Technology Innovation for Reducing Environmental Liability & Business Risk

High Resolution Site Characterization (HRSC) and 3-Dimensional Data Visualization – A Path to Streamlined Closure

Antea®Group

Understanding today.
Improving tomorrow.

INOGEN®

us.anteagroup.com

Presented By:

Intelligent Design - Leveraging technology investments for lifecycle risk reductions

Joshua Orris
Consultant, Antea Group
Joshua.Orris@anteagroup.com
+ 1 717 712 5456

Jason Ruf
S2C2
Jason.Ruf@s2c2inc.com
+ 1 908 256 2710

INOGEN®

Understanding today.
Improving tomorrow.

Business Challenge

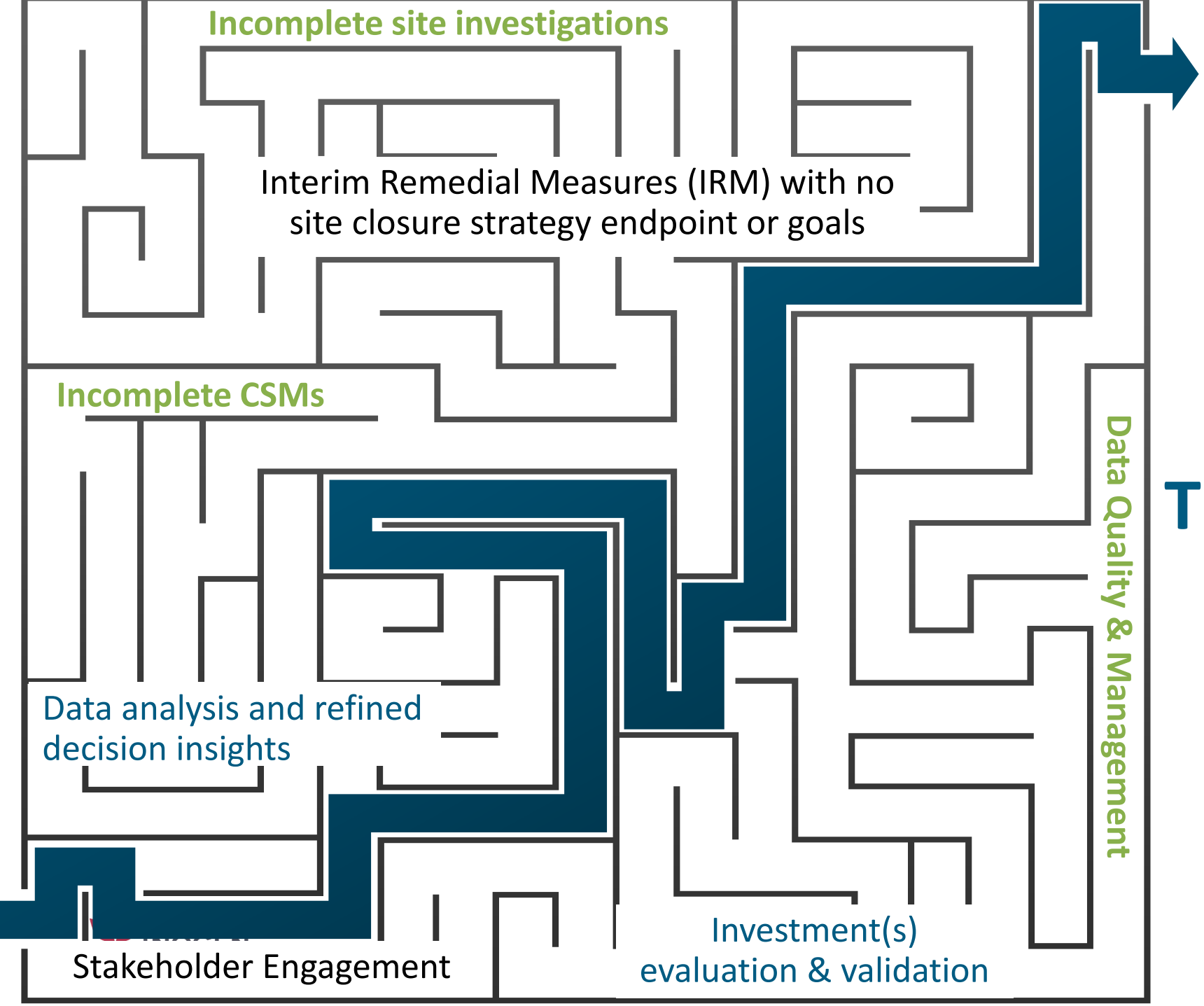
Client Site Summary

- Projected 30+ year lifecycle
- Interim Remedial Measure (IRM); Pump & Treat for hydraulic control
- Incomplete site investigation and source area characterization
- Complex geo/hydro systems
- Complex biochemical systems

Business Solution

- Leveraging technology for complete site models to streamline site closure strategies, leading to better business decisions
- Data visualization is a solution to bridge the abstract science for refined engineering design and enhanced data analytics for continuous quality performance

Understanding today.
Improving tomorrow.



The Challenge(s)

Understanding today.
Improving tomorrow.

Challenges to Enhance Better Business Decisions

Technical Management Challenges	Site-Specific Challenges
Complex data sets over several years	Incomplete site investigations
Complex environmental systems	Interim Remedial Measures (IRM) with no site closure strategy endpoint or goals
Varied site investigation methods	Incomplete Conceptual Site Models (CSMs)
Performance inconsistency	Wetlands, overburden/fractured bedrock groundwater system
Stakeholder engagement	Historical data, data quality, data analysis
Receptors & third-party potential impacts	Investment(s) evaluation and validation
Varied regulatory requirements for cleanup: numeric vs risk-based	Off-site delineation, access & sensitive receptors
Real estate & corporate liability reserves	NJDEP ISRA, site remediation and LSRSP program changes

