

**DISCHARGE AND TURBIDITY IN TRIBUTARIES
TO THE LOWER MATTOLE RIVER:
2008-2009 WINTER RUNOFF SEASON**

A Report to the Mattole Restoration Council

Randy Klein, Hydrologist
Certified Erosion and Sediment
Control Specialist (CPESC) No. 361

April 21, 2009

TABLE OF CONTENTS

Background and Project Objectives.....	1
Project Scope	1
Methods	2
Site Selection	2
Turbidity and Discharge Measurements	4
Data Analysis	5
Results.....	5
Hydrologic Conditions.....	5
Turbidity/discharge Ratios.....	7
Lower Bound Lines.....	11
Discussion and Recommendations.....	13
Literature Cited	13
Appendix A: Discharge and Turbidity Sample Data	14
Appendix B: Discharge, Turbidity, and Lower Bound Line Graphs	18
Appendix C. Standard Operating Procedures for Turbidity and Discharge Monitoring	28

TABLES

Table 1. Tributary turbidity and discharge monitoring sites, Lower Mattole River, WY2009	2
Table 2. Lower bound line slopes	12

FIGURES

Figure 1. Map of Lower Mattole River tributary monitoring sites	3
Figure 2. Lower Mattole River hydrology, WY2009	6
Figure 3. Lower Mattole tributary turbidity/discharge ratios, WY2009	7
Figure 4. Lower Mattole tributary turbidity/discharge ratios, November, 2008	8
Figure 5. Lower Mattole tributary turbidity/discharge ratios, December, 2008	8
Figure 6. Lower Mattole tributary turbidity/discharge ratios, January, 2009	9
Figure 7. Lower Mattole tributary turbidity/discharge ratios, February, 2009	9
Figure 8. Lower Mattole tributary turbidity/discharge ratios, March, 2009	10
Figure 9. Lower bound lines for Mattole tributaries, WY2009	11

BACKGROUND AND PROJECT OBJECTIVES

The Mattole Restoration Council, (MRC) has undertaken an erosion control and prevention program to reduce long-term sediment yield from roads in the Mattole River watershed. The primary focus of the erosion control and prevention program is to remove ('decommission') forest roads that are not needed for transportation and upgrade roads in use that pose sedimentation risks to downstream resources (aquatic habitat for salmonids and other species). Beginning in 2009, MRC will begin treating roads in tributaries to the Lower Mattole River. Pre-project stream turbidity and discharge monitoring was performed in winter 2008-2009 (water year (WY) 2009) at ten tributary sites with the following objectives: 1) determine effects on tributary water quality attributable to road treatments, and 2) determine the need for and nature of any modifications to the style or rate of road treatments that may be warranted to reduce water quality impacts.

In the fall of 2008, I developed a monitoring plan for MRC to be implemented by staff and local volunteers with technical training and oversight. Methods and materials chosen were low-tech and relatively inexpensive, combining qualitative and quantitative approaches designed to be implemented by MRC staff with minimal training, but still provide useful, repeatable information. This report presents the results from the first winter of monitoring that preceded road treatments in the subject watersheds.

While road removal reduces the long-term erosional risks from forest roads, short-term erosional responses, primarily from stream crossing excavations, can occur in the form of surface erosion, rilling, and gullyng, channel scour, and minor slumping in treated areas. Typically, most erosional responses occur within the first winter following road removal and greatly diminish as vegetation grows on excavation sideslopes and channels find stable grades and armor themselves with rock and woody debris (Madej, 2001). Some level of post-treatment erosion must be viewed as a worthwhile trade-off between smaller short-term impacts and larger long-term impacts that would result without treatment.

Studies of erosional responses to road removal work performed elsewhere in the region show that most road treatment sites will likely experience minimal erosion, but a few may experience relatively large volumes of erosion (Klein, 1984; Madej, 2001). This skewed distribution reduces the ability to make broad conclusions based on a relatively small sample as in the case of this study. However, data collected for even a limited study such as this can provide meaningful feedback for adaptive management.

PROJECT SCOPE

The monitoring project includes two phases: an initial phase was implemented during the 2008-2009 winter runoff season to collect data that characterize pre-treatment turbidity-discharge relationships, while a second phase will be implemented in subsequent years to assess changes anticipated from the treatment work. Ten tributaries were selected for monitoring discharge and turbidity. Of these, three are considered "control" sites because no road treatments are currently planned within their upstream watershed areas, while road work at various levels is planned for the other seven. It is anticipated that tributary monitoring will continue at these same sites for at least two additional years, allowing changes in response to road treatments to be quantified.

METHODS

Site Selection

Road treatments are planned within the 25,000 acre “Petrolia Project Area” in the Lower Mattole River watershed (Fig. 1). In 2007 an inventory of hillslope, streambank and road-related sediment delivery sites was conducted by MRC personnel on participating landowners’ properties. Volumes of deliverable sediment were estimated using the “Star Sediment Delivery Worksheet”. Sampling locations selected for monitoring are described in Table 1. Monitoring sites were selected based on level of landowner cooperation (inventory access to at least 80% of the basin), similarly small drainage areas, ease of winter access and to encompass a range of magnitude of planned road treatments. Three tributaries just upstream of the Petrolia project area were selected as control sites. Note that all three control sites are located on the west side of the Mattole River (Table 1), however, two east side tributaries (NSEM and SSEM) may also serve as controls representing the east side of the basin depending on the persistence of dam removal effects (SSEM) and whether or not planned treatments will actually be implemented (NSEM).

Table 1. Tributary turbidity and discharge monitoring sites, Lower Mattole River.

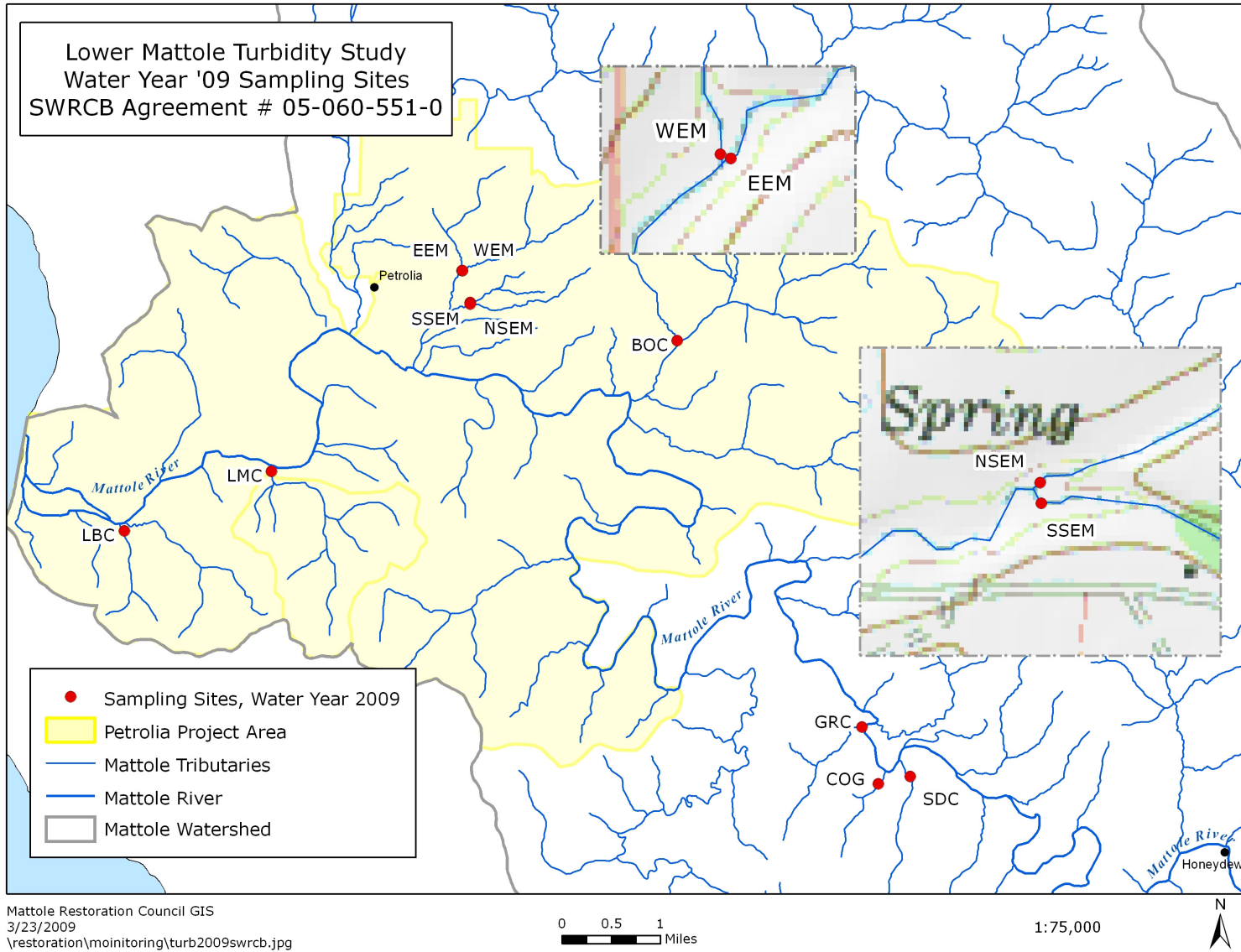
Monitoring Site	Site Code	Drainage Area (sq. mi)	Mattole River Side	Treatment Status
Cook Gulch	COG	0.61	West	control
Saunders Creek	SDC	0.83	West	control
Granny Creek	GRC	0.93	West	control
North Fork South Branch East Mill Creek	NSEM	0.34	East	treatment *
Lower Mill Creek	LMC	2.10	West	treatment
West Branch East Mill Creek	WEM	0.89	East	treatment
Lower Bear Creek	LBC	0.59	West	treatment
East Branch East Mill Creek	EEM	0.86	East	treatment
Boots Creek	BOC	1.00	East	treatment
South Fork South Branch East Mill Creek	SSEM	0.42	East	treatment **

* planned treatment may not be implemented; ** no treatment after dam removal in 2008

Road treatments in the Lower Mattole begin in summer, 2009. Because the data for all sites during this past winter represent pre-treatment conditions, they are important for establishing relative conditions among the sites for comparison with those after treatment has begun. Subsequent data analyses and reports will quantify changes in relative conditions attributable to the treatments performed.

An important source of uncertainty is the likelihood of other, non-treatment-related erosion and turbidity sources in the watersheds upstream of sample sites, particularly large erosional events such as road crossing failures, debris flows, and channel bank slumping. Since we lack watershed-wide erosion information, other sources may not be quantified unless they occur on proposed treatment areas. Fortunately, these processes are most influential in high flow years, and thus rare and not particularly likely to occur over the life of this monitoring program.

Figure 1: WY09 Sampling Sites and Petrolia Sediment Assessment Area



Turbidity and Discharge Measurements

Because of its ease of measurement and strong correlation with sediment concentration, turbidity was selected as the water quality monitoring parameter. Turbidity was determined by MRC staff using a Hach 2100P portable turbidimeter. The US Geological Survey guidelines (USGS, 2004) recommend reporting data from this particular meter as nephelometric turbidity ratio units (NTRU). Note that turbidity data from different meters and sensors are not necessarily comparable (Lewis and others, 2007).

A suitable reach for monitoring was chosen at each site meeting these criteria as closely as possible:

- Straight reach for at least 5 channel widths in length;
- Relatively low gradient;
- Geomorphically stable;
- Few large boulders, wood pieces, or other sources of flow turbulence.

Grab samples of water were taken at the ten tributary locations in the Lower Mattole River watershed during storms from November, 2008, through March, 2009. Procedures for taking grab samples were demonstrated to MRC staff and volunteers during the pre-winter training session in fall, 2008. Wide mouth sample bottles were used for sampling as these allow rapid water entry without fully submerging the bottle's mouth, a condition that could cause contamination by re-circulation of stream water within the bottle. Care was taken not to contaminate the sample with streambed sediment by selecting locations with sufficient water depth.

Water samples were collected during significant rainstorms; times when erosional activity and turbidity generation within the stream crossing excavations would be expected. However, in small watersheds manual sampling often occurs after a peak has passed. Consequently, offsite water quality data consists primarily of post-peak hydrologic conditions, but most of the largest storms of each season were included in sampling.

Staff gages were installed at each site. They consist of a length of PVC pipe fitted with a length of survey tape, graduated in hundredths of feet, for recording stream water surface height, or stage. Stage readings, or gage heights, were read on the staff gages at turbidity and discharge sample times to the nearest hundredth of a foot. In addition, a lath was placed inside the pipe along with powdered cork to serve as a "crest stage gage". The cork floated up inside the pipe with rising stream stage, and left behind a band of cork following the storm's peak. The height of this cork band was measured against the staff gage during visits and represented the maximum stage (aka, "crest") the creek attained between visits.

Sufficient numbers of discharge measurements were taken over a range of discharges so that stage-discharge rating curves could be developed that allow conversion of all stage data to discharge at each site. With stage-discharge rating curves, each turbidity measurement can be paired with a corresponding discharge by simply recording the stream stage. This was necessary to provide a hydrological context for the turbidity results.

The relationship between stage and discharge will shift if and when channel changes occur. To detect channel changes that might affect stage-discharge relationships, channel cross sections were measured adjacent to the staff gage at each monitoring site and photographs were taken periodically throughout the winter.

Following the pre-winter training session in fall, 2008, MRC staff developed a standard operating procedures ("SOP") document and field forms to guide data collection and fulfill contractually-obligated

quality control/quality assurance requirements. This document details step-by-step procedures for all data collection activities to be used by MRC personnel associated with this project, and is included herewith as Appendix C.

Data Analysis

MRC staff provided me with the data collected over the winter. From the paired measurements of stage and discharge, I developed discharge rating curves. At all but two sites, the channel cross section and hydraulic controls were stable throughout the winter, requiring development and use of a single rating equation for all flows. At one site (Cook Gulch, COG) where the hydraulic control apparently changed after the largest storm on Feb. 23, 2009, a separate rating curve was developed for the subsequent period. At another site (South Fork South Branch East Mill Creek, SSEM), the channel cross section scoured along the left bank, but did not cause a shift in the rating curve.

Some turbidity samples were taken at the same time as a discharge measurement, but most occurred when only stage was recorded. For these, discharge was estimated from the rating curve. For better comparison among sites, discharge was divided by drainage area for analyses (“unit discharge”, in cubic feet per second per square mile).

It is well-established that turbidity generally rises with discharge during storms, but comparing manually-collected data among various sites is problematic due to the uncertainty of knowing where on the storm hydrograph a particular sample was taken, and whether or not a sample on another stream occurred at the same hydrograph point. To reduce this problem, ratios of turbidity to discharge were computed.

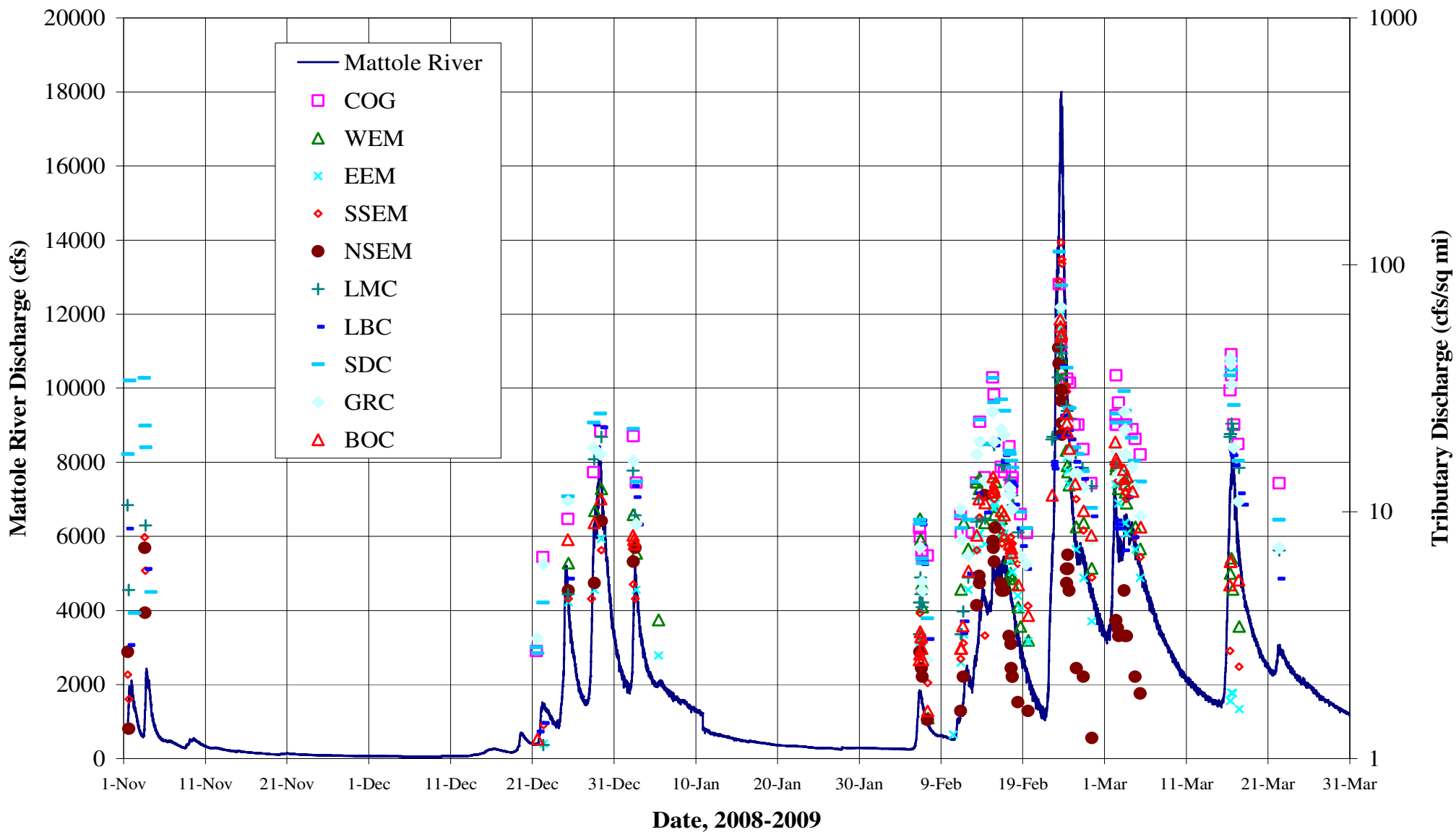
In a recent study by Klein and others (2008), a watershed diagnostic parameter, termed “lower bound line”, was developed and shown to index watershed disturbance level and to be independent of storm magnitudes as they vary from year to year. Plotting unit discharge (X-axis) against corresponding turbidity (Y-axis) produces a scattergram, with wide scatter in the upper portion of the graph, but a relatively sharp clustering of points along the lower edge of scatter. The lower bound line (“LBL”) is a line fitted to the relatively sharp bottom edge of the scatter, and a slope was determined from this line. The points along this lower edge represent turbidity-discharge relationships during storm recessional flows; times when turbidity is low relative to discharge, unlike rising stormflows when turbidity is higher and less consistent. A steeper slope of the LBL indicates relatively greater levels of chronic turbidities, which in turn suggests less erosionally-stable watershed conditions.

