Chapter 11
History of U.S. Ocean Incineration

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This chapter discusses several facets of the history of ocean incineration in the United States. Past burns, the designation of sites for ocean incineration, and recent Environmental Protection Agency (EPA) activities, including the recently denied proposal for a PCB research burn, are discussed.

PAST BURNS

Four sets of research or interim burns occurred under EPA's authority between 1974 and 1982. All four used the *Vulcanus I* and included varying degrees of monitoring and analysis of stack emissions and the marine environment. In addition, EPA monitored a test of the *Vulcanus II* in the North Sea in 1983. This section describes each of these burns and discusses the reported results. Table 26 presents a summary of these five sets of burns, indicating locations, types of waste incinerated, destruction efficiencies, and other reported results. In each case, a primary reference is indicated for additional information.

Shell Chemical Organochlorine Wastes in the Gulf of Mexico: First Series

Use of ocean incineration was first proposed in the United States in 1974, when Shell Chemical Co. sought permission to use the Dutch-owned vessel *Vulcanus I* to incinerate liquid organochlorine wastes. This type of waste had previously been dumped in the Gulf of Mexico, until EPA halted the practice in 1973. The waste proposed for incineration was a mixture of chlorinated hydrocarbons derived from production of vinyl chloride and other chemicals. The chlorine content of the waste was 63 percent.

In October 1974, EPA granted Shell a research permit to incinerate one shipload (4,200 metric tons, or mt) of the waste at a site 190 miles from land in the Gulf of Mexico. Because several problems arose during the monitoring of this burn, a second research permit for another shipload was granted, and a second burn took place in December 1974. The generally favorable results led EPA to grant a special interim permit for the incineration of two remaining shiploads of waste, which were burned in late December 1974 and early January 1975.

EPA reported that destruction efficiencies for this set of burns averaged 99.95 percent, measured on the basis of total organic carbon. No separate measurement of individual principal organic hazardous constituents (POHCs) or products of incomplete combustion (PICs) was undertaken. Seawater samples taken from the area of contact between the incinerator plume and the ocean surface were analyzed for organochlorines, pH, chlorine content, and trace metals. EPA was unable to detect any changes over background levels.

Shell Chemical Organochlorine Wastes in the Gulf of Mexico: Second Series

In 1977, Shell obtained a special permit to conduct another set of burns in the Gulf of Mexico, and again used the *Vulcanus I* to incinerate four shiploads, or about 16,000 mt, of organochlorine wastes. EPA conducted extensive testing of the first of these burns. Trace amounts of known waste constituents (POHCs) were detected in the stack gas samples; these measurements were used to calculate the POHC-specific destruction efficiencies reported in table 26. The analysis of emissions found very low amounts of other compounds, which had not been identified in the waste, and which may have been PICs.

EPA reported that the DE for total hydrocarbons ranged from 99.991 to 99.997 percent. The DE for the major waste constituent, trichloropropane, ranged from 99.92 to 99.98 percent.

The environmental monitoring of these burns revealed the first evidence of an environmental effect from ocean incineration. Fish in towed cages

Table 26.—Summary of Past Ocean Incineration Burns Monitored by EPA

Date	Vessel	Type of waste	Location	Results reported by EPA[a]	Reference[b]
1974-75	*Vulcanus*	Organochlorines 63% chlorine Metals ≤1 ppm	Gulf of Mexico	DE 99.92-99.98%, average 99.95%, determined for total organic carbon No detectable emissions in marine water samples No separate sampling for POHCs or PICs	Wastler, et al., 1975 (32)
1977	*Vulcanus*	Organochlorines 60-70% chlorine Metals 1-200 ppm	Gulf of Mexico	DE 99.991-99.997% for total hydrocarbons 99.92-99.98% for POHC: trichloropropane Possible PICs, <0.01% of waste feed Transient increase in stress-related enzyme in fish exposed to plume No effects observed on plankton	Clausen, et al., 1977 (9) TerEco Corp., unpublished work reported in Kamlet, 1981 (17)
1977	*Vulcanus II*	Herbicide Agent Orange[c] with trace of TCDD (≈2 ppm) 30% chlorine	South Pacific	DE >99.999% for 2,4-D and 2,4,5-T; >99.999% for total chlorinated or 99.982-99.992% for total organics 99.88->99.99% for TCDD Very limited environmental testing, no effects detected	Ackerman, et al. 1978 1
1981-82		PCBs and chlorobenzenes	Gulf of Mexico	Inconclusive"	Metzger, et al. 1983 (21)
1982	*Vulcanus I*	PCBs and chlorobenzenes	Gulf of Mexico	DE >99.99989 for PCBs >99.99993 for chlorobenzenes No trace of waste in plume, water samples, or organisms No TCDD (dioxin); possible other PICs at very low level	Ackerman, et al., 1983 (3)
1983	*Vulcanus II*	Organochlorines 84% chlorine	North Sea	DE from 99.998% for chloroform (lowest) to >99.99995% for trichloroethane (highest)	Ackerman, et al., 1983 (4)

[a]See symbol ">" in front of reported DEs indicates that the compound was not detected in emissions, and the actual DE is greater than that listed.
[b]See reference list at end of chapter.
[c]This waste was composed of the n-butyl esters of 2,4-dichlorophenoxyacetic acid (2,4-D) and 2,4,5-trichlorophenoxyacetic acid (2,4,5-T). Trace quantities of 2,3,7,8-tetrachlorodibenzo-p-dioxin (TCDD) were found, ranging from 0 to 47 ppm in various samples.

