Feasibility Study for Groundwater
Former TNT and Red Water Pond Areas
Plum Brook Ordnance Works
Sandusky, Ohio

Shaw Environmental, Inc.,
Knoxville, Tennessee

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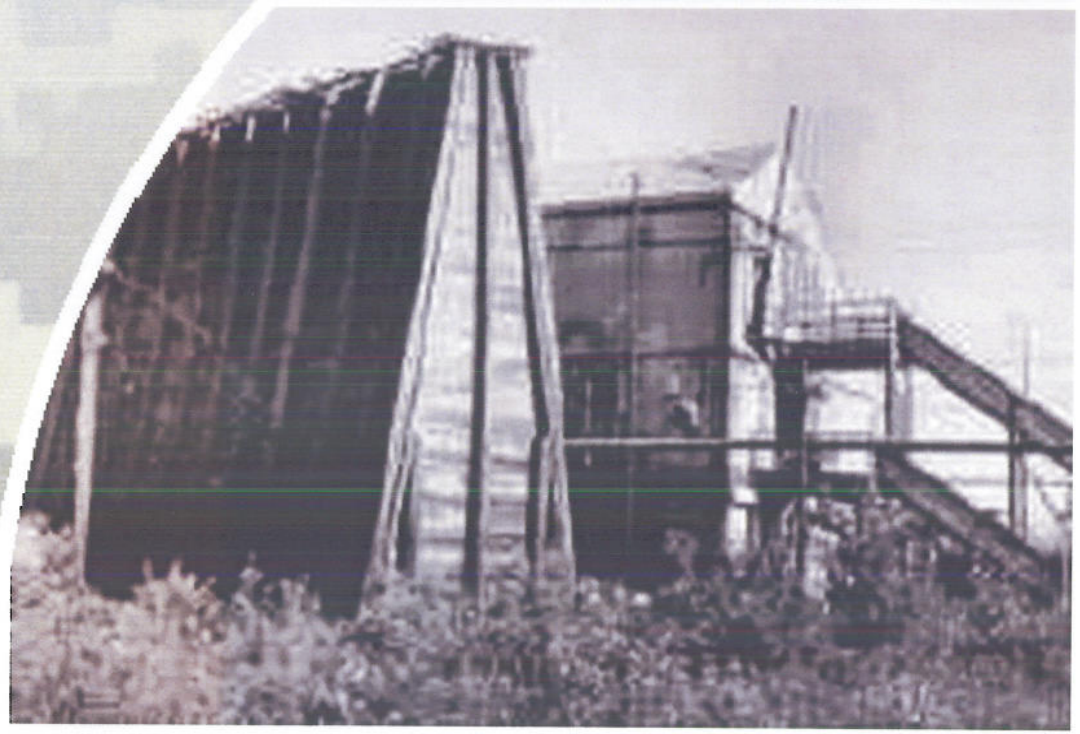

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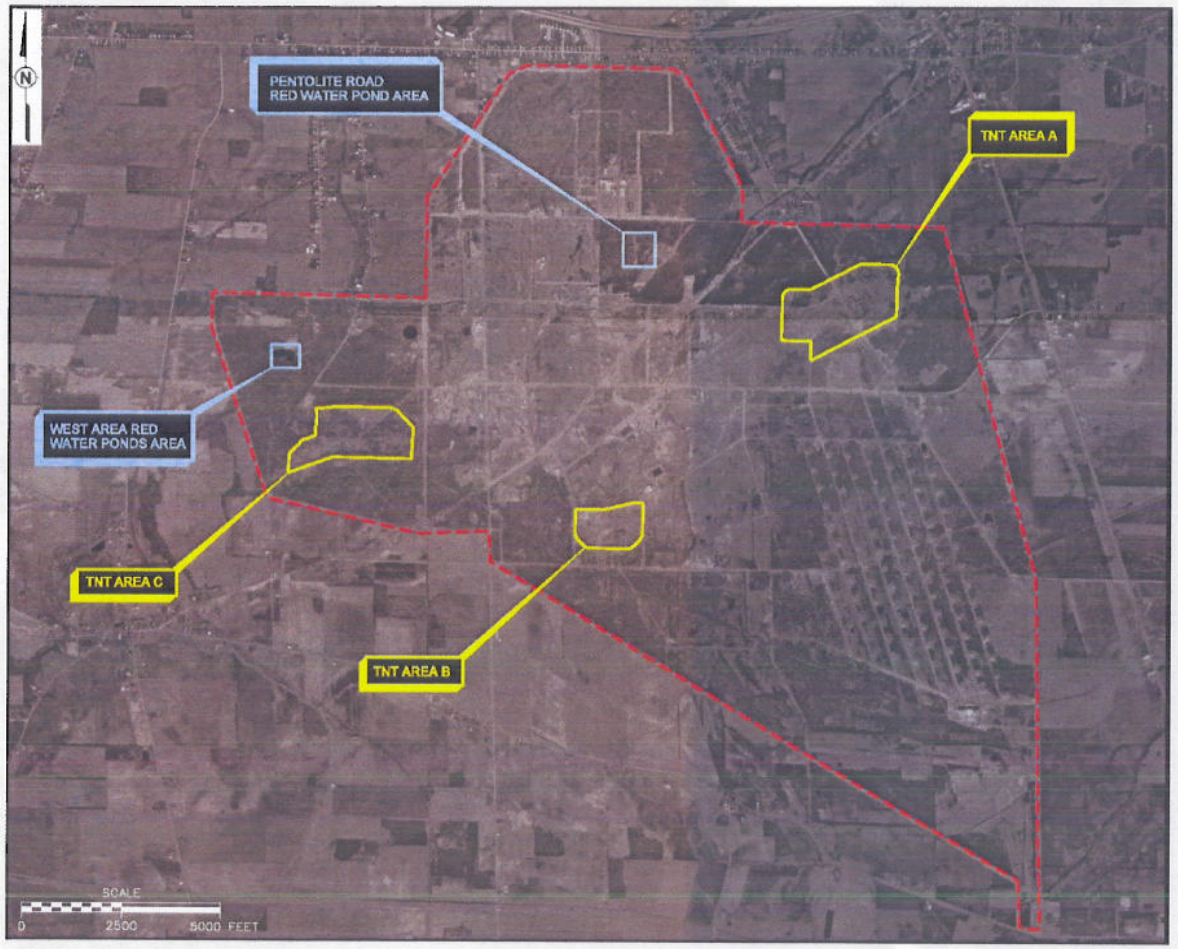
Outline

