Beale Canal Seepage Investigation 2010

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Background

Montana Salinity Control (MSC) has noted saline seep conditions on fields down gradient from a portion of the Beale Canal near Sims Montana. It is hypothesized that seepage from the canal may be contributing to the problem and that lining the canal could help to alleviate the saline seeps. Scott Brown with MSC identified four sites along the canal delineating sections where losses might be occurring. Funding was made available by the US Bureau of Reclamation for MSU Extension Water Quality (MSUEWQ) to perform discharge measurements at the selected sites during May and July of 2010. The results of the discharge measurements are discussed below.

Methods

Discharge measurements were taken on two dates at four locations along Beale Canal, approximately 2 miles northwest of Sims Montana. Sites were identified by Scott Brown with MSC and are depicted in Figures 1 through 5. Coordinates and site descriptions are included in Table 1. Alan Rollo (Sun River Watershed Coordinator) communicated with the irrigation district to get notes about changes in diversions above the reach associated with sampling events and these notes are outlined in Table 3. Observations of headgates present within the reach are outlined in Table 2. Discharge measurements were taken with a Marsh-McBirney FLO-MATE 2000 and top setting rod. The FLOW-MATE was checked for accuracy against a Doppler velocity meter in a flume at the MSU hydrology laboratory on July 6th 2010 and performed well within expectations. FLO-MATE deviations from the Doppler system were within 2% at a velocity of 2 feet per second. Field water quality parameters (EC, Temperature, and pH) were collected with a YSI 556 multi-parameter meter. The YSI was calibrated within 24 hours of the time measurements were taken for both sample events.

Table 1. Site coordinates and descriptions (Datum = NAD 83)

Site	Latitude	Longitude	Description
1	47.529308	- 111.948875	80 feet below check structure, 10 feet below location where channel narrows
2	47.52445	- 111.943731	Directly between an abandoned headgate and a fence across the channel; fence is just upstream from a check structure
3	47.520269	- 111.9404	About 50 feet upstream from a headgate which is just upstream from a board across the canal
4	47.514953	- 111.939428	Standing at this site looking west directly upslope (perpendicular to the channel), there is a brace in the barbed wire fence

