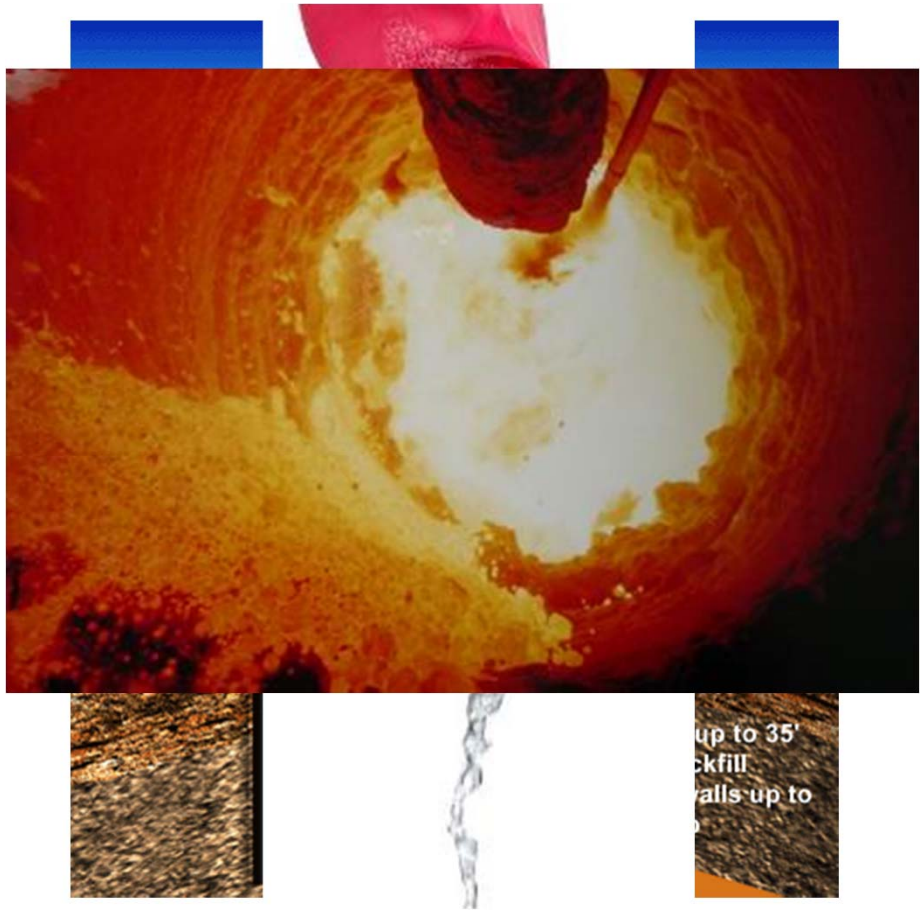
Analysis of Predicted Coal Tar Fluid Volume, Goals, and Disposal Options Optimize Project Success



NorthWestern Energy

ARCADIS
Infrastructure, environment, buildings

Safety Moment

NorthWestern Energy

Former Manufactured Gas Plant Site

Aberdeen, South Dakota

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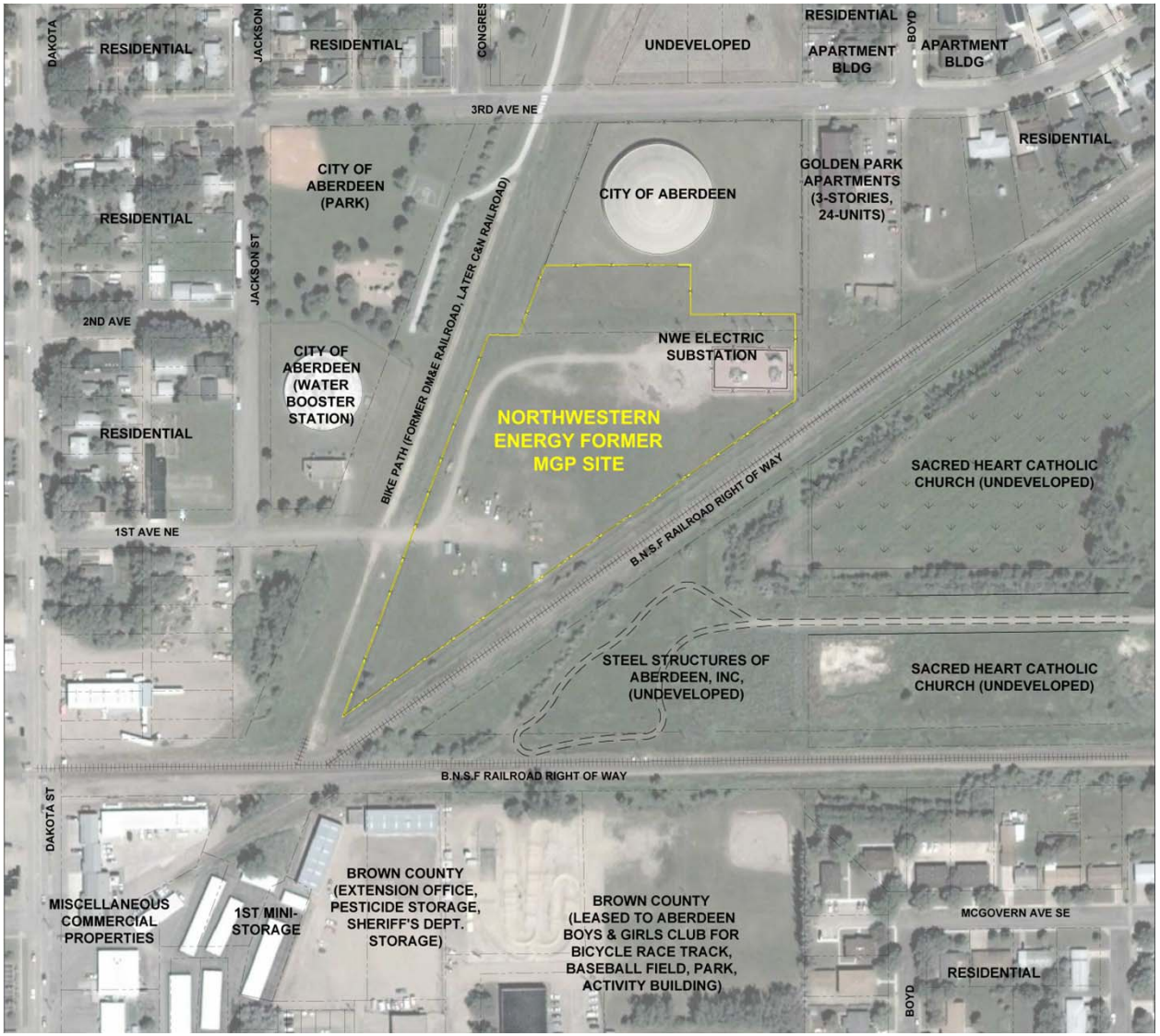
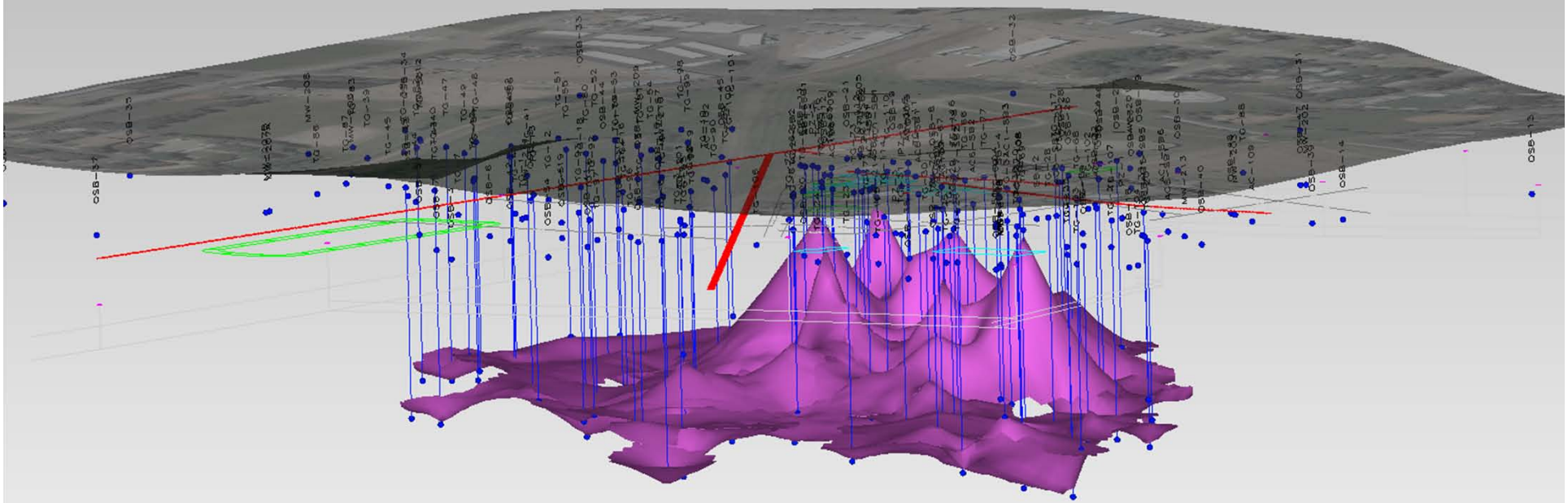
Location, Size, and Configuration of Site have Important Implications for Remedial Implementation

