Upper He Creek hydraulic and hydrogeologic control solutions in east central Tennessee

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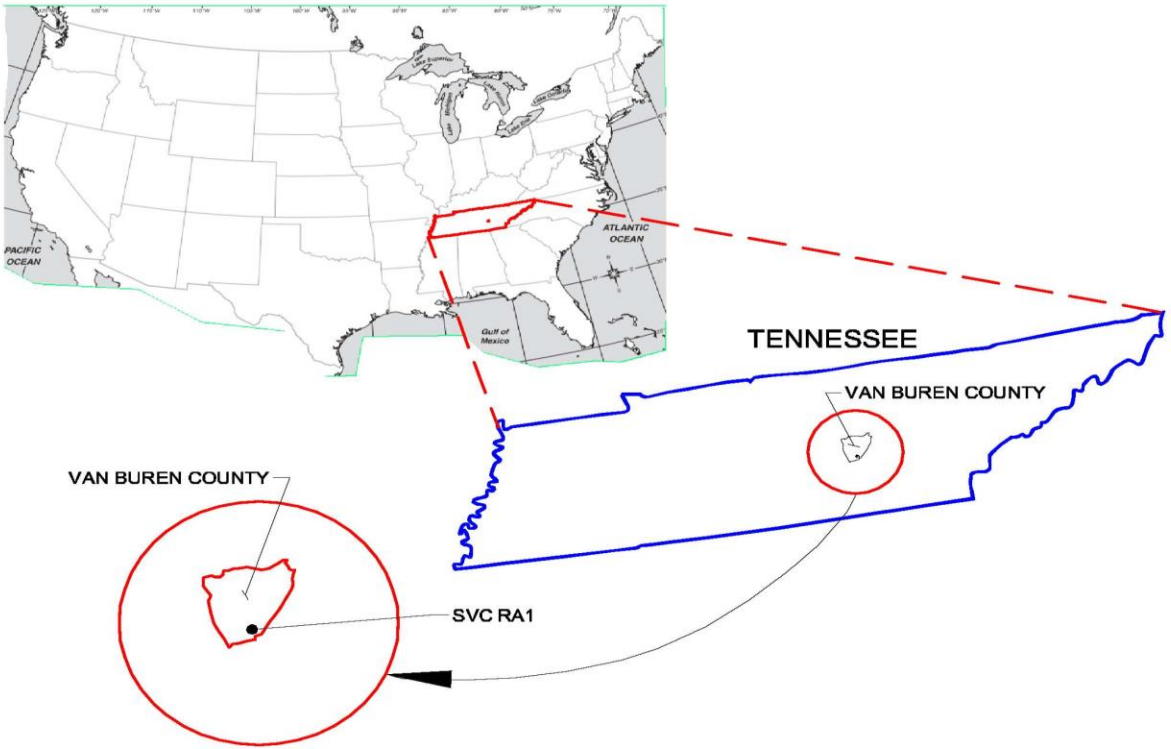
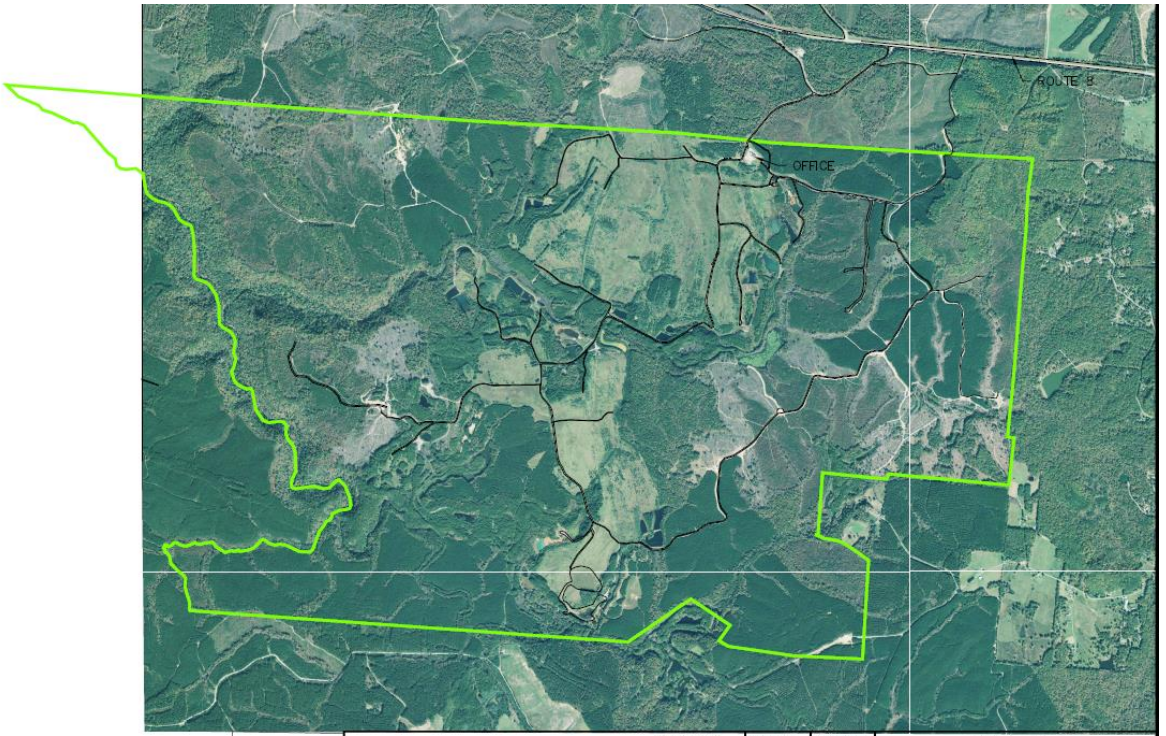
Project Location



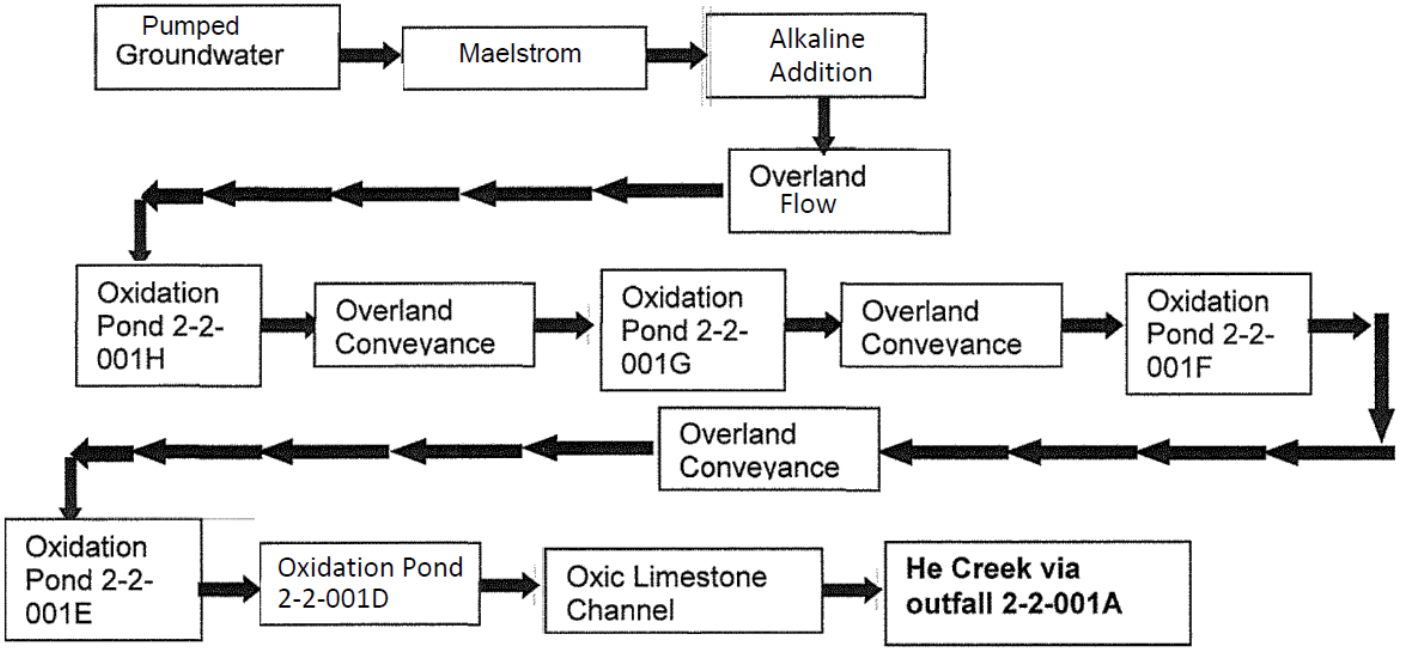
Background

- Sequatchie Valley Coal Corporation (SVC) Main Area
- 1,000+ acre area dragline mine
- Owned by Navajo Transitional Energy Company (NTEC)
- Surface coal mine reclamation site since 1992
- Primarily pumping to control GW with active treatment
- Discharges to Upper He Creek

