Case Summary:
Electrical Resistance Heating

ICN Pharmaceuticals, Inc.

Portland, Oregon

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State of Oregon Department of Environmental Quality

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Why don't we just remove all the DNAPL source material? The answer is that it's never easy and sometimes not possible with existing technologies.

Lack of reliable cost and performance data is often cited as a major impediment to deploying innovative source removal technologies like electrical resistance heating. Here we have a classic "chicken or the egg" scenario (or is it a "Catch 22"?) By definition, an innovative technology is one that is lacking in either cost or performance data (or both) – if this information were known, then the technology would no longer be innovative. Innovation also implies risk – if there was no risk, there would be a lot more innovators! Cost and performance data will come as the technologies are used, instrumented, and accepted. As shown in the previous slide, the DNAPL Team is currently tracking some 20 case examples where innovative DNAPL remediation technologies are being used and obtaining cost and performance data is a high priority.

Most DNAPL remediation technologies work by making the DNAPL more mobile which raises concerns that the DNAPL could migrate in an uncontrolled manner. This concern can be addressed during design of the remediation system, for example by maintaining hydraulic containment using pumping wells or other means. Our experience in looking at these sites and talking with regulators and technology vendors is that uncontrolled migration is not a common occurrence.

The uncertain benefit of partial source removal, in particular how groundwater will respond to mass removal, is probably the biggest reason why problem holders and regulators are hesitant to go after DNAPL sources more aggressively. The way in which we manage this uncertainty has political and societal implications. For instance, removing 85% of the DNAPL mass certainly sounds good, but if it ultimately means that you will only have to pump & treat for 100 years instead of 500 years, then is it worth the effort? EPA's Technology Innovation Office (TIO), the U.S. Army Environmental Center, and other federal agencies, are currently funding studies to evaluate this question.

Fear of failure is always a key reason that promising innovative technologies are not considered as a remedial option and DNAPL source reduction technologies are no different. Regulators, consultants, PRPs – we all have nothing to lose by playing it safe and doing what everyone else does – even if it may not be the best thing to do. We hear the concern of PRPs that they will be asked to invest in one of these expensive DNAPL source removal technologies AND still be required to operate their pump and treat systems for an indefinite amount of time. Regulators are beginning to understand this dilemma and are seeing the benefit of being more flexible in setting remedial action objectives and establishing exit criteria in order to see more aggressive action take place at their sites.

Site Background

- ICN Pharmaceuticals, Inc. joined DEQ’s Voluntary Cleanup Program in 1992
- Former clinical laboratory: 1960-1980
- Primary COCs: chlorinated solvents (TCE and daughter compounds) as well as benzene and toluene
- Former dry well considered source of groundwater contamination - suspected DNAPLs present
- Need to prevent downward contaminant migration into potential drinking water aquifer

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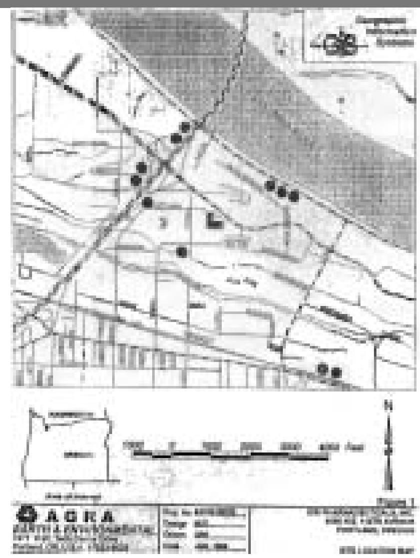
Site Proximity to City Wells



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Site Geology

- Fluvial and lacustrine deposits (Overbank Deposits) to 60 ft bgs
- Troutdale Gravel Aquifer (TGA) consisting of unconsolidated and cemented gravels (approx. 175 ft thick)
- Confining unit (CU1) of sand, silt, and clay encountered at base of TGA (approx. 100 t thick)
- Troutdale Sandstone Aquifer (TSA) lies beneath CU1