RESULTS

Hydrologic Conditions

Figure 2 shows a hydrograph of 15-minute discharges for the Lower Mattole River near Petrolia along with both measured and estimated unit discharges (cfs/sq mi, log scale) for the monitored tributaries for winter, 2008-2009. The highest peak for the Lower Mattole River occurred on Feb. 23, 2009, peaking at 18,000 cfs. Several other moderate-sized storms peaked at 4,000 to 8,000 cfs. MRC sampling in tributaries was well-distributed across all the major storms of the season, particularly during the largest storms, providing a relatively detailed data set for the manual sampling program, with over 600 turbidity samples taken from November, 2008, through March, 2009. Turbidity and discharge data are given in Appendix A.

Figure 2. Lower Mattole River hydrology. winter 2009



Turbidity/discharge Ratios

Figure 3 plots ratios of turbidity divided by unit discharge (cfs/sq mi) for the entire sampling period. Figures 4-8 show these same data plotted on a monthly scale for the period of Dec., 2008, through Mar., 2009. Dividing turbidity by unit discharge “normalizes” turbidity results to allow hydrologically-conditioned comparisons among sites. Turbidity/discharge ratios are plotted on a log scale to better view results from low ratio samples.

In the first sampled storm of Nov. 1-3, 2008, the South Fork South Branch East Mill Creek (SSEM) was most turbid (note that not all sites were sampled during this storm). The neighboring site, North Fork South Branch East Mill Creek (NSEM) was less turbid in early November, a condition that reversed in later storms. The high turbidities in this first storm were probably due to flushing of fine sediment at a location upstream from the site where a dam was removed in summer, 2008. During later storms SSEM had mostly lower turbidities than NSEM, indicating that once the initial flushing had passed, SSEM returned to what is likely its typically cleaner condition relative to NSEM.

For the rest of the season, several sites had consistently higher turbidities than the rest. These were West Branch East Mill Creek (WEM), Cook Gulch (COG), and North Fork South Branch East Mill Creek (NSEM). As shown in Table 1, Cook Gulch is one of the three control sites in this study. I note here that control sites need not be the cleanest among sites because treatment effects will be evaluated on the basis of deviations from pre-treatment relationships.

Figure 3. Lower Mattole River discharge and tributary turbidity/discharge ratios, winter 2008-2009.

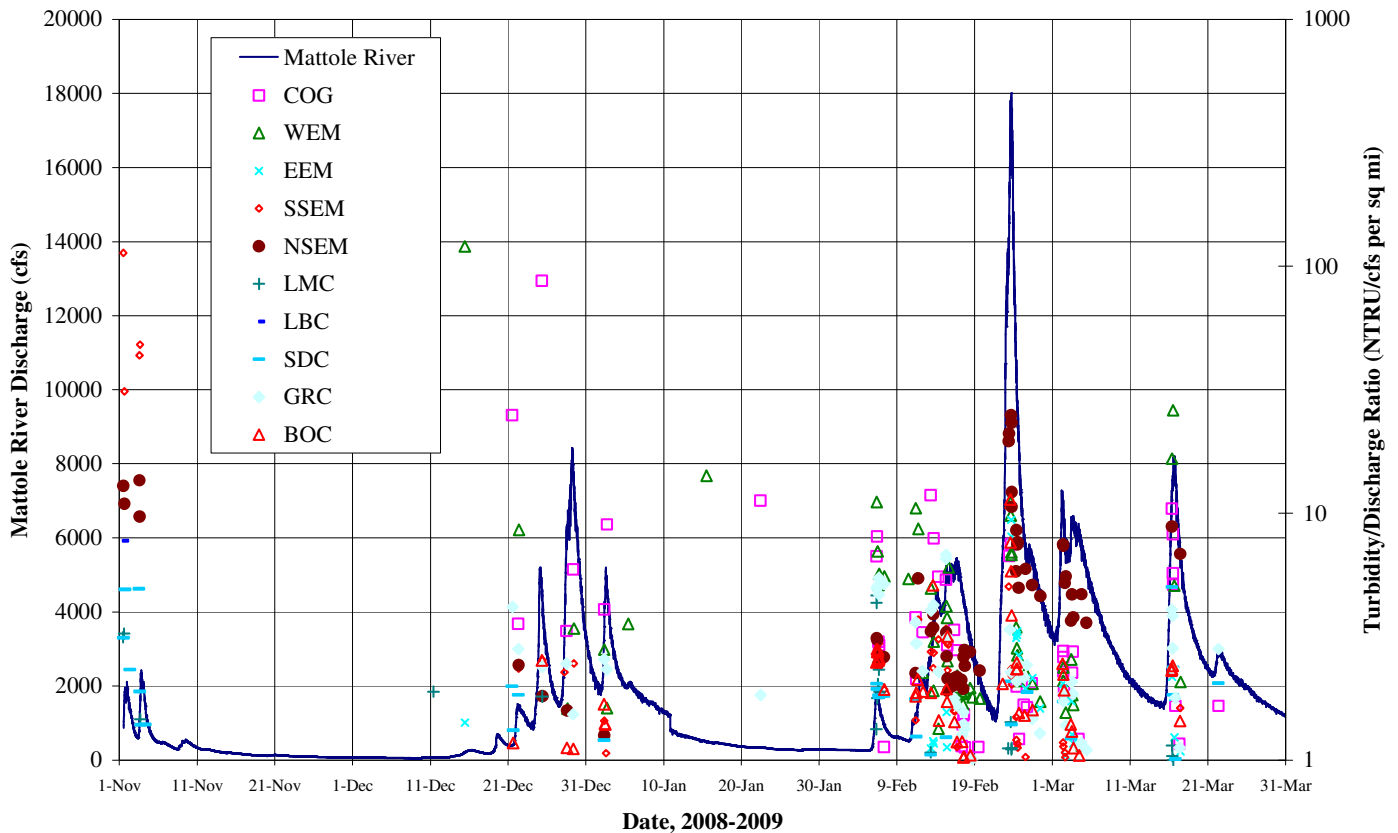


Figure 4. Lower Mattole River discharge and tributary turbidity/discharge ratios, Nov. 2008.

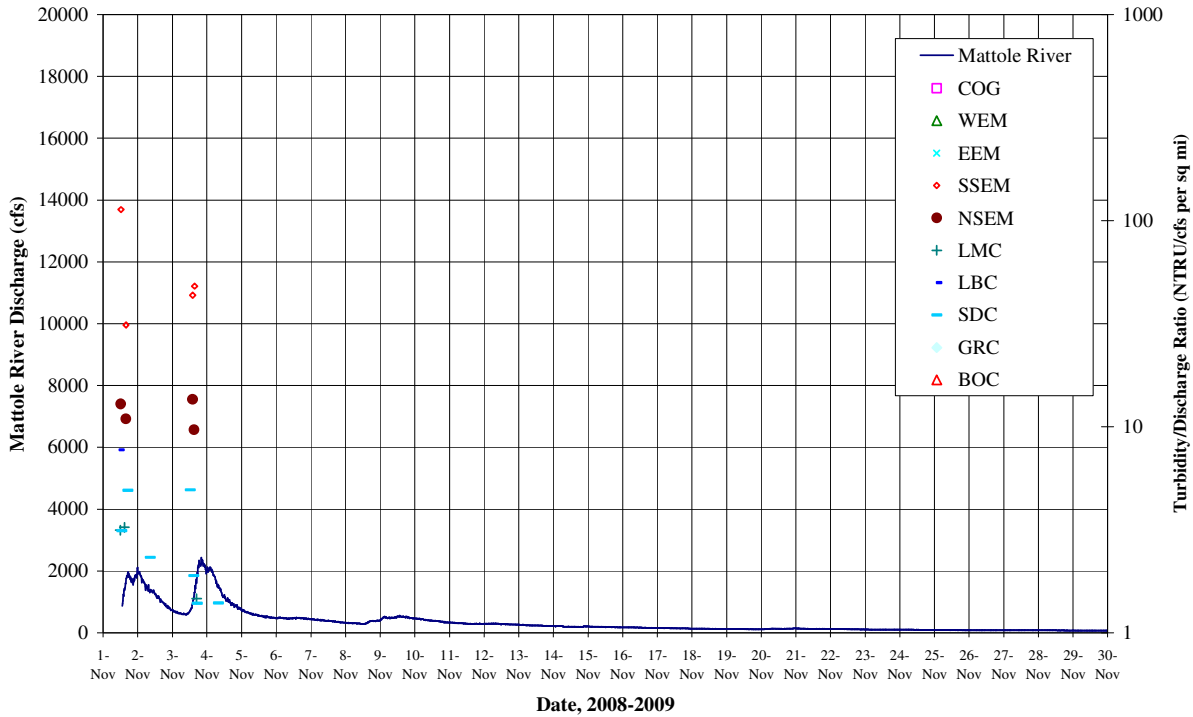


Figure 5. Lower Mattole River discharge and tributary turbidity/discharge ratios, Dec. 2008.

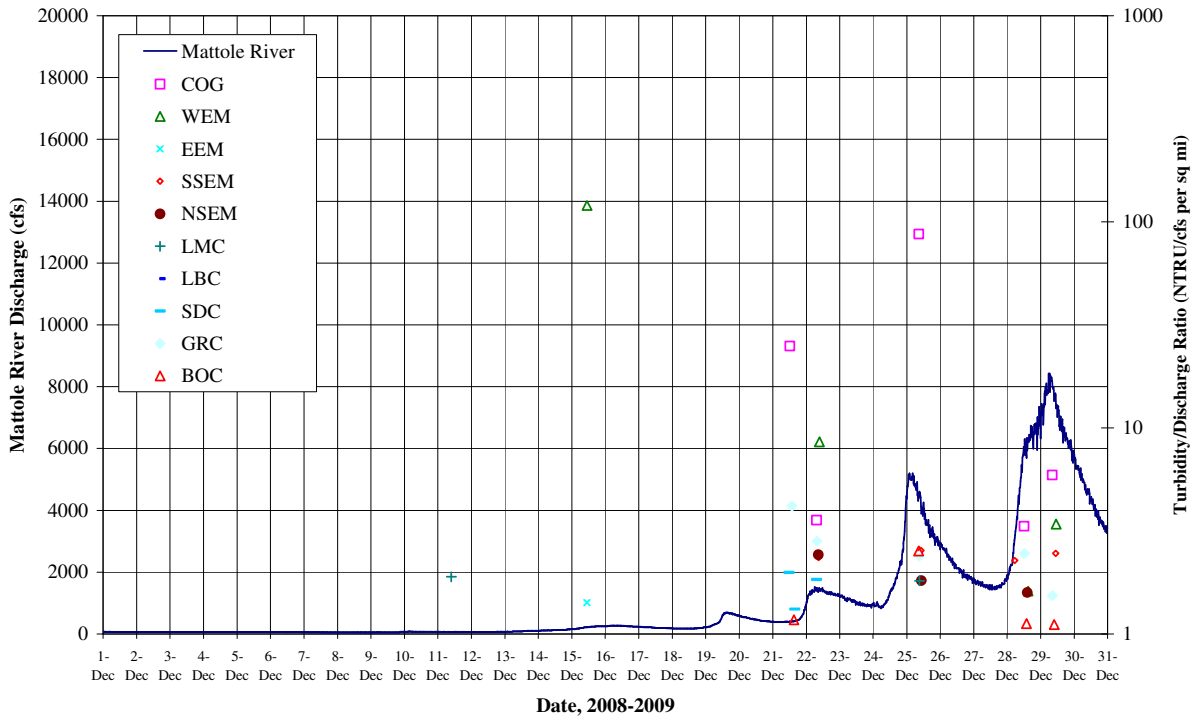


Figure 6. Lower Mattole River discharge and tributary turbidity/discharge ratios, Jan. 2009.

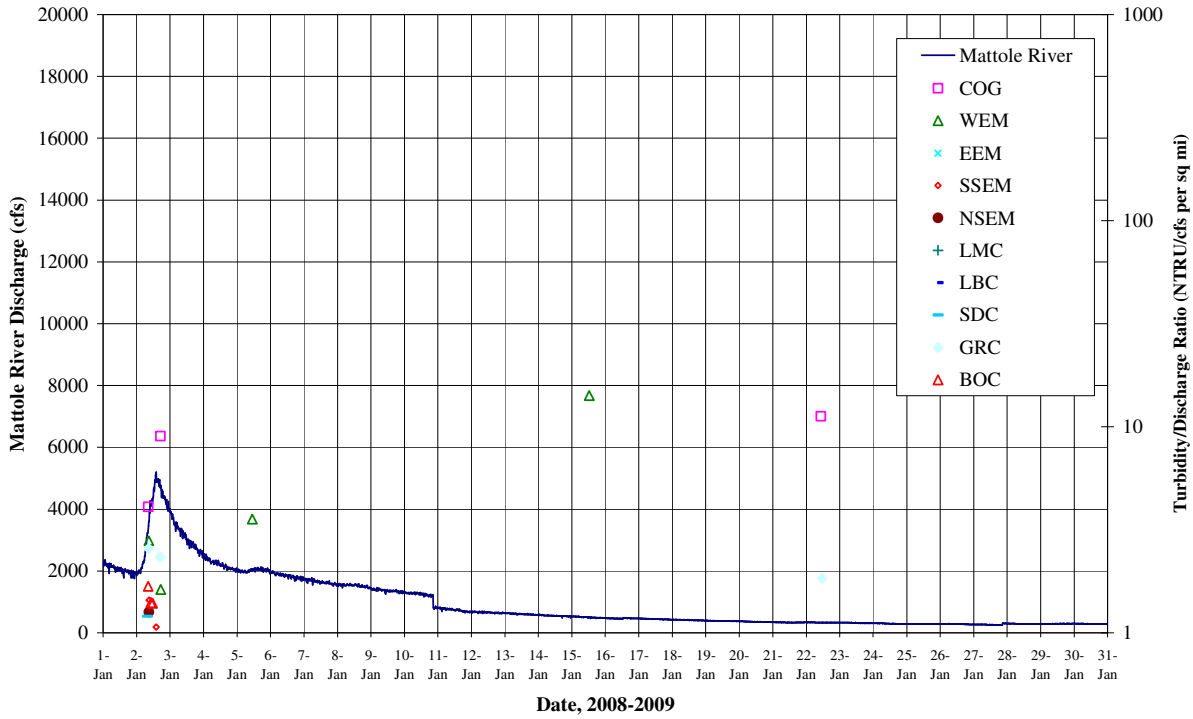


Figure 7. Lower Mattole River discharge and tributary turbidity/discharge ratios, Feb. 2009.

