Practical Ways to Improve Remediation Well Performance

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What is the connection between well performance and remedial systems?

- All remedial systems must get something in or out of the formation.
- The success a remedial system is direct function of well performance.
What is the connection between monitoring well construction and assessment data?

- Monitoring wells are the window into the dynamic subsurface
- The accuracy of the assessment/site characterization depends on properly designed/constructed wells
Background

- 300+ sites for groundwater/soil assessment & remediation
- Personally installed 500+ monitoring wells and 150 remediation/recovery wells
- SPH economic recovery
- Emergency response operations
- Public water supply protection
Cost of a typical remedial well program:

- Eight wells
- 4” diameter
- 20’ deep
- Hand clear to 5’
- Little to no development
- $7000-10,000 and three days of labor
Reality...

- Wells did not provide capture zone anticipated

- Return and install four additional wells to fill in “dead spots”

- Cost for additional wells – another $5000-7000
So the question is...

- Could these additional costs been avoided?

- Could the eight installed wells have a greater impact on the contaminated formation?

- Yes.
Maximum remedial well performance is the result of:

- Proper design
- Creative drilling selection
- Methodical well development
Effects of drilling on assessment data
SPH Assessment/Definition
Split Spoon Sample
Starts with accurate sampling

- Does the selected sampler match the formation?
  - Tube samplers and liners (Macro-core)
  - 2” split spoon samplers
  - 3” split spoon samplers
  - Run sieves of fine-grained formation
  - Take into account inter-bedded formations – not always noted in logs
Well Design

- Size the sand pack first
- Next the screen
- Maximize the open area
  - 10-slot vs. 20-slot
  - Machine slotted vs. continuous slot
  - 2” diameter vs. 4” diameter
Example of a sieve
Sand pack

- What is the purpose of the sand pack
  - Filter?
  - Stabilizer?
- As coarse as practical – look at the sieve data
- As thin as practical – Why?
Well Design

- Maximize the open area
  - 10-slot vs. 20-slot
    - Small decision doubles your open area
  - Machine slotted vs. continuous slot
    - 4” diameter – 10 slot
    - 5.6 in\(^2\) vs. 11.6 in\(^2\)
    - $50 vs. $250
  - Why is open area important?
Well Installation

- All drilling methods cause formation damage
- The original permeability of the formation is reduced
- A real issue in fine-grained formations
- A real issue in inter-bedded formations
Which drilling method causes the most damage

- Augers!
- Which drilling is most common?
- Augers!
- Why are not alternative means considered?
- We don’t know what we don’t know...
Potential alternative drilling methods

- Spun casing
- Drive casing (cable tool)
- Fluid/air rotary
- Rotosonic
Example of formation damage caused by drilling – Augers vs. Spun Casing

<table>
<thead>
<tr>
<th></th>
<th>6-1/4” hollow stem augers (10” OD)</th>
<th>6” diameter spun casing (6.5” OD)</th>
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<tbody>
<tr>
<td>Specific capacity prior to any development</td>
<td>1.7 gpm/ft</td>
<td>3.7 gpm/ft</td>
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Drilling with Spun Casing
Drilling with Spun Casing
Augers create thick sand packs

- 10” OD Auger vs. 4” ID PVC Well
- Difference creates 3” thick sand pack on all sides of the well
Casing creates thin sand packs

- 6.5” OD casing vs. 4” ID PVC Well
- Difference creates 1” thick sand pack on all sides of the well
Why develop remedial wells?

- Initial well yield – 1.7 gpm/ft of drawdown
  - After two hours of surging and two hours of pumping at 5 gpm
- New well yield – 2.6 gpm/ft of drawdown – 35% increase in yield!
- Increase the size of the capture zone – less wells required
Two Common Methods of Development

- Physical well development is basically putting energy down the borehole.
- Chemical well development compliments physical means by keeping removed material in suspension.
Common Physical Methods

- Surge
- Brush
- Pump
- Jetting
- By mixing technology, you can reduce field time
Chemical methods

- Would you wash your clothes without soap?
- Dispersants for initial development
- Acids and acid enhancers for redevelopment
Chemical additives do work!

<table>
<thead>
<tr>
<th>Well ID</th>
<th>HSA-10</th>
<th>FR-10</th>
<th>FR-6</th>
<th>SC-6</th>
</tr>
</thead>
<tbody>
<tr>
<td>After 2 hours of development</td>
<td>2.0 gpm/ft</td>
<td>2.0 gpm/ft</td>
<td>2.6 gpm/ft</td>
<td>3.7 gpm/ft</td>
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<tr>
<td>An additional hour + dispersant</td>
<td>2.6 gpm/ft</td>
<td>2.9 gpm/ft</td>
<td>3.7 gpm/ft</td>
<td>5.5 gpm/ft</td>
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Additional general comments about well development…
Well development

- Maintain open area free of precipitates, biomass and particulates
- Consider an aggressive sand pack for injection wells or bedrock wells
  - Number 3 gravel with a 10-slot screen
- Consider a regular re-development program
- Thin sand packs easier maintained
Augers create thick sand packs

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Pick an appropriate criteria for development monitoring progress

- Inaccurate criteria – pH and temperature have stabilized....three well volumes....(sampling)

- Better – look at the end purpose of the well
  - Example – injection vs. withdrawal
  - Compare to formation values
Typical development curve
Most important element to development – a conscientious effort and field crew!
Summary

- All wells impact the natural subsurface environment to some degree
- The level of impact is a combination of geology characteristics and drilling method
- Collect site specific data to match sand pack and well screen to lithologies
- Well development and maintenance key to good data and efficient well yield
Summary (Cont.)

- Match drilling techniques to well use applications and subsurface environments
- Utilize both physical and chemical methods for well development where applicable
- All wells need periodic maintenance for quality data recovery and optimum remedial performance