11th Annual Española Basin Workshop

Espanola Basin Watersheds: Natural and Anthropogenic Impacts on Surface and Ground Water Resources

Nylander, Charles, editor

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11th Annual Workshop, May 15-16, 2012

Location: Santa Fe Community College, in the *Jemez Rooms* of the Main Administration Building

Workshop Theme: "Española Basin Watersheds: Natural and Anthropogenic Impacts on Surface and Ground Water Resources"

Optional Field Trip: Watershed impacts of the Las Conchas Wildfire (May 16th, see below)

EBTAG Members:

An ad hoc group of technical people who represent government and academic institutions conducting geologic, geophysical, hydrogeologic, and hydrologic studies related to improving the understanding of the geology and water resources of the Española Basin.

City of Santa Fe	Santa Fe County
Espanola Basin Regional Issues Forum (EBRIF)	U.S. Geological Survey
Jemez y Sangre Regional Water Planning Council	U.S. Bureau of Indian Affairs
New Mexico Bureau of Geology and Mineral Resources	University of New Mexico
New Mexico Office of State Engineer	New Mexico Environment Department

11th Annual Workshop Sponsor: Espanola Basin Regional Issues Forum (EBRIF)

EBTAG Web Site: http://geoinfo.nmt.edu/ebtag

WORKSHOP PROGRAM and ABSTRACTS

7:45-8:30 a.m.	**Registration** *Pick up badges, programs and sign in; poster set up and viewing*
8:30-8:45 a.m.	**Welcome and Introductory Remarks** *What is EBTAG and why the annual Espanola Basin Workshops? Charlie Nylander, Chair, EBTAG*
8:45-9:15 a.m.	**Analysis of Floods and Debris Flow Hazards Following Short Duration, High Intensity Rainfall Events on Las Conchas and Track Fire Burn Scar Areas During the Summer 2011, Northern New Mexico**; *Anne C. Tillery and Kerry Jones*
9:15-9:45 a.m.	**Post Las Conchas Fire Impacts on Water Quality in the Rio Grande During 2011**: *Ralph E. Ford-Schmid*
9:45-10:15 a.m.	**The Buckman Direct Diversion (BDD) Project's Proactive Approach to Protect Public Drinking Water Safety in the Wake of the Las Conchas Fire**: *Erika Schwender and Robert Mulvey*
10:15-10:30 a.m.	**Coffee Break**
10:30-11:00 a.m.	**Post-Las Conchas Fire Effects in Los Alamos Canyon Stormwater**: *Amanda B. White, Paul Mark, Steve Renuau, and Danny Katzman*
11:00-11:30 a.m.	**Post-Fire Sediment Transport and Erosion in the Water Canyon and Cañon de Valle Watershed, Jemez Mountains New Mexico**: *Paul Drakos, Steven Reneau, Emily Schultz-Fellenz, Jim Riesterer, Rick Kelley, Elizabeth Miller, Phillip Goetze, and Paul Chamberlain*
11:30-12:00 p.m.	**Los Alamos County San Juan Project Water Project**: *Kelly Anne Collins and Steve Finch*
12:00-1:15 p.m.	**Lunch Break** (food available for purchase at cafeteria next door)
1:15-1:45 p.m.	**Estimates of Sediment Yield and Peak Flows Following a Potential Catastrophic Fire and Prescribed Fire in the Santa Fe Upper Watershed, New Mexico**: *Amy C. Lewis*
1:45-2:15 p.m.	**Geochemical Processes Controlling Transport and Deposition of Uranium, Española Basin, New Mexico**: *Patrick Longmire, David Vaniman, Michael Rearick, Virginia T. McLemore, Stephen Wiman, Dennis McQuillan, Ardyth Simmons*

2:15-2:45 p.m.	**A Summary of Syn-Rift Depositional, Tectonic, and Volcanic Changes in the Española Basin, Northern Rio Grande Rift, New Mexico**: *Daniel J. Koning, David Broxton, and Sean D. Connell*
2:45-3:00 p.m.	**Break**
3:00-3:30 p.m.	**Water Resource Investigations within the Lower Santa Fe Watershed, Santa Fe County, New Mexico**: Karen Torres
3:30-4:00 p.m.	**Vulnerability Factors for Groundwater Contamination From Onsite Wastewater Systems**: *Dennis McQuillan & James Vincent*
4:00-5:00 p.m.	**Poster Session**
Poster	**Utilizing the Las Conchas Fire to Improve Standarized Burn Severity Classification and Determine Nutrient Contribution in Surface Water Runoff from Various Wildfire Severity Classes in the Jemez Mountains, Northern New Mexico**: *Anita Lavadie, Edward Martinez, Sarah Brown, and Joseph Zebrowski*
Poster	**Tectonic Evolution of the Western Margin of the Española Basin, Rio Grande Rift, NM: Rock Magnetic, Paleomagnetic, And Petrologic Data**: *Rhonda V. Trujillo, Michael S. Petronis, and Jennifer Lindine*
Poster	**The Defective Groundwater Protection Practices at the Large Number of Waste Dumps at the Los Alamos National Laboratory (LANL)**: *Robert H. Gilkeson and Joni Arends*
Poster	**Baseline Polychlorinated Biphenyls (PCBs) on the Pajarito Plateau and Northern New Mexico (LA-UR-12-20939)**: *Armand Rossini Groffman, Bruce Gallaher, and Rebecca V. Hollis*
Poster	**Hydrochemistry of the Valle Toledo, Valles Caldera, New Mexico**: *Michael Dale, Kim Granzow, Patrick Longmire, David Englert, Michael Rearick, and George Perkins*

Wednesday, May 16, 2012

WATERSHED IMPACTS OF THE LAS CONCHAS WILDFIRE FIELD TRIP

8:00 a.m.-3:00 p.m.

