Kettle Creek Watershed Dirt and Gravel Road Studies: Cross Fork and Little Kettle Creek

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I. Introduction

Sediment is the largest non-point source of pollution to Pennsylvania streams and also within the Chesapeake Bay. The production and transport of sediment in our watersheds are natural processes, but it is when human activities accelerate these processes that sediment loading can become a problem. Excess sediment can impair streams and aquatic life in many ways. For instance, high sediment loads often increase erosion and create streambank instability, which in turn decreases habitat for fish and benthic macroinvertebrates. More specifically, accumulations of fine sediment reduce spawning habitat for trout and result in high turbidity that may clog fish gills. Dirt and gravel roads, the focus of this study, have the potential to contribute significant amounts of sediment to streams. To address sediment pollution caused by unimproved roads in the Commonwealth, the Task Force on Dirt and Gravel Roads was prompted into action by PA Trout in 1993. Funds to improve and maintain dirt and gravel roads are distributed by the State Conservation Commission through this Task Force to the Bureau of Forestry and County Conservation Districts (CCD). The Bureau of Forestry uses its share of the funds for the many miles of dirt and gravel forestry-owned roads in PA. The CCDs redistribute their portion of the money to local townships based on a grant program with priority given to areas identified within exceptional value and high quality watersheds.

Like any stream, the streams within the Kettle Creek watershed erode, transport, and deposit sediment as a part of their normal function. These three processes act in response to the geology, climate, gradient, and land uses found within the watershed. If one or more of these natural processes change, the stream will adjust by changing the amount of sediment it erodes, transports, or deposits in order to return to equilibrium. Sediment is a normal part of a stream system, but excessive amounts will generally lead to alterations in stream form and eventually degradation of stream habitat. Implementing best management practices through improving and maintaining dirt and gravel roads (DGR) will help to reduce the amount of sediment delivered to nearby stream and the related problems caused by excess sediment.

The Kettle Creek Watershed Association (KCWA) and Trout Unlimited (TU), in partnership through Trout Unlimited's Home Rivers Initiative, have committed to improving water quality in the Kettle Creek watershed. A first step towards accomplishing this goal is to establish a working committee consisting of representatives from the local townships, Bureau of Forestry districts, Conservation Districts, and PSU Center for Dirt and Gravel Road Studies. With nearly 120 miles of road, many being DGRs, that are within 250-ft of a stream in the Kettle Creek watershed the potential for sediment delivery into the streams can be very significant. Both the townships and Bureau of Forestry have already implemented several projects and many more sites identified as problem areas have yet to be addressed. It is the intention of KCWA/TU that through this committee all agencies and organizations that have a role in the management of dirt and gravel roads can work together to monitor completed projects and improve strategies (technical and cost-effective) for future projects so that the benefits may be increased throughout the watershed.

This study was conducted between October and December 2001. It is intended to identify and prioritize DGR problem areas by monitoring turbidity as an indicator of fine sediment load in streams adjacent to DGRs. In particular, monitoring was conducted where DGRs cross streams (e.g. bridges) as it is here that the road runoff is most likely to have direct access to the stream. Due to budget and time restraints this study was confined to those DGRs found within the Cross Fork and Little Kettle Creek watersheds. Cross Fork watershed was selected because at 50 square miles it is the largest subwatershed of Kettle Creek and it was given the highest ranking for road sediment impact in the PSU Center for Watershed Stewardship's Kettle Creek Report.

II. Environmental and Economic Impacts

Traditional management techniques of DGRs have focused on getting water off of and away from the road surface and into the nearest stream as quickly as possible. When this is carried out any sediment carried by the road runoff is discharged directly into the streams. Unfortunately the sediment, in particular the very fine sediment, delivered to the streams by these management techniques has contributed to the degradation of aquatic ecosystems.

