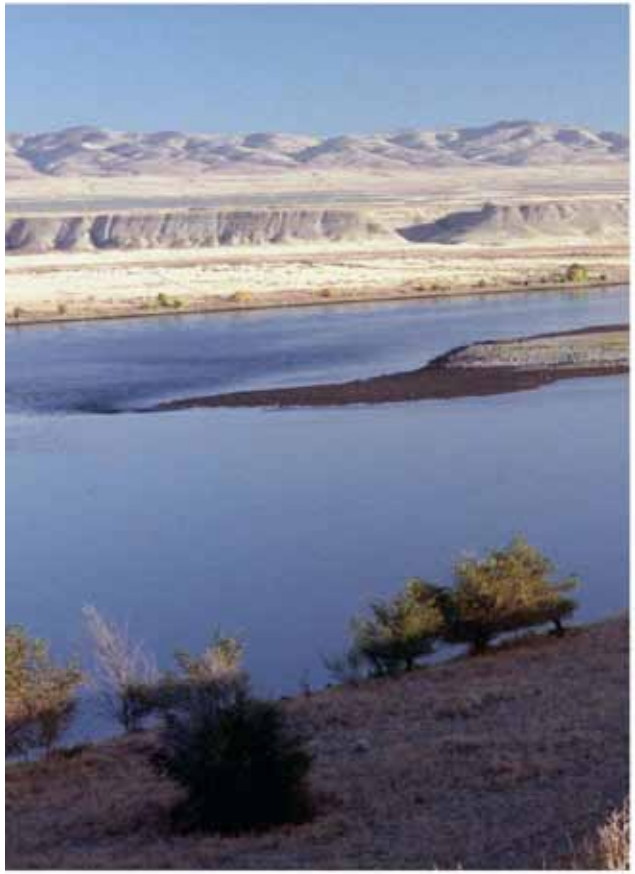
CH2MHILL
Plateau Remediation Company



General Response Action – Removal, Excavation Methods

Presented by: J. R. Schneider/T. A. DeBiase

Location: Shilo Inn, Richland, Washington
Date: June 7, 2011

U.S. DEPARTMENT OF ENERGY

General Response Action – Removal, Excavation Methods

General Description

- Excavation is advanced by using earthmoving equipment
- Overlying clean soil is removed and stockpiled
- Contaminated soil is removed and disposed
- Clean stockpiled soil is replaced to extent possible
- Excavation sides are sloped or supported
- Methods can be combined to achieve greater excavation depths

Potential Contaminants:
- All

General Response Action - Removal, Excavation Methods

- Three primary methods for deep excavations:
  1. Open excavation using sloping or benching
  2. Drilling and soil replacement
  3. Excavation with braced sidewalls, such as
     a. Sheet pile walls
     b. Soldier piles wall
     c. Diaphragm walls
     d. Soil nail walls
     e. Cast pile wall
     f. Caisson wall
     g. Other misc methods

Superior Foundation, Inc.

Technology - Deep Excavation with Sloping and/or Benching (Open Pit Mining)

General Description

- Excavation is advanced by using earthmoving equipment
- Excavation sides are sloped or benched
- Can be combined with shoring to achieve greater excavation depths

Potential Contaminants:
- All

Technology - Deep Excavation with Sloping and/or Benching (Open Pit Mining)

State of Development

- Mature - uses proven heavy equipment
- Depth is essentially unlimited

Limitations/Development Needs

- Large surface area impacted because of sloped sides and may also impact surface features such as tanks, piping, structures, etc.
- Requires large stockpiles and separate disposal facility

100-B-27

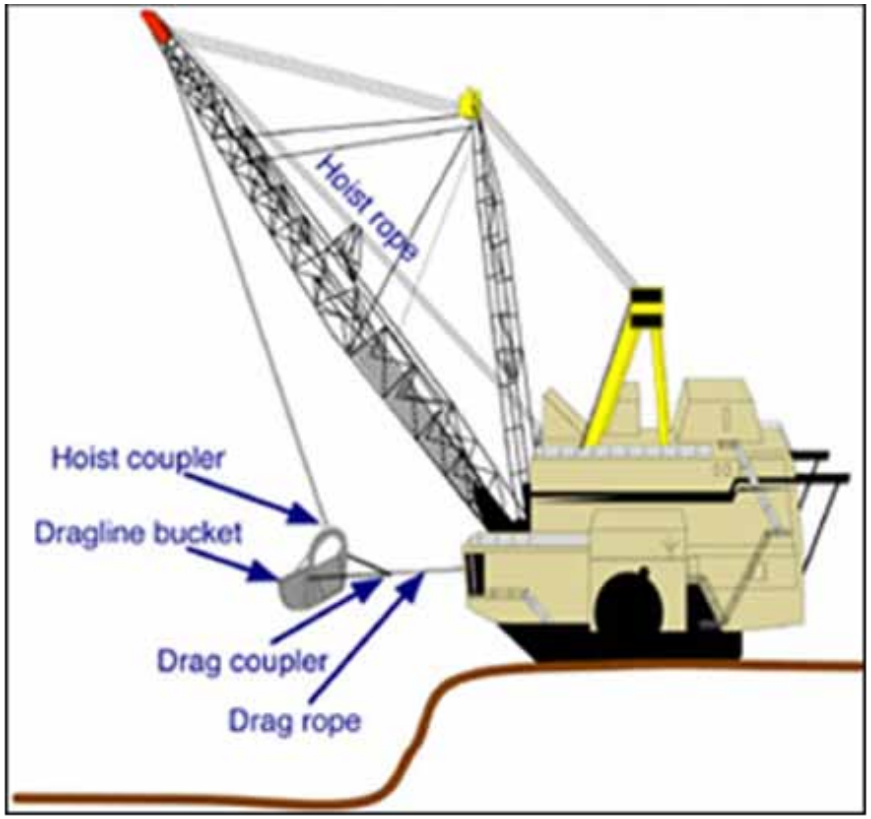
Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Dragline Excavators

