

Life Cycle Analysis of a Nearly 29-Year-Old AMD Passive Treatment System's Vertical Flow Pond

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Visitor Center and Educational Hikes



Soil, Water, and Mine Reclamation Research



Prairie Ecosystem Studies and Conservation

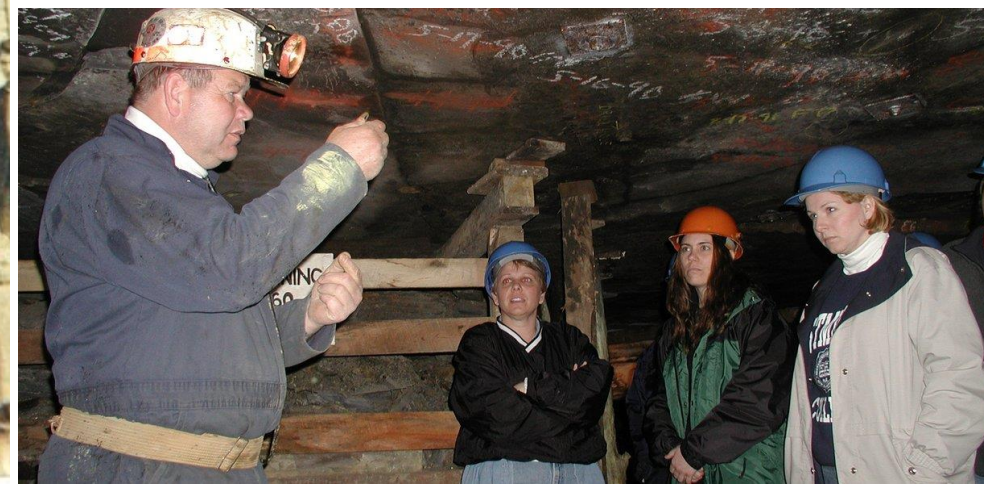
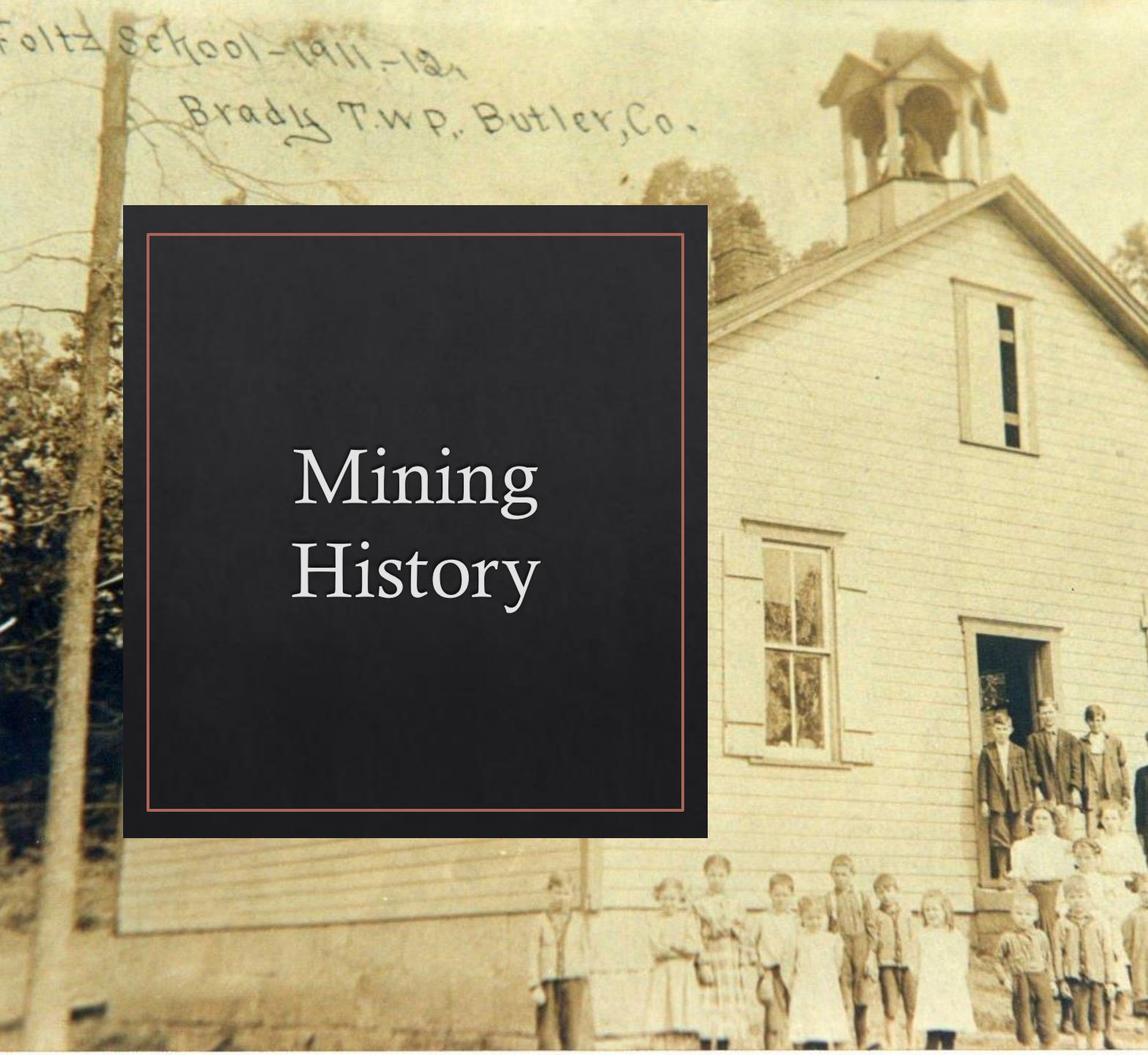


Native Wildlife Conservation and Education

The Site:

Jennings Environmental Education Center Slippery Rock, Butler County, Pennsylvania







