MUNICIPAL SOLID WASTE POLICY FORUM

Results and Conclusions
of a
Forum

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Conveners

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INTRODUCTION

The Municipal Solid Waste (MSW) Policy Forum held on 24 January 1986 was the second in a series of such forums sponsored by Stony Brook's Waste Management Institute. The Agenda for the Forum is contained in Appendix A; the list of participants in Appendix B.

These Forums are designed to bring together small groups of knowledgeable people to explore a wide range of municipal solid waste management issues. This particular Forum concentrated on the residuals--emissions and ash--from mass burn resource recovery facilities and was designed to give several of the major resource recovery industries an opportunity to present their assessment of state-of-the-art technology and the characteristics and levels of the residuals--emissions and ash--that can be achieved with modern plant design and proper plant operation. The Forum also provided an opportunity to identify research needs and opportunities, and to discuss alternative approaches to conducting this research. The New York State Energy Research and Development Authority's municipal solid waste research program was described in detail, Appendix C.

This report summarizes those major findings and recommendations which emerged from the discussion which are particularly pertinent to Long Island and the Metropolitan New York City area. While all participants had the opportunity to review and comment on this document before printing, it does not necessarily follow that all participants endorse all of the findings and recommendations presented here. There was broad consensus, however, on all statements.

FINDINGS AND CONCLUSIONS

General

- The per capita production of MSWs is higher in the United States than in any other country in the world; averaging nearly 5 pounds per person per day. On Long Island, the figure is nearly 6 pounds per person per day.
- Every day New York State produces more than 40,000 tons of MSW.
- The relative contributions of different kinds of wastes to the MSW stream are summarized in Figure 1.
- Municipal solid waste--garbage and trash--presents a risk; MSW is itself a potential pollutant.
- This garbage and trash must be disposed of.
- The alternatives available for disposal of garbage and trash are limited in number and in variety. Each has advantages and disadvantages. None is ideal; not even recycling. All entail risks.
- The best--most appropriate--disposal strategy is the alternative which minimizes risk to public health and to the environment at acceptable cost, both in the short term and in the long term.
- Active source reduction and recycling programs could reduce the volume of MSW requiring disposal, but not eliminate it. Such programs also could change the character of the ultimate waste product to make it more innocuous. In addition, source reduction and recycling programs conserve valuable natural resources, reduce pollution, and save energy.

PERCENT (BY WEIGHT) CONTRIBUTION TO THE MUNICIPAL SOLID WASTE STREAM (dry basis)

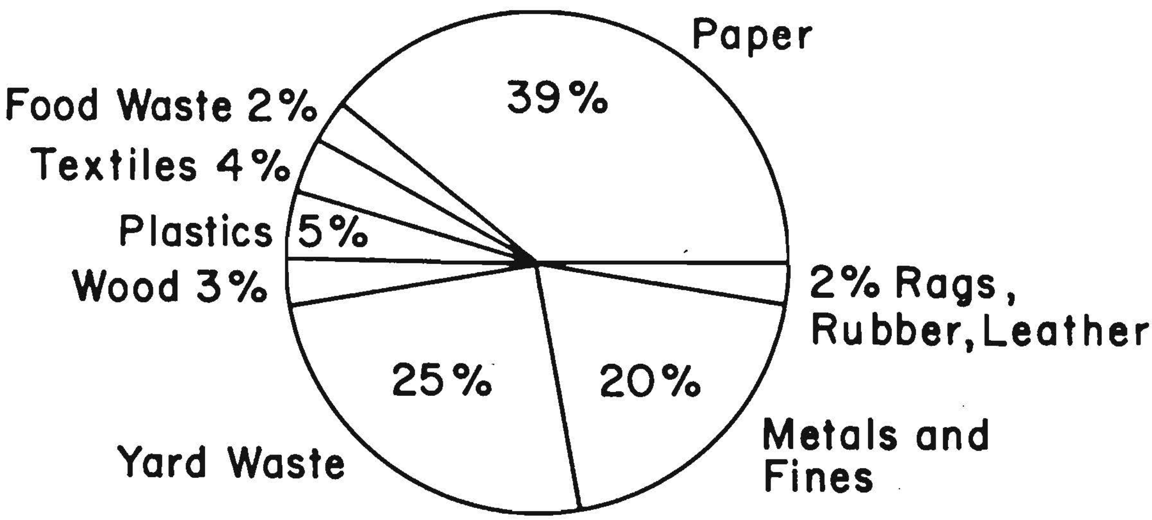

Figure 1

- o Municipalities should develop comprehensive waste management strategies. Source reduction and recycling are appropriate and desirable components of such strategies.

