NAVFAC RPM Tech Update: Design Considerations for Enhanced Reductive Dechlorination (ERD)

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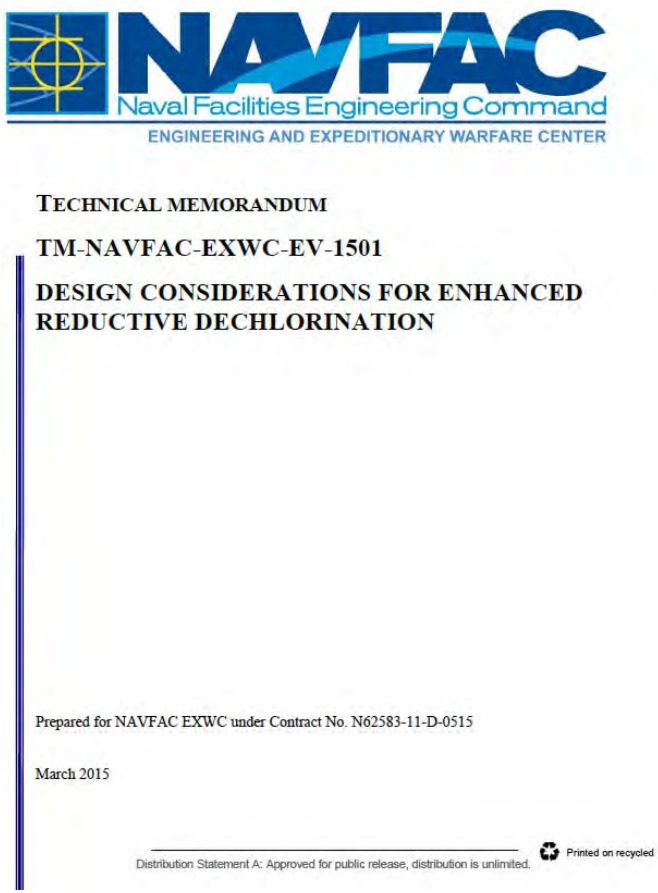
Presentation Overview

- Purpose
- Remedial Design Submittals
- Key CSM Elements
- Key Design Elements
- Drawings
- Specifications and Standards
- Schedule


NAVFAC
Naval Facilities Engineering Command
ENGINEERING AND EXPEDITIONARY WARFARE CENTER

TECHNICAL MEMORANDUM

TM-NAVFAC-EXWC-EV-1501

DESIGN CONSIDERATIONS FOR ENHANCED REDUCTIVE DECHLORINATION

Prepared for NAVFAC EXWC under Contract No. N62583-11-D-0515

March 2015

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Purpose

Develop improved and consistent design submittals within DON Environmental Restoration Program

- Provides a framework for ERD design submittals
- Summarizes best practices for ERD design
- Tips on appropriate QA/QC measures
- Information can be incorporated into a design format suitable to the scope of the project
  - Work Plan Approach
  - Design-Build Approach

