2018 Poster Abstracts

Toxicity of the Water Bodies in the Animas River Valley

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Abstract 3

The Gold King Mine "blowout" of August 2015 created a lot of tension for the cities of Silverton and Durango. The Gold King Mine blowout was a giant problem for the cities of Silverton and Durango, and even temporarily effected Farmington's amount of power. Up to three million gallons of mine water was released, all of which was full of iron oxyhydroxide that flowed all the way into Utah. The water even turned orange, bringing a lot of national attention to the Animas River, the river that was affected greatly by this spill.

In this presentation, I will discuss the results of my science fair project that I performed on the toxicity of the water bodies in the Animas River Valley. I entered my project into the Environmental science Division at State Science Fair in Socorro, NM.

I tested the water from various creeks with Daphnia magna and lettuce seeds from water bodies around Durango and Silverton, Daphnia being small crustaceans that are usually used in feeding aquarium fish. Along with these tests, I found the PH and TDS of the samples. Daphnia magna and lettuce seeds are commonly used in bioassays for water quality and toxicity. I expected to discover that the water bodies with mine water feeding into them would be toxic, and this hypothesis has proven to be accurate.

My results showed the Gold King Mine output, Cement Creek, and Mineral Creek grew short lettuce seed roots, did not support suitable life for Daphnia magna, had low PH, and had high TDS. These water bodies had mines feeding into them, which supports my hypothesis. My results also showed that the least toxic water bodies were Junction Creek, Cascade Creek, and Deer Creek. Likewise, all of these creeks had long lettuce seed roots, supported suitable life for Daphnia magna, had high PH, and had low TDS. These creeks had very few mines feeding into them.

Post Gold King Mine Release Water Quality in the Animas and San Juan River During Spring Snowmelt Updated with 2017 Water Sampling

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Abstract 5

An accidental breach of the Gold King Mine on August 5, 2015 released approximately 500,000 kg (455 tons) of particulate and dissolved metals into the Animas River at Silverton, Colorado. The released mass flowed through the Animas and San Juan Rivers as a slurry of acidic water with high concentrations of particulate and dissolved metals that declined rapidly as the plume travelled due to dilution, geochemical reactions, and deposition. Ninety-five percent of the GKM release mass was deposited in the rivers in the form of iron and aluminum oxides. The mineral deposits were later re-entrained and moved to the receiving waters in Lake Powell, UT in timesteps that varied by location. The metals left behind in the lower Animas and San Juan Rivers amounted to 10% of the initial release and were remobilized within 3 weeks of the initial event. The mass deposited in the upper Animas River between Silverton and Durango, CO comprised 85% of the initial release and remained in place for 8 months until it was washed through the rivers during snowmelt runoff the following spring. Based on extensive post-event monitoring, EPA concluded that all the GKM released metals were delivered to Lake Powell by the time the 2016 snowmelt season ended (USEPA 2016; Sullivan *et al.* 2017). EPA monitored water quality during snowmelt in 2017 to further evaluate that hypothesis.

Our assessment used several approaches to characterize and pinpoint GKM-related metals within the typical seasonal patterns of metals transport and the historic effects of mining-related contamination in the rivers. Metal concentrations before and after the GKM event were compared, depending on the availability of data. Reclamation efforts in the mining impacted segment of the Animas from Silverton to Durango have generated an extensive database for comparison, while pre-GKM data is relatively sparse in the lower Animas and San Juan Rivers. Accounting for the GKM mass was accomplished with sampled metal concentrations and flow data available at well distributed USGS gages. A simple “finger printing” technique using the relationships among metals available in most water and sediment samples was very effective for identifying the Gold King release within the background concentrations normally transported by the rivers.

Snowmelt sampling in 2016 found that most of the GKM metals were mobilized and transported episodically from April through June (U.S. EPA 2016). Increased metals concentrations were pronounced in the upper Animas River where most of the release had been deposited.

Elsewhere, the fingerprinting technique could detect GKM release metals as they passed through the rivers even though concentrations were quite low and within state water quality criteria. The excess metals mass attributed to the GKM release that was delivered to Lake Powell during 2016 snowmelt was in reasonable agreement with the estimated deposition within the river.

