Application of Life Cycle Assessment to Compare Sustainability of Novel Evaporative Desorption Technology (EDT) for Soil Remediation to Conventional "Dig and Haul"

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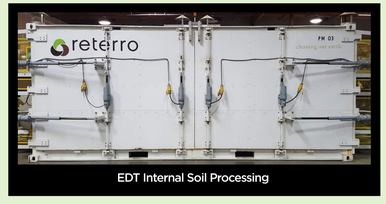
Direct Load Soil Treatment Bins

Weigh Filled Soil Bins Pre-EDT Process

Load Soil Bins to EDT Process Unit

Approximately 20 Tons Soil Loaded for EDT Treatment



EDT Internal Soil Processing


Empty, Cool, Rehydrate Treated Soil

FOLLOW THE EDT ADVANTAGES FOR SUSTAINABLE REMEDIATION

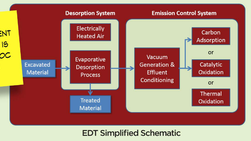
THE EDT PROCESS - TOTAL PROCESSING TIME ON AVERAGE 2 - 3 HOURS FOR 20 TONS OF SOIL PER EDT UNIT

INTRODUCTION to EDT

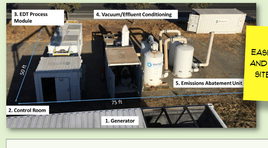
EDT PROCESS

- Contaminated Soil Placed in Treatment Bins (10 Tons Nominally)
- Two Bins (One "Batch") Loaded Into EDT Process Unit (Multiple Units can be Deployed to Meet Required Production Rate)
- Heated Air Drawn Through Soil Volatizes Contaminants Which are Extracted as Off Gas
- Off-Gas Modules Destroy, Collect, or Recover Contaminants in the Off Gas
- Data for Each Batch are Recorded and Archived to Document Contaminant Removal
- Treated Soil can be Reused On Site

CORE TREATMENT COMPETENCY IS TPH, VOC, CVOC AND SVOC



EDT Simplified Schematic



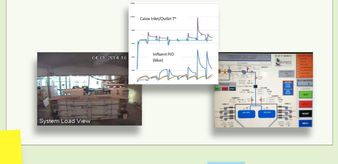
EASILY DEPLOYED AND SCALABLE TO SITE CONDITIONS

EDT PROCESS PARAMETERS

- Batch: 18 – 22 Tons (20 Tons Nominal)
- Temp: 380°F to 650°F (500°F Nominal)
- Flow: 2,000 to 2,400 SCFM (Air)
- Time: 1.25 to 4 Hours (2 Hrs Nominal)
- Energy: 480v, 3ϕ (Grid or Portable)

AUTOMATED DATA COLLECTION and ANALYSIS

- Operating Data Collected Continually & Remotely Monitored 24/7 for Safety and Security
- Real Time Process Control
  - Reduces Process Times
  - Increases Energy Efficiency
  - Predictive Maintenance



BENEFITS

- No NOx, SOx Or PM-10 Particulate Emissions
- Easily Deployed to High Density and Rural Areas
- Alternative to Transport and Landfill Disposal of Soil and Associated Emissions and Traffic Risks
- Eliminates Landfill Costs and Liability
- On-Site EDT Treatment has been Designated "Ceqa-Insignificant"
- Guaranteed Results
- Cost-Effective (Price Per Ton Quotations)

SAFE BY DESIGN

COST EFFECTIVE WITH GUARANTEED RESULTS

GREENER CLEANUP (ASTM E2893-13)

A PROVEN BMP FOR GREENER CLEANUPS

The Standard Guide for Greener Cleanup (2013) set the stage for implementing remediation technologies with lower environmental impacts and evaluating those impacts with a Life Cycle Assessment (LCA)

PROJECT OBJECTIVE

To compare selected environmental impacts of the EDT soil remediation technology to conventional dig and haul by conducting a screening-level LCA

PROJECT BACKGROUND

1. Project Statistics

- RFI/Corrective Action at Former Instrument Manufacturing Facility
- Regulatory Oversight: DTSC
- Drivers: Regulatory/Redevelopment
- Contaminants of Concern CVOCS:
  - PCE
  - TCE
- Project Size: ~100,000 Tons
- Duration: 14 Months
- Soil: Clay and Silt
- Excavation: 8- to 24-foot Depth

Aerial view of the 46-acre site in Fullerton, CA during remediation activity.

Indoor EDT Soil Treatment Operations

2. Challenges

- Residential Level (Vapor Intrusion) Clean-up Standard for Treated Soil Reuse Required
- Proximity to Schools and Commercial Properties Created Emission and Sound Limitations
- Ceqa Study Set Limits on Truck Traffic to/from Site

3. Solutions

- Reterro EDT Selected to Remediate Soil to Levels Surpassing Residential and Soil-to-Groundwater Target Goals
- On-Site Soil Treatment Performed Under Corrective Action Management Unit Rules (CAMU- 40 CFR 264.550)
- Initial EDT Pilot Tests Proved Successful and DTSC Approved EDT as the Remedial Measure for all CVOC-Impacted Soil
- Deployed Two EDT Systems to Accelerate Treatment Production Rates
- EDT Operated 24 hours, 7 days/week
- Electric, Flameless Units Both Quiet and Zero-Emission
- Granular Activated Carbon Off-Gas Treatment
- Permitted to South Coast Air Quality Management District Standards

