

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

2003 Interim Progress Report

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Executive Summary

Preliminary fieldwork was conducted in August 2003 as the first steps toward developing new tools for landscape evaluation for the San Juan County Planning Commission. We met with the San Juan County Planning Commission on 29 July 2003 to receive their recommendations for high priority basins. Extensive field surveys, covering a total land area of approximately 22 km², were conducted in the Arrastra, Blair, and Deer Park Basins, where spatial distribution and aerial extent of numerous landscape types and point locations were mapped. A total of nineteen water samples were collected from flowing streams in each basin, with particular focus on points in streams that drained uniform landscape types, and from weekly alpine and subalpine sampling of the same two sites along the main channel in Arrastra Basin. After the field season, field maps were transferred to clean base maps and digitized into a Geographic Information System (GIS) by Bill Ball, a Mountain Studies Institute affiliate, and his team.

Laboratory analyses including pH, ANC (acid neutralizing capacity), conductance, anions (Cl⁻, NO₃⁻, SO₄²⁻, PO₄³⁻), cations (NH₄⁺, Ca²⁺, Mg²⁺, Na²⁺, K⁺), total N (nitrogen), total P (phosphorous), and dissolved organic carbon (DOC) were conducted on all water samples at the University of Colorado.

Results of the landscape mapping showed that Arrastra Basin consisted mostly of tundra (35 percent), while Blair and Deer Park Basins were comprised predominantly of forested areas (40 and 46 percent, respectively). Landscape types in the “other” category (i.e., unidentified or having more than one major landscape type) decreased as a function of time and experience, and additional mapping of these sites is planned for the 2004 season to minimize the aerial extent of “other” types. Water quality data were used as a proxy for assessing ecosystem health across the three study areas. In particular, acid neutralizing capacity (ANC), or buffering capacity, was used to assess sensitivity to acidification, and nitrate (NO₃⁻) concentrations were used to evaluate sensitivity to nutrient loading. All San Juan County samples had relatively high ANC concentrations, ranging from 251 μeq to 1,224 μeq/L, indicating that these systems are well-buffered. These values are particularly high compared to a site along the Colorado Front Range, where samples collected over the same time period ranged from 9 μeq to 62 μeq/L. Nitrate concentrations ranged widely, from below detection limits of about 0.07 μeq to 62 μeq/L. Nitrate values at some sites were surprisingly high, compared to values less than 5 μeq/L for most high-elevation streams in the Front Range during the month of August. Weekly sampling of alpine and subalpine sites within Arrastra Basin showed consistent differences between surface waters in the upstream (alpine tundra) and downstream (subalpine forest) locations. In particular, ion concentrations, specific conductance, and ANC values were generally higher at the subalpine forest site compared to the alpine site.

Task 1: Planning

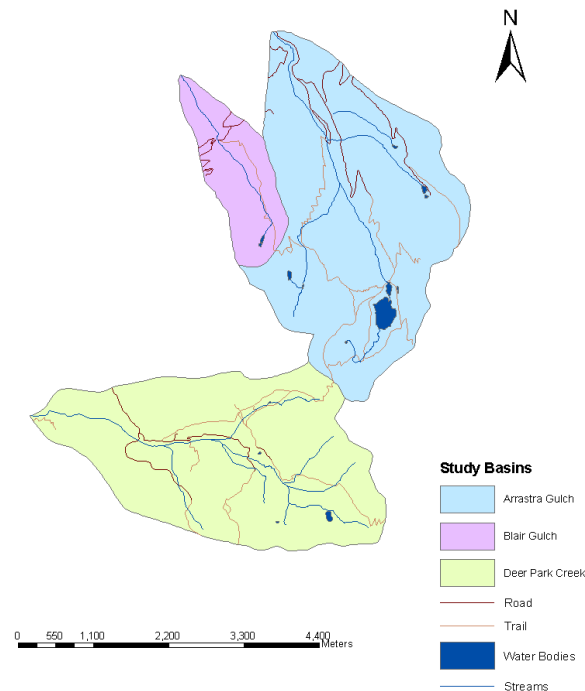
Three meetings were held in July 2003 with partners involving San Juan County Planners and other officials to determine high priority study areas. One of these meetings was at a regular San Juan County Planning commission meeting which was open to the public. These meetings served to set project goals and to answer any questions by those in attendance.

Task 2: Hydrogeomorphic Identification of Sensitive Alpine Regions by Kim Raby & Mark Williams, University of Colorado

I. Introduction

Preliminary fieldwork was conducted in August 2003 as the first steps toward developing new tools for landscape evaluation for the San Juan County Planning Commission. We met with the San Juan County Planning Commission on 29 July 2003 to receive their recommendations for high priority basins. They identified Arrastra, Blair, Cunningham, Deer Park, Minnie, and Maggie watersheds as priority basins for study. Onsite coverage of an area of approximately 10 km² within those drainages was expected. Fieldwork was conducted from 1 August 2003 through 17 August 2003 and covered approximately 20 km² of land area in the Arrastra Gulch, Blair Gulch, and Deer Park Creek watersheds (see Figure 1).

Figure 1. San Juan County Study Areas, August 2003



II. Field Methods

Standard 7.5 minute United States Geological Survey (USGS) topographic maps were enlarged for use in the field. Extensive physical field surveys were conducted in the Arrastra, Blair, and Deer Park basins, where spatial distribution and aerial extent of numerous landscape types and point locations were mapped. Landscape types consisted of talus, tundra, bedrock, meadow, forest, riparian area, wetland, lake/tarn, and willows. Other mapped landscape features included mine waste, adits, debris flows, snow fields, seeps, waterfalls, mining structures such as cabins and tram towers, sample collection sites, streams, and roads. Landscape elements were delineated on field maps as points,

lines, or polygons, depending on feature type. Where possible, a Garmin handheld GPS unit was used to mark the location of particular features.