For example, salmonids are negatively impacted by excessive sediment in the following ways. Clean gravel, or gravel that is not clogged with fine-grained sediment, is needed for spawning. Filling of voids in gravel substrate by fine-grained sediment lowers water flow and thus available dissolved oxygen to developing brook trout embryos and fry. Fine sediment abrades and clogs gills and entombs fry within the gravel. More active pursuit of food is required in turbid water increasing metabolic demands. Many of the macroinvertebrates that form the foundation of the aquatic food chain also rely on clean gravel as their habitat. All of these effects are subtle but they are cumulative.

Sediment laden runoff is not just an environmental problem; it is an economic burden as well. The economy of the Kettle Creek watershed is highly influenced by the amount of anglers that visit its exceptional quality streams, so anything that affects fish populations directly affects the amount of people and money that enters the watershed. In addition, the cost of hauling road material to this remote watershed is a burden to local townships. This is where proper maintenance of DGRs has multiple benefits. Less erosion of the road surface means less grading and ditchwork, less road material to replace and less sediment in the streams. In-stream habitat structures and dams will last longer if sediment load is reduced. Sediment deposited behind a dam, such as the Alvin R. Bush Dam, reduces its effectiveness in flood control by decreasing the volume of water it can store. This fact is a multimillion-dollar problem that is only exacerbated by the sediment contributions from dirt and gravel roads. By reducing the rate of erosion you effectively extend the life of the dam.

III. Methods

Thirty five sample sites were chosen within the Cross Fork and Little Kettle Creek watersheds, including several non-designated sites that were sampled if sedimentation was apparent during a storm event. Six sampling points were located on the main stem of Cross Fork as well as points on Short Run, Little Lyman Run, Dry Hollow, Yochum Run, Big Hollow, Hungry Hollow, Windfall Run and Elk Lick Run. In Little Kettle Creek watershed there are eight sampling points on the main stem as well as points on Zeorb Hollow and Karhan Creek. Yochum Run and Elk Lick Run have very few roads so they are used as a standard for comparison.

Turbidity was measured at these sites using a LaMotte 2020 Turbidimeter during times of base flow as well as during and following storm events. All turbidity data is given in Nephelometric Turbidity Units (NTU). Because flow data was not collected these data are only qualitative but they can be used to show relative impacts of road crossing on their respective streams. Sites were positioned upstream and downstream of road crossings to isolate the roadway as a source of any observed increases in sediment.

Rainfall totals and intensity were measured at two locations using wedge type rain gauges. In Cross Fork watershed a gauge was installed at the bridge over Windfall Run on Cross Fork Road. The other gauge was installed at Godras' Store in Oleona. Precipitation was well below normal for the period of study limiting the number of opportunities to collect data.

Rainfall during deer season provided good opportunities to collect data during this seasonal time of high traffic density. Since deer season represents the yearly maximum traffic density, sediment transport is theoretically at a maximum during rain events at this time.

IV. Data and Discussion

Selected sites are discussed here because of their significance with respect to sediment contribution. The sites are listed by site name under their respective watershed. All turbidity data for all sites can be found in Appendix A. Recommendations are only preliminary. Additional site investigations must be completed before addressing any problem areas. Nearly all of the problems at the discussed sites begin with poor road surface. It is recommended that all improvement projects must include resurfacing with material meeting PennDOT's DGR specification.

A. Little Kettle Creek

In the Little Kettle Creek watershed, sediment loading appears to be more a result of land uses such as logging and a surface mining operation located in the watershed rather than from the dirt and gravel roads found there. This is only an observation that requires much more study but is based on the fact that there are relatively few roads in the Little Kettle Creek watershed and the turbidity of the stream does not increase much where the roads are near the stream. In fact the turbidity values for the stream actually decreases from headwaters to mouth. This is attributed to both influx of clean water and numerous settling pools (especially beaver dams) found along this reach of stream. However, simply trapping the sediment behind a beaver dam is not a solution to sedimentation problems since the goal is to prevent the erosion in the first place. Beaver dams are not permanent structures and once gone, all sediment trapped behind it will be released and transported downstream along with all of the problems associated with excessive sediment.

