FINAL REPORT

C & K GLASGOW PASSIVE TREATMENT SYSTEM PROJECT

Clearfield Creek Watershed Association
March 2010

Executive Summary

The C&K Glasgow passive treatment system was constructed by C&K Coal Co in 1998 to treat highly acid and metal-rich water emerging from the toe of a large area of surface mining adjacent to Muddy Run just east of PA 253. The discharge flowed at 40-200 gpm with pH 3.3-3.8, acidity 600-900 mg/L, Fe 150 mg/L, Mn 150-200 mg/L, and Al 40-60 mg/L. After C&K bankruptcy, members of the Clearfield Creek Watershed Association flushed the system and evaluated treatment. VFP 1 continued to treat moderately well, but VFP 2 was largely plugged and overflowing. The discharge was being only partly treated. An "autopsy" under a TAG grant showed that accumulation of Fe and Al precipitate on top of the limestone in both VFP's was largely responsible for the problems. Thin and degraded compost, and coating of some limestone was also noted.

In 2008, a grant for $174,000 from the Remining Incentive Program was awarded to the Clearfield Creek Watershed Association for renovation of the passive system. A detailed survey of the site by Cree Surveying and engineering design by Hedin Environmental led to a design for the renovation. A bid of $144,300 from Smith Construction and Excavating was awarded for the main construction in June 2009. Construction was completed in November 2009.

The major elements of the renovation were:

1. Removal of 6 in. to 1 foot of Fe and Al precipitate from VFP 1 and VFP 2.
2. Placement of 2 ft. of new compost mixed 3:1 with fine limestone in VFP 1.
3. Placement of a new limestone layer with new underdrain and water level control in VFP 2, and a new 2 ft. compost-limestone layer overtop it.
4. "Stirring" of the Mn-removal limestone bed, which had extensive coatings of Mn and Fe hydroxide, to expose fresh limestone.
5. Separation of the passive system from the active system ponds.
6. Repair of uphill diversion ditches to eliminate flow from them into the system.

Sampling in January and February 2010 showed that effluent from VFP 1 was distinctly net alkaline with low metals, and the final effluent had pH above 6 with negligible metals. The total cost of the project came in under budget. AMaintenance and Operation Program for the passive system is commencing under the Bond Forfeiture Program.

Introduction

The C&K Passive Treatment System (Glasgow) Project is located on the south side of highway PA 253 about 1.5 miles east of the village of Glasgow and just west of Muddy Run. The system is in Reade Township in northern Cambria County, PA, at lat 40.71585N, long. 78.42295W. The C&K Passive Treatment System (Pit 431 site) was constructed in 1998 by C&K Coal Co. It treats a flow of very acid and Fe-rich water emerging at the downdip toe of a large area of surface mining. Typical flow into the system prior to 2009 was 40 to 200 gal/min with 150 mg/L Fe, 150-200 mg/L Mn, 40-60 mg/L Al, pH 3.3-3.8 and 600-900 mg/L acidity. Data on flow and chemistry of the discharge are listed in Table 1. This very acid water is a major source of contamination affecting Muddy Run for many miles downstream, though several other severe discharges also degrade Muddy Run.

A sketch map showing the layout of the treatment system prior to the current project is shown as Figure 1.

Under C&K, much of the time, most of the flow of the discharge was directed into the passive system, consisting of two vertical flow ponds (VFP's or SAPS), about 1800 ft of wetland channels, a limestone bed for Mn removal and 3 ponds (Figure 1). Because of the high Al of the discharge, the VFP's were flushed occasionally. At higher flow, part of the flow was treated with NaOH, utilizing the three ponds and a short section of wetland.