Identification of these landscape types in the field proved to be a challenging task, and was sometimes problematic. In many cases, it was difficult to make decisions about areas that appeared to be comprised of more than one major landscape type. For example, there were relatively large expanses of land, particularly in the Deer Park Creek watershed, that were covered by alternating patches of willow thickets and exposed bedrock; individual clusters of either landscape type were too small to be mapped, but it would have been misleading to label the area as a whole either “willow” or “bedrock.” In addition, the USGS topographic maps we used did not always contain the correct locations of roads, trails, streams, and other landmarks, making it difficult to properly orient ourselves and to accurately map the landscape types adjacent to these markers.

Water samples were collected from flowing streams in each basin. Particular focus was given to points in streams that drained uniform landscape types. Additionally, at least one subalpine sample and one alpine sample were collected along the main stream channel in each basin. Moreover, two weekly samples were collected from Arrastra Creek from one alpine and one subalpine site along the main channel. Sample collection at each site followed the protocol outlined in Williams et al. (1996) and Inyan (1999). At each sampling location, water was injected through a syringe filtering apparatus with a pre-rinsed Gelman 47 mm glass fiber filter with effective pore size of approximately 1.0 μ m. Two pre-rinsed 250-mL plastic bottles were filled at each site and then frozen within 1-5 hours of collection.

III. GIS Methods

Following field activities, mapped landscape features were transferred from field maps to similar clean USGS topographic maps. These maps were sent to Bill Ball, a Mountain Studies Institute (MSI) associate working at Fort Lewis College in Durango, Colorado. Mr. Ball and his students obtained 7.5 minute digital raster graphic (DRG) base maps from USGS in the UTM 13, NAD 27 coordinate system. Using these base maps, Mr. Ball and his team digitized the watershed boundaries, landscape type borders, and other point and line features from the hand-marked maps into a Geographic Information System (GIS). They also added other applicable map layers obtained from the United States Forest Service (USFS), including roads, trails, streams, and water bodies (MSI 2003). The roads and trails layer was originally obtained from the Government Service Center by USFS and then edited by USFS in April 2003. Layers for streams and water bodies were also acquired from the USFS and were updated in April 2003. Finally, marked GPS points were downloaded and incorporated into the same GIS.

IV. Laboratory Methods

Laboratory measurements including pH, ANC (acid neutralizing capacity), conductance, anions (Cl^- , NO_3^- , SO_4^{2-} , PO_4^{3-}), cations (NH_4^+ , Ca^{2+} , Mg^{2+} , Na^+ , K^+), total N (nitrogen), and total P (phosphorous), were conducted following the protocol outlined in Williams et al. (1996) and Inyan (1999) at the University of Colorado Mountain Research Station’s Kiowa Environmental Chemistry Laboratory. Details regarding sample analysis at the Kiowa Laboratory, including information on instrumentation, standard methods for testing each analyte, general laboratory procedures, and quality

control, can be found at <http://snobear.colorado.edu/Seiboldc/kiowa.html>. DOC (dissolved organic carbon) was measured at the Institute for Arctic and Alpine Research (INSTAAR) Dissolved Organic Matter Laboratory. All samples were analyzed using the same protocol as samples analyzed for the National Science Foundation’s Long-Term Ecological Research (LTER) project. These protocols meet the standards outlined in the EPA Quality Assurance Project Plans (QAPP) agreement (EPA 2001).

V. Basin Characterization

The three drainages studied had a total land area of approximately 22 km²: Arrastra Basin covered 10.6 km², Blair Basin occupied 2.1 km², and Deer Park Basin had an area of 9.4 km² (Table 1). Of the major landscape types mapped, most of the land area in Arrastra Basin was tundra (35 percent), while 14 percent was forested. Arrastra Basin was sampled first and therefore included many areas that were mapped as combinations of landscape types. This yielded a relatively large “other” category of 35 percent of total basin area.

Table 1. Landscape Type Area and Percent Coverage for Each Study Basin

Landscape Type		Basin		
		Arrastra	Blair	Deer Park
Forest	%	13%	40%	46%
	km ²	1.42	0.83	4.35
Meadow	%	1%	0%	1%
	km ²	0.15	0.00	0.06
Wetland	%	0.04%	0%	4%
	km ²	0.00	0.01	0.34
Willow	%	3%	0%	10%
	km ²	0.27	0.00	0.85
Riparian	%	0.17%	1%	0%
	km ²	0.02	0.02	0.03
Talus	%	8%	18%	4%
	km ²	0.87	0.38	0.33
Tundra	%	30%	6%	23%
	km ²	3.15	0.13	2.21
Mine Waste	%	2%	0%	0%
	km ²	0.21	0.00	0.00
Bedrock	%	7%	7%	6%
	km ²	0.78	0.14	0.52
Other*	%	35%	27%	8%
	km ²	3.68	0.56	0.75
Total	%	100%	100%	100%
	km ²	10.55	2.08	9.44

* The “other” category consists of landscape types identified as combinations (e.g., talus/tundra) or unidentified areas.

Blair Basin consisted mainly of forest (40 percent) and also had a great deal of talus (18 percent). Deer Park Basin logged the least land area in the “other” category (8 percent). The predominant landscape types in this basin were forest (46 percent) and tundra (23 percent). Of the three watersheds, Deer Park Basin had the greatest amount of land area covered by willows (10 percent) and wetlands (4 percent).

Percentage of land in the “other” category decreased as a function of time and experience. One goal of landscape mapping is to develop consistent protocols for categorizing landscape types. As we became more familiar with the areas to be mapped and with the process of landscape mapping, land areas attributed to mixed categories declined substantially. Areas currently found in the “other” category will be remapped next season based on our experiences in 2003.

VI. Water Quality Results

Nineteen samples were collected at 15 sites in Arrastra, Blair, and Deer Park watersheds in San Juan County during the summer of 2003. In total, samples were collected at 7 sites along a main stream channel, and 8 samples were collected at stream channel tributaries. Of all sampling events, 11 were in alpine areas and 8 were in subalpine areas. Table 2 provides details about sampling dates and site locations.