General Description

- Excavation is advanced by using large draglines
- Walls are sloped or benched

Potential Contaminants:
- All



Technology - Deep Excavation using Dragline Excavators

Limitations/Development Needs

- Sloped sides & dragline size may impact surface features
- Requires large stockpiles and separate disposal facility
- Cannot practically be combined with shoring
- Equipment availability

P&H Cranes/Harnishfeger Corp.

Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Drilling and Soil Replacement

Potential Contaminants:
- All

General Description

- Large diameter holes are drilled to remove contamination
- Each hole is backfilled with a low strength soil-cement mixture that does not require compaction

Bored-Piles.com

Technology - Deep Excavation using Drilling and Soil Replacement

State of Development

- Mature - uses proven heavy equipment
- Large diameter borings have been drilled to over 200 feet at sites that included large cobbles

Limitations/Development Needs

- Large equipment is required
- Large number of borings required to cover a large area or very accurate knowledge of contamination required
- Excavation control is more difficult with greater depth (e.g. achieving vertical borings)
- Requires re-excavation of some previously placed backfill if borings must overlap to remove entire target

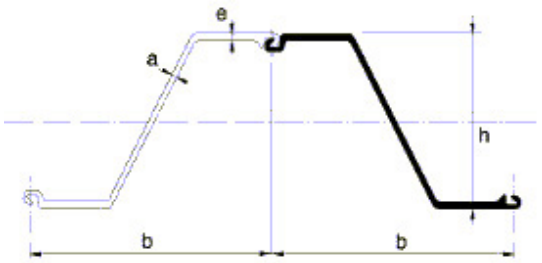
Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Sheet Piling

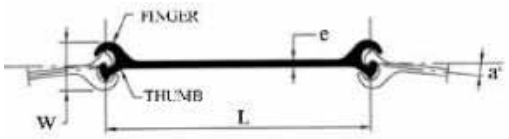
General Description

- Steel sheet piling with interlocking grooves at the sides are inserted into soil by hammering or vibrating
- Excavation uses conventional equipment

Potential Contaminants:
- All



Z Section



Flat Section

University of Syracuse, NY

Technology - Deep Excavation using Sheet Piling

State of Development

- Mature - uses proven equipment and materials
- Maximum depth is about 50 feet
- Walls can be supported or excavation can be stepped to achieve greater depths

Limitations/Development Needs

- Boulders and cobbles can prevent sheet pile insertion
- Wall support may be impractical at great depths

Dywidag Systems International/DSIAmerica

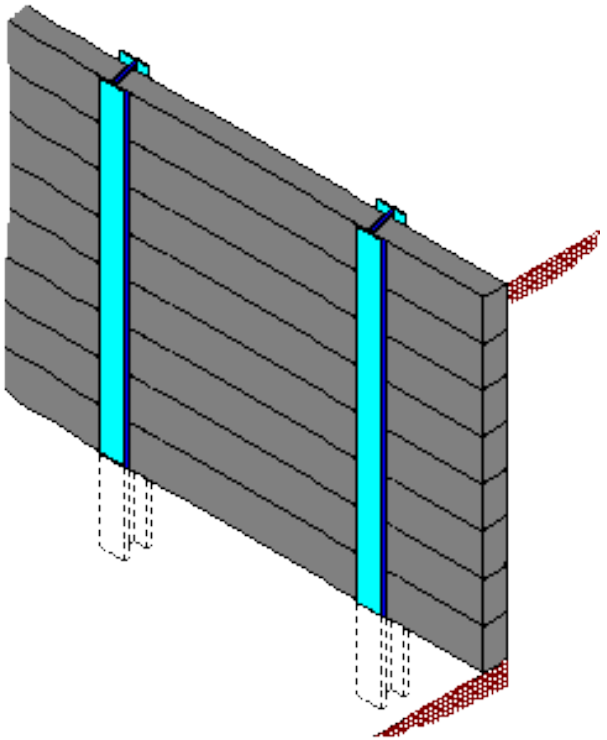
Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Soldier Pile and Lagging Wall

General Description

- Steel H-piles are inserted into soil at regular intervals by driving or by placing in drilled holes
- Timber or steel “lagging” is placed between the piles to support the ground as the excavation is advanced
- Excavation inside wall uses conventional equipment

Potential Contaminants:
- All



www.retainingwalldesign.com

Technology - Deep Excavation using Soldier Pile and Lagging Wall

State of Development

- Mature - uses proven equipment and materials
- Maximum depth is about 100 feet
- H-piles usually supported by anchors
- Excavation can be stepped to achieve greater depths

Limitations/Development Needs

- Boulders and cobbles can make vertical control difficult
- Loose material can make lagging insertion difficult

Neo Samwoo Vietnam Co., Ltd.

