

# Groundwater Remediation at the Hanford Site

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Ion exchange resin and adsorption technology has been used successfully to treat diversified types of toxic waste water for many years. Even though the Hanford Site presents many unique problems, we believe these technologies can remediate the groundwater at this site. However, treatment of the sludge in tanks generally is beyond the pale of these technologies except for the possibility of experimental studies being performed at the University of Idaho (Troescher 1989).

## Definition of Problem

A reasonable composite analysis of the Hanford groundwaters, Table 1 (Garrett and Olsen 1990; Evans et al. 1990), indicates the water is unique to our experience and difficult to treat. The greatest difficulty is the large variety of contaminating chemical species present. This eliminates the possibility of treating the contaminants selectively and cheaply and also producing a potentially valuable concentrated waste regenerant stream. Additional complicating factors are the high nitrate level and the presence of chlorinated hydrocarbons which will require special considerations.

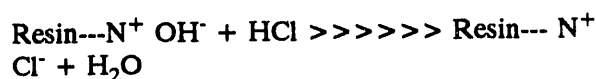
On the positive side, the composite water analysis indicates that most of the contaminating substances are ionic, with the exception of tritium, iodine, and chlorinated hydrocarbons. The former are amenable to ion exchange removal; the latter, except for tritiated water, are amenable to adsorption. Also, the total concentration, both contaminants and innocuous chemicals, is not particularly high at about 450 ppm (as CaCO<sub>3</sub>).

## System Decision Process

The results of a flow chart exercise (Figure 1) suggest that the most reasonable approach is a complete ion exchange resin deionization (D.I.)

(a) Rohm and Haas Company, Spring House, Pennsylvania

system along with specific treatment resin bed(s). The core of this approach would be a two-bed D.I. system of classical packed-bed design. The first would be a strong acid cation exchange resin operated in the hydrogen cycle and the second a strong base anion exchange resin operated in the hydroxide cycle. The overall reaction using NaCl as a simple model would be



Since there is some question as to whether some portion of the contaminants are filterable and presumed insoluble, some sort of a mechanical prefiltering system may be necessary.

There is a possibility that a second ion exchange deionization system would be necessary. This would be a mixture of the same resins as used in the two-bed D.I. system above but in a single, mixed-bed operation. This would act as a polishing system by assuring the highest quality effluent and guarding against the premature "dumping" of the less selectively held contaminants to the effluent. This should be a relatively small bed which would be regenerated much less often than the preceding two-bed D.I. system. This compensates for the greater difficulty and expense of operating a mixed-bed system.

Complete automation would be possible with automatic monitoring of the conductivity after each D.I. system. This should be sufficient to guaranty satisfactory quality effluent on a routine basis. Of course, periodic complete analyses of the effluent will be necessary to the extent that local regulations require.

In addition to the core D.I. system, it would be necessary to have a selective treatment system of a hydrophobic adsorbent, either an Amberlite XAD

Table 1. Hanford Groundwater (Garrett and Olsen 1990)

| <u>Radiological Chemicals</u> | <u>Median Level</u> | <u>Radiological Chemicals</u> | <u>Median Level</u> |
|-------------------------------|---------------------|-------------------------------|---------------------|
| Gross Alpha                   | 70 pCi/L            | Technetium-99*                | 1250 pCi/L          |
| Gross Beta                    | 260 pCi/L           | Iodine-129*                   | 50 pCi/L            |
| Tritium*                      | 50000 pCi/L         | Iodine-131* @                 | not present when    |
| Cobalt-60*                    | ?                   | Ruthenium-103* @              | N-Reactor idle      |
| Strontium-90*                 | 150 pCi/L           | Uranium (total) #             | 45 pCi/L            |
|                               | 330 ppb             |                               | 75 ppb              |