However, careful comparison to historic data indicated that an additional ~ 110,000 kg of particulate material that had apparently deposited in Cement Creek during the initial release was remobilized during peak runoff, bringing the total GKM release to the Animas River to ~ 600,000 kg (550 tons). This release value was consistent with the previously reported estimated delivery to Lake Powell in 2016 (U.S. EPA 2016).

Metals concentrations during 2017 snowmelt were well within their typical ranges observed prior to the GKM release at all locations within the Animas and San Juan Rivers. There were no lingering GKM release effects

detectable in concentrations or with the fingerprinting technique. Within the 20-year record available in the upper Animas, the total and dissolved concentrations of many metals during snowmelt reached historic lows in 2017, especially copper and zinc that have been shown to impact aquatic communities within this segment (Figure 1). Lower concentrations were only partially accounted for by the removal of metals at the treatment plant installed by EPA in Cement Creek after the GKM release.

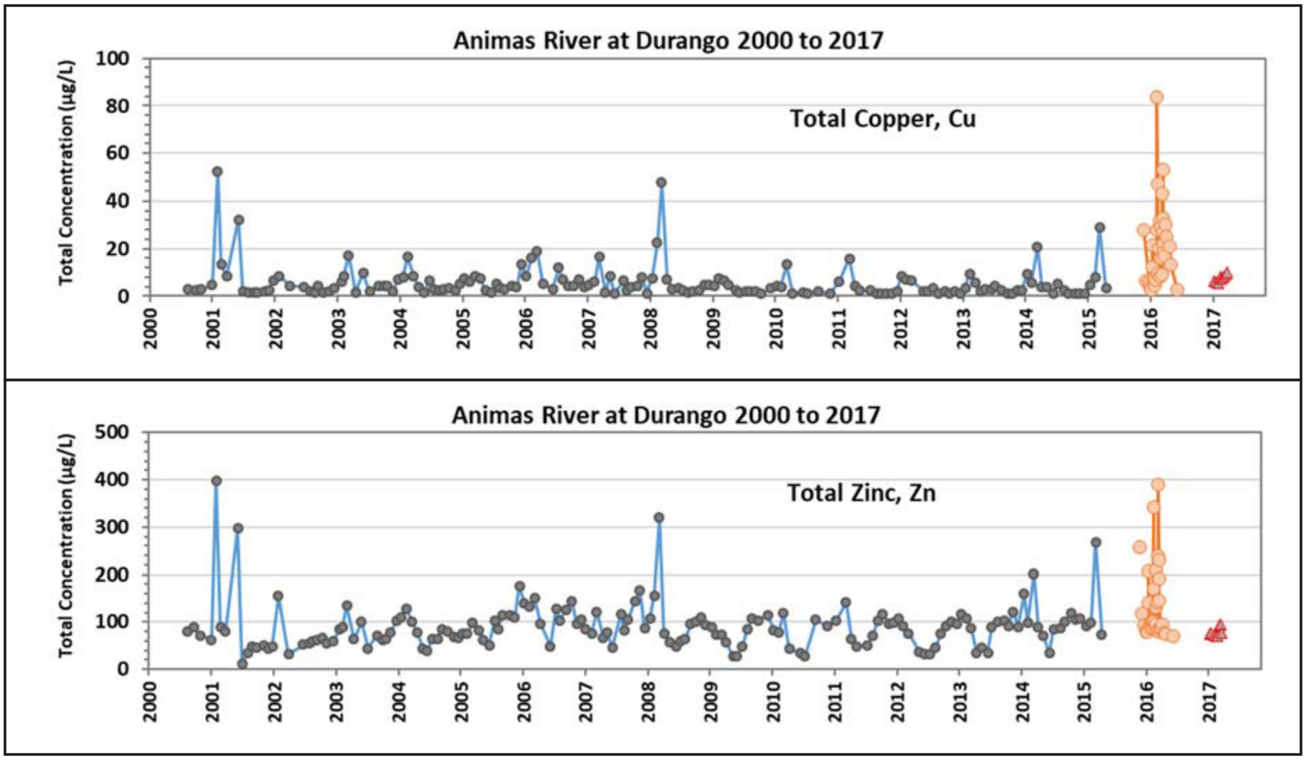

Figure 1. Record of total copper and zinc concentrations in the Animas River at Durango from 2000 to 2017. Data was composited from samples collected by Colorado River Watch, Colorado Department of Public Health and Environment, and U.S. EPA Region 8. The GKM release and Fall 2015 data are not included in these figures to emphasize the movement of metals during 2016 snowmelt from March 1 to June 30. (See U.S. EPA 2016 for release event concentrations)

References

U.S. EPA. 2016 Analysis of the Transport and fate of metals released from the Gold King Mine in the Animas and San Juan Rivers (Final Report). U.S. Environmental Protections Agency, Washington. D.C. EPA/600/R-16/296. Available at: https://www.epa.gov/goldkingmine/fate-transport-analysis.

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Mineralogy and Chemistry of Mine Waste Rock Piles in Mining Districts in Southern Colorado and New Mexico

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Abstract 10 – Both Oral and Poster

Legacy issues of past mining activities forms negative public perceptions of mining, and inhibits future minerals production in the state. There are tens of thousands of inactive or abandoned mine features in mining districts in New Mexico and southern Colorado (including coal, uranium, metals, and industrial minerals districts), however many of them have not been inventoried or prioritized for