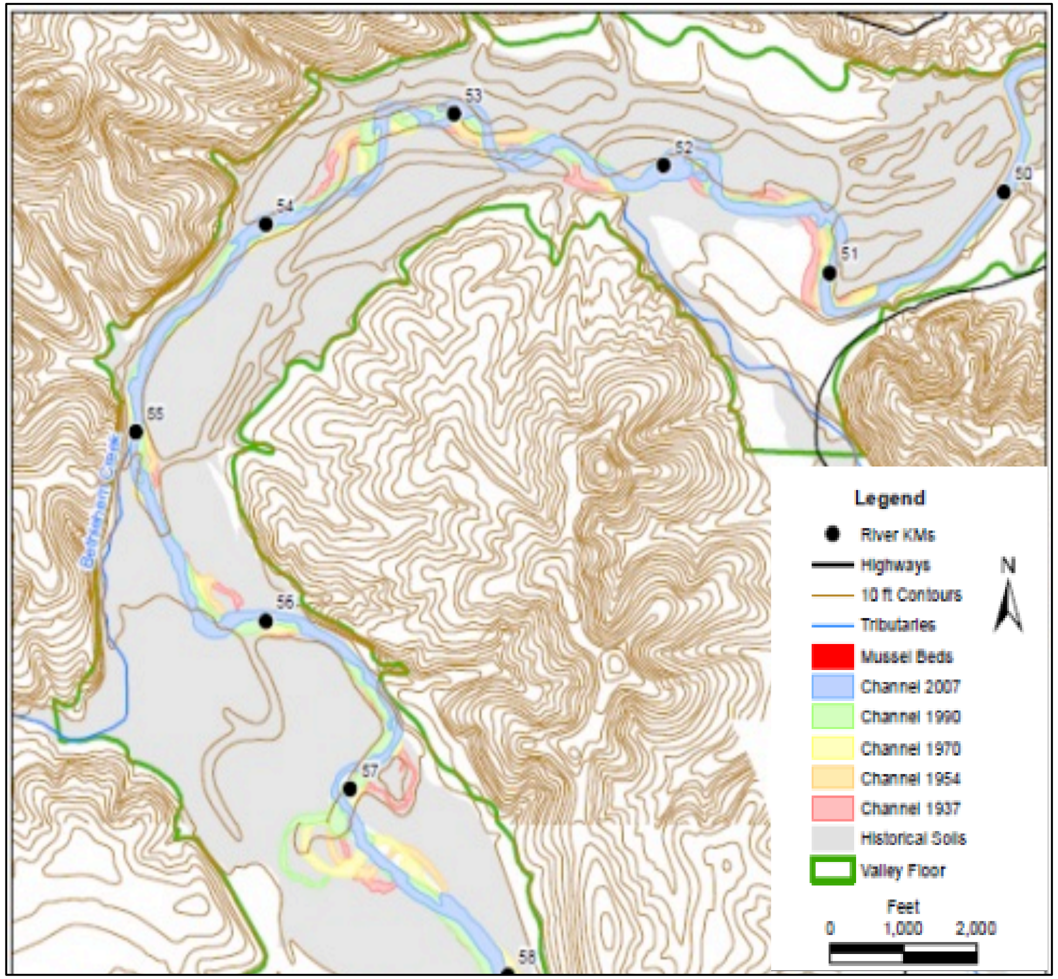
Harnessing Natural River Processes to Remediate 120 km of the Big River in Jefferson County, Missouri

HGL
HydroGeoLogic, Inc
Exceeding Expectations

Shane Cherry

Integrate Natural Processes Into Remediation

- Aggregate contaminated sediments
- Fast flowing channel segments flush sediment downstream
- Slow moving channel segments deposit and store sediment
- Contaminated sediments accumulate in depositional zones
- Strategically enhance deposition
- Remove contaminated sediments multiple times from same locations



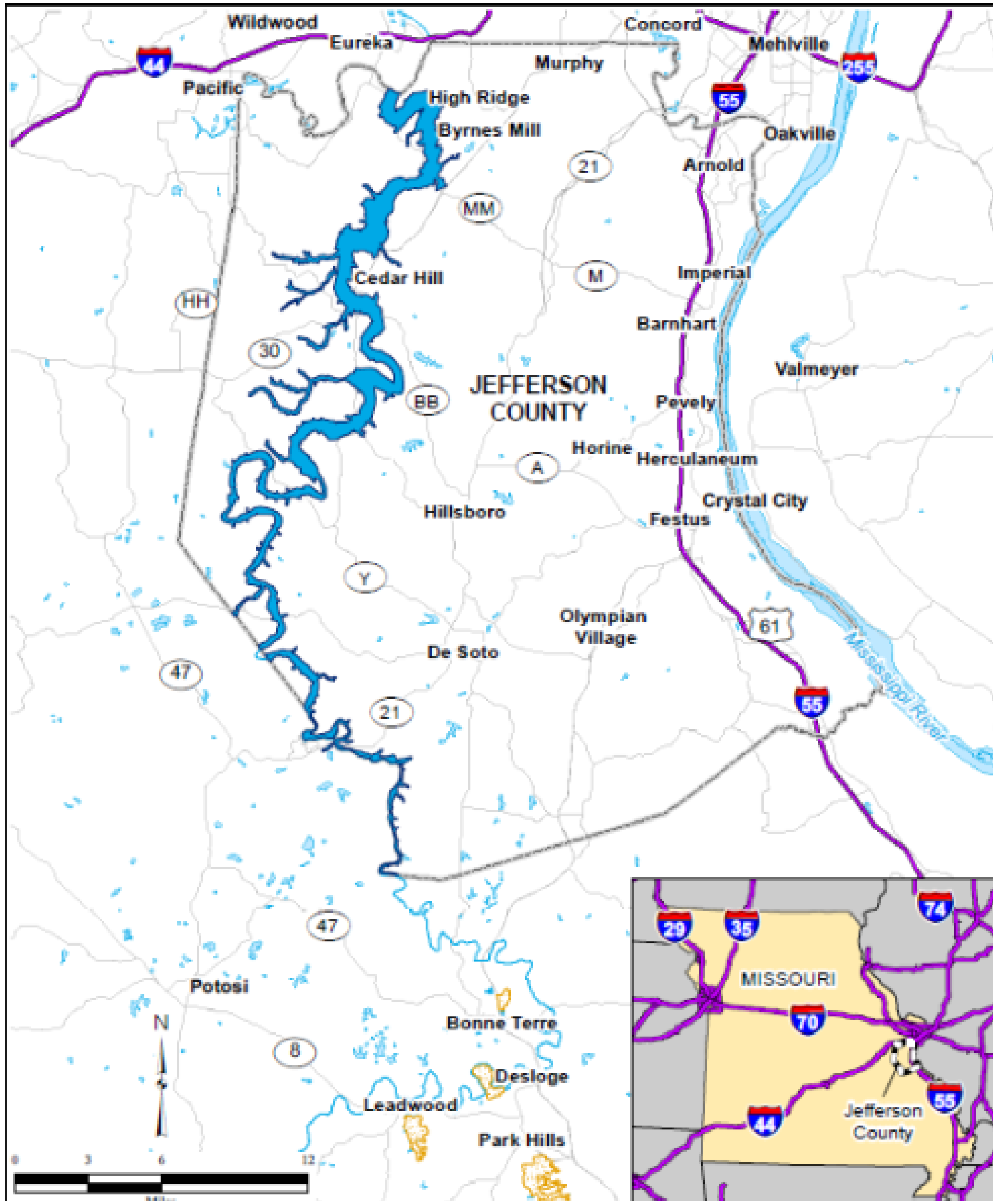
Source: Pavlowsky & Owen 2013

Applicability of Watershed Science to Remedial Strategy

- Geomorphic processes provide necessary context for diagnosis and treatment of contaminated watersheds
- Remedial strategy and selection of effective remedial technologies varies across different settings
- Comparison to Spring River illustrates adaptability
- Treatability Investigations of innovative technologies inform optimal application

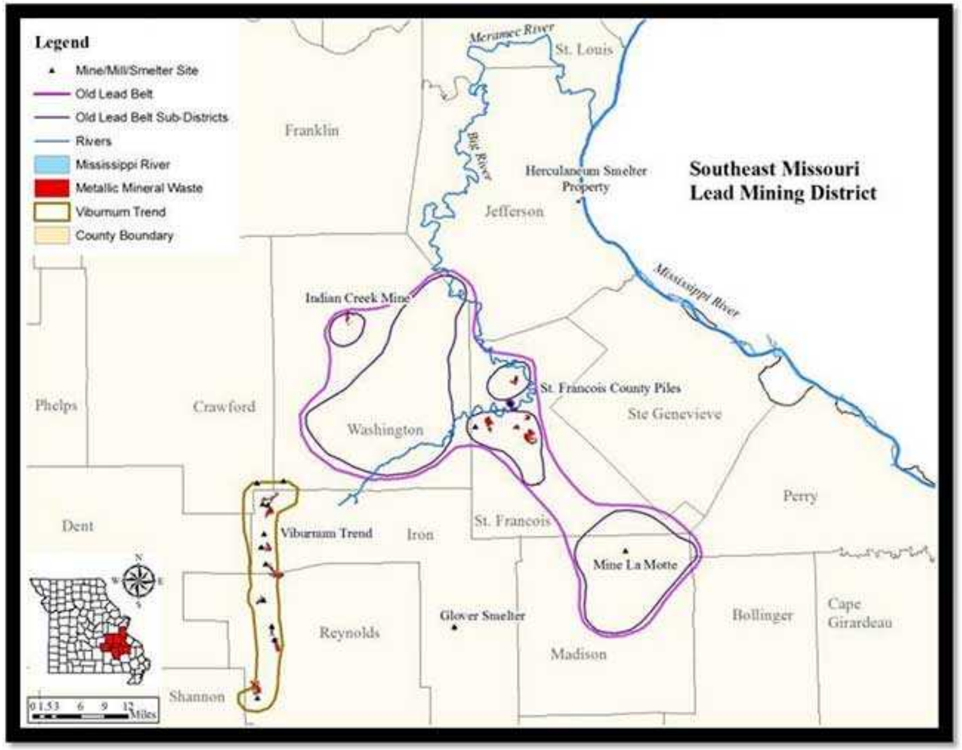
Big River Site Location

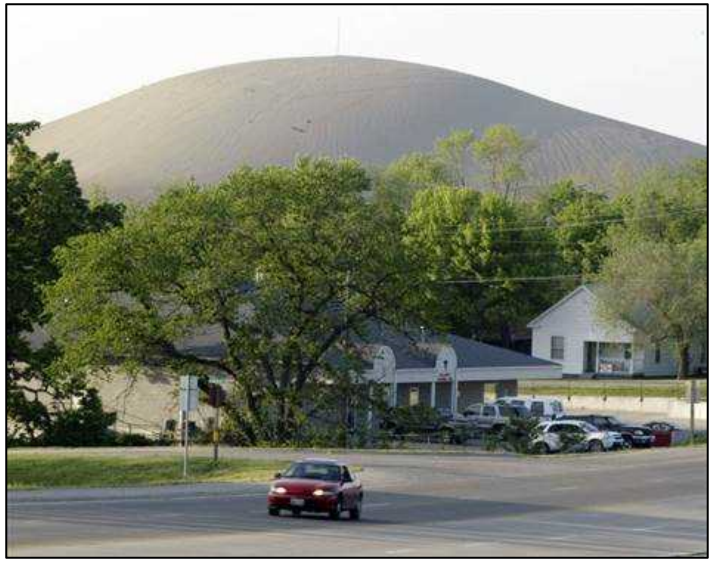
- Jefferson County, Missouri
- Tributary to Meramec River
- Historic mining upstream
- River length 120 km in Jefferson County (200 km overall)
- Low gradient meandering river
- Gravel and sand bed with dispersed bedrock outcrops
- Floodplain expands to over 2 km width in lower half of site