Navajo Transitional Energy Company
Sequatchie Valley Coal Corporation (SVC)



Pumped Water Treatment Flow Diagram



Navajo Transitional Energy Company
SVC Main Area – Upper He Creek

Water Management Evaluation Goals

- Define source and quantity of water exposed to acid bearing minerals
- Determine how water moves through the site
- Provide insight regarding how to

  - reduce water infiltration

  - improve treatment success

  - manage groundwater levels
- Provide a tool to measure costs versus benefits

Watershed Drainage Areas

- **Big He Creek (1,310 acres)**

  - 640 acres from permit areas + 670 acres from other areas

- **Little He Creek (1,050 acres)**

  - 400 acres from permit areas + 650 acres from other areas

- **He Creek (2,750 acres)**

  - 1085 acres from permit areas (40%) + 1665 acres from other areas

- **Other areas include abandoned mined land and forest**

Water Balance Parameters

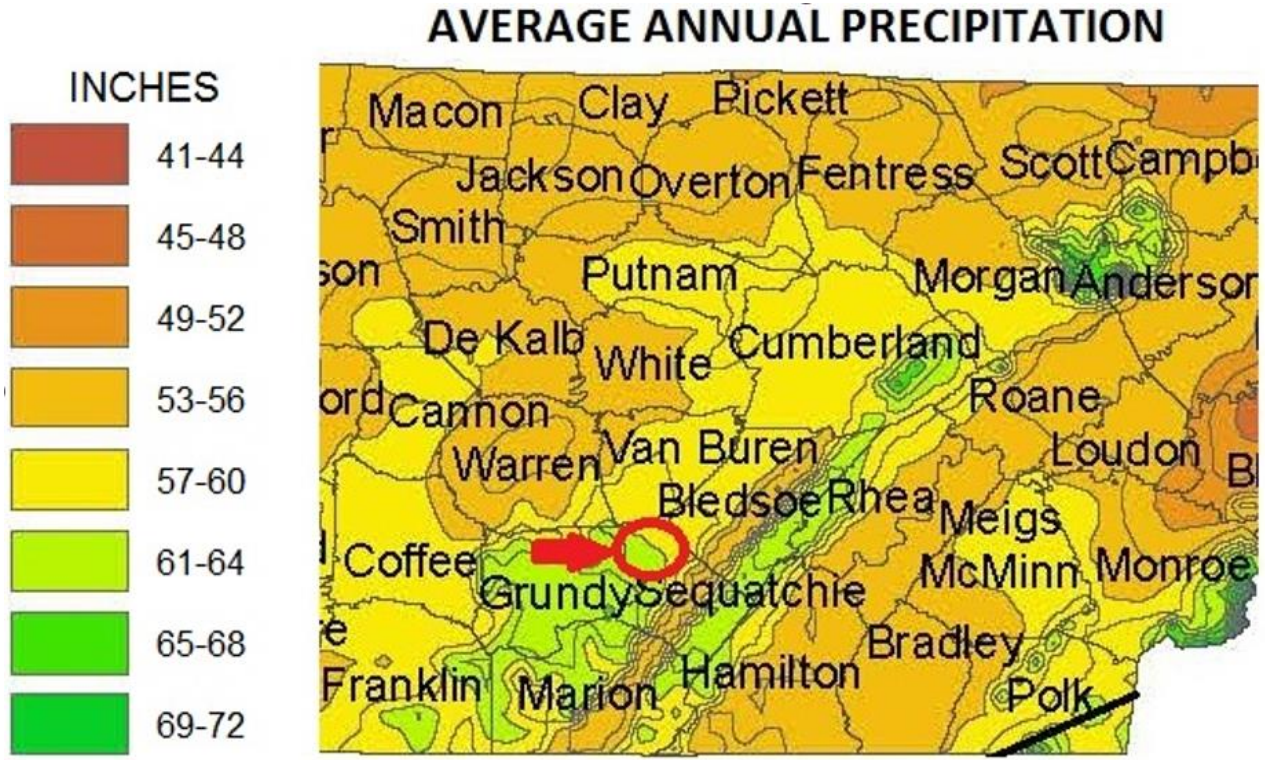
- Precipitation
- Surface Runoff
- Evapotranspiration (ET)
- Infiltration
- Pumping Withdrawals
- Change in Groundwater Storage
- Groundwater Inflow

Monitoring Stations

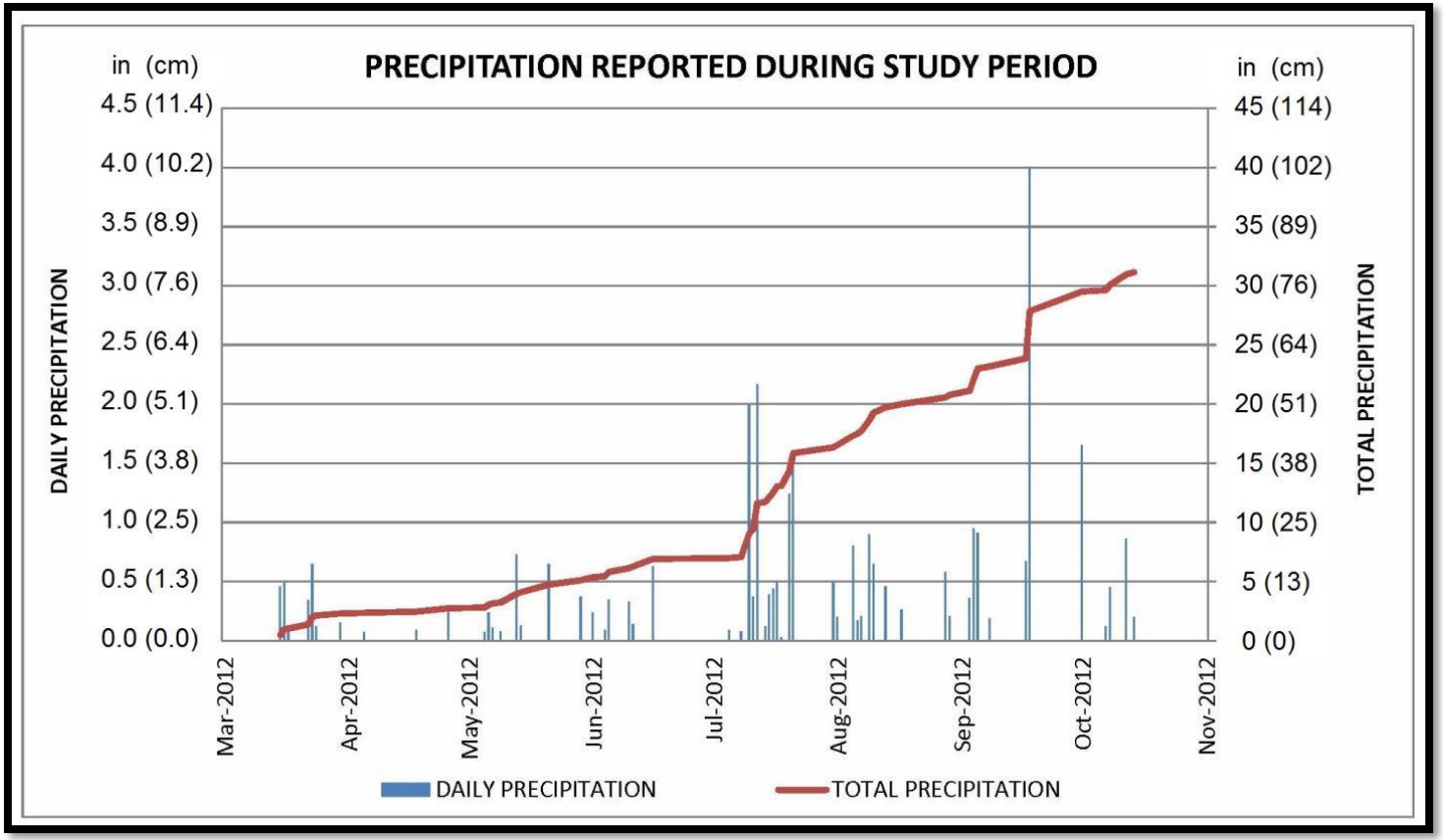
- 1 Weather Station (Precipitation)
- 7 Surface Water Flow Stations
  - 3 stream flow stations
  - 3 pump flow stations
  - 1 gravity flow discharge station
- 5 Groundwater Level Stations
- 1 Evapotranspiration Lysimeter
- Monitored 3/15/12 – 10/11/12 (10 min intervals)

