What is a Multilevel Groundwater Monitoring System?

Monitoring Well Cluster

Multilevel Well

Source: Schlumberger
Multilevel Systems

- **Major systems are on the market**
  - Model 401 Waterloo Multilevel System (Solinst)
  - Westbay (Schlumberger)
  - Water FLUTe™ (Flexible Liner Underground Technologies, Ltd. Co)
  - Solinst Continuous Multichannel Technology (CMT) system
  - All are good quality and widely used

- **Other systems not covered in this presentation**
  - BESST Barcad and ZIST
The decision to use a multilevel system is driven by the site conceptual model that includes elements, such as:

- Project objectives
  - Need to characterize complex site conditions
- Hydrogeology
  - Depth to water
  - Aquifer Thickness
- Stratigraphy
- Vertical and lateral extent of groundwater contamination
Site Characterization Using Multilevel Well Data
Comparison of Vertical Head at Wells EPA-1 and EPA-2
Selection of a Multilevel Groundwater Monitoring System
Selection Considerations

- Sustainability
- Equipment downhole
- Surface support equipment
- Water level monitoring
- Groundwater sampling
- Post installation problems
- Operations and maintenance
- Decommissioning

- Driller support (subcontractor)
- Layout area
- Construction procedure
- Installation issues
- Surface completion
- Development
Advantages of a Multilevel System

- Depth discreet water quality and water level elevation data
- Reduced footprint/increased sustainability
  - Install one well with many ports versus multiple borings and wells
- Reduced drilling costs/increased sustainability
  - One borehole
  - Reduced investigation derived waste (IDW)
  - Deal with difficult drilling conditions one time
- Reduced sampling costs relative to the same number of conventional wells
Disadvantages and Assumptions of a Multilevel System

♦ Disadvantages
  » Requires specialized support equipment and training
    › Waterloo and FLUTE™: gas drive pump/bladder pump
    › Westbay: wire line tool
  » Limited use as observation wells during aquifer testing

♦ Assumptions
  » All systems assume that ambient groundwater flow maintains representative groundwater at the sampling port
  » Stakeholders must agree
Waterloo System

Installation in an open borehole

Installation in a well

Monitoring fracture zones

Source: Solinst
Westbay System

- **Packer** - reliable seal for a range of borehole sizes
- **Measurement port** - for fluid sampling and in-situ measurement
- **Casing**: variable lengths
- **Pumping port** - hydraulic conductivity testing and purging

Source: Schlumberger
Design of a Multilevel Groundwater Monitoring System
Design Considerations

♦ **A good multilevel system design is based on:**
  » Good site conceptual model
  » Clear objectives
  » Vertical and lateral hydrostratigraphic data
  » Groundwater quality data

♦ **Overburden:**
  » Lithologic and groundwater sampling during borehole drilling using direct push, sonic drilling, or hollow stem auger

♦ **Bedrock:**
  » Rock core, air rotary, casing advance
  » Borehole geophysical logging
  » Packer testing or fluid sampler
Design Considerations

♦ Optimum borehole or well diameter
♦ Installation in open borehole or well in bedrock
♦ Installation in unconsolidated formation
  » Direct burial
  » Completion inside well
♦ Number of ports
♦ Port interval length
♦ Maximum depth of installation
♦ Packer system
Design Using Packer Testing and Borehole Geophysics
Construction: Waterloo System
Waterloo System Advantages

♦ Gas drive sampling (double valve or bladder pump)
♦ Practical to obtain large sample volumes (important at Superfund sites)
♦ Can run a “low-flow” type method and collect water quality parameters
♦ Minimizes IDW
♦ Proven technology
Waterloo System Disadvantages

♦ Relatively complicated installation process

♦ Requires significant work area
  » Equipment must be laid out on ground

♦ Transducers and pumps are downhole
  » Cannot be recovered in the event they fail (unless removable packers are used)

♦ Water level readings: can take instantaneous readings but can’t use a data logger.

♦ Can’t do slug tests

♦ Tubing vulnerable to kinks during installation
  » Kinks only discovered during final testing before packer inflation
Waterloo System Layout
Waterloo Components Going Downhole
Pump, Transducer and Port Installation

Bladder Pump
Transducer
Sampling Port
Waterloo Sampling
Westbay System Advantages

♦ Relatively simple installation
♦ Requires relatively small work space
♦ Transducer and sampler are on a wire line
♦ Joints are pressure tested during installation
♦ Packers are inflated with water to a specific pressure
♦ Transducers can be installed in each port to monitor water levels
♦ Can be converted into a monitoring well open to one zone for long term water level monitoring using transducers and slug testing
♦ Minimizes IDW
♦ Long term maintenance requirements are low
♦ Proven technology
Westbay System Disadvantages

- Requires specialized sampling equipment (subcontractor)
- Instrumentation for pumping test very complicated/expensive
- Interval cannot be purged before sampling
- Maximum volume per trip is 1 liter
- Not always possible to obtain reliable water quality data especially dissolved oxygen (DO)
- Technology is static
Westbay Equipment Layout
Packer Installation and Pressure Testing
Westbay Sampling Equipment
Construction: FLUTE System
FLUTE™ System Advantages

♦ Liner seals entire borehole wall
♦ Relatively simple installation process
♦ Relatively small work area
♦ Gas drive sampling
♦ Practical to obtain large sample volumes
♦ Can run a “low-flow” type method and collect water quality parameters
♦ Minimizes IDW
♦ Innovative company
♦ Proven technology
FLUTe™ System Disadvantages

- Pumps are downhole
  - Transducers can be installed downhole or at the surface
- Fabric liner can tear on sharp bedrock borehole wall
- Water must be purged from gas lines to obtain current water level readings
- The water level inside the liner must be checked and maintained above the static head in the formation
- Can’t conduct slug tests
- Transducers can be used for long term water level monitoring but implementation is complex
Water FLUTe™ and Blank Liner
FLUTe™ Installation

Installation sequence:
- Fully lined hole
- Tether
- Excess head in liner
- Liner

Removal sequence:
- Nearly removed
- Reel
- Inverted liner

Installation sequence:
- Removal sequence
FLUTe™ Installation
Construction: CMT
Continuous Multi-Channel System
CMT Advantages

♦ Inexpensive – one piece construction
♦ Standard screen/seal well construction
♦ No packers needed
♦ Can be installed in rough/collapsing boreholes
♦ Up to 7 ports per boring
♦ Very flexible port/screen length
♦ Samples collected by peristaltic or inertial pumps
CMT Disadvantages

- One piece construction – challenging for deep installations
- Very small port size
- Difficult to develop/potential for clogging
- Very small channel size
- Limited ability to instrument
- Requires inertial pump if water table is deep
- Can be difficult to obtain large volume samples
CMT Construction
Site Characterization Using Multilevel Well Data
Site Characterization Using Multilevel Well Data
Comparison of Vertical Head at Wells EPA-1 and EPA-2
Takeaways

- Select a multilevel groundwater sampling system based on:
  - Project objectives
  - Hydrogeologic conceptual model
  - Site conditions

- Design of a multilevel system requires significant hydrogeologic and groundwater quality data collection and analysis

- Construction of multilevel systems is a team effort requiring input from the site manager, vendor, consultant, and drilling subcontractor

- When properly selected, designed, and constructed multilevel systems provide a cost effective alternative to conventional monitoring wells.
Questions?
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