Theme: The field trip will include a tour of Las Conchas Wildfire Burned Area, including Dixon Apple Orchard area to see burn severity, current status of erosion, soil stability, and vegetation rehabilitation, as well as areas susceptible to future mass wasting and erosion.

Field Trip Coordinator: Charlie Nylander

Meeting Place and Time: Meet at the De Vargas North, Shopping Center Parking Lot at 8:00 a.m. for car pool.

Directions: Travel north on HW 84/285 to Pojoaque; turn on SR 502 and drive to Los Alamos on Main Hill Road; drive through Los Alamos on Trinity Drive; turn left past the hospital and cross the bridge; turn right to intersect SR 4; turn right on SR 4 and drive to Forest Road (FR) 289 (will be on your left about 20 minutes from last intersection as you drive towards the Valle Grande); Field Trip will begin as we travel down FR 289.

Maximum Number of People: 50

Logistical Notes: We would like to consolidate the trip using 10-12 vehicles, so please car pool. Bring lots of water and a lunch. Four or five stops will involve short walks to view the canyon rim. The burned areas have dead trees that can fall over at any time, so use caution around dead trees. Also, beware of collapse zones where tree roots have burned beneath the surface. Please watch your footing and approach the canyon rims with caution. The road is very dusty, so drive slowly and allow ample space between cars to let the dust settle. None of the stops will have restroom facilities. Four-wheel drive is not necessary, but high- clearance vehicles are recommended. Participants should dress appropriately for the season with layers of clothing that can be worn or taken off as needed. Sunscreen is highly recommended regardless of weather conditions on the day of the field trip. Rain gear may be needed.

ESTIMATES OF SEDIMENT YIELD AND PEAK FLOWS FOLLOWING A POTENTIAL CATASTROPHIC FIRE AND PRESCRIBED FIRE IN THE SANTA FE UPPER WATERSHED, NEW MEXICO

[1]**Amy Lewis**

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The impact of management alternatives on the hydrology and soils in the Upper Santa Fe Watershed were analyzed using a series of analytical and empirical tools. The USFS is proposing to conduct a prescribed fire within a 2,900-acre area of the Santa Fe River municipal watershed located in designated Wilderness of the Santa Fe National Forest for the purpose of reducing the risk of a high-intensity fire. The potential sediment yield and peak flows were estimated for existing conditions, under the worst-case scenario in which a catastrophic fire consumes the entire area (8,500 acres); and for a prescribed fire in the proposed action area (2,900 acres).

To develop a range of estimates for sediment yields and peak flows, several models were used and compared to empirical methods. The conclusion was that a catastrophic fire followed by intense rainfall events could result in damaging peak flows, impair the storage capacity and water quality of the municipal reservoirs. Predicted sediment yields and peak flows resulting from the proposed action are insignificant and pose no threat to the water storage and treatment systems or to the ecosystem.

POST-LAS CONCHAS FIRE EFFECTS IN LOS ALAMOS CANYON STORMWATER

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The effect of the 2011 Las Conchas fire was particularly evident at gage station E109.9, which measures discharge from a total drainage area of 37,800 acres, with 11% impermeable surface area before the fire and an additional 13% of the watershed experiencing high- or moderate-severity burn during the fire. A small portion of this watershed is downstream of Los Alamos National Laboratory (LANL), and is a tributary of the Rio Grande. The total and permeable surface areas in this watershed were more highly correlated to suspended sediment concentrations (SSCs) than the impermeable surface area, suggesting the amount of sediment in the runoff is strongly related to the permeable surface area contributing to the station. This is counter to the well-documented observations that converting permeable surfaces to impermeable surfaces can increase the peak and shorten the duration of a hydrograph, thereby creating a conduit for sediment to reach the stream and increasing SSC. This effect is most likely because of the influence of the Las Conchas fire, which created a similar impermeable “conduit” for sediment transmission and greatly increased the supply of sediment, in part ash-laden, from the upper watersheds of Los Alamos and Guaje Canyons. Runoff from burn areas typically has high concentrations of suspended sediment (partly related to the entrainment of ash), and the runoff volume typically increases. Indeed, SSC was elevated at E109.9 as a result of floods in Guaje Canyon from the Las Conchas burn area, and E109.9 recorded discharge greater than 5 cfs only 4 times during 2010 (pre-fire) and 15 times during 2011 (post-fire). When the Guaje Canyon gage station (E099) was operational, increases in stage height were measured during all 10 events when E109.9 also measured discharge, indicating runoff from Guaje Canyon was the dominant contribution to discharge at E109.9. As for the water chemistry, elevated concentrations of manganese, selenium, total cyanide, total polychlorinated biphenyls (PCBs), dioxins, gross alpha, americium-241, plutonium-239/240, and strontium-90 measured at E109.9 are similar to those measured in upper Los Alamos Canyon, above LANL-impacted sites, and are consistent with the transport of these constituents from the Las Conchas burn area down Guaje Canyon. Analyses of ash, sediment, and stormwater in Guaje and Rendija Canyons after the 2001 Cerro Grande fire indicated that these elevated constituents also had a source in the Cerro Grande burn area.

