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Session 6 Groundwater Basics

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Session 6 Agenda: Groundwater Basics

- Introduction
- Groundwater Monitoring Plan
- Groundwater Characteristics
- Monitoring System Design and Construction
- Monitoring System Construction
- Sampling and Analysis

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Introduction

- Ultimate Goal
  - Evaluate adequacy of groundwater monitoring requirements for RCRA Permit Application
- Session Goal
  - Highlight basic groundwater principles to improve understanding of groundwater monitoring requirements and ultimately ensure that the groundwater monitoring plan is capable of early detection of a release from a unit

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Four Considerations for a Groundwater Monitoring Plan

1. Groundwater Characteristics

- Aquifer identification
- Hydraulic gradients
- Determination of groundwater flow rate and direction

2. Monitoring System Design

Represent the quality of:

- Background groundwater
- Groundwater passing the point of compliance

Must allow for the detection of contamination when hazardous wastes or hazardous constituents from unit reach groundwater

3. Monitoring System Construction

- Installation/type of wells
- Integrity of casing
- Screening and gravel pack
- Annular seal

4. Sampling and Analysis Procedures

Must include:

- Sample collection
- Sample preservation and shipment
- Analytical procedures
- Chain of custody control

Methods must be appropriate and accurately measure hazardous constituents in groundwater

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Groundwater Characteristics

- Aquifer Identification
  - Confined
  - Unconfined
  - Perched
  - Semi-confined
- Groundwater flow rates
  - Hydraulic conductivity
  - Hydraulic gradient
    - Vertical and horizontal

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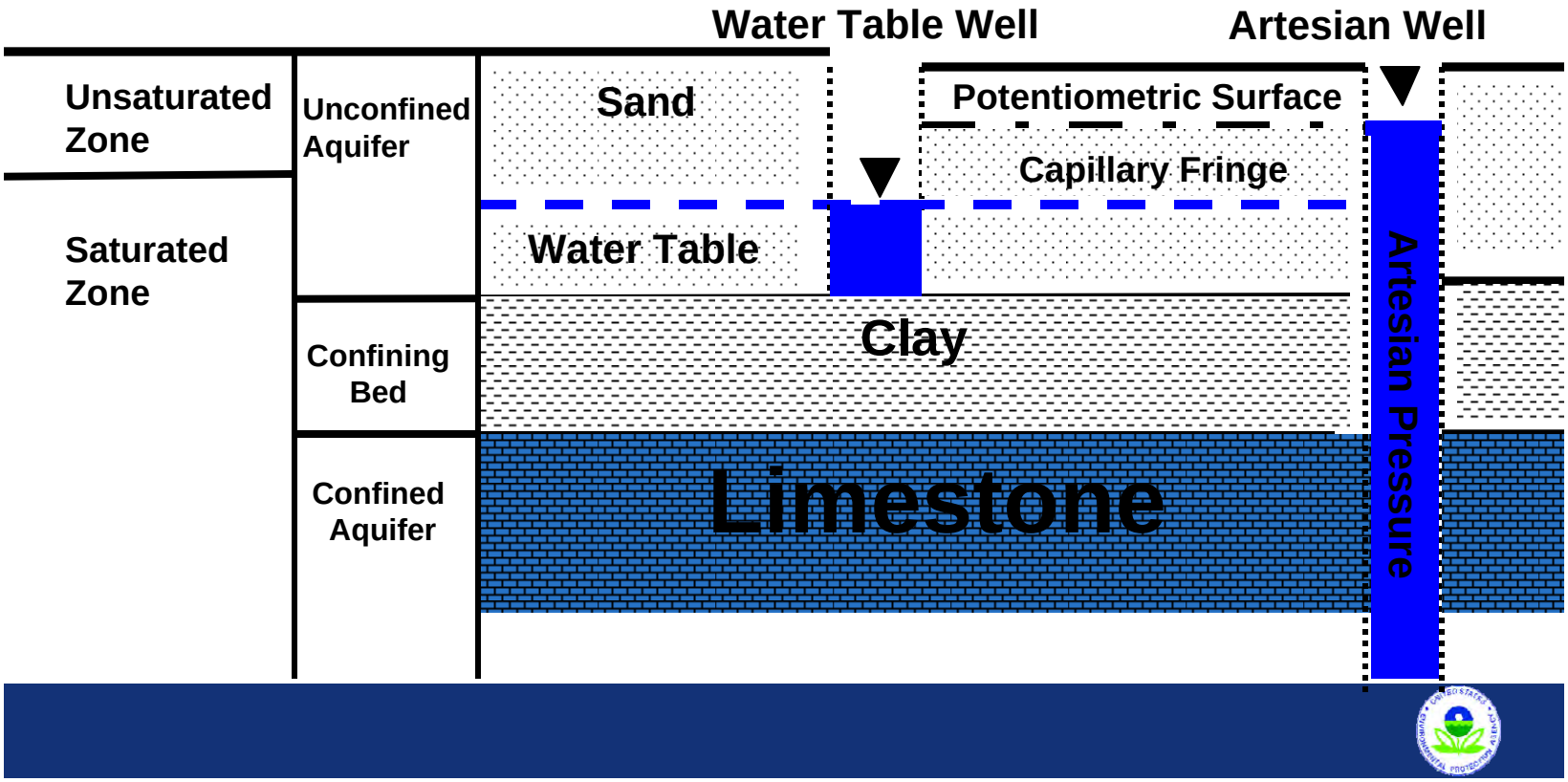
Groundwater Characteristics (cont.)



