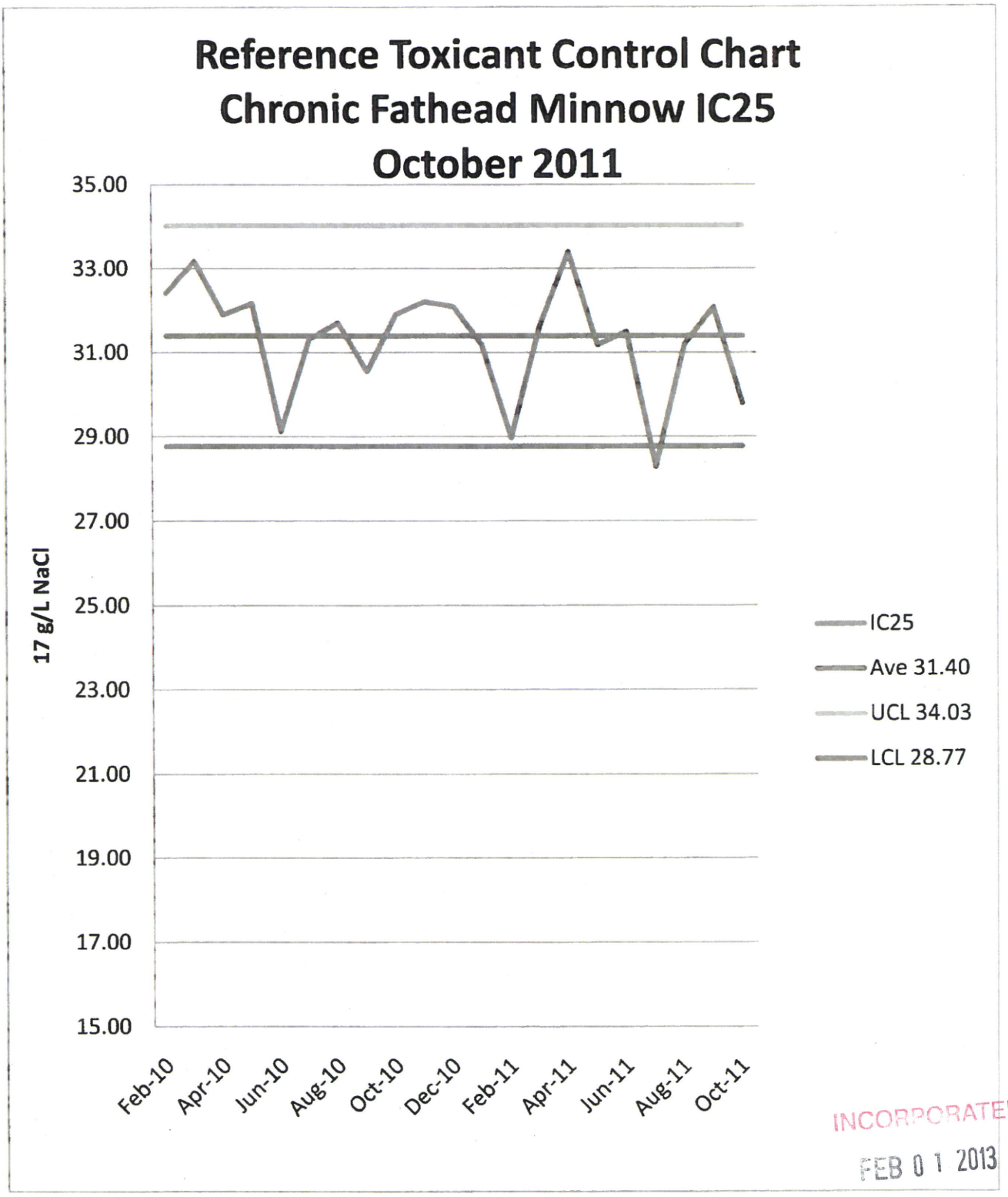

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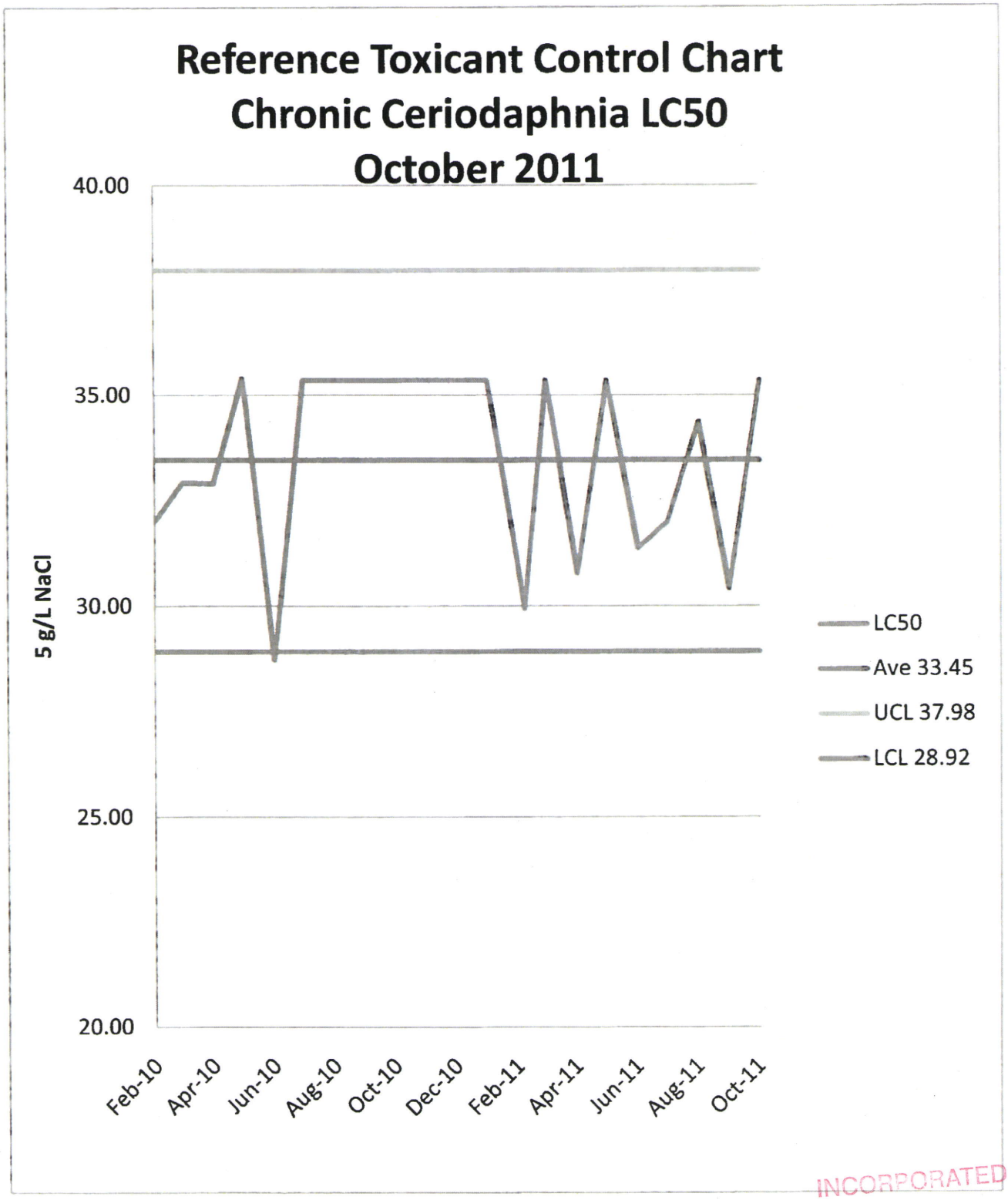

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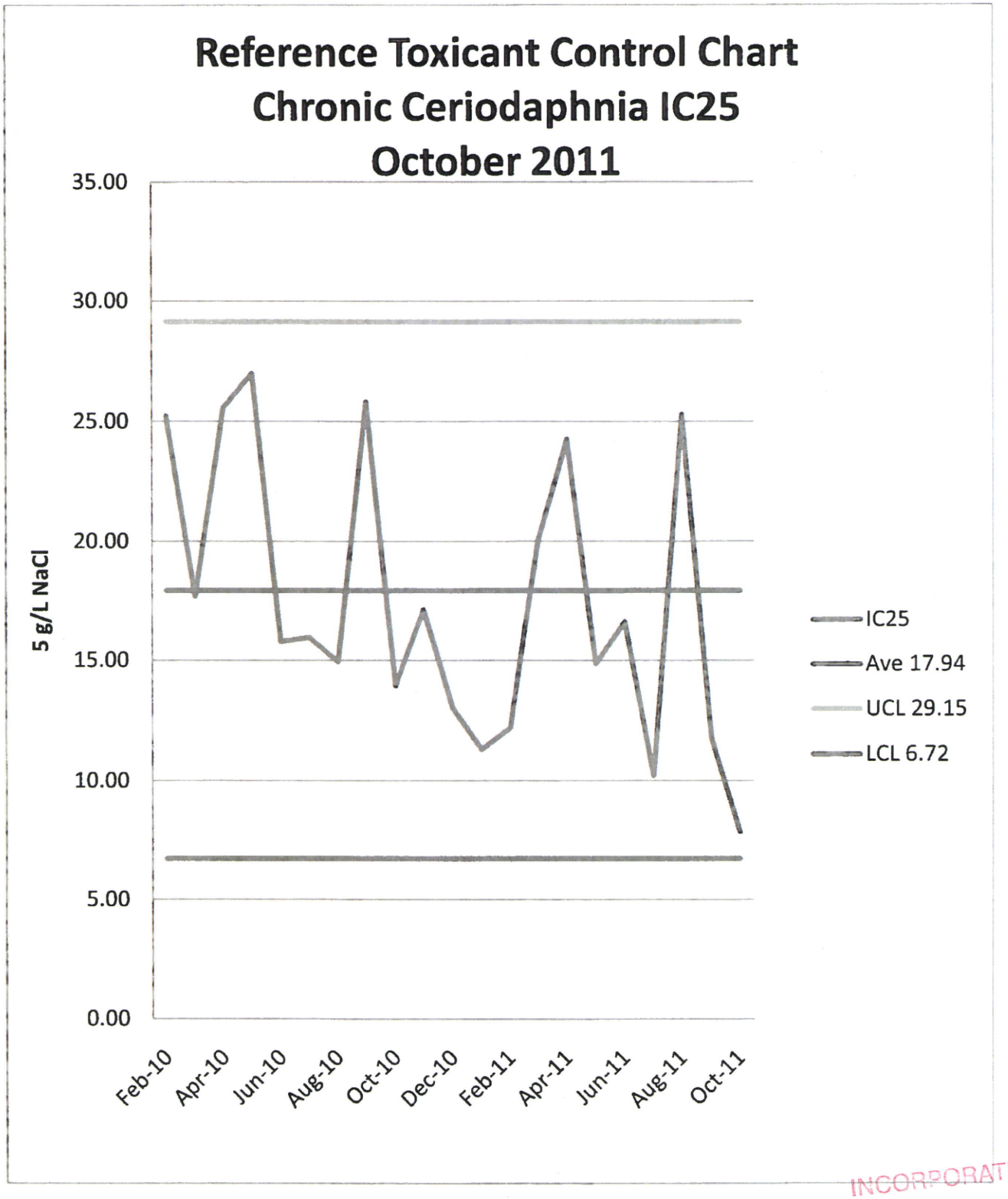

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Chain of Custody

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W.E.T. Inc.

Water & Environmental Testing Inc. 223 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax (801)763-0440

Chain of Custody Record

Customer: UTAH AMERICAN	Sampler: DANA MARRELLI
Sample Date: 10-03-11	Project: CRANDALL

Sample Information

Sample #	Date	Time	Composite/Grab	Location	Analysis Requested
1	10-3-11	9:30	GRAB	CRANDALL 002	

Sample Custody Record

Relinquished by: D Marrelli	Received by: K. A	Date/Time October 3, 2011 12 45
Relinquished by: K. A	Received by: Jim Rawlings	Date/Time 10/3/11 1900
Relinquished by:	Received by:	Date/Time
Sample Received in Lab by SR	Date/Time 10-3-11 1:00	

Comments: _____

Temperature Received in the Lab: Effluent: TC

Receiving Water: _____

W.E.T. Inc. Use Only

Cooler: Wet Ice ___ Blue Ice ___ None ✓	Hand Delivery ✓ W.E..T. Inc. Courier ___ Shipped ___	Arrived in Shipping Container: (Y) / N Sealed: (Y) / N / NA	Samples- Custody Seals Used (Y) / N Intact (Y) / N / NA	COC and Labels Match? Yes ✓ No ___	Holding Time Met (36 hours) Yes ✓ No ___
Broken, Damaged or Leaking? Yes ___ No ✓	Correct Containers Used? Yes ✓ No ___	Sufficient Quantity Sample? Yes ✓ No ___	Sufficient Quantity of Receiving Water? Yes NA No ___	Adequate Info provided? Yes ✓ No ___	Sample Acceptance Accepted ✓ Rejected ___

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Utah American

Crandall Canyon Mine

Toxicity Identification Evaluation- 10/03/2011

Phase II- Toxicity Identification

By: Water & Environmental Testing, Inc

February 15th, 2012

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Ceriodaphnia dubia IC25

Chain of Custody

Appendix A (pictures)

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W.E.T. Inc.

Water Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801) 763-0660 FAX (801) 763 04440

February 10th, 2012

Dana Morrelli
Crandall Canyon Mine
194 North 100 West
Huntington, Utah 84528

re: Summary Report for Phase II Toxicity Identification Evaluation on the Crandall Canyon Mine

Executive Summary

Included in the executive summary are the highlights of the Phase II testing completed on the samples collected starting 10/03/2011. Actual copies of each test and the associated data reduction have been included in the data section of this report.

Summary of Phase II Testing

Second Baseline Test

A second baseline test was set up to see if the toxicity was still present and to be used as the control for the chemical precipitation test. The results of this tests gave a IC25 of 57.3%. similar to the first baseline test. This tells us that the toxicity is still present and active in the sample. making it a good control to compare results with the chemical precipitation test.

Chemical Precipitation Test

In the initial test and first baseline test it was noted by the technicians that a gritty film developed below the waterline in the test chambers during each 24 test period between renewals. especially in the 100% dilution. This grit can be seen after pouring out the water and allowing the inside of the cup to dry. I have taken pictures of several of the cups showing the solids that have developed and included them in the appendix A.

The chemical precipitation test was designed to use a chemical base to increase precipitation and rapidly complete the precipitation process. This was done by first raising the pH of the sample to 11.23 using concentrated sodium hydroxide. High pH initiates the formation of calcium carbonate molecules, combining the hardness and alkalinity, creating solids large enough to settle out of solution. Under these conditions some metals will form metal hydroxide solids and also precipitate out of solution. Next the sample was mixed for 15 minutes on a stir plate then removed from the stir plate and allowed to stand for 30 minutes. After settling for 30 minutes the supernate was poured off leaving about 20 mls of solution containing solids in the bottom of the beaker. This solution was died at room temperature and the solids submitted for metals analysis to see what if any metals were

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removed from solution in the precipitation process. Approximately 2.5 grams of dried solids were produced in this process, a picture of the died solids has also been included in appendix A. The chemistries before and after treatment are shown in Table 1.

Table 1

Sample	Hardness mg/L	Alkalinity mg/L	Conductivity umhos/cm2	Ammonia mg/L
Initial Sample	472	382	970	0.43
Chemical Precipitation	100	270	1,946	0.54
Natural Precipitation	412	304	870	not anlayzed

The supernate was then adjusted back the pH 7.85 using concentrated hydrochloric acid. Concentrated forms of the acid and base were used to minimize dilution of the sample. The adjusted solution was tested alongside the second baseline test to see how the procedure affected toxicity. The results of the chronic ceriodaphnia test showed no toxicity in the chemical precipitation sample. producing 33.7 young/adult in the control and 32.5 in the 100% dilution. The technicians did not notice any solids or grit forming on the inside of the test chambers in the chemical precipitation test.

Natural Precipitation Test

After seeing the results of the chemical precipitation test which was successful in removing toxicity. the question was raised if the sample was allowed to stand would precipitation occur on its own and when the sample came to equilibrium would the toxicity be removed in the process. If this process was allowed to occur over an extended time and successfully remove the toxicity. this would suggest that extending the holding time of the treated water before discharge could be a viable way to remove toxicity.

The sample was prepared by filling a 2, 1 liter beakers with sample that had been warmed to 20 degree Celsius. A magnet was added and the beakers placed on a stir plate and stirred slowly for 24 hours. After 24 hours the stirrer was turned off and the sample was allowed to stand for 30 minutes. The supernate was then poured off into a sample storage bottle and placed in the fridge until needed. Chemistries for this sample are shown in Table 1, and pictures of the beakers are in Appendix A. A new baseline test was run alongside this test using the same series 25, 50 and 100%.

Observations from sample preparation had white flakes floating on the surface of the sample after 24 hours and white solids sticking to the inside of the glass beaker. The supernate was clear and during the test no solids formed on the sides of the test chamber. However, toxicity was still present in the natural precipitation sample with data from the test estimating an IC25 of 27.2%, similar to the baseline test at 32.5%. The results from this test suggest that 24 hours is not long enough for the precipitation to happen and for the sample to come to a stable state. The test should be repeated if needed as part of phase 3.

Metals

The EDTA tests from phase I indicated the possibility toxicity from the presence of metals. Aliquots

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of the sample was sent out to Chemtech-Ford for analysis using 200.7/200.8 to give the lowest possible detection limits. The thirteen most common metals were analyzed and the results are shown in Table 2. None of the metals tested were at a level high enough to be considered the cause of the toxicity, nor is any combination close to the toxic limits.

Iron (ferric chloride) and Aluminum (alum) representing the metals portion of the two coagulants and/or flocculents used at the mine were analyzed to check if unreacted chemical(s) were present in the sample and perhaps contributing to the continued precipitation seen during the testing process. Both of these metals were undetectable at the method MDL in the dissolved portion which suggests what little of the metals is present in the sample is attached to molecules large enough to be filtered out.

Metals Analysis in Chemically Induced Precipitate

The solids formed in the precipitation test were dried at room temperature and delivered to the lab for analysis of the same 13 metals. The results are shown in Column 4 of Table 2. The metals concentrations of the dried solids have large portions of aluminum and iron showing that these metals were removed from solution by the chemical precipitation process.

Table 2

Metals	**Total Metals mg/L (liquid)**	**Dissolved Metals mg/L (liquid)**	**Metals in Chemical Precipitate mg/kg wet (solid)**
Aluminum	0.09	<0.05	4.220
Arsenic	<0.0005	---	5.74
Cadmium	<0.0005	---	<0.50
Chromium	0.0027	---	<0.50
Copper	<0.0010	0.0017	0.529
Iron	0.03	<0.02	1.750
Lead	<0.0005	---	1.77
Mercury	<0.0002	---	<0.06
Molybdenum	<0.0014	---	0.43
Nickel	0.0160	---	15.8
Selenium	0.0005	---	3.47
Silver	<0.0005	---	<0.50
Zinc	<0.01	---	2.92

Conclusions

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It appears that the most likely scenario for the toxicity seen in this sample is the test organisms are being subjected to an environment where solids are forming and precipitating from solution. This process adds stress to the organisms which results in increased mortality and lower reproduction. The mechanism allowing the EDTA to remove toxicity in the Phase I tests must be one where the EDTA combines with the calcium and magnesium in solution interfering with solids formation.

The chemical precipitation test was able to remove toxicity demonstrating that if the precipitation process was completed the organisms are able to produce normal reproduction totals as compared to the control. The ongoing precipitation is most likely due to either a residual of ferric chloride, an excess of coagulant in the sample or the reaction of the coagulant initiating the hardness/alkalinity precipitation process which extends over time into the testing period.

Recommendations for Phase III Toxicity Elimination

Back in July when the first toxicity was found an on-site review of the treatment process showed a recent change of coagulant used from alum to ferric chloride. As ferric chloride is known to be an irritant it was recommended that they change back to alum which is much less of an irritant than ferric chloride. This recommendation was accepted and the chemicals changed back sometime in August. Following the change back to alum toxicity was found again in the September test where the cause was thought to be residual ferric chloride in the system and that with time the system would flush the residual out. A second failure in October initiated this Toxicity Identification Evaluation.

The routine testing for the fourth quarter passed for both the Ceriodaphnia and Fathead Minnows suggesting that the system is now clean or clean enough to pass the chronic toxicity requirements of the permit. In the fourth quarter test there were still some solids formation on the inside of the test chambers but not enough to cause the test to fail. The permit requires the IC25 to be higher than 65.5% and the result for the chronic ceriodaphnia portion of the test was 80.97%.

The fourth quarter test passing suggests that activities taken at the mine have got the situation under control and I do not recommend any additional work be done as part of Phase III at this time. Should the problem return several possible treatments have become evident through this TIE process. The first being to closely monitor the volumes of coagulant and flocculent added. The second would be to extend the time following chemical treatment to allow complete stabilization to occur. Extending the length of time would require a bigger pond or adding a secondary stabilization pond.

If you have any questions or need any additional information please feel free to give me a call at 801-763-0660, or on my cell phone at 801-360-5438.

Sincerely,

Lee Rawlings
Laboratory Director
Water & Environmental Testing, Inc

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Phase II Testing

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Chronic Toxicity Testing
Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase 2- Baseline Test #2

TIE sample made by compositing samples collected: 12/18/2011

Analyses Dates/Times Beginning 12/18/2011 6:00 p.m Ending 12/26/2011 6:00 p.m **IC25 Estimated from Test:** 57.27%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia
Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	36	31	35	28	20	15	27.5	0%
25.0%	25	33	30	14	18	12	22.0	0%
50.0%	16	36	20	21	29	22	24.0	0%
100%	8	11	8D	1D	7D	5D	6.7	67%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
DO New/Old	7.7	7.9/7.6	7.6/7.1	7.3/7.5	7.3/7.1	7.4/7.4	7.3/7.1	7.4/7.1	7.3
Temp New/Old	25.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	24.0
Ph New/Old	8.28	8.14/8.35	8.11/8.31	8.52/8.54	8.34/8.50	8.47/8.53	8.43/8.44	8.30/8.44	8.38

Physical Data- 25%

DO New/Old	8.6	8.0/7.6	8.0/7.3	7.5/7.4	7.4/7.1	7.8/7.4	7.6/7.4	7.3/7.0	7.6
Temp New/Old	25.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	24.0
Ph New/Old	8.26	7.98/8.46	7.99/8.40	8.26/8.54	8.14/8.54	8.26/8.52	8.19/8.44	8.21/8.46	8.41

Physical Data - 50%

DO New/Old	8.7	8.2/7.7	7.7/7.4	7.9/7.5	7.7/7.3	8.1/7.3	7.6/7.6	7.4/7.3	7.7
Temp New/Old	25.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	24.0
Ph New/Old	8.16	7.88/8.43	7.88/8.37	8.14/8.48	8.04/8.48	8.12/8.45	8.06/8.37	8.14/8.41	8.40

Physical Data - 100%

DO New/Old	9.1	8.9/7.7	8.3/7.5	8.2/7.8	8.2/7.4	8.6/7.3	8.4/7.7	7.5/7.4	7.7
Temp New/Old	25.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	24.0
Ph New/Old	8.04	7.84/8.26	7.85/8.26	8.01/8.36	7.90/8.34	7.99/8.31	7.94/8.23	8.02/8.29	8.31

Comments: Some fine solids formed on the surface of the 100% on days 3 & 4, with grit forming on the inside of the test chamber on most days.

LC50 estimated at 84.1%

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Ceriodaphnia Survival and Reproduction Test-7 Day Survival

Start Date:	12/18/2011 18:00	Test ID:	CCPhase2cc	Sample ID:	Crandall Canyon Phase II Base chronic
End Date:	12/26/2011 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

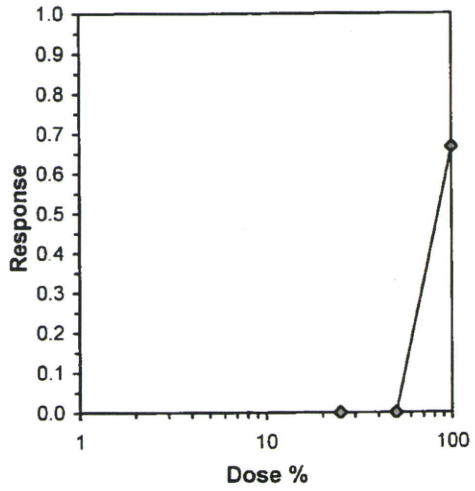
Conc-%	1	2	3	4	5	6
D-Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
100	1.0000	1.0000	0.0000	0.0000	0.0000	0.0000

Conc-%	Mean	N-Mean	Resp	Not Resp	Total	N	Fisher's Exact P	1-Tailed Critical	Number Resp	Total Number
D-Control	1.0000	1.0000	0	6	6	6			0	6
25	1.0000	1.0000	0	6	6	6	1.0000	0.0500	0	6
50	1.0000	1.0000	0	6	6	6	1.0000	0.0500	0	6
*100	0.3333	0.3333	4	2	6	6	0.0303	0.0500	4	6

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Fisher's Exact Test	50	100	70.7107	2
Treatments vs D-Control				

Trimmed Spearman-Karber

Trim Level	EC50	95% CL	
0.0%			
5.0%			
10.0%			
20.0%			
Auto-33.3%	84.090	62.286	113.525



ToxCalc v5.0.32

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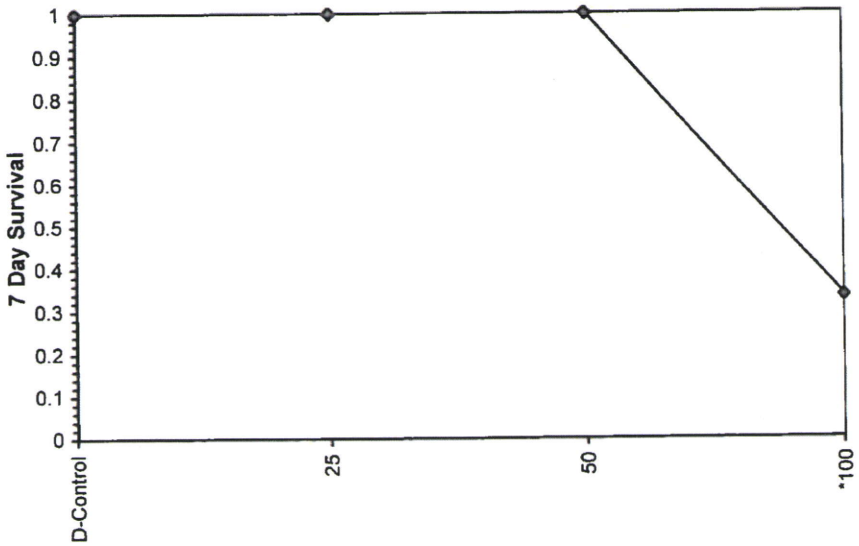
Ceriodaphnia Survival and Reproduction Test-7 Day Survival

Start Date:	12/18/2011 18:00	Test ID:	CCPhase2cc	Sample ID:	Crandall Canyon Phase II Base chronic
End Date:	12/26/2011 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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ToxCalc v5.0.32

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	12/18/2011 18:00	Test ID:	CCPhase2cc	Sample ID:	Crandall Canyon Phase II Base chronic
End Date:	12/26/2011 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	36.000	31.000	35.000	28.000	20.000	15.000
25	25.000	33.000	30.000	14.000	18.000	12.000
50	16.000	36.000	20.000	21.000	29.000	22.000
100	8.000	11.000	8.000	1.000	7.000	5.000

			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	27.500	1.0000	27.500	15.000	36.000	30.576	6				27.500	1.0000
25	22.000	0.8000	22.000	12.000	33.000	39.312	6	1.317	2.190	9.148	23.000	0.8364
50	24.000	0.8727	24.000	16.000	36.000	30.162	6	0.838	2.190	9.148	23.000	0.8364
*100	6.667	0.2424	6.667	1.000	11.000	50.794	6	4.988	2.190	9.148	6.667	0.2424

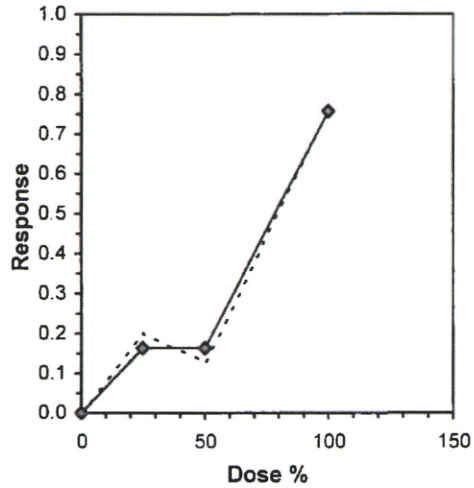
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.97846	0.916	0.02156	-0.805
Bartlett's Test indicates equal variances (p = 0.27)	3.96718	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	50	100	70.7107	2	9.1476	0.33264	508.042	52.3417	3.7E-04	3, 20
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05*	7.639	17.490	1.187	76.808	1.2003
IC10*	15.278	18.536	2.375	78.616	0.6804
IC15*	22.917	19.261	3.562	80.424	0.1494
IC20	53.061	18.720	0.000	70.979	-0.3274
IC25	57.270	17.038	0.000	74.594	-0.8736
IC40	69.898	6.726	44.187	85.660	-0.2097
IC50	78.316	5.655	59.323	93.019	0.0332

* indicates IC estimate less than the lowest concentration



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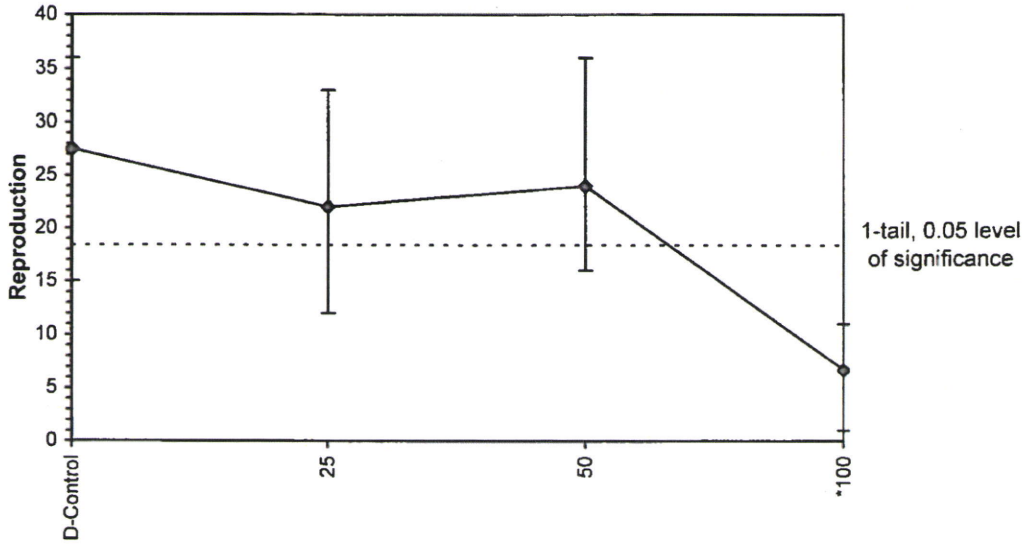
Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	12/18/2011 18:00	Test ID:	CCPhase2cc	Sample ID:	Crandall Canyon Phase II Base chronic
End Date:	12/26/2011 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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Chronic Toxicity Testing

Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase 2- Chemical Precipitation Test

TIE sample made by compositing samples collected: 12/18/2011

Analyses Dates/Times Beginning 12/18/2011 6:15 p.m Ending 12/26/2011 6:00 p.m **IC25 Estimated from Test:** >100%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia

Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	32	39	32	32	34	33	33.7	0%
25.0%	36	33	36	33	36	33	34.5	0%
50.0%	31	31	32	30	38	23	30.8	0%
100%	33	35	30	35	31	31	32.5	0%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7	Day 8
DO New/Old	7.8	7.6/7.7	7.4/7.4	7.5/7.7	7.3/7.3	7.7/7.4	7.1/7.1	7.3/7.1	7.7
Temp New/Old	25.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	24.0
Ph New/Old	8.31	8.15/8.35	8.08/8.37	8.51/8.59	8.30/8.58	8.45/8.59	8.41/8.47	8.30/8.46	8.39

Physical Data- 25%

DO New/Old	8.0	7.5/7.7	7.6/7.3	7.7/7.5	7.4/7.2	7.8/7.4	7.5/7.5	7.1/7.0	7.7
Temp New/Old	25.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	24.0
Ph New/Old	8.16	8.07/8.41	8.01/7.40	8.39/8.61	8.20/8.57	8.32/8.58	8.31/8.52	8.31/8.51	8.41

Physical Data - 50%

DO New/Old	8.2	7.5/7.6	7.6/7.4	7.9/7.4	7.7/7.1	8.3/7.3	7.6/7.7	7.2/7.0	7.6
Temp New/Old	25.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	24.0
Ph New/Old	8.04	8.01/8.49	8.00/8.39	8.26/8.64	8.15/8.59	8.25/8.63	8.23/8.55	8.30/8.55	8.44

Physical Data - 100%

DO New/Old	8.5	8.4/7.6	8.2/7.5	8.2/7.5	7.9/7.2	8.4/7.5	8.3/7.7	7.2/7.1	7.7
Temp New/Old	25.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	25.0/24.0	24.0
Ph New/Old	7.94	7.98/8.60	8.00/7.55	8.13/8.71	8.11/8.64	8.16/8.70	8.10/8.62	8.36/8.65	8.56

Comments: No solids formed on either the surface or on the sides of the test chambers.

Preparation of the sample- Sodium hydroxide was added to a 1 liter aliquot of sample to raise the pH to 11.38 to initiate calcium carbonate precipitation. The solution was mixed for 15 minutes on a stir plate then allowed to stand 30 minutes for the solids to settle out of solution. After 30 minutes the supernate was poured off and adjusted back to the original pH using hydrochloric acid. The prepared sample was then tested alongside the original sample to see if the forced precipitation would remove the toxicity by either stabilizing the sample or dropping out the toxicant.

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	12/18/2011 18:15	Test ID:	CCPhase2cc	Sample ID:	Crandall Canyon Phase II Prec chronic
End Date:	12/26/2011 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	32.000	39.000	32.000	32.000	34.000	33.000
25	36.000	33.000	36.000	33.000	36.000	33.000
50	31.000	31.000	32.000	30.000	38.000	23.000
100	33.000	35.000	30.000	35.000	31.000	31.000

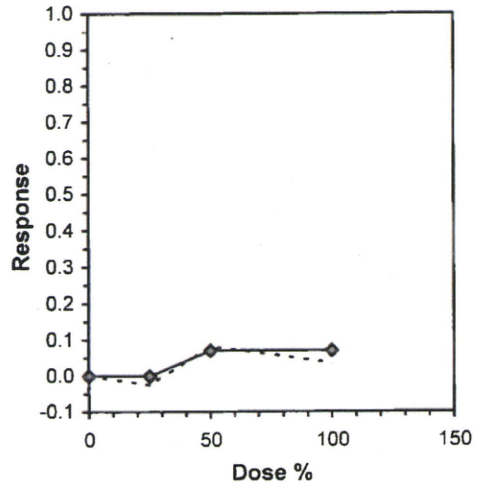
			Transform: Untransformed					Rank	1-Tailed	Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Sum	Critical	Mean	N-Mean
D-Control	33.667	1.0000	33.667	32.000	39.000	8.116	6			34.083	1.0000
25	34.500	1.0248	34.500	33.000	36.000	4.763	6	46.50	26.00	34.083	1.0000
50	30.833	0.9158	30.833	23.000	38.000	15.543	6	27.50	26.00	31.667	0.9291
100	32.500	0.9653	32.500	30.000	35.000	6.671	6	34.50	26.00	31.667	0.9291

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.9047	0.916	0.07038	2.73836
Bartlett's Test indicates equal variances (p = 0.11)	6.01051	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU
Steel's Many-One Rank Test	100	>100		1
Treatments vs D-Control				

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)	Skew
IC05	42.629			
IC10	>100			
IC15	>100			
IC20	>100			
IC25	>100			
IC40	>100			
IC50	>100			



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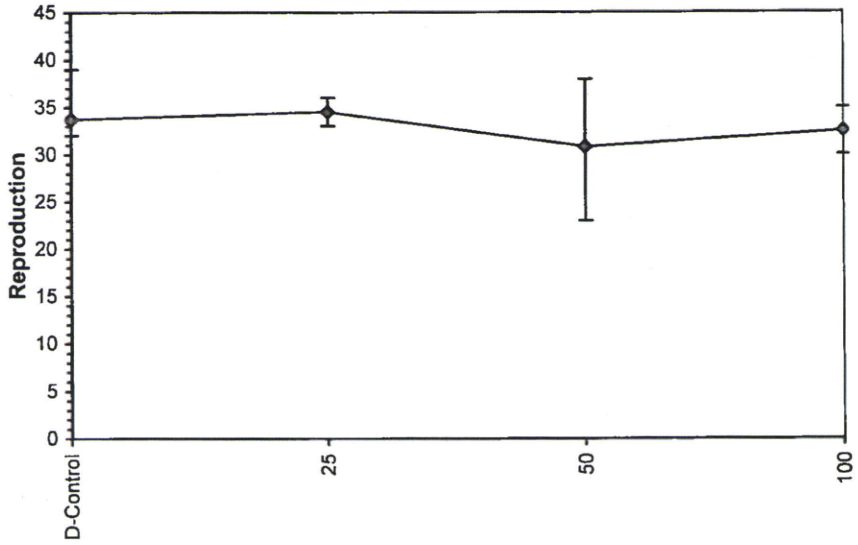
 ToxCalc v5.0.32 Reviewed by:_____

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	12/18/2011 18:15	Test ID:	CCPhase2cc	Sample ID:	Crandall Canyon Phase II Prec chronic
End Date:	12/26/2011 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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 ToxCalc v5.0.32 Reviewed by:_____

Chronic Toxicity Testing
Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase 2- Baseline #3 Test

TIE sample made by compositing samples collected: 1/28/2012

Analyses Dates/Times Beginning 1/28/2012 5:30 p.m Ending 2/4/2012 5:45 p.m **IC25 Estimated from Test:** 32.45%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia
Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	38	41	41	38	39	39	39.3	0%
25.0%	29	34	37	32	35	24	31.8	0%
50.0%	25	22	20	30	28	19	24.0	0%
100%	6	15	18	10D	15	8D	12.0	33%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
DO New/Old	8.0	7.2/7.3	7.6/7.6	7.8/7.4	8.0/7.9	7.1/7.0	7.4/6.8	6.6
Temp New/Old	25.0	25.0/25.2	25.0/25.2	25.0/25.4	25.0/25.2	25.0/25.4	25.0/25.0	25.2
Ph New/Old	8.34	7.96/8.21	8.31/8.34	8.17/8.30	8.29/8.31	8.31/8.36	8.25/8.29	8.18

Physical Data- 25%

DO New/Old	7.9	7.3/7.3	8.1/7.4	7.8/7.4	8.1/7.9	7.5/7.0	7.5/6.7	6.7
Temp New/Old	25.0	25.0/25.2	25.0/25.2	25.0/25.4	25.0/25.2	25.0/25.4	25.0/25.0	25.2
Ph New/Old	8.26	8.15/8.35	8.20/8.47	8.27/8.45	8.30/8.41	8.29/8.48	8.23/8.40	8.31

Physical Data - 50%

DO New/Old	8.2	7.8/7.3	8.3/7.4	7.9/7.4	8.1/7.8	7.8/7.0	7.6/6.7	6.7
Temp New/Old	25.0	25.0/25.2	25.0/25.2	25.0/25.4	25.0/25.2	25.0/25.4	25.0/25.0	25.2
Ph New/Old	8.21	8.15/8.45	8.19/8.55	8.24/8.52	8.29/8.50	8.31/8.54	8.21/8.50	8.43

Physical Data - 100%

DO New/Old	8.7	7.6/7.2	8.1/7.5	7.8/7.5	8.2/7.8	7.8/7.0	7.7/6.8	6.9
Temp New/Old	25.0	25.0/25.2	25.0/25.2	25.0/25.4	25.0/25.2	25.0/25.4	25.0/25.0	25.2
Ph New/Old	8.21	8.15/8.21	8.09/8.35	8.22/8.35	8.27/8.35	8.25/8.35	8.18/8.34	8.25

Comments: Some fine solids formed on the surface of the 100% on days 3 & 4, with grit forming on the inside of the test chamber on most days.