- Proximity to Community Emphasizes Significance of Off Gas Emissions, Traffic, Noise, and Most Importantly Safety



Extrapolated Subsurface Data Provide Insight as to Configuration of Coal Tar Fluid Body



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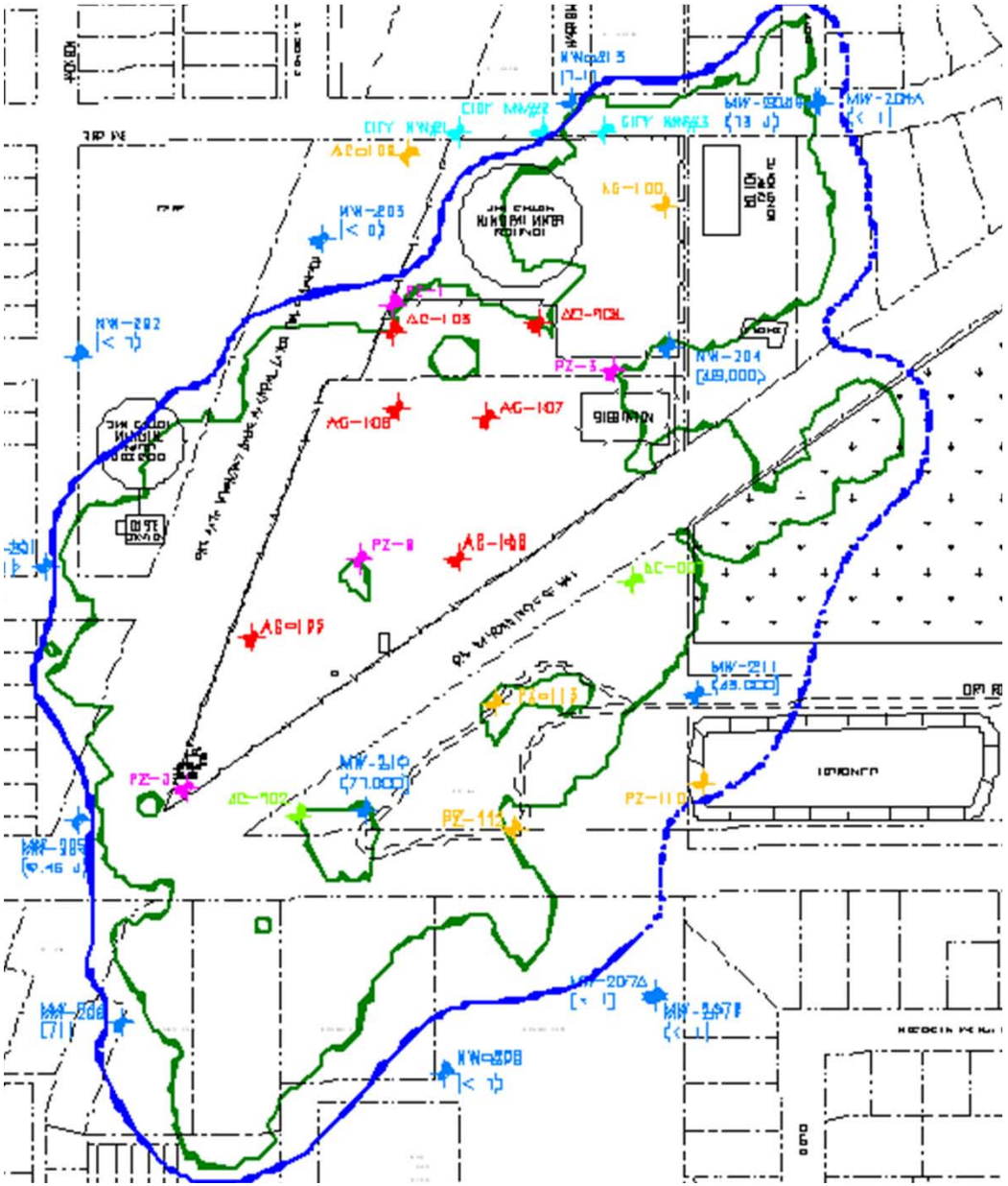
Collectively These Investigations Identified and Delineated the Coal Tar Distribution



