Monitoring Well Construction

Presenter: Art Becker, MGWC, CPG, Past President NGWA
President of Drilling and Safety Consultants LLC

Meeting logistics

- ❖Please turn off cell phones or switch to vibrate
- ❖Presentation will be approximately 50 minutes with a 10 minute question and answer period
- ❖The continuing education course credit code will be announced at the end of the presentation
- ❖Nearest rest room location
- ❖Nearest Emergency Exit location

About your instructor

- Graduated with a degree in Geology from Rutgers The State University, New Brunswick, NJ.
- Drilling experience – worked in domestic, commercial, industrial and municipal water well drilling, construction dewatering, and environmental drilling. Certified Professional Geologist # 9001. 32 years experience in environmental drilling.
- Started environmental drilling company in 1985, sold company to a global Swiss based firm, SGS, in 1991. Managed SGS Environmental Drilling Division for 17 years and retired. Licensed driller in 11 states. Current Chairman of the New Jersey State Well Drillers and Pump Installers Examining and Advisory Board. NGWA certified Master Ground Water Contractor.
- Current - Owner of Drilling and Safety Consultants LLC. providing business, drilling, safety and administrative consulting services for clients in the drilling industry.

About our students taking this course:

- Drilling contractors…
- Scientists and Engineers…
- Manufacturers and Suppliers…
- Students…
- How may have been involved with the installation of monitoring wells

Overview

- This course will provide ***"general information"*** on the drilling methods, design, construction, materials and installation procedures of monitoring wells. Specific drilling methods, design, construction materials and installation procedures will vary from project to project.
- In this course the term "monitoring well" will be as applied to investigation of potentially contaminated or known contaminated sites.
- Monitoring wells typically are one to four inches in diameter and ten to five hundred feet in depth.
- The specific requirements for installation and construction of monitoring wells will vary from state to state and can be subject to federal requirements if the client is a federal government entity (i.e. EPA, Army Corp, Military Base/Facility, etc.)

Before you drill…

- Do you have detailed well specifications from client
- Do you have a signed contract with payment terms
- Did you call for the "utility mark out" (811)
- Are private "client owned" facilities and utilities marked out
- Do you have the required permits (local, state, federal) for the well installations
- Is there a "site specific" health and safety plan outlining safety requirements and worker PPE

Before you drill... (continued)

- Is your drill team compliant with the OSHA training and medical surveillance requirements as per CFR 1910.120 for working on this site
- Do you have the correct PPE (personal protective equipment)required for this site
- Do you have a written drilling safety program for the tasks you will perform at this site
- Do you have a plan for handling and managing IDW (Investigation Derived Waste)

Preparation to drill

- Have you made an assessment of the local geology in which these wells will be drilled
- Have you made a selection of drill equipment needed
- Is there a potable water source on site, if not where can you get potable water for drilling and well construction
- What are the soil sampling requirements, do you have the correct soil sampling equipment in your inventory (split spoons, macrocore, etc.)

Preparation to drill (continued)

- Do you have the well casing and screen materials in stock for the well construction (PVC, stainless steel, fiberglass, etc.)
- Do you have the specified filter sand in stock
- Do you have the specified grouting materials and grouting equipment
- Do you have the specified well protectors in stock (stick up protectors, manholes, vaults, etc.)

Typical Drilling methods utilized for monitor well installation

I will provide general information for the utilization of the drilling methods listed below for monitor well construction and installation. There are other drilling methods that can be utilized for monitoring well construction and installation, however, the objective of this course is to identify and discuss those methods that are most commonly used in the industry.

- Auger drilling - Hollow stem augers
- DPT (Direct Push Technology)
- Mud rotary
- Air rotary
- Sonic

Auger Drilling – HOLLOW STEM

- Drill bit looks like a large screw (conveyor)
- Cuttings lifted (excavated) by flights of screw, flight sections are 5 ft. long
- Generally limited to shallow wells (0 to 100 ft.), diameter (8 to 16 inches O.D.; 4 to 12 inches I.D.) soft formations (unconsolidated)

Auger Drilling – HOLLOW STEM (continued)

- Well is installed inside the hollow portion of the auger
- Auger is withdrawn (pulled- not rotated) from borehole as filter pack and grout is installed
- Truck, trailer, track or rubber tire ATV mounted drill rig