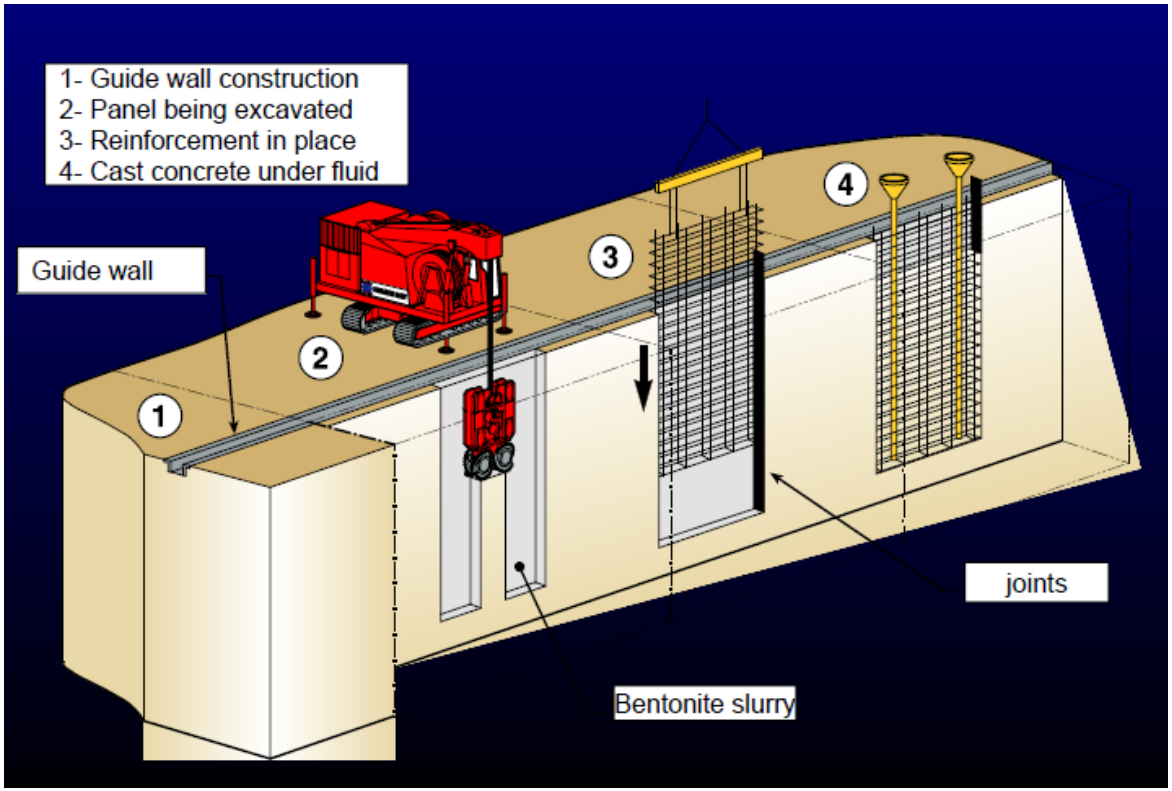
Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Diaphragm Walls

General Description

- Reinforced concrete wall constructed in panels
- Bentonite slurry is used to support each panel excavation
- Excavation inside wall uses conventional equipment

Potential Contaminants:
- All



Technology - Deep Excavation using Diaphragm Walls

State of Development

- Mature - uses proven heavy equipment
- Maximum depth is about 200 feet
- Wall is usually supported by anchors

Limitations/Development Needs

- Uses highly specialized equipment
- Slurry makes the work somewhat “sloppy”
- Wide corridor (75 - 100 feet) required along wall alignment

StroyInject, Bulgaria

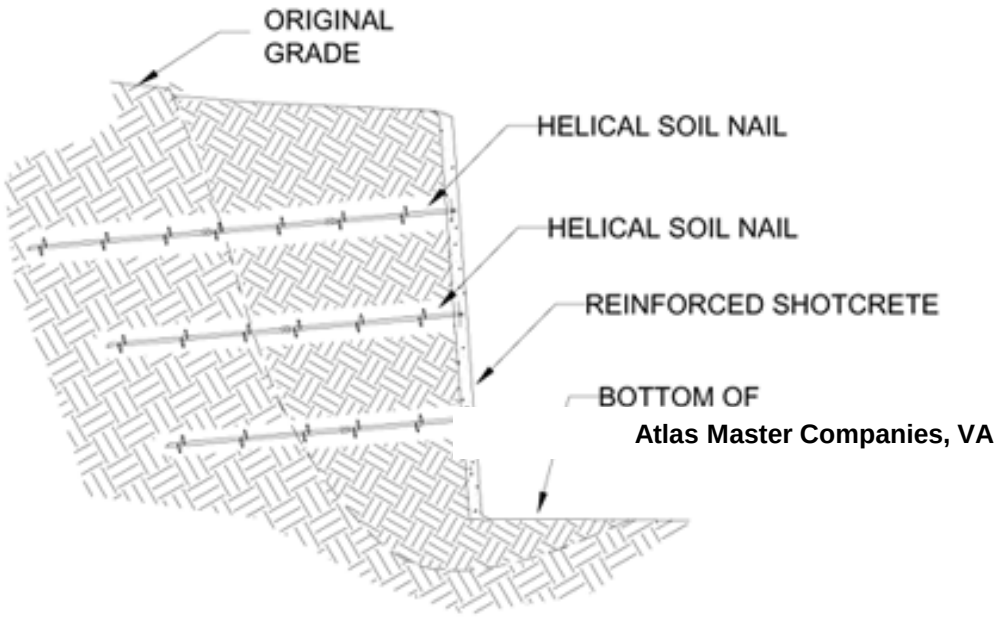
Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Soil Nail Walls

Potential Contaminants:
- All

General Description

- A shallow cut is made, and steel reinforcing bars are inserted into the cut face at regular intervals
- Wire mesh and sprayed-on concrete are applied to protect and support the face (other materials can be used)
- The process is repeated until target depth is reached