reclamation. Abandoned mine lands (AML) are areas that were mined and left unreclaimed where no individual or company has reclamation responsibility (also called inactive, legacy, and orphaned mines). These may consist of excavations that have been deserted and where further mining is not intended. Most of these mine features do not pose any physical or environmental hazard and many more, pose only a physical hazard, which is easy, but costly to remediate. A complete inventory and characterization of these features is needed.

Some of these sites have the potential to contaminate surface water, groundwater and air quality. Heavy metals in mine waste piles, tailings and acid mine drainage can potentially impact water quality and human health. State and federal agencies and mining companies have mitigated many of the physical safety hazards by closing some of these mine features, but very few of these reclamation efforts have examined the long-term environmental effects. There is still potential for environmental effects long after remediation of the physical hazards, as found in several areas in New Mexico (for example Terrero, Jackpile, and Questa mines).

The NMBGMR in cooperation with the Mineral Engineering Department at New Mexico Tech, EPSCoR, and the NMAML program is conducting research on legacy mine features in New Mexico and southern Colorado. The project involves field examination and data collection of the mine features. Samples are collected to determine total whole rock geochemistry, mineralogical, physical, and engineering properties, acid-base accounting (Fig. 1), hydrologic conditions, particle size analyses, soil classification, shear strength testing for stability analysis, and prioritization for remediation, including hazard ranking. Not only are samples collected for geochemical and geotechnical characterization, but the mine features are being mapped, evaluated for future mineral-resource potential, and evaluated for slope stability.

Some waste rock piles and tailings could be potential resources for critical minerals and other commodities needed for U.S. technologies. Potential mineral recovery from mine wastes has the potential not only to support cleanup efforts financially, but to remove metals that could be part of the environmental and public safety hazard. Some of the critical minerals identified recently by the U.S. Department of the Interior are found in some of the existing mining districts and legacy mines. Most of the waste rock piles surrounding the mine features are suitable for backfill material in areas of remediation.

