The Solar Passive Mine Water Treatment System: Current Effectiveness and Long-term Operation and Maintenance Expectations

Prepared for Independence Conservancy by Hedin Environmental

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Executive Summary

The Independence Conservancy has acquired a treatment system that passively treats acid mine drainage intercepted during the construction of the Southern Beltway, Section 54C. The system consists of a large anoxic limestone drain constructed beneath the highway, a small anoxic bed of limestone and compost, and two serially-connected settling ponds. The system was studied to determine its effectiveness and to estimate long-term operation and maintenance needs. The discharge was sampled at the effluent of the anoxic limestone and compost drain, and at the effluent of each pond. On average in 2006 and 2007, the discharge flowed 134 gpm and contained 77 mg/L Fe and 4 mg/L Mn. The limestone and compost pre-treatment is currently generating a net alkaline discharge with an average 276 mg/L alkalinity and –133 mg/L net acidity. The ponds are very effectively removing Fe and Mn. The final discharge from the second pond averaged pH 6.9, 1 mg/L Mn and < 1 mg/L Fe. At this time, there are no problems with the passive treatment system that require correction.

A site map was developed. The treatment system is located on property originally owned by Imperial Land Corporation that was sold to Chapman Properties LLC in 2007. As part of that transaction, the treatment system was declared non-developable and transferred to Independence Conservancy. A map was developed for the Conservancy that combined information provided by the Turnpike Commission, a survey conducted as part of the property sales, and a survey of the treatment system conducted by this project. The map revealed that part of the treatment system and a minewater channel were *not* transferred to the Conservancy, as intended. Chapman Properties is aware of the problem.

A simple O&M Plan was developed involves routine inspections and measurements of pH and alkalinity. Samples should be collected for laboratory analysis every six months. The major long-term treatment risk is the failure of the limestone and compost pre-treatment system and the loss of the net alkaline conditions. If this failure occurs, it can be recognized by a gradual decrease in alkalinity concentrations. If the net acidity rises above -25 mg/L, the IC should obtain professional assistance to evaluate the system in detail and develop remedial plans. It is likely that the declining system can be corrected through the installation of an anoxic limestone drain. Preliminary evaluations for a 3,000 ton ALD indicate that it can be fit largely within the boundaries of the IC property, but that it will likely infringe onto the neighboring property. The accumulation or iron sludge is a secondary long-term concern. The large size of the ponds makes it unlikely that sludge will impact treatment effectiveness for at least 30 years.

Introduction

During construction of the Pennsylvania Turnpike Southern Beltway Section 54C in Findlay Township (Allegheny County), remnants of the abandoned Solar underground coal mine were encountered. A flow of acid mine drainage (AMD) was produced. After discussion with the Greensburg District Mining Office, it was decided that the AMD would be transferred beneath the highway to existing ponds that were located on abandoned surface mine spoils, outside the turnpike right-of-way. The water was transferred beneath the highway in a limestone-filled trench that discharges into a buried bed of limestone aggregate and mushroom compost. The effluent from this unit discharges to a series of pre-existing ponds and natural wetlands.

The passive treatment system was originally located on property owned by Imperial Land Corporation. The property was part of a parcel that was sold in 2007 to Chapman Properties for land development purposes. As part of the sale, a portion of the property that includes the treatment system was declared non-developable and donated to the Independence Marsh Foundation, now the Independence Conservancy (IC). The IC will be responsible for maintaining the property and the treatment system. The IC has obtained intentions of cooperation from Chapman Properties to access and maintain the system, and to perform major O&M activities as required.

This report describes the current effectiveness of the passive treatment system, provides conceptual solutions for major maintenance problems that *might* develop, provides operation and maintenance recommendations, and provides a monitoring plan whose results would be used to anticipate the need for major maintenance activities. This report includes a site map that was developed from turnpike mapping, a property survey conducted by Chapman Properties, and a survey of the treatment system conducted by DEM Survey for this report.

Site Background

The Solar Mine is an abandoned deep mine and surface mining complex that originally comprised 380 acres of deep mine workings and 450 acres of surface mine spoils. All of the mining was in the Pittsburgh coal seam. Approximately 180 acres of the deep mine were removed through remining operations between 1970 and 1991. The mine historically produced a highly acidic discharge that polluted Potato Garden Run, a tributary of Raccoon Creek. Remining eliminated AMD production and resulted in substantial water quality improvements to Potato Garden Run and Raccoon Creek.

