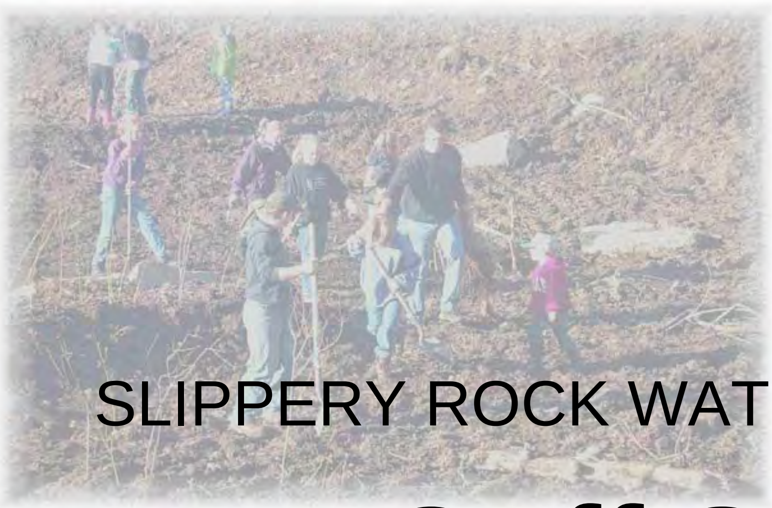
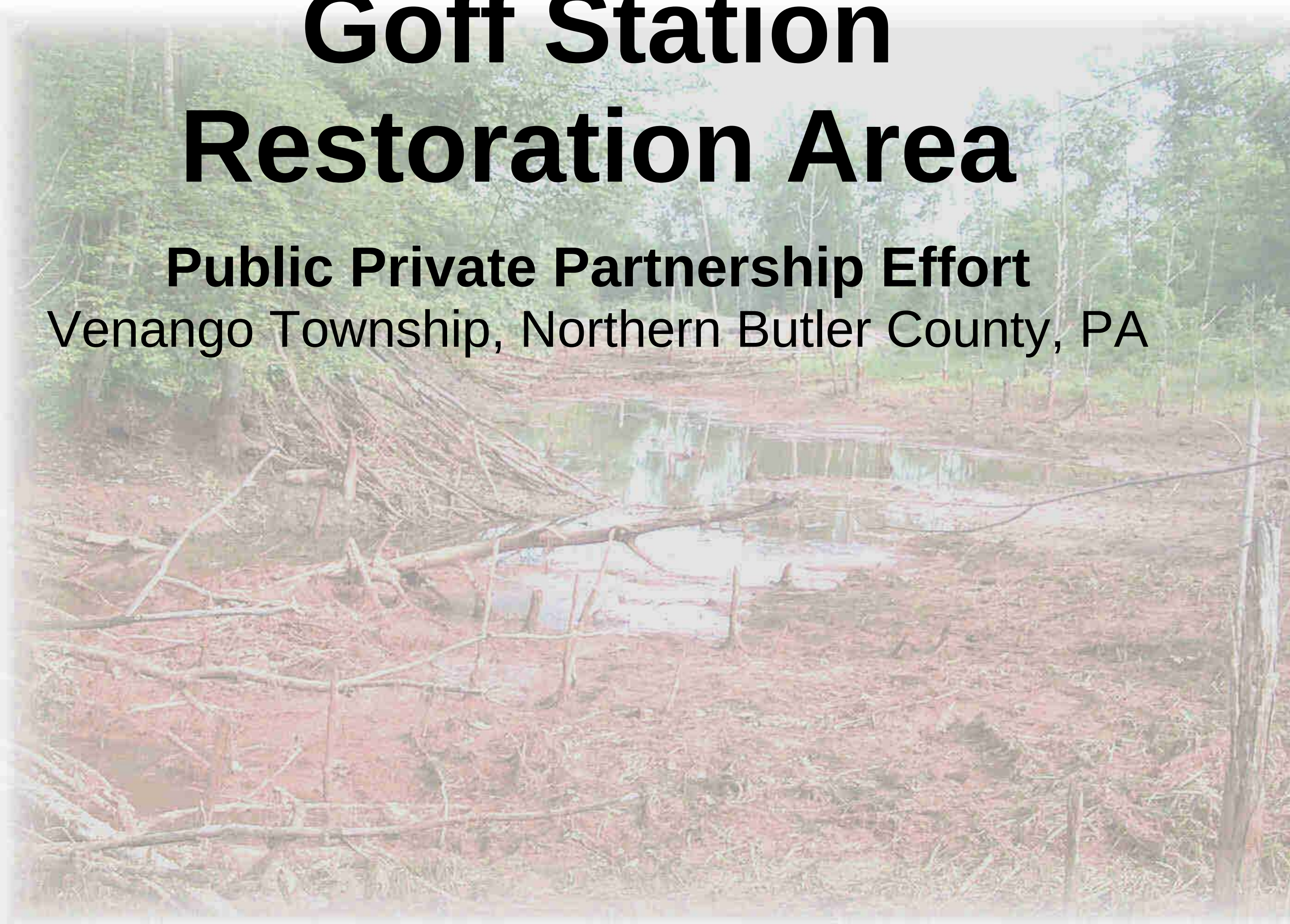


SLIPPERY ROCK WATERSHED COALITION

Goff Station Restoration Area



Public Private Partnership Effort

Venango Township, Northern Butler County, PA

Stream Restoration Incorporated
A PA Non-Profit Organization 501(c)(3)
3016 Unionville Rd., Cranberry Twp., PA 16066
PH: 724-776-0161 FX: 724-776-0166 sri@streamrestorationinc.org
www.streamrestorationinc.org

Date: March 19, 2002

To: PA Department of Environmental Protection
Bureau of District Mining Operations, P.O. Box 669, Knox, PA 16232-0669

Attn: Sherry Carlin, Watershed Manager

Re: Final Report for Project #NW90003
Growing Greener - Environmental Stewardship and Watershed Protection Grant ME #359747
Goff Station Restoration Area, Slippery Rock Creek Watershed, Venango Twp., Butler Co., PA
200212/FR-trans

Enclosed is the final report for the above noted project. We are very proud of this project and everyone involved.

We believe that this project exemplifies the capability of **public-private partnerships** not only to successfully complete but also to substantially exceed the work outlined in a grant. The expansion can be directly attributed to the participation of **private industry without the bid process or change orders.** Preliminary estimates indicate **in-kind contributions exceeded $350,000.** It has also been very rewarding to have **over 400 visitors** and **local, regional, and multi-state news coverage.**

We can not express our appreciation adequately to the PA Department of Environmental Protection and the **Growing Greener initiative for making this possible.**

This report represents only a small portion of the "success stories" associated with this effort. The timeliness of this funding allowed the project to be coordinated with other restoration activities occurring in the area. We hope that this report will meaningfully acknowledge the importance of this project in the **development of passive treatment technology and innovative wildlife habitat and in the sustainability of the entire Slippery Rock Creek Watershed restoration effort.**

Please review and comment and do not hesitate to contact any of the participants with questions. The submission of a good quality work product is important to all of us.

Your patience and assistance are very much appreciated.

From: Stream Restoration Incorporated

Margaret Dunn, PG; Timothy Danehy, EPI; Shaun Busler, Bio.; Cliff Denholm, Env. Sci.; Deanna Funkhouser, Comm.
Sent: First Class Mail

Copy: Joe Aloe, Pres., Quality Aggregates Inc.; Bob Beran, Pres., Aquascape; Dave Johnson, Mgr., and Will Taylor, Prog. Dir., Jennings Env. Ed. Ctr.; Tiff Hilton, Pres., WOPEC; Fred Brenner, PhD, Grove City College; Paul Linnan, Chief Field Ops., BAMR; Ron Stanley, Dir., DEP Grants Center; David Hess, Sec., PADEP; Bob Dolence, VP, SAIC; Mark Schweiker, Gov., Commonwealth of PA; Mary Jo White, PA Senator; Bernie Sarnoski, Coordinator, AMD Initiative, EPA Reg. III; Glen Anderson, Chairman, Butler Co. Comm.; Jeff Jarrett, Director, OSM, USDOI

SLIPPERY ROCK WATERSHED COALITION

GOFF STATION RESTORATION AREA FINAL REPORT

Murrin Run, Seaton Creek Watershed, Slippery Rock Creek Headwaters
Venango Township, Butler County, PA

"Making It Happen" through a Public-Private Partnership Effort

A Growing Greener Watershed Restoration Project

Brief Description of Project Work

- Completed applications and received permits and approvals
- Installed approved Erosion and Sediment Controls including a upland diversion ditch ½-mile in length
- Designed passive system complex (25-year design life) with individual and shared components for six abandoned mine discharges utilizing monitoring from PADEP, Knox DMO, 1998, CMRS
- Included innovations/project expansion not in proposal such as a Bioswale, underdrain clean-outs, limestone-only Vertical Flow Pond, etc.
- Substantially increased size of Vertical Flow Ponds and doubled quantity of treatment media from 4000 tons to 8200 tons of limestone aggregate and added a limestone-only VFP (first known side-by-side comparison of limestone-only with limestone/compost VFP in PA)
- Created naturally-functioning wetlands with microrelief and diverse plant community, successfully expanding effort to support 38 plant species (6 listed in original proposal) providing exceptional wildlife value with fish (not stocked) presently utilizing the deeper water areas. Also observed is evidence of raccoon, fox, deer, and bear utilizing the wetlands.
- Included innovations/project expansion not in proposal such as usage of fabricated soil hand-placed in Bioswale, construction of hydrologic connection from Final Wetland to riparian area, muskrat damage prevention feature, adjustable outlet structure, level spreader, directional barriers, bio-monitoring program, etc.
- Continued riparian area restoration, formerly overlain by abandoned coal refuse, along Murrin Run using willow wattles for bank stabilization and diverse flora and vernal pools for wildlife value
- Improved site drainage essentially neutralizing 100% of the acidity and removing about 100% of all metals (iron, manganese, aluminum). Estimated annual elimination from the receiving stream of 83,000 lbs/yr acidity and 13,200 lbs/yr metals
- Expanded project from original proposal to include first known constructed bat hibernaculum in eastern United States

- Planted wetlands and uplands and constructed wildlife facilities through efforts not only by Girl Scouts and other volunteers but also by expanding the program to include adjudicated youth and contributions by individuals from local retirement center
- Expanded monitoring of Seaton Creek to include a new fish inventory program by Grove City College not in proposal. Common Shiner, Brown Bullhead, and Johnny Darter were documented in the receiving stream, Murrin Run, after installation of the passive systems. Remining in the headwaters is also responsible for stream improvement.
- Doubled “In-Kind” partners to 14 from 7 in proposal
- Conducted 12 site tours and workshops for over 400 visitors
- Participated in news media coverage, resulting in 9 articles in local, regional, and out-of-state newspapers and a regional television news report
- Kept photographic log and submitted electronic updates, quarterly status reports, final report with “As-Builts” and selected photos, and administered the contract
- Completed all work including project innovations and expansion without change orders and without the bid process

<u>Grant Information:</u> PADEP Growing Greener; NW-90003; ME#359747; $815,751

<u>In-Kind Partners:</u>
Aquascape
Quality Aggregates Inc.
PADEP, Bureau of District Mining Operations, Knox Office
PADEP Bureau of Abandoned Mine Reclamation
Grove City College
Urban Wetland Institute (non-profit)
Butler County Juvenile Court Working Opportunities to Repay the Community Program
PA Game Commission
Girl Scout Troop #653
WOPEC
BioMost, Inc.
Slippery Rock Watershed Coalition volunteers
Northwest Sanitary Landfill
Concordia Haven residents
Jennings Environmental Education Center, PADCNR
Stream Restoration Inc. (non-profit)

November 2001

cover photos: Girl Scout Troop #653 planting a wetland (top left); construction of Vertical Flow Ponds by Quality Aggregates Inc. (top right); iron-laden, mine drainage-filled, strip cut before being converted to the Upper Wetland (bottom)

PUBLIC-PRIVATE PARTNERSHIP

Construction, Stone Supplier, Youth Programs

Quality Aggregates Inc., 200 Neville Rd., Neville Island, PA 15225
ALOE, Joseph, President; ANKROM, Jeff, Vice President; STOOPS, John, Foreman; STINER, Kevin and COLOSIMO, Michael, Equipment Operators (412) 777-6717

Wetlands, Bioswale, Riparian Area Design, Youth Programs

Aquascape, 114 Deer Road, Boyers, PA 16020
BERAN, Robert, Pres.; REIDENBAUGH, Jeff, Env. Consult.; SPENCER, Laura, Biol. (724) 735-2766

Educational Outreach

Jennings Environmental Education Center, PA Dept. of Conservation and Natural Resources, 2951 Prospect Road, Slippery Rock, PA 16057
JOHNSON, David, Mgr.; TAYLOR, Will, Env. Ed. Director; SHIRLEY, Cindy, Admin. Asst.; BEST, Eric, RUKOSKI, Tanya, & GRAHAM, Mary Jo, Env. Ed. Specialists (724) 794-6011

Wildlife Management

PA Game Commission, PA Gamelands 95, 2026 W. Sunbury Rd., W. Sunbury, PA 16061
HOCKENBERRY, Dale, Land Mgr.; BRUNST, Chip, WCO (724) 637-3120

Conceptual and Engineering Design of Passive Treatment System

BioMost, Inc., 3016 Unionville Rd., Cranberry Twp., 16066
DANEHY, Timothy, EPI; DUNN, Margaret, PG; BUSLER, Shaun, Biologist; DENHOLM Cliff, Env. Scientist; FUNKHOUSER, Deanna, Communications (724) 776-0161

WOPEC, Rt. 2, Box 2948, Lewisburg, WV 24901
HILTON, Tiff, Mining Engineer, (304) 645-7633

Monitoring and Oversight

PADEP, Bureau of District Mining Operations, PO Box 669, Knox, PA 16232
CARLIN, Sherry, Watershed Mgr.; GILLEN, Timothy, PG; BOWMAN, Roger, Eng.; PLESAKOV, James, MCI; ELICKER, Theresa, MCI; VanDYKE, Timothy, Insp. Supervisor; ODENTHAL, Lorraine, Permit Chief; MIRZA, Javed, Dist. Mining Mgr. (814) 797-1191

Stream Monitoring

Grove City College, 100 Campus Drive, Grove City, PA 16127
BRENNER, Frederick, PhD, Biologist, Biology Dept. (724) 458-2113

Urban Wetland Institute, [non-profit] 789 North Liberty Road, Grove City, PA 16127
BRENNER, Frederick, PhD, President (724) 748-4310

Topographic Base Mapping

PADEP, Bureau of Abandoned Mine Reclamation, PO Box 669, Knox, PA 16232
LINNAN, Paul, Chief, Field Ops.; STEFANKO, John, PE, AMD Abatement (814) 797-1191

Surveying

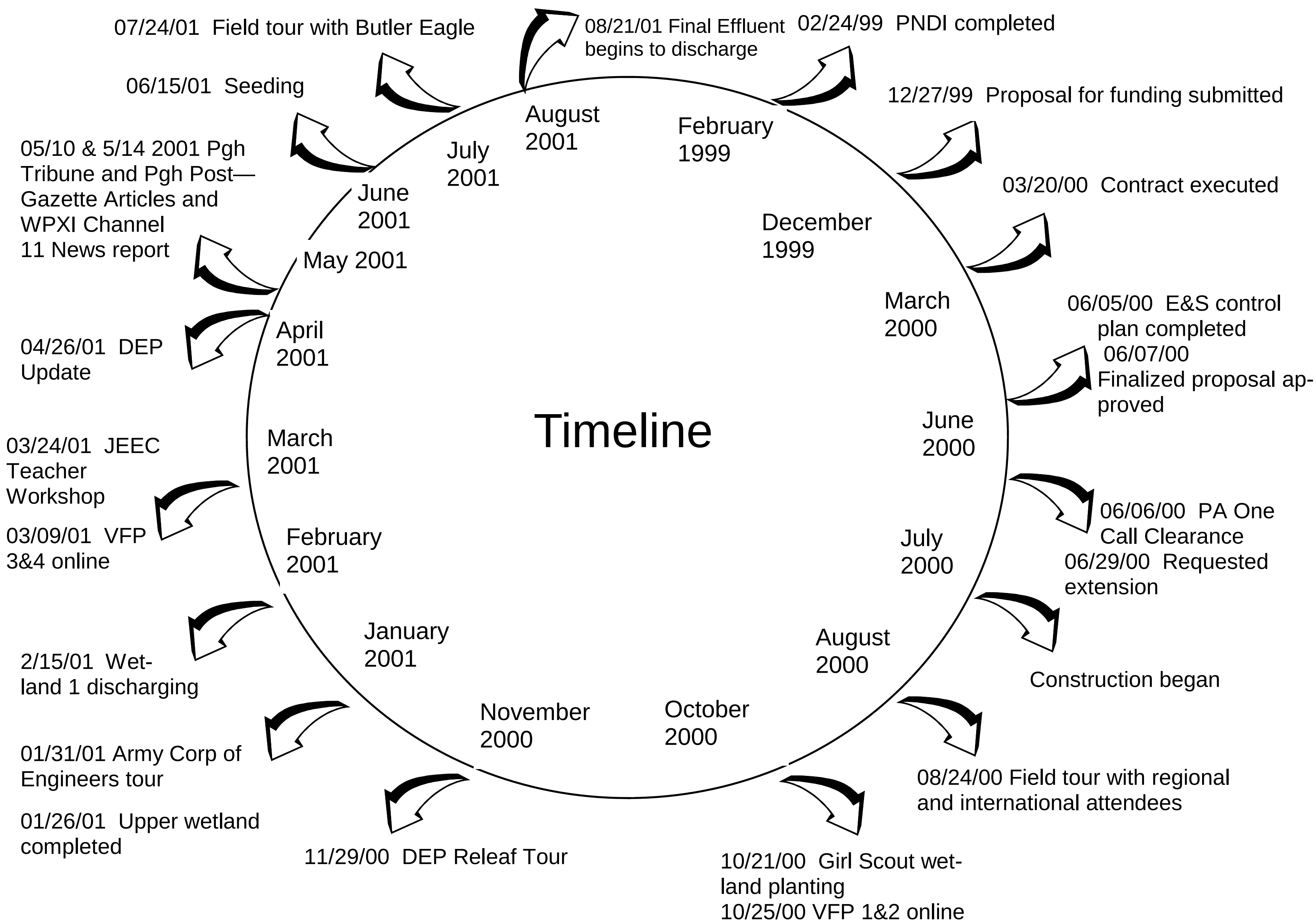
Jack R. Chamberlin Surveying & Consulting, 128 Chamberlin Rd., Brookville, PA 15825
CHAMBERLIN, Jack, PLS (814) 849-4181

Grant Administration and Public Outreach

Stream Restoration Incorporated, [non-profit] 3016 Unionville Rd., Cranberry Twp., 16066
DANEHY, Timothy, EPI; DUNN, Margaret, PG; BUSLER, Shaun, Biologist; DENHOLM Cliff, Env. Scientist; FUNKHOUSER, Deanna, Communications; (724) 776-0161

Goff Station Restoration Area

Selected Highlights



Comprehensive Timeline

DEP Inspection
Tour
News Item

Date	Description
prior to 12/27/99	Water sampling, site investigation, planning
12/27/99	Growing Greener grant submitted
01/14/00	Revised grant submitted
01/14/00	Growing Greener grant awarded
01/19/00	Field meeting for the passive treatment system development plans
02/02/00	Field meeting, site investigation, and development of design plans
03/29/00	Contract forms received
04/15/00	Grant executed
04/17/00	Water sampling and site investigation
04/19/00	Field meeting and site investigation to choose location for bat hibernaculum
04/24/00	Environmental Assessment for Restoration Waiver submitted
05/26/00	E&S control plan submitted
06/01/00	Field meeting to review E&S plan
06/16/00	Notice of Intent submitted
06/26/00	Field meeting to discuss construction plans
06/27/00	Meeting to review E&S plan
06/27/00	Restoration waiver approved
06/28/00	Revised E&S control plan submitted
07/05/00	Field meeting to review 38/39 PTS plan; E&S Plan approval
07/17/00	Field meeting
07/20/00	Construction of 38/39 VFP 1 & 2 begins; DEP insp.(T. Elicker, MCI)
07/21/00	Water sampling
07/22/00	Beavers removed by PA Game Commission
07/24/00	Field meeting; DEP insp. (T. Elicker, MCI)
07/31/00	Field meeting; VFP 1 & 2 excavated to grade; DEP insp. (T. Elicker, MCI)
08/07/00	DEP insp. (T. Elicker, MCI)
08/14/00	DEP insp. (T. Elicker, MCI)
08/17/00	DEP insp. (T. Elicker, MCI)
08/21/00	Field meeting; limestone placement VFP 1 & 2; DEP insp. (T. Elicker, MCI)
08/24/00	USGS Tour with international visitors (~15 visitors); DEP insp. (T. Elicker, MCI); lower underdrain being installed; reported in 09/00 “Catalyst”
08/28/00	DEP insp. (T. Elicker, MCI)
08/31/00	DEP insp. (T. Elicker, MCI)
09/05/00	DEP insp. (T. Elicker, MCI)
09/08/00	DEP insp. (T. Elicker, MCI)
09/11/00	Field meeting; DEP insp. (T. Elicker, MCI)
09/12/00	Meeting at Knox DMO
09/14/00	DEP insp. (T. Elicker, MCI)
09/18/00	Field meeting; DEP insp. (T. Elicker, MCI)
09/21/00	DEP insp. (T. Elicker, MCI)
09/25/00	Field meeting; DEP insp. (T. Elicker, MCI)
09/28/00	Field meeting to review pipe installation; DEP insp. (T. Elicker, MCI)