SOURCE: Office of Technology Assessment.

were exposed to surface water in the area of contact between the incineration plume and the ocean surface. Assays were then conducted on three enzyme systems that increase in activity in response to physiological stress induced by the presence of pollutants. One enzyme system (Cytochrome P-450) showed a significant increase in activity.

When the exposed fish were placed in clean water for several days in the laboratory, the activities of all three systems were found to be normal. Although EPA interpreted the temporary nature of the effect optimistically, detection of such an effect illustrates the need for caution and further monitoring and research of ocean incineration activities. This would be particularly important if incineration at particular sites became frequent or routine, because longer term exposures to marine organisms might result.

Agent Orange Wastes in the South Pacific

Another set of burns employing the *Vulcanus I* occurred later in 1977, in the South Pacific about 120 miles west of Johnston Atoll. The waste incinerated was the herbicide Agent Orange, which came from an Air Force stockpile of many separate drums remaining from production that occurred during the Vietnam War. The waste consisted of roughly equal amounts of 2,4-D and 2,4,5-T (see table 26 for full chemical names), contaminated with the highly toxic dioxin TCDD at a level that ranged from O to 47 milligrams per kilogram (mg/kg) and averaged 1.9 mg/kg. Total chlorine content was about 30 percent.

A total of about 10,400 mt of Agent Orange was incinerated in three separate burns. An initial burn of 3,520 mt took place under an EPA research permit. Favorable monitoring results led EPA to authorize incineration of the remaining stock, about 6,880 mt in two shiploads, under a special permit.

Destruction efficiencies were reported in several forms by EPA. For all three burns, the DE for the two main components of Agent Orange, 2,4-D and 2,4,5-T, and for total chlorinated hydrocarbons, exceeded 99.999 percent. In fact, none of these substances was detected at all in the emissions. The *minimum* DE of 99.999 percent was reported, even though the actual DE might have been higher, because the detection limits of the sampling and analytical instruments employed did not allow measurement of a higher DE. Destruction efficiencies for total hydrocarbons ranged from 99.982 percent to 99.992 percent.

Emissions were also analyzed for the presence of TCDD (dioxin), which was found only in samples from the second trial; its detection in these samples may have been caused, however, by interference from other substances. Because TCDD was below the limit of detection in burns 1 and 3, the reported DEs again represent minimum values: 99,99 percent for burn 1 and 99.96 percent for burn 3. A DE of 99.88 percent was calculated for the second burn.

Only limited environmental monitoring was conducted during the Agent Orange burn. Plankton samples at the site collected before and after the first burn showed no consistent differences in numbers or species composition, No other tests were performed on marine organisms.

PCB Wastes in the Gulf of Mexico

An additional set of burns occurred in the Gulf of Mexico, beginning in late 1981/early 1982 and completed later in 1982. Both sets of burns were carried out under research permits. In the first burn, about 3,500 mt of PCB-containing waste was incinerated aboard the *Vulcanus I* (which by then had been acquired by Chemical Waste Management, Inc., of Oakbrook, Illinois). EPA monitored the burn, but later indicated that the data collected were ‘ ‘inconclusive because of major problems with sampling and analysis. This test in particular is cited by critics of ocean incineration as evidence of the unreliability, if not total unacceptability, of incineration at sea.

The *Vulcan us I* was also used for a second burn of about 3,500 mt of PCB wastes conducted in August 1982. The waste composition included 27.5 percent PCBs, 7 percent chlorobenzenes, and trace amounts (estimated at 0.0000048 percent) of highly toxic tetrachlorodibenzofurans (TCDF). None of the emissions samples analyzed showed any trace of these components, which means that the reported DEs again represent minimum values. These DEs are as follows:

- PCBs . . . . . >99.99989 percent

- Chlorobenzenes . . . . >99.99993 percent
- TCDF . . . . . >99.96 percent.

Both waste and emissions were analyzed for the presence of TCDD, none of which was detected in any samples. The plume itself was also sampled for PCBs and other organochlorine compounds, and none was detected. However, some nonchlorinated compounds were detected in the plume, and EPA suggested that they either were PICs or arose from the vessel's propulsion engines.

