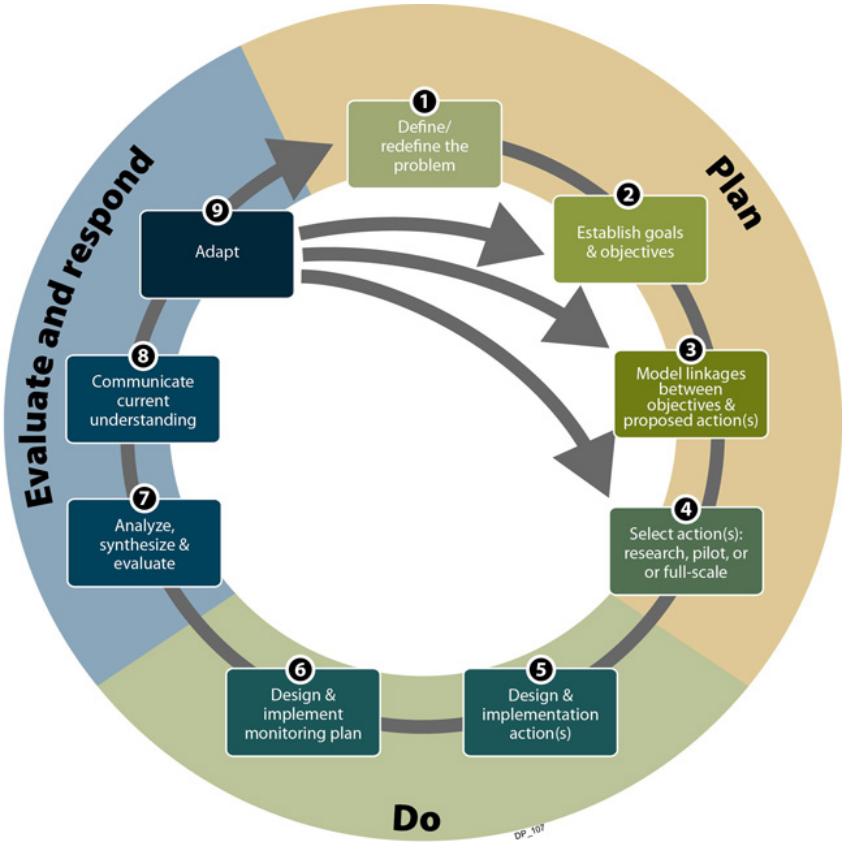
Adaptive Management Approach

- Consultation with USEPA & SCDHEC to implement an Adaptive Management Approach
  - Media-specific remedies implemented in steps and evaluated
  - A step-wise approach to design and implement technically appropriate and cost effective remedial actions



Define Problem and Establish Goals/ Objectives

Problem:

- Erosion of tailings and tailings acting as a source to acid mine drainage (AMD) to groundwater and surface water near the Site.

Objectives:

- Promote evapotranspiration to reduce infiltration through tailings
- Stabilize tailings and impoundment features to prevent erosion
- Address visual eyesore



