to take from 28 to 42 years; at the Davis Liquid Waste site in Rhode Island, it was estimated to take from 5 to 10 years; and at the Re-Solve site in Massachusetts, it was estimated to take 10 years. There is, however, no obvious alternative for groundwater cleanup at IEL, EPA has said: "The actual performance of a ground water remedial action is difficult to predict until the remedy has been implemented and operational data have been assessed." (U.S. Environmental Protection Agency, "Guidance on Remedial Actions for Contaminated Ground Water At Superfund Sites," draft, October 1986.)

Before a permanent remedy is implemented, more wells may become contaminated. Also, contaminants can migrate at substantially different rates, and, therefore, the nature of the spreading contamination can change over time. Such changes are well verified by research. (See, for example, R.L. Johnson et al., ***Ground Water,*** September/October 1985.) Wells that are contaminated early can get worse as new, more slowly moving contaminants reach them; wells not yet contaminated eventually see the effects of the most rapidly moving contaminants, On this point the ROD noted: "Since the publication of the FFS [Focussed Feasibility Study], recent data revealed that levels of nickel exceeded Ambient Water Quality Standards." Also, "vinyl chloride has migrated off-site quickly . . . while its parent compounds pose a threatened release from the site because they are migrating at a slower rate. " The ROD also noted: "the shallow and deep aquifers are continuous and linked to one another." Therefore, the complexit y of groundwater contamination and its cleanup could worsen significantly. The possibility of upgradient chemical migration should not be ruled out. (See R.H. Plumb, Jr., ***Proceedings Second Canadian/American Conference on Hydrogeology, 1985,*** pp. 69-77.)

The long history of the site, the extensive groundwater contamination offsite, and the delay in addressing the source of the problem is feeding community lack of confidence in government efforts and demands for new water to more houses.

Case Study 6
Pristine, Inc., Reading, Ohio, EPA Region 5

Capsule OTA findings.—In situ vitrification was developed originally for radioactive soils, but its use for chemically contaminated sites is still unproven. Without treatability test results, in situ vitrification was selected for this site chiefly because its estimated cost was about half that of onsite incineration. But the estimated cost for incineration is probably high by a factor of two. Incineration offers more certainty and probably costs no more than the selected remedy. Groundwater will be pumped and treated by air stripping and carbon adsorption.

Key dates:

- Entered Superfund system: 4/1/79
- Preliminary Assessment: 1/1/83
- Site Inspection: 9/1/82
- National Priorities List
  –proposed date: 12/1/82
  –final date: 9/1/83
  —site rank: #531 out of 770
- RIFS start and completion: 9/5/84 to 11/87
- Public comment period before Record of Decision: 11/13/87 to 12/11/87
- Signing of ROD: 12/31/87

Estimated complete remediation: 8/91; 2 years for source control, 5 to 10 years for groundwater cleanup (August 1991 is given in ROD, but this seems optimistic and inconsistent with other groundwater cleanups; 10 years for groundwater cleanup is more realistic)

Total **time.—20 years**

Brief description of site.—The site is in a suburb of Cincinnati. The site is 2.2 acres and "is bordered by residential and industrial areas. There are two aquifers under the site." In the late 1970s, a liquid waste incinerator was operated at the site. "In April 1979, as many as 8,000 to 10,000 drums and several hundred thousand gallons of bulk liquids were on site, consisting of acids, solvents, pesticides, PCBs and other chemicals. " A consent order shut down the facility in September 1981.

Major contamination/environmental threat.—" . . . over 90 compounds were detected in the groundwater, soil, sediment, and surface water. "

"Groundwater in the upper aquifer is contaminated primarily with volatile organic compounds (VOCs) such as benzene, vinyl chloride, tetrachloroethene (TCE), and 1,2-dichloroethane. Semi-volatile compounds (semi-VOCs) and pesticide compounds occurred in relatively lower concentrations. The lower aquifer is contaminated with benzene and 1,2-dichloroethane. There are also elevated levels of lead and fluoride."

" . . . the presence of VOCs in the [Reading municipal wells] indicates that the groundwater quality in the vicinity is compromised and continued monitoring is recommended . . . The lower aquifer is the source for the regional water supply [13,000 people]. " This route of exposure poses the largest risk.

"Sediment . . . and soil in the upper two feet of the site are contaminated with a variety of VOCs semi-VOCs, and pesticides. Principal contaminants in surface soils are benzene, dieldrin, and DDT." Low levels of dioxins and furans were also found.

"Subsurface soil contained VOCs . . . There were also elevated levels of cadmium, lead, mercury and zinc. "

"Surface water was contaminated with **VOCs,** semi-VOCs and pesticides . . . There were also elevated levels of inorganic compounds (cadmium, chromium, and mercury)."