Marine sampling and monitoring was conducted during the second burn, and no detectable increase in PCBs was found in water samples or organisms. Nor did any physiological indicators of exposure-related stress exceed normal levels.

Organochlorine Wastes in the North Sea Using the Vulcanus II

With EPA in attendance, the newly built *Vulcanus II* was tested in February 1983, burning waste from vinyl chloride production at the designated incineration site in the North Sea. The waste consisted almost entirely of four compounds: trichloroethane (39 percent), chloroform (26 percent), carbon tetrachloride (20 percent), and dichloroethanes (15 percent). The waste's total chlorine content was 84 percent; in addition, two of the waste's components (chloroform and carbon tetrachloride) are ranked by EPA as among the most difficult compounds to destroy thermally, because of their high chlorine content. Thus, this waste provided an unusually difficult test of the incinerator.

The reported DEs were high, ranging from 99.998 percent for carbon tetrachloride to more than 99.999995 percent for trichloroethane.

Canceled Burns

In October 1983, EPA proposed issuing two 3-year special permits and one 6-month research permit to Chemical Waste Management, Inc., to incinerate 300,000 mt of PCB-containing waste and 900 mt of DDT-containing waste in the Gulf of Mexico. EPA based its tentative approval on the successful 1982 PCB burn (using *Vulcanus I)* and the 1983 European organochlorine burn (using *Vulcanus II).*

Major public opposition mounted, culminating in a public hearing in Brownsville, Texas, on November 21, 1983, attended by more than 6,400 people, the largest public hearing in EPA history. In May 1984, EPA denied the permits and announced that no further *operating* permits would be issued until the Agency had promulgated specific ocean incineration regulations and completed several ongoing studies.

In December 1985, EPA published its tentative determination to issue a *research* permit to Chemical Waste Management, Inc., for incineration at sea using the *Vulcanus II (50* FR 51360, Dec. 16, 1985). EPA initially solicited the research permit as part of its Ocean Incineration Research Strategy (26).[1] The permit would have authorized the incineration of one shipload (about 700,000 gallons) of a waste consisting of 10 to 30 percent PCBs in fuel oil. The waste was to have been loaded at the Port of Philadelphia, transported through Delaware Bay, and incinerated at the North Atlantic Incineration Site. In its application, Chemical Waste Management indicated that the waste it planned to burn would actually contain 12 percent PCBs, and would be transported by rail from its storage facility in Emelle, Alabama (8).

The Coastal Zone Management Act, which is administered at the Federal level by the National Oceanic and Atmospheric Administration (NOAA), grants States the right to review Federal activities affecting their coastal zones for consistency with State management plans. As part of its application procedure, Chemical Waste Management, Inc. sought coastal zone management (CZM) consistency determinations from three coastal States: Delaware, New Jersey, and Pennsylvania. These States were consulted because the *Vulcan us II* would pass through their coastal waters en route to the incineration site. Pennsylvania granted approval without conditions for the single research burn. Delaware

[1] EPA received a separate application from At-Sea Incineration, Inc. (ASI), for the *Apollo I*. However, ASI's parent company, Tacoma Boat, filed Chapter 11 bankruptcy proceedings in the fall of 1985. This move, brought on partly by delays in the finalization of EPA's regulations, forced ASI to default on $68 million in guaranteed loans granted earlier by the U.S. Maritime Administration for construction of its two incineration vessels (14). The loan was paid in full by the Maritime Administration. The uncertain financial status of ASI led EPA to hold its permit application in abeyance pending resolution of the situation (50 FR 51361, Dec. 16, 1985).

also reached a determination of CZM consistency but limited transit to daylight hours and required prior notification of the ship's movement (13). In addition, Delaware was considering suing EPA to require the agency to prepare a separate Environmental Impact Statement on the transit route (13).

New Jersey originally placed several conditions on its finding of CZM consistency. These included prohibiting transit during the summer, extending the moving safety zone, modifying Coast Guard contingency plans for managing a spill, allowing 60 days for the State to verify waste composition, and requiring State approval of the level of liability coverage. In the course of litigation, however, New Jersey withdrew its conditions regarding the moving safety zone and contingency plans, and modified its waste analysis requirement.

In early 1986, the State of Maryland appealed to NOAA for the right to make a CZM consistency determination, claiming that the proposed test burn could adversely affect the States coastal zone. Maryland argued that, although the vessel would not pass through Maryland waters, those waters could nevertheless be adversely affected by the activity. In February, NOAA ruled in favor of Maryland, despite strong opposition from EPA. Maryland was granted 6 months to conduct its review and reach a consistency determination (letter cited in ref. 1 1).

In response to the NOAA decision and the strict conditions imposed by New Jersey, Chemical Waste Management filed suit in March against NOAA and EPA (15). The suit contended that Maryland was not entitled to conduct a consistency review for an activity that would occur outside of its coastal zone. In addition, Chemical Waste Management contended that the Marine Protection, Research, and Sanctuaries Act preempts New Jersey from imposing conditions.

