Lower Turwar Creek Restoration Effectiveness Monitoring Project

SP-14

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1. Introduction

The Yurok Tribe Environmental Program (YTEP) has been coordinating with the Yurok Tribe Fisheries and Watershed Restoration Programs since 1996 to identify locations to monitor the effects of land management activities and restoration projects. YTEP installed continuous turbidity, water temperature and water level monitoring station in Lower Turwar Creek to monitor the effectiveness of current and future restoration projects. The location of this monitoring station was installed downstream of the upslope and instream restoration projects that were implemented by the Yurok Watershed Restoration and Fisheries Programs.

The objectives of operating this monitoring site are to:

1. To establish baseline conditions across a wide array of water years
2. To track long-term trends through consistent, comparable sites and methods
3. To document effects of various short-term and long-term management and restoration activities throughout the Turwar Creek watershed.

In addition to installing and operating this continuous monitoring station YTEP has performed suspended sediment sampling in Lower Turwar Creek adjacent to the monitoring station. This sampling is done to develop a relationship between turbidity and suspended sediment over a range of water years and storm events. YTEP also performed macroinvertabrate sampling annually in Lower Turwar Creek in the Spring of 2006 through 2012. This monitoring has been done to assess the benthic macroinvertabrate assemblages prior to and following the restoration work. The macroinvertabrate monitoring site was located adjacent to the instream riparian restoration project and downstream of the upslope restoration projects.

1. a. Lower Turwar Creek Monitoring Station

The Lower Turwar Creek Monitoring Station was installed in October 2007 just downstream of the Highway 169 bridge that crosses Turwar Creek (see Figure 1). The continuous water level height began recording on October 30, 2007 and the turbidity and water temperature probe was installed and began operating on November 2, 2007. The water level height, water temperature and turbidity data is collected until the stream flow is affected by the lower control and the stream reaches PZF (point of zero flow) (See figure 4). Historically this reach of Lower Turwar Creek has been intermittent. However, the exact times that the channel goes dry in the Spring or Summer is determined by the amount of precipitation received in the late winter and early spring months.

The monitoring station begins collecting data once the stream channel starts to flow again in the Fall. This timing is influenced by when the Fall rains start, stream morphology, and amount of precipitation during storm events. This monitoring station will continue to be operated into the future and the data will be published with Clean Water Act (CWA) Section 106 funding that YTEP receives.

The Lower Turwar Creek Monitoring Station data is available real-time at http://exchange.yuroktribe.nsn.us/lrgsclient/stations/lowturwar.php. The real-time component allows staff to understand and keep track of the current stream conditions. This allows staff to visit sites to take flow measurements and collect suspended sediment samples during high flow events. Real-time accessibility also ensures a more complete data set of high quality because the operator can determine when equipment is malfunctioning and visit the site to correct any problems.

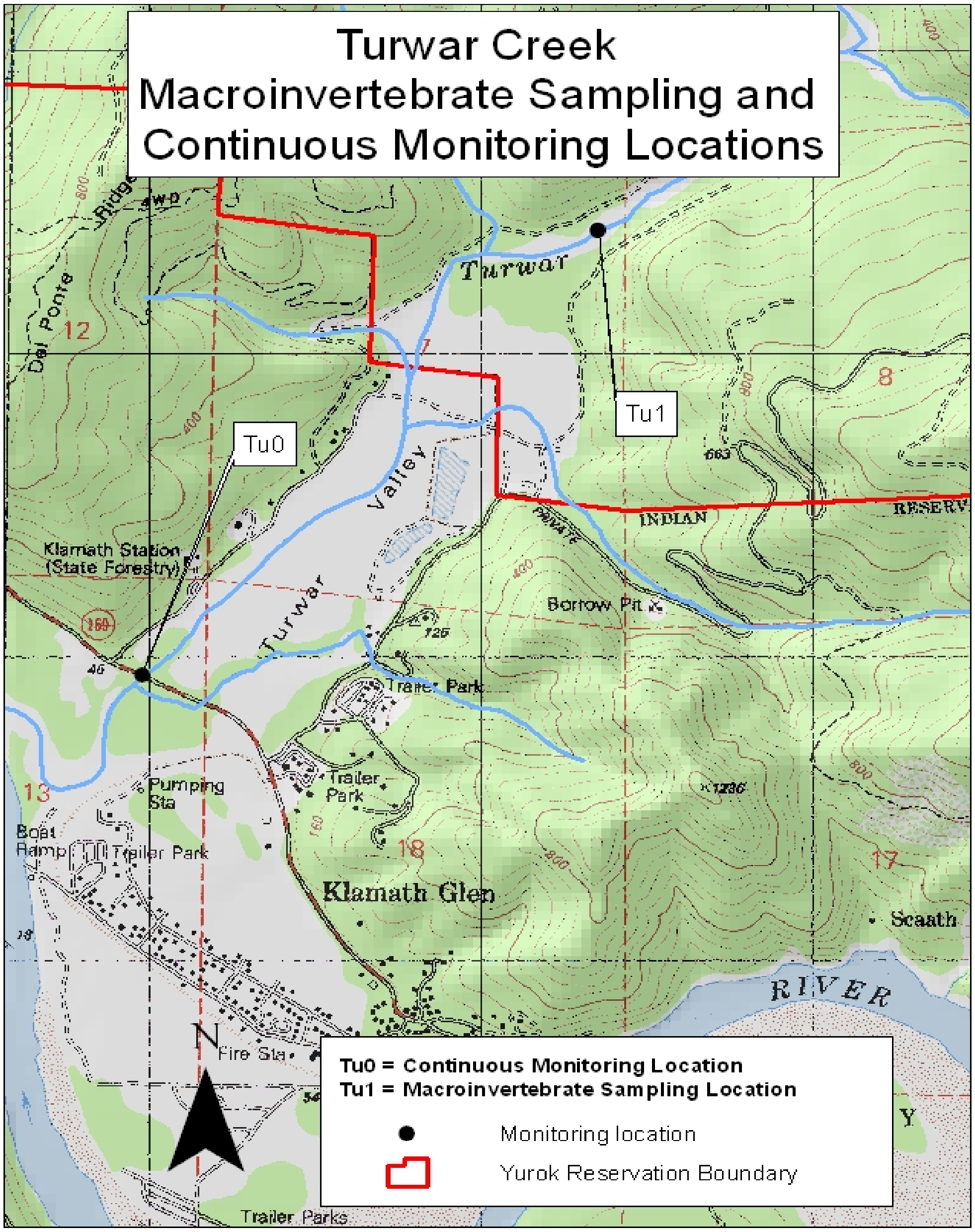

Figure 1. Turwar Creek Macroinvertabrate Sampling and Continuous Monitoring Location.


Figures 2 and 3. Photo of Lower Turwar Creek Monitoring Station and Monica Hiner programming the datalogger.

Figure 4. Photo of Lower Turwar Creek going subsurface.WY09

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Figure 5. AmeriCorps member Charles Schembre taking SSC samples using a US D-74 depth integrated sampler

Figure 6. Photo of Ken Fetcho mounting staff plate on bridge abutment Lower Turwar Creek, WY 2008.

Figure 7. Photo of bridge crane mounted flow measuring equipment at Highway 169 bridge crossing at Lower Turwar Creek, December 27, 2007.

Figure 8. Photo of Micah Gibson and Bill Patterson operating the bridge crane, Lower Turwar Creek, WY 2009.

1. b. Lower Turwar Creek Macroinvertebrate Sampling

YTEP collected macroinvertebrate samples in Lower Turwar Creek on April 28, 2006, May 7, 2007, April 30, 2008, April 21, 2009, June 28, 2010, June 6, 2011, and May 8, 2012. This sampling was part of an effort to assess the physical/habitat and biological conditions on the lower reach of Turwar Creek. This data was added to YTEP macroinvertebrate data as part of an endeavor to build a multi-year dataset on the Lower Klamath River. This summary is part of YTEP's comprehensive program of monitoring and assessment of the chemical, physical, and biological integrity of the Klamath River and its tributaries in a scientific and defensible manner.

Figure 9. Transect F looking downstream 2006

Figure 10. Transect F looking downstream 2007

Figure 11. Transect F looking downstream 2008

Figure 12. Transect F looking downstream 2009

Figure 13. Transect F looking downstream 2010

Figure 14. Transect F looking downstream 2011


Figure 14. Transect F looking downstream 2012

2. Methods

2. a. Lower Turwar Creek Monitoring Station

Gage height is measured at the Lower Turwar monitoring station using a WaterLog® H-350XL Pressure Transducer/Data Collection Platform. The following parameters are measured at this site on a fifteen-minute time interval throughout the year: date, time, stage, air temperature (inside the gaging box), and battery voltage. Turbidity and water temperature are also measured at a 15 minute interval using a digital turbidity sensor (DTS-12) manufactured by Forest Technology Systems, Inc.

During site visits, gage height was compared visually to water level on a fixed, graduated staff. If gage height was adjusted during site visits, it was noted in the site field notebook and the data file was flagged accordingly. Data is downloaded from the gaging station using a portable USB flash drive. The location of the turbidity probe is monitored and adjusted throughout the season to ensure that it is positioned above the streambed and approximately mid-water column depth to ensure accurate data collection.

Flow measurements are collected at or near the gaging station during monthly site visits and periodically during high flow events in winter months. Stream discharge is measured by wading or with a bridge crane USGS methodology (Buchanan and Somers 1969, Nolan and Sultz 2001). Discharge is measured using either a Price AA® or Pygmy® flow meter, depending on stream depth, and an AquaCalcPro® flow computer. Flow measurements taken were used to create a rating curve based on USGS methodology (Kennedy 1984). To estimate a continuous flow record at this gaging station, the rating curve equation was applied to gage height datum.

YTEP also periodically collected suspended sediment samples at this gaging station during WY07 through WY12. Depth integrated samples were collected using either a US-D-48 wadable sediment sampler or US-D-74 sampler attached to a crane for non-wadable sampling. YTEP followed Equal Width Increment (EWI) methodology developed by USGS (Edwards and Glysson 1998). Sediment samples were analyzed by Graham Matthews and Associates (Arcata, California) following all USGS protocols to determine suspended sediment concentrations (SSC) and turbidity. See table 2 for the samples collected in water year 2008 -2012. YTEP has taken box samples as well, which are single samples at the deepest swiftest part of the stream flow. Given enough box samples a correlation can be made between the box samples and the DIS (Depth Integrated Sampling) so in future storm events YTEP is much more efficient with our time, yet still highly accurate in data collection and representation of the SSC.

In 2013 YTEP further refined its analysis of suspended sediment transport by using Upper Turwar and Klamath River near Klamath (USGS site) as surrogate signals to remove data affected by high flows in the Klamath River, (see figure 15). When signals from these three locations are overlaid it becomes visibly apparent that Lower Turwar Creek starts to back up when high river levels make it difficult for Turwar Creek to flow at the mouth. The Lower Turwar gage is located approximately ¼ mile from the Klamath River. YTEP has determined it is not a static gage height or velocity that causes this, but rather variables such as storm intensity, duration, location, snow melt and possibly a few others that have not been identified. YTEP has completed intense monitoring at this location to help understand the effectiveness of stream and riparian restoration by Yurok Tribe Fisheries upstream of the gaging station. YTEP has revised the amount of suspended sediment transported over water years 2008-2012 and estimated it on the conservative side (see figure 27). In the future YTEP plans on measuring and creating a separate rating and sediment curve for the slower velocities created during times when the Klamath River influences the velocity and sediment transport at the site. This will give us a better understanding of this dynamic and allow us to more accurately estimate the amount of suspended sediment transported over the water year.