Auger Drilling – HOLLOW STEM (continued)

- Pros – economical, easy to drill, lower cost drill rig, no drilling fluid required,
- Cons – can smear clay/silt formations, limited depth capability, unconsolidated formation only, limited capabilities in glacial till and outwash, sand heave issue with high water tables or confined aquifers, can sometimes be difficult to install well while pulling augers, augers must be maintained and rebuilt on a regular basis, significant IDW generated

Auger Drilling – HOLLOW STEM (continued)

Direct Push Technology

- Hollow steel rods/casing (typical 5 foot lengths) are "pushed" into the formation using the static weight of the drill machine. Soil particles are rearranged by the push process and allows rods/casing to be advanced. Soil inside of the rod/casing is removed utilizing a core tool that catches soils and then is removed and emptied of soil. When needed, to assist in penetrating the soils, a hydraulic actuated hammer is used to apply a percussion energy force to the casing for additional ease of rod/casing advancement.

Direct Push Technology

- Used in unconsolidated formations with limited large gravel/cobble composition
- Excellent soil sample recovery
- Borehole diameters 1.25 to 6 inches
- Borehole depth – 0 to 50 feet typically
- Offers ability to install small diameter (1 inch and up) monitoring wells with prepacked well screens when appropriate for specific projects

Direct Push Technology

- Pros – very economical, quick and efficient, excellent soil sampling collection, extensive array of specialized soil and water sampling tooling is available, lower capital cost drill rig, no drilling fluid required, limited IDW generation
- Cons – can smear clay/silt formations, limited depth capability, unconsolidated formation only, limited capabilities in glacial till and outwash, sand heave issue with high water tables or confined aquifers, primarily limited to 1 or 2 inch diameter well installations

Direct Push Drill Rig

Mud Rotary Drilling


Tri-cone

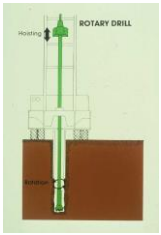

Drag/Wing Bit


PDC Bit

- Rotary drilling with tri-cone, drag/wing or PDC bits, drilling fluid required to lift cuttings from borehole, piston or centrifugal mud pump to move drilling fluid
- Primarily used in unconsolidated formations and limited consolidated formations
- Depth capabilities - unlimited in most monitoring well drilling
- Diameter capabilities suitable for most monitoring well applications
- Potable water needed to mix drilling fluid

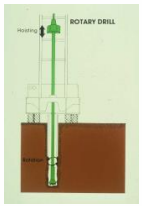
Mud Rotary Drilling (continued)

- Rotating bit fixed to the lower end of a hollow steel shaft "drill pipe" – 10, 15, 20, 25 feet typical drill pipe length
- Top head drive (as shown on right)
- Table drive is also available (provides higher rotary torque)



Mud Rotary Drilling (continued)

- Requires circulation fluid (water, bentonite, organic polymer)to remove cuttings from borehole as drilling advances depth of borehole

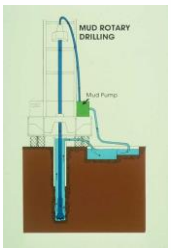


Mud Rotary Drilling (continued)

- Settling or "mud" pit allows drill cuttings to settle out of drill mud.
- Mud is re-circulated to remove more cuttings from hole as hole is drilled deeper
- Portable pits are typically used in monitor well drilling
- Ideally pit should have volume of 3 x borehole

Mud Rotary Drilling (continued)

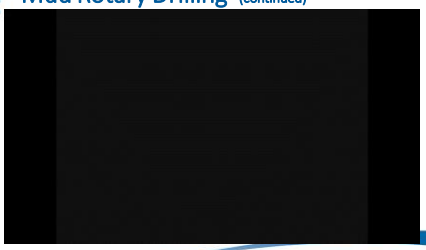
- Fluid pumped down through drill rod and out bit
- Fluid and drill cuttings pumped up and out by way of the borehole
- Primarily used in unconsolidated formations, effective in some rock types
- Large quantities of make up water are required. Make up water must also be in reserve to abate lost circulation areas. Water must be potable. Transporting water to drill site must be considered.