Prior to any decision in the suit, the State of Maryland and Chemical Waste Management reached a settlement in which Maryland withdrew its request to conduct a CZM consistency review of this research permit but retained its right to pursue such a review in the future (16).

Following the announcement of its tentative determination to grant a research permit to Chemical Waste Management, EPA held a series of public hearings in Philadelphia; Red Bank, New Jersey; Wilmington, Delaware; and Ocean City, Maryland. Through the course of these hearings, strong public opposition again surfaced, focusing particularly on the land and nearshore marine transportation risks. These concerns led to the issuance of a Hearing Officer's report (31) that called for the resolution of several major issues of public concern before proceeding with the burn.

In May 1986, EPA announced its decision to deny the research permit, and to grant no permits, research or otherwise, until finalization of its Ocean Incineration Regulation (51 FR 20344, June 4, 1986). In its decision, EPA argued that the nature of the issues raised in considering the research permit could be more appropriately addressed through the regulatory development process.[2]

As a result of EPA's decision, the suit brought by Chemical Waste Management was dismissed without a ruling on the circumstances under which permit applicants are required to demonstrate CZM consistency or the rights of States to place conditions on their finding of CZM consistency (11).

[2]The PCB wastes that were to have been incinerated under *the* research permit are now expected to be transported to Chicago for incineration in Chemical Waste Management land-based incinerator,

ADEQUACY OF PAST BURNS IN DEMONSTRATING THE SAFETY OF OCEAN INCINERATION

All of the burns discussed above took place under EPA regulations that incorporated the technical requirement of the London Dumping Convention mandating a minimum destruction efficiency of only 99.9 percent. Therefore, all but one of the reported DEs met the required standard. (The exception was the reported DE for TCDD in the second burn of Agent Orange, which appears to have

been anomalous and may have resulted from interference by chemically related compounds.)

In 1981, EPA adopted rules requiring land-based hazardous waste incinerators to achieve a 99.99 percent DE. In addition, the Toxic Substances Control Act requires a minimum 99.9999 percent DE for PCBs. EPA has proposed that the same values be adopted in the regulations governing ocean incineration. The ability of ocean incineration to achieve this DE has not yet been demonstrated. Past test burn data for PCBs was derived from analysis of samples that were not large enough to definitively establish that the *Vulcanus I* is capable of meeting a 99.9999 percent DE. However, EPA believes that this DE was achieved in the burn and is achievable using ocean incineration (28).

No consensus exists with regard to the adequacy and accuracy of EPA's past efforts to monitor ocean incineration. Based on its monitoring of incinerator performance and the environment during past ocean incineration activities, EPA reported that it had been unable to detect any increase in background levels of waste constituents in ambient air, water, or marine organisms. Many members of the public and EPA's own Science Advisory Board (SAB), however, have expressed concerns about these conclusions and the methods and adequacy of EPA's monitoring efforts. (For further critical discussion of these past efforts, see refs. 6,7,18, 19,29).

In response to these concerns, EPA has called for additional test burns before operating permits are issued. The test burns would be intended to provide more accurate assessments of the performance, levels of emissions, and environmental consequences of ocean incineration. In addition, the proposed regulations governing ocean incineration contain provisions for comprehensive environmental monitoring, which would be conducted by EPA with the participation of permitters.

Past Incidents

Several small spills and contamination of the vessel occurred during three of the sets of burns described in this chapter.

During the incineration of Agent Orange in the Pacific (l), several small spills of herbicide occurred, caused by accidental breakage of a sampling bottle; sloshing of liquid through a tank hatch, as a result of rough seas; and overfilling of a tank during rinsing. One or more of these spills was apparently tracked by personnel, leading to the contamination of other areas of the vessel. This contamination was detected during routine monitoring of the vessel performed as a precautionary measure.

There have also been reports of a more serious release of waste from this burn, caused by the intentional discharge of bilge water, which was apparently contaminated with Agent Orange, into a lagoon at Johnston Atoll (12,22). Sampling of lagoon water in the immediate vicinity of the bilge water discharges revealed concentrations of herbicide that significantly exceeded water quality criteria. Reported concentrations were as high as 3 to 5 parts per million, and the total release of herbicide was estimated to have been about 270 pounds (12). In addition, a visible orange cloud in the water was noted, although the captain of the Vulcanus I maintained that the color was caused, not by herbicide, but by rust (22).

Several small spills on deck were reported during the first of the PCB burns that took place in the Gulf of Mexico in 1981-82 (2,25), Some contamination of other parts of the vessel (the burner room, pumproom, and a gangway) was also reported, identified during routine monitoring of the vessel.