Remedial Design Submittals

Work Plan Approach

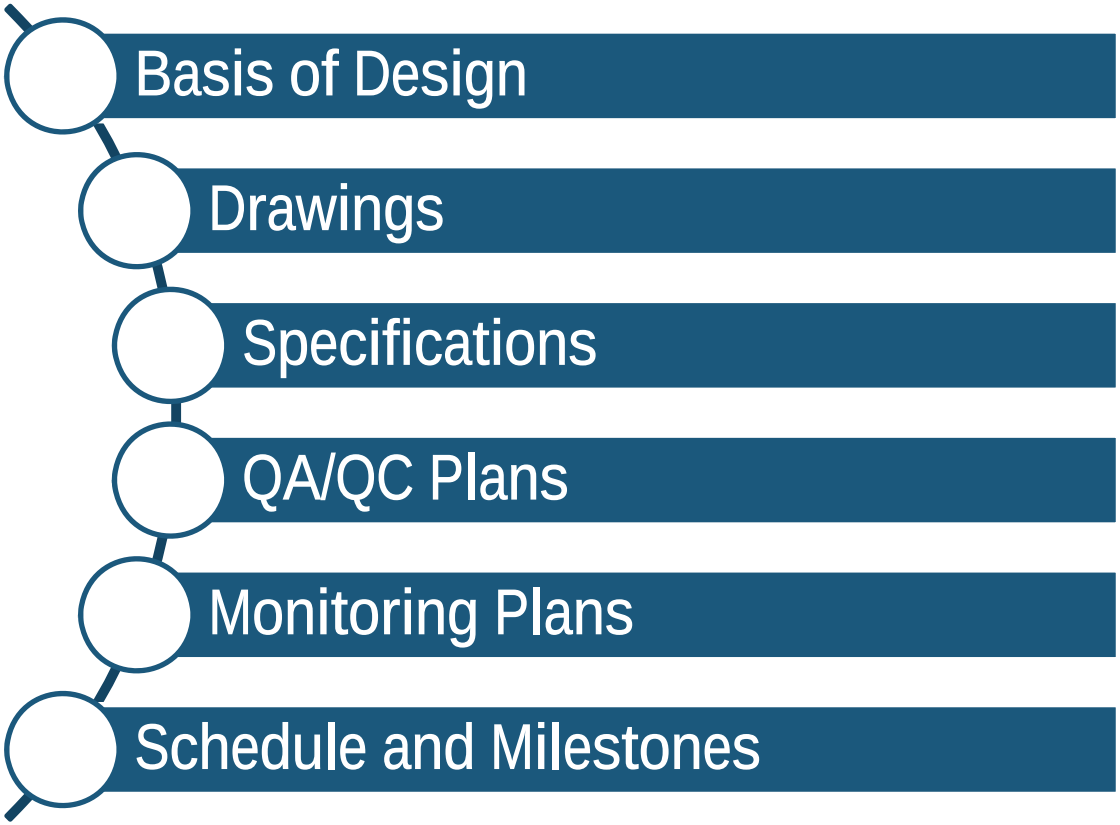
- Draft review (15-30% design = conceptual design)
- Draft final review (50-60% design = preliminary design submittal)
- Final submittal (90-100% = final design)

Design-Build Approach

- Contains Performance-Based Language
- Drawings and Specifications

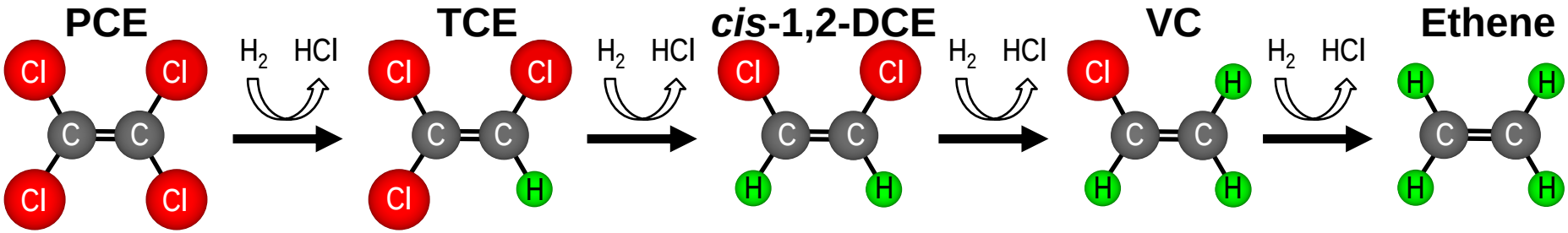
Remedial Design Submittals

- Provided to RPMs for review and approval prior to remedy implementation



ERD Conceptual Process

- Enhances in situ bioremediation strategy of degradation of chlorinated solvents via reductive process
- Performed by bacteria from genus Dehalococcoides
- Respiratory dechlorination = direct dechlorination
- Involves biostimulation and/or bioaugmentation
- Amendments may include: ē donors, pH buffer, nutrients
- Bioaugmentation includes addition of ē donors to target treatment zones