Site Background

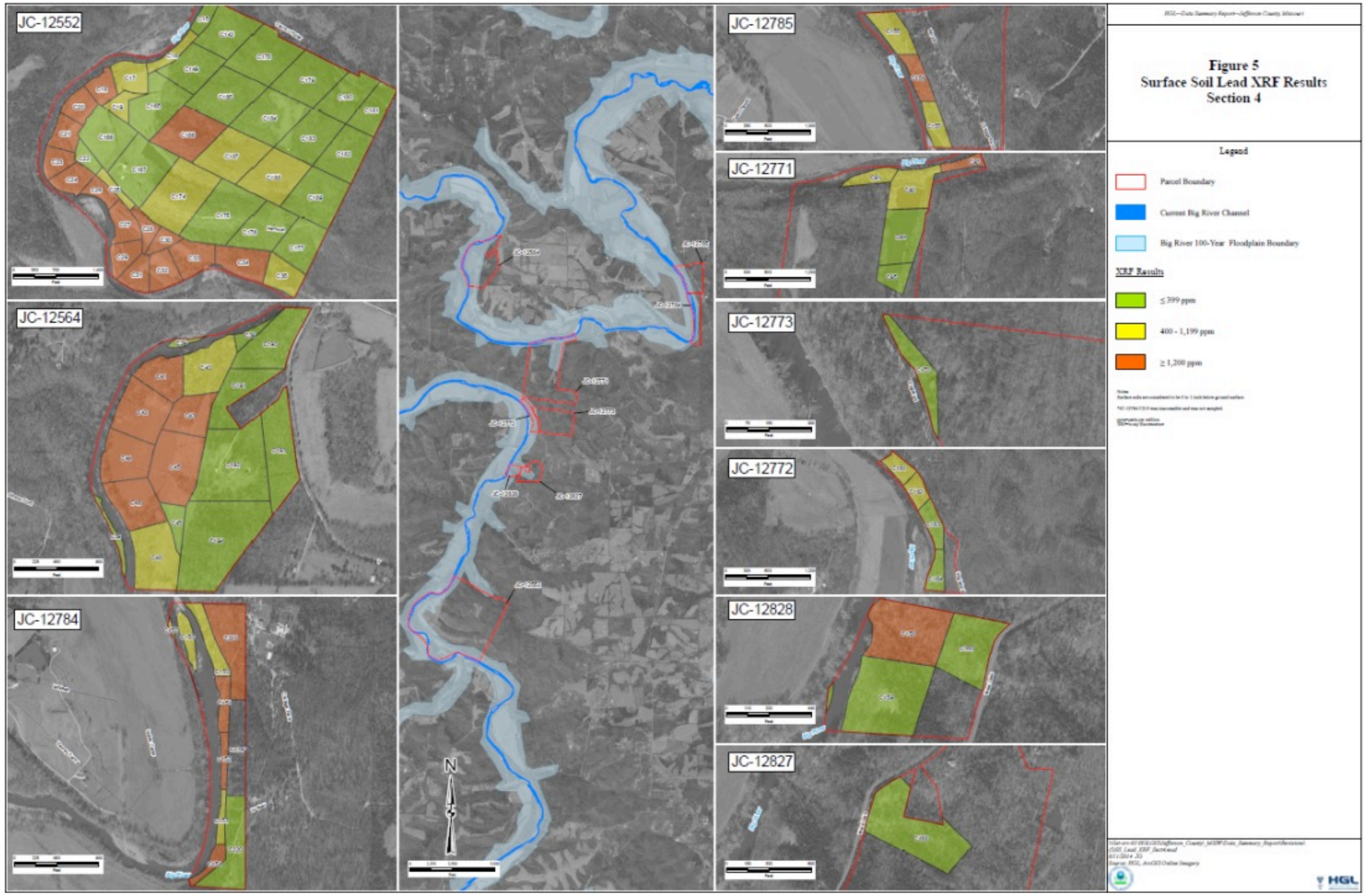
- Mining process
- Historic releases of COCs