During the Agent Orange burns (1) and the 1977 organochlorine burns in the Gulf of Mexico (9), several ' 'impingements' of the incinerator plume onto the deck of the vessel were reported. These were attributable to momentary flameouts caused by water in the waste being incinerated or to high wind velocities and erratic wind direction, and in some cases resulted in brief exposure of crew members to emissions. Based on consideration of the circumstances surrounding these incidents, steps were taken to avoid or reduce their subsequent occurrence.

Several other incidents have been reported or alleged to have occurred during ocean burns that occurred in Europe. These are discussed in reference 20.

Certain provisions of EPA's proposed Ocean Incineration Regulation directly address these types

of incidents. In particular, bilge and ballast waters and tank washings would have to be tested for the presence of waste constituents and, if contaminated, either incinerated at sea or disposed of in an approved land-based facility (50 FR 8236, Feb. 28, 1985). In addition, the vessel would at all times be required to maintain a course and speed which, in combination with the prevailing wind speed, would yield a combined effective wind speed over the vessel of 3 knots or more, to ensure that the plume remained aft of the vessel and would not come into contact with the crew (50 FR 8251, Feb. 28, 1985).

SITE DESIGNATION

Under the Marine Protection, Research, and Sanctuaries Act, incineration sites must be designated by EPA, and operational permits for ocean incineration may only be granted for designated sites. The site designation process falls under formal rulemaking procedural requirements mandating public hearings. In addition, an Environmental Impact Statement (EIS) must be prepared for each site.

The following discussion highlights the status of designation activities for ocean incineration sites.

Gulf Site

Currently, only one site has been designated for ocean incineration. The final EIS for the Gulf of Mexico Incineration Site was issued in 1976 (23). This site lies in the middle of the Gulf, about 190 miles from land, and occupies an area of 4,900 square kilometers (see figure 12). The site is beyond the edge of the continental shelf, in waters ranging in depth from 1,000 to 2,000 meters (5).

The Gulf Site was initially designated *in* **1976** (41 FR 39319, Sep. 15, 1976) and redesignated in 1982 (47 FR 17817, Apr. 26, 1982). The 1982 rule designated the Gulf Site for ‘‘continued use. The proposed Ocean Incineration Regulation would limit designation of the Gulf Site to a period of 10 years, assuming that the additional proposed requirements for site designation were met (see ch. 10). Some members of the public and elected officials have called for the designation process for the Gulf Site to be reopened, based on new information and developments since 1976 (see ch. 2).

North Atlantic Site

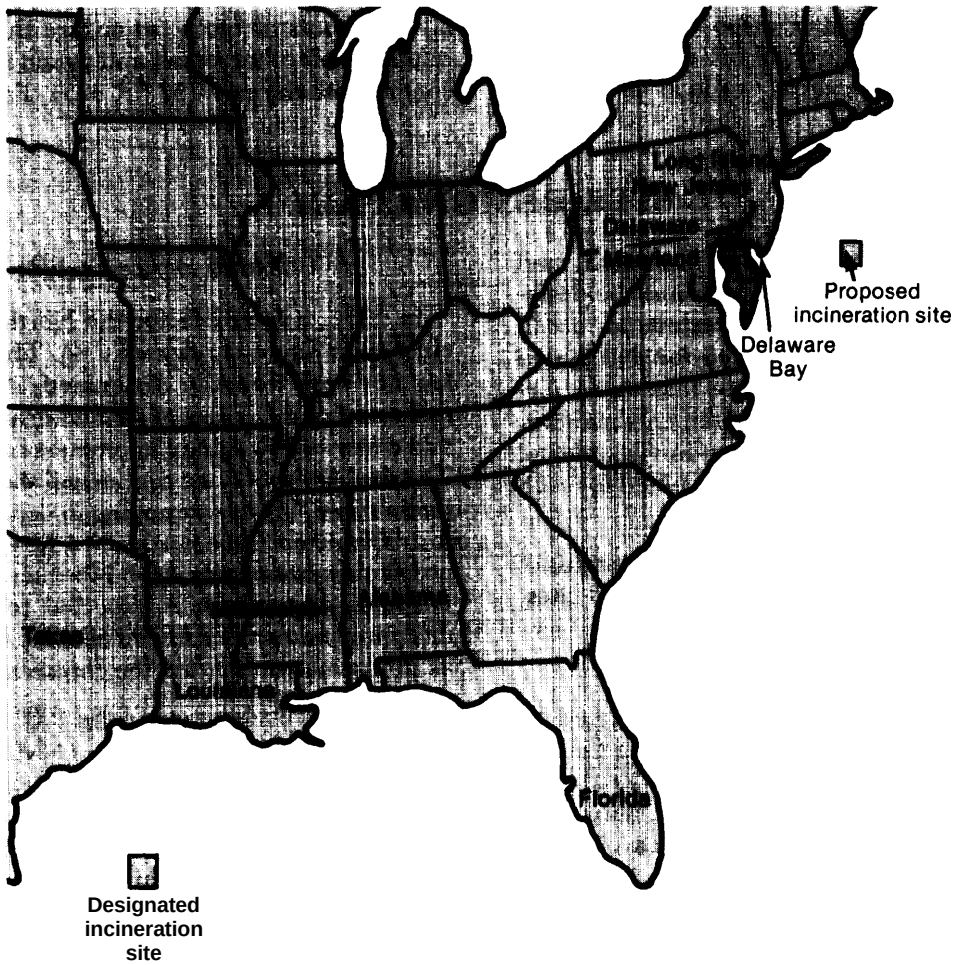
In 1981, a final EIS for the North Atlantic Incineration Site was released (24). This site, which has not been formally designated, lies about 140 miles east of the coasts of Delaware and Maryland and covers 4,250 square kilometers (see figure 12). The site lies beyond the continental shelf on the continental rise, in waters ranging in depth from 2,400 to 2,900 meters. Due north and adjacent to the proposed incineration site is the 106-mile Ocean Waste Disposal Site, which is expected to be used for dumping industrial acid and alkaline wastes as well as municipal sludge for the foreseeable future.