A good risk assessment established cleanup goals at 1 in 1 million risk level. The RIFS calculated how much soil would have to be removed to "eliminate both the risk associated with adsorption and ingestion of soils and ingestion of groundwater contaminated through leaching from the soil."

HRS scores.—groundwater 60.00; surface water 10.91; air 0.00; total 35.25

Removal actions.—The site operator removed waste from June 1980 to November 1983 under a consent decree. Some responsible parties removed waste and soil from March 1984 to July 1984 under an administrative order. The ROD did not say how much material was removed, nor its disposition, but it was probably landfilled.

Cleanup remedy selected.—This ROD was a final source control remedial action but also included groundwater cleanup. Another ROD might be issued for additional groundwater cleanup.

The key component of the selected remedy is in situ vitrification (ISV) for 37,700 cubic yards of contaminated soil and sediment. ISV was chosen over onsite incineration. ISV is an innovative technique that uses electrodes in the ground to pass electricity through soil, melt it, vaporize and at least partially destroy organic chemicals, and leave in place a chemically inert, stable, glass-crystalline mixture. Temperatures in the range of 2,000 to 3,6000 F are possible. Different cells of soil are melted in order to cover a site. The melt grows downward and outward as power is applied. As the vitrified zone grows, it incorporates nonvolatile elements and destroys organic components by pyrolysis. The pyrolysis byproducts migrate to the surface of the vitrified zone, where they combust in the presence of oxygen. "The estimated time required to complete the vitrification process is two years assuming the use of one vitrification unit."

Groundwater will be pumped and treated with an air stripper and carbon adsorption. That is, separation, not destruction, technology was selected. Groundwater monitoring was set up. The possibility of deed restrictions was raised. "It is estimated that it will take five to ten years to extract and treat the contaminated groundwater,"

Estimated cost: $22 million.

Satisfaction **of SARA statutory requirements:**

1) Selection of permanent cleanup.—In its initial two screening stages, the FS examined a large number of treatment technologies. However, after more detailed screening, many of the treatment technologies said to be applicable were dropped without much justification. For example, three in situ treatment technologies passed the initial screening, but solution mining and soil vapor extraction were dropped and only vitrification was retained for more detailed analysis. Onsite treatment technologies that passed the initial screening included fixation/solidification, soil washing, and dechlorination, but only incineration was analyzed further.

The ROD said that the selected ISV remedy "will significantly reduce the mobility, toxicity, and volume of hazardous substances in the soil through treatment. The mobility of the contaminants will be reduced significantly, such that no leachate is expected to be produced from the vitrified material. This is a permanent technology, the results of which are expected to last for a million years. The toxicity of organic components will be decreased because the organics are destroyed or changed to other forms by pyrolysis or vaporization. The volume of the soil will be reduced by 25 to 30 percent because the vitrification causes the soil mass to consolidate."

A chief issue is whether or not ISV is a proven technology. ISV is an alternative treatment and an innovative technology that was developed originally for treating radioactive contaminated soils, but its use for chemical contamination raises new questions. How should ISV be classified? Is it thermal destruction or stabilization? EPA's SITE technology demonstration program categorizes it as stabilization, as do others. (N. Nelson et al., Toxic ***Chemicals, Health, and the Environment,*** The Johns Hopkins University Press, 1987, pp. 205-279.) Stabilization is a reasonable label because metal contaminants remain in the final glass-like material and because the leaching of metals and the complete destruction and removal of organic contaminants are uncertain. Although very high temperatures are reached, not all organic contaminants will either be destroyed or be able to escape and be captured. However, EPA also calls ISV thermal destruction. (U.S. Environmental Protection Agency, ***Technical Resource Document: Treatment Technologies for Halogenated Organic Containing Wastes,*** vol. 1, January 1988.) This EPA report describes ISV as: "Not commercial, further work planned. No [performance] data available, but DREs [destruction-removal efficiencies] of over six nines reported. "

ISV's developer, Battelle Pacific Northwest Laboratories, which supports ISV's inclusion in SITE, has commented on treatability testing: "While the results are promising, feasibility testing to confirm applicability is strongly recommended ***prior to any commitment to deploy the process*** on a site that contains significant quantities of organics that are unconfined in the soil column. . . . feasibility testing is relatively inexpensive [a few thousand dollars]. The focus of the feasibility testing is the performance requirements for the off-gas treatment system and the type and quantity of ***secondary waste generated.*** Experience with low boiling point organics that are uncontained in the soil column is very limited, and feasibility testing with actual site samples prior to application is strongly recommended" (emphasis added). (V.F. Fitzpatrick, "In Situ Vitrification–A Candidate Process for In Situ Destruction of Hazardous Waste," ***Proceedings of the 7th Conference on the Management of Uncontrolled Hazardous Waste Sites,*** December 1986, pp. 325-332.)