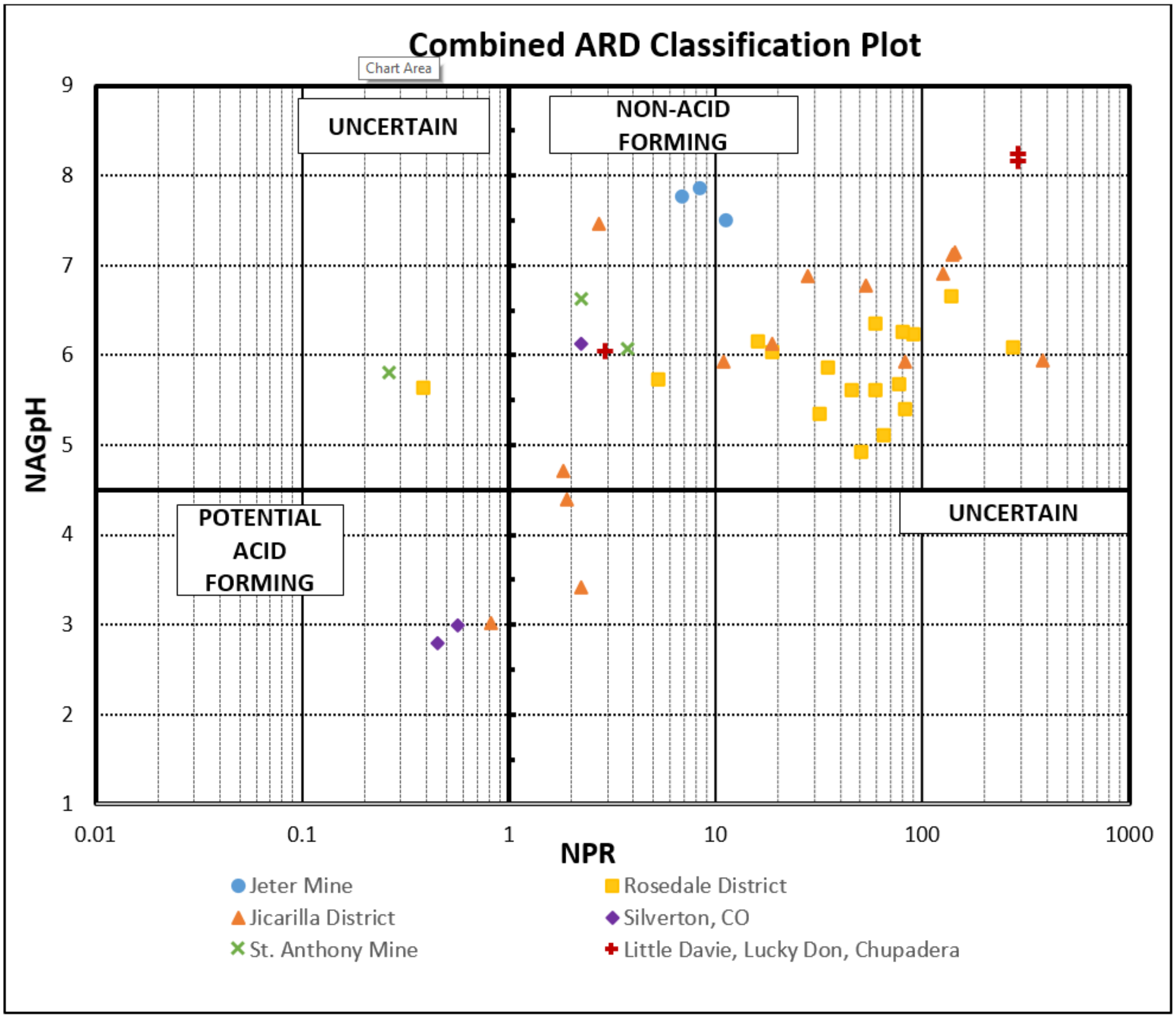

Figure 1. Acid Rock Drainage (ARD) plot of waste rock pile at mines examined during the NMBGMR AML project. The results for the waste rock piles from the Little Davie, Lucky Don, Chupadera, and Jeter uranium mines (Socorro County), St. Anthony uranium mine (Cibola County), Jicarilla gold mines (Lincoln County) and Silverton gold-silver mines (Colorado) are shown for comparison (unpublished work in progress). Results of these mines will be published in future reports. Samples that plot in the uncertain and potential acid forming fields are not suitable for backfill material and need to be handled with care during reclamation.