EXPEDITED SOIL TREATMENT FOR ON-SITE REUSE

4. Results

- EDT Soil Treatment Exceeded Cleanup Goals
- ~100,000 Tons EDT Treated Soil Used as Backfill
- Projected Average Process Time was Achieved (1.9 Hours or 114 Min. Per Batch)
- On-Site Soil Treatment Reduced Truck Traffic and Associated Hazards
- DTSC Issued "Soil Corrective Action Completion" for 100,000-ton Soil Treatment Phase of RCRA Site Remediation Process

EDT Soil Throughput and Process Time Met Baseline Project Schedule Requirements

KEY TAKE-AWAYS

- ***According to the screening-level LCA results, EDT has lower Global Warming Potential (GWP), Particulate Matter ($PM_{2.5}$), & Primary Non-Renewable Energy Demand (PNRED) than dig & haul***
- ***Significantly higher diesel combustion required for dig and haul to transport soil than EDT***
- ***High throughput (5 month) EDT electric scenario has lower impacts per ton of soil by 52%, 53% and 54% for GWP, PNRED and $PM_{2.5}$, respectively than low throughput (14 month) EDT scenario***
- ***Running EDT project on diesel-generated power results in lower GWP, PED, and $PM_{2.5}$, than drawing electricity from the grid (US average grid mix)***

SCREENING-LEVEL LCA DEMONSTRATES THAT THE EDT PROCESS IS MORE EFFICIENT AT HIGHER THROUGHPUT

SCREENING-LCA APPROACH

LCA Scenarios and Modeling Assumptions

SCENARIO	TREATMENT TYPE	MONTHS	TONS SOIL	ELECTRICITY SOURCE
1	DIG & HAUL	14	97,764	DIESEL GENERATOR
2	RETERRO EDT	14	97,764	DIESEL GENERATOR
3	RETERRO EDT	14	97,764	ELECTRICITY GRID
4	RETERRO EDT	5	51,498	DIESEL GENERATOR
5	RETERRO EDT	5	51,498	ELECTRICITY GRID

- Evaluated Dig and Haul and 4 Reterro Scenarios
  - 14 Months is Full Project (97,764 Tons Soil Treated)
  - 5 Months is "Steady State" of the Project (51,498 Tons Soil Treated, 53% of Total Project Soil)
- Results Presented Per Ton of Soil Treated and per Total Soil Treated
- Impact Categories Quantified
  - GWP in kg CO_2eq
  - PNRED in MJ
  - $PM_{2.5}$ in kg$PM_{2.5}$

LCA Inputs

Dig And Haul

- Diesel Of On-site Operations
  - Excavation
  - Staging Soil
  - Load Soil into Truck
  - Borrow Source Excavation
  - Borrow Source Load Trucks
  - Stage and Backfill Soil
  - Compacting
  - Ancillary Site Operations
- Diesel for Transportation of Clean Soil from Borrow Source and Excavated Soil from Site to Hazardous Waste (20%) and Municipal Landfill (80%)
- Water Used On-Site from Municipal Water Source

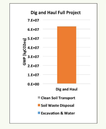
EDT

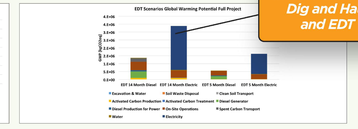
- Diesel For On-Site Operations
- Electricity to Run Equipment (Replaced with Diesel Generator in Diesel Scenarios)
- Water Used On Site from Municipal Water Source
- Production of Activated Carbon
- Transport of Spent Carbon to Treatment by Evoqua
- Treatment of Activated Carbon

SCREENING-LCA RESULTS

GWP Comparison

~95% Reduction In GWP Between Dig and Haul and EDT

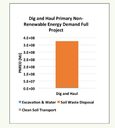


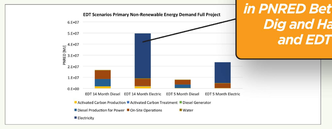


- Soil Transportation Drives Dig and Haul GWP
- Diesel Combustion (On-Site Operations + the Diesel Generator) Drives GWP in Reterro Diesel Scenarios
- Electricity Generation (Us Electric Grid Mix) Drives GWP in Reterro Electric Scenarios
- Reterro 5 Month Steady State with Diesel has the Lowest GWP of all Scenarios

PNRED Comparison

~85% Reduction in PNRED Between Dig and Haul and EDT

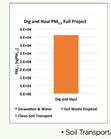


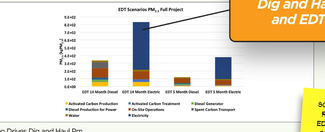


- Soil Transportation Drives Dig and Haul PNRED
- Diesel Combustion (On-Site Operations + the Diesel Generator) Drives Pnred in Reterro Diesel Scenarios
- Electricity Generation (Us Electric Grid Mix) Drives PNRED in Reterro Electric Scenarios
- Reterro 5 Month Steady State with Diesel has the Lowest PNRED of all Scenarios

$PM_{2.5}$ Comparison

~98% Reduction in $PM_{2.5}$ Between Dig and Haul and EDT





- Soil Transportation Drives Dig and Haul $PM_{2.5}$
- Diesel Combustion (On-Site Operations + the Diesel Generator) Drives $PM_{2.5}$ In Reterro Diesel Scenarios
- Electricity Generation (Us Electric Grid Mix) Drives $PM_{2.5}$ in Reterro Electric Scenarios
- Reterro 5 Month Steady State with Diesel has the Lowest $PM_{2.5}$ of all Scenarios

SCREENING-LCA RESULTS SHOW EDT HAS LOWER GWP, PM, AND PNRED THAN DIG AND HAUL

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