Table 2. Surface Water Sampling Points

Kiowa Lab No.	Sample Location	Date Collected (yymmdd)	Time Collected	Basin	Drained Landscape Type
1	Arr.Downstream	030802	0930	Arrastra	forest
2	Arr.Upst.Wcbasintrib	030802	1115	Arrastra	willow
3	Arr.Netrib	030802	1305	Arrastra	forest
4	Arr.Upstream	030803	1115	Arrastra	tundra
5	Arr.Silverlake	030803	1245	Arrastra	tundra
6	Arr.Setrib.Lgbasin	030804	1030	Arrastra	tundra
7	Blair.Downstream	030805	1230	Blair	forest
8	Blair.Upstream	030806	1200	Blair	talus
9	DP.Downstream	030809	1000	Deer Park	riparian
10	Arr.Downstream	030810	0830	Arrastra	forest
11	Arr.Upstream	030810	1030	Arrastra	tundra
12	DP.Confluence	030814	1230	Deer Park	willow
13	DP.Up.Setrib	030814	1530	Deer Park	wetland
14	Blair.Up.Talusout	030815	1230	Blair	talus
15	Blair.Down.Wlout	030815	1300	Blair	wetland
16	Arr.Upstream	030817	0900	Arrastra	tundra
17	Arr.Downstream	030817	1000	Arrastra	forest
18	DP.No.Upstream	030817	1200	Deer Park	talus
19	DP.No.Talusout	030817	1230	Deer Park	talus

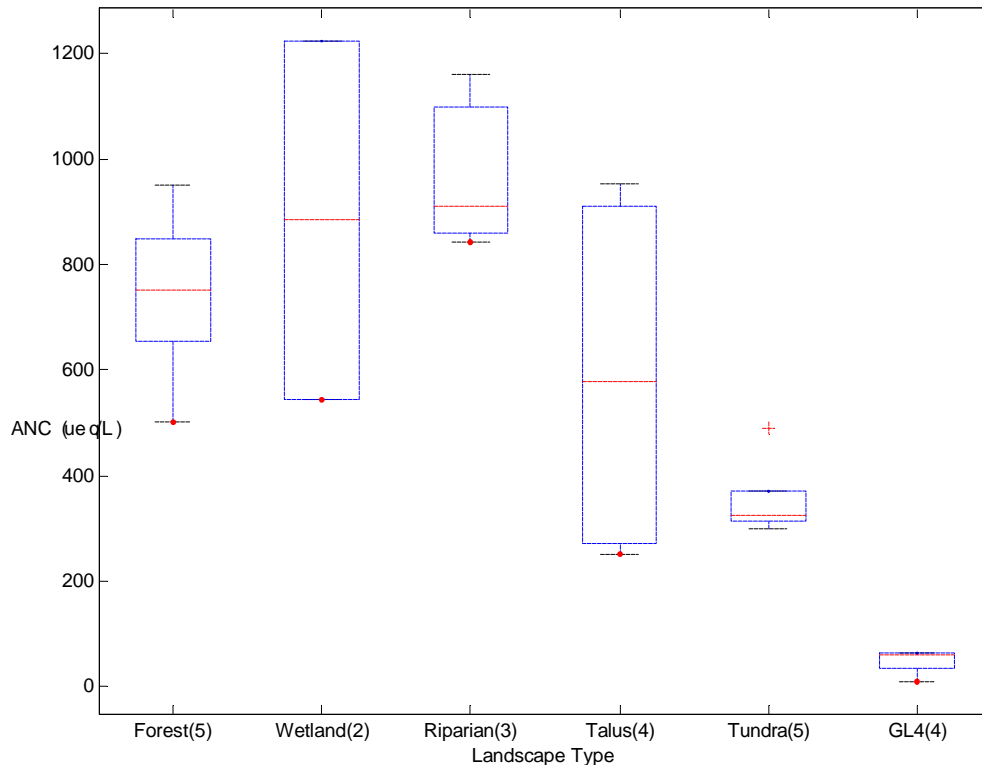
A. *Initial Interpretations of Water Quality*

This analysis uses water quality data as a proxy for assessing ecosystem health across the three study areas. In particular, acid neutralizing capacity (ANC), or buffering capacity, is used to assess sensitivity to acidification, and nitrate (NO_3^-) concentrations are used to evaluate sensitivity to nutrient enrichment. Acidification and nutrient loading are both potential ecosystem problems in San Juan County because (1) high elevation areas such as those found in San Juan County receive more atmospheric deposition of nitrogen and acid-causing pollutants; (2) the San Juan Mountains, like many areas in the western United States, are comprised of rocks containing disseminated minerals which cause acid rock drainage (ARD), and the exposure of these minerals to air and water has caused acidification of surface waters; and (3) these areas are susceptible greater-than-normal nutrient concentrations, a situation that occurs when an ecosystem's elemental cycling processes are disrupted or are sensitive to disruption in the future.

The remainder of this progress report will provide preliminary results of the landscape type analysis for alkalinity (ANC) and nitrate (NO_3^-); compare concentrations of both solutes from weekly sampling events in Arrastra Basin to another high alpine site along the Colorado Front Range; and report additional results for a variety of solutes measured at the sampled locations. A complete data table is presented in Appendix 1, including results of major solute measurements and other tests for all 19 samples collected during the summer of 2003. Appendix 2 provides maps of the 3 study basins, including mapped landscape types and sampling locations.

B. *Landscape Type Analysis: ANC*

This section of the analysis compares average solute concentrations in streams draining particular landscape types across the major landscape types. Figure 2 presents a box-and-whisker plot illustrating ANC concentrations by landscape type across all surface water samples. To provide context, the column on the far right of the plot contains summer 2003 ANC values at Green Lake 4, a high alpine site along the Colorado Front Range.