\* Beta Emitter

# Alpha Emitter

@ Only Present When Reactors Are Operating

Toxic Chemicals (EPA-MCL and Washington State Dept. of Ecology)

|                                |            |
|--------------------------------|------------|
| Nitrate                        | 310 ppm!!! |
| Chromium (filtered)            | 100 ppb    |
| Trichloroethylene              | 60 ppb     |
| Total Chlorinated Hydrocarbons | 500 ppb    |

Innocuous Chemicals

|                      |                  |  |         |
|----------------------|------------------|--|---------|
| Total Diss. Solids   | 600 ppm          | Total Alkalinity                       | 130 ppm |
| pH                   | 7.7              | Total Carbon                           | 30 ppm  |
| Spec. Conductance    | 570 $\mu$ mho    | Turbidity, nephel                      | 50 ntu  |
| Sodium               | 80 ppm           | 174 ppm (as CaCO <sub>3</sub> )        |         |
| Calcium              | 40 ppm           | 100 ppm (as CaCO <sub>3</sub> )        |         |
| Magnesium            | 23 ppm           | 96 ppm (as CaCO <sub>3</sub> )         |         |
| Potassium (filtered) | <u>5 ppm</u>     | <u>6 ppm (as CaCO<sub>3</sub>)</u>     |         |
| total >>>>>          | 148 ppm          | 376 ppm (as CaCO <sub>3</sub> )        |         |
| Bicarbonate          | 150 ppm          | 123 ppm (as CaCO <sub>3</sub> )        |         |
| Sulfate              | 60 ppm           | 63 ppm (as CaCO <sub>3</sub> )         |         |
| Chloride             | 26 ppm           | 37 ppm (as CaCO <sub>3</sub> )         |         |
| Phosphate            | 5 ppm            | 8 ppm (as CaCO <sub>3</sub> )          |         |
| (Nitrate)            | <u>(310 ppm)</u> | <u>(250) ppm (as CaCO<sub>3</sub>)</u> |         |
| total >>>>>          | 209 ppm          | 481 ppm (as CaCO <sub>3</sub> )        |         |

Trace (ppb) Levels

Aluminum, Fluoride, Barium, Cyanide, Iron (filtered), Zinc, Ammonia, Boron, Copper, Manganese (filtered), Arsenic, Vanadium, Cadmium, Mercury

1. **Small Amount of Suspended Matter**
    - A. **Filter Residue Contains a High Level of Radiological or Toxic Material**
      - **Must Prefilter Before IER and Adsorbent Beds**
    - B. **Residue Does Not**
      - **Need Not Filter**
  
  2. **Level of Total Dissolved Substances**
    - A. **High**
      - **Must Use Selective IER or Adsorbent**
    - \* B. **Low**
      - **Complete Deionization Economically Feasible**
  
  3. **Variety of Contaminating Chemical Species**
    - \* A. **Large**
      - **Must Deionize Totally**
    - B. **Small (1 - 2)**
      - **Possibility of Using Selective System**
  
  4. **Quality Effluent Required**
    - \* A. **High**
      - **Mixed-Bed D.I. System Preferred**
      - **May Get Away with Two-Bed D.I. System**
    - B. **Low**
      - **Two-Bed D.I. System**
  
  5. **Difference in Selectivities Among the Ions**
    - \* A. **Large**
      - **May Cause "Dumping" of Less Selectively Held Ions**
    - B. **Small**
      - **No Special Considerations Required**
  
  6. **Non-Ionic Contaminants Present**
    - \* A. **Not Adsorbed by D.I. Resins**
      - **Must Remove with Adsorbent**
    - \* B. **Adsorbed by D.I. Resins**
      - **Also, Must Remove to Prevent Fouling of D.I. Resins**
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- \* **Apparent Condition at Hanford.**

**Figure 1. Hanford Groundwater Flow Chart**

or Amberlite Carbonaceous Adsorbent. This is to reduce the chlorinated hydrocarbons to a low ppb level (Figure 2).