In 2004, C&K Coal Co. declared bankruptcy and ceased maintenance and treatment at the site. Volunteers from the Clearfield Creek Watershed Association inspected the system and have been flushing the two VFP's monthly since 2005 in an attempt to continue the treatment capability of the system. However, SAP 2 was plugged and most water was overflowing from this pond in 2005. SAP 1 continued to accomplish considerable treatment. In December 2005 the system was evaluated by Hedin Environmental under a Technical Assistance Grant. It was recommended that SAP 2 be drained and trenched to examine the cause of plugging (Hedin Environmental, 2006). This recommendation was accomplished under another TAG grant in2007 (Hedin Environmental, 2007). The main cause of plugging was accumulation of several inches of red mud and clay on top of the compost layer. Also, the compost layer was compacted and the limestone layer was partly cemented with Al and other materials. The compost and limestone layers were highly variable in thickness, and much smaller than the pond dimensions. It was recommended that the two vertical flow ponds be rebuilt, and that the Mn removal limestone bed be converted into another vertical flow pond.

Funds to accomplish renovation were obtained in September 2008 in the form of a grant to the Clearfield Creek Watershed Association (CCWA) for $174,000 from the Remining Incentive Program/Bond Forfeiture Program through the Department of Environmental Protection.

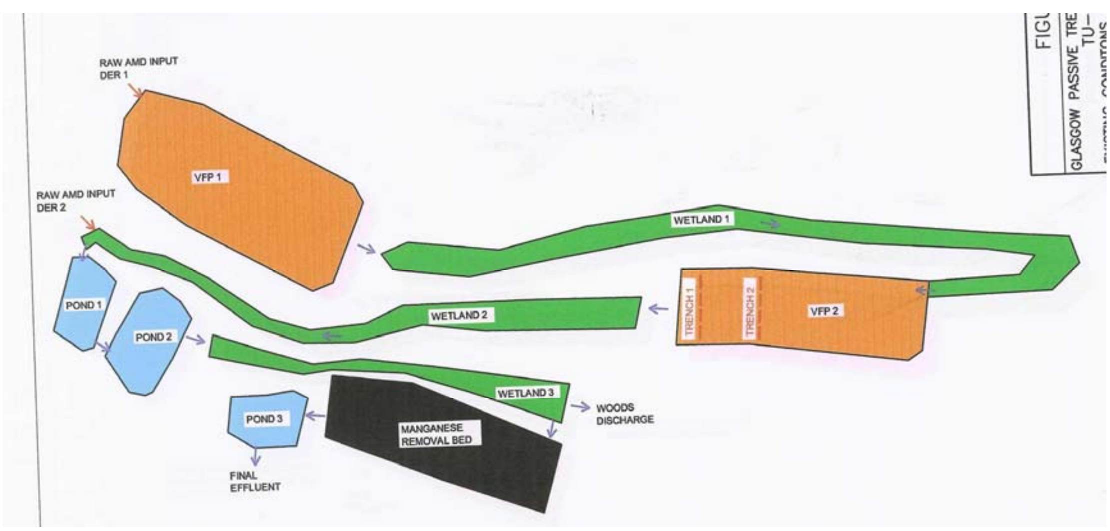

Figure 1. Sketch map of Glasgow C&K system before renovations (after Hedin Environmental (2006).

Detailed plans for renovation of the site were developed by Hedin Environmental. As finally developed, the plan is to add an active treatment system to treat the discharge at flow rates exceeding about 40 gal/min. Lower flows will be treated solely by the passive system. The active system will be funded by the bond forfeiture program.

Project Goals and Activities

In the contract with DEP, the goal of the project was specified as:
"Restore the two vertical flow ponds and associated wetland and settling ponds to treat the normal flow of AMD from this discharge".

Environmental results of the project are expected to be removal of about 500 lb/d of acidity, 120 lb/d of Fe and 70 lb/d of Al from Muddy Run.

Activities and events involving in the project are as follows:

1. Flushing of VFP's and sampling and flow measurement approximately monthly by CCWA, June 2005-June 2009.
2. Field visits and discussion of possible contract, 7/07-9/08
3. Receipt of contract from DEP, 9/17/08
4. Surveying of site by Cree Surveying, 9/08-10/08
5. Field visit by Hedin Environmental , 10/1/08
6. Preparation and review of design by Hedin with A.W.Rose of CCWA, 10/08-4/09.
7. Receipt of final design and some bidding docs, 4/09
8. Announcement of bidding sent to 5 companies, 5/10/09
9. Field meeting with 3 contractors, 5/20/09.
10. Receipt of 3 bids, 6/2/09.
11. Award of bid to Smith Excavating and Contracting of Renovo for $144,390.
12. Start of work by Smith Excavating, 7/8/09.
13. Inspection of work approximately biweekly by A.W. Rose for CCWA, 7/09-11/09.
14. Inspection of project by Hedin Environmental, 10/09
15. Completion of work by Smith Excavating, 11/10/09.
16. Sampling of system, 1/7/10 and 2/16/10.
17. Compiling final report.