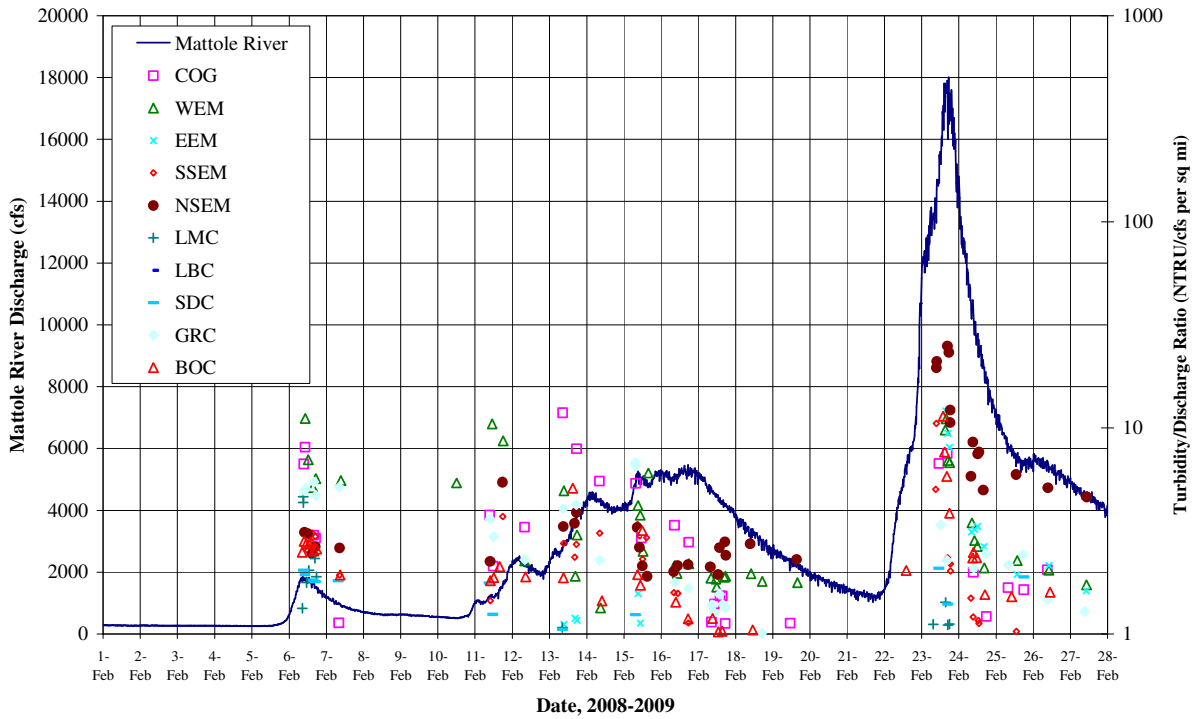
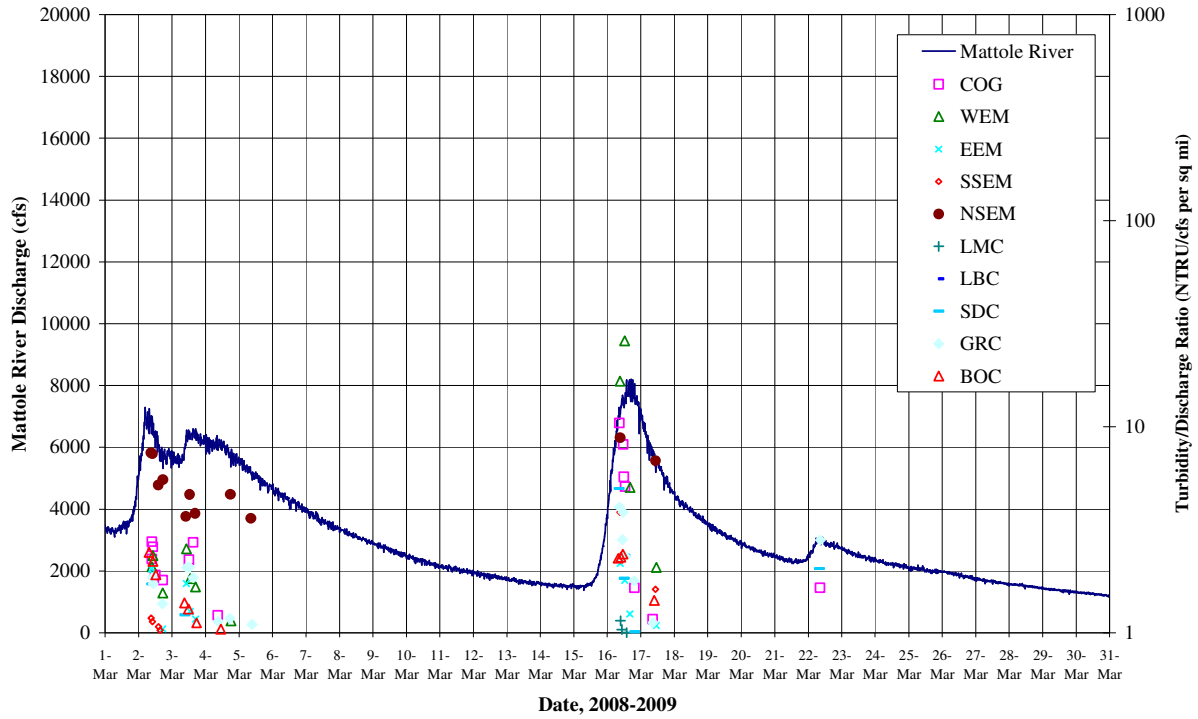


Figure 8. Lower Mattole River discharge and tributary turbidity/discharge ratios, Mar. 2009.



Lower Bound Lines

Lower bound lines (LBL) for monitored tributaries are individually plotted in Appendix B along with time series plots of discharge and turbidity by site. In all but one site (NSEM), lower bound lines were well-described by the samples obtained. At NSEM, only a few points composed the lower boundary of data, so the diagnostic criterion computed (LBL slope) was less certain.

Figure 9 plots lower bound lines along with fitted equations with slopes and Y-intercepts. The broad sweep of lower bound lines expresses large differences in recessional stormflow turbidities among the sites, with WEM having the steepest slope and LMC having the gentlest.

Figure 9. Lower Mattole Tributary Lower Bound Lines, WY2009

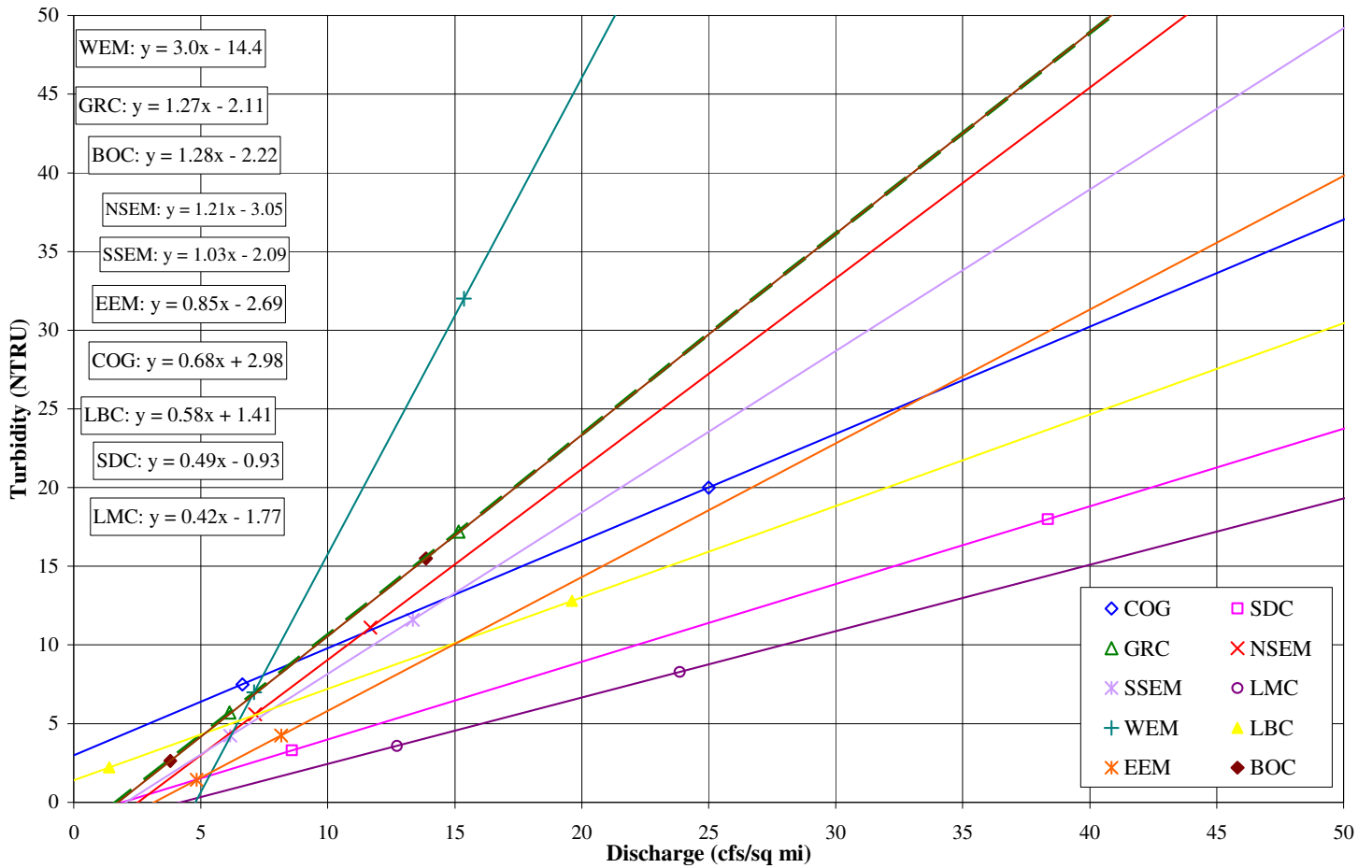


Table 2 shows LBL slopes arranged in increasing order. Site code cells are color-coded, with green representing control sites and orange representing treatment sites. In addition, the basin side refers to the side of the mainstem Mattole River on which each tributary lies.

Table 2. Lower bound line slopes in order of increasing slope. Green cell color indicates control site; all others (orange cells) are sites with upstream treatment beginning after winter, 2008-2009. Basin side indicates on which side of the Mattole River each tributary is located.

Site	LBL slope	Side
LMC	0.4	West
SDC	0.5	West
LBC	0.6	West
COG	0.7	West
EEM	0.9	East
SSEM	1.0	East
NSEM	1.2	East
GRC	1.3	West
BOC	1.3	East
WEM	3.0	East

As shown above, west side sites generally had lower LBL slopes than those on the east side of the Mattole River, indicating they have lower recessional turbidities at a given discharge, with GRC (Granny Creek, control site) being the sole exception. WEM (West Branch East Mill Creek), with a much higher LBL slope than the rest, was by far the most turbid during storm recessional flows.

The three control sites (SDC, COG, and GRC, all west side tributaries) tended to span much of the range of LBL slopes, thus they likely represent conditions in the group of sites as a whole. Although, as mentioned earlier, COG had some of the highest turbidities during the largest storms, it had a relatively low LBL slope among the sites. This indicates that although peak turbidities were high at COG, they fell rapidly during storm recessional limbs compared to other sites. As mentioned in Table 1 above, NSEM and SSEM may in fact serve as additional controls assuming: 1) no road treatments are actually implemented in NSEM, and 2) the effects of the 2008 dam removal in SSEM have subsided, as suggested by turbidities in the latter storms on WY2009.

DISCUSSION AND RECOMMENDATIONS

The first winter of sampling provided a robust data set likely to provide important insights as to how treatment will affect turbidities in the monitored watersheds. Samples at individual sites appeared sufficient to describe lower bound lines and compute their slopes and Y-intercepts. However, given the apparent effect basin side has on turbidity, the lack of any east side tributaries for monitoring as control sites may present difficulties in evaluating treatment effects. It is anticipated that NSEM and SSEM will fill the gap as east side control sites for future monitoring.

A high LBL slope indicates relatively turbid flows during early storm recession, falling from high peak storm turbidities. As Klein and others (2008) showed, LBL slope is correlated with high rates of timber harvest. LBL slope would also be elevated with other types of watershed disturbance that produce chronic turbidity (e.g., unstable hillslopes and stream channels). Conversely, a low LBL slope is indicative of a relatively less disturbed watershed. Turbidity in these streams generally peaks at lower levels, and clears more rapidly after cessation of rainfall, than more disturbed streams that suffer from chronic turbidity impairment.

Analyses in Klein and others (2008) suggest that watersheds in a steady-state of disturbance exhibit LBL slopes that do not vary much from year-to-year, despite annual variability in rainfall intensities. Assuming this holds for the Lower Mattole River tributary monitoring sites, tributaries with road treatments should exhibit increased LBL slopes for the period of treatment and for a few subsequent years.

To help interpret any future shifts in tributary turbidity regimes, inventories of the tributary watersheds for large, fresh erosional features would be of great benefit. All accessible roads planned for erosion control and prevention work should be traversed each summer to look for such features, and any anecdotal information available for other areas should also be compiled.

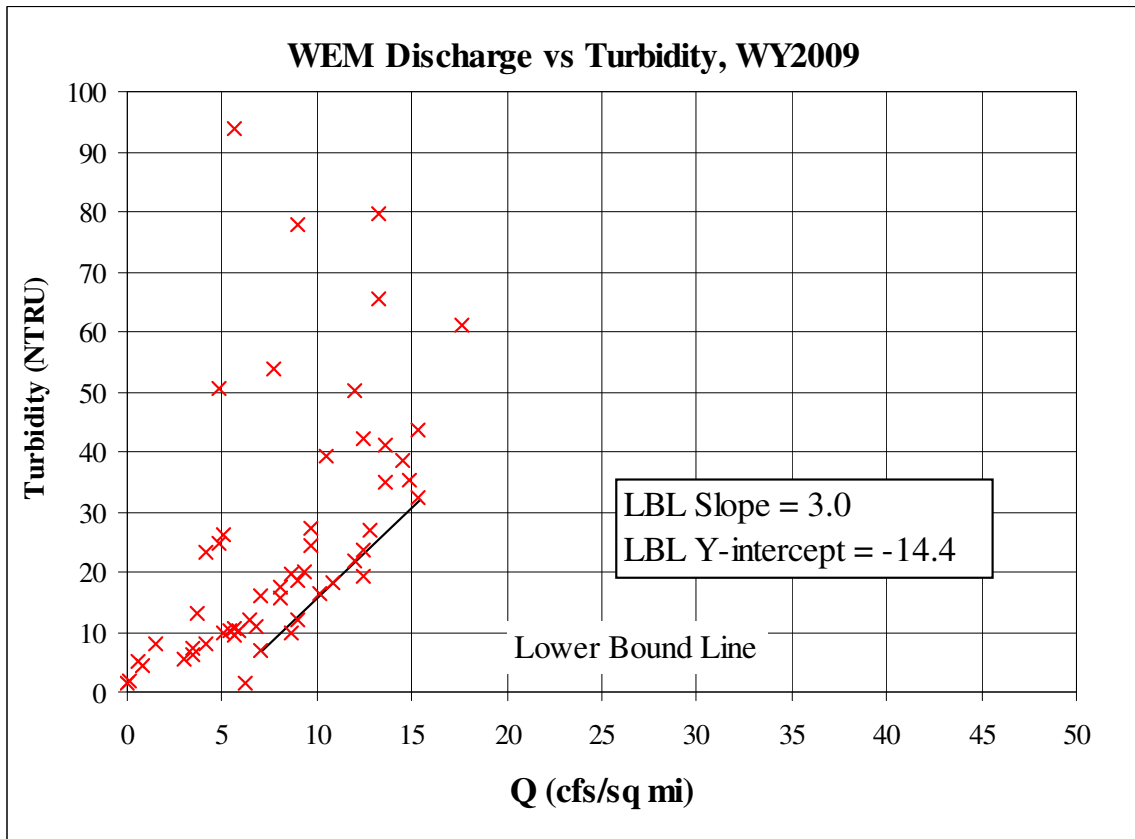
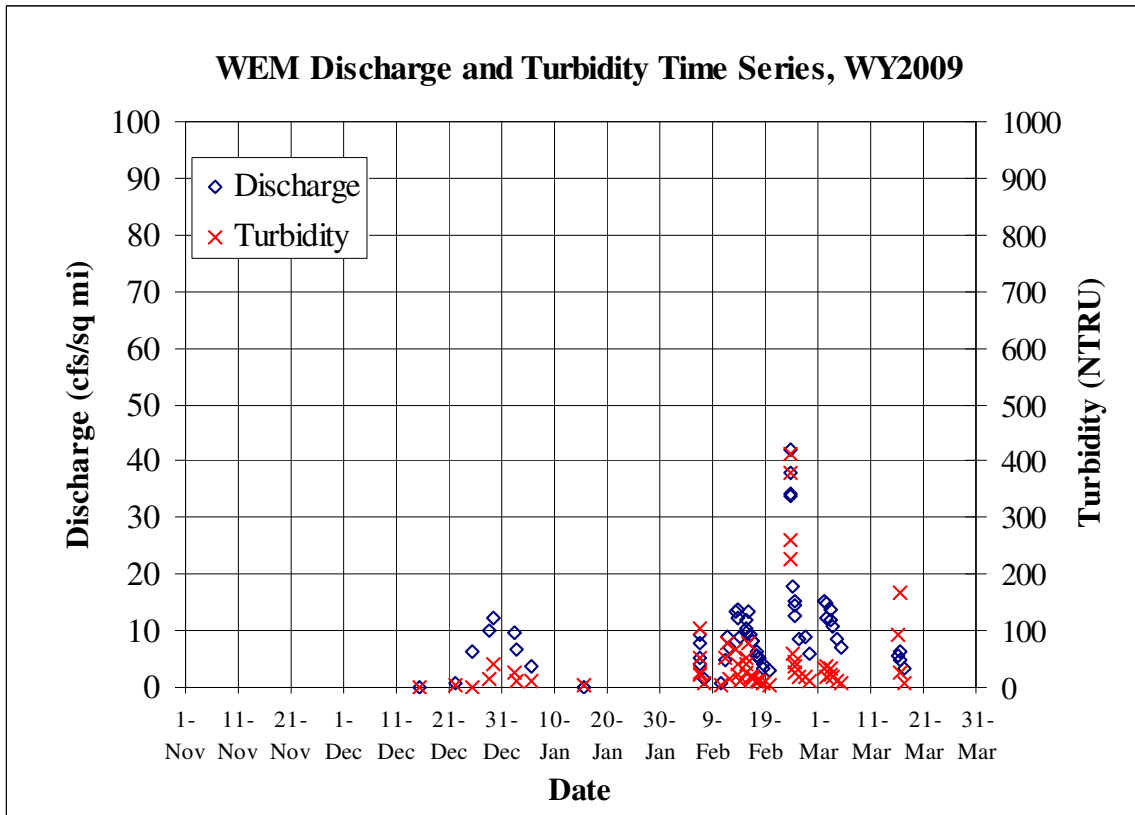
LITERATURE CITED

- Klein, R.D. 1984. Channel adjustments following logging road removal in small steepland drainages. *In* Symposium on Effects of Forest Land Use on Erosion and Slope Stability. C.L. O'Loughlin and A.J. Pearce, eds. Honolulu, HI. 7-11 May, 1984. Pp. 187-195.
- Klein, R.D., Trush, W.J., and M. Buffleben. 2008. Watershed Condition, Turbidity, and Implications for Anadromous Salmonids in North Coastal California Streams. A Report to the California Northcoast Regional Water Quality Control Board, Santa Rosa, CA. 105 p.
- Lewis, J., Eads, R., and R.D. Klein. 2007. Comparisons of turbidity data collected with different instruments. Report to Calif. Dept. of Forestry and Fire Protection and North Coast Regional Water Quality Control Board. 27 p.
- Madej, M.A. 2001. Erosion and sediment delivery following removal of forest roads. *Earth Surface Processes and Landforms*. V. 26, pp. 175-190.
- U.S. Geological Survey (USGS). 2004. National Field Manual for the Collection of Water-Quality Data (NFM), Chap. 6, Sec. 6.7—Turbidity. 64 p.