UTILIZING THE LAS CONCHAS FIRE TO IMPROVE STANDARDIZED BURN SEVERITY CLASSIFICATION AND DETERMINE NUTRIENT CONTRIBUTION IN SURFACE WATER RUNOFF FROM VARIOUS WILDFIRE SEVERITY CLASSES IN THE JEMEZ MOUNTAINS, NORTHERN NEW MEXICO

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Climate change that results in drier, warmer climates has the potential to increase fire occurrence and intensify fire behavior. The rate of erosion on landscapes exposed to wildfire disturbance will increase. Following large fires, surface water runoff contributes high concentrations of nutrients to water bodies and has the potential to impair surface water quality and terrestrial systems. Several studies outline the effects of fire on nutrient concentrations in streams following a fire. However, there is a need to directly investigate nutrient levels transported in surface runoff from specific burn severity classes. In addition, burn severity assessment standards and terminology are limited to remote sensing technology. Burn Area Emergency Response (BAER) teams have often struggled with accurately mapping post-fire soil burn severity and have recognized the need for consistent methodologies, assessment tools, and terminology that quickly and accurately identify on the ground post-fire conditions. As a result they are led to use geospatial assessment tools that have little standardization in field verification.

The first purpose of this study is to compare *Landsat* thematic mapper and *Advanced Spaceborne Thermal Emission and Reflection Radiometer* (ASTER) technology with ground measurements to further refine methodology to standardize burn severity class. To complete this task we will take on-site field measurements in High, Moderate and Low burn severity sites as categorized by the USGS and Monitoring Trends in Burn Severity program (MTBS) to accurately characterize each fire severity class. We will then compare these measurements to Landsat, ASTER-derived burn severity map data to determine if remote sensing fire severity classifications appropriately represent ground measurements. The second purpose of this study is to investigate the contributions of nitrate (NO_3), nitrite (NO_2), organic nitrogen (ON), total phosphate (TP), orthophosphate (OP) and total suspended solids (TSS) concentration levels from surface water runoff originating in various wildfire severity classes from the Las Conchas fire in the Jemez Mountains, New Mexico. To complete this task, the above mentioned nitrogen and phosphorus constituents will be measured and analyzed from surface water runoff flowing from an unburned Control site and predetermined High, Moderate, Low, and Mixed (inclusive of low, moderate and high severity sites) fire severity types.

ANALYSIS OF FLOODS AND DEBRIS FLOW HAZARDS FOLLOWING SHORT DURATION, HIGH INTENSITY RAINFALL EVENTS ON LAS CONCHAS AND TRACK FIRE BURN SCAR AREAS DURING SUMMER 2011, NORTHERN NEW MEXICO

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During the summer of 2011, wildfires burned nearly 500,000 acres of forested lands in the State of New Mexico. Two of the fires in northern New Mexico included the Las Conchas wildfire, the largest in the state's history and the Track Fire which burned much of the Chicorica Creek watershed, a major source of water for the City of Raton, New Mexico. The Las Conchas wildfire burned a total of 156,593 acres including portions of the Santa Clara, Cochiti, San Ildefonso, and Santa Domingo Pueblos and also portions of Bandelier National Monument and the Valles Caldera National Preserve. Some of the Las Conchas wildfire burn area was previously burned by the Cerro Grande Fire in 2000. Freshly burned landscapes are at risk of damage from post-wildfire erosion hazards such as those caused by flash flooding and debris flows. The risk of hydrologic hazards may persist for years after a fire and can negatively impact water resources, ecology, businesses, homes, reservoirs, roads, and utility infrastructure in wildland/urban interface areas. Following the Las Conchas and Track Fires, several high volume (low frequency) floods occurred in and downstream of burn scar areas as the result of otherwise typical summer monsoonal rainstorm events. Personnel from the U. S. Geological Survey and National Oceanic and Atmospheric Administration visited significantly impacted areas in both burn areas, conducted debris-flow assessments of burned areas (http://pubs.usgs.gov/of/2011/1257/ , http://pubs.usgs.gov/of/2011/1308/) and collected data to support numerical modeling (slope-area computations) and documentation of high volume floods downstream of burn scar areas. In response to a design storm of 28.0 millimeters of rain in 30 minutes (10-year recurrence interval), the probabilities of debris flows estimated for basins burned by the Las Conchas Fire were greater than 80 percent for two-thirds (67 percent) of the modeled basins. In response to a design storm of 38 millimeters of rain in 30 minutes (10-year recurrence-interval), the probabilities of debris flows estimated for basins burned by the Track fire were greater than 80 percent for the majority of the tributary basins to Raton Creek in Railroad Canyon and for six basins that flow into Lake Maloya, the main water supply for the City of Raton. Debris-flow hazard assessments and flood-frequency predictions conducted in wildfire threatened areas before fires occur could help land and resource managers plan for and mitigate the effects of post-wildfire hazards in advance of a fire occurrence.