Design of Renovation

The specific tasks of the project were as follows (Figure 1 and Plate 1):

1. Prepare a detailed topographic map of the site, at 1"= 50 ft, with 2 ft. contours.
2. Design the renovation.
3. Remove the Fe sludge from VFP 2, steepen the inside walls of the pond so that a greater area of treatment is available,.and completely rebuild it with new underdrain, compost and limestone layers on top of a permeable geotextile fabric. Install irrigation control box to define water level and provide for flushing of system. Retain the existing limestone layer and underdrain for possible additional treatment through the original outflow.
4. Remove Fe sludge from VFP1, and construct a new compost layer on top of the original compost.

5. Turn over the limestone in the limestone bed to restore permeability and allow uncoated limestone from the bottom of the bed to be available for reaction at the surface of the bed.
6. Separate the passive system from active treatment flow through ponds 1, 2 and 3 by constructing a diversion from Wetland 2 to Wetland 3, closing off the outflow pipe of the Limestone Bed and providing a new outlet from the Limestone Bed to Muddy Run.
7. Construct 3 small dams of hay bales along Wetland 1 and Wetland 2 to capture as much Fe precipitate as possible.
8. Construct a new sludge pond and storage area uphill from Wetland 1, to store sludge from the current project and possible future sludge from active treatment. Repair the outflow of the original sludge pond.
9. Repair diversion ditches uphill from Wetland 1 so that the surface flow during storms and snowmelt is diverted around the treatment system. Prior to the project, flows exceeding the discharge sometimes entered the system from uphill surface flow.

Plate 1 shows the design prepared by Hedin Environmental to accomplish the above.

Bidding of Construction

On 5/10/09, invitations to bid on the construction were sent to the following companies:

1. Smith Excavating and Construction, Renovo, PA
2. Groves Excavating
3. Norm Diehl Excavating, Glen Hope, PA
4. Ligonier Construction, Ligonier, PA.

On 5/20/09, a bidders meeting was held at the site. The first 3 companies above attended. Bids were due on 6/2/09, and were received from the 3 above companies. The total prices for the received bids were as follows:

Smith Excavating and Construction: $144, 390.
Groves Excavating: $178,690.
Norm Diehl Construction: $242,700.

Based on these bids, Smith Excavating was selected for the construction. A contract between CCWA and Smith Excavating was signed on 6/19/09 to cover tasks 3 through 9 listed above. Cree Surveying of Glasgow, PA prepared the map of the site.

Construction and As-built

Construction started on 7/8/09.

After draining VFP1 and removal of Fe sludge, numerous small holes were dug to determine the location and condition of underdrain pipes, and the extent of precipitate in the limestone layer. At most sites, the top 3 to 6 inches of the limestone bed was extensively coated with white material, presumably Al hydroxide, but the deeper material was largely uncoated.

Following the underdrain pipes from the outflow inward, the two outflow pipes came through the berm and then turned outward to the sides of the pond (Figure 2). A 6 inch manifold extended the length of the pond along the west side about 2-4 feet in from the base of the berm. Perforated 4 in. laterals of corrugated white plastic pipe extended from this manifold toward the center of the pond every 10 feet. At the inflow end of the pond, compost and limestone were absent for 20 to 25 feet from the end of the pond. Presumably the east side of the pond has similar underdrain. The pipe was broken near point A on Figure 2 but was later repaired.