LK02 LK02 is located at Hoppe Hollow Road's second crossing of Little Kettle Creek from its intersection with Route 144. Here the road functions more as a conduit for, rather than a source of, sediment from a site adjacent to the road. Sediment laden runoff from a muddy barnyard flows down the roadside ditch for 250ft before being discharged by a culvert on the opposite side of the road. This culvert is located on the eastern ditch 250ft north of the bridge. The flows here are significant enough to have created a channel from the culvert towards the stream. A grassy area between the channel does a good job preventing the sediment from a light rain from entering the stream but sediment laden runoff from a moderately heavy rain was witnessed entering the stream from this channel. It is likely that 100% sediment delivery occurs during high fows. The 250ft of ditch down gradient of the previously mentioned culvert discharges into a flat well vegetated area that seems to be an effective sediment barrier.

LK02 Hoppe Hollow Rd upstream of second bridge

Date	Time	Comments	NTU
10/5/01		Base Flow	<1
10/16/01	6:45PM	0.3in rain event ending at ~5:00PM	11.5
10/24/01	10:40AM	0.8" rain event ending at ~9:00 AM	1.9
11/25/01	10:29AM	during 1.6+" rain event	165
11/26/01	12:40PM	day after 1.6+" event	5.2
11/27/01	11:39AM	48hrs after 1.6" event with Lt drizzle	2.5

AVE	37.2
MAX	165
MIN	<1

LK05/LK06 These sites flank the Cheese Factory Hill road crossing of Little Kettle Creek. Here the degree of the sediment problem on Little Kette Creek is made obvious by the deep sediment accumulated behind a debris dam. The sediment has the appearance of a small beach complete with ripple marks on its surface. Just upstream of the large sediment deposit is a small delta of sediment deposited by a road ditch that discharges directly into the stream. This ditch drains about 420ft of roadway with a grade ranging from nearly flat to 11% as well as runoff from over 100ft of an access road. During high flows a spring discharges onto this access road causing erosion and icing problems at its intersection with Cheese Factory Road. The first culvert uphill from the Little Kettle Creek crossing drains over 650ft of roadway with a grade reaching 10% and several small springs discharging into the ditch. Effluent from this culvert has scoured a channel preventing diffusion into the adjacent vegetated area.

Turbidity data showed only a minor increase at this road crossing. But this is misleading because a large amount of the sediment in this slow moving portion of stream has already been deposited in the above mentioned bars and deltas. Future high water events will flush this sediment downstream disguising the DGRs as the true source of the turbidity.

LK05 **Upstream of culvert behind white grange building in Carter Camp**

Date	Time	Comments	NTU
10/5/01		Base Flow	<1
10/16/01	6:52PM	0.3in rain event ending at ~5:00PM	3.1
10/24/01	10:50AM	0.8" rain event ending at ~9:00 AM	3
11/25/01	10:35AM	during 1.6+" rain event	50
11/26/01	12:46PM	day after 1.6+" event	6.3
11/27/01	11:50AM	48hrs after 1.6" event with Lt drizzle	3.9

AVE	15.6
MAX	50
MIN	<1

LK06 **Downstream of culvert behind white grange building in Carter Camp**

Date	Time	Comments	NTU
10/5/01		Base Flow	<1
10/16/01	6:53PM	0.3in rain event ending at ~5:00PM	3.3
10/24/01	10:54AM	0.8" rain event ending at ~9:00 AM	2.8
11/25/01	10:37AM	during 1.6+" rain event	64
11/26/01	12:47PM	day after 1.6+" event	7
11/27/01	11:49AM	48hrs after 1.6" event with Lt drizzle	4.5

AVE	16.32
MAX	64
MIN	<1

CC01/Z01 Z01 is located at a small dam in front of “Circle Bell Camp” on Zeorb Hollow Road. This small stream functions as the ditch on the western side of the road and collects runoff from a logging operation and several construction sites. Turbidity data reflects these activities with rapid and extreme responses to rain events. Zeorb Hollow empties into Karhan Creek that in turn flows past the Carter Camp Lodge and under Rt. 144. Just upstream of the Rt. 144 bridge over Karhan Creek is the sample point named CC01. Sediment loading in Karhan Creek is of special concern because the deck of the Rt. 144 bridge lies only a few feet above the bed of the stream. Now that the ditch on the upstream side of the road is depositing a delta of sediment from the recent ditchwork (discussed further below) performed there; the bridges capacity to transmit flood event flows is diminishing even further. At this point even a minor flood event would cause an almost certain overtopping of the roadway.