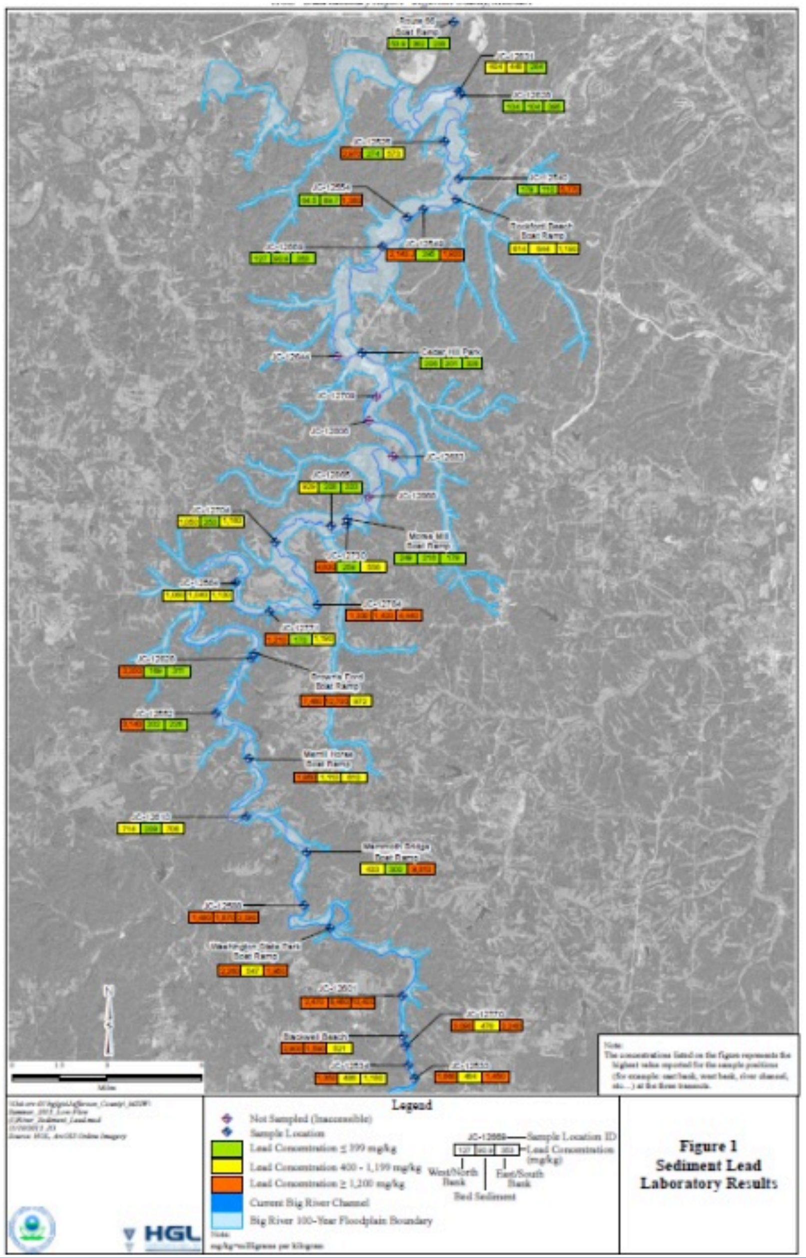




Site Background

- Distribution of COCs

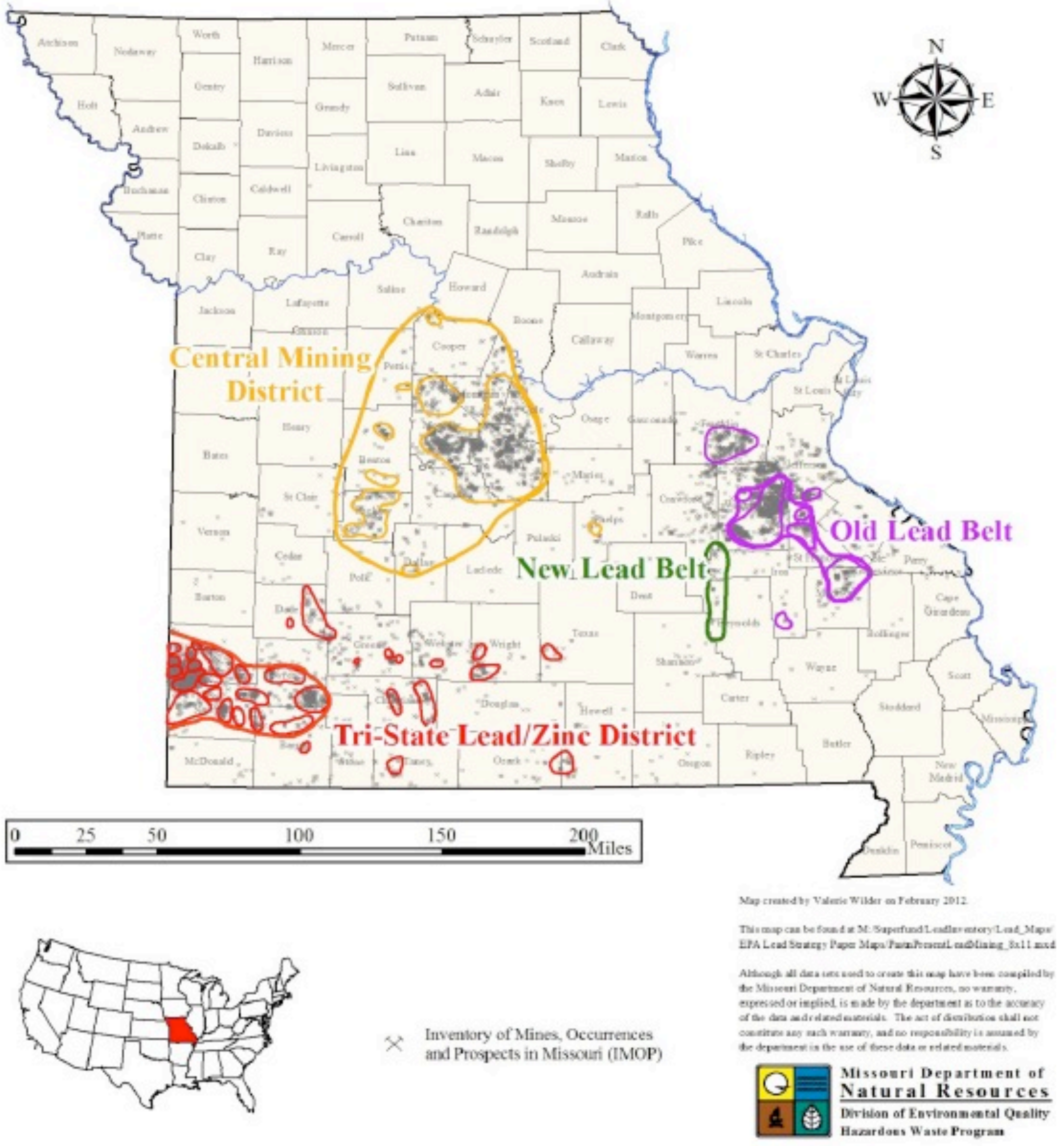


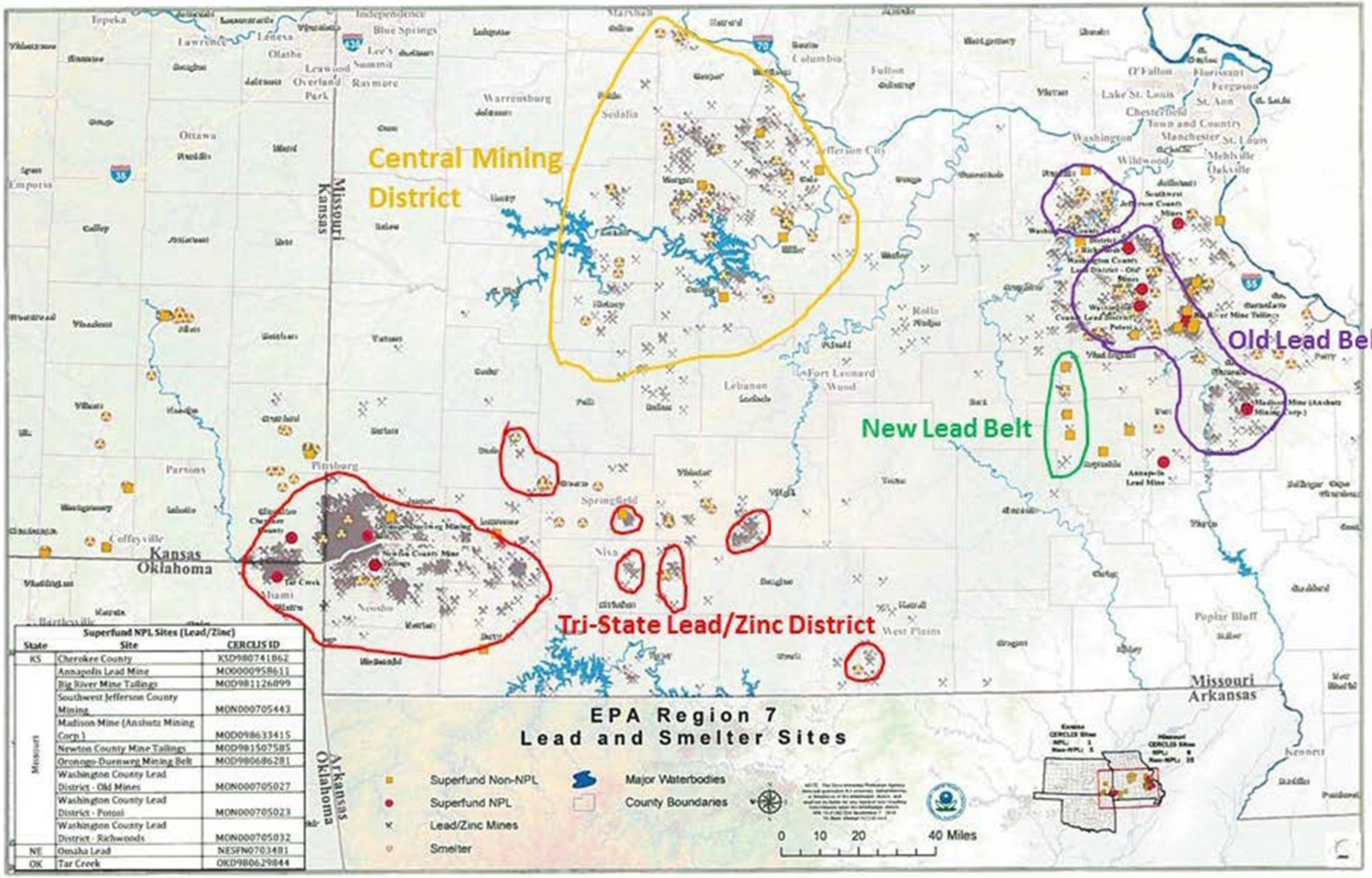


Data are pre-decisional – ROD and Proposed Plan for OU4 are not yet developed.

Regional Context

- Widespread historic mining
  - Old Lead Belt
  - New Lead Belt
  - Central Mining District
  - Tri-State Lead/Zinc District
- Strategy is adaptable to apply to diverse watershed conditions
  - Adaptations must account for scale, hydrology, land use, dominant geomorphic processes





Note: Image provided by EPA Region 7 Superfund Division.

Tri-State Mining District –

National Priority List (NPL) Superfund Sites

<u>Missouri:</u>

1.Jasper County/Oronogo-Duenweg Mining Belt NPL Site

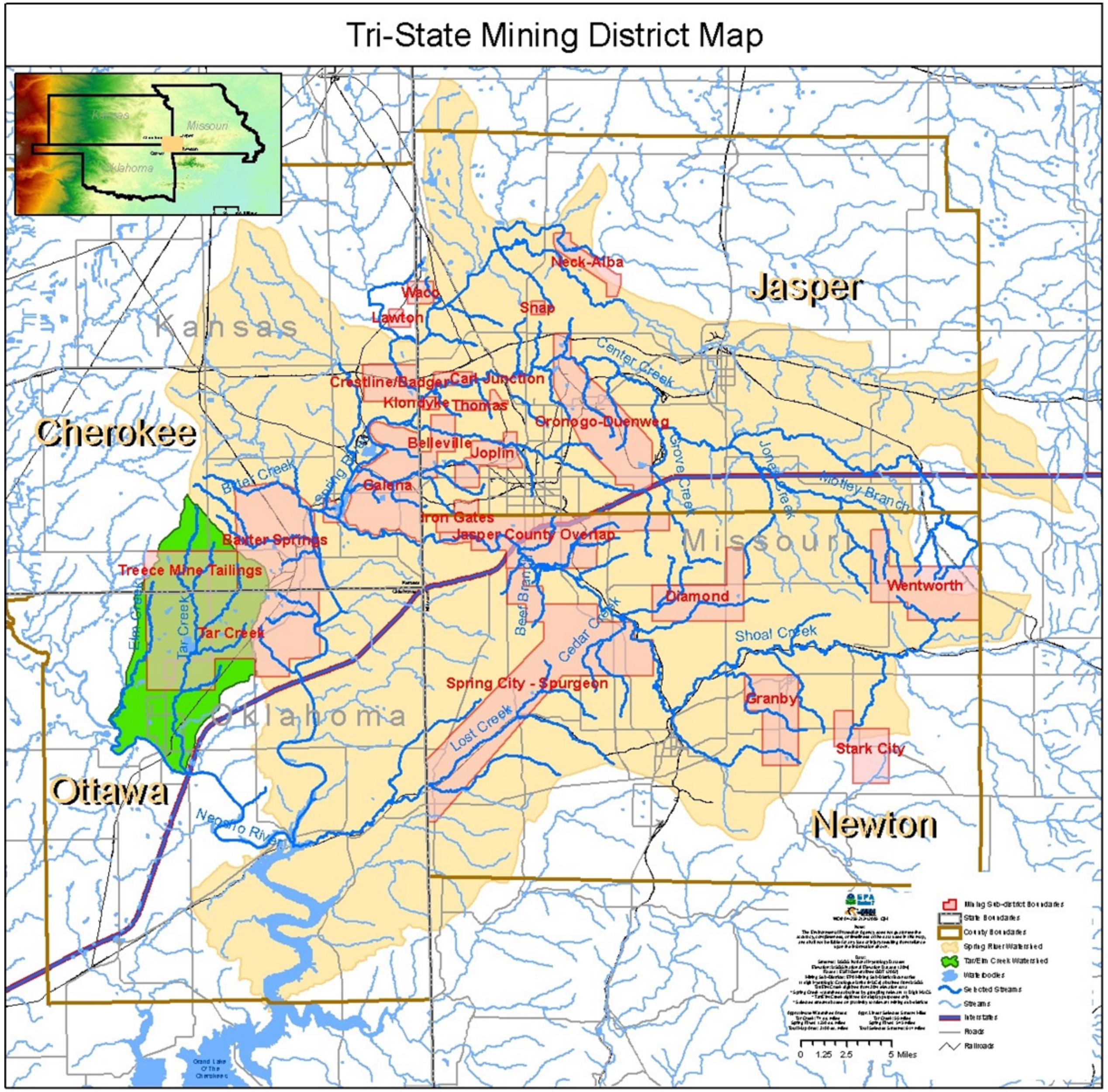
2.Newton County/Newton County Mine Tailings NPL Site

<u>Kansas:</u>

3. Cherokee County NPL Site

<u>Oklahoma:</u>

4.Ottawa County – Tar Creek NPL Site

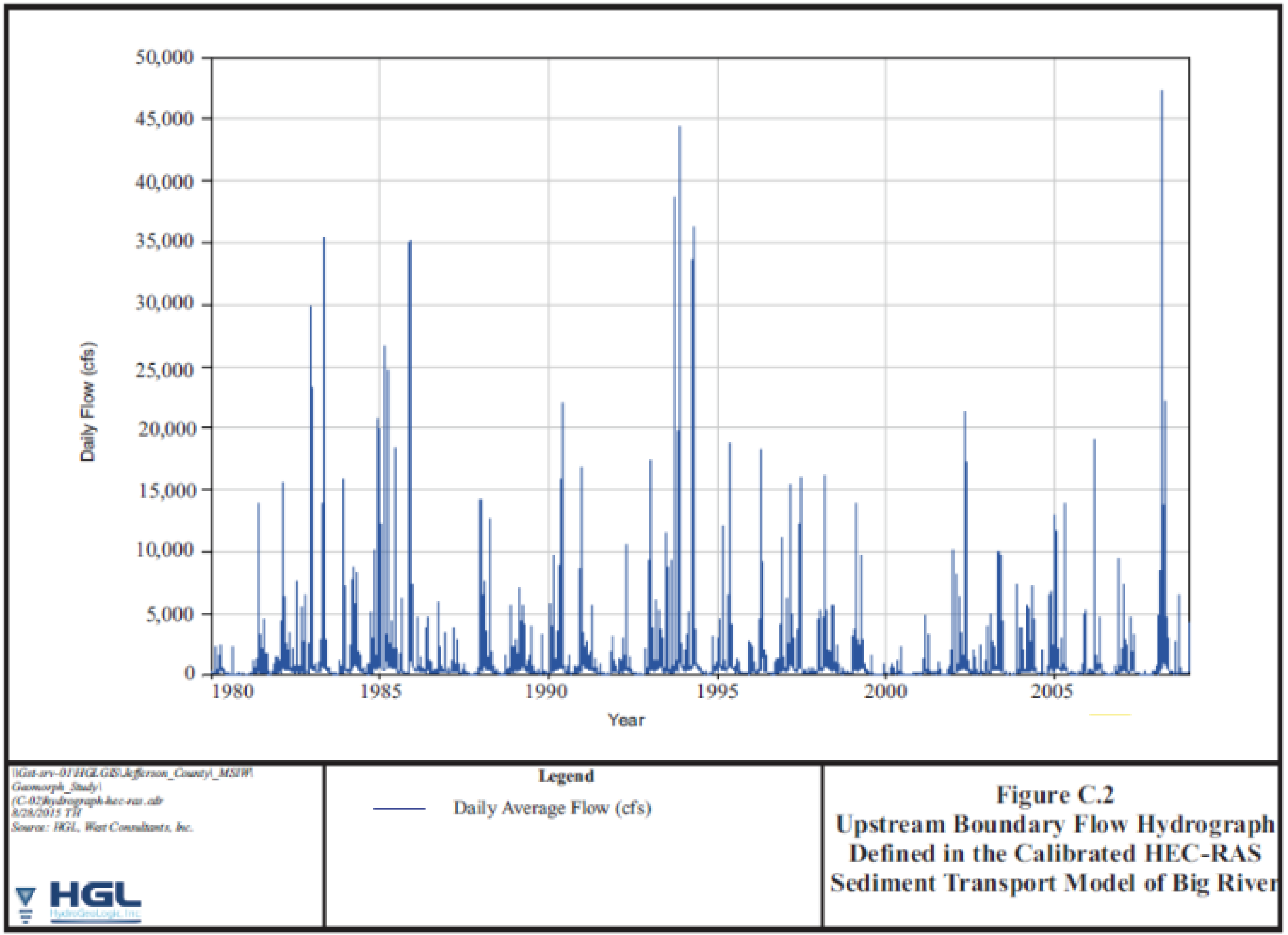


Note: Image provided by EPA Region 7 Superfund Division.