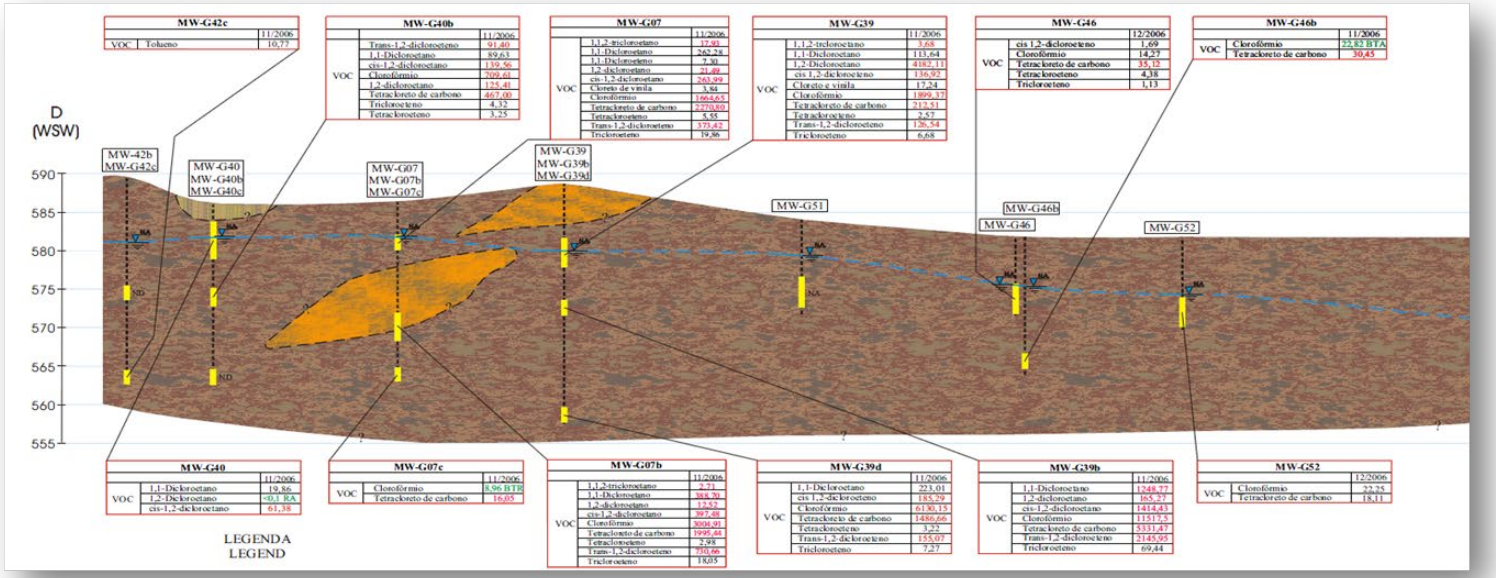
S2C2 inc.

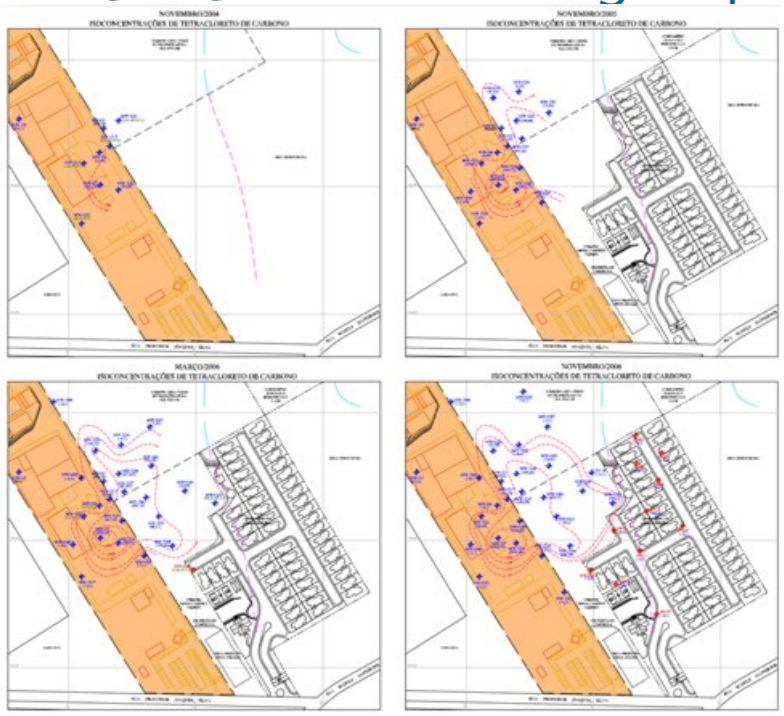
anteagroup

INOGEN®

Understanding today.
Improving tomorrow.

Traditional Workflow Challenges

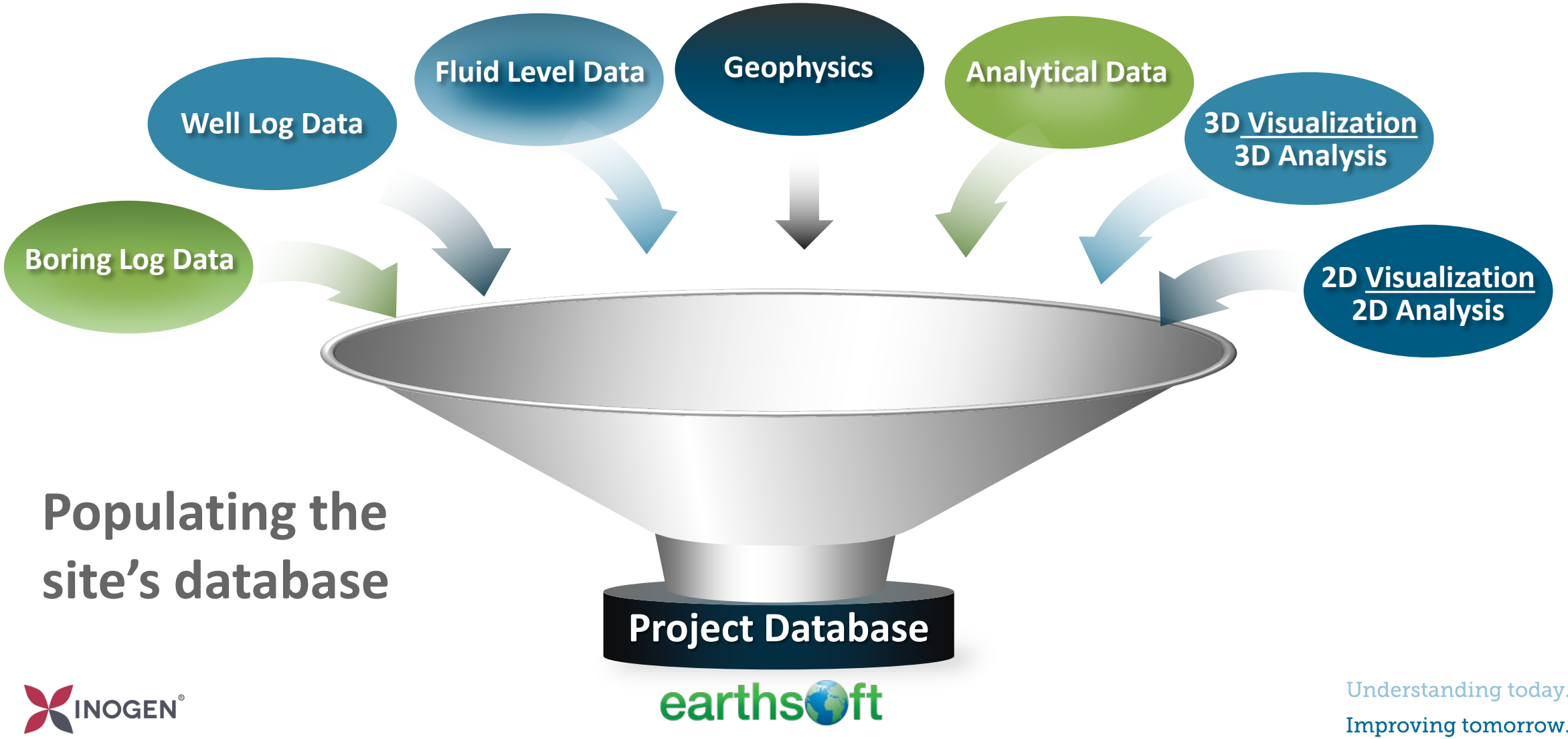




Not a Comprehensive Site Model (CSM)!
(# Figures in SI/RI Report vs one CSM)