Also, a pretreatment system may be necessary, positioned before the D.I. system(s). Its function would be to selectively exchange the large quantity of nitrates for the chloride ions. This would be necessary to 1) prevent dumping, elution of a highly concentrated plug, of the less selectively held contaminants by the very selectively held nitrate ions in the D.I. system(s) and 2) reduce regeneration cost of the relatively expensive caustic in the D.I. systems.

Further minor refinements of this multi-bed system are possible which may save operating costs in the area of tens of percent.

## Proposed System

The proposed system and possible options are shown in Figure 3. The necessary unit operations are indicated by the solid boxes. The optional ones, to be decided by experimentation, are shown by the slashed boxes.

The overall waste water treatment cycle is shown by the solid lines/arrows. An idealized example of the quality that might be expected from a mixed-bed D.I. system treating a municipal water is shown in Table 2 (Sabadell 1973). The ultimate use or disposal of this large volume of nearly perfectly deionized water must be considered. Except for its tritium content, there may be no restrictions to its use.

The regenerant solution flow for each bed is shown by the slashed lines/arrows. The waste regenerants will contain the concentrated contaminants along with the excess regenerant chemicals and/or solvent. Each waste regenerant will contain different contaminating species but our best guess of which contaminant will be where is limited by the lack of exact knowledge of the species of each element. Clearly, further thought must be given to the ultimate disposal of each of these concentrated ion exchange and adsorbent regeneration waste streams.

**Table 2.** Freshly Prepared D.I. Water by Mixed Beds (ppb) (Sabadell 1973)

|    |        |    |      |
|----|--------|----|------|
| Al | 0.1    | Mg | 0.3  |
| Sb | <0.5   | Mn | 0.05 |
| Be | <0.005 | Hg | <1   |
| Bi | <0.1   | Mo | <0.1 |
| B  | 3      | Ni | <0.1 |
| Cd | <0.1   | Nb | <0.1 |
| Ca | 1      | Si | <0.5 |
| Cr | <0.1   | Ag | 0.01 |
| Co | <0.1   | Na | 1    |
| Cu | 0.2    | Sn | <0.1 |
| Ga | <0.2   | Ti | <0.1 |
| Ge | <0.5   | V  | <0.1 |
| Fe | 0.2    | Zn | <0.1 |
| Pb | 0.1    | Zr | <0.1 |

## References

- Garrett, L., and P. M. Olsen. 1990. *Purge Water Characterization and Treatment Summary*. WHC-SP-0568, Westinghouse Hanford Company, Richland, Washington.
- Evans, J. C., R. W. Bryce, D. J. Bates, and M. L. Kemner. June, 1990. *Hanford Site Groundwater Surveillance for 1989*. PNL-7396, Pacific Northwest Laboratory, Richland, Washington.
- Troescher, P. D. 1989. *Metals Recovery from Industrial Sludge*. D9C, pp. 1549-1565, Idaho National Engineering Laboratory, Idaho Falls, Idaho.
- Sabadell, J. E. 1973. "Traces of Heavy Metals in Water Removal Processes and Monitoring." In *Proc. of a Symposium Conducted by the Center for Environmental Studies and the Water Resources Program*, Princeton University.

