The interest in using innovative treatment technology is commendable, and some biological remedy may, in fact, be found effective. But the ROD decision was made without supporting technical information. The ROD and the FS contained no details about the technology. There are many forms of biological treatment, and it is still too new a cleanup technology to make assumptions on effectiveness at a site with so many organic contaminants, some at relatively high concentration. Technology specificity is high for biological treatment, which means that it is difficult to extrapolate success from one waste to another. Delay of treatability testing until after the ROD creates considerable uncertainty and the potential for actions which are not fully protective of public health and environment because of either substantial loss of time or a compromise of cleanup goals if the testing shows problems in the biotreatment. Indeed, because of the need for extensive treatability testing, the estimated time for complete implementation seems overly optimistic. Such biological treatment (both aerobic and anaerobic processes) of contaminated soil was rejected at an early screening stage in the Pristine FS because "Mixed wastes and low concentrations (less than 100 ppm) are difficult to treat. " The same condition exists at Renora.

Because of the use of landfilling and the selection of an unproven treatment technology, the selected remedy cannot be assured to be permanent. Moreover, compliance with SARA's requirement on the reduction in toxicity, mobility, or volume was described in three different ways: complete, substantial, and significant. This puzzling situation may indicate end-of-fiscal-year ROD rushing or confusion over the capabilities of the selected remedy.

Case Study 8
Sand Springs Petrochemical Complex, Tulsa County, Oklahoma, EPA Region 6

Capsule OTA findings.–EPA originally said solidification technology was ineffective for the high organic content site wastes and incineration was effective. Nevertheless, EPA reversed itself and selected solidification for most of the cleanup, which the responsible party had found effective in its treatability study. Incineration is to be used if solidification technology is not successfully demonstrated or fails after solidified material is landfilled on the floodplain site, but the criteria for failure are unspecified.

Key dates:

- Entered Superfund system: 8/1/80
- Preliminary Assessment: 6/1/80
- Site Inspection: 11/1/80
- National Priorities List
  –proposed date: 10/84
  –final date: 6/86
  —site rank: #761 out of 770
- RIFS start and completion: 6/29/84 to 5/4/87
- Public comment period before Record of Decision: 7/29/87 to 9/1/87
- Signing of ROD: 9/29/87
- Estimated complete remediation: 11/91

Total time.—11 years

Brief description of site.–"The site operated as a refinery from the turn of the century through the 1940s. The property has since been developed as an industrial area and consists of an abandoned solvent and waste oil recycler, an active transformer salvage/recycler, active chemical manufacturers and various other industries. . . . the site is located on the northern bank of the Arkansas River, immediately west of Tulsa, Oklahoma. The site encompasses approximately 235 acres [and] includes unlined acid sludge pits, a surface impoundment, surficial sludge contamination, solvent and waste oil lagoons and contaminated sediments. The [site] is located in the alluvial floodplain of the Arkansas River."

Major contamination/environmental threat.—''Total known waste volume is approximately 130,000 cubic yards. During the period of operation hazardous substances were stored or disposed of in drums, tanks, unlined pits and lagoons or buried on-site. These substances include various volatile and non-volatile organics, chlorinated solvents, and sludges containing heavy metals. Waste pits have contaminated local

groundwater and caused migration of surface contaminants. ”

EPA concluded that there are four major sources of risks: direct contact with organic carcinogens and highly acidic wastes and surface waters; air emissions of acid fumes and volatile organic compounds; surface waters polluted by runoff during heavy rains; and groundwater being contaminated directly by lagoons and indirectly from site runoff: “in heavy rains the site is submerged.”

According to the FS: “It is believed that contaminants from the pits, ponds, and lagoons are leaching into the alluvial aquifer, therefore, a major pathway for migration is probably groundwater. However, by definition this pathway has been excluded from consideration during the FS for the Operable Unit.” The same contamination problem exists for surface water migration offsite. The FS also said: “Several on-site ponds and lagoons have a history of breaching their containment structures: there have been incidents of dike walls breaching for one of the Glen Wynn lagoons, as well as flow of materials from the river acid sludge pits into the Arkansas River, which have occurred in the past . . . . the contents of the large and small acid sludge pits had breached their dike walls on several occasions.”

HRS scores.-groundwater,44 .90; surface water 21.82; air 0.00; total 28.86

Removal actions.—A private party performed a removal action in 1984; there are no details in the ROD.