Sample ID	NJ Higher of PQLs and GW Quality 2005 Criteria	MW-101	MW-103	MW-106	MW-108	MW-109	MW-110	MW-111	MW-112	MW-113	MW-115	MW-116R	MW-201
Lab Sample No.		952192	952225	952193	952226	952227	952228	952194	952195	952229	952196	952197	952230
Sampling Date		9/19/08	9/19/08	9/19/08	9/19/08	9/19/08	9/19/08	9/18/08	9/18/08	9/19/08	9/18/08	9/18/08	9/18/08
(Matrix: Water) Dilution Factor		1	1	1	1	1	1	2000	5000	1	1000	1000	10
VOLATILE COMPOUNDS (GC/MS) ug/l													
Chloromethane	NS	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	880 U	2,200 U	0.4 U	440 U	440 U	4.4 U
Bromomethane	10	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	880 U	2,200 U	0.4 U	440 U	440 U	4.4 U
Vinyl Chloride	1	3.9	0.2 U	0.2 U	0.2 U	0.2 U	0.2 U	480 U	1,200 U	0.2 U	480	1,700	4.8
Chloroethane	NS	1.5	0.4 U	0.4 U	5.1	0.4 U	0.4 U	63,000	2,200 U	0.4 U	1,700	130,000	650
Methylene Chloride	3	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	800 U	2,000 U	0.4 U	400 U	400 U	4 U
Trichlorofluoromethane	2000	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	740 U	1,800 U	0.4 U	370 U	370 U	3.7 U
1,1-Dichloroethene	1	2	3.1	0.5 U	14	0.5 U	0.5 U	920 U	23,000	0.5 U	4,600	460 U	4.6 U
1,1-Dichloroethane	50	14	1.8	0.3 U	32	0.3 U	0.3 U	130,000	12,000	0.3 U	16,000	7,100	7.2
trans-1,2-Dichloroethene	100	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	0.4 U	780 U	2,000 U	0.4 U	390 U	390 U	3.9 U

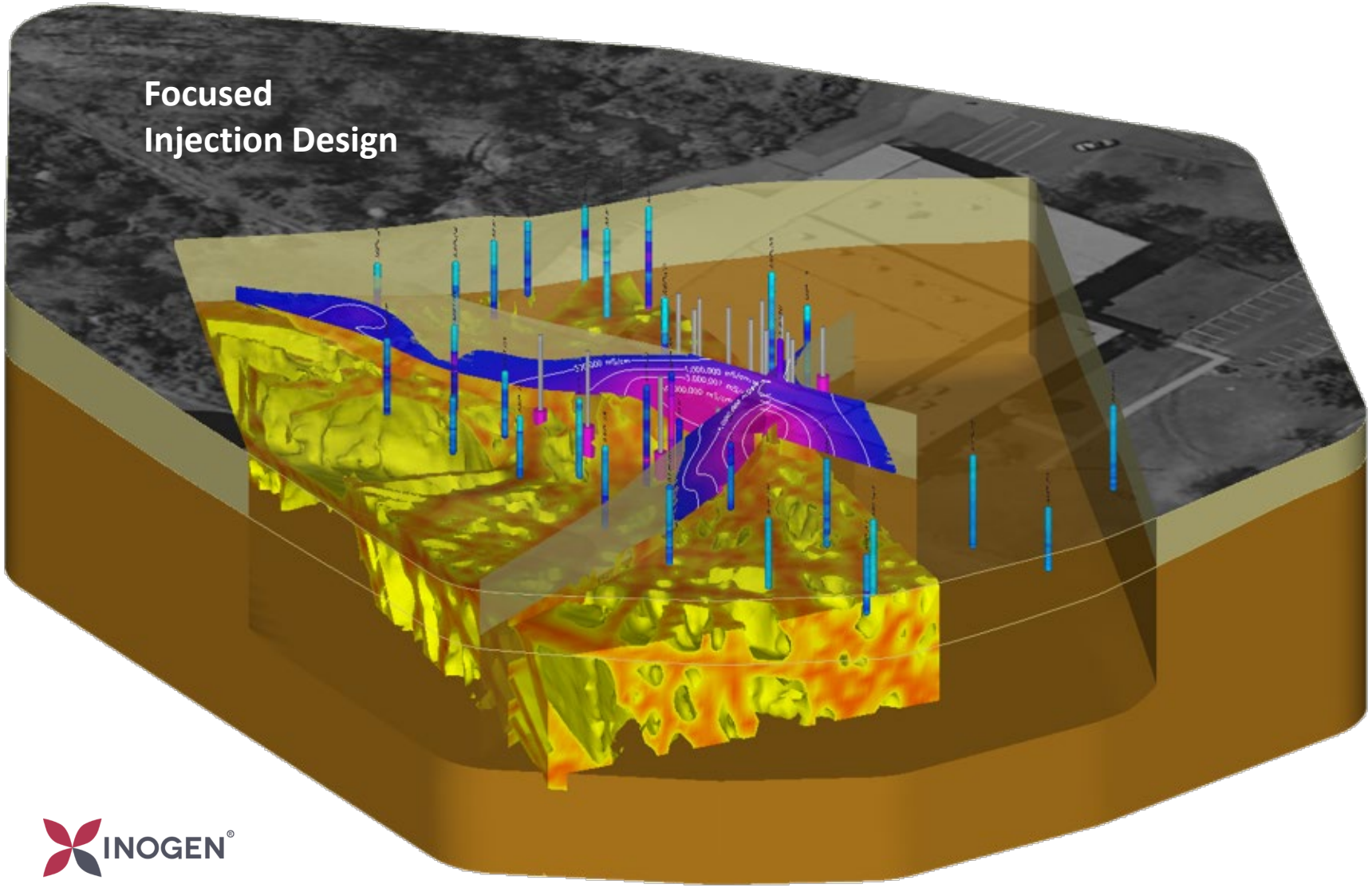
Conceptual Site Model (CSM)



Populating the site's database

Understanding today.
Improving tomorrow.