LC50 estimated at >100%

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Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	1/28/2012 17:35	Test ID:	CCTIEP2	Sample ID:	Crandall TIE P2 base 3 chronic cero
End Date:	2/4/2012 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	38.000	41.000	41.000	38.000	39.000	39.000
25	29.000	34.000	37.000	32.000	35.000	24.000
50	25.000	22.000	20.000	30.000	28.000	19.000
100	6.000	15.000	18.000	10.000	15.000	8.000

			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	39.333	1.0000	39.333	38.000	41.000	3.474	6				39.333	1.0000
*25	31.833	0.8093	31.833	24.000	37.000	14.790	6	3.207	2.190	5.122	31.833	0.8093
*50	24.000	0.6102	24.000	19.000	30.000	18.447	6	6.556	2.190	5.122	24.000	0.6102
*100	12.000	0.3051	12.000	6.000	18.000	39.087	6	11.687	2.190	5.122	12.000	0.3051

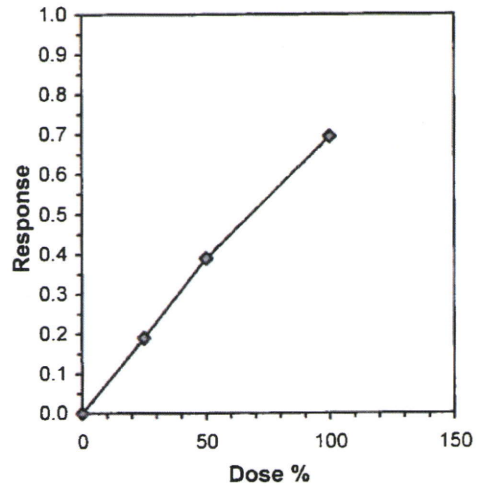
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.97631	0.916	-0.2228	-0.6163
Bartlett's Test indicates equal variances (p = 0.09)	6.47004	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	<25	25			5.12172	0.13021	818.597	16.4083	1.8E-09	3, 20
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05*	6.556	1.892	3.227	13.189	0.8785
IC10*	13.111	3.695	6.454	26.378	0.6670
IC15*	19.667	4.713	9.682	33.222	0.1379
IC20	26.170	4.970	12.935	38.956	-0.1324
IC25	32.447	5.249	16.302	44.534	-0.3038
IC40	51.667	5.341	40.110	67.772	0.3029
IC50	68.056	5.496	51.408	82.786	-0.1805

* indicates IC estimate less than the lowest concentration



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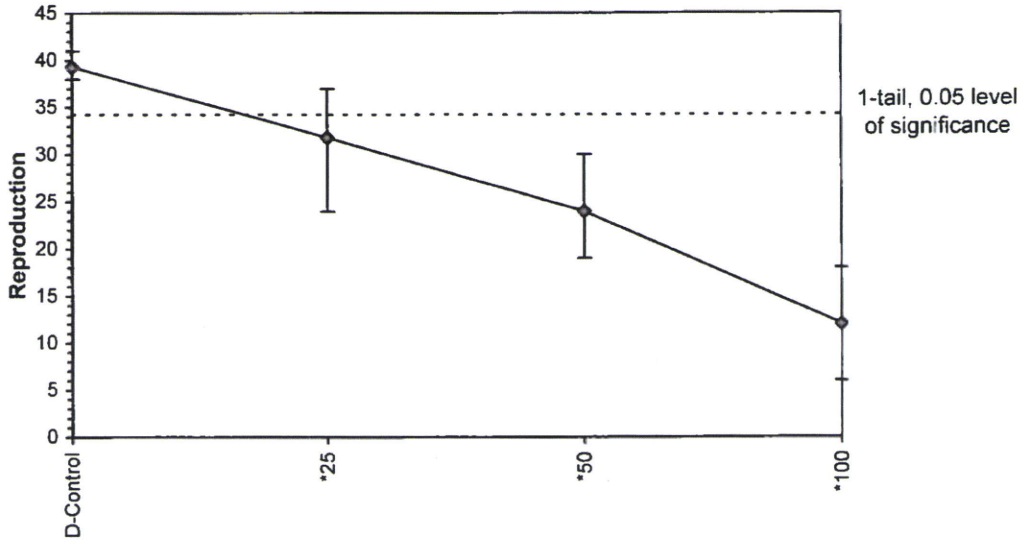
Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	1/28/2012 17:35	Test ID:	CCTIEP2	Sample ID:	Crandall TIE P2 base 3 chronic cero
End Date:	2/4/2012 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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ToxCalc v5.0.32

Reviewed by:_____

Chronic Toxicity Testing
Ceriodaphnia

Customer ID: Utah American- Crandall Canyon Mine TIE Phase 2- Natural Precipitation

TIE sample made by compositing samples collected: 1/28/2012

Analyses Dates/Times Beginning 1/28/2012 5:35 p.m Ending 2/4/2012 6:00 p.m **IC25 Estimated from Test:** 27.15%

Dilution Water Hardness: Moderately Hard Synthetic Fresh Water Approx. 200 mg/L. **Organism Age:** Ceriodaphnia dubia <8 hours

Ceriodaphnia
Replicates- Total Number of Young Produced in Three Broods ("D" = dead)

Sample ID	A	B	C	D	E	F	Mean # Produced	% Lethality
Control	36	41	39	37	39	39	38.5	0%
25.0%	26	22	35	36	34	26	29.8	0%
50.0%	13	18	18	29	19D	15D	18.7	33%
100%	4D	6	16D	11	12D	5D	9.0	67%

Physical Data - Control

	Day 0	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
DO New/Old	7.9	7.4/7.2	7.5/7.1	7.5/7.4	8.2/7.7	7.4/6.8	6.9/6.7	6.7
Temp New/Old	25.0	25.0/25.2	25.0/25.2	25.0/25.4	25.0/25.2	25.0/25.4	25.0/25.0	25.2
Ph New/Old	8.31	8.17/8.21	8.30/8.35	8.34/8.30	8.37/8.28	8.36/8.35	8.28/8.27	8.17

Physical Data- 25%

DO New/Old	7.8	7.4/7.2	7.6/7.2	7.5/7.3	8.2/8.6	8.2/6.9	7.0/6.8	6.6
Temp New/Old	25.0	25.0/25.2	25.0/25.2	25.0/25.4	25.0/25.2	25.0/25.4	25.0/25.0	25.2
Ph New/Old	8.27	8.17/8.30	8.27/8.41	8.29/8.37	8.33/8.36	8.31/8.44	8.26/8.36	8.28

Physical Data - 50%

DO New/Old	7.6	7.3/7.2	7.7/7.1	7.7/7.4	8.2/7.6	7.5/6.8	7.1/6.6	6.6
Temp New/Old	25.0	25.0/25.2	25.0/25.2	25.0/25.4	25.0/25.2	25.0/25.4	25.0/25.0	25.2
Ph New/Old	8.30	8.19/8.40	8.27/8.48	8.32/8.45	8.33/8.45	8.33/8.51	8.28/8.44	8.37

Physical Data - 100%

DO New/Old	7.0	6.9/7.1	7.8/7.1	7.7/7.4	8.3/7.6	7.7/6.9	7.1/6.7	6.8
Temp New/Old	25.0	25.0/25.2	25.0/25.2	25.0/25.4	25.0/25.2	25.0/25.4	25.0/25.0	25.2
Ph New/Old	8.25	8.17/8.33	8.22/8.53	8.27/8.55	8.29/8.55	8.30/8.55	8.25/8.53	8.45

Comments: No fines formed on the surface or grit on the inside of the test chamber in the 100% concentration.
LC50 estimated at 73.19%
The sample was prepared by first warming 1 liter of sample to 20 degrees Celsius in a glass beaker. A stir bar was then added and the sample placed on a stir plate and stirred at low speed for 24 hours. The sample was then allowed to stand for 30 minutes and the supernatant solution poured off into a sample storage container until needed. This solution was then tested using standard EPA methods for chronic toxicity using ceriodaphnia dubia.

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Ceriodaphnia Survival and Reproduction Test-7 Day Survival

Start Date:	1/28/2012 17:35	Test ID:	CCTIEP2	Sample ID:	Crandall TIE P2 Nprecip chronic cero
End Date:	2/4/2012 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
25	1.0000	1.0000	1.0000	1.0000	1.0000	1.0000
50	1.0000	1.0000	1.0000	1.0000	0.0000	0.0000
100	0.0000	1.0000	0.0000	1.0000	0.0000	0.0000

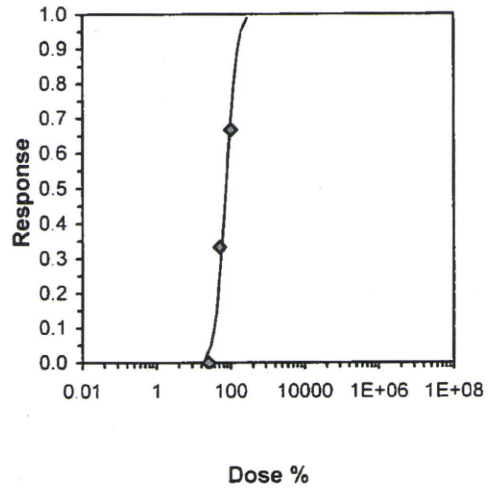
			Transform: Arcsin Square Root					Number	Total
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	Resp	Number
D-Control	1.0000	1.0000	1.0472	1.0472	1.0472	0.000	6	0	6
25	1.0000	1.0000	1.0472	1.0472	1.0472	0.000	6	0	6
50	0.6667	0.6667	0.8727	0.5236	1.0472	30.984	6	2	6
100	0.3333	0.3333	0.6981	0.5236	1.0472	38.730	6	4	6

Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates non-normal distribution (p <= 0.05)	0.89707	0.916	-1E-15	0.2987
Equality of variance cannot be confirmed				

Maximum Likelihood-Probit

Parameter	Value	SE	95% Fiducial Limits		Control	Chi-Sq	Critical	P-value	Mu	Sigma	Iter
Slope	4.04627	1.76074	0.59521	7.49733	0	0.44598	3.84146	0.50425	1.86444	0.24714	5
Intercept	-2.544	3.18476	-8.7861	3.6981							
TSCR											

Point	Probits	%	95% Fiducial Limits	
EC01	2.674	19.4761	0.0205	36.1702
EC05	3.355	28.703	0.27539	46.3517
EC10	3.718	35.2951	1.07876	53.9412
EC15	3.964	40.5782	2.66123	60.8519
EC20	4.158	45.3356	5.34044	68.4007
EC25	4.326	49.8591	9.44047	77.755
EC40	4.747	63.3616	30.0569	141.742
EC50	5.000	73.1877	44.3901	276.432
EC60	5.253	84.5378	55.7347	634.132
EC75	5.674	107.432	70.7625	2898.83
EC80	5.842	118.151	76.263	5405.01
EC85	6.036	132.003	82.6426	11250.9
EC90	6.282	151.762	90.8105	28494.7
EC95	6.645	186.616	103.539	113927
EC99	7.326	275.026	130.534	1555474



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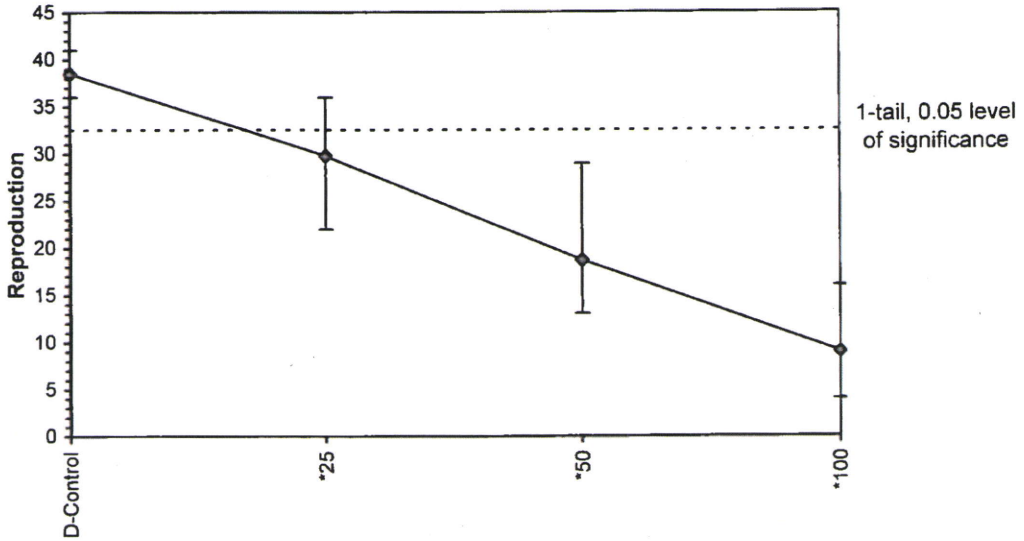
Ceriodaphnia Survival and Reproduction Test-7 Day Survival

Start Date:	1/28/2012 17:35	Test ID:	CCTIEP2	Sample ID:	Crandall TIE P2 Nprecip chronic cero
End Date:	2/4/2012 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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ToxCalc v5.0.32

Reviewed by:_____

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	1/28/2012 17:35	Test ID:	CCTIEP2	Sample ID:	Crandall TIE P2 Nprecip chronic cero
End Date:	2/4/2012 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Conc-%	1	2	3	4	5	6
D-Control	36.000	41.000	39.000	37.000	39.000	39.000
25	26.000	22.000	35.000	36.000	34.000	26.000
50	13.000	18.000	18.000	29.000	19.000	15.000
100	4.000	6.000	16.000	11.000	12.000	5.000

			Transform: Untransformed						1-Tailed		Isotonic	
Conc-%	Mean	N-Mean	Mean	Min	Max	CV%	N	t-Stat	Critical	MSD	Mean	N-Mean
D-Control	38.500	1.0000	38.500	36.000	41.000	4.573	6				38.500	1.0000
*25	29.833	0.7749	29.833	22.000	36.000	19.707	6	3.152	2.190	6.022	29.833	0.7749
*50	18.667	0.4848	18.667	13.000	29.000	29.667	6	7.213	2.190	6.022	18.667	0.4848
*100	9.000	0.2338	9.000	4.000	16.000	52.587	6	10.728	2.190	6.022	9.000	0.2338

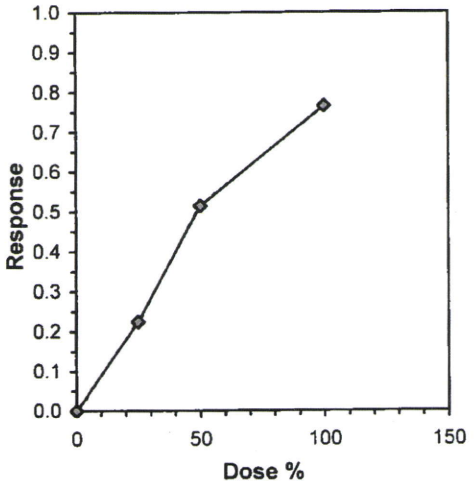
Auxiliary Tests	Statistic	Critical	Skew	Kurt
Shapiro-Wilk's Test indicates normal distribution (p > 0.05)	0.97531	0.916	0.47755	-0.124
Bartlett's Test indicates equal variances (p = 0.12)	5.90766	11.3449		

Hypothesis Test (1-tail, 0.05)	NOEC	LOEC	ChV	TU	MSDu	MSDp	MSB	MSE	F-Prob	df
Dunnett's Test	<25	25			6.02195	0.15641	995.444	22.6833	5.5E-09	3, 20
Treatments vs D-Control										

Linear Interpolation (200 Resamples)

Point	%	SD	95% CL(Exp)		Skew
IC05*	5.553	1.824	2.705	12.508	1.6803
IC10*	11.106	3.523	5.410	25.016	1.3569
IC15*	16.659	4.531	8.115	32.163	0.7124
IC20*	22.212	4.574	10.820	34.210	0.2057
IC25	27.146	4.366	13.834	36.858	-0.0273
IC40	40.075	4.194	28.114	53.482	0.3846
IC50	48.694	5.900	38.984	71.568	0.8020

* indicates IC estimate less than the lowest concentration



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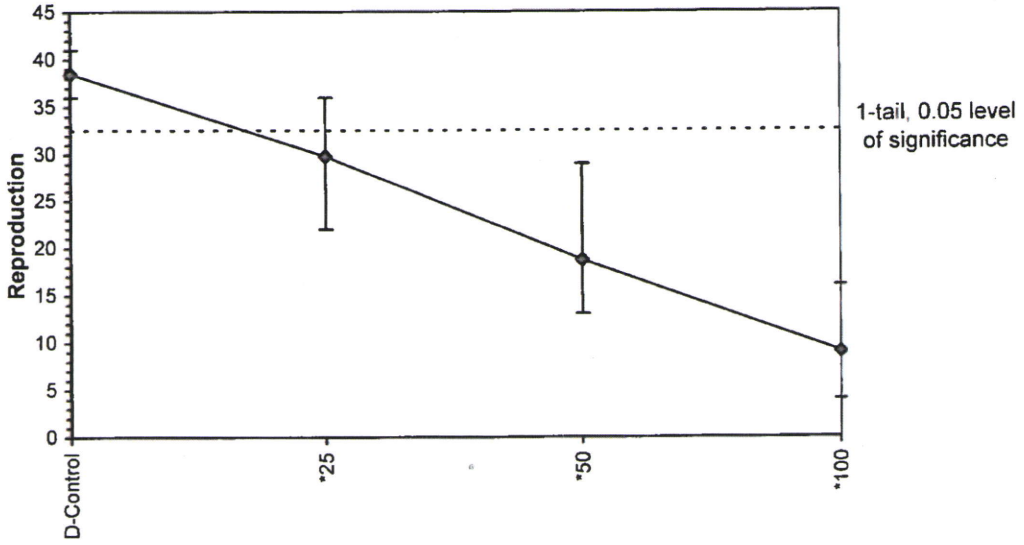
 ToxCalc v5.0.32 Reviewed by:_____

Ceriodaphnia Survival and Reproduction Test-Reproduction

Start Date:	1/28/2012 17:35	Test ID:	CCTIEP2	Sample ID:	Crandall TIE P2 Nprecip chronic cero
End Date:	2/4/2012 18:00	Lab ID:	WET Inc	Sample Type:	EFF2-Industrial
Sample Date:		Protocol:	EPAF 94-EPA/600/4-91/002	Test Species:	CD-Ceriodaphnia dubia
Comments:					

Dose-Response Plot



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Metals Analysis

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CHEMTECH-FORD
LABORATORIES

Certificate of Analysis

Lab Sample No.: 1109670-01

Name:	WET, Inc.	***Sample Date:***	11/15/2011 9.00 AM
Sample Site:	Gen TIE	***Receipt Date:***	11/15/2011 2.00 PM
Comments:	Gen Effluent	***Sampler:***	WET, Inc.
Sample Matrix:	Water	***Project:***	

Parameter	Sample Result	Minimum Reporting Limit	Units	Analysis Date/Time	Analyst Initials	Analytical Method	CAS No.	Flag
Metals								
Aluminum, Dissolved	ND	0.05	mg/L	11/30/2011 15:47	PNM	EPA 200.7	7429-90-5	
Aluminum, Total	0.09	0.05	mg/L	11/30/2011 15:51	PNM	EPA 200.7	7429-90-5	
Arsenic, Total	ND	0.0005	mg/L	11/23/2011 15:49	MJB	EPA 200.8	7440-38-2	
Cadmium, Total	ND	0.0005	mg/L	11/23/2011 15:49	MJB	EPA 200.8	7440-43-9	
Chromium, Total	0.0027	0.0005	mg/L	11/23/2011 15:49	MJB	EPA 200.8	7440-47-3	
Copper, Dissolved	0.0017	0.0010	mg/L	11/23/2011 15:46	MJB	EPA 200.8	7440-50-8	
Copper, Total	ND	0.0010	mg/L	11/23/2011 15 49	MJB	EPA 200.8	7440-50-8	
Iron, Dissolved	ND	0.02	mg/L	11/30/2011 15 47	PNM	EPA 200 7	7439-89-6	
Iron, Total	0.03	0.02	mg/L	11/30/2011 15 51	PNM	EPA 200 7	7439-89-6	
Lead, Total	ND	0.0005	mg/L	11/23/2011 15.49	MJB	EPA 200.8	7439-92-1	
Mercury, Total	ND	0.0002	mg/L	11/16/2011 16 30	AKL	EPA 245.1	7439-97-6	
Molybdenum, Total	0.0014	0.0005	mg/L	11/23/2011 15 49	MJB	EPA 200.8	7439-98-7	
Nickel, Total	0.0160	0.0005	mg/L	11/23/2011 15 49	MJB	EPA 200.8	7440-02-0	
Selenium, Total	0.0005	0.0005	mg/L	11/23/2011 15 49	MJB	EPA 200.8	7782-49-2	
Silver, Total	ND	0 0005	mg/L	11/23/2011 15 49	MJB	EPA 200.8	7440-22-4	
Zinc, Total	ND	0.01	mg/L	11/30/2011 15 51	PNM	EPA 200.7	7440-66-6	

5100 South Stratler
801-262-7299 Office

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CHEMTECH-FORD
LABORATORIES

Certificate of Analysis

Lab Sample No.: 1200523-01

Name:	**WET, Inc.**	***Sample Date:***	12/29/2011 11:00 AM
Sample Site:	Crandal Canyon	***Receipt Date:***	1/19/2012 1:46 PM
Comments:	Precipitate	***Sampler:***	Lee Rawlings
Sample Matrix:	As Received	***Project:***	

Parameter	Sample Result	Minimum Reporting Limit	Units	Analysis Date/Time	Analyst Initials	Analytical Method	CAS No.	Flag
Metals								
Aluminum, Total	4220	10.0	mg/kg wet	1/25/2012 17:13	PNM	EPA 6010B	7429-90-5	
Arsenic, Total	5.74	5.00	mg/kg wet	1/25/2012 17:13	PNM	EPA 6010B	7440-38-2	
Cadmium, Total	ND	0.500	mg/kg wet	1/25/2012 17 13	PNM	EPA 6010B	7440-43-9	
Chromium, Total	ND	0.500	mg/kg wet	1/25/2012 17:13	PNM	EPA 6010B	7440-47-3	
Copper, Total	0.529	0.500	mg/kg wet	1/25/2012 17:13	PNM	EPA 6010B	7440-50-8	
Iron, Total	1750	5.00	mg/kg wet	1/25/2012 17:13	PNM	EPA 6010B	7439-89-6	
Lead, Total	1 77	5.00	mg/kg wet	1/25/2012 17:13	PNM	EPA 6010B	7439-92-1	J
Mercury, Total	ND	0.06	mg/kg wet	1/25/2012 11:00	AKL	EPA 7471A	7439-97-6	
Molybdenum, Total	0.43	1.00	mg/kg wet	1/25/2012 17 13	PNM	EPA 6010B	7439-98-7	J
Nickel, Total	15 8	0.500	mg/kg wet	1/25/2012 17:13	PNM	EPA 6010B	7440-02-0	
Selenium, Total	3 47	5.00	mg/kg wet	1/25/2012 17.13	PNM	EPA 6010B	7782-49-2	J
Silver, Total	ND	0.500	mg/kg wet	1/25/2012 17.13	PNM	EPA 6010B	7440-22-4	
Zinc, Total	2 92	1.00	mg/kg wet	1/25/2012 17 13	PNM	EPA 6010B	7440-66-6	

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Sample Chemistries

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W.E.T. Inc.
Water & Environmental Testing Inc. 235 West 400 South, American Fork, Utah 84003 (801)763-0660 Fax(801)763-0440

Chronic Whole Effluent Toxicity Chemical Result Report

October 28, 2011

CUSTOMER NAME:
Genwal Resources
Attn: Gary Gray
194 North 100 West
Huntington, Utah 84528

SAMPLE DESCRIPTION:
Chemistries to go with Chronic Biomonitoring sampling began 10/03/2011

Analysis	Chronic Ceriodaphnia		
	Repl. 1	Repl. 2	Repl. 3
Log #	8490	NA	NA
Total Hardness, Recon (EPA 130.2), mg/L	176		
Total Hardness, Effluent (EPA 130.2), mg/L	472		
Ammonia, Effluent (EPA 350.2/350.3), mg/L	0.43		
Initial Chlorine Residual (EPA 330.5), mg/L	<0.05		
Final Chlorine Residual (EPA 330.5), mg/L	N/A		
Conductivity, Effluent (EPA 120.1), umhos/cm	970		
Alkalinity, Effluent (EPA 310.1), mg/L $CaCO^3$	382		
Recon Initial pH (EPA 150.1)	8.45		
After 24 hours pH (EPA 150.1)	8.27		
100% Initial pH (EPA 150.1)	7.71		
100% After 24 hours pH (EPA 150	7.81		

LR

Reviewed: Lee Rawlings. Lab Director
Water & Environmental Testing. Inc.

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Quality Control Charts

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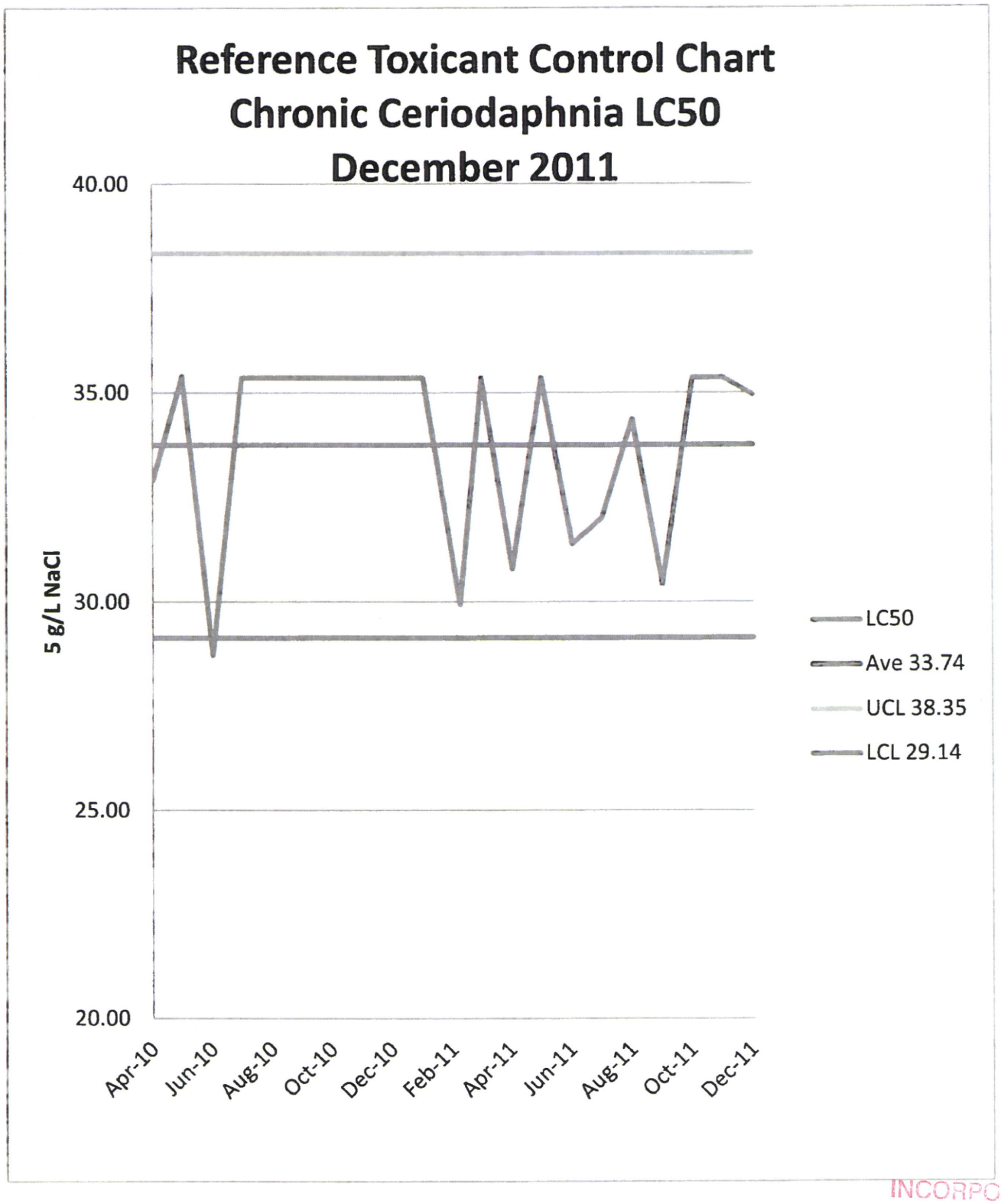

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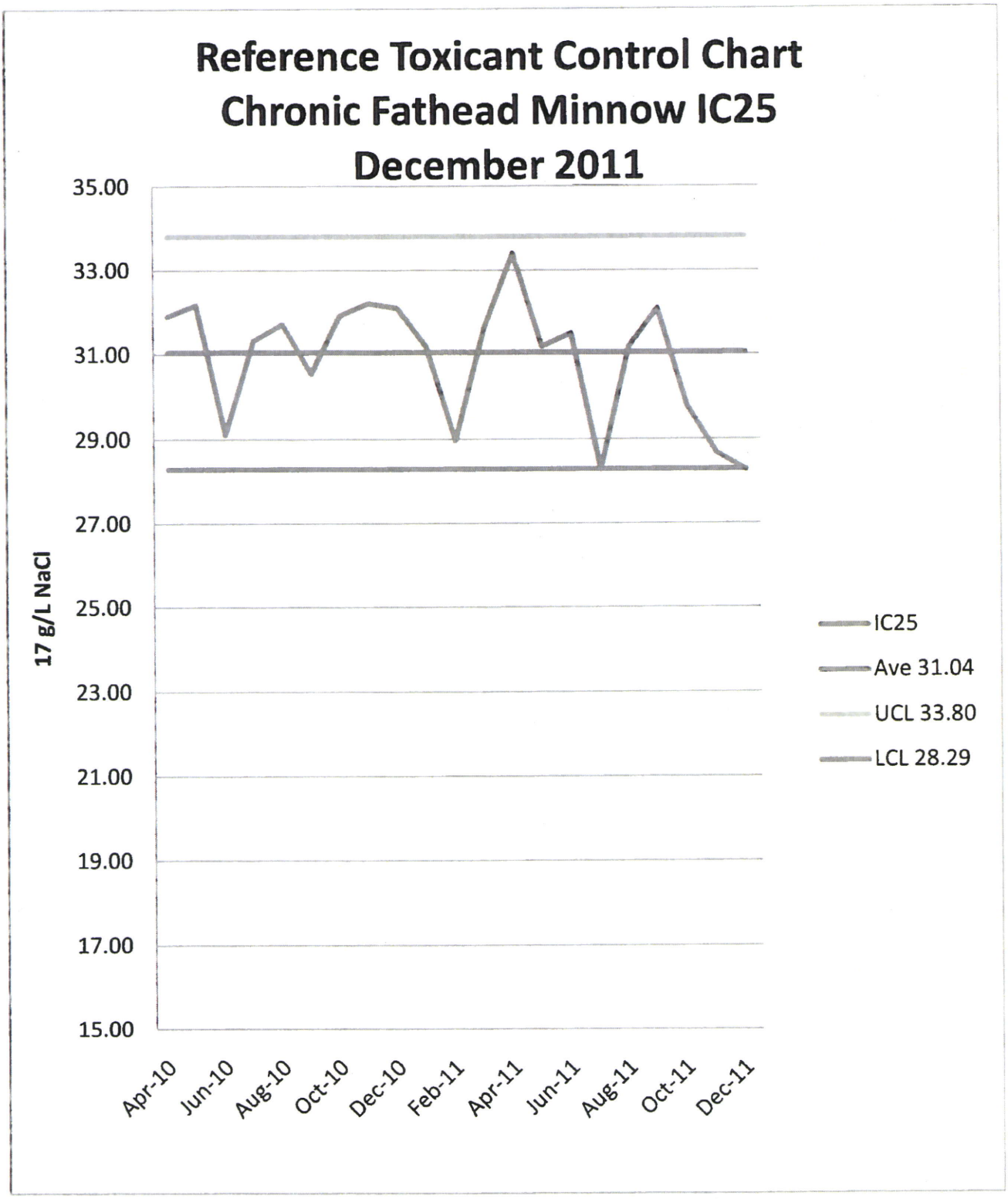

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Chain of Custody

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Appendix A

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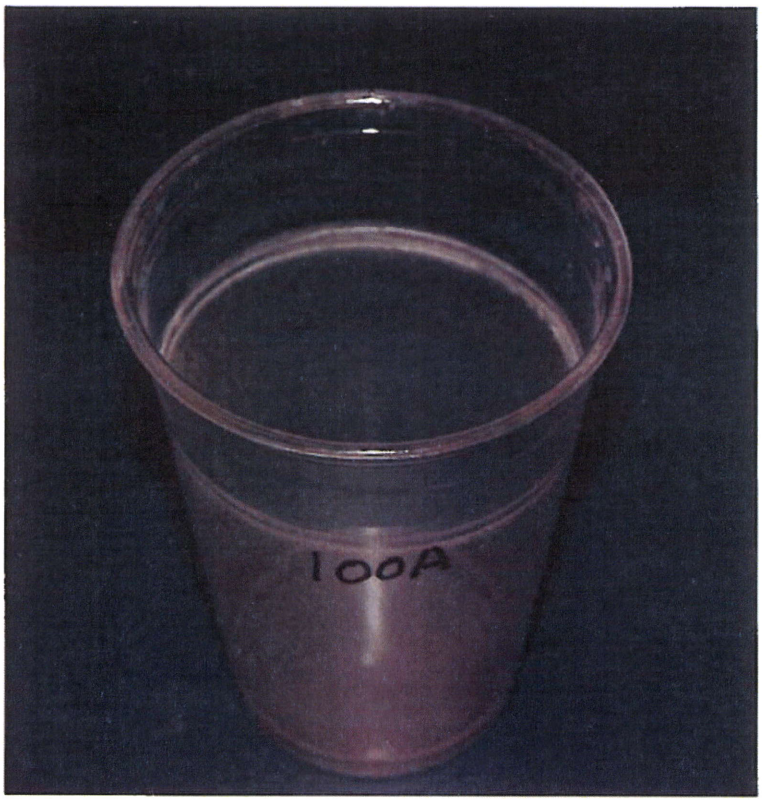
Appendix A

This appendix contains pictures of various stages of the TIE test demonstrating the observations seen by the analysts as they worked with the tests. This first picture shows the solids buildup in a Ceriodaphnia test chamber which developed during the 24 hours between renewals.

The next picture shows a week long buildup in a fathead minnow test chamber.



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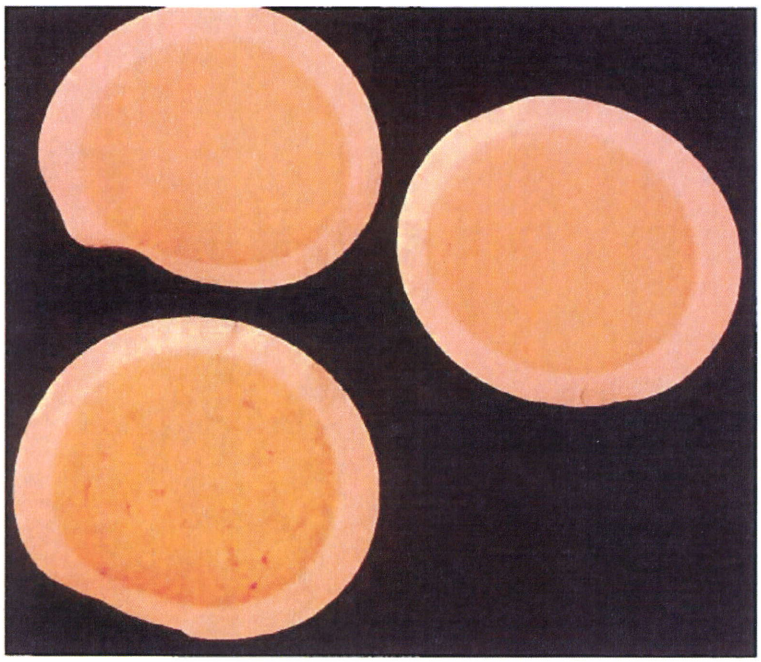
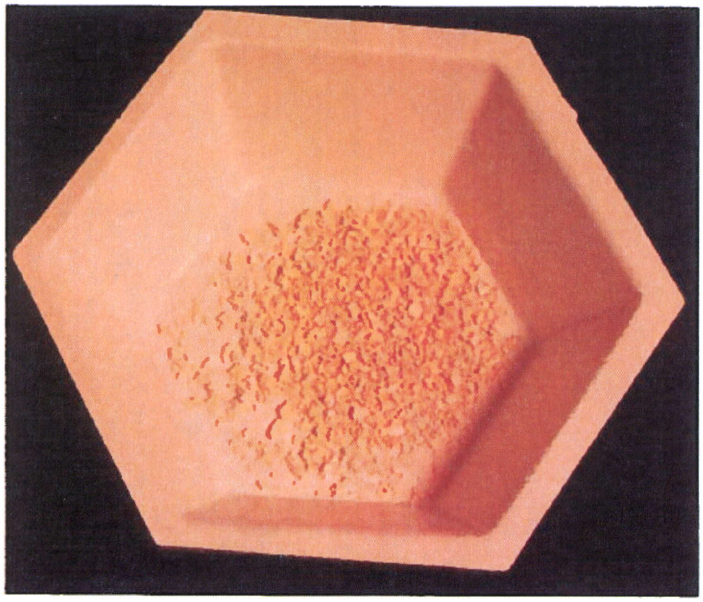
This picture is of the filter which was used in the TIE Phase I filter test showing the solids removed from the sample. This amount of solids came from filtering approximately 4 Liters of sample.



This picture shows the solids from the chemical precipitations test, approximately 2.5 grams of dried solids taken from 1 liter of sample.



These next two pictures are of the beakers where the natural precipitation process was completed, the supernate removed and the beakers being allowed to dry, again showing solids buildup.

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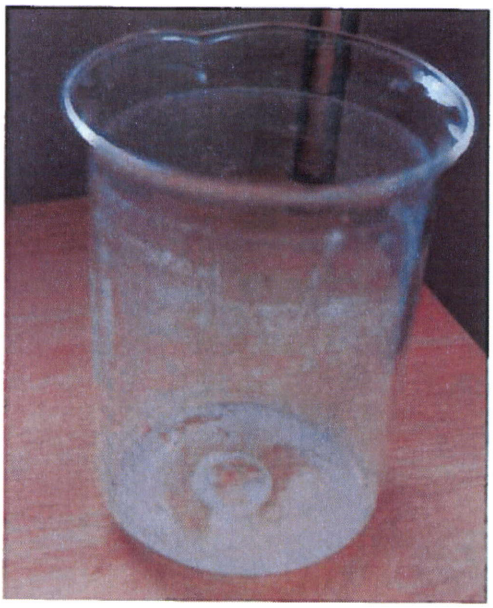

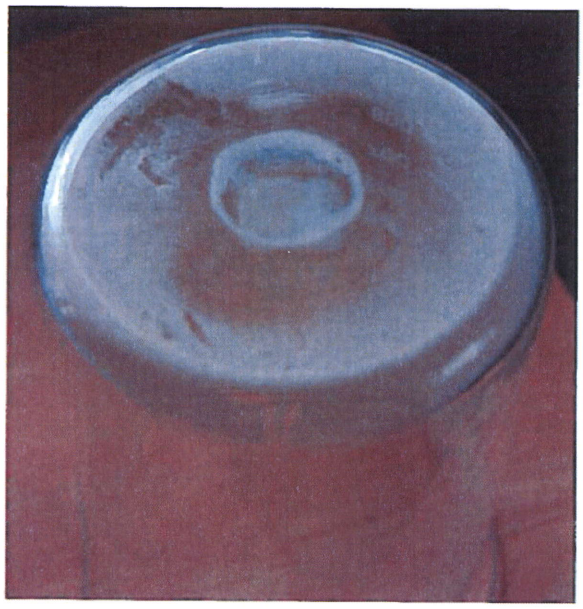

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Appendix 7-69

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creating solutions for today's environment

December 5, 2011

Dana Marrelli
UtahAmerican Energy, Inc.
West Ridge Mine
P.O. Box 910
East Carbon, UT 84520

RE: Crandall Canyon Macroinvertebrate Study

Dear Dana,

Enclosed is the bound copy of the Spring 2011 Macroinvertebrate Report for the Crandall Canyon Mine. This is the same as the electronic copy that we sent earlier. We will begin work on the Fall 2011 report once we receive the lab report.

Thank you for the opportunity to conduct this ongoing work. Feel free to contact me if you have any questions or comments.

Regards,

Karla Knoop, Hydrologist

JBR Environmental Consultants, Inc.
Corporate Headquarters
8160 S. Highland Dr.
Sandy, Utah 84093
[p] 801.943.4144
[f] 801.942.1852
www.jbrenv.com

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Crandall Canyon Mine Macroinvertebrate Study July 2011

Prepared for:
Genwal Resources, Inc.
Crandall Canyon Mine
P.O. BOX 910
East Carbon, Utah 84520

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Crandall Canyon Mine Macroinvertebrate Study July 2011

1.0 Introduction

On July 14, 2011, JBR Environmental Consultants, Inc. (JBR) collected benthic macroinvertebrate samples from Crandall Creek, which is located near Huntington, Utah. The samples were collected both upstream and downstream of an underground coal mine operated by Genwal Resources, Inc. (Genwal) and permitted by the Utah Division of Oil, Gas and Mining (DOGM) through its coal mining program. The mine, known as the Crandall Canyon Mine, has been idle for several years. However, intercepted groundwater continues to discharge from the sealed portals and Crandall Creek is the receiving stream for the discharged water.

Beginning in the fall of 2009, JBR has sampled the creek's benthic macroinvertebrates twice yearly to determine whether or not the mine discharge is affecting Crandall Creek's aquatic community, and prepared biannual reports based upon the laboratory data (JBR 2010; JBR 2011a; JBR 2011b). This report discusses the results from the July 14, 2011 sampling event. After giving some relevant background information, it describes the data collection and analysis methodology, provides the laboratory data, and discusses the study results to date.

1.1 Background

The Crandall Canyon Mine began discharging groundwater in late 1995, and did so more or less continuously for 12 years. During operations, groundwater entering the underground mine had to be collected and pumped to the surface to ensure safe working conditions. Except for some passive in-mine settling, this groundwater was not treated prior to being released to Crandall Creek. Its discharge was regulated by the Utah Division of Water Quality (DWQ) through the Utah Pollutant Discharge Elimination System (UPDES) permit program, and water quality limits were imposed to ensure that Crandall Creek and downstream water resources were protected. With very few exceptions, those permit limits were met during the 12 years of near-continuous pumped groundwater discharge.

Subsequent to mine closure in mid-2007 and without active pumping, groundwater discharge ceased. The UPDES permit continued to be in effect, and the "no discharge" status was reflected on the monthly discharge monitoring reports. However, after about three months with no discharge, groundwater unexpectedly began flowing out of the mine from beneath the portal seals. It has continued without interruption since that time.

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While gravity-flow rates have been similar to the flow rates that prevailed during the operational pumping, water quality changed once the discharge resumed in early 2008 (JBR 2010). In particular, total iron concentrations increased by up to three orders of magnitude and exceeded the established UPDES permit limits. The iron-laden discharge also resulted in iron-stained streambed substrate along an approximate 3,000-foot reach of Crandall Creek immediately downstream of where the groundwater discharge enters the stream. In early 2010, Genwal began operating an iron treatment system, and total iron concentrations have consistently been kept at less than 1.0 mg/L since March 2010. However, the iron-stained substrate is still present.