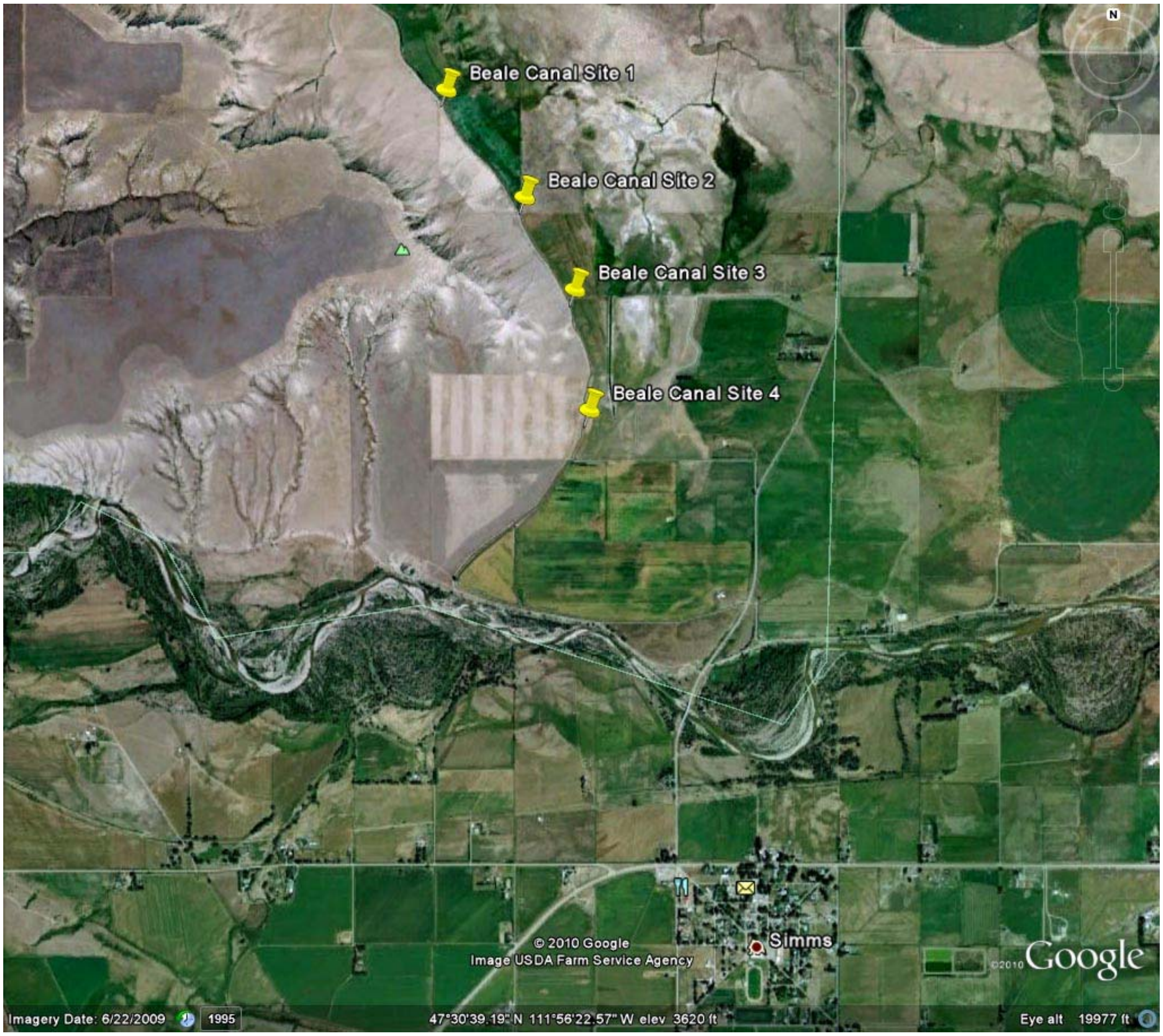

Figure 1. Aerial image from Google Earth of the study reach on Beale Canal. The canal is flowing from North to South along the contour. The wetter down-gradient east side of the canal can easily be picked out as the greener portion of the image.

Table 2. Observations of headgates within the study reach.

Reaches (upstream to downstream)	Headgates noted
Between sites 1 & 2	1 abandoned/overgrown headgate just upstream from site 2
Between sites 2 & 3	1 headgate noted just below site 2 (not flowing)
Between sites 3 & 4	2 headgates noted (neither flowing)

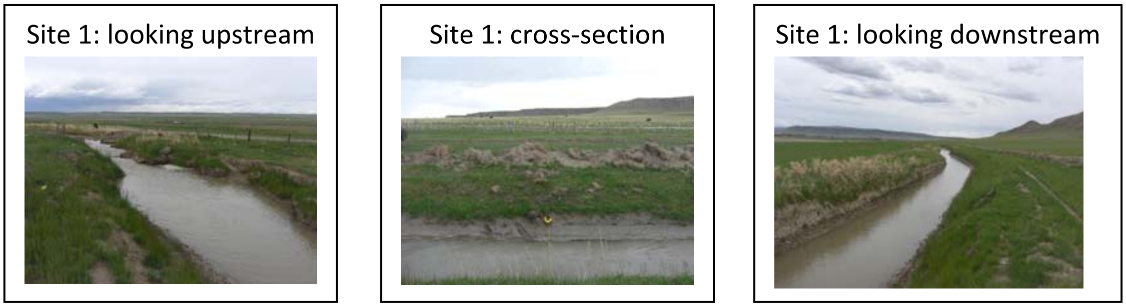

Figure 2. Photos taken at Site 1 (most upstream site).

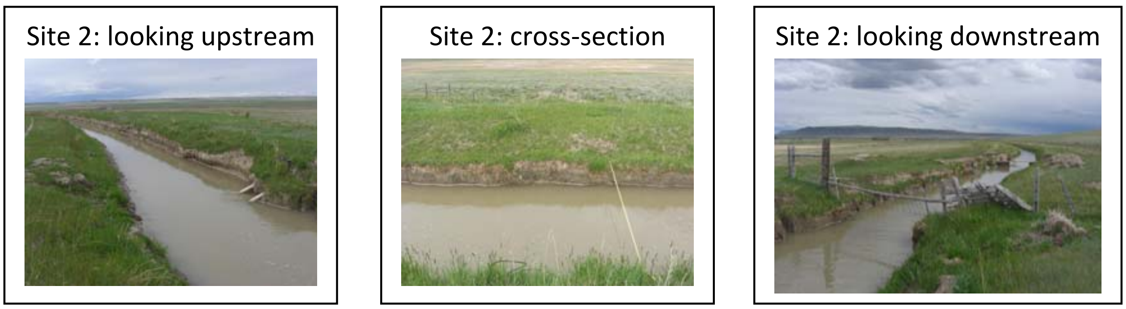

Figure 3. Photos taken at Site 2.