Basin Hydrology

USGS Gage 07018500 Big River at Byrnesville, MO

- 2-yr flood: 17,700 cfs
- 10-yr flood: 36,200 cfs
- 25-yr flood: 45,700 cfs
- 50-yr flood: 52,800 cfs
- 100-yr flood: 59,800 cfs



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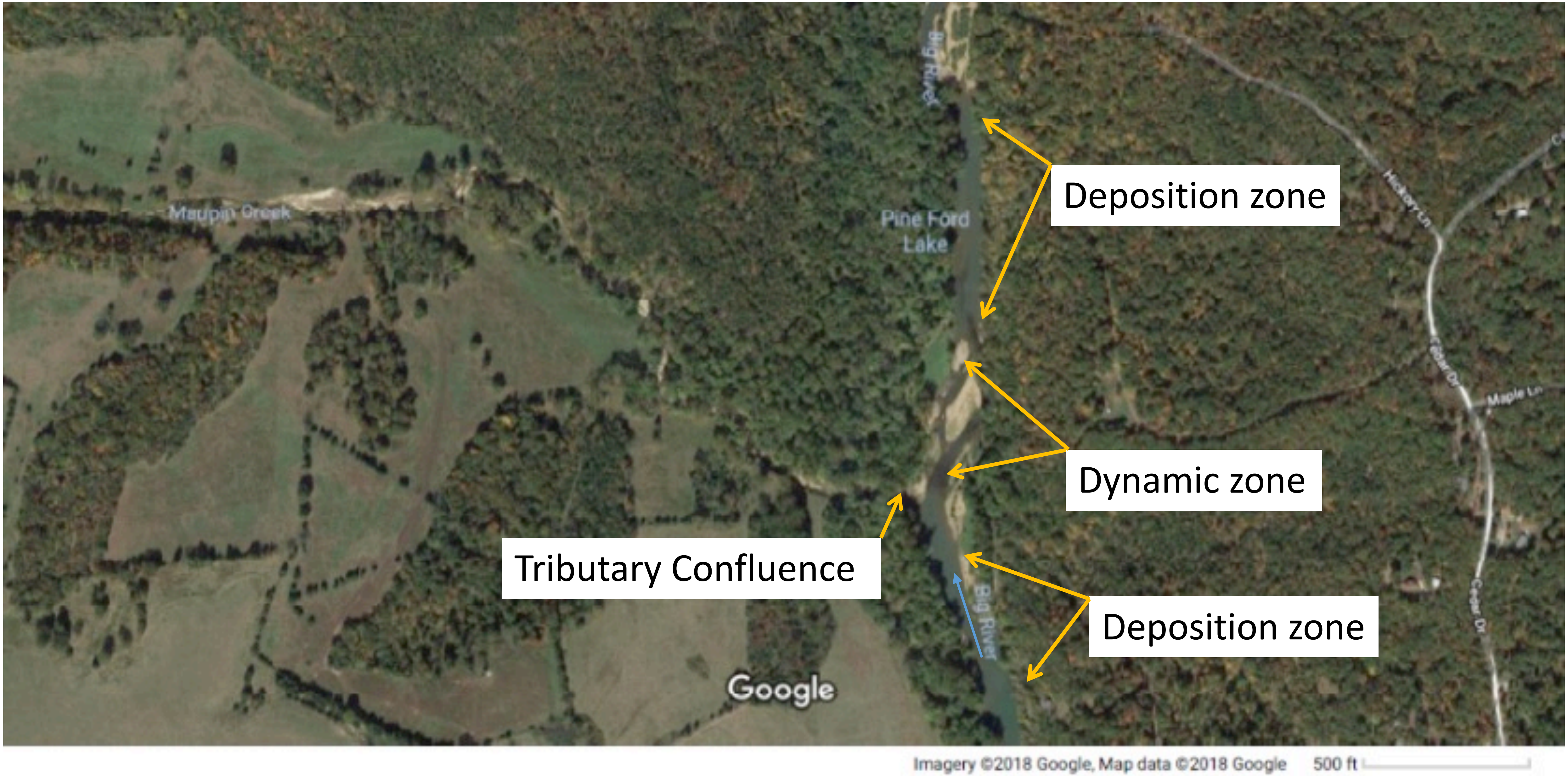
Widespread Bank Erosion

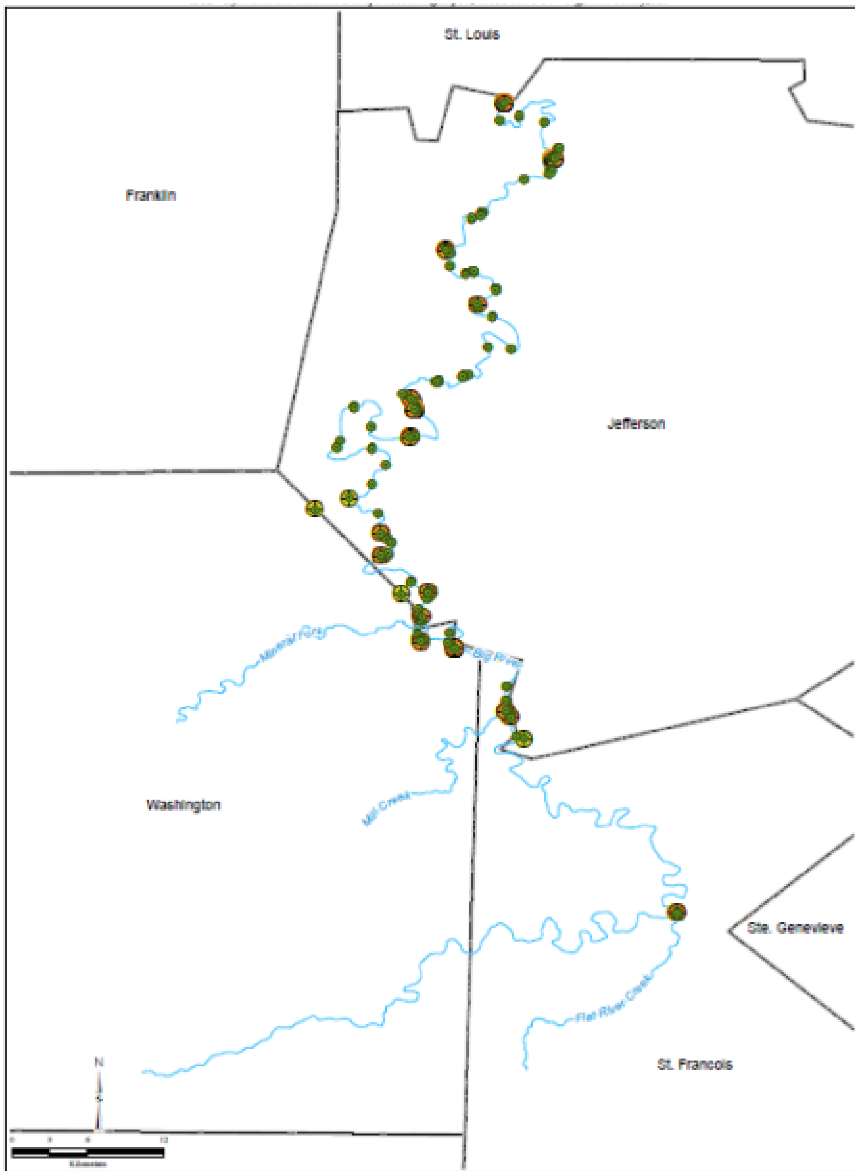
In-stream Sediment Storage

- Gravel and sand bars
- Tributary confluence
- Locally steep channel segments
- Bedrock outcrops and channel constrictions


Deposition zone
Pine Ford Lake
Maupin Creek
Big River
Dynamic zone
Tributary Confluence
Deposition zone
Big River
Google
Imagery ©2018 Google, Map data ©2018 Google 500 ft

Environmental Sampling

- Riverbed sediments
- Riverbanks
- Floodplain soils



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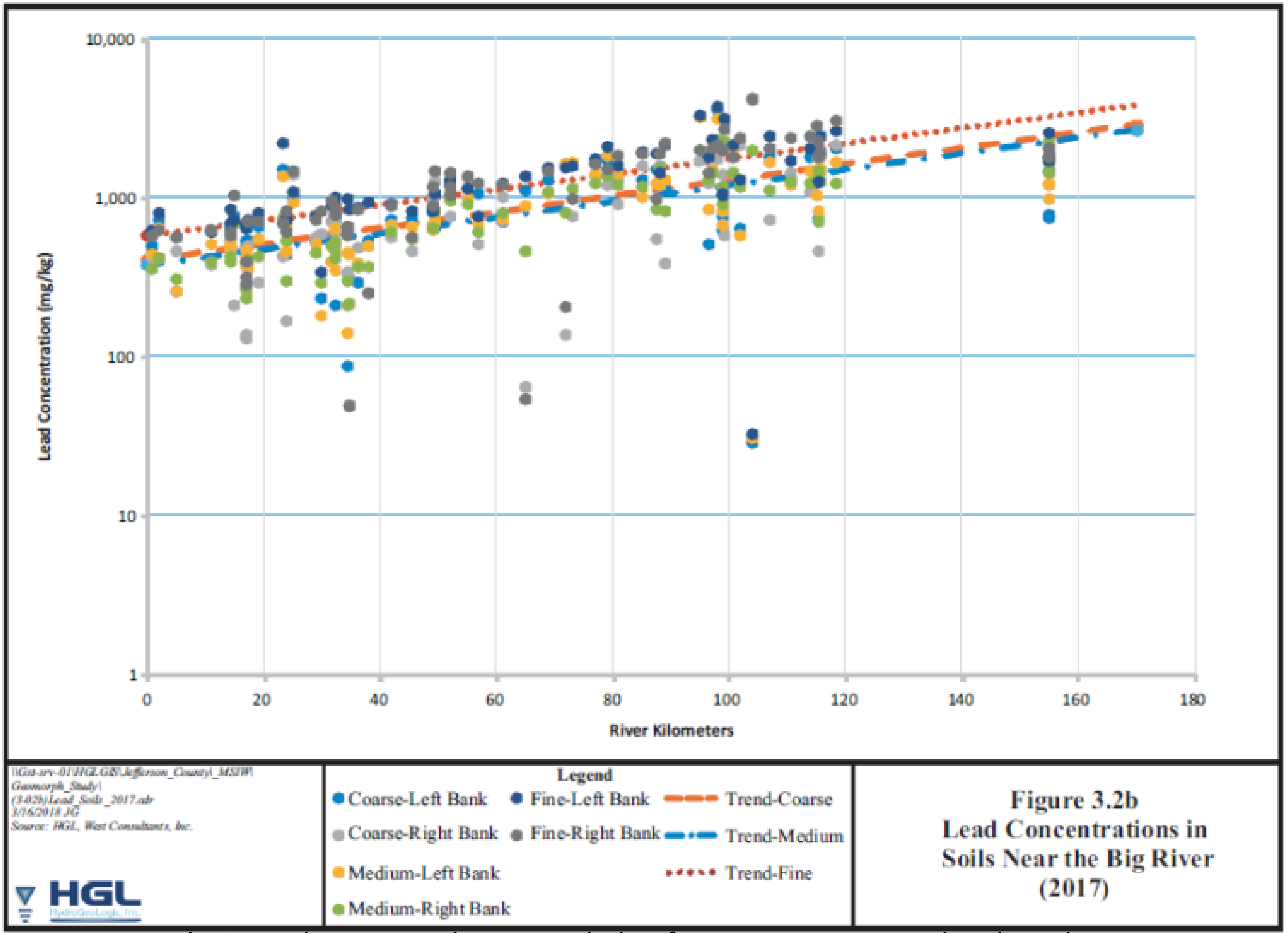
Contaminant Distribution Floodplain Soils

- Trend: concentration decreases downstream
- Three size classes evaluated separately
- Fine sediment class has largest mass and strongest trend



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Contaminant Distribution Riverbed Sediments

- Trend: concentration decreases downstream
- Three size classes evaluated separately
- Fine sediment class has largest mass and strongest trend