ISV depends on the effectiveness of the collection and treatment system for released gases to keep undestroyed organic contaminants (or products of incomplete combustion) from entering the environment, This off-gas system is like a separation technology; hazardous residues can be either destroyed or landfilled after carbon adsorption. The greater the volatility of contaminants, the greater their release into the off-gas collection system. At Pristine, many of the contaminants are highly volatile at relatively low temperatures. By the time the soil is melted, therefore, many contaminants have moved.

What happens to organic contaminants in ISV is crucial to understanding its cleanup effectiveness relative to other technologies, such as incineration. A published paper reported on a test of ISV on PCB contaminated soil: “Small quantities of PCBs, furans, and dioxins were detected in the untreated off-gas, but none were detected in the vitrified mass. A few samples directly adjacent to the block contained measurable concentrations up to 0.7 ppm PCBs. ” (R.R. Battey and J.T. Harrsen, “In Situ Vitrification for Decontamination of Soils Containing PCBs,” ***Proceedings of the Oak Ridge Model Conference,*** February 1987, pp. 233-245.) In another report on the same experiment, the “process destruction was slightly greater than 99.9 percent. The small amount of material released to the off-gas system was effectively removed, yielding an overall system DRE of >99.9999 percent.” (V.F. Fitzpatrick, “In Situ Vitrification—A Candidate Process for In Situ Destruction of Hazardous Waste,” ***Proceedings of the 7th Conference on the Management of Uncontrolled Hazardous Waste Sites,*** December 1986, pp. 325-332.)

The ROD responsiveness summary said: “with worse case conditions, 97 percent of all organics are destroyed. Most tests indicate that 99 to 99.99 percent destruction is achieved.” Another ROD statement is more optimistic about destruction versus removal: “The test results [on PCBs] indicate that the organics are destroyed and not merely collected in the off-gas system.” All this information shows that ISV might be very effective but that the issue of total destruction of organics through both thermal treatment and off-gas collection, removal and possible treatment needs clarification. Lateral migration of vaporized organics into adjacent soil or perhaps downward into groundwater is also important and needs detailed resolution for application of ISV to any large, uncontained site.

This last issue has received major attention by Larry Penberthy, who calls it vapor retreat. While Penberthy is a competitor of ISV, he makes a good technical arguement: “Instead of being destroyed, the vaporizable chemical contaminants simply move away from the hot core melt by Vapor Retreat, unaltered. They move downwardly below the melt core as well as horizontally away from the melt core. This vaporizing/condensing action is progressive, building up concentration in the isotherm layers corresponding to each chemical’s boiling point. This writer expects the DRE to be only 25-50 percent.” (Larry Penberthy, letter to Laura A. Ringenbach, attorney for responsible parties, Mar. 28, 1988; Pyro 32A and 32 newsletter of Penberthy Electromelt International, Inc., Apr. 7 and 13, 1988.) This vapor retreat phenomenon could lead to increased contamination of groundwater. Moreover, in order to test for this effect it would be necessary to test a rather large volume of soil so that temperatures away from the molten zone are low enough to have condensation of vaporized contaminants, However, most testing is done on too small a volume of contained material to see this effect.

Penberthy has a number of other criticisms of the tests performed by Battelle which, even after examination of Battelle’s comments on Penberthy’s analysis, seem important enough to require additional study and testing. Moreover, Penberthy has raised important safety questions, such as effects from soil heating and subsidence, about using ISV at such a heavily industrialized area as the one around Pristine. No significant examination of the risks posed by ISV has been made.

The ROD did not focus on the depth of ISV. The plan is to go down to 8 feet for half the site and 12 feet for the other half. The Battey and Harrsen article (see above) noted that the greatest efficiencies for ISV occur when it is used to depths of 10 to 20 feet. The technology does not work well when contaminants are on the surface and therefore, soil covers are sometimes used, The ROD also noted: “The equipment must be specially designed and produced, ” The depth and equipment issues are possible causes of underestimated costs.

The other big issue for the Pristine site is the rejection of onsite incineration. The ROD acknowledged: “incineration is a proven technology. “ “Incineration ., . is fully protective of human health and the environment since the ingestion and leachability threats are eliminated.” The ROD did not acknowledge that some stabilization of the incinerator residues might be necessary because of toxic metal contaminants. But overall, the ROD did not note any disadvantages of incineration: "The use of mobile incinerators is common and the performance of these systems has been demonstrated. It is relatively easy to operate the system although a trained operator will be needed."