Since the development of the 1981 EIS, the National Marine Fisheries Service (NMFS) has found that the proposed North Atlantic Incineration Site lies in a “high use” area for several species of endangered or threatened marine mammals (see ch. 9). In response to this finding, EPA reevaluated the site and concluded that endangered species would not be affected by incineration there (30). NMFS has concurred with this conclusion with respect to limited use of the site for research burns. However, NMFS must develop a formal biological opinion for consideration prior to EPA’s final designation of the site.

Other Possible Sites

EPA-sponsored studies have tentatively examined areas off the coasts of California and Florida as possible future sites for ocean incineration. However, no steps in the actual site designation process have taken place to date.

Figure 12.-Location of the Designated (Gulf of Mexico) and Proposed (North Atlantic) incineration Sites



SOURCE: Office of Technology Assessment.

RECENT EPA EFFORTS

In conjunction with the development and issuance of its proposed Ocean Incineration Regulation, EPA sponsored several studies.

Science Advisory Board (SAB) Study

In April 1985, EPA's SAB released its "Report on the Incineration of Liquid Hazardous Wastes by the Environmental Effects, Transport, and Fate Committee" (29). The report examined various scientific issues bearing on incineration's impacts on human and environmental health and compared and contrasted the current level of understanding of land-based and ocean incineration technologies.

Although stating that "incineration is a valuable and potentially safe means for disposing of hazardous chemicals, and that the report's intent was to "strengthen already existing incineration programs rather than to discontinue what is already in place, the SAB identified several major areas where existing data are insufficient. In particular, the SAB found that no reliable characterization of

incinerator emissions or their toxicities was available, which meant that the potential for environmental or human exposure and impact could not be assessed. The study challenged EPA's measurement of destruction efficiency, which addresses only a few selected compounds, as a basis for evaluating the total performance of incinerators. It recommended that EPA undertake a complete characterization of emissions, including products of incomplete combustion (PICs).

The report stressed that the uncertainties the SAB had identified applied equally to land-based and ocean incineration and, in many cases, to other common combustion processes, such as the burning of fossil fuels. The report also argued that, because it destroys waste, incineration is preferable to current methods of disposal, such as landfilling and deep-well injection.

Incineration Study

EPA's Office of Policy, Planning and Evaluation (OPPE) (27) published an "Assessment of Incineration as a Treatment Method for Liquid Organic Hazardous Wastes" in March 1985. The study compared and evaluated land-based and ocean incineration with respect to technology, regulation, commercial market potential, relative environmental and health risks, and public concerns. The major conclusions are the following:

. incineration, whether at sea or on land, is a valuable and environmentally sound treatment option for destroying liquid hazardous wastes, particularly when compared to land disposal options now available;
- there is no clear preference for land-based or ocean incineration in terms of risks to human health and the environment; and
- future demand for hazardous waste incineration will significantly exceed capacity as other disposal alternatives are increasingly restricted.

Ocean Incineration Research Strategy

EPA's Office of Water published an Ocean Incineration Research Strategy (26) detailing the means by which EPA intends to address the areas of uncertainty identified in the SAB and OPPE reports, in previous research burns, and in comments received from the public. The strategy calls for several research burns, both on land and at sea. Initial dockside burns with diesel fuel would allow development and testing of methodology; subsequent burns of hazardous waste would be designed to gather data on incinerator performance, the quantity and composition of emissions, and environmental effects.