Crandall Creek is a small perennial stream that drains a 2,500-acre watershed located within the bounds of the Manti-La Sal National Forest and conveys flow to Huntington Creek. Genwal's intercepted groundwater enters Crandall Creek approximately 1.5 miles upstream of the confluence of those two streams. Both Crandall Creek and Huntington Creek support aquatic resources, and Huntington Creek is a noted trout fishery. These fish rely in part upon a healthy and abundant macroinvertebrate community as a food source. The Utah Division of Wildlife Resources (DWR), in a 1995 letter to Genwal, indicated that Crandall Creek had a small resident cutthroat population and was also important spawning habitat for trout in Huntington Creek (Moretti 1995).

Iron is an essential element for both fish and the macroinvertebrates upon which they rely as a food source, as well as all other terrestrial and aquatic biota. However, in the aquatic environment, iron can be harmful or even toxic depending upon its chemical form and its concentration. Largely as a function of the water's pH and dissolved oxygen content, iron is typically present in either an insoluble ferric form or a soluble ferrous form. It can also be present as an integral component of individual sediment particles whose parent rock contains iron. While the chemistry of iron in water can be complex and is not fully discussed here, it is important to note a couple of key points. Commonly, iron found in groundwater is in the ferrous form, but when exposed to the atmosphere, this dissolved iron often oxidizes to the ferric form and then precipitates (Hem 1985). These iron precipitates can physically degrade aquatic habitat by covering bed substrate and organic matter; the covering can also reduce food sources for both fish and macroinvertebrates. The particulates (either from precipitates or fine sediments) can clog an organism's gills or filtering apparatus, and thereby hinder oxygen intake. Iron can also precipitate directly onto an organism's body, physically harming its body structure and function. In its soluble (dissolved) form, iron can also be toxic when ingested by aquatic life.

Taking all of these things into account, EPA has conservatively recommended a (nationwide) criterion (chronic) of 1.0 mg/L iron, as part of their published National Recommended Water Quality Criteria for the protection of aquatic life (EPA 2009). Following EPA's recommendation, Utah, in its Water Quality Standards given at U.A.C. R317-2-14, adopted a maximum dissolved iron criterion of 1.0 mg/L for all streams that are classed for aquatic wildlife beneficial uses.

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DWQ set the Crandall Canyon Mine's UPDES permit limit at 1.0 mg/L total iron to provide protection at an even more conservative level than the stream standard without accounting for any dilution effects.

1.2 Purpose of Study

In 2009, due to ongoing elevated iron concentrations associated with Genwal's permitted groundwater discharge, the relevant regulatory (DWQ, DOGM) and management (U.S. Forest Service (USFS), DWR) agencies became concerned about the potential impacts of the discharge on aquatic life. In mid-August, 2009, DOGM issued a Citation for Non-Compliance (#10044) that required Genwal to engage a qualified biologist to collect macroinvertebrate samples from Crandall Creek twice each year (in June and September) and prepare comprehensive reports that describe and evaluate each study's results.

This report is intended to meet the ongoing DOGM requirements for the biannual sampling and reporting. Its purpose is to assess both the spatial and temporal variation in the macroinvertebrate community of Crandall Creek with the goal of determining what, if any, iron-caused impacts have occurred or are still occurring in that community.

In addition, study results can be used to assess the overall health of Crandall Creek. Because they are sensitive to water quality and respond quickly to stressors, including water pollutants, and also because they are fairly stationary within a given stream feature, benthic macroinvertebrates integrate variations in water quality or other habitat components (Davis et al. 2001). Numerous indices and metrics such as diversity, taxa ratios, richness, and the like can be calculated and used to assess the macroinvertebrate community at a given site in regard to its ability to tolerate environmental pollution. The presence or absence of a specific macroinvertebrate taxon can indicate a perturbation that may not have been captured by grab samples analyzed for specific water chemistry. Ideally, these repeat studies may provide insight on the general condition of Crandall Creek as well as the iron-specific impact (if any) of Genwal's discharge on the creek's aquatic community.

2.0 Previous Studies

Prior to the initiation of sampling in 2009 in response to the previously noted DOGM citation, Crandall Creek's macroinvertebrate community had been periodically assessed by others. In 1980, macroinvertebrate samples were collected at several locations along Crandall Creek before the mine start-up. A follow-up macroinvertebrate study was conducted in 1994, after several years of mine operations; at the time of sampling, groundwater had not been intercepted in a quantity sufficient to require surface discharge. In addition, the USFS samples benthic macroinvertebrates in Huntington Creek every five years. Brief descriptions of each of these other studies were given in a previous JBR report (JBR 2010).

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To comply with DOGM Citation #10044, JBR collected macroinvertebrate samples in Crandall Creek in September 2009 (JBR 2010), in June 2010 (JBR 2011a), and again in September 2010 (JBR 2011b). During these studies, samples were collected at three locations. The uppermost sampling reach (CRANDUP-01) was upstream of any influence of the mine's groundwater discharge, thus serving as a reference reach. The middle reach (CRANDMD-02) included the area immediately downstream of the discharge location where flow mixing, aeration, and iron precipitation were occurring. The downstream reach (CRANDLWR-03) was a short distance upstream of the confluence with Huntington Creek, outside of the area with a visibly impacted substrate. During the September 2009 event, sample collection methodology was generally based upon the reach-wide, multi-habitat sample methodology outlined in the (EMAP) Field Operations Manual for Wadeable Streams (EPA 2001), modified as per discussions with the Manti-La Sal National Forest fisheries biologist. During the 2010 sampling events, targeted-riffle samples were added to the protocol.

Overall, the study results from the 2009 and 2010 sampling indicated that the Crandall Creek macroinvertebrate community downstream of the mine's discharge appeared to have been negatively impacted. However, both downstream reaches of the creek were still supporting a variety of macroinvertebrates, signifying that the mine discharge had not completely decimated macroinvertebrate populations.

3.0 Site Locations and Descriptions

3.1 Site Locations

Prolonged snow melt runoff with high flow rates prohibited collecting macroinvertebrate samples in June 2011. With prior approval from DOGM, sampling was postponed until July. Although flows were still elevated, macroinvertebrate samples were collected on July 14, 2011 after peak runoff had diminished. The samples were collected at the same three sites that were sampled during the 2009 and 2010 sampling events. The uppermost site (CRANDUP-01) is near the upstream edge of the upper parking lot and outside of any influence of the mine's groundwater discharge. Its downstream endpoint is approximately 2 meters above the flow measurement flume and the reach extends upstream approximately 150 meters. The middle site (CRANDMD-02) includes the area immediately downstream of the discharge location where flow mixing and aeration are occurring, and where the iron previously precipitated. Its upstream endpoint (Transect K) is approximately 5 meters downstream of the discharge point, with the reach extending downstream approximately 150 meters. The downstream site (CRANDLWR-03) was chosen to be approximately 2 meters upstream of the mine road crossing near the confluence of Crandall Creek and Huntington Creek, and its reach extended upstream from that point approximately 150 meters.

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As per EMAP protocol, during the September 2009 study 11 cross-section transects were established at regular intervals within each of these reaches, and were flagged and marked (JBR 2010). These same transects were used in the 2010 studies.

3.2 Site Descriptions

The report that presented the 2009 study results (JBR 2010) described stream morphology, substrate, and riparian vegetation. During the June 2010 (JBR 2011a) sampling, additional observations were made on bed substrate at each reach, in order to provide some context for variation in macroinvertebrate communities among the three reaches. Substrate at CRANDMD-02 is notable for iron-stained particles and the presence (seasonally) of filamentous algae. CRANDLWR-03 substrate is generally calcified and cemented in place.

July 2011 channel conditions were generally similar to those noted during the previous sampling events. Snow melt runoff had subsided, but a thunderstorm event elevated flows and resulted in turbidity during sampling. At Site CRANDMD-02, filamentous algae appeared to be reduced (likely due to season and scour from snow melt), and surface iron staining also appeared to be less noticeable (however, kicking up substrate during sampling re-exposed iron-stained particles). The following photos provide a visual description of the site conditions at the time of the July 2011 sampling.

CRANDUP-01 on July 14, 2011

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CRANDMID-02 on July 14, 2011

CRANDLWR-03 on July 14, 2011

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4.0 Methods

JBR collected two macroinvertebrate samples, a multi-habitat sample and a riffle sample, from each of the locations described above. Sample collection for the multi-habitat sample was the same as described in JBR (2010) and was based upon the reach-wide sample methodology outlined in the (EMAP) Field Operations Manual for Wadeable Streams (EPA 2001). The specific application of this sample methodology was modified as per discussions with the Manti-La Sal National Forest fisheries biologist who is responsible for USFS macroinvertebrate sampling on the Forest. Section 4.1.1 below describes the modified methodology. The riffle sample was collected following the EMAP targeted riffle sample methodology. Section 4.1.2 below describes the targeted riffle methodology.

The collected and preserved samples were then delivered to the National Aquatic Monitoring Center (the BugLab) in Logan, Utah for processing and taxonomic identification. The BugLab is a cooperative venture between the U.S. Bureau of Land Management (BLM) and Utah State University. It focuses on processing macroinvertebrate samples, and processes a large percentage of the samples collected on federal land in the western U.S. The DWQ Monitoring Manual (DWQ 2006) specifies that macroinvertebrate samples be processed by the BugLab. DWQ's methodology is described in Section 4.2., and the BubLab's complete report (Judson and Miller 2011) is attached as Appendix 1.

4.1 Sample Collection Methods

4.1.1 Modified Multi-Habitat Sample Collection

The EMAP methodology for the multi-habitat sample specifies that one macroinvertebrate subsample is taken at each of the eleven transects within the delineated reach. These subsamples are then combined into a composite sample. The sample location at the first transect is randomly selected using a six sided dice (i.e., sample is taken at a location 25, 50, or 75 percent of the distance from the channel's left edge depending upon the roll of the dice), with the sampling point at subsequent transects chosen systematically. However, the Manti-La Sal National Forest regularly collects only 4-5 macroinvertebrate subsamples within each reach, which are then combined into a single composite sample. The 4-5 subsamples are collected from as many habitat types as possible in order to sample the full range of habitat types present within the reach. In order to be more consistent with the methodology used by the Forest, the EMAP reach-wide, multi-habitat sample methodology was modified to only include five samples. However, to keep the modified methodology as similar to EMAP procedure as possible (which improves consistency and keeps the samples as replicable as possible), the five samples were collected at every other transect starting with Transect B, where possible.

As Crandall Creek is a narrow stream at all sites, and particularly CRANDUP-01, sample location at each transect was not chosen randomly or systematically, rather the site that was most suitable to sampling was chosen (i.e., the location that allowed placement of the sampler). All sampling was conducted using a 500-micron mesh D-frame kick net. The samples were

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collected in a downstream-to-upstream order to avoid including organisms dislodged from upstream samples.

For sampling transects the following procedures were utilized.

1. The kick net was quickly and securely positioned on the bottom of the channel with the opening facing upstream. Gaps between the frame and substrate were minimized.

2. The sample area was checked for heavy organisms, such as mussels and snails. Any such organisms were placed into the composite sample bucket. All substrate particles larger than golf balls and that were at least halfway into the sample area were picked up and rubbed with hands or a brush to dislodge organisms into the net. Particles that were more than halfway outside the sample area were pushed aside and not sampled. After particles were washed, they were placed outside of the sample area.

3. Starting at the upstream end of the sample area, the remaining substrate was kicked vigorously for 30 seconds. The water was allowed to clear before removing the net from the water column.

4. The net was lifted out of the water then quickly immersed several times to concentrate sample material in the end of net. Care was taken not to further disturb channel substrate with the net, or allow for organisms to escape.

5. The net was inverted into the composite bucket, which had been ¼ to ½ filled with stream water. The net was inspected for clinging organisms and forceps were used to place these organisms into the bucket.

6. The net was rinsed in the stream before moving to the next transect.

7. The dominant substrate and habitat type were recorded on the field data sheet.

After sampling was completed at the five transects, the following procedures were employed to prepare a multi-habitat composite index sample to be sent to the lab.

1. The contents of the sample bucket were manually swirled to separate organisms from the sample material. The sample material was poured through a 300-micron mesh sieve and the inside of the bucket was inspected for organisms. Organisms were rinsed off any large objects (rocks, organics, etc.) with a spray bottle filled with stream water before discarding the objects. Additional serial bucket rinses were employed until no remaining organisms were noted in the sample bucket.

2. Using the spray bottle, the sample material inside the sieve was rinsed to one side and transferred into the sample container using as little water as possible. The sieve was carefully examined for clinging organisms and these were placed into the sample bottle using forceps.

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3. The sample container was completely filled with 95-percent ethanol so that the final concentration was between 75 and 90 percent. The container was slowly tipped horizontally and rotated to allow complete mixing of the ethanol and sample.

4. Sample containers were labeled with the information listed below. A duplicate of this label was written on ethanol-safe paper and placed inside of the container. Samples were then delivered to the BugLab for analysis.

   * Type of Sample (e.g., multi-habitat or riffle)
   * Stream Name
   * Site I.D.
   * Forest (Manti-La Sal National Forest)
   * Date and Time of Collection
   * Number of Jars

4.1.2 Targeted Riffle Sample Collection

The EMAP methodology for the targeted riffle sample specifies that eight macroinvertebrate subsamples be taken within available riffle macrohabitat units within the delineated reach. These subsamples are then combined into a composite targeted riffle sample. The sample locations are identified by surveying the delineated reach prior to sampling to visually estimate the number and area of riffle units. If the reach contains more than one distinct riffle macrohabitat unit but less than eight, the eight sampling points are allocated among the units to spread the effort throughout the reach as much as possible, with it possible to collect more than one kick sample from a single riffle unit. If the number of riffle macrohabitat units is greater than eight, one or more habitats is skipped at random. Within each riffle unit, EMAP specifies that the sample locations be chosen at random from nine equal quadrats (visually estimated). However, as already noted, Crandall Creek is a narrow stream at all sites, and particularly CRANDUP-01. As a result, the riffle samples from each macrohabitat unit were not chosen randomly, rather the site that was most suitable to sampling was chosen (i.e., the location that allowed placement of the sampler). The samples were collected in a downstream-to-upstream order to avoid including organisms dislodged from upstream samples.

Once locations were chosen, samples were collected and composited following the same procedures outlined for the modified multi-habitat sample.

4.2 Analysis Methods

As noted above, the BugLab identified the taxa represented in the macroinvertebrate samples that JBR collected. The lab processed the samples using methods similar to those recommended by the United States Geological Survey (Cuffney et al 1993, as referenced in Judson and Miller 2011). For all six samples, 100 percent of the sample material was processed (i.e., sub-sampling procedures were not used). Generally, organisms were removed under a

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dissecting microscope at 10-30 power and separated into taxonomic orders. Organisms were then identified to a lower taxonomic level (family, genus, and/or species, as feasible). Once identified and counted, samples were placed in 20-ml glass scintillation vials with polypropylene lids in 70% ethanol, given a catalog number, and retained. The results report (Judson and Miller 2011) includes a complete list of taxa and the number of organisms by taxa (see Appendix 1).

The BugLab also provided data summaries and calculated various indices and metrics (Judson and Miller 2011), many of which will be discussed in the results discussion. These include: abundance, total taxa richness, EPT (Ephemeroptera, Plecoptera, and Trichoptera) taxa richness, Ephemeroptera taxa richness, Plecoptera taxa richness, Trichoptera taxa richness, percent EPT abundance, percent Ephemeroptera abundance, percent Chironomidae abundance, Intolerant taxa richness, percent tolerant organisms, Community Tolerant Quotient (CTQd), Hilsenhoff Biotic Index (HBI), percent contribution of the dominant taxon, clinger taxa richness, percent clinger abundance, percent collector-filterer abundance, and percent scraper abundance. Definitions/descriptions of these individual metrics and their usefulness are given in their report (Judson and Miller 2011), which can be found in Appendix 1.

In addition, JBR used the BugLab's data set to calculate several other metrics that various literature sources consistently indicate as being potentially useful for macroinvertebrate analysis, particularly in regard to potential metals pollution. These are described below.

Ratio of Specialist Feeders to Generalist Feeders - Specialist feeders include shredders and scrapers and generalist feeders include filterers and gatherers. Generalists are typically more tolerant to environmental stressors, so their proportion often increases in response to degraded water quality or stream habitat. This ratio has been used successfully to assess impacts from mining (Mize and Deacon 2002).

Ratio of EPT to Chironomidae - Ideally, communities have a near-even distribution among all four of these major groups. The Chironimid Family, in general, is more tolerant than most of the taxa in the Ephemeroptera, Plecoptera, and Trichoptera orders (Barbour et al 1999). Therefore, this ratio can indicate environmental stress when it shows disproportionate numbers of Chironomidae (Davis et al 2001).

Percent *Baetis*, Hydropsychidae, and Orthocladinae; Ratio of *Baetis* to all Ephemeroptera – These two similar measures express the documented higher tolerances of *Baetis*, Hydropsychidae, and Orthocladinae, than other members of their families. Mize and Deacon (2002) among others have used the presence of these taxa when assessing environmental conditions specific to mining (some studies have found the opposite conclusion with *Baetis*; however, the majority appear to consider it one of the more tolerant of the mayflies).

Percent Heptageniidae, Chloroperlidae, and *Rhyacophila*; Ratio of Heptageniidae to all Ephemeroptera – Similarly to the above-noted tolerant taxa, Heptageniidae, Chloroperlidae,

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and *Rhyacophila* were considered by Mize and Deacon (2002) when assessing elevated trace metals impacts. Heptageniidae, Chloroperlidae, and *Rhyacophila* were chosen due to their apparent sensitivity to such elements, thus their absence can indicate poor water quality. Many other authors have associated a lack of Heptageniidae organisms, in particular, with heavy metals pollution (i.e. Kiffney and Clements 1994).

As with analysis of any set of macroinvertebrate data, multiple metrics and their predicted response to perturbations (as given by EPA (2009a) and others in the scientific community) will be relied upon to make a finding of impact or nonimpact in regard to Genwal's groundwater discharge and Crandall Creek. Whether looking at data from an individual sample, comparing data from different sites for a spatial assessment, or examining temporal changes, no one metric can ever be presumed to tell the whole story. First, there is typically some natural variability in community makeup, so reliance on a single metric can be misleading. Further, some metrics are better at ascertaining specific conditions than others (i.e., organic pollution versus metals pollution). For these reasons, most researchers use a variety of metrics and would expect to see similar indications in several of them before making a conclusion regarding impact to a given site. In contrast, there is some redundancy among metrics because they use at least some of the same data. EPA (Barbour et al 1999) and others have developed techniques for combining various metrics into a single index, and also for ranking sites based upon individual metrics in a way that a potentially impacted site can be compared to reference sites (known to be unimpacted). In this study, the low number of sample sites, lack of replicates, and inadequate information on historical baseline make these techniques impossible or impractical to use. Further, the natural variability of any of one these metrics is not known, so it is difficult to determine whether a difference between sites as shown by one metric is due to degraded conditions or simply a reflection of natural variability.

Instead, as was done for the previous JBR reports (2010; 2011a; 2011b) on macroinvertebrate sampling in Crandall Creek, individual metrics were calculated for each site and graphed to provide an easy visual means of comparison (Appendix 2). Although some metrics are not independent of each other, there was a specific intent to choose metrics that are of different types (i.e., tolerance as measured by CTQd, community composition as measured by EPT abundance, feeding mechanism as measured by specialist-to-generalist ratio), as recommended by EPA (Barbour et al 1999). Metrics that would be expected to decrease as site conditions worsen (e.g., richness) are shown in blue and those that would be expected to increase as site conditions worsen (e.g., HBI) are shown in green, further facilitating visual interpretation. Comparisons between CRANDUP-01 and CRANDMD-02, across matrices, allow an assessment of whether conditions are degraded below Genwal's discharge. The presumption is that if multiple matrices indicate the same trend (e.g., impact), there is a greater likelihood that there is a degradation between sites as a result of mine discharge. Similarly, comparisons between CRANDMD-02 and CRANDLWR-03 can be made to assess whether there is a spatial limit to the degradation (recovered conditions downstream).

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5.0 Results and Discussion

The laboratory results report that was prepared by the BugLab (Judson and Miller 2011) is provided in full as Appendix 1. That report includes the raw data (taxonomic lists of organisms that were sampled, counts, etc.) as well as numerous tables giving various metrics and indices that the lab calculated based upon the data. The BugLab's report (Judson and Miller 2011) does not discuss or interpret the study results. This section focuses on those tasks, beginning with a brief summary of the data and a general discussion of the results.

A total of 61 operational taxonomic units (OTUs) were identified in the 6-sample set, which is similar to the June 2010 sampling event, when 65 OTUs were reported (JBR 2011a). At 31, the number of families and number of genera were within the ranges those previously reported in JBR (2010; 2011a; 2011b). Variations in these numbers can be caused by flow conditions, time of year, macroinvertebrate life cycles, and environmental degradation.

All of the insect orders most commonly found in macroinvertebrate communities (Coleoptera, Diptera, Ephemeroptera, Plecoptera, and Tricoptera) as well as individuals from some non-insect classes were represented in both sample sets. Composition (e.g., proportion of members of the order Diptera) continues to show that none of the three Crandall Creek sites is in optimum condition, though there is variation among the sites, which will be described further below. CTQd, which can range from about 20 in the best quality streams up to about 100 in the poorest, was between 63 and 84 in the Crandall Creek July 2011 samples. Though this range of values is improved over the previous two sampling events (JBR 2011a and 2011b), it still indicates a stream that is providing less than ideal aquatic habitat.

Although Crandall Creek as a whole may provide less-than-ideal habitat, all of the sites had at least a somewhat diverse assemblage of taxa, and all supported at least some taxa that are considered intolerant to pollution or other habitat alterations. Knowing that (1) Crandall Creek overall has an aquatic community that is not optimum, and (2) in spite of Genwal's discharge, the creek is still supporting aquatic life provides a useful context for the remainder of the results discussion. Those two things being said, by the majority of the metrics discussed below, there continues to be a less healthy macroinvertebrate community at both CRANDMD-02 and CRANDLWR-03, which are downstream of the discharge, than at CRANDUP-01, which is upstream of the discharge.

Habitat differences among the three sites (described briefly above in Section 3.2) could be at least partially reflected in the results and their interpretation. For example, CRANDUP-01 and CRANDLWR-03 have similar substrate size compositions, but at the latter much of the substrate is embedded and cemented. This lack of interstitial spaces results in poor physical habitat for macroinvertebrates at CRANDLWR-03. Therefore, the site comparisons in Section 5.2 must consider that habitat is degraded at this site due to characteristics unrelated to any that have potentially occurred due to the discharges of iron-laden water. Additionally, the substrate at CRANDMD-02 is similar to that at the other two sites, but proportionally has more graveled

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riffle reaches than the other two sites. These features generally offer the best physical habitat for macroinvertebrates, but at CRANDMD-02, much of this high-quality substrate is now iron-stained and covered with filamentous algae.

5.1 Comparison of Targeted Riffle and Multi-Habitat Samples

As with the 2009 and 2010 analyses (JBR 2010; 2011a; 2011b), numerous metrics and indices have been calculated and graphed for the September 2010 samples. These graphs are included in Appendix 2. They provide a visual means to determine whether there were differences between the samples collected from targeted riffle sites and those collected from the multi-habitat sites.

One of the reasons that the first study report (JBR 2010) recommended that targeted riffle samples should be collected along with the multi-habitat ones during future monitoring events was based upon the observation that habitat types varied somewhat between each reach. It was felt that the spatial data comparison would be more robust using the results of targeted riffle sampling. In addition, Utah's DWQ monitoring program calls for macroinvertebrate samples to be collected using only a targeted riffle method (DWQ 2006). Collecting targeted riffle samples in Crandall Creek, as well as continuing to collect multi-habitat samples, would allow a broader means of data interpretation in the future, as the data set grows.

Notably, at CRANDMD-02 the riffle sample reflected much better macroinvertebrate habitat than did the multi-habitat sample. Overall, however, conclusions regarding trends or spatial differences are the same regardless of sample types, so both riffle and multi-habitat results are used in the following discussions.

5.2 Spatial Variation in Macroinvertebrate Community

As noted above, numerous metrics and indices based upon the September 2010 sampling at CRANDUP-01, CRANDMD-02, and CRANDLWR-03 have been calculated and graphed. These graphs are included in Appendix 2 and provide a visual aid for analyzing the spatial variation in the macroinvertebrate community along Crandall Creek. CRANDUP-01 is upstream of any potential impact from Genwal's discharge, CRANDMD-02 is immediately below the discharge where impacts would presumably be the greatest, and CRANDLWR-03 is further downstream where impacts could presumably be either similar those seen at CRANDMD-02 or reduced, thus indicating a spatial limit to the impact.

Out of the 20 metrics graphed in Appendix 2, 14 of the targeted riffle sample results and 16 of the multi-habitat samples results indicate a decline in macroinvertebrate community health between CRANDUP-01 and CRANDMD-02. These are similar percentages as were shown with the 2009 and 2010 samples (JBR 2010; 2011a; 2011b). The noted decline in the aquatic community between these two sites is based upon a range of tolerance, community composition, diversity, and feeding group metrics, which strengthens the conclusion that the mine discharge has negatively affected habitat. Similarly, based upon the majority of the

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metrics (and again across metric types), CRANDUP-01 has a healthier macroinvertebrate community than does CRANDLWR-03.

5.3 Temporal Variation in Macroinvertebrate Community

As previously mentioned, macroinvertebrate studies were conducted in Crandall Creek in 1980 and 1994. However, those data are of limited use for temporal comparisons due to unknowns in either sampling locations and/or collection methodology. Instead, the four sets of data collected by JBR from September 2009, June 2010, and September 2011, and July 2011) are examined herein to assess temporal variation.

Examination of the graphed metrics does not show a strong overall trend in either improvement or degradation at any of the sites across the period of sampling; some metrics indicate improvement, some indicate degradation, and others are essentially the same. The previous sample report (JBR 2011b) noted that CRANDUP-01 had poorer macroinvertebrate conditions in June 2010 than in either of the two September sampling events. This was likely due to the high snowmelt runoff that was occurring at the time of sampling.

Comparisons made among like seasons when stream flow rates and macroinvertebrate life cycles are more likely to be similar may be more meaningful; however to date there are only two sampling events for each season, which limits interpretations. The July 2011 samples indicated improvements over the June 2010 samples at all three sites. While these noted improvements were reflected at CRANDMD-02 (particularly in the riffle set) and CRANDLWR-03, the fact that improvements were also reflected at the upstream, unaffected site precludes an interpretation that the downstream improvements reflect recovery from the iron-laden mine discharges. Instead, these differences could be all or partially due to more optimum flow conditions (e.g., later in the runoff cycle) during the more recent sampling event, for example.

5.4 Metric Refinement

With the inclusion of the latest set of data, collected July 2011, a total of four sampling events are now available for analysis. While a set of four events limits the potential for robust statistical analysis (especially given the different seasons represented) or development of an integrated index, the large number (20) of metrics can be winnowed down. As noted above in Section 4.2, there was some redundancy among the 20 metrics that were initially selected. However, different metric types (e.g., tolerance, diversity, community composition, feeding mechanism) were represented. Reducing the number of metrics that are looked at from here out should reduce the redundancy but still include a variety of metric measures; the new set of metrics should also reflect the same general conclusions as does the full set.

In order to refine the set of metrics upon which subsequent reports will focus, the range (as indicated by the highest and lowest value) of each metric across the four data sets was compared for each of the three sites. The riffle samples and the multi-habitat samples were both included in this analysis. The spread in the values of each metric encompasses at least

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some measure of seasonality, natural variation, or trends, albeit within the short timeframe between fall 2009 and spring 2011. The primary goal of the monitoring has been to determine whether or not the sites downstream of the mine discharge have been affected by it, and the data collected to date consistently shows that CRANDMD-02 and CRANDLWR-03 have poorer macroinvertebrate communities than does CRANDUP-01. The metrics that may show this result most clearly may be those where the distributions in the data between the upstream and downstream sites are the most divergent.

For each metric, the maximum and minimum values at the site immediately below the mine discharge (CRANDMD-02) were compared with those at the upstream, unaffected site (CRANDUP-01) and categorized as being either: within the spread of values, completely outside the it, or overlapping it. None of the 20 metrics had completely disparate spreads between CRANDUP-01 and CRANDMD-02 (i.e., there was always some overlap). For 9 out of the 20 metrics (richness, EPT taxa abundance, number of intolerant taxa, HBI, number of clinger taxa, number of long-lived taxa, percent scrapers, percent chironomids, and percent tolerant organisms), the CRANDMD-02 range was within the range reported for CRANDUP-01. The remaining 11 metrics were outside the range in one direction of the other (though sometime only minimally); in all but one of those, the direction outside the overlap reflected degradation at the downstream site compared to the upstream (i.e., was consistent with the overall interpretation using all 20 metrics). Coincidently or not, several of these are metrics that have been noted to be indicative of mining and/or elevated trace elements. Further, these divergent metrics encompassed tolerance, diversity, community composition, and feeding mechanism measures. A comparison between CRANDUP-01 and CRANDLWR-03 showed similar results, but with fewer metrics found to be within the CRANDUP-01 range. A table at the end of Appendix 2 shows this comparison.

6.0 Recommendations for Future Study

JBR recommends that future sampling events use the same methodology and equipment as was used in 2010. Samples should include both a multi-habitat sample at each site and a targeted riffle sample at each site.

Future sample reports should focus on a reduced set of metrics. The following 10 metrics are recommended based upon the assessment in Section 5.4: Shannon's Diversity; evenness; CTQd; percent shredders; ratio of specialist feeders to generalist feeders; percent EPT; ratio of EPT to Chironomids; percent Heptageniidae, Chloroperlidae, & Rhyacophila; percent Baetis, Hydropsychidae, & Orthocladiinae; and percent of Baetis to all Ephemeroptera. In addition, percent scrapers will also be retained as a metric, due to its potential usefulness to tie into the presence/absence of filamentous algae. (Note that any of the other "discarded" metrics will either still be available within the BugLab reports or can easily be calculated from data contained with those reports.) In addition to the spread of values as indicated by the maximum

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and minimum, box-and-whisker plots should also be considered to provide a more refined analysis.

7.0 Summary and Conclusions

In July 2011, benthic macroinvertebrate samples were collected from three reaches of Crandall Creek. One reach was located upstream of Genwal's Crandall Canyon Mine groundwater discharge while the other two reaches were located downstream of the discharge. One of the primary goals of the study was to determine whether the previously elevated iron concentrations have impacted Crandall Creek's macroinvertebrate population. Macroinvertebrate community composition at these three reaches was determined by taxonomic identification of the organisms collected during the sample collection, and numerous indices and metrics were calculated for ease in interpreting results.

Overall, the study results indicate that the Crandall Creek macroinvertebrate community immediately downstream of the mine discharge continues to show negative impacts of the mine water discharge. Although the furthest downstream reach of Crandall Creek (CRANDLWR-03) also has a degraded macroinvertebrate community, its poor substrate condition (embedded and cemented) is likely a contributing (if not dominating) factor affecting macroinvertebrate community health at that site. However, both downstream reaches of the creek are still supporting a variety of macroinvertebrates, indicating that neither the past iron-laden discharge nor the continuing treated discharge has completely eliminated macroinvertebrate populations.

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APPENDIX 1
BUGLAB REPORT

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Aquatic Invertebrate Report For Samples Collected By JBR Environmental Consultants - Sandy, UT

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28 September 2011

Sampling Locations

Table 1. Sampling site locations

Station	Location	Latitude	Longitude	Elevation (meters)
CRANDLWR-03	Crandall Creek, Lower, Emery County, UT	39.464	-111.1460	2363
CRANDMD-02	Crandall Creek, Middle, Emery County, UT	39.460	-111.1650	2384
CRANDUP-01	Crandall Creek, Upstream, Emery County, UT	39.460	-111.1680	2389

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Methods

Field sampling

Samples were collected on July 14, 2011 (Table 2). Aquatic invertebrates were collected quantitavely and qualitatively from riffle and reachwide habitats with a Kick Net

Laboratory methods

General procedures for processing invertebrate samples were similar to those recommended by the United States Geological Survey (Cuffney et al. 1993) and are described in greater detail and rationalized in Vinson and Hawkins (1996). Samples were sub-sampled if the sample appeared to contain more than 600 organisms. Sub-samples were obtained by pouring the sample into an appropriate diameter 500 micron sieve, floating this material by placing the sieve within an enamel pan partially filled with water and leveling the material within the sieve. The sieve was then removed from the water pan and the material within the sieve was divided into two equal parts. One half of the sieve was then randomly chosen to be processed and the other half set aside. The sieve was then placed back in the enamel pan and the material in the sieve again leveled and split in half. This process was repeated until approximately 600 organisms remained in one-half of the sieve. This material was placed into a Petri dish and all organisms were removed under a dissecting microscope at 10-30 power. Additional sub-samples were taken until at least 600 organisms were removed, All organisms within a sub-sample were removed, and separated into taxonomic Orders. When the sorting of the sub-samples was completed, the entire sample was spread throughout a large white enamel pan and searched for 10 minutes to remove any taxa that might not have been picked up during the initial sample sorting process. The objective of this "big/rare" search was to provide a more complete taxa list by finding rarer taxa that may have been excluded during the sub-sampling process. These rarer bugs were placed into a separate vial and the data entered separately from the bugs removed during the sub-sampling process. All the organisms removed during the sorting process were then identified using appropriate identification keys (see literature cited list for list of taxonomic resources used). Once the data had been entered into a computer and checked, the unsorted portion of the sample was discarded. The identified portion of the sample was placed in a 20 ml glass scintillation vial with polypropylene lids in 70% ethanol, given a catalog number, and retained. In this report, metrics were calculated using data from the sub-sampled and big/rare portions of the sample. Abundance data are presented as the estimated number of individuals per square meter for quantitative samples and the estimated number per sample for qualitative samples.

Table 2. Field comments and laboratory processing information.

Sample	Station	Sampling Date	Habitat Sampled	Sampling Method	Sampling Area Sqmts	% of sample processed	Number of individuals identified
146827	CRANDLWR-03	07/14/2011	Reachwide	Kick Net	0.37	100	77
146828	CRANDLWR-03	07/14/2011	Targeted Riffle	Kick Net	0.74	100	647
146825	CRANDMD-02	07/14/2011	Reachwide	Kick Net	0.37	100	201
146826	CRANDMD-02	07/14/2011	Targeted Riffle	Kick Net	0.74	100	456
146823	CRANDUP-01	07/14/2011	Reachwide	Kick Net	0.37	100	230
146824	CRANDUP-01	07/14/2011	Targeted Riffle	Kick Net	0.74	100	551

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Data summarization

A number of metrics or ecological summaries can be calculated from an aquatic invertebrate sample. A summary and description of commonly used metrics is available in Barbour et al. (1999, http://www.epa.gov/owow/monitoring/rbp/index.html#Table%20of%20Contents) and Karr and Chu (1998). Both of these publications suggest use of the following metrics for assessing the health of aquatic invertebrate assemblages: Total taxa richness, EPT taxa richness, Ephemeroptera taxa richness, Plecoptera taxa richness, Trichoptera taxa richness, % EPT abundance, % Ephemeroptera abundance, % Chironomidae abundance, Intolerant taxa richness, % tolerant organisms, Hilsenhoff Biotic Index, % contribution of the dominant taxon, clinger taxa richness, % clinger abundance, % collector-filterer abundance, and the % scraper abundance. Assessments are best made by comparing samples to samples collected similarly at reference sites or from samples collected prior to impacts or management actions at a location. In this report, the following metrics were calculated for each sample.

Taxa richness - Richness is a component and estimate of community structure and stream health based on the number of distinct taxa. Taxa richness normally decreases with decreasing water quality. In some situations organic enrichment can cause an increase in the number of pollution tolerant taxa. Taxa richness was calculated for operational taxonomic units (OTUs) and the number of unique genera, and families. The values for operational taxonomic units may be overestimates of the true taxa richness at a site if individuals were the same taxon as those identified to lower taxonomic levels or they may be underestimates of the true taxa richness if multiple taxa were present within a larger taxonomic grouping but were not identified. All individuals within all samples were generally identified similarly, so that comparisons in operational taxonomic richness among samples within this dataset are appropriate, but comparisons to other data sets may not. Comparisons to other datasets should be made at the genera or family level.

Abundance - The abundance, density, or number of aquatic macroinvertebrates per unit area is an indicator of habitat availability and fish food abundance. Abundance may be reduced or increased depending on the type of impact or pollutant. Increased organic enrichment typically causes large increases in abundance of pollution tolerant taxa. High flows, increases in fine sediment, or the presence of toxic substances normally cause a decrease in invertebrate abundance. Invertebrate abundance is presented as the number of individuals per square meter for quantitative samples and the number of individuals collected in each sample for qualitative samples.

EPT - A summary of the taxonomic richness and abundance within the insect Orders Ephemeroptera, Plecoptera, and Trichoptera (EPT). These orders are commonly considered sensitive to pollution (Karr and Chu 1998).

Percent contribution of the dominant family or taxon - An assemblage largely dominated (>50%) by a single taxon or several taxa from the same family suggests environmental stress. Habitat conditions likely limit the number of taxa that can occur at the site.

Shannon diversity index - Ecological diversity is a measure of community structure defined by the relationship between the number of distinct taxa and their relative abundances. The Shannon diversity index was calculated for each sampling location for which there were a sufficient number of individuals and taxa collected to perform the calculations. The calculations were made following Ludwig and Reynolds (1988, equation 8.9, page 92).

Evenness - Evenness is a measure of the distribution of taxa within a community. The evenness index used in this report was calculated following Ludwig and Reynolds (1988, equation 8.15, page 94). Value ranges from 0-1 and approach zero as a single taxa becomes more dominant.

Clinger taxa - The number of clinger taxa have been found by Karr and Chu (1998) to respond negatively to human disturbance. Clinger taxa were determined using information in Merritt et al. (2008). These taxa typically cling to the tops of rocks and are thought to be reduced by sedimentation or abundant algal growths.

Long-live taxa - The number of long-lived taxa was calculated the number of taxa collected that typically have 2-3 year life cycles. Disturbances and water quality and habitat impairment typically reduces the number of long-lived taxa Karr and Chu (1998). Life-cycle length determinations were based on information in Merritt et al. (2008).

Biotic indices - Biotic indices use the indicator taxa concept. Taxa are assigned water quality tolerance values based on their tolerance to pollution. Scores are typically weighted by taxa relative abundance. In the United States the most

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commonly used biotic index is the Hilsenhoff Biotic Index (Hilsenhoff 1987, Hilsenhoff 1988). The USFS and BLM throughout the western United States have also frequently used the USFS Community Tolerance Quotient.

Hilsenhoff biotic index - The Hilsenhoff Biotic Index (HBI) summarizes the overall pollution tolerances of the taxa collected. This index has been used to detect nutrient enrichment, high sediment loads, low dissolved oxygen, and thermal impacts. It is best at detecting organic pollution. Families were assigned an index value from 0- taxa normally found only in high quality unpolluted water, to 10- taxa found only in severely polluted waters. Family level values were taken from Hilsenhoff (1987, 1988) and a family level HBI was calculated for each sampling location for which there were a sufficient number of individuals and taxa collected to perform the calculations. Sampling locations with HBI values of 0-2 are considered clean, 2-4 slightly enriched, 4-7 enriched, and 7-10 polluted. Rather than using mean HBI values for a sample, taxon HBI values can also be used to determine the number of pollution intolerant and tolerant taxa occurring at a site. In this report, taxa with HBI values ≤ 2 were considered intolerant clean water taxa and taxa with HBI values ≥ 8 were considered pollution tolerant taxa. The number of tolerant and intolerant taxa and the abundances of tolerant and intolerant taxa were calculated for each sampling location.

USFS community tolerant quotient - Taxa are assigned a tolerant quotient (TQ) from 2 - taxa found only in high quality unpolluted water, to 108 - taxa found in severely polluted waters. TQ values were developed by Winget and Mangum (1979). The dominance weighted community tolerance quotient (CTQd) was calculated. Values can vary from about 20 to 100, in general the lower the value the better the water quality.

Functional feeding group measures - A common classification scheme for aquatic macroinvertebrates is to categorize them by feeding acquisition mechanisms. Categories are based on food particle size and food location, e.g., suspended in the water column, deposited in sediments, leaf litter, or live prey. This classification system reflects the major source of the resource, either within the stream itself or from riparian or upland areas and the primary location, either erosional or depositional habitats. The number of taxa and individuals of the following feeding groups were calculated for each sampling location. Functional feeding group designations were from Merritt et al. (2008).

Shredders - Shredders use both living vascular hydrophytes and decomposing vascular plant tissue - coarse particulate organic matter. Shredders are sensitive to changes in riparian vegetation. Shredders can be good indicators of toxicants that adhere to organic matter.

Scrapers - Scrapers feed on periphyton - attached algae and associated material. Scraper populations increase with increasing abundance of diatoms and can decrease as filamentous algae, mosses, and vascular plants increase, often in response to increases in nitrogen and phosphorus. Scrapers decrease in relative abundance in response to sedimentation and higher levels of organic pollution or nutrient enrichment.

Collector-filterers - Collector-filterers feed on suspended fine particulate organic matter. Collector-filterers are sensitive to toxicants in the water column and to pollutants that adhere to organic matter.

Collector-gatherers - Collector-gatherers feed on deposited fine particulate organic matter. Collector-gatherers are sensitive to deposited toxicants.

Predators - Predators feed on living animal tissue. Predators typically make up about 25% of the assemblage in stream environments and 50% of the assemblage in still-water environments.

Unknown feeding group - This category includes taxa that are highly variable, parasites, and those that for which the primary feeding mode is currently unknown.