Weather Station

AVERAGE PRECIPITATION
(Source: University of Tennessee, Institute of Agriculture)

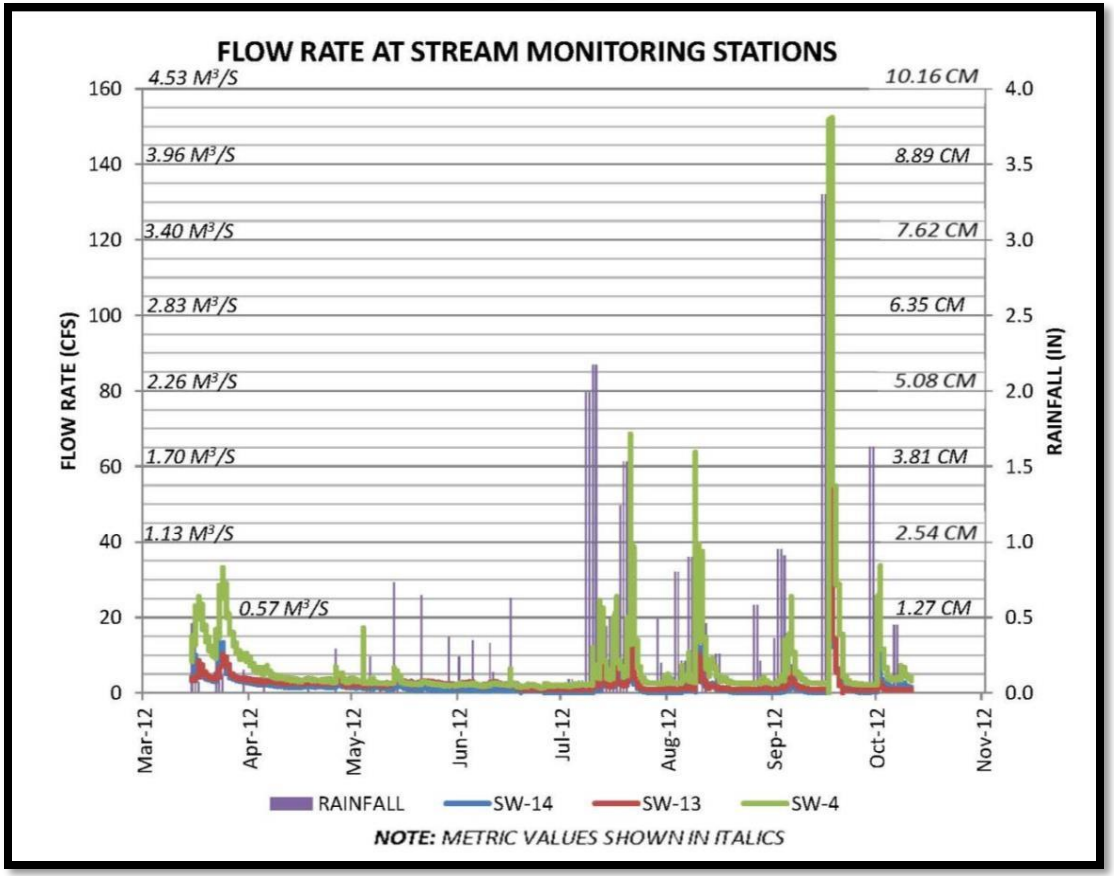


Precipitation Summary From Weather Station



Example - Big He Creek Monitoring Station

Stream Flow Gauge Rates Summary

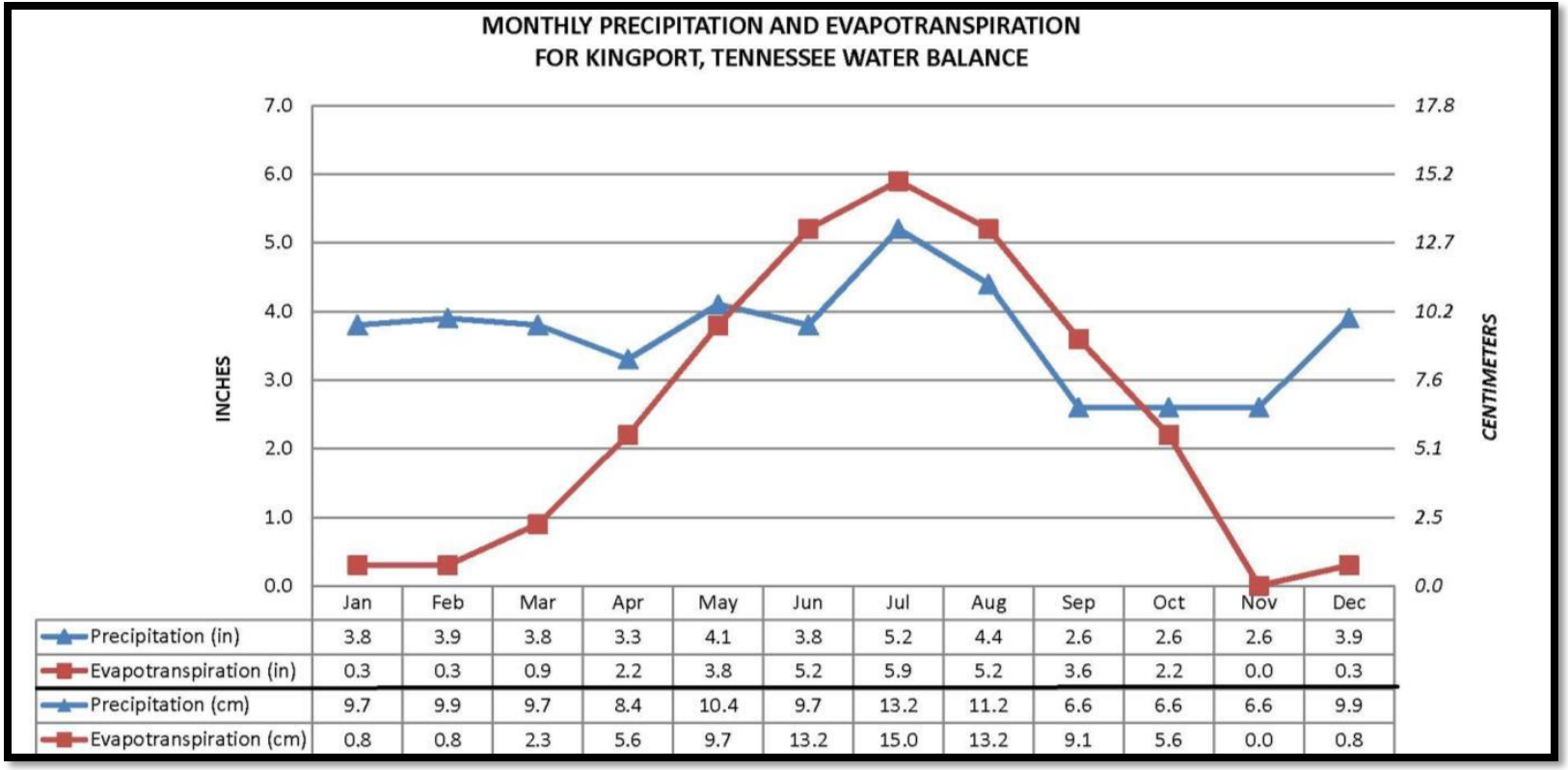


Stream Runoff %

TABLE 3
PRECIPITATION AND RUNOFF FROM ALL DRAINAGE SHEDS
DURING THE STUDY PERIOD IN INCHES

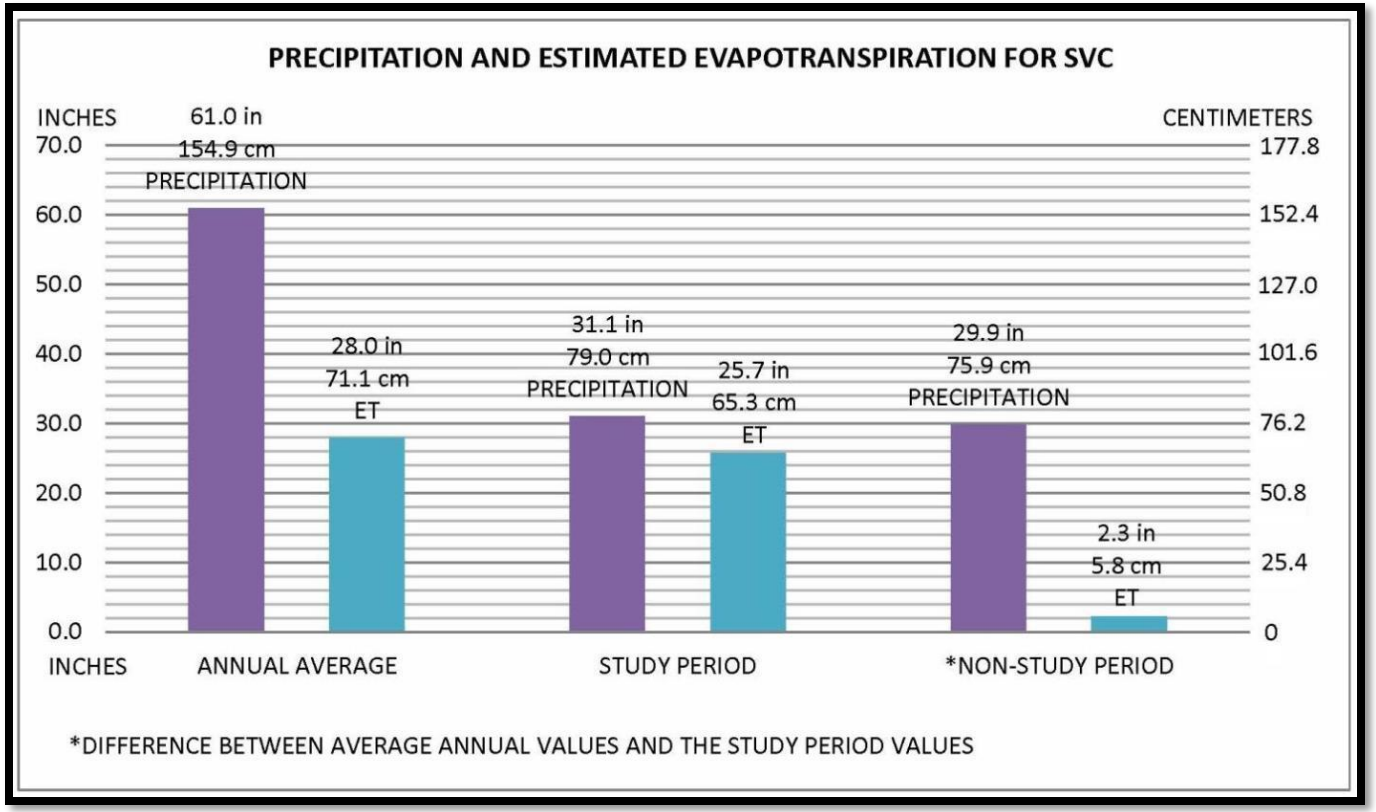
	STUDY PERIOD (210 DAYS MID-MARCH THROUGH MID-OCTOBER)		
	BIG HE CREEK (SW-13)	LITTLE HE CREEK (SW-14)	HE CREEK (SW-4)
Precipitation [in (cm)]	31.1 (79.0)	31.1 (79.0)	31.1 (79.0)
Runoff [in (cm)]	6.5 (16.5)	8.3 (21.0)	8.5 (21.5)