Date	Description
10/02/00	Field meeting; DEP insp. (T. Elicker, MCI)
10/05/00	DEP insp. (T. Elicker, MCI)
10/10/00	DEP insp. (T. Elicker, MCI)
10/12/00	DEP insp. (T. Elicker, MCI)
10/13/00	Growing Greener Conference; Power Point presentation
10/16/00	Field meeting; DEP insp. (T. Elicker, MCI)
10/20/00	Educational program and wetland plants harvesting with Junior Girl Scouts Troop 653 by Bob Beran of Aquascape; DEP insp. (T. Elicker, MCI)
10/21/00	Wetland #1 of the 38/39 system planted by Girl Scout Troop 653, Aquascape, Quality Aggregates Inc., and Stream Restoration
10/23/00	DEP insp. (T. Elicker, MCI)
10/25/00	VFP 1 & 2 for ST38/39 system on-line(receiving influent); DEP insp. (T. Elicker, MCI)
10/27/00	38/39 seeded
10/28/00	Closed 39 pit breech
10/30/00	Field meeting; ST41 Upper Wetland construction begins; DEP insp. (T. Elicker, MCI)
11/03/00	DEP insp. (T. Elicker, MCI)
11/06/00	Field meeting; DEP insp. (T. Elicker, MCI)
11/08/00	DEP insp. (T. Elicker, MCI)
11/09/00	DEP Stream Releaf Tour (>40 visitors); reported in 12/00 "Catalyst"
11/13/00	Construction of 40/42 VFPs begins; DEP insp. (T. Elicker, MCI)
11/17/00	DEP insp. (T. Elicker, MCI)
11/20/00	Field meeting; DEP insp. (T. Elicker, MCI)
11/28/00	Email status report
11/29/00	DEP insp. (T. Elicker, MCI)
12/04/00	Field meeting; VFP3 rough excavation complete; VFP4 excavation begins; DEP insp. (T. Elicker, MCI)
12/13/00	Wetland quarry fines & off-site hydric soils placement; VFP1 discharging; DEP insp. (T. Elicker, MCI)
12/17/00	Pittsburgh Post-Gazette article featuring Vertical Flow Ponds
12/18/00	VFP2 discharging; Wetland1 spillway lined; DEP insp. (T. Elicker, MCI)
12/22/00	VFP2 final graded; VFP4 final grading; SP1 discharging; DEP insp. (T. Elicker, MCI)
12/29/00	VFP1 receiving all 38/39 flow; VFP2 pipes frozen being replaced; limestone ditch to convey discharge to 41 WL; DEP insp. (T. Elicker, MCI)
12/ – /00	Restoration activities placed on SRWC website; reported in 01/01 "Catalyst"
01/08/01	Field meeting; VFP3 geotextile & #57 placed; 41 WL conveyance ditch completed; DEP insp. (T. Elicker, MCI)
01/11/01	VFP4 geotextile & #57 placed; VFP3 lower underdrain; VFP1 no inflow VFP2 refilling; DEP insp. (T. Elicker, MCI)
01/15/01	Field meeting; grading substrate in ST41 Upper Wetland; placing upper tier of piping in Vertical Flow Pond #3

Date	Description
01/18/01	VFP3 #1 placed; VFP4 u'drain installed; Grading of 41 WL complete; Placement of materials for 41 WL almost complete; DEP insp. (T. Elicker, MCI)
01/22/01	New seepage discovered near 40; attempt to seal seep with Bentafix unsuccessful; 40A seepage discovered during removal of gob to be combined with new seep and conveyed to 40/42 PTS; VFP4 #1 over lower tier; Field meeting; DEP insp. (T. Elicker, MCI)
01/26/01	VFP3 upper layer #1 placed; 38/39 Wetland1 discharging; DEP insp. (T. Elicker, MCI)
01/28/01	VFP4 upper u'drain complete
01/29/01	Field meeting
01/31/01	Army Corp of Engineers tour site (3 visitors); 02/01/01 letter of appreciation
02/02/01	VFP3 southern berm complete; DEP insp. (T. Elicker, MCI)
02/05/01	Field meeting; VFP4 upper layer #1 complete; DEP insp. (T. Elicker, MCI)
02/14/01	Settling Pond completed
02/15/01	FP1 complete; constructing collection system for 40/42; Wetland1 20 gpm discharge; DEP insp. (T. Elicker, MCI)
02/23/01	DEP insp. (T. Elicker, MCI)
03/02/01	Wetland2 under const.; VFP4 compost placed; VFP1 filling; VFP2 all 8 pipes discharging; DEP insp. (T. Elicker, MCI)
03/03/01	Junior Girl Scout Troop 653 installed bluebird boxes that they built
03/05/01	clean-outs on ST40 piping (~100' intervals); DEP insp. (T. Elicker, MCI)
03/09/01	VFP3 & 4 riprap placement spillway & outlet; Upper WL discharging; DEP insp. (T. Elicker, MCI)
03/16/01	Grading of WL2 almost complete; Eastern berm of Final WL compacted; DEP insp. (T. Elicker, MCI)
03/19/01	DEP insp. (T. Elicker, MCI)
03/24/01	Jennings Env. Ed. Center Teacher Workshop and Tour (~50 visitors)
03/27/01	Cement blocks installed in WL1 to control water level; Excavating completed for bat hibernaculum; DEP insp. (T. Elicker, MCI)
03/ – /01	Bat Hibernaculum & SRWC field tour announced in 04/01 "Catalyst"
04/02/01	Field meeting; Grading between final WL and stream complete; DEP insp. (T. Elicker, MCI)
04/06/01	Slippery Rock Watershed Coalition's Symposium Field Tour (~70 visitors); reported in 05/01 "Catalyst"
04/13/01	Hydric substrate trucked in; Final WL grading; Plunge pond built; DEP insp. (T. Elicker, MCI)
04/16/01	Field meeting; DEP insp. (T. Elicker, MCI)
04/20/01	Bat hibernaculum covered; DEP insp. (T. Elicker, MCI)
05/01/01	VFP1&2 discharging; final wetland under const.; DEP insp. (T. Elicker, MCI)
05/07/01	Field meeting; Final WL Muskrat fence installed ; DEP insp. (T. Elicker, MCI)
05/08/01	DEP insp. (T. Elicker, MCI)
05/10/01	Pittsburgh Tribune Review article about bat hibernaculum
05/14/01	Pittsburgh Post-Gazette article about bat hibernaculum WPXI Channel 11 news broadcast about bat hibernaculum

Date	Description
05/15/01	Final WL settling basin being installed; Growth in 41 WL; DEP insp. (T. Elicker, MCI)
05/19/01	Junior Girl Scout Troop 653 wetland planting
05/21/01	Field meeting; Hydric substrate being placed in Final WL; Water flowing into VFP3&4; DEP insp. (T. Elicker, MCI)
06/01/01	Karns City first graders hands-on tour/education program; Final WL embankment in place; Bioswale built; DEP insp. (T. Elicker, MCI)
06/05/01	Water Sampling
06/11/01	Extension request submitted
06/15/01	Seeding and mulching of site; DEP insp. (T. Elicker, MCI)
06/18/01	Extension request granted
06/26/01	Butler County Juvenile Court WORC program wetland planting
06/28/01	grasses growing; Trees planted; Bioswale planted; ST42 collected and flowing to VFP 3&4; DEP insp. (T. Elicker, MCI)
06/–/01	Participants in national ASMR conf. express interest in bat hibernaculum; reported in 07/01 “Catalyst”
07/17/01	Butler County Juvenile Court WORC program wetland planting
07/17/01	Site inspection
07/18/01	PA DEP Watershed Academy Tour (>60 visitors); reported in 08/01 “Catalyst”
07/19/01	Riparian design submitted to PADEP; DEP insp. (T. Elicker, MCI)
07/23/01	ST41 flow directed to Upper Wetland
07/27/01	All discharges flowing through system; All wetlands have good growth; Gates placed across deep mine entries and bat hibernaculum; DEP insp. (T. Elicker, MCI)
07/–/01	“The Kids Catalyst” activity on bat hibernaculum
08/06/01	Dr. Fred Brenner, Grove City College students, & volunteers conduct fish survey of Murrin Run and Seaton Creek; reported in 09/01 “Catalyst”
08/21/01	Discharges flowing through system & final wetland discharging; Flow measuring device being installed at outlet of Final WL; Riparian area planted; DEP insp. (T. Elicker, MCI)
08/30/01	Mist-netting for bats and tour (~25 visitors); reported in 10/01 “Catalyst”;
08/31/01	Wrap-up meeting
08/08/01	Shamokin Watershed Group tour (~12 visitors); reported in 09/01 “Catalyst”
09/06/01	School teacher & youth save turtle and free in wetland; reported in 10/01 "Catalyst"
09/13/01	Final WL flow measuring device installed; DEP insp. (T. Elicker, MCI)
09/18/01	Water sampling
09/26/01	Butler Co. Env. Quality Board tour (4 visitors); reported in 11/01 “Catalyst”
09/28/01	Jennings Environmental Education Center Workshop/Tour; PASDA Tour; reported in 11/01 “Catalyst”
10/16/01	DEP insp. (T. Elicker, MCI)
11/08/01	Water sampling and site investigation
11/15/01	DEP insp. (T. Elicker, MCI)
11/26/01	Watershed Weekly features Goff Station Restoration Project

SLIPPERY ROCK WATERSHED COALITION

<u>GOFF STATION RESTORATION AREA FINAL REPORT</u>

Murrin Run, Seaton Creek Watershed, Slippery Rock Creek Headwaters
Venango Township, Butler County, PA

"Making It Happen" through a Public-Private Partnership Effort

<u>A Growing Greener Watershed Restoration Project</u>

<u>PROJECT SUMMARY</u>

<u>**This project exemplifies what can be accomplished by a public-private partnership effort**</u> not only to successfully treat abandoned mine drainage passively but also to develop mine restoration technology, to create unique wildlife habitat, and to expand the cooperative effort including many individuals with diverse interests in a meaningful, state-of-the-art watershed project.

Participants in the Slippery Rock Watershed Coalition received funding from the Pennsylvania Department of Environmental Protection Grant Center through the Growing Greener program. The scope of work described in the proposal was to passively treat degraded drainage (400 gpm maximum aggregate flow) from abandoned underground and surface mines on the Brookville coalbed (Clarion Fm.; Allegheny Gp.) and to restore the riparian buffer along ~500 feet of Murrin Run.

With this grant and generous in-kind contributions, within approximately one year, permitting, design, and construction of a multi-component, multi-faceted restoration project were completed. Through an <u>**increase of in-kind contributors from 7 to 14**</u>, the project was expanded from a fourteen-component passive treatment system to an <u>**innovative, fifteen-component, complex that included the creation of wildlife habitat, unique to the eastern United States.**</u> This expansion effort can be largely attributed to the <u>**unwavering commitment of private industry to this public-private partnership effort eliminating the need of the bid process and change orders.**</u>

The following table identifies a portion of the <u>**project expansion by comparing the scope of work outlined in the proposal with the current accomplishments:**</u>

<table>
<tr><th><u>Original Proposal</u></th><th><u>Current Accomplishments</u></th></tr>
<tr><td>ST38 Collection System</td><td rowspan="2">ST38/39 Combined Collection System
(excavated barriers between strip pits)</td></tr>
<tr><td>ST39 Collection System</td></tr>
<tr><td>ST38 Vertical Flow Pond
<u>Media:</u> 730 tons LS; 110 CY SMC
<u>Bedding:</u> 66 tons LS
<u>Underdrain:</u> 950' piping; 4 valves</td><td rowspan="2">ST38/39 Vertical Flow Ponds 1 & 2

<u>VFP1:</u> <u>Media:</u> 3000 tons LS; 300 CY SMC
<u>Bedding:</u> 245 tons LS
<u>Underdrain:</u> >6500' piping; 8 valves

<u>VFP2:</u> <u>Media:</u> 3000 tons LS; 300 CY SMC
<u>Bedding:</u> 245 tons LS
<u>Underdrain:</u> >6500' piping; 8 valves

[Flow Splitter Box; 2-tiered, 4 cells/tier, underdrain with clean-outs; <u>Totals</u>: 6490 tons LS; 16 valves; >13,000' (~2 ½ miles) piping]</td></tr>
<tr><td>ST39 Vertical Flow Pond
<u>Media:</u> 4,960 tons LS; 660 CY SMC
<u>Bedding:</u> 780 tons LS
<u>Underdrain:</u> 3060' piping; 6 valves</td></tr>
<tr><td>ST38 Wetland
<u>Area:</u> 4,900 SF
<u>Plant Species:</u> 6
<u>Substrate:</u> 150 CY SMC</td><td rowspan="2">ST38/39 Settling Pond 1
<u>Area:</u> 16,000 SF
(Settling of solids and VFP flushing)

ST38/39 Wetland 1
<u>Area:</u> 12,000 SF
<u>Plant Species</u>: 18 (documented by monitoring)
<u>Substrate:</u> salvaged off-site hydric material</td></tr>
<tr><td>ST39 Wetland
<u>Area:</u> 12,700 SF
<u>Plant Species:</u> 6
<u>Substrate:</u> 400 CY</td></tr>
<tr><td>ST41 Wetland
<u>Area:</u> 1 ½ ac.
<u>Plant Species:</u> 6
<u>Substrate:</u> off-site substrate mixed with alkaline pond fines</td><td>ST41 Collection System
(expose underground mine workings and lower mine pool; construct earthen barrier with rip-rap lined channel 500' in length along abandoned highwall to intercept drainage and convey to Upper Wetland)

ST41 Wetland (Upper Wetland)
<u>Area:</u> 38,000 SF
<u>Plant Species:</u> 26 (documented by monitoring)
<u>Substrate:</u> salvaged off-site hydric material mixed with alkaline pond fines</td></tr>
</table>

<table>
<tr><th><u>Original Proposal (cont.)</u></th><th><u>Current Accomplishments (cont.)</u></th></tr>
<tr><td>ST40 Collection System</td><td>ST40/40A Collection System (ST41 option)
(ST40 flow used by bat hibernaculum; ST40A seepage discovered during construction; intake in rip-rap channel from ST41 Upper Wetland for optional combination with ST40/40A)</td></tr>
<tr><td>ST42 Collection System</td><td>ST42 Collection System
(ST42 with other seepage, combined, and conveyed to ST40/40A Collection System)</td></tr>
<tr><td>ST40 Vertical Flow Pond
<u>Media:</u> 560 tons LS; 87 CY SMC
<u>Bedding:</u> 50 tons LS
<u>Underdrain:</u> 960' piping; 4 valves</td><td rowspan="2">ST40/40A/41/42 Vertical Flow Ponds 3 & 4

<u>VFP3:</u> <u>Media:</u> 1120 tons LS
<u>Bedding:</u> 102 tons LS
<u>Underdrain:</u> >3500' piping; 8 valves

<u>VFP4:</u> <u>Media:</u> 1120 tons LS; 141 CY SMC
<u>Bedding:</u> 94 tons LS
<u>Underdrain:</u> >3500' piping; 8 valves

[Flow Splitter Box; 2-tiered, 4 cells/tier, underdrain with 8 valves; <u>Totals:</u> 2,436 tons LS; 16 valves; 7000‘ (>1 1/4 miles) piping]</td></tr>
<tr><td>ST42 Anoxic Limestone Drain
<u>Media:</u> 440 tons LS; inlet and outlet
<u>Manifolds:</u> 125' piping</td></tr>
<tr><td>ST40 Wetland
<u>Area:</u> 1,300 SF
<u>Plant Species:</u> 6
<u>Substrate:</u> 35 CY SMC</td><td rowspan="2">ST40/40A/41/42 Flush Pond 1
<u>Area:</u> 900 SF
(removal of solids during flushing)

ST40/40A/41/42 Wetland 2
<u>Area:</u> 2,100 SF
<u>Plant Species:</u> (not inventoried)

ST40/40A/41/42 Bioswale
<u>Area:</u> 7,000 SF
<u>Plant Species:</u> 10 (documented by monitoring)
<u>Substrate:</u> mixture of peat moss, topsoil, and salvaged hydric soil

(check dams and netting installed)</td></tr>
<tr><td>ST42 Wetland
<u>Area:</u> 500 SF
<u>Plant Species:</u> 6
<u>Substrate:</u> 10 CY SMC</td></tr>
</table>

Original Proposal (cont.)	**Current Accomplishments (cont.)**
ST38/39/40/41/42 Wetland Area: 2 ac. Plant Species: 6 Substrate: off-site substrate with alkaline pond fines	**ST38/39/40/40A/41/42 Final Wetland** Area: 37,000 SF Plant Species: 28 (documented by monitoring) Substrate:; hydric substrate salvaged from mitigation project in nearby county mixed with alkaline pond fines from nearby LS quarry (deeper water inlet drop structure; adjustable outlet control structure; hydrologic connection to riparian restoration area; deeper water areas provide successful fish habitat)
Riparian Restoration	**Riparian Restoration** Area: 1/4-acre Plant Species: 9 (vernal pools; willow wattles for stream bank stablization)
	Bat Hibernaculum (ST40 provides flowing water; risers for temperature regulation; manhole for research; remote temperature sensor; plastic mesh lined for grip; bat gate; 36" culvert pipe 60' length; potential to house 5000 bats; first known facility in eastern United States) **Bluebird, Kestrel, and Bat Boxes** (within the first year most boxes were in use)

Abbrev.: limestone(LS); spent mushroom compost(SMC)
(See detailed description of each effort in body of report.)

Coordination of the manpower and construction equipment, instrumental in the success of this project, was made possible by Quality Aggregates Inc., which is operating a nearby surface mine while also reclaiming an abandoned open strip cut (about ½-mile in length). Abandoned coal refuse from the Goff Station Restoration area (partially funded under a PA DEP WRAP Grant) was placed in the backfill of the abandoned strip cut after incorporation of alkaline, circulating, fluidized-bed coal ash from the Scrubgrass Generating Plant (Kennerdell, PA).

As the ~78,000 CY of abandoned coal refuse piles formed and covered the western bank of Murrin Run, removal allowed for the restoration of the riparian area and creation of the Final Wetland, a shared component of the passive treatment systems.

In order to demonstrate the success of the naturally-functioning wetlands, these systems have been included in the **biomonitoring program**. The **wetlands are extremely successful** supporting **38 plant species** and various aquatic life including **whirligig beetles, water boatmen, water striders, damselflies, dragonflies, toads, frogs, tadpoles, diving beetles, and fish.** **Racoon, fox, deer, and bear tracks** have been observed along the berms and/or within the wetlands with cropped plants indicating foraging.

To evaluate the degree of success in improving the Slippery Rock Watershed on a long-term basis, **Grove City College students and faculty, PA Department of Environmental Protection - Knox District Mining Office personnel, and other participants in the Slippery Rock Watershed Coalition** are continuing to monitor the system and associated streams after the term of the grant. Also as part of biomonitoring, an aquatic survey has demonstrated that **fish (Common Shiner, Brown Bullhead, Johnny Darter)** and macroinvertebrates **(Midge Larva, Caddisfly Larva, Water Striders)** are now present in Murrin Run (due not only to this restoration effort but to remining in the headwaters).

Although current monitoring is during the dry season and during a drought, the analyses indicate that the passive system is extremely successful in treating the abandoned mine drainage.

Raw vs. Treated Water Quality

Drainage	pH	acidity		Fe		Mn		Al	
		mg/l	lbs/day	mg/l	lbs/day	mg/l	lbs/day	mg/l	lbs/day
RAW post-construction (38/39/40/40A/41/42)	3.6	104	80	20	15	3	2	7	5
TREATED post-construction (38/39/40/40A/41/42)	6.5	0	0	<1	0	<1	<1	<1	<1

Weighted average based on flow/sampling event for raw; average values; total metals; H ion concentrations not used in determining average pH (See additional explanation in body of report.)