Coal tar is pervasively distributed across Site, present at several off-site locations, and under numerous permanent obstructions

Extent of contaminated groundwater limited by distribution of coal tar

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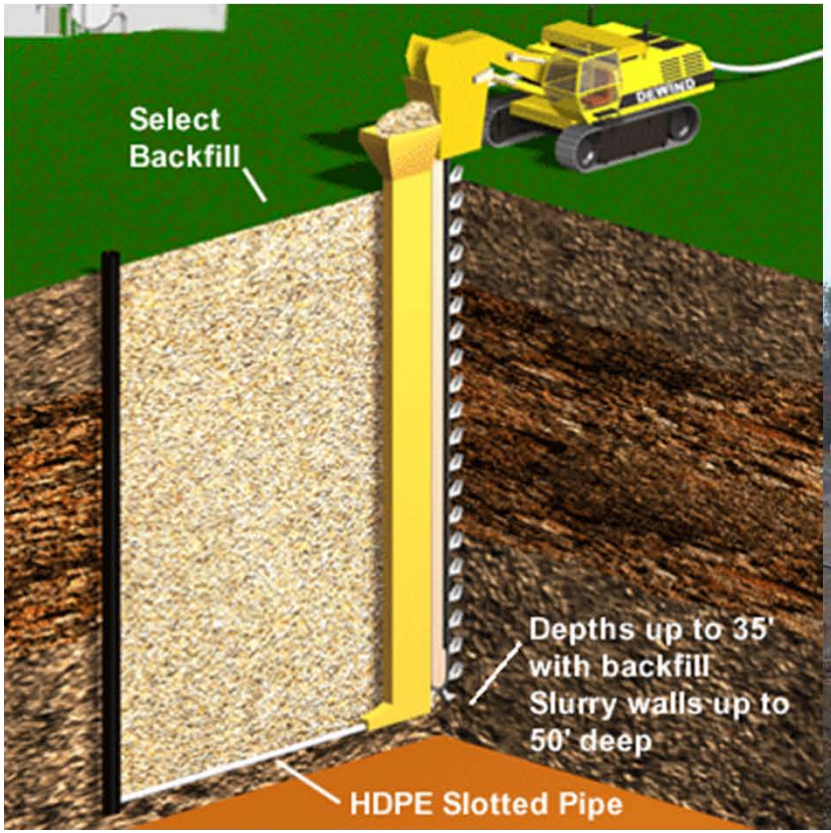
Collection Galleries will be Installed using Specialized, Industry Standard Equipment

Full implementation of approach includes over 9,000 tons of soil to be excavated and disposed in local landfill



Off Gas Emissions from Excavated Sediment will be Suppressed by Foams and Other Physical Barriers

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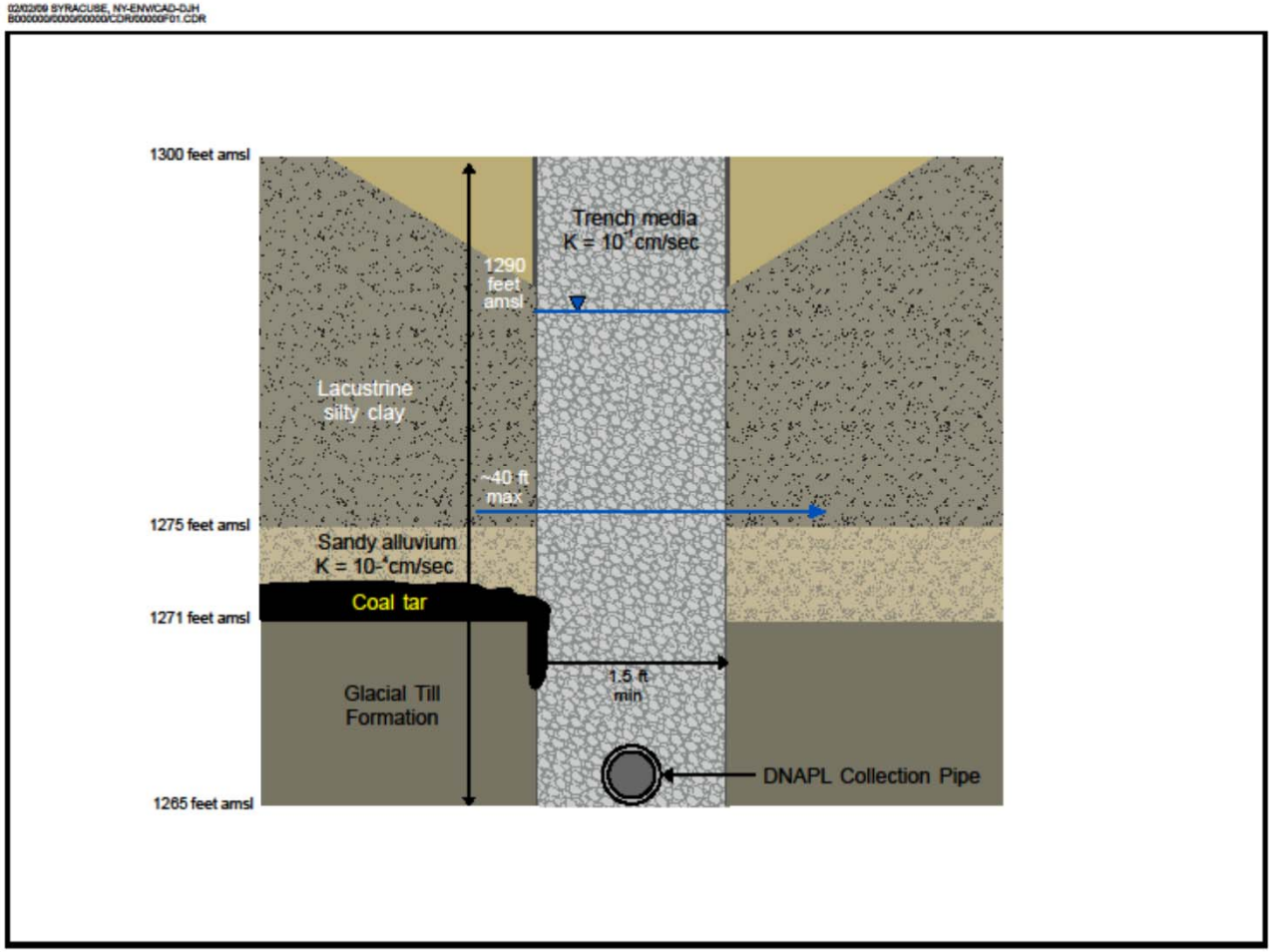
Collection Galleries will Form the Key Component of the Planned Remedial Action