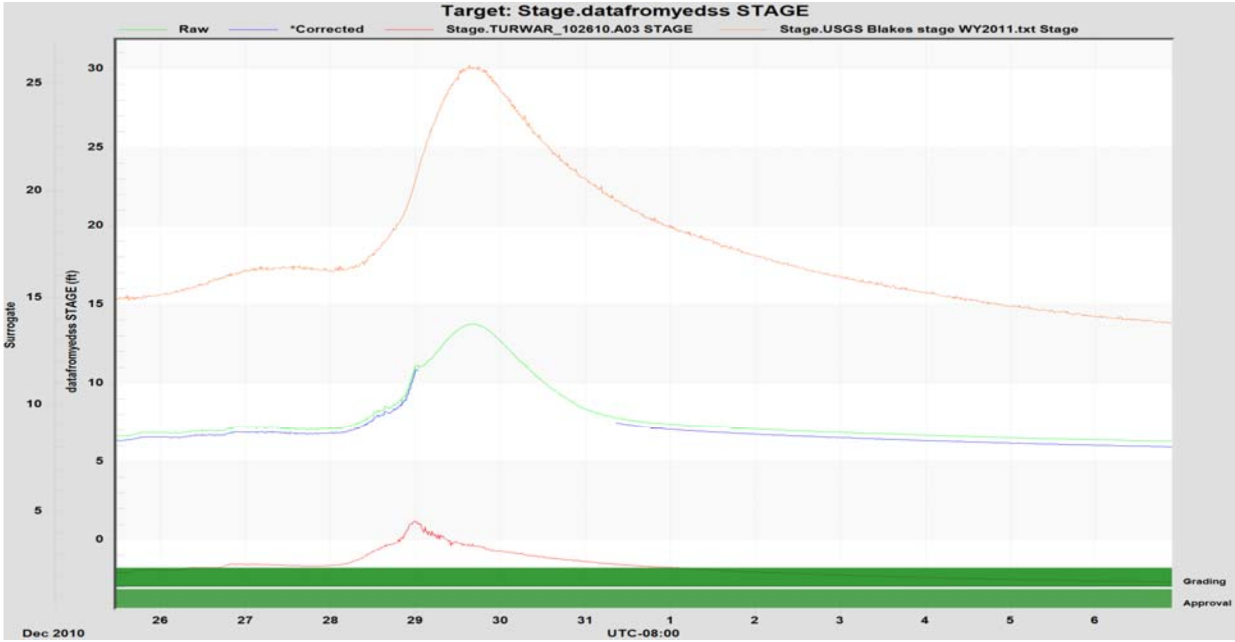

Figure 15. Surrogate signals from USGS gaging station Klamath River Near Klamath and Upper Turwar.

The top orange line is stage height at the USGS gaging station at Klamath River near Klamath, the blue line is stage height at the YTEP gaging station at Lower Turwar Creek corrected data, the green line is Lower Turwar Creek raw stage height data, and the bottom red line is stage height at the YTEP gaging station at Upper Turwar Creek. This shows the event on 12-28-2010 where the hydrograph for Lower Turwar Creek was affected by the Klamath River and shows stage increasing and following the rivers trend while Upper Turwar Creek was receding. After looking at numerous years of data YTEP has determined that Upper and Lower Turwar Creek stage heights peak simultaneously over 90% of the time. Therefore, discharge data has been removed from the final dataset from Lower Turwar Creek gaging station when Lower Turwar Creek backs up so we do not over estimate flow or sediment transport.

2. b. Lower Turwar Creek Macroinvertebrate Sampling

YTEP sampled benthic macroinvertebrate populations in Lower Turwar Creek during the spring from 2006 to 2012. Sampling was performed using the multi-habitat methods located in the State of CA Surface Water Ambient Monitoring Program (SWAMP) *Standard Operating Procedures for Collecting Benthic Macroinvertebrate Samples and Associated Physical and Chemical Data for Ambient Bioassessments in California February 2007* that the DFG has adapted from the US EPA's "Rapid Bioassessment Protocols of use in Streams and Rivers".

Although this protocol was not finalized until February 2007 a draft version was available to YTEP and was used in the spring of 2006 to collect its macroinvertebrate samples. The methods used are identical to the ones laid out in the above mentioned 2007 protocol. A newer protocol finalized in 2009 has resulted in a larger stream reach to be sampled and assessed. If a stream on average has a width greater than 10 meters, the sample reach must then increase from 150 meters to 250 meters. Lower Turwar Creek meets this criterion and for 2009 through 2012 this method was used. This protocol also includes the collection of water quality parameters and physical habitat conditions in the channel and the riparian zone. This report does not contain this information.

The parameters measured include:

- Epifaunal Substrate/Available Cover
- Embeddedness
- Instream Habitat Complexity
- Bank Stability
- Bankfull and wetted width
- Pebble Count
- Vegetative Protection
- Riparian Vegetative Zone Width
- Canopy Cover
- Stream Flow
- Physical water quality parameters
- Micro and macro algal percent cover in stream.

A variety of quality control (QC) measures were undertaken in the macroinvertebrate sampling. Quality control is defined as the routine application of procedures to obtain prescribed standards of performance in the monitoring and measuring process (QAPP, 2001). Sample labels were properly completed, including the sample identification code, date, stream name, sampling location, and collector's name and placed into the sample container. The outside of the container was labeled with the same information. The chain-of-custody forms included the same information as the sample container labels. After sampling had been completed at a given site, all nets, pans, etc. that had come in contact with the sample were rinsed thoroughly, examined carefully, and picked free of organisms and debris. The equipment was examined again prior to use at the next sampling site.

Data generated in the laboratory are reviewed by DFG prior to being released internally or to an outside agent. DFG data review of 2006 results reported that the taxonomist ID's are accurate and the data is acceptable. Laboratory processing is contracted to Jonathan Lee, a qualified local California Stream Bioassessment Protocol (CSBP) taxonomist and California Bioassessment Laboratories Network (CAMLnet) member. The CSBP has three levels of Benthic Macroinvertebrate (BMI) identification. Level 3 is the professional level equivalent and requires identification of BMI's to a standard level of taxonomy, usually the genus and/or species.

After processing the samples, the biological matrices are received from the taxonomist in an Excel spreadsheet format identifying the sample ID and the breakdown of BMI species into standard taxonomic levels.