Atlas Master Companies, VA

Figure 4

Technology - Deep Excavation using Soil Nail Walls

State of Development

- Mature - uses proven equipment
- Limited to about 30-40 feet
- Excavation can be stepped to achieve greater depths

Limitations/Development Needs

- Requires cohesive soil and unsaturated or minimal water flow conditions

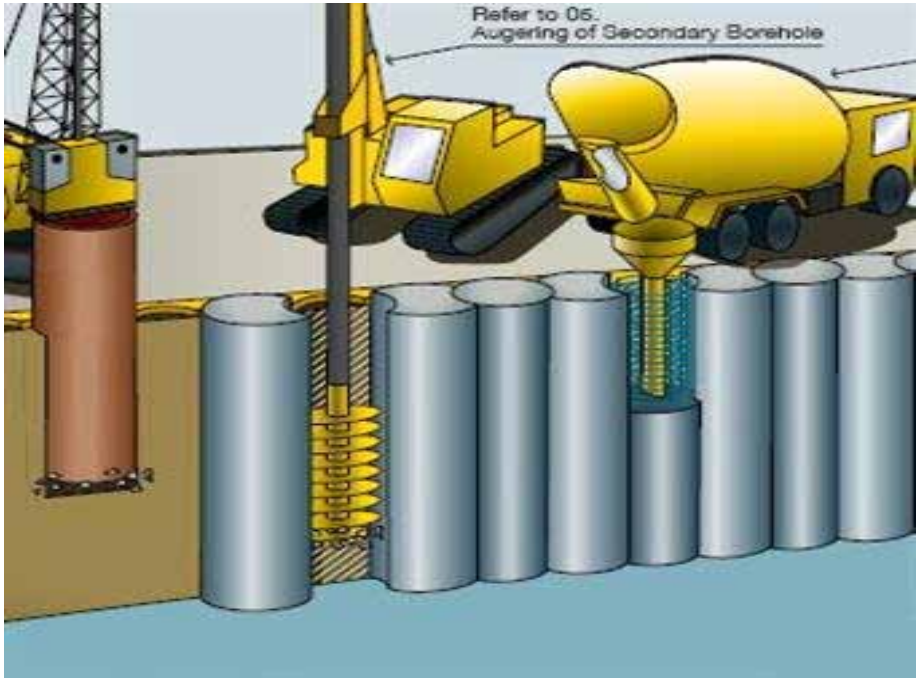
Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

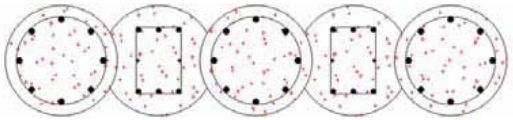
Technology - Deep Excavation using Secant Pile Wall

Potential Contaminants:
- All

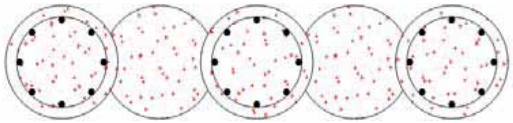
General Description

- Secant pile walls are formed by constructing intersecting drilled reinforced concrete piles
- Piles reinforced with steel reinforcing bars or H-piles





“Hard/Hard” Wall



“Hard/Soft” Wall

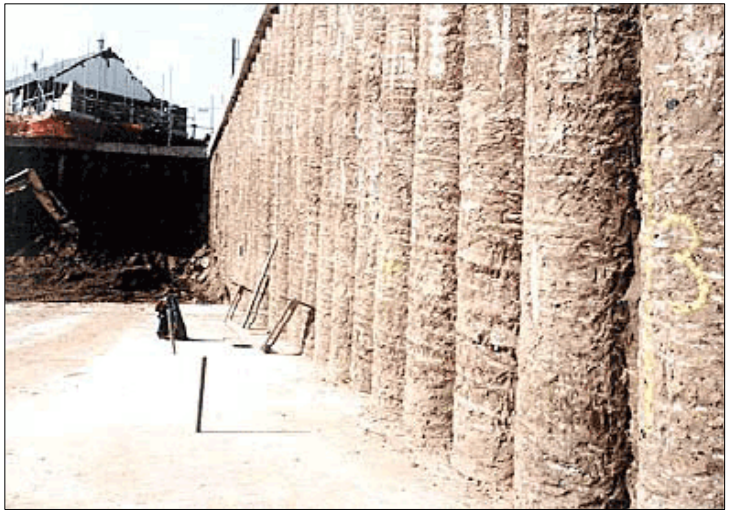
Technology - Deep Excavation using Secant Pile Wall

State of Development

- Mature - uses proven heavy equipment
- Maximum depth for single stage is about 50 feet; walls often anchored
- Excavation can be stepped to achieve greater depths

Limitations/Development Needs

- Vertical alignment control is critical and becomes more difficult with increasing depth and rocky ground



USDOT - FHWA

Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Tangent Pile Wall

Potential Contaminants:
- All

USDOT - FHWA

General Description

- Same as secant pile walls, except that piles touch but do not intersect

State of Development

- Mature - uses proven heavy equipment
- Maximum depth for single stage is about 50 feet; walls often anchored
- Excavation can be stepped to achieve greater depths

Limitations/Development Needs

- Vertical alignment control is critical and becomes more difficult with increasing depth and rocky ground
- More potential for gaps between piles than with secant pile wall