Figure 2. ANC Concentrations by Landscape Type

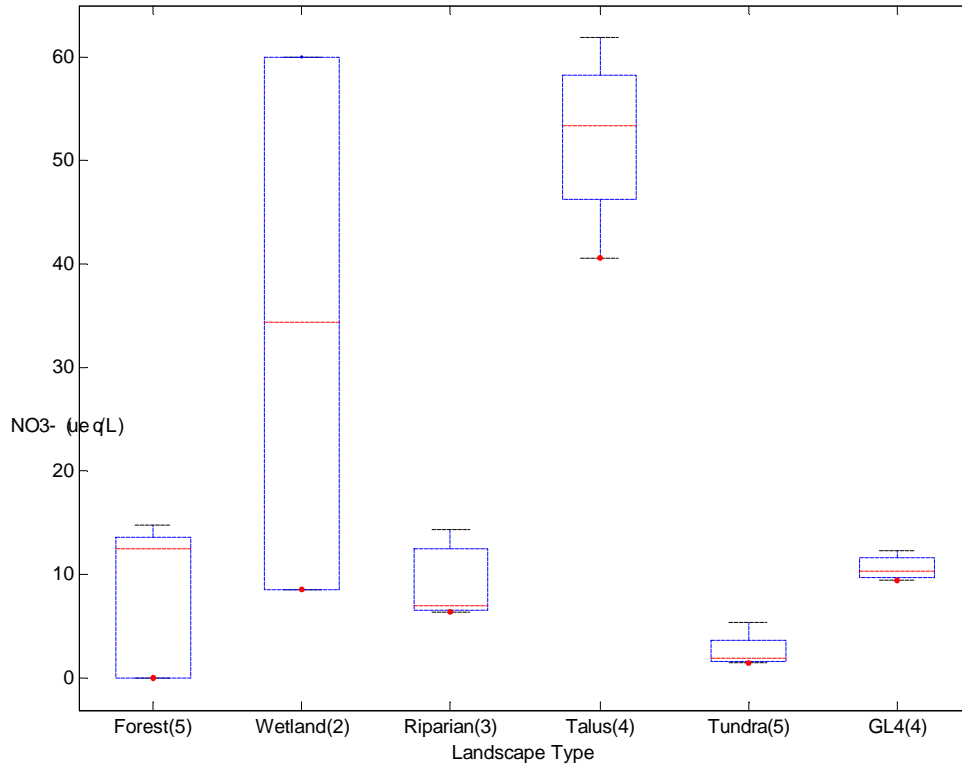
Note: Riparian category includes willows.

A one-way analysis of variance conducted on ANC concentrations from each of the different landscape types sampled in San Juan County revealed an overall significant effect of landscape type on ANC ($F_{(5,14)} = 3.86$, $R^2 = 0.53$, $p = 0.026$). The study sites in San Juan County generally exhibited higher acid neutralizing capacity values in surface waters draining forest, wetland, and riparian landscape types. ANC concentrations for these landscape types ranged from 502 μeq to 1,224 $\mu\text{eq/L}$. Lower ANC values were detected for talus and tundra landscape types, with concentrations for those areas ranging from 251 μeq to 954 $\mu\text{eq/L}$. A significant effect was found when comparing talus and tundra sites with the other landscape types ($F_{(1, 14)} = 11.49$, $p = 0.004$), indicating that ANC concentrations across these landscape types were significantly lower than ANC concentrations across the other landscapes. ANC concentrations at Green Lake 4 were much lower than those at any of the San Juan County sites. San Juan County results are corroborated by a similar study conducted in neighboring San Miguel County, where ANC concentrations for waters draining talus sites ranged from 18 μeq to 59 $\mu\text{eq/L}$, and waters draining tundra sites ranged from 14 μeq to 392 $\mu\text{eq/L}$. These data suggest that the San Juan County sites sampled appear to be well-buffered, considering that acid rock drainage occurs in the area. For comparison, waters in areas that have experienced acid mine drainage (AMD) can result in ANC concentrations less than 0 $\mu\text{eq/L}$.

C. *Landscape Type Analysis: Nitrate*

Nitrate concentrations by landscape type are displayed in a similar a box-and-whisker plot shown in Figure 3. Like the ANC boxplot, the box on the far right of the diagram provides summer 2003 nitrate values measured at Green Lake 4.

Figure 3. NO₃⁻ Concentrations by Landscape Type



Note: Riparian category includes willows.

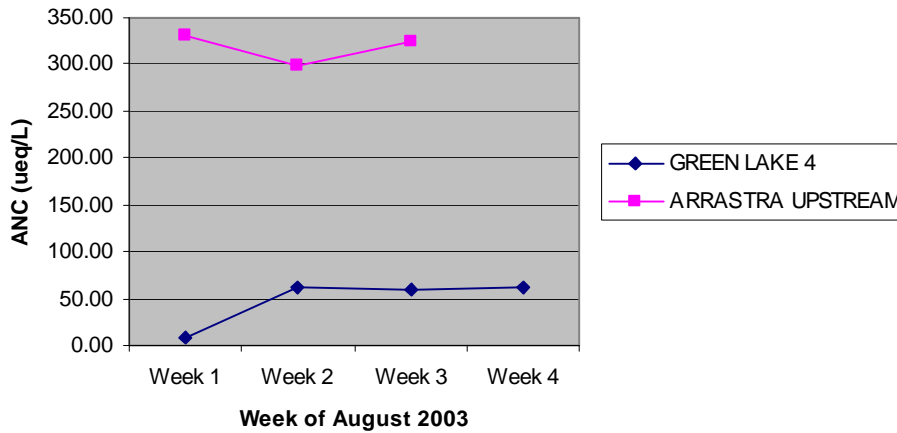
Nitrate concentrations at the Green Lake 4 site (9 µeq to 12 µeq/L) fell within the range of values detected at the San Juan County sites. A one-way analysis of variance was conducted on the nitrate concentrations from each of the different landscape types sampled in San Juan County. Overall, there was a significant effect of landscape type on nitrate concentrations ($F_{(5,14)} = 14.45$, $R^2 = 0.74$, $p = 0.0001$). Nitrate (NO₃⁻) concentrations were comparatively low for forest, riparian, and tundra landscape types. In fact, 2 samples from tundra outflows showed nitrate concentrations below instrument detection limits (0.07 µeq/L). Nitrate concentrations in surface waters draining these landscape types ranged from below detection limits to 15 µeq/L. Even in these areas, nitrate values at some sites were surprisingly high, compared to values less than 5 µeq/L for most high-elevation streams in the Front Range during the month of August. A single degree of freedom test indicated that nitrate concentrations in waters flowing out of talus were significantly higher than other landscape types ($F_{(1,14)} = 40.96$, $p < 0.0001$), ranging from 41 µeq to 62 µeq/L. Nitrate concentrations in wetland-drained waterways varied considerably, with a wide range of 9 µeq to 60 µeq/L. The anomalously high wetland