Recharge + ET [in (cm)]	24.6 (62.6)	22.8 (58.0)	22.7 (57.6)
Runoff (%)	*20.8%*	*26.6%*	*27.2%*
Recharge + ET (%)	*79.2%*	*73.4%*	*72.8%*

Evapotranspiration



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Precipitation (in)	3.8	3.9	3.8	3.3	4.1	3.8	5.2	4.4	2.6	2.6	2.6	3.9
Evapotranspiration (in)	0.3	0.3	0.9	2.2	3.8	5.2	5.9	5.2	3.6	2.2	0.0	0.3
Precipitation (cm)	9.7	9.9	9.7	8.4	10.4	9.7	13.2	11.2	6.6	6.6	6.6	9.9
Evapotranspiration (cm)	0.8	0.8	2.3	5.6	9.7	13.2	15.0	13.2	9.1	5.6	0.0	0.8

PRECIPITATION AND ET

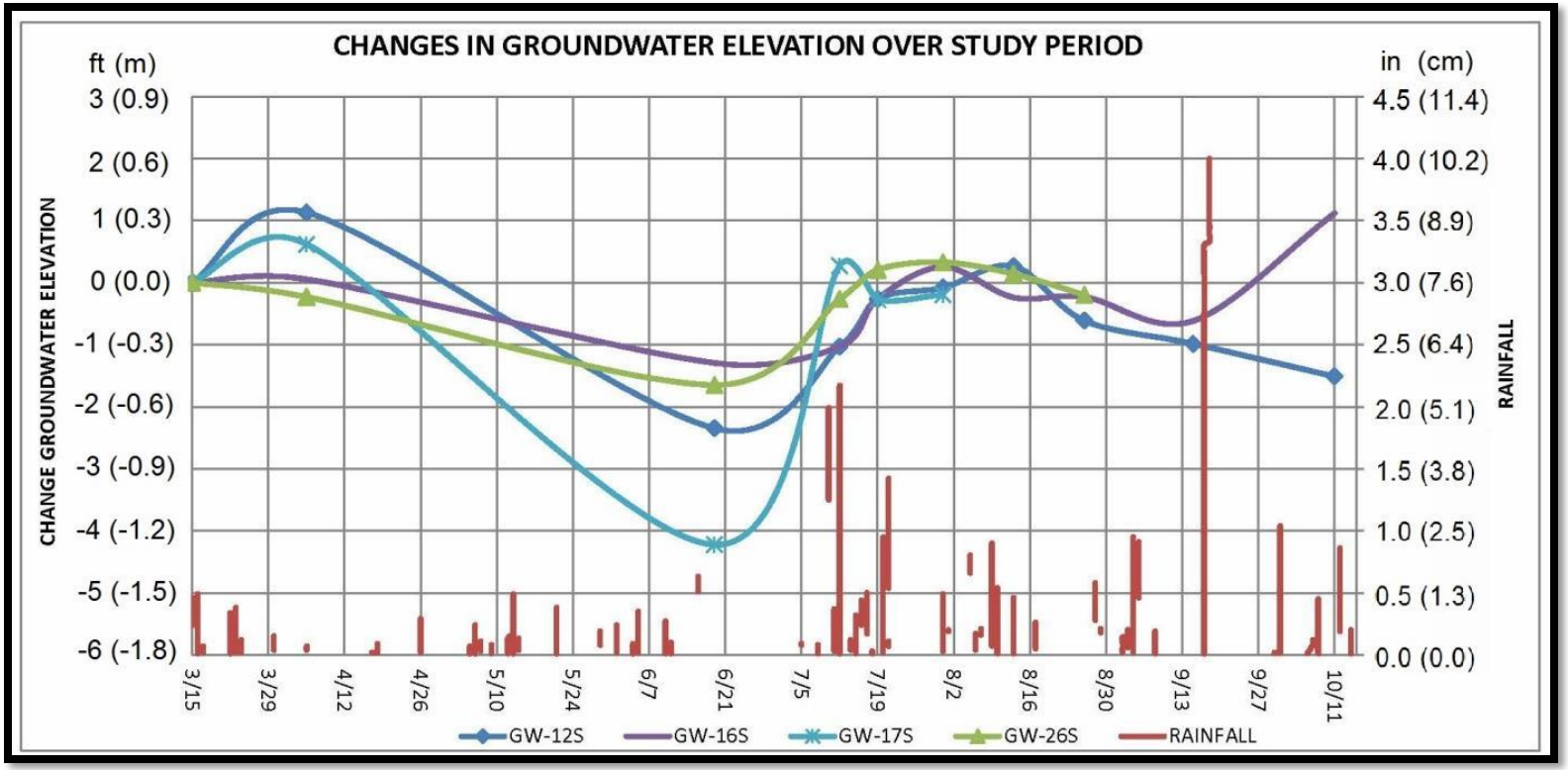


INFILTRATION

TABLE 6
AVERAGE ANNUAL ESTIMATED INFILTRATION
(Recharge + ET) – ET = Infiltration Recharge