CSM: 3D Analytical Data Visualization



A baseline CSM analysis of site conditions and remedial options provided strategic insights for:

- Bedrock 3D Fracture Model confirming contaminant transport and one source area
- Analyzing well network to determine statistical significance of each well for bio-degradation
- Refining GW monitoring well network
- Standardizing the calculation of mass and volume of groundwater plumes
- Identifying targeted treatment areas (location and depth)
- More precise reserve lifecycle cost modeling
- Targeted remedial investigation

- 1967 to 1990 – water based adhesive manufacturing

- Primary Contaminants of Concern:
  - *TCA/TCE & degradation products*
- Late 1990s Envt'l Due Diligence
- Early 2000's cessation of operations: NJDEP ISRA 7:26E
- 2008-2009 Building Renovation & Expansion – Resumed New Operations

Site History

Geology

0-6 ft bgs fill/weathered bedrock
6-60 ft bgs Brunswick shale-bedrock

Hydrogeology

Perched groundwater in overburden
Fractured groundwater flow in bedrock

Initial Remediation Strategy

Pump & Treat 2001-2006

Site History Summary

1997 – 2003
Site Characterization & Remedial Investigations

2001 – 2006
GW Pump & Treat System
- IRM - hydraulic control $180k annual O&M

2002
Remedial Bench Scale Study
- Confirmed presence of *dehalococcoides* ethenogenes (d. ethenogenes)
- Dechlorination occurring under anaerobic conditions of TCA/TCE concentrations
- Proved that zero-valent iron could also radically reduce TCA concentrations
- pH range 5.8-6.1; at time believed to be less optimal

2004
First Field Pilot Study Area
- Co-injection of a zero-valent iron & emulsified vegetable oil
- Performance GW monitoring – yielded positive results that anaerobic dechlorination could be enhanced

Injection Array and Manifold

Site Remediation Summary

2005 to 2007
Phase II/III Full Scale Summary

- Source Area – present under existing site building & east loading dock
- Injection wells
  - 20 Injection wells $125k
  - Installed within two zones
    - 5-12 ft bgs
    - 15-25 ft bgs *(open borehole for pneumatic injection)*
- GW monitoring
  - Level loggers installed across MW network
  - Baseline GW geochemistry
  - GW monitoring

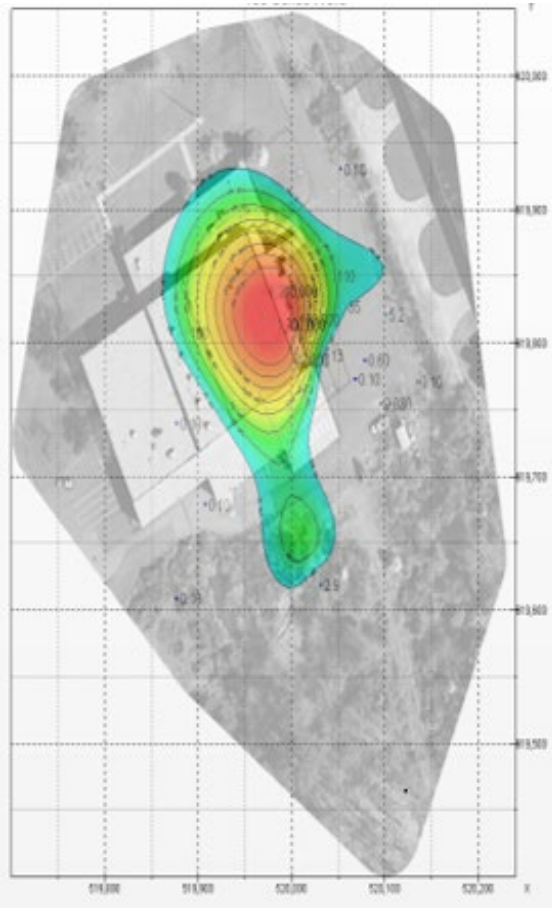
Injection Summary
Phase II

- 6,822 gal of ZVI/EVO
- ROI increased +100% with pneumatic injection

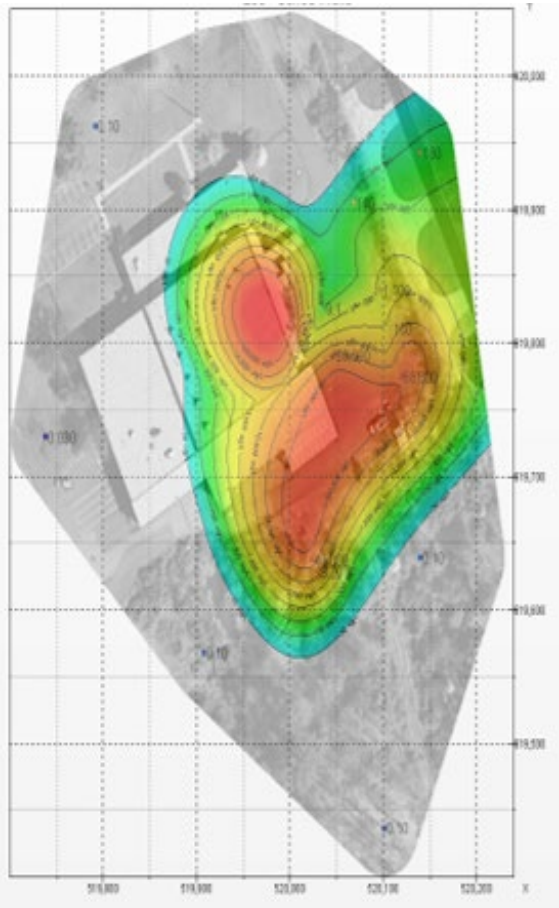
Injection Summary
Phase III

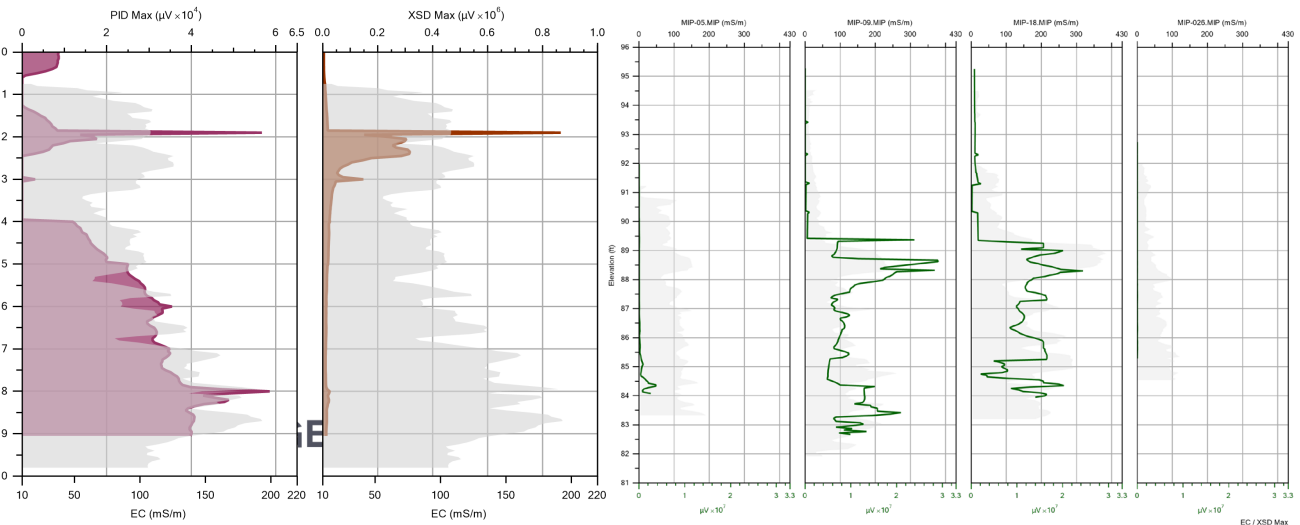
- Two additional injection wells installed
- 17,000 lbs. of ZVI
- 6,700 lbs EVO
- ROI sustained from Ph II
- P&T system decommissioned