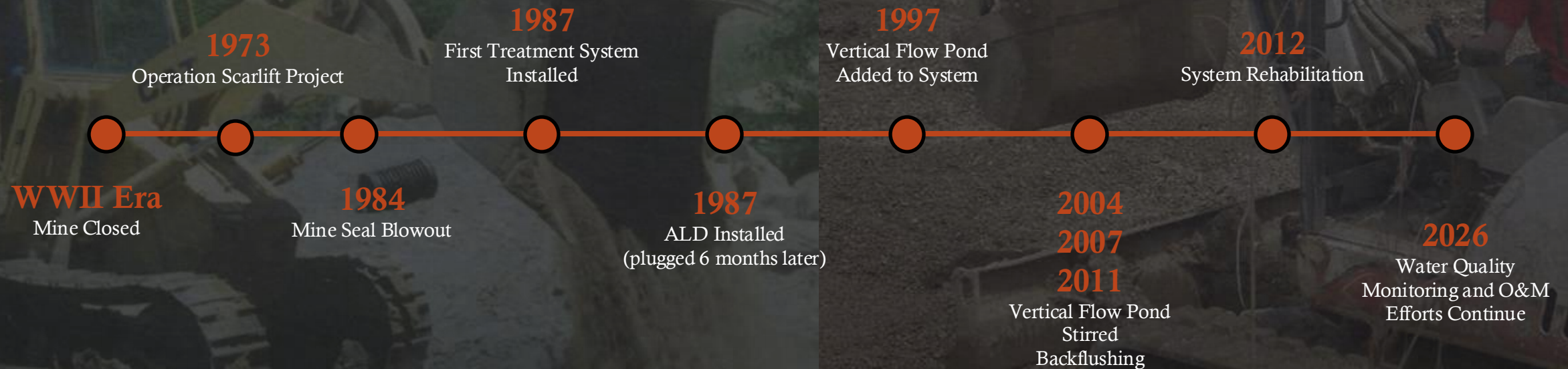
Quick History Aside: Foltz Schoolhouse

- ◆ Opened in the 1880s
- ◆ Closed in 1963
- ◆ Restored by volunteers



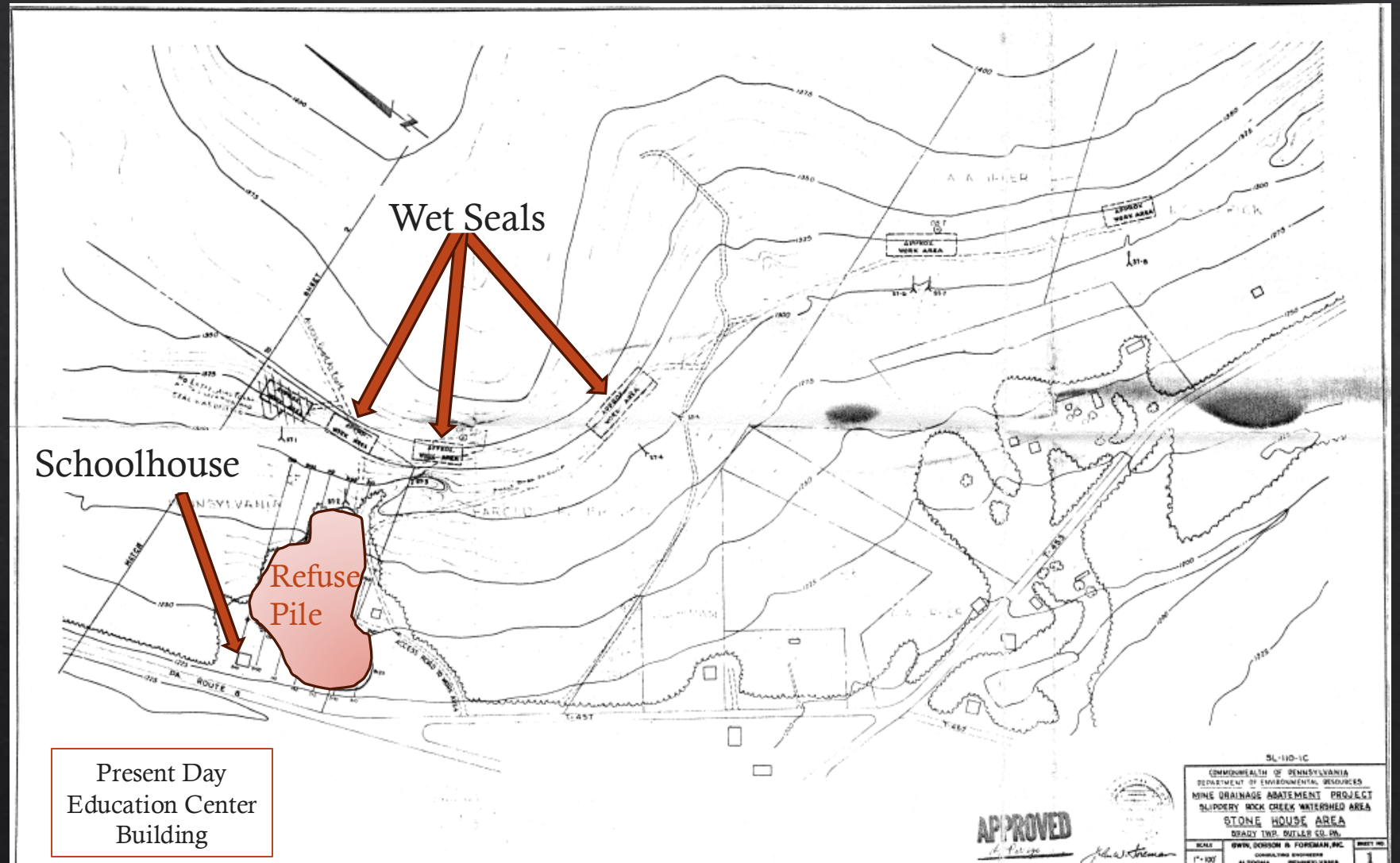
Photos: DCNR Staff

Reclamation at Jennings



Operation Scarlift

- ◇ 1973
 - ◇ Wet Seals
 - ◇ Refuse removal



Initial Treatment Systems

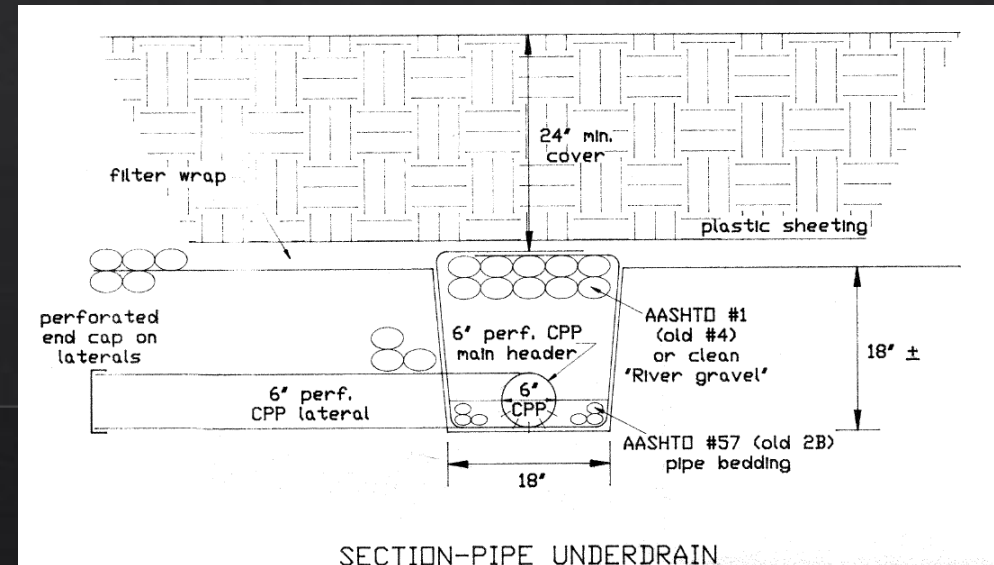
“Lower Wetland System”

- ◇ 1984 – Wet Seal blow out
- ◇ 1987
 - ◇ Sediment Pond
 - ◇ Two Aerobic Wetland Cells



Anoxic Limestone Drain (ALD)

- ◇ 1992
 - ◇ 362 metric (400 short tons) of limestone
 - ◇ 6 cells 0.9m x 0.9m x 175m (3ft x 3ft 575ft)
 - ◇ Plugged within 6 months



ALD plugged within 6 months

Table 2. Anoxic Limestone Drain: Comparison of Influent and Effluent Characteristics (average values)

Point	Flow Rate	pH	Alkalinity	Acidity	T. Fe	T. Mn	T. Al	Sulfates
Influent	na	3.3	0	NR	81	9	21	691
Effluent	92 (24)	6.3	177	NR	62	9	<1	680

Flow rate-L/min (gpm); pH-standard units; alkalinity & acidity-mg/L CaCO₃; total metal values-mg/L [iron (TFe), manganese (TMn), aluminum (TAl)]; sulfates-mg/L; not available (NA), not reported (NR) (Ref: Hedin et al, 1994)