	BIG HE CREEK (SW-13)	LITTLE HE CREEK (SW-14)	HE CREEK (SW-4)
Recharge + ET [in (cm)]	48.3 (122.7)	44.8 (113.7)	44.4 (112.8)
ET [in (cm)]	28.0 (71.1)	28.0 (71.1)	28.0 (71.1)
Infiltration Recharge [in (cm)]	**20.3 (51.5)**	**16.8 (42.6)**	**16.4 (41.7)**

Groundwater Monitoring

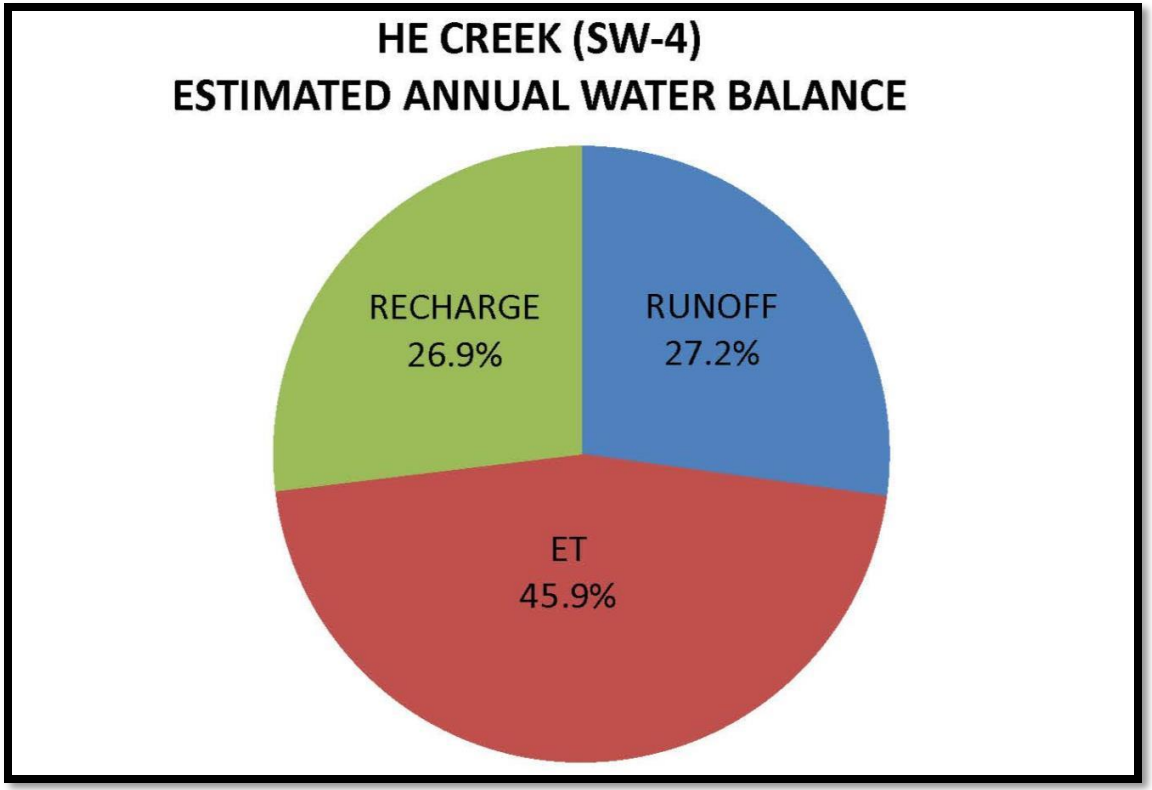


WATER BALANCE

TABLE 8
ANNUAL WATER BALANCE RESULTS

	PRECIPITATION	RUNOFF	ET	INFILTRATION
	GPM (M^3/min)	GPM (M^3/min)	GPM (M^3/min)	GPM (M^3/min)
BIG HE CREEK	4,128 (15,624)	860 (3.26)	1,895 (7.17)	1,373 (5.20)
LITTLE HE CREEK	3,309 (12,525)	880 (3.33	1,519 (5.75)	910 (3.45)
HE CREEK	**8,667 (32,805)**	**2,356 (8.92)**	**3,978 (15.06)**	**2,332 (8.83)**
	IN (CM)	IN (CM)	IN (CM)	IN (CM)
BIG HE CREEK	61.0 (154.9)	12.7 (32.3)	28.0 (71.1)	20.3 (51.5)
LITTLE HE CREEK	61.0 (154.9)	16.2 (41.2)	28.0 (71.1)	16.8 (42.6)
HE CREEK	**61.0 (154.9)**	**16.6 (42.1)**	**28.0 (71.1)**	**16.4 (41.7)**

WATER BALANCE



Convert Infiltration to Runoff – Hydraulic Controls

- Pumping and treatment system flow path improvements
- Remove unlined (leaky) basins
- Route runoff directly to streams where possible

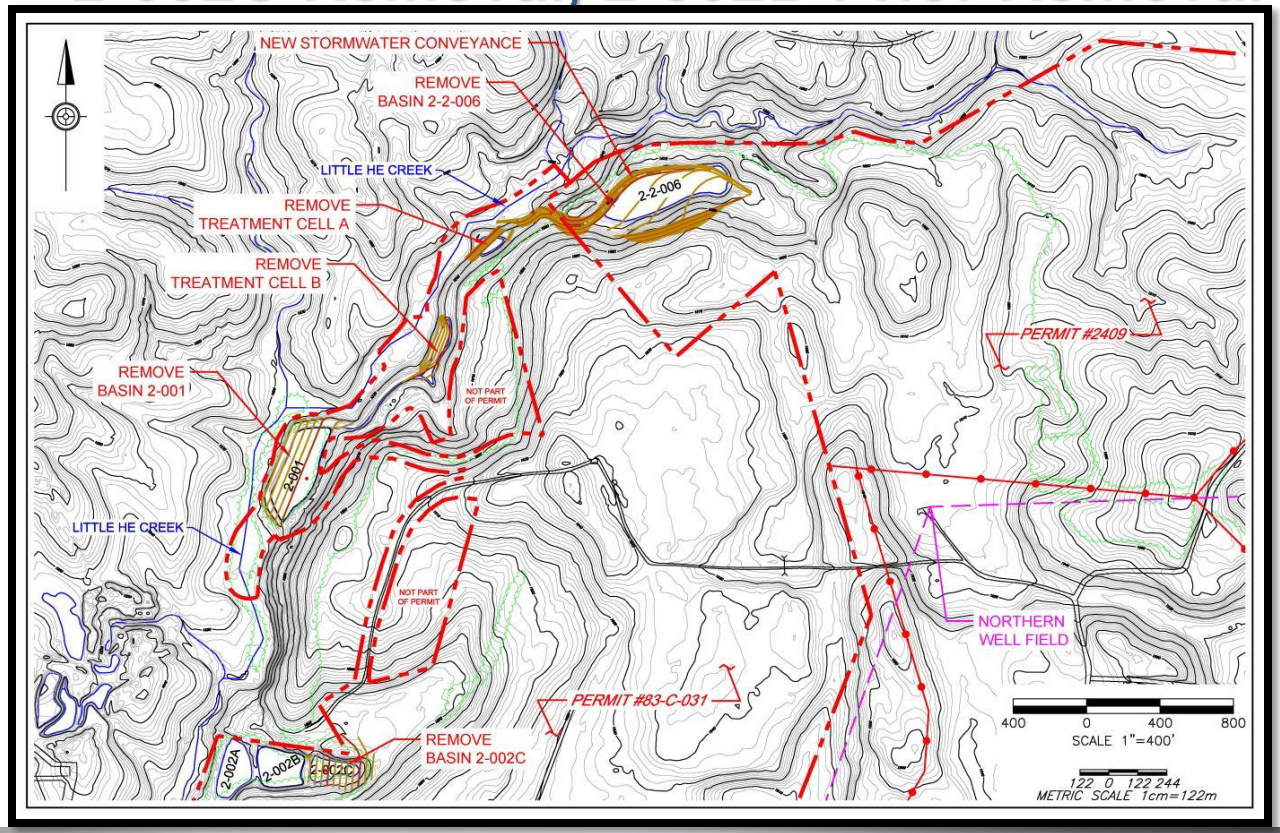
Pumping and Treatment System Flow

- Average Pumping Rate 1,000 GPM +/-
- Average Discharge Rate 700 GPM +/-
- Pump water losses 300 GPM +/-
- Average 30% recycle through infiltration (>1/3 loss seasonally)
- Hydraulic Improvement 1 – re-route to avoid infiltration points
- Hydraulic Improvement 2 – extend discharge pipe/line channel