Incineration

- o Burning has inherent advantages as a method for garbage and trash disposal because of its purification properties, and because it reduces the amount of residual waste.
- o Municipal solid waste is not the best fuel; neither is it the worst.
- o If all of New York's MSW were burned in resource recovery facilities, it would generate 500 megawatts of electricity.
- o The selective removal of certain components from MSW before combustion may reduce risk to human health and the environment. Removal of batteries, for example, could reduce levels of nickel (Ni), cadmium (Cd), mercury (Hg) and lead (Pb).
- o Combustion technology used in modern resource recovery facilities constructed by major vendors represents a significant evolution from earlier designs typical of older incinerators.
- o Municipal solid waste burns readily but possesses a number of negative characteristics including: (1) heterogeneity in composition and particle size, (2) relatively low heating value (3800-5000 BTU/lb.), (3) relatively high chlorine (Cl_2) content (0.5%), (4) low ash fusion temperature, and (5) high ash and moisture content of fuel.
- o The basic principles of good combustion are described by the three "Ts"--Time, Temperature, and Turbulence. Time: the

longer a particle is held at a high temperature, the more complete the combustion. Temperature: the higher the temperature, the more complete the combustion. Turbulence: the better the mixing, the greater the likelihood of getting oxygen (O_2) (air) to each waste element thus enhancing the completeness of combustion.

- There are several diagnostic indicators of good combustion:
  - (1) low emissions of carbon monoxide (Co), high levels of oxygen (O_2), hydrocarbons and oxides of nitrogen (N_2);
  - (2) very low content of carbon (C) and combustible material in the ash residue; and
  - (3) boiler efficiency.
- Two primary goals of incineration are to maximize combustion and minimize air pollution. There are two other goals: high plant availability (absence of shutdowns) and low facility maintenance cost.
- The principal indicators of incomplete combustion are high levels of O_2 and CO. Carbon monoxide is an air pollutant and contributes to the corrosion of boiler surfaces. Carbon monoxide is an indicator of the presence of other products of incomplete combustion.
- Conditions for and characteristics of good combustion in resource recovery facilities include:
  - (1) a hot uniform firebed devoid of cool and hot spots on the grate;
  - (2) an adequate secondary air supply mixed thoroughly into the hot fire gases rising from the fire bed;

(3) flue gas temperatures at, or above, $1600^{o}F$ for approximately 1 second after the flu gas leaves the secondary firing zone; and

(4) avoiding combustion upsets on the grate or in the second firing zone.

- Evidence that good combustion has been achieved and maintained is manifested in the flue gas by a steady 7-10% oxygen level and less than 100 ppm CO.
- Carbon monoxide and oxygen can be monitored continuously, although CO monitoring is difficult.
- Continuous monitoring of CO is the best single method for assessing how well a plant is operating.
- Products of incomplete combustion include a wide range of organics and particulates.
- As combustion becomes more complete, Cl_2 produced from burning of organochlorines is converted to HCl. This is the desired fate for Cl_2 since it can be removed with scrubbers.
- More than 700 compounds have been identified in the emissions of resource recovery facilities.
- The U.S. Environmental Protection Agency and many state environmental and health agencies are developing criteria to assess the quality of combustion in resource recovery facilities.

Ash

- The incineration of garbage produces large amounts of ash which must be disposed of. The problem of how to accomplish this disposal will be particularly acute on Long Island and in the metropolitan New York City area. More than eleven million tons of solid wastes are collected annually. This translates into a potential of more than 2.2 million tons of incinerator ash each year; enough ash to make more than 65 million cinder block-size blocks each year.