Cleanup remedy selected.—EPA designated this cleanup as a source control operable unit that covered surface liquids, sludges, and heavily contaminated solids but not minimally contaminated soil or groundwater. The latter is to be addressed in a subsequent ROD. Originally, before the ROD was officially signed, EPA selected onsite incineration of wastes and solicited public comment on it as part of the RIFS public comment period; the agency had already evaluated solidification and onsite landfill and solvent extraction, all of which were rejected. EPA changed its mind and selected solidification, accepting a five-part proposal by Atlantic Richfield Company (ARCO), a responsible party, that included:

1. excavation and offsite thermal destruction of some unspecified volume of surficial sludges;
z. solidification and/or stabilization of all remaining sludges and containment of the resulting material in an onsite RCRA hazardous waste landfill;
3. demonstration that solidification technology meets EPA approved criteria and, should it not do so, use thermal destruction [apparently onsite];
4 no liability release for the site or from future maintenance and monitoring; and
5 repair or restoration of the landfill to ensure no migration or destruction or treatment of all or a portion of its contents, as EPA deems appropriate, should monitoring show that the solidification/stabilization remedy fails.

It appears that ARCO is anticipated by EPA to sign a consent decree, agreeing to pay for the cleanup.

Cost data on the selected remedy is absent because the combination of solidification and incineration was not evaluated in the FS. It is unclear how much material will be incinerated offsite initially. But if solidification is used it will cost less than incinerating all the waste. Incineration was estimated in the ROD to cost $67 million and complete solidification was estimated at $38 million (the comparable figures in the FS are $54 million and $31 million). OTA estimates that the probable comparable cost of the five-part remedy is $45 million, but this figure is highly uncertain because there are many different forms of solidification.

Satisfaction **of SARA statutory requirements:**

I) Selection of permanent cleanup.—EPA said in the ROD that the selected remedy, based mostly on solidification, fulfills the statutory preference. However, as EPA stated: “on-site thermal destruction of wastes . . . appears to meet more statutory selection criteria than the other remedies evaluated. ” With solidification,

"unlike on-site thermal destruction, the toxicity of wastes would not be reduced and the volume of wastes would be increased."

EPA views in the ROD on the chosen solidification option at this site included the following:

- ". . . [there was a] lack of demonstrated permanence."
- ". . . the capability of solidification or stabilization techniques to permanently bind with high organic wastes, such as those found at Sand Springs, has not been demonstrated in the pilot studies conducted on-site."
- ". . . without further treatment free liquid contaminant concentrations were not reduced to meet RCRA land ban restrictions."
- ". . . the unconfined compressive strength of the stabilized material . . . does not meet the recommended disposal criteria."
- "leaching tests conducted by EPAs Cincinnati laboratory show that the solidified material leaches contaminants."
- ". . . leaching of contaminants, and incomplete encapsulation [small globules of waste were seen] raises questions about the long term effectiveness and permanence of the process."
- the waste" . . . contains 50 percent organic compounds raising doubts about the abilit y of stabilized or solidified waste to meet RCRA requirements in the long term."
- samples " . . . show obvious degradation of the solidifying matrix following analysis for total organic content."
- "the net assessment is that solidification or stabilization processes present difficult problems with respect to meeting ARARs [standards]."
- ". . . possible air emissions."
- ". . . volumetric increase of 50 [to 200 percent]."
- ". . . the potential for failure was determined to be greatest for the on-site solidification remedy."
- ". . . the source of the contamination will not be destroyed."
- additional " . . . studies will need to be performed on the subsurface petroleum wastes."

The FS summed up its evaluation of onsite solidification: "Not a proven technology for high organic waste. Contaminant source isolated, may not be rendered nonhazardous. May not meet ARAR." It remains unclear whether the test results supplied by ARCO removed all of the above concerns for EPA; but the inclusion of the third provision in the five-part remedy which requires demonstration of solidification technology suggests that EPA was not fully convinced by the ARCO test data or that it did not have enough time to fully evaluate it prior to signing the ROD.

EPA has tied the environmental acceptability of the solidification remedy to two conditions: "if the effectiveness of this concept is adequately assured or if ARCO undertakes the corrective actions deemed appropriate by EPA should the remedy fail." No such conditions would have been attached to the originally chosen thermal destruction remedy, which ARCO also examined in its treatability study and which was found to work effectively. Cause for EPA rejecting the incineration option in the ROD was said to be its "serious implementation problems," but EPA's FS analysis also said that all the processes that would treat waste onsite "are judged to each have the same degree of implementability." Moreover, the ROD stated: "Actual implementation time for solidification and thermal destruction is comparable . . . "

EPA said: "The proposed remedy is considered permanent." And that it "is cost-effective compared to equally environmentally protective alternatives." But EPA also said that the thermal destruction alternative offered more overall protection than solidification. The FS summed up its case for onsite incineration: "Proven technology destroys hazardous material, Containment source worker health and safety addressed in remediation. Meets ARAR."