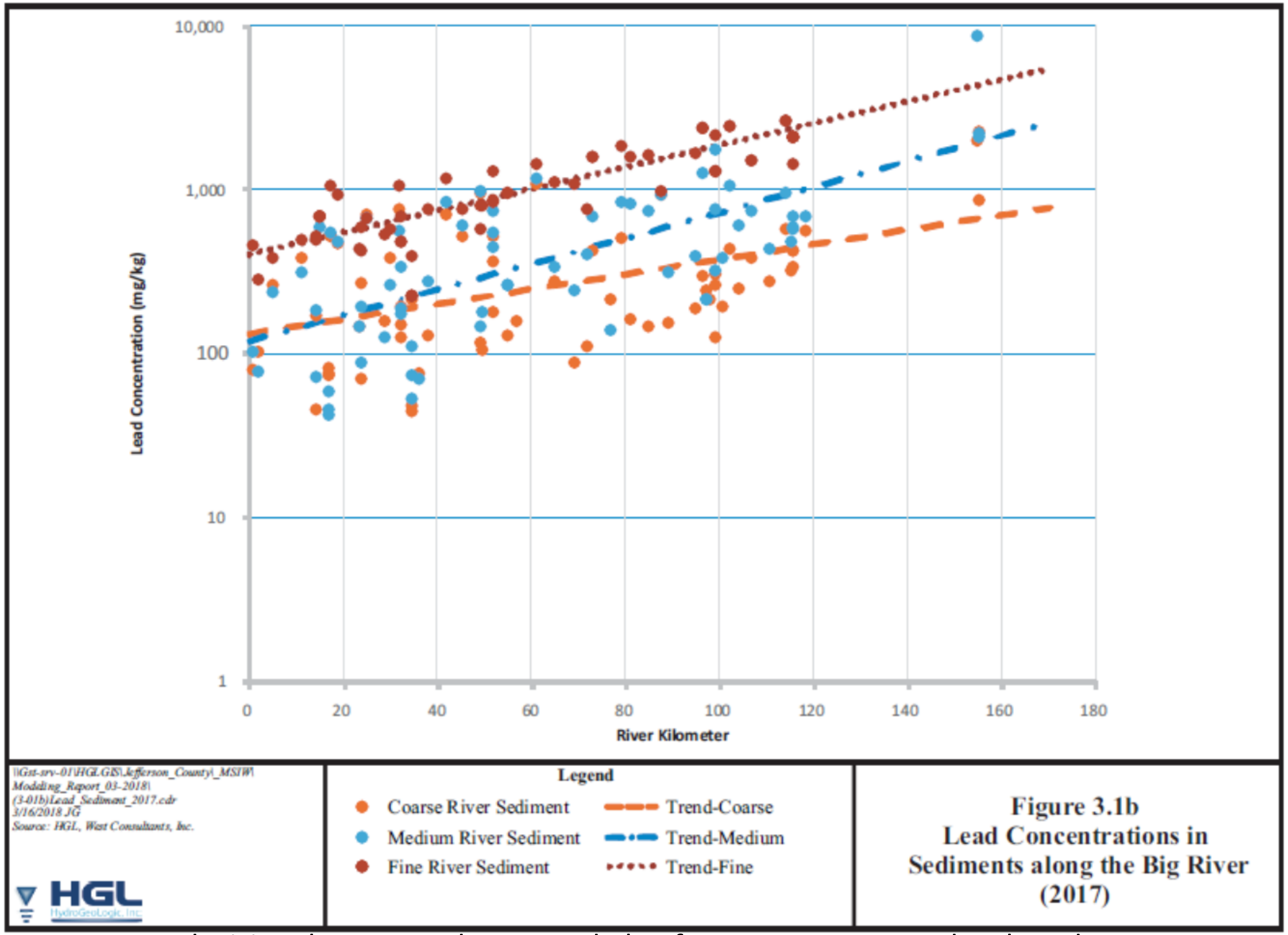
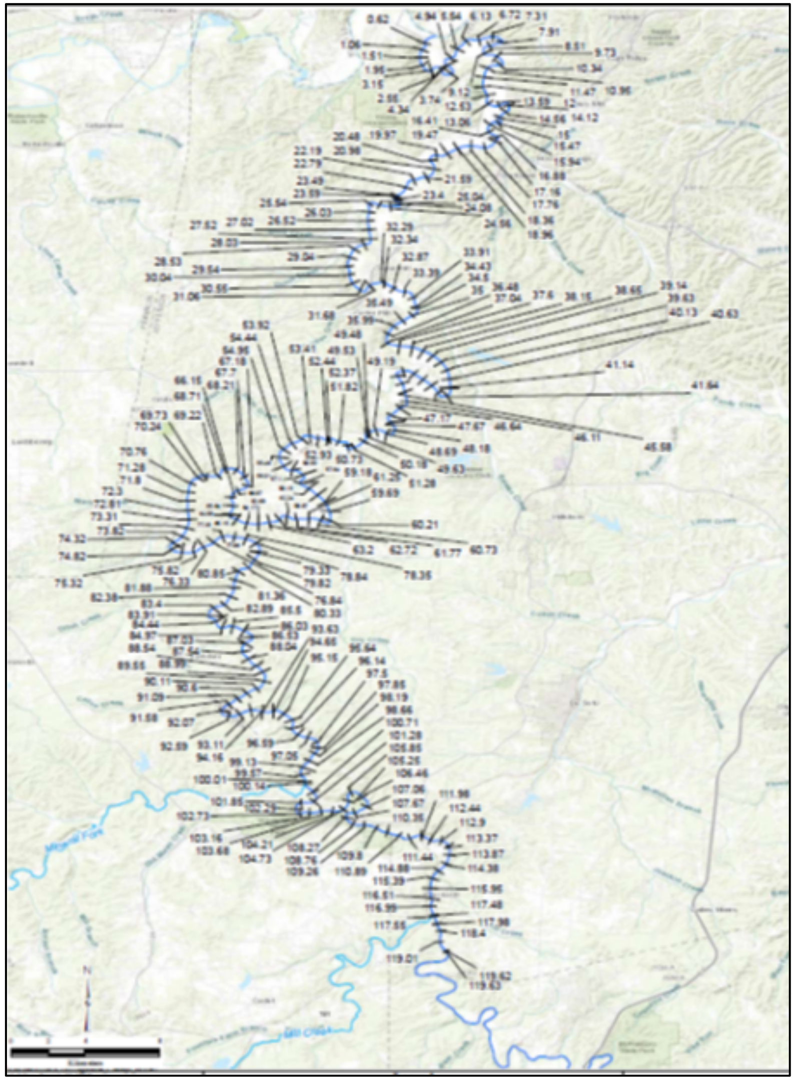


Figure 3.1b
Lead Concentrations in Sediments along the Big River (2017)

Data are pre-decisional – ROD and Proposed Plan for OU4 are not yet developed.

Hydraulic and Sediment Transport Modeling

- HEC-RAS Version 5.0
- Peak flow scenarios ranged from 2-year to 100-year floods
- 83 surveyed transects plus bridges and mill dams
- Interpolated transects improved model resolution – 241 total transects
- Tributary inputs
- Sediment characteristics
- Boundary conditions



Model Results

- Flow depth ranged 12 – 30 ft
- Velocity ranged 2 – 8 ft/sec
  - Decreased downstream
  - Locally, not much difference between high/low flow velocity
- Channel segments mapped to show sediment deposition versus scour/transport

Summary of Average Hydraulic Characteristics for the Lower Big River

Reach	DS RK	US RK	ER	Average Depth (ft)			Average Velocity (ft/s)			Average Bed Shear Stress (lb/ft²)		
				1.2 yr	10 yr	100 yr	1.2 yr	10 yr	100 yr	1.2 yr	10 yr	100 yr
1	0.5	10.24	16.3	18.0	27.1	30.8	3.5	4.0	4.3	0.28	0.32	0.36
2	10.61	16.01	15.9	14.7	21.2	24.5	2.9	3.1	3.6	0.21	0.21	0.27
3	16.46	19.31	15.9	14.1	19.3	22.9	4.1	5.1	5.5	0.42	0.58	0.69
4	20.14	23.33	17.2	14.3	19.6	22.8	2.9	3.5	4.4	0.21	0.27	0.40
5	23.41	31.67	16.9	14.2	19.9	23.3	3.6	4.4	5.1	0.32	0.48	0.59
6	31.78	46.11	11.9	15.0	22.1	26.5	3.7	5.0	5.8	0.32	0.56	0.71
7	46.43	52.74	12.0	12.9	20.4	24.9	3.0	3.1	3.4	0.24	0.21	0.24
8	53.79	59.66	7.7	12.2	17.1	20.9	4.2	5.5	6.3	0.46	0.79	1.06
9	60.19	74.58	6.9	14.3	21.4	26.3	4.1	5.5	6.0	0.42	0.67	0.79
10	75.41	98.99	6.3	14.1	20.7	25.6	4.1	5.1	5.8	0.41	0.58	0.71
11	99.78	110.47	8.6	14.7	21.7	26.5	4.6	6.3	7.0	0.52	0.85	0.97
12	110.55	118.19	5.5	14.4	21.9	27.9	4.0	5.4	6.3	0.40	0.66	0.86
13	118.66	123.19	5.1	14.8	23.0	28.6	4.8	6.7	7.9	0.56	0.93	1.19

Notes:
DS = downstream
ER = entrenchment ratio
ft = feet
ft/s = feet per second
lb/ft² = pounds per square foot
RK = river kilometer
US = upstream
yr = year