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Results

Abundance data and taxa richness are reported as the estimated number of individuals per square meter for quantitative samples and the number per sample for qualitative samples. NC = Not calculated. * = unable to calculate. EPT = totals for the insect orders, Ephemeroptera, Plecoptera, Trichoptera. QL = qualitative sample.

Sample	Sampling date	Station	Total abundance	EPT abundance	Dominant family	% contribution dominant family
146823	07/14/2011	CRANDUP-01	622	435	Baetidae	26.53
146824	07/14/2011	CRANDUP-01	741	619	Heptageniidae	34.82
146825	07/14/2011	CRANDMD-02	541	73	Chironomidae	64.14
146826	07/14/2011	CRANDMD-02	614	291	Baetidae	25.57
146827	07/14/2011	CRANDLWR-03	207	97	Chironomidae	26.09
146828	07/14/2011	CRANDLWR-03	871	348	Chironomidae	37.43
Mean			599.3	310.5		35.76

Diversity indices

Sample	Sampling Date	Station	Total taxa richness	Total genera richness	Total family richness	EPT taxa richness	Shannon diversity index	Evenness
146823	07/14/2011	CRANDUP-01	35	21	20	15	2.700	0.760
146824	07/14/2011	CRANDUP-01	26	19	17	11	2.030	0.620
146825	07/14/2011	CRANDMD-02	22	16	17	8	1.870	0.600
146826	07/14/2011	CRANDMD-02	33	21	22	13	2.550	0.730
146827	07/14/2011	CRANDLWR-03	18	9	13	8	2.450	0.850
146828	07/14/2011	CRANDLWR-03	28	16	21	13	2.140	0.640
Mean			27.0	17.0	18.3	11.3	2.290	0.700

Genera richness by major taxonomic group.

Sample	Sampling Date	Station	Coleoptera	Diptera	Ephemerotpera	Heteroptera	Megaloptera	Odonata	Plecoptera	Trichoptera	Annelida	Custacea	Mollusca
146823	07/14/2011	CRANDUP-01	1	13	6	0	0	0	5	4	1	0	1
146824	07/14/2011	CRANDUP-01	1	11	5	0	0	0	3	3	0	0	1
146825	07/14/2011	CRANDMD-02	3	9	5	0	0	0	2	1	0	0	1
146826	07/14/2011	CRANDMD-02	1	13	6	0	0	0	3	4	1	0	1
146827	07/14/2011	CRANDLWR-0	0	4	4	0	0	0	1	3	1	0	1
146828	07/14/2011	CRANDLWR-0	0	9	5	0	0	0	4	4	1	0	0
Mean			**1.0**	**9.8**	**5.2**	**0.0**	**0.0**	0.0	**3.0**	**3.2**	0.7	**0.0**	**0.8**

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Total abundance by major taxonomic group.

Sample	Sampling Date	Station	Coleoptera	Diptera	Ephemerotpera	Heteroptera	Megaloptera	Odonata	Plecoptera	Trichoptera	Annelida	Custacea	Mollusca
146823	07/14/2011	CRANDUP-01	3	138	370	0	0	0	41	24	16	0	5
146824	07/14/2011	CRANDUP-01	3	98	531	0	0	0	47	40	0	0	4
146825	07/14/2011	CRANDMD-02	57	401	54	0	0	0	16	3	0	0	5
146826	07/14/2011	CRANDMD-02	40	215	250	0	0	0	24	16	13	0	4
146827	07/14/2011	CRANDLWR-03	0	70	78	0	0	0	5	13	5	0	5
146828	07/14/2011	CRANDLWR-03	0	422	305	0	0	0	27	16	20	0	0
Mean			17.2	224.0	264.7	0.0	0.0	0.0	26.7	18.7	9.0	0.0	3.8

Biotic Indices

Sample	Sampling date	Station	Hilsenhoff Biotic Index		USFS Community CTQd
			Index	Indication	
146823	07/14/2011	CRANDUP-01	3.53	Possible slight organic pollution	69
146824	07/14/2011	CRANDUP-01	3.65	Possible slight organic pollution	63
146825	07/14/2011	CRANDMD-02	5.01	Some organic pollution	84
146826	07/14/2011	CRANDMD-02	3.55	Possible slight organic pollution	75
146827	07/14/2011	CRANDLWR-03	3.74	Possible slight organic pollution	83
146828	07/14/2011	CRANDLWR-03	4.35	Possible slight organic pollution	77
Mean			3.97		75.2

Taxa richness and relative abundance values with respect to tolerance or intolerance to pollution were based on the Hilsenhoff Biotic Index (HBI). Intolerant taxa have HBI score <= 2. Tolerant taxa have a HBI score >= 8. Data are presented as estimated count per square meter for quantitative samples and total number per sample for qualitative samples.

Sample	Sampling date	Station	Intolerant taxa				Tolerant Taxa			
			Richness		Abundance		Richness		Abundance	
146823	07/14/2011	CRANDUP-01	9	(26)	100	(16)	0	(0)	0	(0)
146824	07/14/2011	CRANDUP-01	7	(27)	120	(16)	0	(0)	0	(0)
146825	07/14/2011	CRANDMD-02	5	(23)	24	(4)	0	(0)	0	(0)
146826	07/14/2011	CRANDMD-02	8	(24)	82	(13)	1	(3)	1	(0)
146827	07/14/2011	CRANDLWR-0	2	(11)	11	(5)	0	(0)	0	(0)
146828	07/14/2011	CRANDLWR-0	6	(21)	40	(5)	0	(0)	0	(0)
Mean			6.2	(22)	62.8	(10)	0.2	(1)	0.2	(0)

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Functional feeding groups

Taxa richness by functional feeding group. The percent of the total is shown in parentheses.

Sample	Sampling date	Station	Shredders		Scrapers		Collector-filterers		Collector-gatherers		Predators		Unknown	
146823	07/14/2011	CRANDUP-01	4	(11)	4	(11)	3	(9)	9	(26)	12	(34)	3	(9)
146824	07/14/2011	CRANDUP-01	1	(4)	3	(12)	4	(15)	6	(23)	11	(42)	1	(4)
146825	07/14/2011	CRANDMD-02	2	(9)	2	(9)	2	(9)	6	(27)	8	(36)	2	(9)
146826	07/14/2011	CRANDMD-02	4	(12)	3	(9)	3	(9)	9	(27)	12	(36)	2	(6)
146827	07/14/2011	CRANDLWR-0	1	(6)	1	(6)	2	(11)	5	(28)	9	(50)	0	(0)
146828	07/14/2011	CRANDLWR-0	2	(7)	2	(7)	2	(7)	7	(25)	14	(50)	0	(0)
Mean			2.3	(8)	2.5	(9)	2.7	(10)	7.0	(26)	11.0	(42)	1.3	(5)

Invertebrate abundance by functional feed group. The percent of the total is shown in parentheses.

Sample	Sampling date	Station	Shredders		Scrapers		Collector-filterers		Collector-gatherers		Predators		Unknown	
146823	07/14/2011	CRANDUP-01	16	(3)	192	(31)	14	(2)	289	(46)	100	(16)	11	(2)
146824	07/14/2011	CRANDUP-01	11	(1)	283	(38)	19	(3)	312	(42)	114	(15)	3	(0)
146825	07/14/2011	CRANDMD-02	5	(1)	40	(7)	8	(1)	355	(66)	78	(14)	54	(10)
146826	07/14/2011	CRANDMD-02	8	(1)	83	(14)	7	(1)	324	(53)	148	(24)	43	(7)
146827	07/14/2011	CRANDLWR-0	5	(2)	11	(5)	8	(4)	126	(61)	57	(28)	0	(0)
146828	07/14/2011	CRANDLWR-0	11	(1)	7	(1)	3	(0)	651	(75)	198	(23)	0	(0)
Mean			9.3	(2)	102.7	(16)	9.8	(2)	342.8	(57)	115.8	(20)	18.5	(3)

The 10 metrics thought to be most responsive to human induced disturbance (Karr and Chu 1998).

Sample	Sampling Date	Station	Total taxa	Epheme-roptera taxa	Plecoptera taxa	Trichoptera taxa	Long-lived taxa	Intolerant taxa	Clinger taxa	% tolerant indi-viduals	% contribution dominant taxon	% predators
146823	07/14/2011	CRANDUP-01	35	6	3	4	2	9	11	0.00	23.95	16.08
146824	07/14/2011	CRANDUP-01	26	5	2	3	2	7	11	0.00	33.47	15.38
146825	07/14/2011	CRANDMD-02	22	4	2	1	3	5	7	0.00	53.79	14.42
146826	07/14/2011	CRANDMD-02	33	5	3	3	2	8	9	0.16	25.57	24.10
146827	07/14/2011	CRANDLWR-03	18	2	0	2	0	2	4	0.00	26.09	27.54
146828	07/14/2011	CRANDLWR-03	28	3	1	3	1	6	7	0.00	36.17	22.73
Mean			27.0	4.2	1.8	2.7	1.7	6.2	8.2	0.03	33.17	20.04

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Taxonomic list and counts for 6 samples collected on July 14, 2011. Count is the total number of individuals identified and retained. Samples heading refers to the number of samples containing that taxon.

Order	Family	Subfamily/Genus/Species	Samples	Count
Phylum: Annelida				
Class: Clitellata	SubClass: Oligochaeta			
			4	33
Phylum: Arthropoda				
Class: Arachnida	SubClass: Acari			
Trombidiformes			4	11
Trombidiformes	Arrenuridae	Arrenurus	3	4
Trombidiformes	Hydryphantidae	Protzia	1	3
Trombidiformes	Hydryphantidae	Wandesia	1	1
Trombidiformes	Lebertiidae	Lebertia	5	79
Trombidiformes	Sperchonidae	Sperchon	3	29
Class: Insecta	SubClass: Pterygota			
Coleoptera	Dytiscidae		1	1
Coleoptera	Elmidae	Narpus concolor	4	51
Coleoptera	Elmidae	Optioservus quadrimaculatus	1	2
Diptera			1	2
Diptera	Ceratopogonidae		3	4
Diptera	Ceratopogonidae	Ceratopogoninae Sphaeromiini Probezzia	4	27
Diptera	Chironomidae		4	20
Diptera	Chironomidae	Chironominae	4	30
Diptera	Chironomidae	Orthocladiinae	6	487
Diptera	Chironomidae	Tanypodinae	4	14
Diptera	Empididae		2	3
Diptera	Empididae	Hemerodromiinae Hemerodromiini	2	14
Diptera	Empididae	Hemerodromiinae Hemerodromiini Chelifera	5	57
Diptera	Empididae	Neoplasta	3	28
Diptera	Empididae	Wiedemannia	1	1
Diptera	Psychodidae	Pericoma	1	1
Diptera	Simuliidae		1	2
Diptera	Simuliidae	Simuliinae Prosimuliini Helodon	3	8
Diptera	Simuliidae	Simuliinae Simuliini Simulium	1	3
Diptera	Stratiomyidae	Caloparyphus	2	32
Diptera	Tabanidae	Tabanus	1	17
Diptera	Tipulidae	Dicranota	3	6
Diptera	Tipulidae	Limoniinae Antocha monticola	3	7
Diptera	Tipulidae	Limoniinae Eriopterini Ormosia	1	4
Diptera	Tipulidae	Limoniinae Hexatomini Limnophila	1	2
Diptera	Tipulidae	Tipulinae Tipula	3	4
Ephemeroptera	Ameletidae	Ameletus	4	7
Ephemeroptera	Baetidae		2	8
Ephemeroptera	Baetidae	Baetis	6	501
Ephemeroptera	Baetidae	Diphetor hageni	2	7
Ephemeroptera	Ephemerellidae	Drunella	4	69
Ephemeroptera	Heptageniidae		2	8
Ephemeroptera	Heptageniidae	Cinygmula	4	281
Ephemeroptera	Heptageniidae	Epeorus	5	111
Ephemeroptera	Leptophlebiidae		2	2

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Hemiptera	Gerridae		1	1
Plecoptera	Chloroperlidae	Chloroperlinae	1	1
Plecoptera	Nemouridae	Amphinemurinae	1	7
Plecoptera	Nemouridae	Zapada	4	14
Plecoptera	Nemouridae	Zapada cinctipes	2	2
Plecoptera	Perlodidae		4	13
Plecoptera	Perlodidae	Isoperlinae Isoperla	5	58
Plecoptera	Taeniopterygidae		1	1
Trichoptera	Brachycentridae	Brachycentrus americanus	1	1
Trichoptera	Hydropsychidae	Arctopsychinae Parapsyche	1	1
Trichoptera	Hydropsychidae	Arctopsychinae Parapsyche elsis	2	3
Trichoptera	Hydropsychidae	Hydropsychinae Hydropsyche	2	2
Trichoptera	Limnephilidae		3	4
Trichoptera	Rhyacophilidae	Rhyacophila	3	19
Trichoptera	Rhyacophilidae	Rhyacophila angelita group	2	11
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	4	26
Trichoptera	Uenoidae	Neothremma	1	2
Phylum: Mollusca				
Class: Bivalvia	SubClass: Heterodonta			
Veneroida	Pisidiidae	Pisidiinae Pisidium	5	12
Phylum: Nemata				
Class:	SubClass:			
			2	3

Total: OTU Taxa: **61** Genera: **39** Families: **31** Individuals: **2162**

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Taxa Lists for Individual Samples

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Taxonomic list and densities of aquatic invertebrates identified and retained from a sample collected July 14, 2011 at station CRANDUP-01, Crandall Creek, Upstream, Emery county, Utah. The sample was collected from reachwide habitat using a Kick Net. The total area sampled was 0.370 square meters. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 230 individuals were removed, identified and retained. The sample identification number is 146823. OTU=operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D- damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/Species	Life Stage	Density	Notes
Phylum: Annelida					
Class: Clitellata		SubClass: Oligochaeta			
			adult	16.22	
Phylum: Arthropoda					
Class: Arachnida		SubClass: Acari			
Trombidiformes			adult	8.11	U
Trombidiformes	Lebertiidae	Lebertia	adult	8.11	
Trombidiformes	Sperchonidae	Sperchon	adult	5.41	
Class: Insecta		SubClass: Pterygota			
Coleoptera	Elmidae	Narpus concolor	larvae	2.70	
Diptera			larvae	5.41	U
Diptera	Ceratopogonidae		pupae	2.70	
Diptera	Ceratopogonidae	Ceratopogoninae Sphaeromiini Probezzia	larvae	13.51	
Diptera	Chironomidae		pupae	13.51	
Diptera	Chironomidae	Chironominae	larvae	37.84	
Diptera	Chironomidae	Orthocladiinae	larvae	24.32	
Diptera	Chironomidae	Tanypodinae	larvae	2.70	
Diptera	Empididae	Hemerodromiinae Hemerodromiini Chelifera	larvae	13.51	
Diptera	Empididae	Wiedemannia	larvae	2.70	
Diptera	Simuliidae		pupae	5.41	U
Diptera	Tipulidae	Limoniinae Antocha monticola	larvae	2.70	
Diptera	Tipulidae	Limoniinae Eriopterini Ormosia	larvae	10.81	
Diptera	Tipulidae	Tipulinae Tipula	larvae	2.70	
Ephemeroptera	Ameletidae	Ameletus	larvae	8.11	
Ephemeroptera	Baetidae	Baetis	larvae	148.65	
Ephemeroptera	Baetidae	Diphetor hageni	larvae	16.22	
Ephemeroptera	Ephemerellidae	Drunella	larvae	35.14	
Ephemeroptera	Heptageniidae	Cinygmula	larvae	143.24	
Ephemeroptera	Heptageniidae	Epeorus	larvae	18.92	
Plecoptera	Nemouridae	Zapada	larvae	8.11	U
Plecoptera	Nemouridae	Zapada cinctipes	larvae	2.70	
Plecoptera	Perlodidae		larvae	8.11	I
Plecoptera	Perlodidae	Isoperlinae Isoperla	larvae	18.92	
Plecoptera	Taeniopterygidae		larvae	2.70	I
Trichoptera	Hydropsychidae	Arctopsychinae Parapsyche	larvae	2.70	I
Trichoptera	Rhyacophilidae	Rhyacophila	larvae	8.11	I
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	larvae	8.11	
Trichoptera	Uenoidae	Neothremma	larvae	5.41	I
Phylum: Mollusca					
Class: Bivalvia		SubClass: Heterodonta			
Veneroida	Pisidiidae	Pisidiinae Pisidium	adult	5.41	
Phylum: Nemata					
Class:		SubClass:			
			adult	2.70	

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Total:	OTU Taxa:	**35**	Genera:	**23**	Families:	**20**	621.62	

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Taxonomic list and densities of aquatic invertebrates identified and retained from a sample collected July 14, 2011 at station CRANDUP-01, Crandall Creek, Upstream, Emery county, Utah. The sample was collected from targeted riffle habitat using a Kick Net. The total area sampled was 0.743 square meters. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 551 individuals were removed, identified and retained. The sample identification number is 146824. OTU=operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D- damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/Species	Life Stage	Density	Notes
Phylum: Arthropoda					
Class: Arachnida		SubClass: Acari			
Trombidiformes	Arrenuridae	Arrenurus	adult	2.69	
Trombidiformes	Lebertiidae	Lebertia	adult	14.80	
Class: Insecta		SubClass: Pterygota			
Coleoptera	Elmidae	Narpus concolor	larvae	2.69	
Diptera	Ceratopogonidae		pupae	1.35	
Diptera	Ceratopogonidae	Ceratopogoninae Sphaeromiini Probezzia	larvae	2.69	
Diptera	Chironomidae		pupae	8.07	
Diptera	Chironomidae	Chironominae	larvae	4.04	
Diptera	Chironomidae	Orthocladiinae	larvae	49.78	
Diptera	Chironomidae	Tanypodinae	larvae	2.69	
Diptera	Empididae	Hemerodromiinae Hemerodromiini Chelifera	larvae	12.11	
Diptera	Simuliidae	Simuliinae Prosimuliini Helodon	larvae	8.07	
Diptera	Simuliidae	Simuliinae Simuliini Simulium	larvae	4.04	
Diptera	Tipulidae	Dicranota	larvae	4.04	
Diptera	Tipulidae	Limoniinae Antocha monticola	larvae	1.35	
Ephemeroptera	Ameletidae	Ameletus	larvae	2.69	
Ephemeroptera	Baetidae	Baetis	larvae	238.15	
Ephemeroptera	Ephemerellidae	Drunella	larvae	32.29	
Ephemeroptera	Heptageniidae	Cinygmula	larvae	247.57	
Ephemeroptera	Heptageniidae	Epeorus	larvae	10.76	
Plecoptera	Nemouridae	Zapada	larvae	10.76	U
Plecoptera	Perlodidae		larvae	6.73	I
Plecoptera	Perlodidae	Isoperlinae Isoperla	larvae	29.60	
Trichoptera	Hydropsychidae	Arctopsychinae Parapsyche elsis	larvae	2.69	
Trichoptera	Rhyacophilidae	Rhyacophila	larvae	14.80	I
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	larvae	22.87	
Phylum: Mollusca					
Class: Bivalvia		SubClass: Heterodonta			
Veneroida	Pisidiidae	Pisidiinae Pisidium	adult	4.04	
Total: OTU Taxa: **26**	Genera: **20**	Families: **17**		741.37	

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Taxonomic list and densities of aquatic invertebrates identified and retained from a sample collected July 14, 2011 at station CRANDMD-02, Crandall Creek, Middle, Emery county, Utah. The sample was collected from reachwide habitat using a Kick Net. The total area sampled was 0.372 square meters. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 201 individuals were removed, identified and retained. The sample identification number is 146825. OTU=operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D- damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/Species	Life Stage	Density	Notes
Phylum: Arthropoda					
Class: Arachnida		SubClass: Acari			
Trombidiformes			adult	5.38	U
Class: Insecta		SubClass: Pterygota			
Coleoptera	Dytiscidae		larvae	2.69	I
Coleoptera	Elmidae	Narpus concolor	larvae	48.44	
Coleoptera	Elmidae	Optioservus quadrimaculatus	adult	5.38	
Diptera	Ceratopogonidae	Ceratopogoninae Sphaeromiini Probezzia	larvae	10.76	
Diptera	Chironomidae	Chironominae	larvae	29.60	
Diptera	Chironomidae	Orthocladiinae	larvae	290.63	
Diptera	Chironomidae	Tanypodinae	larvae	26.91	
Diptera	Empididae	Hemerodromiinae Hemerodromiini Chelifera	larvae	13.45	
Diptera	Simuliidae	Simuliinae Prosimuliini Helodon	pupae	2.69	
Diptera	Stratiomyidae	Caloparyphus	larvae	21.53	
Diptera	Tipulidae	Dicranota	larvae	2.69	
Diptera	Tipulidae	Tipulinae Tipula	larvae	2.69	
Ephemeroptera	Baetidae	Baetis	larvae	8.07	
Ephemeroptera	Baetidae	Diphetor hageni	larvae	2.69	
Ephemeroptera	Ephemerellidae	Drunella	larvae	2.69	
Ephemeroptera	Heptageniidae	Cinygmula	larvae	37.67	
Ephemeroptera	Leptophlebiidae		larvae	2.69	D
Plecoptera	Nemouridae	Zapada	larvae	2.69	U
Plecoptera	Perlodidae	Isoperlinae Isoperla	larvae	13.45	
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	larvae	2.69	
Phylum: Mollusca					
Class: Bivalvia		SubClass: Heterodonta			
Veneroida	Pisidiidae	Pisidiinae Pisidium	adult	5.38	
Total: OTU Taxa: **22**	Genera: **16**	Families: **17**		540.89	

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Taxonomic list and densities of aquatic invertebrates identified and retained from a sample collected July 14, 2011 at station CRANDMD-02, Crandall Creek, Middle, Emery county, Utah. The sample was collected from targeted riffle habitat using a Kick Net. The total area sampled was 0.743 square meters. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 456 individuals were removed, identified and retained. The sample identification number is 146826. OTU=operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D- damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/Species	Life Stage	Density	Notes
Phylum: Annelida					
Class: Clitellata	SubClass: Oligochaeta				
			adult	13.45	
Phylum: Arthropoda					
Class: Arachnida	SubClass: Acari				
Trombidiformes			adult	5.38	U
Trombidiformes	Hydryphantidae	Protzia	adult	4.04	
Trombidiformes	Lebertiidae	Lebertia	adult	37.67	
Class: Insecta	SubClass: Pterygota				
Coleoptera	Elmidae	Narpus concolor	larvae	40.36	
Diptera	Ceratopogonidae	Ceratopogoninae Sphaeromiini Probezzia	larvae	21.53	
Diptera	Chironomidae		pupae	1.35	
Diptera	Chironomidae	Chironominae	larvae	2.69	
Diptera	Chironomidae	Orthocladiinae	larvae	106.29	
Diptera	Chironomidae	Tanypodinae	larvae	1.35	
Diptera	Empididae		pupae	2.69	
Diptera	Empididae	Hemerodromiinae Hemerodromiini Chelifera	larvae	37.67	
Diptera	Empididae	Neoplasta	larvae	1.35	
Diptera	Psychodidae	Pericoma	larvae	1.35	
Diptera	Simuliidae	Simuliinae Prosimuliini Helodon	pupae	1.35	
Diptera	Stratiomyidae	Caloparyphus	larvae	32.29	
Diptera	Tipulidae	Dicranota	larvae	2.69	
Diptera	Tipulidae	Tipulinae Tipula	larvae	2.69	
Ephemeroptera	Ameletidae	Ameletus	larvae	1.35	
Ephemeroptera	Baetidae	Baetis	larvae	157.42	
Ephemeroptera	Ephemerellidae	Drunella	larvae	41.71	
Ephemeroptera	Heptageniidae	Cinygmula	larvae	40.36	
Ephemeroptera	Heptageniidae	Epeorus	larvae	8.07	
Ephemeroptera	Leptophlebiidae		larvae	1.35	D
Plecoptera	Nemouridae	Zapada	larvae	2.69	U
Plecoptera	Nemouridae	Zapada cinctipes	larvae	1.35	
Plecoptera	Perlodidae	Isoperlinae Isoperla	larvae	20.18	
Trichoptera	Hydropsychidae	Arctopsychinae Parapsyche elsis	larvae	1.35	
Trichoptera	Limnephilidae		larvae	1.35	I
Trichoptera	Rhyacophilidae	Rhyacophila	larvae	6.73	I,U
Trichoptera	Rhyacophilidae	Rhyacophila vofixa group	larvae	6.73	
Phylum: Mollusca					
Class: Bivalvia	SubClass: Heterodonta				
Veneroida	Pisidiidae	Pisidiinae Pisidium	adult	4.04	
Phylum: Nemata					
Class:	SubClass:				
			adult	2.69	
Total: OTU Taxa: **33**	Genera: **23**	Families: **22**		613.55	

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Taxonomic list and densities of aquatic invertebrates identified and retained from a sample collected July 14, 2011 at station CRANDLWR-03, Crandall Creek, Lower, Emery county, Utah. The sample was collected from reachwide habitat using a Kick Net. The total area sampled was 0.372 square meters. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 77 individuals were removed, identified and retained. The sample identification number is 146827. OTU=operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D- damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/Species	Life Stage	Density	Notes
Phylum: Annelida					
Class: Clitellata		SubClass: Oligochaeta			
			adult	5.38	
Phylum: Arthropoda					
Class: Arachnida		SubClass: Acari			
Trombidiformes			adult	5.38	D,U
Trombidiformes	Arrenuridae	Arrenurus	adult	2.69	
Trombidiformes	Lebertiidae	Lebertia	adult	10.76	
Trombidiformes	Sperchonidae	Sperchon	adult	10.76	
Class: Insecta		SubClass: Pterygota			
Diptera	Chironomidae	Orthocladiinae	larvae	53.82	
Diptera	Empididae		pupae	2.69	
Diptera	Empididae	Hemerodromiinae Hemerodromiini	larvae	5.38	I
Diptera	Empididae	Neoplasta	larvae	8.07	
Ephemeroptera	Baetidae		larvae	10.76	
Ephemeroptera	Baetidae	Baetis	larvae	37.67	
Ephemeroptera	Heptageniidae		larvae	10.76	I,D
Ephemeroptera	Heptageniidae	Epeorus	larvae	18.84	
Plecoptera	Perlodidae		larvae	5.38	D
Trichoptera	Hydropsychidae	Hydropsychinae Hydropsyche	larvae	2.69	
Trichoptera	Limnephilidae		larvae	5.38	D
Trichoptera	Rhyacophilidae	Rhyacophila angelita group	larvae	5.38	
Phylum: Mollusca					
Class: Bivalvia		SubClass: Heterodonta			
Veneroida	Pisidiidae	Pisidiinae Pisidium	adult	5.38	
Total: OTU Taxa: **18**	Genera: **9**	Families: **13**		207.21	

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Taxonomic list and densities of aquatic invertebrates identified and retained from a sample collected July 14, 2011 at station CRANDLWR-03, Crandall Creek, Lower, Emery county, Utah. The sample was collected from targeted riffle habitat using a Kick Net. The total area sampled was 0.743 square meters. The percentage of the sample that was identified and retained was 100% of the collected sample. A total of 647 individuals were removed, identified and retained. The sample identification number is 146828. OTU=operational taxonomic unit. Notes - identification to genus or species was not supported because: I - immature organisms, D- damaged organisms, M - poor slide mount, G - gender, U - indistinct characters or distribution, R - retained in our reference collection.

Order	Family	Subfamily/Genus/Species	Life Stage	Density	Notes
Phylum: Annelida					
Class: Clitellata	SubClass: Oligochaeta				
			adult	20.18	
Phylum: Arthropoda					
Class: Arachnida	SubClass: Acari				
Trombidiformes	Arrenuridae	Arrenurus	adult	1.35	
Trombidiformes	Hydryphantidae	Wandesia	adult	1.35	
Trombidiformes	Lebertiidae	Lebertia	adult	44.40	
Trombidiformes	Sperchonidae	Sperchon	adult	30.95	
Class: Insecta	SubClass: Pterygota				
Diptera	Ceratopogonidae		pupae	2.69	
Diptera	Chironomidae		pupae	10.76	
Diptera	Chironomidae	Orthocladiinae	larvae	314.85	
Diptera	Empididae	Hemerodromiinae Hemerodromiini	larvae	16.15	
Diptera	Empididae	Hemerodromiinae Hemerodromiini Chelifera	larvae	13.45	
Diptera	Empididae	Neoplasta	larvae	32.29	
Diptera	Tabanidae	Tabanus	larvae	22.87	
Diptera	Tipulidae	Limoniinae Antocha monticola	larvae	3.36	
Diptera	Tipulidae	Limoniinae Hexatomini Limnophila	larvae	2.69	
Ephemeroptera	Ameletidae	Ameletus	larvae	1.35	
Ephemeroptera	Baetidae		larvae	5.38	D
Ephemeroptera	Baetidae	Baetis	larvae	181.64	
Ephemeroptera	Heptageniidae		larvae	5.38	D
Ephemeroptera	Heptageniidae	Epeorus	larvae	111.68	
Hemiptera	Gerridae		larvae	1.35	I
Plecoptera	Chloroperlidae	Chloroperlinae	larvae	1.35	D
Plecoptera	Nemouridae	Amphinemurinae	larvae	9.42	
Plecoptera	Perlodidae		larvae	4.04	D
Plecoptera	Perlodidae	Isoperlinae Isoperla	larvae	12.11	
Trichoptera	Brachycentridae	Brachycentrus americanus	larvae	1.35	
Trichoptera	Hydropsychidae	Hydropsychinae Hydropsyche	larvae	1.35	
Trichoptera	Limnephilidae		larvae	1.35	I
Trichoptera	Rhyacophilidae	Rhyacophila angelita group	larvae	12.11	
Total: OTU Taxa: **28**	Genera: **16**	Families: **21**		870.54	

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APPENDIX 2
MACROINVERTEBRATE METRICS

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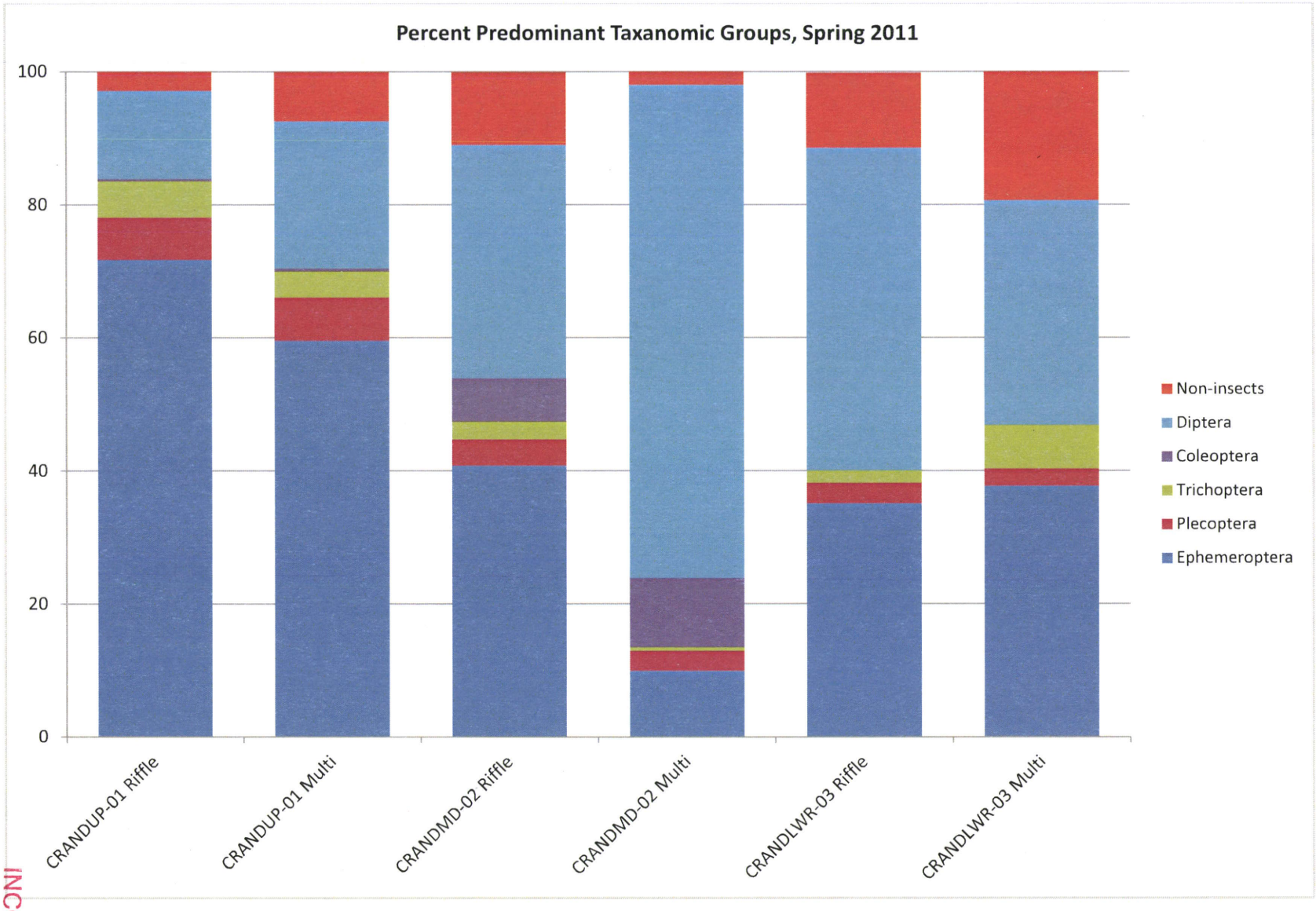

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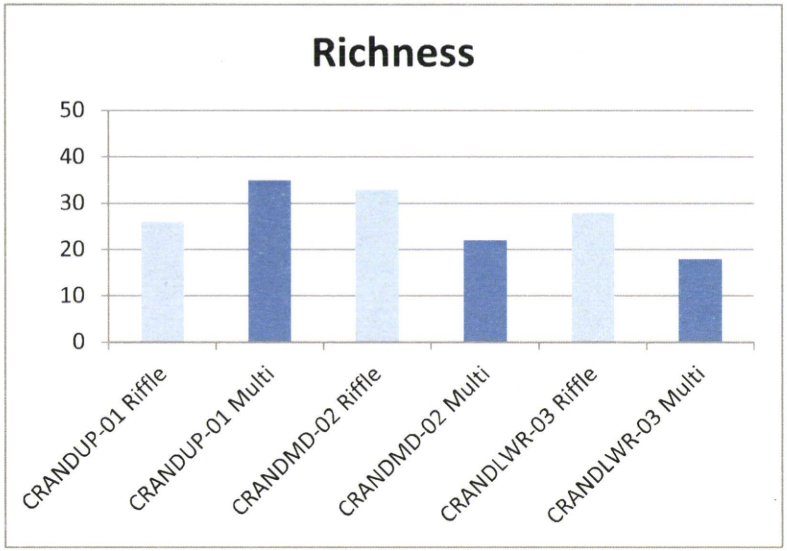

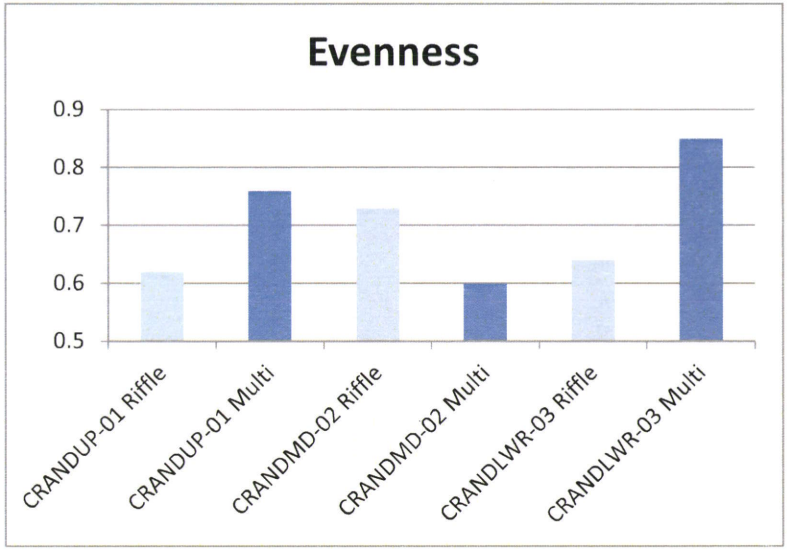

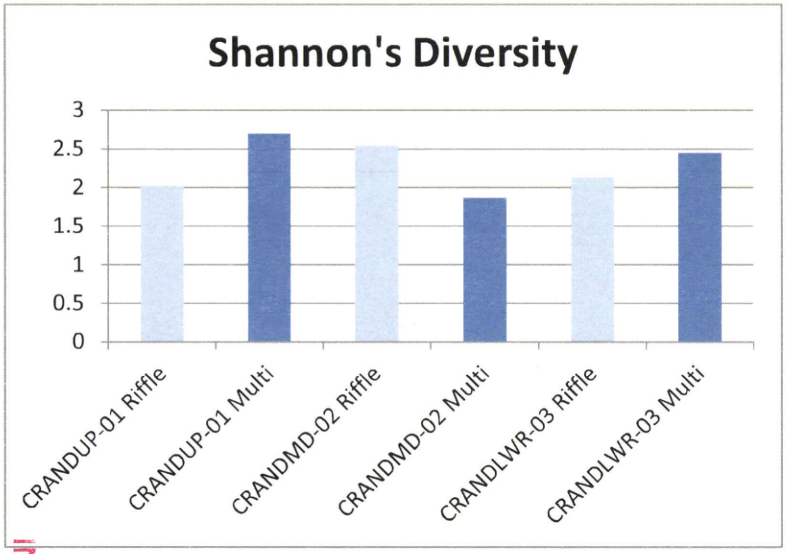

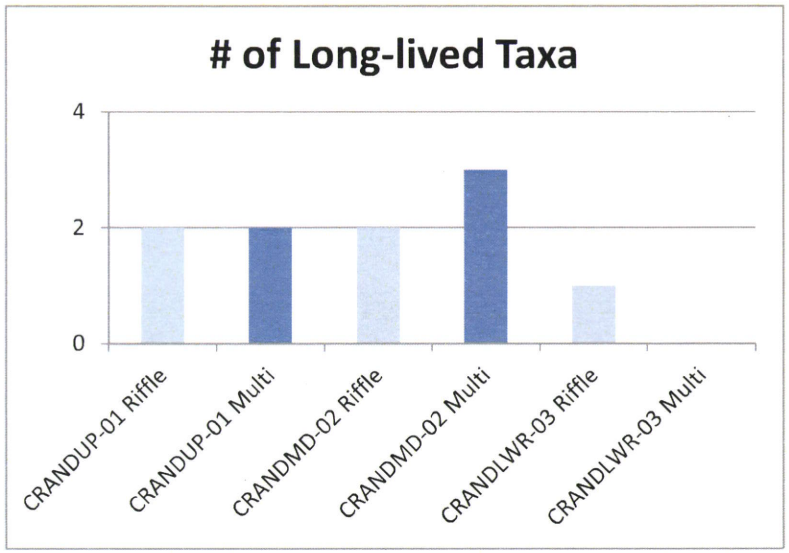

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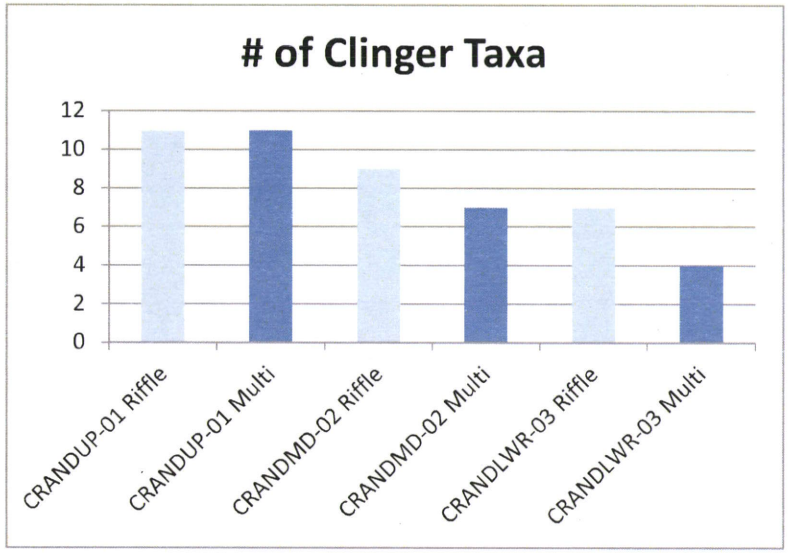