USDOT - FHWA

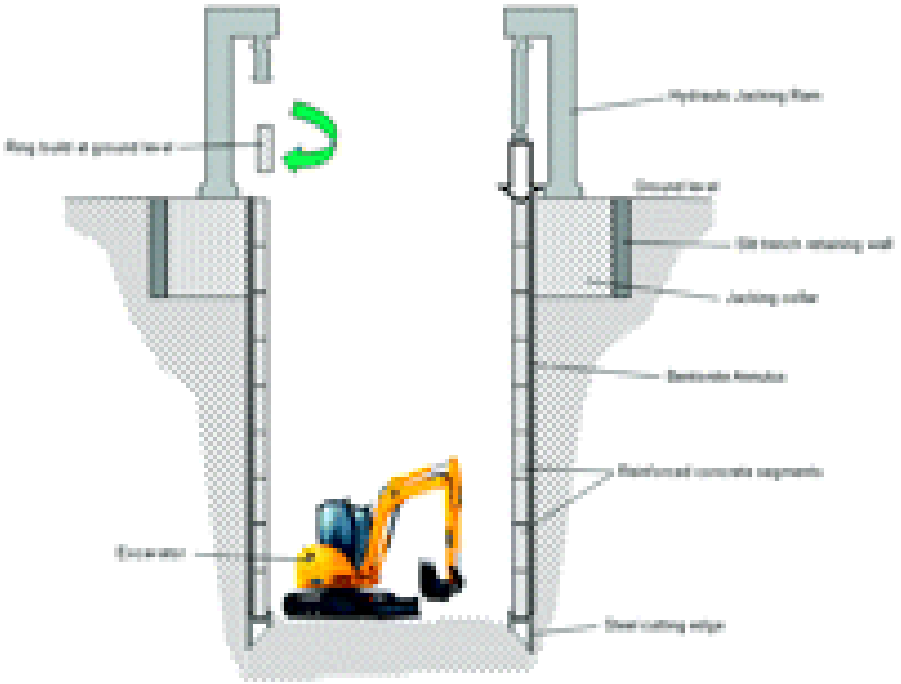
Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Caissons

General Description

- A reinforced concrete box open at the top and bottom is “sunk” into the ground by excavating inside
- More sections can be added on top to go deeper

Potential Contaminants:
- All



qjegh.lyellcollection.org

Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Caissons

Example 1 Acre Site, 200 ft deep:
- The required depth cannot be achieved.

State of Development
- Mature - uses proven heavy equipment
- Can be used where soil contains large boulders that obstruct penetration of driven or bored piles
- Maximum practical depth is about 80 feet

Limitations/Development Needs
- Complex construction; requires large equipment
- Caisson remains in place; area my be limited
- Caissons can hang on cobbles, boulders, dense soil, etc.
- Goes straight down only

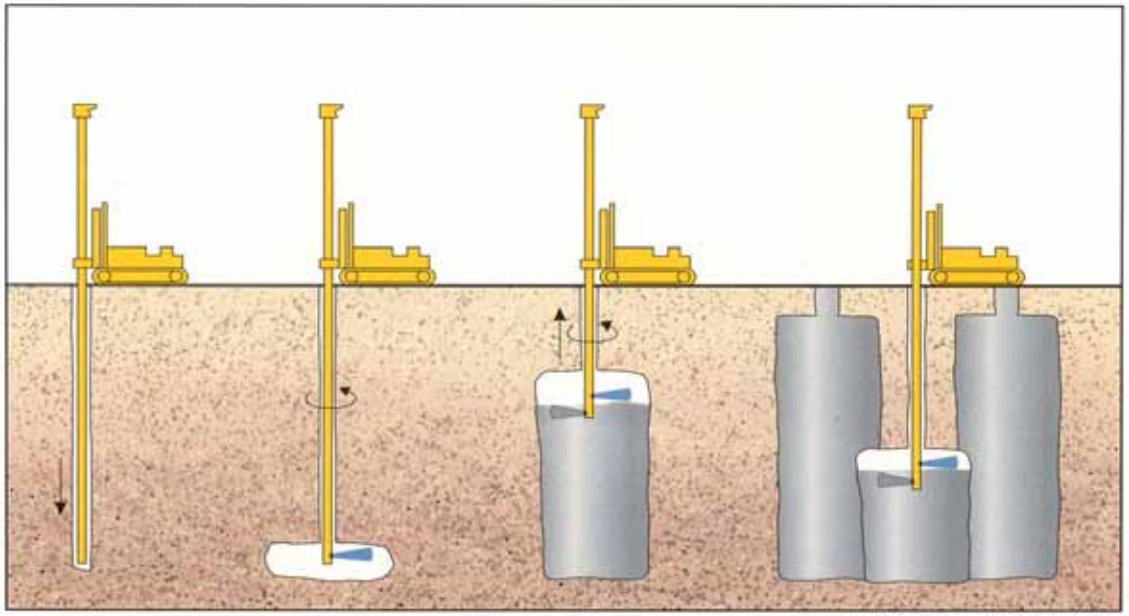
Ward & Burke, Ireland

Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Jet Grout Walls

Potential Contaminants:
- All

General Description
- One to three rows of grouted columns are formed by jetting grout horizontally under high pressure to form a wall
- Reinforcing may be placed in the center of each columns



Hayward Baker

Portland Cement Association

Technology - Deep Excavation using Jet Grout Walls

State of Development

- Mature - uses proven heavy equipment
- Wall may be laterally supported
- Maximum depth for single stage is about 50 feet; walls often anchored
- Excavation can be stepped to achieve greater depths