Courtesy of Battelle

Key CSM Elements

CSM Element	Description
Nature and extent of contamination	▪ Determine horizontal and vertical distribution of COCs ▪ Presence of DNAPL
Hydrogeology	▪ Lithology (lithologic units, heterogeneities, grain size, permeability, presence of bedrock, etc.) ▪ Hydrogeology (gradients, confined or unconfined conditions, saturated thickness, conductivities, flux, gw flow direction, Darcy velocity, anisotropy, etc.) ▪ Mineralogy (e.g., metal mobilization)
Hydrogeochemistry	▪ Distribution coefficients (Kd), pH, buffering, temperature, ORP, terminal electron acceptor concentrations ▪ Potential inhibitors for the desired microbiological reaction
Microbiology	▪ Determine microbial characteristics for degrading the specific COCs • *Dehalococcoides* for chlorinated ethenes, • Specific genes for dechlorinating vinyl chloride [e.g., *vcrA*], and • *Dehalobacter* for chlorinated methanes and ethanes ▪ Determine if bioaugmentation will be beneficial for the design

Key CSM Elements (cont.)

CSM Element	Description
Human and ecological health risks	▪ Risks presented by COCs ▪ Risks associated with ERD amendments (e.g., methanogenesis) that influence amendment dose and injection frequency
Fate and transport	▪ Fate and transport of COCs affect the delivery of ERD amendments to the subsurface (i.e., injection/recirculation locations, concentrations of amendments, flow rates, and the method of introduction into the aquifer)
Site-specific infrastructure and characteristics	▪ Consider urban vs. rural environment ▪ Presence of buildings and utilities ▪ Proximity to nearby receptors ▪ Current and future land use

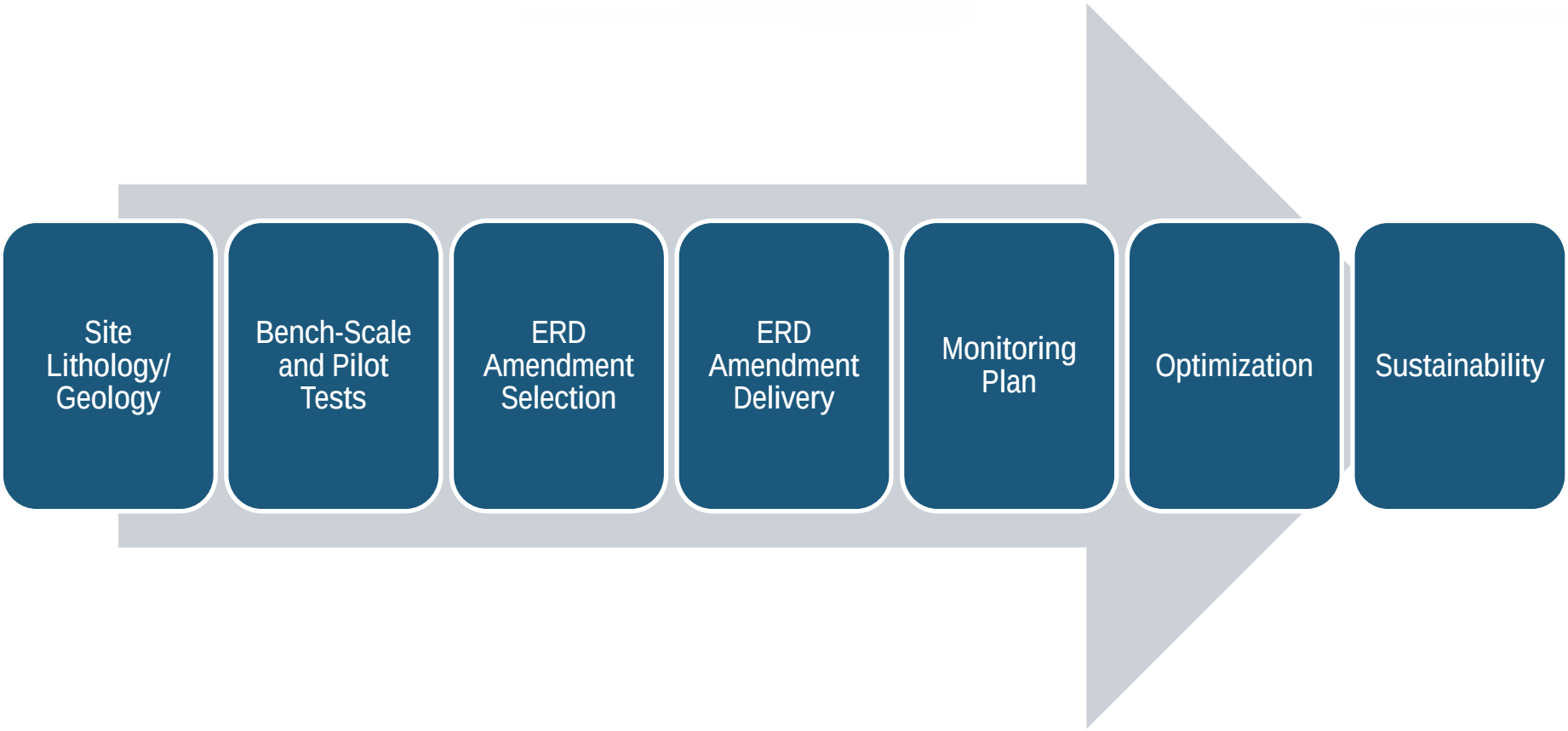
Key Concerns for Regulators and Stakeholders