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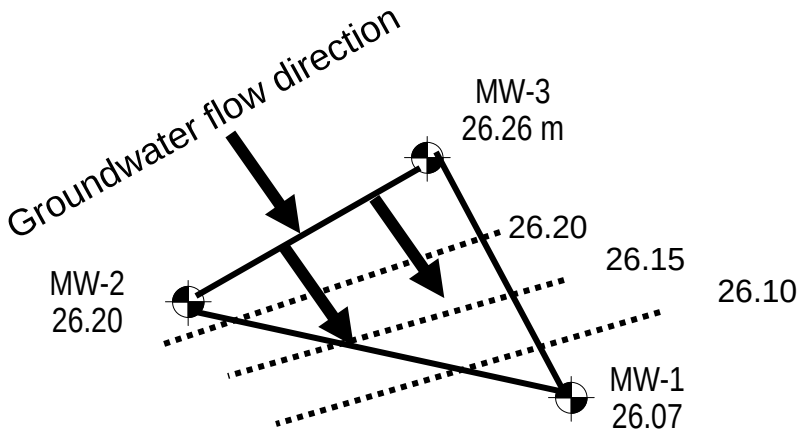
Groundwater Characteristics (cont.)



Calculating direction of groundwater flow direction and hydraulic gradient

1. Need a minimum of three wells
2. Need horizontal distance between wells
3. Identify well with intermediate water level (MW-2 26.20m below ground surface [bgs])
4. Determine where 26.20 m (bgs) is on the line between MW 1 and MW 3
5. Perpendicular line to the dashed line is flow direction
6. Hydraulic gradient is calculated using the change in head over change in horizontal distance