The portion of the Solar Mine that was not remined continues to produce acid mine drainage. During construction of section 54C of the Findlay Connector (Southern Beltway Turnpike), flow of AMD from the Solar Mine was intercepted. The discharge was transferred to an existing pond on the western side of the highway in a 1,200 ft long by 8 ft wide by 8 ft deep trench constructed on native limestone. The limestone in the trench was fractured to promote flow through it. The estimated quantity of native limestone aggregate is 4,000 tons. 900 tons of quarried limestone was added to the top three feet of the trench. A 12" perforated PVC pipe was placed on top of the stone. The idea was that water flowing through the native and quarried limestone would gain alkalinity. The pipe was provided to assure a conduit that would carry water in the event that the limestone in the trench became plugged. The pipe was slotted to allow interaction between water in the limestone-filled trench and pipe.

The pipe and trench are buried at least 60 feet below the highway. It is not feasible for the trench or pipe to be modified. The presence of the large pipe *and* the aggregate-filled trench provides a very large porous path that is unlikely to be clogged with AMD precipitates in the next 50 years. If the pipe became clogged, it is possible that the line could be accessed from the west side of highway and cleaned out.

The discharge of the drain was sampled in February 2005 by Keith Lucas of PADEP. Table 1 shows the analytical results.

Table 1. Sample of "Raw Water 54C Drain" collected February 18, 2005 by PADEP

Flow	pH	Alk	Acid	Cl	Ca	Mg	Na	Fe	Al	Mn	Zn	Ni	SO_4
80-100	5.8	78	183	23	274	120	300	122	5	5	0.3	0.2	1,388

Flow is gpm; pH is standard units; all other parameters are mg/L; alkalinity and acidity are as $CaCO_3$

The chemistry of water flowing from underground mines in the Pittsburgh coal seam in southwestern PA is dependent on whether the flow is from unflooded or flooded mines. Unflooded mines generally produce low pH water with elevated Al. Flooded mines produce pH 6-7 water with alkalinity, high Fe and Na, and low Al. The chemistry of the 54C Drain suggests that the flow is primarily from a flooded mine (high Fe and Na) with a secondary component from an unflooded mine containing acidic water with Al. It is unknown how much of the alkalinity contained in the sample (78 mg/L) is from limestone in the trench or from the original Solar Mine discharge.

The discharge of the 54C drain was directed into an existing sedimentation pond that discharges into an existing AML pond. Because the water was net acidic (189 mg/L, Table 1), the discharge from the pond had pH less than 6. DEP required treatment of the water. During highway construction, alkaline chemicals were placed on the effluent spillway of the 1st pond to neutralize the acidity.

In 2005, a buried bed of limestone and organic substrate was installed between the outfall of the drain pipe and the settling pond. The purpose of the bed was to add alkalinity to the flow and eliminate the need for chemical treatment. The alkalinity is generated by bacterial sulfate reduction in compost and calcite dissolution in the limestone. The bed is a combination of an anoxic limestone drain (which contains all limestone) and a sulfate reducing bioreactor (which contains alkaline organic substrate). The unit will be referred to as an anoxic limestone and compost drain or ALCD. The ALCD is 100 ft long by 50 ft wide by 6.5 ft deep and contains three feet of job[1] limestone, 1.5 feet of quarried limestone, and 2 feet of spent mushroom compost. The material quantities are approximately: 700 tons of job limestone, 300 tons of quarried limestone, and 100 tons of compost.

Water flows from the ALCD down a ditch to the 1st settling pond. A flume was installed in the ditch to facilitate accurate flow rates. The first settling pond has a surface area of 42,688 ft^2 (1.0 acre). This surface area is about twice the acreage shown on the original turnpike map. There are several dead trees present in the pond. Apparently the water level in the pond was raised during the turnpike construction. This may have occurred when an aggregate spillway was installed at the pond effluent.

The discharge from the 1st pond flows down a small channel to a 4.7 acre pond that was created by historic surface mining activities. This pond discharges through a spillway to a long narrow pond that is about 3.3 acres and contains open water and wetlands. The spillway from the second pond has been dammed by beavers for the last 18 months. The beavers are active, re-damming the spillway within of month of its clearance.