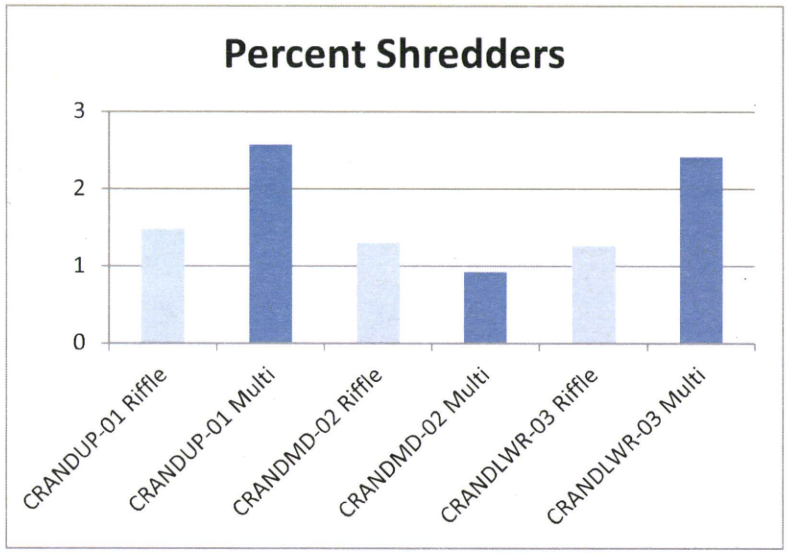

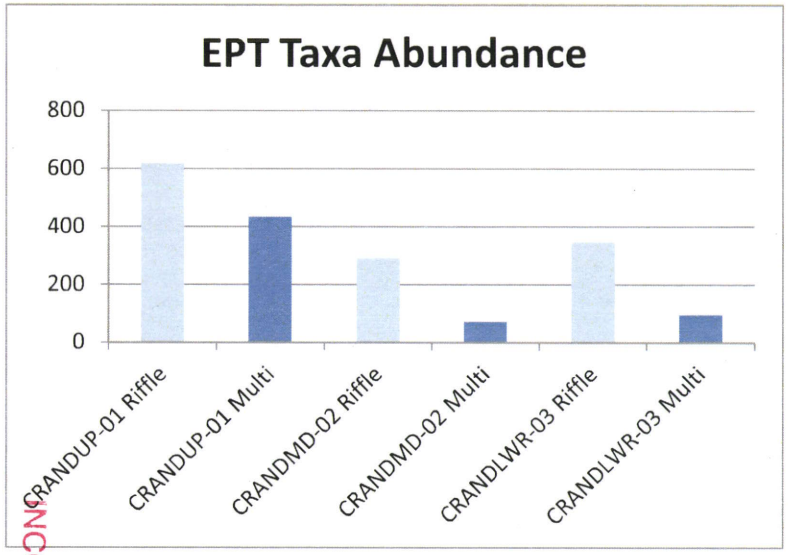

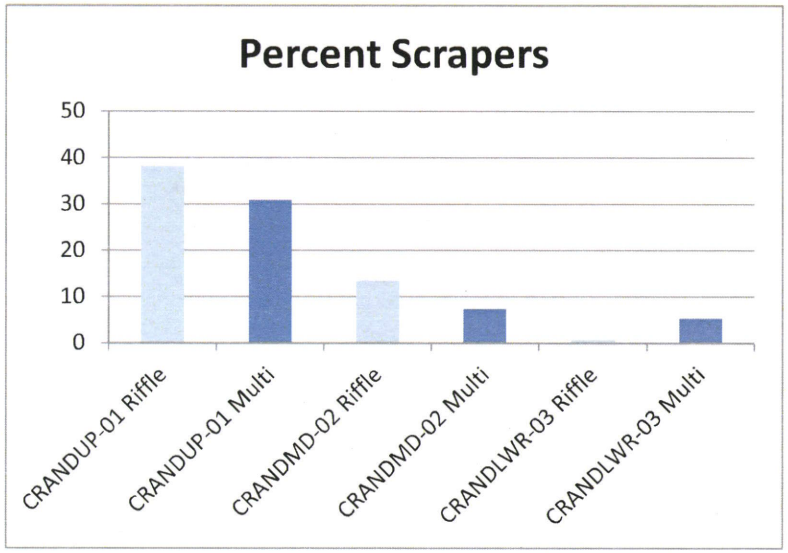

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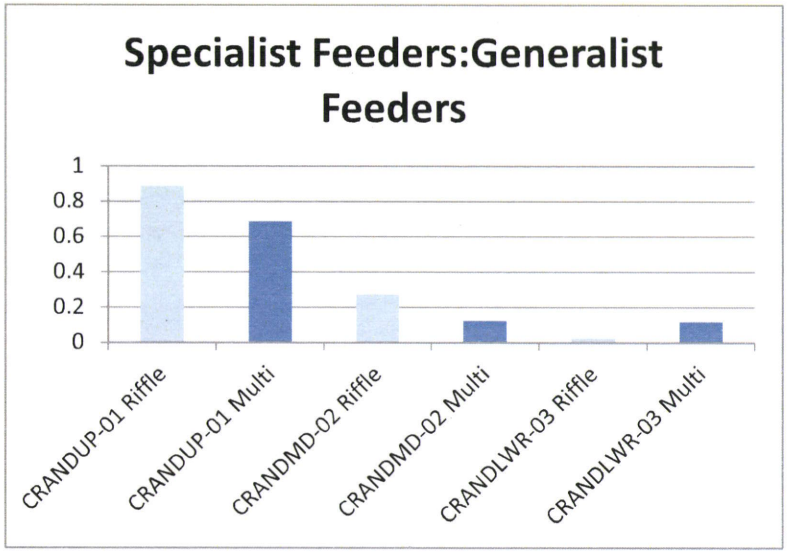

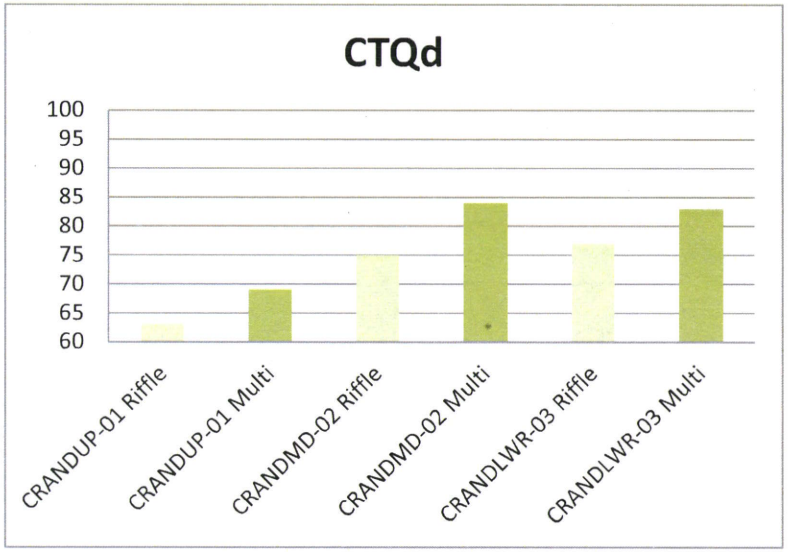

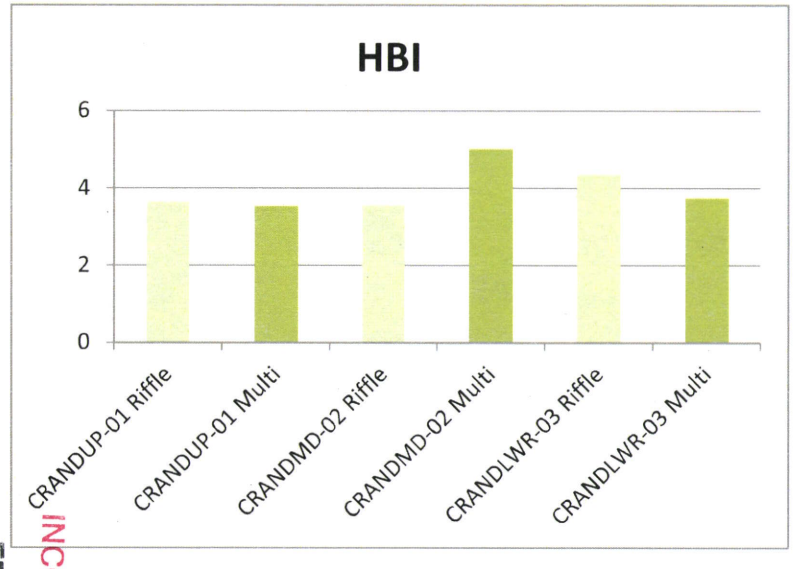

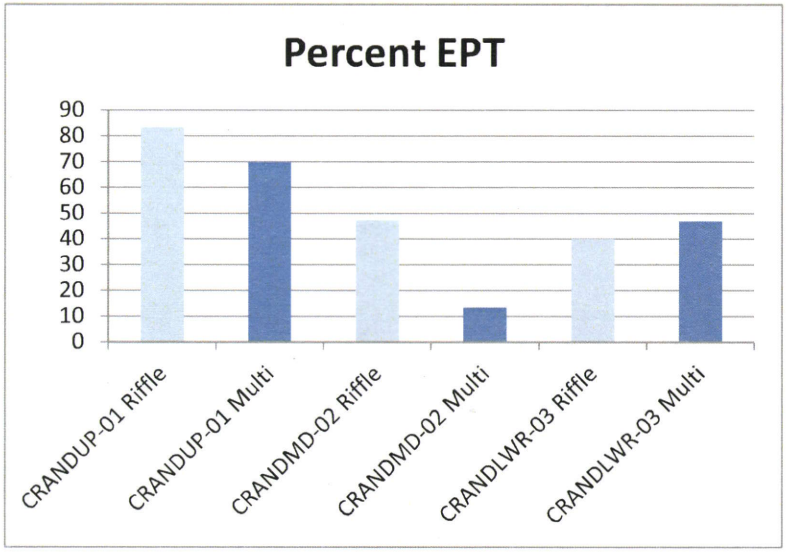

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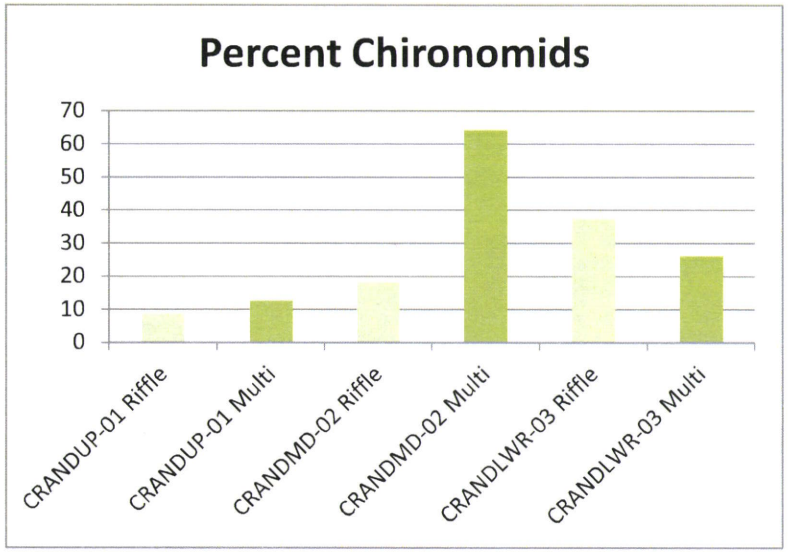

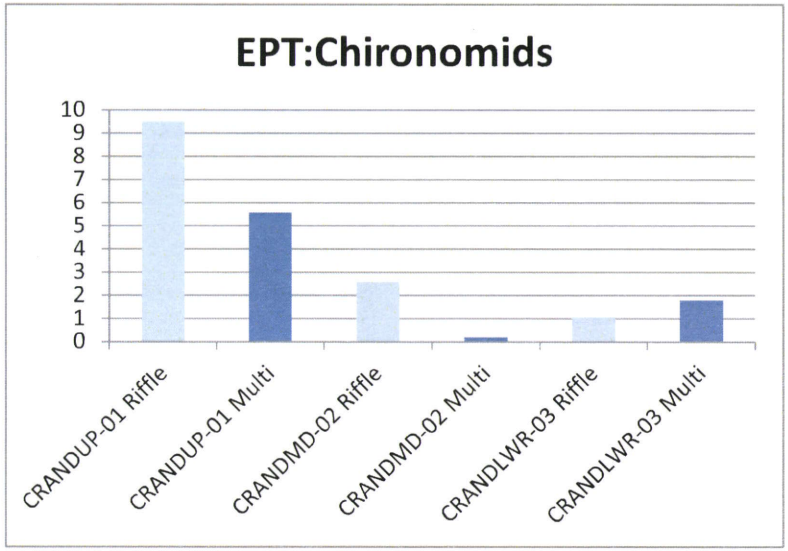

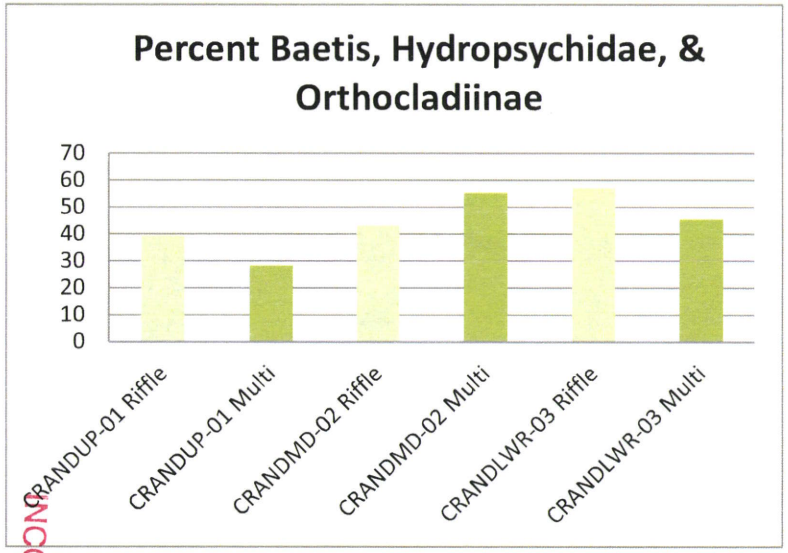

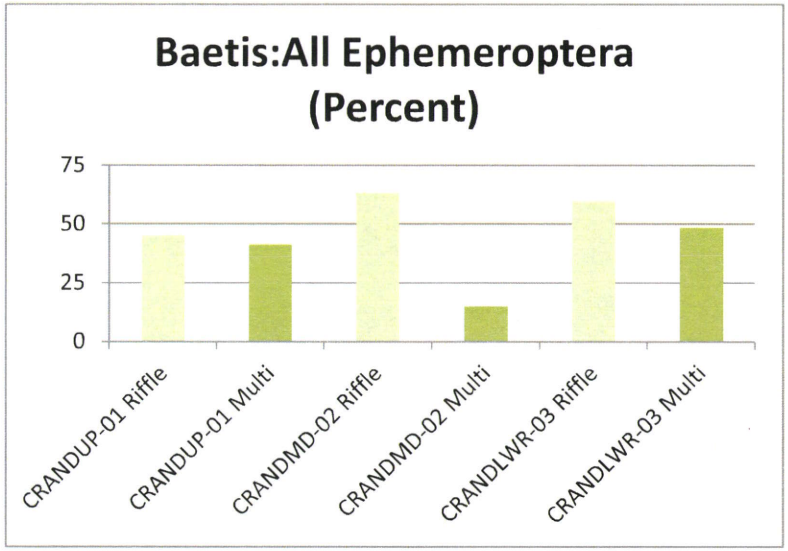

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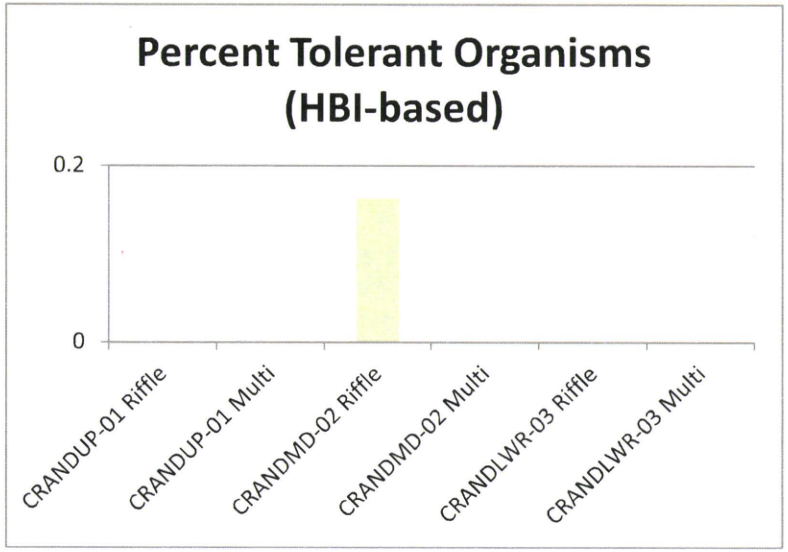

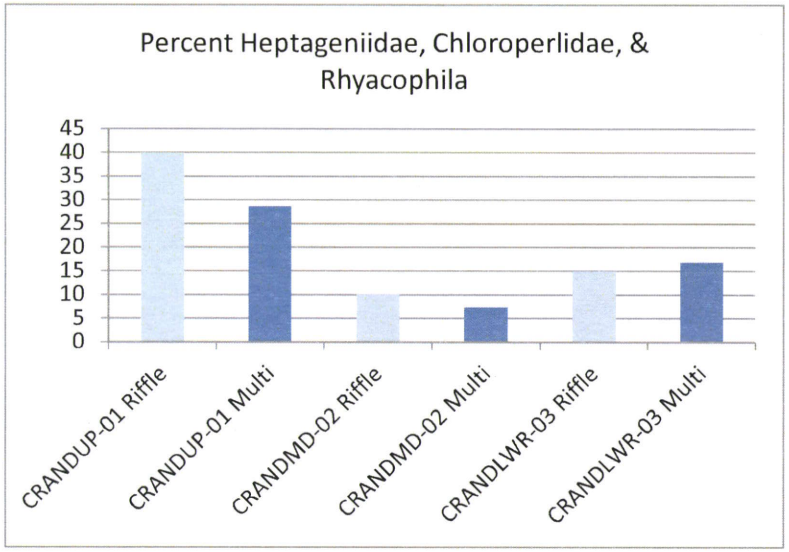

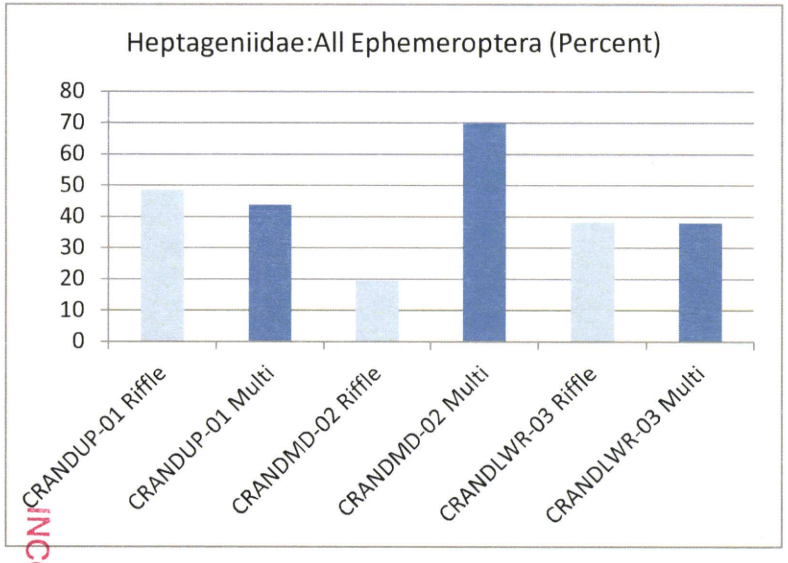

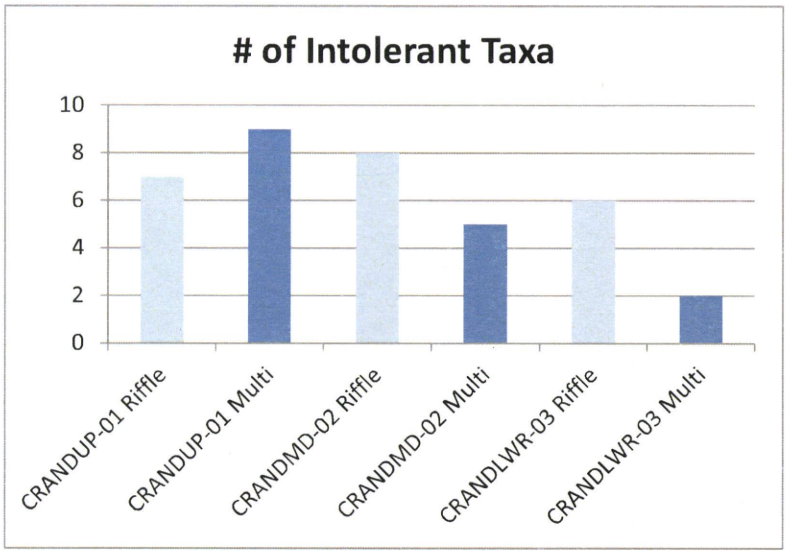

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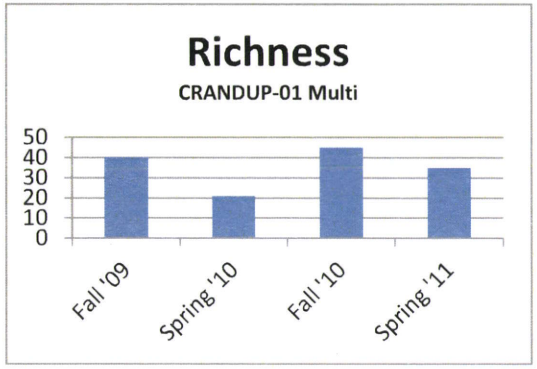

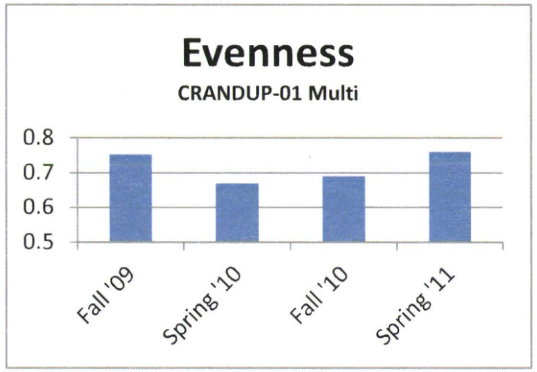

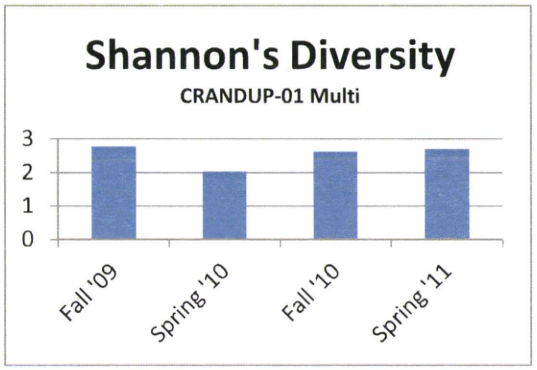

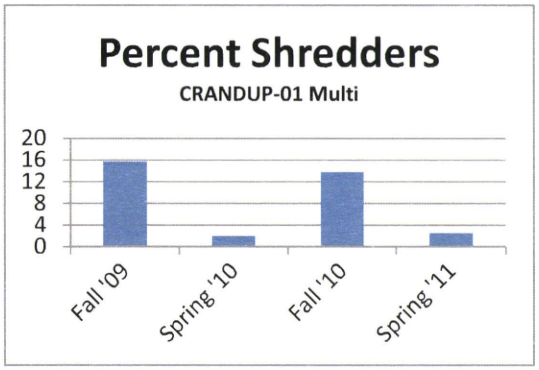

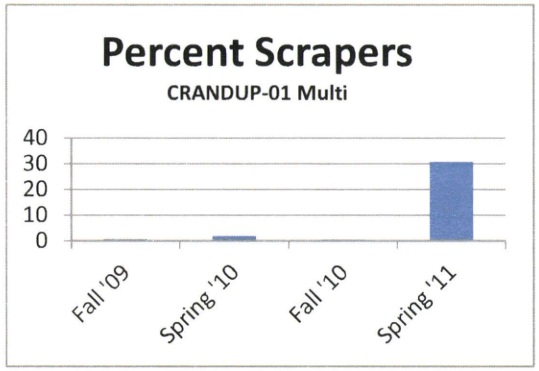

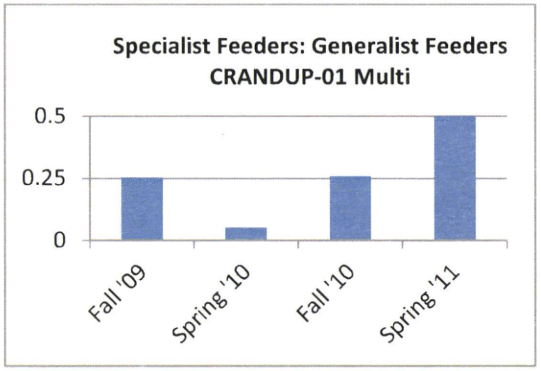

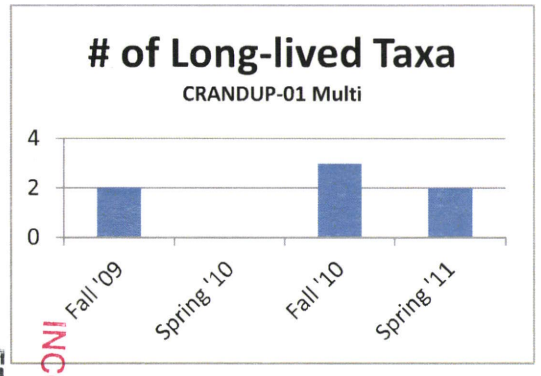

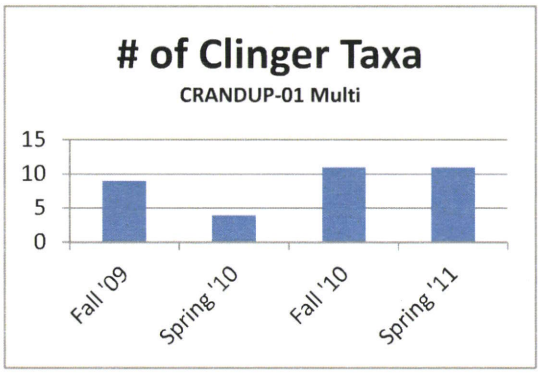

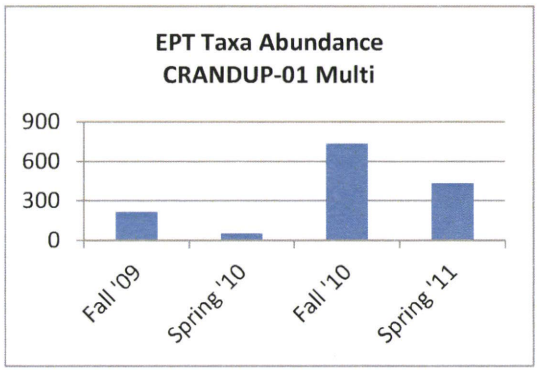

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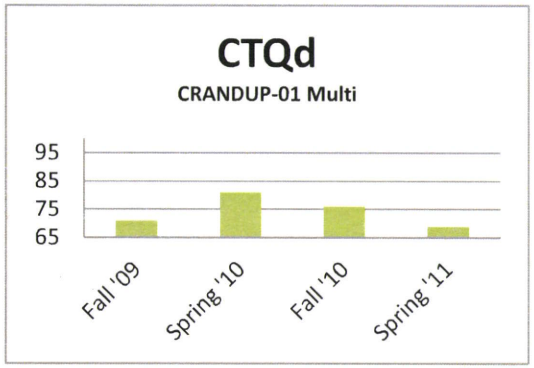

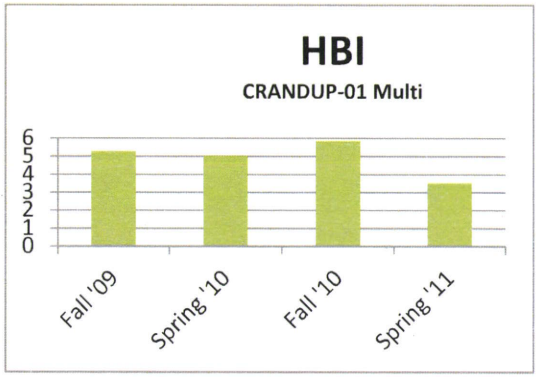

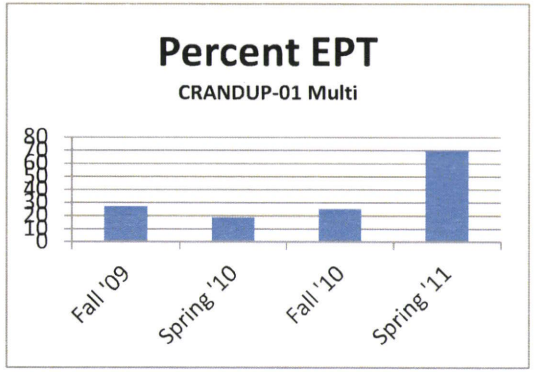

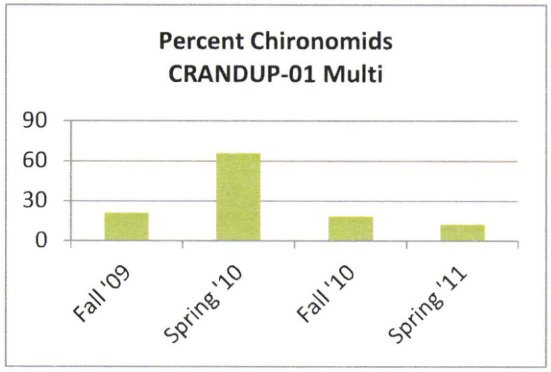

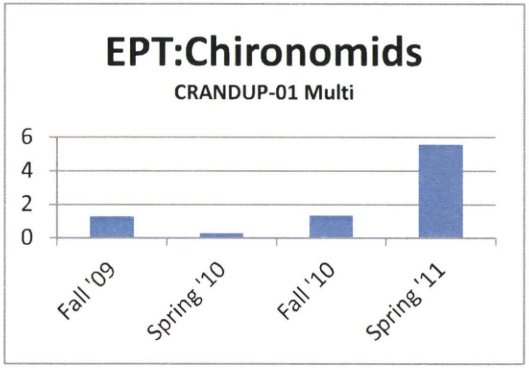

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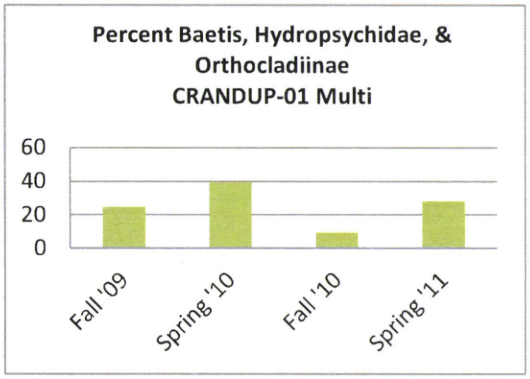

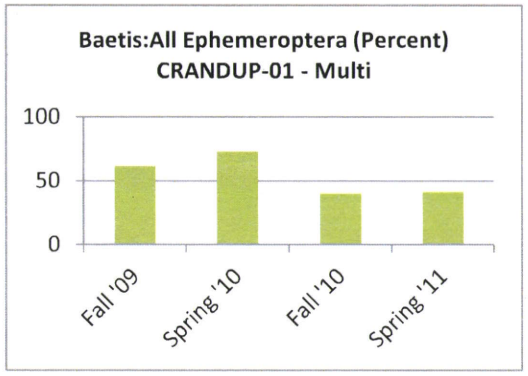

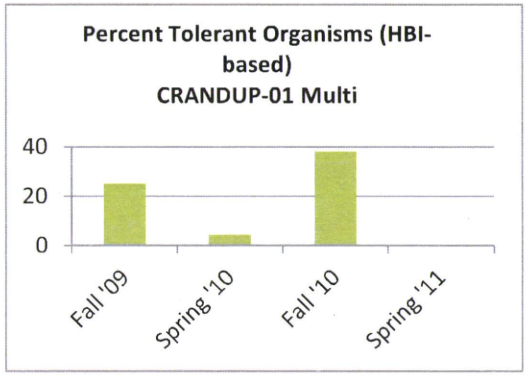

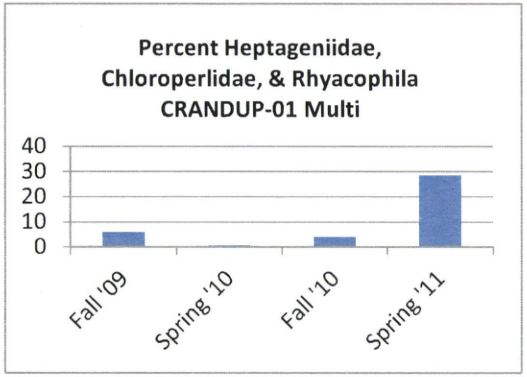

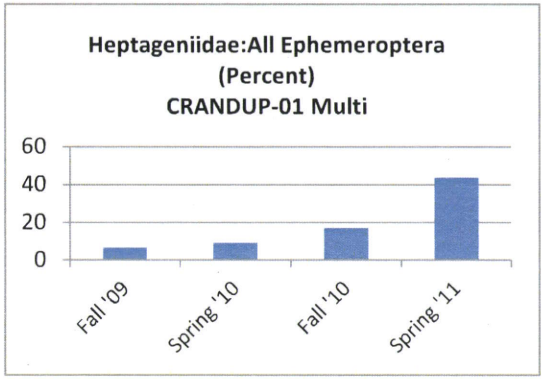

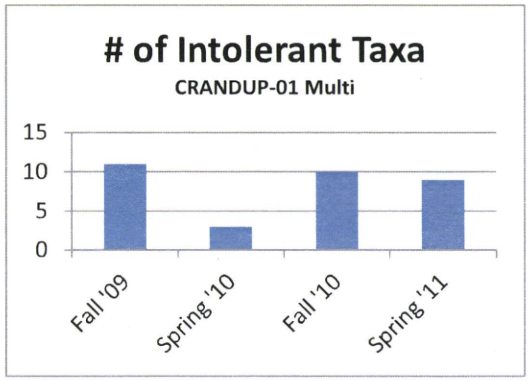

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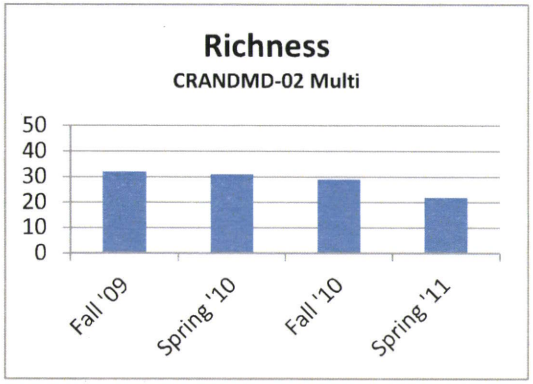

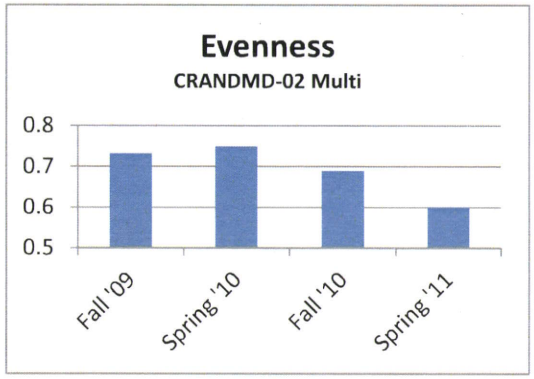

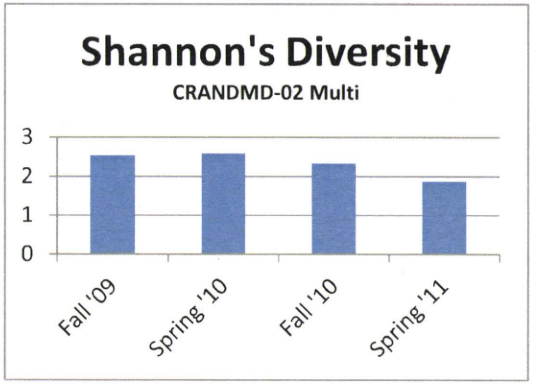

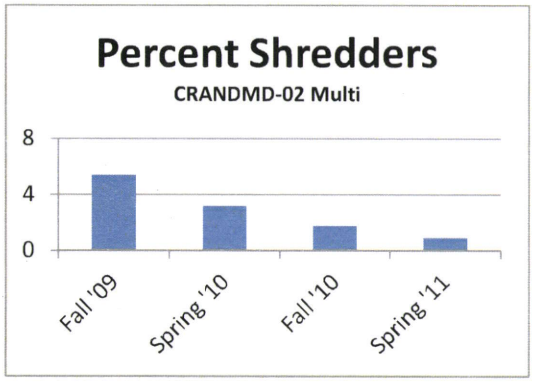

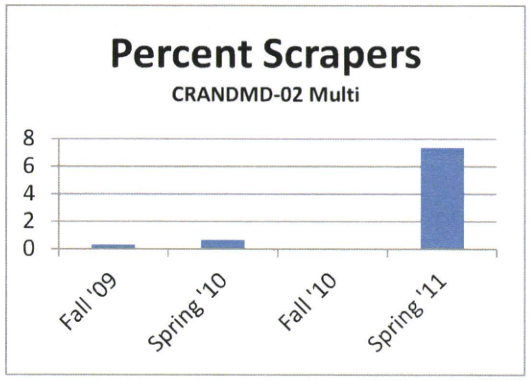

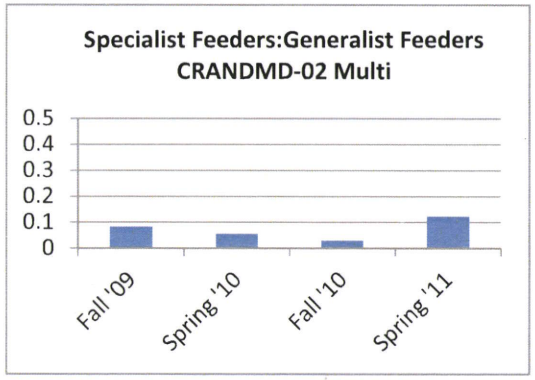

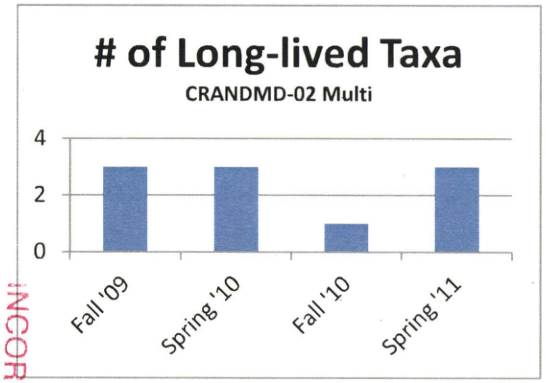

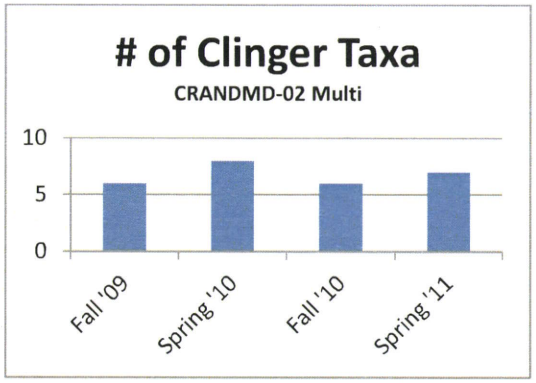

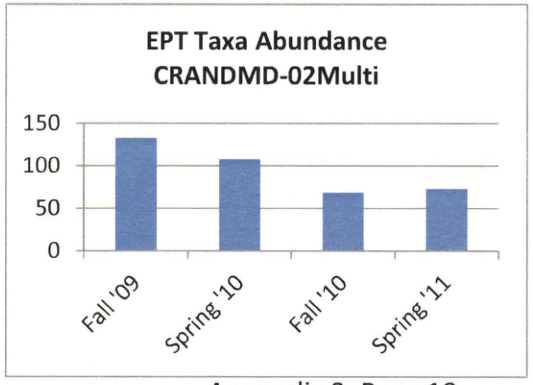

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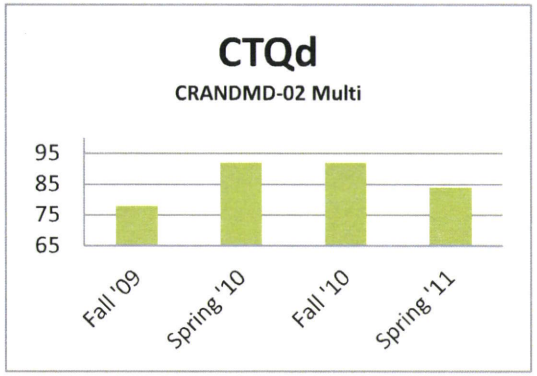

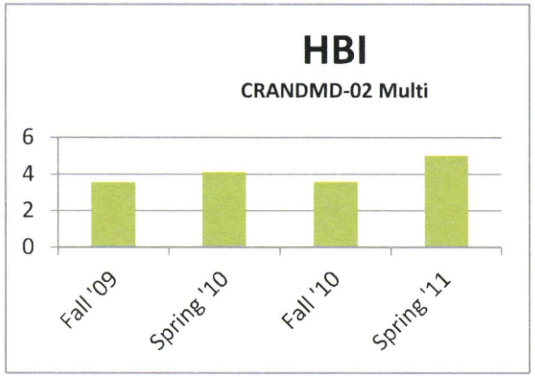

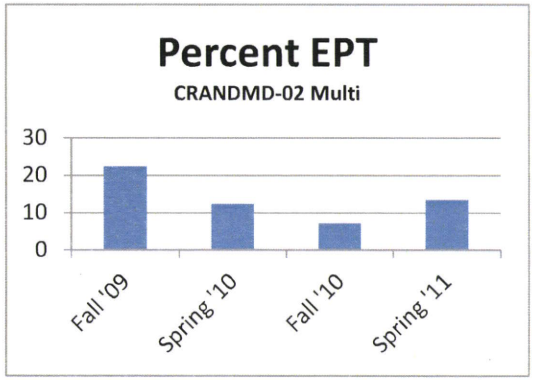

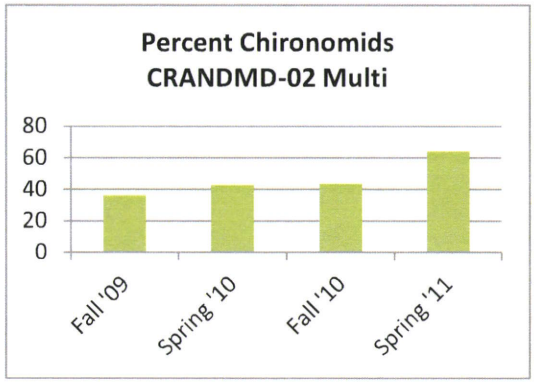

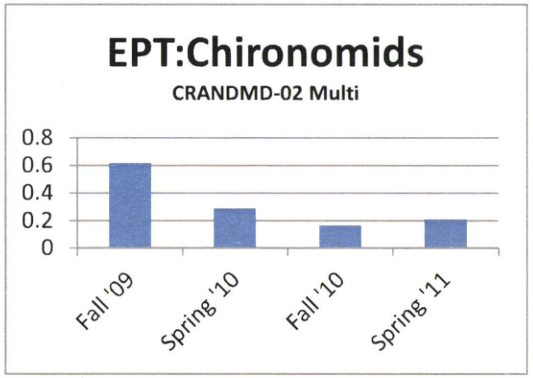

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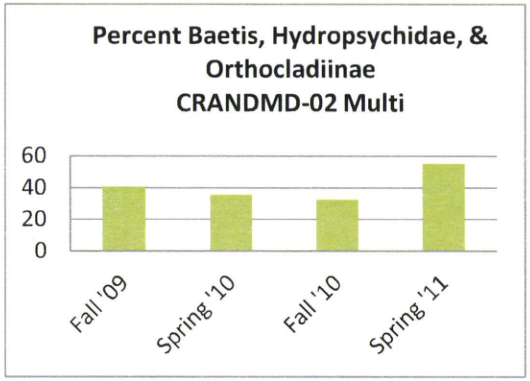