Baseline Polychlorinated Biphenyls (PCBs) on the Pajarito Plateau and Northern New Mexico (LA-UR-12-20939)

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Polychlorinated biphenyls (PCBs) are persistent organic compounds and are ubiquitous on a global scale. The development of a low-level analytical method (1668A) resolves PCB concentrations on the order of 10 pg/L, revealing PCBs in remote locations far from PCB sources including high-latitude arctic and remote marine environments. In 2009, the Laboratory, in cooperation with the New Mexico Environment Department–Department of Energy Oversight Bureau (NMED-DOE OB), initiated a baseline PCB study to estimate the range of PCBs in stormwater runoff in areas not affected by historical Los Alamos National Laboratory (LANL) operations or activities in the Los Alamos townsite. Reference watersheds were identified north of the LANL and Los Alamos townsite in similar terrain at roughly the same altitude and climatic regime. Locations were also sampled upstream of the western boundary of LANL. Stormwater monitoring was conducted from 2009 to 2010. Thirty-seven samples were collected using automated stormwater samplers and analyzed for PCBs by Method 1668A. PCB concentrations for all samples collected from the reference watersheds range from 23 pg/L to 23,999 pg/L, with a median of 489 pg/L and standard deviation of 6186 pg/L. PCB concentrations from all samples collected from the western boundary locations ranged from 33 pg/L to 16,754 pg/L, with a median of 1885 pg/L and standard deviation of 4423 pg/L. These results are important for identifying baseline concentrations and may affect regulatory actions. Final results, including a statistical analysis and a conceptual model, will be presented to account for the variability within the landscape. Results from other surveys will be presented as well to provide perspective on the PCB distribution in northern New Mexico.

A SUMMARY OF SYN-RIFT DEPOSITIONAL, TECTONIC, AND VOLCANIC CHANGES IN THE ESPAÑOLA BASIN, NORTHERN RIO GRANDE RIFT, NEW MEXICO

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We present late Oligocene-Quaternary paleogeographic maps that illustrate the depositional, tectonic, and volcanic history of the Española Basin. These maps are largely a result of recent geologic mapping, stratigraphic correlations, and inspection of subsurface well data. Previous studies using geochemical correlation and radiometric dating of tephra beds, biostratigraphic correlation of mammalian fossils, and paleomagnetic-polarity studies of basin-fill also proved indispensible in constructing these maps.

The Española Basin consists of a general half-graben to the east, which is tilted westward towards a central fault system (CFS). Locally within this half-graben are smaller grabens with thicker basin fill. West of the CFS, thinner basin-fill deposits overlie a faulted structural platform (Abiquiu embayment and northern Jemez Mountains), separated from the Colorado Plateau by a 7-13 km-wide zone of east-down normal faults. We discuss 6 important depositional belts in the Santa Fe Group of the Española Basin, which we list from east to west: 1) an eastern alluvial slope deposited by west-flowing streams that drained the Sangre de Cristo Mountains; 2) an ancestral Rio Embudo that flowed southwest into the basin from the Peñasco embayment; 3) a river draining the southeastern San Luis Basin (<18 Ma); 4) a western alluvial slope deposited by streams sourced in volcanic terrain in the southern San Luis Basin; 5) a river draining the Colorado Plateau (<14 Ma); and 6) alluvial fans along the eastern Jemez Mountains (<12 Ma).

Several paleogeographic changes occurred after 16 Ma. The ancestral Rio Embudo and the toe of the eastern alluvial-slope shifted westward starting at 16 Ma, with deposits of the ancestral Rio Embudo onlapping the CFS footwall during 11-10 Ma. This progradation coincided with high throw rates along the CFS between 15 and 10 Ma, but was also influenced by paleoclimatic changes at 14-13 Ma. A river system draining the Colorado Plateau flowed into the southwest part of the basin starting at ~14 Ma. This paleoriver carried a sandy bedload and displaced south-flowing streams originating from the San Luis Basin. Northeastward eolian transport of sand from this paleoriver resulted in formation of an extensive eolian dune field during 13.5-11 Ma. Coarse ash and lapilli beds (radiometrically dated at 13-12 Ma), intercalated in basin fill, mark the beginning of felsic-to-intermediate volcanism in the Jemez Mountains. The increase in topographic relief from Jemez volcanism, together with elaboration of paleovalleys, resulted in the integration of the Colorado Plateau drainage into a narrower river capable of carrying gravel. Erosion of these volcanic edifices produced east-sloping alluvial fans in the Los Alamos area. A hiatus in deposition, between ~6-5 Ma, was followed by coarse-grained deposition adjacent to the CFS. Erosion dominated the Española Basin since 1.2 Ma, with particularly rapid incision in the last 0.6 Ma.

VULNERABILITY FACTORS FOR GROUNDWATER CONTAMINATION FROM ONSITE WASTEWATER SYSTEMS

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Onsite wastewater systems provide treatment and decrease contaminant concentrations, but do not produce drinking-water quality effluent. Natural attenuation mechanisms, therefore, must be able to decrease contaminants to acceptable concentrations as the effluent migrates from the drainfield, through soil, and into groundwater to the nearest down-gradient water-supply well. Natural attenuation mechanisms that may occur in soil or groundwater include dispersion, diffusion, mechanical filtration, microbe death, cation exchange, adsorption, biodegradation, denitrification and volatilization. A proper site evaluation is critical to designing an onsite wastewater system that, through a combination of treatment and natural attenuation, will not adversely affect drinking water wells. Onsite wastewater systems that are not properly sited, designed, constructed, operated and maintained have contaminated water wells with nitrate, chloride, total dissolved solids, anaerobic respiration byproducts and with pathogenic microbes.

Lot size, depth to groundwater, lithology, and redox conditions can influence the effectiveness of natural attenuation. Lot size has no influence on the groundwater quality impact from a single wastewater system, but can strongly influence the cumulative impact of multiple systems in an area. Increasing depth to groundwater can increase the migration distance and travel time of effluent percolating in the soil, thereby increasing the potential for natural attenuation and decreasing aquifer vulnerability. Lithologic heterogeneities, such as a gravel layer or other capillary barrier inter-bedded with finer-grained sediments, also can increase migration distance, travel time and the potential for natural attenuation. Fractured rock typically provides less opportunity for natural attenuation than do sedimentary deposits with inter-granular porosity. Redox conditions can control the occurrence and transformation of nitrogen compounds.