Remove Unlined (leaky) Basins

- Basin 2-2-006 (Completed 2013/2014)
- Basin 2-001 (Completed 2014)
- Basin 2-002C (Completed 2014)
- Basin 2-2-001A (Completed 2015)
- Basin 2-2-001D and E Reclamation (Future)

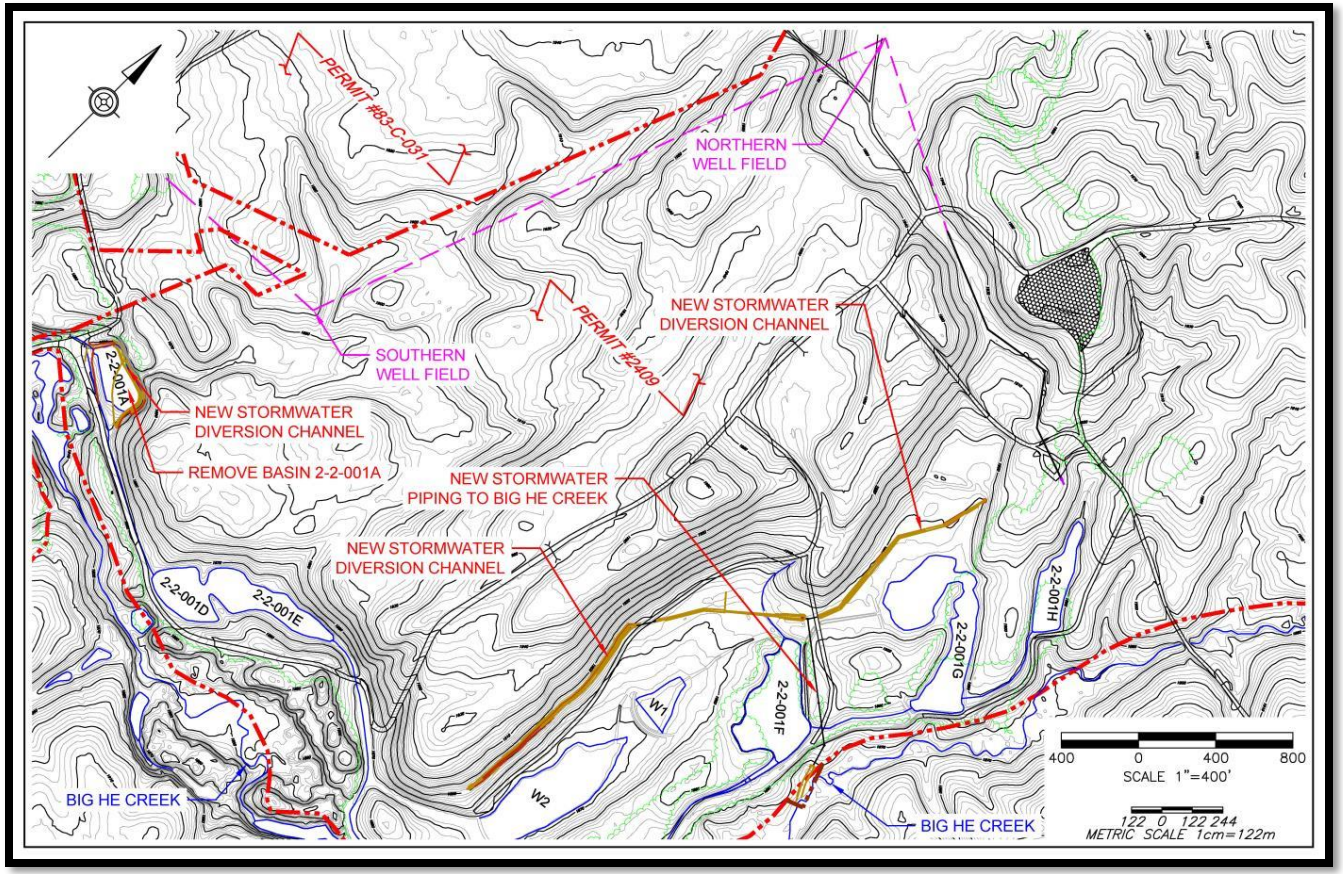
2-2-006 Removal, (129 acres) 2-2-001 Removal 2-002C Removal, 2-002D Prior Removal



Basin 2-2-006 Removal Example
129-acre drainage area

Basin 2-2-006 Channel Failure & Repairs

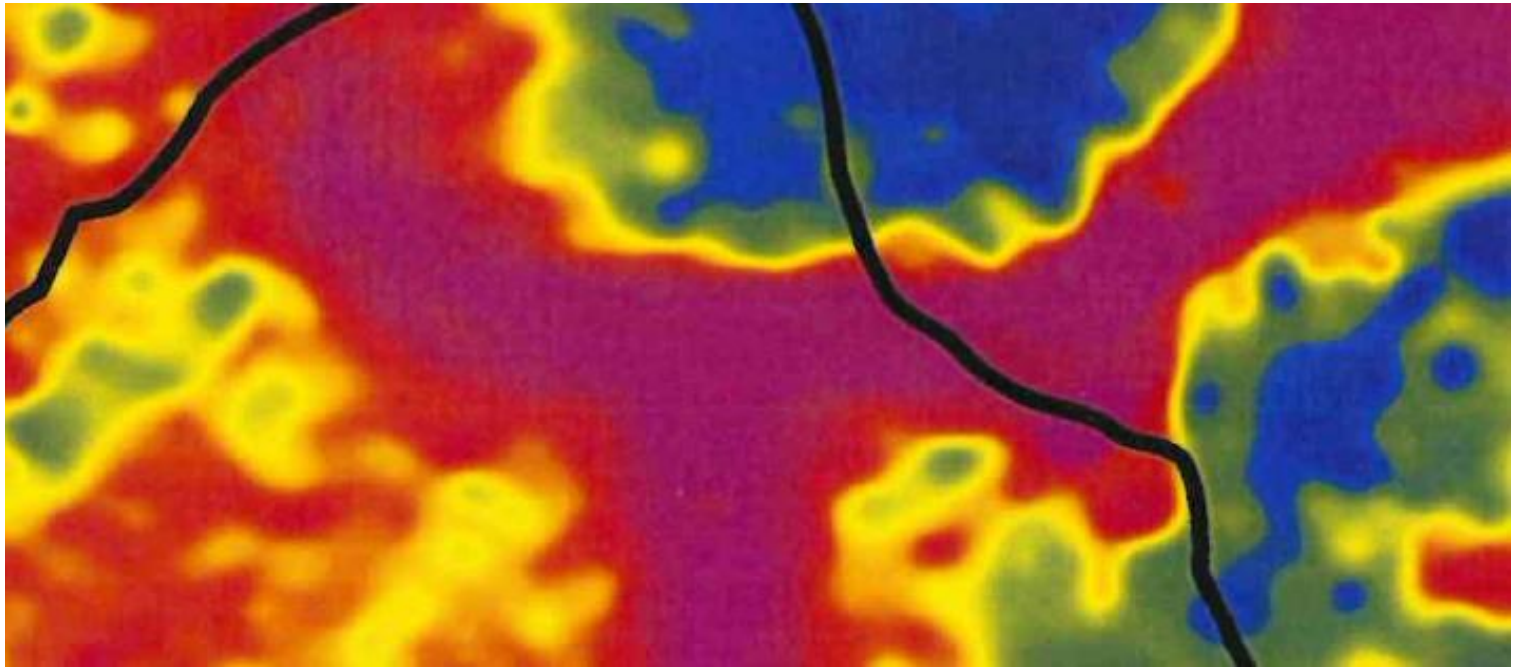
Route Runoff Directly to Streams (>250 acres)