3a. Results Lower Turwar Creek Monitoring Station

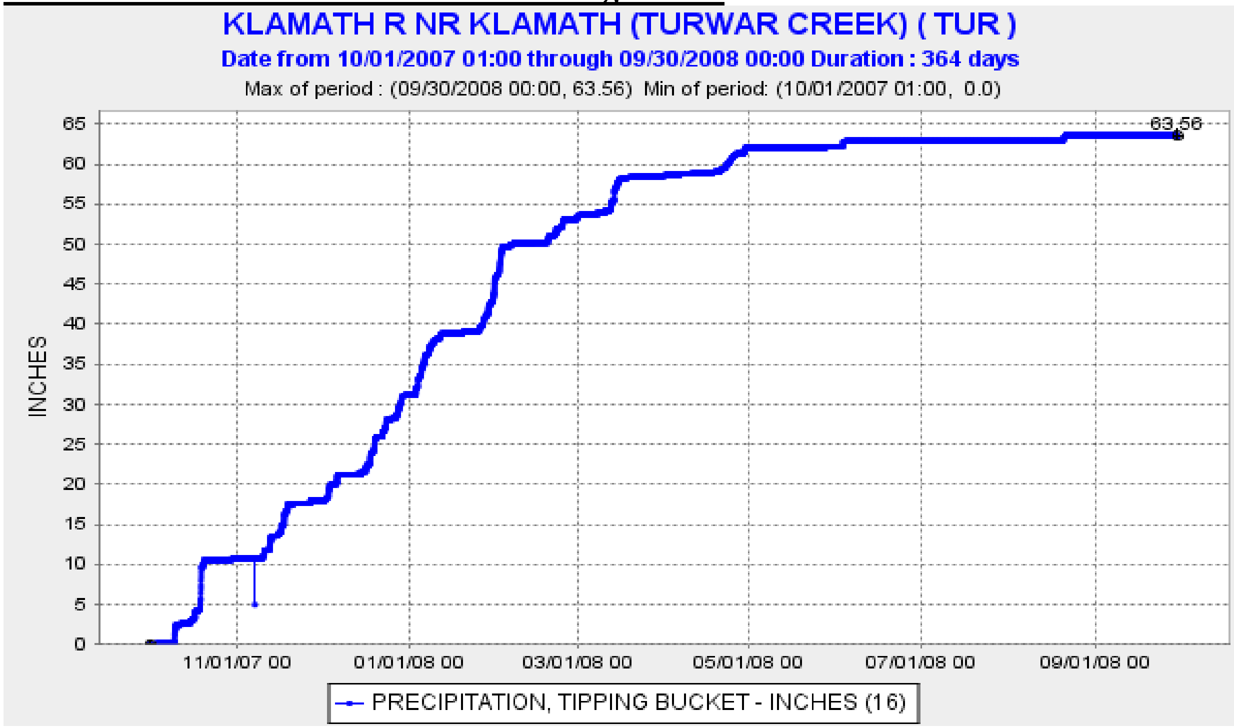

Figure 16. Accumulative rainfall WY 2008 from nearby USGS gage

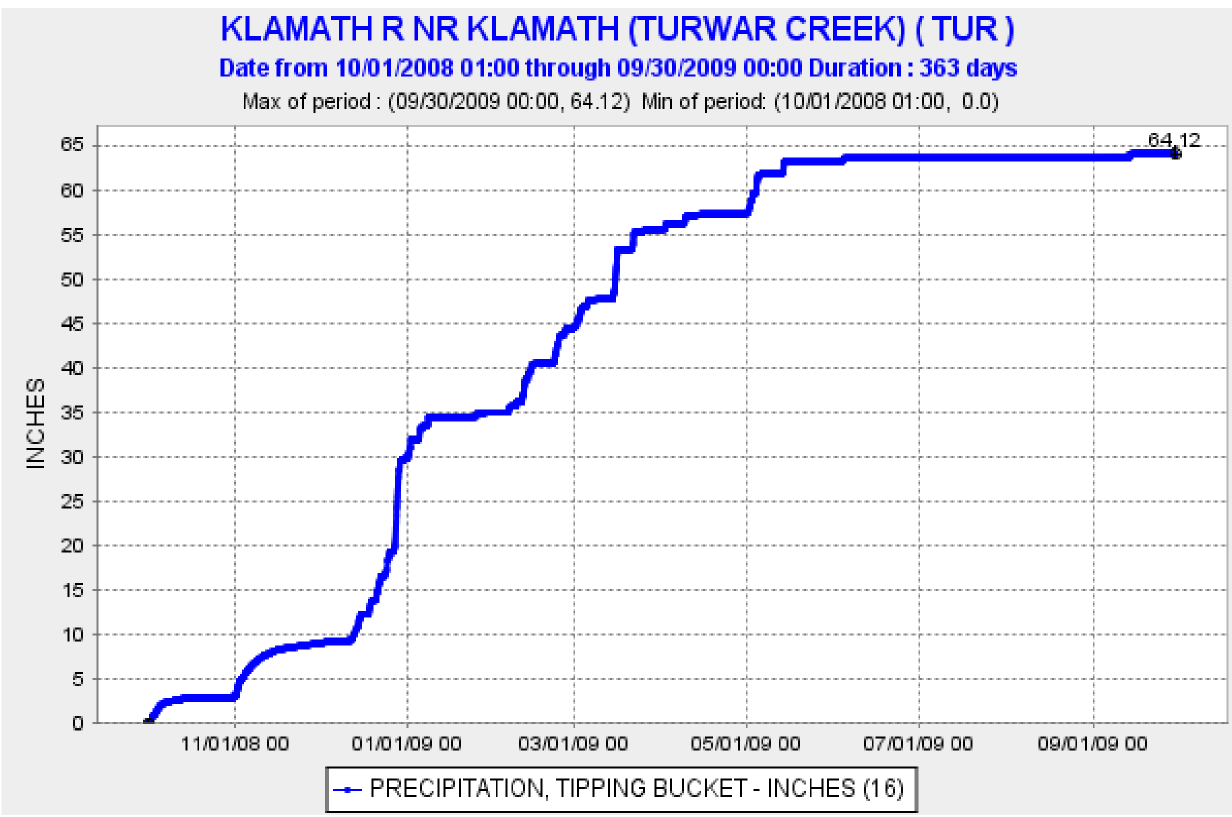

Figure 17. Accumulative rainfall WY 2009 from nearby USGS gage

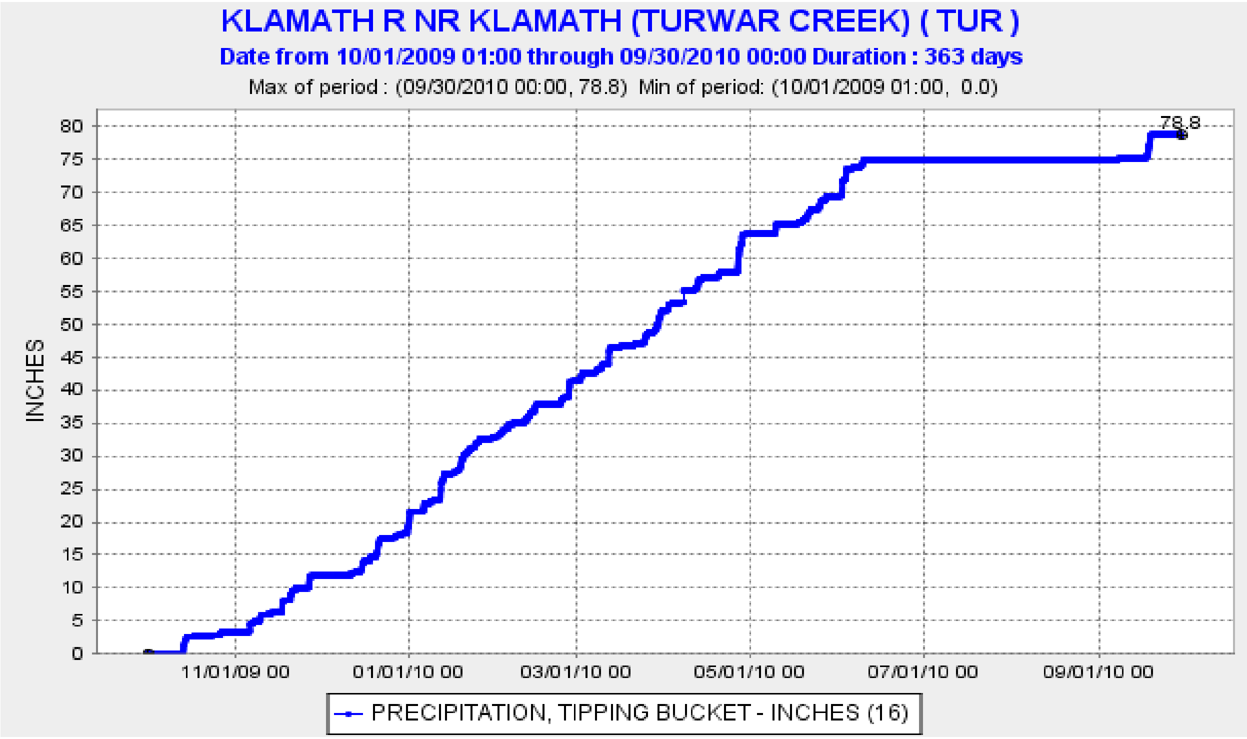

Figure 18. Accumulative rainfall WY 2010 from nearby USGS gage

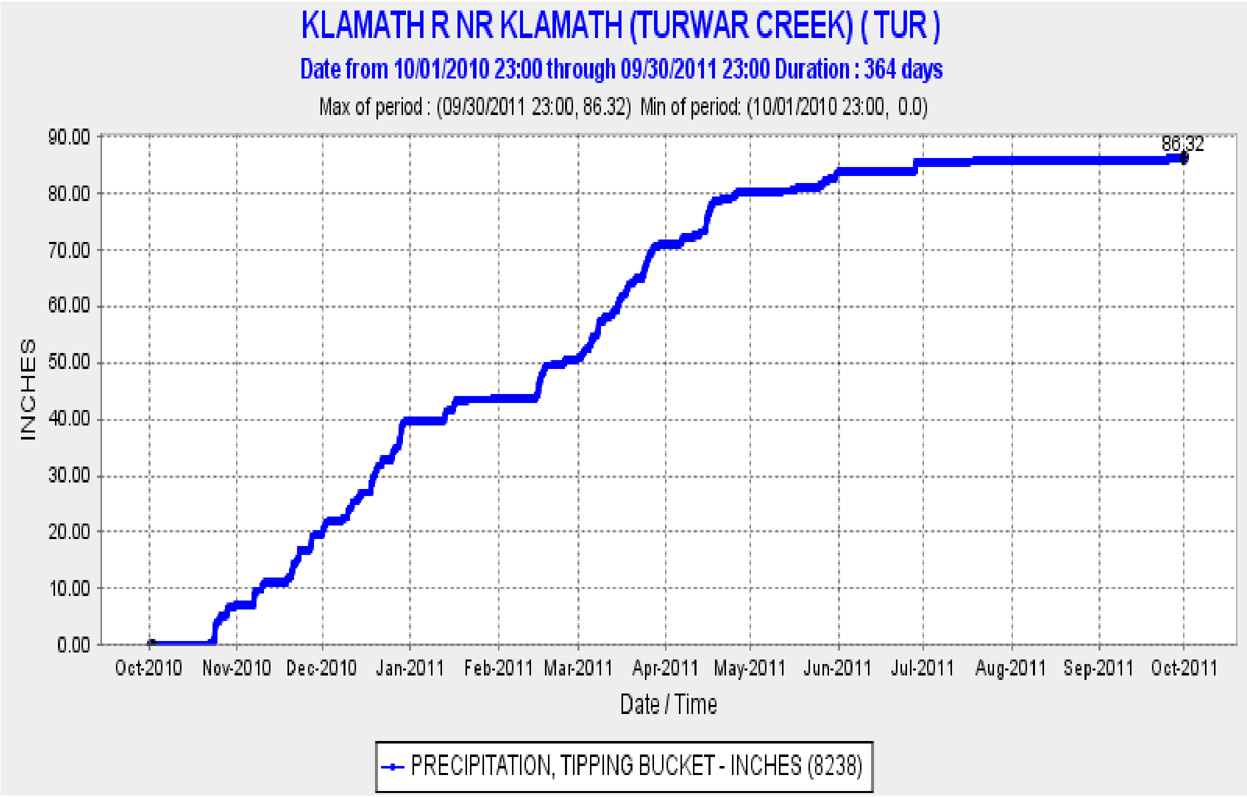

Figure 19. Accumulative rainfall WY 2011 from nearby USGS gage.

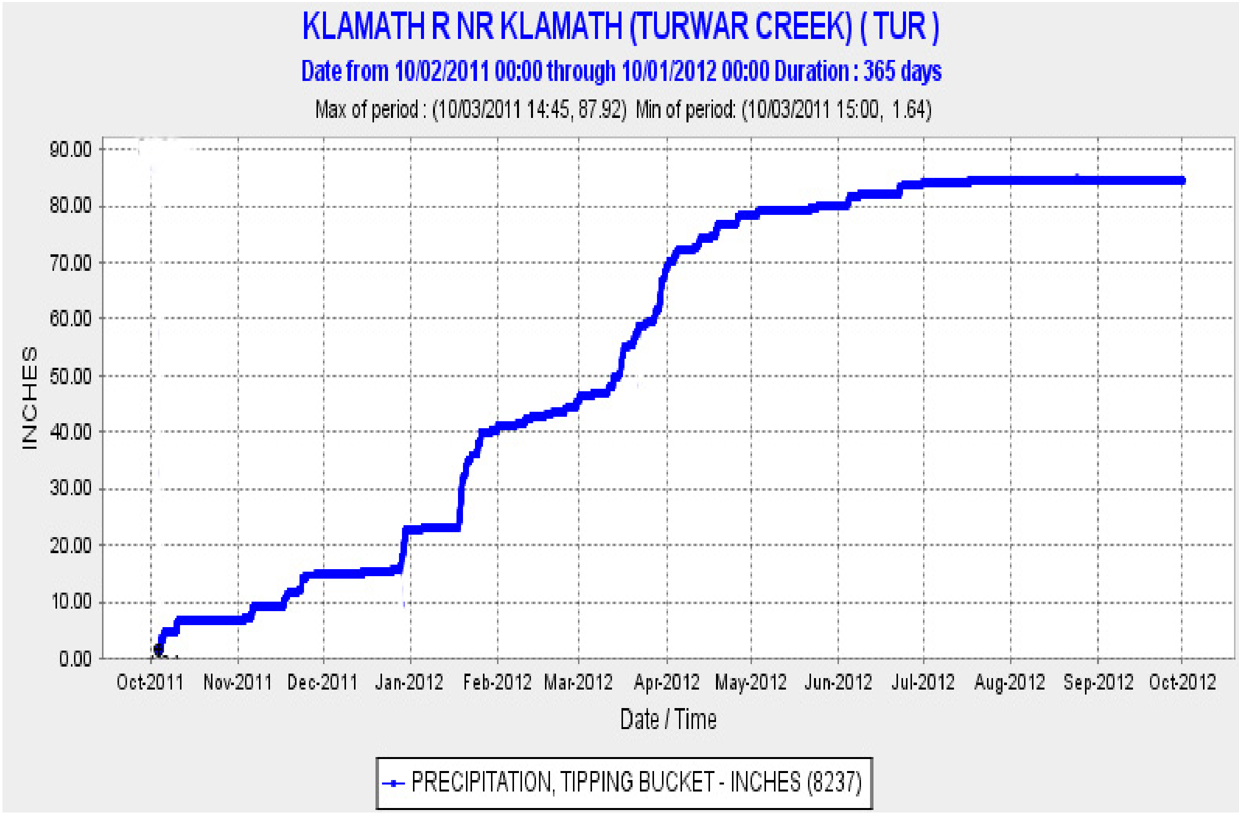

Figure 20. Accumulative rainfall WY 2012 from nearby USGS gage.

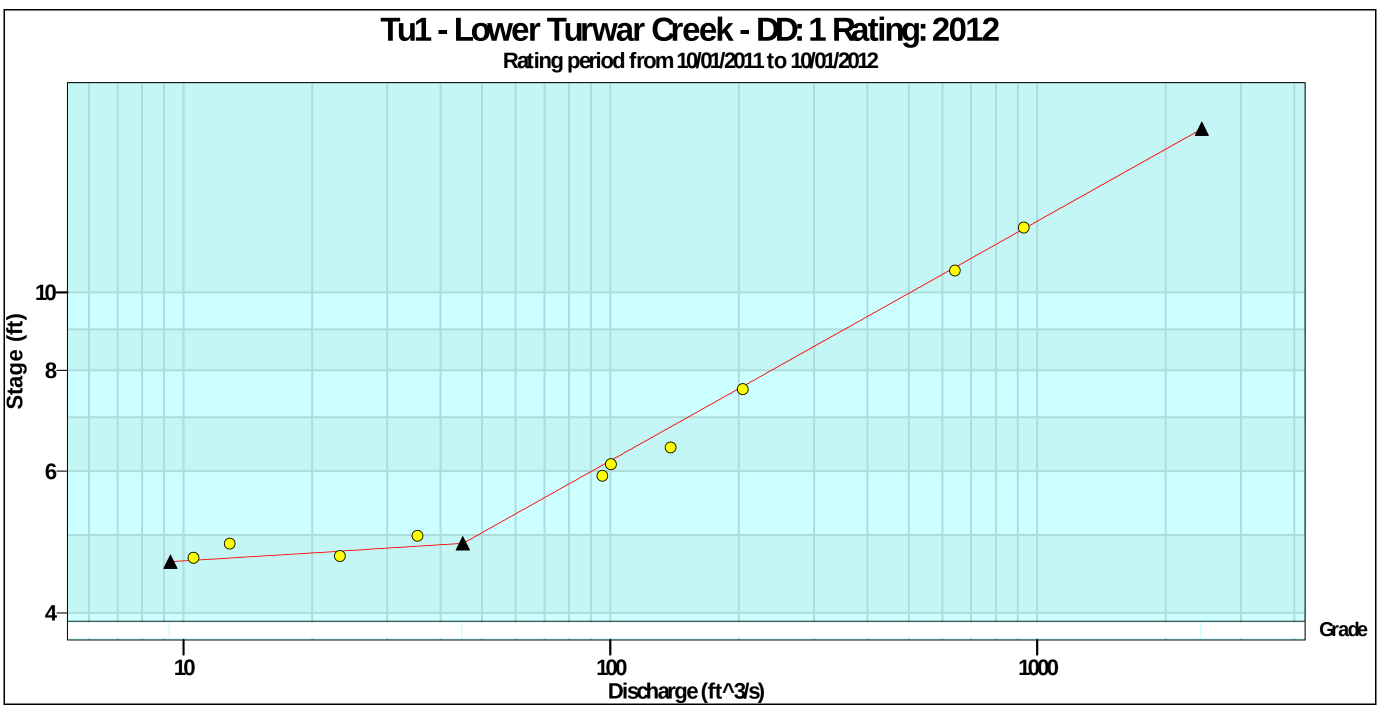

Figure 21. Rating curve expressing relationship between stage height and stream discharge in cubic feet per second (cfs), Lower Turwar Creek WY 2012.