Select Actions

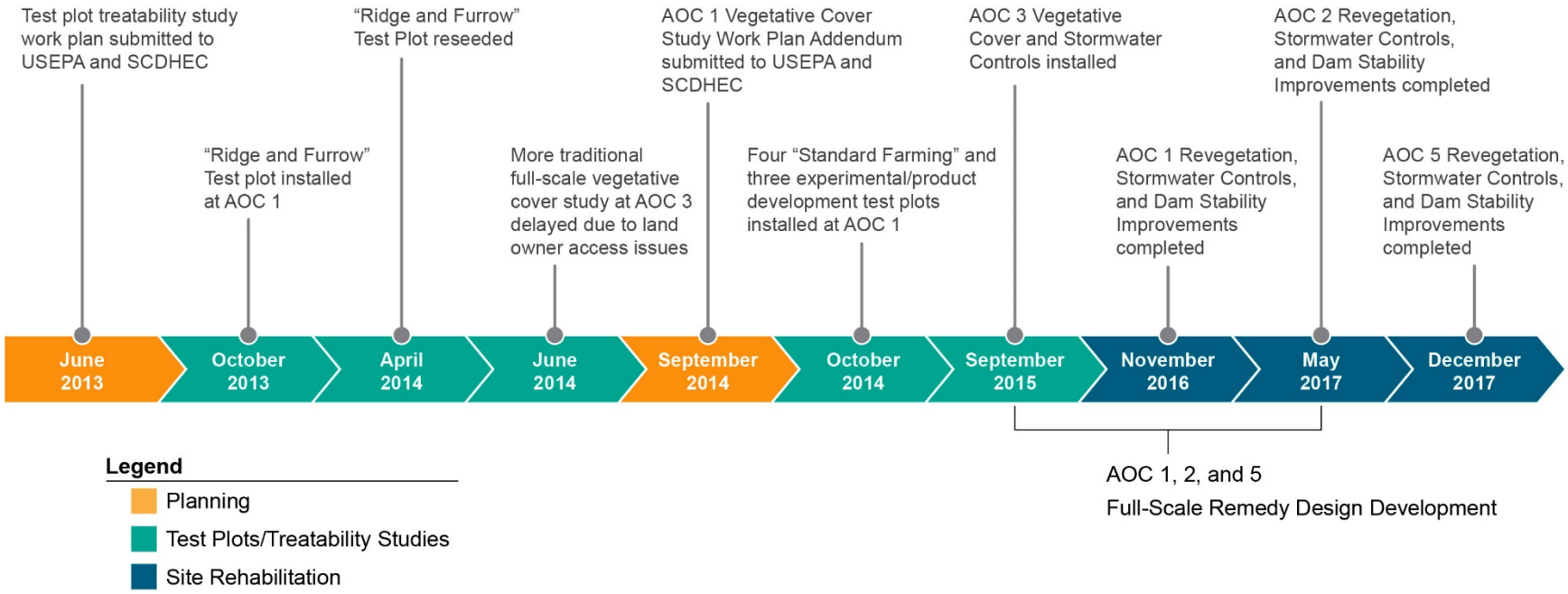
Pre-Construction Existing Conditions

- AOC 1,2, and 5 tailings mostly silica sand
- AOC 3 (former pyrite storage area) tailings larger sized waste rock
- 0% organic matter content
- pH of 2-2.5 standard units
- No plant available nutrients
- Highly susceptible to erosion from wind and stormwater
- Periodic deposition of mine tailings onto public ROWs
- Variations in site topography from relatively flat tailings impoundments to steep undulating slopes
- Deeply incised stormwater erosion channels
- Impoundment dams not maintained (erosion breaches and large tree growth)

Actions

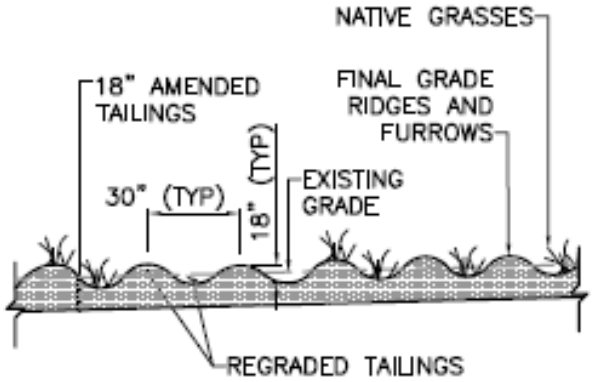
- Establish Vegetative Cover as Source Control
  - Promote evapotranspiration to reduce infiltration through the tailings (mitigate a major AMD source)
  - Increase organic matter content and pH of the shallow tailings so that revegetation can occur
  - Establish Stabilized Stormwater Drainage Conveyance Channels
  - Control surface run-off (mitigate erosion/sedimentation impacts from stormwater)
  - Rehabilitate Tailings Impoundment Dams
  - Implement stability measures (mitigate breaches)
  - Establish acceptable factors of safety (long-term steady state and seismic conditions)

Vegetative Cover Study and Site Revitalization Timeline



Select Actions – Pilot Study (Ridge and Furrow Technique)

- Client had successful experience with revegetation at another kyanite mine site
- Approach for Henry Knob was to pilot-test vegetative pilot study using similar methods
  - Develop organic layer (wheat straw) to minimize wicking of acidic groundwater to the root zone
  - Add alkaline material (limestone) to neutralize acidity
  - Recontour tailings with ridges and furrows to promote leaching of the surface acidity from the ridges and accumulation of rainfall in the furrows
  - Incorporate fertilizer (standard 10-10-10) and native seed mixtures to provide short term and long term reclamation
  - Apply surface layer of mulch (wheat straw) and agricultural tackifier to slow moisture evaporation



Select Actions – Pilot Study (Ridge and Furrow Technique) Continued

- Ridge and Furrow Test Plot installed fall 2013
- Not successful, plot abandoned in 2015