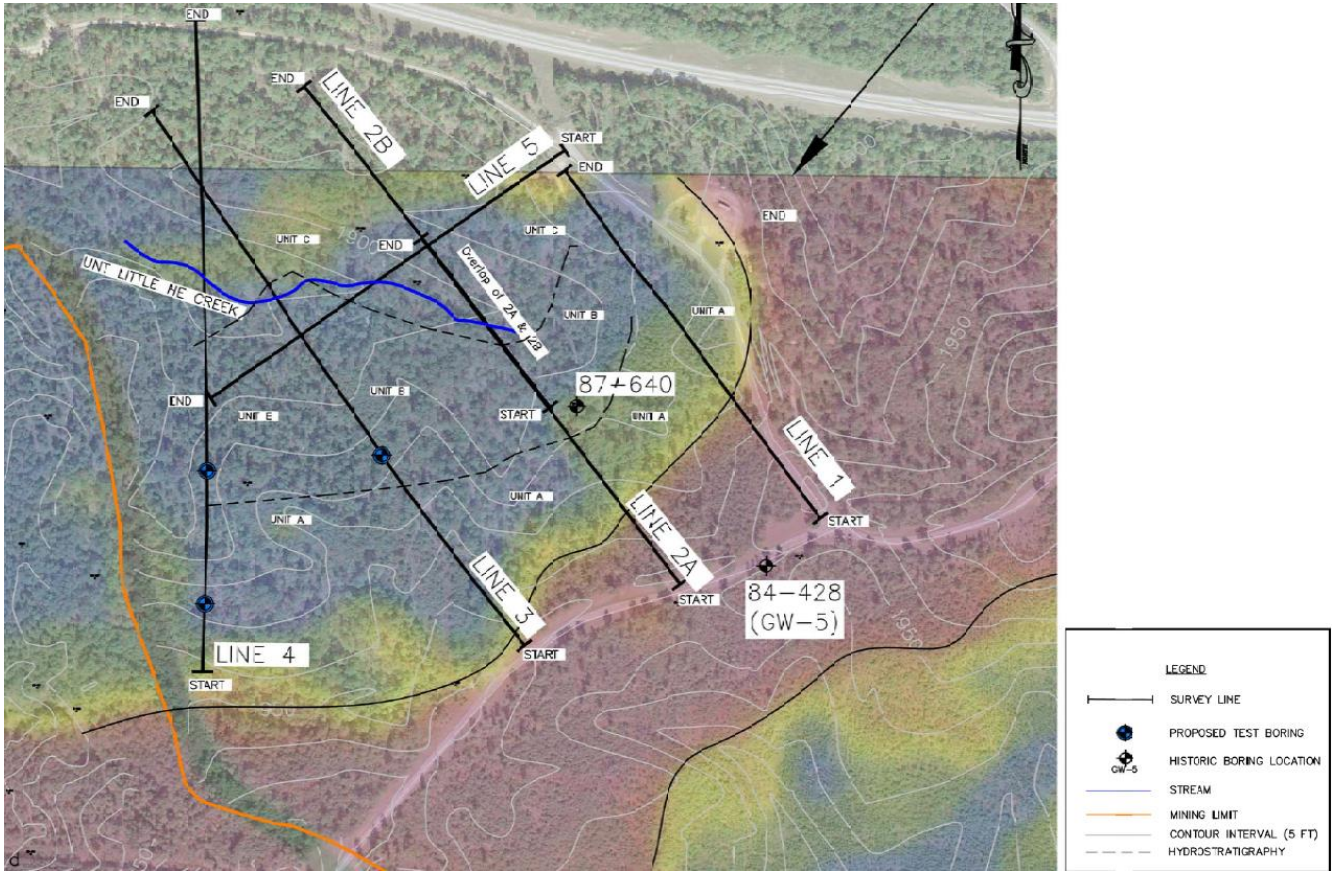
Hydrogeologic Considerations
After path corrections/basin removals

- Rainwater Infiltration << Pumping volume (MODFLOW 2015+/-)
- Additional pumped water originates from groundwater source
- Groundwater flow is generally north to south
- Could clean groundwater be intercepted before entering the backfill and becoming contamination?
- Geophysical techniques employed to evaluate

2004 Airborne Geophysical Survey - RESOLVE



ER Geophysical Investigation - 2017



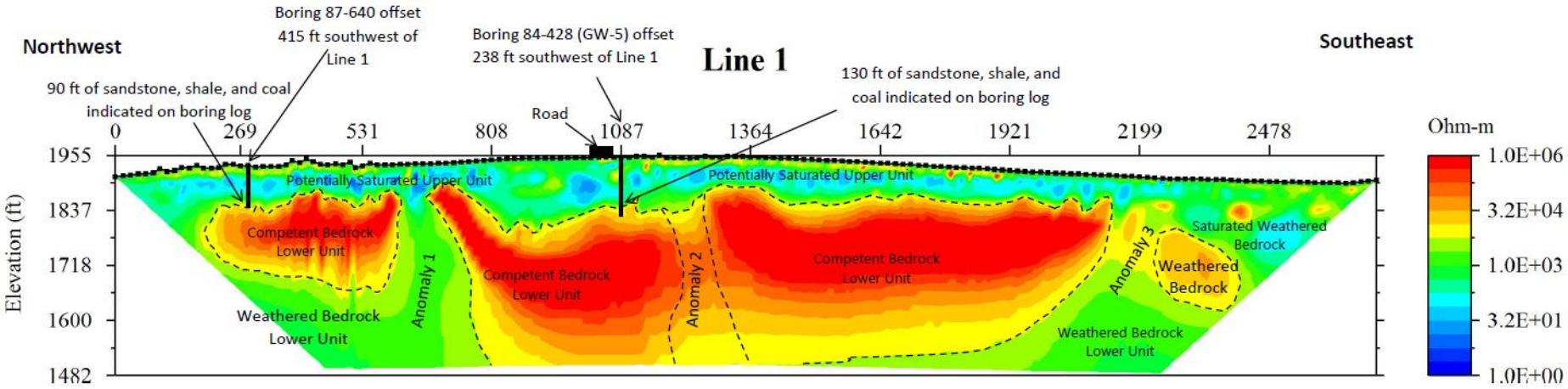
Geophysical Testing on Adjoining Property in and Adjacent to permit boundary

Figure 2. ERT setup on Line 3 SVC Site, Dunlap, TN

Figure 3. AGI Supersting RES/IP Meter

Figure 4. Complete equipment collecting data on Line 4, SVC Site Dunlap, TN

Electrical Resistivity Cross-Section
However, test drilling postponed – property control change



Hydrogeologic Solution Evaluated - 2018
Class I or Class V Injection Well Permit

- Class I likely cost prohibitive and not pursued
- Class V potentially feasible option
- Class V injection well feasibility study completed
- Owner investment went toward pumping system improvements instead of a higher risk injection well permit following a 2018 regulatory meeting

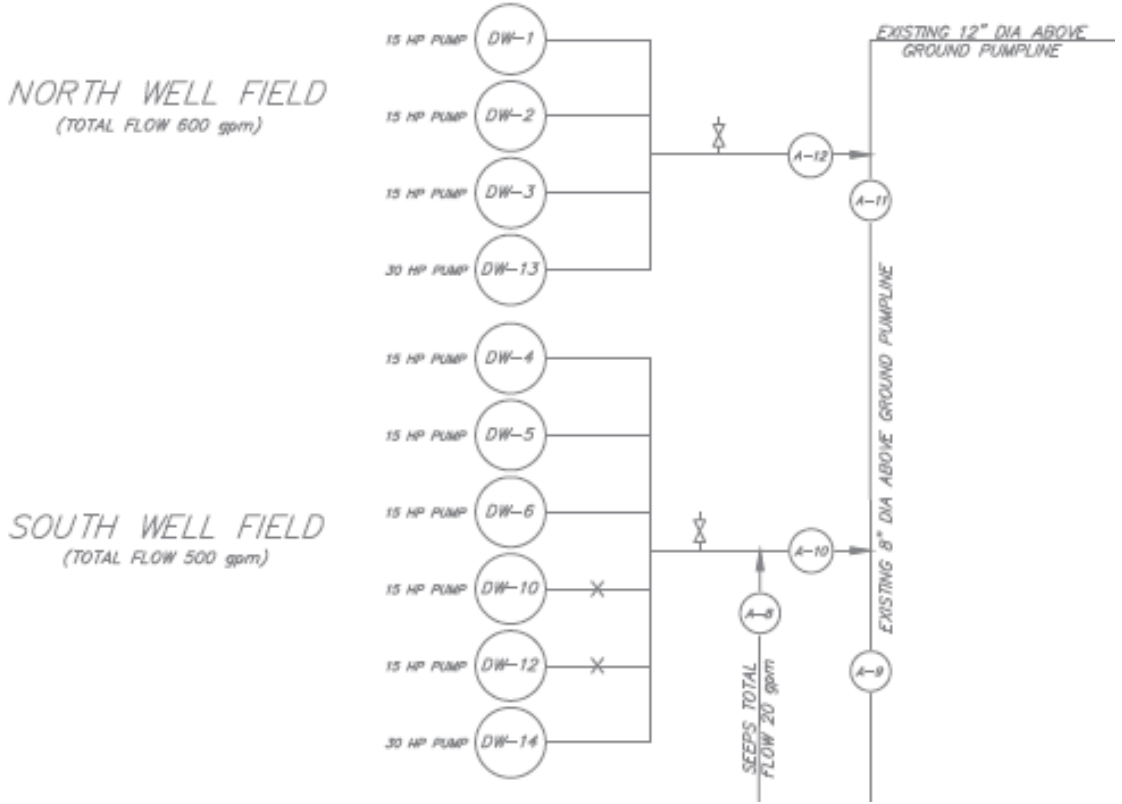
Permittee (Cloud Peak Energy) filed for Chapter 11 Bankruptcy - 2019