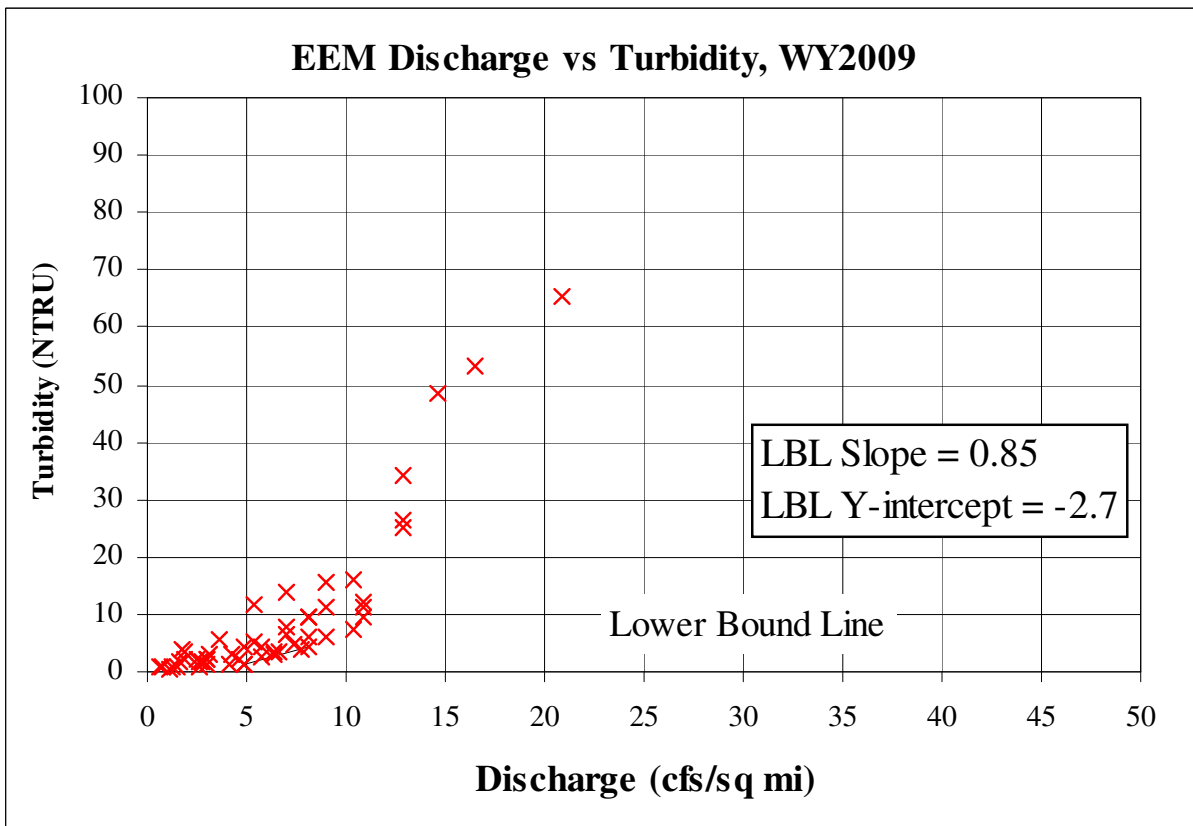
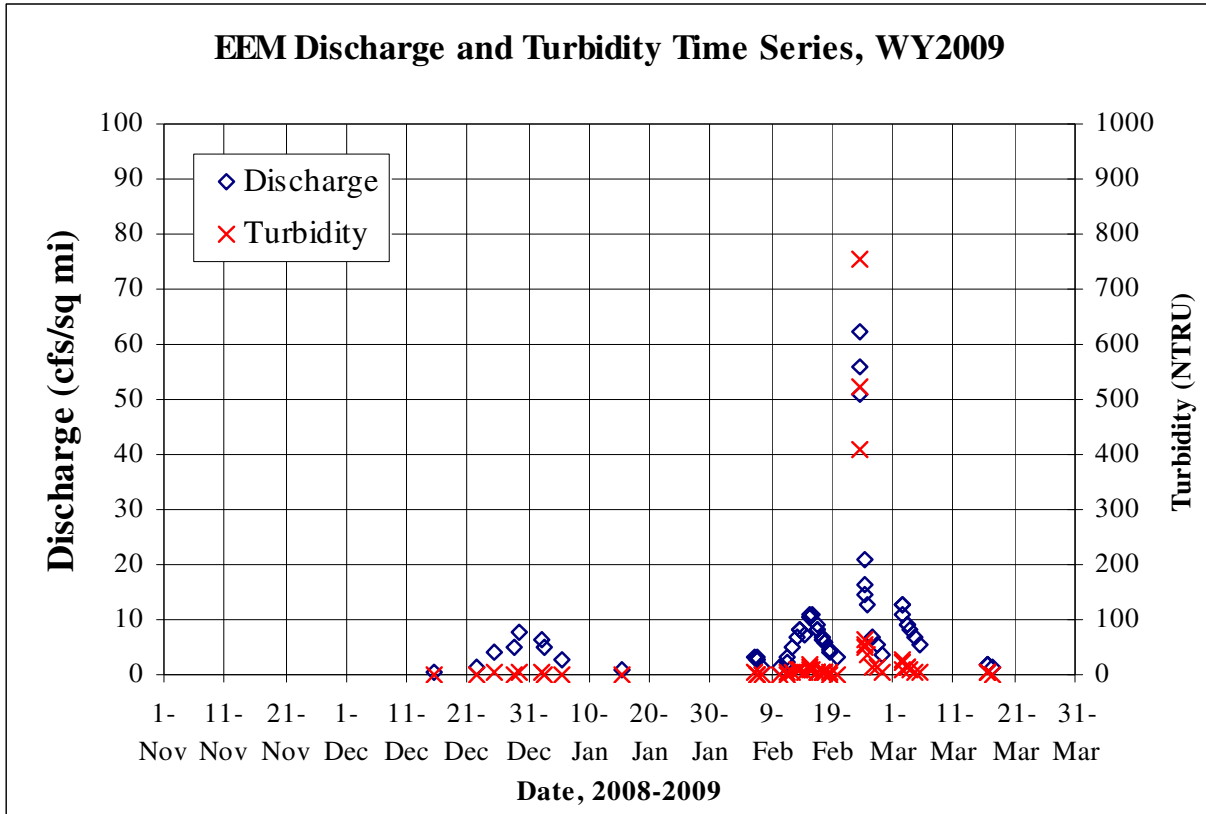
Appendix A: Turbidity and Discharge Data, WY2009 (cont').

Site: NSEM	Discharge	Turbidity	Site: LMC	Discharge	Turbidity	Site: LBC	Discharge	Turbidity
Date/Time	(cfs/sq mi)	NTRU	Date/Time	(cfs/sq mi)	NTRU	Date/Time	(cfs/sq mi)	NTRU
11/1/08 12:15	2.7	35	11/1/08 11:50	10.6	34	11/1/08 11:18	8.5	66
11/1/08 15:51	1.3	14	11/1/08 14:48	4.8	16	11/1/08 15:05	2.9	16
11/3/08 14:00	7.1	97	11/3/08 16:44	8.8	13	11/3/08 17:45	5.9	15
11/3/08 15:04	3.9	38	12/11/08 9:38	0.2	0	12/21/08 16:00	1.3	6
12/22/08 8:37	0.6	1	12/21/08 15:40	0.8	1	12/22/08 7:15	1.4	2
12/25/08 10:28	4.8	9	12/22/08 7:52	1.1	1	12/25/08 9:04	5.4	11
12/28/08 14:27	5.1	8	12/25/08 9:15	4.6	8	12/28/08 13:09	22.6	18
12/29/08 10:46	9.2	8	12/28/08 13:24	16.3	12	12/29/08 10:35	21.9	18
1/2/09 8:43	6.3	8	12/29/08 10:41	20.1	8	1/2/09 7:45	12.7	15
1/2/09 13:59	7.1	6	1/2/09 8:05	14.6	10	1/2/09 12:32	11.5	10
2/6/09 9:55	2.7	8	1/2/09 13:30	9.7	7	1/2/09 19:57	8.9	9
2/6/09 11:55	2.7	8	2/6/09 11:16	5.4	10	2/6/09 11:29	9.2	27
2/6/09 15:00	2.3	6	2/6/09 9:06	4.3	20	2/6/09 8:55	7.3	23
2/6/09 16:55	2.1	6	2/6/09 9:06	4.3	19	2/6/09 12:35	8.9	24
2/7/09 8:28	1.4	4	2/6/09 12:49	4.6	9	2/6/09 15:25	6.4	18
2/11/09 9:42	1.6	4	2/6/09 16:35	4.1	10	2/6/09 17:25	6.1	19
2/11/09 17:40	2.1	12	2/6/09 17:35	4.3	8	2/7/09 8:31	3.0	9
2/13/09 8:57	4.2	14	2/6/09 8:35	3.2	4	2/11/09 10:20	3.6	12
2/13/09 16:07	5.5	19	2/11/09 10:32	3.2	3	2/11/09 12:27	3.2	7
2/13/09 17:18	5.1	20	2/11/09 12:40	3.2	3	2/11/09 16:16	3.6	7
2/14/09 8:26	11.7	11	2/11/09 16:28	3.9	3	2/12/09 8:06	5.6	9
2/15/09 8:33	7.6	25	2/12/09 7:54	5.4	5	2/13/09 8:30	11.9	17
2/15/09 10:05	7.1	19	2/13/09 8:16	9.1	10	2/14/09 9:20	9.9	12
2/15/09 11:55	6.3	13	2/13/09 14:03	11.3	10	2/15/09 9:15	18.5	30
2/15/09 14:59	8.6	16	2/14/09 9:05	9.4	6	2/15/09 10:13	18.5	26
2/16/09 8:13	5.1	10	2/15/09 9:25	19.1	18	2/15/09 12:26	19.6	21
2/16/09 10:40	4.8	10	2/15/09 10:25	19.1	15	2/16/09 9:58	15.9	16
2/16/09 17:26	4.8	10	2/15/09 12:35	18.6	13	2/16/09 13:53	15.9	18
2/17/09 7:44	3.1	7	2/16/09 10:10	15.5	7	2/16/09 16:58	16.9	19
2/17/09 12:45	2.9	6	2/16/09 10:10	15.5	7	2/17/09 8:20	13.1	10
2/17/09 13:40	2.3	6	2/16/09 13:35	15.5	7	2/17/09 12:08	13.1	10
2/17/09 17:03	2.1	6	2/16/09 17:07	15.5	7	2/17/09 16:29	12.7	8
2/17/09 17:49	2.1	5	2/17/09 8:11	13.5	6	2/17/09 19:59	10.7	7
2/18/09 9:28	1.7	5	2/17/09 10:45	12.7	5	2/18/09 8:34	8.5	8
2/19/09 15:25	1.6	4	2/17/09 12:27	12.7	4	2/18/09 9:52	8.5	8
2/23/09 9:36	46.0	900	2/17/09 16:10	11.6	5	2/18/09 18:53	7.3	5
2/23/09 9:43	39.8	838	2/17/09 19:50	10.6	4	2/19/09 7:20	5.9	4
2/23/09 16:40	31.1	777	2/18/09 10:00	8.3	3	2/22/09 13:17	15.9	21
2/23/09 17:40	28.1	654	2/22/09 13:50	19.6	13	2/22/09 15:57	15.0	21
2/23/09 18:25	22.8	242	2/22/09 15:38	20.1	15	2/22/09 13:30	15.4	20
2/23/09 18:36	20.5	250	2/23/09 7:31	35.0	39	2/23/09 7:16	20.2	32
2/24/09 7:51	5.9	34	2/23/09 15:27	49.2	70	2/23/09 15:46	38.8	66
2/24/09 9:06	5.1	44	2/23/09 17:00	46.5	51	2/23/09 17:18	24.4	47
2/24/09 12:20	6.7	50	2/23/09 18:00	43.8	49	2/23/09 17:42	22.6	44
2/24/09 12:59	5.9	45	2/24/09 8:20	26.8	18	2/24/09 7:25	17.4	18
2/24/09 15:52	4.8	24	2/24/09 10:15	25.6	16	2/24/09 8:05	20.2	18
2/25/09 13:00	2.3	14	2/24/09 10:47	25.6	16	2/24/09 10:45	21.3	16
2/26/09 9:36	2.1	11	2/24/09 17:29	23.9	8	2/24/09 17:18	19.6	13
2/27/09 10:42	1.2	6	2/25/09 10:49	17.2	7	2/25/09 7:30	15.9	12
3/2/09 9:00	3.6	27	2/25/09 11:53	17.2	6	2/25/09 11:03	15.0	11
3/2/09 9:54	3.6	27	2/26/09 7:30	15.1	5	2/25/09 11:21	15.0	11
3/2/09 14:13	3.4	18	2/27/09 10:15	12.7	3	2/26/09 7:00	13.6	9
3/2/09 17:30	3.1	17	3/2/09 7:01	15.9	8	2/27/09 10:00	9.6	8
3/3/09 12:35	3.1	15	3/2/09 9:08	15.5	7	3/2/09 6:20	8.5	30
3/3/09 9:50	4.8	18	3/2/09 10:52	15.5	7	3/2/09 8:55	9.2	11
3/3/09 16:25	3.1	12	3/2/09 13:03	15.1	7	3/2/09 10:37	8.9	9
3/4/09 17:56	2.1	10	3/3/09 7:45	13.9	5	3/2/09 12:50	8.5	7
3/5/09 8:31	1.8	7	3/3/09 17:58	14.6	6	3/3/09 7:20	7.0	9
3/16/09 9:18	0.9	8	3/4/09 10:07	12.7	4	3/3/09 18:17	11.5	17
3/17/09 10:41	0.6	4	3/16/09 7:30	20.1	19	3/4/09 10:22	7.9	8
--	--	--	3/16/09 9:19	20.6	24	3/16/09 6:00	18.0	26
--	--	--	3/16/09 10:20	20.6	21	3/16/09 7:02	18.0	24
--	--	--	3/16/09 13:47	22.7	23	3/16/09 9:05	17.4	24
--	--	--	3/16/09 17:17	21.7	16	3/16/09 10:21	16.9	25
--	--	--	3/17/09 10:49	15.1	7	3/16/09 13:32	16.9	22
--	--	--	3/22/09 8:45	7.0	3	3/16/09 19:41	15.4	17
--	--	--	--	--	--	3/17/09 10:40	11.9	10
--	--	--	--	--	--	3/17/09 19:50	10.7	10
--	--	--	--	--	--	3/22/09 7:22	5.4	7