- Fly ash accounts for about 5-10% of the total ash residue from a modern resource recovery facility; the remaining 90-95% is bottom ash.
- The relative contributions of different kinds of wastes to the total MSW ash stream are summarized in Figure 2.
- Most of the fly ash produced is removed from the stacks with electrostatic precipitators or baghouse filters. The particles are very fine, ranging from less than 1 μm (0.00004 in.) in diameter to about 500μm (0.02 in.).
- Bottom ash drops through the grate where it is collected. Most particles range from about 1000 μm (0.04 in.) to 10,000 μm (0.4 in.) in diameter. In addition, there may be larger pieces ranging from bottles and cans to automobile engines.
- Cadmium, lead, and several other metals vaporize during combustion and most precipitate out onto particulates in the stacks.
- Cadmium and lead can not be segregated effectively from municipal solid wastes because of the variety of waste products in which they are found.
- Leaching of landfilled, unstabilized ash from resource recovery plants is a function of a variety of physical and chemical properties including: permeability and porosity of the ash

PERCENT (BY WEIGHT) CONTRIBUTION TO THE ASH STREAM (dry basis)

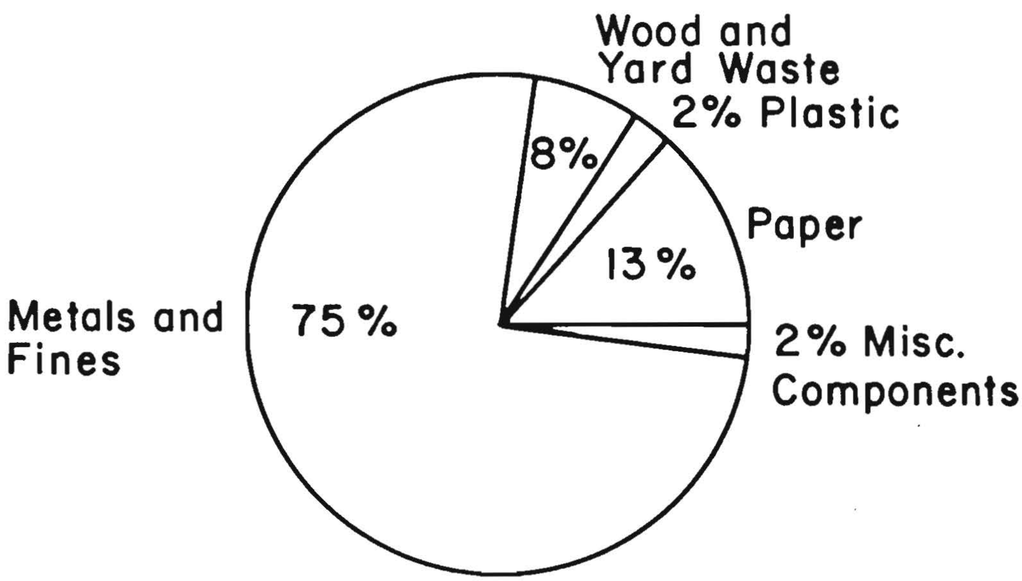

Figure 2

deposit, the frequency of deposition of ash and pH of the precipitation and interstitial waters.

- The mixing of ash and MSW in a landfill promotes leaching of a number of metals, particularly Pb and Cd, from the ash. The decaying organic matter reduces the pH of pore waters and, as a result, accelerates leaching when the buffering capacity of the ash is exhausted.
- The leaching rates of Cd and Pb from MSW ash increase with decreasing pH of precipitation and pore waters.
- While only relatively small fractions of the Cd and Pb in unstabilized fly ash are available to the environment, those fractions which are, may be leached rapidly.
- The elemental concentrations of metals in ashes--fly and bottom--of MSW are presented in Table 1. Concentrations of the same metals in coal ash are shown for comparison. Note the significant enrichment in Cd and Pb in MSW fly ash relative to coal fly ash. The total metals concentrations in either kind of fly ash are not available to the environment through leaching.
- Scientists at Stony Brook's Marine Sciences Research Center have successively stabilized a variety of mixtures of fly ash and bottom ash from resource recovery facilities with Portland cement ($\sim$15%) into blocks which meet ASTM standards for construction.
- Stabilization of fly ash can reduce markedly the potential for leaching of contaminants.