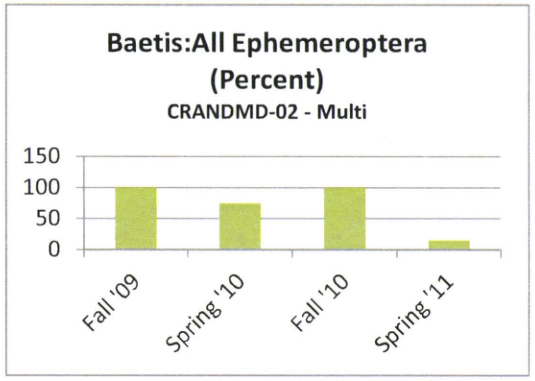

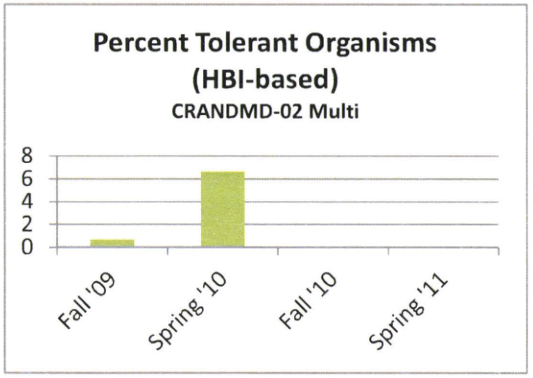

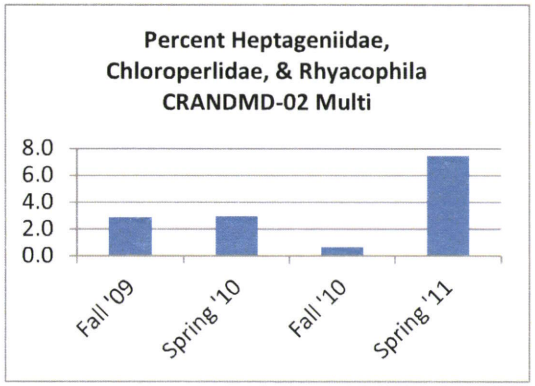

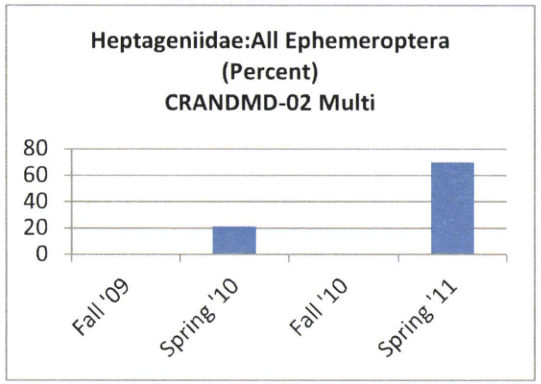

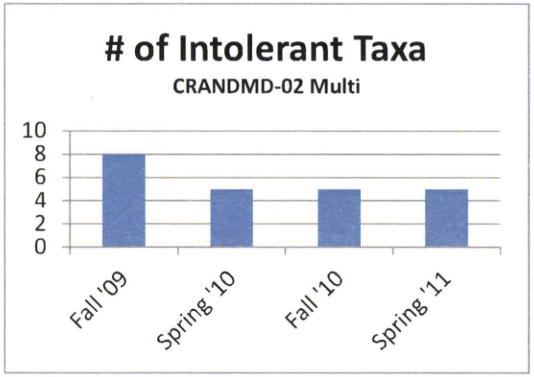

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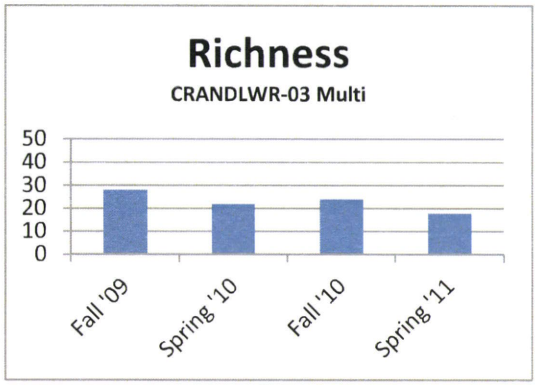

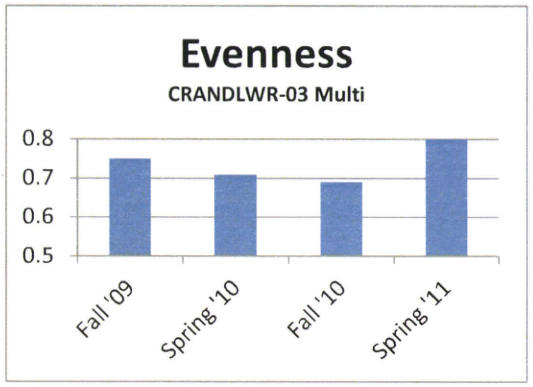

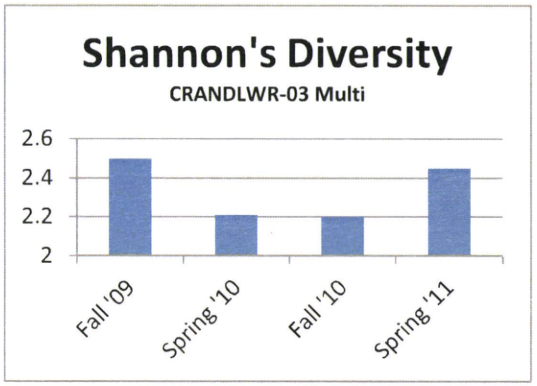

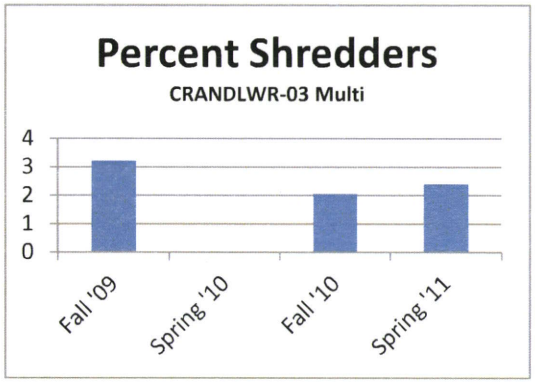

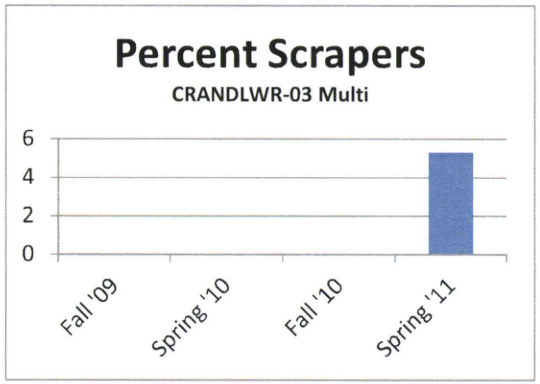

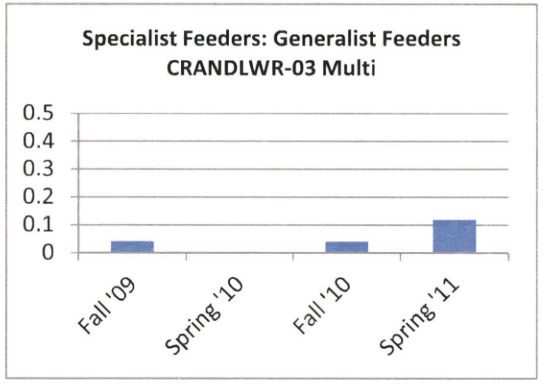

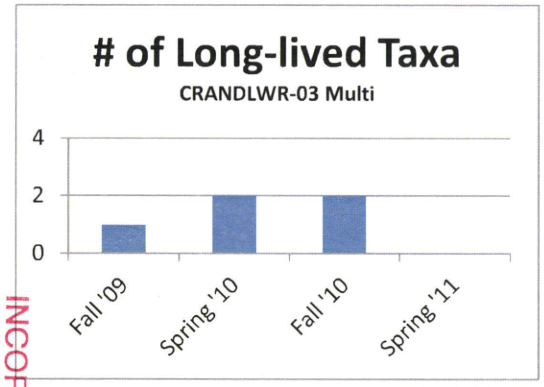

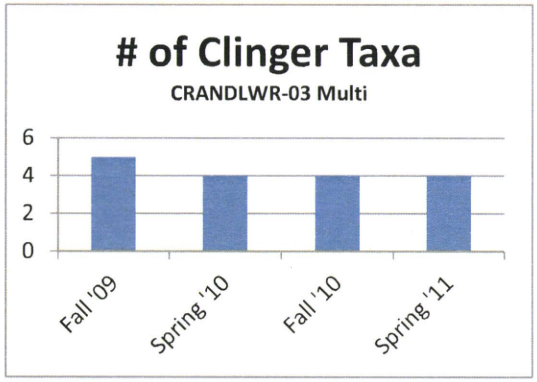

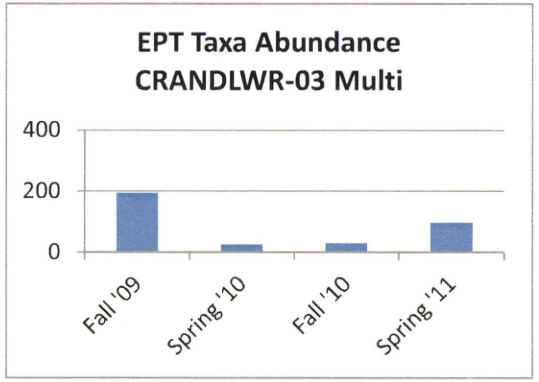

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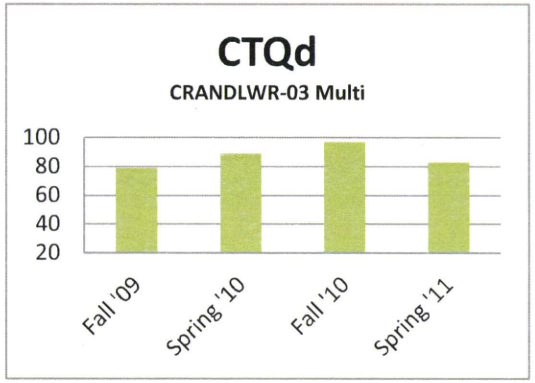

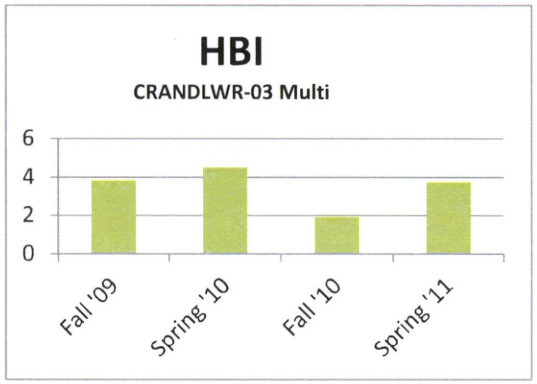

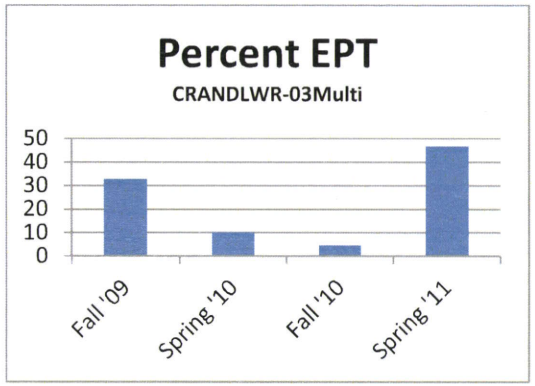

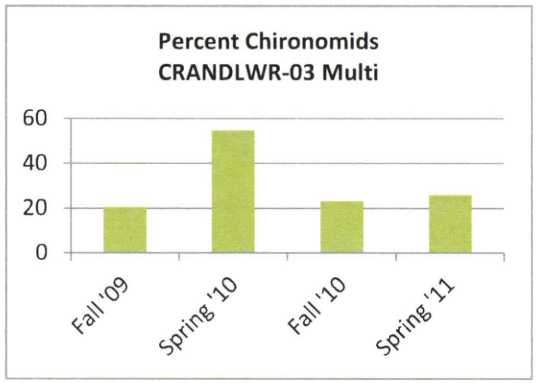

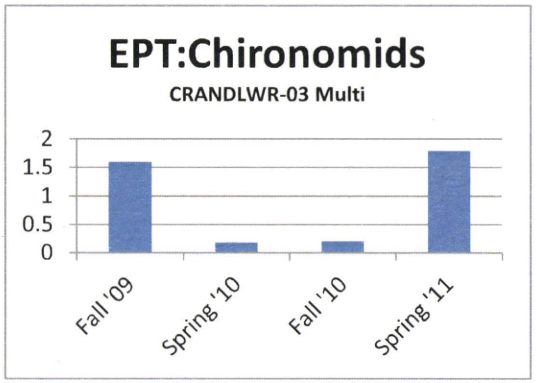

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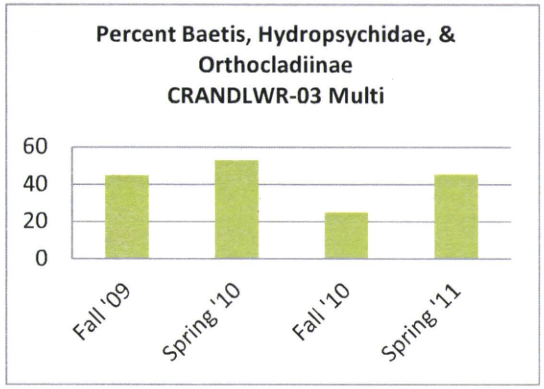

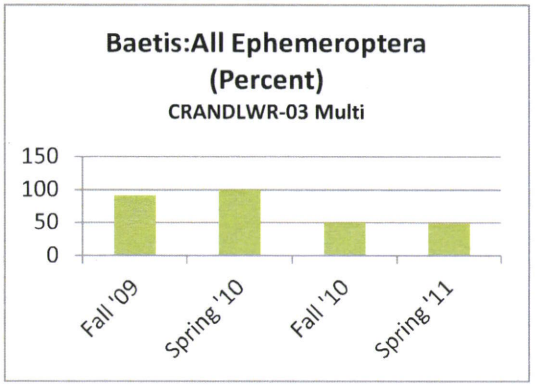

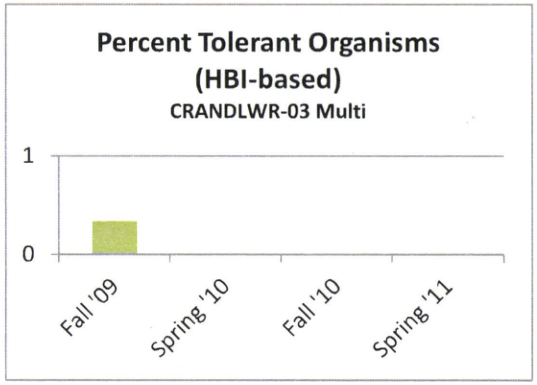

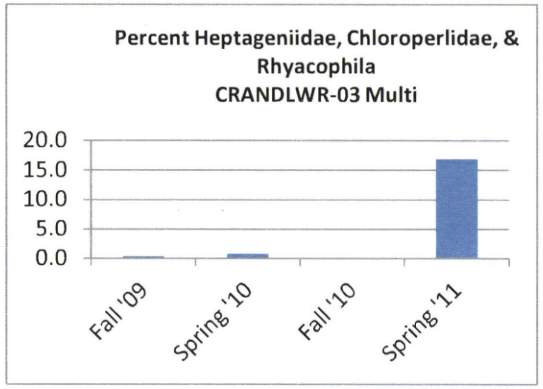

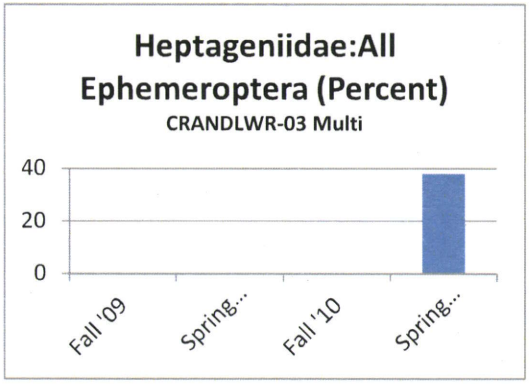

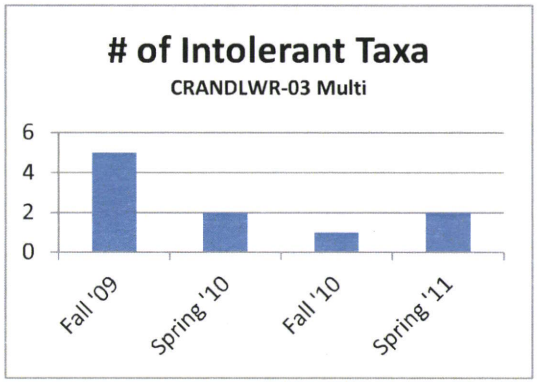

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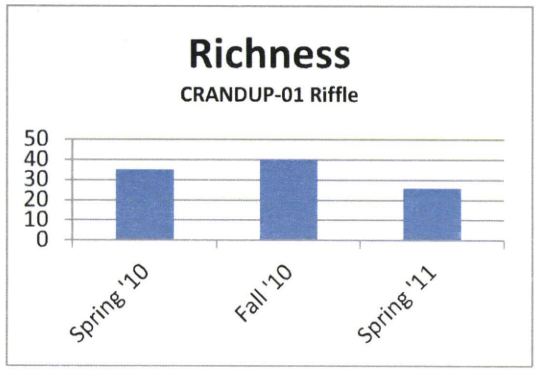

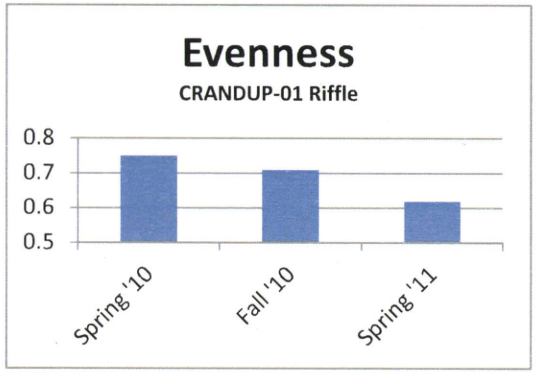

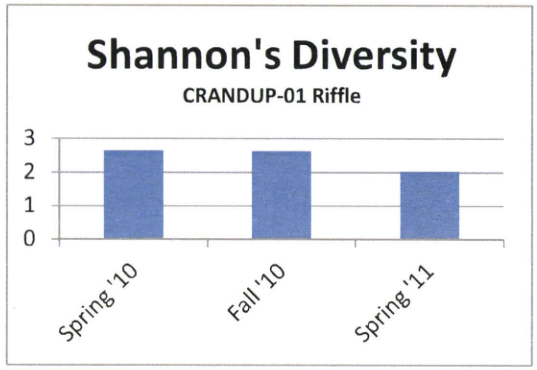

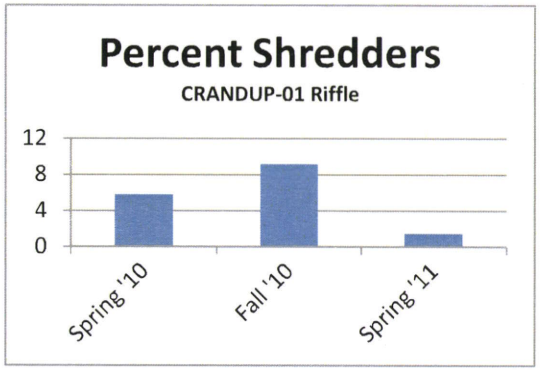

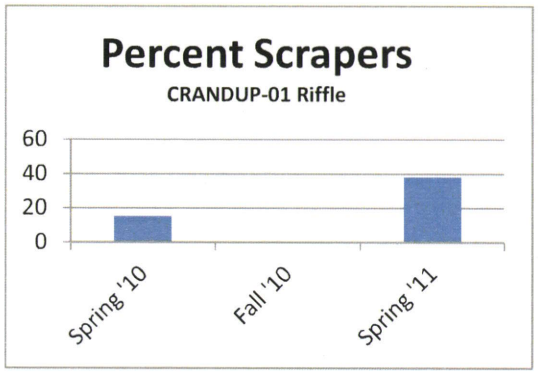

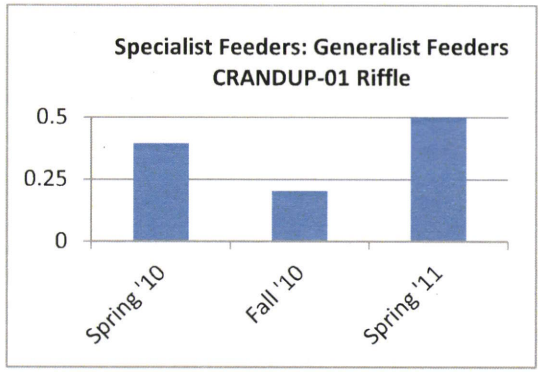

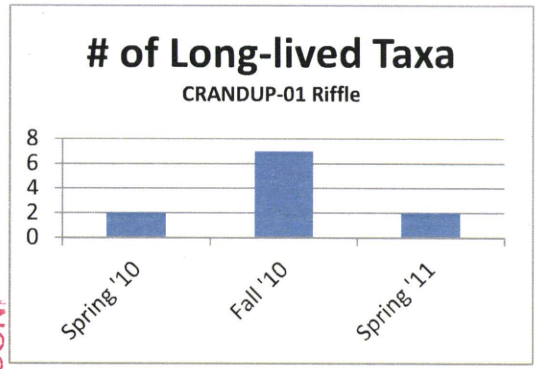

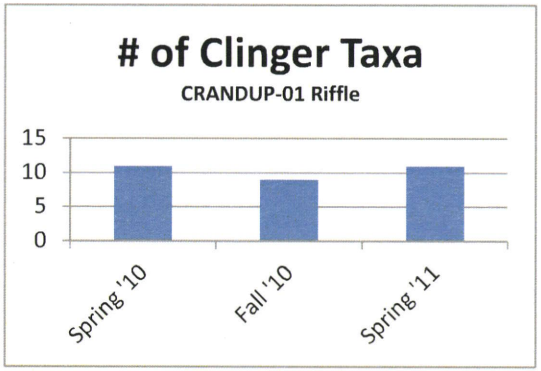

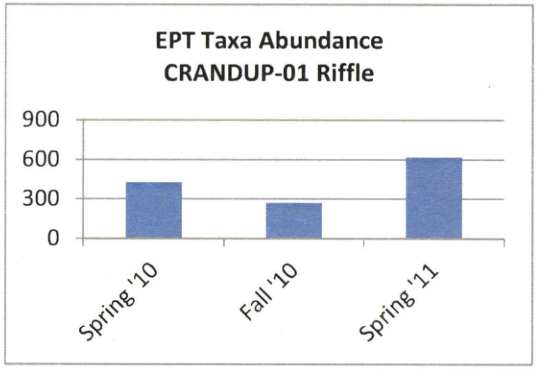

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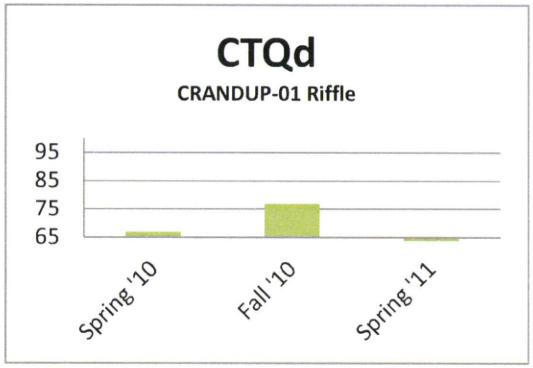

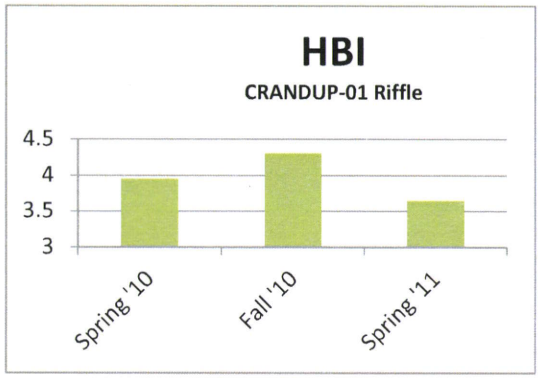

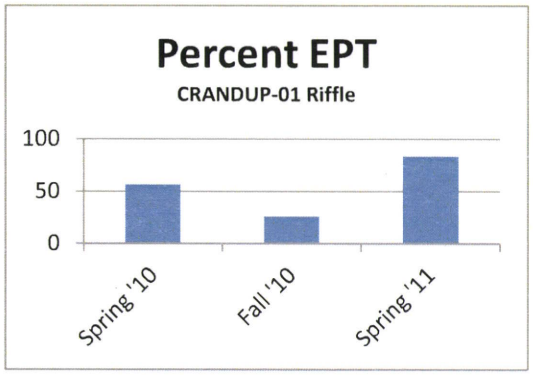

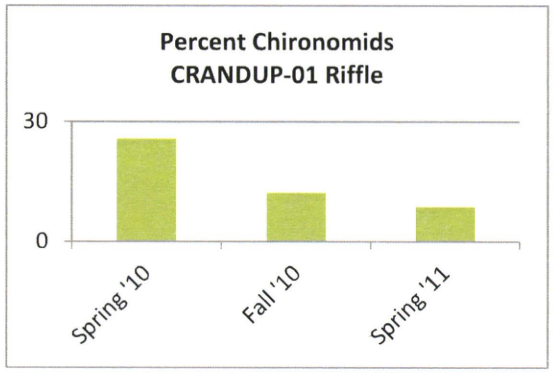

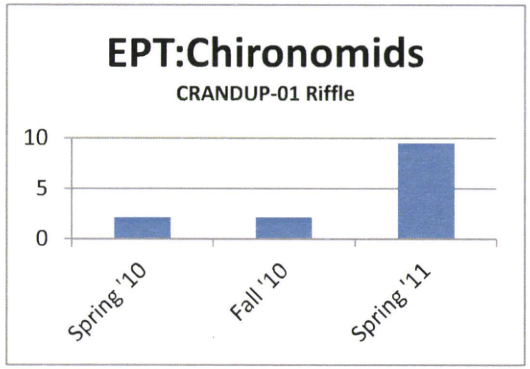

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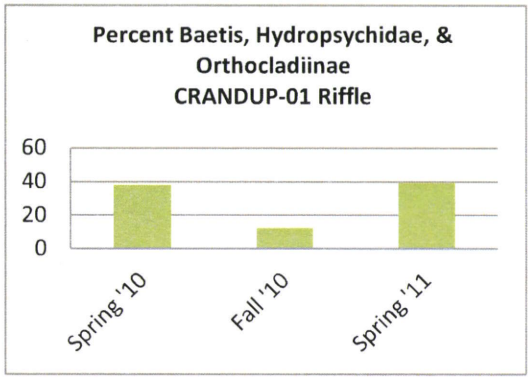

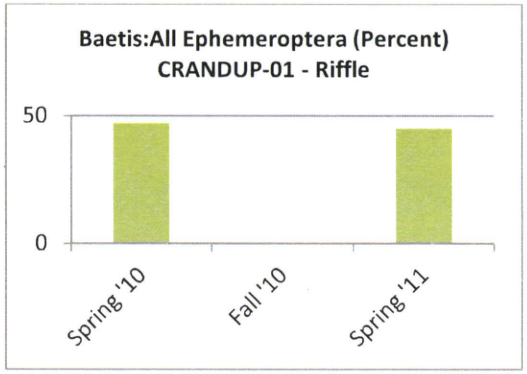

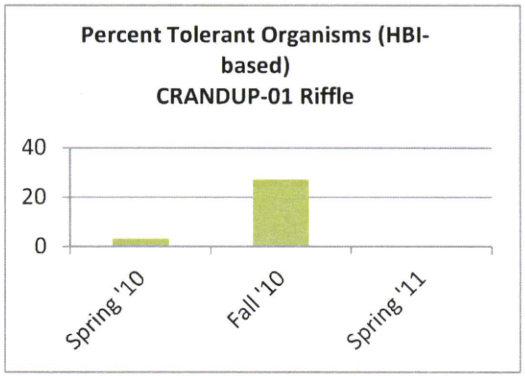

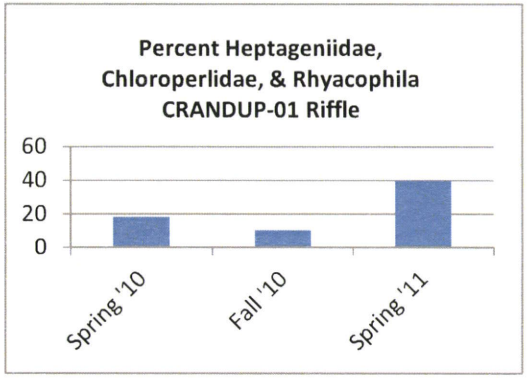

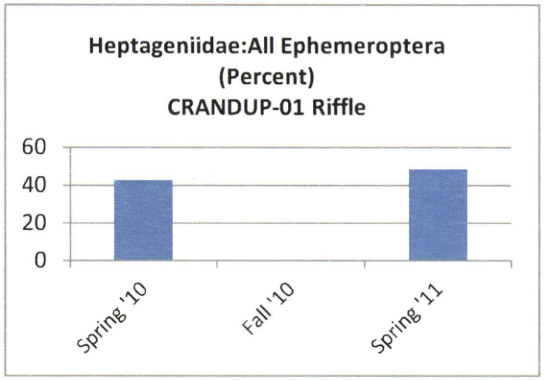

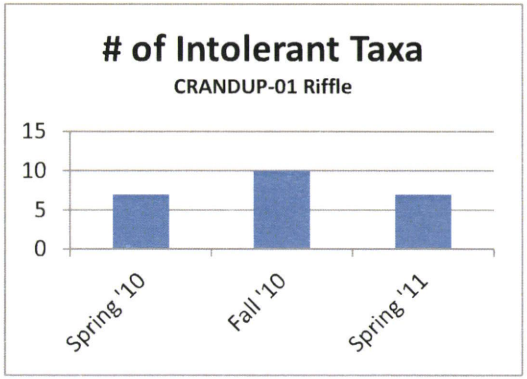

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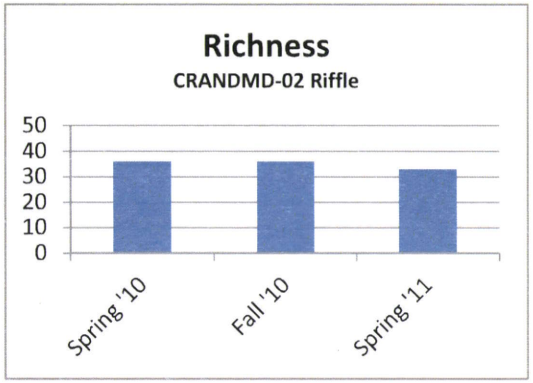

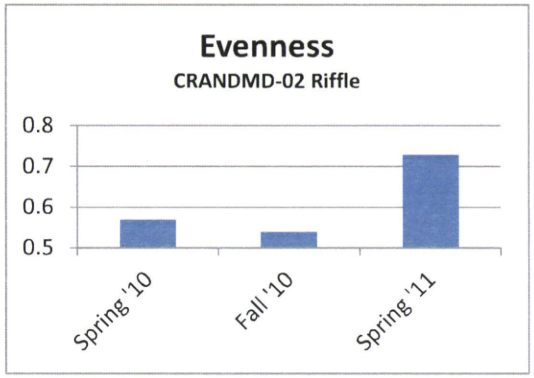

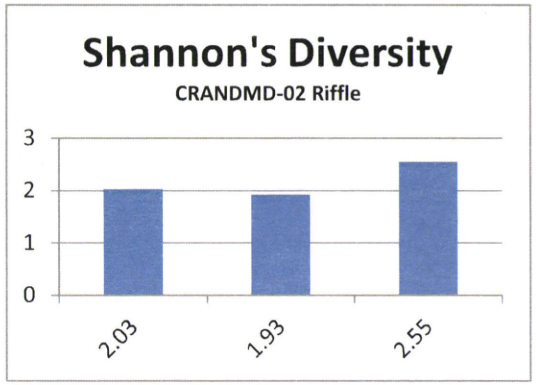

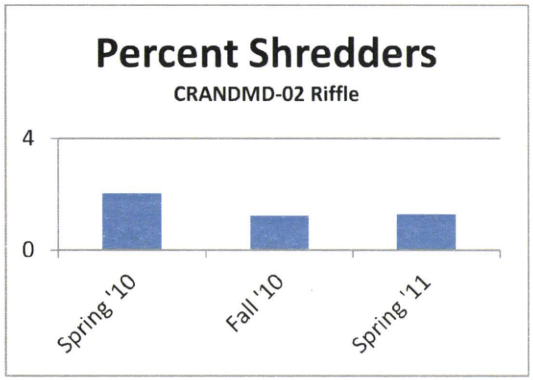

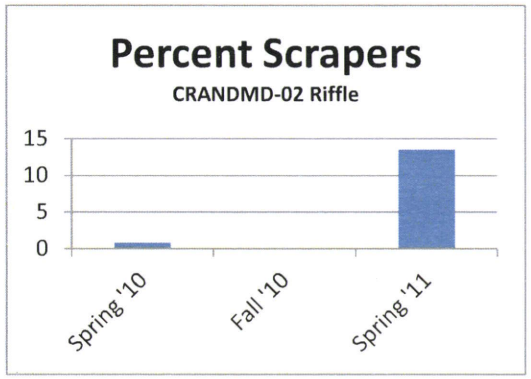

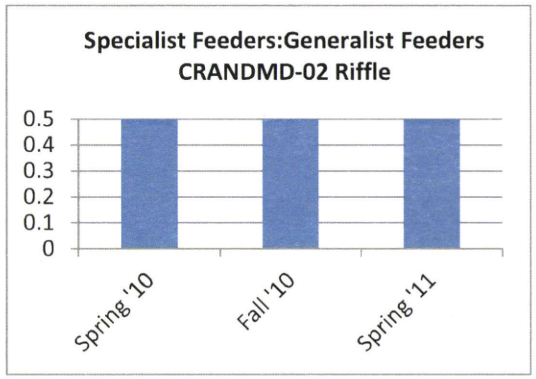

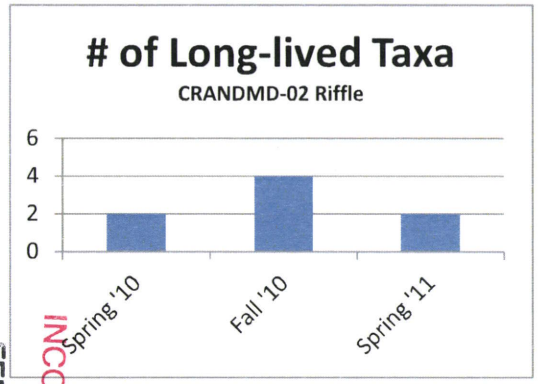

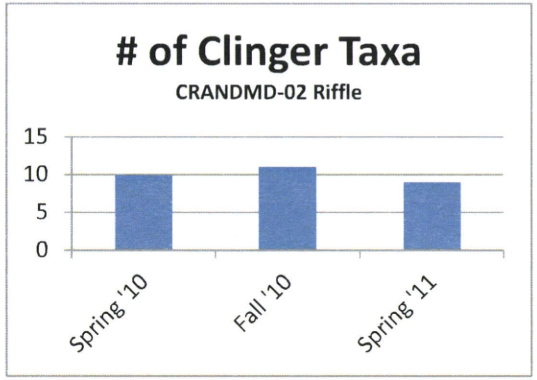

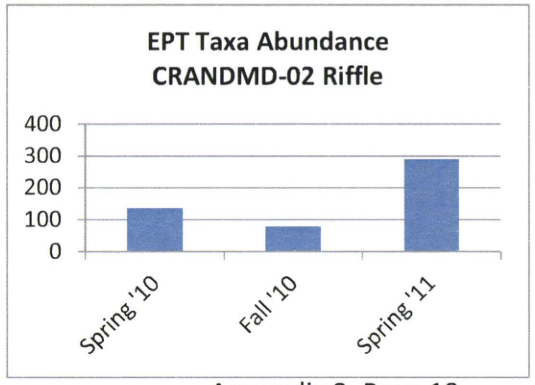

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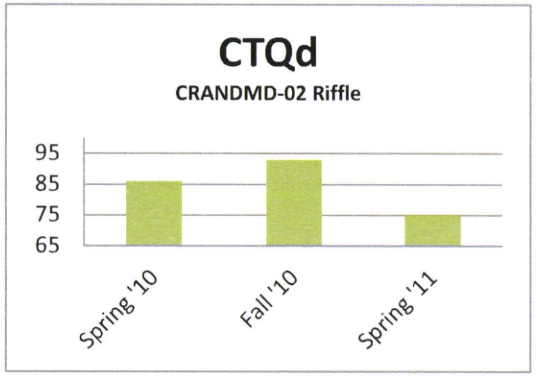

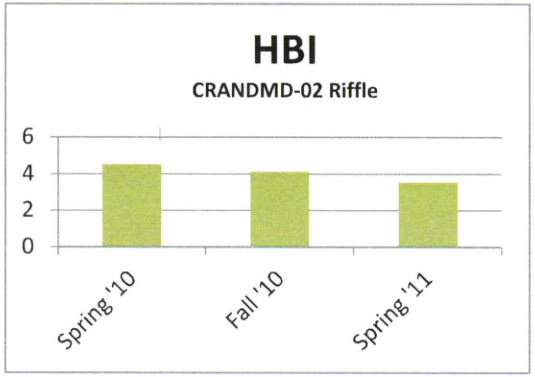

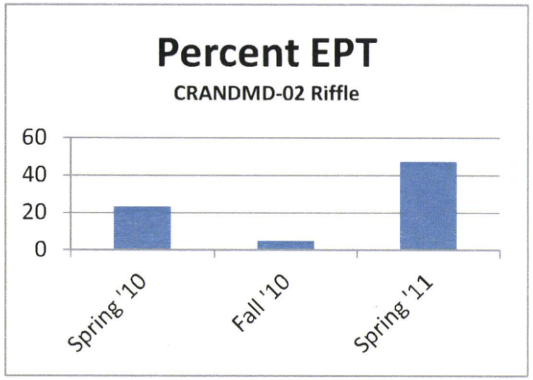

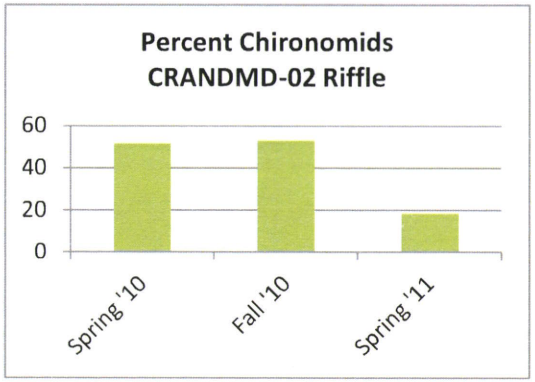

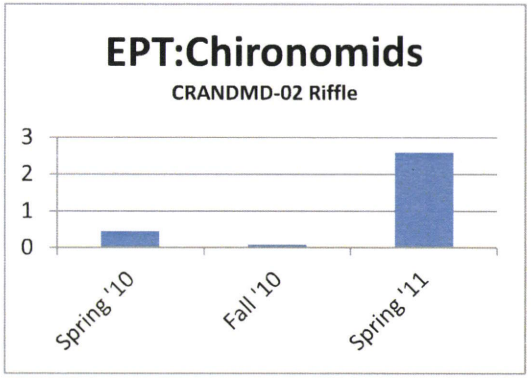

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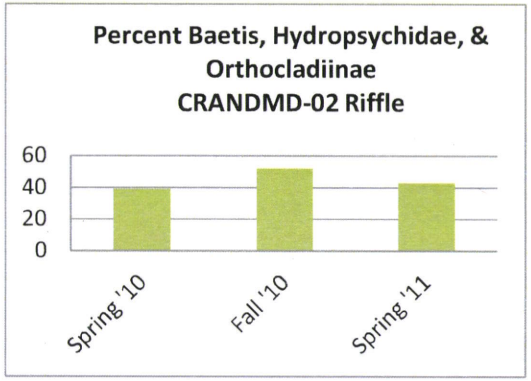