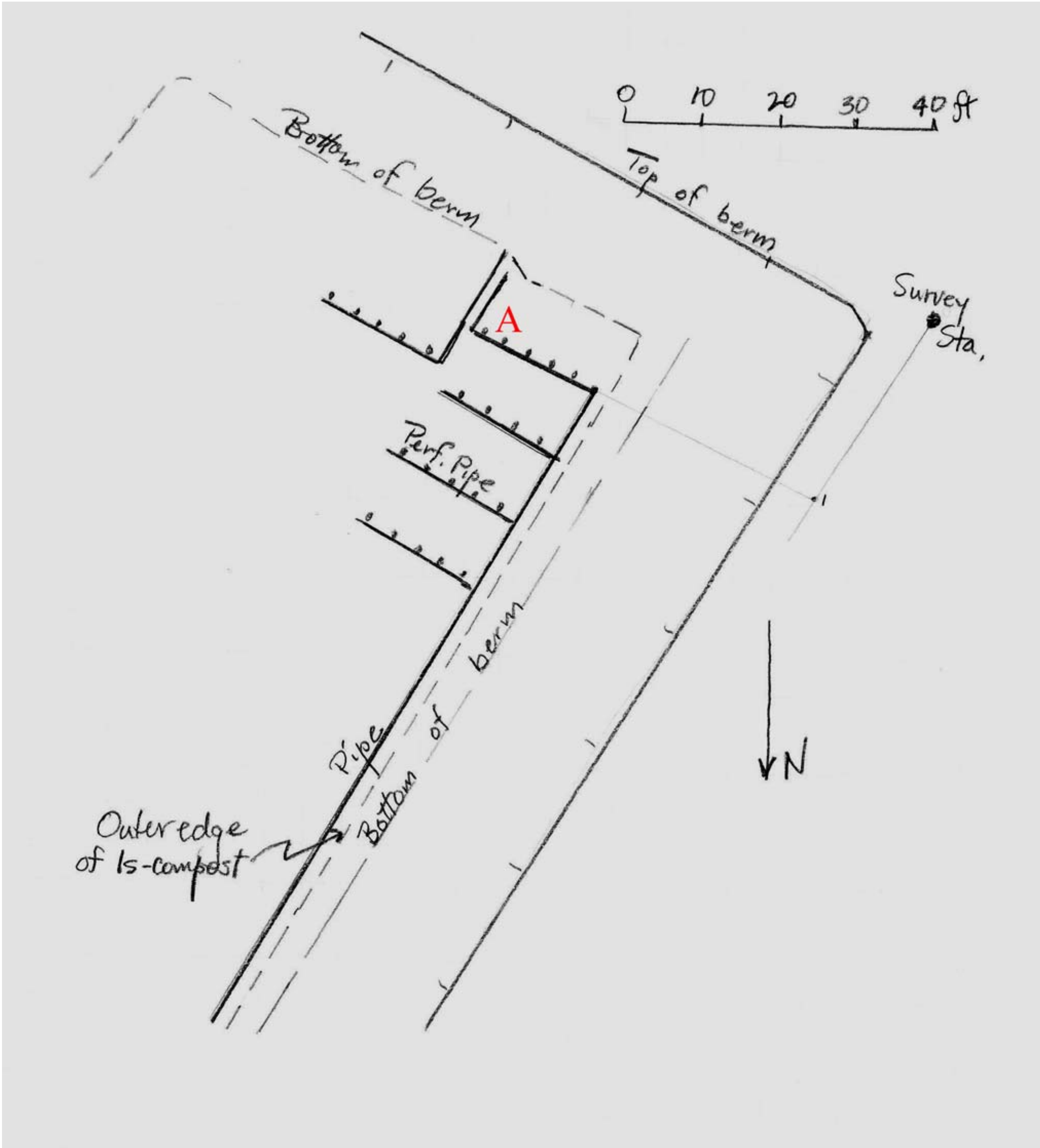

Figure 2. Map showing location of underdrain pipes, limit of compost and berms at VFP 1. Pipe location based on numerous holes dug through compost and limestone. "A" is the location of a break in pipes that was later repaired. Left side of figure is incomplete.

A layer of limestone-amended compost about 2 ft. thick was placed on top of the original compost layer in VFP1. Before emplacing the new compost, the original compost was scored by the teeth of the excavator to provide permeability through the original compost layer, which in places was clayey and sticky. About 10 small holes were dug through the compost to verify that the compost layer was 2 feet thick, as designed. All showed essentially this thickness.