Table 1

ELEMENTAL CONCENTRATIONS OF METALS IN ASHES[1]

ELEMENT	MSW ASH (mg/kg) FLY ASH	MSW ASH (mg/kg) BOTTOM ASH	COAL ASH (mg/kg) FLY ASH	COAL ASH (mg/kg) BOTTOM ASH
Ca	54,500	50,500	45,000	NR
Sr	200	250	775	800
Ba	800	800	991	1600
Cd	470	<100	1.60	0.86
SiO_2	319,000	368,000	483,000	NR
Al	70,000	33,000	92,000	NR
Fe	17,500	132,000	35,000	NR
Ti	14,600	3,600	19,400	NR
Pb	5,200	900	67	7
Cr	400	500	136	120

NR = Not Reported

[1] Courtesy of Signal Environmental Systems

Dioxins and Furans

- As the threshold of our ability to measure dioxins and furans has progressively gone down to lower and lower concentrations, these compounds have been found with increasing frequency.
- It now is possible to detect dioxins in the parts per trillion range. To visualize a concentration in the part per billion range consider that looking for a single individual among the world's population today would be looking for 1 in 4.5 billion. A concentration of one is a trillion would be equivalent to picking out a single second in the last 32,000 years.
- Dioxins and furans recently were found in Milorganite sealed in glass vials in 1933 and exhibited at the 1939 New York World's Fair. They were detected recently in sediments in Lake Huron which have been dated at 80 years old.
- These observations and many others indicate that dioxins and furans have existed in the environment for a long time.
- Data also indicate that the environmental levels of dioxins and furans increased significantly after chlorinated hydrocarbons became important industrial chemicals.
- Existing laboratory data for rats, mice and several other small mammals indicate that 2,3,7,8 tetrachlorodibenzo-p-dioxin (TCDD) is one of the most acutely toxic anthropogenic materials known.
- To date over 40 municipal solid waste burning plants in at least 9 countries have been tested for dioxins and furans in bottom ash, in fly ash and in flue gas. Dioxins and furans have been found in all plants tested except one. The exception is a

facility in Ames, Iowa. This facility burns a mixture of about 10% (by weight) RDF (refuse-derived fuel) and 90% pulverized coal at a temperature hotter than is conventional in modern resource recovery facilities.

- The levels of dioxins and furans emitted from municipal solid waste incinerators varies widely among the plants tested, Table 2.
- The levels of emission of dioxins and furans from mass burning of garbage and trash can vary from plant to plant by a factor of more than 1000 depending upon plant design, construction, and operation (Table 2).
- The differences in emissions shown in Table 2 can be attributed to a variety of factors. Some plants are old; others new. Some have furnaces with refractory walls; others have water-cooled walls. Some were field erected; others were not. Some are small; others are large. Some recover heat; others do not.
- The data in Table 2 indicate that facilities which recover heat tend to have lower emissions of dioxins and furans than those that do not. One exception is the Hamilton (Ontario) plant. This plant is of an old design and had been poorly maintained. A second exception is the Hampton (Virginia) plant which also is poorly designed and was poorly operated.
- The aggregation of emission data from incinerators and resource recovery facilities without discriminating between old and new plants, between well-designed and poorly-designed plants, and between well-operated and poorly-operated plants produces misleading results.

Table 2

DIOXIN (PCDD) STACK EMISSION DATA*

	EMISSION RATE (ng/m^3)	
FACILITY (Country)	ALL PLANTS	HEAT RECOVERY PLANTS
STAPELFELD (Germany)	31	31
CHICAGO N.W. (USA)	42	42
ESKJO (Sweden)	73	73
STELLINGER MOOR (Germany)	101	101
PEI (Canada)	107	107
ZURICH (Switzerland)	113	113
BORSIGSTRASSE (Germany)	128	128
COMO (Italy)	280	280
ALBANY (USA)	316	316
DANISH RDF (Denmark)	316	316
ITALY 1	475	
ITALY 6	569	
BELGIUM	680	680
ITALY 5	1020	
ZAANSTAD (Holland)	1294	
VALMADRERA (Italy)	1568	1568
HAMILTON (Canada)	3680	3680
HAMPTON (USA)	4250	4250
ITALY 4	4339	
TORONTO (Canada)	5086	
ITALY 3	7491	
ITALY 2	48,808	