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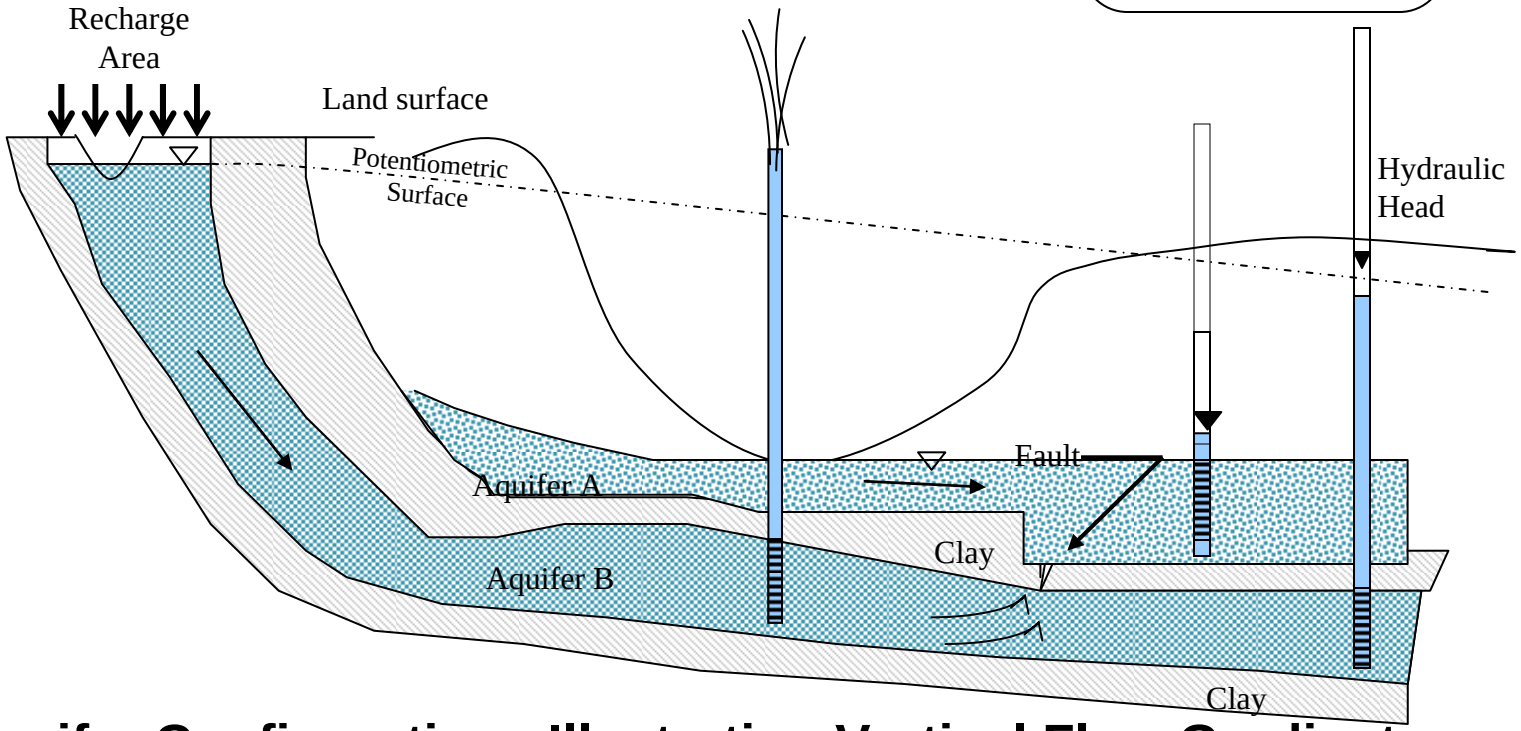
Groundwater Characteristics (cont.)

Since the potentiometric surface of Aquifer B is higher than that of Aquifer A, there is an upward vertical gradient present in the area of the fault.



Aquifer Configurations Illustrating Vertical Flow Gradients

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Groundwater Characteristics (cont.)

- Groundwater Flow Rate
  - Dependent on hydraulic conductivity (K) and hydraulic gradients
- Hydraulic Conductivity (K)
  - Rate in distance over time (M/Sec) at which water moves through a permeable medium
  - Can be measured using aquifer tests or can use literature values
  - More porous the medium the higher the conductivity
    - Gravel and sand have high conductivity; clays and shale have lower conductivity

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Monitoring System Design

- Considerations for Well Design and Location
  - Sufficient wells properly located to yield both background groundwater quality and water quality passing the point of compliance
  - Location of point of compliance well(s)
  - Background groundwater quality
  - Ability to determine groundwater flow direction
  - Consider vertical and horizontal gradients
  - Contaminants being monitored such as DNAPL and LNAPL

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Monitoring System Design (cont.)