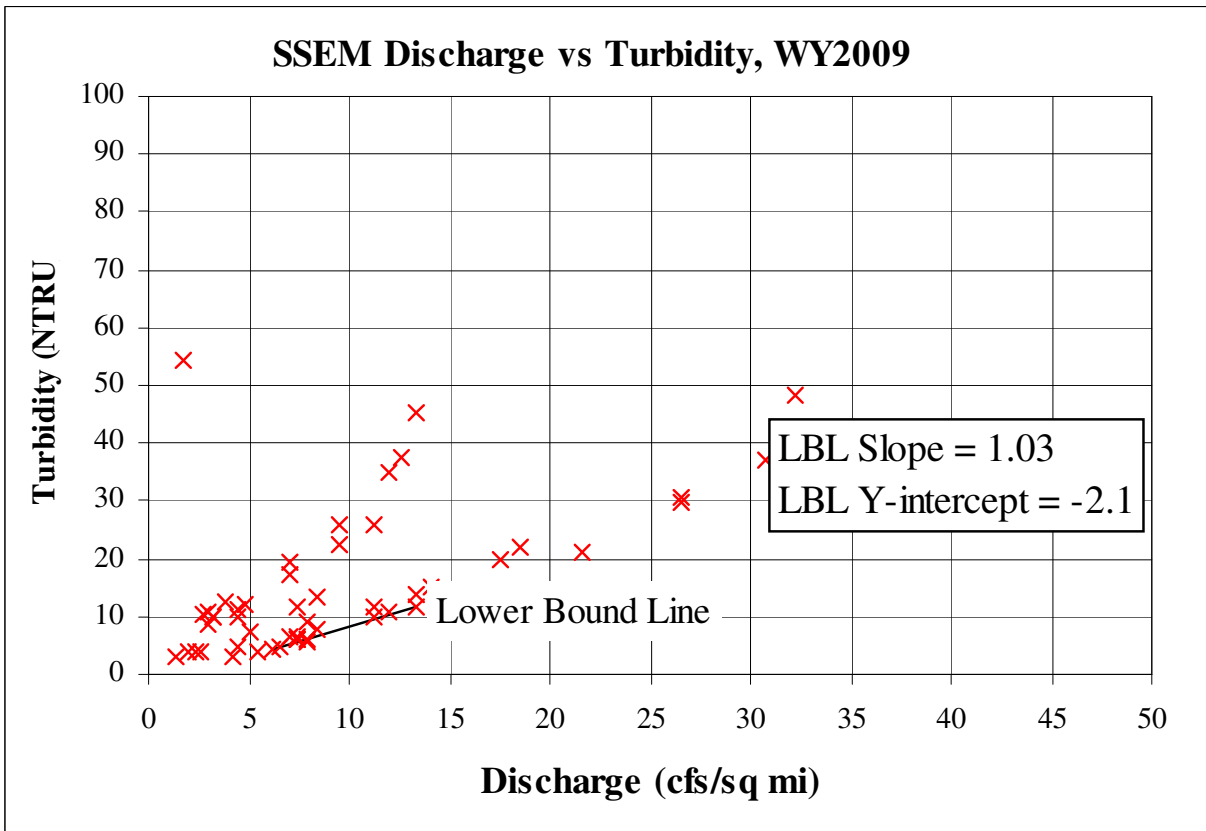
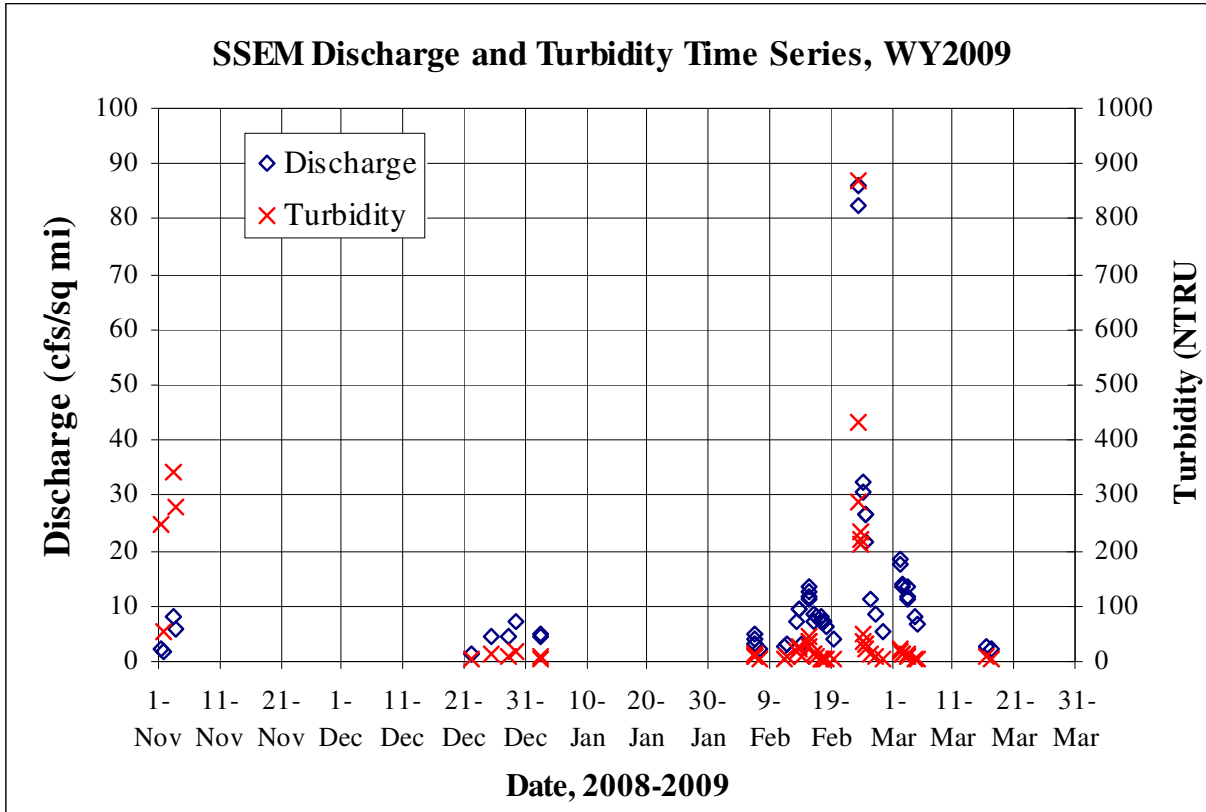
Appendix B: Tributary Discharge, Turbidity, and Lower Bound Lines, WY2009



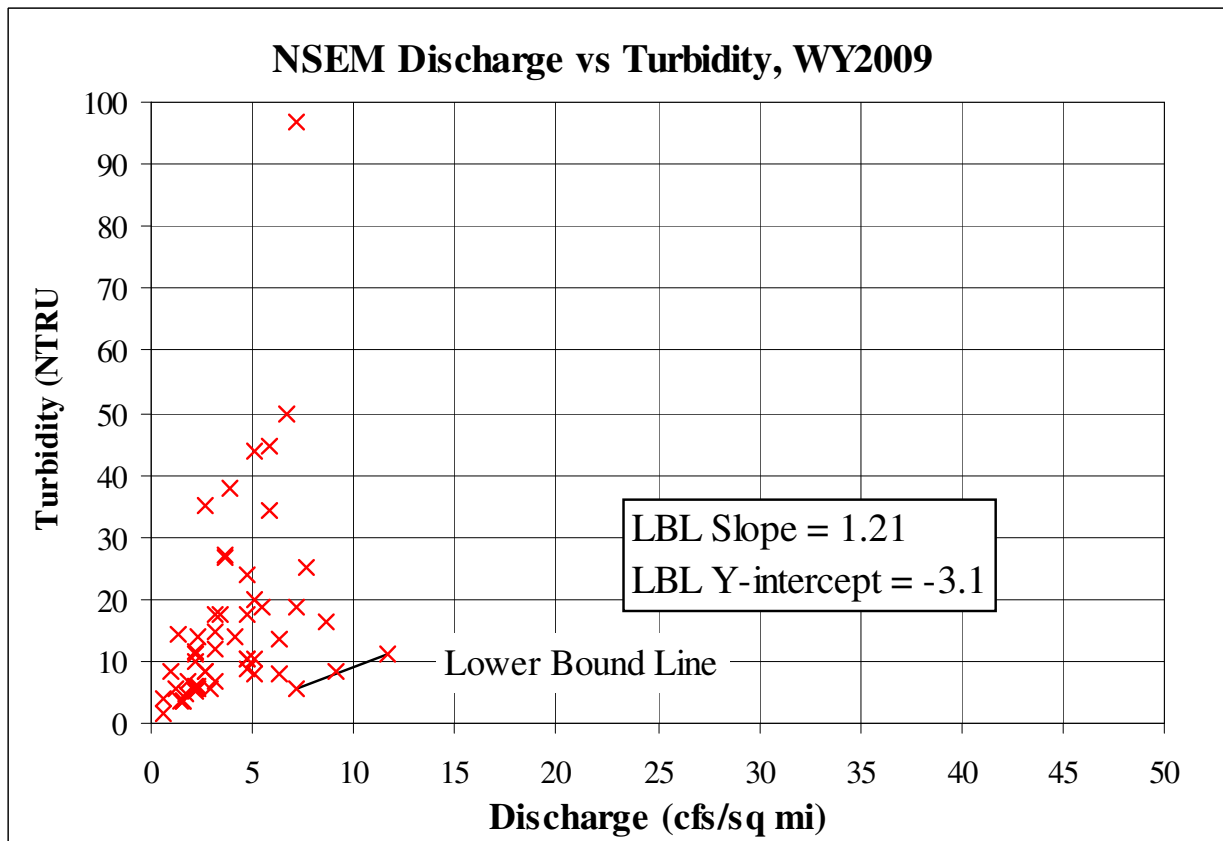
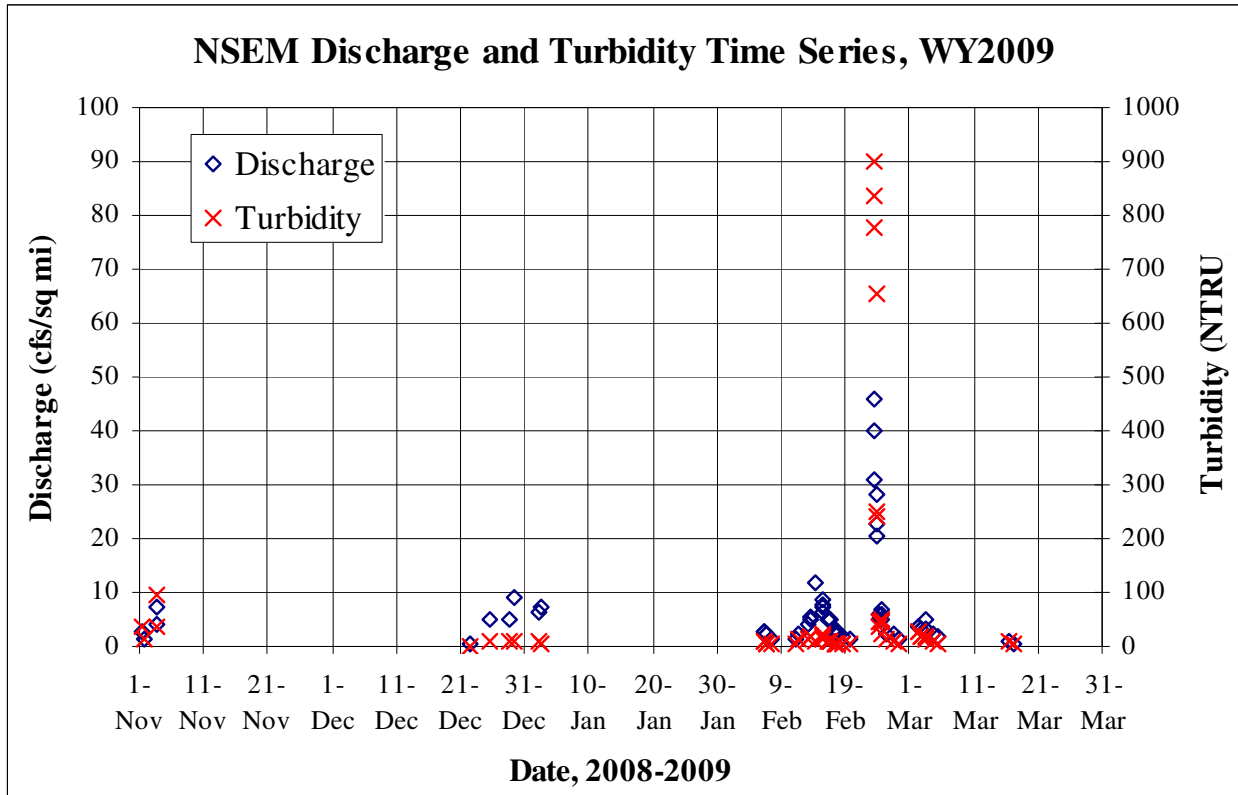
Appendix B: Tributary Discharge, Turbidity, and Lower Bound Lines, WY2009 (cont'.)



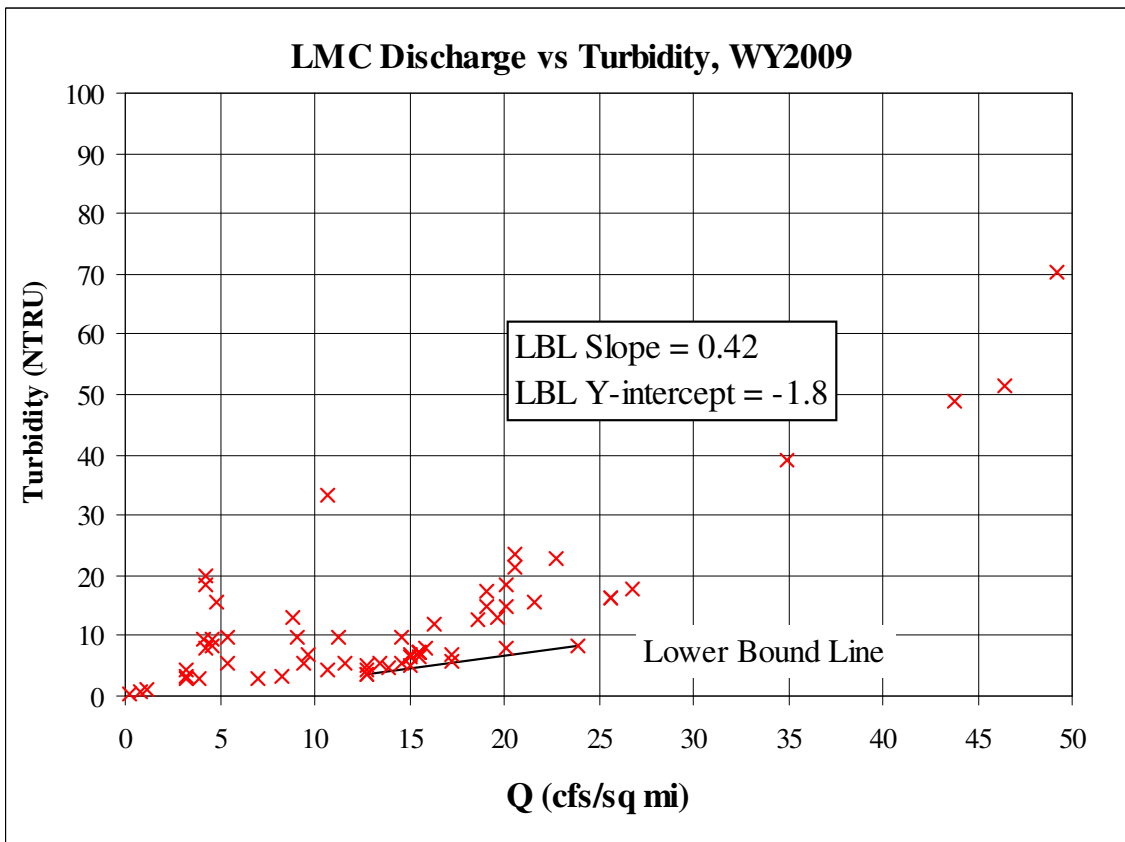
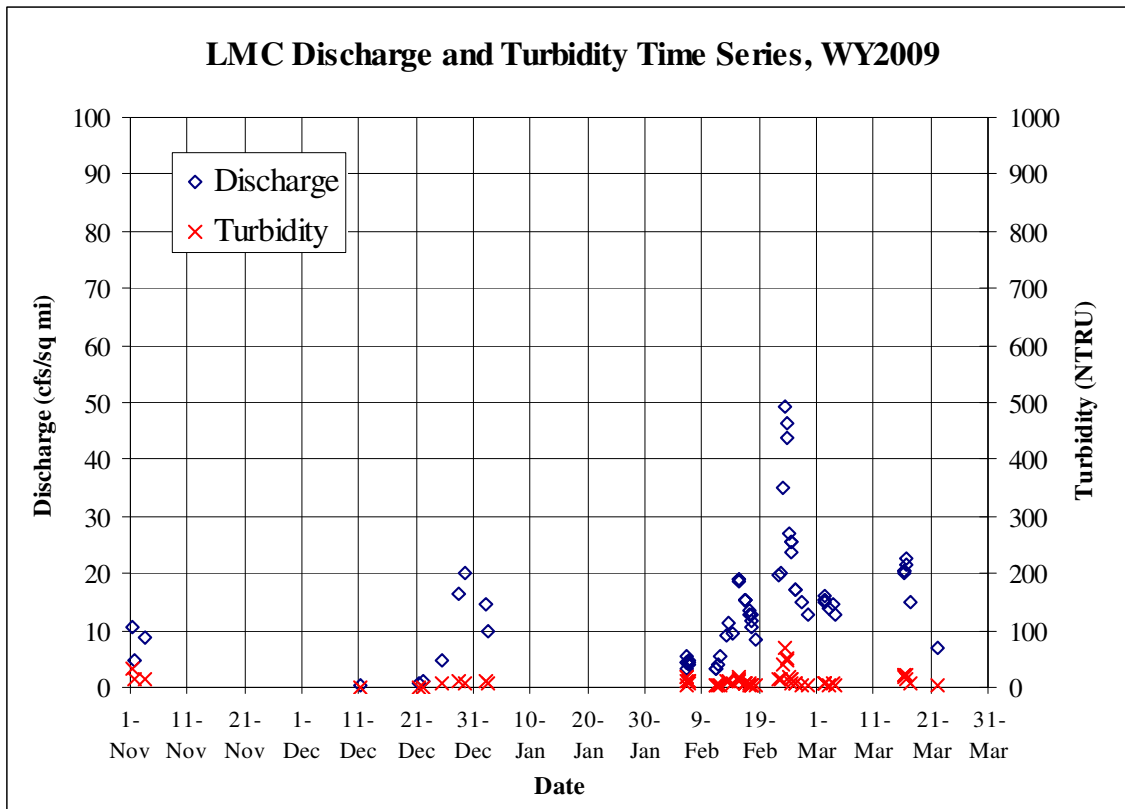
Appendix B: Tributary Discharge, Turbidity, and Lower Bound Lines, WY2009 (cont'.)