December 2013

May 2014

April 2015

Ridge and Furrow Test Plot Lessons Learned

- Depth to groundwater considered a key difference between the Henry Knob Site and other site where ridge and furrow technique was successful
- Organic material application rate too low
- Use of hydroseeding methods not believed to be effective

Select Actions – Pilot Study (Standard Farming)

- Back to basics – keep it simple, keep it sustainable
- Relied upon Amec Foster Wheeler personnel with agricultural backgrounds and outreach to the local farming community
- Standard Farming approach
  - Eliminate ridge and furrow technique
  - Utilize a traditional farm tractor and PTO driven rototiller
  - Use of leaf compost to introduce organic matter
  - Use of turkey/hen and horse manure
  - Increase seed application rate
  - Use mechanical seeding in lieu of hydroseeding
  - Incorporate a garden type, high calcium, hydrated lime for immediate and short-term pH buffering of acidic soil
  - Test the application of a commercial soil supplement to modify soil textural properties
  - Test the application of a water retention agent (horticultural product)
  - Increase surface mulch (wheat straw) application rate

Select Actions – Pilot Study (Standard Farming Technique) Continued

- Standard Farming Test Plot installed fall 2014
- Very successful, carried to full scale design for AOC 1, 2, and 5

October 2014

June 2015

June 2016

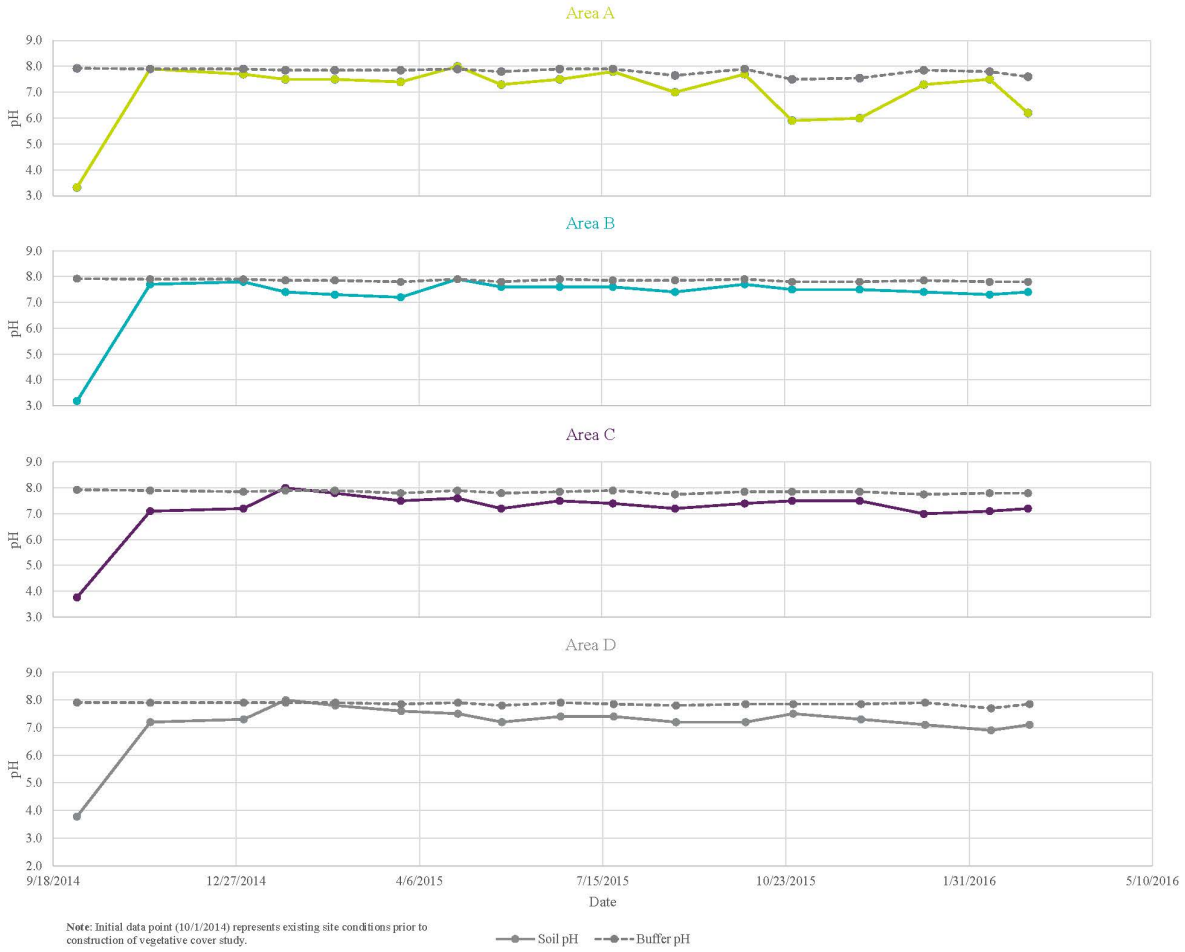
Standard Farming Test Plot Lessons Learned