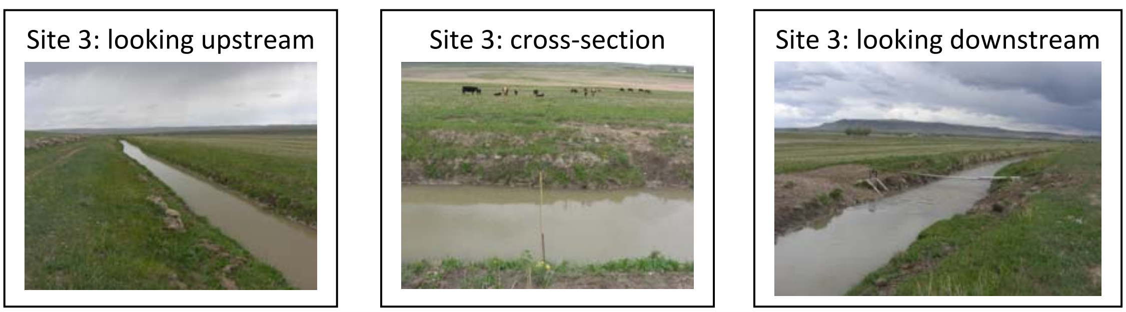

Figure 4. Photos taken at Site 3.

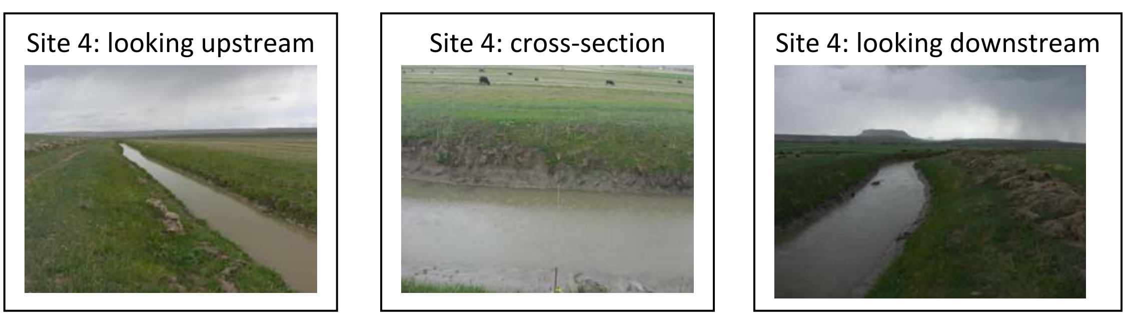

Figure 5. Photos taken at Site 4 (most downstream site).

Table 3. Notes from irrigation district about diversions before and during sample events.

	Comment
May Event	No water being withdrawn on May 25th or 26th
July Event	T/O #1 - 1.0 CFS for several days before and after July 27th
	T/O #2 - 1.5 CFS for several days before and after July 27th
	T/O #4 - was shut off on July 23 and remained off
	T/O #7- was shut off on July 12 and remained off
	T/O #8- was shut off on July 26, 7 AM and remained off

Results

Discharge measurements on May 26th shortly after the canal was turned on indicated losses of approximately 1.2 CFS between sites 1 and 3. The distance between sites 1 and 3 is approximately three quarters of a mile. Velocity measurements at site 4 relative to the other sites seem to have been confounded by a low battery in the meter which was changed between sites 3 and 4. A linear trendline fit to discharge results for sites 1 through 3 produces an R-squared value of 0.999 indicating that a constant rate of loss between sites 1 and 3 is supported by the data. Multiple discharge measurements were taken at site 4 on this date indicating reasonable precision among measurements. The largest deviation from the mean of 12.57 CFS was 0.31 (2.47% difference). Multiple discharge measurements were not taken at sites 1 through 3, so precision at these sites cannot be assessed. The unexpected results at site 4 on May 26th prompted an investigation of the influence of battery voltage on velocity readings produced by the FLO-MATE. Velocity trials in a flume in the MSU Engineering Hydrology Laboratory revealed that a battery with voltage low enough to produce a low battery warning (~1.2 volts) will produce velocity readings ~5% less than readings produced with new 1.5 volt batteries. This observation partially explains the unexpectedly high results for discharge at site 4 on May 26th.

On July 27th the FLO-MATE was equipped with new batteries and triplicate measures were taken at each site. Results do not strongly support losses at levels great enough to be quantified with the traditional discharge measurements used. The trendline fit to the data indicates a subtle loss of discharge through the reach (0.27 CFS between sites 1 and 4), but the distribution of data points and the low R-squared value do not strongly indicate a quantifiable loss of discharge.