C. Denholm, JSMR 2010

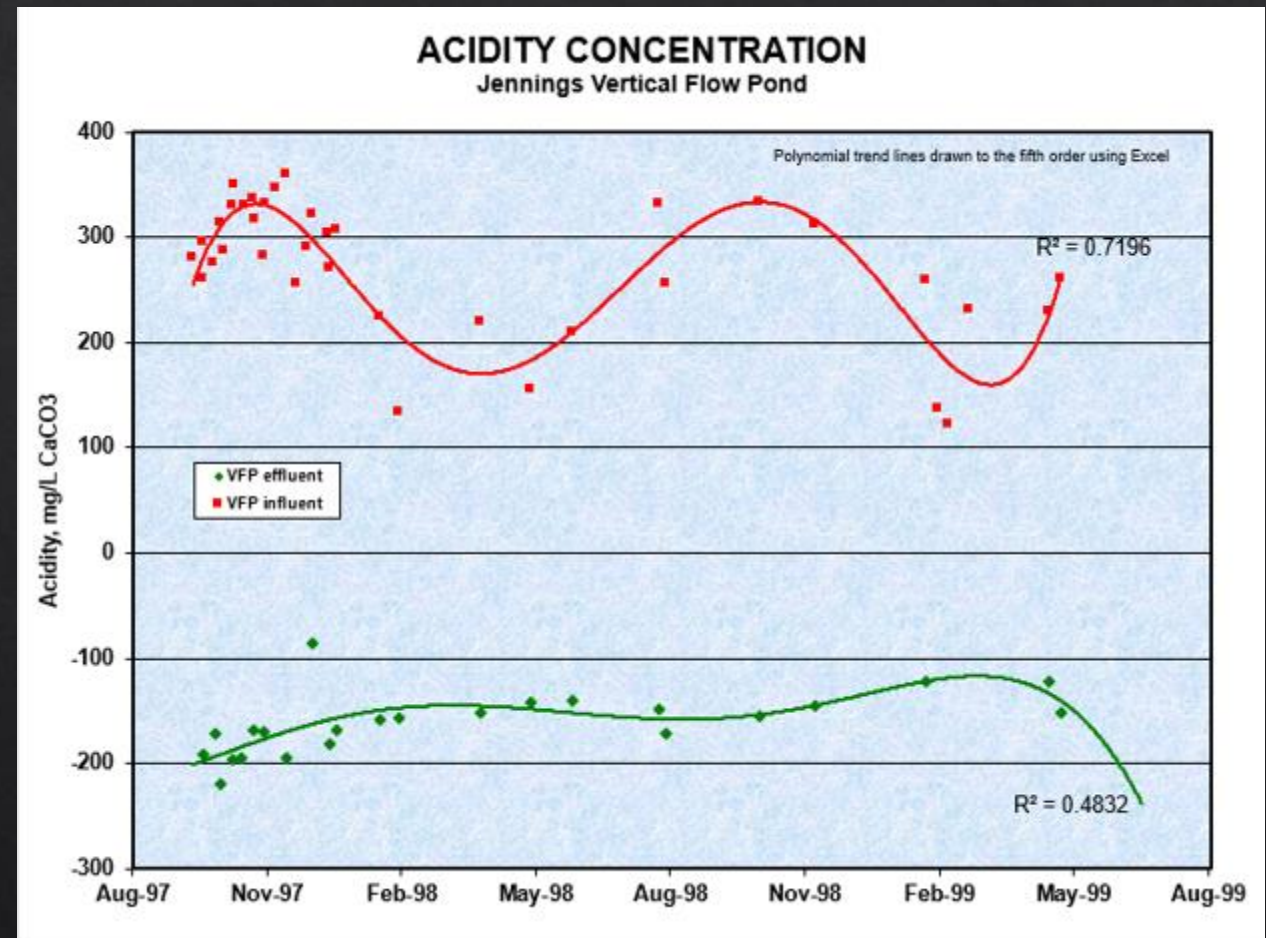
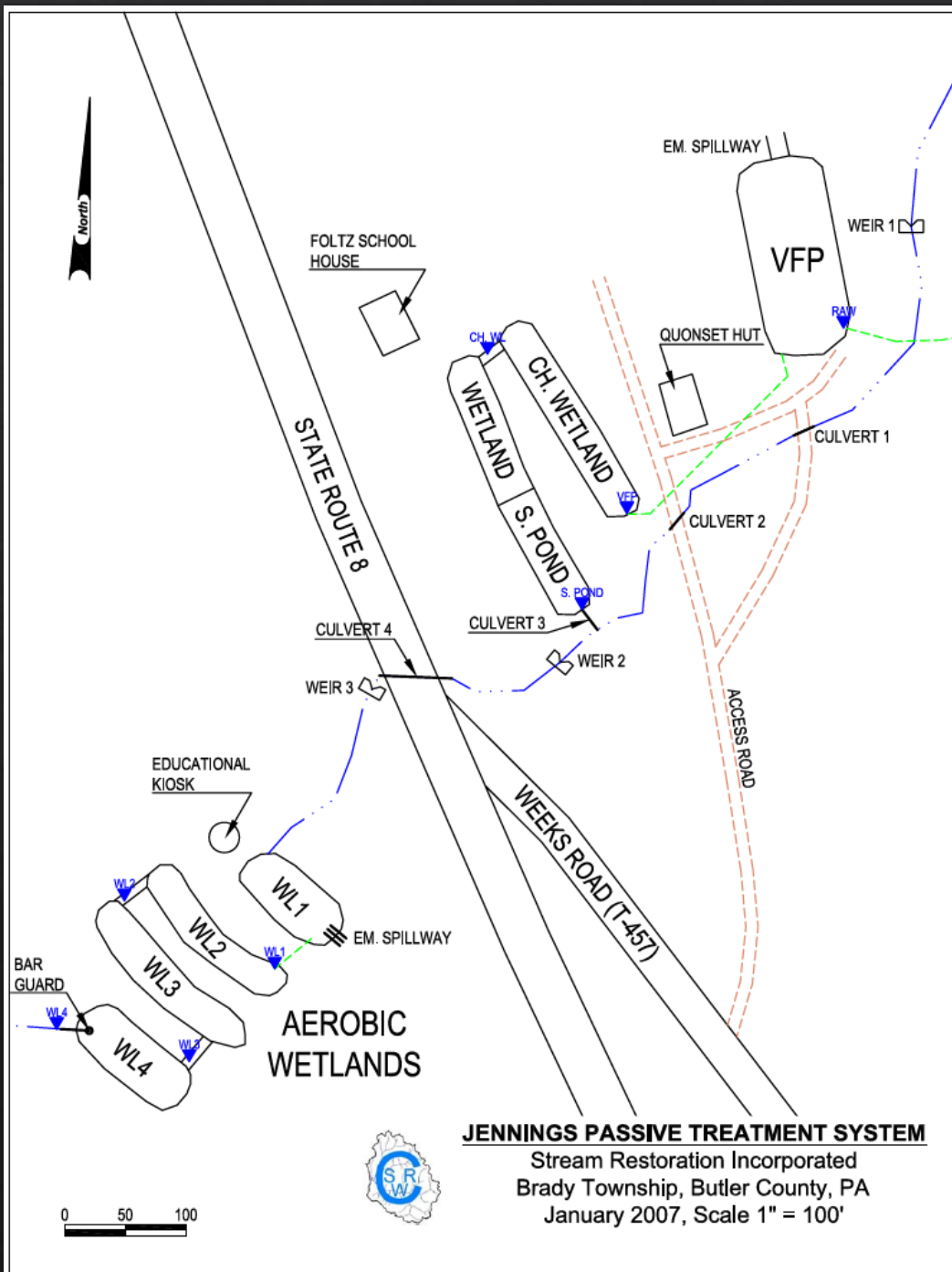
More treatment needed and hydraulic issues to be fixed...

Alkaline Addition New Tech

Vertical Flow Pond (VFP)

- ◆ 1997
 - ◆ 272 metric tons (300 short tons) Spent Mushroom Compost
 - ◆ 345 metric tons (380 short tons) >90% CaCO₃ Limestone
 - ◆ Overdrain mimicking a sand mound
 - ◆ PVC Underdrain piping
 - ◆ 2-inch solid headers
 - ◆ ¾ inch perforated laterals
 - ◆ River gravel bedding stone
 - ◆ Technology studied in pilot scale project
 - ◆ Construction mostly performed by volunteers





Data from Stream Restoration Inc.

