

**New Tools for Evaluating Alpine and
Subalpine Sensitivity and Water Quality in
the Upper Animas Watershed,
San Juan County, Colorado**

Draft Executive Summary

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The Silverton area is similar to other gateway communities bordering scenic public lands in the western United States. As a result of rapid growth, many of these areas have experienced increased real estate values and property taxes, supplanted traditional industries with service-oriented ones, and in many cases modified the attributes that drew people to these communities in the first place. Local land-use planners and resource managers need tools to help guide policy decisions, and are charged with finding a way to balance the often conflicting influences of local history and culture, politics, economic goals, and science. We used water quality data as an indicator of ecosystem health across a variety of alpine and subalpine landscapes, and produced a set of sensitivity maps to aid in the formulation of informed land-use decisions.

This study builds on similar research conducted in neighboring San Miguel County, Colorado. Both studies addressed two primary water quality issues: sensitivity to acidification and elevated nitrogen concentrations. Acid neutralizing capacity (ANC), or alkalinity, serves as an indicator of ecosystem sensitivity to acidification because it measures the ability of surface waters to buffer acidic inputs. In addition, elevated nitrate (NO_3^-) concentrations in streams can be a sign of nitrogen cycling changes across the ecosystem.

Extensive field surveys were undertaken in drainages designated as priority by the San Juan County Planning Commission, and the spatial distribution and aerial extent of landscape types were mapped during the summers of 2003 and 2004:

- Arrastra Gulch
- Blair Gulch
- Deer Park Creek Basin

- Northern Cunningham Gulch
- Maggie Gulch
- Prospect Gulch
- Senator Beck Basin

Surface water samples for this study were collected during the peak of the growing season (mid-July through late August) in order to capture baseflow and avoid the effects of diluted ANC concentrations and magnified nitrate concentrations as a result of spring snowmelt. Water samples were collected and analyzed for inorganic and organic solutes, and water quality values were associated with different land covers to enable alpine sensitivity analysis at the landscape unit scale.

The seven drainages studied occupied a total land area of approximately 55 km², averaging about 7.8 km² per basin. Across the seven study basins as a whole, the ten most predominant landscape types: forest, meadow, wetland, willow, riparian, talus, tundra, mine waste, bedrock, and rock glacier were mapped. More than 85% of the total mapped watershed area was composed of tundra (41%), forest (22%), bedrock (15%) and talus (9%). All of the study basins included some portion of mine waste, defined as tailings piles or mounds of waste rock. The predominant landscape types mapped in my study of San Juan and Ouray Counties were the same as the major landscape types mapped in the San Miguel County study, indicating that these high-elevation watersheds have similar land cover trends.

Acid neutralizing capacity concentrations ranged from -6,000 µeq/L to +1,600 µeq/L. This extremely wide range in ANC values was driven by the underlying geology of the region, where areas directly underlain by and down-gradient from intensely

hydrothermally altered acidic bedrock generally had the low ANC values, and areas underlain by volcanic bedrock infused with propylitic carbonate minerals had the high ANC concentrations.

Because areas underlain with propylitic bedrock are widespread across San Juan County, ANC values in the county in general were very high (median = 750 $\mu\text{eq/L}$), indicating that most areas are well-buffered and highly resistant to acidification.

However, although areas underlain by intensely hydrothermally altered acidic bedrock are found much less extensively across the county, these areas export negative alkalinity down-gradient through both surface waters and ground waters. Of the study basins, these altered areas mainly occur in the Prospect Gulch area, and in small localized areas throughout some of the other study basins. Maps of alteration assemblages in Deer Park Creek Basin, however, were not available.

In general, San Juan County sites exhibited much higher growing season ANC values (median = 797 $\mu\text{eq/L}$) than sites in San Miguel County (median = 309 $\mu\text{eq/L}$). The San Miguel County study did not use geologic criteria to determine sensitivity to acidification, but rather used landscape types. The San Miguel County study mapped talus areas as sensitive to acidification, with talus values ranging from 18 to 59 $\mu\text{eq/L}$. In the San Juan County study, waters draining talus environments did show the lowest alkalinities of all landscape types, but they were still comparatively robust (median = 314 $\mu\text{eq/L}$).