The average **alkalinity in the final effluent is about 30 mg/l.** This data indicates that the passive treatment complex is **100% effective in neutralizing the acidity** and is **almost 100% effective in preventing all metals (Fe, Mn, Al) from entering Murrin Run.**

Based on historical monitoring of the discharges and continued functioning of the Goff Station passive treatment system, an estimated average of **83,900 lbs/year (42 tons/year) of acidity and 13,200 lbs/year (7 tons/year) of metals** are expected to be eliminated from the stream. With the combined improvement from previous reclamation efforts such as Chernicky, De Sale Phase I & II and future reclamation efforts such as Erico Bridge and De Sale Phase III, **Seaton Creek, the most heavily-impacted tributary in the headwaters, is expected to be substantially improved from the uppermost reaches to its confluence with Slippery Rock Creek or over 7 stream miles.**

In addition to the successes in watershed restoration, **of great importance to the Slippery Rock Watershed Coalition and to the sustainability of the entire watershed restoration effort is public outreach and environmental education opportunities for all age groups and interest levels.** Since initiation of this project, **12 site tours and workshops** have been conducted with an **attendance totaling over 400.** The Slippery Rock Watershed Coalition is particularly proud of including "hands-on" restoration projects. **Girl Scout Troop #653** have planted wetlands and constructed, installed, and monitored Bluebird and Kestrel boxes. Through the **Butler County Juvenile Court Working Opportunities to Repay the Community Program**, adjudicated youth carried and hand-placed fabricated soil in the Bioswale and planted wetlands. In addition, residents of the **Concordia Haven Retirement Center** constructed bat boxes from designs provided by the PA Game Commission.

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INTRODUCTION

In northern Butler County in western Pennsylvania, coal mining has been conducted in a 27-sq. mi. area of the Slippery Rock Creek headwaters for over 100 years. Mining communities which once flourished have been abandoned leaving polluted streams, coal refuse, and spoil. Historically, watershed residents called Slippery Rock Creek, “Sulfur Creek”, due to the affects of mine drainage. In 1970, during the Commonwealth’s Operation Scarlift, the quality of the headwaters was documented to be “the most severe condition of coal mine drainage... . Indeed, very little drainage from this region is produced exclusive of contact with, or issuance from mine workings.” About 4000 acres (25% of the area) are underlain by mine workings and 8000 acres (50% of the area) were included in surface mine permits. Streambed sediments in this headwaters area were documented in an unpublished report by Dr. Ferenc Suzc, Geochemist (retired), Slippery Rock University, as having the highest heavy metal concentration within the 300-square mile Slippery Rock Creek Watershed.

Since late 1994, the Slippery Rock Watershed Coalition has worked to restore the headwaters and has successfully constructed thirteen passive treatment systems. These systems are treating over 500 million gallons per year of abandoned mine drainage (AMD) from 16 discharges and removing about 150 tons of iron, 8 tons of aluminum, and 182 tons of acidity annually from Slippery Rock Creek, a public water supply for the downstream community of Ellwood City. Each year, that is the amount of iron and aluminum in approximately 150 small trucks and 273,333 aluminum soda cans. In addition, about 100 acres of abandoned mine lands have been reclaimed to productive farms or wildlife habitat, while over 10 acres of wetlands have been created. These efforts have resulted in an amazing improvement in water quality demonstrated by the return of fish in six miles of streams in the Slippery Rock Creek headwaters, probably for the first time in a hundred years. According to the PADEP, Knox DMO, 2001 Progress Report for this area, over 11 miles of streams have been improved.

The Goff Station Restoration Area was identified in the Pennsylvania Department of Environmental Protection, Knox District Mining Office, 1988, Comprehensive Mine Reclamation Strategy (CMRS) as being one of the 10 major areas of abandoned minelands impacting the Slippery Rock Creek headwaters.

Goff Station (aka Deegan), a small unincorporated community, was historically a mining town and railroad stop. Both surface and underground mining activities were conducted here. The Middle Kittanning coalbed (Kittanning Fm.; Allegheny Gp.) was mined on the hilltops, cropping at an elevation of ~1430 feet with the Brookville (aka Clarion) coalbed (Clarion Fm.; Allegheny Group) mined in the valleys, cropping at an elevation of ~1275 feet. Piles of coal refuse from an abandoned drift mine on the Brookville coalbed were dumped in Murrin Run, defining the western bank and riparian area. These piles contained acid-producing materials and contributed to the acid, metal, and sediment loading of Murrin Run and subsequently Seaton Creek. In addition, several discharges from the abandoned pre-act surface mine and old underground workings associated with the Brookville coalbed flowed into Murrin Run.

Due to the large scale of the project and the extensive, interdisciplinary contributions needed to provide optimal restoration, numerous groups and individuals participated in the efforts. Indeed, the restoration of Goff Station demonstrates the ability of a public-private partnership effort to accomplish common goals. Participants included 5 private companies, 4 government agencies, a private college, and two non-profits with assistance from other service groups.

In all, there were four separate, yet interconnected, projects. The Goff Station Restoration Area included two projects located west of Murrin Run;- (1) the removal, neutralization and placement of coal refuse piles, and (2) the abatement of abandoned mine discharges; and, two projects located east of Murrin Run;- (3) the Tiche Abandoned Mine Reclamation Project, consisting of backfilling an old abandoned cut on the Brookville coalbed and incorporating coal ash for acid neutralization, and (4) the project which provided the catalyst for all the restoration efforts, the reactivation of a long-inactive surface mine on a non-banded coal correlative with the Middle Kittanning coalbed by Quality Aggregates Inc. Because of the proximity of all the sites, the reactivation of the neighboring surface coal mine, provided a window of opportunity, although very limited, to share equipment and manpower among all of the projects. Travel costs and projected multiple mobilization/demobilization costs were essentially eliminated. Without this partnership, innovative, timely, and cost-effective restoration would not have been possible.

<u>Phase I: Coal Refuse Removal coordinated with Tiche Abandoned Mine Reclamation</u>
Funding was received in 1999 through a PA DEP Watershed Restoration and Assistance Program (WRAP) grant to remove and dispose of 20,000 cubic yards of coal refuse on the west bank of Murrin Run identified in the PA DEP's Comprehensive Mine Reclamation Strategy (CMRS). The proposal included constructing a temporary crossing and transporting the material a few hundred yards across Murrin Run, mixing alkaline, circulating, fluidized-bed, coal ash from the Scrubgrass Generating Plant (Kennerdell, PA), and incorporating the material in the 330,000 cubic yards of backfill needed to reclaim the abandoned open cut (highwall height ~40 to 60 feet) on the Brookville coalbed east of Murrin Run. The reclamation of the old cut, known as the Tiche Abandoned Mine Reclamation Project, is being conducted under a 09/29/99 Consent Order and Agreement between the PADEP and Quality Aggregates Inc. and is currently being used for the placement of other coal refuse from the Erico Bridge Restoration Area. Due to the presence of iron sludge and additional coal waste material encountered during excavation, the quantity of waste material handled was more than tripled to 78,000 cubic yards. This would have typically posed a significant threat to the project, but, due to the strong partnerships and in-kind contributions, work was continued without change orders and at no additional cost to the Commonwealth. Further description of the effort is included in the previously submitted final report for the WRAP grant.

Phase II: Passive Treatment of Abandoned Discharges

The second phase of the restoration effort was the abatement of six abandoned mine discharges associated with historical mining activities on the Brookville coalbed through the use of passive treatment technology. These discharges based on monitoring data in the PADEP CMRS had combined flows averaging ~400 gpm and contributed about 83,900 lbs/yr of acidity and 12,600 lbs/yr of metals to Murrin Run. Other drainage was intercepted during construction and passively treated. This restoration effort has been substantially expanded to include numerous innovations and unique wildlife habitat. This is the Final Report for this restoration effort.

Combined Environmental Benefits with Other Projects

Completion of these three reclamation projects combined with previous (De Sale Phases I and II) and current (Erico Bridge and De Sale Phase III) efforts is predicted to significantly improve not only receiving tributaries but also the entire length of Seaton Creek to its confluence with Slippery Rock Creek or about 11 miles of streams.

SITE DESCRIPTION AND LOCATION

The 35-acre Goff Station Restoration Area is located within the Slippery Rock Creek headwaters in Venango Township, Butler County, PA along and west of Murrin Run approximately 2,500 feet north of its confluence with Seaton Creek. Access to the site is from North Erico Road (T-540) approximately 2,000 feet south of the intersection with SR 58. A temporary road crossing was approved and installed to span Murrin Run as part of Phase I in order to access the property and to haul coal refuse to the Tiche Abandoned Mine Reclamation site. The Phase II site is located on property of John Hindman. The pre-construction landuse was unmanaged forestland and recreation (hunting and ATV trails) on an abandoned minesite. Logging was recently conducted. The post-construction landuses are unique wildlife habitat and mine drainage treatment. There is currently no residence or private water supply on the property. **(See location on Slippery Rock Creek Target Area map.)**

SLIPPERY ROCK CREEK TARGET AREA

Goff Station (2001)
Four Vertical Flow Systems
Acid Removed: 7,258 lbs/mo
Fe Removed: 417 lbs/mo
Al Removed: 367 lbs/mo
Bat Hibernaculum
Naturally-Functioning Wetlands

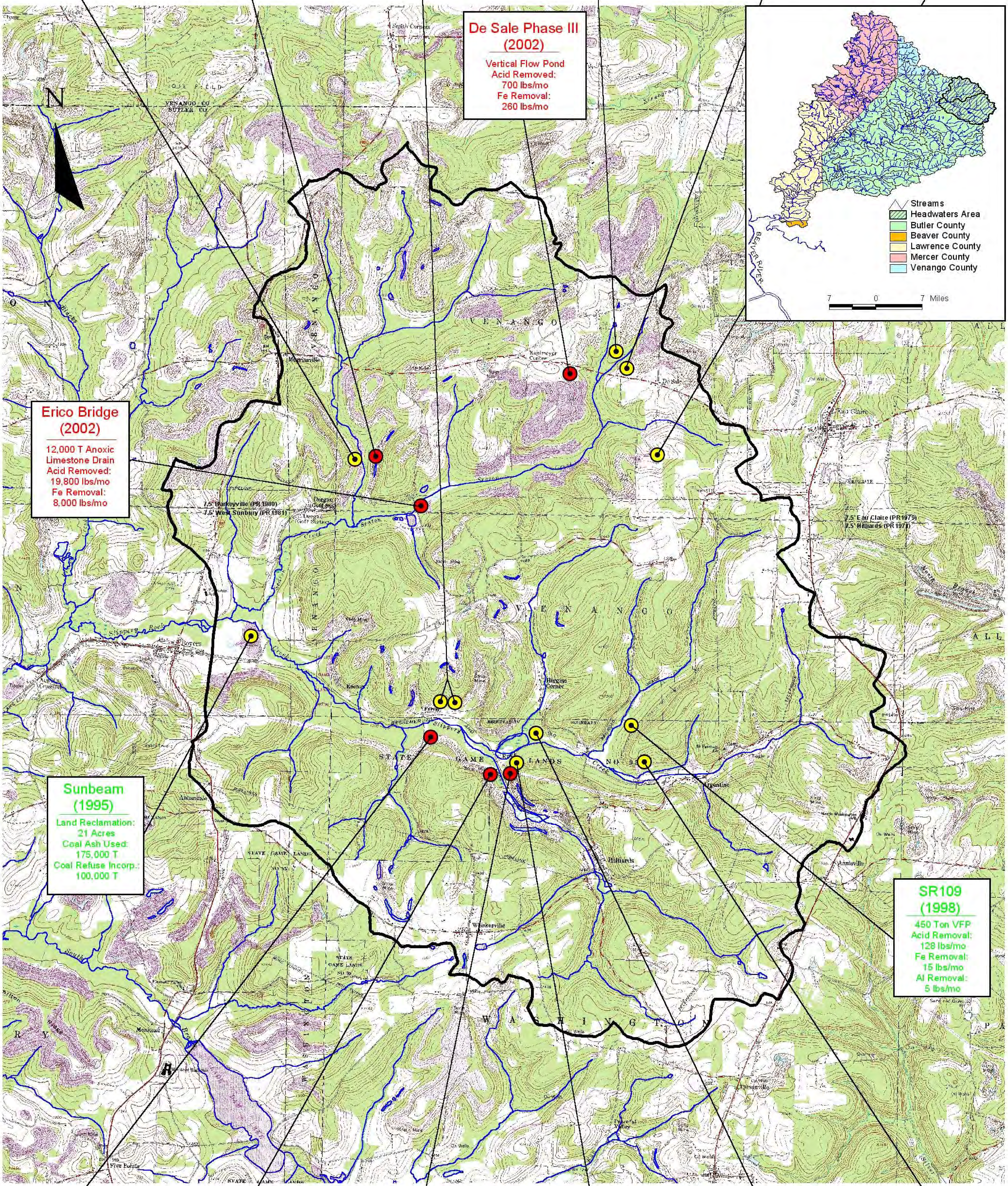
Brookville Pit (2002)
Land Reclamation: 20 Acres
Coal Ash Used: 200,000 Tons
Coal Refuse Incorporated: 94,000 T

Ferris Complex (1997)
Four Vertical Flow Systems
Acid Removed: 12,078 lbs/mo
Fe Removed: 437 lbs/mo
Al Removed: 372 lbs/mo

DeSale Phase II (2001)
4,400 Ton VFP
Acid Removed: 5,561 lbs/mo
Fe Removed: 249 lbs/mo
Al Removed: 218 lbs/mo

DeSale Phase I (2000)
3,000 Ton VFP
Acid Removed: 5,371 lbs/mo
Fe Removed: 1029 lbs/mo
Al Removed: 225 lbs/mo

Chernicky (1998)
Land Reclamation: 58 Acres
Coal Ash Utilization
Abandoned Open Pits Reclaimed



SR81(2002)
1,300 Ton ALD
Acid Removed: 173 lbs/mo
Fe Removed: 25 lbs/mo

SR96 (2002)
700 Ton ALD
Acid Removed: 292 lbs/mo
Fe Removed: 78 lbs/mo

SR89 (2002)
2,100 Ton VFP
Acid Removed: 7,127 lbs/mo
Fe Removed: 1,188 lbs/mo
Al Removed: 190 lbs/mo

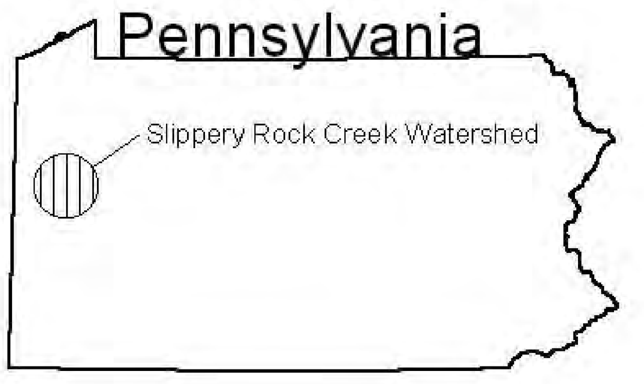
Big Bertha (1996)
900 Ton ALD
Acid Removed: 548 lbs/mo
Fe Removed: 740 lbs/mo

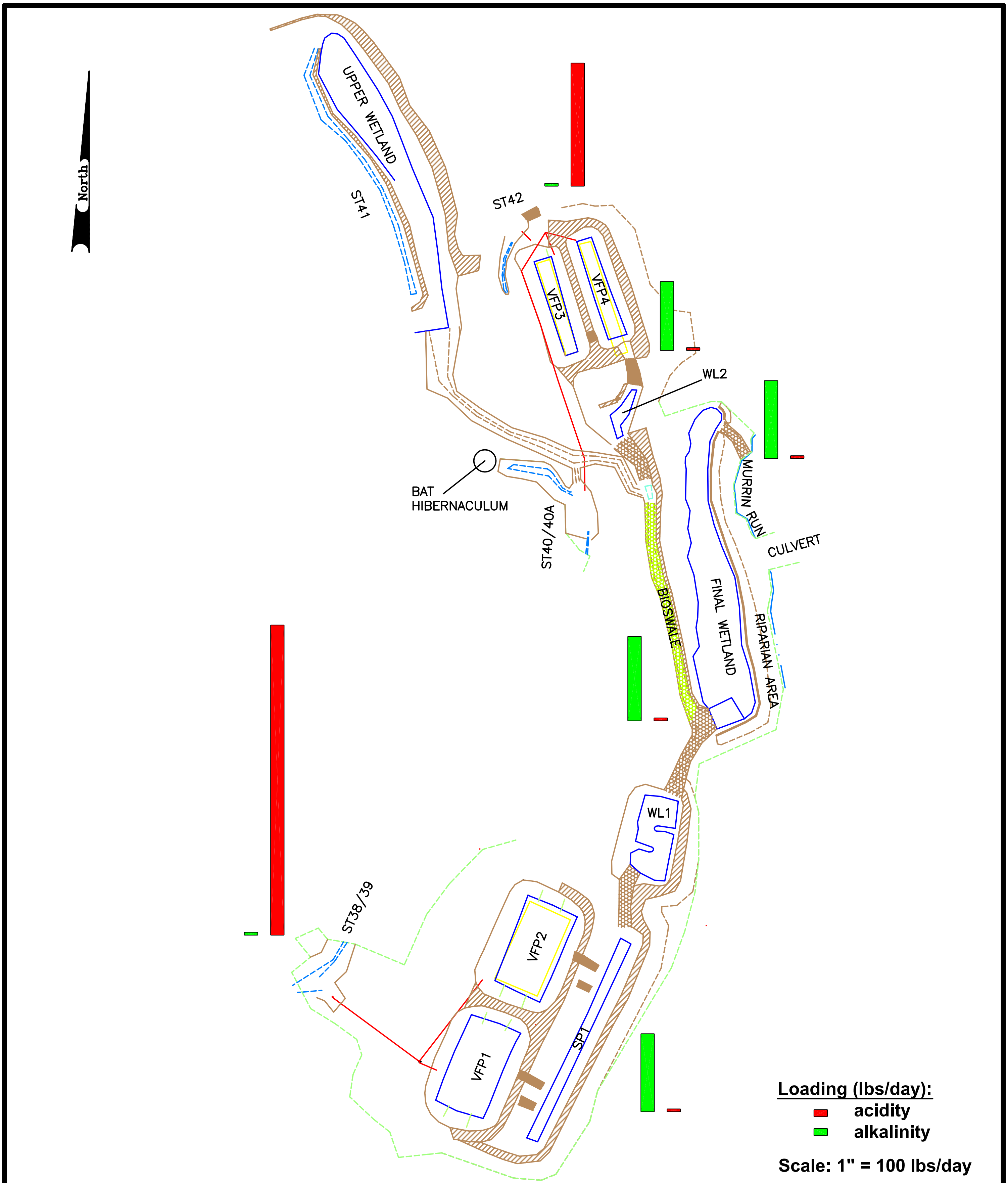
SR101A (1998)
900 Ton ALD
Acid Removed: 1,644 lbs/mo
Fe Removed: 800 lbs/mo

SR114 (1995)
1,450 Ton ALD
Acid Removed: 3,289 lbs/mo
Fe Removed: 2,566 lbs/mo

COMPLETED PROJECT
PROJECT UNDER CONSTRUCTION
Headwaters Study Area
Stream

2000 0 2000 4000 Feet





"Snapshot" (01/25/02) of alkalinity and acidity through Goff Station Passive Treatment System.

BioMost Inc/102903/System Performance1

PRE-EXISTING CONDITIONS

As noted earlier, the coal refuse, previously removed through a public-private partnership effort utilizing a PA DEP WRAP grant, left a large "footprint" that was used to create the final polishing wetland under this Growing Greener grant. Removal of the coal refuse had eliminated one source of sediment and acidic metal-bearing material to Murrin Run; however, abandoned mine discharges continued to degrade Murrin Run. These discharges had been identified by the Commonwealth as ST38, ST39, ST40, ST41, and ST42. These five discharges have a combined average flow of approximately 400 gpm contributing around 83,900 lbs/yr of acidity and 13,200 lbs/year of metals into Murrin Run. ST40A and other seeps were discovered during construction and included in the passive treatment systems. Murrin Run often has a "milky" color as a result of aluminum hydroxide solids from numerous abandoned mine discharges.

The mine discharges identified as ST38-ST41 issue from the abandoned Annandale #2 deep mine on the Brookville coalbed and flow into abandoned open strip cuts remaining from a pre-act surface mine also conducted on the Brookville coalbed. ST42 emanates from the toe of spoil, cast below the coal crop, and is also thought to be hydrologically related to the underground mine workings.

Pre-Restoration Drainage Characteristics
(average/"worst case")

Point	Flow (gpm)	pH (s.u.)	Alkalinity (mg/l)	Acidity (mg/l)	Fe (mg/l)	Mn (mg/l)	Al (mg/l)
ST38	35/78	3.4/3.0	0/0	106/208	9/32	2/3	7/14
ST39	203/564	3.6/3.3	0/0	58/138	3/15	2/3	3/11
ST40	38/50	3.7/3.3	0/0	39/114	2/9	2/3	2/5
ST41	72/331	4.2/3.5	4/0	31/64	1/6	2/3	1/3
ST42	37/50	5.1/4.0	12/3	18/46	2/4	1/2	1/1

Note: values as reported in PADEP, 1998, CMRS, Slippery Rock Creek Watershed Mine Drainage Abatement Area; total metal concentrations; $n_{(ST38)}$ = 17(01/30/96 to 07/10/97); $n_{(ST39)}$ = 26(10/13/94 to 10/09/97); $n_{(ST40)}$ = 20(06/07/95 to 02/11/97); $n_{(ST41)}$ = 24(06/07/95 to 10/09/97)

The PADEP Murrin Run upstream (#13) and downstream (#18) monitoring points are located about 3/4 mile above and 1/4 mile below the final effluent from the passive treatment systems. Flow data for Murrin Run was not available. Influences from tributaries, base flow, and other drainage may also have an impact on the stream quality. Pollutant loadings, however, based on measured flow rates and water monitoring data for the abandoned mine discharges (See preceding table.) can be used to describe the impact of the drainage on Murrin Run.