- Activities slowed as cash flow was low 2018-2019
- All activities other environmental compliance were suspended until further notice when bankruptcy filed
- On-going basin inspections, pumping, and treatment are part of environmental compliance
- Navajo Transitional Energy Company (NTEC) took over late 2019

Backfill Water Level Observations and Subsequent Plan of Action

- Backfill water levels tracked for decades
- Seasonal variances could exceed 30 feet (10 meters)
- Pumping system rates at both field < peak infiltration
- Addition pumping capacity recommended at both fields
- NTEC agreed and pursued additional pumping capacity

Northern and Southern Pumping Fields



Navajo Transitional Energy Company Dewatering Well Capacity Investments

- 2020-2022 Catch up on routine maintenance activities
- Basin Cleanouts, Treatment System Modifications, etc.
- 2022 - drilled new production well at Northern Field
- 2023 - drilled new production well at Southern Field
- Due to supply chain issues, activation of wells delayed until mid-2023 NWF and late 2023 SWF

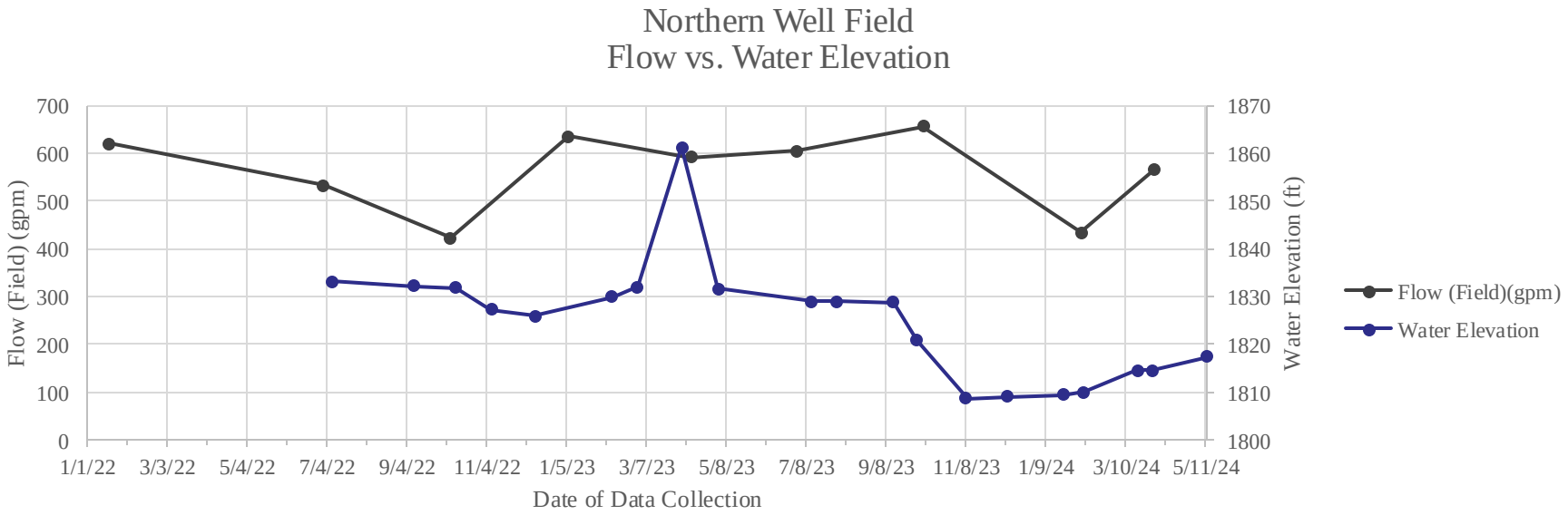
Northern and Southern Production Wells

- Typical SVC dewatering wells - 15 HP pumps
- New wells used proprietary casing for 80 feet
- Proprietary filter pack used versus sand filter pack
- New - 30 HP pumps for 200 GPM+/- design
- Single phase power converted to 3-phase

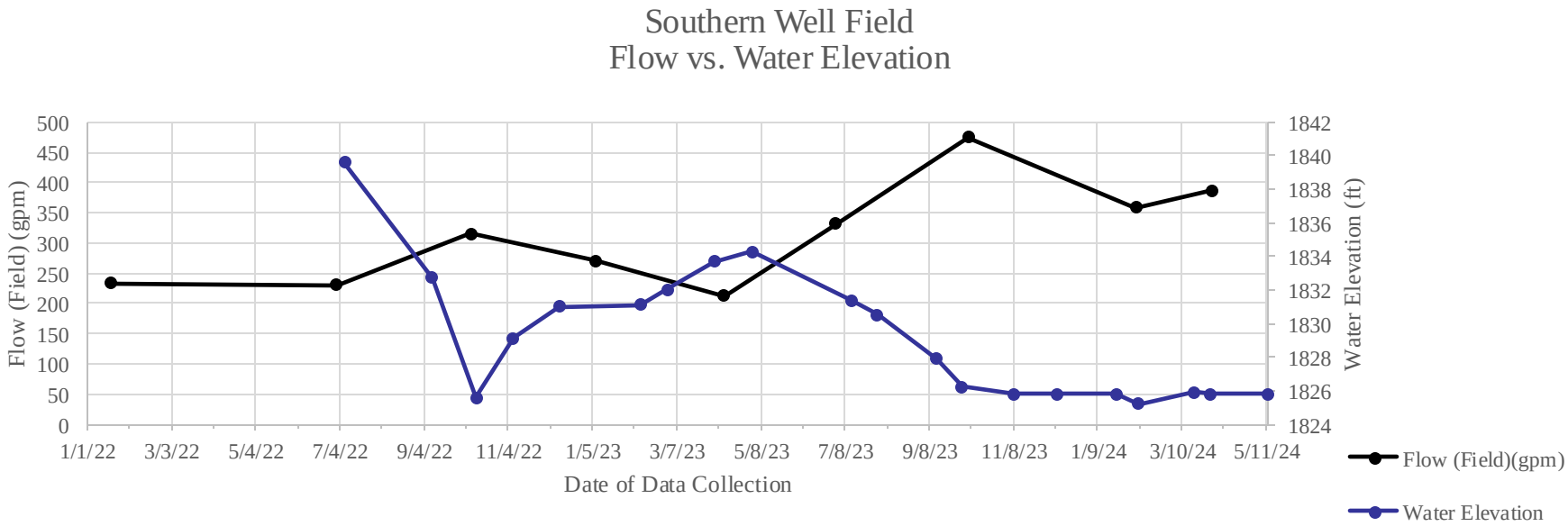
Northern and Southern Groundwater Elevations

- Drawdown aided by near draught conditions late 2023 through early 2024
- Pumping capacity increased by 200 GPM+/- at each field
- Backfill groundwater elevation reached 30-year low

Northern Well Field Elevations and Flows



Southern Well Field Elevations and Flows



Groundwater Elevations Goals 2024

- Select optimum groundwater elevations
- Allow adequate storage for equipment or power failure
- Hold groundwater elevations constant (as possible)
- Reduce DO introduction to backfill groundwater

Thanks

- Navajo Transitional Energy Company (NTEC) for willingness to share data
- Office of Surface Mining
- Tennessee Department of Environment and Conservation
- Current/prior owners for opportunity to work at SVC on interesting and challenging projects for over 30 years

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