- Local knowledge and resources important to selecting appropriate materials
- Amend existing tailings to minimize material import quantities
- Mechanical seeding effective
- Reduce agricultural lime application rate
- Increased organic matter content critical

July 2017

Select Actions – Pilot Study (Standard Farming Technique) Continued

Standard Farming Technique - Soil pH Results



Note: Initial data point (10/1/2014) represents existing site conditions prior to construction of vegetative cover study.

Select Actions – Pilot Study (AOC 3 Vegetative Cover)

Completed September 2015 and included:

- Construction of a vegetative cover
- Stormwater drainage channel/controls

Materials used during construction:

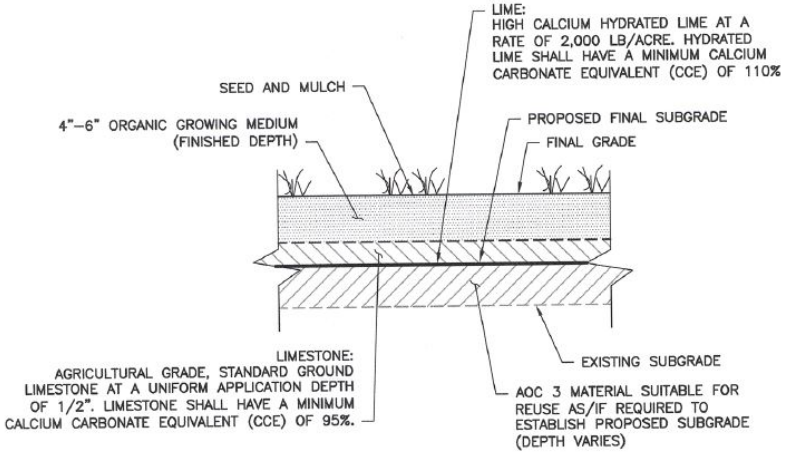
- 650 tons of rip rap (channels)
- 600 cubic yards growing medium (leaf compost)
- 25 tons of lime
- 750 pounds of fertilizer
- 90 pounds of grass seed mix

Challenges:

- Site access constraints
- Location of nearby residence
- Physical properties of tailings/material
- Working within ROW of SC Highway 55

Lessons learned:

- AOC 3 material properties are unlike other tailings (additional application of growing medium required)
- Incorporate stormwater controls/channel in designs
- Leaf compost sources and variations in product



COMMON NAME	SCIENTIFIC NAME	SEEDING RATE(POUNDS/ACRE)
COMMON BERMUDA (1)(2)	*Cynodon dactylon*	25
TALL FESCUE (KY31)	*Lolium arundinaceum*	50
WEEPING LOVEGRASS	*Erogratis curvula*	10
CLOVER (NATIVE MIX) (3)	*Trifolium spp.*	20
RYE GRAIN (4)	*Secale cereale*	20

(1) HULLED
(2) DO NOT USE GIANT BERMUDA GRASS (NK–37)
(3) ONLY USE PRE–INOCULATED LEGUMES OR AN APPROPRIATE INOCULANT WITH THE SEED AT PLANTING
(4) RYE GRAIN: DO NOT USE ANNUAL ITALIAN RYE GRASS (*Lolium multiforum*)

Select Actions – Pilot Study (AOC 3 Vegetative Cover) Continued

AOC 3 Pre-Construction (2013)



October 2015 (2 weeks after seeding)


February 2016

Select Actions
Transition to Full-Scale Remedy

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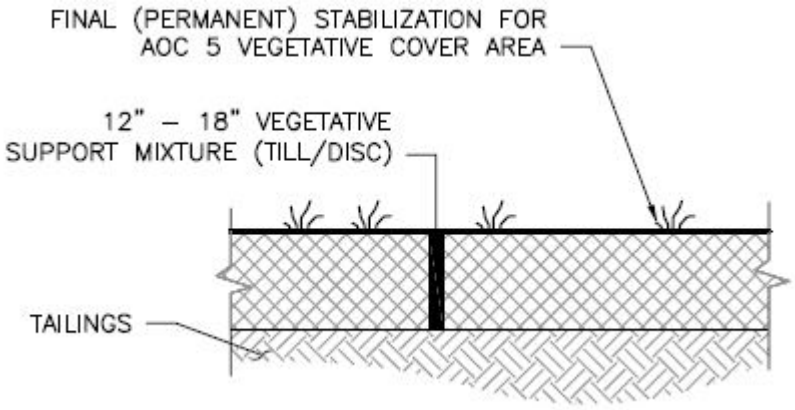
Full Scale Remedy Selection