Pre-Restoration Pollutant Loadings From Site Drainage to Murrin Run

Point	Acidity (lbs/yr)	Iron (lbs/yr)	Manganese (lbs/yr)	Aluminum (lbs/yr)
ST38	16,300	1,400	300	1,100
ST39	51,600	2,700	1,700	2,700
ST40	6,700	300	300	300
ST41	8,500	600	600	600
ST42	800	300	300	0
Totals	**83,900**	**5,300**	**3,200**	**4,700**

Based on average values reported in PADEP, 1998, CMRS, Slippery Rock Creek Mine Drainage Abatement Area.

PROJECT DEVELOPMENT

Timing of Pre-Construction Applications

Permits, Approvals, Contracts, Notifications	Date Submitted	Date Approved	Approval Agency	Project Partner
Endangered/Threatened Birds/Mammals; State Game Lands impacts	02/04/99	02/17/99	PA Game Commission	Aquascape
PA Natural Diversity Index (007292)	02/04/99	02/24/99	PA Department of Conservation and Natural Resources	Aquascape
Natural Resources of Special Concern; Federal Listed/Proposed Species	02/04/99	03/03/99	US DOI Fish and Wildlife Service	Aquascape
Endangered/Threatened Reptiles/Amphibians/ Fishes/Invertebrates	02/04/99	03/09/99	PA Fish and Boat Commission	Aquascape
Archeological Resources (ER99-0959-121-A)	02/04/99	03/08/99	PA Historical and Museum Commission	Aquascape
Growing Greener Grant	12/27/99	01/14/00	DEP Grants Center	all
Landowner Support Letter	-----------	01/07/00	Jack Hindman	SRI/ landowner
State Contract	04/15/00	06/02/00	Commonwealth of PA	SRI
Environmental Assessment	04/24/00	06/27/00	DEP Bureau of Water Management	Aquascape
E&S Control Plan (NPDES PAR10E128)	05/26/00	07/05/00	Butler County Conservation District	BMI
NPDES Application Notification	06/16/00	------------	Butler County Commissioners	BMI
NPDES Application Notification	06/16/00	------------	Venango Township Supervisors	BMI
Compliance Review	06/29/00	------------	PADEP Bureau of Office Systems & Services	SRI

Other Pre-Construction Tasks

- As part of the partnership effort, the Pennsylvania Department of Environmental Protection Bureau of Abandoned Mine Restoration provided topographic mapping from recent aerial photography (02/16/99). This was an extremely important contribution for the expeditious development of the site plans.

- The wetland waiver was received with the assistance of the PA DEP, Knox District Mining Office. Road bonds and permits were handled by Quality Aggregates Inc.
- Passive system design plans submitted by BioMost, Inc. and WOPEC were reviewed by the PA DEP, Knox District Mining Office.

- PA One Call (14711500) relating to underground utilities was contacted and the response was “no involvement”; however, a high-pressure gas line limits the southern extent of the construction area and an overhead electric line traverses the site (northwest-southeast). These facilities were taken into consideration during design of the passive treatment systems.

Use of Existing Facilities

The access road and stream crossing to the site were previously constructed as part of the coal refuse removal project funded through the PA WRAP grant program.

Site Preparation

Erosion and Sedimentation Pollution Controls, constructed after plan approval, primarily consisted of filter fabric installed below the construction area and a diversion ditch(DD1D), more than 2100 feet in length, located above the construction area.

The disturbance area was selectively cleared and grubbed with mature trees left to enhance the post-construction wildlife habitat, particularly in relation with the bat hibernaculum, an “outgrowth” project expanding the restoration effort.

PASSIVE TREATMENT SYSTEM INSTALLATION

The passive treatment system complex at the 35-acre Goff Station Restoration Area essentially consists of fifteen components, some of which are shared, by three passive systems treating six abandoned mine discharges (ST38, ST39, ST40, ST40A, ST41, and ST42) and small unlabeled seeps. The combined maximum flow (See previous table.) reported in the CMRS is over 1000 gpm and the minimum is 85 gpm. This is more than a 10-fold variation in flow. The quality of the discharges does not appear to be as variable; metal concentrations were generally low to moderate in all discharges, not exceeding 35 mg/l. The pH was characteristically between 3 and 4 with moderate acidity, generally not exceeding 200 mg/l. An innovative facility was designed to provide acceptable long-term, low-maintenance, environmentally-friendly, treatment during both low and high flow periods and to provide exceptional wildlife habitat and to restore the riparian area. Of equal importance to the participants in the project, the facility was also designed and installed to provide unique educational and public outreach opportunities. (See schematic view of the entire system.)

Description of Passive Treatment Components

Discharge ST#	Component	Description
38, 39	38/39 Collection System	18" perf. riser in collection pond; 700', 10", SDR35, pipe to Inlet Control Structure
	Vertical Flow Ponds 1 & 2	VFP1 & 2 Inlet Control Structure - Type M concrete box (5'Lx 3'Wx 3½'H) with two, 8", pipes (1 ea. to VFP1&2); top inside dimensions: 200' x 130'; 245T/pond, #57 bedding stone (LS); >6500', 4" perf. laterals with 4" headers (2 u'drain tiers); 3000 T/pond #1 LS ; 300CY spent mushroom compost; 8 adjustable effluent pipes/pond & 8 valved (gate-type) flush pipes/pond ; rip-rap lined, R4, spillway to Settling Pond 1
	Settling Pond 1	60' x 450' with rip-rap lined, R4, spillway to Wetland1
	Wetland 1	90' x 160' rip-rap, R4, lined spillway to Final Wetland
40, 40A, minor seeps	40/40A Collection Pond	75' x 25' with down-turned elbow and 400', 10", SDR35, PVC pipe to VFP3 & 4 Inlet Control Structure
42, minor seeps	42 Collection Pond	0.01 ac. down-turned inlet elbow; 30', 10", SDR35 PVC pipe to 40/40A pipe to VFP3 & 4 Inlet Control Structure
	Vertical Flow Ponds 3 & 4	Inlet Control Structure, Type M conc. box (5'Lx3'Wx3½'H) with two 8" pipes (1ea. VFP3 & 4); top inside: 65' x 220'; 102T(VFP3) & 94T(VFP4) #57 bedding stone (LS); >7000', 4", perf. laterals with 4" headers (2 u'drain tiers); 1120 T/pond, #1 LS; 141CY spent mushroom compost VFP4 only; 8 adjustable effluent pipes/pond & 8 valved (gate-type) flush pipes/pond; rip-rap lined, R4, spillway to Wetland 2
	Flush Pond 1	0.01 ac.; ~2' storage; 2½' freeboard; 4", valved, discharge pipe to Wetland 2
	Wetland 2	0.01 ac.; rip-rap, R4 , lined spillway to Final Wetland
41	41 Collection System	500', LS collection/conveyance channel
	Upper Wetland	38000 SF; off-site hydric soil and alkaline pond fines placed as substrate; 500', rip-rap lined, R4, spillway to Bioswale
40, 40A, 41, 42, minor seeps	Bioswale	inlet 35' x 40' combining flows from Upper Wetland & Wetland 2 spillways; 400' length; vegetated channel with fabricated substrate to Final Wetland
38, 39, 40, 40A, 41, 42, minor seeps	Final Wetland	37,000 SF naturally-functioning wetland with salvaged hydric substrate; fish support areas; level spreader, outlet control, rip-rap, R4, lined spillway to Murrin Run

Notes: all pipes SCH40 PVC unless otherwise noted; all limestone (LS) aggregate, 90% $CaCO_3$, AASHTO sizes; See "As-Builts" and detail discussion of various components.

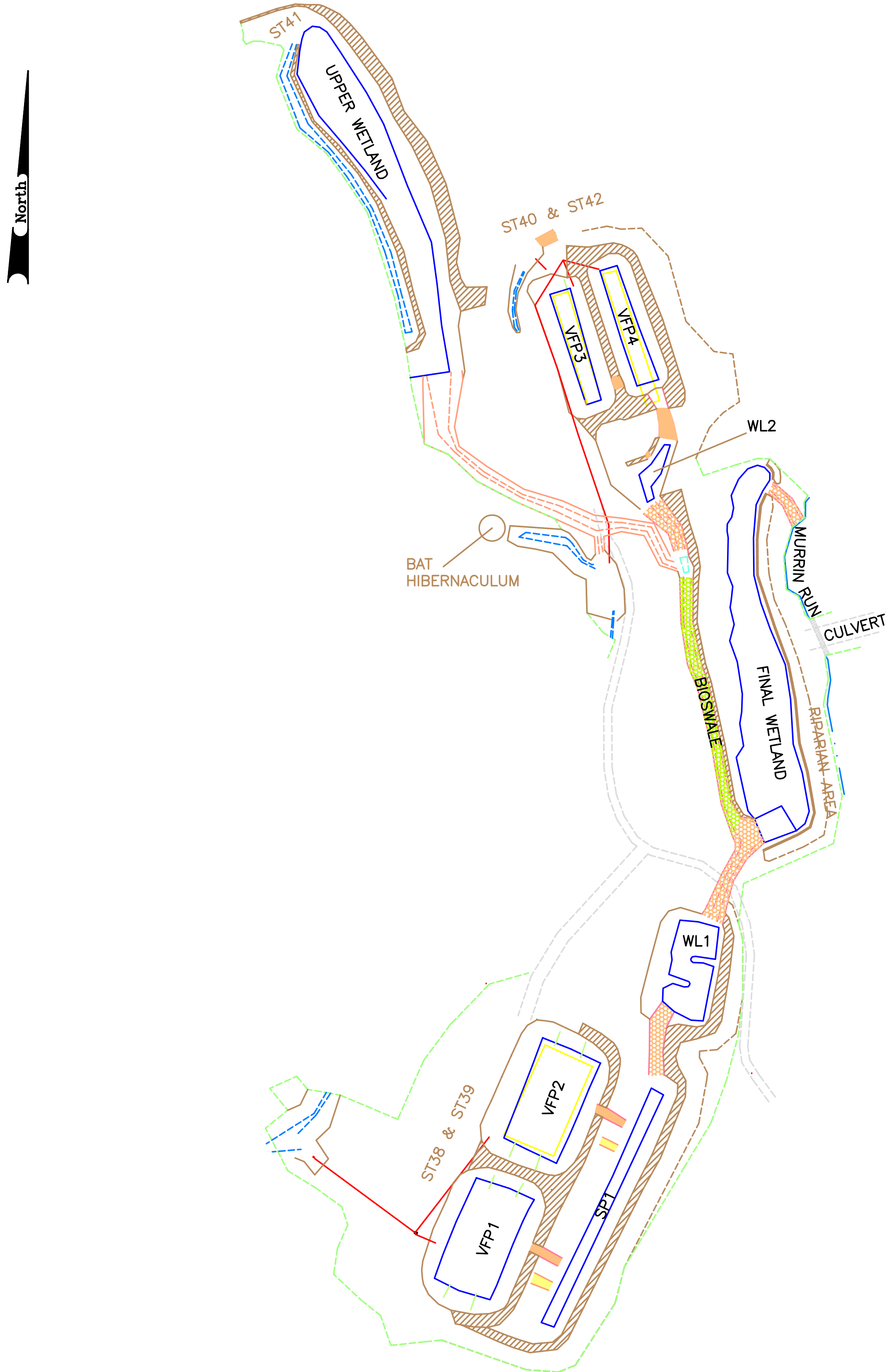


Figure I. Schematic view of the Goff Station Restoration Area Passive Treatment System. Murrin Run, the receiving stream, flows south along the east side of the system. The schematic is not to scale.

ST38/39
PTS

Goff Station
Restoration Project

Public Private Partnership Effort
Venango Township, Butler County, PA

ST 38/39
Passive Treatment
System

Vertical Flow Ponds #1 and #2

ST38 & ST39 Passive Treatment System

General Overview: Two abandoned open pits were joined in order to combine ST38 and ST39 flows. The combined discharge was then divided by the Flow Splitter Box between Vertical Flow Pond 1 and Vertical Flow Pond 2, which operate in parallel to neutralize acidity and generate alkalinity. From the Vertical Flow Ponds, the water is conveyed through a rip-rap lined channel, aerating the water before entering Settling Pond 1 for further oxidation and precipitation of metal solids. Following Settling Pond 1, the water is then conveyed by a rip-rap lined spillway to Wetland 1 for further retention of metal solids before entering the Final Wetland, which is a naturally-functioning wetland providing exceptional wildlife habitat. The final effluent is then conveyed by rip-rap spillway to Murrin Run**.**

Collection System: Discharges from pits 2 and 3 (See “As-Built” drawings.) were identified and monitored by the PA DEP, Knox District Mining Office as ST39 and ST38, respectively. As the discharges were of similar quality, an earthen ramp from old logging activities was removed to allow the drainage to be combined. After installation of the collection system, the spoil breach at the former location of ST38 was then backfilled to a specified elevation. A perforated riser and solid barrel were installed to convey the raw water to the Inlet Control Structure(Flow Splitter Box). This structure splits the flow between Vertical Flow Ponds 1 & 2.

Vertical Flow Ponds 1 & 2 (VFP1 & 2): Construction of these ponds required excavation and regrading of the outslope of old spoil piles. The two Vertical Flow Ponds of equal size are used in parallel. These facilities are designated as VFP1 and VFP2. Geotextile was used to line the bottom and sides of the pond to the approximate elevation of the top of the limestone (See photos.). A ½-foot layer of #57 limestone aggregate was then placed on the geotextile and the lower underdrain piping system was installed. Directly overlying the lower underdrain system, a two-foot layer of #1 limestone aggregate was placed followed by the upper tier of the underdrain piping system. An additional two-foot layer of #1 limestone was placed and covered by a ½-foot layer of spent mushroom compost. Each pond contains a total of 3000 tons of AASHTO#1, 90% $CaCO_3$, limestone aggregate. Each tier in each pond was divided into quadrants. 4-inch, perf., Sch. 40 PVC pipe laterals, about 18 feet in length (bottom tier) and 20 feet in length (upper tier), were placed on 4 ½-foot centers and plumbed into 4-inch, solid, Sch. 40 PVC mains (headers). There are a total of 16 “cells” (4 quadrants per tier X 2 tiers X 2 ponds) which outlet through individual discharge pipes. Each main extends though the breastwork to a flush valve located in a valve box at the outside toe of the Vertical Flow Pond. Approximately 30 feet before the flush valve, a tee was installed with a vertical riser pipe extending to an elevation 7.5 feet above the bottom of the pond. At the design water level, there is about 2 ½ feet of standing water. (See “As-Builts”.) The vertical risers are adjustable in order to maximize system utilization of limestone and treatment efficiency. As an “outgrowth project” to this grant “clean-out” pipes were installed for each of the lower tier headers. The emergency and primary outlet spillways are stabilized with 90% $CaCO_{3,}$ R4 limestone rip-rap.

This plumbing system allows for distribution of flow throughout the pond. As aluminum and iron solids accumulate within the Vertical Flow Ponds, a decrease in permeability is expected due to the filling of void space within the AASHTO #1 limestone layers. As the permeability decreases, the amount of head (difference between water elevation in the Vertical Flow Pond and the discharge pipe elevation) needed to push the water through the system will increase. This decrease in permeability will cause the water level in the Vertical Flow Ponds to rise.

Flushing of the solids collected in the pipes will be conducted during system monitoring. The amount of time for the metal sludge to flush from the pipes should be about 15 or 20 minutes. Flushing is terminated once the effluent begins to “run clear”.

The more extensive system flushing is planned annually, or longer based on experience with the individual system, flow rates, and calculated quantity of metal solids retained. Increased flushing efficiency should be realized with increased amounts of head. In order to maximize the amount of head during a single-day flushing event, valves would be opened on alternating ponds in sequence. An example of this flushing sequence is as follows: 1UF, 5UF, 2UF, 6UF, 3UF, 7UF, 4UF, 8UF, 1LF, 5LF, 2LF, 6LF, 3LF, 7LF, 4LF, 8LF. It is recommended that flushing events be monitored and adjustments be made to the flushing sequence as needed.

A new and expanded method of cleaning the pipes and the system was suggested by John Stoops, Kevin Steiner, and Mike Colossimo of Quality Aggregates Inc. which consists of 4-inch Schedule 40 PVC pipe that plumbed directly into the mains of the lower tier of the underdrain system. This will allow the use of pressurized air or water to further clean the pipes and assist with the flushing of the Vertical Flow Ponds. This is the first known installation of this design.

The collected flow of ST38/39 was turned into VFP1 and VFP2 on 10/25/00. Flow was decreased to VFP1 and VFP2 on 10/30/00 with the lowering of the mine pool during construction of the ST41 Upper Wetland in the abandoned open strip cut. On 12/29/00, some of outlet piping in VFP2 was replaced due to freezing.

<u>Settling Pond 1 (SP1):</u> SP1 serves two functions. The primary function is to provide an opportunity for oxidation and precipitation of metals. The settling pond is 16,000 SF and was sized at the removal rate of 10 g m^{-2} day^{-1}. The secondary function is to serve as a flushing pond were metal precipitates within the Vertical Flow Ponds can be flushed to increase the “life expectancy” of the pond and treatment media.

<u>Wetland1 (WL1):</u> The hydrophytic vegetation in wetlands encourages further removal of metal solids. Wetland 1 is naturally-functioning with a diverse vegetation for wildlife habitat. **(See section on Wetlands.)**

<u>Final Wetland:</u> This is the final component of the passive system complex and the flows of all treated discharges enter this wetland prior to entering Murrin Run. **(See section on Wetlands.)**

Pre-construction: ST38 discharge flows into an abandoned strip pit from an old underground mine.

Pre-construction: the ST39 discharge flows into an abandoned strip pit from an old underground mine.

Quality Aggregates constructing ST38/39 Vertical Flow Ponds #1 & #2 which operate in parallel.

Placement of 3000 tons of AASHTO #1 limestone in Vertical Flow Pond #2 for ST38/39. Note the flushing system with additional clean outs (first known of this design in Pennsylvania).

Basin excavated for the ST 38/39 treatment wetland. (10/12/00)

ST 38/39 wetland basin with flow diversion structures and limestone spillway inlet. Laser level was used to monitor elevations of the wetland basin during construction. (10/16/00)

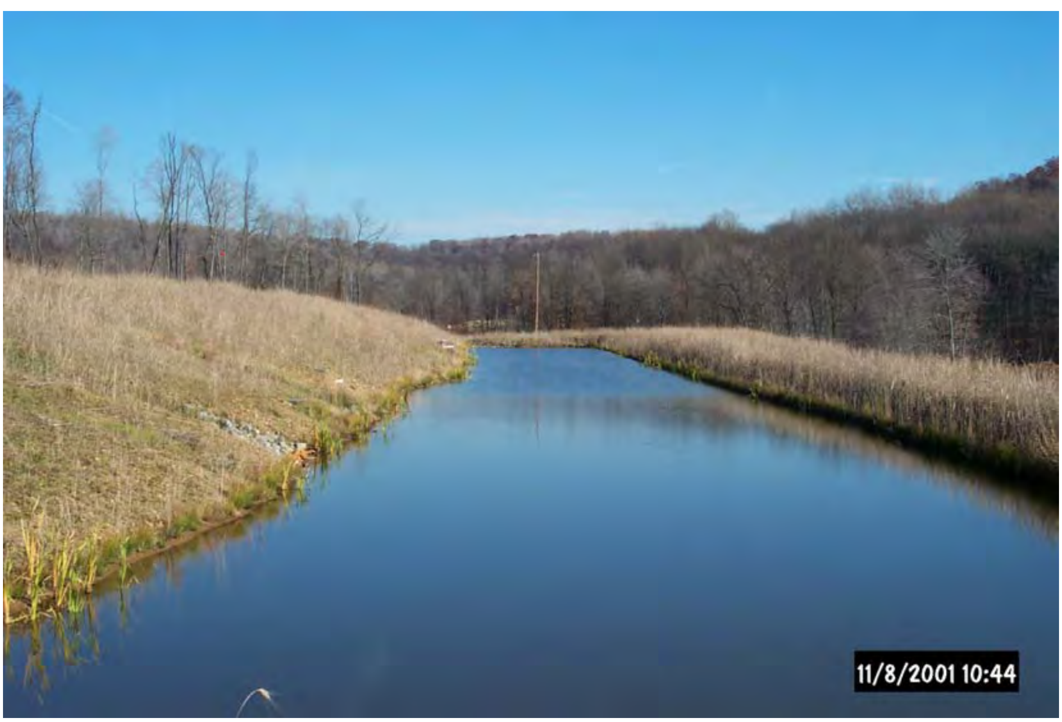
ST 38/39 wetland planting. Laser level was used to transplant vegetation to appropriate elevations. (10/21/00)

Junior Girl Scout Troop 653 planted the ST 38/39 wetland basin along with Aquascape and Quality Aggregates employees and family members. (10/21/00)

ST 38/39 wetland with following installation of new outlet structure. (5/7/01)

The ST 38/39 wetland in August 2001. (8/16/01)

ST38/39 Vertical Flow Ponds #1 and #2



The ST38/39 Settling/Flush Pond (SP1)

Goff Station Restoration Project

Public Private Partnership Effort
Venango Township, Butler County, PA

ST40/40A/4
2 PTS

ST 40/40A/42 Passive Treatment System

Vertical Flow Ponds # 3 and #4 under construction.