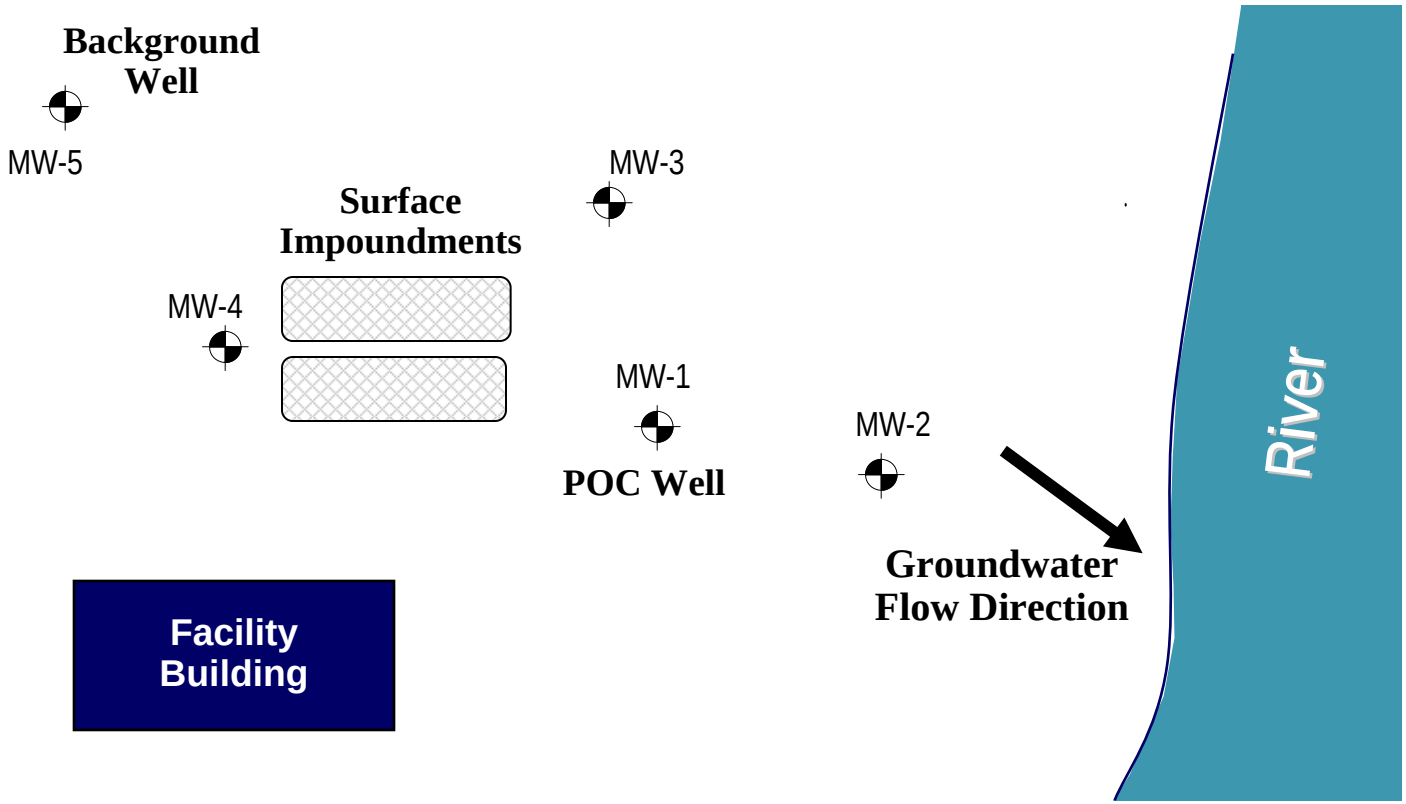

Illustration of Point of Compliance (POC)

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Monitoring System Design (cont.)