Maintenance to VFP

Study and Stir the Media

2004



2007



2011



Stirring and Backflushing Efforts



VFP Renovation – 2012

On-Site Placement



VFP Renovation – 2012

New Underdrain



VFP Renovation - 2012

New Media Composition

- ◇ Original: Spent mushroom compost and AASHTO #9/#8 >90% CaCO₃ limestone replaced with the same tonnage as original design
- ◇ New mix: Half the organic media now woodchips. Replaced 380 (short ton) AASHTO #8 >90% CaCO₃ limestone
 - ◇ 0.5 T/CY of organic media
 - ◇ 1.35 T/CY of clean limestone
- ◇ Reduce preferential flow to maximize surface area.

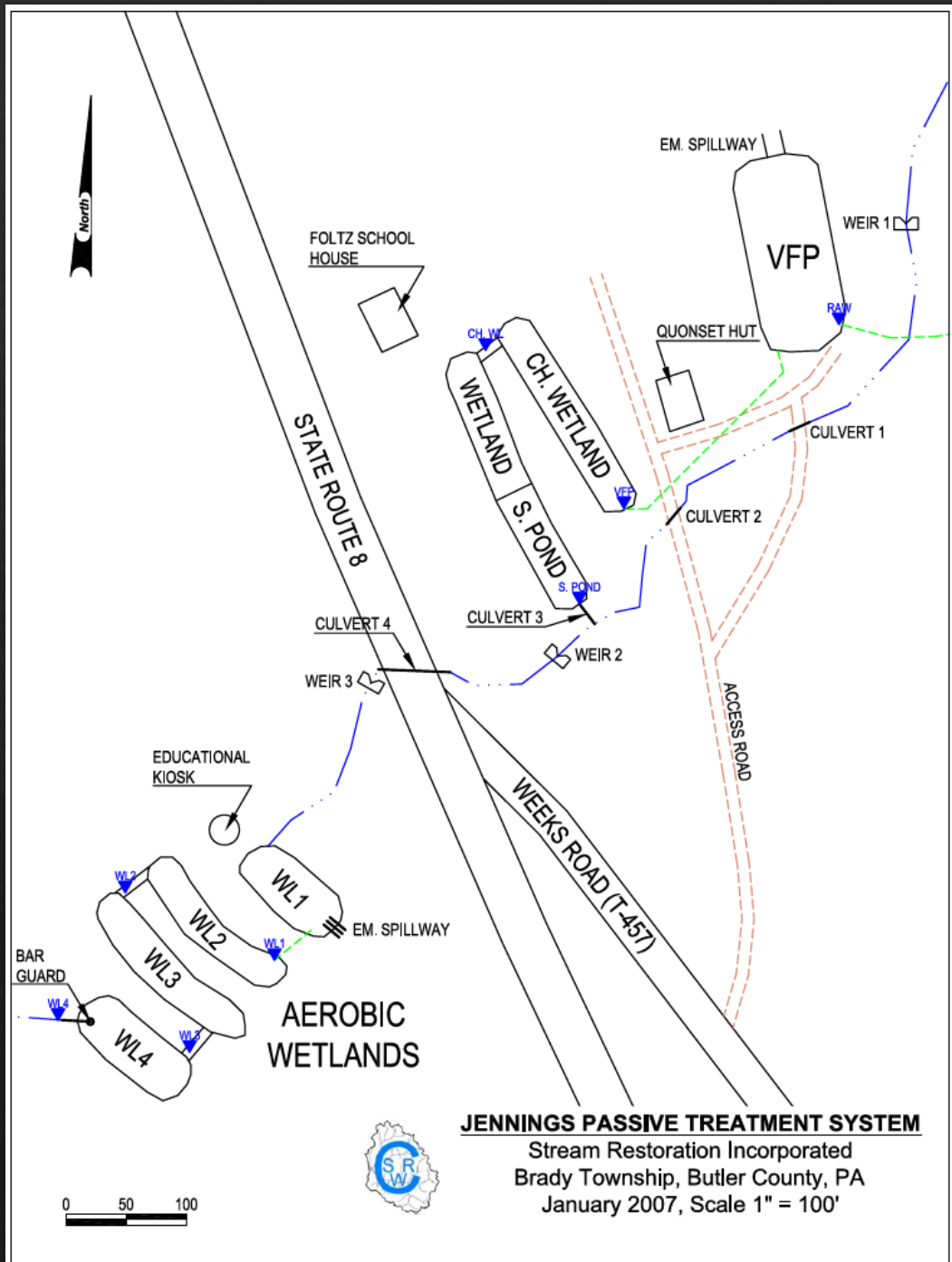


BULK MATERIALS			
AASHTO #8 (PADOT 1B) LIMESTONE	380 T	90% CaCO ₃ OR BETTER	6,615.80
AASHTO #1 (PADOT 4) LIMESTONE	46 T	(2 LOADS)	721.86
AASHTO #57 (PADOT 2B) GRAVEL	411 T	NON CALCAREOUS	6,370.80
SPENT MUSHROOM COMPOST	281 CY	Horse manure-based compost	7,868.00
WOOD CHIPS	281 CY	Single Shredded; Hardwood Only	

VFP Renovation - 2012

New Media Placement Method





Post Rehab Hydraulic Efficiency



How's the system in 2026?

Status Summary

- ◇ VFP to WL pipe
- ◇ pH Good
- ◇ Alk production reduced
- ◇ Diverted raw water increased in flow
 - ◇ System effluent WQ reduced