Field studies in basin-fill areas utilizing onsite septic systems and domestic wells demonstrate that increasing lot size and depth to groundwater generally decrease the potential for water well contamination. Water wells in Rancho San Marcos, with a minimum lot size of 10 acres and groundwater depths of approximately 175 to 250 feet, show little if any influence from onsite septic systems. In Eldorado, with an average lot size of about 1 acre, significant greenbelt acreage, and groundwater depths in the range of 100 to 200 feet, nitrate-N has been detected above the drinking-water standard of 10 mg/L in only one well, and most nitrate-N levels are less than 5 mg/L. Hernandez, with many small lots ½ acre or less, and groundwater depths of about 50 to 100 feet, onsite wastewater systems polluted at least 76 private domestic water wells with nitrate-N greater than 10 mg/L. Public water was extended into Hernandez to eliminate the widespread health hazard from nitrate pollution.

In some fractured bedrock areas, onsite wastewater systems have polluted drinking water wells with nitrate, chloride, total dissolved solids and E. Coli even though all regulatory requirements for lot size, set back, clearance and suitable soil were met.

WATER RESOURCE INVESTIGATIONS WITHIN THE LOWER SANTA FE WATERSHED, SANTA FE COUNTY, NEW MEXICO

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The lower watershed is the discharge area of the Santa Fe basin where multiple natural and improved springs, in conjunction with discharge from the City of Santa Fe Wastewater Treatment Plant, supply the Santa Fe River and its tributaries. Historically water captured from springs was and currently is used for irrigation through the acequia system. The Santa Fe River Adjudication currently recognizes approximately 325 acres of irrigated land within the lower watershed with prior to 1907 priority dates. This recognition makes this area sensitive to groundwater withdrawals up-gradient and through the water right permitting process mitigation of calculated impacts, predicted to diminish spring supply, is required.

In the fall of 2010 weekly stream flow measurements and water quality samples were performed at the La Cienega flume, El Guique spring and two unnamed springs in La Cieneguilla and Arroyo Hondo. An increase in discharge with the on-set of fall correspond to increased groundwater levels up-gradient and attributed to a decrease in evapotranspiration and groundwater withdrawals.

Isotopic data of $\delta^{15}N$ and $\delta^{18}O$ from 4 surface water and one groundwater site were analyzed by LANL. Isotope ratios of were compared to typical ranges for various natural and anthropogenic sources of nitrate from a known data set (Kendall 1998). The ratios of $\delta^{15}N$ to $\delta^{18}O$ isotopes were consistent with septic systems and animal wastes not atmospheric or fertilizer sources. This empirical data supports the contribution of septic tanks to spring discharge; which was the presumed source. The exception was Guique Spring where the isotopic ratio is consistent with soil water sources.

To assist in the understanding of the variations in spring discharge Santa Fe County will install monitoring equipment at various surface and groundwater locations. The goal is to increase the knowledge of changes up-gradient that may affect surface flows.

LOS ALAMOS COUNTY SAN JUAN PROJECT WATER PROJECT – ALTERNATIVES AND HYDROLOGIC CONSIDERATIONS

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Los Alamos County has a contract for San Juan-Chama Project (SJCP) water and is currently evaluating alternatives for accessing their SJCP water from the Rio Grande. They are evaluating four alternatives that involve different methods for diversion, transmission route and treatment. The preliminary capital costs for these alternatives range from $7 million to $40 million. The four alternatives are:

1) Collector wells adjacent to the Rio Grande on San Ildefonso Pueblo with conveyance to the Guaje well field;
2) Utilizing Santa Fe's Buckman Direct Diversion Project infrastructure and conveyance to White Rock;
3) Collector wells at the river connected to a tunnel and shaft that allows water to be pumped to the mesa top at White Rock; and
4) Groundwater wells on White Rock Overlook that would intercept river water.

Alternatives 1, 3, and 4 have hydrologic constraints. Alternative 1 relies on diverting water through an existing collector well. However, the results from collector well pumping test indicate that the aquifer limits the rate at which the collector well can sustain pumping and the Rio Grande is not close enough to offset aquifer dewatering. The collector well may be able to sustain pumping rates less than 500 gpm and establish equilibrium between removal of aquifer storage and recharge from the Rio Grande.

Alternative 3 anticipates diverting water through collector wells or raised bores at Site A, located downstream of San Ildefonso Pueblo and the Buckman Direct diversion. A groundwater-flow model was constructed to represent Site "A" and the Rio Grande and was calibrated to pumping test data from shallow wells installed in the alluvium adjacent to the Rio Grande. Model results indicated that a single collector well located on the north side of Site "A" would be capable of producing 1,200 AFY if a paleo-channel consisting of coarse-grained sediments underlies the Rio Grande.

Alternative 4 would divert groundwater through vertical water supply wells. The groundwater that would be diverted using supply wells is groundwater that naturally contributes to the Rio Grande. The reduction in stream flow from groundwater pumping and stream depletion would be offset by SJC Project water releases. Data from regional hydrogeologic studies by LANL were evaluated and the upper 300-ft of the regional aquifer below the White Rock Overlook appears to have adequate hydraulic properties for developing water for supply wells that would intercept stream flow.