Z01 Stream along Zeorb Rd by Circle Bell Camp

Date	Time	Comments	NTU
10/5/01		Base Flow	1.0
10/16/01	7:05PM	0.3in rain event ending at ~5:00PM	54.7
10/24/01	11:00AM	0.8" rain event ending at ~9:00 AM	2.9
11/25/01	10:55AM	during 1.6+" rain event	1470.0
11/26/01	12:56PM	day after 1.6+" event	8.5

AVE	307.4
MAX	1470.0
MIN	1.0

CC01 Rt. 144 bridge by Carter Camp Lodge

Date	Time	Comments	NTU
10/5/01		Base Flow	<1
10/16/01	6:59PM	0.3in rain event ending at ~5:00PM	40.2
10/24/01	10:55AM	0.8" rain event ending at ~9:00 AM	2.5
11/25/01	10:43AM	during 1.6+" rain event	710.0
11/26/01	12:50PM	day after 1.6+" event	6.1
11/27/01	11:54AM	48hrs after 1.6" event with Lt drizzle	3.5

AVE	180.5
MAX	710
MIN	<1

LK07 Although it is not a dirt and gravel road it is still noteworthy to mention that ditch cleaning work was conducted by PennDOT in mid-November along Rt 144/44 around Carter Camp. This included the removal of nearly all vegetation on the roadside. Despite the implementation of such an old fashioned technique, it appears that sediment control was considered in the planning of this project. Improvements were made such as lining portions of the ditch with rock and leaving a 20ft. vegetative filter strip in the ditch, but the ditches still discharged directly into the stream. The vegetative filter strips appear to be too short to completely trap all of the sediment produced by the now unvegetated roadside embankments. In fact, only a month after the work was completed the vegetative filter strips were completely buried by sediment rendering them completely ineffective. A slump approximately 6 feet across has developed at the foot of a driveway where all vegetation had been removed from the bank.

The amount of damage done to the stream as a result of this work is impossible to determine but it is certain that a significant amount of sediment is still being delivered to the stream. In the future longer vegetative filter strips should be left in the ditches as well as leaving the banks vegetated. In addition the work's impact on the stream would be lessened if it was performed in sections allowing the banks to stabilize before moving to the adjacent section. Performing the work in the spring or early fall rather than mid November would allow for revegetation to occur most rapidly. Ditch work could also be segmented into small sections to allow one portion of the ditch to revegetate before performing work on an adjacent section.

LK07 Bridge over Little Kettle on Rt 44/144

Date	Time	Comments	NTU
11/26/01	1:03PM	day after 1.6+" event	7.2
11/27/01	11:57AM	48hrs after 1.6" event with Lt drizzle	4.7

AVE	5.95
MAX	7.2
MIN	4.7

B. Cross Fork

Cross Fork watershed contains Dirt and Gravel Roads which cross a stream at the base of a steep grade. Two such crossings will be discussed here; Windfall Run and Big Hollow, both on Cross Fork Road. In addition to the routine monitoring, turbidity was monitored every twenty minutes for two hours upstream, downstream and in the ditches of the crossings. The two-hour time span started just before a minor rain event and ended after the rain ceased. The resultant data shows how each stream responds to a rain event.

Monitoring was not done on the state owned forestry roads in this watershed because DGR projects were already underway at the time of this study and turbidity from construction would have made the data unreliable. Monitoring of these projects will be conducted after their completion.