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Deposition and Scour Zones

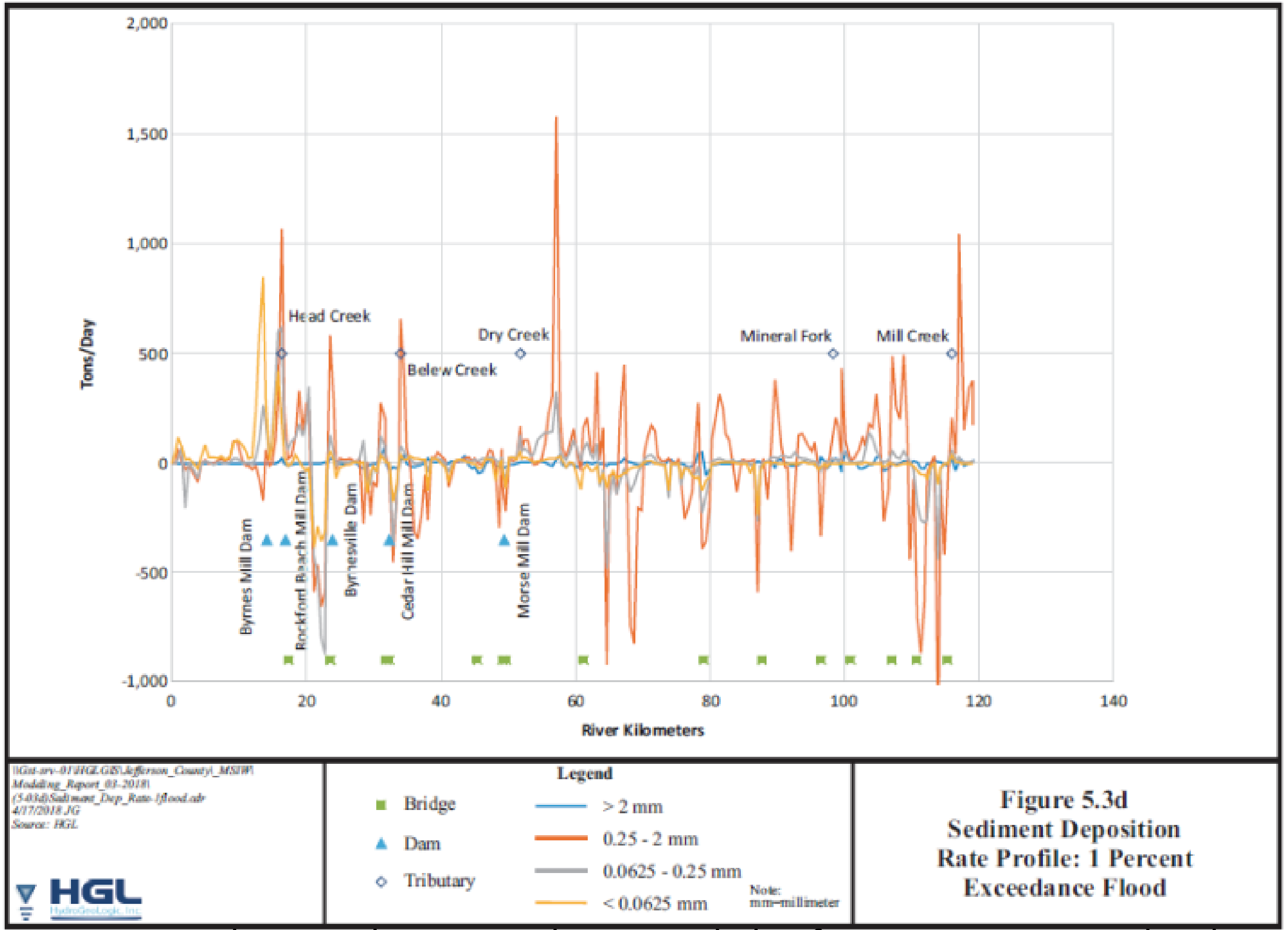

Figure 5.3d
Sediment Deposition Rate Profile: 1 Percent Exceedance Flood

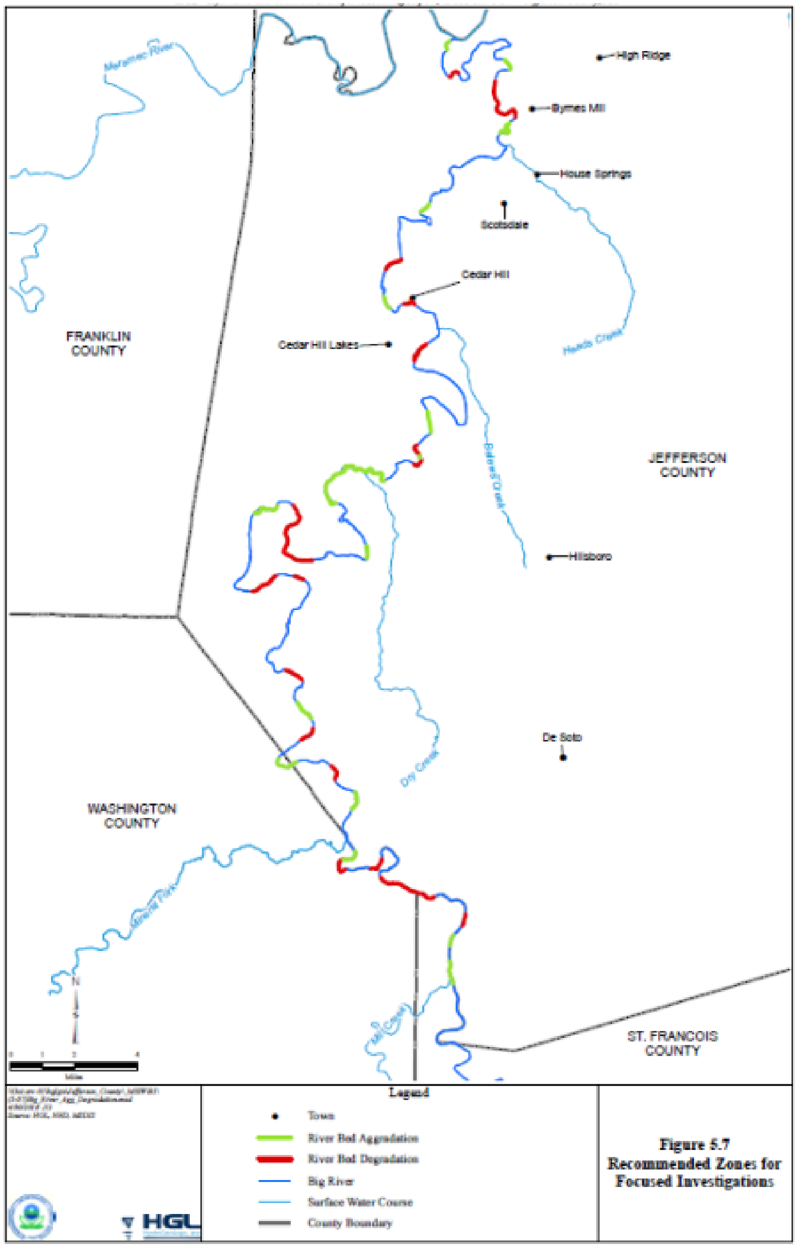

Figure 5.7
Recommended Zones for Focused Investigations

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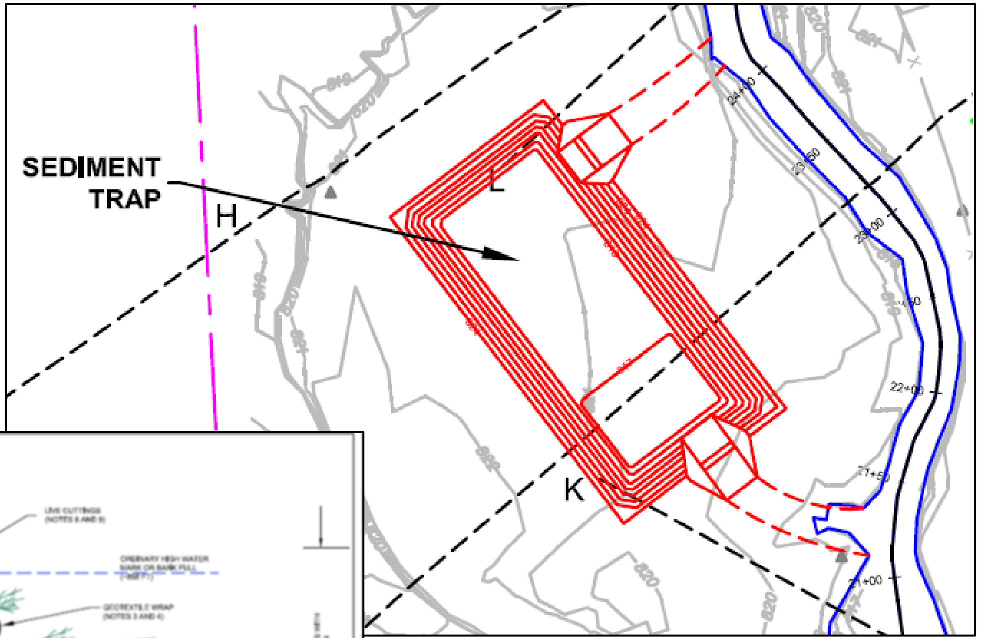
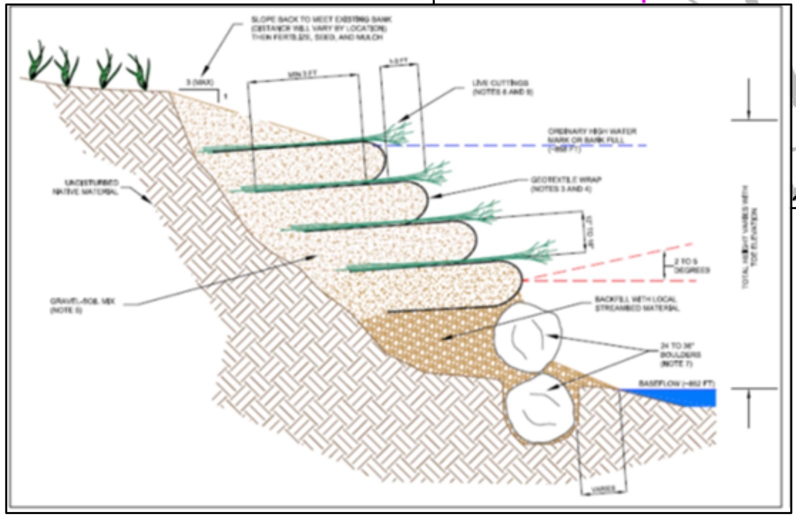
Development of Remedial Alternatives

- Develop mass budgets for sediment and COCs
  - Inputs: upstream sources, bank erosion, tributaries, riverbed sediment storage
  - Outputs: downstream transport, long-term storage/isolation, remedial action removal
- Assess rates of recovery and remedy effectiveness using mass budgets and system dynamics





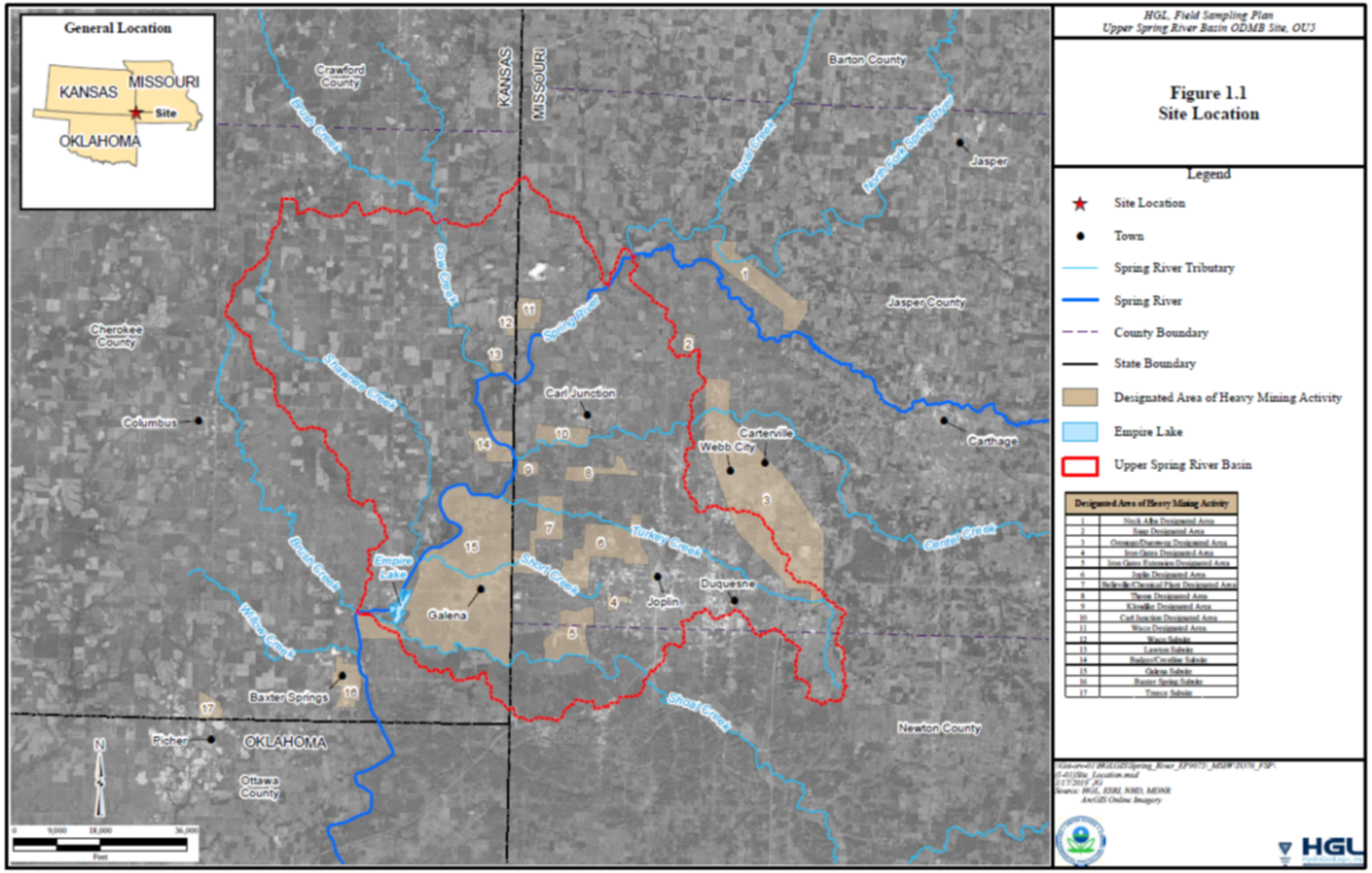
Big River Conclusions

- Differentiate long-term sediment storage from mobile sediment
- Sediment deposition and scour are predicted at the same locations over the range of modeled flows
- Identified 17 deposition zones and 17 scour/transport zones
  - Sediment removal strategies focus on the deposition zones
  - Sediment removal strategies not necessary or effective in transport zones
- Prioritize bank protection where bank erosion could mobilize contaminated floodplain soils