- A Process of Refinement
  - Review results of initial monitoring and analyses
  - Continue outreach to the local community
  - Further assessment of available products and innovative technologies
  - Look for system optimization opportunities
  - Consider long-term sustainability and minimization of maintenance requirements
- Incorporation of sitewide drainage channel and dam stability improvements
- Substitution of leaf matter and manure with locally sourced, plant based, food scrap and leaf compost
- Inclusion of pollinator / wildflower seed mix



Material/Activity	Application Rate	Description
Site Preparation	Not Applicable	Perform layout of vegetative cover area and till/disc upper 12-18 inches
Mulch Hay	22 round bales/acre	Incorporate into the upper 12-18 inches (disc/till)
Organic Compost	9 inch thick layer	Incorporate into the upper 12-18 inches (disc/till)
Lime Garden Type, High Calcium, Hydrated Lime, Min. CCE 110%	½ ton/acre	Shall conform to the current rules, regulations, and standards of the fertilizer board of control - incorporate into amended tailings by tilling
Limestone Agricultural Grade, Coarse Ground, Min. CCE 95%	20 tons/acre	Shall conform to the current rules, regulations, and standards of the fertilizer board of control - incorporate into amended tailings by tilling
Water Retention Agent Profile Products, AquaGel Series B	In accordance with manufacturer's recommendations	Profile Products, AquaGel Series B Incorporate into the upper 6 inches
Fertilizer (Synthetic) 10-10-10	1,000 lbs/acre	Fertilizer shall comply with the South Carolina fertilizer laws – use of liquid fertilizer will not be permitted work into amended tailings a Minimum of 2 inches
Seed *See table below	*See table below	Seed shall conform to the state laws and the requirements and regulations of the South Carolina Department of Agriculture (SCDA) Seed by mechanical methods (no hydro seeding permitted)
Wheat Straw	200 bales/acre	Apply dry wheat straw free from mold damage and noxious weeds as surface mulch using bale chopper/straw blower
Tackifier Profile Products, ConTack	40 lbs/acre, In accordance with manufacturer's recommendations	Shall meet the requirements of the SCDOT standard specifications for highway construction apply in solution by hydro spraying

Common Name	Scientific Name	Seeding Rate (Pounds/Acre)
Common Bermuda Grass	*Cynodon dactylon*	15
Clovers (Native Mix)	*Trifolium spp.*	37.5
Foxtail Millet	*Setaria italica*	60
Little Bluestem	*Schizachyrium scoparium (andropogon scoparius)*	15
Rescuegrass	*Bromus catharticus*	15
Switchgrass	*Panicum virgatum L. (virgatum)*	7.5
Tall Fescue (KY31)	*Lolium arundinaceum*	15
Weeping Lovegrass	*Eragrostis curvula*	7.5
	Total	172.5

SEED SPECIFICATION NOTE: CONTRACTOR SHALL INCORPORATE MMF POLLINATOR MIX (OR APPROVED EQUAL) CONSISTING OF WILDFLOWER SEED ONLY (NO GRASSES) FROM MELLOW MARSH FARM, INC., SILEY CITY, NORTH CAROLINA AT AN APPLICATION RATE OF 15 LBS/ACRES.

Select Actions
Transition to Full-Scale Remedy

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Pollinator Protection at Superfund Sites

Incorporating Pollinator Protection into Superfund Cleanup

When: Remedial investigations and feasibility studies, the remedial design process and five-year reviews are excellent windows of opportunity.

How: Examples of ways to integrate pollinator protection into cleanup plans include:

- Convert capped areas to low-maintenance, pollinator-friendly habitat.
- Integrate pollinator habitat as part of stream restoration projects.
- Consider integrated pest management with ecological reuse.
- Allow beehives on site, partnering with local beekeepers.

Why: Focusing on pollinator protection during the Superfund process can:

- Decrease site management and maintenance costs.
- Beautify communities and strengthen local relationships.
- Increase food security.