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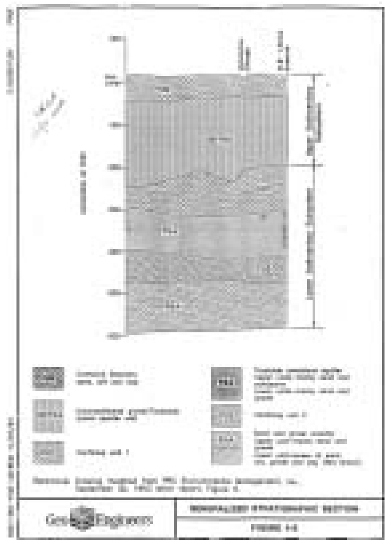
Stratigraphic Cross-Section



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Source Zone Description

- Source zone 120 by 80 ft oblong centered on former dry well (est. 48,000 to 65,000 yd^3)
- DNAPLs believed to exist in Overbank only; however dissolved contamination has migrated to TGA
- Source characterization done using push probe borings extending outward from dry well plus installation of more than 50 monitoring wells

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Remedial Goals and Objectives

- DEQ rules require "hot spot" determination
- Preference for treatment of DNAPL sources
- Remedial action objectives
  - Prevent migration of DNAPLs during treatment
  - Reduce concentrations in groundwater to levels that indicate DNAPL has been addressed
- Need for further remediation will be assessed following remediation of DNAPLs

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Remedial Approach

- Electrical resistive heating selected in ROD
- Six-Phase Heating™ (SPH) technology provided by CES of Richland, WA
- Operational strategy
  - Create "hot floor" to act as barrier to vertical migration
  - Heat up "walls" to prevent lateral migration
- Slurry wall/SVE considered more costly and difficult to implement than SPH
- Biodegradation rejected as being too slow to mitigate imminent threat

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Treatment System

- Initial system: 60 electrodes, 53 vapor extraction points, 13 pressure monitoring points, 8 thermocouple strings, and 950 kW transformer
- Later expanded to include 13 additional electrodes and 67 "electrode vents", plus instrumentation
- SVE system recovers contaminants in multiple phases (steam/vapors/liquids) and separates into liquid and vapor streams for treatment and discharge

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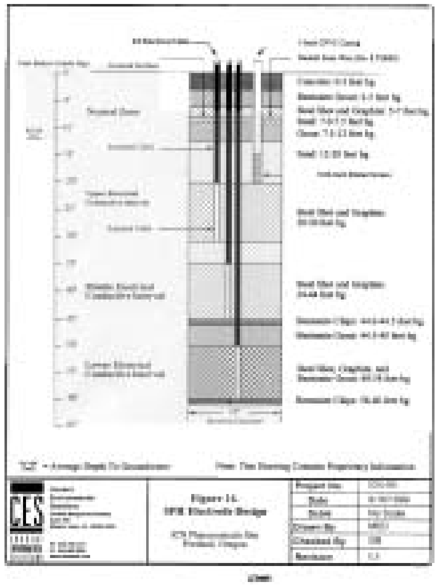

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Lessons Learned

- Sampling of very hot water
- Well construction issues
  - PVC/CPVC wells failed
  - Use stainless steel wells in future
- Steam generation
  - Lateral migration of steam/superheated water into nearby wells
  - Existing electrode vent lines were enlarged
  - Deep vents installed to release pressure

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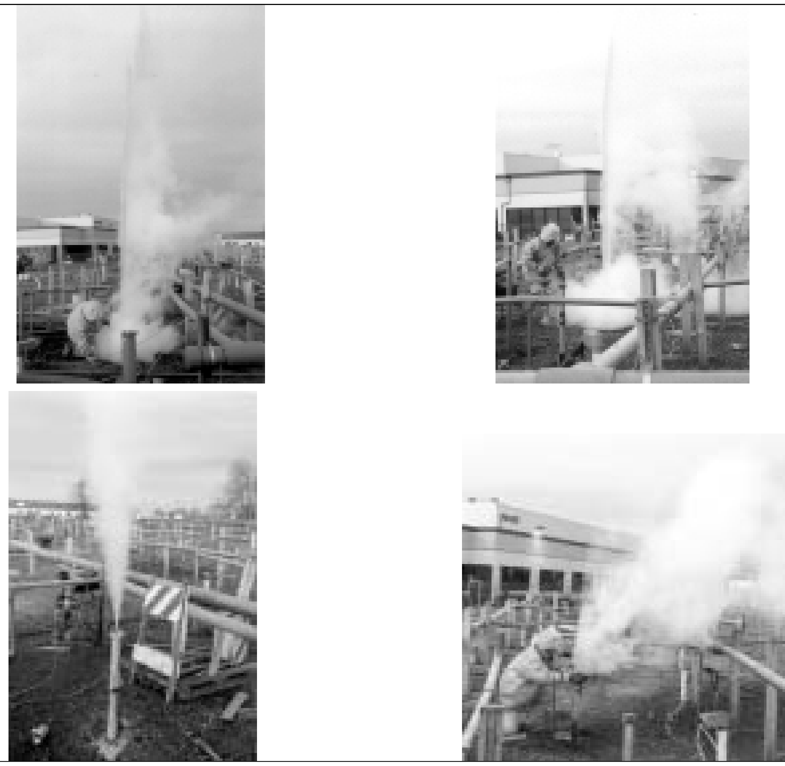