nitrate concentration of 60 μ eq/L was measured along the southeast tributary to Deer Park Creek and may suggest a local perturbation.

D. Comparison to Green Lakes Valley, Colorado

Again, comparison of the Arrastra Basin upstream location (where weekly sampling was conducted) to Green Lake 4, a site in the Colorado Front Range just west of the Denver metropolitan region, provides context for evaluating ANC and nitrate concentrations. Figure 4 presents ANC concentrations during August 2003 for both sites.

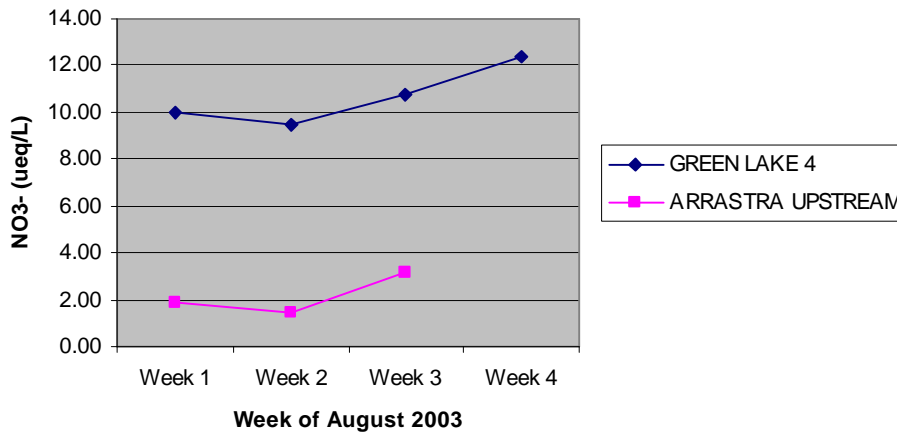
Figure 4. ANC Concentrations at 2 Alpine Sites, August 2003



ANC concentrations in alpine section of Arrastra Basin are consistently higher than those found in the Green Lakes Valley, suggesting that this area is very well buffered.

Figure 5 shows nitrate concentrations for the month of August at both alpine locations.

Figure 5. Nitrate Concentrations at 2 Alpine Sites, August 2003

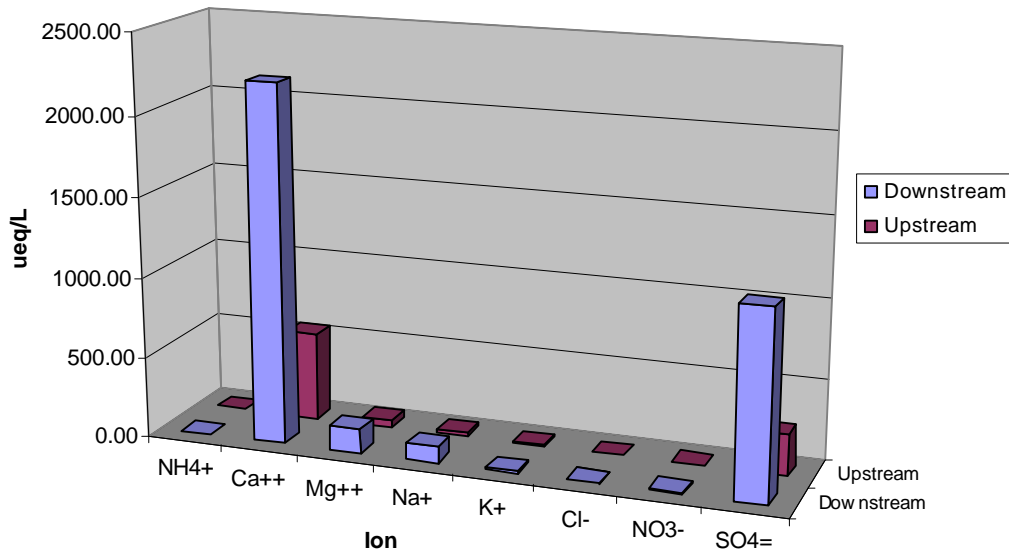


The Green Lakes Valley is known to be somewhat nutrient-enriched, exhibiting relatively high nitrate concentrations throughout the summer. Nitrate concentrations in the alpine portion of Arrastra Basin tend to be much lower.