Where Can I Learn More About Pollinator Protection?

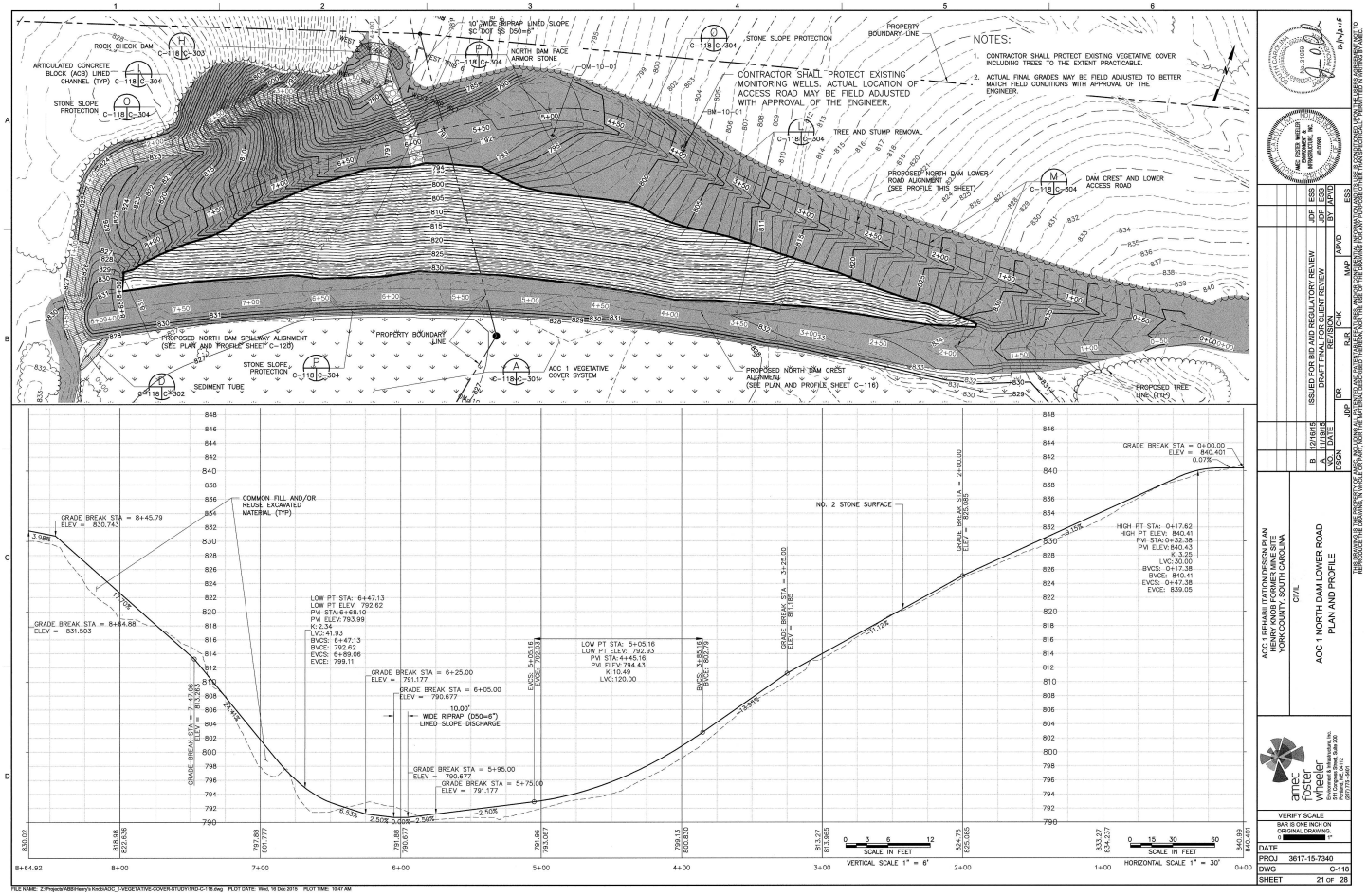
- National Strategy to Promote Pollinator Health Appendices: https://www.whitehouse.gov/sites/default/files/microsites/ostp/Pollinator-Strategy Appendices 2015.pdf
- Native Plant Information Network Database: http://www.wildflower.org/plants
- Pollinator Partnership Ecoregion Planting Guide: http://www.pollinator.org/guides.htm
- Native Plant Nursery Directory: http://www.plantnative.org
- EPA Information on Protecting Bees and Other Pollinators from Pesticides: http://www2.epa.gov/pollinator-protection