2) Accurate assessment of land disposal and containment alternatives.—With regard to future operation and maintenance, the ROD said that these "will be minimized since the source of the contamination will be removed." But, as the ROD also stated, solidification does not destroy the source of contamination that ***will***

be left onsite. The ROD contained a replacement cost of $100 million should failure occur for the onsite solidification and landfilling option but no cost for the incineration alternative. For these two pure (single technology) options, the reduction in cost of about $30 million for solidification is offset by a possible future re-remediation cost of $100 million. And, that tradeoff still exists.

The onsite landfill is supposed "to reduce groundwater infiltration and the chances of any contaminants migrating off-site. " But if " . . . significant, unforeseen, off-site migration or contamination occurs as a result of the site, appropriate remedial measures will be taken, " No detailed analysis of future failures was given. The ROD did not express concern about having the onsite landfill in a location that is submerged in heavy rain and that is in a floodplain adjacent to the river. The ROD stated further: "While a hazardous waste landfill of solidified waste would protect health in the short term, the long term stability of this material is not proven. "

For Sand Springs, the importance of the water level to remedy selection is striking. The ROD for the Tower Chemical Superfund site in Florida, for instance, commented on the use of chemical stabilization followed by onsite land disposal, a remedy the ROD rejected. The comments apply directly to the Sand Springs site: "Although this process is effective in addressing inorganic contamination, the volume of materials would increase, thus causing increased disposal facility requirements. In addition, the soils being solidified contain significant amounts of organic compounds which could affect the integrity of the cement monolith. The presence of organics will require containment of the monolith within an on-site landfill built above the land surface due to the locally high water table. This technology would also require long-term (30 years) monitoring which is less favorable than technologies which provide permanent destruction of wastes. . . . a high water table at the site makes it infeasible to solidify or build an on-site landfill which meets the design specifications outlined in RCRA."

The issue of effectiveness of solidification technology for organics is critical for Sand Springs. The FS for the Re-Solve site in Massachusetts rejected stabilization because "there has been limited success in chemically fixing organic contaminants such as solvents and PCBs." The ROD for the Liquid Disposal site in Michigan, which also selected stabilization for soil contaminated with organic chemicals, said that the hazardous substances "will not be permanently destroyed" and "hazardous chemicals still remain in that [treated] mass. " And the FS for the site said: "Considerable research data exists demonstrating the effectiveness of this technology in immobilizing a wide range of contaminants, primarily inorganic. A substantial amount of data does not exist, however, to accurately judge the long-term reliability of the process. Long-term leaching and volatilization can be expected for soluble and volatile organic wastes." Although, stabilization was selected for Liquid Disposal, so was the use of a slurry wall and impermeable cap around and over the treated material, as a second level of control. The ROD for the French Limited site in Texas (same EPA region as Sands Spring) said: "Fixation is questionable due to high organic content of untreated soils."

An EPA report's observations on halogenated organic wastes also apply to the selection of chemical stabilization for Sand Springs: "the area of solidification/encapsulation is one requiring additional study before it can be considered viable technology. " (U.S. Environmental Protection Agency, Technical ***Resource Document: Treatment Technologies for Halogenated Organic Containing Wastes,*** vol. 1, January 1988.)

Another EPA document, used to teach cleanup workers about waste treatment says: "Solidification technologies are designed to be used for final waste treatment. This means the technology should be applied only after other treatment techniques have been applied, i.e., incineration,

chemical treatment or other. " (U.S. Environmental Protection Agency, **"RCRA/CERCLA** Treatment Alternatives for Hazardous Wastes," October 1987.)

A specific type of solidification tested for Sand Springs was mentioned in the FS for Crystal City, but the solidification/landfill alternative was not selected at Crystal City. Data provided by the vendor, on waste from some other site, and reported in the Crystal City FS on two contaminants also present at Sand Springs (2-methylnaphthalene and phenanthrene] showed high levels in the leachate. A demonstration of the same stabilization technology under EPA auspices concluded: "for the organics, the leachate concentrations were approximately equal for the treated and untreated soils." (P.R. de Percin and S. Sawyer, "SITE Demonstration of Hazcon Solidification/Stabilization Process," paper presented at EPA's Fourteenth ***Annual Research Symposium,*** May 1988.)