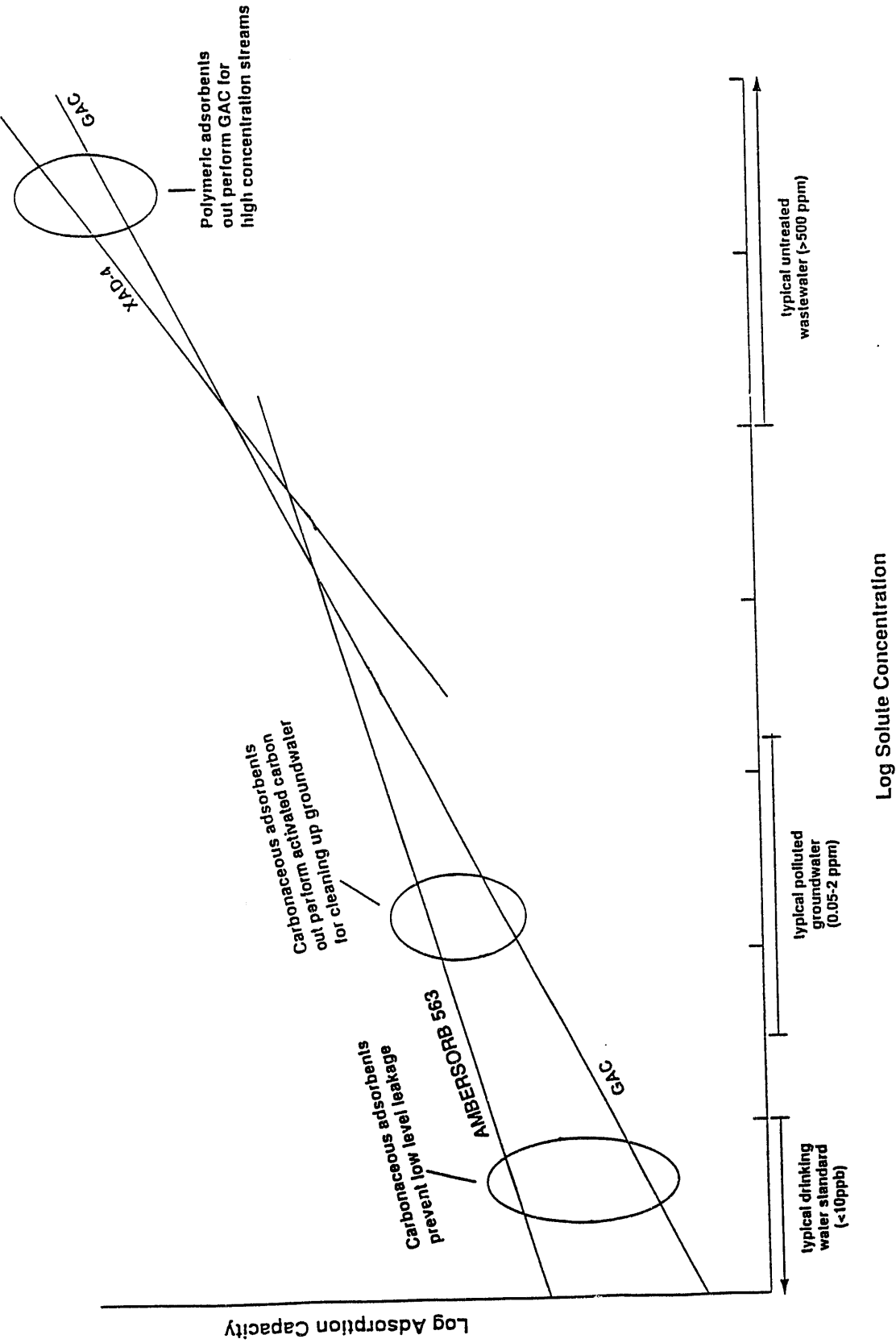


Figure 2. Typical Adsorption Isotherm - Low Molecular Weight Priority Pollutant (Trichloroethylene)