HYDROCHEMISTRY OF THE VALLE TOLEDO, VALLES CALDERA, NEW MEXICO

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Initial groundwater resource investigations were conducted in the Valle Toledo and other areas near Los Alamos, New Mexico during the late 1940's and early 1950's. The investigations included drilling of numerous test holes and installation of several observation and pumping wells. Test holes within the Valle Toledo penetrated an artesian sand and gravel aquifer 122 m thick. Results of the water resource investigations determined that pumping and development of the aquifer would deplete flow to the San Antonio River and potentially obstruct surface-water rights; hence, groundwater resources in the Valle Toledo were not developed. This investigation was conducted to evaluate hydrochemical characteristics and groundwater residence times. Groundwater samples were collected and analyzed for major ions, trace elements, low-level tritium, radiocarbon in dissolved inorganic carbon (DIC), and stable isotopes of hydrogen, oxygen, and carbon in DIC. Groundwater is characterized by a sodium-calcium-bicarbonate composition with total dissolved solids (TDS) ranging from 100 to 130 mg/L. Concentrations of nitrate as nitrogen range from 0.02 to 0.04 mM (0.3 to 0.5 mg/L) and sulfate range from 0.01 to 0.03 mM (1.4 to 2.8 mg/L). Water-rock interactions are not extensive based on the TDS content and chemical composition of the groundwater samples. Compositions of $\delta^{2}H$ and $\delta^{18}O$ range from -92.6 to -88.1 ‰ and from -12.9 to -12.2 ‰, respectively, suggesting that snowmelt and rain provide local recharge to the aquifer system. Activities of tritium were less than detection (0.2 tritium units, 0.6 pCi/L), with no modern component of water present. This suggests that recharge to the artesian aquifer is greater than 60 years. Unadjusted radiocarbon activities as fraction modern carbon in dissolved inorganic carbon range from 0.82 to 0.74, corresponding to estimated ages ranging from 1,521 to 2,400 years. The San Antonio River is the principal drainage from the Valle Toledo and is designated as a High Quality Coldwater Aquatic Life water source. Discharge of groundwater from the Valle Toledo supports headwater baseflow to the San Antonio River. Groundwater discharging to the San Antonio River is not susceptible to present-day contamination, as reflected by the average age exceeding 1,500 years.

GEOCHEMICAL PROCESSES CONTROLLING TRANSPORT AND DEPOSITION OF URANIUM, ESPAÑOLA BASIN, NEW MEXICO

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Uranium is a trace metal of considerable interest within aquifer systems worldwide. Concentrations of natural uranium vary from less than 8.40e-09 M (0.002 mg/L) to 7.65e-06 M (1.82 mg/L) in groundwater within the Española Basin, New Mexico. Uranium concentrations exceeding the EPA drinking water standard of 0.030 mg/L are of public health concern. Oxidative dissolution of uranium(IV) minerals, associated with Proterozoic granitic rocks in the Sangre de Cristo Mountains, and hydrolysis of uranium-bearing volcanic ash and granitic and volcanic detritus within the Tesuque Formation, contribute to highly variable uranium concentrations measured in groundwater. Sub-economical grade uranium is associated with clay galls, opal, chert, fossil bone, carbonaceous material, and ferric (oxy)hydroxide within the San Jose mining district (Arroyo Seco and Oxide Butte). Uranium(VI) phases identified include carnotite ($K_2(UO_2)_2V_2O_8 \cdot 3H_2O$), meta-autunite ($Ca(UO_2)_2(PO_4)_2 \cdot 2\text{-}6H_2O$), and schröckingerite ($NaCa_3(UO_2)(CO_3)_3(SO_4)F \cdot 10H_2O$). Millimolar concentrations of dissolved uranium are required to precipitate meta-autunite, implying that this phase formed in the unsaturated zone. Groundwater, however, approaches equilibrium with respect to carnotite and haiweeite ($Ca(UO_2)_2(Si_2O_5)_3 \cdot 5H_2O$). Haiweeite is a potential hydrolysis product associated with dissolution of soluble volcanic ash. Higher concentrations of uranium in groundwater typically are associated with increasing concentrations of sodium and decreasing concentrations of calcium. PHREEQC simulations suggest that adsorption of Ca^{2+} onto ferric (oxy)hydroxide releases Na^+ and UO_2^{2+} to groundwater. Results of deionized (DI) water leach tests and EPA 3050 partial digestions (pH1) performed on oxidized sediments collected from the San Jose mining district show that concentrations of leached and digested uranium range from 3.21 to 52.21 mg/kg and from 8.48 to 107.8 mg/kg, respectively. Distribution coefficients for the Arroyo Seco and Oxide Butte samples range from 59.4 to 79.11 L/kg and from 24.9 to 35.1 L/kg, respectively, using a 1.5:1 DI water-solid ratio. Ferric (oxy)hydroxide, solid organic matter, and smectite are the dominant adsorbents for uranium(VI) within the study area.

POST-FIRE SEDIMENT TRANSPORT AND EROSION IN THE WATER CANYON AND CAÑON DE VALLE WATERSHED, JEMEZ MOUNTAINS, NM

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The Water Canyon/Cañon de Valle watershed is located north of Frijoles Canyon and Bandelier National Monument and originates on the flanks of the Sierra de los Valles. Water Canyon and its largest tributary, Cañon de Valle, are generally west-to east trending drainages that flow across the southern part of Los Alamos National Laboratory (LANL) on their way to a confluence with the Rio Grande in White Rock Canyon, and comprise a drainage basin with an area of 49.6 km^2. Portions of the Water Canyon/Cañon de Valle watershed were burned in the 1977 La Mesa fire (6.7 km^2 within the burn perimeter), the 2000 Cerro Grande fire (26.2 km^2 within the burn perimeter), and the 2011 Las Conchas fire (16.9 km^2 within the burn perimeter). Post-fire sediment deposits associated with some or all of these fires have been identified during investigation of a series of reaches in this watershed, conducted in 2010 and 2011. These post-fire deposits comprise a significant portion of post-1942 sediment deposits within the watershed.