100-Series Wells



200-Series Wells

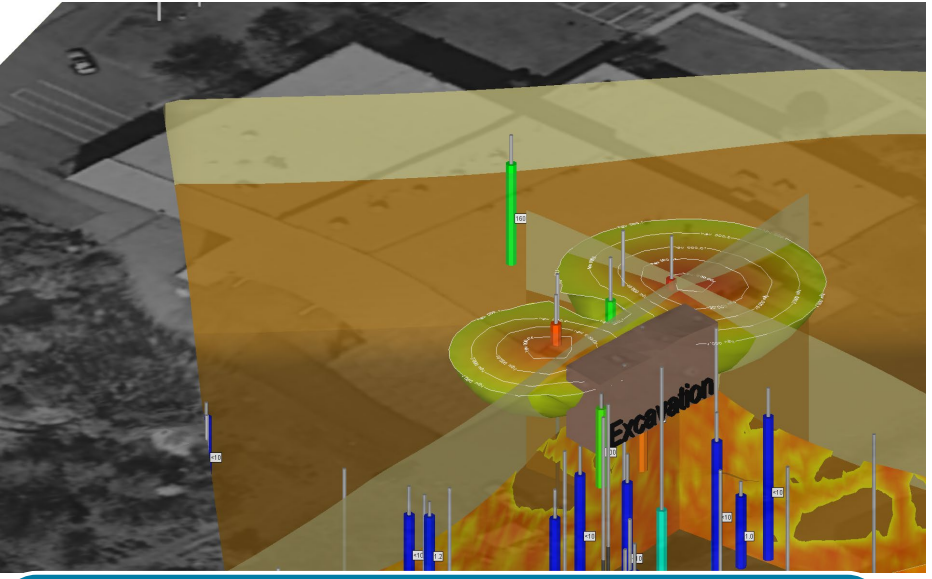




Remediation Performance Validation – HRSC (2009)

- **Implemented HRSC program using MIP to further refine delineation of shallow source(s)**
  - Advanced 22 MIP borings
  - Identified additional shallow source
  - Confirmed suspected second source was transport along bedrock fracture
  - Completed source area soil delineation
  - Completed confirmation soil sampling
- **Updated 3D-CSM data visualization with MIP data**

Understanding today.
Improving tomorrow.

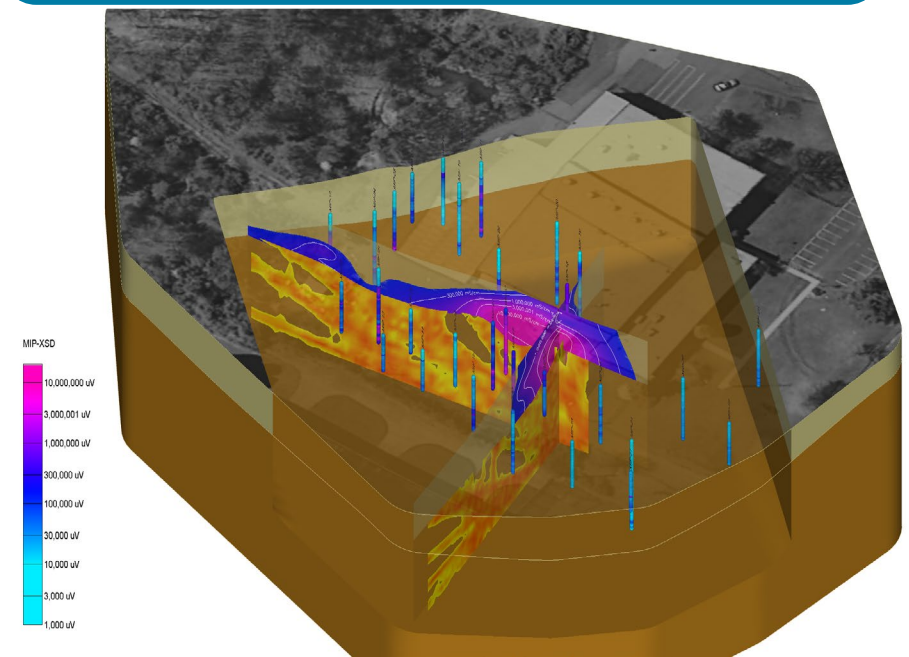


Site Remediation Summary

S2 C2 inc.

anteagroup

Fence of MIP XSD Results and Interpreted Bedrock Fracture Model



2011 Remediation Source Area Excavation based upon HRSC Delineation

- Soil delineation was completed by HRSC & defined remedial excavation limits
- Excavation - 240 tons of CVOC adhesive source removed
- 2000lbs ZVI & 1050lbs EVO placed at base of excavation; along with injection system prior to backfilling

Excavation of Source Material

Understanding today.
Improving tomorrow.