- Areas Evaluated
- Previous Investigations & Activities
- Soil Remediation
- Nature & Extent of Groundwater Contamination
- Remedial Action Objectives
- Screening of Remedial Action Technologies
- Comparative Analysis of Remedial Alternatives
- Groundwater Quality and Natural Attenuation
- Costs
- Conclusions

Areas Evaluated

- TNT Area A
- TNT Area B
- TNT Area C
- Pentolite Road Red Water Pond Area
- West Area Red Water Ponds Area

Site Locations



Previous Investigations & Activities

- Decontamination Activities at TNT Areas (1945 – 1963)
- Red Water Pond Area Investigations (1977 – 1991)
- Site-Wide Inspection (1993)
- TNT Areas Site Investigation and Focused Remedial Investigation at the Red Water Ponds (1994)
- Site-Wide Groundwater Investigations (1996, 1997, and 1998)
- Remedial Investigation/Focused Feasibility Study/Risk Assessment (1998 – 2002)
- TNTB Soil Remediation Activities
- Initial PRRWP Area Soil Remediation Activities

Soil Remediation

- TNTB – 12,156 CY removed from 13 building areas (2002 – 2006)
- PRRWP Area – ~8,000 CY remediated; ongoing investigation likely will result in additional remediation
- TNTA – 18 building areas identified for removal of approx. 17,200 CY (removal has not been performed)
- TNTC – 14 building areas identified for removal of approx. 9,200 CY (removal has not been performed)

Nature and Extent of Groundwater Contamination

- Aerial extent for groundwater contamination was determined based on a combination of:
  - » Analytical groundwater data
  - » Analytical soil data
  - » Former manufacturing activities
  - » Observations from completed soil remediation
  - » Groundwater modeling

Conceptual Site Groundwater Model

- **Major sources of contamination**
  - Drowning tanks
  - Red Water Ponds
  - Minor spills associated with piping and waste handling operations
- **Contaminant distribution**
  - Primarily locked up in overburden and weathered shale
  - No evidence for contamination in deeper competent shale
  - Groundwater contamination in Delaware Limestone primarily occurs at locations where the shale is thin or absent (Red Water Pond Areas)

Remedial Action Objectives and Remedial Goals

- RAOs were developed in the FS
  - Prevent on-site human exposure to groundwater containing COCs at concentrations that exceed Remedial Goals (RGs)
  - Prevent human exposure to downgradient off-site groundwater containing COCs at concentrations that exceed RGs
- These RAOs are based on potable use
  - Poor natural quality should prevent such use on site
- If site groundwater were to impact potable water (if existent at some downgradient location), the naturally occurring contaminants in this water would have to be greatly diluted by a source of higher quality
  - This dilution would also greatly decrease concentrations of the nitros in the downgradient water
  - Thus, potable RGs are overly stringent for protection of downgradient nonpotable groundwater.

Screening of Remedial Technologies

- Consistent with the *Guide for Conducting Remedial Investigations and Feasibility Studies Under CERCLA* (EPA, 1988), the following steps were involved in the screening process:
  - » Identify volumes or areas of contaminated media to which remedial actions might be applied
  - » Identify and screen technology process options to eliminate those that cannot be implemented at the site
  - » Assemble the representative technology process options into alternatives representing a range of treatment and disposal combinations

Screening of Remedial Technologies (cont'd)

- The following technology process options were screened:
  - » Long-Term Monitoring
  - » Monitored Natural Attenuation (MNA)
  - » Groundwater Extraction
  - » Discharge Options for Extracted Groundwater
    - – Discharge to a Publicly-Owned Treatment Works (POTW)
    - – Discharge to an existing NASA wastewater treatment plant on PBOW
    - – Direct discharge to surface water
    - – Re-injection
  - » Granular Activated Carbon
  - » *In Situ* Enhanced Bioremediation