ST40, ST40A, ST42 and Minor Seeps

General Overview: ST40, prior to entering the passive system, is conveyed through the bat hibernaculum. ST40, ST40A, and ST42 are collected and combined and piped to the Inlet Control Structure(Flow Splitter Box) where the flow is divided and piped to both Vertical Flow Pond 3 and 4 which operate in parallel. Effluent from the Vertical Flow Ponds enters an aerobic wetland (Wetland 2). From Wetland 2, the flow then enters the Bioswale to mix with the Upper Wetland effluent in the 500-foot rip-rap, R4 limestone, lined spillway. The Bioswale conveys the ST40/40A/41/42 flow to the inlet of the Final Wetland to mix with the treated flow of ST38/39.

Collection System: The ST40 discharge is first directed through the bat hibernaculum to provide humidity and the sound of running water. The water is then pooled by a small breastwork. Using a down-turned elbow intake, the flow is conveyed by 10" SCH40 pipe to the inlet box for VFP3 & 4. During construction of the sump for ST40, additional seepage (ST40A) was discovered. After an unsuccessful attempt to seal the seep with Bentafix, the drainage was later combined with ST40. Clean-out pipes were installed at ~100-foot intervals along the collection pipe.

As a redundancy in the treatment of ST41, a check dam was constructed in the rip-rap lined spillway from the Upper Wetland. A solid, 10" SCH40 PVC WYE riser was plumbed into the pipe conveying the ST40/40A discharge to the inlet flow control box for VFP3 & 4. This allows the flow from the Upper Wetland, if additional treatment is needed, to be conveyed to Vertical Flow Ponds 3 & 4 by removing the screw-type plug.

ST42 is collected by constructing a small breastwork across a spoil breach. Additional spoil seepage is intercepted by a ditch (~100 feet in length) and conveyed to the pool. From an intake constructed in a similar manner as that for ST40, the flow is piped through 10" SCH40 PVC and plumbed into the ST40/40A conveyance pipe. The combined flows then enter the Inlet Control Box (Flow Splitter Box).

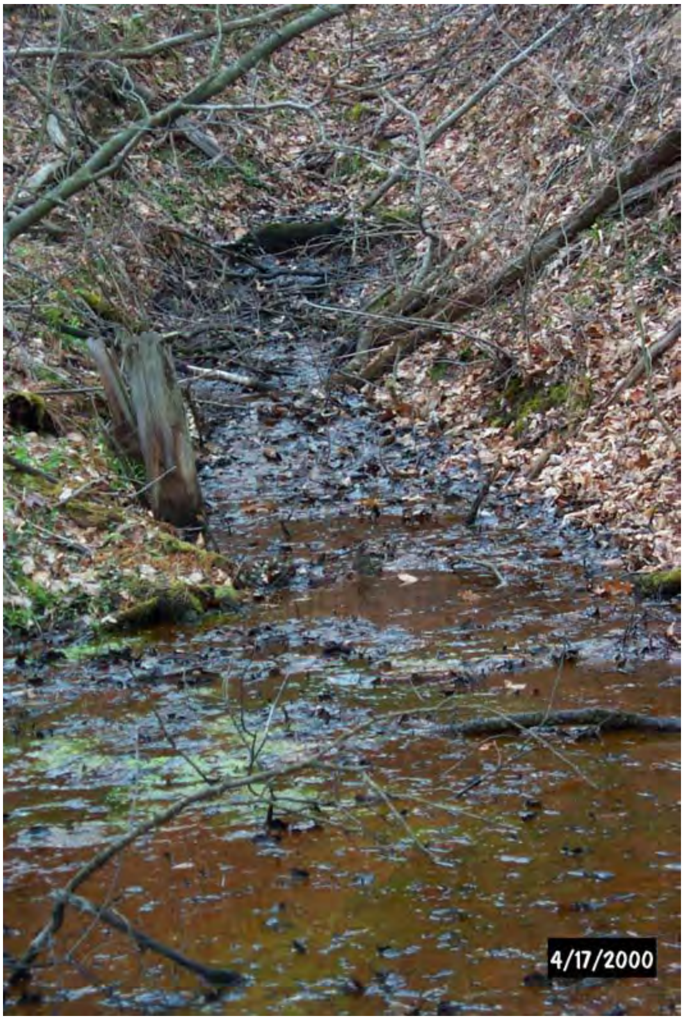
Vertical Flow Ponds 3 & 4 (VFP3 & VFP4): VFP3 & VFP4 are similar in design to that of VFP1 and VFP2 of the ST38/39 system described previously. From discussions with Charles Cooper, PE, Chuck Cravotta, PhD, Geochemist, USGS, George Watzlaf, USDOE, DEP, Art Rose, PhD, Geochemist, PSU, and others after receipt of the Growing Greener funding, the system design for ST40/40A/42 was expanded from one to two Vertical Flow Ponds to operate in parallel in order to directly compare the efficacy of a limestone-only system with that of one containing a spent mushroom compost layer. Based on monitoring data, each Vertical Flow Pond could handle the entire flow if a problem develops or for research purposes. VFP3 was designed to use only 1120 tons of AASHTO#1 limestone aggregate as the treatment medium while VFP4 was designed with an equal amount of limestone aggregate overlain by ½ foot (141 CY) of spent mushroom compost.

Flush Pond (FP1): The purpose of FP1 is simply to provide storage of solids and dewatering associated with flushing events. By having a separate flush pond, the metal solids will not be transported to other sections of the treatment system, but instead will remain and accumulate. The flush pond has a depth of 4 ½' to emergency spillway and a surface area at the outlet pipe of 900 SF.

Wetland 2 (WL2): WL2 will allow for settling of solids during normal operation of the Vertical Flow Ponds. **(See section on Wetlands.)**

Bioswale: The Bioswale conveys the combined flows from the Upper Wetland (ST41) and Wetland 2 (ST40/40A/42 and optionally ST41) to the Final Wetland. **(See Bioswale section.)**

Final Wetland: This is the final component of the passive system complex and the flows of all treated discharges enter this wetland prior to entering Murrin Run. **(See section on Wetlands.)**



Source of abandoned mine discharge ST40 (left) flowing into and pooling in an abandoned pit (right).

View of a portion of the ST 40/40A/42 collection system. Note ST42 pool far left, splitter box center, and clean out far right.

Quality Aggregates constructing Vertical Flow Ponds #3 & #4 of the ST 40/40A/42 system.

Construction of Vertical Flow Ponds #3 & #4 for ST40/40A/42 with the option of including ST41 by Quality Aggregates.

View of ST40/40A/42 System Wetland 2 after construction before planting.

ST40/40A/42 Wetland 2 after planting.

View of ST40/40A/42 Vertical Flow Ponds #3 & #4.

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ST41
Upper WL

ST 41 Upper Wetland

View of abandoned underground mine workings where the ST41 discharge emanates.

ST41

General Overview: ST41 was a pre-existing, net alkaline discharge with low metal content. The Upper Wetland was constructed within a previously unreclaimed abandoned open strip cut.

Collection System: A limestone aggregate ditch was placed along the base of the highwall to intercept and to convey the mine drainage from the underground workings to the northerly end of the Upper Wetland. The mine pool was subsequently lowered; however, if needed to balance flows among the systems, the mine pool elevation can be reestablished. The elevation of the northern end of the limestone collection channel determined the elevation of the basin of the Upper Wetland.

Upper Wetland: The iron precipitate that was found in the area was moved and covered with clean fill from the site. The remaining substrate was then excavated to the appropriate elevation and grade, and the footprint of the treatment wetland was enlarged. Limestone pond fines were then used to line the base of the treatment wetland which were then covered with the hydric substrate material remaining from a mitigation project in another county. This was made possible by Bob Beran and Jeff Reidenbaugh of Aquascape and Quality Aggregates. This cut, which used to discharge dark orange-red, iron-laden water, became within a matter of a few months a widely acclaimed, successfully constructed, naturally-functioning wetland. The water discharging from the Upper Wetland is conveyed by a rip-rap lined, R4 limestone, channel 500 feet in length to a plunge pond to combine with the treated flows from Wetland 2.

As noted previously, a check dam in the channel with an inlet riser plumbed into the collection system piping for ST40/40A was installed to allow the flow from the Upper Wetland to be intercepted and conveyed to VFP3 & 4 for additional treatment, if needed for additional treatment or research, etc.

Bioswale: The Bioswale conveys the combined flows from the Upper Wetland (ST41) and Wetland 2 (ST40/40A/42 and optionally ST41) to the Final Wetland. **(See Bioswale section.)**

Final Wetland: This is the final component of the passive system complex and the flows of all treated discharges enter this wetland prior to entering Murrin Run. **(See section on Wetlands.)**

ST41 flowed into an abandoned strip pit from an old underground mine. This strip pit was then used as the basin for the ST41 treatment Upper Wetland. (7/24/00)

Beavers repeatedly built dams within the drained impoundment, preventing access of construction equipment into the site. Chip Brunst, WCO, PA Game Commission trapped and relocated the beavers so the Upper Wetland could be constructed. (7/7/00)

Collection ditch for seeps from abandoned underground mine workings to be treated by the ST41 Upper Wetland. (11/8/00)

Section of ST41 Upper Wetland excavated to appropriate depth for the placement of hydric substrate. Berm of collection ditch visible to the left. (11/8/00)

Placement of hydric substrate in ST41 Upper Wetland. (11/8/00)

ST41 Upper Wetland under construction. (11/13/00)

ST41Upper Wetland following placement of hydric substrate and woody debris. Standing water is from the spring thaw. Flows from ST41 are not yet entering the treatment wetland. (3/22/01)

Junior Girl Scout Troop 653 planted the ST41 Upper Wetland with Aquascape and Quality Aggregates employees and family members. Flows from ST41 are not yet entering the treatment wetland. (5/19/01)

ST41 Upper Wetland in July 2001. (7/18/01)

ST41 Upper Wetland in September 200,1 4 months after planting. Flows from ST41 began entering the treatment wetland in July.

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Bioswale

Bioswale following construction, before soil amendments and planting. (5/31/01)

Bioswale

The Bioswale is a vegetated drainageway located west of the Final Wetland. Flows from the Upper Wetland (ST41) and Wetland 2 (ST40/40A/41/42) are conveyed in rip-rap lined ditches to a plunge pond, which outlets into the Bioswale.

In addition to conveying flows to the Final Wetland, the Bioswale was designed and built to provide a variety of other functions. The vegetation within the Bioswale provides treatment functions through the biological uptake of nutrients and metals, as well as by providing large amounts of surface area for suspended solids to adhere. The vegetation within the Bioswale will also serve to provide food and cover for wildlife. In addition to the values provided by the vegetation, two small pools were included in the construction of the Bioswale. These features provide for retention of sediments and energy dissipation of high volume flows and for diversity of habitat available to macroinvertebrates, amphibians, and other wildlife. The Bioswale also was designed to aerate the flows before entering the Final Wetland. This is primarily accomplished by the lower pool, which was constructed to incorporate a drop in elevation resulting in a small waterfall, and a section of limestone cobble substrate, which was placed in the Bioswale to create turbulence.

Following the excavation of the drainageway for the Bioswale, the Bioswale substrate was primarily clay and rock. Little topsoil was available within the project site and the location of the Bioswale was not readily accessible to earthmoving equipment. To establish vegetation, a combination of peat moss, topsoil, and hydric substrate were transported to Goff Station, and then manually moved and placed to line the Bioswale.

A seed mix prepared by Ernst Conservation Seeds and amendments were spread using a broadcast seeder. The seed mix included the following species:

Agrostis alba	Red Top
Agrostis stolonifera	Creeping Bentgrass
Elymus riparius	Riverbank Wild Rye
Poa palustris	Fowl Bluegrass
Puccinellia distans	Alkaligrass

The seed mix was supplemented with *Elymus virginicus* (Virginia Wild Rye). Following seeding, the Bioswale was mulched with hay to retain the seed, soil, and amendments.

During isolated incidents in which flows from Wetland 2 were diverted into the Bioswale, the hay mulch was found to be inadequate for the retention of seed and soil. As a result, plastic netting was used as an erosion control fabric. Following the replacement of soil, seed, and hay mulch, the plastic netting was stapled into the Bioswale substrate. Although the application of the netting greatly reduced the problems previously experienced when high volume flows entered the Bioswale, preferential flow pathways and evidence of erosion were still observed beneath the netting before the vegetation was well established. These high flows also resulted in the transport of some hay mulch and seed.

Wetland plants were then transplanted from the Upper Wetland and Final Wetland to the Bioswale to accelerate vegetative establishment. These plants included:

Eleocharis obtusa	Blunt Spikerush
Polygonum coccineum	Swamp Smartweet
Sagittaria latifolia	Arrowhead
Sparganium americanum	American Burreed
Typha latifolia	Broad-leaved Cattail

Locations of these plantings within the bioswale were selected to limit preferential flows and reduce erosion.

Lessons Learned:

- Conventional straw-matting erosion control fabric may be easier to use than the combination of hay and plastic netting. The hay, however, does provide a valuable function aside from erosion control. As was noted earlier, the basin of the Bioswale is primarily clay with numerous rocks. The hay accumulated sediments and served as a medium for plant growth. The hay will also be a future source of organic matter and nutrients as the hay decomposes. Utilization of earthmoving equipment for the placement of soil in the clay basin of the Bioswale during construction would have greatly simplified the establishment of vegetation.

- To avoid erosion problems, sufficient time is needed for the establishment of adequate vegetative growth prior to accepting high volume flows.

Plunge pool within the Bioswale. (5/31/01)

Initial soil amendments, seeding and mulching of Bioswale. (6/20/01)

Installation of netting in Bioswale completed before transplanting wetland plants. (7/13/01)

Growth in Bioswale after approximately 8 weeks. (8/16/01)

Goff Station
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Wetlands

View looking towards the final wetland (Center Right) and the Bioswale (Center Left) during planting of the final wetland.

Wetlands

TREATMENT WETLANDS AND FINAL (FINISHING) WETLAND

Wetlands are capable of providing a variety of water quality functions. Based on hydrogeomorphic (HGM) analysis methodology, wetlands that provide a high degree of function in specific categories have certain measurable features that contribute to their ability to perform these functions. These functions and features may be used to guide wetland construction goals essential in directing the project operations. Wetland functions also provide a means for realistic analysis of the degree of success achieved, as well as a means for the identification of current or developing problems. The wetlands at the Goff Station Restoration Area were designed to incorporate features that will promote high wetland function.

Wetlands have the ability to recycle suspended and dissolved solids between soil, water, vegetation, and the atmosphere. Nutrients, dissolved solids, and other constituents may be incorporated into biomass, or they may be lost or chemically altered such that they become inactive. There are several ways in which this may occur, including absorption and adsorption by soil particles, uptake by vegetation, and loss into the atmosphere.

General considerations that affect wetland functions include: topography of the watershed, wetland size, plant community structure and composition, vegetation density, and flow characteristics. The following features influence the level of function of a particular wetland:

-**Restricted Outlet/flow**: Wetlands with a restricted or no outlet, retain flows longer, facilitating interaction with wetland plants and soil.
-**Cover Distribution**: Cover distribution is an indicator for long-term storage of water, resulting in particulate retention and interaction of nutrients and contaminants with soil and vegetation. Wetlands with more even cover distribution perform to a higher degree than wetlands with patchy cover.
-**Soil Type:** Histosols or hydric soils with high clay content provide a high density of chemically reactive surfaces. Chemical reactions in the soil and at interfaces of soil, water, and vegetation play an important role in the ability of a wetland to improve water quality.
-**Basin Topographic Gradient:** Low gradient wetlands, where water can reside and interact with soils and vegetation, perform higher water quality functions than steeper gradient wetlands.
-**Microrelief of Wetland Surface:** Wetlands with strongly developed microrelief provide more reactive surface area (for both plants and soil), higher vegetation diversity, and better water storage for promoting settling of particulates.
-**Dead Woody Material:** The presence of fallen logs and woody debris encourages particulate retention increasing opportunities for interaction with soil and water.

Wetlands with stable and predictable hydrology can also be expected to provide higher water quality function.

Generally, high vegetative diversity parallels with high faunal diversity. Factors leading to high vegetative diversity include numerous areas with microtopographic relief, high interspersion, high percent of cover, the presence of several vegetative layers, and stable hydrology, especially if associated with standing water. Additionally, juxtaposition to other wetlands and the presence of connecting corridors, will increase wetland function.

By utilizing the above features known to promote a higher functional capability for water quality modification and for contributing to the abundance and diversity of flora and fauna, the goals, incorporated in the design and construction of treatment and finishing wetlands, were to

1) Create a wetland that employs numerous areas with microtopographic relief within a low gradient basin.

2) Create a wetland that encourages even cover distribution with a diverse plant community.

3) Plan for a vegetative community that employs horizontal vegetative stratification.

4) Utilize an outlet structure that functions to restrict flow and maximize available retention capacity.

5) Encourage the establishment of herbaceous and woody plant species.

6) Utilize a high quality substrate to maximize vegetation establishment and provide an additional means of water quality function.

7) Construct a low/no gradient basin with a “drop” structure in the inlet end to facilitate additional sediment removal prior to travel throughout the remaining wetland.

Following final configuration of the treatment and finishing wetlands at the Goff Station Restoration Area, woody debris (logs, stumps, etc.) salvaged during the initial construction process was placed throughout the wetlands.

Throughout construction, flows were diverted from the wetland basins upon implementing an approved erosion control and sedimentation plan.

CONSTRUCTION

Subgrade preparation:
Throughout installation, flows were diverted from the constructed wetlands to allow for manipulation of the final grade. The preparation of the subgrade for the treatment wetlands and finishing wetland utilized clay obtained from the site, as well as "pond fines". Pond fines are slightly alkaline and have a high compaction potential. This material was obtained as a byproduct from the mining of limestone at the nearby Quality Aggregates Inc. quarry in Boyers, PA. The pond fines were hauled to the site and were used to provide an impermeable subgrade for the ST41 treatment wetland (Upper Wetland). Clay from onsite was used to create the impermeable basins for the remaining treatment wetlands and the finishing wetland. The impermeable basins of the constructed wetlands serve to facilitate water retention and prevent infiltration. This surface served as the foundation for the hydric substrate.

Final grade preparation:
The wetland basins of the Upper Wetland and the Final Wetland were designed and constructed with a sediment trap (deeper water area) at the inlet end of the facility. This provides an opportunity for sediments to settle before flowing in these wetlands. [Flush Pond 1 was built as a separate component to allow for oxidation and precipitation of metal solids from the effluent and flush of VFP3 and VFP4.]

Grade was monitored with a laser during construction to maintain a level basin. The wetlands were then configured to provide areas of microrelief within the level basin. The wetland basins were covered with approximately 6 inches of high quality hydric substrate salvaged from an off-site mitigated wetland in a nearby county. This substrate served as an excellent seed source, provided desirable soil characteristics for the establishment of planted vegetation, and provided water quality modification potential.

The laser level was also used in creation of the topographic irregularities to avoid excessive depths that would prevent the growth of wetland vegetation. Water depths within the wetland were designed to be predominantly less than 10 inches, with maximum depths of 18 inches, although locations have been observed within the Final Wetland and the Upper Wetland that exceed 18 inches. Nonetheless, dense vegetation growth was observed throughout all of the constructed wetlands following the wetland plantings in Fall 2000 and Spring and Summer 2001.

Once the final configuration of the wetland basin was completed, woody debris (logs, stumps, etc.) salvaged during the initial construction process was placed throughout the wetlands to provide increased aquatic habitat opportunities. Large sandstone/limestone boulders were also placed to facilitate the meander of flows within the basin and to stabilize the areas subject to erosion.

ST 38/39 Wetland (WL1) Construction Features:

Within WL1, two peninsulas were constructed adjacent to the inlet and opposite each other to prevent the possibility of short-circuiting flows. These landforms function similar to skirted silt booms (baffles) commonly used in sediment pond construction.

The W1 outlet was constructed utilizing concrete blocks to prevent a build-up of sediment and the establishment of vegetation within the spillway. This problem has been observed in the outlets of other constructed wetlands, which can lead to raised water levels and stressed vegetation.

Finishing (Final) Wetland:
To effectively prevent contamination from the remaining refuse and to create a basin that retains water, the footprint of the Final Wetland was sealed using clay excavated from the project site. A plug, or key, was excavated parallel to Murrin Run to a depth below the original clay floor. Clay was used to fill the key trench and seal the existing groundwater connection between the remaining permeable coal refuse and the stream. A clay cap was then placed over the entire Final Wetland construction site utilizing material available from the adjacent upland area to the west.