- **Coal Tar will flow by gravity to the trench**
- **Coal tar will pool within the basal collection pipe and flow to a sump**
- **At the sump it will be pumped to the surface for potential beneficial reuse**



Sequential Installation is Optimal

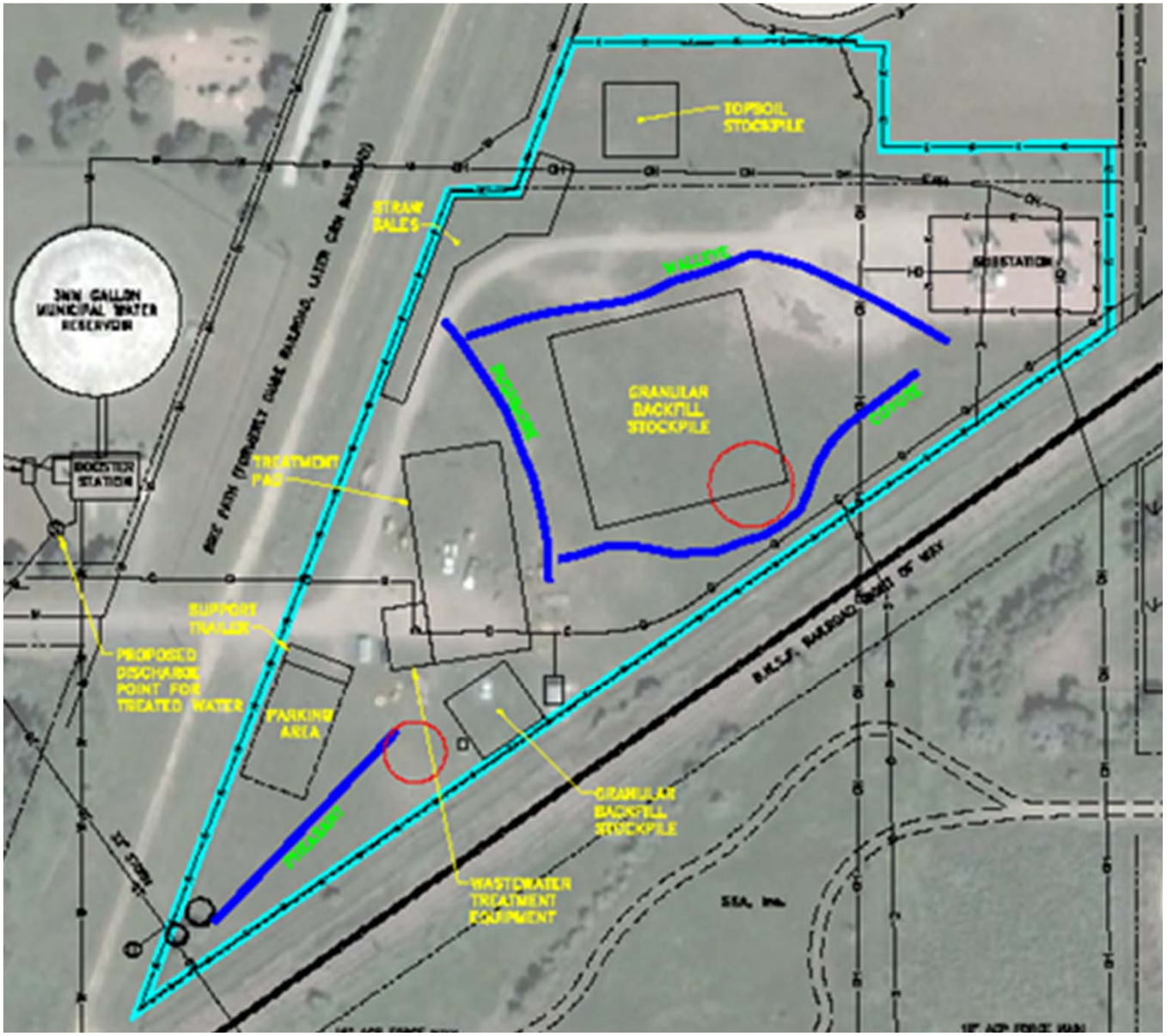
2011 – MGP Site

2013 – Adjacent Properties and More "Remote" Properties

Fully understand performance over time during sustained operation

Time for access agreements

Document safe operation to 3rd parties



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Installation and Operational Approaches Would Aid Future Optimizations

2011 – ~30% Installation of targeted collection galleries (Phase 1)

2012 – a) Design, construction and installation of coal tar fluid handling infrastructure for Phase 1 galleries
b) 1 full year of sustained coal tar fluid collection
c) Aids in evaluating and understanding coal tar fluids collection process
d) Allows subsequent gallery design to benefit from operational information

2013 – Installation of remaining (70%) targeted collection galleries (Phase 2)
Continued operation of Phase 1 galleries

2014 – Design, construction and installation of coal tar fluid handling infrastructure for Phase 2 galleries
Continued operation of Phase 1 and 2 galleries

2015 and beyond – Continued operation per cessation criteria evaluation

Wringing Out a Damp Sponge is an Appropriate Analogy for Determining Success

Sponge is still wet, but residual water is no longer released

Coal tar fluid will still be present but is no longer mobile

Cessation of flow of coal tar fluid into an open trench is a direct measure of success and the resulting immobility of residual coal tar fluid