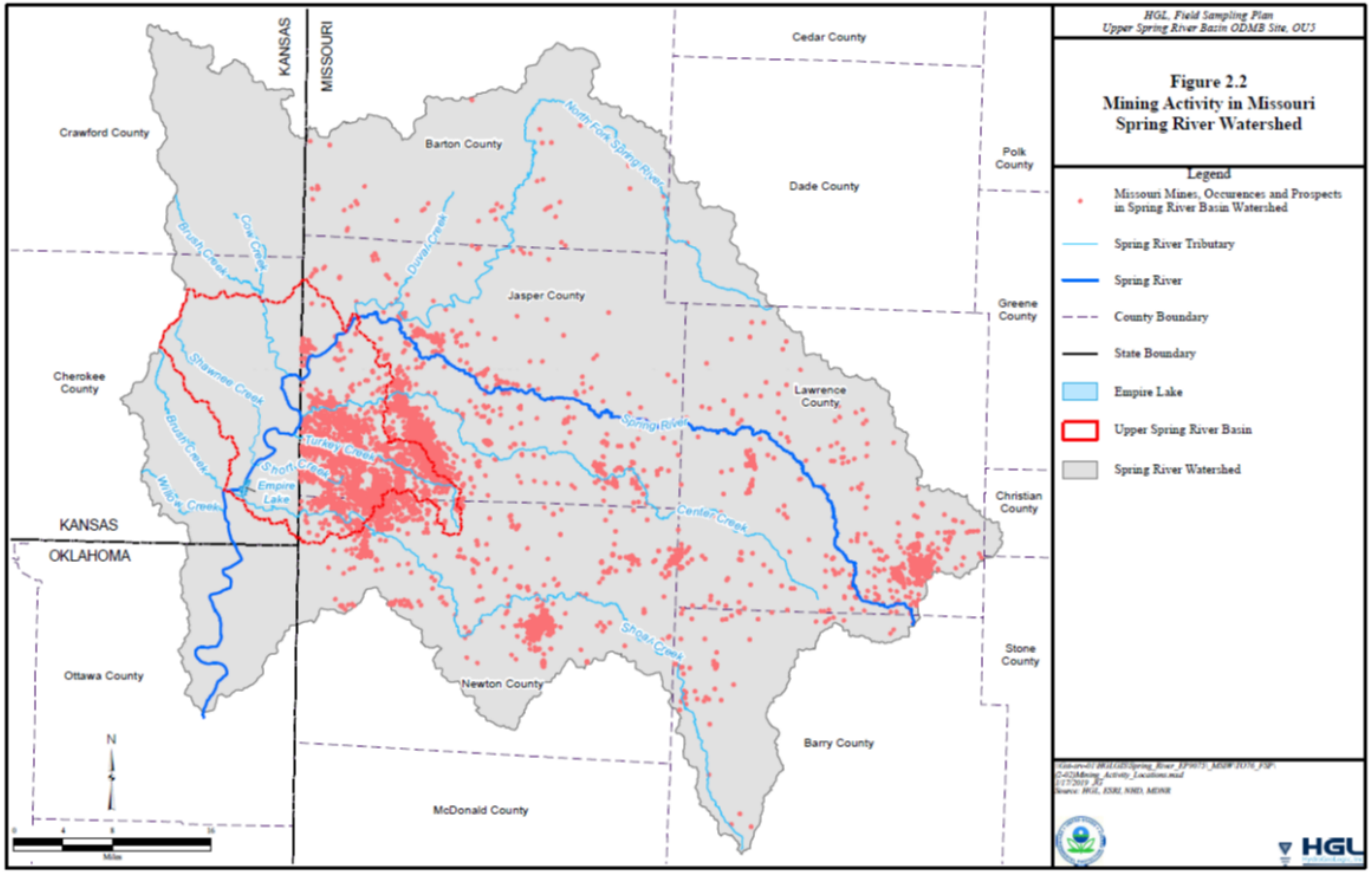
Comparison of Big River and Spring River

- Similar geomorphic processes and COCs
- Contaminated sediments in Spring River are predominantly located within tributaries, which are smaller, more dynamic, and contain more coarse sediment than Big River.
- Primary tributaries are each distinct and separable for remedial planning and design
- Spring River upland source areas are distributed throughout the landscape close to tributary channels – at Big River COC sources were farther upstream

Upper Spring River Basin Site



Historic Mining Activity



Applicability to Spring River Basin

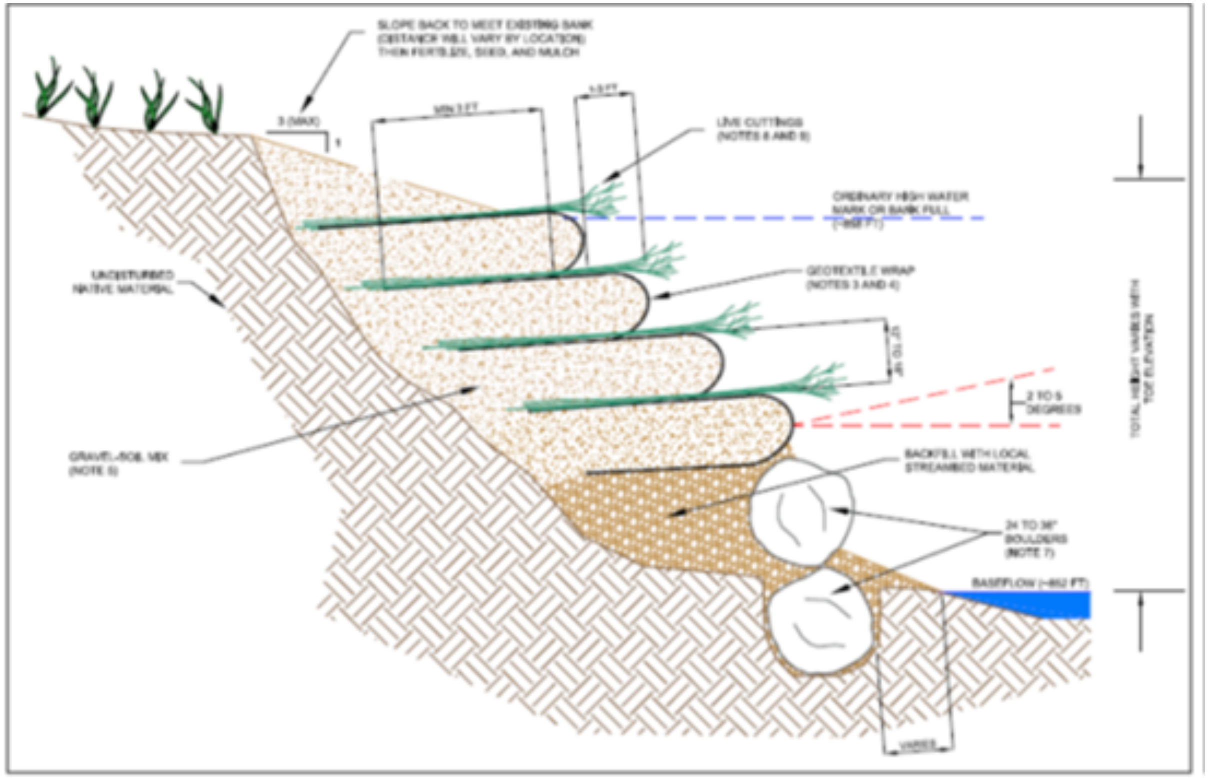
- Refine conceptual site model to interpret COC distribution and predict changes
- Determine specific locations and priorities for components of the remedy
- Evaluate remedy effectiveness
- Assess long-term natural recovery
- Provide essential data for design of in-water remedial technologies

Treatability Testing to Refine Remedial Technologies

- Treatability tests help identify site-specific issues and solutions before full-scale implementation
- Planned, ongoing, and completed treatability tests include:
  - Dredging and material handling
  - Sediment traps (multiple)
  - Wetlands to treat water quality
  - Biochar applications
  - Bank stabilization

Turkey Creek Bank Stabilization Treatability Investigation

- Purpose of Treatability Study: Evaluate soil bioengineering bank stabilization as a remedial technology
  - Determine feasibility and effectiveness
  - Identify challenges and solutions
  - Evaluate cost-effectiveness compared to other approaches

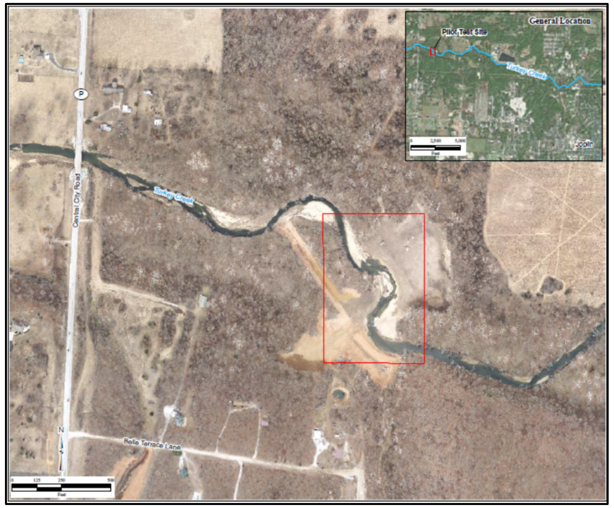


Bank Stabilization Treatability Investigation

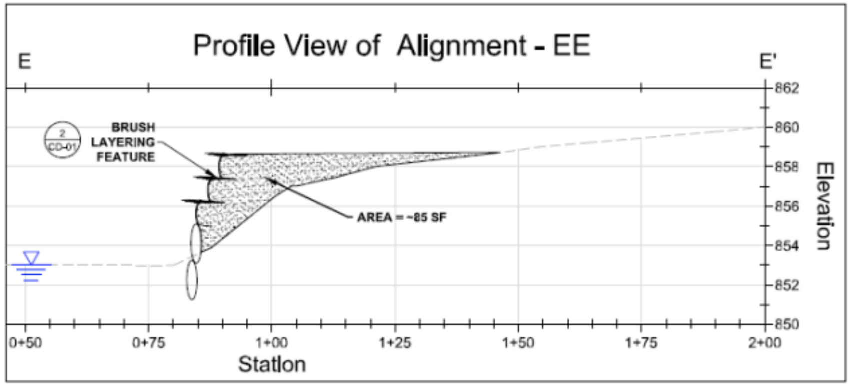
- EPA remediated mine waste on the floodplain
- Turkey Creek is dynamic
  - Meandering riffle-pool channel morphology
  - Frequent overbank flooding
  - High volume gravel bedload sediment transport
- Bank erosion mobilizes and spreads contaminated soil

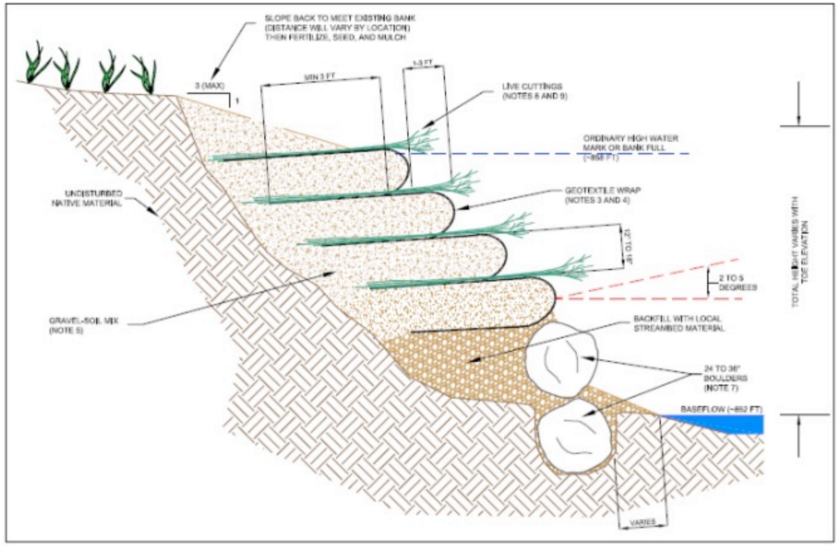
Treatability Investigation Strategy and Approach