Species	Common Name	Mix
Bidens aristosa	Bidens	0.18
Coreopsis tinctoria	Plains coreopsis	0.20
Coreopsis lanceolata	Lance leaf tickseed	0.20
Achillea millefolium	Common yarrow	0.18
Rudbeckia hirta	Blackeyed susan	0.12
Senna hebecarpa	Wild senna	0.04
Helianthus maximilianii	Maximilian's sunflower	0.04
Verbena hastata	Blue vervain	0.02
Aster umbellatus	White topped aster	0.02
		1.00

Design and Implement Actions Transition to Full-Scale Remedy

Full-Scale Remedy Design Development for AOCs 1, 2, and 5

- September 2015 thru May 2017



Design and Implement Actions Transition to Full-Scale Remedy

- Sitewide Rehabilitation and Revitalization (AOC 1, 2, and 5)
  - September 2015 thru December 2017 (design/construct)
- Rehabilitation of 65 +/- acres included:
  - Construction of stormwater controls (grading and drainage improvements and permanent stabilization of channels)
  - Dam stability improvements (removal of existing woody vegetation, grading, armoring of the dam surface, and installation of inclinometers to monitor slope stability
  - Construction of a vegetative cover (incorporated into the top 18 inches of the tailings)

Product	AOC 1	AOC 2	AOC 5	Total	Unit of Measure
Riprap (dam faces and channels)	6,000	15,000	12,000	**33,000**	**Ton**
Stone (dam faces, roads, and ACB infill)	3,500	3,000	3,000	**9,500**	**Ton**
Common Fill (dam faces)	3,500	8,500	2,000	**14,000**	**Ton**
Organic Compost	18,500	4,000	21,000	**43,500**	**Cubic Yard**
Hydrated Lime	8	1	9	**18**	**Ton**
Agricultural Lime	300	80	300	**680**	**Ton**
Fertilizer	15,000	4,000	17,000	**36,000**	**Lb**
Water Retention Agent	4,750	750	5,250	**10,750**	**Lb**
Round Hay Bales	350	25	300	**675**	**Each**
Square Wheat Straw Bales	1,200	350	1,250	**2,800**	**Each**
Native Grass & Pollinator Seed Mix	3,200	1,100	4,000	**8,300**	**Lb**
Agricultural Tackifier	600	200	700	**1,500**	**Lb**
Articulated Concrete Block (ACB) Mattresses	10,200	2,700	2,700	**15,600**	**SF**

Design and Implement Actions
AOC 1 Revitalization

Stormwater Controls – From this…

Design and Implement Actions
AOC 1 Revitalization

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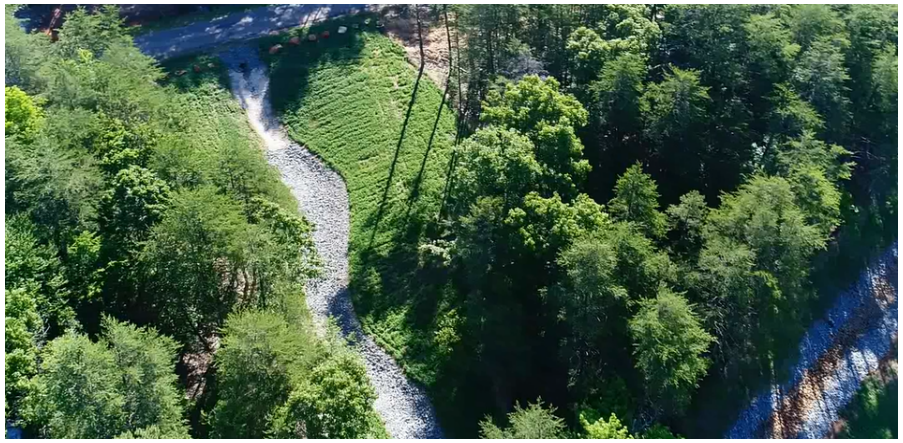
Stormwater Controls – To this…



Design and Implement Actions
AOC 1 Revitalization

Dam Stability - From this…..





Design and Implement Actions
AOC 1 Revitalization

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Dam Stability – To this…

Design and Implement Actions
AOC 1 Revitalization

Vegetative Cover – From this…

Design and Implement Actions
AOC 1 Revitalization

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Vegetative Cover – To this…

Design and Implement Actions
AOC 2 Revitalization

Dam Stability – From this…..