*Source: Kay Jones, Roy F. Weston, Inc., Courtesy BFI, Inc.
Plants are arranged in increasing order of emission of PCDD

- In analyzing emission data, it is appropriate, and indeed desirable, to separate plants by age and design.
- Data such as those in Table 2 contain important information which can be useful in making scientific judgements about the levels of dioxins and furans achievable in modern resource recovery facilities, and in making management decisions regarding such facilities. That information is lost however, if the data are simply averaged without distinguishing among differences in design and operation of the facilities from which the data were collected. Averaging emissions from well-tuned 1986 automobiles equipped with emission control devices along with emissions from Model T's and poorly maintained 1949 Studebakers will not provide an accurate estimate of emission levels achievable with modern automobile technology.
- The data in Table 2, and other data, demonstrate that emissions of dioxins from the stacks of modern, well-designed and well-operated resource recovery facilities are likely to be below 150 nannograms per cubic meter (ng/m^3) of effluent.
- Good combustion minimizes the generation of dioxins and furans in modern resource recovery facilities.
- Effective removal of particulates from the flue gas further reduces the release to the air of dioxins, furans and other organic compounds and metals, especially if the stack temperature is low.
- Effective scrubbing of the flue gas reduces emissions of acid gases to the air.

- Application of existing technology can reduce emission of particulates and acid gases from modern resource recovery facilities to mandated levels.
- With good combustion in a modern resource recovery facility the emissions of dioxins and furans from the stack per ton of MSW incinerated may still be about 10X the amount on the fly ash recovered by the air pollution control system and 100X the amount contained in the bottom ash.

Resource Recovery Facilities and Existing Guidelines and Standards

- The U.S. Environmental Protection Agency (EPA) does not have official guidelines or standards for dioxin and furan emissions from resource recovery facilities, but is in the process of developing emissions criteria for these compounds.
- Guidelines for dioxin and furan emissions have been issued by Ontario, the Netherlands, Sweden and Denmark.
- Other countries, New York and other states in the U.S. are considering issuing guidelines for emissions of dioxins and furans from resource recovery facilities.
- At present, EPA and New York State comply, at least unofficially, to the guidelines set forth in the EPA's 1981 Hernandez document.
- The most stringent guidelines are those set forth in the Hernandez document and adopted by the EPA and New York State. If these guidelines have not been officially adopted by New York and EPA, they can at least be considered to be foster children. These guidelines are about 20X more stringent than Ontario's and 1000X more stringent than those of the Netherlands.

- According to the data in Table 2, the first seven or eight plants would meet the New York State and EPA "guidelines" and several more would meet the Ontario guideline.

Dioxins and Furans--Summary

- Most effective control of emissions of dioxins and furans from resource recovery facilities can be achieved through a combination of good combustion and effective removal of particulates from the flue gas. Scrubbing at low temperature has been shown to be particularly effective.
- Application of state-of-the-art combustion technology in modern resource recovery facilities can reduce emissions of dioxins and furans to levels below the most stringent guidelines now in effect.
- Routine monitoring techniques do not now exist for direct, continuous measurements of dioxins, furans, and other organic compounds in the flue gas.
- Techniques do exist however, to monitor the effectiveness of combustion.
- The available data indicate that properly designed and operated resource recovery facilities can meet the emissions criteria used by New York and the EPA for dioxins and furans.
- Most emission data for resource recovery facilities represent snapshots of instantaneous to short-term (a few hours) conditions taken at infrequent intervals. More data are needed to establish the variability of emissions among facilities and to establish the temporal variability of emissions at individual facilities over a range of seasons and operating conditions.

- More data are needed to demonstrate that resource recovery facilities meet these criteria on a continuing basis.
- There are in the world today several hundred large scale and thousands of small scale (apartment house) municipal solid waste incinerators that do not meet modern design and operating specifications.
- Burning garbage and trash to produce energy is a good idea if the combustion is done in a modern, well-designed, well-maintained and well-operated facility.
- To achieve the lowest emission levels, resource recovery facilities not only must be properly designed, but must also be properly maintained and operated.
- The effective operation of sophisticated modern resource recovery facilities should be in the hands of well-trained operators.
- Proper combustion can significantly reduce the emission levels of most contaminants of concern from resource recovery facilities.
- Proper plant design does not guarantee that the plant will operate at or near design criteria.
- Training for resource recovery facility operators should be mandated by the New York State Department of Environmental Conservation.