The Water Canyon/Cañon de Valle sediment investigation included detailed geomorphic mapping (1:200 scale) in a series of investigation reaches (25 reaches mapped in 2010-2011), descriptions of post-1942 sediment deposits in each reach, measurement of a series of geomorphic cross sections, and sediment sampling and analysis for an extensive suite of potential contaminants. A series of cross sections measured in 2011 will be relocated and resurveyed in May 2012 to systematically evaluate post-fire changes (erosion/deposition) to post-1942 sediment deposits.

A series of cross sections were surveyed after the first post-Las Conchas fire flood, which occurred on August 3, 2011, to investigate post-Las Conchas fire sediment deposition and erosion. Sediment from the August 3 flood, measured at cross section locations, reached a maximum thickness of 22 cm and consisted largely of reworked ash and silt (“muck”). Some scouring also occurred during the August 3 flood. Several sections were surveyed after the second, and larger, post fire flood on August 21, 2011. Two sections surveyed after the first flood were resurveyed after the second flood. In contrast to the deposition of muck in overbank areas during the August 3 event, coarser-grained sediment deposits were observed after the August 21 event in both overbank and channel settings, associated with the deeper flow and greater stream power of the second flood event. Sediment thickness from the August 21 flood at cross section locations reached 50 cm. Considerable local scour and bank widening also occurred during the August 21 flood event, and a large fan was built at the mouth of Water Canyon.

POST LAS CONCHAS FIRE IMPACTS ON WATER QUALITY IN THE RIO GRANDE DURING 2011

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The June 2011 Las Conchas fire burned more than 150,000 acres and the resulting flash flooding from the burned watersheds had the potential to significantly impact water quality in the Rio Grande. The cities of Santa Fe and Albuquerque draw surface water from the Rio Grande for municipal water supply and concerns over potential degraded water quality prompted the New Mexico Environment Department (NMED) and the City of Santa Fe Buckman Direct Diversion (BDD) to conduct extensive stormwater quality monitoring at the BDD intake. NMED has been monitoring stormwater quality in the Rio Grande at the Otowi Bridge on San Ildefonso Pueblo lands, the BDD intake and upstream of the intake for the City of Albuquerque San Juan-Chama Drinking Water Project since 2009 and in 2011 we collaborated with the BDD to install five ISCO automatic samplers triggered by telemetry based on flow from lower Los Alamos Canyon and/or a 500 CFS increase in flow in the Rio Grande. Samples were collected during 13 storm flow events at the BDD intake, 3 flow events at the Otowi Bridge and 3 flow events above the City of Albuquerque San Juan-Chama Drinking Water Project intake during 2011. In most cases, multiple samples were collected during the storm hydrograph. Water samples were analyzed for suites of filtered and unfiltered radionuclides (gross alpha/beta, Pu-239/240, Pu-238, Am-241, Sr-90, U-234, U-235, U-238, Cs-137 and other gamma emitting isotopes), 23 metals plus cyanide (filtered and unfiltered), polychlorinated biphenyl, dioxin/furan, total organic carbon, perchlorate, particle size, carbonate and bicarbonate and SSC. Suspended sediments were separated from the water and analyzed for the same radioisotopes, 23 metals plus cyanide, total alkalinity and carbonate/ bicarbonate alkalinity. Box and whisker plots are used to display data and comparisons to applicable

TECTONIC EVOLUTION OF THE WESTERN MARGIN OF THE ESPAÑOLA BASIN, RIO GRANDE RIFT, NM: ROCK MAGNETIC, PALEOMAGNETIC, AND PETROLOGIC DATA

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The western margin of the Rio Grande rift at the latitude of Espanola, NM, is characterized by a zone >17 km wide of oblique-slip faults. We investigated the possibility that this area experienced some degree of vertical axis rotation associated with rifting. We examined a suite of Miocene mafic dikes in the southern Española Basin using paleomagnetic, rock magnetic, field, and thin section data. We hypothesized that the mafic dikes experienced some degree of vertical axis rotation associated with mid-Miocene to recent rifting.

Paleomagnetic data provided constraints on potential components of vertical-axis rotation across structural blocks, between separate dikes, and along strike. Rock magnetic data provided constraints on the magnetic mineralogy responsible for carrying the remanence directions. Low-field susceptibility versus temperature experiments yielded a spectrum of results reflecting a thermomagnetic behavior typical of intermediate composition titanomagnetite as well as the presence of a Fe-sulfide phase. The Lowrie-Fuller test and acquisition of isothermal remanent magnetization (IRM) and backfield IRM experiments provided information to verify the magnetic mineralogy, domain state, and the coercivity of the remanence. These experiments, as well as other data, indicated that the remanence is carried by single domain to pseudo single domain magnetite and is likely a primary thermoremanent magnetization acquired during cooling and is thus geologically stable.

The dikes are composed of major Ca-plagiclase, augite, olivine, and magnetite. Swallowtail morphologies to the plagioclase laths as well as dendritic habit of the Fe-Ti oxide phases indicate undercooling of the host magmas consistent with shallow emplacement and rapid cooling.