Case Study 1

12-acre Former Specialty Chemical Manufacturer

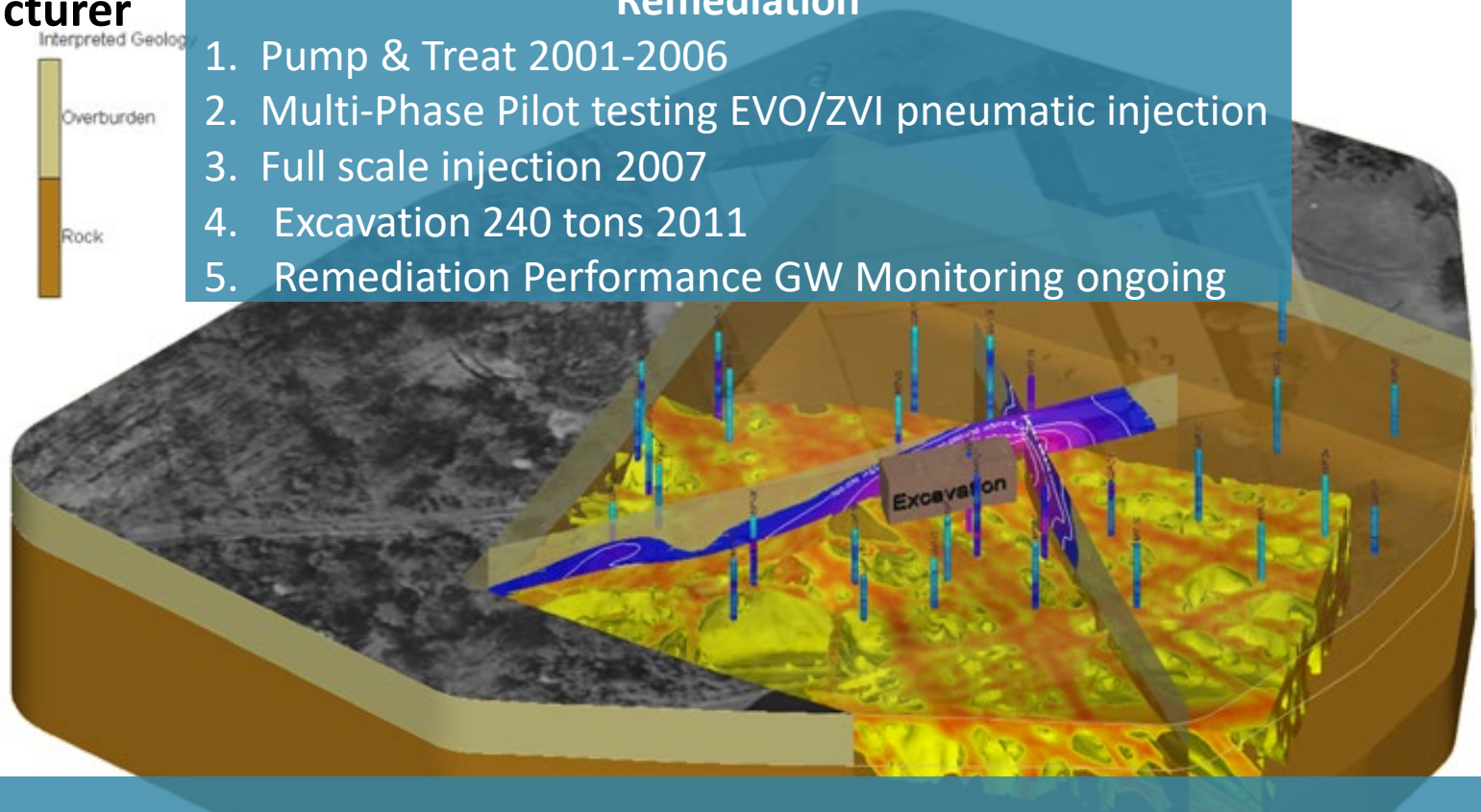
Late 1990s NJDEP ISRA 7:26E

Geology
0-6 ft bgs fill/weathered bedrock
6-60 ft bgs Brunswick shale-bedrock

Hydrogeology
Perched groundwater in overburden
Fractured groundwater flow in bedrock

https://youtu.be/lOHkm-A7x7Y

Remediation
1. Pump & Treat 2001-2006
2. Multi-Phase Pilot testing EVO/ZVI pneumatic injection
3. Full scale injection 2007
4. Excavation 240 tons 2011
5. Remediation Performance GW Monitoring ongoing



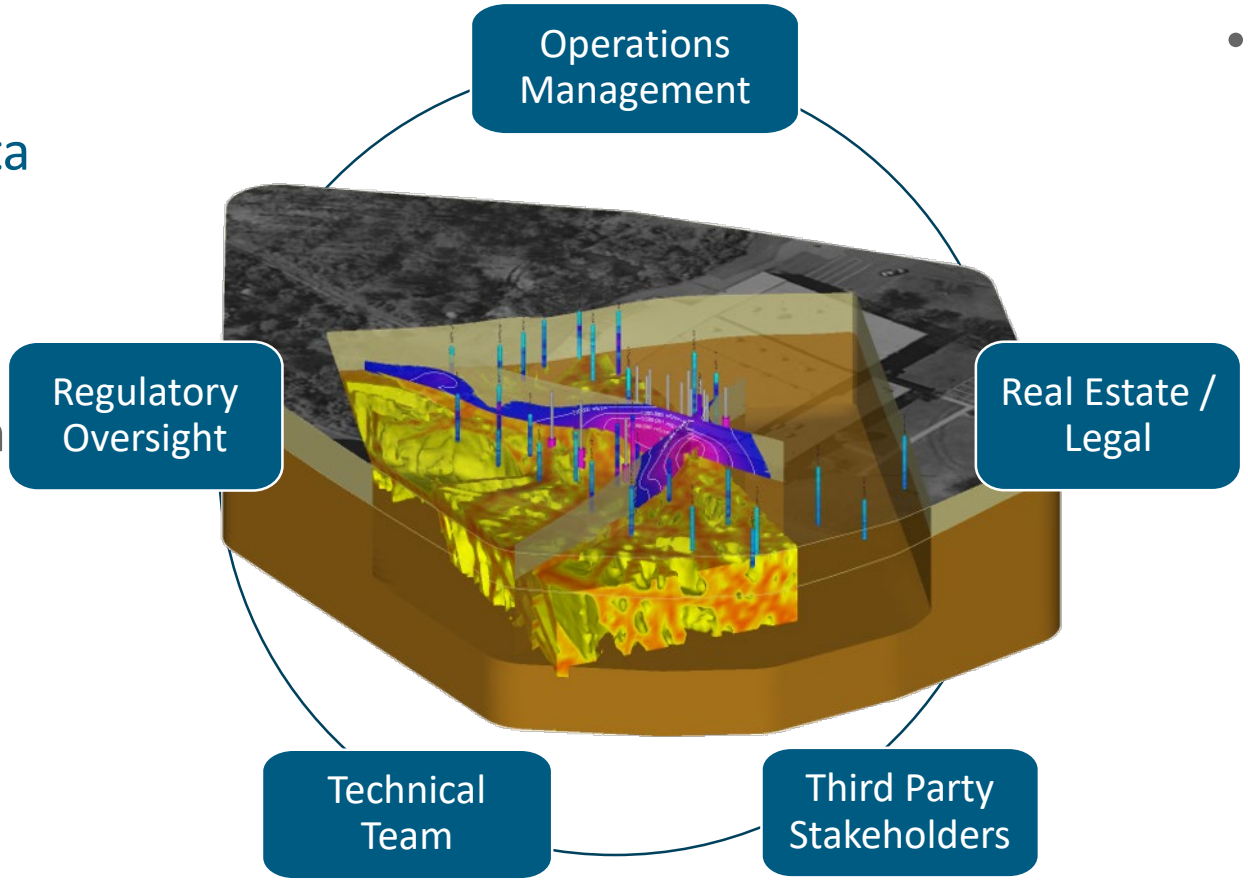
Lifecycle Value
1. IRM shutdown - $180k per year / $2.1M to date savings
2. HRSC / 3D visualization - $300k savings in remediation design & implementation
3. MNA closure strategy $100k monitoring reduction

Understanding today.
Improving tomorrow.