Proposed Research Burn

As described earlier in this chapter, EPA proposed to issue a research permit for incineration at sea as part of its research strategy (50 FR 51360, Dec. 16, 1985). The burn was planned to be continuous for 19 days, during which EPA would conduct extensive sampling and monitoring of all aspects of operation. The following specific tests were planned:

- determination of flow characteristics and combustion efficiency at all points in the stack;
- sampling and analysis of emissions to allow measurement of: 1) semi-volatile trace organic compounds, including PCBs, for calculation of destruction efficiency; 2) volatile organic compounds; 3) particulate; and 4) total chlorinated organic compounds;
- collection of samples for toxicity testing;
- actual toxicity bioassays on five marine plant and animal species, testing for acute toxic effects and chronic effects on growth and reproduction;
- plume sampling and modeling; and
- collection and analysis of samples of air, water, and indigenous organisms for determining the presence of, or effects from, incineration-derived substances.

The Usefulness of Research Burns: Opportunities and Limitations

Recent EPA developments are likely to considerably delay issuance of the final Ocean Incineration Regulation and any subsequent research burns. Clearly, ocean research burns are necessary to resolve some of the technical questions about ocean incineration. In addition, if a decision were made to proceed with ocean incineration, information from research burns could aid in modifying the regulatory program, if necessary.

Nonetheless, there are limits to the usefulness of the data that could be obtained from ocean research burns. Foremost among these is the fact that the data would *not* resolve the basic issue of whether to proceed with the ocean incineration program. Technical analysis is only one of many factors influencing such a decision.

Moreover, one or even a series of research burns would still leave many technical questions unresolved. For example, the recently denied EPA research burn would have used a waste composed of relatively homogeneous PCBs in fuel oil (8). This waste was chosen because toxicity characteristics and detection methods for PCBs are well studied, and because EPA wanted to have as little interference from other chemicals as possible. Typical ocean incineration wastestreams, however, would be more likely to contain complex mixtures of many chemicals, which limits the applicability of results from this test burn to "real" situations. Conversely, choosing a heterogeneous wastestream for the research burn would have introduced a different but comparable set of constraints.

Finally, to be most useful, ocean incineration research must be coupled to research on other alternatives. A proper comparative analysis would require research on both land-based and ocean technologies. EPA does have an ongoing research program on land-based incineration, and EPA's ocean incineration research strategy contains a land-based incinerator component—primarily to allow testing of the protocols for sampling, analysis, and toxicity tests to be used during an ocean research burn.

CHAPTER 11 REFERENCES

1. Ackerman, D. G., Fisher, H.J., Johnson, R.J., et al., *At-Sea Incineration of Herbicide Orange Onboard the M/T Vulcanus*, EPA Technology Series No. EPA-600/2-78-186, prepared for the U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory, Office of Research and Development (Washington, DC: April 1978).
2. Ackerman, D. G., ''Observations During the First PCB Research Burn, " and Attachments, Communication to U.S. Environmental Protection Agency, Incineration Research Branch, Cincinnati, OH, Feb. 18, 1982.
3. Ackerman, D. G., McGaughey, J. F., and Wagoner, D. E., *At-Sea Incineration of PCB-Containing Wastes Onboard the M/T Vulcanus, EPA-600/7-83-024,* prepared for the U.S. Environmental Protection Agency (Research Triangle Park, NC: 1983).
4. Ackerman, D. G., Beimer, R. G., and McGaughey, J. F., *Incineration of Volatile Organic Compounds by the M/T Vulcanus II*, prepared for Chemical Waste Management, Inc., Oak Brook, IL (Redondo Beach, CA: TRW Energy and Environmental Division, 1983).
5. Ackerman, D. G., and Venezia, R. A., "Research on At-Sea Incineration in the United States, in *Wastes in the Ocean, vol. 5,* D.R. Kester, et al. (eds.) (New York: John Wiley& Sons, 1985), pp. 53-72.
6. Bond, D. H., ' 'At-Sea Incineration of Hazardous Wastes," *Environ. Sci. Technol. 18(5)* :148A-152A, *1984.*
7. Bond, D. H., "Ocean Incineration of Hazardous Wastes: An Update, " *Environ. Sci. Technol.* 19(6):486-487, *1985.*
8. Chemical Waste Management, Inc., "Application for a Research Permit To Incinerate Hazardous Waste At Sea: Exhibit B" (Oak Brook, IL: May 24, 1985).
9. Clausen, J. F., Fisher, H.J., Johnson, R.J., et al., *At-Sea Incineration of Organochlorine Wastes Onboard the M/T Vulcanus*, EPA Technology Series No. EPA-600/2-77-196, prepared for the U.S. Environmental Protection Agency, Industrial Environmental Research Laboratory, Office of Research and Development (Washington, DC: 1977).
10. Environment Reporter, "NOAA Decision Allowing Maryland Review May Delay Ocean Test Burn Until Mid-1987, " *Environment Reporter 16(42): 1878,* Feb. 14, 1986.
11. Environment Reporter, "Federal Court Defers to EPA Review in Waste Incineration Permit Dispute, " *Environment Reporter* 17(9):264, June 27, 1986.
12. Graffeo, A. P., and Thomas, T., "Ocean Disposal of Agent Orange—Land-Based Environmental Monitoring at Johnston Island, " paper presented at the Third International Ocean Disposal Symposium, Woods Hole, MA, Oct. 12-16, 1981.
13. Inside EPA, "Delaware Eyes Suing EPA To Force