Table 1. Rating table and equations generated for the rating curve. WY12

Stage	Discharge	Offset	Slope	Equation	
ft	ft^3/s	ft			
4.63	9.31		-----	-----	
4.88	45.13		30.015	X = 0.000 * Y^30.015	
15.96	2430.85		3.364	X = 0.218 * Y^3.364	

Table 2. Rating table and equations generated for the rating curve.WY08-11

Stage	Discharge	Offset	Slope	Equation	
ft	ft^3/s	ft			
3.34	0.84		-----	-----	
5.89	229.09		9.887	X = 0.000 * Y^9.887	
6.83	555.98		5.988	X = 0.006 * Y^5.988	
16.35	12443.46		3.561	X = 0.594 * Y^3.561	

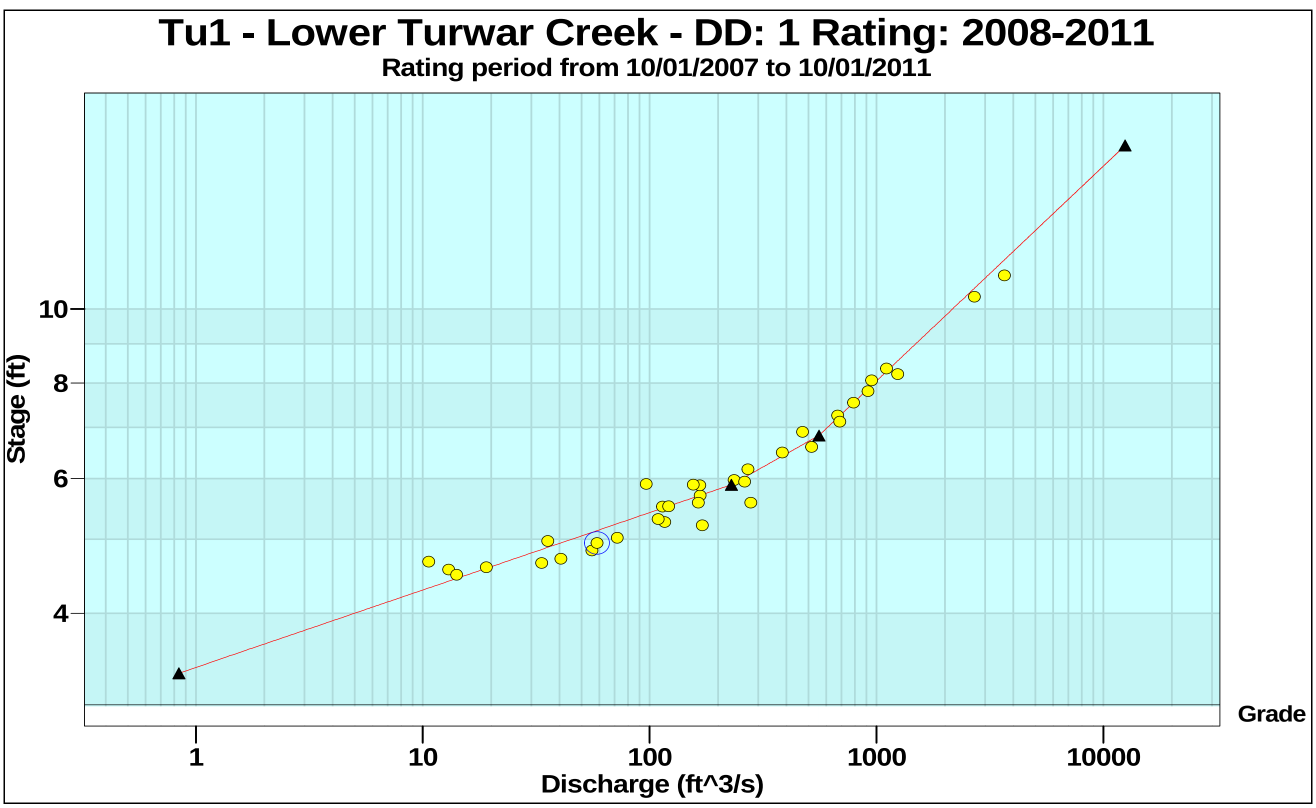

Figure 22. **Lower Turwar Creek rating curve water year 2008-2011**

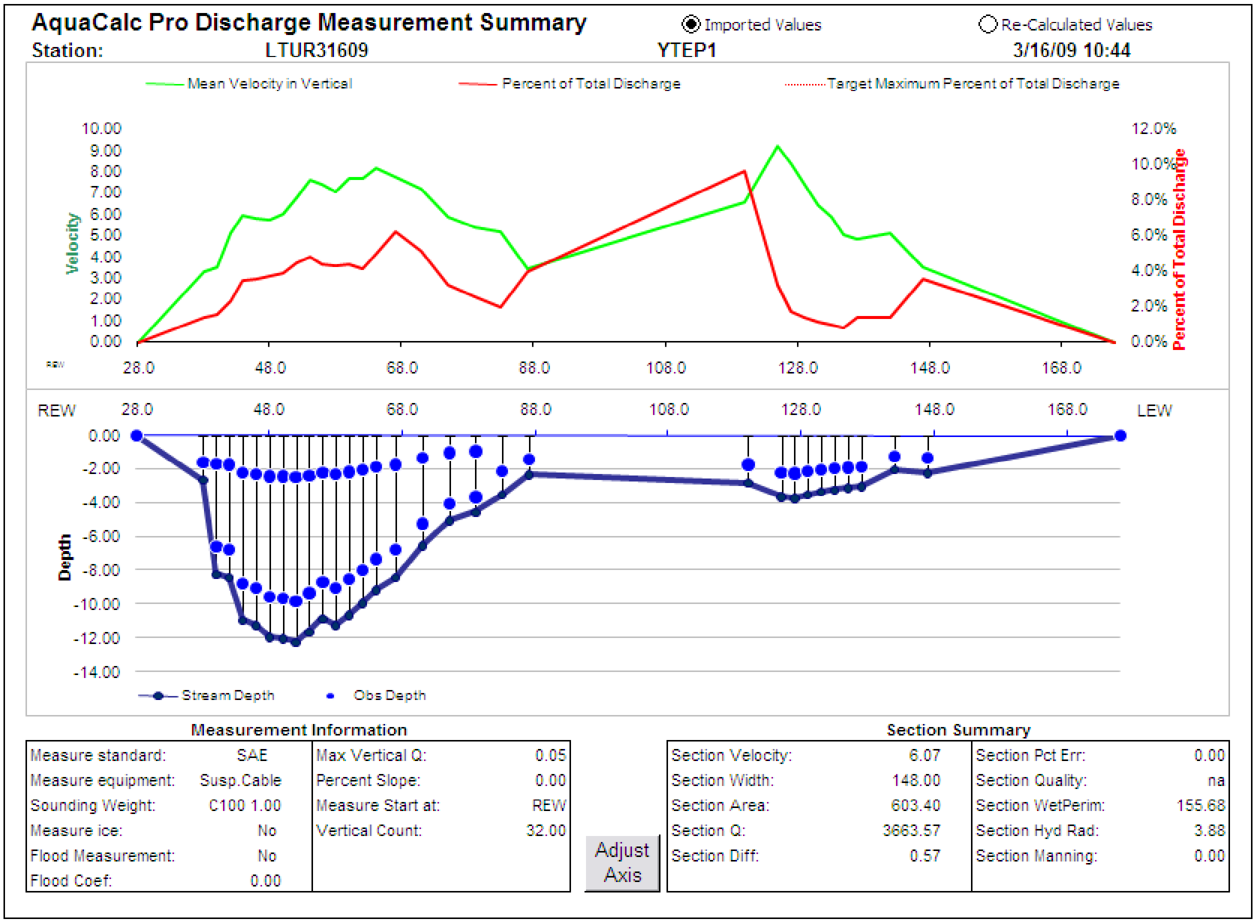

Figure 23. Highest stream measurement from Lower Turwar bridge 03/16/2009

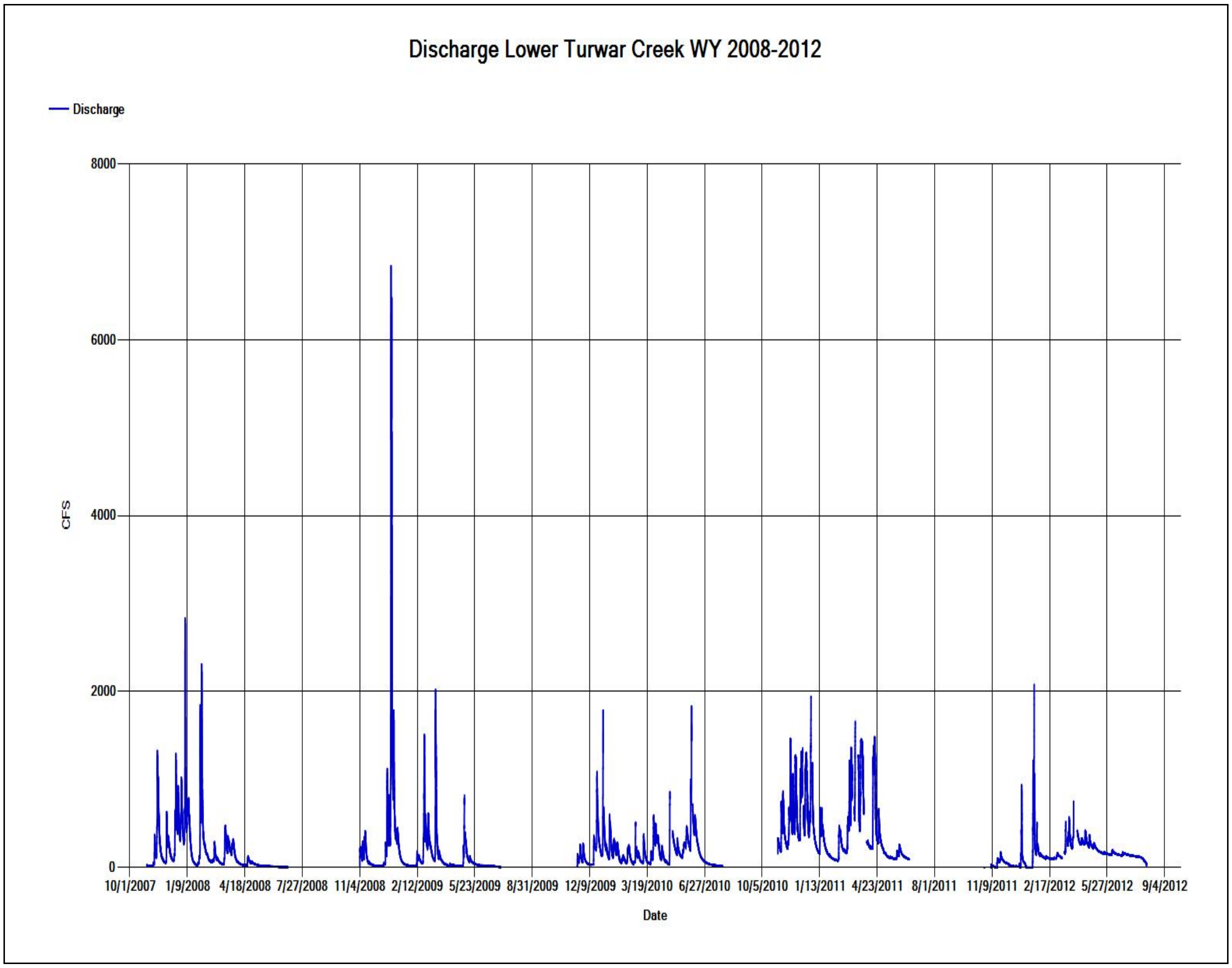

Figure 24. Stream hydrograph for Lower Turwar Creek, Water Year 2008 thru 2012.