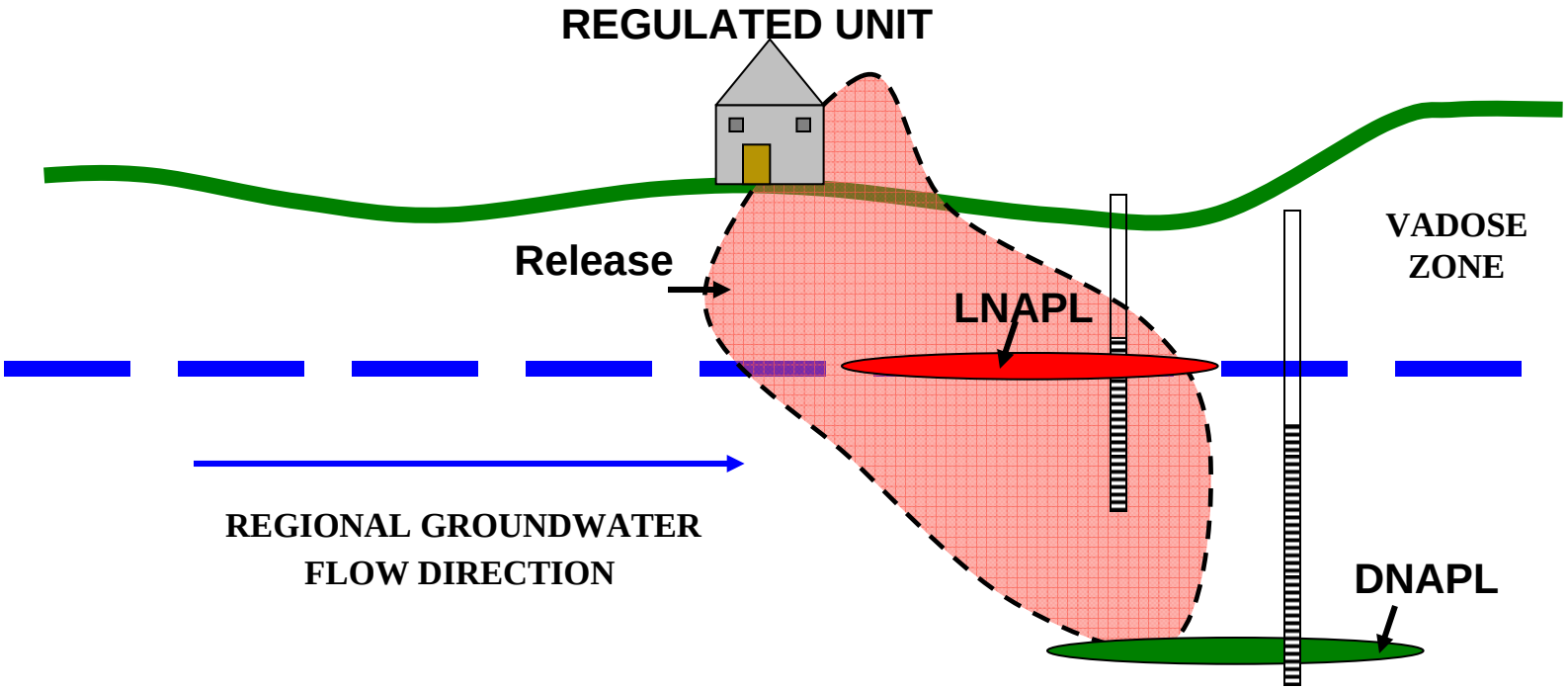

Illustration of vertical placement of wells and screens

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Monitoring System Construction

- Considerations for Well Construction
  - Installation methods and type of wells
  - Integrity of casing
  - Screening and gravel pack
  - Annular seal

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Monitoring System Construction

- Well Installation Methods
  - Hollow-Stem Augers
  - Mud Rotary
  - Air Rotary
  - Reverse Circulation
  - Rotasonic
  - Direct Push/Hydro Punch

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Hollow-Stem Augers

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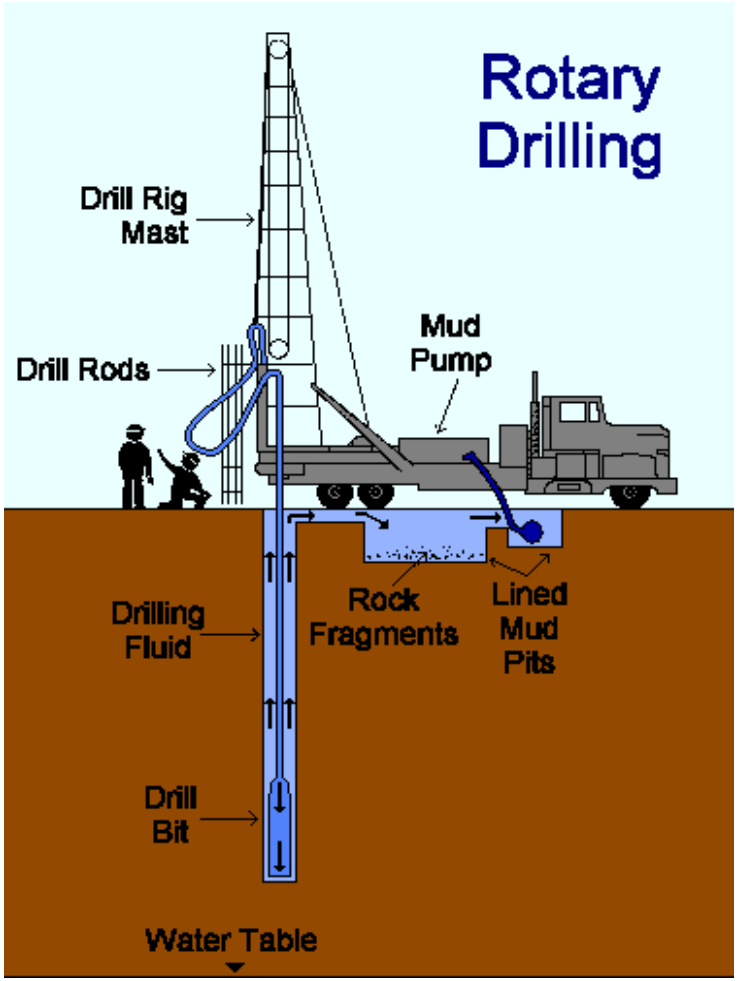
Mud Rotary