Nevertheless, incineration was not selected. The ROD said: "vitrification is the lower cost alternative. Therefore, incineration is not recommended for implementation at the Pristine, Inc. site." However, the costing for incineration seems too high. The ROD's total cost estimate of $51 million for incineration was based on a unit direct cost of $730 per cubic yard (for 37,700 cubic yards). Meanwhile, the FS said that the unit cost ranges from $350 to $500 per cubic yard. Several other recent FSS (for the Davis Liquid Waste and Re-Solve sites) by the same RIFS contractor provided detailed vendor costs and analysis for onsite incineration. From those two FSS, OTA used the cost data for three different technologies for a range of contaminated soil to be treated (4,300 to 57,000 cubic yards) and obtained a (conservative) estimate of a unit cost of about $300 per cubic yard for the level of effort at Pristine. This range is consistent information that other vendors gave to OTA.

EPA said recently that mobile infrared incineration of contaminated soils costs "from $120 to $225 per ton [which could be as high as $180 to $340 per cubic yard], depending on the number of tons incinerated per day." (U.S. Environmental Protection Agency, memorandum from John H. Skinner, Office of Research & Development, Dec. 10, 1987.) The FS for Seymour Recycling gave costs for onsite incineration over a very broad range of amounts of contaminated soil: for 35,000 cubic yards the cost was $186 per cubic yard; at the smallest scale (18,000 cubic yards) the unit cost was $349 per cubic yard. In the Crystal City FS the unit cost for onsite incineration was $240 per cubic yard for about half the amount of material at Pristine. In a recent decision for a Superfund removal action at the Southern Crop Services site in Florida, where mobile incineration was selected, EPA said that it expected bids at from $300 to $500 per cubic yard for less than 5,000 cubic yards of soil.

Actual (bid) costs for incineration can vary but do not explain the high estimate used for Pristine. A recent report showed a cost of about $750 per cubic yard (comparable to the Pristine ROD estimate) for a cleanup, but the soil quantity was under 10,000 tons and there was more than just soil to clean. (J.F. Frank et al., "Use of Mobile Incineration to Remediate the Lenz Oil Site," paper presented at ***Superfund '87, 1987,*** pp. 459-464.) At another site, a vendor (a subsidiary of the Pristine FS subcontractor) got $250 per ton under a turnkey arrangement; total costs probably were about $450 per cubic yard for cleaning between 7,500 and 10,000 tons of PCB contaminated soil. (J.W. Noland, remarks at ***Weston Environmental Forum,*** Washington, DC, February 1988.) Mobile incineration was used to incinerate materials at the Nyanza Superfund site in Massachusetts. The vendor charged about $600 per cubic yard for a very small quantity, about 200 cubic yards. At the Prentiss Creosote Superfund site in Mississippi, a vendor charged about $200 per ton ($300 per cubic yard) for mobile incineration of 7,500 tons; at the Southern Crop Services Superfund site in Florida, the vendor charged $360 per ton for 3,000 tons,

The Pristine ROD cites no technical factors to explain a $730 per cubic yard cost the site. For example, no mention has been made of buried drums. Even if the ash were to be chemically stabilized because of toxic metal content, the additional cost would not account for the cost discrepancies noted above. Moreover, in an internal inconsistency the FS calculation for a cleanup of only 8,100 cubic yards used a unit cost of $658 per cubic yard; instead of the expected higher unit cost for a smaller volume, a lower figure was used.

In the groundwater cleanup, the ultimate disposition of the collected hazardous substances is uncertain because it is not clear how the carbon that becomes contaminated by removing organic substances will be managed. The ROD said: "Bench scale studies will be done to determine the need for metals treatment." Air stripping only removes volatile organics and carbon adsorption is not likely to be effective for the metals. Maximum reported values of lead in groundwater are 178 ppb and 148 ppb in the upper and lower aquifers; the drinking water Maximum Contaminant Level (MCL) for lead is 50 ppb and the proposed MCL Goal is 20 ppb. For cadmium the corresponding groundwater levels are 39 ppb and 9.4 ppb and the standards are 10 ppb and 5 ppb. The complexity and intensity of groundwater contamination are great enough to warrant more detailed analysis of groundwater treatment, as was done for the Operating Industries site in California.

Any cleanup of contaminated surface water at Pristine is left uncertain by the ROD.

2) ***Accurate assessment of land disposal and containment alternatives.-The ROD contained*** an excellent rationale for not leaving contaminated material onsite: "It may leach into the groundwater at levels that will exceed ARAR's [regulatory standards] at some future time and thus increase the groundwater treatment time or require additional future remedial action. The lifetime of a RCRA multilayer cap is finite, and the contaminated soils will be left in place to contribute to groundwater contamination at some future time should the cap fail." The responsiveness summary said: "there are no data available on the long term effectiveness and permanence of RCRA caps."