Performance of the Passive Treatment System

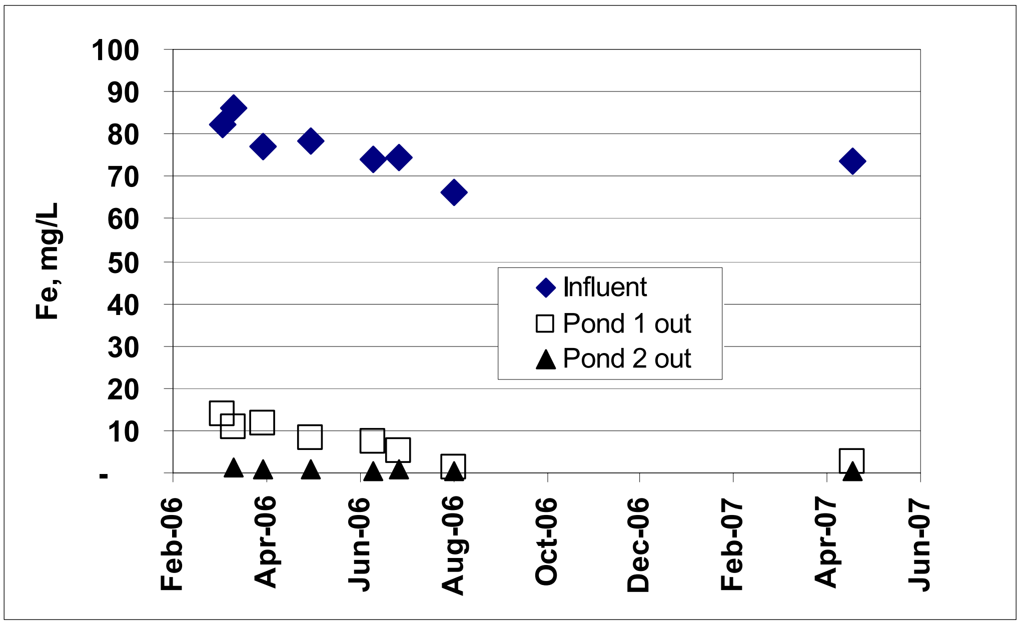
The performance of the treatment system was evaluated by sampling the effluent from the ALCD, the effluent from the 1st pond (P1) and the effluent from the 2nd pond (P2). The average results are shown in Table 2. Figure A shows iron concentrations and flows on the various sampling dates. The flow ranged from 50 – 275 gpm and averaged 134 gpm. The discharge from the ALCD was always strongly net alkaline. Iron concentrations ranged from 66 to 86 mg/L. The higher concentrations occurred at higher flows. Aluminum concentrations ranged from 0.2 to 2.6 mg/L. The presence of any Al in net alkaline water is unusual because of the very low solubility of the Al at pH 6-7. There are several explanations for the Al. There may be pipe within the ALCD that connects with the pipe in the turnpike underdrain that carries AMD that has with minimal contact with limestone or compost. Alternatively, there may be a pre-existing flow of Al-containing AMD at the site and the two discharges mix together above the ditch.

[1] "job" limestone is limestone aggregate produced on the job during construction of the highway

Table 2. Average characteristics of mine drainage at the Solar passive treatment system.

	Flow	pH	Alk	Acid	Fe	Mn	Al	SO_4	TSS
Source	134	6.5	276	-133	76.5	4.1	1.7	1546	58
P1 out		7.0	173	-151	7.7	3.2	0.2	1292	7
P2 out		6.9	155	-152	0.7	1.1	0.1	1384	7

Flow is gpm; pH is standard units; all other parameters are mg/L; alkalinity and acidity are as $CaCO_3$