Settling Pond Effluent Water Quality

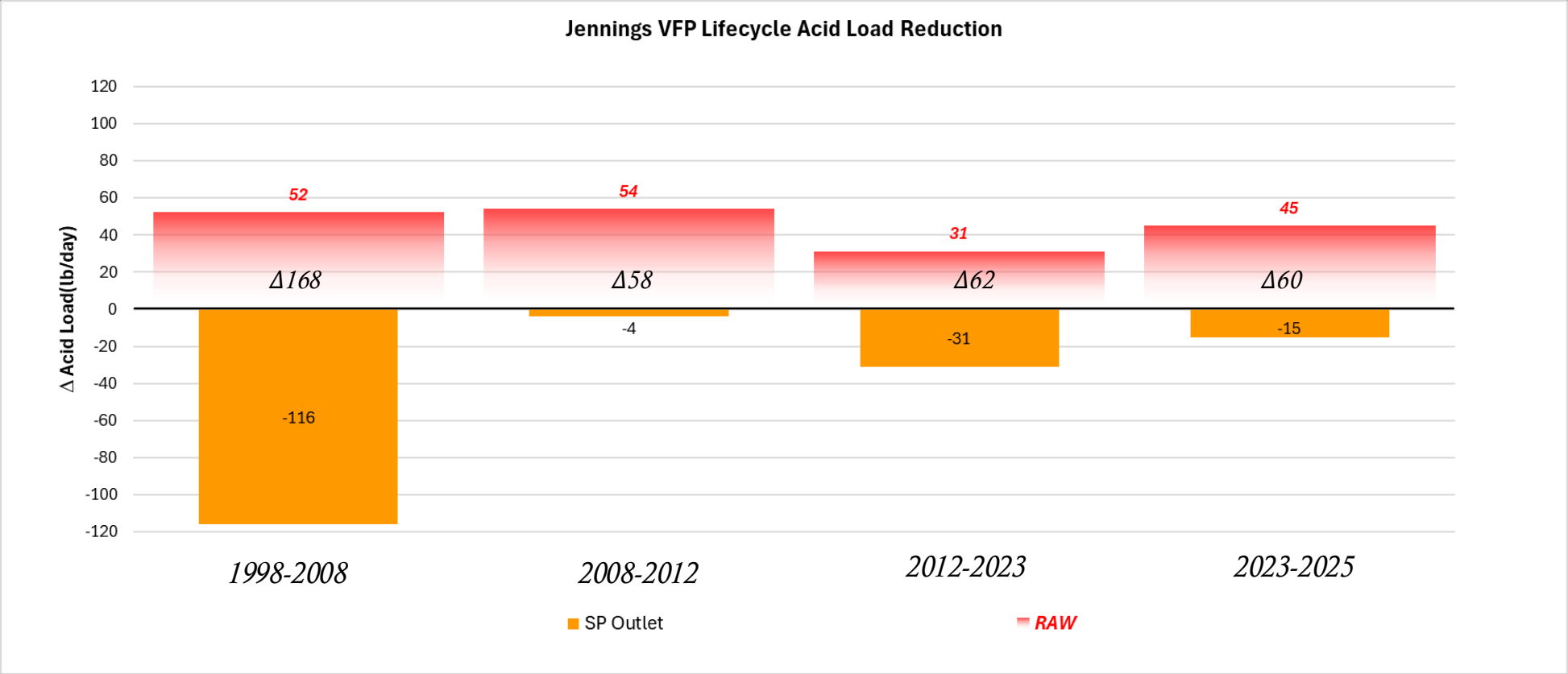
	pH	Alkalinity (mg/L CaCO ₃)
1997-2020 Avg	6.8	123
2020-2025 Avg	6.8	89

VFP Spring 2026



Water Quality Data Summary

1997-2025	Flow GPM	pH	Acidity mg/L CaCO3	Fe (Total) mg/L	Al (Total) mg/L	Mn(Total) mg/L	Sulfate mg/L
Raw (Avg)	20	3.1	253	31.7	13.4	13.5	673.5



Forestry Reclamation Approach (FRA) at Jennings

2008



2013



2026



Other Treatment Tech/Research On Site



Another Pennsylvania VFP Example Site

Lamison Treatment System VFP

- ◇ Use the original Jennings VFP design
- ◇ Built in 2004
- ◇ 300T limestone, 200 CY organic media
- ◇ 1:1 woodchip:compost
- ◇ Stirred after 15 yrs
- ◇ Continues to meet effluent limits



Design with Acid Removal Rate

Using Acid Removal Rate

- ◇ Volume of media used
- ◇ Mass of Acidity expected to be removed

Lb of acidity removed/Day/cu yd of media
(g/day/tonne)

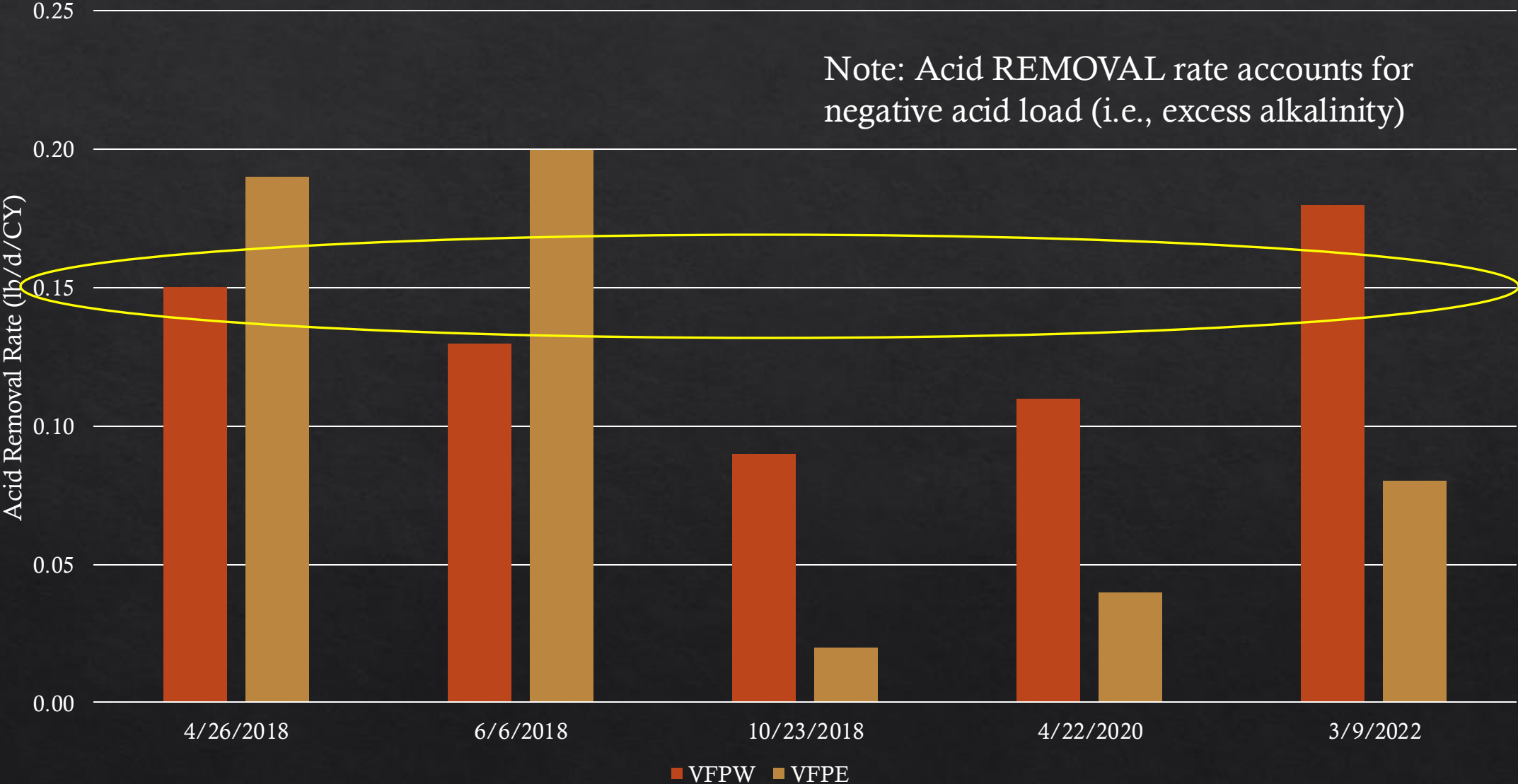
Lifespan and Measurable Alkalinity @ Effluent