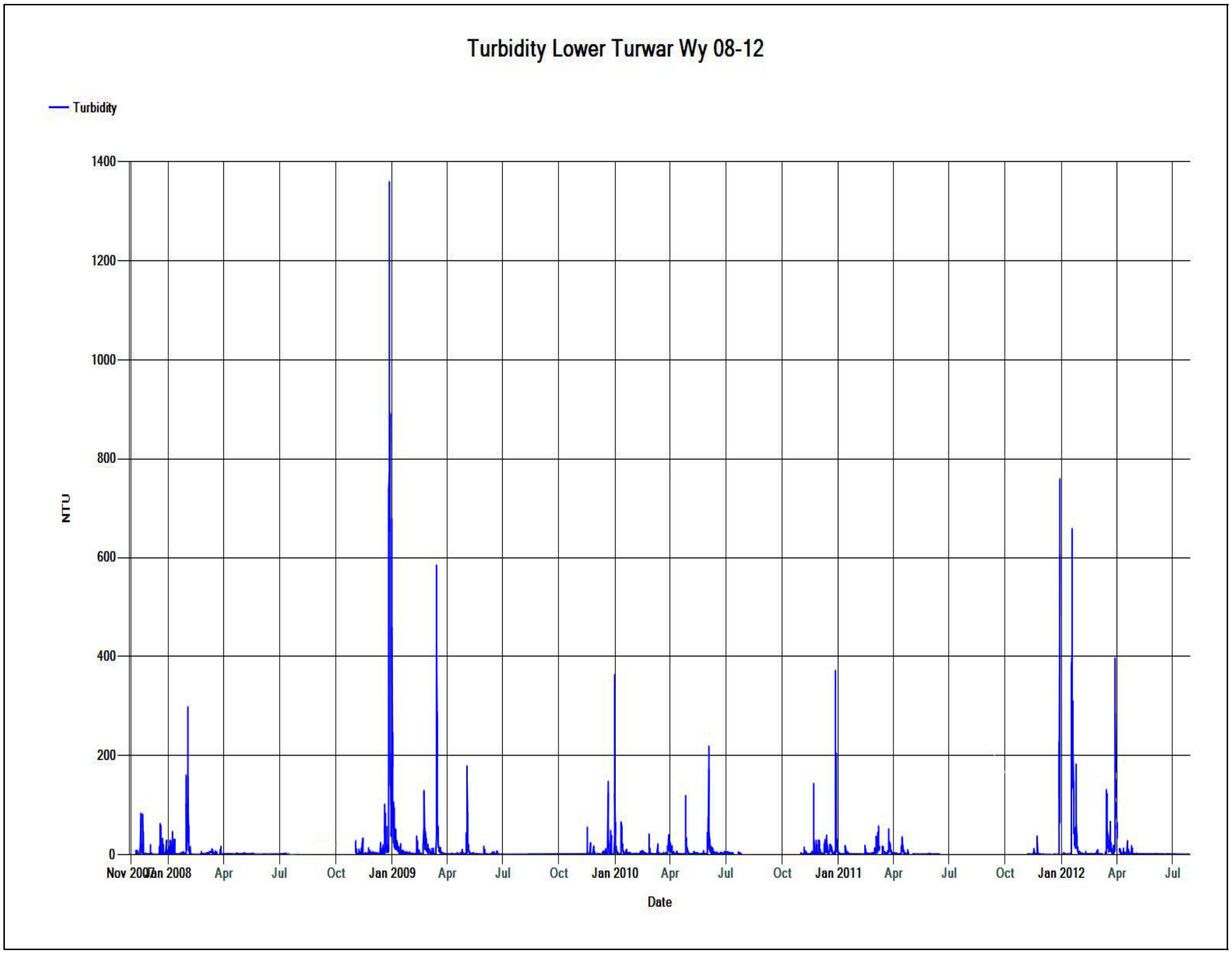

Figure 25. Turbidity values Water Year 2008 thru 2012.

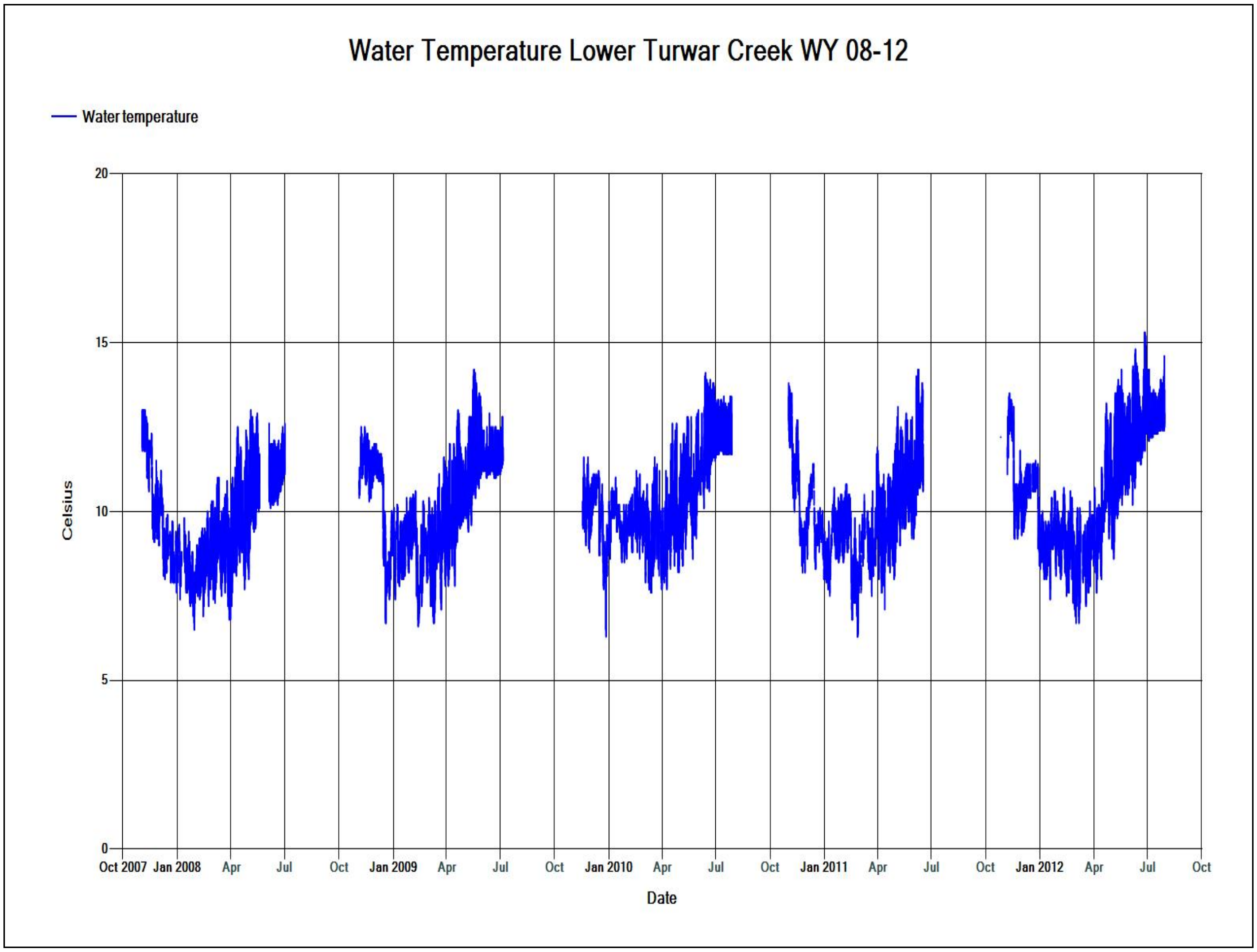

Figure 26. Water Temperature Lower Turwar Creek WY 2008 thru 2012

Table 3. Lower Turwar Suspended Sediment Sample Concentration With Turbidity 2008 – 2012.

	Date	Gage height	Begin time	Sample type	SSC mg/L	Lab turbidity NTU	DTS-12 turbidity NTU
WY2008							
	1/5/2008	9.08	13:55	DIS	68.9	5	11
	1/31/2008	9.46	11:49	DIS	679	75	146
	1/31/2008	9.48	13:15	DIS	717	303	153
	1/31/2008	9.63	12:32	DIS	629	246	158
	1/31/2008	9.66	13:42	DIS	628	100	154
	1/31/2008	9.66	14:05	DIS	581	93	154
	1/31/2008	9.76	14:31	DIS	790	97	144
WY2009							
	3/15/2009	9.83	19:47	DIS	1432	528	556
	3/15/2009	9.83	19:47	BOX	1203	542	564
	3/16/2009	10.94	13:53	DIS	798	352	321
	3/16/2009	10.94	13:53	BOX	764	343	321
	3/17/2009	8.23	16:17	BOX	202	63	69
	3/17/2009	8.23	16:17	DIS	187	64	69
	3/18/2009	7.22	14:44	BOX	69.8	22	27
	3/18/2009	7.22	14:44	DIS	89.2	19	27
WY2010							
	12/21/2009	7.91	12:38	BOX	258	60	107
	12/21/2009	7.99	12:43	DIS	310	60	106
	1/1/2010	9.25	12:40	BOX	591	160	215
	1/1/2010	9.25	12:46	DIS	521	165	215
	2/27/2010	8.44	14:15	BOX	11.6	5	9
	2/27/2010	8.4	14:27	DIS	10.6	6	9
WY2011							
	11/23/2010	7.91	12:48	BOX	64	24	34
	11/23/2010	7.91	13:00	DIS	80.7	21	33
	12/10/2010	7.25	13:51	BOX	20.5	8	12
	12/10/2010	7.25	14:07	DIS	21.1	8	12
	12/14/2010	7.91	12:01	BOX	82.1	19	32
	12/14/2010	7.91	12:15	DIS	63.1	19	31
	12/29/2010	13.36	11:55	BOX	199	75	101
	12/29/2010	13.36	12:05	DIS	180	63	101
	12/29/2010	13.4	15:21	BOX	135	55	76
WY2012							
	12/30/11	9.6	15:09	BOX	765	220	283
	1/18/12	6.91	18:15	BOX	370	60	113
	1/18/12	6.97	18:30-19:00	DIS	462	66	133
	3/16/12	11.65	15:00	Box	152	45	76
	3/16/12	11.7	15:08	DIS	129	39	77
	3/16/12	12.1	16:30	Box	147	40	86