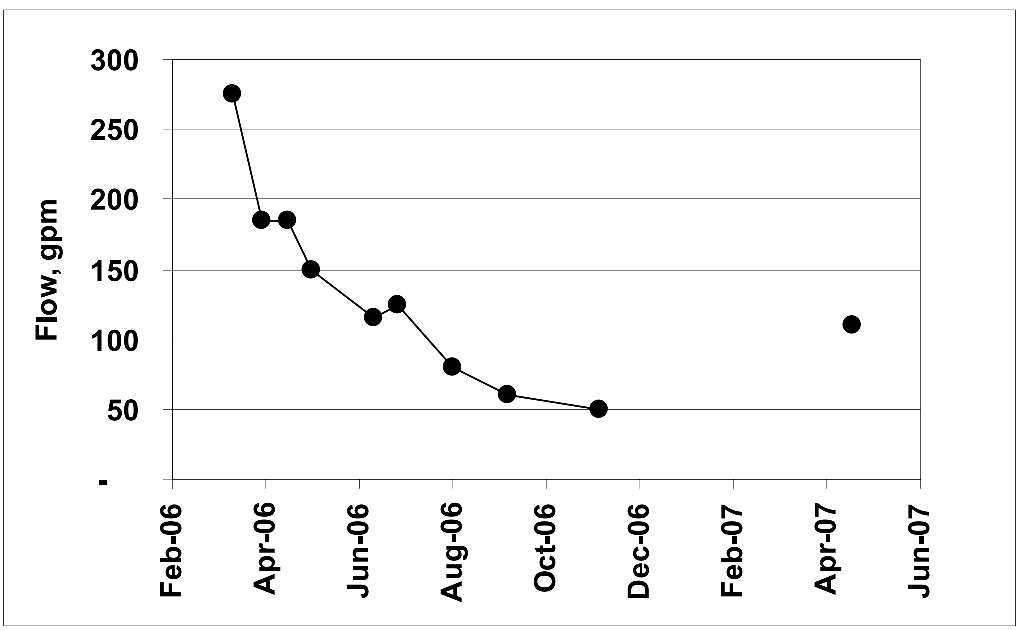


Figure A. Fe concentrations (above) and flow rates (below) for the Solar passive treatment system, March 2006 – April 2007.

As water flows through the ponds, concentrations of Fe decrease to low levels. The discharge from the 2nd pond had Fe concentrations of 0.3 – 1.2 mg/L. The highest concentrations occurred when the flows were high. The effluent from the 2nd pond is good quality water. It would meet a standard NPDES permit, if one existed at the site.

Alkalinity decreases with flow through the system. This is expected because the removal of Fe generates acidity which is neutralized by alkalinity, as shown below.

$$Fe^{2+} + \frac{1}{4} O_2 + 2HCO_3^- \rightarrow FeOOH + \frac{1}{2} H_2O + 2CO_2$$

The removal of 76 mg/L Fe should decrease the alkalinity by about 135 mg/L alkalinity. The discharge averages 276 mg/L. This excess alkalinity assures that the pH of the water will not decrease with flow through the ponds. The excess alkalinity results in a negative acidity value that represents the amount of alkalinity present in the water, after taking into account the acidic aspects of the Fe and Mn.

The 1st pond removes 90% of the iron. Concentrations of sulfate and Mn also decrease by 8-12%, which is likely due to dilution by storm water flowing into the pond from the Turnpike.

The removal of Fe by passive systems is usually measured in a rate manner that calculates the mass of Fe removed by a particular area in a particular time. The common units are grams of Fe removed per square meter of system per day ($g\ m^{-2}d^{-1}$). Iron removal rates have been measured for many passive systems. The rates are dependent on oxygen concentrations, pH and iron concentrations. As Fe concentrations get lower the rate of Fe removal slows. Where the pH is maintained between 6 and 7, Fe removal for waters with more than 10-15 mg/L Fe usually occurs at 15-25 $gFe\ m^{-2}d^{-1}$. For waters with less than 10-15 mg/L Fe, the rate of removal slows to 3-5 $gFe\ m^{-2}d^{-1}$.

Table 3 shows calculated iron data and removal rates for Solar Pond 1. The change in iron concentration is affected by the flow rate. At higher flow rates (>150 gpm), the effluent from Pond 1 is 12-14 mg/L. This is the range where an iron removal rate of 15-25 $g\ m^{-2}d^{-1}$ is expected. The calculated average removal rate for Pond 1 is 24 $g\ m^{-2}d^{-1}$, when the flow is greater than 150 gpm. The system is providing excellent passive removal of iron, probably in part because of the good aeration provided by flow down the influent ditch.

When flows are lower than 150 gpm, the first pond lowers Fe concentrations to as low as 1 mg/L. The Fe removal rate is lower because the rate slows as Fe concentrations decrease. Also, the iron loading rate at lower flow (<100 gpm) is only 7-10 $g\ m^{-2}d^{-1}$. If all of the Fe was removed by the first pond under these low flow conditions, the removal rate would only be 7-10 $g\ m^{-2}d^{-1}$.