E. Additional Results

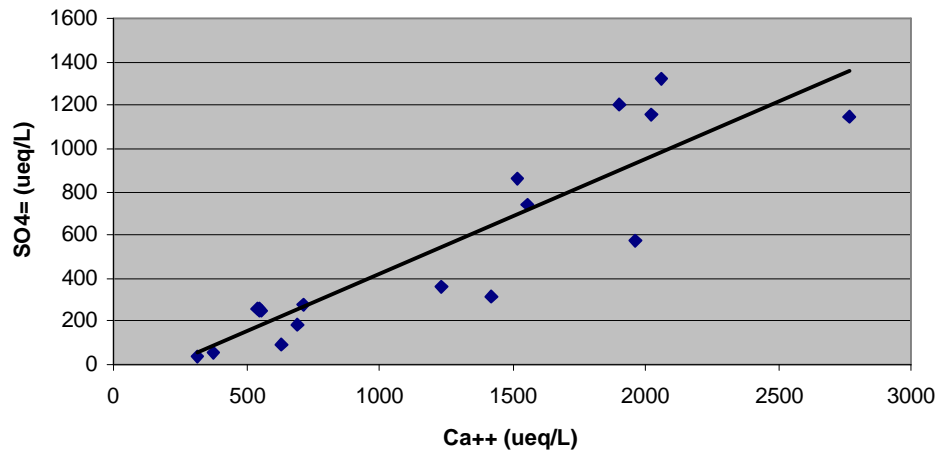
Weekly sampling of alpine and subalpine sites within Arrastra Basin showed consistent differences between surface waters in the upstream (alpine tundra) and downstream (subalpine forest) locations. Figure 6 presents a comparison of major anions and base cations between the two sites. Ion concentrations were generally higher at the subalpine forest site. Specific conductance (not shown) was also higher at the subalpine site, averaging 227 μ S/cm compared to an average alpine conductivity measurement of 61 μ S/cm. ANC concentrations (not shown) followed this trend as well, with a mean of 823 μ eq/L in the subalpine forest and a mean of 317 μ eq/L at the alpine tundra site. Analysis of dissolved organic carbon (not shown) revealed higher DOC concentrations at the alpine site (mean = 1.7 mg/L) compared to the subalpine site (mean = 0.5 mg/L).

Figure 6. Arrastra Basin: Comparison of Upstream and Downstream Sites



Further analysis of ion concentrations indicated that calcium and sulfate concentrations were well correlated across all samples ($R^2 = 0.98$). Removing one outlier with extremely high calcium and sulfate concentrations yielded the results presented in Figure 7 ($R^2 = 0.80$). The outlier was a sample taken in the subalpine portion of Blair Gulch, an area with a visually high metals content and measured high concentrations of most anions and cations. The conductivity measured at this site was 1,290 μ S/cm.

Figure 7. Calcium Versus Sulfate Concentrations



A Pearson's correlation analysis revealed other interesting correlations. Results of this analysis are presented in Table 3. Significant results to the 0.01 level are shaded dark grey, and results significant to the 0.05 level are indicated by a lighter shade of grey. Many of the cations tested were highly correlated with one another, with specific conductance, and also with sulfate (SO_4^{2-}). In addition, a high correlation exists between calcium and inorganic phosphorous ($R = 0.87$) because of the volcanic rocks that are the basis of the geology of much of San Juan County.

Table 3. Pearson's Correlation Analysis

	pH	COND (uS/cm)	ANC (ueq/L)	H+ (ueq/L)	NH4- (ueq/L)	Ca++ (ueq/L)	Mg++ (ueq/L)	Na+ (ueq/L)	K+ (ueq/L)	Cl- (ueq/L)	NO3- (ueq/L)	SO4= (ueq/L)	TDN (umol/L)	DON (umol/L)	IN (umol/L)	TDP (umol/L)
PH	1	0.120	0.817	-0.937	-0.399	0.137	0.684	0.341	0.496	0.214	0.248	0.039	0.292	0.443	0.243	-0.25
COND (uS/cm)	0.120	1	0.286	-0.146	-0.445	0.996	0.520	0.911	0.620	0.372	-0.124	0.995	-0.156	-0.222	-0.131	0.80
ANC (ueq/L)	0.817	0.286	1	-0.722	-0.466	0.322	0.820	0.582	0.665	0.301	0.293	0.189	0.321	0.288	0.288	-0.18
H+ (ueq/L)	-0.937	-0.146	-0.722	1	0.364	-0.157	-0.673	-0.362	-0.523	-0.205	-0.124	-0.076	-0.170	-0.484	-0.119	0.28
NH4+ (ueq/L)	-0.399	-0.445	-0.466	0.364	1	-0.432	-0.649	-0.519	-0.561	-0.460	-0.482	-0.394	-0.483	-0.044	-0.470	-0.24
Ca++ (ueq/L)	0.137	0.996	0.322	-0.157	-0.432	1	0.519	0.919	0.620	0.353	-0.138	0.988	-0.169	-0.216	-0.145	0.78
Mg++ (ueq/L)	0.684	0.520	0.820	-0.673	-0.649	0.519	1	0.738	0.873	0.618	0.408	0.440	0.417	0.100	0.401	0.08
Na+ (ueq/L)	0.341	0.911	0.582	-0.362	-0.519	0.919	0.738	1	0.807	0.481	-0.008	0.874	-0.024	-0.075	-0.016	0.55
K+ (ueq/L)	0.496	0.620	0.665	-0.523	-0.561	0.620	0.873	0.807	1	0.775	0.308	0.564	0.297	-0.085	0.302	0.21
Cl- (ueq/L)	0.214	0.372	0.301	-0.205	-0.460	0.353	0.618	0.481	0.775	1	0.622	0.340	0.600	-0.291	0.620	0.24
NO3- (ueq/L)	0.248	-0.124	0.293	-0.124	-0.482	-0.138	0.408	-0.008	0.308	0.622	1	-0.176	0.995	-0.200	1.000	-0.04
SO4= (ueq/L)	0.039	0.995	0.189	-0.076	-0.394	0.988	0.440	0.874	0.564	0.340	-0.176	1	-0.212	-0.256	-0.183	0.84
TDN (umol/L)	0.292	-0.156	0.321	-0.170	-0.483	-0.169	0.417	-0.024	0.297	0.600	0.995	-0.212	1	-0.103	0.995	-0.05
DON (umol/L)	0.443	-0.222	0.288	-0.484	-0.044	-0.216	0.100	-0.075	-0.085	-0.291	-0.200	-0.256	-0.103	1	-0.202	-0.35
IN (umol/L)	0.243	-0.131	0.288	-0.119	-0.470	-0.145	0.401	-0.016	0.302	0.620	1.000	-0.183	0.995	-0.202	1	-0.05
TDP (umol/L)	-0.259	0.809	-0.181	0.286	-0.243	0.788	0.081	0.555	0.212	0.240	-0.046	0.844	-0.091	-0.395	-0.050	
DOP (umol/L)	-0.766	-0.335	-0.703	0.875	0.350	-0.357	-0.652	-0.551	-0.585	-0.102	0.115	-0.275	0.085	-0.373	0.121	0.15
PO4 3- (ueq/L)	-0.141	0.891	-0.056	0.154	-0.319	0.874	0.210	0.675	0.327	0.276	-0.065	0.916	-0.107	-0.348	-0.071	0.98
IP (umol/L)	-0.142	0.889	-0.058	0.155	-0.319	0.872	0.207	0.673	0.324	0.275	-0.065	0.915	-0.107	-0.347	-0.070	0.98
DOC (mg/L)	0.124	-0.356	-0.119	-0.042	0.359	-0.354	-0.339	-0.401	-0.480	-0.484	-0.380	-0.341	-0.349	0.339	-0.377	-0.30