By its very nature, ISV leaves treated contaminated material onsite. The ROD acknowledged uncertainties about ISV:

- "Vitrification ***is expected to be effective*** on the soil type present. . . "(emphasis added).
- "Air monitoring will be conducted to ensure that the hood is collecting and treating the gases." (Such monitoring is not routine when mobile incinerators are used.)
- "Some limited monitoring of the vitrified mass will be required to assure that it is a reliable and permanent remedy." (Such monitoring is not routine when stabilization is used.)
- "[There is] limited demonstrated performance. 99.9999 percent DRE [destruction removal efficiency] are expected for dioxin and PCBs."
- "Because this is not a proven technology, prior to implementation of this remedial action, bench and/or engineering pilot scale studies will be required to confirm the effectiveness and applicability of this technology to site conditions."
- "If this treatment method is found to be ineffective, this Record of Decision may need to be reopened."
- "Monitoring will be conducted during the treatment process to determine if contamination is migrating through the soil as a result of the treatment." (Such monitoring is not routine with in situ techniques.)

ISV is not easy to implement—at least, the technology costs more—when water content is high. Thus the ROD noted: "Because of concern over the effectiveness of vitrifying the upper outwash lens, consideration will be given, during these bench and/or pilot studies, to whether the lens should be drained prior to vitrification. " Also, the responsiveness summary said twice that the site's soil has "high moisture content" when it defended why vacuum extraction of VOCs was not feasible. However, when the selected ISV remedy was defended, the responsiveness summary—four pages later —said "the moisture content . . . is not high. " Either high is high, or actual measured values could be used to show it is high for one technology but not too high for the other technology, if that was the case; however, no actual data were used. (This may illustrate a lack of ROD quality control and ROD rushing at the end of a fiscal year quarter.)

To its credit, the Pristine ROD specified: "The Toxicity Characteristic Leaching Procedure (TCLP) is the testing mechanism that should be used to verify the complete treatment. If this treatment method is found to be ineffective, this Record of Decision may need to be reopened. " However, a recent technical report said that vitrified contaminated soil performed poorly:

"The vitrified product as evaluated with these standard leaching tests did not perform well. The reason for this is not known. It maybe that the nature of the tests maybe inappropriate for monolithic, vitrified masses, or vitrification might not be as effective as chemical stabilization for simple metal systems." (J.J. Barich et al., "Soil Stabilization Treatability Study at the Western Processing Superfund Site," paper presented at ***Superfund*** '87 conference, 1987, pp. 198-203.) According to the report, for example, leaching of zinc–over a short period in a standard EPA leach test—was about 10 times greater than for conventional stabilization. The responsiveness summary portrayed much more certainty: "the metals are encapsulated and bound up in the ISV process." The responsiveness summary also said: "ISV has been tested on hazardous waste and has been successful." These two statements contradict the Barich findings.

Battelle has said that the TCLP is technically inappropriate for monolithic waste forms. Their principal concern is that reducing treated material to fine particles—and exposing unbonded contaminants–is based on the false assumption that treated material may not maintain monolithic properties. Does this mean that, if Battelle is successful in making its point about the TCLP, the Pristine ROD will be reopened because the TCLP will not be used to test ISV's effectiveness?

A recent EPA study that examined eight emerging treatment processes for decontamination of PCB contaminated sediments ranked ISV last by using two sophisticated methodologies. The report said: "all the processes except In Situ Vitrification appear to merit further development for this application." (U.S. Environmental Protection Agency, "Report on Decontamination of PCB-Bearing Sediments," October 1987.) While PCB contamination is not the dominant problem at Pristine and sediments pose a special problem for ISV unless they are dewatered, this report is important because almost all previous information on ISV has come from its developer, including a lot of emphasis on tests on PCB material. The Pristine ROD said: "An additional application [of ISV] is being planned by EPA for a PCB contaminated site." In August 1987 it was reported that EPA Region 5 had "conditionally accepted" ISV for an emergency response action for PCB contaminated materials at the Greiner's Lagoon site in Fremont, Ohio. ***(Hazardous Waste News,*** Aug. 24, 1987.) As of May 1988, OTA was informed by EPA that no date had been set for the test—the actual removal action at the site—and EPA confirmed that this site action would constitute the ISV test for EPA's SITE program. Only if new test data confirm the presence of high concentrations of PCBs will ISV be used at the Greiner's Lagoon site and, even then, probably not before Spring 1989. If the PCBs are low, then another site would probably be selected, delaying the SITE demonstration still more. The Pristine responsiveness summary said that the demonstration will be performed prior to use of ISV at Pristine.