Cessation of flow requires criteria to support shutdown of galleries

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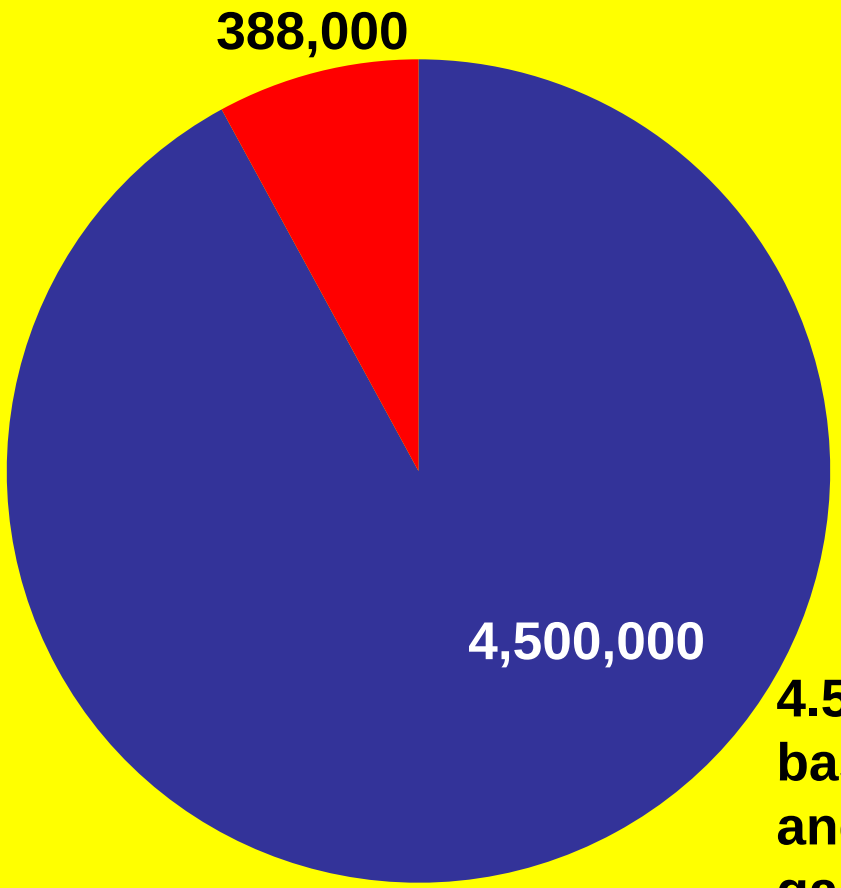
Absolute Volume of Collected Coal Tar Fluid is not Necessarily the Critical Success Factor

Estimated Values (in Gallons)



- **Total Coal Tar Fluids**
- **Collected Coal Tar Fluids**

4.5 Million gallon estimate is based on projected volumetrics and is consistent with historic gas production

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Spreadsheet-Based Modeling Provides Insights as to Collectable Coal Tar Volume

Basic Assumption: 2,700 Linear Feet of Collection Gallery

Modeled Inputs Related to: (Base Case Inputs)

1) Thickness of Saturated Coal Tar Body (2 Feet)
2) Sediment Porosity (30%)
3) Degree of Saturation of the Coal Tar Fluids (100%)
4) Degree of Release of the Coal Tar Fluids (80%)
5) Distance of Lateral Migration of Coal Tar Fluids into the Collection Gallery (20 Feet on both sides of the gallery)

Inputs Strived to Represent "Reasonable" Near-Maximum Values

388,000 Gallons of Coal Tar Fluids in Base Case Model

Consideration of Potential Cessation Criteria Should be Proactively Developed

Allows for full consideration of implications of potential criteria

Provides for agreement developed now that is not subject to the "heat of the moment" in outlying years during operation

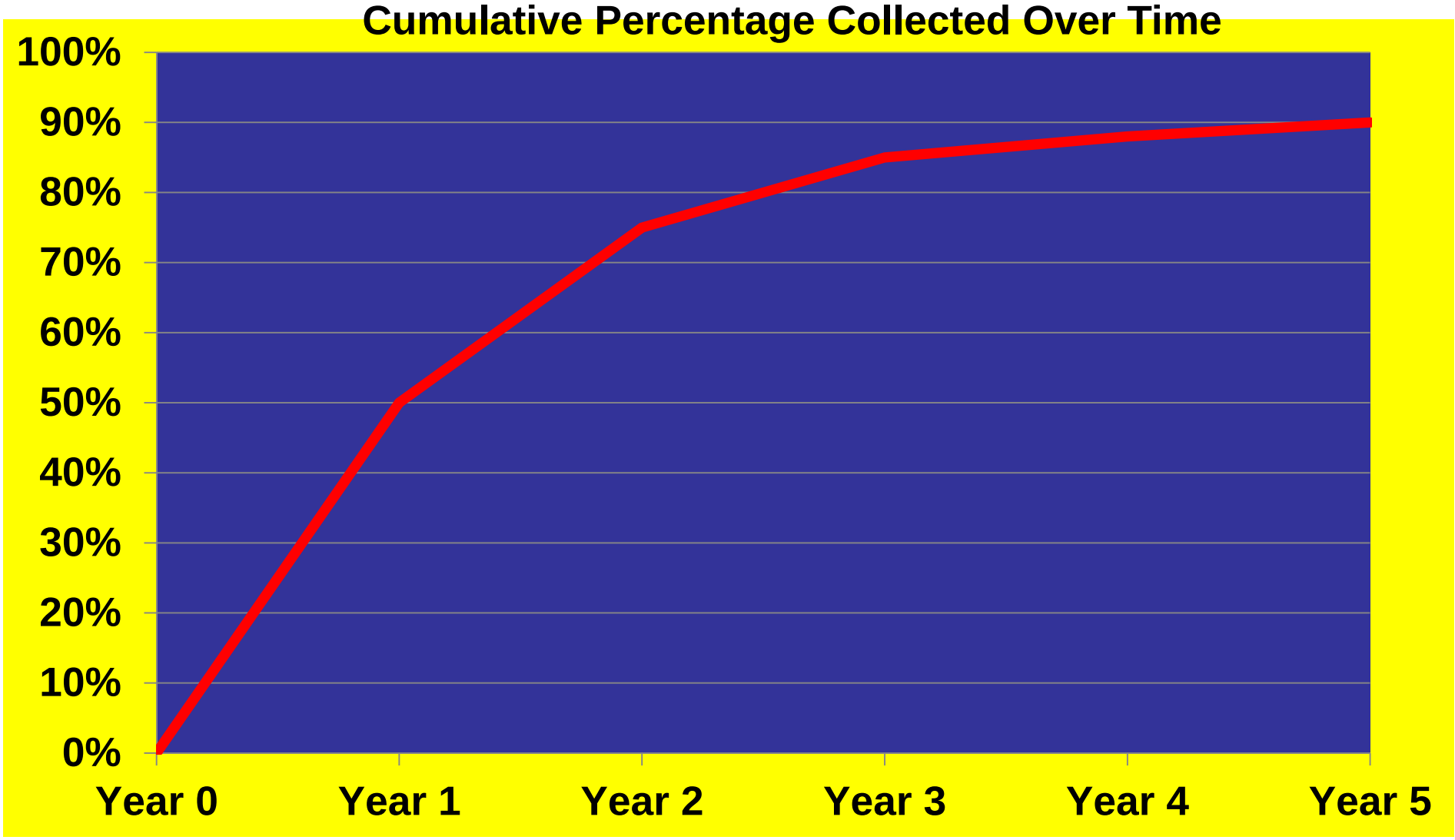
Provides quantified metrics as measures of success

Aids "future" parties in understanding "original intent"

Facilitates planning for cessation of operations

Conceptual cessation criteria need to cover a range of outcomes

A Criterion is Needed to Address Asymptotic Curve Approaching the Targeted Volume