The in situ paleomagnetic results for 20 paleomagnetic sites provide a group mean ofD=345.3°, I=43.1°, α95= 7.1°, k= 46.2, that is statistically distinct from the mid-Miocene expected field direction (D=358, I=58, A95 = 6.0) with an inferred rotation and flattening of -12.7°, and 14.9°, respectively. We interpret this discordant direction to indicate that some degree of counter- clockwise vertical axis rotation was associated with rifting north of the Jemez Mountains. It is possible that oblique motion along the Santa Clara fault and/or the Cañada del Almagre fault facilitated vertical axis rotation between structural blocks.

THE DEFECTIVE GROUNDWATER PROTECTION PRACTICES AT THE LARGE NUMBER OF WASTE DUMPS AT THE LOS ALAMOS NATIONAL LABORATORY (LANL)

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The necessary networks of monitoring wells to detect groundwater contamination from the LANL waste dumps do not exist. Practically all of the wells installed since 1997 are unreliable and require replacement. In 2007, the National Academy of Sciences (NAS) stated, "Many if not all of the [33] wells drilled into the regional aquifer under the Hydrogeologic Workplan appear to be compromised in their ability to produce water samples that are representative of ambient groundwater for the purpose of monitoring." *Plans and Practices for Groundwater Protection at the Los Alamos National Laboratory – Final Report (2007)*, p. 49.
http://www.nap.edu/catalog.php?record_id=11883

Further, in 2010, the New Mexico Environment Department (NMED) stated, "The NAS report references wells that were installed as part of LANL's groundwater characterization efforts that were conducted in accordance with their Hydrogeologic Work Plan (1998)… These wells were not installed for contaminant detection or groundwater monitoring. Therefore, these wells have limited relevance to groundwater protection goals set forth by the March 1, 2005 Consent [Cleanup] Order." *LANL Renewal Permit (November 2010) General Response to Comments,* p. 31. http://www.nmenv.state.nm.us/HWB/Permit.htm

Nevertheless, the unreliable characterization wells are now used as reliable monitoring wells for remedy decisions in the NMED "Cleanup" Order. The attempt to rehabilitate some of the characterization wells was not successful. Replacement of the characterization wells and the new monitoring wells drilled under the "Cleanup" Order is needed because: (1) the screened zones were contaminated with large amounts of organic and bentonite clay drilling additives, (2) the wells were not installed along groundwater flow paths from the dumps, (3) the wells were not installed at locations close to the dumps, and (4) the wells were installed in "tight zones" and not in the permeable aquifer zones where the groundwater contamination is expected.

As a result, there is inadequate knowledge of the direction and speed of groundwater travel at the waste dumps because the careless drilling operations did not locate the water table or correctly locate and install the monitoring wells.

For example, the LANL September 2011 Corrective Measures Evaluation, Rev. 3 report for Material Disposal Area (MDA) G, a 63-acre dump for large inventories of radioactive, toxic and hazardous waste, admits there is inadequate knowledge of the direction of groundwater travel. LANL states, "In the area downgradient from MDA G, the direction of the regional aquifer flow is **believed** to be dominantly towards the southeast based on regional water-table levels and maps." [Emphasis added.] LA-UR-11-4910, p. E-21.
http://content.govdelivery.com/bulletins/gd/USLANL-12ce13 But the data and flow maps clearly demonstrate the direction of flow is to the northeast to the Pueblo de San Ildefonso and further to the Santa Fe Buckman drinking water wells. There are no reliable monitoring wells for groundwater contamination from MDA G.

LANL and NMED continue the mistake to use water quality data alone to determine that the monitoring wells damaged by drilling additives have "cleaned up" to produce representative water samples. However, the NAS and reports by the Environmental Protection Agency Kerr Research Laboratory explain that water quality data alone cannot be used for this purpose.

THE BUCKMAN DIRECT DIVERSION (BDD) PROJECT'S PROACTIVE APPROACH TO PROTECT PUBLIC DRINKING WATER SAFETY IN THE WAKE OF THE LAS CONCHAS FIRE

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When the Las Conchas Fire started on June 26th, 2011, no-one could envision the extensive effects this fire would have on the entire region. While most efforts concentrated on the immediate impacts on air quality and safety of life and structures, personnel of the BDD shifted their focus on water quality of the Rio Grande.

Approximately 80% of the Santa Clara watershed, 30% of the Guaje watershed, and 50% of the Upper Los Alamos watershed experienced moderate to high severity burns. Due to this high percentage of moderate to high burn severity areas in those watersheds, it was anticipated that those regions would experience greater stormwater run-off volumes and velocities as well as flooding during and after rain events. Additionally, stormwater run-off from these burned watersheds were expected to carry high ash concentrations.

The BDD Project diverts water from the Rio Grande, which is under the direct influence of the above mentioned watersheds. With the first signs of impacted water quality of the Rio Grande at the BDD diversion structure, the BDD ceased all diversions. During the following 30 days the BDD developed very conservative and proactive raw water monitoring and diversion protocols to protect the public water supply. The BDD's proactive approach included extensive stormwater water sampling to determine the impact of stormwater run-off from the various watersheds on the overall water quality of the Rio Grande at the BDD diversion structure, as well as increased finished drinking water monitoring, and strict Rio Grande diversion shut-down protocols.

As a brand new water treatment plant during its start-up year the BDD Project was challenged by several unexpected situations, such as the Las Conchas Fire and the continuing drought experienced throughout the region; yet, due to its built-in design redundancies and experienced and knowledgeable operations staff, has lived up to everyone's expectations.