Best Management Practice 3D CSM

1. Communication to Stakeholders

- 3DVA is a tool to communicate technical data sets to all stakeholders
- Facilitates collaborative discussions with regulators
- Helps ownership team gain a better understanding of environmental drivers and risks

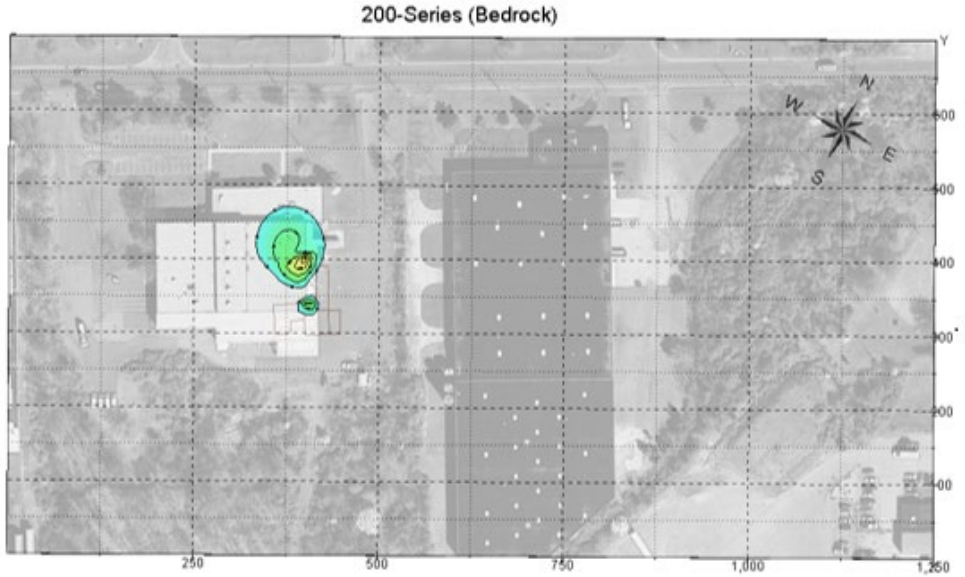


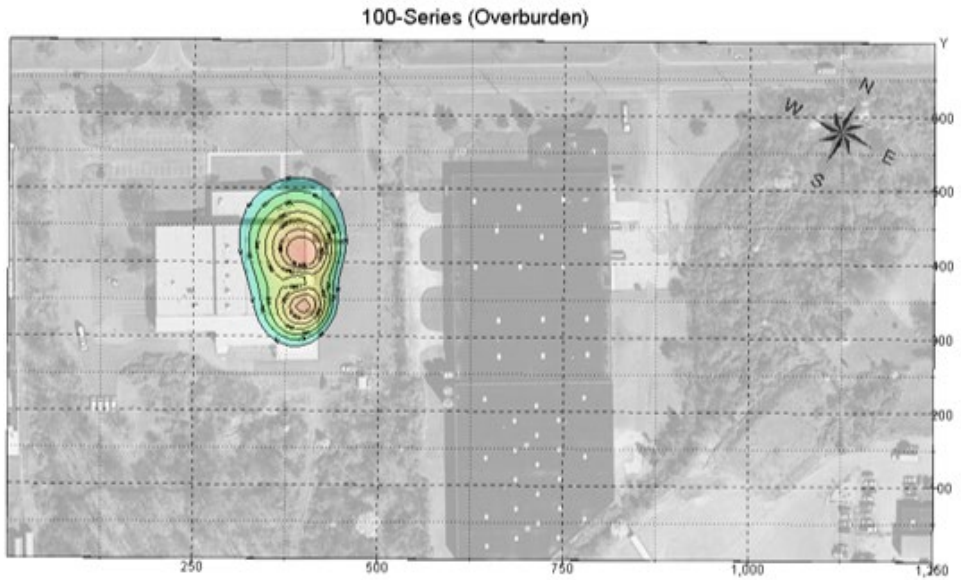
- Provides for a standardized solution process for the management and representation of complex data sets leading to reduction of environmental liabilities & more informed business decisions

INOGEN®

Understanding today.
Improving tomorrow.

Best Management Practice 3D CSM



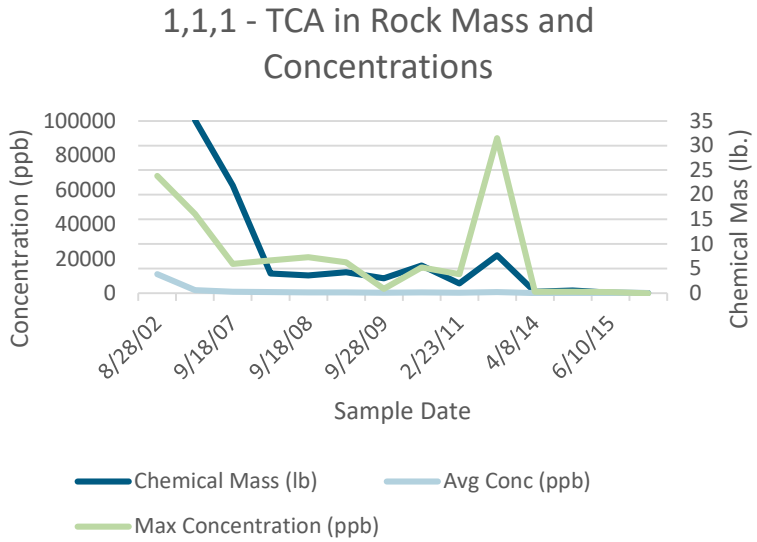


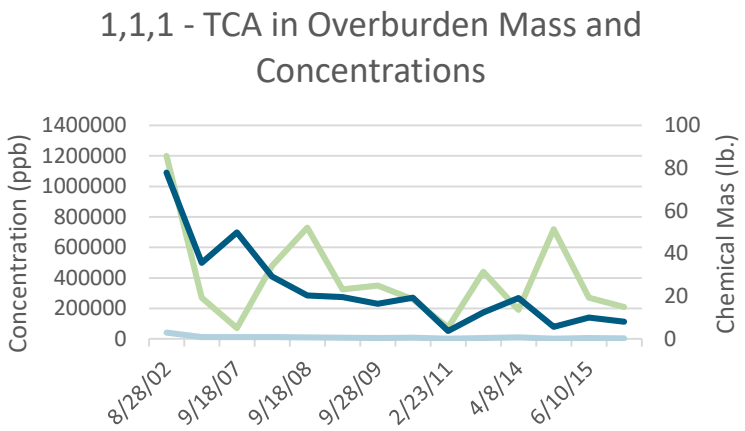
2. Technical Advantages

1. Plume architecture credibility
2. Validation of mass and volume estimates
3. Enhanced visualization of data sets over time; predictive model (simulations)
4. More targeted Investigation & remediation solution strategies
5. Improved risk management
6. Lifecycle cost reductions

S2C2 inc.

anteagroup





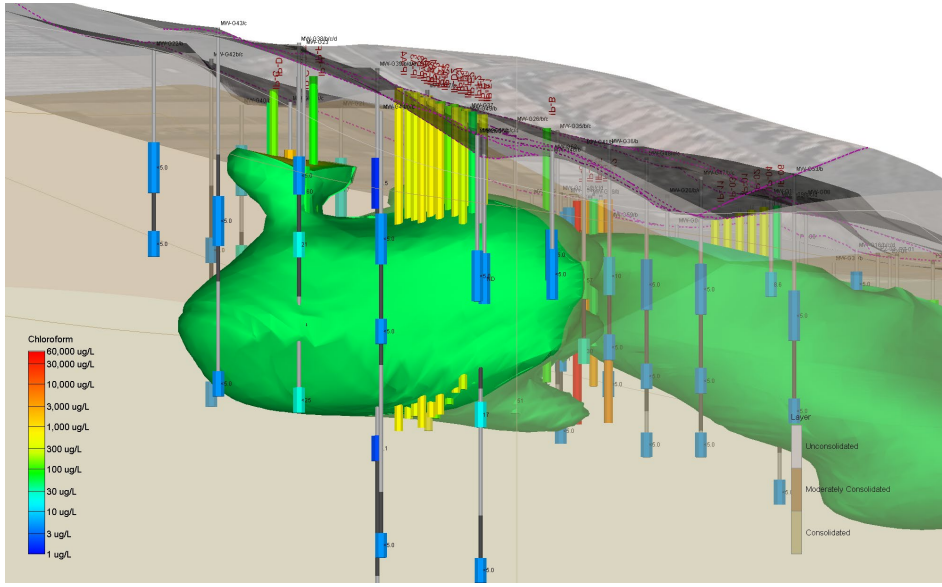
Understanding today.