Design and Implement Actions
AOC 2 Revitalization

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Dam Stability – To this…..

Design and Implement Actions
AOC 5 Revitalization

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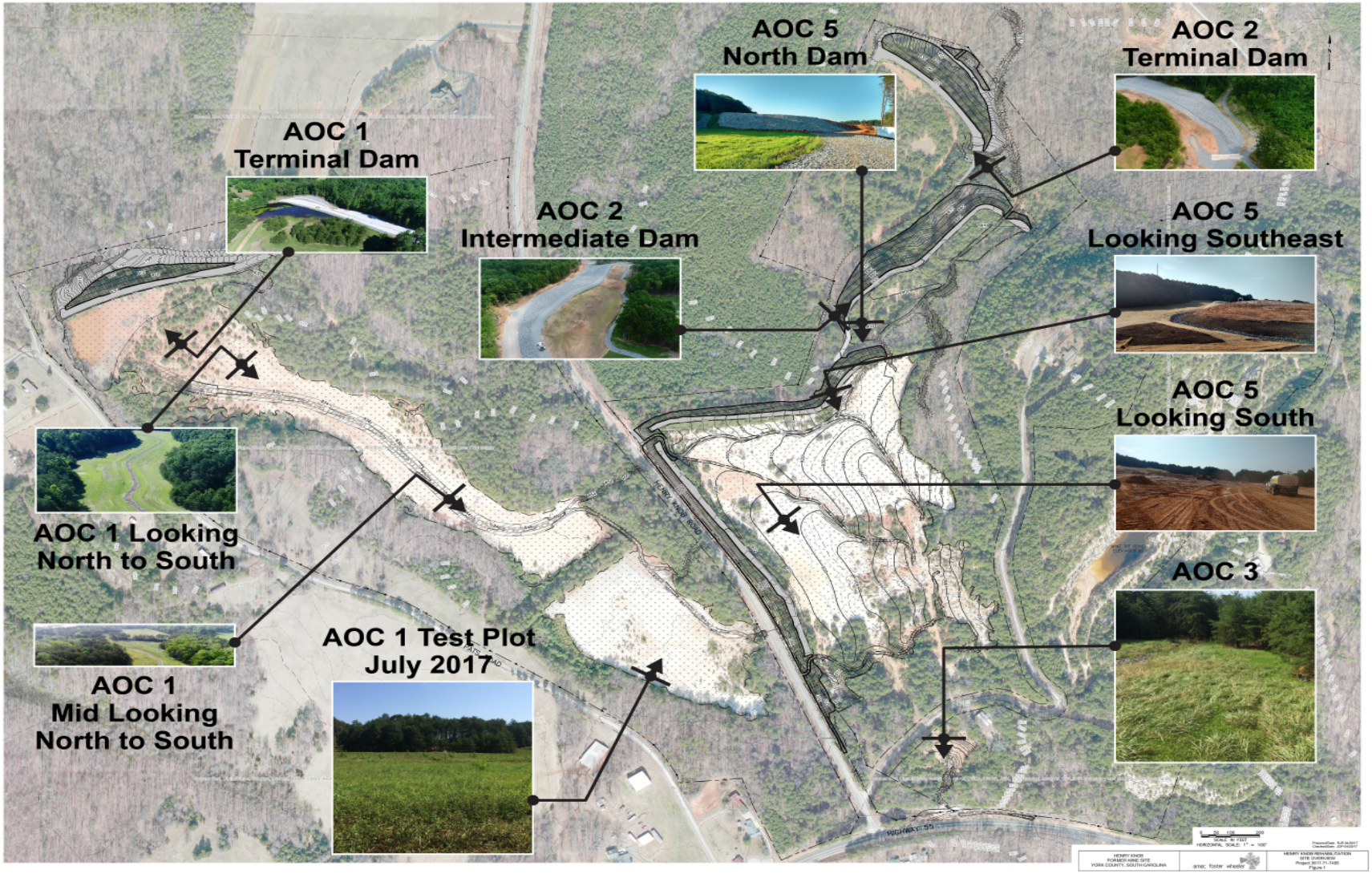
AOC 5 Prior to Construction

AOC 5 December 4, 2017

Design and Implement Actions
Henry Knob Revitalization Overview



Henry Knob Revitalization Questions

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Project awarded the 2017 EPA Superfund Reuse Award in Region 4

Link to USEPA Ecological Revitalization of Contaminated Sites Case Study on Henry's Knob:
https://semspub.epa.gov/work/HQ/100000929.pdf