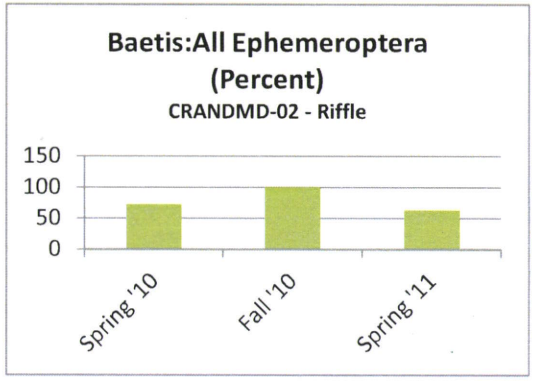

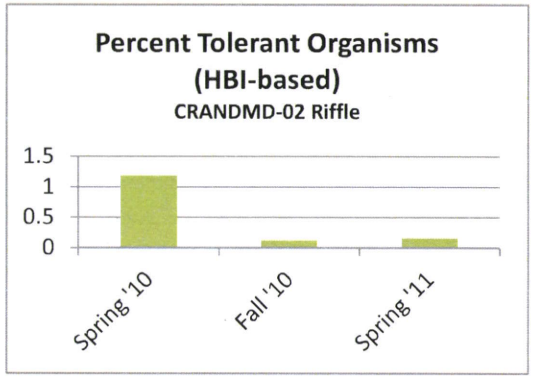

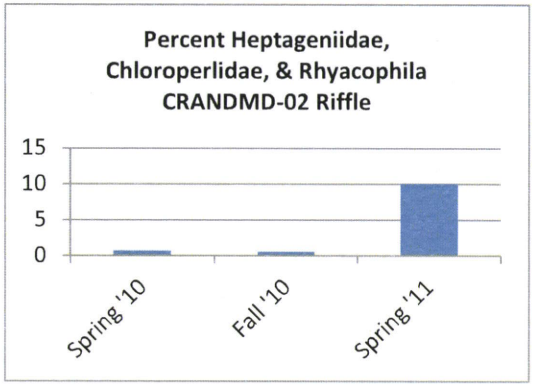

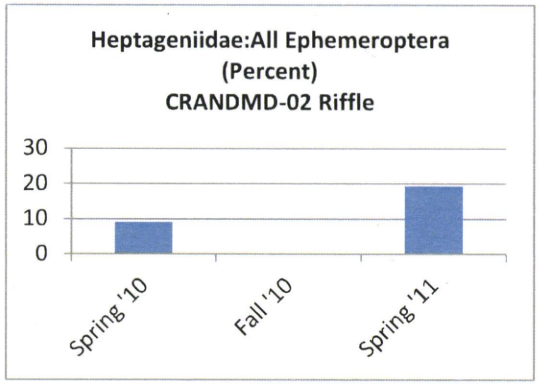

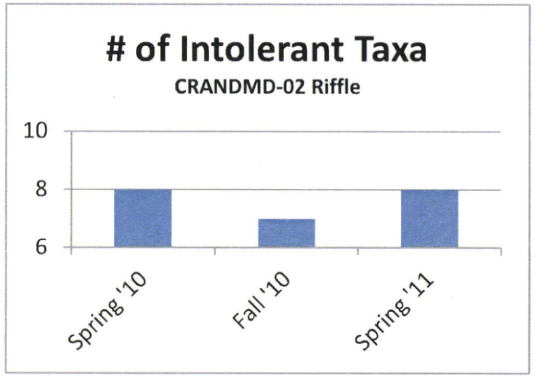

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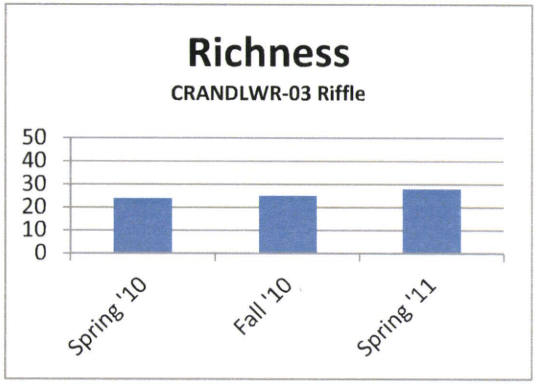

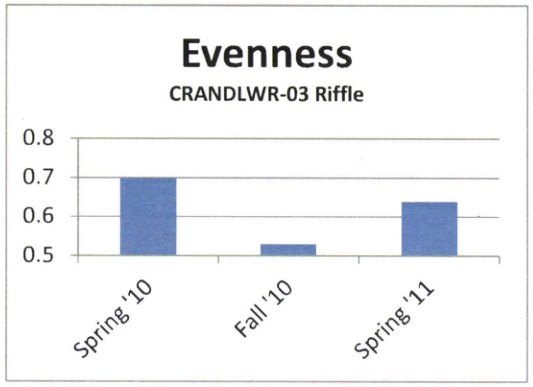

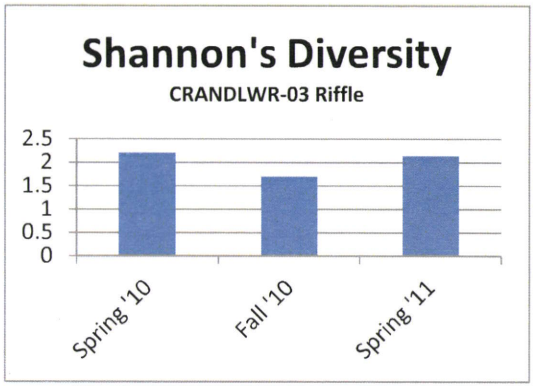

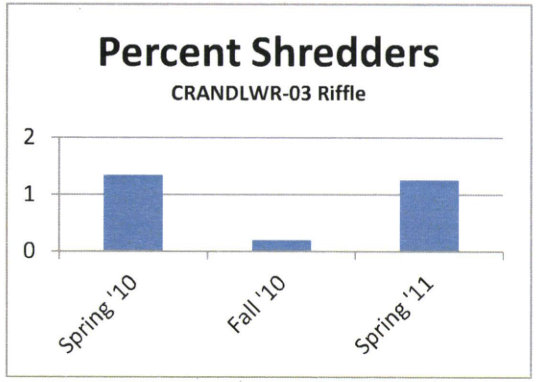

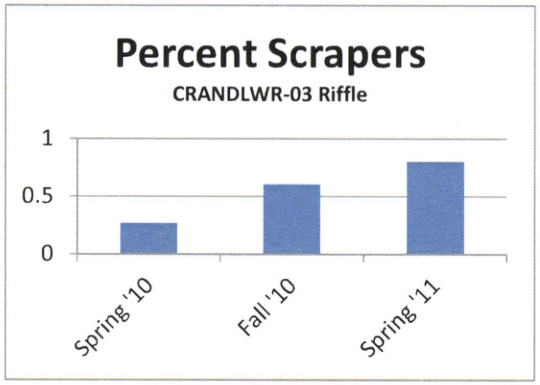

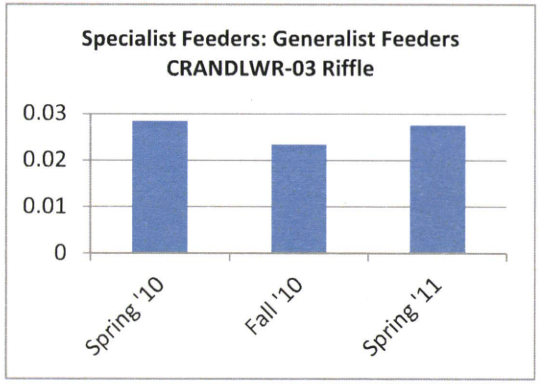

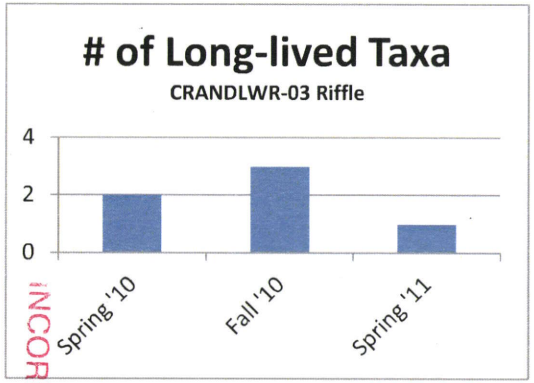

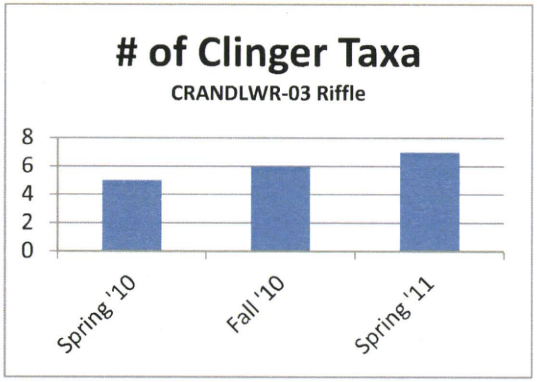

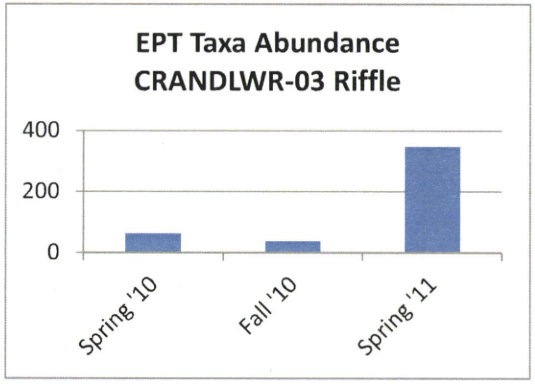

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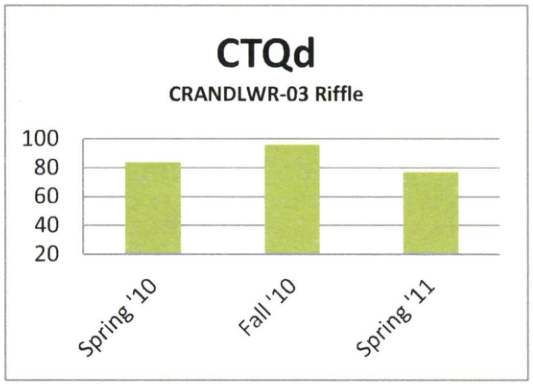

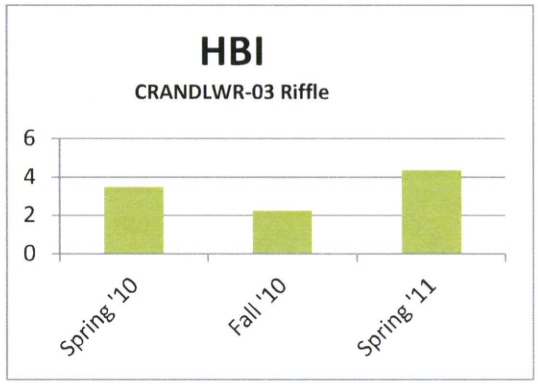

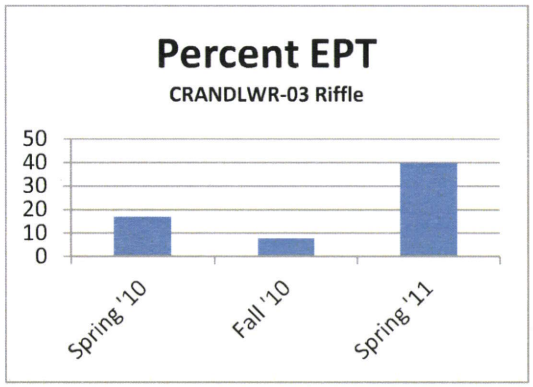

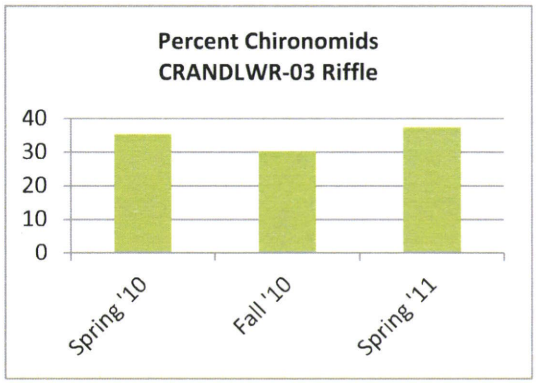

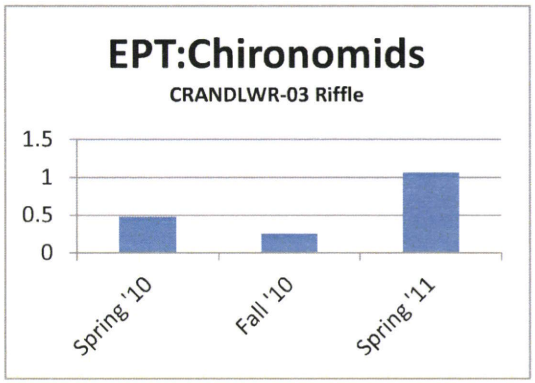

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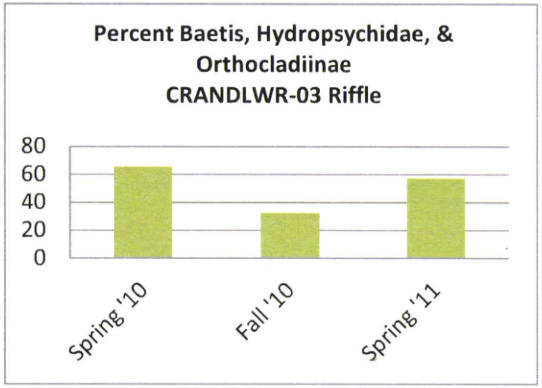

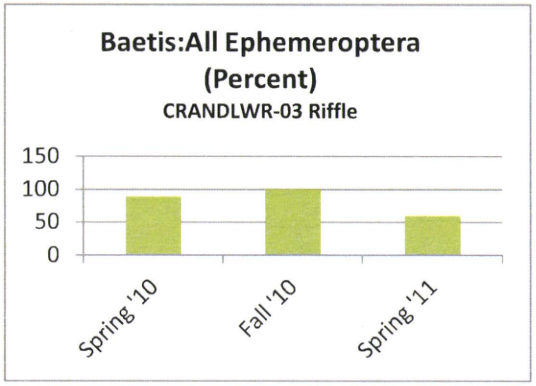

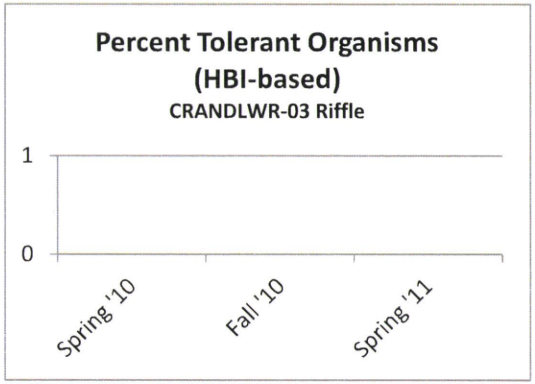

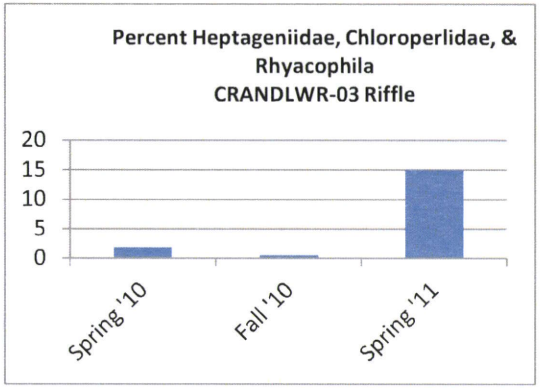

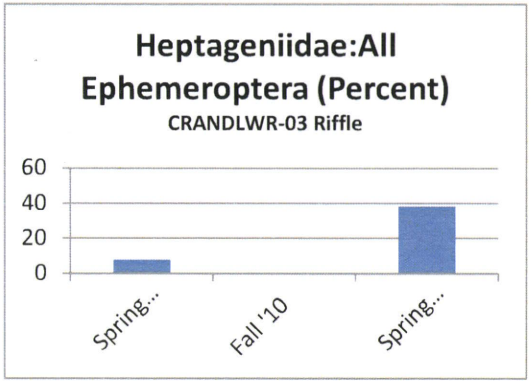

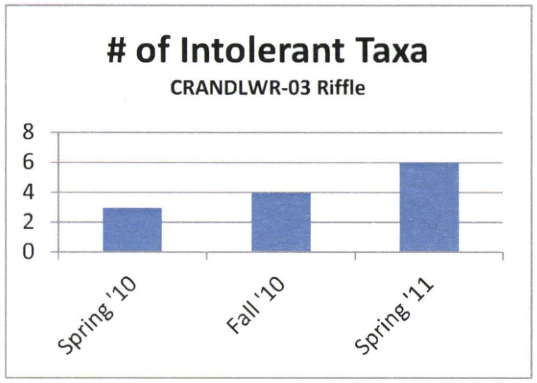

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Range (Minimum & Maximum) of Values for Each Metric, by Location

(Using data from Fall 2009 through Spring 2011)

Metric Name	CRANDUP-01		CRANDMD-02		CRANDLWR-03	
	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
Richness	21	45	22	36	18	28
Shannon's Diversity	2.03	2.78	1.87	2.59	1.7	2.50
Evenness	0.62	0.76	0.54	0.75	0.53	0.85
EPT Taxa Abundance	56	738	69	291	26	348
# of Intolerant Taxa	3	11	5	8	1	6
HBI	3.53	5.86	3.55	5.01	1.91	4.51
# of Clinger taxa	4	11	6	11	4	7
Long-lived Taxa	0	7	1	4	0	3
CTQd	63	81	75	93	77	97
Percent Shredders	1.5	15.7	0.9	5.4	0.0	3.2
Percent Scrapers	0.0	38.2	0.0	13.5	0.0	5.3
Specialist Feeders: Generalist Feeders	0.1	0.9	0.0	0.3	0.0	0.1
Percent EPT	18.9	83.5	5.0	47.4	4.8	46.9
Percent Chironomids	8.8	66.0	18.2	64.1	20.5	54.7
EPT:Chironomids	0.3	9.5	0.1	2.6	0.2	1.8
Percent Baetis, Hydropsychidae, & Orthocladiinae	9.3	39.2	32.6	55.2	25.0	65.7
Baetis: All Ephemeroptera (Percent)	0.0	72.7	15.0	100.0	48.3	100.0
Percent Tolerant Organisms (HBI-based)	0.0	38.1	0.0	6.7	0.0	0.3
Percent Heptageniidae, Chloroperlidae, & Rhyacophila	0.7	39.9	0.6	10.1	0.0	16.9
Heptageniidae: All Ephemeroptera (Percent)	0.0	48.6	0.0	70.0	0.0	38.3

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SAFETY DATA SHEET

PRODUCT

NALCLEAR® 7763

EMERGENCY TELEPHONE NUMBER(S)
(800) 424-9300 (24 Hours) CHEMTREC

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME : **NALCLEAR® 7763**

COMPANY IDENTIFICATION : Nalco Company
1601 W. Diehl Road
Naperville, Illinois
60563-1198

EMERGENCY TELEPHONE NUMBER(S) : (800) 424-9300 (24 Hours) CHEMTREC

NFPA 704M/HMIS RATING
HEALTH : 0 / 1 FLAMMABILITY : 1 / 1 INSTABILITY : 0 / 0 OTHER :
0 = Insignificant 1 = Slight 2 = Moderate 3 = High 4 = Extreme * = Chronic Health Hazard

2. COMPOSITION/INFORMATION ON INGREDIENTS

Our hazard evaluation has found that this product is not hazardous under 29 CFR 1910.1200.

3. HAZARDS IDENTIFICATION

****EMERGENCY OVERVIEW****

CAUTION
May cause irritation with prolonged contact.
Do not get in eyes, on skin, on clothing. Do not take internally. Wear suitable protective clothing. Keep container tightly closed. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. After contact with skin, wash immediately with plenty of water. Use a mild soap if available. Protect product from freezing. Wear suitable protective clothing, gloves and eye/face protection.
May evolve oxides of carbon (COx) under fire conditions. May evolve oxides of nitrogen (NOx) under fire conditions.
Water in contact with the product will cause slippery floor conditions.

PRIMARY ROUTES OF EXPOSURE :
Eye, Skin

HUMAN HEALTH HAZARDS - ACUTE :

EYE CONTACT :
May cause irritation with prolonged contact.

SKIN CONTACT :
May cause irritation with prolonged contact.

INGESTION :
Not a likely route of exposure. If swallowed a jelly mass may form which in digestion may cause blockage.

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INHALATION :
Not a likely route of exposure. Repeated or prolonged exposure may irritate the respiratory tract.

SYMPTOMS OF EXPOSURE :
Acute :
A review of available data does not identify any symptoms from exposure not previously mentioned.
Chronic :
Frequent or prolonged contact with product may defat and dry the skin, leading to discomfort and dermatitis.

AGGRAVATION OF EXISTING CONDITIONS :
A review of available data does not identify any worsening of existing conditions.

4. FIRST AID MEASURES

EYE CONTACT :
Immediately flush with plenty of water for at least 15 minutes. If symptoms develop, seek medical advice.

SKIN CONTACT :
Remove contaminated clothing. Wash off affected area immediately with soap and plenty of water. If symptoms develop, seek medical advice.

INGESTION :
Do not induce vomiting without medical advice. If conscious, washout mouth and give water to drink. Get medical attention.

INHALATION :
Remove to fresh air, treat symptomatically. If symptoms develop, seek medical advice.

NOTE TO PHYSICIAN :
Based on the individual reactions of the patient, the physician's judgement should be used to control symptoms and clinical condition. If swallowed a jelly mass may form which in digestion may cause blockage.

5. FIRE FIGHTING MEASURES

FLASH POINT : Not flammable

LOWER EXPLOSION LIMIT : Not flammable

UPPER EXPLOSION LIMIT : Not flammable

EXTINGUISHING MEDIA :
Foam, Dry powder, Carbon dioxide, Other extinguishing agent suitable for Class B fires

UNSUITABLE EXTINGUISHING MEDIA :
Do not use water unless flooding amounts are available.

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FIRE AND EXPLOSION HAZARD :
May evolve oxides of carbon (COx) under fire conditions. May evolve oxides of nitrogen (NOx) under fire conditions. Water in contact with the product will cause slippery floor conditions.

SPECIAL PROTECTIVE EQUIPMENT FOR FIRE FIGHTING :
In case of fire, wear a full face positive-pressure self contained breathing apparatus and protective suit.

6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS :
Restrict access to area as appropriate until clean-up operations are complete. Notify appropriate government, occupational health and safety and environmental authorities. Ensure clean-up is conducted by trained personnel only. Do not touch spilled material. Stop or reduce any leaks if it is safe to do so. Use personal protective equipment recommended in Section 8 (Exposure Controls/Personal Protection). Spill may be slippery.

METHODS FOR CLEANING UP :
SMALL SPILLS: Soak up spill with absorbent material. Place residues in a suitable, covered, properly labeled container. Wash affected area. LARGE SPILLS: Water in contact with the product will create a voluminous, slippery gel. Soak up as thoroughly as possible with inert absorbent material or sawdust. Do NOT hose down area until all possible traces of polymer are removed. Contact an approved waste hauler for disposal of contaminated recovered material. Dispose of material in compliance with regulations indicated in Section 13 (Disposal Considerations).

ENVIRONMENTAL PRECAUTIONS :
Harmful to aquatic organisms., Prevent material from entering sewers or waterways., If drains, streams, soil or sewers become contaminated, notify local authority.

7. HANDLING AND STORAGE

HANDLING :
Do not take internally. Have emergency equipment (for fires, spills, leaks, etc.) readily available. Ensure all containers are labeled. Do not get in eyes, on skin, on clothing. Use with adequate ventilation. Keep the containers closed when not in use.

STORAGE CONDITIONS :
Store in suitable labeled containers. Store the containers tightly closed. Store separately from oxidizers. Protect product from freezing.

SUITABLE CONSTRUCTION MATERIAL :
Compatibility with Plastic Materials can vary; we therefore recommend that compatibility is tested prior to use.

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

OCCUPATIONAL EXPOSURE LIMITS :
This product does not contain any substance that has an established exposure limit.

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ENGINEERING MEASURES :

General ventilation is recommended. Local exhaust ventilation may be necessary when dusts or mists are generated.

RESPIRATORY PROTECTION :
Where concentrations in air may exceed the limits given in this section or when significant mists, vapors, aerosols, or dusts are generated, an approved air purifying respirator equipped with suitable filter cartridges is recommended. Consult the respirator / cartridge manufacturer data to verify the suitability of specific devices. In event of emergency or planned entry into unknown concentrations a positive pressure, full-facepiece SCBA should be used. If respiratory protection is required, institute a complete respiratory protection program including selection, fit testing, training, maintenance and inspection.

HAND PROTECTION :
When handling this product, the use of chemical gloves is recommended. The choice of work glove depends on work conditions and what chemicals are handled. Please contact the PPE manufacturer for advice on what type of glove material may be suitable. Gloves should be replaced immediately if signs of degradation are observed.

SKIN PROTECTION :
Wear standard protective clothing.

EYE PROTECTION :
Wear chemical splash goggles.

HYGIENE RECOMMENDATIONS :
Use good work and personal hygiene practices to avoid exposure. Keep an eye wash fountain available. Keep a safety shower available. If clothing is contaminated, remove clothing and thoroughly wash the affected area. Launder contaminated clothing before reuse. Always wash thoroughly after handling chemicals. When handling this product never eat, drink or smoke.

HUMAN EXPOSURE CHARACTERIZATION :
Based on our recommended product application and personal protective equipment, the potential human exposure is: Low

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE	Emulsion
APPEARANCE	Opaque Off-white
ODOR	Hydrocarbon
SPECIFIC GRAVITY	1.03 - 1.07 @ 77 °F / 25 °C
DENSITY	8.6 - 9.0 lb/gal
SOLUBILITY IN WATER	Emulsifiable
pH (100 %)	8
VISCOSITY	400 - 1,200 cps @ 77 °F / 25 °C
FREEZING POINT	< -4 °F / < -20 °C
VOC CONTENT	27.4 % EPA Method 24

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Note: These physical properties are typical values for this product and are subject to change

10. STABILITY AND REACTIVITY

STABILITY :
Stable under normal conditions.

HAZARDOUS POLYMERIZATION :
Hazardous polymerization will not occur.

CONDITIONS TO AVOID :
Freezing temperatures. Extremes of temperature

MATERIALS TO AVOID :
Addition of water results in gelling. Contact with strong oxidizers (e.g. chlorine, peroxides, chromates, nitric acid, perchlorate, concentrated oxygen, permanganate) may generate heat, fires, explosions and/or toxic vapors.

HAZARDOUS DECOMPOSITION PRODUCTS :
Under fire conditions: Oxides of carbon, Oxides of nitrogen

11. TOXICOLOGICAL INFORMATION

No toxicity studies have been conducted on this product.

SENSITIZATION :
This product is not expected to be a sensitizer.

CARCINOGENICITY :
None of the substances in this product are listed as carcinogens by the International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP) or the American Conference of Governmental Industrial Hygienists (ACGIH).

HUMAN HAZARD CHARACTERIZATION :
Based on our hazard characterization, the potential human hazard is: Low

12. ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL EFFECTS :

The following results are for the product, unless otherwise indicated.

ACUTE FISH RESULTS :

Species	Exposure	LC50	Test Descriptor
Sheepshead Minnow	96 hrs	> 1,000 mg/l	1% Aqueous Solution of a Similar Product
Rainbow Trout	96 hrs	> 1,000 mg/l	1% Aqueous Solution of a Similar Product
Fathead Minnow	96 hrs	34.3 mg/l	Product
Inland Silverside	96 hrs	52.5 mg/l	Product

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ACUTE INVERTEBRATE RESULTS :

Species	Exposure	LC50	EC50	Test Descriptor
Daphnia magna	48 hrs	280 mg/l		1% Aqueous Solution of Product
Mysid Shrimp (Mysidopsis bahia)	96 hrs	400 mg/l		1% Aqueous Solution of Product
Daphnia magna	48 hrs	0.12 - 0.69 mg/l		Similar product tested in clean water

MOBILITY :
The environmental fate was estimated using a level III fugacity model embedded in the EPI (estimation program interface) Suite TM, provided by the US EPA. The model assumes a steady state condition between the total input and output. The level III model does not require equilibrium between the defined media. The information provided is intended to give the user a general estimate of the environmental fate of this product under the defined conditions of the models.
If released into the environment this material is expected to distribute to the air, water and soil/sediment in the approximate respective percentages;

Air	Water	Soil/Sediment
<5%	10 - 30%	70 - 90%

BIOACCUMULATION POTENTIAL
This preparation or material is not expected to bioaccumulate.

ENVIRONMENTAL HAZARD AND EXPOSURE CHARACTERIZATION
Based on our hazard characterization, the potential environmental hazard is: Moderate
Based on our recommended product application and the product's characteristics, the potential environmental exposure is: Moderate

If released into the environment, see CERCLA/SUPERFUND in Section 15.

13. DISPOSAL CONSIDERATIONS

If this product becomes a waste, it is not a hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, nor is it listed under Subpart D.

As a non-hazardous waste, it is not subject to federal regulation. Consult state or local regulation for any additional handling, treatment or disposal requirements. For disposal, contact a properly licensed waste treatment, storage, disposal or recycling facility.

14. TRANSPORT INFORMATION

The information in this section is for reference only and should not take the place of a shipping paper (bill of lading) specific to an order. Please note that the proper Shipping Name / Hazard Class may vary by packaging, properties, and mode of transportation. Typical Proper Shipping Names for this product are as follows.

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LAND TRANSPORT :

Proper Shipping Name : PRODUCT IS NOT REGULATED DURING

TRANSPORTATION

AIR TRANSPORT (ICAO/IATA) :

Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

MARINE TRANSPORT (IMDG/IMO) :

Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

15. REGULATORY INFORMATION

This section contains additional information that may have relevance to regulatory compliance. The information in this section is for reference only. It is not exhaustive, and should not be relied upon to take the place of an individualized compliance or hazard assessment. Nalco accepts no liability for the use of this information.

NATIONAL REGULATIONS, USA :

OSHA HAZARD COMMUNICATION RULE, 29 CFR 1910.1200 :
Our hazard evaluation has found that this product is not hazardous under 29 CFR 1910.1200.

CERCLA/SUPERFUND, 40 CFR 302 :
Notification of spills of this product is not required.

SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 (TITLE III) - SECTIONS 302, 311, 312, AND 313 :

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355) :
This product does not contain substances listed in Appendix A and B as an Extremely Hazardous Substance.

SECTIONS 311 AND 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS (40 CFR 370) :
Our hazard evaluation has found that this product is not hazardous under 29 CFR 1910.1200.

Under SARA 311 and 312, the EPA has established threshold quantities for the reporting of hazardous chemicals. The current thresholds are: 500 pounds or the threshold planning quantity (TPQ), whichever is lower, for extremely hazardous substances and 10,000 pounds for all other hazardous chemicals.

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372) :
This product does not contain substances on the List of Toxic Chemicals.

TOXIC SUBSTANCES CONTROL ACT (TSCA) :
The substances in this preparation are included on or exempted from the TSCA 8(b) Inventory (40 CFR 710)

FOOD AND DRUG ADMINISTRATION (FDA) Federal Food, Drug and Cosmetic Act :
When use situations necessitate compliance with FDA regulations, this product is acceptable under : 21 CFR 176.170 Components of paper and paperboard in contact with aqueous and fatty foods and 21 CFR 176.180 Components of paper and paperboard in contact with dry foods.

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Limitation: For use as an adjuvant in the manufacture of paper and paperboard in an amount not to exceed that necessary to accomplish the technical effect and not to exceed 2 percent (as polymer) by weight of the paper or paperboard.

NSF INTERNATIONAL :
This product has received NSF/International certification under NSF/ANSI Standard 60 in the coagulation and flocculation category. This product has received NSF/International certification under NSF/ANSI Standard 60 in the Filtration Aid category. The official name is "Polyacrylamide." Maximum product application dosage is : 3 mg/l.

FEDERAL WATER POLLUTION CONTROL ACT, CLEAN WATER ACT, 40 CFR 401.15 / formerly Sec. 307, 40 CFR 116.4 / formerly Sec. 311 :
This product may contain trace levels (<0.1% for carcinogens, <1% all other substances) of the following substance(s) listed under the regulation. Additional components may be unintentionally present at trace levels.

Substance(s)	Citations
• Benzene	Sec. 307, Sec. 311

CLEAN AIR ACT, Sec. 112 (Hazardous Air Pollutants, as amended by 40 CFR 63), Sec. 602 (40 CFR 82, Class I and II Ozone Depleting Substances) :
This product may contain trace levels (<0.1% for carcinogens, <1% all other substances) of the following substance(s) listed under the regulation. Additional components may be unintentionally present at trace levels.

Substance(s)	Citations
• Benzene • Acrylamide	Sec. 112

CALIFORNIA PROPOSITION 65 :
This product contains no listed substances known to the State of California to cause cancer, birth defects or other reproductive harm, at levels, which would require a warning under the statute.

MICHIGAN CRITICAL MATERIALS :
Substances listed under this regulation are not intentionally added or expected to be present in this product. Listed components may be present at trace levels.

STATE RIGHT TO KNOW LAWS :
Substances listed under this regulation are not intentionally added or expected to be present in this product. Listed components may be present at trace levels.

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INTERNATIONAL CHEMICAL CONTROL LAWS :

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CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) :
The substance(s) in this preparation are included in or exempted from the Domestic Substance List (DSL).

AUSTRALIA
All substances in this product comply with the National Industrial Chemicals Notification & Assessment Scheme (NICNAS).

CHINA
All substances in this product comply with the Provisions on the Environmental Administration of New Chemical Substances and are listed on the Inventory of Existing Chemical Substances China (IECSC).

EUROPE
The substances in this preparation have been reviewed for compliance with the EINECS or ELINCS inventories.

JAPAN
All substances in this product comply with the Law Regulating the Manufacture and Importation Of Chemical Substances and are listed on the Existing and New Chemical Substances list (ENCS).

KOREA
All substances in this product comply with the Toxic Chemical Control Law (TCCL) and are listed on the Existing Chemicals List (ECL)

NEW ZEALAND
All substances in this product comply with the Hazardous Substances and New Organisms (HSNO) Act 1996,and are listed on or are exempt from the New Zealand Inventory of Chemicals.

PHILIPPINES
All substances in this product comply with the Republic Act 6969 (RA 6969) and are listed on the Philippines Inventory of Chemicals & Chemical Substances (PICCS).

16. OTHER INFORMATION

Due to our commitment to Product Stewardship, we have evaluated the human and environmental hazards and exposures of this product. Based on our recommended use of this product, we have characterized the product's general risk. This information should provide assistance for your own risk management practices. We have evaluated our product's risk as follows:

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* The human risk is: Low

* The environmental risk is: Moderate

Any use inconsistent with our recommendations may affect the risk characterization. Our sales representative will assist you to determine if your product application is consistent with our recommendations. Together we can implement an appropriate risk management process.

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access to this information. For any other uses, exposures should

be evaluated so that appropriate handling practices and training programs can be established to insure safe workplace operations. Please consult your local sales representative for any further information.

REFERENCES

Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, OH., (Ariel Insight™ CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Hazardous Substances Data Bank, National Library of Medicine, Bethesda, Maryland (TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Geneva: World Health Organization, International Agency for Research on Cancer.

Integrated Risk Information System, U.S. Environmental Protection Agency, Washington, D.C. (TOMES CPS™ CD-ROM Version),
Micromedex, Inc., Englewood, CO.

Annual Report on Carcinogens, National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service.

Title 29 Code of Federal Regulations, Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA), (Ariel Insight™ CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Registry of Toxic Effects of Chemical Substances, National Institute for Occupational Safety and Health, Cincinnati, OH,
(TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

Ariel Insight™ (An integrated guide to industrial chemicals covered under major regulatory and advisory programs), North American Module, Western European Module, Chemical Inventories Module and the Generics Module (Ariel Insight™ CD-ROM Version), Ariel Research Corp., Bethesda, MD.

The Teratogen Information System, University of Washington, Seattle, WA (TOMES CPS™ CD-ROM Version), Micromedex, Inc., Englewood, CO.

Prepared By : Product Safety Department
Date issued : 04/14/2011
Version Number : 1.24

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DETERMINATION OF THE PRESENCE OF POLYMER USING THE FLOCCULATION METHOD

1. PURPOSE

The purpose of this method is to provide a means of qualitatively determining the presence of a flocculent or coagulant within a solution, water sample, etc. Additionally, in cases where the polymer present within a sample is known, this method can be tentatively used as a quantitative measure.

2. PRINCIPLE

Slurry of kaolin clay is very easily flocculated or coagulated when either a flocculent or a coagulant is present. Therefore, for qualitative purposes, the sample being tested is mixed with kaolin clay slurry, and the effects are visually assessed by comparison to a blank. If polymer is present, significant coagulation or flocculation will be seen from the sample being tested as compared to that seen in the blank.

These principles can also be applied to the quantification of the concentration of polymer present within a sample. However, the exact product present within the sample must be known, and the water used to prepare all solutions must be similar in pH, hardness, etc. to the water present in the sample being tested. Standard solutions containing the known product are prepared at different concentrations. Each solution is then mixed with a kaolin clay slurry, and the settlement time of each is measured. A curve and the equation of the curve are then generated from the obtained results, the settlement time of the unknown sample is measured, and the concentration of the specific product in the unknown sample is calculated by substitution into the obtained equation.

3. PROCEDURE DESCRIPTION

3.1 Hazards and Safety Precautions

The information provided below is not a substitute for the MSDS but is supplementary to it. All users must have read and be familiar with the appropriate manufacturer's MSDS before using the chemicals listed below.

All unknown water samples and polymer solutions should be considered irritants to the skin and eyes.

Contact with calcium chloride powder may cause irritation to the skin, eyes, or respiratory tract.

General laboratory safety procedures should be followed.

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3.2 Apparatus and Reagents

Apparatus	Reagents
General Apparatus: 1) 100 mL Glass Mixing Cylinders with Stoppers 2) Syringes (as appropriate) 3) Three Place Top Loading Balance 4) Bottles with Caps (as appropriate) **Additional Apparatus Required for Quantification Procedure:** 1) Stopwatch 2) Graduated Cylinders [200 mL and 50 mL] 3) 400 mL Glass Beakers (2)	1) ACS Grade Calcium Chloride 2) Laboratory Grade Kaolin Clay

3.3 Procedures

Preparation of the Clay Slurry

1. Preparation of a 1% Calcium Chloride Solution

   a. Determine how much 1% calcium chloride will be needed to perform the required testing. Please note that approximately 1.7 mL of a 1% calcium chloride solution is required for each test.
   b. Calculate the required weight of calcium chloride needed to obtain the desired weight of 1% calcium chloride solution using the equation below.

$$W_1 = \frac{W_2 \ x \ C_2}{C_1}$$

   Where:
   W_1 = Weight of Calcium Chloride Required to Prepare the Solution (g)
   C_1 = Concentration of the Calcium Chloride Being Used (%)
   W_2 = Desired Weight of 1% Calcium Chloride Solution (g)
   C_2 = Concentration of Calcium Chloride Solution Required (1%)

   c. Tare an appropriately sized bottle on a three place top loading balance.
   d. Accurately weigh out the calculated weight of calcium chloride required into the tared bottle. The accuracy of this weight should be ±0.002 g. Add deionized water to the bottle to achieve the desired final solution weight. For example, if 100 g of 1% calcium chloride solution is desired, add 1.000 g of pure calcium chloride to a tared bottle, and add deionized water to achieve a final weight of 100.000 g.

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2. Preparation of the Clay Slurry

a. Determine how much clay slurry will be needed to perform the required testing. Please note that 5 mL of slurry is needed for each test.
b. Tare an appropriately sized bottle on a three place top loading balance.
c. Into the tared bottle, weigh out 1 parts laboratory grade Kaolin clay and 3 part 1% calcium chloride solution.
d. Cap the bottle, and shake vigorously until the contents are homogeneous.

Qualitative Determination of the Presence of Polymer in a Sample

1. Perform a blank as follows. To a 100 mL glass mixing cylinder, add 5 mL of the previously prepared clay slurry and 90 mL of water. Please note that the water used for this blank should be similar in quality to the water present in the sample which is to be tested with regard to hardness, pH, etc.

2. To a second 100 mL glass mixing cylinder, add 5 mL of the previously prepared clay slurry and 90 mL of the sample being tested.

3. Invert both cylinders three times, and visually assess whether flocculation or coagulation has occurred in the sample being tested by comparing the settlement rate and floc size of the clay in the sample cylinder to the settlement rate and floc size of the clay in the blank sample. Record observations.

Quantitative Determination of the Presence of a Specific Product in a Sample

1. A quantitative determination of the presence of polymer in a sample can only be performed with any accuracy in cases where the exact product present within a sample is known and when the quality of the water being used to prepare all solutions does not vary significantly from the quality of the water sample being tested.

2. Obtain a sample of the product which is known to be present within the sample to be tested.

3. For Liquid Dispersion or Emulsion Grade Products – Prepare a 0.5% standard stock solution using a sample of the product known to be present and water which is similar in quality to the water present in the sample to be tested.

   a. Measure 200 mL of sample water in a graduated cylinder.
   b. With a 1 mL syringe measure 1 mL of the product know to be present.
   c. Cap the cylinder and mix vigorously for two minutes.