Failure of the vacuum off-gas collection system is possibile and of concern because of the high population density near the site. The responsiveness summary said: "Should this occur, the organics will be rapidly dispersed in the air, allowing for a very low probability of any adverse impacts through inhalation downwind of the site. "

ISV received very detailed examination in the FS for the BF Goodrich and AIRCO site in Kentucky, which was completed several months after the Pristine ROD. ISV was not selected at the BF Goodrich/AIRCO site, primarily because its high cost made it not cost-effective. Several of the comments about ISV in that FS (from a different EPA region and contractor) are important relative to the decision to use ISV at Pristine:

- "The effectiveness of off-gas collection and treatment is not known. "
- "The complexities of this repetitive process [incremental movement across a site] are not known since it has not been fully demonstrated on a large site."
- "There is very little data available as to whether vitrification is a reliable technology." (Compare this to the Pristine ROD: "results indicate vitrification to be a reliable technology.")

- "The mass could take several years to cool, depending on the size; therefore, a temporary fence should be constructed to prevent physical contact with the cooling material."
- "Implementation of the vitrification process has yet to be demonstrated on a commercial scale . . . It is probable that the frequency of operation and maintenance problems would be higher than for a proven technology. As a result, reliability would be lower than for proven technologies. Emissions during implementation would require extensive control for both VOCs and dust. " These concerns are especially relevant to Pristine because of its location in a highly industrialized area.

Similarly, ISV was rejected at several Superfund sites in Colorado in 1987 (Denver Radium Operable Units: Open Space, Card Property, 1000 West Louisiana Properties, and 12th and Quivas Properties). What is especially interesting is that contamination by radioactive materials would seem to be an ideal application of ISV because it was originally developed as a cleanup technology for radioactive materials. However, all three RODS say the same thing: "[ISV] was eliminated during the initial screening because its implementability for this particular application is unproven. [ISV] has not been demonstrated on a large scale of utilized in a highly-populated urban area like that of the Card property." Moreover, in these cases ISV was ***also*** rejected because of the possible "escape of radon gas and associated radon decay products." This would seem to also be applicable to escape of trapped gaseous organic contaminants at a site like Pristine, and the concern undermines the belief that monolithic, solidified ISV material offers secure, tight, and permanent encapsulation.

RIFS contractor.–Camp Dresser and McKee (CDM); the cost was at least $500,000. The ROD did not indicate who did the FS, but a copy of the FS shows it was CDM with Roy F. Weston performing the FS as a subcontractor. The ROD said that several figures in the FS were wrong and recalculated figures were used in the ROD. The ROD also said that after the RI was completed "several gaps were identified" and additional work was done which took another year.

State concurrence.—The ROD said that Ohio's letter of concurrence is forthcoming. This suggests that the ROD was rushed to get it out by the end of the fiscal year quarter.

Community acceptance.–"The community and PRPs are generally in agreement with the groundwater extraction and treatment component of the alternative. Some members of the community have fully supported U.S. EPA's recommended alternative, while the PRPs rejected vitrification and have proposed installation of a RCRA cap with soil gas venting. The City of Reading prefers that U.S. EPA fund a less expensive remedial action and give it the remaining funds to build a new municipal treatment plant."

Special comments.—The FS had an initial discussion of the two main treatment alternatives where unit costs and other data were presented. For in situ vitrification the sole technology developer, Battelle Pacific Northwest Laboratories, was acknowledged and was the source of the data. For onsite incineration, the source of information is described as "Firm A." Only rotary kiln incineration is used in the detailed analysis. Because a wholly-owned subsidiary of the FS subcontractor, Roy F. Weston, Inc., does cleanups with a transportable rotary kiln incinerator it seems likely that subsidiary was Firm A.

The ROD acknowledged some uncertainty about the groundwater cleanup: "The extent of contamination from Pristine, Inc., will be determined by additional studies during the remedial design." However, this ROD addressed the final source ***control*** remedy and should not be expected to be definitive about the groundwater cleanup. The ROD also noted that contamination in the lower aquifer may be the result of "a multi source groundwater contamination problem in the area. " According to the ROD, a variety of other types of actions might be used, including RCRA corrective action.

The responsiveness summary had an interesting interpretation of the provision in SARA

Section 121(b)(2) that says that a technology can be selected even if it has not "been achieved in practice" elsewhere. The interpretation was that the provision allows a technology selection without directly applicable data on its effectiveness before the ROD. Legally, this position seems correct because congressional intent was not to prevent full-scale application just because there has been no prior ***full-scale*** application of a new technology. But traditional engineering practice does not condone choosing or using a technology without supportive site-specific test data. The issue is that ISV has not been tested sufficiently at Pristine nor on large, unconfined contaminated soil not the absence of successful full-scale use of it at a similar site.

The responsiveness summary would have been more useful had it provided the sources of specific comments, which is normally done.