Working with Nature to Heal the San Juan

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Abstract 12

In the years following the 2015 Gold King Mine Spill much uncertainty still exists along the San Juan River among the farmers on the Navajo Nation. The studies currently being conducted in respects to the event are concentrating on monitoring the levels of heavy metal contaminates in the river, soil and plants. This study will use bioremediation techniques, phytoremediation ponds and a bio swale to remove heavy metals from the water and soil in agricultural fields at a location in Hogback, New Mexico. The soil, water and plants will be tested over the course of the growing to track the effectiveness of the filtration methods in place. The test site will serve as economically feasible model for farmers who have concerns of contaminates entering their water, soil and produce.

Contaminant Element Cycling through Animas River Biota 2-years After the Gold King Mine Spill

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Abstract 16

In the New Mexico reach of the Animas River, the Gold King Mine spill led to slight decreases in pH, elevated metal concentrations, and significant deposition of metal-bearing sediments and oxides. Analysis of Gold King release effects on the aquatic and riparian ecosystems are complicated by past release events and chronic acid mine drainage into the Animas River system for more than a century. Few if any acute toxicological effects on fish werereported from the event, but chronic exposure to the contaminated sediments and mobilization into food-webs is a lingering concern. Plant uptake of contaminants through soil-pore water-stream connectivity could increase the pool of those elements in vegetation.

Decomposition processes return organic matter to the stream for potential uptake by filter feeding fish and invertebrate larvae, which in turn are consumed by predatory invertebratesand other fish species. Thus, there is a strong expectation that biota will affect contaminant element cycles, and understanding element pathways through biota is necessary to assess persistent effects of the GKM spill.

In March and August 2017, we sampled sediment, overbank soil, aquatic and riparian vegetation, aquatic invertebrates from three GKM spill-affected sites along the Animas and San Juan Rivers, as well as samples from a non-spill affected reference site on the San Juan. Fish muscle and liver tissue was procured from samples taken at the same sites by NM Game and Fish in August 2017. We report concentrations of 9 metal and contaminant elements (Al, Mn, Fe, Cu, Zn, As, Pb, Cd, U) determined with ICP-MS. We couple these data with ^{13}C and ^{15}N analysis of the same material and tissues to reconstruct the aquatic and riparian food and assess contaminant pathways through biota. Cottonwoods (*Populus fremontii*) from spill- affected sites expressed higher leaf and stem Al, Zn and Cd than plants from the reference site. Spill-affected coyote willow (*Salix exigua*) contained higher concentrations of Al and Zn, and saltcedar (*Tamarix ramosissima*) leaves had higher concentrations of Zn than plants from the reference site. We did not discern an easily interpretable pattern of aquatic invertebrate community response to the GKM spill. Grouping invertebrates by functional group showed that detritivores and scrapers typically had higher whole-body contaminant concentrations than predatory invertebrates. All invertebrate functional groups sampled in spill-affected areas had higher Zn concentrations compared to invertebrates at the reference site, and Cd concentrations were elevated in detritivores and predators at the spill-affected site relative to the reference site. There were significant, positive correlations between fish liver 15N (an indicator of trophic position) and liver Cu, As and Cd concentrations. However, significant negative correlations were found between 15N and liver Al and Pb. Zinc, which was found in elevated concentrations in spill-affected plants and all groups of invertebrates sampled, correlated only weakly ($R = 0.08$) and non-significantly with fish liver Zn.

We observe elevated levels of some contaminant elements, especially Zn and Cd, in Animas and San Juan River plants and invertebrates in riparian areas and stream reaches affected by the GKM spill. The element-dependent nature of contaminant movement through food-webs confirms that bio-accumulation is possible, but not a universal characteristic of mine-contaminated ecosystems. These data help understand contaminant biogeochemistry across trophic levels; however, future directions should aim toward fish diet reconstruction via gut content analysis for contaminants and stable isotopes, coupled with additional sampling efforts to increase invertebrate capture.