Screening of Remedial Technologies (cont'd)

- The following technology process options were screened (continued):
  - Phytoremediation (Constructed Wetlands)
  - *In Situ* Chemical Oxidation
  - *In Situ* Chemical Reduction
  - Groundwater Use Restrictions
  - Apatite II
  - *Ex Situ* Biological Treatment
  - Air Stripping
  - Suspended Solids Removal

List of Remedial Alternatives for Groundwater

- A range of groundwater remedial alternatives was developed that meet the RAOs (Some more aggressive than others)
- The following 4 alternatives were selected for detailed evaluation in the FS:
  - GW-1: No further action
  - GW-2: Groundwater monitoring and institutional controls (ICs)
  - GW-3: In situ enhanced bioremediation/pump&treat (ISEB/P&T) for mitigation/protection of the Delaware Limestone bedrock groundwater, groundwater monitoring, and ICs
  - GW-4: ISEB/P&T for mitigation/protection of the overburden/shale and Delaware Limestone bedrock groundwater, monitoring, and ICs

GW-1: No Further Action

- A no-action alternative is required by the NCP as a baseline for detailed comparison
- Includes all planned (TNTA, TNTC, PRRWP Area) and completed (TNTB, PRRWP Area) soil remedial actions
- No further active remediation or monitoring would be conducted

GW-2: Groundwater Monitoring and Institutional Controls

- Includes all planned (TNTA, TNTC, PRRWP Area) and completed (TNTB, PRRWP Area) soil remedial actions
- No further active remediation would be conducted
- Implement a groundwater monitoring program
- Implement institutional controls which would restrict groundwater use

GW-3: ISEB/P&T for Mitigation/Protection of the Delaware Limestone bedrock groundwater, Groundwater Monitoring and Institutional Controls

- Includes all planned and completed soil remedial actions
- Implement a groundwater monitoring program
- Implement institutional controls which would restrict groundwater use
- ISEB in the overburden/shale groundwater for protection of the bedrock groundwater
- P&T for remediation of bedrock groundwater

GW-4: ISEB/P&T for Mitigation/Protection of the Overburden/Shale and Delaware Limestone Bedrock, Groundwater Monitoring, and Institutional Controls

- Includes all planned (TNTA, TNTC, PRRWP Area) and completed (TNTB, PRRWP Area) soil remedial actions
- Implement a groundwater monitoring program
- Implement institutional controls which would restrict groundwater use
- ISEB in the overburden/shale groundwater for remediation of the overburden/shale and protection of the bedrock groundwater
- P&T for remediation of bedrock groundwater

Groundwater Modeling

- TNT, 2,4-DNT and 2,6-DNT modeled under different simulations
- Vast majority of the modeled groundwater contamination is associated with existing overburden/shale groundwater (rather than potential soil leachate)
- Simulation of soil excavation with ISEB results:
  - Greatly reduced overburden/shale groundwater concentrations
  - No discernible effect on the Delaware Limestone bedrock concentrations

Groundwater Modeling (cont'd)

- Addition of P&T in the Delaware Limestone bedrock at Red Water Ponds results
  - Virtually no effect on maximum concentrations at the PRRWP Area
  - Would measurably reduce maximum concentrations in WARWP Area
  - Even after 150 years, maximum bedrock concentrations would remain above RGs, especially at the WARWP Area
  - Contamination would be contained to smaller areas.

Natural Groundwater Quality

- Overburden/Shale
  - Naturally elevated levels of chloride, sulfate, TDS, and sodium
  - Natural petroleum is present regionally in the shale
  - Undependable yield
- Limestone
  - Presence of naturally occurring petroleum at depth
  - presence of H_2S
  - Naturally elevated levels of sulfate

Natural Attenuation

- Movement of contamination appears to be impeded by the presence of shale
- Breakdown products co-occur with contaminants in the bedrock
- Geochemical conditions are favorable for the degradation of nitroaromatics
  - Dissolved $O_2 < 1$ mg/L
  - Oxidation-reduction potential ≤ 0.0 mV
- Summary: Natural attenuation is likely
  - Note that model does not consider chemical degradation
  - Further monitoring would be needed to confirm

Estimated Costs

- Alternative GW-1 – $0
- Alternative GW-2 – $1.4 to $3.0 M
- Alternative GW-3 – $11.1 to $23.8 M
- Alternative GW-4 – $13.7 to $29.4 M

(Above estimates reflect present worth costs)

Conclusions

- Most of the residual contamination modeled is associated with overburden/shale groundwater (not residual soil)
- Bedrock groundwater is present only in the two RWP Area (thin/absent shale)
- 4 Alternatives were developed including no further action
- P&T is not effective at reducing bedrock groundwater concentrations to below RGs, even after 150 years

Conclusions (cont'd)

- Further delineation is required if active remediation were selected to refine cost estimates
- Natural groundwater quality is undesirable regionally
- Geochemical conditions are conducive to natural degradation
- Monitoring with institutional controls only (GW-2) may be appropriate