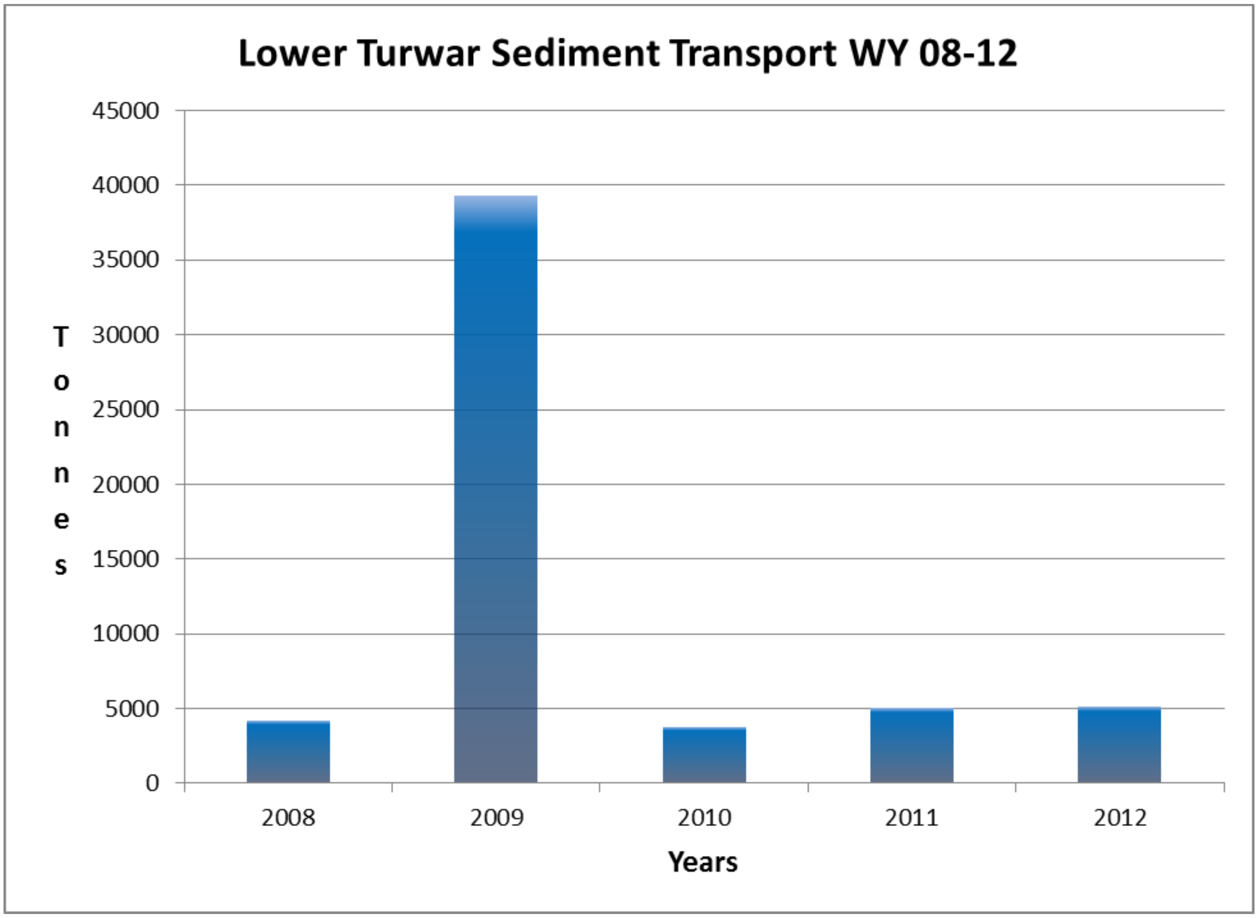

Figure 27. Lower Turwar Total Sediment Mass in metric Tonnes 2008-2012.

3. b. Lower Turwar Creek Macroinvertebrate Sampling

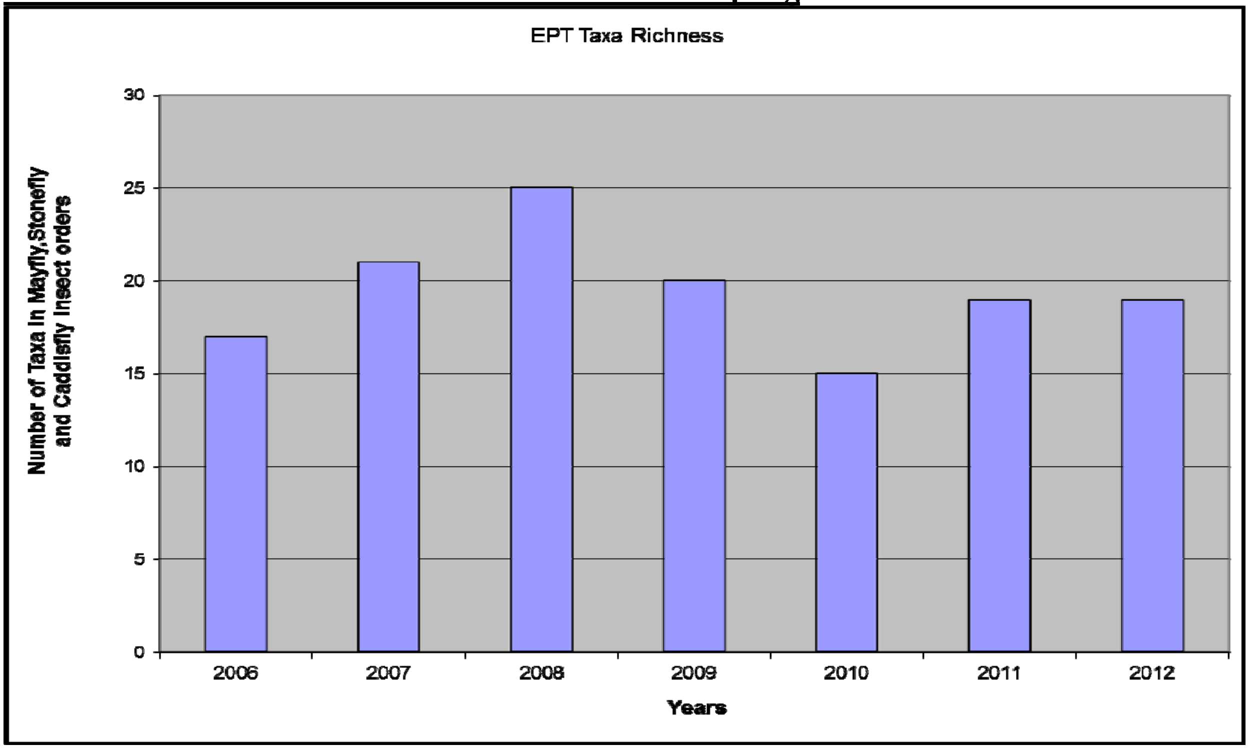

Figure 28. EPT Taxa Richness, Lower Turwar Creek

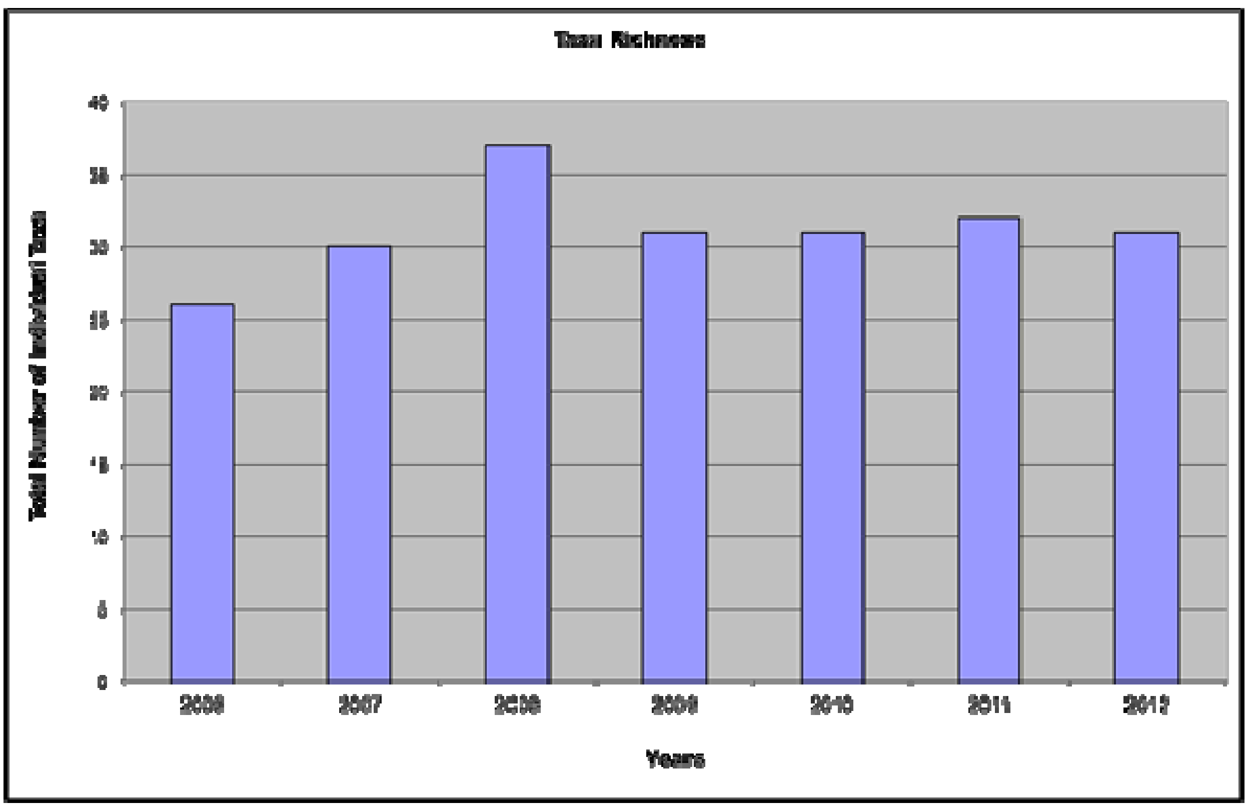

Figure 29. Taxa Richness, Lower Turwar Creek.

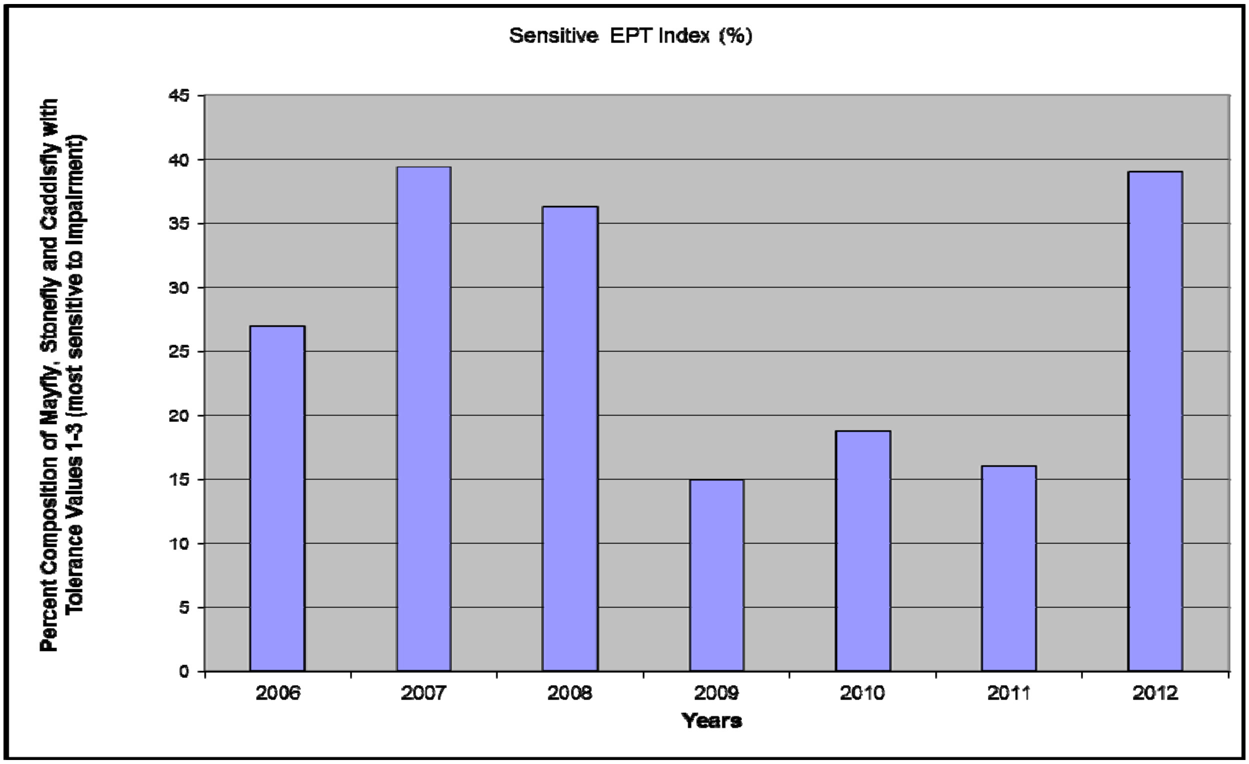

Figure 30. Percent Sensitive EPT Taxa, Lower Turwar Creek.