Table 3. Removal of Fe by the first pond of the passive system

Date	Flow, gpm	Fe Source, mg/L	Fe P1 out, mg/L	Fe removal, g $m^{-2}day^{-1}$
Mar 16, 2006	275^{est}	82.3	13.9	25.8
Mar 23, 2006	275	86.2	10.8	28.5
Apr 11, 2006	185	77.1	11.9	16.6
May 12, 2006	150	78.3	8.4	14.4
Jun 21, 2006	115	74.2	7.5	10.5
July 17, 2006	125	74.6	5.2	11.9
Aug 11, 2006	80	66.2	1.3	7.1
Apr 24, 2007	110	73.4	2.4	10.7
Average	*153*	*76.5*	*7.7*	*14.4*

Fe removal by the system is not a concern. As long as the flow remains net alkaline, its treatment requires adequate retention in the two ponds. Pond 1 is large enough to remove 97% of the iron under warm low-flow conditions. Under cold high-flow conditions, Pond 2 provides excessive treatment capacity. There are currently no problems with the Ponds that require correction.

Photo A. The discharge from the ALCD and its flow down the ditch into Pond 1.

Development of a Site Map

One of the project deliverables is a reliable map of the existing treatment system. The site map is attached this report. The mapping was developed by DEM Survey (Brookville, PA). The project map was developed from three sources. Mapping used for the highway's design was provided by the Turnpike Commission. Mapping prepared for land development purposes by Lennon, Smith, Souleret Engineering (Coraopolis, PA) was provided by Chapman Properties. DEM Survey, with Hedin Environmental instruction, conducted a survey of the existing treatment system.

The project map shows features of the passive treatment system and the property boundaries as provided by Chapman Properties and verified from field benchmarks by DEM. The 2007 property sale between Imperial Land Company and Chapman Properties intended to cut out the passive treatment system for transfer to the Independence Conservancy. The boundaries established errantly included the anoxic limestone and compost drain, the discharge, and the ditch that carries the AMD into the first pond as part of Chapman Properties. It was intended for all aspects of the treatment system to be transferred to the Conservancy. It appears that the ditch that carries drainage from the Turnpike to the first pond was misinterpreted as the ditch carrying the mine water.

During a site meeting in 2007, Chapman Properties was made aware of the problem. It was stated that the property sale was too advanced to change the property boundary. Chapman representatives indicated that this error would be corrected in the future. At this time, the error does not impact the treatment system in any way. If the error is not corrected and future development activities include excavation around the discharge, the treatment effectiveness of the treatment system could be impacted. The Conservancy should have this problem corrected in the next couple years.

Operation and Maintenance of the Solar Passive Treatment System

Routine Inspections

The operation of the Solar Passive Treatment System is simple because its passive elements do not require regular maintenance. The system's effective operation requires that the discharge to the first pond is net alkaline and that the water flows through the system without short circuiting. The net alkalinity of the system is not something that can be maintained or corrected with routine operations. The "Sampling" and "Major Maintenance" sections of the plan will discuss how to recognize failure of the alkalinity-generating components and how to correct this problem. The routine operation of the system can be assessed through a simple walking inspection that requires attention to how water is flowing through the system. The attached Inspection Form can be used to conduct inspections and keep a record of the system conditions.

Sampling

The need for major maintenance can be assessed through periodic sampling and tracking of the results. Several types of sampling are provided below. There are three sampling stations: the flume, the outlet channel of Pond 1, and the outlet of Pond 2.

<u>Flow Measurements</u>

Flow is measured at the flume installed in the ditch between the discharge and Pond 1. Measurements are made by measuring the depth of the water in the flume. The flume should be first cleaned of sediment and debris and allowed to re-equilibrate for one minute. The flume should be level. If it is out-of-level, attempt to level it and wait a couple minutes for the flow to re-equilibrate. Flow is determined by measuring the depth of water in the middle of the flume and referring to the chart attached to the end of this report. Flow should be measured every time the system is inspected.

<u>Field Measurements</u>

The general performance of the system can be reliably judged with field pH measurements and visual observations. pH should be measured at all three stations. When the water is net alkaline, the pH will be above 6 at all locations. If the pH is less than 6, then: 1) verify that the pH meter is working correctly, 2) plan on taking a set of samples for laboratory analyses. Observe the clarity of the final (Pond 2) discharge. If the discharge is clear, then iron concentrations are likely less than 3 mg/L. A digital photo of the effluent can provide a good record of the clarity of the pond effluents.

Hanna Instruments manufactures a portable waterproof pH and temperature tester that is easy to use, accurate and inexpensive. It is the "HI 98129 Combo pH/EC/TDS/Temperature Tester." The device can be obtained through most environmental equipment supply companies. The cost is about $150.