Correlation is significant at the 0.01 level (2-tailed).

Correlation is significant at the 0.05 level (2-tailed).

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Appendix 1

MARK WILLIAMS/KIM RABY
 2003 WATER SAMPLES
 SILVERTON, CO
 Preliminary results 031031

KIOWA LAB NO.	SAMPLE LOCATION	DATE COLLECT	TIME COLLECT	pH	COND uS/cm	ANC uEQ/L	H+ uEQ/L	NH4+ uEQ/L	Ca++ uEQ/L	Mg++ uEQ/L	Na+ uEQ/L	K+ uEQ/L	Cl- uEQ/L	NO3- uEQ/L
1	ARRASTRA.DOWNSTREAM	030802	0930	7.60	231.60	950.77	0.03	0.61	2763.97	152.40	97.87	13.09	4.17	12.44
2	ARRASTRA.UPST.WCBASINTRIB	030802	1115	7.58	250.00	841.20	0.03	0.89	2062.87	203.60	94.82	13.58	4.60	14.34
3	ARRASTRA.NETRIB	030802	1305	7.54	78.40	502.02	0.03	0.46	715.57	71.18	40.50	5.91	0.99	u
4	ARRASTRA.UPSTREAM	030803	1115	7.51	62.10	330.16	0.03	0.66	544.91	47.54	48.41	6.88	3.55	1.86
5	ARRASTRA.SILVERLAKE	030803	1245	7.45	59.90	316.82	0.04	0.53	546.41	45.84	19.18	7.11	4.20	1.58
6	ARRASTRA.SETRIB.LGBASIN	030804	1030	7.84	68.50	491.14	0.01	0.69	691.12	36.07	17.59	7.93	2.26	5.31
7	BLAIR.DOWNSTREAM	030805	1230	7.59	1290.00	752.35	0.03	u	10678.64	251.97	248.37	17.52	5.44	u
8	BLAIR.UPSTREAM	030806	1200	7.14	33.90	250.86	0.07	0.64	317.56	21.02	17.01	5.96	3.81	40.54
9	DEERPARK.DOWNSTREAM	030809	1000	7.88	134.00	911.94	0.01	0.46	1230.04	218.00	73.95	8.98	2.34	6.35
10	ARRASTRA.DOWNSTREAM	030810	0830	7.46	222.00	705.77	0.03	0.46	1900.20	160.66	115.27	14.17	4.65	13.13
11	ARRASTRA.UPSTREAM	030810	1030	7.38	60.70	298.32	0.04	0.54	548.90	46.18	20.01	7.08	2.91	1.45
12	DEERPARK.CONFLUENCE	030814	1230	8.19	126.90	1161.59	0.01	0.71	1422.65	140.14	86.13	10.87	3.13	6.97
13	DEERPARK.UP.SETRIB	030814	1530	8.07	202.80	1223.72	0.01	u	1960.58	243.91	91.34	10.59	4.23	59.98
14	BLAIR.UP.TALUSOUT	030815	1230	7.26	40.40	288.53	0.05	0.66	377.20	25.13	23.45	6.60	4.85	51.95
15	BLAIR.DOWN.WLOUT	030815	1300	7.22	63.70	544.04	0.06	0.44	633.23	38.13	33.45	7.19	2.31	8.55
16	ARRASTRA.UPSTREAM	030817	0900	7.41	61.00	323.73	0.04	1.32	559.88	49.00	18.83	6.80	3.30	3.14
17	ARRASTRA.DOWNSTREAM	030817	1000	7.69	227.00	812.29	0.02	0.49	2025.45	155.82	102.65	14.17	5.22	14.84
18	DEERPARK.NO.UPSTREAM	030817	1200	7.90	193.00	954.37	0.01	u	1556.89	260.28	84.39	16.21	6.29	54.63
19	DEERPARK.NO.TALUSOUTFLOW	030817	1230	8.01	199.00	867.95	0.01	u	1515.97	299.28	89.60	17.95	7.22	61.85