Some Ways to Improve Management of Municipal Solid Wastes

- A comprehensive municipal solid waste management program which incorporates resource recovery is not incompatible with source reduction and recycling. Indeed, the strategies can be complementary.

- Construction of a modern, well-designed facility that is poorly maintained and operated does not represent an achievement for technology or society.
- Disposal of hospital wastes may pose a greater public health threat than garbage and trash because of microbiological contamination.
- Operation of resource recovery facilities by the private sector may have advantages over operation by the public sector. If the enforcer is not the operator, appropriate enforcement is more likely.
- Contracts for operation of resource recovery facilities can be written to require the operator to handle the municipality's garbage and trash in the event of shutdowns--planned or unplanned.
- Permitting can and should be used to ensure that resource recovery plants operate within the design envelope and, as a result, keep emissions within an acceptable range.
- The permitting process is sufficiently flexible that many societal concerns can be accommodated and alleviated in the permitting and licensing procedures.
- Arrangements should be made to accommodate a municipality's garbage and trash during short periods when its resource recovery facility is shut down for planned or unplanned reasons. Options include landfilling and transfer to other resource recovery facilities.

- o Failure to make rigorous comparative assessments of the environmental and public health effects of the different disposal alternatives has been a major drawback in selecting the best--most desirable--strategy.
- o Proper environmental assessments of different disposal strategies must include cross media (air-land-water) assessments. To date they have not.
- o The configuration of existing Federal agencies makes rigorous and well balanced cross media analysis exceedingly difficult and improbable. Agencies are aligned along lines of each individual medium creating competition among units to protect turf, rather than to select the most desirable alternative. A total ecosystem approach is needed.
- o At the present time, integration of municipal solid waste management programs at the federal level is weak and ineffective.
- o Major changes in the permitting process are needed to ensure selection of the best alternative to manage municipal solid waste. Multi-media assessments are required.
- o This situation could be resolved with an organic environmental law which focuses attention on the total ecosystem and requires cross media analysis.

RESEARCH NEEDS*

General

- A critical assessment is needed of the impacts of sanitary landfills on the total environment. Existing assessments have neglected the effects of landfills on the air. Information is needed both on gases and on particulates and adsorbed contaminants. This information is needed to compare and contrast the landfilling option with the resource recovery option.
- Research is needed to evaluate the environmental effects of land disposal of resource recovery ash (fly and bottom) and flue gas scrubber products and to develop techniques to mitigate any undesirable effects.
- Research is needed to assess the environmental and public health effects of disposal in the ocean of stabilized and unstabilized ash from resource recovery facilities. Questions concerning the products of leaching and their ecological effects, and the stability of both the ash and leachates should be studied under different environmental conditions in the laboratory and in the field.
- Additional research is needed to resolve uncertainty as to the locations and strengths of other sources of dioxins and furans to the environment, and to improve our understanding of the fates and affects of these families of compounds in the environment and on public health.

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*These are selective needs; no attempt was made to compile a comprehensive list of research needs.

Resource Recovery

- A critical assessment is needed to determine which type of particulate control device--electrostatic precipitators or baghouse filters--are most effective in controlling particles and particle-bound contaminants.
- Additional research is needed to define the time-temperature conditions to promote adsorption of contaminants onto particles.
- Additional research is needed to obtain real-time measurements of the combustion process using physical sensing techniques such as fourier-transform infrared spectroscopy and Roman spectroscopy.
- Additional research is needed to test the efficacy of O_2-enrichment as a method of enhancing completeness of combustion.
- An accelerated research and development effort is needed to develop creative uses of ash from resource recovery facilities; uses which are safe and beneficial to society.

A FINAL MESSAGE

Most participants agreed that further forums on the subject of municipal solid wastes would be useful and urged the themes suggest for future forums included: risk assessment of different municipal solid waste management strategies; information on resource recovery for decision makers; source reduction and recycling; an examination of municipal solid waste management alternatives; and reconciling the differences between real and perceived public health risks of dioxins and furans from modern resource recovery facilities.