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System Performance

- Groundwater monitored within, below, and surrounding DNAPL zone
- Concentration reductions up to 4 orders of magnitude observed in “former” DNAPL zone
- Approx. 96 gallons of total VOCs recovered
- DEQ conclusion: DNAPL no longer present

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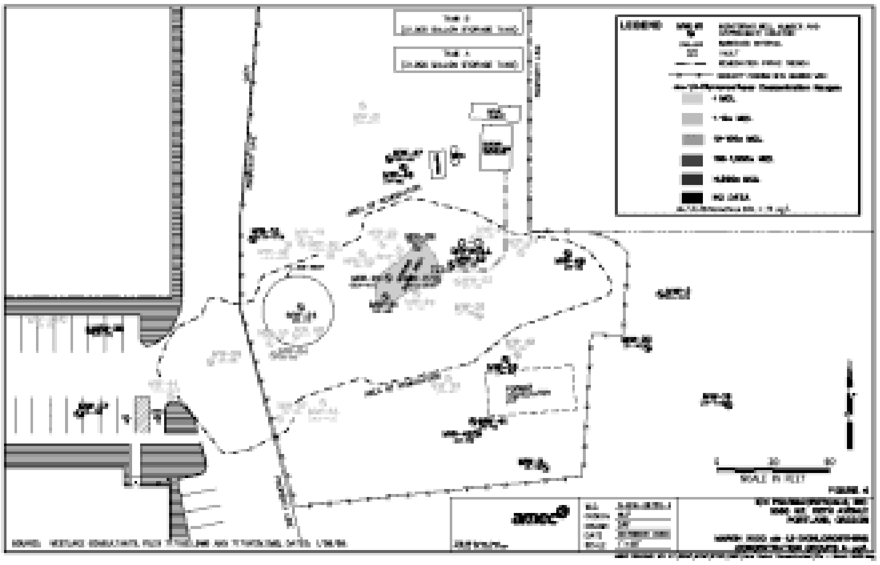

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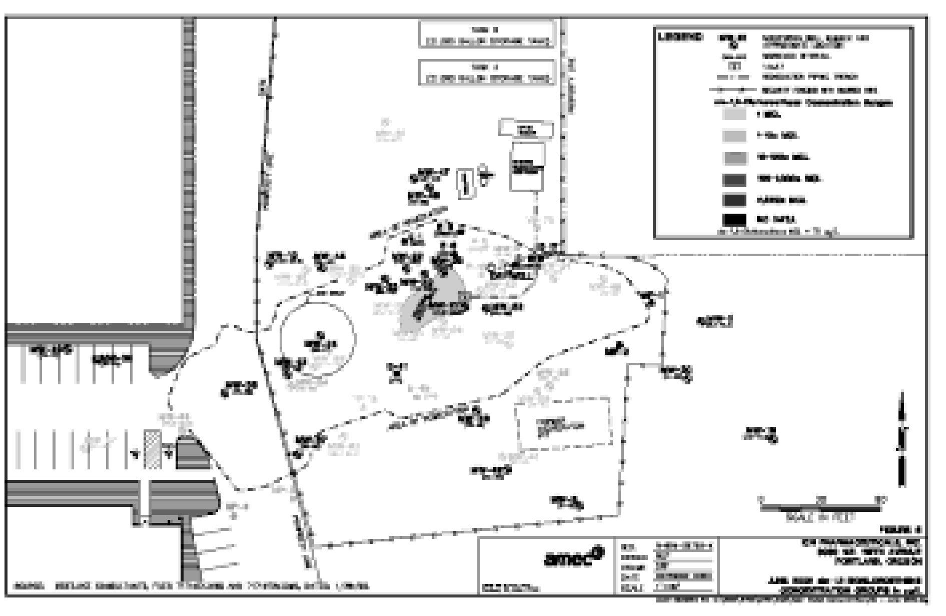