Other features of the Final Wetland include the level spreader, the muskrat fence and gravel lens which are within the berm, and the outlet structure.

The level spreader was constructed immediately beyond the drop structure of the Final Wetland. The level spreader provides a continuous surface 3 inches to 5 inches below the final water level that encourages uniform flow across the width of the wetland. This discourages flows from developing preferred flow paths (short-circuiting) that could reduce retention time within the Final Wetland.

The muskrat fencing and gravel(sand) lens, installed within the berm of the Final Wetland, parallels Murrin Run. When the berm was constructed to the height of the final water level, limestone sand was placed in a thin layer 1 to 2 inches in thickness. This feature was placed in the berm to provide a hydrologic contribution from the Final Wetland to the adjacent riparian area. Otherwise, upland surface flows and subsurface hydrologic contributions to the riparian area would be intercepted by the Final Wetland and diverted from the restored riparian area.

Above the gravel lens an additional 1 foot of soil was added to the berm before digging a trench along the eastern edge that parallels Murrin Run. The trench was dug to a depth of 3 feet and a wire fence inserted into the trench. This will discourage muskrats from burrowing through the berm causing the Final Wetland to be drained, creating short-circuiting and reducing the ability of the wetland to provide water treatment.

Concrete blocks were also used in the outlet of the Final Wetland to prevent a build-up of sediment and the establishment of vegetation within the spillway, as previously mentioned. In addition, an outlet control structure was constructed to provide the ability to raise or lower the water level within the Final Wetland to allow flexibility for providing optimal water levels for the performance of vegetation within the wetland.

VEGETATION

The wetlands at the Goff Station Restoration Area have been designed and constructed to provide a variety of predictable hydrologic levels as detailed below:

Zone A	Elevated areas	> 6” above water level
Zone B	Capillary fringe	0 to 6”
Zone C	Submerged	0 to -6”
Zone D	Submerged	> 6” below water level

The vegetative component of the wetland areas included placement of salvaged hydric substrate with an inherent seed bank, as well as supplemental planting, and volunteer plant establishment.

The topographic variation throughout the wetland coupled with predictable flows will promote the establishment of a diverse community of wetland plants, each uniquely adapted to a variety of specific site conditions. The following table identifies the seedbank present within the salvaged hydric substrate as well as the species used in the supplemental plantings of Wetland 1, the Upper Wetland, and the Final Wetland. Species used in the supplemental plantings were selected based upon a review of the current and projected site conditions, regional suitability, wildlife value, and hardiness.

A large portion of transplanted species was obtained with permission of the PA Game Commission from State Game Lands No. 95. Species were also obtained from property owned by Robert Beran of Boyers, PA.

WETLAND VEGETATION

Scientific name	Common name	Life stage	Hydrologic Level/Zone	Wetland(s)
Alisma plantago-aquatica	Water Plantain	Seed, Plant	C & D	Wetland 1; Upper Wetland; Final Wetland
Asclepias incarnata	Swamp milkweed	Plant	B & C	Upper Wetland; Final Wetland
Carex spp.	Unidentified Sedge	Seed, Plant	B & C	Wetland 1; Upper Wetland; Final Wetland
Carex vulpinoidea	Fox Sedge	Plant	B & C	Wetland 1; Upper Wetland; Final Wetland
Ceratophyllum demersum	Coontail	Plant	D	Upper Wetland
Cornus amomum	Silky Dogwood	Cutting	B	Wetland 1; Upper Wetland; Final Wetland
Cornus racemosa	Red-Osier Dogwood	Cutting	B	Wetland 1; Upper Wetland; Final Wetland
Cyperus strigosus	Umbrella Sedge	Seed	B & C	Upper Wetland
Dulichium arundinaceum	Three way sedge	Plant	C & D	Upper Wetland; Final Wetland
Elatine americana	American Waterwort	Seed	C & D	Upper Wetland; Final Wetland
Eleocharis rostellata	Spike Rush	Seed	C & D	Wetland 1; Upper Wetland; Final Wetland
Elodea canadensis	Common Waterweed	Seed	C & D	Upper Wetland
Epilobium coloratum	Purple-leaved Willow Herb	Seed	B & C	Upper Wetland
Eupatorium perfoliatum	Boneset	Seed, Plant	B	Upper Wetland
Gratiola neglecta	Hedge hyssop	Seed	C & D	Upper Wetland; Final Wetland
Haloragaceae spp.	Water milfoil	Plant	D	Upper Wetland
Impatiens capensis	Jewelweed	Seed	A & B	Wetland 1; Upper Wetland
Juncus effusus	Soft Rush	Plant	B & C	Wetland 1; Upper Wetland; Final Wetland
Leersia oryzoides	Rice Cut-Grass	Seed, Plant	C	Wetland 1; Upper Wetland; Final Wetland
Lindernia dubia	False Pimpernel	Seed	C	Upper Wetland; Final Wetland
Ludwigia palustris	Water Purslane	Plant	C & D	Wetland 1; Upper Wetland; Final Wetland
Lycopus americanus	Bugleweed	Seed	B & C	Wetland 1
Nuphar luteum	Spatterdock	Plant/Rhizome	D	Upper Wetland; Final Wetland
Polygonum arifolium	Halberd-leaved Tearthumb	Seed	B & C	Wetland 1; Upper Wetland
Polygonum coccineum	Swamp Smartweed	Seed	C & D	Upper Wetland
Polygonum hydropiper	Common Smartweed	Seed	C & D	Wetland 1; Final Wetland
Polygonum hydropiperoides	Mild Water Pepper	Plant	C & D	Wetland 1; Upper Wetland; Final Wetland
Polygonum pensylvanicum	Pink Knotweed	Seed	A, B & C	Wetland 1; Upper Wetland; Final Wetland
Polygonum persicaria	Lady's Thumb	Seed	A & B	Final Wetland
Polygonum sagittatum	Arrow-leaved Tearthumb	Seed	A, B & C	Wetland 1; Upper Wetland; Final Wetland
Rumex spp.	Dock	Seed, Plant	A & B	Upper Wetland; Final Wetland
Sagittaria latifolia	Arrowhead	Seed	C & D	Wetland 1; Upper Wetland; Final Wetland
Salix purpurea	Purple-Osier Willow	Cutting	B	Wetland 1; Upper Wetland; Final Wetland
Scirpus cyperinus	Wool Grass	Plant	B & C	Wetland 1; Upper Wetland; Final Wetland
Scirpus validus	Soft-stemmed Bulrush	Plant	C & D	Wetland 1; Upper Wetland; Final Wetland
Sparganium americanum	American Burreed	Seed, Plant	C & D	Wetland 1; Upper Wetland; Final Wetland
Trifolium spp.	Clover	Seed	A	Final Wetland
Typha latifolia	Broad-leaved Cattail	Seed	C & D	Wetland 1; Upper Wetland; Final Wetland

Zones: A > 6" above water level; B = 0 to 6"; C = 0 to -6"; D > 6" below water level

Gob removal in progress. The footprint of the removed gob pile is the location of the finishing wetland. (5/12/00)

Gob removal largely completed. (6/26/00)

Basin for footprint of the finishing wetland, final component for ST38/39, ST 40/42. And ST 41 discharges. (7/28/00)

Basin for footprint of the finishing wetland, final component of the passive treatment system. (2/8/01)

Placement of clay over remaining coal refuse to seal the floor of the final wetland. (3/23/01)

Placement of clay to seal the floor of the final polishing wetland. Murring Run can be seen in center of the photo. (3/28/00)

Final polishing wetland being planted by youth from the Butler County Juvenile Court Services WORC program.

Butler County WORC youth planting the final wetland along with employees of Aquascape.

Final polishing wetland, the final component of the passive treatment system, in August 2001 only 1 month after planting by volunteers.

Final polishing wetland two months after planting. Effluent from this final component discharges into Murrin Run.

ST38/39 Wetland (Wetland 1):
For the treatment wetland in the passive system of the ST38/39 discharges, wetland planting was conducted prior to inundation. A laser level was used to indicate the varying elevations of the wetland basin with respect to the final water level. Plants harvested with permission of the PA Game Commission from State Game Lands No. 95 were used to supplement the existing seed stock in the hydric substrate that was used to provide a medium for plant growth. Junior Girl Scout Troop 653 (11 girls and two leaders, Deb Bowser and Marian Hall) from West Sunbury participated in the wetland planting on Saturday, October 21, 2000. On the evening of October 20th, Bob Beran provided a site tour and discussed the characteristics and functions of wetlands and wetland plants. On the morning of October 21st, the troop harvested selected plants from a nearby wetland for planting. In addition to Troop 653, employees from Quality Aggregates and Aquascape assisted in the harvesting and planting activities.

ST41 Wetland (Upper Wetland):
Planting of the Upper Wetland was conducted before flows were diverted into the wetland. Nonetheless, at the time of the wetland planting, surface water had ponded within the basin to approximately 6 inches below final water level. Planting was conducted during Spring 2001, also with the assistance of Junior Girl Scout Troop 653 and employees of Aquascape and Quality Aggregates Inc.

ST42 Wetland (Wetland 2):
Wetland 2 received a highly concentrated supplemental planting of cattails (*Typha latifolia*). These plants were removed from dense growth areas established within Wetland 1 and the Final Wetland to encourage species diversity. The dense planting of cattails within Wetland 2 will help to maximize the treatment potential within the relatively small footprint.

Finishing(Final)/Polishing Wetland:
The vegetative component of the wetland area resulted from (1) salvaged hydric substrate rich in propagules, (2) supplemental plantings, and (3) volunteer plant establishment. The design and construction of the Final Wetland and predictable flows have facilitated the establishment of a diverse plant community. Plant species composition within this wetland, as with the treatment wetlands mentioned above, will ultimately be determined by the varying hydrologic regimes resulting from the microtopographic variation within the wetland. As with the Upper Wetland, the Final Wetland was planted prior to receiving flows, although surface water and spring seeps had resulted in ponded water within the wetland basin. Vegetation of the Final Wetland was conducted in multiple plantings with employees of and youth from the Butler County Juvenile Court Services.

Without stocking, fish have been observed living in the deeper water areas of this wetland, particularly near the inlet end. The mechanism(s) that introduced fish is unknown. This area has been changed spectacularly as this area was formerly overlain by abandoned, essentially barren, coal refuse.

BIO-MONITORING

Wetlands Overview

Initial monitoring has indicated that the wetlands are extremely successful relating to plant diversity and coverage and wildlife habitat.

In addition to the 38 species (See wetlands construction section for compilation.) of plants identified in the various plots (See following descriptions.), wildlife are utilizing the wetlands. Evidence of foraging including floating and cropped plants, deer seen in the wetlands, and tracks on the berms of deer, raccoon, fox, and bear have been observed. Within the wetlands, whirligig beetles, water boatmen, water striders, damselflies, dragonflies, toads, frogs, tadpoles, diving beetles, and fish have been documented. The fish noted in the deeper water areas of the wetlands were introduced by natural means, as there was no stocking program.

Stations have been placed in the Goff Station **ST38/39 wetland (WL1)**, the **ST41 wetland (Upper Wetland)**, and the **finishing wetland (Final Wetland)** in order to monitor the success of the wetland establishment and functions. Two plots were randomly chosen in the ST38/39 wetland (WL1), three plots were randomly chosen in the ST41 wetland (Upper Wetland), and four plots were chosen in the finishing wetland (Final Wetland). Vegetation was identified within a 15-foot radius of all plots. Each plot covered one square meter. Water conductivity and pH were measured at each wetland. All sampling plots were marked with a PVC pipe for future sampling events. The PVC pipes also function as wetland monitoring photopoints.

Goff Station: ST38/39 Wetland (WL1)

The ST38/39 wetland was planted during October 2000. Flows from the ST38/39 Vertical Flow Ponds (VFP1 & 2) were directed into the wetland after the planting event. Vegetative and hydrological monitoring was conducted during the afternoon of July 23, 2001. The daytime temperature was in the mid-80s, humid, and clear to partly cloudy. The total monthly rainfall at time of the monitoring event was 1.89 inches. Two plots were studied at the wetland treating the ST38/ST39 abandoned mine discharges.

ST38/39 (WL1) – Plot 1: The first plot is located on the northern end of the wetland. Water depth in the area was a maximum of 2 inches. The majority of the area was saturated to the surface. Vegetation within a 15-foot radius included: *Polygonum sagittatum* (Arrow-leaved Tearthumb), *Polygonum arifolium* (Halberd-leaved Tearthumb), *Sagittaria latifolia* (Arrowhead), *Eleocharis rostellata* (Spike Rush), *Typha latifolia* (Broad-leaved Cattail), *Leersia oryzoides* (Rice Cut-Grass), *Polygonum pensylvanicum* (Pink Knotweed), *Scirpus cyperinus* (Wool Grass), *Polygonum hydropiper* (Common Smartweed), *Sparganium americanum* (American Burreed), *Juncus effusus* (Soft Rush), *Scirpus validus* (Soft-stemmed Bulrush), *Carex vulpinoidea*

(Fox Sedge), *Carex* spp. (unidentified Sedge), *Impatiens capensis* (Jewelweed), *Ludwigia palustris* (Water Purslane), *Alisma plantago-aquatica* (Water Plantain) and *Polygonum hydropiperoides* (Mild Water Pepper). The square meter plot included: *Typha latifolia*, *Sagittaria latifolia*, *Eleocharis* spp., *Leersia oryzoides*, *Polygonum hydropiper, Ludwigia palustris*, *Polygonum sagittatum*, *Carex vulpinoidea*, *Sparganium americanum*, *Juncus effusus,* and unidentified grasses. The estimated percent areal coverages are as follows: 80% *Eleocharis rostellata;* 55% *Leersia oryzoides;* 45% *Sagittaria latifolia;* 35% *Typha latifolia;* 5% *Juncus effusus;* and <5% *Ludwigia palustris*, *Polygonum sagittatum*, *Carex vulpinoidea,* and *Sparganium americanum*.

The water sample taken at this plot was very turbid. Conductivity was measured at 1425 *u*S/cm. Average water temperature was 33.87 ^{o}C.

<u>ST38/39 (WL1) – Plot 2</u>: The second plot is located in the southern portion of the wetland. Water depth in the area ranged from 0.5 to 3 inches with the average depth at 2 inches. Vegetation within the 15-foot radius included: *Juncus effusus*, *Eleocharis rostellata*, *Polygonum pensylvanicum*, *Lycopus americanus* (Water Horehound), *Carex vulpinodea, Polygonum sagittatum*, *Polygonum hydropiper*, *Gratiola neglecta* (Clammy Hedge Hyssop), *Scirpus validus*, *Sagittaria latifolia,* unidentified grasses, *Sparganium americanum*, *Ludwigia palustris*, *Leersia oryzoides*, *Carex* spp., *Lindernia dubia* (False Pimpernel), *Polygonum hydropiperoides,* and *Alisma plantago-aquatica*. Vegetation and coverage in the square meter plot included: 35% *Juncus effusus;* 25% *Typha latifolia;* 7% *Eleocharis rostellata;* <5% *Sagittaria latifolia*, *Polygonum sagittatum*, *Carex vulpinodea,* Carex spp. and unidentified grass.

The water sample at this plot was slightly turbid. The conductivity measured 1278 *u*S/cm and the pH was 7.41. The average water temperature was 37 ^{o}C.

Overall vegetative health is excellent, many species were found to be flowering or spreading horizontally. The survival rate of plants is estimated to be very high. This is deduced from the overall health and species variability within the wetland. A small percentage of plants were found floating in the wetland as evidence of foraging. This has not affected the survival rate or overall health of the wetland significantly. Many species that were not planted were found to be present and very healthy. It is assumed that these plants are a result of seed and root mass located in the salvaged hydric substrate.

It was observed that the wetland is accumulating sediment from the spillway and from erosion of the western slope. Several animals and insects are utilizing the wetland for food and habitat. Raccoon prints were observed in the vicinity and foraging was evident. Whirligig beetles, water boatmen, water striders, damselflies, dragonflies, toads, and frogs were observed within the wetland.

Goff Station: ST41 Wetland (Upper Wetland)

The ST41 wetland (Upper Wetland) was planted on May 19, 2001. Vegetative and hydrological monitoring were conducted the mornings of July 21, 2001 and July 23, 2001, respectively. Flows from the abandoned mine seep ST41 were turned into the wetland the afternoon of July 23rd. Weather conditions for the day were clear, sunny and in the lower 80s. The total monthly rainfall at time of the monitoring event was 1.89 inches. Three plots were studied at the ST41 wetland.

ST41 (Upper Wetland) – Plot 1: The first plot was located in the northern end of the wetland. Average water depth was 6.5 inches. Hummocks within the area were common up to 7 inches above the water surface. Vegetation within a 15-foot radius included: *Sagittaria latifolia*, *Polygonum arifolium, Typha latifolia, Leersia oryzoides*, *Polygonum pensylvanicum*, *Sparganium americanum, Carex vulpinodea, Juncus effusus*, *Cyperus strigosus* (Umbrella Sedge), *Carex* spp., *Eleocharis rostellata, Polygonum hydropiperoides*, *Scirpus validus*, *Polygonum coccineum* (Swamp Smartweed), *Gratiola neglecta*, *Alisma plantago-aquatica*, *Lindernia dubia*, *Dulichium arundinaceum* (Three-way sedge), *Polygonum sagittatum*, *Eupatorium* perfoliatum (Boneset), *Impatiens capensis,* and unidentified grasses. Coverage estimates within the plot include: 65% *Eleocharis rostellata*; 45% *Typha latifolia;* 40% *Leersia oryzoides;* 30% Juncus *effusus;* 15% *Sagittaria latifolia;* 10% *Polygonum sagittatum;* 5% *Polygonum pensylvanicum*.

The water sample taken at this station had a conductivity of 1041 *u*S/cm and a pH of 7.08. Average water temperature was 24.8 ^{o}C.

ST41 (Upper Wetland) - Plot 2: The second plot was located in the center of the wetland. The average water depth was approximately 4 inches, with areas as deep as 8.5 inches and hummocks rising 10 inches above the water. Vegetation in the 15-foot radius included: *Polygonum sagittatum, Typha latifolia, Sagittaria latifolia, Juncus effusus, Eleocharis rostellata, Polygonum hydropiperoides, Polygonum pensylvanicum, Carex vulpinodea, Leersia oryzoides, Alisma plantago-aquatica, Polygonum arifolium, Epilobium coloratum* (Purple-leaved Willow Herb)*, Gratiola neglecta, Elatine americana* (American Waterwort)*, Sparganium americanum, Scirpus cyperinus* (Wool Grass)*, Dulichium arundinaceum, Ceratophyllum demersum* (Coontail)*, Elodea canadensis* (Common Waterweed)*, Rumex spp.* (Dock), unidentified grasses. The coverage estimates for the square meter plot are: 50% *Juncus effusus;* 45% *Sagittaria latifolia;* 40% *Eleocharis rostellata;* 20% *Sparganium americanum;* 15% *Leersia oryzoides;* 15% *Polygonum pensylvanicum;* 15% *Typha latifolia;* 5% *Carex vulpinodea;* < 5% each of *Scirpus cyperinus* and unidentified grasses.

The water samples taken at this plot had a conductivity of 1167 *u*S/cm and a pH of 7.11. Average water temperature was 27.7 ^{o}C.

<u>ST41 (Upper Wetland) – Plot 3</u>: The third plot was taken at the southern end of the wetland. The water depth ranged from 15 to 5.5 inches. The average depth was 10 inches. Vegetation within the 15-foot radius includes: *Sparganium americanum*, *Eleocharis rostellata, Typha latifolia, Sagittaria latifolia*, *Nuphar luteum* (Spatterdock), *Ceratophyllum demersum, Ludwigia palustris, Polygonum pensylvanicum, Leersia oryzoides*, *Elatine americana, Polygonum* spp*., Elodea canadensis, Rumex* spp., *Haloragaceae* spp. (Water milfoil), *Polygonum hydropiperoides*, *Gratiola neglecta,* and unidentified grasses. Species and cover estimates within the square meter plot include: 60% *Sparganium americanum;* 50% *Eleocharis rostellata;* 25% *Typha latifolia;* 20% *Sagittaria latifolia;* 10% *Ludwigia palustris;* 5% *Elatine americana, Polygonum hydropiperoides,* and unidentified grass.

Water samples taken at this plot consisted of a conductivity of 1048 *u*S/cm and a pH of 6.85.

Overall vegetative health is excellent within the ST41 wetland (Upper Wetland), as many species were found to be flowering or spreading horizontally. Survival rates of plants were estimated to be very high. Effects of foraging, such as torn and eaten leaves and uprooted plants were observed. Foraging has not significantly affected the overall health of the wetland or the survival rates of plants. Many species that were not originally planted were found to be present and very healthy. It is assumed that these plants are a result of seed and root mass located in the hydric substrate salvaged substrate.