Nitrate concentrations across the county ranged from below detection limits to 85 $\mu\text{eq/L}$, with the highest values observed in streams draining rock glaciers and talus fields. Nitrate concentrations were low in general (median = 4.8 $\mu\text{eq/L}$), and the only landscape

types with more consistently elevated nitrate concentrations were talus (median = 34 $\mu\text{eq/L}$) and rock glaciers (median = 58 $\mu\text{eq/L}$), landscape types with naturally high nitrate.

In general, grazing, logging, mining, off-road vehicle use, or other perturbations exerted minimal impact on nitrate values.

However, a few anomalous samples exhibited elevated nitrate levels, suggesting that nitrate works as a diagnostic tool. Deer Park Creek Basin has an occasional source of very high nitrate, and this occurrence should be examined further. A high nitrate concentration of 60.0 $\mu\text{eq/L}$ was observed from a stream draining a wetland (median = 5.5 $\mu\text{eq/L}$). In addition, a subalpine forested site in Arrastra Gulch had an elevated but not excessive nitrate concentration of 13.0 $\mu\text{eq/L}$, serving as a warning sign that nitrogen cycling in the ecosystem is being impacted by some disturbance.

Median growing season nitrate concentrations from major landscape types in San Juan County (median = 5.3 $\mu\text{eq/L}$) were about half those in San Miguel County (median = 9.3 $\mu\text{eq/L}$). Like San Juan County results, the San Miguel County study also reported the highest nitrate values in streams draining talus, with concentrations ranging from 10 to 15 $\mu\text{eq/L}$. Overall, landscape types designated sensitive in the San Miguel County study were tundra, talus, and rock glaciers (mean growing season nitrate concentrations greater than 9 $\mu\text{eq/L}$). Riparian areas were deemed moderately sensitive (mean growing season nitrate concentrations between 5 and 9 $\mu\text{eq/L}$). In contrast, tundra and riparian areas were not considered sensitive in San Juan County because of low nitrate values.

Based on the results of our study, we developed geographically-referenced maps of sensitivity to disturbance in each of the study basins. All areas that were propylitically

altered were not considered sensitive to acidification, but areas experiencing any of the more intense forms of hydrothermal alteration (acid-sulfate altered, quartz-sericite-pyrite altered, and weak sericite-pyrite altered) were designated as sensitive to acidification. In addition, a 100 meter buffer was created around intensely altered areas surrounded by propylitic bedrock to account for potential groundwater flow through fractured rock. The down-gradient area below the disseminated pyrite in Prospect Gulch was also deemed sensitive because of possible widespread groundwater contamination, and formation of iron hydroxide deposits, ferricrete, and iron bogs.

Another mapping layer comprised areas that are potentially sensitive to disturbance based on elevated nitrate concentrations, and was derived from the landscape mapping conducted in this study. Talus and rock glacier landscape types were mapped directly as sensitive to elevated nitrogen concentration because surface waters draining these landscape types had median growing season nitrate concentrations in the range of 12 to more than 50 $\mu\text{eq/L}$ (34.3 and 58.1 $\mu\text{eq/L}$, respectively).

Following the production of sensitivity maps in San Miguel County, researchers worked directly with the planning department and legal representatives to draft Land Use Code (LUC) amendments designed to protect headwater catchments from future degradation while allowing reasonable development. However, development activities that may potentially aggravate sensitive areas were restricted or prohibited. For example, residences constructed in sensitive areas are limited to building footprints of 800 square feet; septic systems and leach fields are banned; landscaping and fertilizer use requires permits; and new road construction is permitted pending Board of Commissioners review, but only if the roads are less than 10 feet wide and no winter plowing occurs. The

Board of County Commissioners for San Miguel County adopted these amendments on 3 June, 1998. The San Juan County Planning Commission will be equipped with the results of this San Juan County study, and will have the opportunity to use this information in a manner that best benefits the citizens, economy, and environment of the county.