A recent EPA study found "large losses of organics during the mixing process." (L. Weitzman et al., "Evaluation of Solidification/Stabilization As A Best Demonstrated Available Technology," paper presented at EPA's ***Fourteenth Annual Research Symposium,*** May 1988.) Another EPA study showed that stabilization was not competitive with thermal and chemical treatment technologies and soil washing for organic contamination. (R.C. Thurnau and M.P. Esposito, "TCLP As A Measure of Treatment Effectiveness: Results of TCLP Work Completed on Different Treatment Technologies for CERCLA Soils," paper presented at EPA's ***Fourteenth Annual Research Symposium,*** May 1988.)

RIFS contractor.—State led; ***$1.1*** million; John Mathes & Assoc.

State concurrence.—The State of Oklahoma favored solidification over incineration,

Community acceptance.–EPA judged that the community was more in favor of solidification than incineration. The community was very concerned about the future use of an incinerator for waste from other sites, the worsening of the area's air pollution, and harm to the local economy. (Building an incinerator for industrial waste is frequently sold by industry to communities as a local economic advantage; several efforts to site a hazardous waste incinerator in Oklahoma are underway.) Although EPA tried to allay the community's concerns about incineration, ultimately the community preferred the uncertainties of the solidification technology and accepted the assurances that incineration would be used if solidification was less effective.

On this issue of the safety of mobile incineration, Sand Springs can be compared to the Davis Liquid Waste site in Rhode Island where there also was substantial, documented community concern about onsite incineration, concern to which EPA responded with good technical points but, unlike Sand Springs, did not alter its choice of incineration. Also, in the ROD for the French Limited site (in the same EPA region as Sand Springs), EPA defended mobile incineration: "Performance standards for air emissions from incinerators would be met, minimizing the risk from these emissions. EPA considers the implementation of an incinerator to be relatively simple in comparison to the other alternatives evaluated in the summary. "

Moreover, it is not clear that the community was totally aware of air pollution problems with solidification. EPA's responsiveness summary said: "Pilot studies have shown that some volatile compounds are driven off during excavation and mixing of the waste with the solidifying agent. Mass emission rates have not been quantified."

Special comments.—The ROD's analysis of cleanup alternatives said that for any alternative it will be necessary to pump and treat surface impoundment liquids and to discharge them into the Arkansas" River; no details were given. Moreover, the accepted ARCO proposal made no mention of these needs.

General conclusions.—Sand Springs has ***some*** good points: 1) pilot treatability studies were used to evaluate treatment technologies; 2) alter-

native treatment remedies were analyzed; 3) EPA responded to the concerns and interests of responsible parties, the community, and the State; and 4) some preferred treatment technology was selected by EPA.

But Sand Springs has many problems too, including a lot of confusion about what test data were used by EPA and when. The ROD selected not a reliable permanent remedy but a plan with several contingencies, with no assurance of a permanent remedy. Over a short period of time —about one month—EPA reversed a well-supported, technically sound decision to use incineration rather than solidification/stabilization technology. In the ROD, EPA said: "Solidification was considered in detail during the Feasibility Study and actual pilot studies. Adequate information is available on which to base a decision." Was EPA talking about the information available when it signed the ROD, including the ARCO test results, or information obtained by EPA prior to the RIFS public comment period? The ROD suggested that EPA had conducted its own tests on solidification of site materials. But it may have used a very different type of solidification technology. In the ROD responsiveness summary EPA said: "The [ARCO] pilot studies had a major influence on the remedy selected. " If that was so, then why did the ROD still contain so many negative comments about solidification? Part of the answer may be revealed in another statement by EPA in the ROD's responsiveness summary: "Solidification pilot tests [presumably ARCO's] were only conducted on the surficial acid sludge waste. Additional waste characterization and pretreatment studies will need to be performed on the subsurface petroleum wastes." Another part of the answer is that EPA had ***conflicting*** **test** data from two different sources on several solidification technologies. Therefore the question persists: Was there enough test data to justify the ROD's selection of remedy?

The ROD contained no details on how EPA will assure that independent, detailed, and timely testing will track progress on the selected remedy and detect ineffective performance in the long term, if that occurs. If the treatment technology is ineffective, contaminants will leach out of the solidified mass, because the treated material will be placed into a landfill on a floodplain adjacent to the Arkansas River. Landfill failure was not considered, nor is its location compatible with regulated use of land disposal. Moreover, cause for concern about independent testing and verification of solidification's effectiveness is driven by ARCO's position that ***any*** form of waste treatment is unnecessary: "Improved site security and a clay cap would mitigate this [accidental direct contact] potential risk." (ARCO, letter to Carl Edlund, EPA Region 6, Aug. 31, 1987.) ARCO's critique of EPA's FS of August 31, 1987, said that fencing and a cap "could be a sufficient remedy." Moreover, in this document ARCO also said: "Long term effectiveness of incineration, stabilization and solidification are comparable." These views of ARCO suggest that the selection of solidification, with costs much lower than incineration, was a compromise made by both EPA and ARCO and that future, post-ROD actions require close EPA scrutiny.