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Rotasonic

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Geoprobe

- Truck-mounted

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Summary – Subsurface Investigatory Tools

Tool	Advantage	Limitation
Hollow-Stem Auger	- Monitor well construction - All types of soils - Relatively simple and inexpensive	- Only unconsolidated formations - Limited to 100 to 150 feet in depth - Borehole smearing
Mud Rotary / Reverse Circulation	- Consolidated and unconsolidated formations - Virtually unlimited depth	- Drilling fluids required - More complicated
Air Rotary	- Consolidated and semi-consolidated formations - No drilling fluids needed	- Air may impact saturated zones - Air discharge may need filtration
Rotasonic	- True continuous sampling - Little or no investigation derived waste (IDW) - Rapid drilling rates	- Expensive - Not readily available
Direct Push Technology	- Fast – many sample points in one day - Relatively inexpensive - Reduced IDW	- Only unconsolidated formations - Fine to medium-grained material only - Water samples are for screening purposes

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Monitoring System Construction

- **Well Casing Design and Material**
  - Polyvinyl Chloride (PVC)
  - Polytetrafluoroethylene (PTFE)
  - Stainless Steel (Type 304 or Type 316)
  - New and as chemically inert as technically possible
  - Diameter should allow commonly available equipment to be used to collect appropriate quantities of water (commonly 2” or 4”)
- **Casing/Screen Thickness**
  - PVC and PFTE casing should be at least Schedule 40 or meet Standard Dimension Ratio (SDR) 26
  - Stainless steel casing thickness should withstand anticipated formation and hydrostatic pressures

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Monitoring System Construction (cont.)

- Types of Well Screens
  - Only commercially fabricated
  - Factory slotted
  - Continuous-slot
  - Wire-wound
- Select appropriate slot size - based on grain size data
  - Silt use 10 slot (0.010 inch slots)
  - Sand and gravel use 20 slot (0.020 inch slots)
- Screen length (TEGD recommends 5 to 10 feet)
- Silt trap/sump required (not to exceed two feet in length)
- Placed at the aquifer of interest

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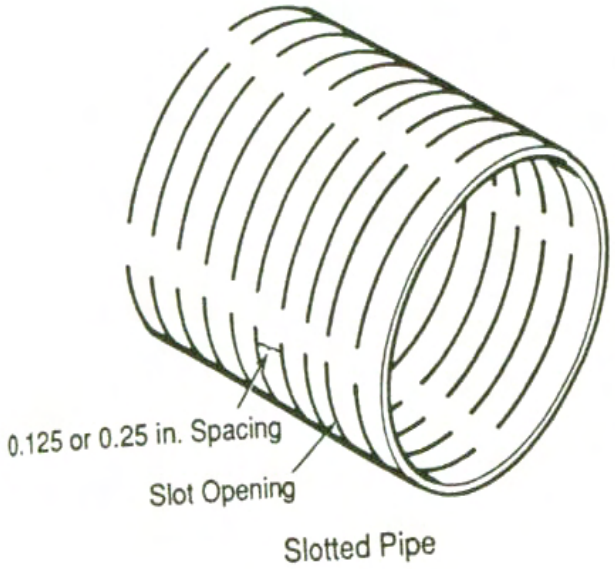
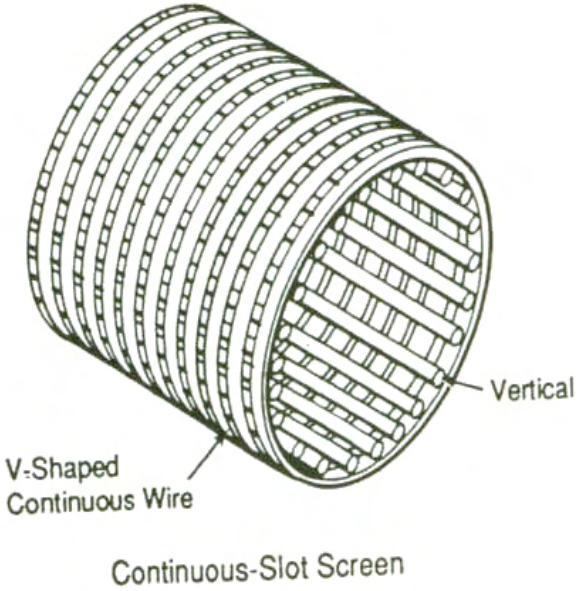
Monitoring System Construction (cont.)