General conclusions.—There area number of outstanding aspects to the Pristine ROD. The commitment to meeting SARA's preference for permanent treatment technology is excellent. The commitment to an innovative technology is commendable. The risk assessment is exceptionally good, detailed, and well presented. For example, using a 1 in 1 million risk for ingestion and direct contact, the cleanup targets for soil are 3,182 ppb and 15,041 ppb for benzene and trichlorethylene; but, when removing the threat to groundwater from leaching of the contaminated soil was used, the targets for the two chemicals decreased to 116 ppb and 175 ppb to meet drinking water standards.

Unlike most FSS, the Pristine FS presented a preferred alternative that was recommended for implementation. It is OTA's understanding, from speaking to RIFS contractors, that EPA usually directs them not to give a recommended cleanup. Why was ISV so strongly supported for Pristine, especially before the use of it in the removal action planned by Region 5?

As reported in Pristine's responsiveness summary, EPA's selection of ISV got a poor reception, apparently from responsible parties, because of its unproven state, high cost, and preferential handling in the FS and ROD: "Because of its obvious bias in favor of ISV . . . the FS does not properly evaluate all existing relevant technologies . . . " EPA was accused of being "arbitrary and capricious. " EPA defended its selection at great length, including a discussion of why vacuum extraction of VOCs, apparently considered a viable alternative by the responsible parties, is not applicable to the site. (The technology was not analyzed in the FS.) However, EPA's discussion did not resolve the questions raised here about ISV, nor did EPA go into any technical depth in discussing vacuum extraction. Extensive work done for the responsible parties indicates that vacuum extraction, which has been selected for cleanups elsewhere, may be feasible and cost-effective at Pristine (see below). To the extent that ISV reduces risk mainly through removal of volatile organic contaminants, it performs functionally like vacuum extraction removal of volatile organics. But vacuum extraction is intrinsically a lower cost technology that uses less capital intensive equipment and energy than does ISV.

The problem is the decisionmaking process and the accuracy of crucial data upon which it is based, As with so many sites, treatability tests for Pristine were postponed to the post-ROD Design Phase even though test data are necessary to fully support the selection of remedy. ***This criticism is not directed at the ISV technology itself,*** which might eventually work at the site and which ***is*** an important new cleanup technology. But the wisdom of choosing ISV for the Pristine site remains questionable for several reasons.

Consider the following initial criterion to be complied with for a technology to pass the initial screening in a feasibility study: "There must be a demonstrated history of successful use of the technology in environments similar to the site. All technologies of a research and development nature, and which cannot be reasonably said to be in common use, are rejected." This criterion is from the 1987 ROD for the Northern Engraving Corp. site in Wisconsin ***in the same EPA Region as Pristine.*** ISV technology could not meet that criterion, nor is the criterion consistent with SARA, but the point here is inconsistency within the Superfund program.

Either EPA's SITE program needs to prove in situ vitrification or the technology should be released from the demonstration program and accepted as proven technology in ROD selections. Without ***treatability study results,*** the uncertainty about ISV's effectiveness, when coupled with no cost advantage over proven incineration (see below), weakens Pristine's ROD and the government's attempts to get responsible parties to take over the cleanup. Although SARA allows the use of new innovative cleanup technologies, there is little engineering or public support for selecting an unproven technology without supportive data. Data are necessary to substantiate a technology's ability to meet specific cleanup goals, especially when other proven and cost-effective permanent treatment technologies are available. Moreover, in the Pristine FS, treatment technologies other than incineration were eliminated from detailed evaluation with no technical basis. Although the FS and ROD were clearly committed to using a treatment technology, the alternatives became very restricted. Aside from ISV and conventional incineration technology, no consideration was given, for example, to above ground vitrification of excavated soil in a furnace. This technology was said, by its developer (Penberthy Electromelt International, Inc.), to cost $180 per ton ($280 per cubic yard) in direct unit costs; a transportable furnace would take about 500 days to perform the work at Pristine. These figures are competitive with ISV.

Is EPA prepared to alter its decision in the Design Phase if test results are negative? The ROD said that manufacture of the specially designed equipment "will occur concurrently with the remedial design. " In other words, a big investment will be made before test results can support the selection.

The cost of the ISV choice may have been under estimated for several reasons discussed earlier (depth of treatment and building special equipment). The range of unit cost for ISV given in the FS is $250 to $350 per cubic yard. The FS used a mid-range value of $290 per cubic yard. If a unit cost of $350 is used, it leads to a total cost of $26 million instead of the ROD estimate of $22 million. (Total costs include burdens and groundwater cleanup.)

The FS contained initial screening costs for the two treatment options: ISV and incineration. At the screening stage, the two costs looked comparable: ISV at $13 million and incineration at $18 million. These figures seem to come from using the upper range of the unit costs given in the FS ($500 for incineration and $350 for ISV, with no burden added). But the ISV cost increased by 70 percent in the final cost calculations in the FS, while the incineration cost increased by 183 percent, with no explanation provided. There is more uncertainty about the cost of the ISV option, however, than about incineration and just the opposite change in cost would have seemed more plausible.