ARCO's effort to get EPA to retrench from its original decision to use incineration probably was helped by its apparently successful criticism of the quality of the RIFS. Indeed, a number of ARCO's comments are consistent with OTA's observations in this report for RIFSsin general. For example, ARCO said: 1) "significant gaps exist in the data presented and considered in the FS"; 2) "The analysis reflected by the FS is cursory and of limited detail"; 3) "The lack of back-up, the limited detail and the lack of references suggested that the analysis may not have involved the development of any additional information beyond that provided by the authors' experience"; and 4) "The FS is characterized by an over-reliance on assumptions rather than actual performance data."

A big question still remains. Who bears the burden of proof that a treatment technology works before EPA officially endorses its use at an actual cleanup? There is no basis in the technical literature for concluding that solidification/stabilization technology is likely to be effective for wastes with so much and so many different kinds of organic contamination. The presence of negative laboratory results, which

EPA suggested it had prior to the ARCO test data, would normally prevent application of a cleanup technology at the site in question. It is true that unusual conditions might justify an unproven technology; for example, in an emergency situation and where all other treatment technologies are less applicable. But this site is not generally considered to require emergency attention, and the pilot study on incineration was successful. (Note that stabilization of incinerator residue contaminated with metals only is proven technology.) It may well be that, as EPA says, the technology proposed by ARCO is "a promising innovative technology," but sanctioning its full-scale application through a ROD on the basis of limited data obtained by the responsible party that conflicts with data obtained by the government, is a big step, especially because the data are inconsistent with what is generally understood about the capabilities of the technology. In fact, there are a number of very different proprietary forms of solidification and stabilization (ARCO actually tested two and got similar results), and it is not clear that either ARCO or EPA has considered or evaluated enough of them and their performance relative to the technologies used in the ARCO treatability study.

The degree to which the ARCO data support EPA's decision also raises the issue of how accurately current EPA tests—in this case for hazardous waste treated by stabilization—predict long-term environmental effectiveness. Much more rigorous testing appears necessary to make the case that stabilization of hazardous ***organic*** material, such as at Sand Springs, assures insignificant leaching of organic contaminants under long-term conditions at the site. Therefore, although the ARCO test data do look good, they are limited by the test procedures themselves. Nor were the ARCO test data obtained by using standard test protocols and quality assurance procedures to assure the public and the government that the data are reliable. Doing this is a major effort and an important characteristic of EPA SITE program and most treatability testing done by or for the government.

After the ROD was issued, a news publication reported: "Solidification poses 'very little risk whatsoever,' says an EPA headquarters source, who is encouraged that the agency is willing to allow its use at a Superfund site. The technology has not been proven to 'truly bind organics,' but any release of organic substances would be slight, the source explains. " ***(Inside EPA,*** **Nov. 27, 1987, p.** ***13.)***

Moreover, the solidification technology evaluated by ARCO appears to be one which is in EPA's SITE technology demonstration program to "resolve issues standing in the way of actual full-scale application, " The demonstration was conducted October 13-16, 1987, at the Douglassville Disposal Superfund site in Pennsylvania, but results of the test were not made available before the ROD and EPA made no reference to them for Sand Springs. Results recently made available were negative for organic contaminants.

The way the remedy selection was made illustrates what can happen when there is much pressure to issue a ROD by the end of the fiscal year. ARCO submitted its treatability study results to EPA on July 15, 1987. As late as August 21, 1987, results from ARCO's pilot tests were still being obtained and disseminated among EPA staff. Several formal ARCO reports are dated August 31, 1987, including one criticizing EPA's RIFS. This site, like a very high percentage of all Superfund sites, had its ROD issued in the last days of the fiscal year (September). In this case, EPA might have stayed with its original, technically supported decision and kept on schedule or delayed issuing the ROD while it: 1) designed more tests for ARCO to carry out to convincingly demonstrate, before actual use, the long-term effectiveness of solidification/stabilization technology for the diverse wastes at the site; and 2) developed detailed protocols for future testing and monitoring as well as technical criteria which would trigger the switch to incineration, if solidification failed. In this case, the responsiveness ***of*** EPA to local pressures seems to be related to selecting a lower cost technology and facilitat-