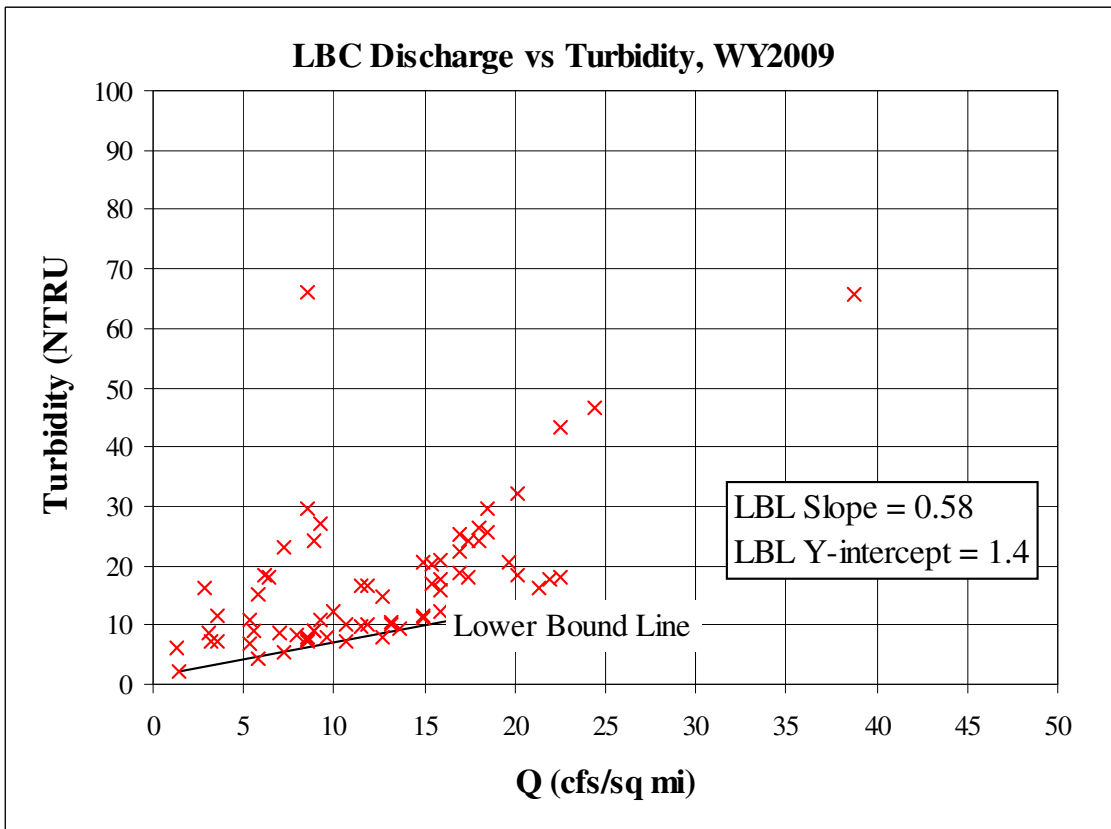
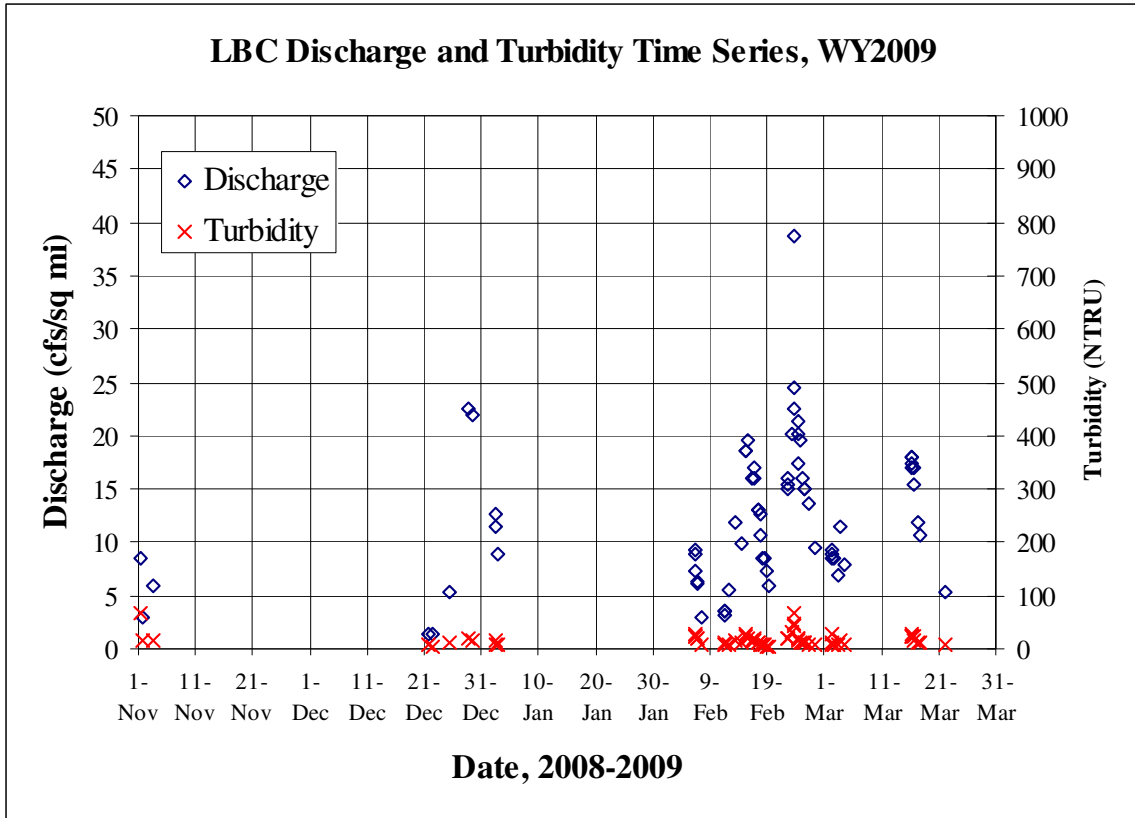
Appendix B: Tributary Discharge, Turbidity, and Lower Bound Lines, WY2009 (cont'.)



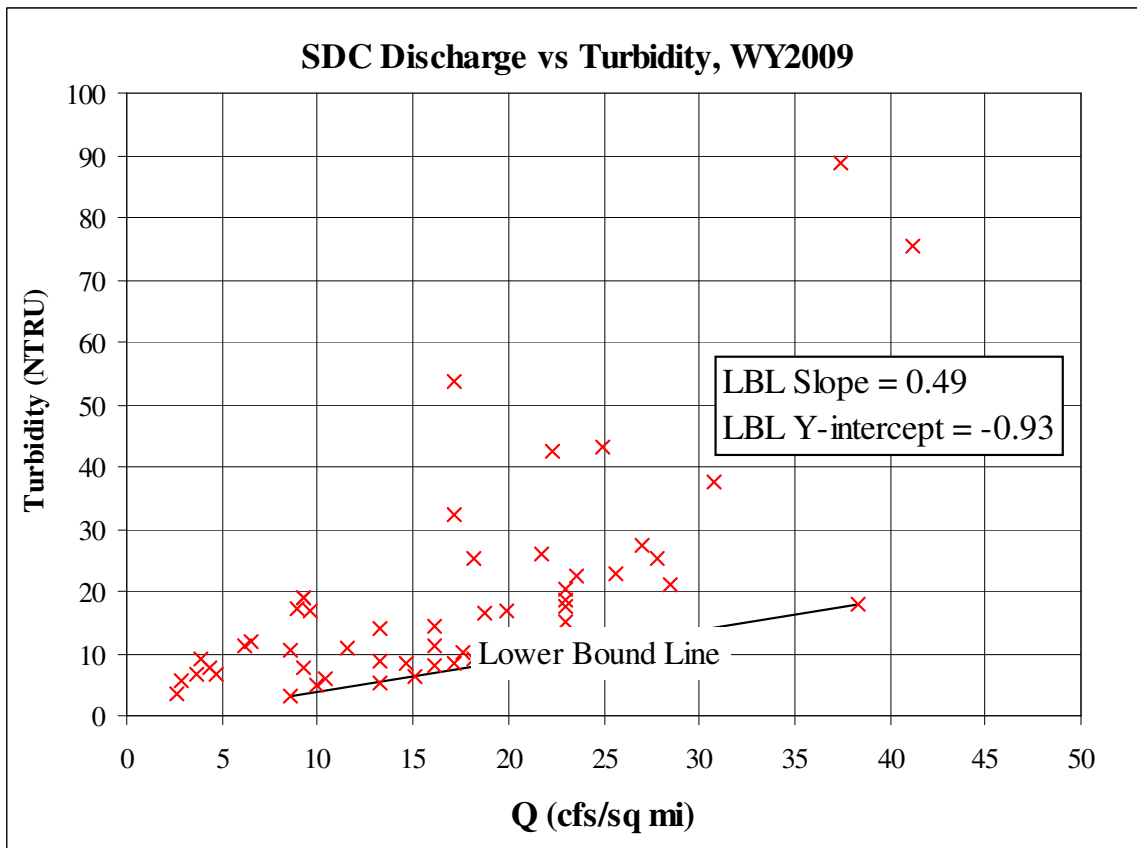
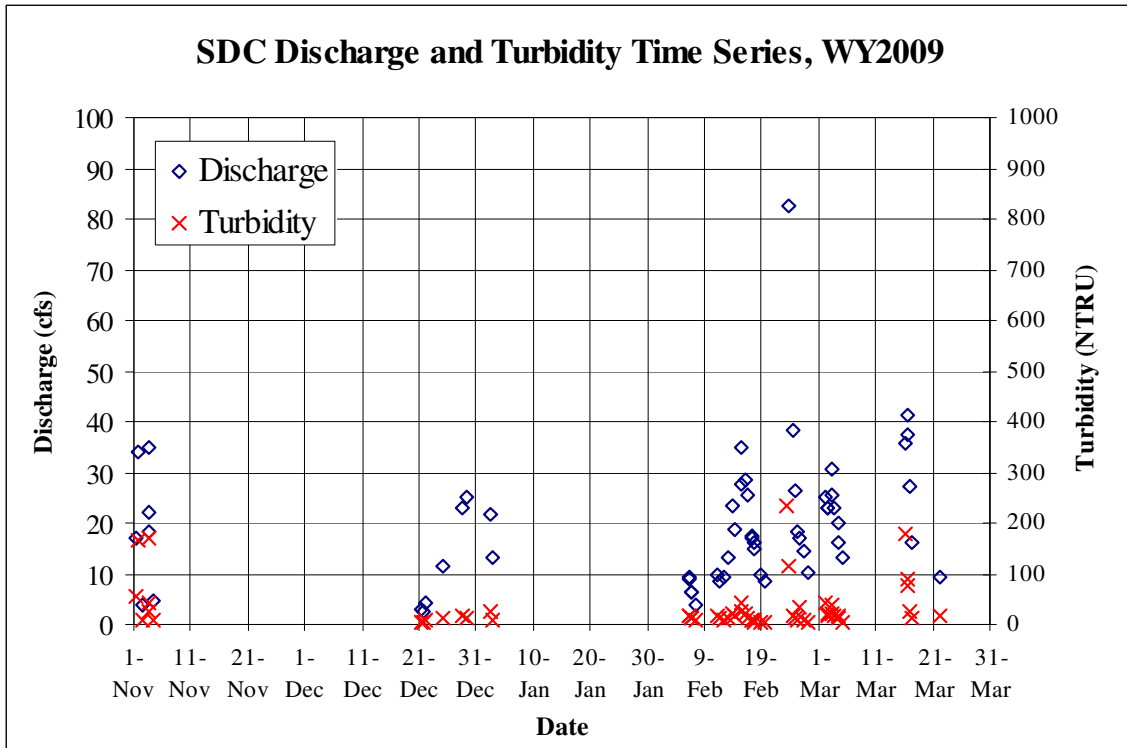
Appendix B: Tributary Discharge, Turbidity, and Lower Bound Lines, WY2009 (cont'.)



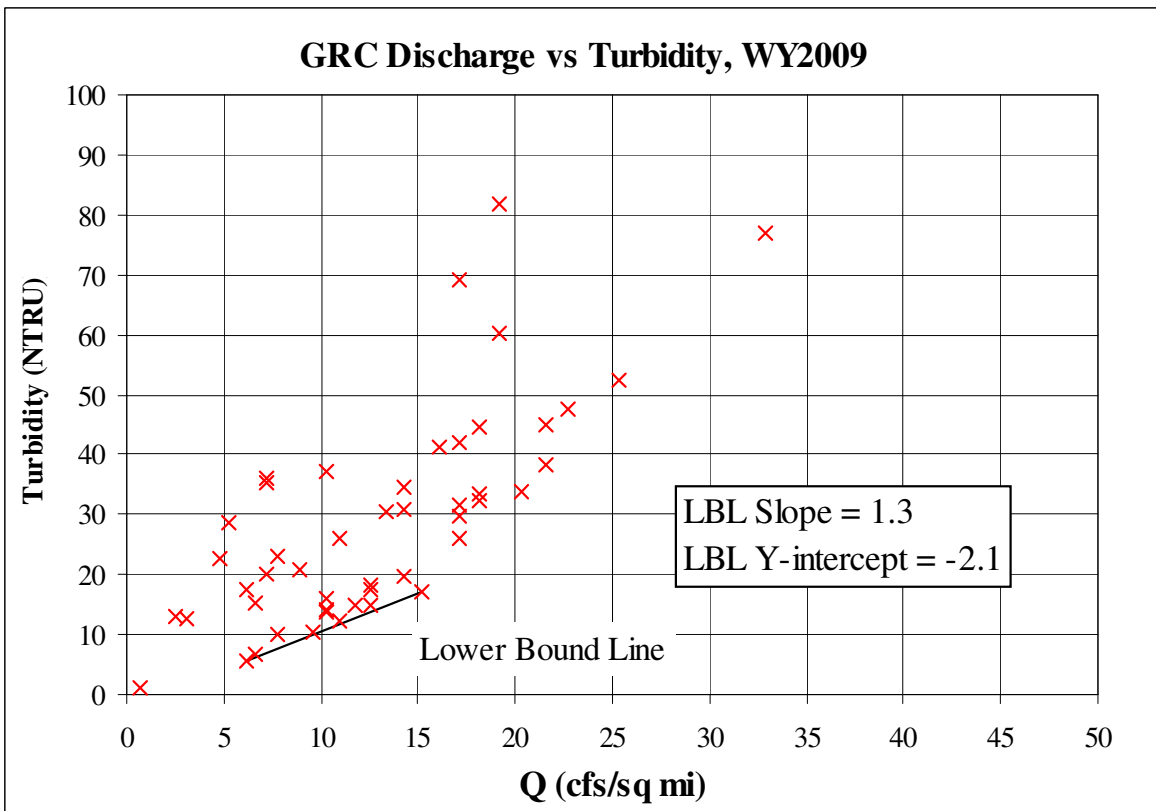
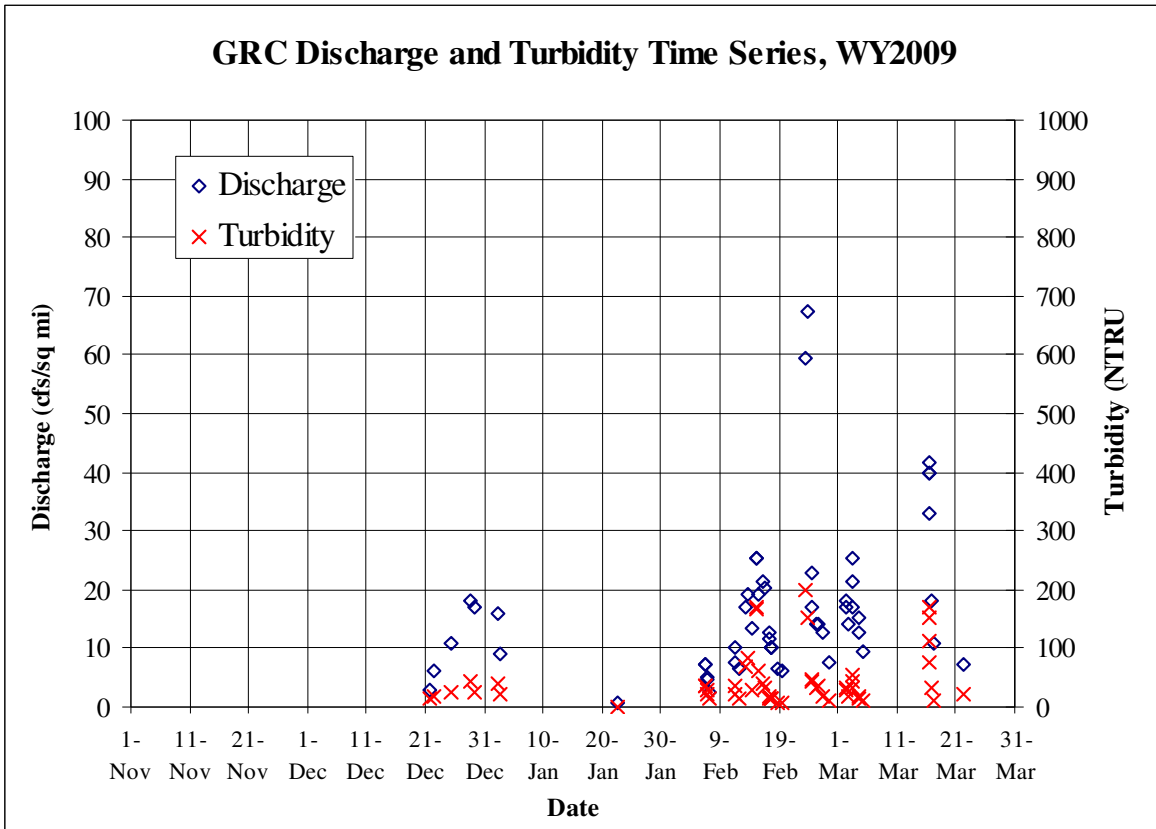
Appendix B: Tributary Discharge, Turbidity, and Lower Bound Lines, WY2009 (cont'.)