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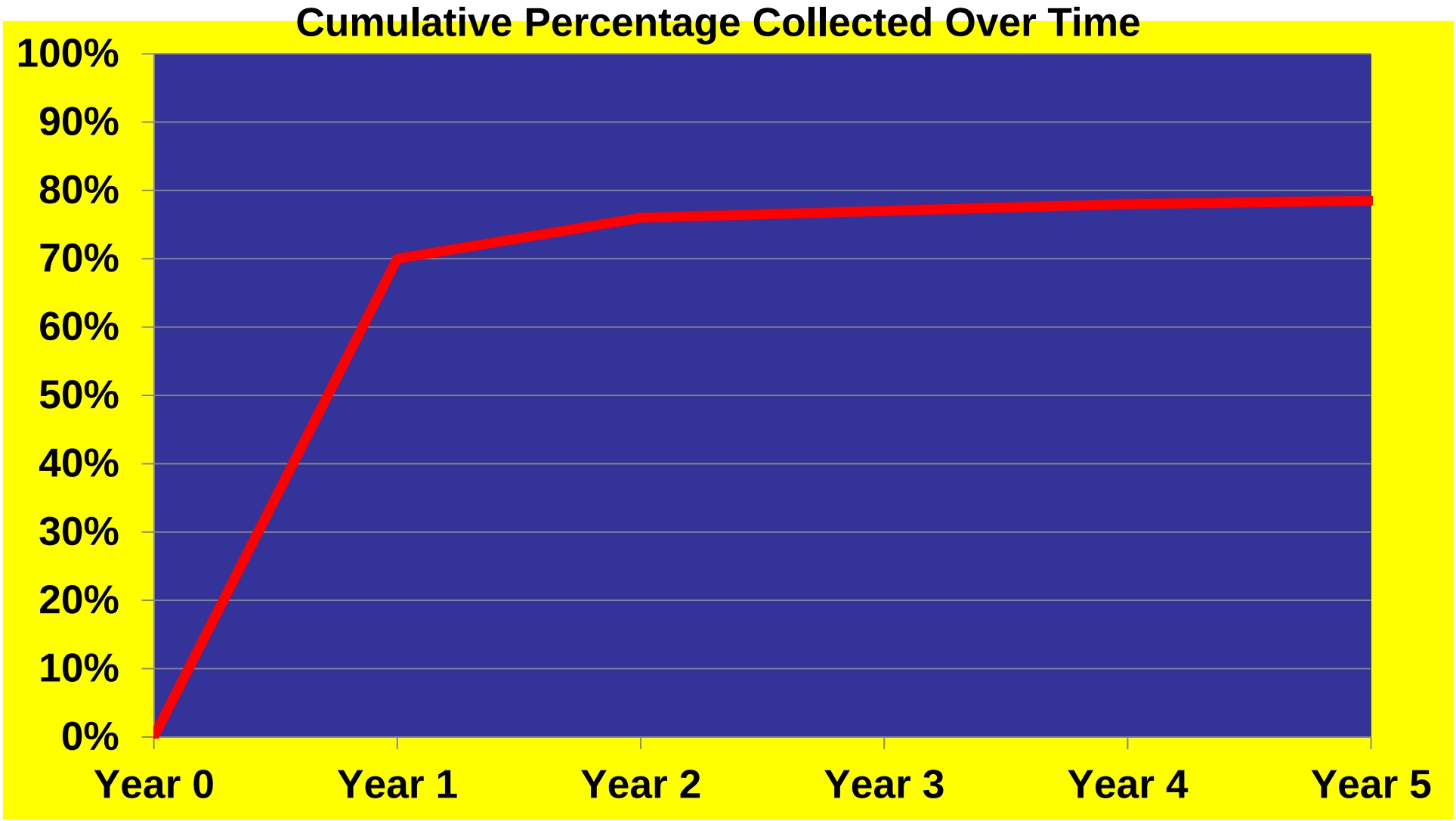
A Criterion is Also Needed for Rapid and Material Decline in Collection Rate



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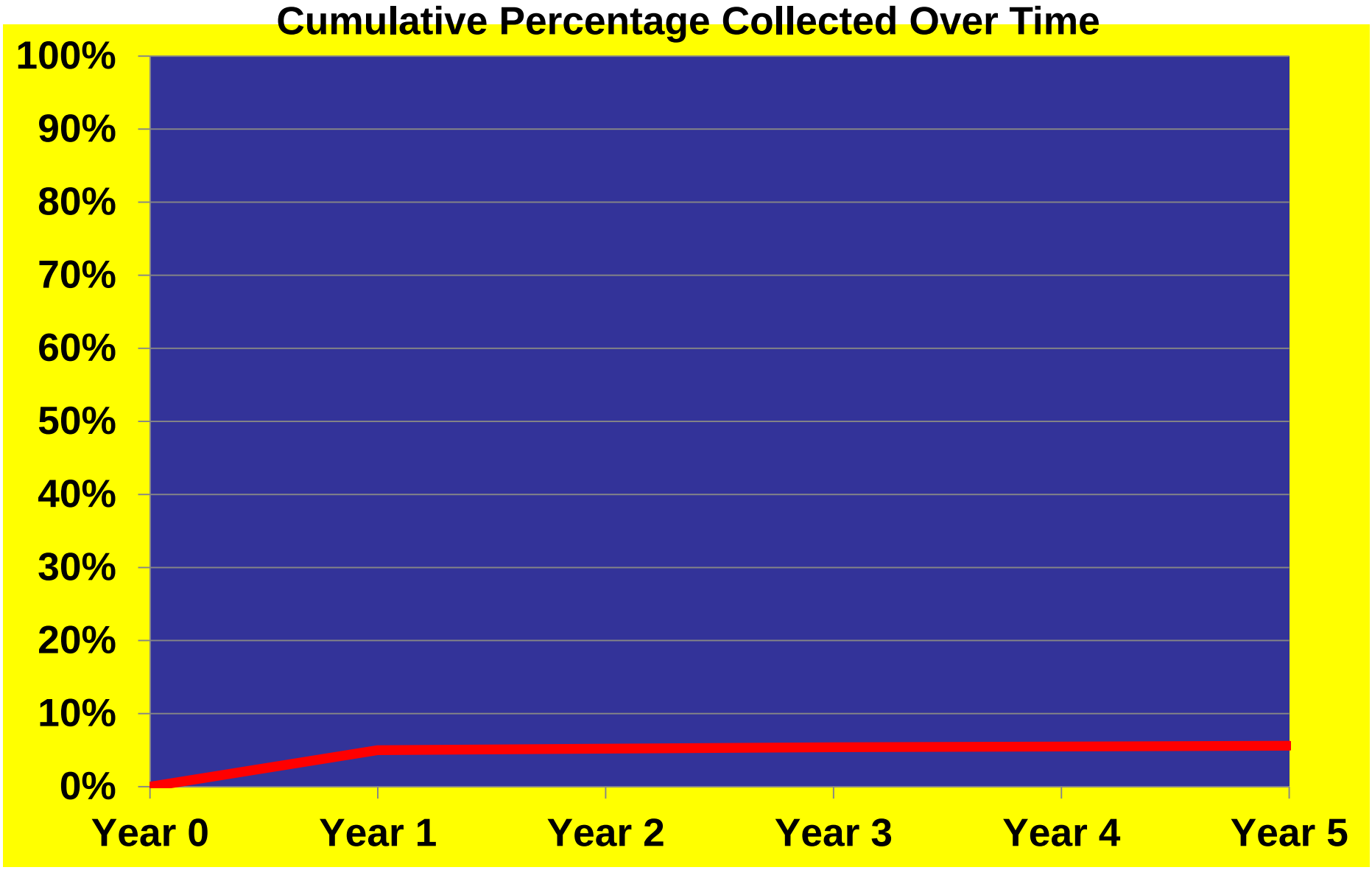
A “Zero” Collection Rate Criterion is Needed