Limitations/Development Needs

- Vertical control is critical and becomes more difficult with increasing depth and rocky ground
- Complete mixing may not be achieved, and thus wall many not have required strength

Spie Fondation, France

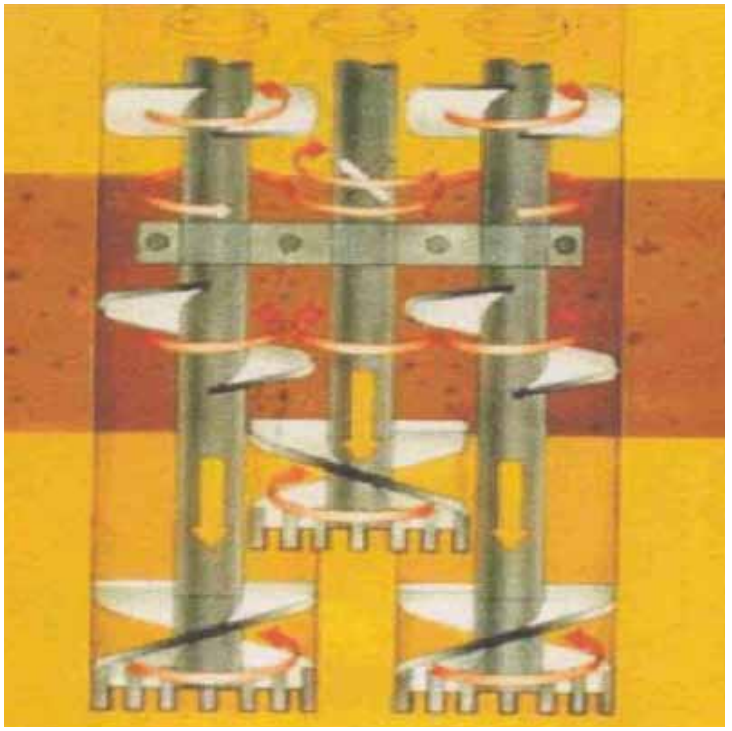
Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Deep Mixed Walls

Potential Contaminants:
- All

General Description

- Multi-auger mixers are used to mix Portland cement grout with in-place soils in panels; panels overlap
- H-piles can be inserted for reinforcement



Technology - Deep Excavation using Deep Mixed Walls

State of Development

- Mature - uses proven heavy equipment
- Wall may be laterally supported
- Practical limit is about 50 feet
- Excavation can be stepped to achieve greater depths

Limitations/Development Needs

- Generates substantial volumes of excess excavated material due to bulk swell and fluid injection
- Vertical control and panel overlap can be difficult

Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Reinforced Concrete Walls

Potential Contaminants:
- All

General Description

- Excavation is temporarily supported using methods such as sheet piles, soils nails, soldier piles, etc.
- Reinforced concrete wall is constructed to support the ground; wall may be anchored into the ground
- Method usually used for permanent construction

Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Reinforced Concrete Walls

State of Development

- Mature - uses proven heavy equipment
- Can remove impacted materials that can be reached

Limitations/Development Needs

- Intended for permanent support

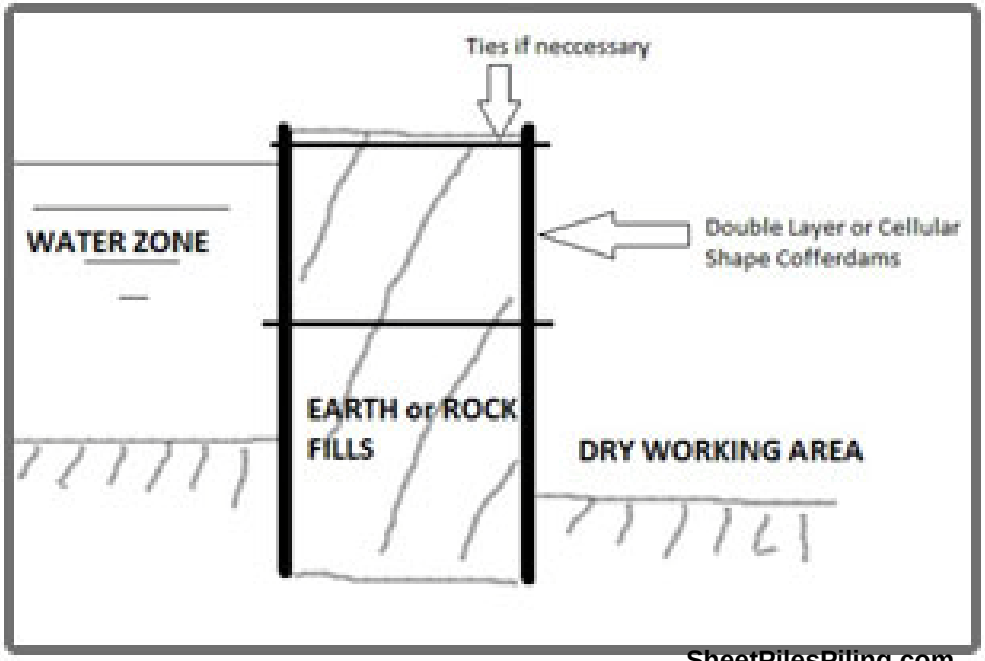
Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Cofferdams

Potential Contaminants:
- All

General Description

- Sheet-pile, tangent pile, secant pile, or diaphragm walls are constructed in circular or rectangular shapes to enclose an earth mass
- Internal bracing or anchoring may be used
- Use to support heavy vertical and horizontal loads (normally used near water bodies)