It was also noted that several animals, amphibians and insects are utilizing the wetland for habitat and food. Deer and raccoon tracks were seen on the berm of the wetland. Deer have been observed in the wetland on numerous occasions. Foraging is evident. Water striders, tadpoles, diving beetles, damselflies, dragonflies, frogs, toads, and water boatmen were observed within the wetland.

<u>Finishing Wetland (Final Wetland)</u>

The finishing wetland had two stages of plantings. The southern half was planted June 26, 2001 and the northern half was planted July 17, 2001. Vegetative and hydrological monitoring was conducted the morning of July 23, 2001. Weather conditions for the day were clear to partly cloudy, humid and in the mid-80s. The total monthly rainfall at time of the monitoring event was 1.89 inches. Four stations were randomly chosen within the finishing wetland.

<u>Finishing Wetland (Final Wetland) – Plot 1</u>: The first station is located in the northern section of the wetland. The maximum water depth in the area was 6 inches. On average, hummocks extended 4 inches above the water. Typical water depth in the area was 5 inches. Vegetation within the 15-foot radius included: *Ludwigia palustris, Sagittaria latifolia, Polygonum persicaria, Eleocharis rostellata, Alisma plantago-aquatica, Typha latifolia, Lindernia dubia, Gratiola neglecta, Sparganium americanum,*

Leersia oryzoides, unknown grasses, *Polygonum sagittatum, Carex vulpinodea* and *Trifolium* spp. (Clover). Cover estimates of vegetation within the square meter plot include: 8% unknown grass; 5% *Eleocharis rostellata;* < 5% each of *Gratiola neglecta, Typha latifolia*, *Carex vulpinodea*, *Lindernia dubia,* and *Polygonum persicaria*.

Water samples collected at this plot had the average conductivity as 940.3 *u*S/cm, 3.23% dissolved oxygen and a pH of 6.78. The average water temperature was 32.48 ^{o}C.

Finishing Wetland (Final Wetland) – Plot 2: The second station had a water depth ranging from 2 to 6 inches, with an average of approximately 5 inches. The hummocks in the area extended above the water to a maximum height of 3 inches. Vegetation within the area included: *Nuphar luteum*, *Asclepias incarnata* (Swamp Milkweed), *Polygonum persicaria, Eleocharis rostellata, Rumex* spp., *Lindernia dubia, Gratiola neglecta, Typha latifolia, Alisma plantago-aquatica, Juncus effusus*, unknown grasses, *Trifolium* spp., *Carex vulpinodea*, *Sagittaria latifolia, Leersia oryzoides* and *Polygonum sagittatum*. Coverage and vegetation within the square meter plot include: 25% unknown grass; 8% *Lindernia dubia;* 8% *Eleocharis rostellata* spp.; 5% *Alisma plantago-aquatica;* < 5% each *Typha latifolia, Polygonum persicaria,* and *Sagittaria latifolia*.

Water samples at this plot revealed a conductivity level of 997.3 *u*S/cm and a pH of 5.89. Average water temperature was 35 ^{o}C.

Finishing Wetland (Final Wetland) – Plot 3: The water depth at the third station ranged from 3 to 5 inches and averaged 4 inches. Vegetation within the 15-foot radius included: *Asclepias incarnata, Polygonum spp., Scirpus validus,* unidentified grasses, *Alisma plantago-aquatica, Eleocharis rostellata, Dulichium arundinaceum, Lemna* spp. (Duckweed), *Polygonum persicaria*, *Sparganium americanum, Typha latifolia*, *Sagittaria latifolia, Gratiola neglecta, Nuphar luteum*, *Scirpus* spp., *Lindernia dubia,* and *Carex* spp. Within the square meter plot, vegetation and estimated coverage are: 15% unidentified grasses; 8% Polygonum persicaria; 5% *Dulichium arundinaceum; 5% Eleocharis rostellata; 5% Lemna* spp.; < 5% each of *Trifolium spp., Lindernia dubia, Typha latifolia, Sparganium americanum, Gratiola neglecta,* and *Carex* spp.

Water samples taken at this plot had a conductivity of 1133 *u*S/cm and a pH of 6.46. Average water temperature was 35.6 ^{o}C.

Finishing Wetland (Final Wetland) – Plot 4: The fourth plot was chosen along the southern side of the wetland between the drop structure and the level spreader. Water depth in this area ranged from 9.5 to 15 inches. The average water depth was 11 inches. Vegetation in this area included: unknown grasses, *Typha latifolia*, *Eleocharis rostellata, Nuphar luteum, Polygonum persicaria, Leersia oryzoides, Cardamine pratensis* (Cuckooflower), *Sparganium americanum, Sagittaria latifolia, Elatine americana*, *Lindernia dubia, Polygonum hydropiper, and Carex* spp. The vegetation and estimated coverage within the square meter plot are: 5% *Typha latifolia;* 5% *Leersia* *oryzoides;* 5% *Nuphar luteum;* < 5% each of unknown grasses, *Eleocharis rostellata* and *Sagittaria latifolia*.

Water samples at this station had a conductivity of 949 *u*S/cm and a pH of 6.67. Average water temperature was 33.9 ^oC.

Overall vegetative health is moderate. The wetland had been recently planted and vegetation has not yet had time to spread horizontally. Survival rates among the plants appears good. Cattails were harvested from this wetland affecting the survival rate. Survival rate among the other plants is good. Evidence of foraging is less noticeable in this wetland. Many species that were not originally planted were found to be present, healthy and flowering. It is assumed that these plants are a result of seed and root mass located in the hydric substrate salvaged from off-site.

It was observed that the western side of the finishing wetland is receiving sediment from erosion of the hillside. Seeps from the hillside are resulting in some slumping into the wetland.

Several insects, both in the larval and adult forms, were observed in the wetland. Dragonflies, damselflies, whirligig beetles, water boatmen, water divers and water striders were observed. Frogs, toads, tadpoles, and fish were observed. Evidence of foraging was apparent.

Goff Station Restoration Project

Public Private Partnership Effort
Venango Township, Butler County, PA

Riparian Buffer

Riparian Area

Riparian area prior to gob removal. (4/28/00)

Riparian Area

Another goal of the Goff Station Reclamation project was the restoration of the riparian area along the western bank of Murrin Run, previously disturbed by past mining activities. It was anticipated that the riparian area between Murrin Run and the Final Wetland was to be disconnected from surface water and groundwater flow due to the various components of the passive treatment system especially the Final Wetland, which would intercept the majority of the drainage upgradient of the riparian area. This meant that the riparian buffer to be created would not be acting as a filter to prevent nutrients and sediment from entering Murrin Run.

The designed purpose of the riparian area was (1) to stabilize the streambank, (2) to provide wildlife habitat, (3) to provide and protect aquatic habitat, (4) to provide shade to moderate and stabilize water temperature, (5) to provide a source of organic material to the stream system, and (6) to promote visual diversity. A forested riparian buffer, however, could not be established for its potential to negatively affect the structural integrity of the breastwork of the adjacent Final Wetland. A mixture of shrub and herbaceous vegetation was used. The species and planting patterns were chosen based on existing plant communities along Murrin Run both upstream and downstream as well as other reaches in the Slippery Rock Creek headwaters.

In addition to providing bank stabilization and erosion control, the riparian area provides a diversity of hydrologic regimes, habitat, and vegetation. Bank stabilization and erosion control were provided primarily through the establishment of vegetation, bioengineering techniques, and the use of an erosion control fabric. The riparian area was designed to consist of wet slopes, vernal pools, and dry upland areas to encourage a diversity of vegetation to provide food and habitat for a variety of wildlife.

The portion of the riparian area to the north of the outlet from the Final Wetland provides a strip of upland between the Final Wetland to the west and the wetland area to the north and east. This upland area will be planted with a native upland wildlife forage and cover mix designed by Ernst Conservation Seeds. The forage and cover mix contains the following species:

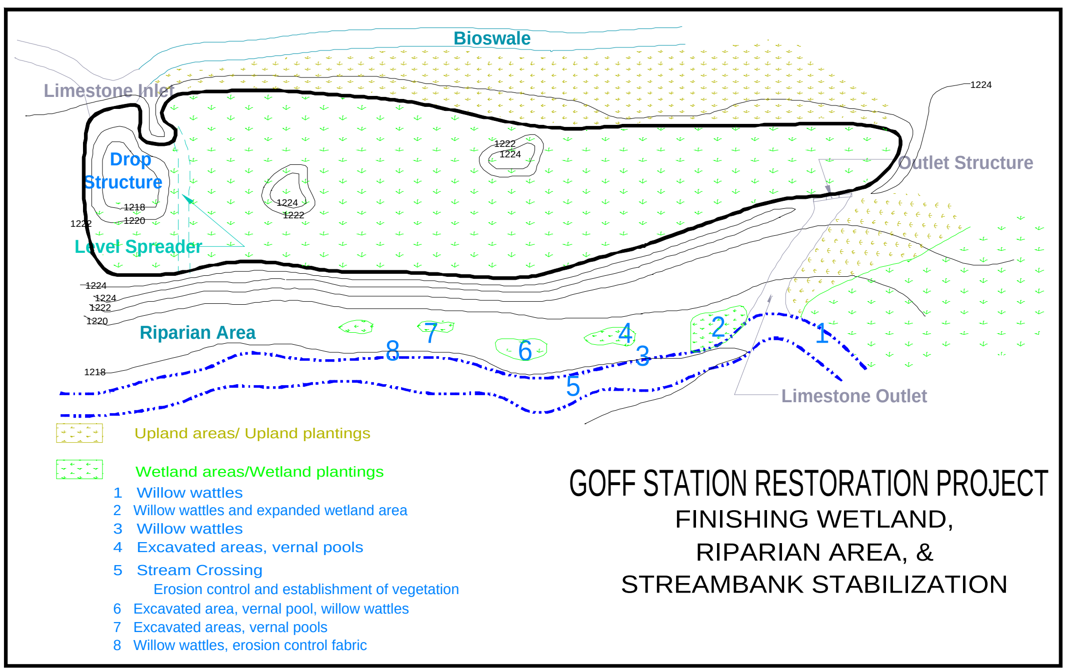
Tripsacum dactyloides	Eastern Gamagrass
Elymus canadensis	Canada Wild Rye
Chamaecrista fasciculata	Partridge Pea
Panicum virgatum	Switchgrass
Sorghastrum nutans	Indiangrass
Poa palustris	Fowl Bluegrass
Andropogon gerardii	Big Bluestem
Coreopsis tinctoria	Plains Coreopsis
Andropogon scoparius	Little Bluestem

This seed mix was supplemented with additional Switchgrass seed provided by the PA Game Commission. Transplants of shrubs and herbaceous plants were also utilized to establish vegetation in this area.

There is a 1- to 2-foot sheer bank along the western side of Murrin Run to the north of the spillway from the Finishing Wetland. Willow wattles were utilized to establish a dense concentration of quick-rooting shrubs to inhibit further erosion of the bank. (Designated as Area “1” on the following figure.) The willow wattles were obtained from Ernst Conservation Seeds and utilized cuttings from silky dogwood, buttonbush, and two species of willow.

To the south of the spillway, a small wetland area adjacent to Murrin Run was expanded (Area 2). Excavating into the adjacent bench, during abandoned coal refuse removal, created the footprint for the wetland in this area. Transplants and cuttings from the riparian area in the northern portion of the project area were used to establish vegetation. Three willow wattles were also installed at this location to assist in the stabilization of the western bank of Murrin Run.

An additional three willow wattles were placed along the west bank of Murrin Run between the expanded wetland area and the stream crossing to the south (Area 3). These were placed at locations with sheer banks and relatively sparse vegetation.



The riparian area was regraded to provide a diversity of habitat through the establishment of a variety of hydrologic regimes (Areas 4 and 7). Regrading of the riparian area provided a greater degree of microtopographic relief, aiding in the establishment and continuance of a more diverse vegetative community. Higher elevations within the riparian area were seeded with the native upland wildlife forage and cover mix. Low lying areas within the riparian area were seeded with an area annual and perennial wildlife food mix for seasonally flooded areas. The wildlife food mix for seasonally flooded areas contains the following species:

Echinochloa crusgalli	Japanese Millet
Poa palustris	Fowl Bluegrass
Polygonum lapathifolium	Nodding smartweed
Elymus virginicus	Virginia Wild Rye
Bidens aristosa	Tickseed Sunflower
Panicum virgatum	Switchgrass
Carex crinita	Fringed Sedge
Carex lupulina	Hop Sedge

Each seed mix was supplemented with additional Switchgrass seed, provided by the PA Game Commission. Seeding and mulching were conducted immediately after regrading. Shrubs and herbaceous plants were then harvested from the riparian areas in the northern and southern portions of the project area and transplanted to provide more immediate and more diverse establishment of vegetation. Transplants included the following species:

Alnus rugosa	Speckled Alder
Carex spp.	Sedges
Eleocharis obtusa	Blunt Spikerush
Eupatorium perfoliatum	Boneset
Leersia oryzoides	Rice Cutgrass
Mimulus ringens	Monkey-flower
Osmunda cinnamomea	Cinnamon Fern
Panicum clandestinum	Deertongue
Physocarpus opulifolius	Ninebark
Polygonum sagittatum	Arrow-leaved tearthumb
Scirpus cyperinus	Wool-grass
Spiraea alba	Meadow-sweet
Spiraea tomentosa	Steeple-bush
Thelypteris noveboracensis	New York Fern
Typha latifolia	Cattail
Verbena hastate	Blue Vervain
Vernonia noveboracensis	New York Ironweed

The area of the stream crossing was improved through the addition of topsoil and the establishment of vegetation (Area 5). Prior to the addition of topsoil on the slopes of the stream crossing, silt fence or staked hay bales were installed to prevent the transport of materials into Murrin Run.

Within the riparian area immediately downstream of the crossing, a basin was excavated and two willow wattles installed (Area 6). The existing trees along the streambank at this location are lessening the effects of erosion resulting from the flows in Murrin Run. The dense root mats that were established from the cuttings of dogwood and buttonbush coupled with willows in the wattles assisted in the stabilization of the streambank and significantly reduced the potential of bank failures in the future.

An additional seven willow wattles were placed along a section of the west bank of Murrin Run south of the stream crossing (Area 8). Installation of willow wattles will assist in preventing unwanted erosion and migration of the stream channel toward the finishing wetland of the passive treatment system. Following the installation of the willow wattles within the bank, this area was seeded with a wildlife forage mix for seasonally flooded areas prepared by Ernst Conservation Seeds. The bank was then covered with straw-matting erosion control fabric. Shrubs and herbaceous plants were then harvested from the riparian area in the southern portion of the project area and transplanted to this portion of the streambank for more immediate establishment of vegetation and to increase vegetative diversity.

During the removal of coal refuse, vegetation was left wherever possible along the west bank. Erosion, however, is evident at the outlet of the temporary culvert installed for the stream crossing to access the restoration site. When this crossing is removed a meander within the stream will be created to direct flow away from the west bank of Murrin Run. The east bank is well armored with a base of boulders. Willow wattles and/or brush layering will be used to stabilize the banks that are reconstructed following the stream crossing removal. Banks will also be vegetated with transplants and cuttings.

Murrin Run and Riparian Area (south of stream crossing) following gob removal. (6/26/00)

Riparian area (south of stream crossing) with addition of topsoil. (4/4/01)

Riparian area (south of stream crossing) with initial growth for stabilization. (5/5/01)

Planting of riparian area (north of stream crossing) with group from Butler County Juvenile Court Services. (8/7/01)

Installation of willow wattles in riparian area (south of stream crossing). (8/8/01)

Planting of riparian area (south of stream crossing) following addition of soil, seeding, and installation of willow wattles and erosion control fabric. (8/9/01)

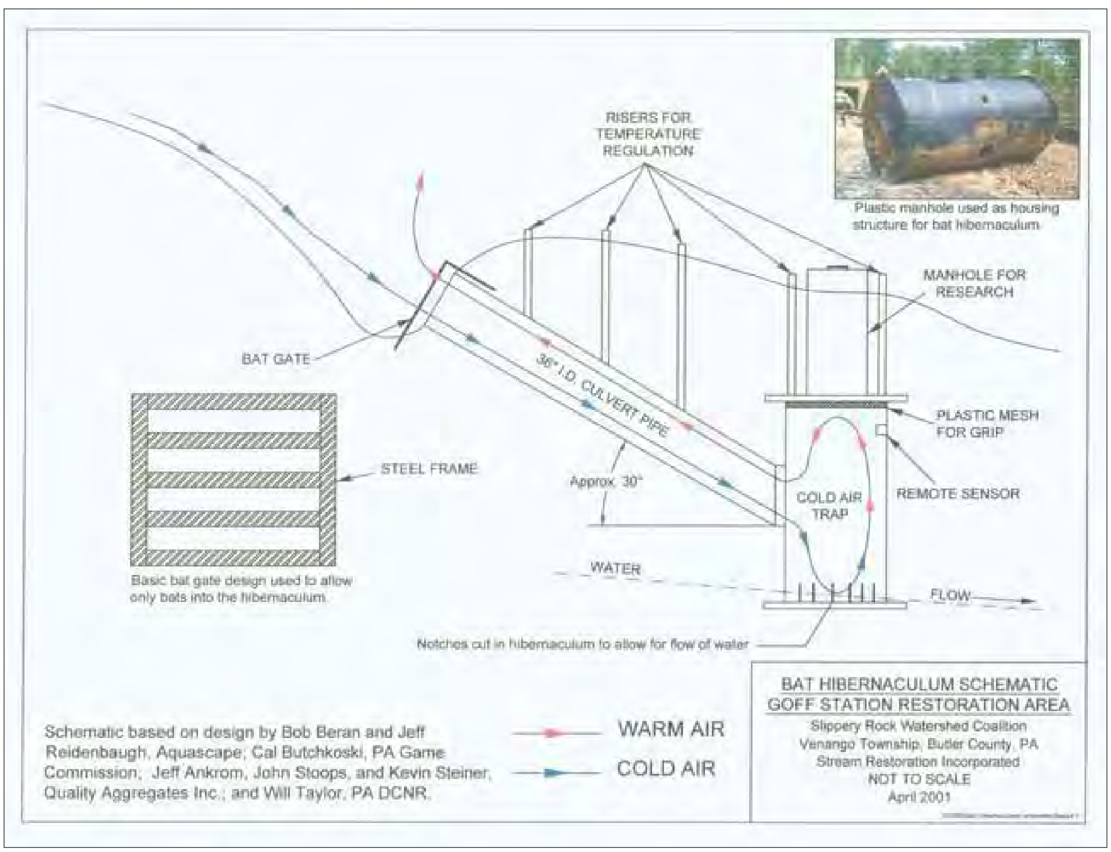
Planting of riparian area (south of stream crossing) with group from Butler County Juvenile Court Services. (8/14/01)

Riparian area (south of stream crossing) following regrading and August 14th planting. (8/14/01)

Goff Station Restoration Project

Public Private Partnership Effort
Venango Township, Butler County, PA

Bat Hibernaculum:
An Outgrowth Project



Schematic drawing of the bat hibernaculum at Goff Station.

Bat Hibernaculum

The bat hibernaculum is an outgrowth project that was not included in the original Growing Greener proposal, but was developed after the grant was awarded during an informal discussion among project partners. The idea was presented, discussed, and supported in less than 10 minutes. As with all of the expansions and innovations to the project, the bat hibernaculum was completed at no additional cost to the Commonwealth, eliminating the need for change orders. Based on information from Bat Conservation International, this is the first known constructed bat hibernaculum east of the Mississippi River.

The location of the bat hibernaculum was selected during a site visit by Cal Butchkoski (PA Game Commission), Margaret Dunn (Stream Restoration Incorporated), Robert Beran (Aquascape), and Will Taylor (Jennings Env. Ed. Center, PA DCNR). The restoration area was assessed, and a swale below the discharge of ST40 was selected as the most appropriate area. Location downgradient of the discharge had the advantage of utilizing the abandoned underground mine drainage with relatively constant temperature to add humidity and to stabilize temperatures within the hibernaculum. It was located within a wooded area with mature trees, some of which had peeling bark, suitable for summer roosting. The setting is also near clearings, a small reservoir collecting flows from mine seeps and large constructed wetlands to the north and east. The existing ravine of the former mine entry reduced the need for excavation to place the artificial cave, and the presence of a depression in the ground surface to the west of the drift entry provided a natural cold air sink that would be beneficial as the location of the tunnel opening.

An HDPE manhole, 10-feet long and 5-feet in diameter, was salvaged from an active treatment site near Snowshoe, PA and donated by Northwest Sanitary Landfill/Waste Management, Inc. for use as the artificial cave for the bat hibernaculum. Sixty feet of 36-inch diameter culvert pipe was purchased and donated for use as the tunnel entry into the bat hibernaculum by Quality Aggregates. Prior to installation, Tex-net (plastic netting) was used to line the inside of the culvert pipe to provide foot-holds for bats within the hibernaculum. Notches were also cut at the base of the walls of the HDPE manhole to allow for the flow of groundwater into and out of the hibernaculum.