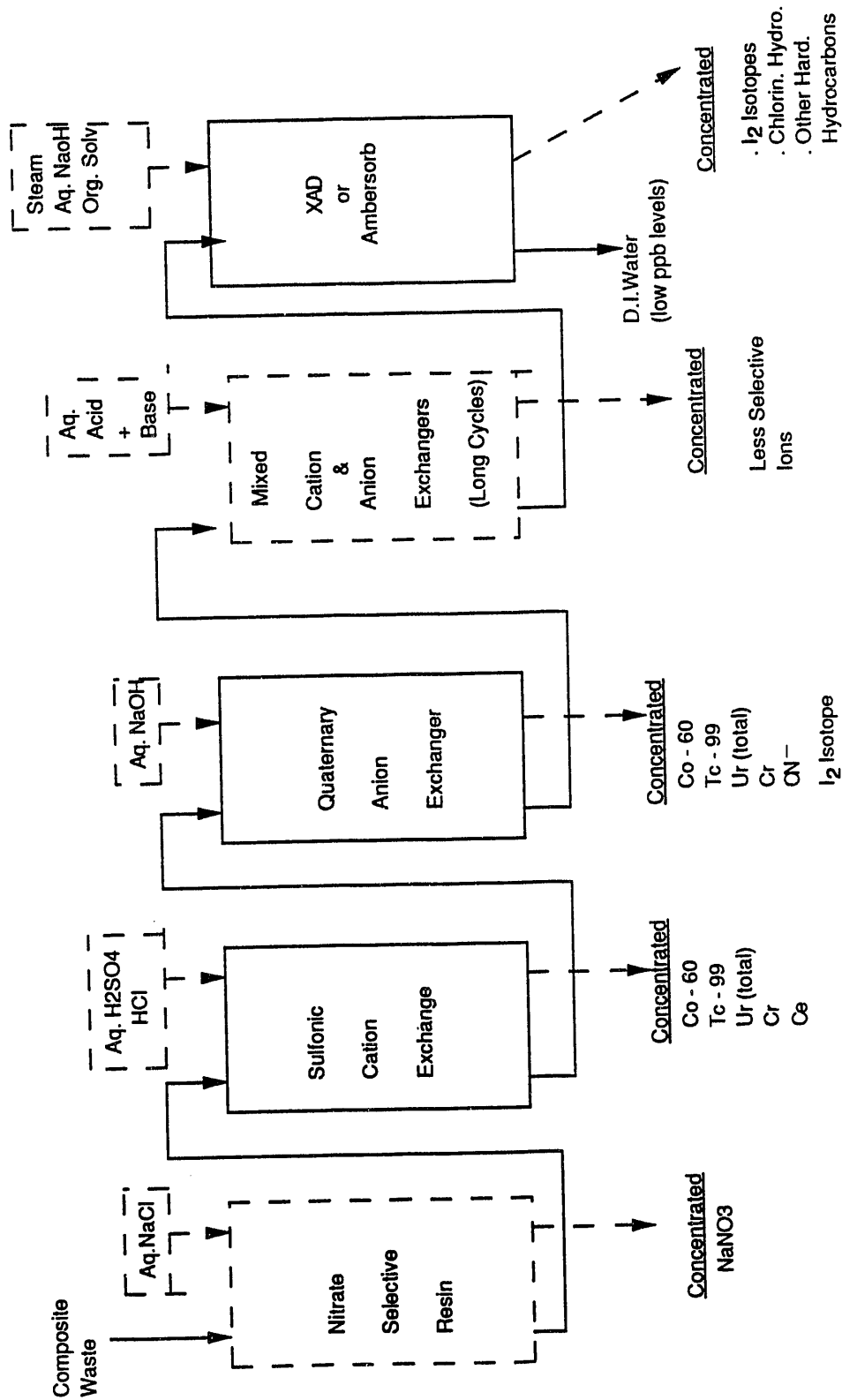
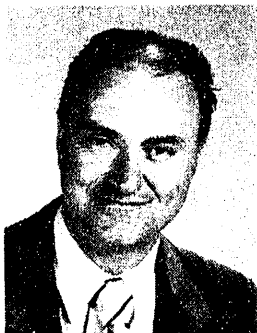


Figure 3. Proposed System - Ion Exchange Resin and Adsorbents



William Fries is a Senior Research Scientist with Rohm and Haas Co., Spring House, Pennsylvania. His work has focused on ion exchange resin and adsorbent applications and synthesis research, in particular speciality applications including sugar processing, catalysis, chemical processing, and waste treatment. Mr. Fries received BS and MS degrees in chemistry from Temple University.