Mud Rotary Drilling (continued)

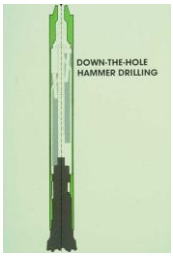
- Pros – good mix of diameter and depth capability, provides open borehole for well installation, reasonably fast drill times
- Cons – generates large IDW quantities, limited consolidated formation capabilities, large quantity of potable water required to drill, set up and teardown time is significant as compared to other drilling methods, lost circulation can be a problem, time required to properly develop well can be significant, drilling in freezing temperatures is challenging

Mud Rotary Drilling (continued)



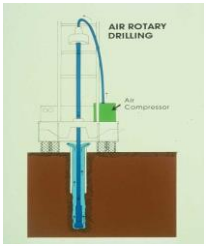
Air Rotary Drilling

- Rotary drilling with tri-cone bits, PDC, air percussion/down-the-hole hammer drilling
- Best suited for consolidated formation drilling
- Depth capabilities - unlimited in monitoring well drilling
- Diameter capabilities varied and suitable for monitoring well applications



Air Rotary Drilling (continued)

- Similar to mud but compressed air is used as the drilling fluid
- Unable to support unstable geology
- Used primarily in hard rock – consolidated formations
- Minimal or no water needed to drill



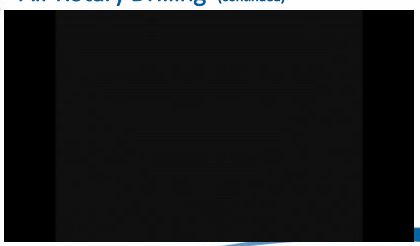
Air Rotary Drilling (continued)

- Depth- 0 to 750 feet +, Diameter 6 to 18 inches
- Provides open borehole for good annular space seal grout area
- Very fast drilling times
- Quick rig set up and tear down

Air Rotary Drilling (continued)

- Pros – excellent mix of diameter and depth capability, provides open borehole for well installation, fast drill times, quick set up and tear down, minimal well development required
- Cons – can generate large quantities of drill production water from bedrock aquifers which would be considered IDW if contaminated and must be contained, limited unconsolidated formation capabilities, significant fuel and operating costs

Air Rotary Drilling (continued)



Sonic Drilling

- Sonic is a rotary vibratory drill. The drill head is top drive and contains an oscillator mechanism that creates a high frequency vibratory force (50 – 160 hertz or cycles/second)on the drill rods. This frequency causes the surrounding soil to liquefy or fluidize and coupled with a rotary motion allows the drill rod to penetrate the soil and rock. An inner core device captures soil and rock for removal from the borehole. The term "Sonic" is applied as the frequency is within the normal hearing range of a human. The sound of the head changes as the frequency is changed to drill. ***HEARING PROTECTION IS REQUIRED.***

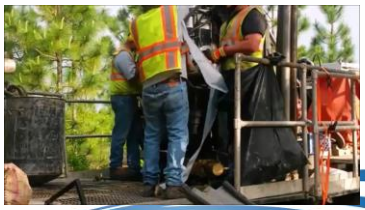
Sonic Drilling (continued)

- Frequency is adjusted by driller to obtain highest penetration rate in the formation being drilled
- Drill rod cutting shoe is vibrated up and down as downforce and rotation is applied. This allows the advancement of the borehole.
- Drill rods can be 5, 10 and 20 feet in length depending upon machine size
- As each 10 feet of borehole is drilled the core liner barrel is removed to discharge the cuttings to the surface
- Can be used in both unconsolidated and consolidated formations

Sonic Drilling (continued)

- Excellent soil/rock recovery
- Very fast penetration in favorable geologic conditions
- Depth- 0 to 200 feet +, Diameter 4 to 12 inches
- Potable water needed to facilitate drilling

Sonic Drilling – Core/cuttings removal (continued)



Sonic Drilling (continued)

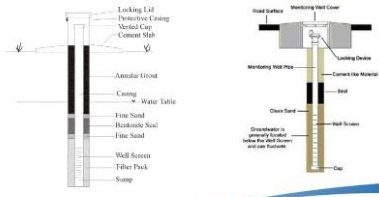
- Pros – very fast drill times, minimize IDW, excellent mix of diameter and depth capability, provides cased borehole for well installation, quick set up and tear down, minimal well development required
- Cons – potable water needed to drill, limited in some consolidated formation, high capital cost for drill rig and tools