The treatment system's continued good performance requires that the discharge from the ALCD has a negative net acidity, or positive net alkalinity. While net acidity can only be measured in a laboratory, tracking of *field alkalinity* will provide valuable information on the performance of the ALCD. Alkalinity is not stable for the ALCD discharge because of the presence of high concentrations of Fe. If the IC is intends to measure alkalinity (recommended) then the measurements should be made in the field or within one hour of collection.

Hach Company manufactures several simple devices that measure alkalinity. The digital titrator with the High Range Alkalinity Reagent kit is recommended. This kit is referred to as the "Alkalinity Test Kit, Model AL-DT, Digital Titrator, 10-4000 mg/L." The cost is approximately $200 and the kit has enough supplies to make 100 alkalinity measurements. The titrator can be used to measure other water quality parameters using reagent kits provided by Hach.

<u>Laboratory Measurements</u>

Samples should be collected periodically from all three stations and submitted to a laboratory for analysis of AMD parameters. The standard analytical parameters are: pH, alkalinity, hot acidity, sulfate, total suspended solids, Fe, Mn, and Al. Two samples should be collected: a raw sample and one acidified in the field. Most laboratories will supply sampling bottles, including one containing acid.

The cost for analysis of standard AMD parameters is typically about $30 per sample. The Western Pennsylvania Coalition for Abandoned Mine Reclamation manages the FACTS Program which provides free laboratory analyses for non-profit groups. The Solar System should qualify for this program. A description of WPCAMR's FACTS program is attached.

<u>Sampling Schedule</u>

The table below shows recommended sampling locations and schedules. Flow and pH should be measured during every inspection. If an alkalinity kit is available, the alkalinity of ALCD should also be measured during every inspection. If this is not possible, then measure alkalinity at least quarterly. Samples should be collected for laboratory analysis at least twice per year. If the performance of the system appears to be declining, increase the frequency of laboratory analyses.

Table 4. Recommended sampling protocols of the Solar System

Parameter	**Locations**	**Frequency**
Flow	Flume	Every inspection
pH and temperature	Everywhere	Every inspection
Alkalinity	Flume	At least quarterly
Laboratory analyses	Flume and final	Every six months

Major Maintenance

The two major maintenance items that can be expected are: 1) replacement of the ALCD, and 2) cleanout of iron sludge from Pond 1.

ALCD Replacement

The need for the ALCD replacement will be recognized when the alkalinity of the raw discharge decreases. The cause for the decline is exhaustion of organic substrate and/or limestone within the ALCD. It is likely that the alkalinity will decrease gradually, so the monitoring program should provide a warning and allow the IC to plan for the ALCD replacement. The discharge has recently maintained a field alkalinity of at least 250 mg/L and a net acidity of at least –100 mg/L (negative is good). As the ALCD declines the field alkalinity will decrease and the net acidity will increase. If the net acidity rises above –75 mg/L, then IC should increase its laboratory sampling of the ALCD to at least quarterly. If the net acidity rises above -25 mg/L, the IC should consider actions to replace or supplement the ALCD within 12-18 months.

The specifics of the ALCD replacement cannot be defined at this point because the chemistry of the degrading discharge is not known. If the degradation involves decreased concentrations of alkalinity, but NOT increased concentrations of aluminum, then the simplest action will be to add an anoxic limestone drain (ALD) to the existing system. If the degradation involves increased Al, then the construction of a mixed limestone/substrate system is likely appropriate.

Based on the available information for the limestone drain carrying water beneath the Turnpike and for the ALCD, it is likely that the system will continue to produce net alkaline water for many years. The two treatment units contain a total of ~6,000 tons of limestone. This is 1.5 times greater than the amount of limestone usually recommended for 25 years of treatment of a 130 GPM discharge that is suitable for ALD treatment. This calculation suggests that alkalinity generation should continue for at least 20 years. The uncertainty in this projection is: 1) the presence of pipes in the underdrain and 2) the possible presence of Al in the original discharge. Both these factors would lessen the longevity of the alkalinity-producing system.