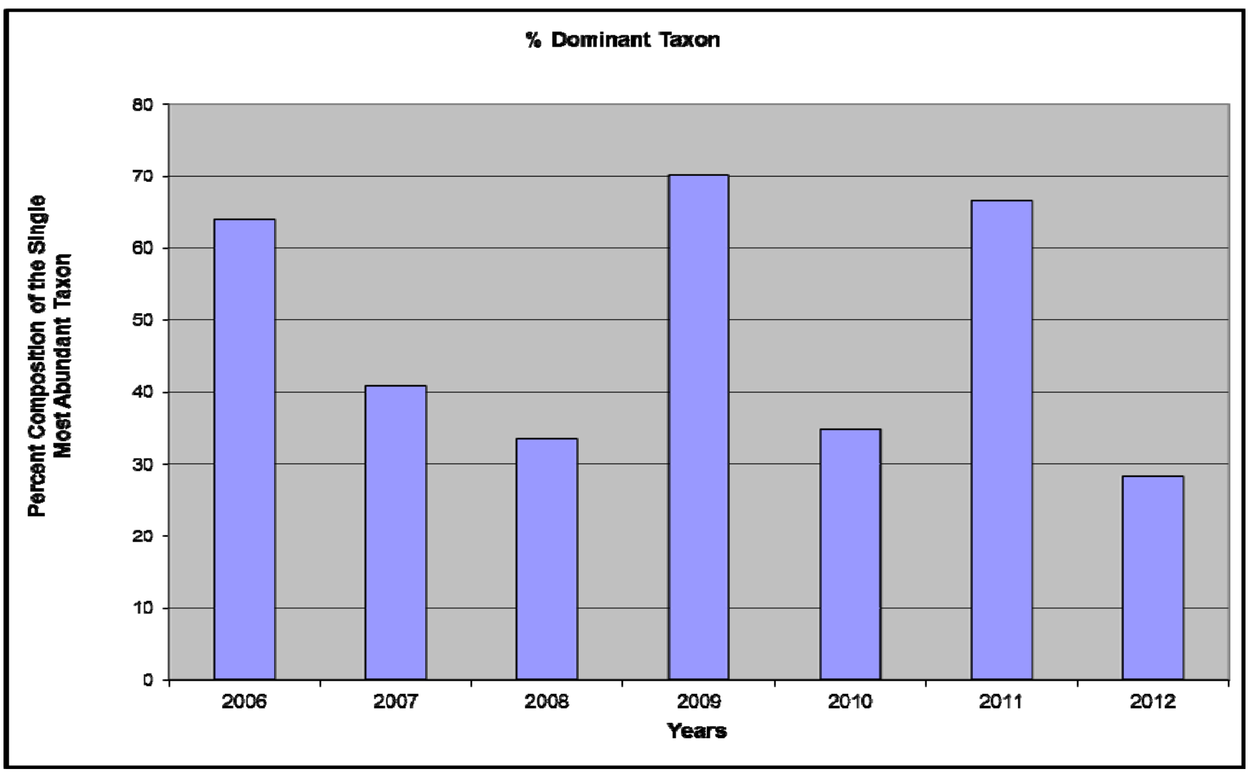

Figure 31. Percent Dominant Taxon, Lower Turwar Creek.

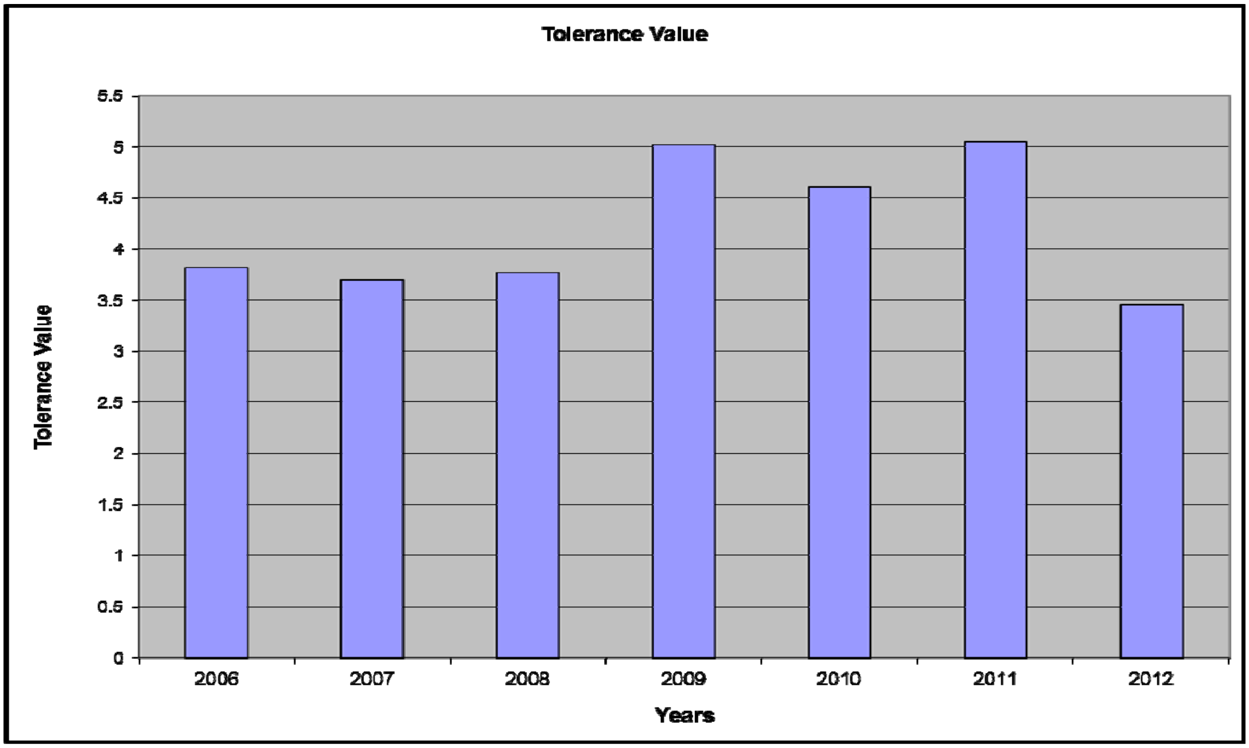

Figure 32. Average Tolerance Value for all taxa recorded, Lower Turwar Creek.

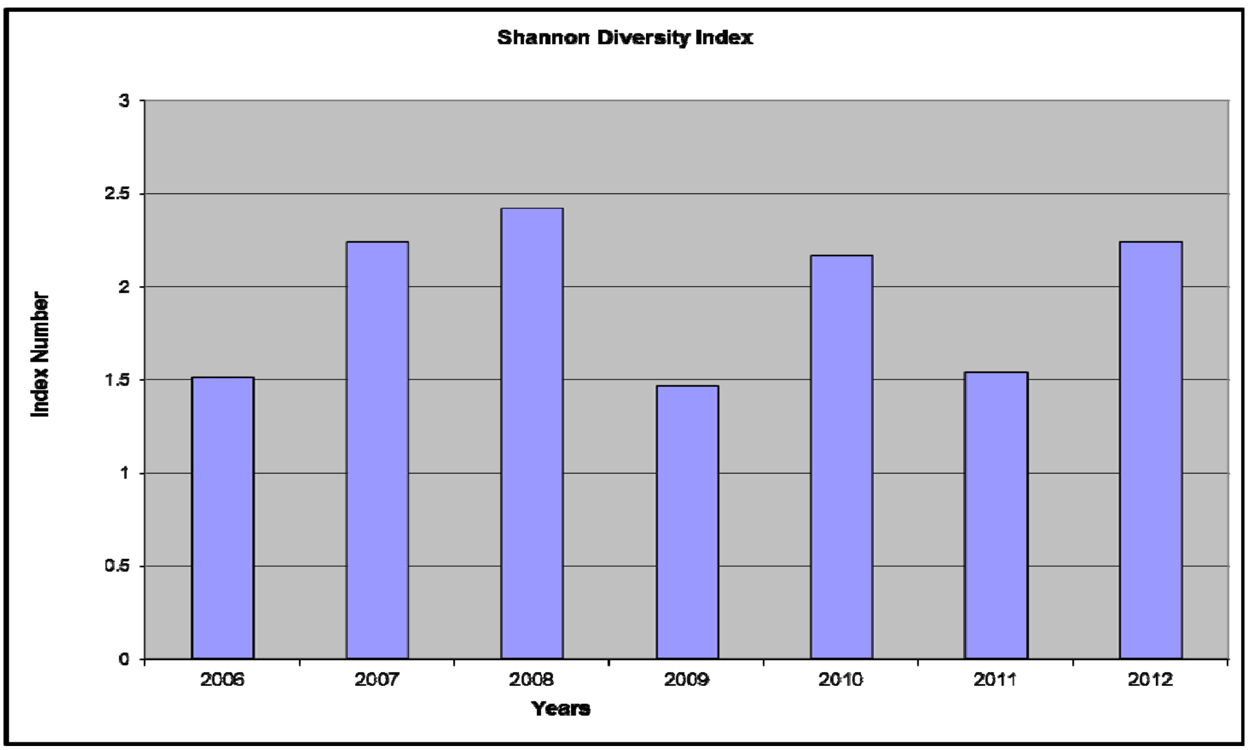

Figure 33. Shannon Diversity Index, Lower Turwar Creek.

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Table 4. North Coast Index of Biological Integrity (NC-IBI) Metric Values and Final Score, Lower Turwar Creek, 2006 to 2012.

Stream	Date	EPT Richness	Coleoptera Richness	Diptera Richness	% Intolerant	% non-Gastropod Scraper	% Predator	% Shredder	% non-Insect	NC-IBI Score Total
Lower Turwar	4/28/2006	17	1	3	27	10	12	0	9	45
Lower Turwar	5/7/2007	21	2	4	35	16	12	7	10	61.25
Lower Turwar	4/30/2008	25	2	5	37	10	23	11	14	70
Lower Turwar	4/20/2009	20	3	3	16	11	7	3	16	48.75
Lower Turwar	6/28/2010	15	3	5	17	8	14	6	23	51.25
Lower Turwar	6/9/2011	19	2	6	17	3	15	16	16	60
Lower Turwar	5/18/2012	7	7	5	9	10	10	2	9	73.75

Table 5. Key to NC-IBI final metric scores.