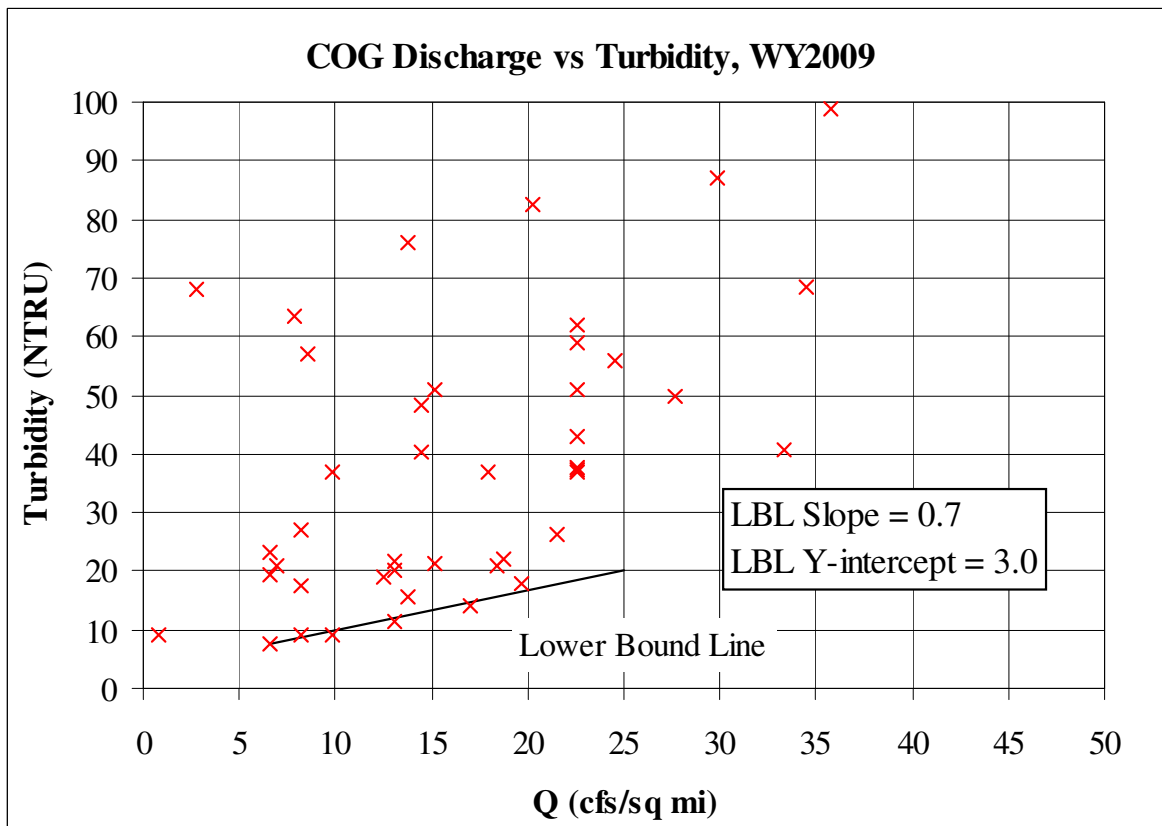
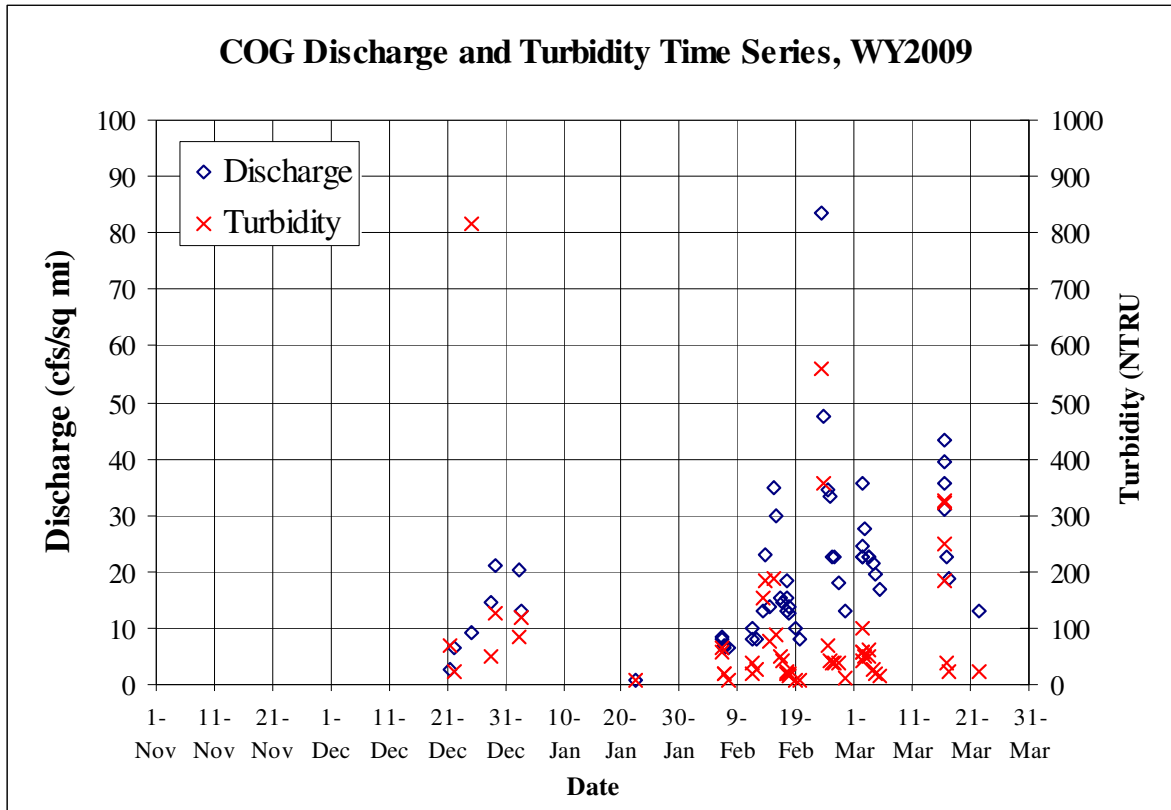
Appendix B: Tributary Discharge, Turbidity, and Lower Bound Lines, WY2009 (cont'.)



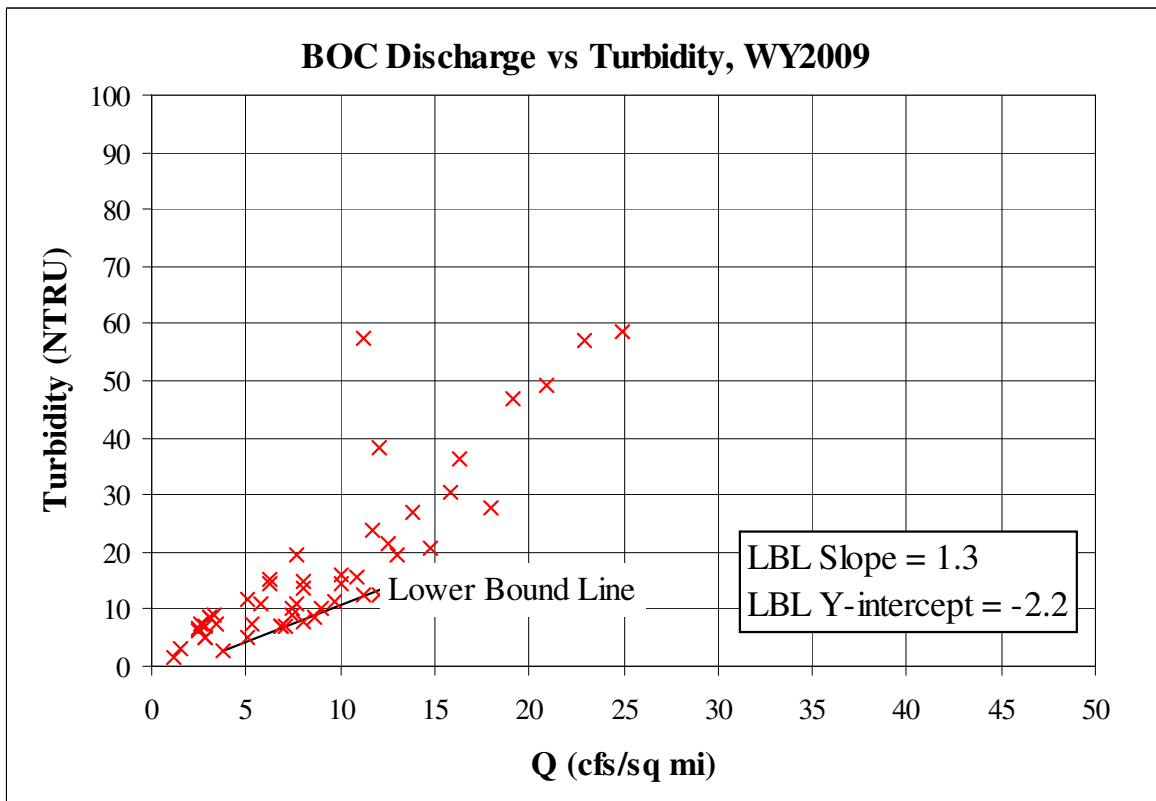
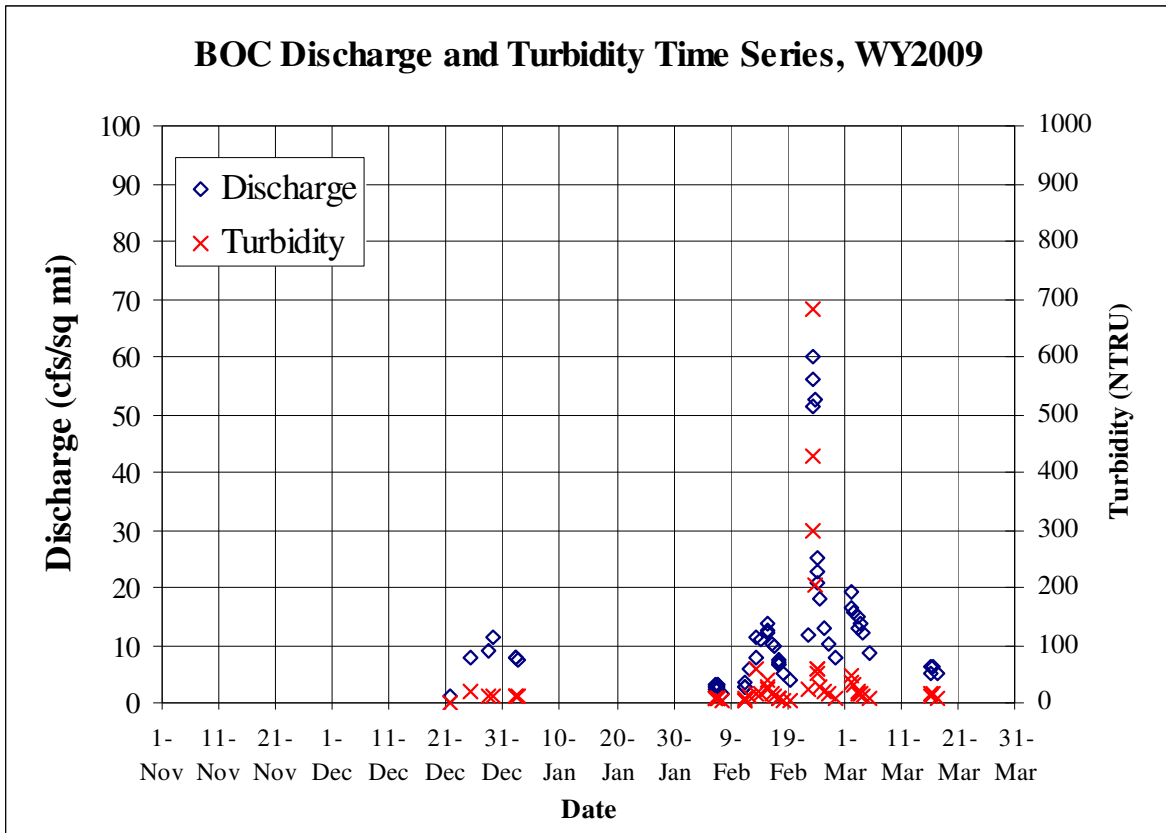
Appendix B: Tributary Discharge, Turbidity, and Lower Bound Lines, WY2009 (cont'.)



Appendix B: Tributary Discharge, Turbidity, and Lower Bound Lines, WY2009 (cont'.)



Appendix B: Tributary Discharge, Turbidity, and Lower Bound Lines, WY2009 (cont'.)



Appendix C

Standard operating procedures for data collection: Lower Mattole turbidity and discharge monitoring

November 2008
Version 1.0

Mattole Restoration Council

PO Box 160
Petrolia, CA 95558
707-629-3514
www.mattole.org

Contact:

Nathan Queener, Monitoring Coordinator
nathan@mattole.org

TABLE OF CONTENTS

Establishing a Cross-section for the Development of Stage-Discharge Rating.....	2
Taking Turbidity Sample and Reading Staff and Crest Gage	5
Using Hach 2100P Turbidimeter to Determine Turbidity Values (NTRU) ...	8
Velocity and Flow Measurement Using a Flowmeter	10

FIGURES – DATASHEETS

Figure 1. Cross-section Data Sheet	4
Figure 2. Lower Mattole Turbidity Sampling and Stage Log.....	7
Figure 3. Turbidity Lab Sample Log – Hach 2100P Turbidimeter	9
Figure 4. Flowmeter Streamflow Measurement Datasheet	13
Figure 5. Equipment Calibration and Maintenance Log - Marsh-McBirney 210D Flowmeter.....	14

Establishing a Cross-section for the Development of Stage-Discharge Rating

Equipment

For surveying cross-section:

25' or 50' measuring tape (tenths of feet)

Stadia rod (tenths of feet)

Rebar or other permanent stakes

String on plastic reel

Line level

Hand Pruners

Paint pen

For installing crest gage:

Crest Gage

Cork

Metal T-post

Hose Clamps

Nut Driver/screwdriver

1. Choosing a site for the x-section

The ideal reach has the following attributes:

- trapezoidal channel
- low channel roughness with no large cobbles or boulders
- relatively flat gradient (otherwise gage creates turbulence at higher flows)
- straight channel reach
- low likelihood of channel change – no eroding bank, little chance of scour/fill
- minimum of interfering vegetation

Vegetation may be pruned judiciously, and a few boulders moved if necessary in order to smooth out the cross section.

2. Placing benchmarks

Place stakes on stable ground far enough above the active channel that they will not be washed out in high flow events. A nail placed in a tree can be used as well. Make sure that the benchmarks are placed so that the cross-section will be perpendicular to the direction of flow. Mark the stakes/nail with orange paint to facilitate relocating them. If livestock will be in the area, make sure stake does not pose a hazard. Using a line level make sure that benchmarks are at equal height so tape/tag line will be level.

3. Stretching the measuring tape and leveling

Attach zero end of tape to left bank benchmark and stretch across the channel, attaching to the right bank benchmark. If the span being measured is $\sim >20'$, there will be considerable tape sag – use a tag line in this case as the level line. Use the line level to level the tape/tag line. Adjust the benchmark height if necessary. Mark on the benchmarks where the center of tape/tag line is attached following leveling, to facilitate remeasurement.

4. Measuring the cross-section

Always begin cross-section measurements on the left bank, at the zero end of the measuring tape. Take the first measurement at 0.0' on the tape, marking that distance in the appropriate

box on the data sheet. Record the distance from the ground to the tape/tag line (whichever is the “leveled line”) in the “rod reading” box on the data sheet. Where exactly is the “ground?” Don’t bury the bottom of the stadia rod into the dirt, but on the other hand be careful that you aren’t measuring from the top of deep duff that is likely to be displaced/rot away. Continue taking tape and rod measurements at breaks in slope in order to adequately characterize the cross-section. Use approximately 2’ centers, with more frequent measurements where needed to capture changes in slope. Note breaks in slope, left and right edge of water, and other prominent features in the remarks column. Take final measurement at right bank benchmark.

5. Placing staff/crest gage

It may be easier to put in the gage prior to stretching the tape. The gage should be in line with the surveyed cross-section, in a location where it will be easy to read at high flows. It should be low enough in the channel that it will be in the water at stages just above base flow, but not so low that the chance of it filling with sediment is high. Driving a metal post into the streambed can be quite difficult in spots, and may require repeated attempts. The post, and gage, should be as straight up and down as possible. Attach gage to post securely with metal hose clamps. Mark on gage with the paint pen the point where the top of the metal post rests, in case gage is bumped or moved.

6. Cross-section photos

Before taking down the tape/tag line, take panoramic photos of the cross section, and describe photo location on the data sheet. When downloading photos to the computer in the office, name the photos with the site code and the date they were taken. These can be used to detect changes in the cross-section from season to season.

7. Stage at zero flow (SZF)

Measure from the zero level of the staff gage to the level of water if the creek were so low that flow stopped – i.e. intermittent pools. This is analogous to the riffle crest depth. Either a line level or carpenter’s level needs to be used to provide a level line from the zero point at staff gage to measure against, using a stadia rod or measuring tape at the downstream control point. Record the height from SZF to the zero on the staff gage on the data sheet in hundredths of feet.