If the IC observes declining performance of the ALCD, the advice of an expert in mine water treatment and chemistry be obtained. At this time, this advice could be obtained from the Office of Surface Mining or PADEP Bureau of Abandoned Mine Reclamation. In the past, DEP has supported various Technical Assistance programs that have provided access to professional consultation (for free). The IC should determine if a Technical Assistance provider exists. If the expert concludes that the ALCD is declining and major repairs will be necessary, then the IC should secure the services of an environmental consultant experienced in passive treatment who can assist in the development of a plan and in the preparation of proposals to fund and implement the plan.

Possible configuration of the ALCD Replacement

One concern about the need for rebuilding the ALCD is whether there is sufficient land area on the IC's property to accommodate construction. The adjacent property is intended for commercial development and the IC should not assume permanent easement to developable property. To address this concern, a calculation was made of the size of a hypothetical treatment unit and its placement on IC property was assessed.

If the ALCD fails through decreased alkalinity generation, then the recommended action will be installation of an anoxic limestone drain (ALD) between the discharge point and Pond 1. An ALD is a buried bed of limestone aggregate that adds alkalinity to minewater. ALDs are sized to provide at least 12 hours of retention time for the targeted flow and to account for limestone losses that occur as calcite dissolves over a 25 year lifetime. Based on the flow rates observed recently, a 3,000 ton ALD would be appropriate. Assuming that the limestone bed was 6 ft thick, the surface area of the ALD would be 10,000 ft^2.

Figure B shows a possible location for the ALD that is between the current discharge and Pond 1. The existing discharge from the ALCD would be excavated, collected and piped to the ALD. The ALD would be buried and would discharge by pipe into Pond 1. The ALD is located on both IC and Chapman property. This layout would require cooperation by Chapman Properties. The infringement is not in an area with high development potential. Also, an ALD is a buried structure that could support light use (grass, low-level parking) and would not be a visual eyesore to adjacent commercial use.

This analysis suggests that it will be feasible to install a large ALD at the Solar passive treatment system that is largely on IC property. The design is only conceptual. If the need for an ALD arises, the IC's consultant should be instructed to work with the property boundaries and existing contours to provide a system that infringes as little as possible on Chapman property and also discharges the ALD effluent into Pond 1 in a manner that maximizes retention and Fe removal in the pond. These are reasonable expectations.

Iron Sludge Management

The system is accumulating, on average, 35 tons of iron sludge per year. Most of the accumulation is occurring in Pond 1. If the iron content of the discharge is sustained, then Pond 1 will eventually fill with sludge, the retention time for water in the Pond 1 will decrease, and the effectiveness of the Pond will decrease. Because of the large excess capacity of Pond 2, it is likely that the decline in treatment by Pond 1 will be taken up by Pond 2. However, when sludge accumulation begins to cause a serious decline in Pond 1 Fe removal, the IC should consider actions to remove the sludge.

Sludge removal is not likely to be a problem for at least 15 years. It appears that Pond 1 is at least 8-12 feet deep. At the current rate of iron removal, the pond is accumulating about 2 inches per year of iron sludge. As long as there is a 4-5 feet depth of free water in the pond, it should treat water effectively. Assuming that sludge accumulates 2 inches per year and the pond averages 10 ft deep, the sludge will not reach 6 ft in depth for 36 years.

Iron sludge is generally removed from settling ponds through pumping, followed by burial. EPA and DEP have determined that treatment system sludge is not hazardous and can, at this time, be buried on site (with proper erosion and sediment control precautions). Alternatively, the iron sludge might be recovered as a saleable iron oxide product. Pigment-grade iron oxide has been recovered during the last six years from passive systems with water chemistry similar to the Solar system. If these iron oxide recovery efforts continue, it is possible that the Solar sludge could be removed as a resource recovery project, at little net cost to the IC.

The need for sludge removal will be apparent from the monitoring data, because the pond will retain less iron under similar flow conditions than is occurring currently. The need will be visually apparent because sludge will have accumulated so much that it will be visually obvious throughout the pond. When a decline in Fe-removal performance of Pond 1 is recognized, the IC should contact a sludge recovery company and have an assessment made of the feasibility of removing the sludge as a product. If the recovery requires a subsidy, then IC should expect the company to assist in the preparation of a grant proposal that would result in the pond's cleanout. If the recovery can be accomplished without subsidy, then IC should try to negotiate a royalty payment.

Solar Passive Treatment System Inspection Form

Inspector Name ______________________________ Date ___________________
Current Weather_______________________ Recent Precipitation?______________

<u>Discharge Area</u> Is water flowing freely from the ground into the ditch? ________
If the flow is blocked, clear the blockage away.