KIOWA LAB NO.	SAMPLE LOCATION	SUM +	SUM -	UM+ - SUM JM+ + SUM	TDN uMOLES/L	DON uMOLES/L	IN uMOLES/L	TDP uMOLES/L	DOP uMOLES/L	PO4 3- uEQ/L	IP uMOLES/L	DOC mg/L
1	ARRASTRA.DOWNSTREAM	3027.97	2114.80	0.18	13.79	0.75	13.04	u	u	u	u	0.467
2	ARRASTRA.UPST.WCBASINTRIB	2375.80	2184.78	0.04	15.00	u	15.23	0.11	0.05	0.16	0.05	0.891
3	ARRASTRA.NETRIB	833.64	779.50	0.03	1.16	0.70	0.46	u	u	u	u	0.959
4	ARRASTRA.UPSTREAM	648.44	597.62	0.04	5.80	3.28	2.53	0.07	0.03	0.14	0.05	1.291
5	ARRASTRA.SILVERLAKE	619.10	571.74	0.04	4.97	2.86	2.11	0.09	0.09	u	u	1.368
6	ARRASTRA.SETRIB.LGBASIN	753.41	685.99	0.05	11.09	5.09	6.00	0.15	u	0.23	0.08	0.933
7	BLAIR.DOWNSTREAM	11196.53	9948.77	0.06	0.64	0.64	0.00	1.36	u	4.42	1.47	0.488
8	BLAIR.UPSTREAM	362.26	337.62	0.04	41.72	0.54	41.18	0.47	0.16	0.95	0.32	0.655
9	DEERPARK.DOWNSTREAM	1531.43	1282.58	0.09	15.81	9.01	6.80	u	u	u	u	1.285
10	ARRASTRA.DOWNSTREAM	2190.80	1926.77	0.06	18.06	4.47	13.59	u	u	u	u	0.616
11	ARRASTRA.UPSTREAM	622.76	561.70	0.05	4.86	2.88	1.98	0.08	0.08	u	u	2.258
12	DEERPARK.CONFLUENCE	1660.51	1485.23	0.06	12.65	4.97	7.68	u	u	u	u	2.250
13	DEERPARK.UP.SETRIB	2306.43	1858.36	0.11	63.93	3.96	59.98	u	u	u	u	1.055
14	BLAIR.UP.TALUSOUT	433.08	396.43	0.04	53.37	0.76	52.61	0.44	0.13	0.93	0.31	0.786
15	BLAIR.DOWN.WLOUT	712.50	647.74	0.05	12.45	3.46	9.00	0.09	0.09	u	u	1.051
16	ARRASTRA.UPSTREAM	635.88	583.99	0.04	6.67	2.21	4.46	0.05	0.05	u	u	1.461
17	ARRASTRA.DOWNSTREAM	2298.60	1990.45	0.07	20.05	4.73	15.33	u	u	u	u	0.526
18	DEERPARK.NO.UPSTREAM	1917.78	1757.75	0.04	57.05	2.42	54.63	u	u	u	u	0.713
19	DEERPARK.NO.TALUSOUTFLOW	1922.81	1793.55	0.03	63.68	1.82	61.85	0.08	u	0.27	0.09	0.590

u=Undetected

Task 2: Objective 2: Wetlands Identification

By mid fall Kim Raby, University of Colorado graduate student had completed the identification and mapping of land types including potential sensitive areas such as wetlands, streams, and open water. These initial maps were used by

Alpine Environmental Services (AES) to ground truth wetland identification and boundaries, as well as watershed boundaries and stream positions. A few minor additions and boundary changes are anticipated as a result of 3 days being spent in the field. The suggested changes and additions will be approved by other participants before incorporation into the GIS.

Task 3: Mapping of Drinking & Domestic Water Quality

Data on both surface and ground water continues to be compiled in the ARSG data base. Data gathered since 1998 has now been added to the data base to provide coverage from 1989 through 2002. Several new wells were drilled this fall; however sampling cannot occur at these new sites until spring of 2004. Samples of most existing wells were accomplished in the summer of 2003. Data from all wells and surface water samples have been compiled into the ARSG database. This winter the data will be validated and areas where water quality is known will be mapped as described in the original proposal.

Data from springs and seeps in the basin currently reside in the USGS database for the Animas watershed. These data will be used to create a separate map overlay of springs and seeps with known water quality during the second year of the project.

San Juan RC&D has agreed to assist with the development of a GIS layer that will include all draining adits and related data. This is currently scheduled for development during the summer of 2004.

Task 4: Provide map and tables of the State of Colorado water quality 303 (d) list of non-compliant streams and parameters

This task will be complete during the 2003-2004 winter months. A map has already been created but needs to be adapted to the new GIS format.

Task 5: Re-mapping of Mining Claims

Computer Terrain Mapping (CTM) of Boulder, CO was contracted by the BLM to do an extensive mapping project on the Alpine Loop, a scenic (mostly) four-wheel-drive road system in the mountains north of Silverton. As a part of this project, a re-mapping of mining claims is being done, since mining claim boundaries are notoriously inaccurate in San Juan and surrounding mountain counties. This project dovetails nicely with the San Juan County EPA project in that it will allow water quality data and alpine sensitivity analysis to occur in the context of a more accurate land parcel map.

To date, significant progress is being made in the mapping project. A key component of this re-mapping is to accurately identify the original US Locational Monuments that the original surveys of claims were tied to. Many of these have

been lost over time. However, a list of approximately 50 of these monuments was obtained from the BLM that lists locational monuments that have been GPS'd in the past few years. Monuments yet to be identified (but are known to exist from the original records) were digitized from BLM sectional maps and utilized as a guide for locating more of these. MSI's role in this work has been to go out into the field, locate and GPS as many of those monuments as possible. This proved to be an extraordinarily difficult process. These monuments are generally carved in rock or trees—some of which no longer exist or are overgrown with lichens. The monument locations digitized from the sectional maps proved to be as much as 700 meters away from monuments identified in the field. Ultimately, 3 new monuments were GPS'd and approximately 8 more were located “virtually”, by identifying a landmark on the original survey record and backtracking to the locational monuments utilizing the bearings and directions specified in the original survey plat. It is thought that these “virtual” locations are probably within 50 meters of the actual location. This will provide a much more accurate map than currently exists for San Juan County.

Concurrent with this, CTM has been doing extensive parcel digitizing (mining claim parcels) from the BLM sectional maps. These will be “rubber sheeted” utilizing the GPS'd control points obtained from the BLM and those identified “virtually” and through field work.

In addition, geological hazard maps have been digitized from hard copy mylar scans by CTM. No avalanche polygons have been created in the study areas and creation of those is beyond the scope of this project.

Task 6: Assembling data into hard copy & GIS format

Currently, base maps have been identified and obtained. The maps have been described in the section above, “GIS Methods”. The base maps have been used by Kim Raby in the field for drawing land type polygons on. The digitization and attribution of land type polygons from the field maps was accomplished this fall.