Sonic Drill Video

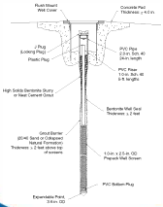
Monitor well construction design

- Typical monitoring wells are:
  - single cased construction
  - 2 or 4 inches in diameter
  - Have 10 feet of well screen
  - Have an above grade (stick up) or at grade (flush mount) well protector
  - Have a security lock
  - Constructed of PVC materials
  - Annular space is grouted
  - Gravel pack installed around well screen

Monitor well construction design

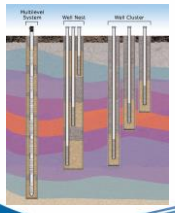


Monitor well construction design (continued)



DPT- Direct Push Technology small diameter (1 inch diameter) monitor well diagram with prepack well screen

Monitor well construction design (continued)



Alternate monitoring well construction types

Monitor well construction design (continued)

- In confined formations it may be necessary to have a double of triple cased well to isolate multi aquifer zones in unconsolidated formations and isolate fracture zones in consolidated formations. Outer well casings should be at least 4 inches in diameter larger than the inner well casing. i.e. 8”x 4”; 6”x 2” for double cased wells, 12”x 8”x 4”; 10”x 6”x 4” for triple cased wells

Monitoring well materials

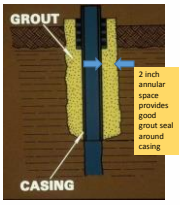
- Casing and well screen
  - Typical monitoring wells are constructed of schedule 40 PVC casing and well screen
  - PVC is flush joint thread ASTM F-480 – DO NOT USE GLUE PVC CASING AND SCREEN. Glue contents contains VOC’s (volatile organic compounds)
  - Stainless Steel Type 304, 316 and 316L are used on sites where PVC is not suitable with the contaminates in the soil or ground water

Monitoring well materials (continued)

- PVC well screens are typically "mill slot" (saw cut) design
- Vee-wire wrapped well screens are available in both PVC and Stainless Steel. Vee wire wrap construction provides a significant increase in the open area of the well screen. Larger open area provides more flow into the well and better well development. Vee-wire wrap screen is used in a very small percentage of monitoring well projects primarily because of the substantial higher cost per foot of well screen.
- Typical slot sizes for monitoring wells are .010 and .020. Slot size is dependent upon formation grain size.

Grouting

- Typical grouts are bentonite chips, bentonite slurry, neat cement or cement – bentonite slurry. Grout selection can vary from state to state
- Liquid grout must be placed with a tremie pipe. Typically a 1 inch FJT PVC tremie pipe is used
- Grout must be mixed in accordance with specifications and pumped as required
- When using a liquid grout a choker sand (very fine sand) should be placed above the well screen filter sand to avoid grout infiltration in well screen

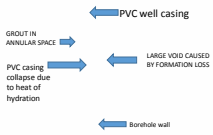


Grouting (continued)

Mixing "neat" cement grout (cement and water) to pump and tremie in annular space.

Grouting (continued)

Heat of Hydration



Be aware of damage to PVC wells caused by "heat of hydration" when using cement based grouts. When cement cures it dissipates significant heat. This heat along with the weight of the grout in the vertical borehole can cause the PVC to heat up and deform or collapse. This condition is prevalent where there are irregularities and variation in the borehole diameter.

Filter Sand/Gravel Pack

- Wells screens have a filter sand or gravel pack placed in the annular space between the borehole wall and the well screen. Filter sand is typically gravity placed however tremie placement may be desired in deeper monitoring wells.
- Well screens are available with a manufactured "prepack" gravel packed envelope around the screen. These are frequently used in DPT monitor well installations.

Well protection

- Monitoring wells are protected with a stick up (above ground) protective casing or flush mounted (at grade) manhole/vault. These devices limit access to the well from unauthorized personnel

Well Development

- Well development is performed with a variety of industry tools and proven methods:
  - submersible pumps,
  - bailers,
  - air lift,
  - centrifugal pumps
  - tubing and check valve for DPT micro well
- Typical development time is .5 to 1 hour/well

Thank you (support, information, pictures and drawings)

- NGWA
- SGS North America Inc. Drilling Division West Creek, N.J.
- Geoprobe Systems, Salina Kansas

Questions ??

THANK YOU FOR ATTENDING