Examples of Well Screens





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Monitoring System Construction (cont.)

- Filter Pack Composition
  - Washed and contaminant free
  - 95%+ siliceous material (quartz)
  - Water-soluble material not to exceed 1%
  - Inert
- Filter Pack Construction
  - Should extend from the base of the sump to a minimum of two feet above the screen
  - “Sugar” sand (fine sand) may be placed above the filter pack
  - Use tremie pipe to place the filter pack material

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Monitoring System Construction (cont.)

- Bentonite Seal
  - Protect monitored zone against surface infiltration of contaminants and cross contamination between permeable zones
  - Required to be two feet in thickness
  - Allow a minimum of eight hours to hydrate before grouting
- Annular seal materials
  - Cement-bentonite grout—Portland cement, bentonite, and potable water
  - High solids bentonite—designed for grouting

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Monitoring System Construction (cont.)

- Grout
  - Mechanical mixing of grout is recommended
  - Grout weight should be verified and recorded within + or – 0.2 pounds per gallon of the desired/appropriate weight
  - Grout should be placed using a rigid, side discharge tremie pipe and grout pump from the top of the bentonite seal to the ground surface
- Types of Surface Completions
  - Above-ground
  - Flush mount

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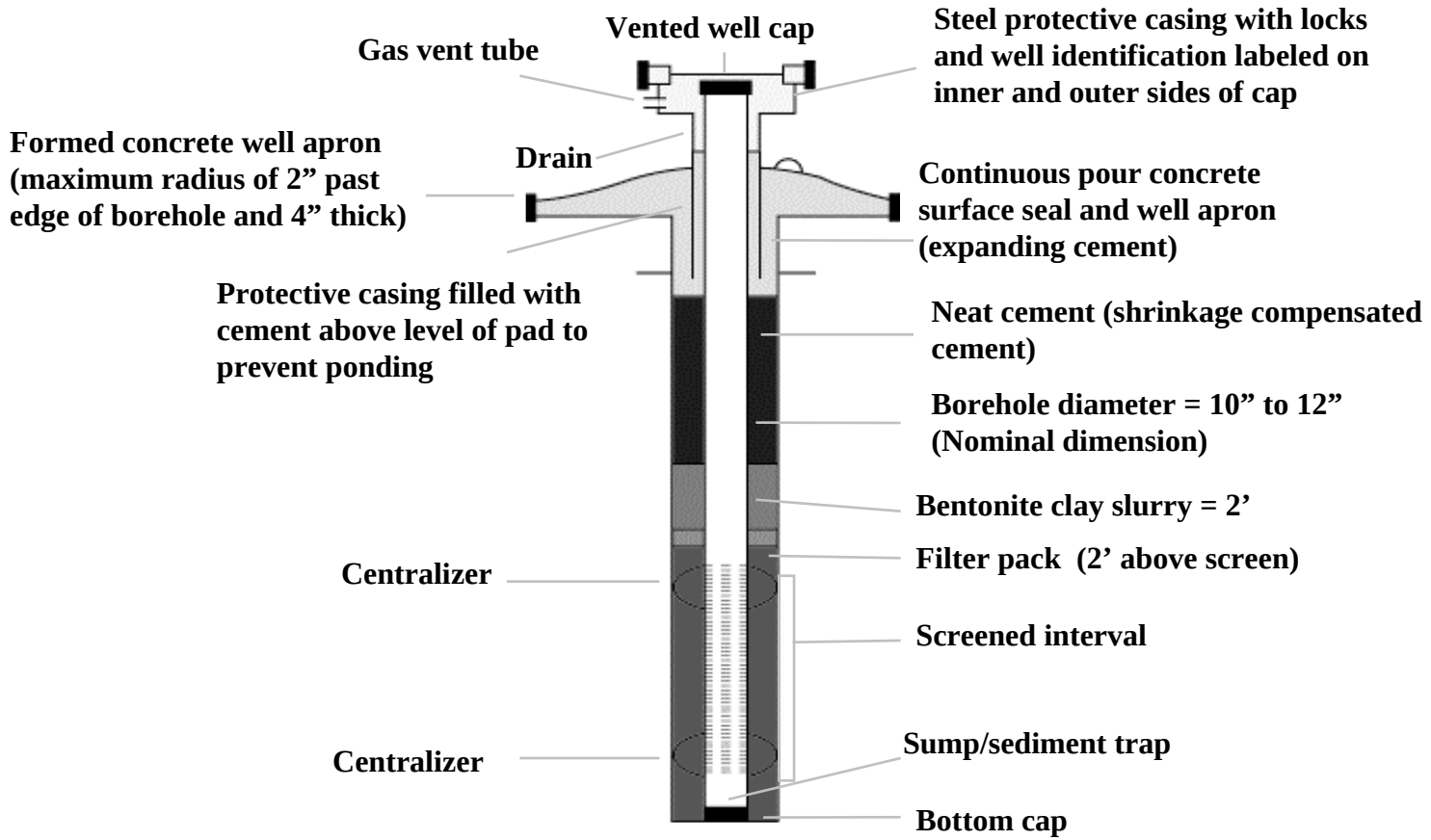
Typical Monitoring Well Construction