Ocean Incineration Transit Route, EIS," *Inside EPA* 6(41):2, Oct. 11, *1985*.
14. Inside EPA, "EPA Okays At-Sea Research Burns, But Pool of Applicants Dwindles, " *Inside EPA* 6(48):5, Nov. *29, 1985*.
15. Inside EPA, "EPA, NOAA Sued for Allowing Maryland Incineration-At-Sea Review Rights, ' *Inside EPA* 7(12):8, Mar. 21, 1986.
16, Inside EPA, "Justice Asks Court To Dismiss Industry Incineration-At-Sea Suit, ' *Inside* EPA 7(18):3-4, May 2, 1986.
17, Kamlet, K. S., "Ocean Disposal of Organochlorine Wastes by At-Sea Incineration, " *Ocean Dumping of Industrial Wastes,* B.H. Ketchum, et al. (eds.) (New York: Plenum Publishing Corp., 1981), pp. 295-314.
18. Kleppinger, E. W., and Bond, D. H., *Ocean Incineration of Hazardous Waste: A Critique* (Washington, DC: EWK Consultants, Inc. , 1983).
19. Kleppinger, E. W., and Bond, D. H., *Ocean Incineration of Hazardous Waste: A Revisit to the Controversy* (Washington, DC: EWK Consultants, Inc., 1985).
20 Lentz, S. A., Testimony Before the Subcommittee on Oceanography, House Committee on Merchant Marine and Fisheries, U.S. Congress, Hearing on ' 'Incineration of Hazardous Waste At Sea, " Nov. 11 and Dec. 3, 1985, Serial No. 99-25 (Washington, DC: 1986).
21 Metzger, J. F., and Ackerman, D. G., "A Summary of Events, Communications, and Technical Data Related to the At-Sea Incineration of PCB-Containing Wastes Onboard the M/T Vulcanus, 20 December, 1981-4 January, 1982, " prepared for the U.S. Environmental Protection Agency, March 1983.
22. Smith, G., "The Burning Question, *San Francisco Chronicle, This World,* May 12, 1985, pp. 7-9.
23 U.S. Environmental Protection Agency, Office of Water and Hazardous Materials, Division of Oil and Special Materials Control, *Final Environmental Impact Statement of Designation of a Site in the Gulf of Mexico for Incineration of Chemical Wastes* (Washington, DC: 1976).
24. U.S. Environmental Protection Agency, Office of Water Regulations, Criteria and Standards Division, *Environmental Protection Agency Final Environmental Impact Statement (EIS) for North Atlantic Incineration Site Designation* (Washington, DC: Nov. 25, 1981).
25. U.S. Environmental Protection Agency, ' 'Preliminary Report, Research Permit for Incineration At Sea of PCB Wastes, HQ 81-002, Results of Test Burn on M/T Vulcanus, " May 20, 1982, p. 57.
26. U.S. Environmental Protection Agency, Office of Water, *Incineration-At-Sea Research Strategy* (Washington, DC: Feb. 19, 1985).
27. U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation, "Summary and Conclusions, *Assessment of Incineration as a Treatment Method for Liquid Organic Hazardous Wastes* (Washington, DC: March 1985).
28. U.S. Environmental Protection Agency, Office of Policy, Planning and Evaluation, "Background Report I: Description of Incineration Technology, " *Assessment of Incineration as a Treatment Method for Liquid Organic Hazardous Wastes* (Washington, DC: March 1985).
29. U.S. Environmental Protection Agency, Science Advisory Board, *Report on the Incineration of Liquid Hazardous Wastes by the Environmental Effects, Transport and Fate Committee* (Washington, DC: April 1985).
30. U.S. Environmental Protection Agency, Marine Operations Division of the Office of Marine and Estuarine Protection, *Assessment of the Impact of Incineration of Chemical Wastes in the Proposed North Atlantic Incineration Site on Endangered and Threatened Species* (Washington, DC: July 9, 1985).
31. U.S. Environmental Protection Agency, "Hearing Officer's Report on the Tentative Determination To Issue the Incineration-At-Sea Research Permit HQ-85-001" (Washington, DC: May 1, 1986).
32 Wastler, T. A., Offutt, C. K., Fitzsimmons, C. K., et al., *Disposal of Organ ochlorine Wastes,* EPA-430/9-75-014, contract report prepared for the U.S. Environmental Protection Agency (Washington, DC: July 1975).