Appendices

A. Agenda

B. List of participants

C. The New York State Energy Research and Development Authority's Resource Recovery Research Program

MUNICIPAL SOLID WASTE
POLICY FORUM

24 January 1986

Challenger Hall 165
Waste Management Institute
Marine Sciences Research Center
State University of New York at Stony Brook

0930 Welcome and Introductions (Homer A. Neal and J.R. Schubel)

0945 An Overview of What We Hope to Achieve Today (Homer A. Neal and J.R. Schubel)

1000 Environmental Concerns and Emissions from Resource Recovery Facilities (D. Sussman, Ogden Corp.)

1030 Dioxins (Clinton Kemp, BFI)

1100 Designing for Good Combustion (A. Licata, Dravo Energy Resources)

1200 Lunch

1230 MSRC's Ash Research Program (F. Roethel, MSRC)

1245 Emissions and Ash from Modern Mass Burn Resource Recovery Facilities: An Overview of Unresolved problems and Unexploited Opportunities (G. Smith, EPA)

1300 Management of Residues from Resource Recovery (M.R. Surgi, Allied Signal, Inc.)

1330 An Overview of the N.Y. State Energy Research and Development Authority's (NYSERDA) Resource Recovery Research Program (Parker Mathusa, NYSERDA)

1400 Discussion and Formulation of Conclusions and Recommendations

1530 Conclude

Appendix B

LIST OF PARTICIPANTS

1. Ann Anderson, Senior Engineering Technician, New York State Department of Conservation, Region 1
2. Harold Berger, Director, Region 1, N.Y. State Department of Environmental Conservation
3. Marc David Block, Co-Director, Science and Decision Making Project, New York Academy of Sciences
4. Gerald Brezner, Regional Solid and Hazardous Waste Engineer, N.Y. State Department of Environmental Conservation, Region 1
5. Maggie Clarke, Environmental Scientist, New York City Department of Sanitation
6. Terrence Curran, Executive Director, N.Y. State Environmental Facilities Corp.
7. Norman G. Einspruch, Dean, College of Engineering, University of Miami
8. Robert J. Fitzpatrick, Vice President, Grumman Corp.
9. Ted Goldfarb, Associate Professor of Chemistry and Associate Vice Provost for Curriculum, SUNY at Stony Brook
10. F.D. Hutchinson, President, Dravo Energy Resources
11. Clinton C. Kemp, Consultant, American Refuel, Canruf Company, Canada
12. Lee Koppelman, Executive Director, L.I. Regional Planning Board
13. Evan Liblit, U.S. Environmental Protection Agency, Region 2
14. Anthony Licata, Vice President, Dravo Energy Resources
15. Parker D. Mathusa, Program Director, Energy Resources & Environmental Research, New York State Energy Research Development Authority
16. Judith McEvoy, Assistant to the Director of Legislative and Economic Affairs, Long Island Association

17. Homer A. Neal, Provost, SUNY at Stony Brook
18. Linda O'Leary, Project Manager, Regional Waste Task Force, Port Authority of New York and New Jersey
19. George Proios, Senate Executive Director, New York State Legislative Commission on Water Resource Needs of Long Island
20. Frank Roethel, Associate Professor, Nassau Community College, and Research Professor, Marine Sciences Research Center
21. Pat Roth, Ombudsman (Community Relations Specialist), New York State Department of Health
22. T. Sanford, Regional Engineer, BFI of New York
23. J.R. Schubel, Director, Marine Sciences Research Center, SUNY at Stony Brook
24. Ronald Scrudato, Research Associate, Rockefeller Institute of Government
25. Frederick Seitz, President Emeritus, Rockefeller University
26. Garrett Smith, Special Assistant for Air and Waste Management, U.S. Environmental Protection Agency, Region 2
27. Marion R. Surgi, Signal Research Center
28. David Sussman, Vice President of Ogden Projects, Ogden Martin Systems Inc.
29. A. Szurgot, Signal Environmental Systems
30. Vincent Taldone, Office of Resource Recovery, New York City Department of Sanitation
31. Peter M.J. Woodhead, Research Professor, Marine Sciences Research Center
32. Roberta Weisbrod, Special Assistant to Commissioner, New York State Department of Environmental Conservation