CFBH01/BH02/BHDitchL/BHDitchR The crossing of Cross Fork Road significantly impacts Big Hollow. On the north side of the stream the road climbs for 650 feet with an average grade of 5% with a maximum grade of 8%. There is not a single culvert along this entire length. In addition the road does not have a well-defined crown and as a result the western ditch drains almost the entire slope, discharging directly into the stream. This hill's steep grade results in rapid respond in terms of both turbidity and flow within the western ditch. This is well demonstrated by the sampling conducted on 11/30/01 (see appendix B). To the south the road has a similar grade as to the north but is shorter with a total length of 600ft without a culvert. The major contrast between the two road segments is that the roadway approaching from the south is nearly flat for about 100ft before reaching the stream. As a result the western ditch shows muted responses to rain events and increased lag time between peak rainfall and peak turbidity. Big Hollow upstream of the crossing (BH01) at 13:10 on 11/30/01 was crystal clear having a turbidity of 6.1NTU while at the same instant the turbidity downstream (BH02) was 205NTU. To visually describe the appearance of the stream below the crossing would be to liken it to chocolate milk.

For the spring of 2002 two monitoring points will be added. One sample site will be located upstream and one downstream of the confluence of Big Hollow and Cross Fork to determine if there is a significant increase of turbidity in Cross Fork due to sediment loading from Big Hollow.

CF-BH01 Big Hollow upstream of road

Date	Time	Comments	NTU
11/25/01	8:57AM	During 1.6+" rain event	1.5
11/26/01	1:58PM	day after 1.6+" event	5.1
11/27/01	1:06PM	48hrs after 1.6" event with Lt drizzle	1.7

AVE	2.8
MAX	5.1
MIN	1.5

CF-BH02 Big Hollow downstream of road

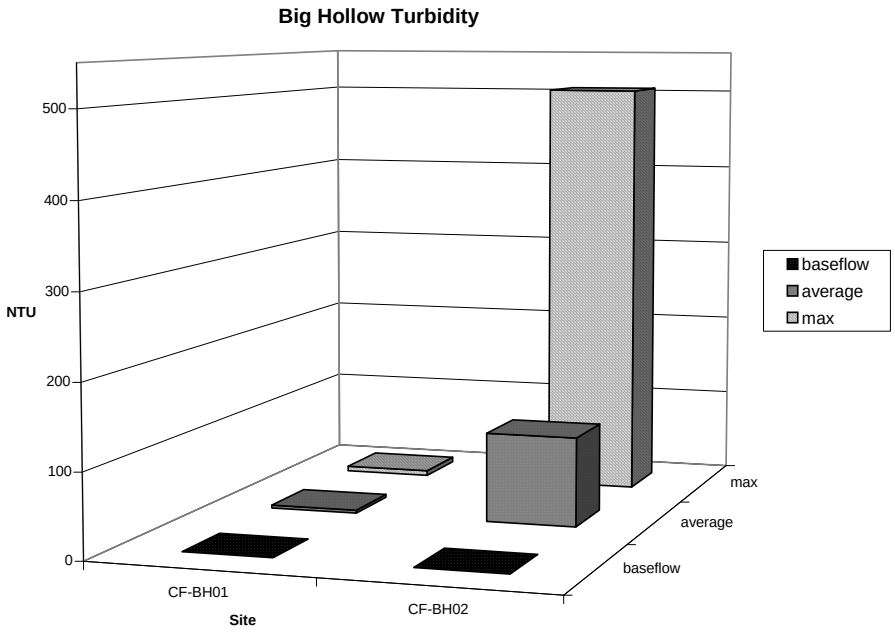
Date	Time	Comments	NTU
10/16/01	5:31PM	0.3in rain event ending at ~5:00PM	15.1
10/19/01	5:31PM	Base Flow	<1
10/22/01	1:29PM	0.11in rain event ending at 1:20PM	7.1
10/24/01	11:35AM	0.8" rain event ending at ~9:00 AM	1.6
11/25/01	8:56AM	During 1.6+" rain event	505
11/26/01	1:57PM	day after 1.6+" event	7.1
11/27/01	1:05PM	48hrs after 1.6" event with Lt drizzle	1.6