The spent mushroom compost was obtained from a site in southeastern PA. It was mixed with No. 10 "limestone" at a proportion of 1 part limestone to 3 parts compost. This mixing was done with a front end loader and appeared to be very thorough. The mixture was stored along the uphill side of VFP 1 while the Fe sludge was removed. In contrast to the instructions on Plate 1, the No 10 limestone was purchased from the Union Furnace quarry of New Enterprise Stone and Lime, instead of being taken from the limestone bed.

The No. 10 "limestone" was sampled on about 7/15 and submitted to Mahaffey Labs for determination of %$CaCO_3$ on 7/24. The analysis was received 8/4, and showed only 49% $CaCO_3$, instead of the >85% required in the specifications (Table 2). Further testing and inquiry showed that the "limestone" was actually fine dolomite ($CaMg(CO_3)_2$), rather than limestone, based on only slight reaction with acid vs. vigorous fizzing on true limestone. Unfortunately, by this time, most of the compost for VFP 1 had been mixed. Apparently the quarry and the contractor did not pay any attention to the 85% specification. No. 10 limestone was actually available for a slightly lower price.

After the error was discovered, new No 10 limestone that met the 85% specification was delivered. A sample (GL-Ls2) showed 87.6% $CaCO_3$). The contractor was instructed to test each load of limestone with acid on a small chip to verify strong effervescence and high content of $CaCO_3$. Sample GL-Ls 3 collected on 9/1/09 showed 87.8% $CaCO_3$ for a load of No 10 limestone..

To correct the deficiency in $CaCO_3$, Change Order #1 was given to the contractor on 8/10/09 indicating that the compost mixture should have an additional ½ bucket of 85% limestone mixed with each bucket of mixture. For most of the compost layer, this mixing was done after the compost had been placed in VFP1. Several tests and observations indicated that the mixing was generally good, but occasional concentrations of limestone were encountered. About 15% of the compost for VFP 1 was mixed after the good limestone was obtained, and contains only good limestone..

Table 2. Analyses of "limestones"			
Sample	%$CaCO_3$	%$MgCO_3$	Date Collected
GL-Ls 1 (No.10 limestone	49.07		Approx 7/15/09
GL-Ls 2	87.63	5.37	8/5/09
GL-Ls 3	87.79		9/1/09
GL- #3 limestone	85.4		Approx 9/15/09

All limestone, both No. 10 and AASHTO #3 size, placed in VFP 2 was >85% $CaCO_3$, based on analyses in Table 2 and vigorous effervescence with acid.

Essentially all other features of the project were accomplished as designed on Plate 1. The road crossing over Wetland 1 was placed about 300 feet downflow from the VFP 1 outflow. A hay bale dike was installed about 600 feet downflow from the VFP1 outflow, and in Wetland 2 about 300 ft. downflow from the VFP 2 outflow. In addition, the culvert for the road crossing is 6-12 inches higher than the bottom of the wetland, forming a small settling basin up-flow from it. Also, a small settling basin has been constructed from a dirt dam at the inflow to VFP 2.

Specifications in the bidding process did not include caps for the pipe connecting Wetland 3 and Pond 3, or from the Limestone Bed to Pond 3. The price of these caps was added to the bid value as Change Order 2. In addition, 40 ft. of outflow pipe from the Limestone Bed were to be furnished by DEP, but after discussion with Malcolm Crittenden of DEP, the pipe was purchased. The amount of cost added to the bid amount is $186.

Amounts of limestone delivered to the site and used in the construction are as follows, based on truck weights:

#10 dolomite	428 tons
#10 limestone (>85%)	738 tons
#3A limestone	1917 tons

Construction on the renovation by the contractor was completed on approximately 11/10/09. However, the flow from the manhole into the system was <1 gpm until about 12/25/09, so the ponds did not fill immediately. On 1/5/10 both ponds had filled, and water was flowing through the entire system and out the pipe from the Limestone bed.