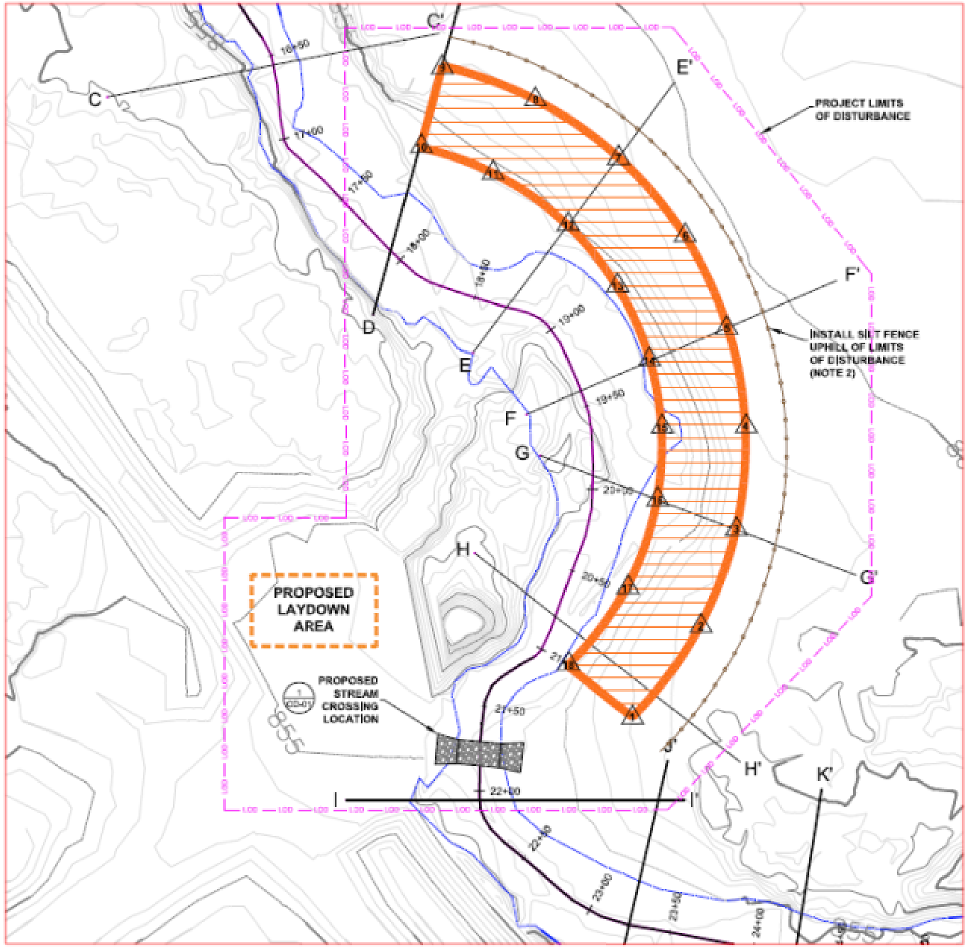
- Identify extent of channel instability adjacent to soil contamination
- Design and install bank stabilization measures using rock toe protection and live branch layering
- Monitor plant establishment, bank stability, channel change, and changes in sediment chemistry
- Use adaptive management to manage change



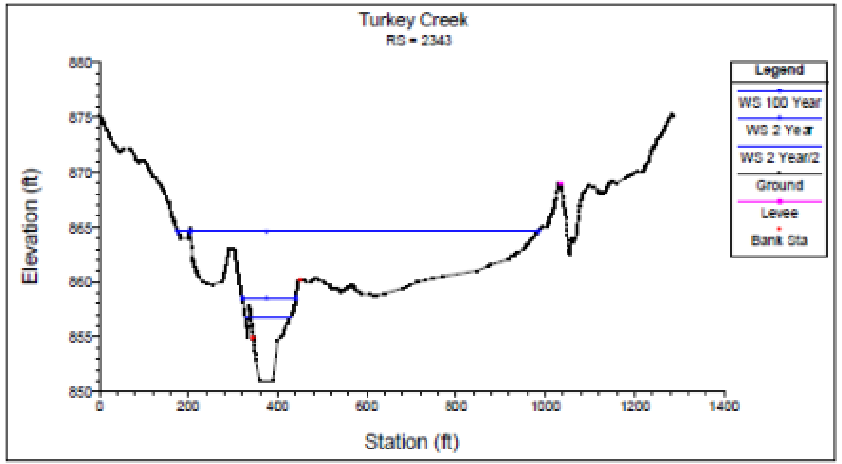
Design Components

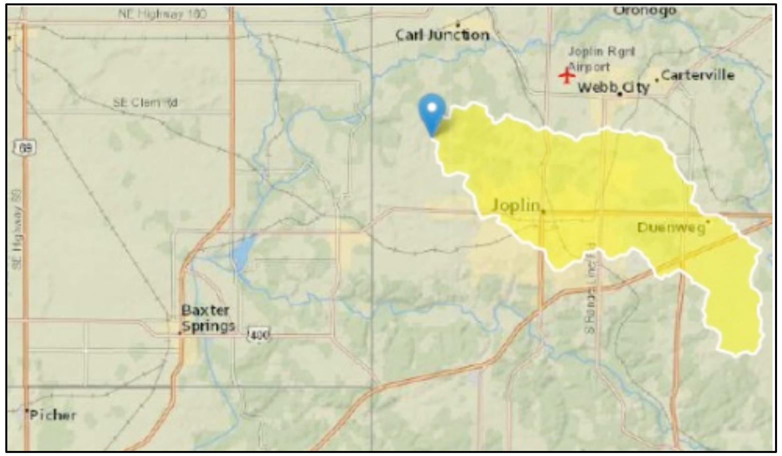


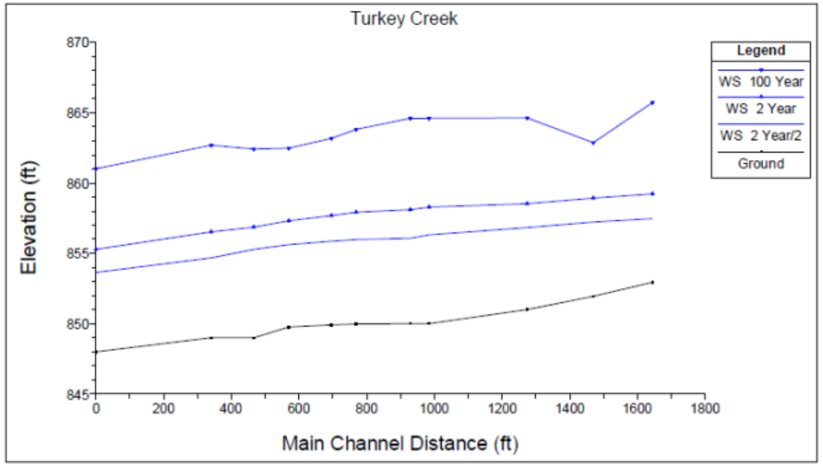




Hydrologic and Hydraulic Analysis







Basin Area: 41.3 sq. mi.

2-year peak flood: 2,830 cfs

10-year peak flood: 6,230 cfs

100-year peak flood: 12,100 cfs

Construction Phase

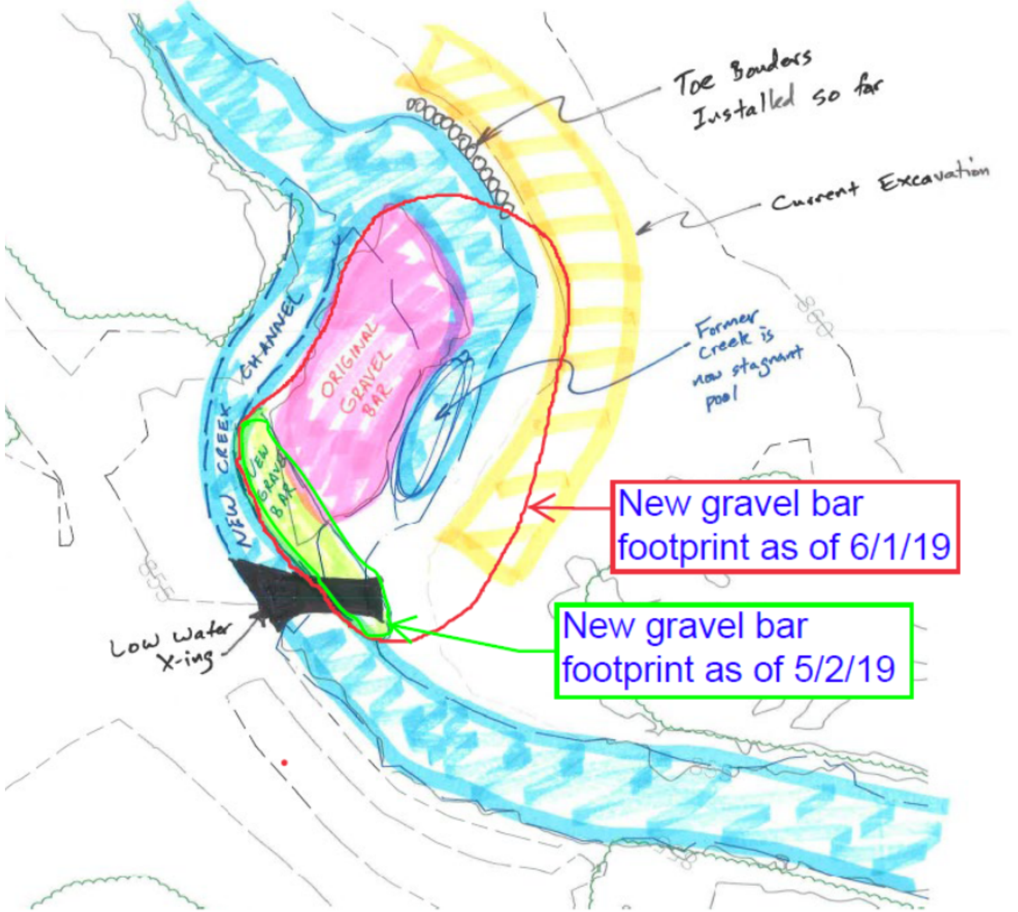
- Large boulders stabilize the toe of the streambank and extend below grade
- Live branch layering is built in soil lifts wrapped in a coir fabric geotextile
- Soil was prepared on site by blending organic soil with stream gravel

Issues and Solutions

- ISSUE: Seasonal dependence of the work
  - Live branch material should be harvested when dormant (late autumn through early spring)
  - Plant survival is impacted by long storage, dry conditions, and hot weather
  - Peak rainfall and flood events occur April – September
- SOLUTIONS
  - Allow for many wet weather delays
  - Plan for plant replacement to mitigate mortality
  - Stabilize the work area prior to wet weather events
  - Alter the design so that plant installation does not have to happen at the same time as earthwork

Issues and Solutions

- ISSUE: Dynamic channel change
- SOLUTION:
  - Apply adaptive management approach
  - Develop a design that anticipates and accounts for channel change
  - Plan for change with contingencies
  - Evaluate whether to modify the channel or adjust the design



Concluding Remarks

- Watershed sciences and adaptive management support a strategic, cost-effective approach to remediating contaminated watersheds.
- Hydrology, hydraulics, sediment transport, and geomorphology provide essential context for analysis and remediation of watersheds impaired by contaminated soils, sediments, surface water, and groundwater.

Concluding Remarks

- Natural processes may be integrated into remedial actions beyond the passive approach of natural recovery.
- Watershed approach adapts well to diverse settings and situations where contaminants are widespread throughout a drainage network
- Treatability investigations support development and implementation of innovative remedial technologies

Acknowledgements

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