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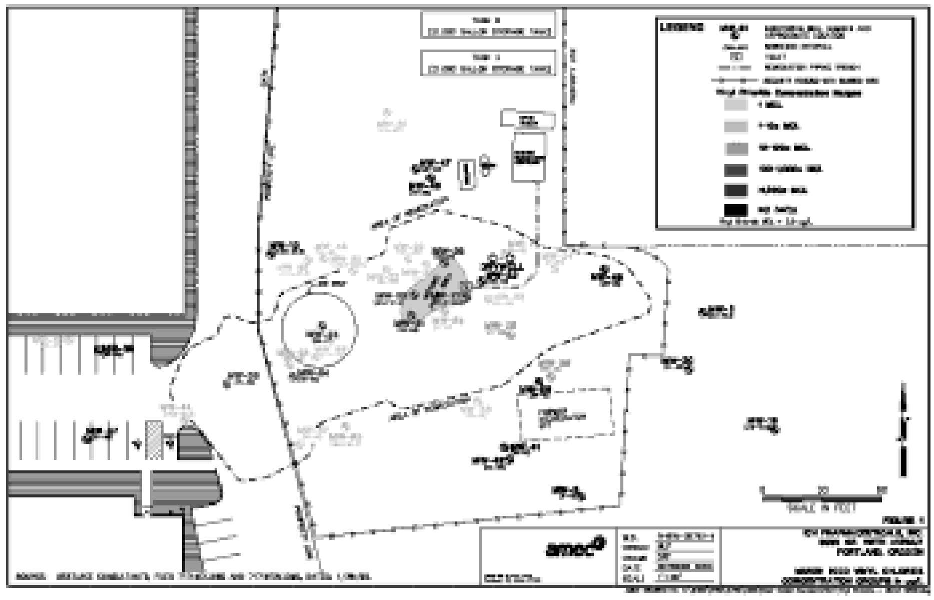

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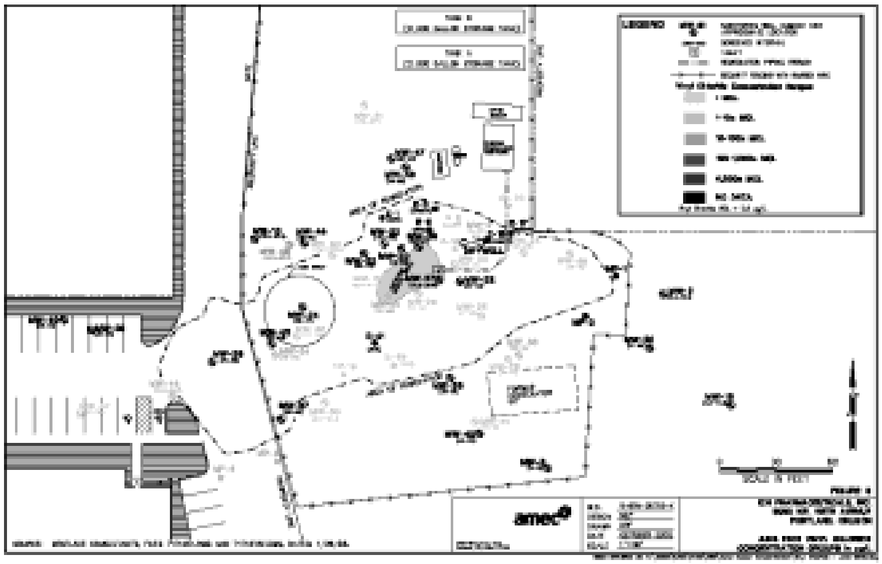

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Next Steps

- SPH system shutdown December 2001
- Low-level heating or air sparging to promote biodegradation
- Residual risk assessment
- Confirmation monitoring network
- Closure/NFA Notice

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