Expected Measurable Alkalinity: 30mg/L
Desired Design Limestone needed =
 $(30\text{mg/L} + \text{Avg. Raw Acid mg/L}) * \text{Limestone CCE} * \text{Avg. Flow} * \text{Lifespan}$

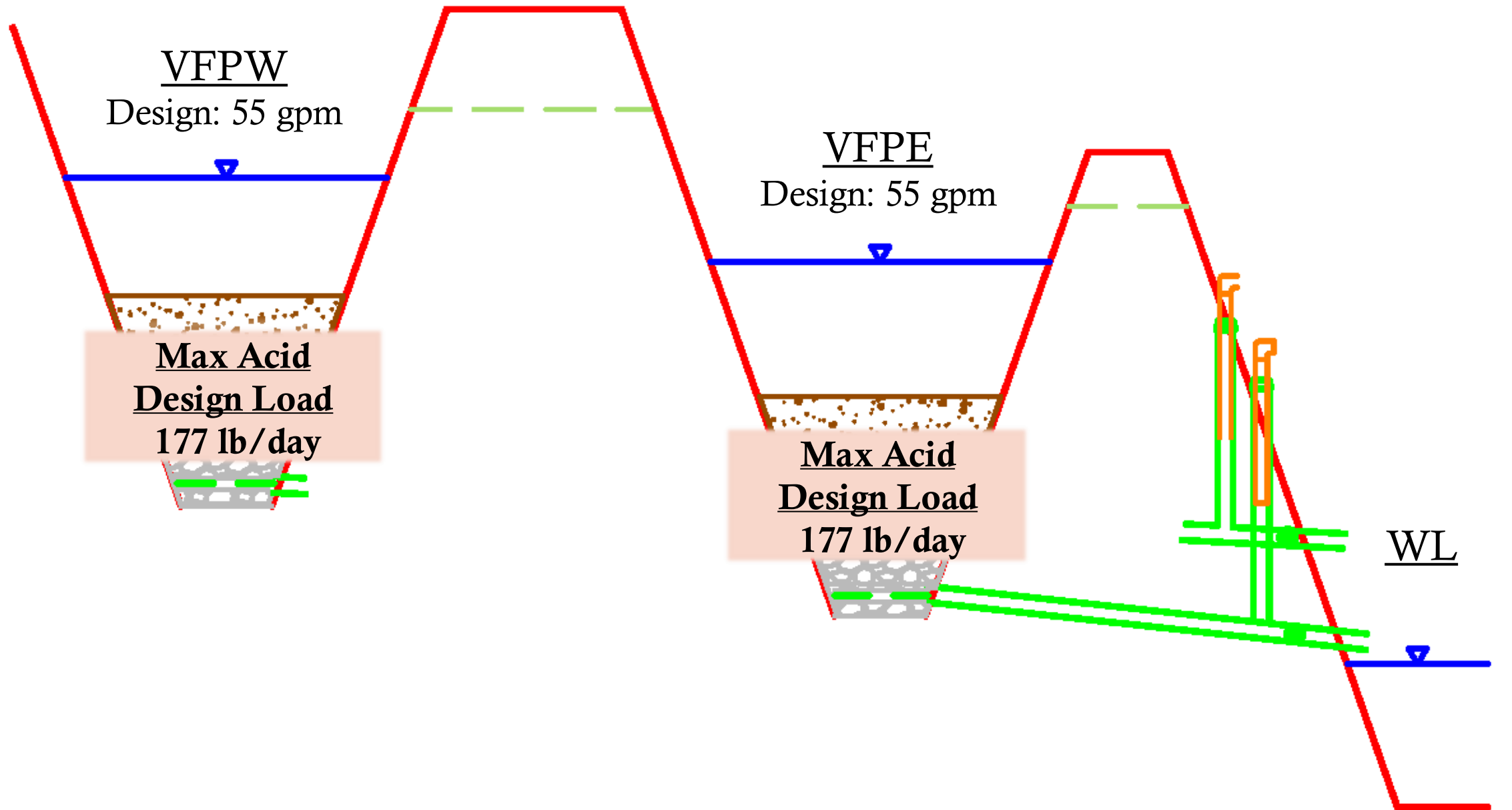
Result = Ton of CCE needed for the life of the system
We use >90% CCE with a density of 1.35 ton/CY of
Limestone