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All Potential Cessation Criteria Eventually Display a “Near Zero” Rate of Collection

Limited or no incremental risk from residual coal tar fluids

Arguably greater risk is incurred through continued operation without commensurate degree of coal tar fluid collection

Significant Operation & Maintenance (O&M)-related cost savings

Galleries would be operated as long as a “materially significant” rate of coal tar fluid is being collected

Need to consider quantification of “materially significant”

Cessation Criteria will be used to Evaluate "Success" of Trial Collection Galleries

Believe collection galleries will "work" – gravity induced fluid flow into porous media-filled trench

Trial galleries constructed in areas documented to have significant mobile coal tar – "center" of the coal tar body on the NorthWestern Energy property – consists of several discrete galleries closely positioned together

Volume of coal tar fluids judged relative to "cessation" criteria

"Success" allows full program to be implemented

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Beneficial Use Appears to the Optimal Choice for Final Disposition of Coal Tar Fluids

Beneficial use as secondary fuel source

Use of industry standard solidification reagents was unsuccessful

Presence of water-containing “emulsion” needs to be addressed

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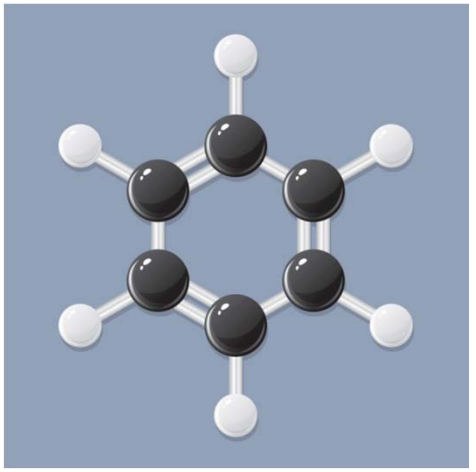
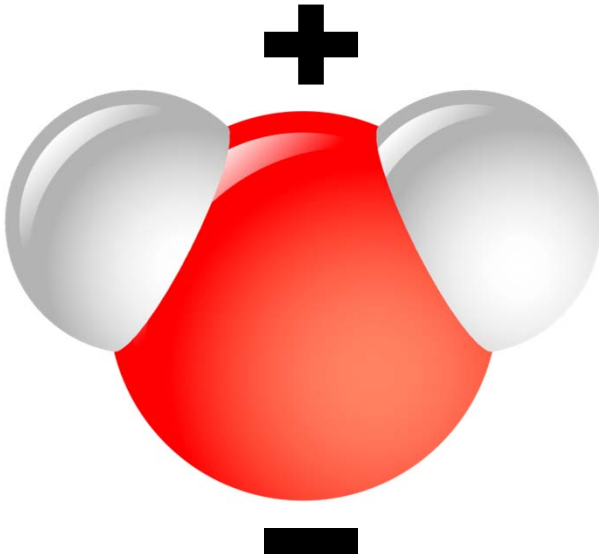
Problem Arises Due to the Fact that Coal Tar and Water Have Limited Mutual Miscibility

High School Chemistry – "Like Dissolves Like"



Organic solvents (non-polar) dissolve other organics (non-polar)

Water (polar) dissolves inorganics (polar)



Coal Tar (organics) and water will not dissolve together

But also won't separate – problem noted in 1914 MGP conference proceedings

Probably why it was originally not sold or reused

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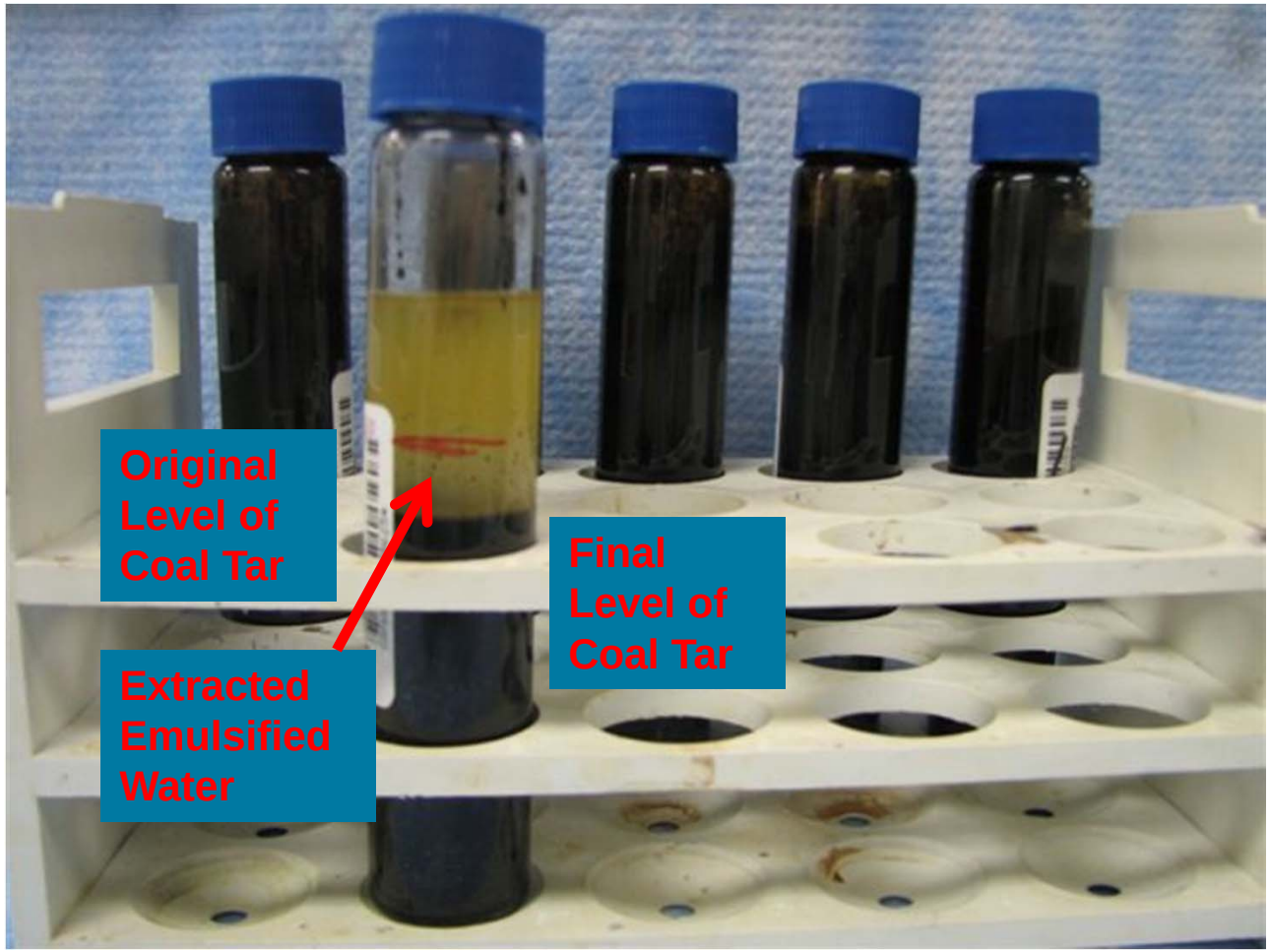
Specialized Reagent has been Shown to Break the Coal Tar-Water Emulsion