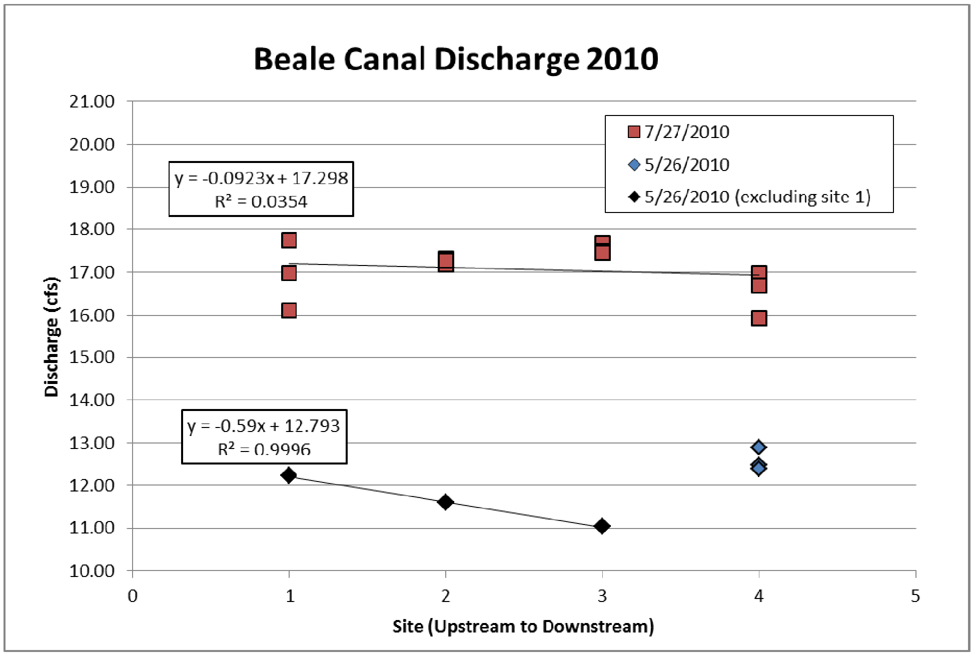

Figure 6. Discharge measurements. A single discharge measurement was taken at each site in May except Site 4 where three measurements were taken. Triplicate measurements were taken at all sites in July. The trendline for May only includes sites 1 through 3. The trendline for July includes all measurements.

Following are some possible explanations for differences in discharge measured at different sites and a comment about the relevance to each explanation to this investigation.

- **Increases in discharge moving downstream**
  - Water entering the canal within the reach (not observed)
  - Canal inflow changes – Increase in water entering the reach over the course of measurements being taken moving downstream. (not likely based on notes from the irrigation district)
- **Decreases in discharge moving downstream**
  - Diversion within the reach (no active diversions within the reach were observed)
  - Canal inflow changes – Decrease in water entering the reach over the course of measurements being taken moving downstream. (not likely based on notes from the irrigation district)
  - Seepage (likely an explanation for decreases between site 1 and 3 in May)
- **Noise in the data as a result of measurement error**
  - Muddy bottoms can result in over estimation of discharge by reading depths that are greater than the actual water depth. Some caution was taken to read the water depth from the surface of the mud rather than letting the foot of the top-setting rod sink in the mud. (likely partial explanation for variation between July discharge measurements)

Field water quality data collected on both sample dates is depicted in Table 5. Temperature, pH and specific conductivity are relatively stable throughout the reach as would be expected. Specific conductivity (a proxy for total salts) is somewhat lower in July than in May.

Table 5. Water quality parameters for May 26th and July 27th 2010 (Site 1 is most upstream).

	Temperature	pH	Specific Conductance
May 26th			
Site 1 (18:42)	17.21	8.44	427
Site 2 (17:30)	17.50	8.41	437
Site 3 (17:00)	17.62	8.41	434
Site 4 (16:26)	17.41	8.28	443
July 27th			
Site 1 (21:37)	16.83	8.66	384
Site 2 (20:51)	16.92	8.62	381
Site 3 (20:00)	16.96	8.59	385
Site 4 (19:23)	16.77	8.51	386

Discussion

Discharge measurements conducted in May shortly after water was turned into Beale Canal indicate loses of just over 1 CFS over a 0.75 mile reach. While the data collected at sites 1 through 3 in May make a strong case supporting losses of a 1 CFS, the results at site 4 raise some uncertainty about the precision of this estimate. While the trendline produced from the overall July dataset indicates a loss of approximately 0.25 CFS over the reach, the distribution of the data points does not provide a high degree of confidence in the precision of this number. Overall the discharge data collected suggests that the canal loses water at a higher rate in the spring shortly after water is turned into it and then the rate of loss decreases later in the season to a point where it may not be measurable by a conventional discharge mass balance approach. Other indications suggesting seepage from the canal include the stark contrast on the aerial image between the green vegetation below the canal and brown vegetation above, the extent of saline seeps down gradient and conventional hydrological concepts of infiltration and subsurface water movement.