SheetPilesPiling.com

Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Cofferdams

State of Development

- Mature - uses proven heavy equipment
- Limited to about 40 feet
- Excavation can be stepped to achieve greater depths

Limitations/Development Needs

- Wall is much thicker since it relies on gravity instead of anchors to prevent overturning

CJ Mahan Construction Company

Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Tunneling

General Description

- Tunnel is created by full-face excavation, boring machine, pipe jacking, or other conventional tunneling technique
- Completely enclosed tunnel except for access openings

Potential Contaminants:
- All

TunnelTalk.com

Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology - Deep Excavation using Tunneling

State of Development

- Mature - uses proven heavy equipment
- Access shafts will be required, or tunnels must be sloped
- Can remove impacted materials that can be reached

Limitations/Development Needs

- Large cobbles and boulders will impact the selection of tunneling equipment/techniques
- Excavation of unconsolidated materials can be difficult since material is not self-supporting

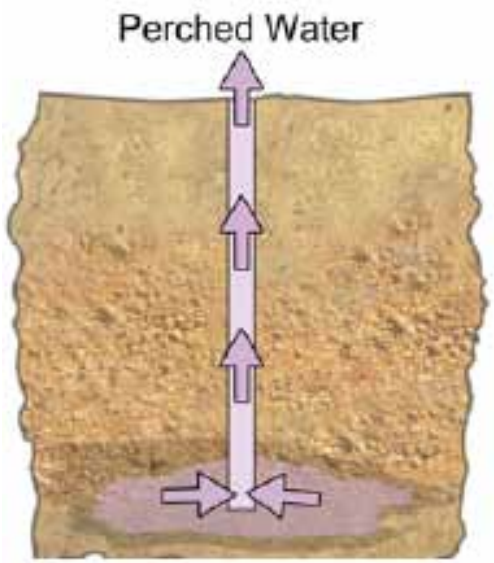
TunnelTalk.com

Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology – Perched Water Removal

General Description

- Water perched above low-permeability areas within the vadose zone is pumped before it migrates to groundwater
- Wells must be correctly placed to adequately capture the extent of the perched water



Potential Contaminants:
- U, Tc-99, Cr(VI)

Perched Water Extraction Pilot Test at B Complex

Technology – Perched Water Removal

State of Development

- Technology is well proven; currently being deployed in the B Complex

Limitations/Development Needs

- Low flow rates and delays to allow recharge can extend remediation time
- Perched water is ephemeral (transitory)

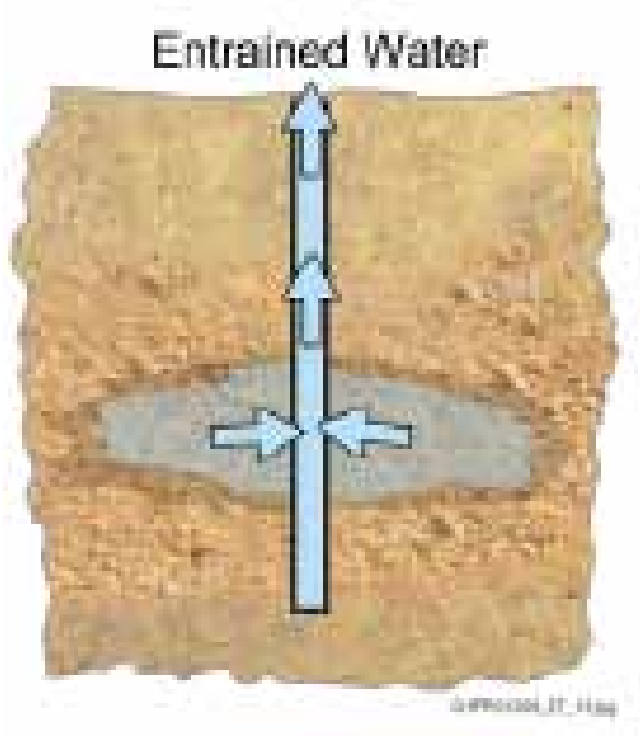
Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology – Pore Water Extraction

General Description

- Subsurface water within the unsaturated zone containing mobile contaminants is extracted
- Soil gas with entrained water is extracted from the subsurface through a well using high vacuum to induce high vapor extraction rates

Potential Contaminants:
- All



Technology – Pore Water Extraction

State of Development

- Pore water extraction is being evaluated in a pilot test planned for the 200 East Area of the Hanford Site

Limitations/Development Needs

- Pore water is difficult to completely remove; some contaminants will adsorb to the soil and not move freely with the pore water
- Need to optimize recovery rates and determine the effectiveness in removing pore water held in tighter formations