Detection of Vegetation Change In Farmlands Near The San Juan River After the Gold King Mine Spill Using Remote Sensing

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Abstract 20

After the Gold King Mine Spill (GKMS), Navajo communities were concerned about using river water for farming, watering livestock and fishing and wondered anxiously if the water was really safe to use for other activities such as swimming and cultural practices. Though there was a general concern of using the river water to farm, Navajo communities responded differently regarding the timing of restarting irrigation after the Spill. It is assumed that many other agricultural communities along the San Juan River had resumed irrigation at some point, but there is a lack of record for each chapter. The whole picture of the impact of the GKMS on farming practices is missing for the Navajo communities along the San Juan River. The study uses different vegetation indices (VIs) to determine change in vegetation greenness and water stress level to examine change in farming practices and evaluate its impact on farmland productivity. Preliminary results will be presented in the poster.

Bioremediation of Heavy Metals with Lemna Minor (Duckweed)

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Abstract 21

There are concerns of heavy metals building up in the soil of irrigation ditches downstream of legacy mining. Soils were collected from near an acid rock drainage site in Silverton, CO and an irrigation channel downstream 97km near Aztec, NM. Both samples were initially analyzed to confirm levels of heavy metal elements. Using inductively coupled plasma mass spectrometry (ICP-MS) the levels of Arsenic in the samples was 14.76 ppm in Silverton and 9.72 ppm in the Aztec Sample. These both exceed the guidelines of the NMED of 7.07 ppm. A concern is that arsenic will leach from the soil of these irrigation canals into the irrigation water supplying farm fields. This study will compare the variable oxidation-reduction potential states and pH of the soils to see if arsenic could leach into irrigation water. Duckweed will be grown on the leachate solution at different pH and oxidation-reduction potentials to see if it is a possible sink for arsenic leached into solution.

Lingering Heavy Metal and Metalloid Toxins in the Allium cepa Root Tipand Bulb from the Animas and San Juan Riverbeds, due to the 2015 Gold King Mine Spill

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Abstract 22

Finding potential heavy metal and metalloid toxins in the Animas and San Juan riverbeds and onion bulb after the 2015 Gold King Mine Spill are crucial to the effects of the mitotic index of *Allium cepa* root tip. Initial tests on the mitotic index from the Animas and San Juan Rivers wereconducted in 2015-2016. The hypothesis states that if both Riverbeds, and onion bulb samples have potential heavy metals and metalloids, then the samples from both rivers will contain abbreviated cells, and a lower mitotic index.

Water and riverbed samples were collected after the 2015 Gold King Mine Spill. Green onions were planted in each water and riverbed sample for one month. The onion root tips werethen analyzed using a digital microscope at 400X for mitotic phases and cellular aberrations. Non-dividing and dividing cells were counted to measure the mitotic index. Onion bulbs exposedto the riverbed were tested for metals using Oxford ED-2000 Geology Majors + Traces XRF.

The hypothesis was accepted; both riverbeds affected the mitotic index (0%) of the root tip with cellular aberrations. Onion bulbs in the XRF study had higher ppm concentrations of Zincindicating cytotoxic effects on the mitotic index. The Animas Riverbed had high weight percentages of specific metal oxides, thus reducing the weight percent of common sand. The XRF Machine also found that the Animas River having higher concentrations of metalloids, while the San Juan Riverbed had higher weight percentages of sand because it had less specificmetal oxides.