As discussed earlier, the cost of onsite incineration was seriously over estimated and beyond EPA's standard allowable range of +50/–30 percent. (This allowable range, itself, is large enough to invalidate a technology decision based on cost.) The FS did not use the $425 per cubic yard mid-range value from its own incineration data ($350 to $500); data which appears higher than reliable cost estimates. OTA recalculated the cost of the onsite incineration option. Instead of using $730 per cubic yard (which the ROD used to calculate incineration costs), OTA used $300 per cubic yard (see discussion above). Including all the other costs for the incineration alternative, such as groundwater cleanup, as done in the FS, the total cost for the incineration alternative then becomes $23 million (close to ISV's cost). If the cost of the ISV option is also recalculated to reflect the high end of the cost range supplied by the vendor, then its cost is $26 million. The conclusion is: ***onsite incineration is not likely to be more expensive than ISV at Pristine.***

In these recalculations the indirect or burden costs (83 percent) are those used in the Pristine FS; however, these are much higher than those in the FSS for the Davis and Re-Solve sites. At Pristine, various contingencies, construction services, and design costs amounted to a burden of 83 percent, while in the Davis and Re-Solve FSs the burden is 35 percent; the latter explicitly included costs for pilot study work, while the figures for Pristine did not. For Crystal City, the burden was 29 percent; for Chemical Control, 56 percent; and for Seymour Recycling, 60 percent. For the BF Goodrich/AIRCO site in Kentucky where ISV received extensive examination, the total overhead on the ISV direct costs was 60 percent (and the unit cost was $275 per cubic yard). The markup at Pristine was substantially higher than the markups in these other recent FSs. That is, both treatment estimates at Pristine would have been lower if a lower burden were used; with 35 percent, used by the same RIFS contractor in other FSs, the cost for ISV becomes $16 million instead of $22 million and the incineration option (at $730 per cubic yard) becomes $38 million instead of $51 million.

Indeed, mobile incineration might be less costly; if the low $186 per cubic yard figure from the Seymour site (which is in agreement with other data given above for recent actual ***contracted costs)*** is correct and is used for Pristine, with the same high burden rate as the other alternatives, the total cost of the rejected incineration option is about $15 million [instead of the estimated $51 million) versus $22 million for the selected remedy of in situ vitrification. With the lower, more typical burden rate of 35 percent, the incineration option comes to about $11 million (versus $16 million for ISV at the same, lower burden rate). The Seymour site is in the same EPA Region as Pristine. These two sites illustrate that more regional oversight is necessary to catch inconsistencies in data critical to technology selection.

The lower figures for incineration are important in the context of the government obtaining a settlement with the responsible parties; if this estimate proves correct on closer scrutiny and true costs of incineration at Pristine are indeed much lower than the cost of ISV, then incineration becomes the more attractive ***cost-effective*** permanent remedy. However, onsite incineration is likely to cost more than vacuum extraction of volatile organic contaminants, which the responsible parties favor. But vacuum extraction is a separation technology, and an important issue (as it is for ISV) is what is done with the extracted contaminants. If they are destroyed rather than landfilled after carbon adsoption, the costs increase. Moreover, the diversity of contaminants at Pristine requires careful analysis of vacuum extraction's ability to remove them; it might be able to do so.

Although at Pristine ISV was rated comparable in effectiveness to incineration and better for cost, its implementability is lower than that for incineration because ISV has not been routinely used for chemical waste cleanups. ISV has a higher level of uncertainty with regard to site conditions, and there is a need for site-specific design. Indeed, the FS said, "There is more data to support incineration . . . Of the soil contaminant destruction alternatives, only [incineration] has a demonstrated performance and reliability, " Incineration offers considerably more certainty as to effectiveness, reliability, and cost.

Cost aside, incineration is a less risky selection at this time in the absence of treatability study data that could remove uncertainties about ISV for the Pristine site, especially with regard to off-gas collection and treatment, the migration of contaminants into surrounding soil, the degree of destruction of all organic site contaminants, and safety uncertainties for the surrounding community.

There is another uncertainty about the implementation of ISV. Battelle has exclusive rights from the Department of Energy to market ISV for nonradioactive sites. The ROD acknowledged that "ISV is a patented process which requires a license." Other companies who do actual cleanup work are not familiar or experienced with the technology. However, the Pristine responsiveness summary said: "The selection of ISV is not patently unfair since the developer will be licensing firms to carry out the process and the bid process will be competitive." Subsequently, Battelle changed the way it offers the technology such that its