A set of samples was collected through the system on 1/7/09, with results shown on Table 3. The severely acid inflow (acidity 990 mg/L $CaCO_3$, Fe 125 mg/L, 69 mg/L Al) was being entirely neutralized to net alkaline in VFP1 (acidity -310 mg/L, pH 7.0, alkalinity 501 mg/L) with most of the Fe and all of the Al removed (Fe 17 mg/L, Al 0.74 mg/L). The VFP pond and the limestone bed increased the pH as high as 7.4 and removed Fe to 0.33 mg/L. Acidity and alkalinity varied in these sample points, probably because the inflow to the system varied in chemistry.

The above results indicate that the renovation has been very successful, though the results are probably somewhat better than will be the case in the long term, as found at other new systems. Based on these initial results, the system is removing 658 lb/d acidity, 113 lb/d Fe and 35 lb/d Al, and decreasing the load in Muddy Run by these amounts.

Maintenance and Operation

Future M&O will be conducted under the bond forfeiture project contracted to Gongaware Environmental Systems, who will be maintaining the supplemental active system. A set of 9 points on the passive system will be sampled quarterly and sent for lab analysis. In addition, Gongaware will make field measurements at 5 points and examine flow and [potential problems on a weekly schedule. Flushing will be conducted at least quarterly, and initially on a monthly schedule. Arthur Rose will assist with quarterly sampling and flushing, evaluate performance and suggest needed additional maintenance. To help accomplish the field analysis, several meters and field kits were purchased (pH, conductance, Fe, ferrous, alkalinity).

Cost Breakdown

See the separate Financial Report.

References

Hedin Environmental, 2006, Evaluation of the C&K Coal Pit 431 passive treatment system, Glasgow, Cambria County: Unpublished report to Clearfield Creek Watershed Association, 9 p.

Hedin Environmental, 2007, Pit 431 passive treatment system, Autopsy and Recommendations, Glasgow, Cambria County: Unpublished report to Clearfield Creek Watershed Association, 19 p.

Ziemkiewicz, P.F., Skousen, J.G., Brant, D.L., Sterner, P.L. and Lovett, R.J., 1997, Acid mine drainage treatment with armored limestone in open limestone channels: Jour. Of environmental Quality, v. 26, p. 1017-1024.

Photo 1. VFP 1 after draining, showing Fe precipitate.

Photo 2. VFP 1 after removal of Fe precipitate and partial addition of new compost.

Photo 3. VFP 1 after addition of new compost.

Photo 4. VFP 1 after partial refilling with water

Photo 5. VFP 2 after draining, showing Fe precipitate.

Photo 6. VFP 2 after emplacement of new limestone, underdrain and part of compost.

Photo 7. VFP2 after completion of compost addition.

Photo 8. Straw bale dam in Wetland 1

Table 2. Pre-renovation chemical data. See separate table.

Table 3. Post-renovation chemistry in passive system

Date	Flow gal/min	Method	Pipe	pH (fld)	pH (lab)	SpCon uS/cm	Temp C	Alkalinity mg/L	Acidity mg/L	Fe mg/L	Mn mg/L	Al mg/L	SO4 mg/L	TSS mg/L	Ca mg/L	Mg mg/L
Inflow																
1/7/2010	40	est.		2.92	3.5	3480	10	-	990	125	117.0	69.3	2566	5.0	196	320
2/16/2010	40	est.		2.84												
Outflow of VFP 1				NW and SE refer to the two outflow pipes												
1/7/2010			NW	6.59		3800	8	300	-292	8						
1/7/2010			SE	6.54		4900	8.3	520	-375	15						
1/7/2010			both	7.00		5420		501	-310	16.7	22.3	0.74	2483	46	473	256
2/16/2010	25	meas.	NW	6.17												
2/16/2010	30	meas.	SE	6.28												
2/16/2010			both					380		<10						
3/18/2010	20	meas.	NW	6.25				280								
3/18/2010	19	meas.	SE	6.34												
Outflow of VFP 2																
1/7/2010				7.34	7.4	4260	4.6	428	-294	1.81	5.51	0.25	1690	10	394	150
Outflow of Limestone Bed																
1/7/2010				7.03	6.8	4410	1	216	-175	0.33	12.5	0.88	1770	15	274	117
2/16/2010				6.91				240		0						