Impacted Zea Mays After Gold King Mine Spill

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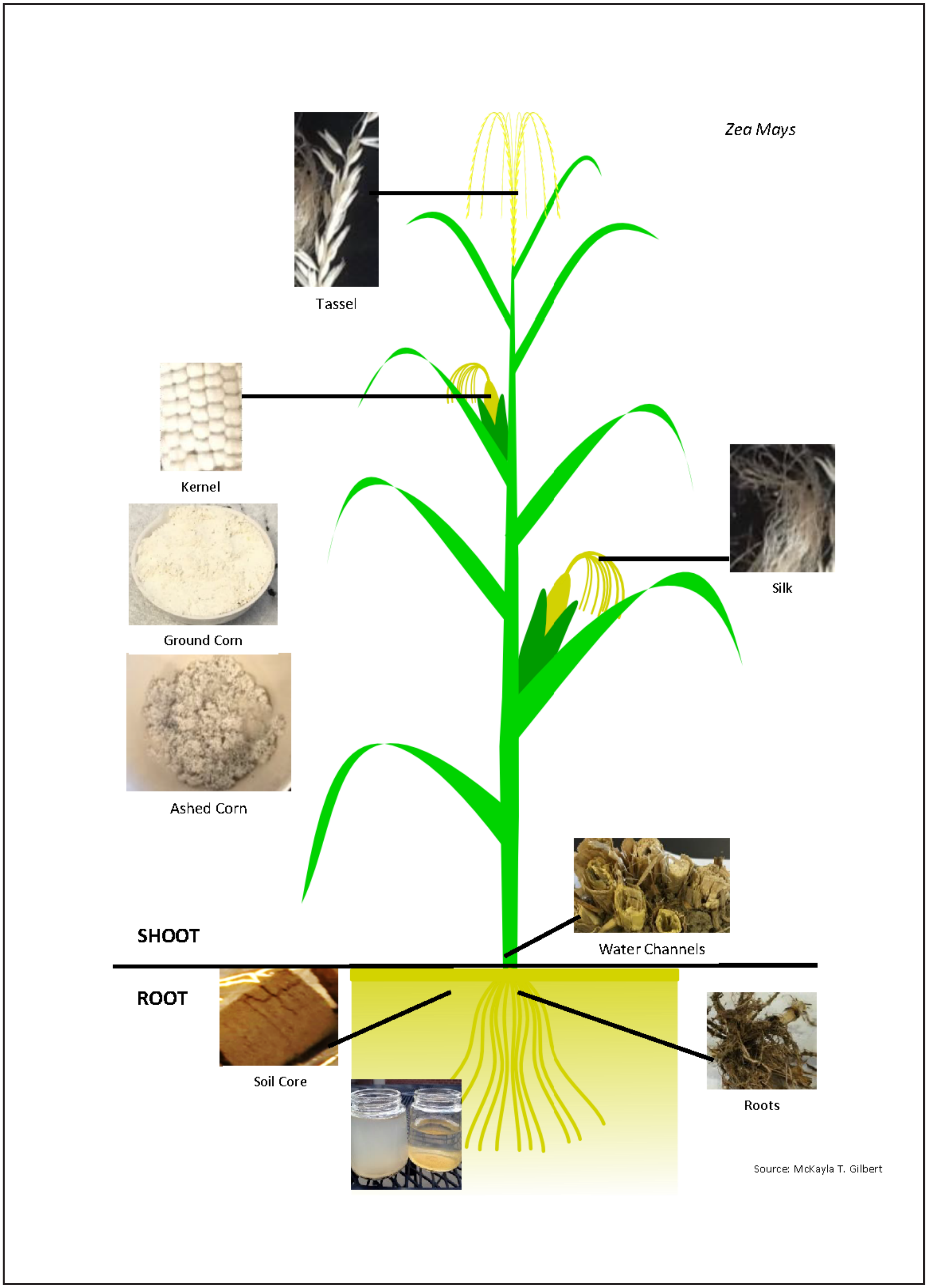
Abstract 24

Contaminated agriculture caused by mining activities, as the Gold King Mine Spill, posea long-term threat to riverside communities. Accumulated wastes from abandoned mines contain toxic metals and metalloids that spill into rivers used for irrigation. *Zea Mays* irrigated with contaminated river water may or may not uptake contaminants throughits water channels. Long term exposure to metals and metalloids such as uranium, cadmium, lead, and arsenic can have a dangerous effect on development of the human body. Cognitive development can be detrimentally impactful on children. In 2015, the Gold King Mine, located in Silverton, Colorado, spilled three million gallons of mine waste water into the Animas River. The Animas River is a tributary to the San Juan River in New Mexico.