Specialized reagent apparently breaks emulsion allowing phase separation

~ 92% of initial water removed by as discrete phase

Critical increment of water removed allowing for beneficial fuel reuse

Does not otherwise adversely impact acceptability of fluid



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Conceptual Use of Specialized Reagent May Be Quite Simple

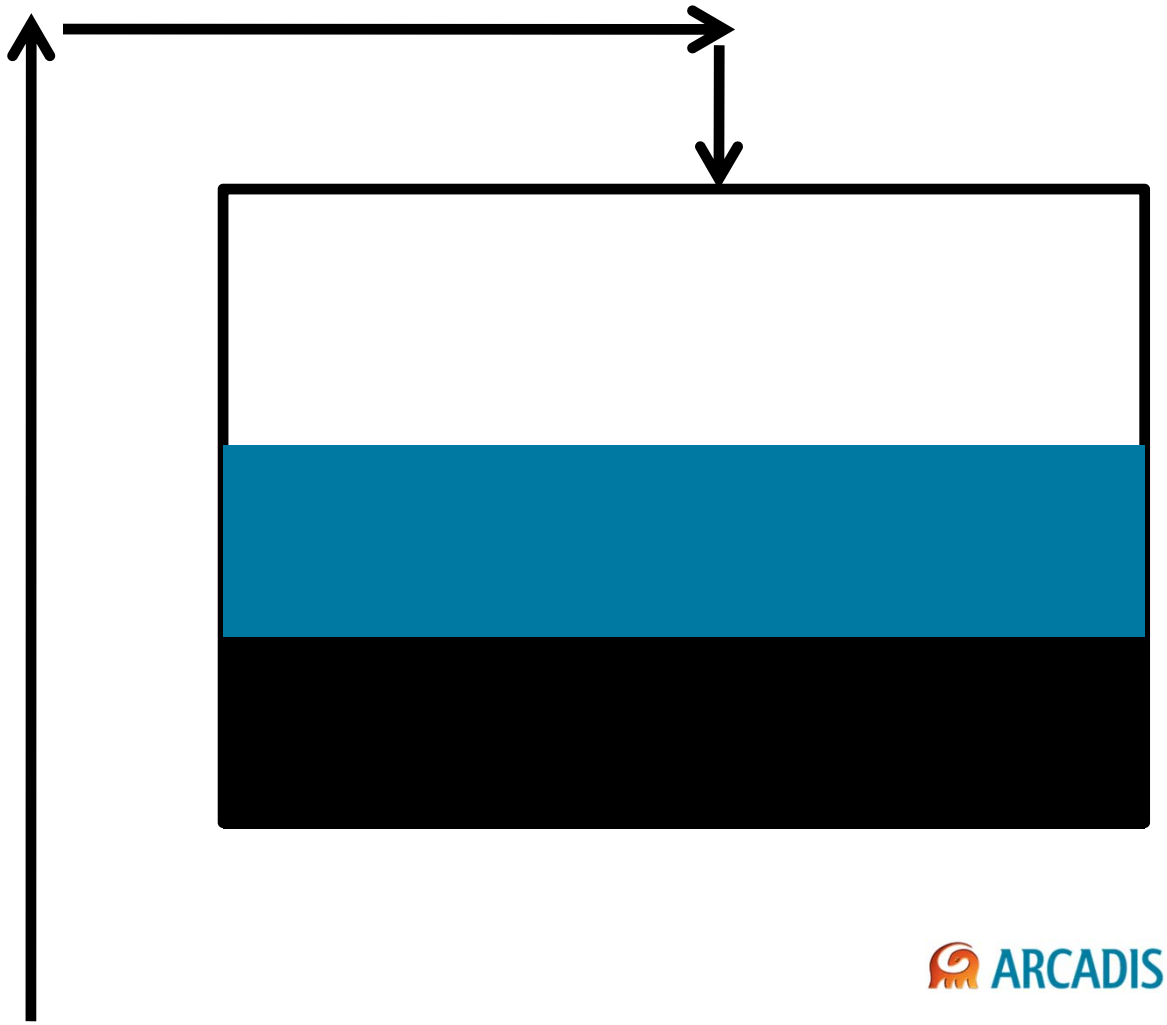
Add specialized reagent

Add coal tar fluid

Allow for density mediated mixing

Allow for spontaneous "unmixing"

Tap off discrete phases



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A Video of the Reagent Treatability Work Further Demonstrates this Process

A Distillation Apparatus is being used to Accurately Determine Water/Volatile Content

1) Coal tar heated to 105º C

2) Gasses directed to condensation column

3) Cold water chills condensation column condensing gases

4) Condensed fluid flows downward into burette

5) Requires heat tape and insulation

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Distillate Apparently Consists of an Aqueous and an Organic Phase

Distillation

- **documents both water and organic volatiles driven off at 105º C (221º F) temperature**

And subsequently

- **recondensed at 10º C (50º F)**

Conforms to

- **projected behavior of benzene**

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Alternatives are also Available to Address Low BTU Content of Coal Tar Fluid

Addition of diesel fuel to coal tar fluid

Paying for additional cost of reuse or disposal

Cost benefit analysis

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Imagine the result