Common stakeholder concerns include:

- Time required to complete active portion of remedy and time to achieve remedial action objectives
- Redistributing contamination
- Injection of microorganisms
- Potential for reinjection contaminated groundwater
- Byproducts creation or changes to geochemistry that can adversely impact the aquifer

Address concerns early in the design process and incorporate countermeasures into plans

Key Design Elements



ERD Amendment Selection

The type of amendments used in a design depends on:

- Existing subsurface conditions
- Desired transformation
- Results of any bench-scale testing performed

Substrate Type	Electron Donor Substrates	Typical Delivery Techniques	Form of Application	Frequency of Injection
Soluble Substrates	Lactate, Butyrate	DPT injection, injection wells, or recirculation systems	Acids or salts diluted in water	Continuous to monthly
	Methanol, Ethanol	DPT injection, injection wells, or recirculation systems	Diluted in water	Continuous to monthly
	Sodium Benzoate	DPT injection, injection wells, or recirculation systems	Dissolved in water	Continuous to monthly
	Molasses, High-fructose corn syrup	Injection wells	Dissolved in water	Continuous to monthly
	Whey (soluble)	DPT injection or injection wells	Dissolved in water or slurry	Monthly to annually

ERD Amendment Selection (cont.)

Substrate Type	Electron Donor Substrates	Typical Delivery Techniques	Form of Application	Frequency of Injection
Slow-Release Substrates	Polylactate ester	DPT injection	Neat injection	Annually to biennially
	Vegetable oil	DPT injection or injection wells	Neat oil injection with water push or high oil concentration (>20%) emulsions in water	One-time application (typical)
	Vegetable oil emulsions	DPT injection or injection wells	Low oil concentration (<10%) microemulsions suspended in water	Every 2 to 3 years (typical)

Adapted from U.S. EPA, 2013; ITRC, 2008a; and AFCEC et al., 2004.

ERD Amendment Delivery

An amendment delivery plan is a critical component of success

Elements of the delivery plan are discussed

- Amendment dosing and longevity considerations
  - Amendment concentrations
  - Volume of fluids to be introduced into the aquifer
- Delivery method
  - Delivery via DPT injection, recirculation, PRB, or pull-push
  - Number of events or frequency
- Treatment well/ point source layout and characteristics
  - Bioremediation reaction kinetics
  - Amendment concentration
  - Soil retardation factors
  - Injection flow rate
  - PV of the TTZ
  - Direct injection versus recirculation approaches

Monitoring Plan

Process Monitoring Example Elements

Process and performance monitoring involves observing and measuring parameters that provide information about the state of the remedial action during implementation

- Groundwater levels, pressures, flow rates and volumes
- Vapors in treatment systems
- Radius of influence
- Total dissolved or organic carbon
- Dissolved hydrogen gases, soil gas and well vapors
- Specific dechlorinating bacteria
- Alkalinity, dissolved or total metals