AVE	89.6
MAX	505
MIN	<1

BR Ditch Ditch emptying into Big Hollow from upstream side

Date	Time	Comments	NTU
10/24/01	11:36AM	0.8" rain event ending at ~9:00 AM	3.7
11/25/01	8:58AM	During 1.6+" rain event	2021
11/26/01	1:53PM	day after 1.6+" event	8.6
11/27/01	1:06PM	48hrs after 1.6" event with Lt drizzle	5.3

AVE	509.7
MAX	2021.0
MIN	3.7



Turbidities measured on Big Hollow upstream (CF-BR01) and downstream (CF-BR02) of the Cross Fork Road crossing. Clearly the road is contributing to the turbidity and thus the sediment load of Big Hollow. Note scale.

CF-WR01/WR02/WR03/WRT01/WRT02 The crossing of Cross Fork Road over Windfall Run has been a persistent maintenance problem for some time now, in particular the southern approach of Cross Fork Road and its intersection with Windfall Road. The problem arises from a combination of a long stretch of steep roadway and a lack of room to properly handle the road runoff. There is a total of about 700ft of ditch that drains directly into the stream from this southern approach. The eastern ditch drains the entire length of the hill without a diversion structure and discharges directly into Windfall Run via a washed out culvert. Sedimentation effects can clearly be seen at the outflow of this culvert as a delta of road material has formed as well as a string of lateral bars downstream.

To assess the impact of this road crossing on Windfall Run with respect to sediment input sampling points were established upstream (WR02) and downstream (WR03) of the bridge. A third monitoring point was located upstream of the confluence of a small ephemeral stream and Windfall Run (WR01) that will be discussed below. Data from WR02 and WR03 show a marked increase in turbidity at the crossing of Cross Fork road during storm events. Turbidity levels measured during baseflow conditions were very similar upstream and downstream of the bridge but during a storm event the turbidity downstream soared to 13 times that of the upstream location during the 11/30 event.

Also, a small ephemeral stream that crosses Windfall Road about 300ft from its intersection with Cross Fork Road was sampled. The southern ditch of Windfall road drains most of the western side of Cross Fork Road. This ditch comprises the majority of the ephemeral stream's flow during storm events. Therefore its turbidity response shows the relative amount of sediment the road is contributing. Sampling points were established on the upstream side of Windfall Road (WRT01) and downstream (WRT02) as well as upstream of the confluence of the ephemeral stream and Windfall Run (WR01). Data from WRT01 and WRT02 clearly indicate that there is

an erosion problem on this section of Cross Fork Road. A maximum turbidity reading of 1.3NTU was attained from WRT01 during a storm event. Compare this to the 1523NTU attained at WRT02 at the same time. These two monitoring points are no more than forty feet apart with the road ditch in between them so the source of the increased turbidity is quite clear.

CF-WR01 Upstream of confluence of first trib and Windfall Run

Date	Time	Comments	NTU
10/5/01		Base Flow	<1
10/16/01	5:24PM	0.3in rain event ending at ~5:00PM	2.9
10/24/01	12:00PM	0.8" rain event ending at ~9:00 AM	1.4
11/25/01	9:18AM	During 1.6+" rain event	4.2
11/26/01	2:50PM	day after 1.6+" event	3.6
11/27/01	12:38PM	48hrs after 1.6" event with Lt drizzle	1.6