<u>Ditch to Pond 1</u> Is the ditch carrying water to the pond as intended? ____________
If the ditch is obstructed with iron sludge and litter, were you able to remove it? _______
If there is an obstruction that could not be removed by hand, plan to remove it at a later date with appropriate equipment or assistance.

<u>Flume</u> Depth of water in flume ______inches; flow rate ______gpm
Water: pH_____ temperature__________ alkalinity ________________

<u>Turnpike Drainage to Pond 1</u> Pond 1 receives storm runoff from a turnpike drain.
Is the turnpike drainage ditch in good shape? __________________________________
Is there a large amount of sediment flowing into Pond 1 from the Turnpike? _________
If the ditch appears to be causing problems to Pond 1, contact the Turnpike Commission.

<u>Pond 1</u> The pond's effectiveness can be compromised by: 1) the accumulation of sludge and litter or, 2) obstructions in the pond that cause short-circuited flow.
Has sludge accumulated so deep that it is visible throughout the pond? _____________
If YES, then see consider sludge cleanout options
Is there an obstruction in the Pond that causes preferential flow? __________________
If YES, then plan a way to remove the obstruction.

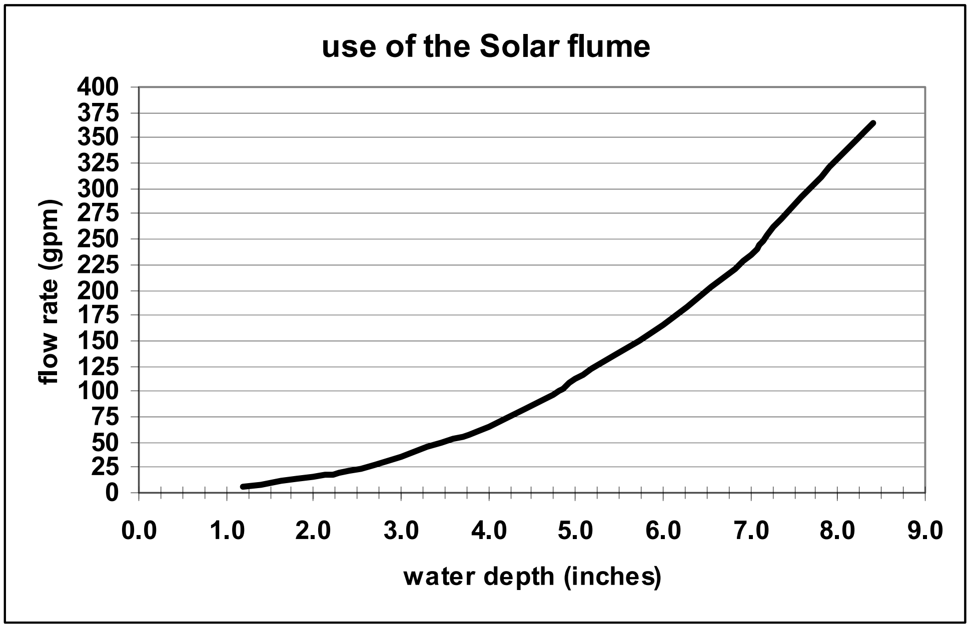
<u>Pond 1 Discharge Channel</u> Is the channel obstructed? __________________________
If YES, were you able to remove the obstruction? ______
If there is an obstruction that could not be removed by hand, plan to remove it at a later date with appropriate equipment or assistance.
Water: pH_____ temperature__________ alkalinity ________________

<u>Pond 2</u> Is there an obstruction to the free flow of water through the pond? ______
If YES, plan to have it removed at a later date.

<u>Pond 2 Discharge</u> Beavers have dammed the Pond 2 discharge spillway.
Is the Pond 2 Discharge Channel still dammed? ______
Inspect the pond breast, looking for evidence of erosion or undercutting.
Does the Pond 2 breast show signs of increased recent erosion? ______
If YES, discuss the conditions at the next Independence Conservancy meeting and plan to remove the beaver dam as soon as possible.
Water: pH_____ temperature__________ alkalinity ________________

Record miscellaneous observations on back of this sheet

Flow Measurements using the 0.75 ft H flume



inches	**gpm**
1.2	6
2.0	16
2.4	22
3.0	36
3.6	53
4.0	66
4.8	101
5.0	112
6.0	166
7.0	235
7.2	254
8.0	329
8.4	365