A study of corn grown along a section of the San Juan River on the Navajo Nation in New Mexico was carried out to determine concentration levels of contaminants from the spill. *Zea Mays*, soil, and river water samples were collected and analyzed. Concentration levels of uranium, cadmium, lead, and arsenic, were measured with the Inductively Coupled Plasma Mass Spectrometer (ICP-MS). One of the major reasons I researched the impacts of the Gold King Mine Spill is to help the community understand the potential dangers of what chronic toxicity poses to the corn. Results from this investigation are preliminary findings and are a contribution as baseline data to an ongoing long-term impact study of the mine waste water that flowed into an irrigation river water source on the Navajo Nation. This investigation project earned first place honors at the 2018 NM State ISEF Science Fair and student received invitation to observe at the 2018 Intel International Science and Engineering Fair in Pittsburgh, Pennsylvania.


Zea Mays
Tassel
Kernel
Ground Corn
Ashed Corn
Silk
Water Channels
SHOOT
ROOT
Soil Core
Roots
Source: McKayla T. Gilbert

Forest and Watershed Treatments in the San Juan – Chama Watershed Partnership Region

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Abstract 26

This poster describes the practical application of research and mapping conducted by the Navajo- Blanco Resilience Partnership to prioritize and maximize the effectiveness of forest treatments in the San Juan and Chama watersheds of northwestern New Mexico and southwestern Colorado, including the headwaters above the Bureau of Reclamation's San Juan-Chama Project (SJCP) and the private lands affiliated with the Chama Peak Land Alliance. The Nature Conservancy (TNC) has conducted extensive research and GIS mapping to evaluate fire and debris-flow risks in these forested watersheds, which provide a significant portion of the water supply to Santa Fe, Albuquerque, and the Middle Rio Grande Conservancy District. Anticipated high-severity wildfires and subsequent post-fire flooding threaten these watersheds and the downstream communities that depend on them. Reduced runoff, increased soil erosion, and post-fire debris flows have the potential to degrade water supplies and impact SJCP operations. The Chama Peak Land Alliance, TNC's Rio Grande Water Fund, and other members of the Navajo-Blanco Resilience Partnership, have used TNC's research as a basis for prioritizing forest treatment projects to promote forest health and watershed security in the Navajo and Blanco basins, both of which are within the San Juan – Chama Watershed Partnership Region. With partner funding from the Albuquerque-Bernalillo County Water Utility Authority, projects are underway to reduce the threat of high-severity wildfire in these critical watersheds. This poster highlights these implementation projects and this exciting partnership between government agencies, nonprofits, and landowners.

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Impacts of the Gold King Mine Spill have Measurable Effects on Navajo Agricultural Lands

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Abstract 28

August of 2015 the soil plug at the entrance of the Gold King Mine near Silverton, Colorado was disturbed, ensuing a release of an estimated three million gallons of acid mine drainage (AMD) into Cement Creek connecting to the Animas River, a tributary of the of San Juan River. The San Juan River is a major source of water for drinking water, recreation, and agriculture for the Navajo Nation. Following the Gold King Mine Spill (GMKS), water and soils samples were collected along the San Juan River from Upper Fruitland, NM to Aneth, UT. Preliminary studies demonstrated that the regions of Shiprock and Upper Fruitland had elevated levels of heavy metals and metalloids, but the concentrations were still below EPA guidelines.

The purpose of this agricultural study was to investigate if heavy metals contamination from AMD affected the Navajo Nation agricultural systems. Sampling occurred in August 2017 at local farms in the Shiprock that used San Juan River water to irrigate their fields. The control site was a farm upstream from the Animas River inlet in Bloomfield, NM. At each location canal water, canal sediment cores, field sediment cores and mature corn plants were collected, digested, and analyzed via inductively coupled plasma mass spectrometry for arsenic, lead, manganese, cadmium, and uranium. Canal water was tested for major anions by ion chromatography and major cations by flame atomic absorption spectrometry to explore the difference in water chemistry for each sampling location. Results from the water, soil, and plants were paired to study the persistence of the analytes over time since the spill, determine the mobilization of heavy metals/metalloids in the environment, and inform community farmers if the current farming practices with San Juan River water is potentially toxic for those consuming their corn now or in the future.