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Sampling and Analysis

- Considerations for sample collection and analysis
  - Equipment decontamination
  - Static water level measurements
  - Well purging/sample withdrawal
  - Quality assurance samples
  - Preservation, shipment and chain of custody

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Sampling and Analysis (cont.)

- Equipment Decontamination Goal
  - Eliminate cross contamination of samples
- Required Steps
  - Physical removal
  - Detergent wash – lab grade, non-phosphate (e.g., Alconox)
  - Tap water rinse
  - Deionized water rinse
  - Air dry
- Optional Steps
  - 10% nitric acid rinse
  - Solvent rinse – pesticide grade (e.g., hexane)

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Sampling and Analysis (cont.)

- **Static Water Level Measurements Measure prior to purging**
  - To 0.01-foot increment
  - Reference vertical datum (e.g., above mean sea level)
  - Measure inner casing
  - Steel tape/sounding device
  - Immiscible layers (i.e., LNAPLs)

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Sampling and Analysis (cont.)

- **Well Purging/Sample Withdrawal**
  - Bailers
  - Low-Flow Pump
  - Hydrasleeve
  - Peristaltic Pump
  - Bladder Pump
  - Diffusion bag

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Summary – Groundwater Collection Devices

Collection Device	Advantage	Limitation
Bailers	- Low cost - No depth limit - Disposable	- Physically demanding - Chemical alterations to GW - Grab samples only
HydraSleeve	- Low cost - Disposable - No purge water	- Samples discreet interval - Not appropriate for low-yield wells
Peristaltic Pump	- Relatively low cast pump - Easy to operate - Easy decontamination	- GW > 25 ft in depth - Negative displacement - Low pumping rates
Bladder Pump	- Easy to operate - Continuous sampling - Little chemical alteration to GW	- Relatively expensive - Requires compressed gas - Decontamination
Submersible Centrifugal Pump	- Easy to operate - Continuous sampling - Little chemical alteration to GW	- Relatively expensive - Requires power source
Permeable Diffusion Bag	- Low cost - Disposable - No purge water	- Samples discreet interval - Not appropriate for low-yield wells - Not appropriate for some compounds

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Sampling and Analysis

- **Sample order**
  - Volatiles
  - Semi-volatiles
  - Metals
- **Preservatives**
  - Typical – Acid, Refrigeration < 4°C
  - Method-specific

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Sampling and Analysis (cont.)

- **Sample Collection - QA/QC Requirements**
  - Trip blank
  - Equipment blank/rinsate
  - Field Duplicates
  - Field/Ambient Blank
  - Matrix Spike/Duplicates

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Sampling and Analysis (cont.)

- Analytical Method Selection should consider
  - Site history (e.g., landfill, refueling station, or vehicle maintenance)
  - Historical analytical data for site soils and groundwater (e.g., data from PA/SI or RI/FS)
  - Historical analytical data from upgradient sites that may impact groundwater quality
  - Regulatory criteria applicable to groundwater monitoring at the site
  - Background contaminants

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Sampling and Analysis (cont.)

- Documentation
  - Chain-of-custody
  - Sample labels/tags
  - Custody seals
  - Field logbook