VFPW & VFPE Example Acid Removal Rate (lb/d/CY)

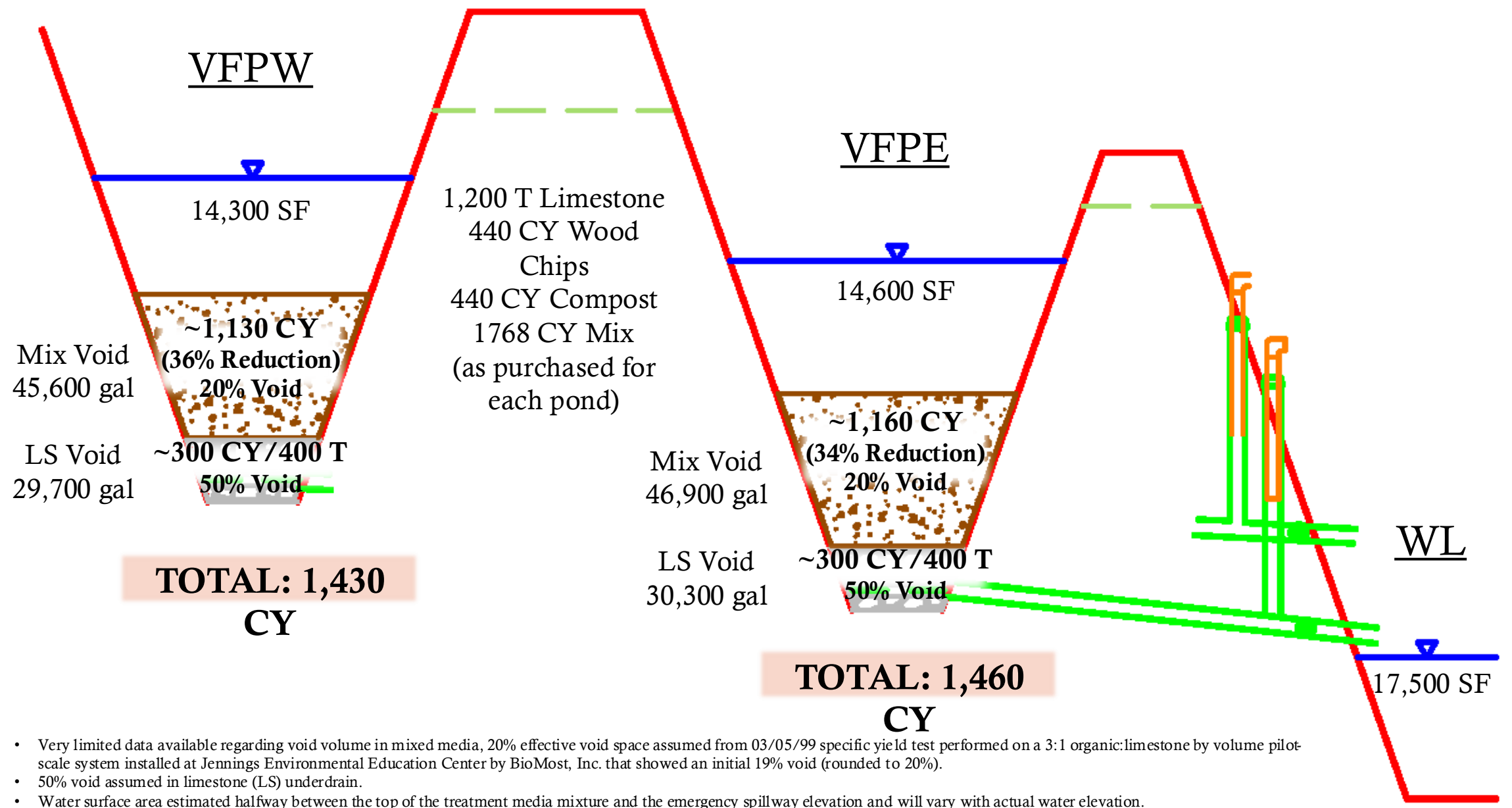
Note: Acid REMOVAL rate accounts for negative acid load (i.e., excess alkalinity)



Vertical Flow Pond Design (Max)



Vertical Flow Pond Treatment Media Example



- Very limited data available regarding void volume in mixed media, 20% effective void space assumed from 03/05/99 specific yield test performed on a 3:1 organic:limestone by volume pilot-scale system installed at Jennings Environmental Education Center by BioMost, Inc. that showed an initial 19% void (rounded to 20%).
- 50% void assumed in limestone (LS) underdrain.
- Water surface area estimated halfway between the top of the treatment media mixture and the emergency spillway elevation and will vary with actual water elevation.

Summary and Recommendations

- ◆ Jennings will be stirring the VFP media June 2026
 - ◆ First time stirring since 2012 renovation (14 years): The wood chips worked!
 - ◆ Original design required stirring at 6 years.
- ◆ The VFP – WL pipe has been cleaned. Backup to be installed.
- ◆ Consider adding diverted water to the system.

Biomost Recommendations:

- ◆ Size based on expected acidity from raw flow data
- ◆ Include Woodchips!
- ◆ HDPE Underdrain Piping
- ◆ Media stir frequency: Only as needed, Avoid to protect existing underdrain or hydraulic short circuiting.
- ◆ Media replacement frequency: 20+ year design life

Invitation to ASRS 2027 in Pittsburgh, PA!

Joint Conference with
PA Abandoned Mine Reclamation
And
WV Mine Drainage Task Force

June 6-10th, 2027

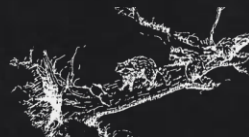


Thanks to...

- ◆ Cliff Denholm and Natalie Lamagna at Stream Restoration Inc.
- ◆ Wil Taylor and the crew at Jennings Environmental Education Center for caring for the site for decades.
- ◆ Dr. Helen Boylan Funari and student Shelby at Westminster College for recent data collection efforts.



WESTMINSTER
COLLEGE
New Wilmington, PA



AWARE

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