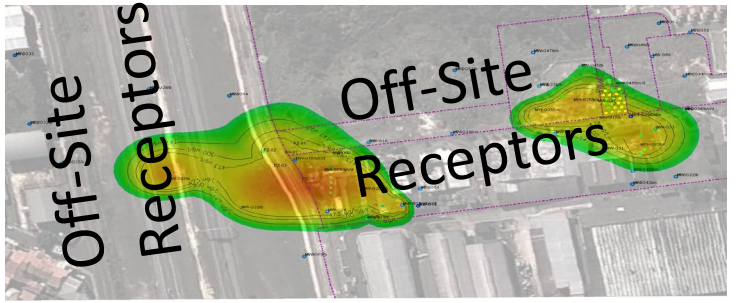
Improving tomorrow.

Best Management Practice 3D CSM

3. Global Management Continuity

1. ***Best-fit solution strategy***
2. Global continuity
3. Collaborative tool for aligning operations, management and EHS to project goals
4. Corporate reserve cost validation





Understanding today.
Improving tomorrow.

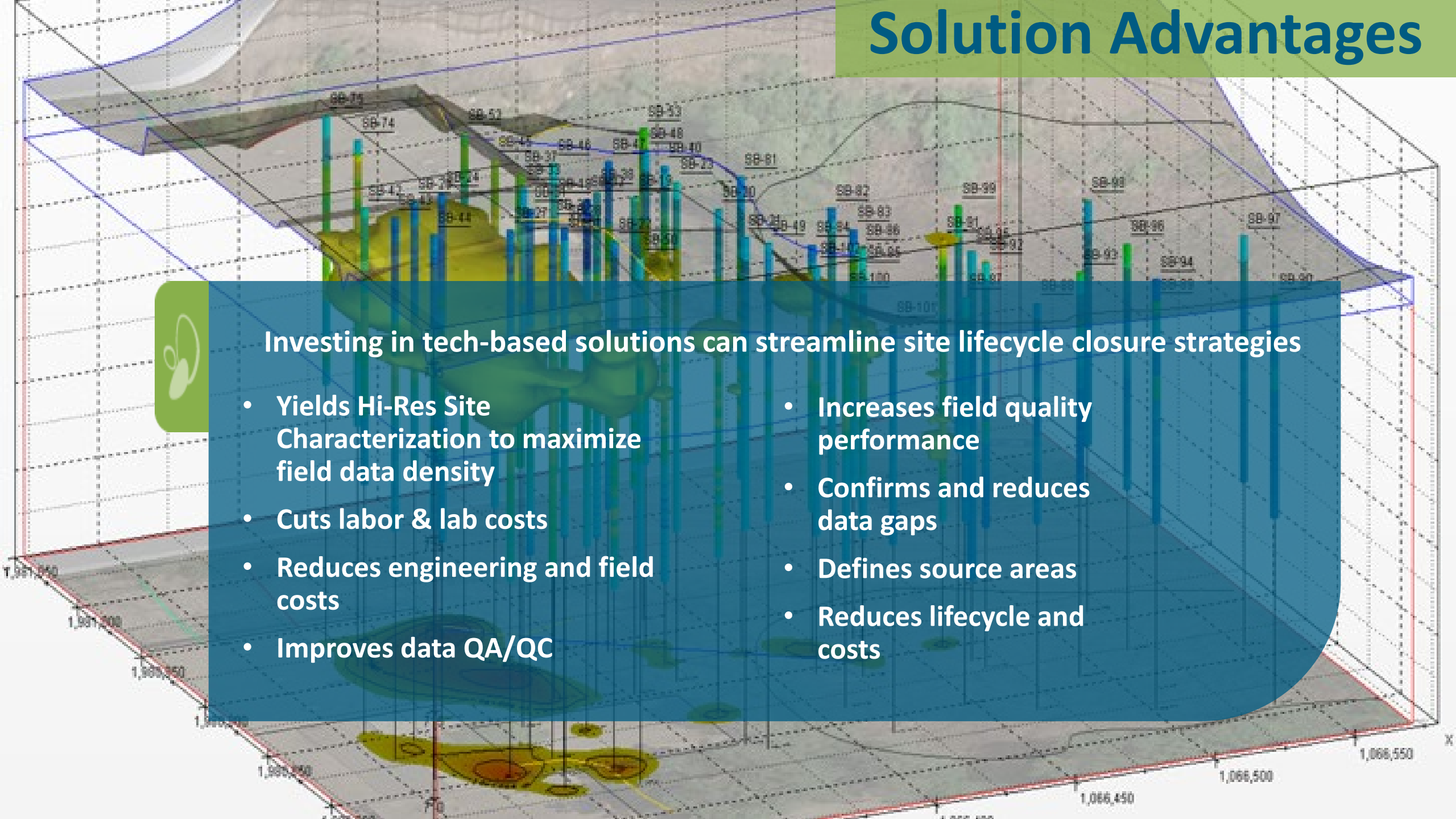
Solution Advantages

MODEL CALCULATIONS

"Garbage In – Garbage Out" Paradigm

Garbage Data	Perfect Model	Garbage Results
Perfect Data	Garbage Model	Garbage Results

Solution Advantages



Investing in tech-based solutions can streamline site lifecycle closure strategies

- Yields Hi-Res Site Characterization to maximize field data density
- Cuts labor & lab costs
- Reduces engineering and field costs
- Improves data QA/QC
- Increases field quality performance
- Confirms and reduces data gaps
- Defines source areas
- Reduces lifecycle and costs

Q&A

Intelligent Design - Leveraging technology investments for lifecycle risk reductions

Special thanks to

Jack Sheldon, Antea Group

Deborah Schnell, P.E., GeoSierra / Panther Technologies

AnteaGroup

@AnteaGroup

Joshua Orris

Consultant, Antea Group

Joshua.Orris@anteagroup.com

+ 1 717 712 5456

Jason Ruf

S2C2

Jason.Ruf@s2c2inc.com

+ 1 908 256 2710

INOGEN®

Understanding today.
Improving tomorrow.