Total Metric Score	Value
0-20	very poor
21-40	poor
41-60	fair
61-80	good
81-100	very good
>52	"unimpaired"

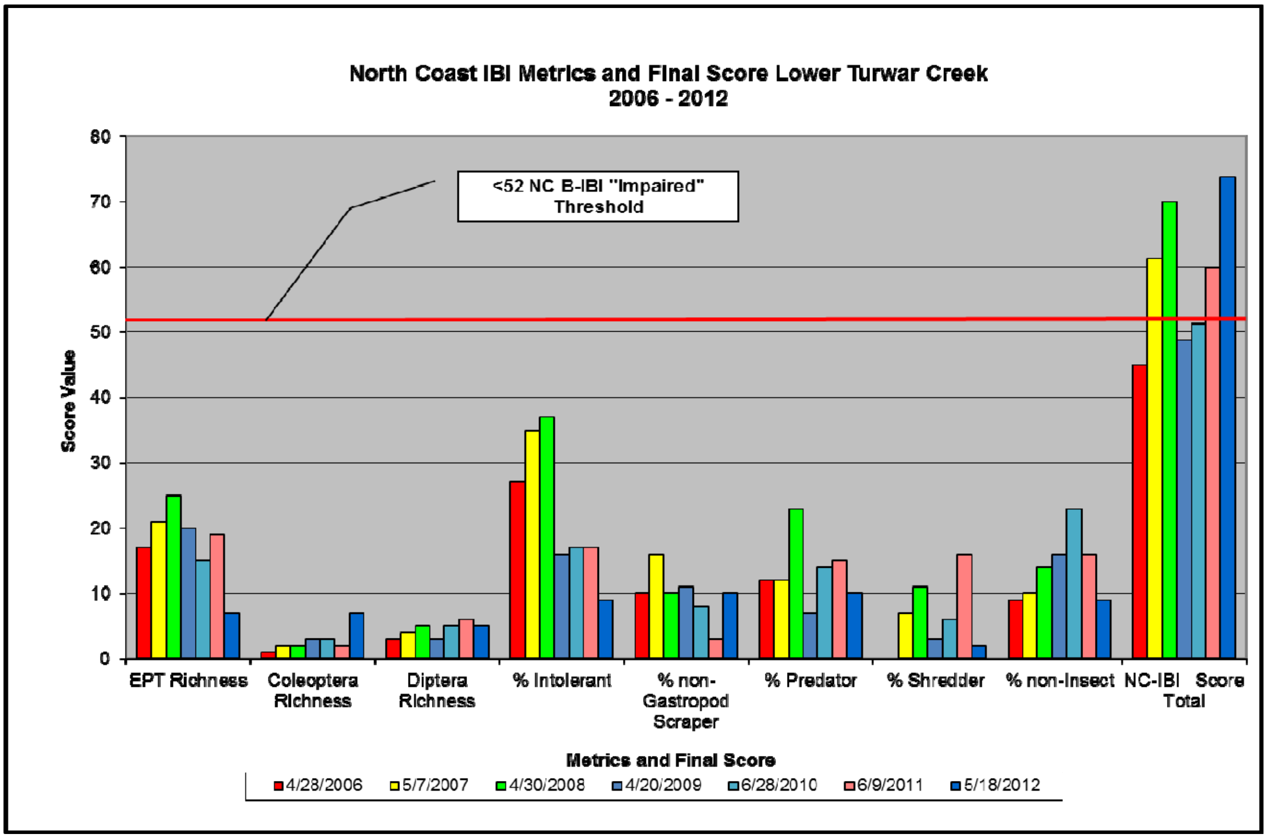

Figure 34. North Coast Index of Biological Integrity (NC-IBI) Metric Values and Final Score, Lower Turwar Creek, 2006 to 2012.

Table 6. Summary of Discharge, Water Temperature and Turbidity Values, Lower Turwar Water Years 2008 - 2012.

Water year	Max Discharge cfs/date	Max Water Temp/date	Min Water Temp/date	Max Turbidity NTU/date
2008	3,136/2-4-08	13.1°C/7-17-08	6.6°C/1-30-08	598/2-4-08
2009	6,600/12-28-08	16.3°C/10-23-08	6.7°C/3-11-09	1,358/12-29-09
2010	2,977/6-5-10	14.1°C/5-31-10	6.3°C/3-14-10	385/1-2-10
2011	1,942/12-29-10	14.3°C/6-9-11	6.3°C/2-27-11	371/12-29-10
2012	2,080/1-21-12	15.33°C/6-26-12	6.7°C/3-2-12	760/12-30-11

4. Discussion

4. a. Lower Turwar Creek Monitoring Station

The continuous monitoring station at Lower Turwar Creek collected stage height, water temperature and turbidity data at a 15 minute interval from late October to mid May in Water Year 2008 mid October to late June in 2009, November to June in water year 2010, and November to June in water year 2011. In Water Year 2012 Lower Turwar Creek flow began at the end of October 2011and went sub surface in July of 2012. In general the monitoring station performed well with few malfunctions.

2008

On December 28, 2008 during a large storm event, the orifice line was pulled away from the attached rip rap, causing a 3.42' shift in the end of the orifice line. Data after that date was heavily scrutinized and 98% of it still passed our quality assurance standards. Erroneous data due to equipment malfunction, operator error or equipment out of water was removed prior to reporting as part of the internal data validation process.

Measured flows ranged from 13 cfs to 3663 cfs. The rating curve slope equation was used to equate discharge values for the entire record in Water Year 2008 to the end of 2011. Efforts will be made in the future to capture additional high flow events to increase the confidence in the stage height discharge relationship. Using our rating curve to estimate flows our highest estimate occurred on 2/4/2008 at 3136 cfs. Water temperature ranged from 6.6 on 1/30/2008 to 13.1 on 3/4/2008. Using a DTS-12 optical turbidity probe the highest recorded turbidity level was 598 on 2/4/2008 which correlates with our highest estimated discharge on the same day. (See table 6)

Suspended sediment samples were collected during storm events on January 5 and January 31, 2008. The storm on 1/05/08 was the first sizable storm during the water year. One set of samples were collected and it occurred on the descending limb of the hydrograph, the suspended sediment concentration (SSC) was 68.9 mg/L (Table 3). The second storm was sampled during the ascending limb of the hydrograph and SSC ranged between 581 - 791 mg/L for the six sets of composite samples that were collected (Table 3).

2009

The highest flow event measured for the entire record occurred on 3/16/2009 the stage height was 10.99 feet, discharge was 3666cfs. (See figure 24) This figure shows that the stream exceeded its normal channel banks and spread to bank full width. This causes the discharge to continue to be higher, but stage did not rise as quickly due to the increased area covered. The flow was taken using our bridge crane with a Price AA® flow meter. There was also a large storm event December 28th 2008 with stage reaching 12.79 feet and an estimated discharge of 6600 cfs. This event was unique because the Klamath River reached a stage of 23.64 and a discharge of 77,500cfs before it started to influence Lower Turwar Creek. It is because of this large event that the sediment transport was extremely higher than other water years. Lower Turwar Creek has been affected at stages as low as 7.5 feet at the Lower Turwar gage. Numerous variables come into play at this site when it is affected by the Klamath River. Rain intensity, snow melt, micro storm events in certain watersheds, all play a role at this location.. YTEP is refining this to better understand the relationship with such close proximity to the larger Klamath River. The lowest flow event measured in Lower Turwar Creek was 13 cfs and occurred on 11/9/07.

Turbidity peaks concurred with storm events during the period of record. The highest turbidity measurement recorded was 1358 NTU during a storm that occurred on 12/29/2009. Water temperatures throughout the period of record ranged from 6.7 degrees Celsius on 3/11/2009 to 16.3 degrees Celsius on 10/23/2008 (table 6)

In Water Year 2009 there were only 2 large events again. The first and largest happened in December of 2008. YTEP lost equipment in the stream from large debris and unseen submerged objects and were unable to continue to monitor this event. The next event was between 3/15/09-3/18/09. (See table 3) All dates were sampled. The 15th was ascending and 16th, 17th, and 18th were all descending. This data set will prove to be very valuable to YTEP to help develop the box and depth integrated sample relationship.

2010

The highest flow event measured in water year 2010 was taken on 1/1/2010 with a measured discharge of 2702 cfs. and stage height of 10.37. (See figure 24) When compared to 2009 where stage was 10.99 and flow was significantly higher at 3666 cfs. This is due to the Klamath River discharge and stage growing rapidly. At midnight 1/1/2010 Klamath River discharge was 13,100 cfs At 20:30 on the same day the river was flowing at 62,700 cfs. Klamath River discharge on 3/16/2009 was 45,900. Because of the proximity (about ¼ mile) of the Klamath River from our monitoring location, Turwar creek backs up showing a larger stage height, but significantly lower flows. YTEP is working on refining the point at which the Klamath River has this effect on our gaging station and flows.

Maximum turbidity measured for the water year occurred on 1/2/2010 measuring 385 NTU's. This turbidity measurement occurred on the first big storm event of the year with a discharge of

2767 cfs. The second event of the water year and largest discharge on 6/5/2010 produced 218 NTU's but it was so late in the year Turwar creek had transported the majority of the sediment load downstream earlier in the year. Water temperature for water 2010 ranged from a maximum of 14.1 degrees Celsius on 5/31/10 to a minimum of 6.3 degrees Celsius on 3/14/10.

2011

The highest flow event measured in water year 2011 was taken on 12/29/2010 with a discharge of 2,266 cfs and a stage height of 12.93. Klamath River discharge was 87,600. Once again the height of the river influenced actual stage height and flow at our gaging station.

Maximum turbidity also occurred on 12/29/2010 measuring 371 NTU's. Water temperature ranged from a maximum of 14.3 degrees Celsius on 6/9/2011 to a minimum of 6.3 degrees Celsius on 2/27/2011.

2012

The highest flow taken in 2012 was on 12/30/2011 with a stage height of 10.46 and discharge of 1080 cfs. The Klamath River was flowing at 25,200cfs and was not an influence during this event.

Maximum turbidity also occurred on 12/30/2011 with 760 NTU's. Water temperature ranged from 6.7 on 3/2/2012 to 15.3 on 6/26/2012.

4. b. Lower Turwar Creek Macroinvertebrate Sampling

Macroinvertabrate sampling results were combined for the years samples were collected in Lower Turwar Creek from 2006 through 2012. Figures 28 to 33 report popular metrics that are commonly reported in YTEP's taxonomic results from the lab. EPT Taxa richness and taxa richness (figure 28 and 29) indicate that diversity of taxa has increased from 2006 to 2008, a slight decline in 2009 and slight increase in 2010, 2011 showed another slight increase. This trend is also confirmed by Figure 30 which illustrates that the percentage of a single taxa present in samples has decreased from 2006 to 2008 and increase in 2009. 2010 showed a large drop in dominant taxon with corresponding increase in diversity. 2011 once again showed a fair percentage of dominant taxon. It appears that species abundance is also increasing as illustrated in Figure 33 in which the Shannon Diversity Index increased from 2006 to 2008. Water year 2009 through 2012 is varied when looking at the Shannon diversity index, but the IBI score is on an upward trend indicating the stream seems to be rebounding from 2009. A higher Shannon's diversity index value is representative of a more diverse community.

The 2006 to 2012 macroinvertabrate sampling results were used to generate metrics used in the North Coast index of biological integrity (NC-IBI) developed by the Department of Fish and Game. These results are reported in table 4 and in Figure 34. The NC-IBI metrics and final scores indicate that the macroinvertebrate assemblages have improved from 2006 to 2008. The NC-IBI defines a score of less than 52 to be in the "impaired" range. Following, the 2006 sample event results in 2007 and 2008 showed an improvement in stream health. The NC-IBI scores based on macroinvertebrate samples indicate that the stream health of Lower Turwar Creek has moved from being “fair” to “good” from 2006 to 2008 and then back to fair in 2009 and 2010 and now returning to “good” in 2011.

In 2009 there was a significant drop not only in the NC-IBI score but in the overall diversity of the population sampled. Out of a sub sample of 515 specimens 361 were Chironomidae. It is difficult to say why this is but a few ideas are; that there was a large storm event between March 15th and the 18th. This event was the 2nd largest of the year for Lower Turwar. Even though we followed SWAMP protocol and waited 30 days or longer before sampling, the event may have created optimal conditions for a proliferation of the Chironomidae. YTEP also implemented the larger reach of 250 meters following the SWAMP protocol. This large number of Chironomidae contributes to the lower numbers of other taxa, and may be misleading to say that the stream habitat and diversity have changed for the worse. 2010 and 2011 has already shown a slight trend continuing to improve not only in diversity but in taxa richness.

2011 results showed a healthy improvement in EPT richness and upward trend in overall IBI score. These positive trends show that benthic macroinvertabrate are once again on the rise. The Yurok Tribe Fisheries has implemented willow mattresses and baffles along with some large woody debris near the bottom of our monitoring reach. This may be a contributing factor in stream health and creating a more natural streambed for these assemblages to thrive. It is likely that the instream habitat restoration projects implemented by the Yurok Tribe Fisheries Program have influenced this stream health improvement trend. The restoration treatments that were designed to provide reduction of sediment delivery, increased channel and streambank stability, increased habitat complexity, improved large woody debris recruitment and self-sustaining riparian forests have improved habitat for macrioinvertebrates and have provided additional trophic levels to improve diversity.

2012 results once again showed significant improvement not only in diversity and sensitive taxa, but overall with an IBI score of 73.75(Figure 34), which is the highest score Lower Turwar Creek has received. This year Yurok Tribe Fisheries constructed a barb wire fence along the riparian zone along the stream reach that is sampled for benthic macroinvertabrates. This has stopped or minimalized the presence of nearby cows that routinely grazed adjacent to Turwar Creek. This along with the riparian and in stream restoration has all been beneficial in creating a more stable environment for these assemblages to increase in numbers and diversity.