Taking Turbidity Sample and Reading Staff and Crest Gage

Equipment:	Field forms	If flows might be below bottom of gage, also need:
Plastic Sample containers	Extra cork for Crest gage	Line Level
Adhesive tape	Waders	String
Felt-tip Pen or Wax Pencil	Watch	Stadia rod or measuring tape
Pencil		

Note: Safety trumps gathering data every time. If flows at a sampling site are high enough that entering the stream is dangerous, don't wade. High flows could also prohibit accessing the lath inside the crest gage.

a. Recording Stage

- Read stage in 100ths of feet from staff gage. Prior to taking a reading, remove any visible debris, sticks, leaves, etc. that may have lodged against the post or pipe. In fast-moving water, flows will "pile up" on the upstream side of the gage, and the water level may be much lower on the downstream side of the gage. If this is the case, the recorded stage should represent what the water level would be without an obstruction to flow (usually the approximate mean of the upstream and downstream water levels). If the water level is surging or undulating, the stage is the mean of the levels of the peak and trough of the waves.
- **If water level is below zero level of gage, but still directly below gage:** Measure distance from "zero" on gage to water surface with stick or stadia rod to the nearest 100th of a foot. Record distance as negative, and circle it on the data sheet.
- **If water level is below zero level of gage, and not directly below gage:** Attach string to gage at "zero." Use line level to level string and measure vertical distance (in 100ths) from water surface to string. Record distance as negative, and circle it on the data sheet.
- Record date, time, and stage on site-specific "Turbidity Sampling and Stage Log" in binder. Also record stage on turbidity sample bottle label.

b. Turbidity Sampling Location

Turbidity samples should be taken in well-mixed flow. Avoid eddies or backwater areas. Sample doesn't need to be taken exactly at the location of the staff gage. If a location slightly up or downstream of gage is safer to access or flow is more well-mixed, this might be a superior sampling location provided there are no inflows that would bias sample.

c. Turbidity Sampling Procedure

If stream is wadeable:

- Enter stream so as to collect sample at least a foot from the bank to ensure well-mixed sample.
- Wade in a manner to avoid disturbing excess sediment that could bias sample (don't sample downstream from where you've waded!).
- Face upstream and remove cap from sampling bottle.
- With bottle facing flow, place bottle in water inclined at a 45 degree angle, with half of the bottle's mouth submerged. Submerging the bottle's mouth entirely has the potential to bias the sample. Re-cap bottle.
- Don't fill bottle more than half full – if you overfill, pour water out and sample again.

If stream is not wadeable:

- Sample using sampling stick. Do not enter stream. Be careful on slippery banks!

- If you have any concerns about representativeness of sample, take replicate from other side of stream, if at site with bridge.
- Otherwise, follow instructions above.

d. **Turbidity Data Recording and Storage**

- After taking sample, place strip of adhesive tape on bottle. Write on tape the 3 letter site code, date, time of sample, stage, and sampler's initials.
- Turbidity samples should be stored in a cool, dark place to facilitate accurate readings with the turbidimeter. Store sample bottles away from car heat vents, in small cooler, or in trunk.

Note: Scan stage log to determine if flow measurement has been taken within 0.20' of present stage. If not and stream is safely wadeable, take flow measurement prior to reading crest gage. See Flow SOP for step-by-step instructions.

Note: If stage at end of flow measurement differs by 0.05' or more than stage at beginning of flow measurement, take a second turbidity sample, using same procedure as for first sample.

e. **Reading Crest Gage**

- Remove cap from top of staff gage. Remove wooden lath.
- Line up notch on bottom of lath with zero level on staff gage (or use stadia rod if more convenient).
- Record stage level of highest cork band on lath in turbidity sampling and stage log, in 100ths of feet. Also record level of any lower cork bands.
- Before replacing lath in pipe, wash all cork off of lath. If flows permit and cork is reusable, use bottle/cup to wash cork back into pipe. If necessary, add additional cork.
- Before replacing lath in pipe, allow water level in pipe to recede if cork washed back in pipe, in order to avoid false crest. **Check to make sure that drainage holes on bottom of gage are not clogged, and permit water to drain!**
- Replace lath very gently and slowly to minimize displacement which can create a false crest reading. If necessary, remove lath again to check that cork does not register false crest.
- Make sure the index line (marked in pencil near the top of the lath) matches up with the top of the threaded portion of the PVC pipe. If the lath sits too high, it may be an indication that substantial sediment has accumulated within the pipe. If so, it may be necessary to remove accumulated sediment by unscrewing the bottom cap (this should only be attempted during lower flows when the bottom threaded cap can be easily accessed).
- Replace cap on top of gage. Don't screw on too tightly.

f. **After Returning to the Office**

- Check that all sample bottles are properly labeled and field data sheets have been filled out.
- Place sample bottles in box in shed.
- Leave field book in appropriate location in office.

Figure 2.

Lower Mattole Turbidity Sampling and Stage Log

Site (descriptive) _____ Site 3-letter Code _____

Date	Stage	Time	High Crest	2 nd Crest	3 rd Crest	Flow ?	Pers- onnel	Remarks

Instructions for filling out table:

1. **Date:** Record in mm/dd/yyyy format.
2. **Stage:** Record in hundredths of feet after taking turbidity sample. Check that gage has not shifted position.
3. **Time:** Record time stage noted, 24 hour clock (midnight=00:00).
4. **High Crest:** Record stage level of highest cork band on lath, in hundredths of feet.
5. **2nd and 3rd Crest:** Record stage level of next highest cork band(s) on lath, if present.
6. **Flow?:** Mark “X” if flow measurement taken during site visit. Leave cell empty if no flow measurement taken.
7. **Personnel:** Record initials of sampling personnel.
8. **Remarks:** Record any additional observations or notes. Note if “negative” stage.

Using Hach 2100P Turbidimeter to Determine Turbidity Values (NTRU)

Equipment:

Hach 2100P Turbidimeter

Turbidimeter case should contain:

- Silicone Oil and Cloth
- glass sample cells
- StablCal standards
- Gelex standards

Clean, lint free cloths (in bag next to turbidimeter)

Plastic sample bottles with turbid water

Lab notebook

1. Sample Storage

Samples should be stored in a cool dark place, for no more than 48 hours before being run in the turbidimeter. If a sample has not been stored according to the above specifications, or has been held for longer than 48 hours, note this in the remarks column of the lab log book, and consult with the project manager.

2. Transferring Sample to Sample Cell

Remove glass sample cell from turbidimeter case, taking care to handle the sample cell by the top. Make sure cell is not scratched, which can bias the sample reading. Remove cap from cell. Remove cap from sample bottle. Gently swish bottle - in order to remix sample - while holding sample cell by the top in other hand. After a moment of swishing pour into sample cell, filling to the line. Cap cell. If cell is over- or under-filled, pour contents back into sample bottle, and swish and fill again.

3. Cleaning and Oiling Sample Cell

Wipe the cell with a soft, lint-free cloth to remove water spots and fingerprints. Apply a drop or two of silicone oil to the cell, and wipe with the black cloth in turbidimeter case to distribute the oil evenly over the cell. Make sure to keep cloths clean.

4. Inserting Cell in Turbidimeter

Turn on the turbidimeter. Make sure the instrument is on a flat surface. Invert the sample cell five times (do not shake the cell) to mix the contents, then insert in the instrument cell compartment so the diamond mark aligns with the raised orientation mark. Close the lid.

5. Running Sample

Select automatic range mode by pressing the “Range” key. The display will show “Auto Rng.” Press the “Read” key and wait a moment while instrument is averaging multiple readings. Record the value displayed in the lab book, along with the other information for the sample from the bottle label.

6. Cleaning Cells and Bottles

Rinse sample cells three times with tap water following each reading. Remember to handle sample cell by top, and take care to not scratch the cell. Rinse sample bottles thoroughly at sink in office, and return to shelf in shed.

7. Sources of Error

- Sample not mixed: After a sample is taken, the larger particles will fall out of suspension and settle on the bottom of the bottle. Gently swishing the bottle (step 2) prior to pouring into the sample cell is important to ensure a representative sample, as is inverting the cell prior to placing in the turbidimeter.
- Bubbles in sample: Do not shake the sample, as this will introduce cause bubbles to form, which can bias the reading.
- Scratches on the glass cell: keeping the workspace clean, and handling the sample cells by the top and cap only will help decrease the chance of scratching the cells. Heavily scratched cells should be discarded.
- Temperature changes and bio-fouling: storing the sample in a cool, dark, place, and processing the sample promptly will decrease the chance of biasing the sample from condensation or algal growth.

8. Calibration

The Hach 2100P turbidimeter should be calibrated with StablCal primary standards every three months. For step-by-step instructions please refer to the HACH 2100P manual, pgs 37-39 and 44-54. The manual is located in the back flap of the green lab notebook. Record calibrations in the calibration log in the green lab book.

Turbidimeter accuracy should be “verified” with the Gelex secondary standards every two weeks, and immediately following each calibration. For step-by-step instructions refer to page 54 of the instrument manual. Record values in the calibration log. After completing verification, calculate the % difference between the current reading and the previous reading. If the reading is not within 5% of the previously established value, the instrument should be recalibrated with the primary standards.

Figure 3.

Lower Mattole Turbidity Sampling - Turbidity Lab Sample Log – Hach 2100P Turbidimeter Site 3-letter Code

Field Data					Lab Data				
Date Sampled	Stage	Time	High Crest	Sampler's Initials	Date Sample Run	Time Sample Run	NTUs	Lab Personnel	Remarks

Velocity and Flow Measurement Using a Flowmeter

(Portions of this document are modified from “Appendix 5: SOPs for Velocity and Flow Measurement Using a Flowmeter”, in *Quality Assurance Project Plan for Low-flow Trend Monitoring, Mattole River Watershed*)

Equipment List

Portable Flowmeter (Marsh-McBirney 201D)	Stakes to hold measuring tape	Straight-blade screwdriver
Top-setting wading rod	Binder clamps	Stopwatch or clock
25’ measuring tape (tenths of feet) or Stadia rod	Field data sheets & mech. pencil	Line level
	Flow-meter manual	Sandbags and shovel (if flows are very low)
	6 spare D-cell batteries	

1. Safety

Safety concerns will limit our ability to measure discharge at high flows. Wading should never be attempted when water depth is over an individual’s waist, in a stream reach lacking current. At sites with substantial water velocity, the maximum water depth that can be safely waded is significantly shallower! If in doubt about the safety of entering the stream, don’t wade and don’t take the measurement!

2. When to take measurements

Streamflow measurements with a current meter will be taken at each sampling site a sufficient number of times (6-10) over the course of each sampling season to establish a valid stage-discharge relationship. After taking turbidity sample and noting stage, scan the stage log(s) for the site to determine if a flow measurement has been taken within 0.20’ of present stage. If not and stream is safely wadeable, take flow measurement prior to reading the crest gage (See turbidity and stage SOP).

3. Where to take measurements

Flow measurements do not need to be taken right where the staff gage is located, but shouldn’t be taken upstream or downstream of any tributaries that would change the measurements. In considering where to take a flow measurement, look for the following:

- a. A straight reach, with a uniform depth and a trapezoidal channel (as canal-like as possible).
- b. Few large rocks, vegetation, and obstructions which would create turbulence or backwaters.
- c. The flowmeter cannot be used in depths shallower than 0.2’ – anywhere flow measurements will need to be taken should be at least this deep.
- d. If flows are very low, sandbags can be used to create a rectangular or trapezoidal channel and enough depth to allow for a flow measurement.
- e. Rocks and obstructions in the channel may be moved prior to beginning the flow measurement.

4. Measuring stream width

Stretch tape (or place stadia rod) perpendicular to the direction of flow, with the zero end on the left bank. Make sure tape is level, above the water, and attached securely to stakes. Measure the total wetted width, i.e., distance from left edge of water (LEW) to right edge of water (REW), and record these values to the nearest tenth of a foot in the far left column on the flowmeter data sheet. Also record depth at LEW and REW.

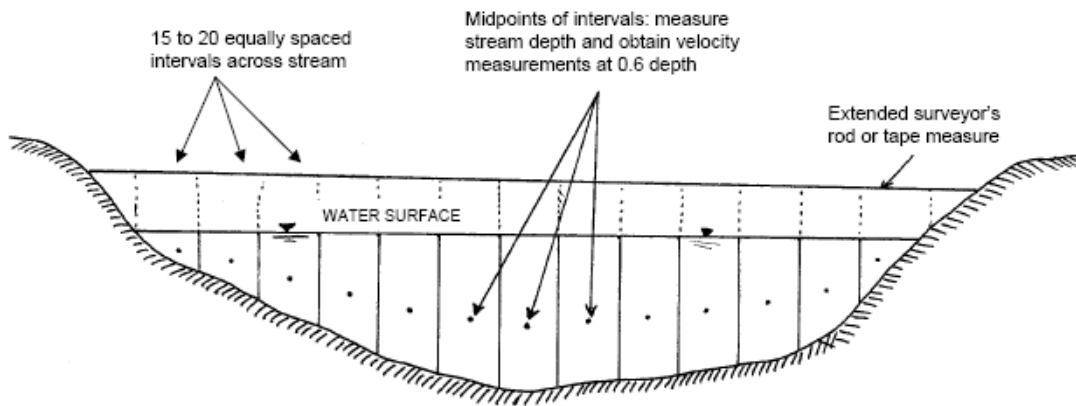
5. Preparing flow meter for use

Attach flowmeter sensor to top-setting wading rod, making sure that thumb-screw is seated securely in groove, but do not over-tighten. Do not touch or bump the front of the sensor where the 3 electrodes are situated. Turn selector switch to “CAL” setting. After approximately ten seconds, the readout should be on

or between 9.8 and 10.2. If this is not the case, turn off the meter, replace the batteries, and check the unit again. Turn selector switch to the FT/SEC setting.

6. Determining cell width

Determine the left and right edge of water movement, using the flow meter, and write those distances and the water depths on the form, noting “REW movement” and “LEW movement” in the remarks column. Determine distance between “REW movement” and “LEW movement.” Divide distance into equal widths so there will be at least ten velocity measurements, preferably at least 15. For example, if LEW movement is at 1.2’ on the stretched tape, and REW movement at 6.4’, the channel can be divided into 13 cells, each 0.4’ in width ($5.2' / 13 = 0.4'$).



A greater number of measurements (hence narrower cell width) will result in a more accurate discharge measurement. However, when stage is changing rapidly (during or following a storm), or completing a measurement quickly is important for other reasons one might opt for fewer measurements – but ten is still a minimum.

7. Prior to taking velocity measurements with flow meter

After the cell width to be used has been determined, **record the time and the current stage – it is especially important to do this just before commencing flow measurements when stage may be changing rapidly.** Velocity measurements are taken at the **midpoint** of each cell, to be representative of the velocity of the entire cell. In the example above, the first measurement would be done at 1.4’ on the tape (the cell begins at 1.2’ and ends at 1.6’). The next measurements would be taken 0.4’ to the right of the first, at 1.8’, the midpoint of the second cell (the cell extends from 1.6’ to 2.0’).

8. Measuring velocity with the flow meter

- When wading, the rod person should stand downstream and off to the side of the flow sensor to avoid influencing stream velocity at the measurement point. Set the wading rod vertically in the water so that the rod barely touches the downstream side of the measuring tape at the desired measurement point.
- Using the wading rod, measure the depth at the midpoint of the first cell and record to the nearest 0.1 feet (Each single mark represents 0.1 foot, each double mark represents 0.5 foot, and each triple mark represents 1.0 foot). If the water level is surging or undulating, the depth is the mean of the levels of the peak and trough of the waves.
- Position aluminum rod at proper location on depth scale (this positions the sensor at 0.4 from the streambed, and 0.6 from the water surface).

- The flow probe must face upstream, perpendicular to the measuring tape. Make sure the rod stands upright, sits flat and securely on the streambed, and that there are no rocks, sticks, leaves, etc., obstructing the probe. Hold the cord straight up from the probe so that there is no slack in the cord.
- Once the sensor is set at the proper depth, make sure that the time constant switch is set at the lowest of the three settings (“2”). When on this setting, hold sensor in position for at least ten seconds (the switch setting times 5) before reading velocity to allow for reading to stabilize. If numbers on readout are still erratic, switch time constant switch to next highest setting (“6”) and wait 30 seconds before reading value. If numbers are still erratic switch to highest setting (“20” – wait 100 seconds) and repeat process. This meter seems to be most constant on readings less than 1.0 ft/sec, and at these lower velocities there is also less natural surge and ebb in the current.
- Record velocity measurement in hundredths of ft/sec on data form – If a measurement is negative, record it as negative and circle it on the data sheet.
- Repeat the process of measuring and recording depth and velocity at mid-points of all remaining cells.

9. After completing velocity measurements

Note ending stage and the time, and record on the form. Check form for obvious errors and omissions, and initial and date at the bottom.

10. Zero Calibration of Flow Meter

Weekly during the field season perform the “Zero Check” procedure using a bucket of quiescent water for the MM-210D flowmeter. First clean the sensor using soap and water. Hydrocarbon solvents must not be used as they will damage the sensor. Avoid touching the 3 electrodes on the front of the probe. Nonconductive coatings (oil and grease) on the electrodes, even minute amounts of oils on human skin, can cause noisy readings. Then fill a clean bucket or other container with at least 4” of water. Allow the water to still before inserting the meter – proceed as if taking a flow measurement in stream. Meter should read zero. Document the results of all performance checks, maintenance, adjustments and/or calibration on the Equipment Calibration & Maintenance Log, found at the end of this document. Calibration by the manufacturer or by the USGS Hydrologic Instrumentation Facility (Stennis Space Center, Mississippi) is recommended if the flowmeter is damaged or fails to perform up to specifications.