4. Prepare a series of standard solutions with various ppm from the stock solution.

5. Measure the settlement time of each solution.

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a. To a 50 mL glass graduated cylinder with topper, add 5 mL of the previously prepared clay slurry and 90 mL of the sample with a predetermined ppm.
b. Invert the cylinder three times, and using a stopwatch, measure the time taken for the mudline formed by the flocculated clay to travel from the 50 mL mark on the cylinder to the 40 mL mark on the cylinder. The stopwatch is to be started after the third inversion and stopped when the mudline reaches the 40 mL. This constitutes the settlement time, in seconds, given by the know ppm standard.
c. Repeat Steps a and b for the various known ppm standard, and for the water sample being tested.

6. Determine the quantity of the specific product in the sample being tested.

a. Using the obtained settlement times for the standards, plot a graph of settlement time vs. concentration.
b. Fit this data with the best fit curve, and obtain the equation of the generated curve from the software.
c. Substitute the obtained settlement time from the unknown sample for Y in the obtained equation. Solve this equation for X. The resulting value obtained for X is the concentration of the specific product, in mg/L, within the sample.

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SAFETY DATA SHEET

PRODUCT

ULTRION® 8187

EMERGENCY TELEPHONE NUMBER(S)
(800) 424-9300 (24 Hours) CHEMTREC

1. CHEMICAL PRODUCT AND COMPANY IDENTIFICATION

PRODUCT NAME :	**ULTRION® 8187**
APPLICATION :	WATER CLARIFICATION AID
COMPANY IDENTIFICATION :	Nalco Company 1601 W. Diehl Road Naperville, Illinois 60563-1198
EMERGENCY TELEPHONE NUMBER(S) :	(800) 424-9300 (24 Hours) CHEMTREC

NFPA 704M/HMIS RATING
HEALTH : 2 / 2 FLAMMABILITY : 0 / 0 INSTABILITY : 0 / 0 OTHER :
0 = Insignificant 1 = Slight 2 = Moderate 3 = High 4 = Extreme * = Chronic Health Hazard

2. COMPOSITION/INFORMATION ON INGREDIENTS

Our hazard evaluation has identified the following chemical substance(s) as hazardous. Consult Section 15 for the nature of the hazard(s).

Hazardous Substance(s)	CAS NO	% (w/w)
Aluminum Chloride Hydroxide	12042-91-0	30.0 - 60.0

3. HAZARDS IDENTIFICATION

****EMERGENCY OVERVIEW****

WARNING
Irritating to eyes.
Do not get in eyes, on skin, on clothing. Do not take internally. Use with adequate ventilation. In case of contact with eyes, rinse immediately with plenty of water and seek medical advice. After contact with skin, wash immediately with plenty of water.
Wear suitable protective clothing.
Not flammable or combustible. May evolve HCl under fire conditions.

PRIMARY ROUTES OF EXPOSURE :
Eye, Skin, Inhalation

HUMAN HEALTH HAZARDS - ACUTE :

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EYE CONTACT :
Can cause moderate irritation.

SKIN CONTACT :
May cause irritation with prolonged contact.

INGESTION :
Not a likely route of exposure. May cause mucosal damage.

INHALATION :
Not a likely route of exposure. May cause irritation of mucous membranes.

SYMPTOMS OF EXPOSURE :
Acute :
A review of available data does not identify any symptoms from exposure not previously mentioned.
Chronic :
A review of available data does not identify any symptoms from exposure not previously mentioned.

AGGRAVATION OF EXISTING CONDITIONS :
A review of available data does not identify any worsening of existing conditions.

HUMAN HEALTH HAZARDS - CHRONIC :
No adverse effects expected other than those mentioned above.

4. FIRST AID MEASURES

EYE CONTACT :
Immediately flush eye with water for at least 15 minutes while holding eyelids open. Get medical attention.

SKIN CONTACT :
Remove contaminated clothing. Wash off affected area immediately with plenty of water. If symptoms develop, seek medical advice.

INGESTION :
Do not induce vomiting without medical advice. If conscious, washout mouth and give water to drink. Get medical attention.

INHALATION :
Remove to fresh air, treat symptomatically. If symptoms develop, seek medical advice.

NOTE TO PHYSICIAN :
Based on the individual reactions of the patient, the physician's judgement should be used to control symptoms and clinical condition.

5. FIRE FIGHTING MEASURES

FLASH POINT : None

EXTINGUISHING MEDIA :
Not expected to burn. Use extinguishing media appropriate for surrounding fire. Keep containers cool by spraying with water.

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FIRE AND EXPLOSION HAZARD :
Not flammable or combustible. May evolve HCl under fire conditions.

SPECIAL PROTECTIVE EQUIPMENT FOR FIRE FIGHTING :
In case of fire, wear a full face positive-pressure self contained breathing apparatus and protective suit.

6. ACCIDENTAL RELEASE MEASURES

PERSONAL PRECAUTIONS :
Restrict access to area as appropriate until clean-up operations are complete. Use personal protective equipment recommended in Section 8 (Exposure Controls/Personal Protection). Stop or reduce any leaks if it is safe to do so. Ventilate spill area if possible. Ensure clean-up is conducted by trained personnel only. Do not touch spilled material. Have emergency equipment (for fires, spills, leaks, etc.) readily available. Notify appropriate government, occupational health and safety and environmental authorities.

METHODS FOR CLEANING UP :
SMALL SPILLS: Soak up spill with absorbent material. Place residues in a suitable, covered, properly labeled container. Wash affected area. LARGE SPILLS: Contain liquid using absorbent material, by digging trenches or by diking. Reclaim into recovery or salvage drums or tank truck for proper disposal. Wash site of spillage thoroughly with water. Contact an approved waste hauler for disposal of contaminated recovered material. Dispose of material in compliance with regulations indicated in Section 13 (Disposal Considerations).

ENVIRONMENTAL PRECAUTIONS :
Do not contaminate surface water.

7. HANDLING AND STORAGE

HANDLING :
Do not get in eyes, on skin, on clothing. Do not take internally. Use with adequate ventilation. Do not breathe vapors/gases/dust. Keep the containers closed when not in use. Have emergency equipment (for fires, spills, leaks, etc.) readily available. Ensure all containers are labeled. Use personal protective equipment recommended in Section 8 (Exposure Controls/Personal Protection).

STORAGE CONDITIONS :
Store the containers tightly closed. Store separately from bases.

SUITABLE CONSTRUCTION MATERIAL :
PVC, Buna-N, Polyurethane, Polypropylene, Polyethylene, Viton, HDPE (high density polyethylene), 100% phenolic resin liner

UNSUITABLE CONSTRUCTION MATERIAL :
Brass, Hypalon, Stainless Steel 304, EPDM, Mild steel, Stainless Steel 316L, Neoprene, Epoxy phenolic resin

8. EXPOSURE CONTROLS/PERSONAL PROTECTION

OCCUPATIONAL EXPOSURE LIMITS :
Exposure guidelines have not been established for this product. Available exposure limits for the substance(s) are shown below.

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Country/Source	Substance(s)	Category:	ppm	mg/m3

ENGINEERING MEASURES :
General ventilation is recommended.

RESPIRATORY PROTECTION :
Due to its low volatility and toxicity, the hazard potential associated with this material is relatively low. Respiratory protection is not normally needed.

HAND PROTECTION :
When handling this product, the use of chemical gloves is recommended. The choice of work glove depends on work conditions and what chemicals are handled. Please contact the PPE manufacturer for advice on what type of glove material may be suitable. Gloves should be replaced immediately if signs of degradation are observed.

SKIN PROTECTION :
Wear standard protective clothing.

EYE PROTECTION :
Wear chemical splash goggles.

HYGIENE RECOMMENDATIONS :
Use good work and personal hygiene practices to avoid exposure. Keep an eye wash fountain available. Keep a safety shower available. If clothing is contaminated, remove clothing and thoroughly wash the affected area. Launder contaminated clothing before reuse. Always wash thoroughly after handling chemicals. When handling this product never eat, drink or smoke.

HUMAN EXPOSURE CHARACTERIZATION :
Based on our recommended product application and personal protective equipment, the potential human exposure is: Low

9. PHYSICAL AND CHEMICAL PROPERTIES

PHYSICAL STATE	Liquid
APPEARANCE	Colorless
ODOR	None

SPECIFIC GRAVITY	1.34 @ 77 °F / 25 °C
DENSITY	11.1 lb/gal
SOLUBILITY IN WATER	Complete
pH (100 %)	3.5
FREEZING POINT	32 °F / 0 °C
BOILING POINT	219.2 °F / 104 °C
VAPOR PRESSURE	Same as water
VOC CONTENT	0.00 % EPA Method 24

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Note: These physical properties are typical values for this product and are subject to change.

10. STABILITY AND REACTIVITY

STABILITY :
Stable under normal conditions.

HAZARDOUS POLYMERIZATION :
Hazardous polymerization will not occur.

CONDITIONS TO AVOID :
Avoid extremes of temperature.

MATERIALS TO AVOID :
Strong Bases

HAZARDOUS DECOMPOSITION PRODUCTS :
Under fire conditions: HCl

11. TOXICOLOGICAL INFORMATION

No toxicity studies have been conducted on this product.

SENSITIZATION :
This product is not expected to be a sensitizer.

CARCINOGENICITY :
None of the substances in this product are listed as carcinogens by the International Agency for Research on Cancer (IARC), the National Toxicology Program (NTP) or the American Conference of Governmental Industrial Hygienists (ACGIH).

HUMAN HAZARD CHARACTERIZATION :
Based on our hazard characterization, the potential human hazard is: Low

12. ECOLOGICAL INFORMATION

ECOTOXICOLOGICAL EFFECTS :

The following results are for the product.

ACUTE FISH RESULTS :

Species	Exposure	LC50	Test Descriptor
Inland Silverside	96 hrs	> 5,000 mg/l	Product
Rainbow Trout	96 hrs	590 mg/l	Product
Fathead Minnow	96 hrs	1,094 mg/l	Product

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ACUTE INVERTEBRATE RESULTS :

Species	Exposure	LC50	EC50	Test Descriptor
Daphnia magna	48 hrs	> 5,000 mg/l		Product
Mysid Shrimp (Mysidopsis bahia)	96 hrs	4,773 mg/l		Product
Ceriodaphnia dubia	48 hrs	> 5,000 mg/l		Product

CHRONIC INVERTEBRATE RESULTS :

Species	Test Type	NOEC / LOEC	End Point	Test Descriptor
Ceriodaphnia dubia		15 mg/l / 30 mg/l	Reproduction	Product

PERSISTENCY AND DEGRADATION :

Total Organic Carbon (TOC) : 99 mg/l

Chemical Oxygen Demand (COD) : 490 mg/l

Biological Oxygen Demand (BOD) :

Incubation Period	Value	Test Descriptor
5 d	< 14 mg/l	Product

Greater than 95% of this product consists of inorganic substances for which a biodegradation value is not applicable.

MOBILITY :
The environmental fate was estimated using a level III fugacity model embedded in the EPI (estimation program interface) Suite TM, provided by the US EPA. The model assumes a steady state condition between the total input and output. The level III model does not require equilibrium between the defined media. The information provided is intended to give the user a general estimate of the environmental fate of this product under the defined conditions of the models.
If released into the environment this material is expected to distribute to the air, water and soil/sediment in the approximate respective percentages;

Air	Water	Soil/Sediment
<5%	30 - 50%	50 - 70%

The portion in water is expected to be soluble or dispersible.

BIOACCUMULATION POTENTIAL
This preparation or material is not expected to bioaccumulate.

ENVIRONMENTAL HAZARD AND EXPOSURE CHARACTERIZATION
Based on our hazard characterization, the potential environmental hazard is: Low
Based on our recommended product application and the product's characteristics, the potential environmental exposure is: Low

If released into the environment, see CERCLA/SUPERFUND in Section 15.

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13. DISPOSAL CONSIDERATIONS

If this product becomes a waste, it is not a hazardous waste as defined by the Resource Conservation and Recovery Act (RCRA) 40 CFR 261, since it does not have the characteristics of Subpart C, nor is it listed under Subpart D.

As a non-hazardous waste, it is not subject to federal regulation. Consult state or local regulation for any additional handling, treatment or disposal requirements. For disposal, contact a properly licensed waste treatment, storage, disposal or recycling facility.

14. TRANSPORT INFORMATION

The information in this section is for reference only and should not take the place of a shipping paper (bill of lading) specific to an order. Please note that the proper Shipping Name / Hazard Class may vary by packaging, properties, and mode of transportation. Typical Proper Shipping Names for this product are as follows.

LAND TRANSPORT :

Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

AIR TRANSPORT (ICAO/IATA) :

Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

MARINE TRANSPORT (IMDG/IMO) :

Proper Shipping Name : PRODUCT IS NOT REGULATED DURING TRANSPORTATION

15. REGULATORY INFORMATION

This section contains additional information that may have relevance to regulatory compliance. The information in this section is for reference only. It is not exhaustive, and should not be relied upon to take the place of an individualized compliance or hazard assessment. Nalco accepts no liability for the use of this information.

NATIONAL REGULATIONS, USA :

OSHA HAZARD COMMUNICATION RULE, 29 CFR 1910.1200 :
Based on our hazard evaluation, the following substance(s) in this product is/are hazardous and the reason(s) is/are shown below.

Aluminum Chloride Hydroxide : Eye irritant

CERCLA/SUPERFUND, 40 CFR 117, 302 :
Notification of spills of this product is not required.

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SARA/SUPERFUND AMENDMENTS AND REAUTHORIZATION ACT OF 1986 (TITLE III) - SECTIONS 302, 311, 312, AND 313 :

SECTION 302 - EXTREMELY HAZARDOUS SUBSTANCES (40 CFR 355) :
This product does not contain substances listed in Appendix A and B as an Extremely Hazardous Substance.

SECTIONS 311 AND 312 - MATERIAL SAFETY DATA SHEET REQUIREMENTS (40 CFR 370) :
Our hazard evaluation has found this product to be hazardous. The product should be reported under the following indicated EPA hazard categories:

X	Immediate (Acute) Health Hazard
-	Delayed (Chronic) Health Hazard
-	Fire Hazard
-	Sudden Release of Pressure Hazard
-	Reactive Hazard

Under SARA 311 and 312, the EPA has established threshold quantities for the reporting of hazardous chemicals. The current thresholds are: 500 pounds or the threshold planning quantity (TPQ), whichever is lower, for extremely hazardous substances and 10,000 pounds for all other hazardous chemicals.

SECTION 313 - LIST OF TOXIC CHEMICALS (40 CFR 372) :
This product does not contain substances on the List of Toxic Chemicals.

TOXIC SUBSTANCES CONTROL ACT (TSCA) :
The substances in this preparation are included on or exempted from the TSCA 8(b) Inventory (40 CFR 710)

FOOD AND DRUG ADMINISTRATION (FDA) Federal Food, Drug and Cosmetic Act :
When use situations necessitate compliance with FDA regulations, this product is acceptable under : 21 CFR 176.170 Components of paper and paperboard in contact with aqueous and fatty foods and 21 CFR 176.180 Components of paper and paperboard in contact with dry foods.

Product must be used at a pH above 5.5 to retain its FDA status. Limitations: no more than required to produce intended technical effect.

This product has been certified as KOSHER/PAREVE for year-round use INCLUDING THE PASSOVER SEASON by the CHICAGO RABBINICAL COUNCIL.

NSF INTERNATIONAL :
This product has received NSF/International certification under NSF/ANSI Standard 60 in the coagulation and flocculation category. The official name is "Polyaluminum Chloride." Maximum product application dosage is : 180 mg/l.

FEDERAL WATER POLLUTION CONTROL ACT, CLEAN WATER ACT, 40 CFR 401.15 / formerly Sec. 307, 40 CFR 116.4 / formerly Sec. 311 :
Substances listed under this regulation are not intentionally added or expected to be present in this product. Listed components may be present at trace levels.

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CLEAN AIR ACT, Sec. 112 (40 CFR 61, Hazardous Air Pollutants), Sec. 602 (40 CFR 82, Class I and II Ozone Depleting Substances) :
Substances listed under this regulation are not intentionally added or expected to be present in this product. Listed components may be present at trace levels.

CALIFORNIA PROPOSITION 65 :
Substances listed under California Proposition 65 are not intentionally added or expected to be present in this product.

MICHIGAN CRITICAL MATERIALS :
Substances listed under this regulation are not intentionally added or expected to be present in this product. Listed components may be present at trace levels.

STATE RIGHT TO KNOW LAWS :
Substances listed under this regulation are not intentionally added or expected to be present in this product. Listed components may be present at trace levels.

NATIONAL REGULATIONS, CANADA :

WORKPLACE HAZARDOUS MATERIALS INFORMATION SYSTEM (WHMIS) :
This product has been classified in accordance with the hazard criteria of the Controlled Products Regulations (CPR) and the MSDS contains all the information required by the CPR.

WHMIS CLASSIFICATION :
D2B - Materials Causing Other Toxic Effects - Toxic Material

CANADIAN ENVIRONMENTAL PROTECTION ACT (CEPA) :
The substance(s) in this preparation are included in or exempted from the Domestic Substance List (DSL).

AUSTRALIA
All substances in this product comply with the National Industrial Chemicals Notification & Assessment Scheme (NICNAS).

CHINA
All substances in this product comply with the Provisions on the Environmental Administration of New Chemical Substances and are listed on the Inventory of Existing Chemical Substances China (IECSC).

EUROPE
The substances in this preparation have been reviewed for compliance with the EINECS or ELINCS inventories.

JAPAN
This product contains substance(s) which are not in compliance with the Law Regulating the Manufacture and Importation Of Chemical Substances and are not listed on the Existing and New Chemical Substances list (ENCS).

KOREA
All substances in this product comply with the Toxic Chemical Control Law (TCCL) and are listed on the Existing Chemicals List (ECL)

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PHILIPPINES
All substances in this product comply with the Republic Act 6969 (RA 6969) and are listed on the Philippines Inventory of Chemicals & Chemical Substances (PICCS).

16. OTHER INFORMATION

Due to our commitment to Product Stewardship, we have evaluated the human and environmental hazards and exposures of this product. Based on our recommended use of this product, we have characterized the product's general risk. This information should provide assistance for your own risk management practices. We have evaluated our product's risk as follows:

* The human risk is: Low

* The environmental risk is: Low

Any use inconsistent with our recommendations may affect the risk characterization. Our sales representative will assist you to determine if your product application is consistent with our recommendations. Together we can implement an appropriate risk management process.

This product material safety data sheet provides health and safety information. The product is to be used in applications consistent with our product literature. Individuals handling this product should be informed of the recommended safety precautions and should have access to this information. For any other uses, exposures should be evaluated so that appropriate handling practices and training programs can be established to insure safe workplace operations. Please consult your local sales representative for any further information.

REFERENCES

Threshold Limit Values for Chemical Substances and Physical Agents and Biological Exposure Indices, American Conference of Governmental Industrial Hygienists, OH., (Ariel Insight CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Hazardous Substances Data Bank, National Library of Medicine, Bethesda, Maryland (TOMES CPS CD-ROM Version), Micromedex, Inc., Englewood, CO.

IARC Monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Man, Geneva: World Health Organization, International Agency for Research on Cancer.

Integrated Risk Information System, U.S. Environmental Protection Agency, Washington, D.C. (TOMES CPS CD-ROM Version), Micromedex, Inc., Englewood, CO.

Annual Report on Carcinogens, National Toxicology Program, U.S. Department of Health and Human Services, Public Health Service.

Title 29 Code of Federal Regulations, Part 1910, Subpart Z, Toxic and Hazardous Substances, Occupational Safety and Health Administration (OSHA), (Ariel Insight CD-ROM Version), Ariel Research Corp., Bethesda, MD.

Registry of Toxic Effects of Chemical Substances, National Institute for Occupational Safety and Health, Cincinnati, OH, (TOMES CPS CD-ROM Version), Micromedex, Inc., Englewood, CO.

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Ariel Insight (An integrated guide to industrial chemicals covered under major regulatory and advisory programs), North American Module, Western European Module, Chemical Inventories Module and the Generics Module (Ariel Insight CD-ROM Version), Ariel Research Corp., Bethesda, MD.

The Teratogen Information System, University of Washington, Seattle, WA (TOMES CPS CD-ROM Version), Micromedex, Inc., Englewood, CO.

Prepared By : Product Safety Department
Date issued : 07/31/2009
Version Number : 3.0

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THE DETERMINATION OF THE PRESENCE OF ALUMINUM.

- Crandall Canyon Mine - Done monthly as a grab sample and brought to the SGS Lab for Lab results. SGS has already been running aluminum tests on the UPDES samples, therefore UEI does not need to do another monthly test for **Coagulant Ultrion 8187** because it is taken care of in the while sampling UPDES #002.

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APPENDIX 7-71

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PETERSEN HYDROLOGIC

11 May 2012

Mr. David Hibbs
Genwal Resources, Inc.
P.O. Box 1077
East Carbon, Utah 84501

RE: Stable and unstable isotopic compositions of Crandall Canyon Mine discharge water (UPDES 002 pre-treatment)

David,

At your request, we have performed an investigation of stable and unstable isotopic compositions of mine discharge water from the Genwal Resources, Inc. Crandall Canyon Mine. The results of this investigation are presented in this letter report.

Introduction

The Crandall Canyon Mine is located in Huntington Canyon, approximately 15 miles northwest of the town of Huntington, Utah (Figure 1). Mining operations began in 1984 and continued until 2007. Beginning in 1996, sufficient groundwater began to be encountered in the underground mine workings such that it became necessary to pump water from the mine on a nearly continuous basis. In September 2007 the mine pumps were decommissioned and discharge of pumped water from the mine ceased. Beginning in early 2008, gravity discharge of water from the Crandall Canyon Mine portals began to occur. The gravity discharge from the Crandall Canyon Mine portal is the water sampled in this investigation.

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2695 N. 600 E. LEHI, UTAH 84043 (801) 766-4006

Methods of Study

On 18 October 2011, we visited the Crandall Canyon Mine to collect samples of mine discharge water for stable and unstable isotopic analysis. The sampling location is identified as site UPDES 002 pre-treatment. This water represents raw, untreated mine discharge water flowing from the HDPE discharge pipe into the adjacent mine surface facility.

Mine water samples were collected for solute chemical analysis (for use in geochemical modeling) and for unstable radiocarbon (^{14}C) and tritium (^{3}H) analysis, and for the stable isotopes deuterium ($\delta^{2}H$), oxygen-18 ($\delta^{18}O$), and carbon-13 ($\delta^{13}C$). Radiocarbon, tritium, deuterium, oxygen-18, and carbon-13 analyses were performed at the Brigham Young University Laboratory of Isotope Geochemistry of Provo, Utah. A split of the sampled water was sent to the University of Miami, Tritium Laboratory in Miami, Florida for replicate tritium analysis. Solute chemical analyses were performed by SGS Minerals Services of Huntington, Utah.

Mean groundwater residence times were calculated using methods described by Fontes (1979), and Pearson (1972). Input parameters used in the mean residence time calculations were assigned as follows: $\delta^{13}C$ soil gas -18 to -22 ‰, $\delta^{13}C$ mineral carbonate 0 ‰, ^{14}C soil gas 100 percent modern carbon (pmC), and ^{14}C mineral carbonate 0 pmC.

The mine water discharge rate was measured using a Marsh-McBirney brand electromagnetic current-velocity meter and wading rod. Temperature was measured using a Taylor brand digital thermometer. The specific conductance was measured using an Extech brand model EC400 conductivity meter with automatic temperature compensation. The instrument was calibrated using NIST traceable conductivity standard solutions. The pH Measurement was performed using an Oakton brand model pH Testr 30 with automatic temperature compensation, which was calibrated using NIST traceable pH standard solutions. The dissolved oxygen measurement was performed using a YSI brand Model 55 dissolved oxygen meter, which was calibrated using atmospheric oxygen calibration methods.

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Results

The results of the laboratory stable and unstable isotopic measurements are presented in Table 1. Calculated groundwater mean residence times are presented in Table 2. Isotopic and solute laboratory reporting sheets are included in the Appendix.

Radiocarbon (^{14}C)

The measured ^{14}C content of the sampled UPDES 002 pre-treatment water is 13.52 +/- 0.07 pmC (percent modern carbon). The modeled radiocarbon age of the water (depending on the model used and the $\delta^{13}C_{(gas)}$ assumption) ranges from 12,050 to 15,000 years. In evaluating radiocarbon ages of groundwaters, it is important to consider that groundwaters rarely travel from recharge areas to discharge areas via pure piston flow. Rather, it is not uncommon for groundwaters arriving at a well or spring sampling location to have recharged at different times and different locations. Accordingly, it is best to think of a groundwater radiocarbon "age" as the "mean residence time" of all of the water molecules present in the collected sample.

Tritium (^{3}H)

The measured tritium content of the sampled UPDES 002 pre-treatment water is 2.0 +/- 0.1 TU.

The presence of measurable tritium in the sampled water indicates the presence of a component of recharge that is less than about 50 years old.

Deuterium ($\delta^{2}H$) and oxygen-18 ($\delta^{18}O$)

The measured deuterium composition of the sampled UPDES 002 water is -130.7 ‰ +/- 0.5 ‰ (VSMOW). The measured oxygen-18 composition is -18.05 ‰ +/- 0.20 ‰ (VSMOW).

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Discussion

Taken together, the very old radiocarbon age (>12,000 years) and the presence of measureable tritium (2 TU) in the sampled water are indicative of a mixed source for the mine discharge water. The very low measured ^{14}C activity (13.52 pmC) suggests that the bulk of the sampled water is likely from a source that recharged many thousands of years ago. The presence of measurable tritium indicates that there is also some component of modern water present.

Because the tritium content of the modern recharge component is not known, it is not possible to quantitatively determine the relative proportions of the ancient and modern components of the groundwater. However, based on reported typical tritium contents of streams and springs discharging from shallow, active groundwater systems in the region, some general assumptions can be made. Mayo and Associates (1997) report tritium contents for springs and creeks in the vicinity of the Crandall Canyon Mine ranging from 9.3 to 38.2 TU. Mayo and others (2003) report that shallow active-zone groundwaters in the Wasatch Plateau and Book Cliffs coal districts of Utah contain appreciable amounts tritium (mostly in the range of about 6 to 22 TU – refer to Mayo Figure 12). Based on these assumptions (and assuming a 0 TU tritium content for the old component), it would follow that for a mixed water to have a tritium content of 2.0 TU, the amount of the modern contribution would be modest.

A plot of historic stable isotopic deuterium and oxygen-18 compositions at the Crandall Canyon Mine is presented in Figure 2 (See Mayo and Associates, 1997 for historic sampling locations and isotopic compositions). Also plotted on Figure 2 is the UPDES 002 pre-treatment water. Waters plotting near the global meteoric water line ($\delta^2H = 8\ \delta^{18}O + 10$) are indicative of waters originating from meteoric sources. Plots of deuterium and oxygen-18 compositions of groundwaters are often used to differentiate waters that recharged at different locations and/or under different climatic conditions. Using this isotopic technique it is also often possible to distinguish paleogroundwaters that recharged during cooler climatic conditions (such as the late Pleistocene time in North America or Europe) from waters that are more recent in origin. Such paleogroundwaters

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will be depleted with respect to modern waters and will be shifted along the meteoric water line towards the more negative values (Clark and Fritz, 1997). This pattern is apparent in the plot of Crandall Canyon Mine waters shown in Figure 2. This suggests that the groundwaters intercepted in the Crandall Canyon Mine (including UPDES 002 pre-treatment) may largely represent paleorecharge. The disparate plotting locations for the underground and surface samples strongly suggest different recharge origins for these two water types.

References Cited

Clark, I.D., and Fritz, P., 1997, Environmental isotopes in Hydrogeology, CRC Press, LLC, Boca Raton, Florida, 328 p.

Fontes, J.C., and Garnier, J.M., 1979, Determination of the initial ^{14}C activity of the total dissolved carbon: A review of existing models and a new approach: Water Resources Research, v. 15, p. 399-413.

Mayo, A.L., Thomas, H.M., Peltier, S., Petersen, E.C., Payne, K., Holman, L.S., Tingey, D., Fogel, T., Black, B.J., Gibbs, T.D., 2003, Active and inactive groundwater flow systems: Evidence from a stratified, mountainous terrain, Geological Society of America Bulletin, V. 115; no. 12; p. 1456-1472.

Mayo and Associates, 1997, Summary of new isotopic information for LBA 11, consulting report for Genwal Resources, Inc., Huntington, Utah.

Pearson, F.J., Jr., Bedinger, M.S., and Jones, B.F., 1972, Carbon-14 dates of water from Arkansas Hot springs, in Proceeding of eighth international conference on radiocarbon dating: Wellington, Royal Society of New Zealand, v. 1. P. 330-247.

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Please feel free to contact me should you have any questions in this regard.

Sincerely,

LICENSED PROFESSIONAL GEOLOGIST
ERIK CARL PETERSEN
No. 5373615-2250
STATE OF UTAH

Erik C. Petersen, P.G.
Principal Hydrogeologist
Utah PG #5373615-2250

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Figure 1 Location of the Genwal Resources, Inc. Crandall Canyon Mine.

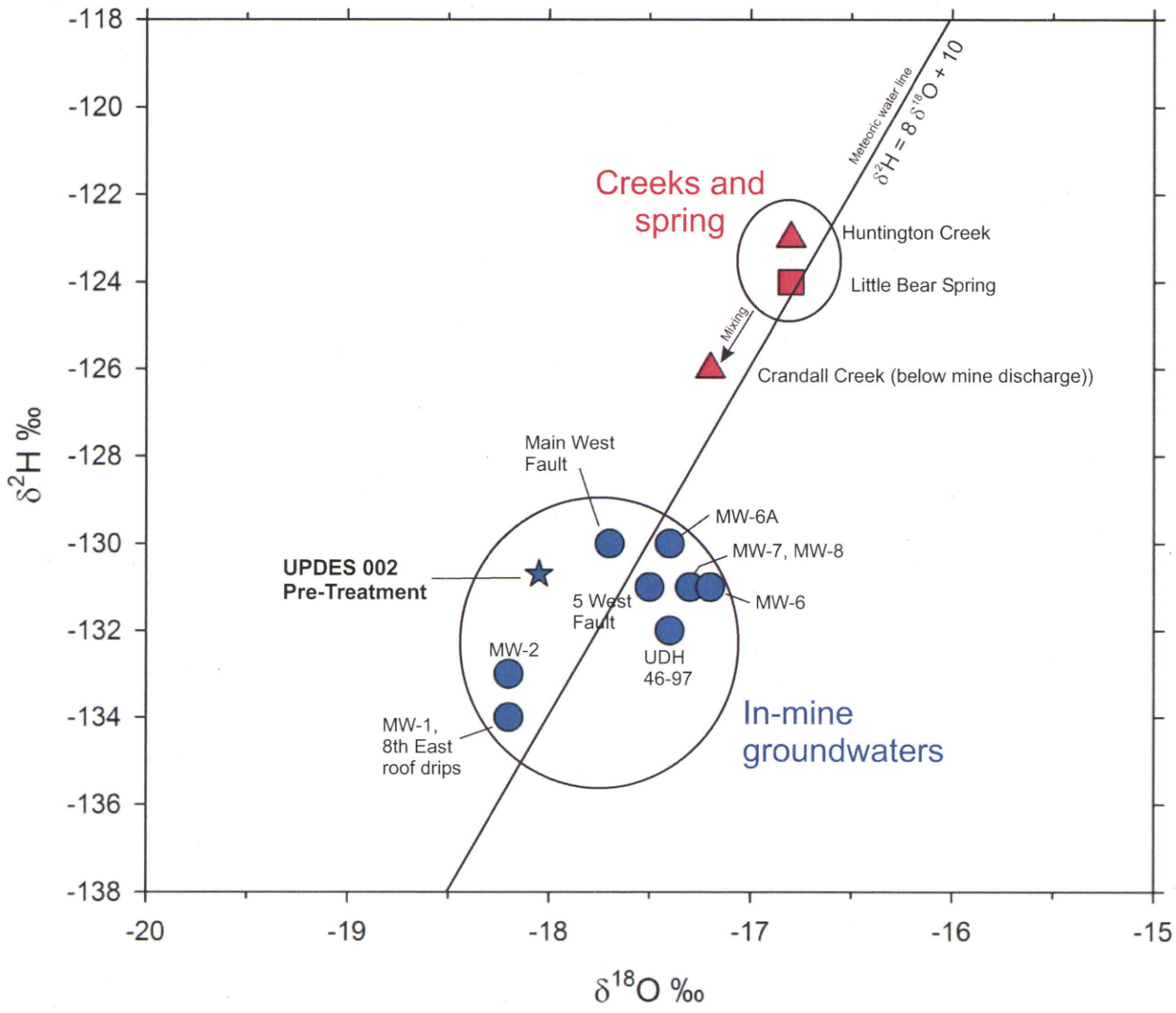

Figure 2 Stable isotopic deuterium and oxygen-18 composition of Crandall Canyon Mine discharge water (UPDES 002 Pre-treatment) plotted together with creek, spring, and other Crandall Canyon Mine in-mine groundwaters.

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Table 1 Solute and isotopic compositions of Crandall Canyon Mine discharge water.

Field measurements		
Date/time sampled	18-Oct-2011	16:45
Discharge	427	gpm
Temperature	11.3	°C
pH	7.17	S.U.
Sp. Conductance	971	µS/cm
Dissolved oxygen	6.0	mg/L
Laboratory solute measurements		
Calcium (Ca^{2+})	84.14	mg/L
Magnesium (Mg^{2+})	50.64	mg/L
Sodium (Na^{+})	26.51	mg/L
Potassium (K^{+})	3.46	mg/L
Bicarbonate (HCO_3^{-})	454.3	mg/L
Fluoride (F^{-})	0.29	mg/L
Chloride (Cl^{-})	11.89	mg/L
Nitrate (NO_3^{-})	0.40	mg/L
Bromide (Br^{-})	<0.01	mg/L
O-Phosphate (HPO_4^{2-})	<0.01	mg/L
Sulfate (SO_4^{2-})	90.10	mg/L
Cations	9.61	mg/L
Anions	9.70	mg/L
analytical error	-0.4	%
Laboratory isotopic mesurements		
Deuterium (δ^2H_{VSMOW})	-130.7	‰
Oxygen-18 ($\delta^{18}O_{VSMOW}$)	-18.05	‰
Carbon-13 ($\delta^{13}C$)	-14.98	‰
Radiocarbon (^{14}C)	13.52	pmC
Tritium (^{3}H)	2.00	TU

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Table 2 Radiocarbon "age" calculations for UPDES 002 pre-treatment water.

	$\delta^{13}C_{(soil\ gas)}$ = -18 ‰	$\delta^{13}C_{(soil\ gas)}$ = -20 ‰	$\delta^{13}C_{(soil\ gas)}$ = -22 ‰	
Fontes model	12,050	12,050	12,050	radiocarbon years
Pearson model	15,000	14,150	13,350	radiocarbon years

Input parameters used in all calculations:

$\delta^{13}C_{(mineral\ carbonate)}$ = 0 ‰

$^{14}C_{(soil\ gas)}$ = 100 pmC

$^{14}C_{(mineral)}$ = 0 pmC

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Appendix

Solute and isotope laboratory reporting sheets

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BYU *Laboratory of Isotope Geochemistry*
Department of Geological Sciences
BYU campus, Provo, Utah 84602
phone: (801) 422-3918

Client: Petersen Hydrologic, LLC
2695 N. 600 E.
Lehi, UT 84043

Reporting Date: 5-Feb-2012

Project: West Ridge
Snell & Willmer, LLP

Radiocarbon Age Analysis

Sample ID	BYU ID	Sample Date	^{14}C (pmc)	+/- 1 σ	$\delta^{13}C$ (‰)	+/- 1 σ
[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]	[redacted]
UPDES 002 pre-treatment	9318	18-Oct-2011	13.52	0.07	-14.98	0.04

NOTES:

Pretreatment: Carbon was extracted from the water sample as barium carbonate precipitate. Carbon dioxide was recovered from the carbonate in a high-vacuum system for processing into benzene and isotopic analysis.

Comments: Percent modern carbon was calculated according to Stuvier, M. and Polach, HA, 1997, Discussion of ^{14}C data: Radiocarbon 19:355-63 by comparison against the activities of 4990C NBS oxalic acid and a total process blank. Based upon a Libby half life of 5568 years for ^{14}C.

David G. Tingey
Research Professor

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BYU *Laboratory of Isotope Geochemistry*
Department of Geological Sciences
BYU campus, Provo, Utah 84602
phone: (801) 422-3918

Client: Petersen Hydrologic, LLC
2695 N. 600 E.
Lehi, UT 84043

Reporting Date: 7-Jan-2012

Project: West Ridge
Snell & Wilmer, LLP

Stable Isotopic Data

Sample ID	BYU ID	Sample Date	$\delta^{18}O_{VSMOW}$	+/- 1 σ	δD_{VSMOW}	+/- 1 σ
[redacted]	[redacted]	[redacted]	[redacted]		[redacted]	
UPDES 002 pre-treatment	9318	18-Oct-2011	-18.05	0.20	-130.7	0.5

NOTES:
$\delta^{18}O_{VSMOW\,(sample)} = [(^{18}O/^{16}O)_{sample} - (^{18}O/^{16}O)_{VSMOW} / (^{18}O/^{16}O)_{VSMOW}] * 1000$
$\delta D_{VSMOW(sample)} = [(^{2}H/^{1}H)_{sample} - (^{12}H/^{1}H)_{VSMOW} / (^{2}H/^{1}H)_{VSMOW}] * 1000$
$\delta^{13}C_{VPDB\,(sample)} = [(^{13}C/^{12}C)_{sample} - (^{13}C/^{12}C)_{VPDB} / (^{13}C/^{12}C)_{VPDB}] * 1000$
$\delta^{18}O_{VSMOW\,(sample)}$, $\delta D_{VSMOW\,(sample)}$ and $\delta^{13}C_{VPDB\,(sample)}$ are the measured "delta" values for the given sample. $(^{18}O/^{16}O)_{sample}$, $(^{2}H/^{1}H)_{sample}$ and $(^{13}C/^{12}C)_{sample}$ are raw isotope ratios, and $(^{18}O/^{16}O)_{VSMOW}$ $(^{2}H/^{1}H)_{VSMOW}$ are the defined isotope ratios for hydrogen and oxygen of the VSMOW international standard. VPDB values for carbon are produced by analysis with reference gases calibrated to NBS-19.
Values are normalized to the VSMOW/SLAP scale (Coplen, 1988; Nelson, 2000; Nelson and Detlman, 2001); however, uncertainties in normalization are not included in error estimates.

David G. Tingey
Research Professor

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BYU *Laboratory of Isotope Geochemistry*
Department of Geological Sciences
BYU campus, Provo, Utah 84602
phone: (801) 422-3918

Client: Petersen Hydrologic, LLC
2695 N. 600 E.
Lehi, UT 84043

Reporting Date: 7-Jan-2012

Project: West Ridge
Snell & Wilmer, LLP

Tritium Analysis

Sample ID	BYU ID	Sample Date	^3H (TU)	+/- 1 σ	Sample Preparation
[redacted]	[redacted]	[redacted]			
UPDES 002 pre-treatment	9318	18-Oct-2011	2.0	0.1	Enriched

NOTES:

Standardization was done using NIST Radioactivity Standard Reference Material SRM 436 1C Hydrogen-3.
Pretreatment:

David G. Tingey
Research Professor

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Client: PETERSEN HYDROLOGIC
Recvd : 12/05/04
Job# : 2986
Final : Preliminary Results

Purchase Order: Bill to: Erik Petersen
Contact: E. Petersen, 801/766-4006
2695 N. 600 E.
Lehi, UT 84043

Cust	LABEL INFO	JOB.SX	REFDATE	QUANT	ELYS	TU	eTU
PETERSEN - UPDES 002	Pre-treat	2986.01	111018	1000	275	2.01	0.09

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SGS

Analysis Report

October 26, 2011

GENWAL RESOURCES INC
794 "C" CANYON ROAD
EAST CARBON UT 84520

Client Sample ID:	PRE 002	Sample ID By:	Genwal Resources Inc.
Date Sampled:	Oct 18, 2011	Sample Taken At:	PRE 002
Date Received:	Oct 19, 2011	Sample Taken By:	E.Peterson
Product Description:	WATER	Time Received:	1325
		Time Sampled:	1645
		Mine:	8

Comments: Dissolved Metals Field Filtered

SGS Minerals Sample ID: 782-1110378-001

TESTS	RESULT	UNIT	METHOD	REPORTING LIMIT	ANALYZED DATE	ANALYZED TIME	ANALYST
Sulfate, SO4	157	mg/L	EPA 300.0	1	2011-10-25	16:03:00	AL
Total Dissolved Solids	606	mg/L	SM2540-C	30	2011-10-19	14:40:00	CM
Chloride, Cl	10	mg/L	EPA 300.0	1	2011-10-25	16:03:00	AL
Alkalinity, mg CaCO3/L (pH 4.5)	381	mg/L	SM2320-B	5	2011-10-20	09:00:00	AL
Carbonate Alkalinity as CaCO3	<5	mg/L	SM2320-B	5	2011-10-20	09:00:00	AL
Bicarbonate Alkalinity as CaCO3	381	mg/L	SM2320-B	5	2011-10-20	09:00:00	AL
METALS BY ICP							
Calcium, Ca - Dissolved	96.86	mg/L	EPA 200.7	0.03	2011-10-20	15:16:00	AL
Iron, Fe - Dissolved	0.29	mg/L	EPA 200.7	0.03	2011-10-20	15:16:00	AL
Iron, Fe - Total	2.15	mg/L	EPA 200.7	0.05	2011-10-26	15:20:00	AL
Magnesium, Mg - Dissolved	54.10	mg/L	EPA 200.7	0.01	2011-10-20	15:16:00	AL
Potassium, K - Dissolved	8.24	mg/L	EPA 200.7	0.14	2011-10-20	15:16:00	AL
Sodium, Na - Dissolved	33.44	mg/L	EPA 200.7	0.09	2011-10-20	15:16:00	AL

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Lab Supervisor

Domenic Ibanez
Lab Supervisor

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