The excavation for the placement of the bat hibernaculum began in March 2001. A laser level and stadia rod were used to set the bat hibernaculum at the appropriate elevation and to obtain an appropriate slope for the placement of the tunnel entry. Placement and assembly of the bat hibernaculum took place in April 2001. An opening was cut into the HDPE manhole using a chainsaw to allow for the placement of the culvert pipe. Once the culvert pipe was set as the tunnel entry, openings were also cut into the “ceiling” of the manhole and culvert pipe to allow for the installation of HDPE risers that allow for the regulation of temperatures within the hibernaculum. A bat gate was also installed at the tunnel entry to prevent the possibility of people and animals entering the hibernaculum through the tunnel. A manhole riser was obtained from the Kelly Run Landfill operated by Waste Management, Inc. that allows for access directly into the HDPE manhole of the bat hibernaculum.

Installation of remote sensing equipment for monitoring of temperatures within the hibernaculum was installed by Cal Butchkoski, Pennsylvania Game Commission. Data obtained from remote sensing will be used to determine if manipulations of the temperature through the installed HDPE risers are needed.

Bat boxes were built by volunteers from Concordia Haven One, a retirement community, utilizing plans provided by the Pennsylvania Game Commission. The bat boxes were installed in nearby trees to provide roosts during the warmer months which will hopefully lead to use of the hibernaculum during the colder winter months.

Location selected for bat hibernaculum, former mine entry with mine drainage seep ST40. (2/12/01)

HDPE Manhole used as artificial cave for bat hibernaculum. (3/23/01)

Culvert pipe was used to provide a 60-foot tunnel entry into the bat hibernaculum. (3/28/01)

Tex-net (plastic netting) was used to line inside of the tunnel and HDPE manhole to provide foot-holds for bats. (3/28/01)

Excavation begins for placement of the hibernaculum within the ravine. (3/23/01)

Stadia rod and laser level used to set the hibernaculum and tunnel to appropriate depth and slope. (3/23/01)

Placement of the bat hibernaculum. (4/4/01)

Installation of tunnel onto the bat hibernaculum. (4/4/01)

Goff Station Restoration Project

Public Private Partnership Effort
Venango Township, Butler County, PA

Education/Outreach

- Professional Tours
- Educational Activities
- Volunteers

Karns City first graders discovering life in the 41 wetland. (6/01/2001)

ENVIRONMENTAL EDUCATION/PUBLIC OUTREACH

The project participants strongly support community involvement and public outreach activities for all of our projects. Through community involvement and education/outreach programs, those interested not only learn about passive treatment technology, habitat restoration, environmental issues, and the concept of public-private partnerships, but are also given the opportunity to take an active role in watershed restoration.

Although we consider all education/outreach activities important, we feel that those involving young people to be particularly important. Junior Girl Scout Troop #653 has been actively involved at the Goff Station site where they have participated in educational programs, planted wetlands, and built and installed bluebird and wood duck boxes. First graders from Karns City school district came for a field trip to participate in a hands-on discovery and environmental education program.

Possibly one of the most rewarding programs that we have had the pleasure to participate in was through the Butler County Juvenile Court Working Opportunities to Repay the Community (WORC) Program. The program, designed to help first-time, non-violent, juvenile offenders meet the community service penalties imposed by the juvenile court system, enables young people to develop a sense of pride/self-respect, and to improve their communities while teaching new skills and fostering new interests. The youth helped in planting the final wetland, bioswale, and riparian area. Because of this experience, a couple of the youth became extremely interested in pursuing a career in this field and asked if their work could continue even after their compulsory hours were completed.

Goff Station has been included in numerous tours, presentations, posters, newspaper articles, television broadcasts, newsletters, and most recently on Watershed Weekly, a web-based news broadcast hosted by the PA DEP website. Below are some of the highlights.

On 08/24/00, the site was part of a field tour organized by Chuck Cravotta, USGS. Environmental professionals from Australia, Pennsylvania, and several adjoining states, participated in the tour.

On 10/13/00 & 10/14/00, Slippery Rock Watershed Coalition participants presented a power point and poster presentation at the PADEP Growing Greener Conference held at Penn State University.

On 10/20/00 & 10/21/00, Girl Scout Troop #653 participated in an educational program and then harvested the wetland plants. The next day they helped to plant a wetland. Understanding the water depths, water quality, and the wildlife value were stressed. The Girl Scouts were enthusiastic and the day was enjoyable for all involved.

On 11/09/00, the Goff Station Restoration Project was included on the PA DEP Releaf Tour. With over 40 in attendance, more than ½ dozen Coalition participants provided information at different stations within the construction area. This was a great opportunity to discuss the challenges and team effort involved in the restoration project and to demonstrate systems in different stages of completion.

On 01/31/01, members of the Army Corps of Engineers toured the Goff Station site along with several other Slippery Rock Watershed Coalition sites.

On 03/03/01, Girl Scout Troop #653 installed blue bird boxes that they built using plans provided by the PA Game Commission.

On 03/24/01, teachers participating in the Jennings Environmental Education Center Workshop as part of accreditation regarding teaching the proposed science and ecology standards toured the site learning about mining history, AMD, environmental laws, passive treatment technology, and wetlands.

On 04/06/01, Goff station was included in presentations as well as part of the field tour of the Slippery Rock Watershed Coalition's Annual Symposium.

On 05/10/01, the Pittsburgh Tribune Review published an article on the bat hibernaculum.

On 05/14/01, the Pittsburgh Post-Gazette published an article on the bat hibernaculum. On the same day, WPXI Channel 11 News broadcast a clip on the bat hibernaculum.

On 05/19/01, Girl Scout Troop #653 participated in another wetland planting.

On 06/01/01, Karns City first graders participated in a hands-on field trip which included a discovery and educational program.

On 07/14/01, members of the Shamokin Creek Restoration Alliance toured several SRWC sites including Goff Station.

On 07/18/01, Goff Station was included in presentations as well as a field tour as part of the PA DEP Watershed Academy that was held at the Jennings Environmental Education Center.

On 08/8/01, Jennings uses Goff Station as part of tour for a teacher workshop for science and ecology standards.

On 09/26/01, members of the Butler County Environmental Quality Board toured various SRWC sites including Goff Station.

On 09/28/01, Goff Station was used as part of a tour for Jennings Environmental

Education Center Workshop training for PA DCNR Environmental Educators.

Local volunteer groups and individuals have donated their valuable time and efforts throughout the project. Equipment and supplies have also been donated to enable additional restoration and enhancement efforts.

The following is an alphabetical listing of volunteers and charitable donations.

1. Beran Fencing- Donated posts for bluebird and wood duck boxes, materials for bat hibernaculum: Robert Beran.

2. Butler County Juvenile Court System- Aided in several polishing wetland plantings, planting of the bioswale and riparian area plantings throughout a 3-month period. Supervisors aiding youth include Angela Lamberto and Sue Daugherty.

3. Concordia Haven One- Donated time and effort in constructing the bat boxes: . Jim Arner, Joe Schiedel.

4. PA Department of Conservation and Natural Resources- Provided assistance with the design and concept of the bat hibernaculum and has shown a tremendous amount of support of the restoration project by coordinating their educational efforts with our project: Will Taylor.

5. Girl Scout Troop 653- Built bluebird and wood duck boxes, aided in the installation of these boxes, monitors boxes. Aided in 38/39 wetland and 41 wetland plantings. The Girl Scout Leaders include Marion Hall and Deb Bowser.

6. Landowners- The landowners have been very generous in donating their property for this project as well as granting long-term access to the site: Mr. Hindman, Mr. Tiche.

7. PA State Game Commission- Donated wood for the bluebird boxes, aided Girl Scouts in building the bluebird and wood duck boxes, permitted plants to be harvested from the state gamelands. Aided in the design of the bat hibernaculum and also provided temperature monitoring equipment for the hibernaculum. Coordinated efforts to mistnet for bats at our project site: Arthur Brunst, Calvin Butchkowski and Dale Hockenberry.

8. Quality Aggregates- Donated wood for the wood duck and bat boxes: Joe Aloe, Jeff Ankrom.

9. Waste Management- Donated materials for the bat hibernaculum: Jim David, Bill Gongoware.

Margaret Dunn, President, Stream Restoration, Inc. and Shaun Busler, Biologist and Slippery Rock Watered Coalition participants, discuss the Goff Station design at a tour with the DEP Watershed Academy. (7/18/2001)

John Stoops, Construction Foreman, Quality Aggregates, and Slippery Rock Watershed Coalition participant, describes the construction techniques used in building the Vertical Flow Ponds. (7/18/2001)

A tour was given to the Stream Releaf Group. The group consisted of employees from NRCS, Conservation Districts, and the DEP. (11/9/2001)

Bob Beran discuses the bat hibernaculum with Karns City first graders. (6/1/2001)

Laura Spencer, Slippery Rock Watershed Coalition participant, discusses stream quality with the Karns City first graders. (6/1/2001)

Goff Station is used as a field trip for teacher workshops held by Jennings Environmental Education Center. (3/24/2001 and 8/8/2001)

Will Taylor and Tonya Rucoski, Jennings Environmental Educational Center, use Goff Station as a field trip for a teacher workshop. (8/8/2001)

Margaret Dunn and Bob Beran discuss the various roles and functions of the passive treatment systems and wetlands as well as environmental laws and regulations as a part of the teacher workshop. (8/8/2001)

Residents of Concordia Haven One volunteered their time and effort to build the bat boxes that were installed at Goff Station. (6/2001)

Local Girl Scout Troop 653 with the help of the PA game Commission built blue bird and wood duck boxes for Goff Station. The Girl Scouts later installed the boxes. (3/2001)

Local Girl Scout Troop 653 and family members volunteered for the ST38/39 and ST41 wetland plantings. (10/2001, 5/2001)

Youth from the Butler County Juvenile Court System aided in several plantings of both the Final Wetland and the Bioswale. (6/2001-7/2001)

The youth from the Butler County Juvenile Court System also worked very hard and gave a lot of effort in planting the Riparian Area of Murrin Run. (7/2001-8/2001)

PASSIVE TREATMENT SYSTEM PERFORMANCE

An evaluation of the success of the various components of the passive treatment system is addressed below. **(See also attached graphs.)**

Table 1: Comparison of Water Quality through the Goff Station Passive System
(mean values)

AMD DISCHARGE	SAMPLE POINT	pH	ALK.	ACD.	Fe	Mn	Al
38/39	**Raw**	3.1	0	462	85.7 (diss. 84.1)	3.4 (diss. 3.1)	34.9 (diss. 25.9)
	VFP1	7.0	114	0	5.0	2.3	0.2
	VFP2	7.4	143	0	3.7	1.6	0.1
	SP1	7.5	108	0	1.0	1.9	0.2
	WL1	7.4	111	0	2.3 (diss. 0.1)	0.9 (diss. 0.5)	1.0 (diss. 0.1)
40/40A/42	**Raw**	3.6	0	57	7.5 (diss. 6.9)	2.9 (diss. 2.6)	2.1 (diss. 1.5)
	VFP3(LS only)	7.1	59	0	2.5	3.1	0.7
	VFP4	6.9	63	0	1.3	1.8	0.4
	WL2	7.1	56	0	0.3 (diss. 0.1)	1.3 (diss. 0.9)	0.2 (diss. 0.1)
41	**Raw**	4.9	7	38	4.1 (diss. 0.1)	2.5 (diss. 2.3)	2.7 (diss. 0.4)
	Upper WL	6.9	89	0	0.6 (diss. 0.3)	0.9 (diss. 0.6)	0.4 (diss. 0.3)
40/40A/41/42	**Bioswale**	7.2	45	0	0.1 (diss. <0.1)	0.6 (diss. 0.2)	0.3 (diss. 0.1)
38/39/40/40A/41/42	**Final WL**	6.5	33	0	0.3 (diss. 0.1)	0.9 (diss. 0.3)	0.5 (diss. 0.2)

alkalinity, acidity, and total metals in mg/l; average pH not calculated from H ion concentration; See attached analyses.

ST38/39 Passive Treatment System

Raw Water Characteristics: Pre- and post-construction flow rates are not equivalent; however, a 2/22/02 inspection report from T Elicker, MCI, PADEP, Knox DMO stated that the overall system flow was ~300 gpm. Although this data was not included in the monitoring data as the water sample analyses were unavailable at the time of writing, this indicates that the flow is re-establishing. For the monitoring available to date, the post-construction flow rate has been much less. The average 38/39 pre-construction flow rate was 238 gpm while the post-construction flow rate has been about 50 gpm until just recently. The substantial decrease in flow can be attributed to (1) lowering the abandoned underground mine pool to enable construction of the ST41 wetland in the abandoned strip cut, (2) the extended drought conditions, and (3) the diversion of surface drainage. In addition, flows are continuing to be deliberately diverted to the ST41 wetland to ensure successful plant establishment. As the elevation of the pit ponds were determined prior to construction and as bench marks have been established to aid system construction and development of the “As-Builts”, unless there are other influences, the elevation of the mine pool can be re-established.

Table 2: Pre- vs. Post-Construction 38/39 Raw Water Characteristics

38/39 Raw	Date	Flow (gpm)	pH	acidity		Fe		Mn		Al	
				mg/l	lbs/day	mg/l	lbs/day	mg/l	lbs/day	mg/l	lbs/day
pre-const.	1/30/1998	190	3.9	58	132	6.1	14	1.9	4	3.6	8
post-const.	1/25/2002	50	3.0	400	240	107.6	65	4.0	2	40.9	25

See attached sample analyses. Pre-construction 38/39 is the weighted average based on flows of ST38 and ST39 for the 1/30/98 sample date. Total metal concentrations. Average pH was not determined from H ion concentration.

As extensive monitoring is not available for the combined 38/39 discharge, pre- and post-construction analyses conducted at about the same time of the year are compared in the above table.

Table 2 indicates that in January post-construction flows were 4x less than pre-construction and that the water quality was substantially worse. There is a 7-fold increase in acidity and an 18-, 2-, and 11-fold increase in the iron, manganese, and aluminum concentrations, respectively. The result: even with the lower flow, the acid and metal loading entering Vertical Flow Pond 1 and 2 has been increased.

Vertical Flow Ponds (VFP1 & 2): Sample analyses demonstrate that both Vertical Flow Ponds are operating successfully. The effluent can be characterized as net alkaline with a relatively low metal content. Based on average values, **100% of the acidity is being neutralized while approximately 97% of the iron, 74% of the manganese, and 99% of**

the aluminum are being retained within the pond. It should also be noted that the **pH increased from 3.1 to 7.0.** (See Table 1 and attached analyses.)

Settling Pond (SP1): SP1 is performing successfully. There is a slight decrease in alkalinity due to the precipitation of metals. Based on mean averages, 75% of the iron remaining in the effluent of the Vertical Flow Ponds is precipitating within SP1.

Wetland (WL1): WL1 does not appear to be contributing to the improvement of the discharge as the influent water quality is of good quality. On individual sample dates, comparison of the influent (SP1 effluent) with the effluent does indicate a decrease in iron and manganese. Note, however, the WL1 effluent has only 0.1 mg/l of dissolved iron and aluminum and only 0.5 mg/l of dissolved manganese. **(See Biomonitoring.)**

ST40/40A/41/42 Passive Treatment System

Raw Water Characteristics: The current aggregate flow appears to be comparable to pre-construction monitoring. ST40A was discovered during construction and was not included in the PA DEP monitoring as the flow did not issue at a discreet point but was within iron sludge deposits. During removal of these deposits, this seep was uncovered. On 10/30/00, ST40A had a flow of 9 gpm with a 3.5 pH and 93 mg/l acidity. Total metal concentrations were 24 mg/l Fe, 3 mg/l Mn, and 6 mg/l Al. ST40A was combined with ST40 and ST42 for treatment in VFP3 & 4. As mentioned earlier in the report, the system was designed to provide the option to include ST41, after flowing through the Upper Wetland, in the ST40/40A collection system.

Table 3: Pre- vs. Post-Construction ST40/40A/41/42 Raw Water Characteristics

Discharge	Date	Flow (gpm)	pH	acidity		Fe		Mn		Al	
				mg/l	lbs/day	mg/l	lbs/day	mg/l	lbs/day	mg/l	lbs/day
40/41/42 pre-const.	1/15/1997	121	4.6	12	17	0.4	1	1.1	2	0.5	1
40/40A/41/42 post-const.	1/25/2002	120	3.6	43	62	8.5	12	3.3	5	2.1	3

See attached sample analyses. Pre-construction values are the weighted average based on the individually measured flows of ST40, ST41, and ST42 for the sample date. Total metal concentrations. Average pH not determined from H ion concentration.

Direct and meaningful comparison of the pre- and post-construction raw water characteristics is tenuous as post-construction monitoring data are limited. ST41 is being directed at this time into VFP3 & 4.

Table 3 indicates that the pre- and post-construction flows are comparable for the winter months. The quality, however, is substantially worse. This is probably due to including ST40A and/or the lowering and re-establishment of the abandoned underground mine pool.

Long-term monitoring will determine trends and aid in the evaluation of the water quality. Note that, although the water quality is worse, the passive system is extremely successful in treating the water. (See Table 1.)

Vertical Flow Ponds (VFP3 & 4): Sample analyses demonstrate that both Vertical Flow Ponds are operating successfully. The current effluent can be characterized as net alkaline with a relatively low metal content. Based on the available analyses (See attached.), **100% of the acidity is being neutralized and over 84% of the total iron and over 70% of the total aluminum are being retained. (See Table 1.) The pH has increased from 3.6 to 7.**

Wetland 2 (WL2): WL2 is functioning very successfully. Dissolved metals oxidize, hydrolyze, and settle within the wetland. The acidity associated with the formation of metal solids is neutralized and a small amount of alkalinity consumed. The effluent from WL2 is of good quality and is net alkaline with a 7 pH. The aggregate total metal content of the parameters analyzed is less than 2 mg/l. Both dissolved iron and dissolved aluminum is 0.1 mg/l and dissolved manganese is 0.9 mg/l. **(See Biomonitoring.)**

Raw Water Characteristics of ST41: Because of the design of the system accurate flow measurements are difficult to obtain. Flows do appear to be significantly lower than pre-construction data suggests, as stated previously, possibly due to the drought conditions and/or to the manipulation of the mine pool caused by draining the pit to construct the Upper Wetland. As with the 38/39 system, flows appear to be returning to the approximate pre-construction rates this spring.

Table 4: Pre- vs. Post-Construction ST41 Raw Water Characteristics
(mean values)

Sampling Events (n)	Flow (gpm)	pH	acidity		Fe		Mn		Al	
			mg/l	lbs/day	mg/l	lbs/day	mg/l	lbs/day	mg/l	lbs/day
30 pre-const. (6/7/95 - 10/16/00)	72	4.2	35	30	1.5	1	1.9	2	1.3	1
2 post-const. (7/27/01 - 9/18/01)	---	4.9	8	---	4.1 (diss. 1.4)	---	2.5 (diss. 2.3)	---	2.7 (diss. 0.4)	---

Post-construction flow rate of ST41 included in measurement for ST40/40A/41/42. See appropriate tables showing combined loadings and concentrations. See attached sample analyses. Total metal concentrations. Average pH not determined from H ion concentration.

The quality of ST41 does not appear to have been significantly impacted during construction. Long-term monitoring will enable evaluation of any changes in the raw water quality.

Upper Wetland for ST41: The Upper Wetland was constructed to improve the ST41 discharge. At times, due to the fabricated substrate consisting of pond fines from a limestone quarry and salvaged hydric soil from an off-site mitigation project in a nearby county, and due to the successful plant community, ST41 is treated entirely by this wetland.

The pH of the effluent was 6.9 compared to the influent pH of 4.9 in July thru September of 2001. The effluent was net alkaline with low metals. Based on the average values, **85% of the iron, 85% of the aluminum, and 64% of the manganese is being retained within the wetland.**

Bioswale: The Bioswale conveys and provides additional treatment to the WL2 effluent for ST40/40A/42. If the flow of ST41 is not combined with ST40/40A/42, ST41 is conveyed by the 500-foot limestone rip-rap lined spillway from the Upper Wetland directly to the Bioswale. Dissolved oxygen is expected to increase due to the cascades which encourage further metal oxidation. In addition, the Bioswale is a naturally-functioning wetland with value for wildlife habitat and for the settling of solids prior to discharging to the Final Wetland. The **Bioswale is very successful** with the **combined total metals** concentration decreased to **1 mg/l** and the **dissolved metals of 0.2 mg/l or less** for each parameter.

Final Wetland for All Treated Discharges (ST38/39/40/40A/41/42)

Final Wetland: The Final Wetland was not designed with the primary purpose of treating water. The main function was to provide wildlife habitat and to restore the area once overlain by abandoned coal refuse. Because the Final Wetland receives the effluent from all three systems and because some of the components were not always discharging at the same time, assessment of the treatment provided is difficult. The effluent of the Final Wetland which is the final discharge for the entire Goff Station passive treatment system is net alkaline with a low metal content. (See Table 1.) The **final effluent not only meets but is better than the PA Title 25, Chapter 93 allowable in-stream concentrations** of 1.5 mg/l total iron, 1 mg/l total manganese, and alkalinity exceeding acidity. **(See also Wetlands and Biomonitoring sections.)**