AVE 2.7
MAX 4.2
MIN <1

CF-WR02 Upstream of Bridge over Windfall Run on Cross Fork Rd

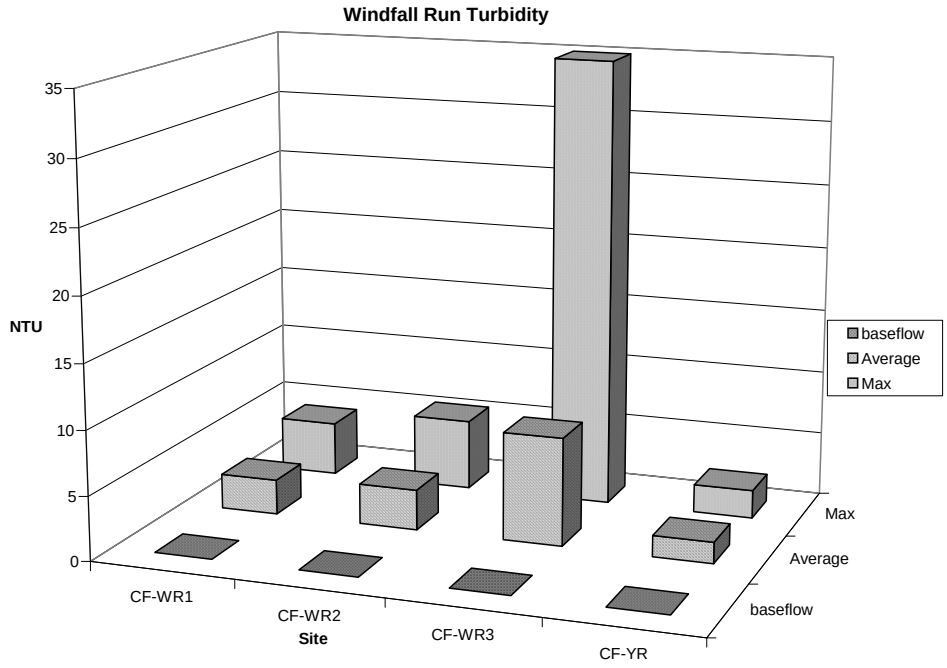
Date	Time	Comments	NTU
10/5/01		Base Flow	<1
10/16/01	5:30PM	0.3in rain event ending at ~5:00PM	3.6
10/22/01	1:20PM	0.11in rain event ending at 1:20PM	<1
10/24/01	11:57AM	0.8" rain event ending at ~9:00 AM	1.5
11/25/01	9:12AM	during 1.6+" rain event	5.5
11/26/01	2:45PM	day after 1.6+" event	3.4
11/27/01	12:47PM	48hrs after 1.6" event with Lt drizzle	1.8

AVE 3.2
MAX 5.5
MIN <1

CF-WR03 Downstream of bridge over Windfall Run on Cross Fork Rd

Date	Time	Comments	NTU
10/5/01		Base Flow	<1
10/16/01	5:28PM	0.3in rain event ending at ~5:00PM	4.4
10/22/01	1:18PM	0.11in rain event ending at 1:20PM	3.1
10/24/01	11:55AM	0.8" rain event ending at ~9:00 AM	1.7
11/25/01	9:10AM	during 1.6+" rain event	35.5
11/26/01	2:43PM	day after 1.6+" event	3.9
11/27/01	12:44PM	48hrs after 1.6" event with Lt drizzle	1.8

AVE 8.4
MAX 35.5
MIN <1



Turbidities from sites at the Cross Fork road crossing of Windfall Run. CF-WR1 is upstream of small tributary, CF-WR2 is just upstream of the bridge and CF-WR3 is downstream of the bridge. CF-YR is Yochum Run, a nearly roadless tributary of Cross Fork shown for comparison.

V. Recommendations

As stated earlier all of the problem areas described in this report must be resurfaced to prevent or reduce sediment transport in the first place. Once the amount of sediment in the road runoff is reduced, its handling becomes much more manageable. Water management devices such as culverts, broad based dips, water bars and breaks in slope must be installed at appropriate intervals on a site by site basis. Devices should make use of any vegetated area between the road and the stream that can act as a sediment trap. In addition, devices should not create channel flow conditions where further erosion can occur. Rather they should be installed to encourage sheet flow away from the road. The Pennsylvania State Conservation Commission (PSCC) provides numerous publications on the recommendations for installing these devices. Of course, cooperation with adjoining landowners is essential. This is especially true in those cases where road runoff must be dispersed through private property or in the case of LK01, where the property itself is a source of sediment.

In the future, a more detailed study should include flow measurements to calculate loading from each tributary. Study of stream temperature versus turbidity may also yield valuable insight, especially in late summer low-flow conditions.