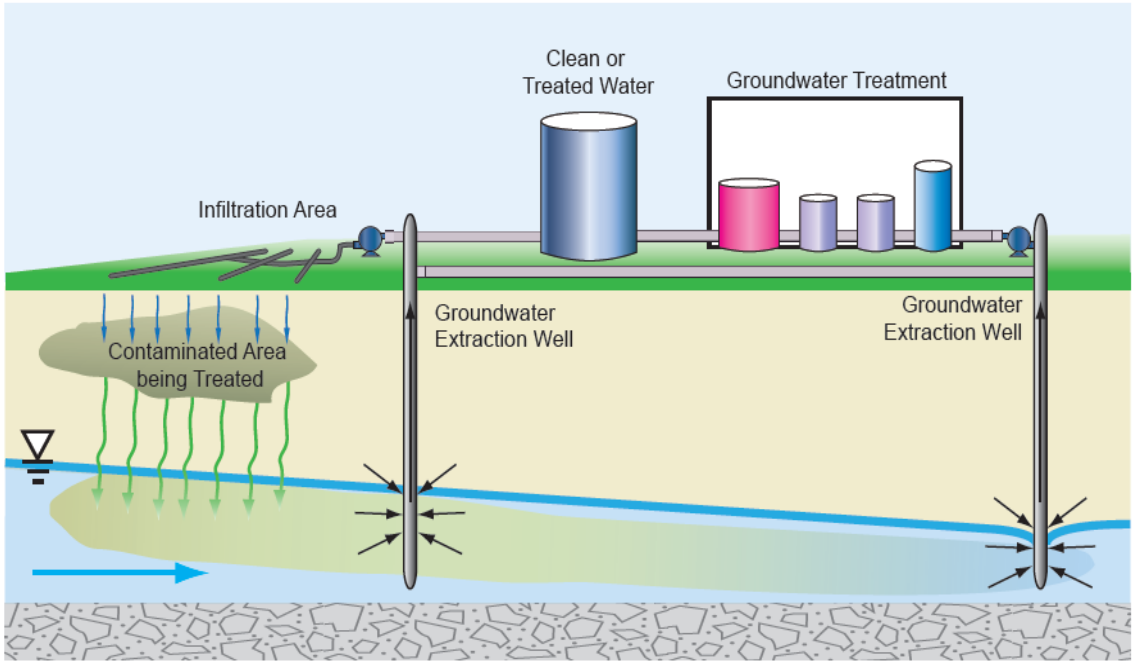
Lab Testing Only	**Field Testing Only**	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology – Soil Flushing

General Description

- Mobilization of contaminants with water so they can be removed and treated or disposed
- Surfactants or other chemical additives may be used to enhance solubilization of contaminants

Potential Contaminants:
- All



In-Situ Soil Flushing using Treated Water (http:\www.epa.gov\

Technology – Soil Flushing

State of Development

- Mature technology for shallow applications

Limitations/Development Needs

- Can only be applied where soil has sufficient permeability to allow circulation and recovery of flushing solution
- Soil heterogeneity can prevent optimum contact and decrease reliability
- Requires flushing through thick vadose zone with effective capture of contaminants in groundwater

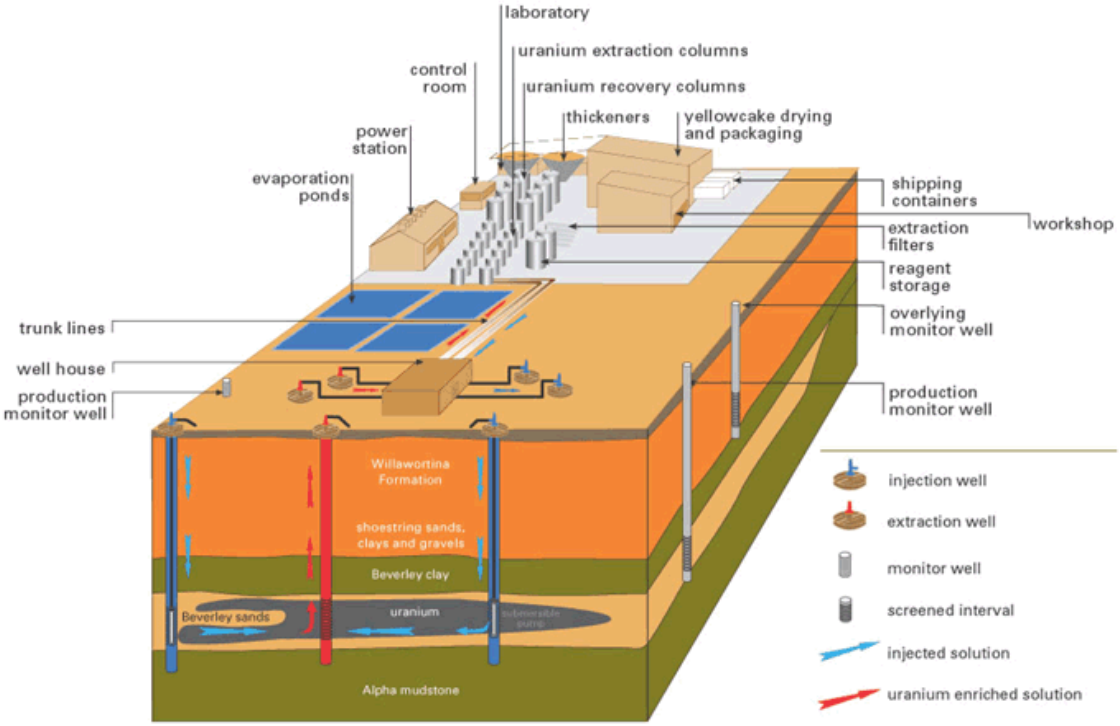
Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready

Technology – In Situ Uranium Recovery

General Description

- Recovers uranium by dissolving it with a solution and pumping the solution to the surface for removal. This technology is most widely used for uranium mining in saturated conditions.

Potential Contaminants:
- U



In Situ Uranium Recovery Process (http:\www.world-nuclear.org\)

Technology – In Situ Uranium Recovery

State of Development

- Proven technology for in situ uranium mining
- No known applications for to remedy uranium contamination

Limitations/Development Needs

- Technology has not been known to be applied successfully in vadose zone strata above a water table
- Spatial heterogeneity in the subsurface makes complete recovery and control of leachate very difficult using extraction wells

Lab Testing Only	Field Testing Only	Limited Field Application	Remediation Ready (limited application)	Remediation Ready