45+ GSR BMP Examples for ERD

Materials Management & Waste Reduction

- Use additional characterization (e.g., 3-D imaging) to minimize the treatment area
- Use aggressive/active treatment for hot spots and source areas
- Use less aggressive/passive treatment for dissolved phase plumes
- Major part of ERD environmental footprint is from amendment manufacturing
  - Optimize the injection program to efficiently use amendments during treatment
  - Reduce number of injection points and/or quantity of reagents
  - Mix the amendment to meet the daily dosing requirement only, thereby avoiding generation and handling of wastes in the event that the injection operation ceases unexpectedly
- Reuse existing wells for injections and monitoring to the extent practical

Drawings

- Site layout drawings
- Target treatment area schematics
- Injection well and DPT injection point location maps
- Well and/or injection point design
- Process and instrumentation diagram (P&ID) for aboveground portion of injection and treatment equip
- Monitoring location map

Specifications and Standards

UFC system is prescribed by MIL-STD-3007 (Department of Defense, 2006a)

- FEAD adheres to the UFC system, RPMs should confirm the applicable format if the project involves FEAD oversight
- The most important message is to ensure that the technical content requirements are met regardless of the selected format

Unified Facilities Guide Specifications (UFGS)

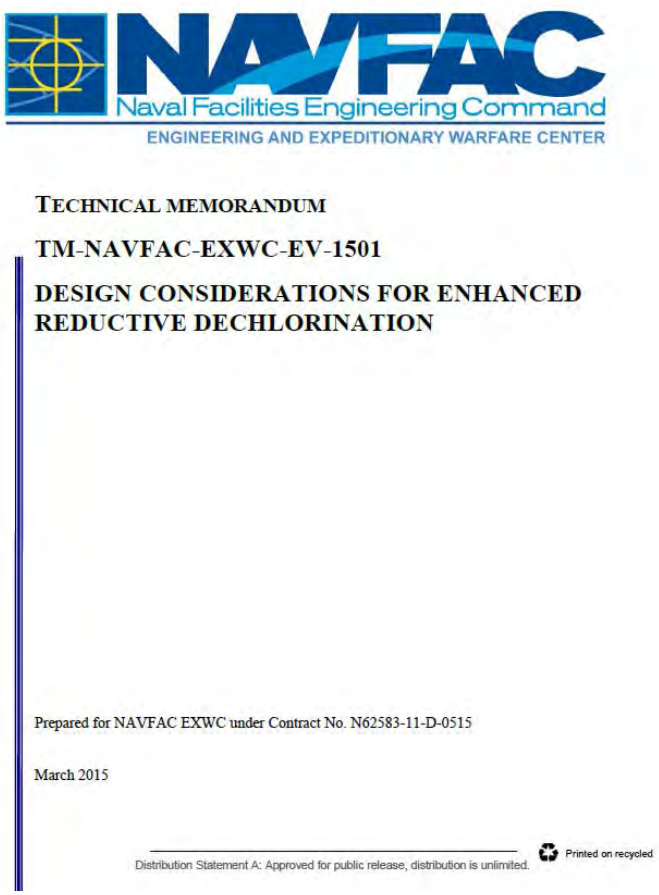
- Used to organize specifications and other project information
- Document identifies UFGS that may be applicable to ERD projects

Schedule

Example Milestones
Submittal and Acceptance of Draft, Draft Final, and Final Work Plans or 30%, 60%, 90%, and 100% Designs
Completion of Site Preparatory Activities
Completion of Construction/Installation of ERD System
Completion of Operation and Maintenance and Process Monitoring Events (e.g., weekly, monthly)
Completion of Groundwater Performance Monitoring Events (e.g., monthly, quarterly, semi-annual, and/or annual)
Completion of Progress Reports (e.g., annual)
Submittal and Acceptance of Draft, Draft Final, and Final Remedial Action Completion Report

Conclusions

- Visit the ERB Web site to download the ERD Design Considerations document
- Share with your team
- Goal is to support optimized ERD design and implementation
- Implement GSR BMPs for ERD when it makes sense for your ER site



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